GLOVE BOX INTEGRATED DEPOSITION SYSTEM

System: 00382

Flexible Display Center
Tempe, Arizona

Prepared by Angstrom Engineering Inc.

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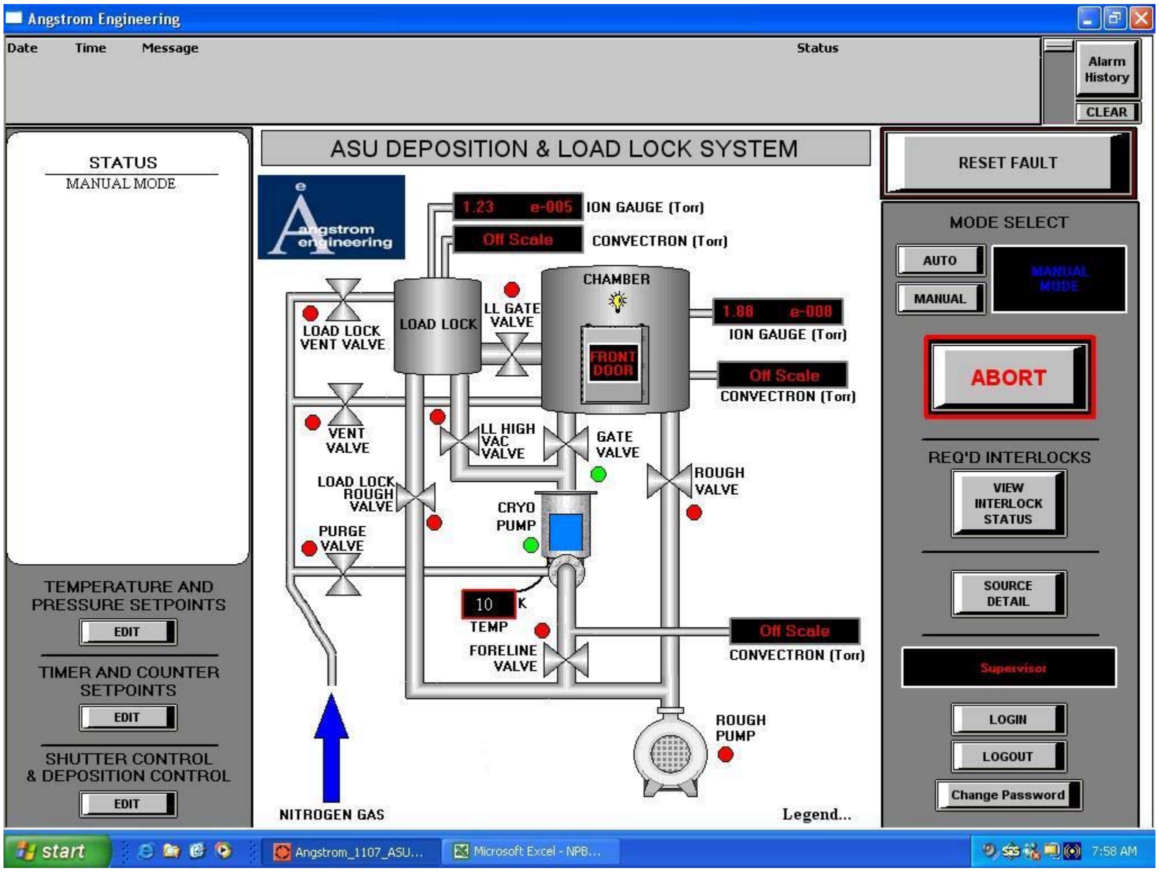
angstrom engineering

SYSTEM OPERATION

Chapter 1 – System Operation

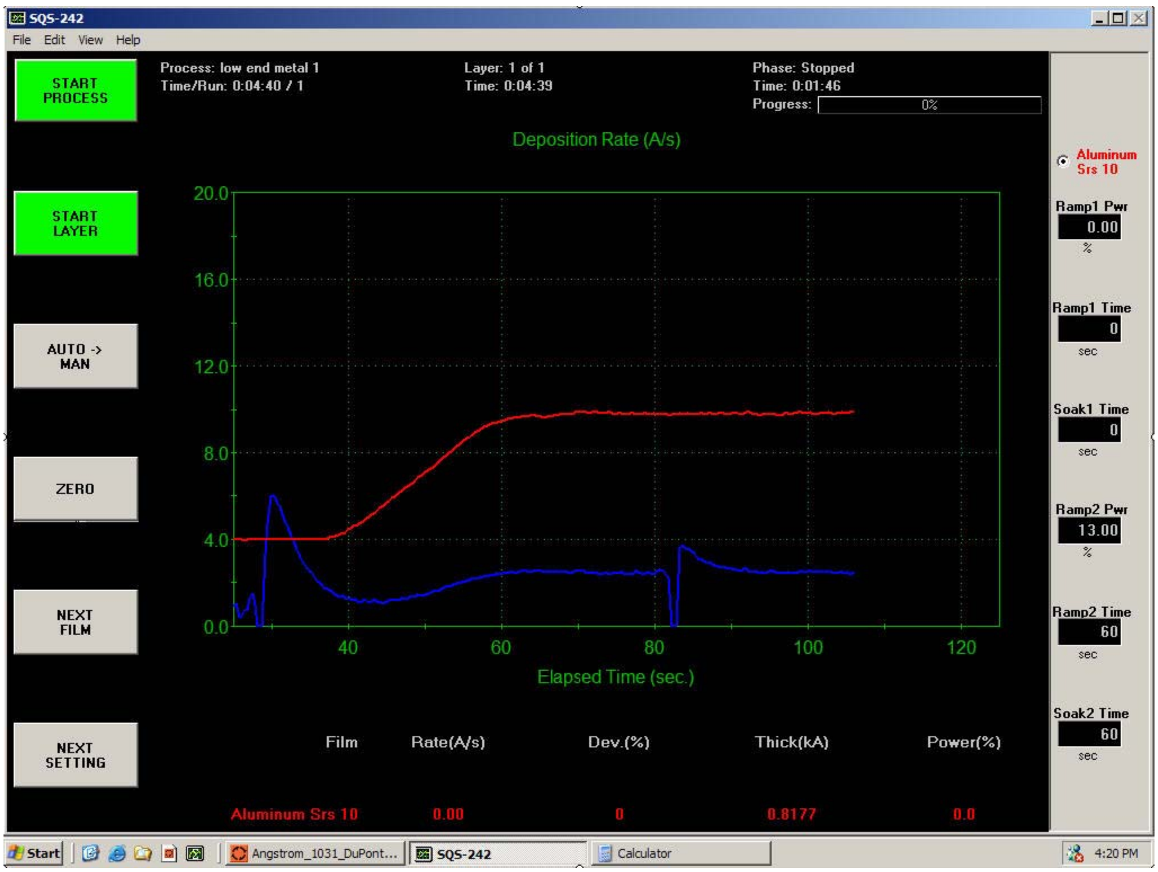


Welcome to your Angstrom Engineering vacuum evaporation system manual. The following pages cover all aspects of the operation of this system. Please report any errors or emissions found to Angstrom Engineering for clarification and revision.

Shown is the main operating page, where all machine control is available, except for deposition control. Deposition control is handled by the Sigma deposition software, which opens as a separate program. The main system page is a windows based page and it is the user interface for the SCADA software, which in turn communicates with the system PLC. The PLC code allows the SCADA (Supervisory Control And Data Acquisition) software to control all of the system's basic functions. Examples of these functions include powering pneumatic solenoids to open and close valves, controlling contactors and relays to turn on pumps and motors, and receiving all the inputs from gauges, switches and other items with feedback. The user, through the SCADA software activates automated sequences programmed into the PLC for pumping and venting the chamber and other routines.

The main page is constructed of many small windows. These include the alarm window at the top of the screen, the Status window on the left of the screen, and the main system schematic with all of the manual controls.   Other buttons open pop up windows to display the interlock status, the source detail, auto and manual mode selection screens, the temperature and pressure setpoints, the timers and counters setpoints, the shutter control and deposition control screen and the login and logout screens. The abort and reset fault buttons are also on the display. All of the systems operations and functions are explained in detail throughout the next few chapters of this manual.

The PLC or Programmable Logic Controller runs a program of commands and sequences, which in conjunction with the SCADA software allow the user to operate and control the system. The PLC program is stored in the PLC memory and is not affected by the system PC. Once the system is running, the PC can be turned off without affecting the operations in the PLC. If the computer needs to be rebooted for any reason or it needs repair, it can be turned off and even removed for short periods of time. However, if an error occurs in the system and the PLC takes appropriate action, the user will be unable to react to the error unless the SCADA software is running on the PC. The Sigma software is entirely PC based, and it communicates to the PLC through a serial cable, as does the SCADA software.

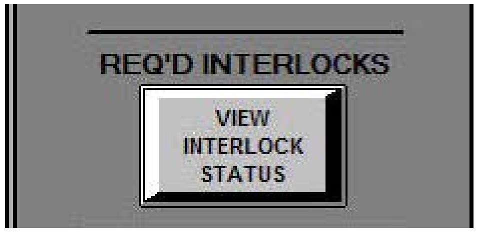


The Sigma deposition control software is a very powerful and feature packed tool for controlling depositions. It allows the user to perform co-depositions of up to four materials at a time with this system. We can deposit two organic materials, one from sources 1-3, and one from sources 4-6 at the same time. Also, we can deposit from one of the metals sources 7-8, and one of 9-11 at the same time. The Sigma deposition control software is provided with a detailed manual. An electronic copy of this manual is enclosed in the appendix of this manual, and provided in hard copy as well for user reference.

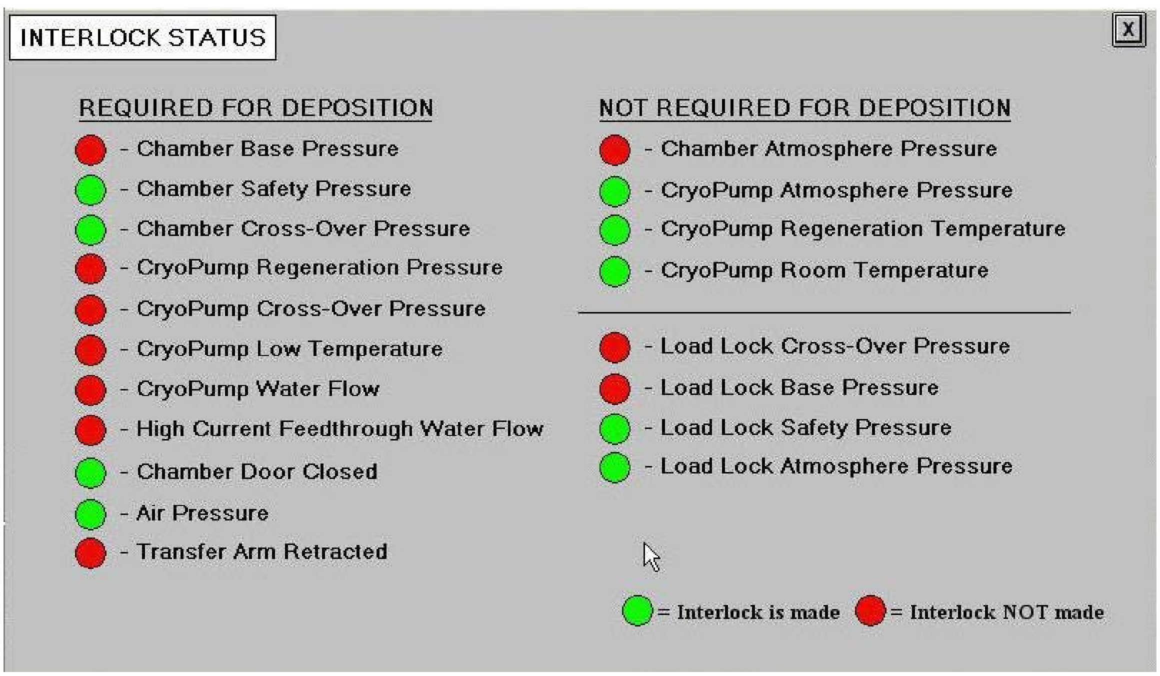
The ability of the software to start a deposition is controlled by the SCADA software and the PLC. If any of the interlocks on the left side of the interlock status page are not met the Sigma software will not be able to perform a deposition. Also, regardless of whether the system control is in manual control, or at the end of an automated pump down sequence, deposition is not permitted unless the system vacuum level is below the chamber base pressure setpoint IGSP1. However, once a deposition has begun, the pressure may then go higher than this setpoint, as long as it does not exceed the chamber safety pressure setpoint, CG1SP2. If any fault occurs in the SCADA software during a deposition, the deposition is stopped, and the Sigma software will abort the process. The source detail lists all of the information you need to assign a particular source to a film in the Sigma software. See the Sigma manual for additional information.

Chapter 2 – Interlocks and Setpoints

Clicking on the button shown bellow will display the interlock status window.



Note that all the interlocks on the left hand side of the screen are interlocks required for deposition. If the operator is attempting to run a deposition and it does not run, a quick look at this interlock screen may show why. Almost all of these interlocks are setpoints relating to pressures or temperatures. All of these setpoints are explained in the section following pertaining to the temperature and pressure setpoints pop up window. The interlocks that are not pressure or temperature setpoints are explained next.



Cryo pump Water Flow

The cryo pump compressor requires water-cooling to operate, so a flow meter is connected to the return line from the cryo compressor to the return water manifold. The flow meter has a settable normally open contact for water flow. Water flow must be present to start and maintain the cryo. When there is sufficient water flow, the contact in the flow meter closes, and the interlock is made. However, if there is insufficient water flow while the cryo is running and the switch opens, the cryo pump compressor contactor is de-energized by the system. This will turn off the cryo pump, and a fault will be shown.

High Current Feed through Water Flow

The metals resistive sources in the chamber are all connected to a single common plate. This common plate is connected to a single vacuum feed through on the chamber bottom. If two metals sources are run together as a co-deposition, the amperage draw could be greater than that allowed by a standard feed through. For this purpose a water-cooled feed through capable of handling a higher amperage load is fitted to the system. The water to cool the feed through is run through a flow meter with a flow switch on the return side water manifold. When there is sufficient water flow, the contact in the flow meter closes, and the interlock is made. If the contact is not made due to insufficient flow a fault is shown, and the interlock is not made. This will stop a deposition in progress, or disallow any deposition to start.

Chamber Door Closed

This interlock is a combination of two conditions, the door position switch, and the output to the door open and close solenoid. We do not receive any feedback from the solenoid, or the door itself to indicate that it has closed or sealed the door against the chamber seal face. The only direct feedback we have is from the normally open door position switch. This switch ensures the front door is in position in front of the chamber opening before the front door can be closed or sealed. The combination of the door position switch being made, and the solenoid de-energized, is our interlock. The front door is sprung to close against the chamber front face. If the solenoid valve that controls the door loses power due to a power failure or loss of air pressure, the door will close in whatever position it is in on the door track. If this occurs, the door will remain in the closed position until the user re-energizes the solenoid by clicking on the door open switch. Note that damage to the o-ring seal on the back of the door may occur if pneumatic pressure is lost and the door closes while in any position other than in front of the chamber opening. Do not attempt to move the door on the door track if this occurs. The door open switch is interlocked to the chamber atmosphere pressure set point G1SP3 read from the chamber Convectron® gauge. The chamber must be at atmospheric pressure in order to open the door.

Note that when the door has been slid open on its tracks the door position switch is open. A message will be displayed in the door open and close switch pop up window, indicating the door is out of position. The switch must be closed indicating the door is in position before the door can be closed and sealed against the chamber face for pump down.

Air Pressure

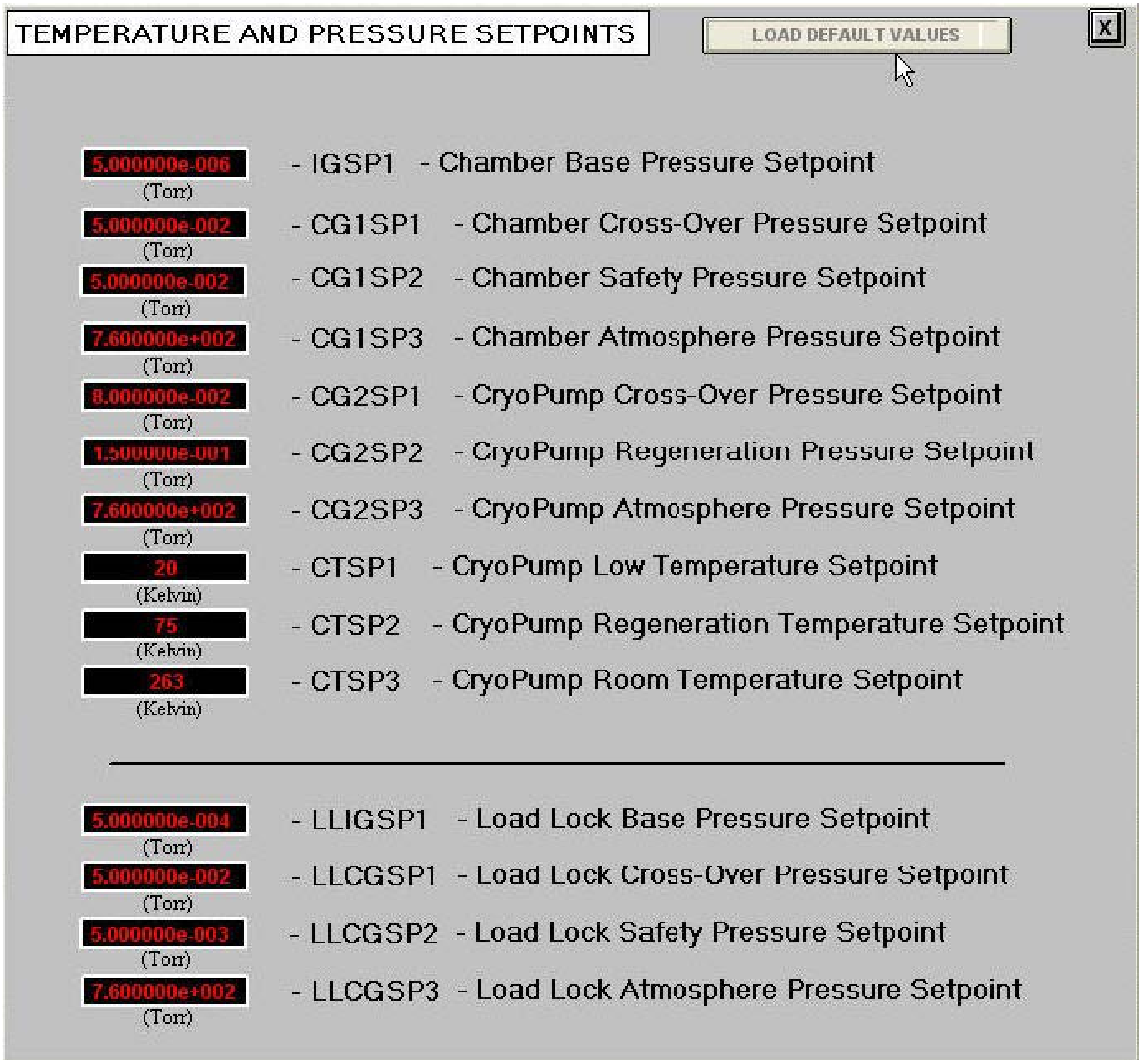
This interlock is a pneumatic pressure switch mounted just inside the feed through marked pneumatic gas 85 psi on the rear system utility panel. This normally open pressure switch has been set to close at approximately 60 psi. The purpose of this interlock is to have enough air pressure to operate valves, especially the gate valve, at all times. If the system loses air pressure and the switch opens, a low-pressure alarm is shown. There is a 5 second timer to account for short-term pressure variations below the switch set point. If the gate valve is open, and an attempt to close it fails, a gate valve faulted warning will also be shown.

Transfer Arm Retracted

This interlock is a triggered by a limit switch that is mounted at the end of the magnetic transfer arm. It is incorporated into the software to ensure that the arm is not damaged when opening and closing the gate valve between the load lock and the chamber. If the switch is not closed meaning that the arm is not fully retracted the contacts in the PLC will open and the gate valve will not be able to be opened or closed. It will also trigger a fault.

Temperature and Pressure Set points

Clicking on the button shown above opens up the pop up box shown below.



Chamber Base Pressure

The chamber base pressure is a user settable setpoint labeled IGSP1, and it is triggered from the chamber ion gauge. This pressure setpoint must be achieved before deposition can take place. When pumping down in full auto pump down mode, the time it takes from the moment the chamber reaches crossover pressure (CG1SP1) until the chamber reaches base pressure after the gate valve opens must be less than the chamber base pressure time delay setpoint T5. If the time exceeds the timer setpoint, a fault is issued and the gate valve is closed.

Chamber Cross-over Pressure

The chamber crossover pressure setpoint is a user settable setpoint labeled CG1SP1, and it is triggered from the chamber Convectron® gauge. This is the pressure the rough pump must pump the chamber down to in manual mode or an auto pump down before the gate valve to the cryo pump can be opened for high vacuum pumping. The time it takes from the moment the rough valve opens to rough pump the chamber until cross-over pressure is reached must be less than the chamber cross-over time delay setpoint T4 when pumping down in full auto pump down mode. If the time exceeds the timer setpoint a fault is issued, the rough valve is closed, and the rough pump is switched off.

Chamber Safety Pressure

The chamber safety pressure is also a user settable pressure setpoint. The setpoint is CG1SP2, and it is triggered from the chamber Convectron® gauge. This setpoint is not considered until the chamber achieves the base pressure set point IGSP1. Then, if the pressure in the chamber ever rises to this pressure setpoint without being vented, the gate valve closes automatically to protect the cryo pump, and a fault is shown.

Chamber Atmosphere Pressure Setpoint

The chamber atmosphere pressure setpoint CG1SP3 is a user settable pressure set point read from the chamber Convectron® gauge. The pressure in the chamber must be higher than the setpoint to allow the user to open the front door on the system.

Cryo pump Crossover Pressure Setpoint

The cryo crossover pressure setpoint CG2SP1 is the pressure the rough pump must achieve as indicated by the cryo Convectron® gauge on the cryo pump before the pump compressor can be started. After this set point has been achieved, the set point is ignored, in that the pressure will traditionally rise slightly in the cryo after the rough valve is closed to the rough pump until the pump has cooled. As the pump cools to base temperature, the pressure will drop again and the gauge will eventually read off scale.

Cryo pump Regeneration Pressure

The cryo pump regeneration pressure setpoint CG2SP2 is a user settable pressure setpoint used during a cryo pump regeneration. The set point is read from the cryo Convectron® gauge on the cryo pump. This is the pressure during a regeneration that the cryo pump must not exceed before the regeneration timer T7 times out. If the pressure is achieved before the timer times out, the pump is not clean enough, and requires more purging. If the timer runs out before the pressure is achieved, then the pump is clean and more regeneration is not required.

Cryo pump Low Temperature Setpoint

The cryo pump low temperature setpoint CTSP1 is a user settable set point read from an analog output signal from the Lakeshore 211 temperature monitor. The monitor reads the temperature from a diode inside the cryo pump. In an auto full pump down, this setpoint is used to indicate that the cryo has achieved low temperature. This allows the sequence to move to the next step, which is pumping the chamber to cross over pressure and eventually opening the chamber to high vacuum pumping. A timer is started after the cryo pump turns on in the cryo or full pump down auto sequence. If the time it takes to achieve the low temperature set point after turning the pump on is greater than the cryo base pressure time delay set point T3, an alarm is shown, and the cryo pump is turned off. If the cryo pump is turned off for any reason, and the temperature in the cryo rises above this setpoint, the user will be unable to turn the cryo back on until the temperature in the cryo pump has risen above the cryo room temperature setpoint CTSP3. The pump can then be started again using an automated pump down sequence.

Cryo pump Atmosphere Pressure

The cryo pump atmosphere pressure set point CG2SP3 is a user settable pressure set point read from the cryo Convectron® gauge on the cryo pump. The set point is used during an auto pump down or cryo regeneration sequence to indicate the pump is at atmosphere. It also allows the gate valve to be opened for maintenance or testing if the chamber atmosphere pressure set point CG1SP3 is also met.

Cryo pump Regeneration Temperature Set point

The cryo regeneration temperature set point CTSP2 is a user settable set point read from an analog output signal from the Lakeshore 211 temperature monitor. It is used in the auto regeneration mode, as well as an interlock to the purge valve in manual mode. The cryo pump temperature must be above this set point to allow the purge valve to open. At temperatures less than this the purge gas may freeze as a solid inside the pump, causing the pump to take longer to warm up.

Cryo pump Room Temperature

The cryo room temperature set point CTSP3 is another user settable set point read from an analog output signal from the Lakeshore 211 temperature monitor. The set point is used in an auto full pump down and auto cryo pump down to indicate the cryo is completely warm. The pump must be at room temperature before these sequences can begin, or the temperature must be below the low temperature set point CTSP1, indicating that the cryo pump is already running. If the cryo pump temperature is between these two values, the cryo must be purged or regenerated until the set point is reached before the sequences can begin. In these auto routines, if the user attempts to start the routine and the temperature is between the two set points a fault is shown and the user is prompted to start a regeneration cycle. The set point is also utilized in the auto regeneration sequence.

Load Lock Cross-over Pressure

The load lock crossover pressure setpoint is a user settable setpoint labeled LLCGSP1, and it is triggered from the load lock Convectron® gauge. This is the pressure the rough pump must pump the load lock down to in manual mode or an auto pump down before the high vacuum valve to the cryo pump can be opened for high vacuum pumping. The time it takes from the moment the rough valve opens to rough pump the load lock until cross-over pressure is reached must be less than the load lock cross-over time delay setpoint T26 when pumping down in full auto pump down mode. If the time exceeds the timer setpoint a fault is issued, the rough valve is closed, and the rough pump is switched off.

Load Lock Base Pressure

The load lock base pressure is a user settable setpoint labeled LLIGSP1, and it is triggered from the load lock ion gauge. This pressure setpoint must be achieved before a load lock auto pump down can be completed. When pumping down in full auto pump down mode, the time it takes from the moment the load lock reaches crossover pressure (LLCGSP1) until the load lock reaches base pressure after the high vacuum valve opens must be less than the load lock base pressure time delay setpoint T27. If the time exceeds the timer setpoint, a fault is issued and the high vacuum valve is closed.

Load Lock Safety Pressure

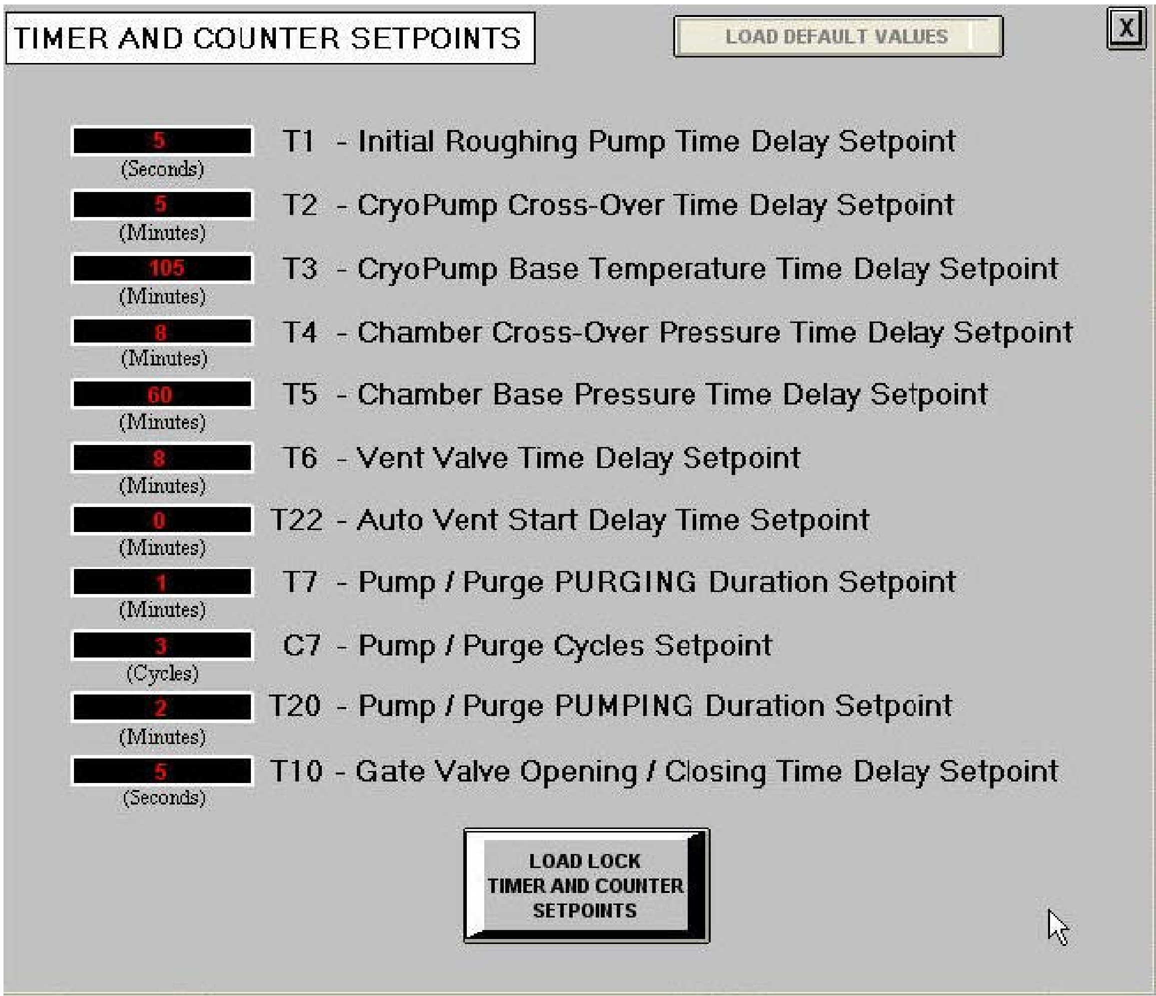
The load lock safety pressure is also a user settable pressure setpoint. The setpoint is LLCGSP2, and it is triggered from the load lock Convectron® gauge. This setpoint is not considered until the load lock achieves the base pressure set point LLIGSP1. Then, if the pressure in the load lock ever rises to this pressure setpoint without being vented, the high vacuum valve closes automatically to protect the cryo pump, and a fault is shown.

Load Lock Atmosphere Pressure Setpoint

The load lock atmosphere pressure setpoint LLCGSP3 is a user settable pressure set point read from the load lock Convectron® gauge. The pressure in the load lock must be higher than the setpoint before the user should open the door to the load lock.

Timer and Counter Set points

Clicking on the button above opens up the pop up window shown below.



All user settable timers are found on the timer and counter setpoints page. Default values can be loaded at any time by clicking on the load default values button.

T1 – Initial roughing pump time delay setpoint

This timer represents the delay between the starting of the rough pump and the opening of the chamber rough valve or the foreline valve during an auto full pump down mode.

T2 – Cryo pump cross-over time delay setpoint

This timer represents the maximum allowable time the rough pump can pump the cryo pump from atmosphere to cross-over pressure set point CG2SP1 during an automated full pump down or auto cryo pump down.

T3 – Cryo pump base temperature delay setpoint

This timer represents the maximum allowable time the cryo pump can take to pump down to the cryo pump low temperature setpoint CTSP1 from the time the cryo pump is turned on after it has been pumped to cross-over pressure set point CG2SP1 during an auto full pump down or auto cryo pump down.

T4 – Chamber cross-over pressure delay setpoint

This timer represents the maximum allowable time the rough pump can pump the chamber from atmosphere to cross-over pressure set point CG1SP1 during an automated pump down.

T5 – Chamber base pressure time delay setpoint

This timer represents the maximum time it can take for the chamber pressure to reach the chamber base pressure setpoint IGSP1 from the time the gate valve opens after the chamber cross-over pressure set point CG1SP1 is reached during an auto full pump down.

T6 – Vent valve time delay setpoint

This timer represents the time the vent valve is held open after the gate valve is closed during an auto vent cycle.

T22 – Auto vent start delay time set point

This set point can be used to delay the opening of the chamber vent valve during an auto vent cycle. This can be utilized if the user wishes to allow the system to cool after a deposition for a set period of time before opening the vent valve. It allows the time to be fixed and the user to not have to worry about keeping track of how long to wait.

Auto pumping sequence pumping and purging

If the user selects an auto full pump down or auto cryo pump down and the cryo pump is at atmosphere pressure set point CG2SP3 and room temperature set point CTSP3 the sequence will automatically pump and purge the cryo pump similar too cleaning out the pump in a regeneration cycle. The following three set points are used.

T7 – Pump/purge PURGING duration set point

This timer represents the time the purge valve stays open during a pump and purge cycle in the pump and purge sequence at the beginning of the auto full pump down and auto cryo pump pump down.

C7 – Pump/purge cycles setpoint

This counter represents the number of pump and purge cycles in the pump and purge sequence at the beginning of the auto full pump down and auto cryo pump pump down modes.

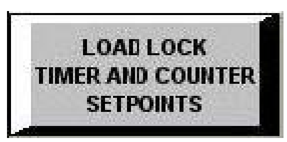
T20 – Pump/Purge Pumping Duration Set point

This is the duration time for the rough pump to rough the cryo pump during the purge portion of the pump and purge sequence at the beginning of the auto full pump down and auto cryo pump down.

T10 – Gate valve opening/closing time delay set point

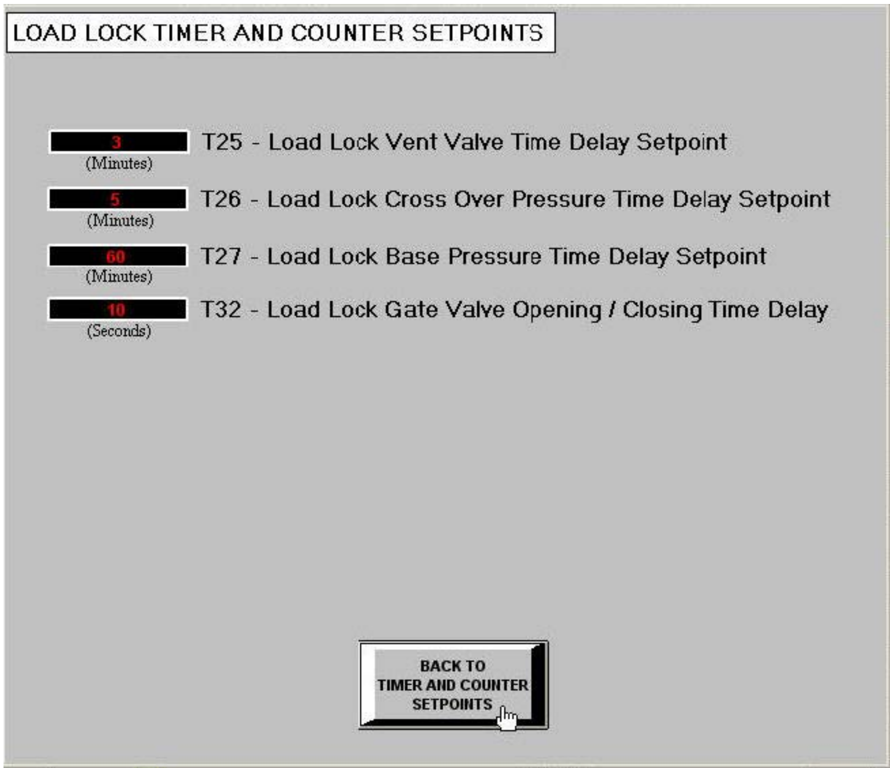
This time delay allows time for the gate valve to open/close before showing the gate valve has faulted. This time delay is present in all modes.

If you select the button at the bottom of the main Timers and Counters screen you will be taken into the Load Lock timers and counters screen.



All user settable timers and counters used in the load lock can be found in the following pop up window. As with the main timers and counters window default values can be loaded by clicking the “load default values” button on the top right corner of the screen.

To get back to the main timers and counters screen select the “back to timer and counter setpoint” button on the bottom of the pop up window.



T25 – Load Lock Vent valve time delay setpoint

This timer represents the time the vent valve is held open after the High vacuum valve is closed during an auto vent cycle.

T26 – Load Lock cross-over pressure delay setpoint

This timer represents the maximum allowable time the rough pump can pump the load lock from atmosphere to cross-over pressure set point LLCGSP1 during an automated pump down.

T27 – Load Lock base pressure time delay setpoint

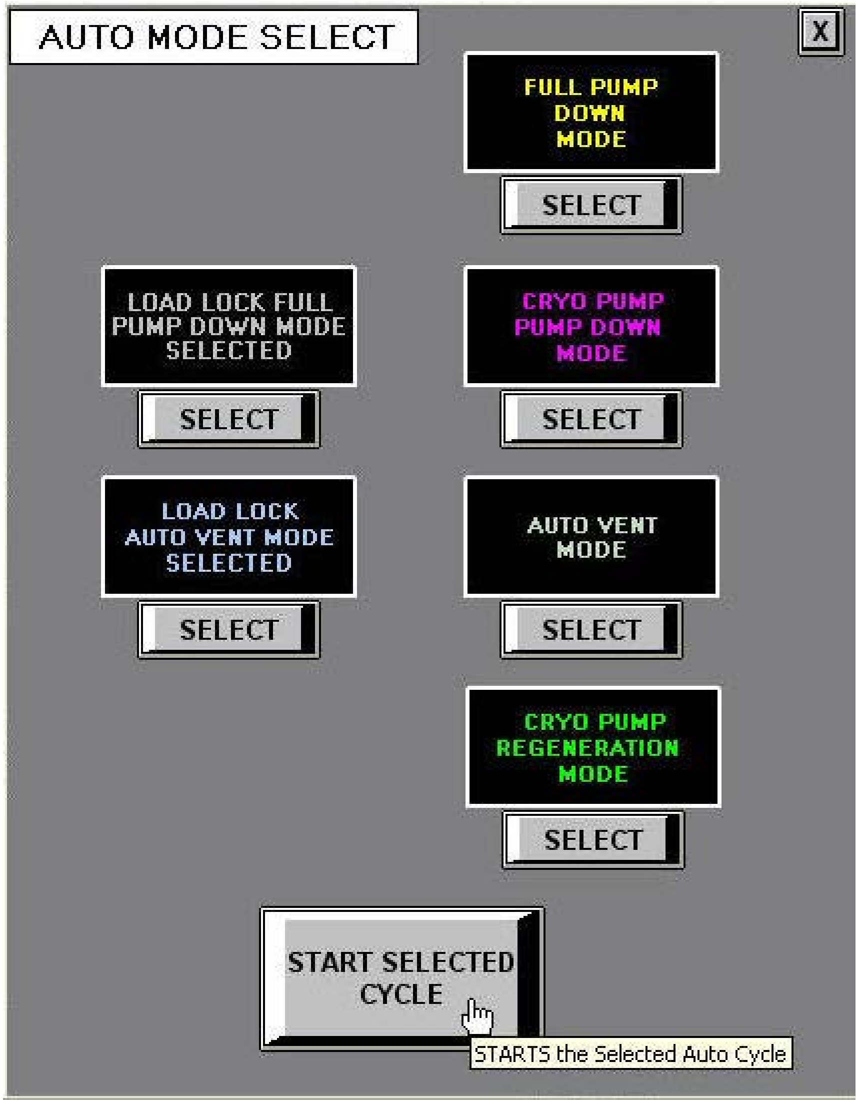
This timer represents the maximum time it can take for the load lock pressure to reach the load lock base pressure setpoint LLIGSP1 from the time the high vacuum valve opens after the load lock cross-over pressure set point LLCGSP1 is reached during an auto full pump down.

T32 – Load Lock Gate valve opening/closing time delay set point

This time delay allows time for the gate valve to open/close before showing the gate valve has faulted. This time delay is present in all modes.

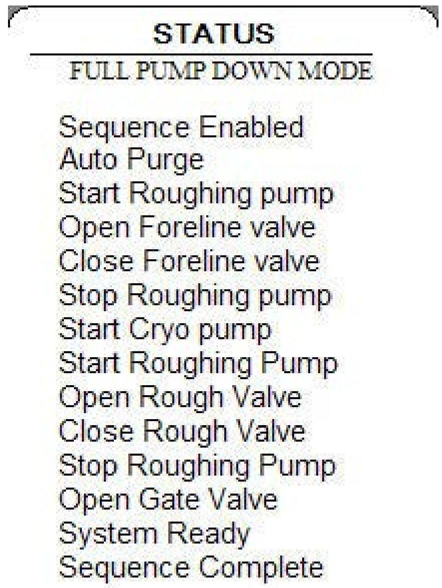
Chapter 3 – Automatic Sequences

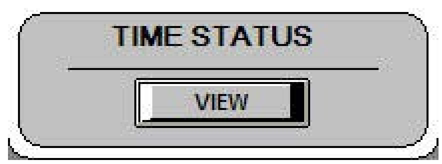
This menu shows a list of the 6 automatic sequences which can be executed upon pressing the select button to the left of the process desired, and then pressing the start selected cycle button outlined in red at the bottom of the pop up box.



Status Bar

During an auto sequence the status of the mode is displayed in the status bar. If the system is in manual it is also noted.





Full Pump Down Mode

Interlocks required to be met to start an auto full pump down include the air pressure interlock, chamber door closed, high current feed through water flow, and cryo pump water flow. If any of these interlocks are lost during the mode, the auto sequence is cancelled and the system reverts to no mode, indicating a fault and waiting for further user commands.

If the interlocks are met and the user starts the full auto pump down, the PLC looks at the first sequence of the mode, which is cryo at atmosphere and cryo at temperature. If the cryo temperature is above the cryo pump room temperature setpoint, CTSP3, and the pressure in the cryo is above the cryo pump atmosphere pressure setpoint CG2SP3, the cryo is put through a series of pump and purge cycles. The number of cycles is user setpoint C7, pump / purge cycles setpoint. The purge duration is T7, pump / purge purging duration setpoint. The pumping duration is T20, pump / purge pumping duration setpoint. While pumping, the next purge cycle is triggered by the pumping timer, T20, or the cryo pump crossover pressure setpoint, CG2SP1. All pump and purge cycles are completed before the sequence moves to the next step. If the cryo pump temperature is

higher than the cryo pump low temperature setpoint, CTSP1, but lower than the cryo pump room temperature setpoint, CTSP3, an alarm informs the user that cryo pump regeneration is required using a cryo regeneration cycle.
Once the pump and purge cycles are complete, if the cryo pump is at crossover pressure, the cryo pump is turned on, and the cryo pump begins cooling towards the cryo pump low temperature setpoint, CTSP1.

If this mode is selected and the cryo pump is already running, and the cryo pump low temperature setpoint CTSP1 has been met, then the PLC jumps to the next part of the sequence, which is rough pumping the chamber. If the chamber cross-over pressure setpoint CG1SP1 is met, then the PLC will open up the gate valve between the chamber and the cryo pump for high vacuum pumping. If the cross-over is not met, the rough pump is started and the chamber rough valve is opened. The chamber is then pumped down to the cross-over set point CG1SP1, and then the rough valve is closed, the rough pump is turned off, and the gate valve is opened.

Once the gate valve has opened, the system looks for the chamber base pressure setpoint, IGSP1. If the chamber base pressure is not met before the chamber base pressure time delay setpoint, T5 has elapsed, a fault is shown and the system reverts to no mode and the gate valve closes. However, the cryo pump remains on.

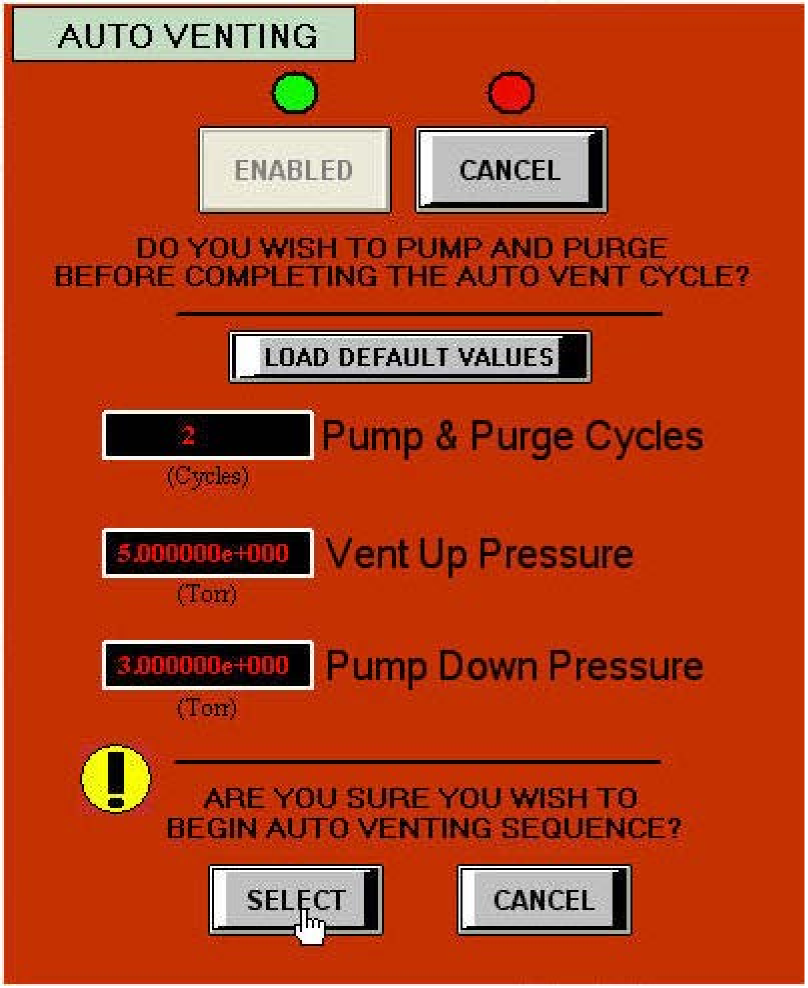
Cryo pump Pump Down Mode

Interlocks required are the same as for a full pump down. This mode is identical to the full pump down mode except that it does not rough pump the chamber and open it to high vacuum pumping.

Auto Vent Cycle

The auto vent cycle is used to vent the chamber to atmosphere from vacuum. There are a couple of venting options presented to the user. Selection of the cycle closes the gate valve and the load lock gate valve. Once the cycle has been selected the dialog box shown bellow pops up. Conditions required to allow an auto vent cycle include the door position switch closed to indicate the door is in position, the door closed, and the air pressure interlock met so that air can be used to operate the vent valve.
When the dialog box is displayed after selecting the auto vent cycle the user needs to choose to pump and purge the chamber before venting to atmosphere or simple to vent the chamber by opening up the vent valve. The user may chose to pump and purge the chamber if it is to be opened to the atmosphere of the room and there is concern about vapors from a deposition escaping to the room. If the user is going to work in the vacuum chamber from the glove box side traditionally the pump and purge cycles are not needed.
If the user chooses to select the pump and purge option by pressing the select key, then the number of pump and purge cycles, the vent up pressure, and the pump down pressure default values are highlighted. These values are user settable, and can be changed simply by clicking on the display box beside each of the descriptions. Once the user has

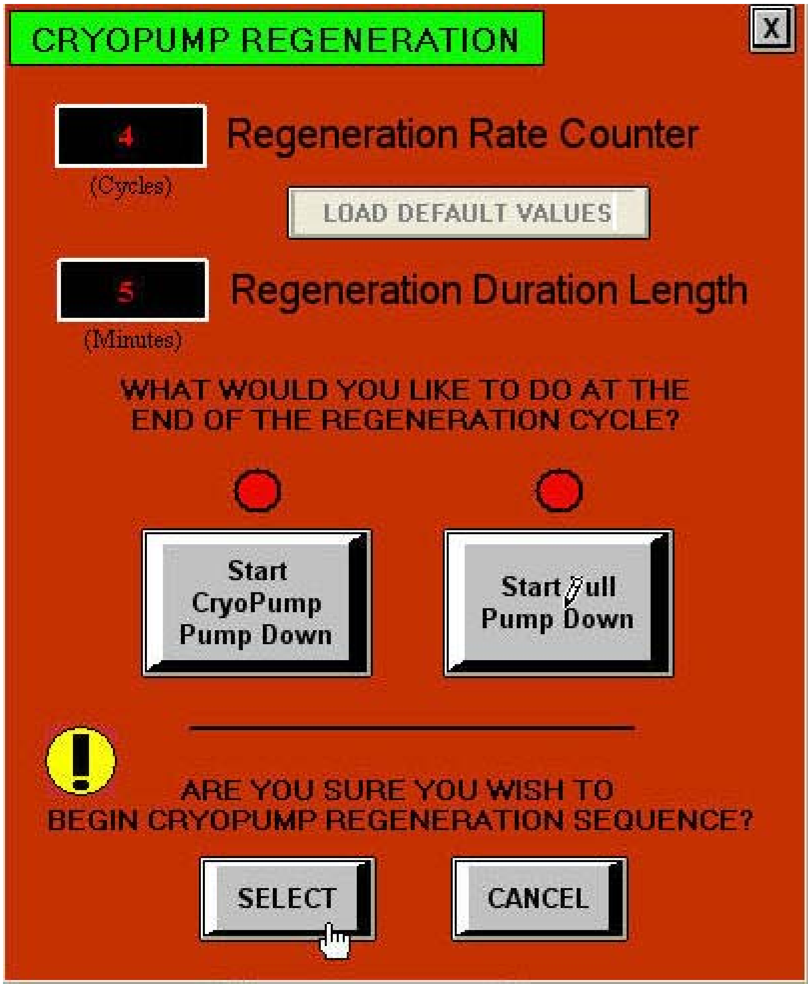
determined what they wish to do, they must then press the select button at the bottom of the dialog box, or if they wish they can cancel out of the cycle all together.



A user settable timer T6, vent valve time delay, controls how long the vent valve is open. After the timer times out the vent valve is closed, and the mode ends, reverting the system to no mode. If the vent valve time delay set point T22 has a value greater than zero minutes, the vent valve will not open, or the pump and purge cycles will not begin until the delay set point time has elapsed.

Cryo pump Regeneration Mode

Selecting the cryo pump regeneration mode displays the following dialog box.



The interlocks required to start cryo pump regeneration include the air pressure interlock and cryo pump water flow. There are three scenarios available to pick from in the cryo pump regeneration dialog box. You can click to start the cryo pump only after the regeneration, or click to start a full pumpdown after the regeneration. The system will simply revert to the mode selected, and all mode specific interlocks and conditions will apply. The user can also choose neither of these automated modes, and the system will regenerate the cryo pump and leave it at the cryo pump cross-over pressure setpoint CG1SP1.

When cryo pump regeneration is started, if the cryo pump is running and the gate valve is open to the chamber, the gate valve will close, and the cryo pump will turn off. Gradually the cryo pump will begin to warm. Once the temperature in the cryo pump is greater than the cryo pump regeneration temperature setpoint, the purge valve will open and purge the cryo pump until it reaches the cryo pump room temperature setpoint, CTSP3. This extended purge is usually sufficient to regenerate the pump, however the system now checks to see how ‘clean’ the pump is with a series of pumping cycles. The number of cycles is the regeneration rate counter in the dialog box.

In a regeneration cycle, the cryo pump is pumped by the roughing pump to the cryo pump cross-over pressure setpoint, CG1SP1. If the rough pump fails to pump to the setpoint before the cryo pump cross-over delay setpoint, T2, the mode is stopped and an error is shown. The user can attempt the regeneration cycle again, or check for problems with the pump. Once the cryo pump pressure is at cross-over the foreline valve closes, the rough pump turns off, and the regeneration duration length counter starts. If the regeneration duration length passes before the cryo pump pressure rises above the cryo pump regeneration pressure setpoint, CTSP2, then the pump is considered clean and the regeneration is complete. If the pressure rises to the regeneration pressure before the duration length, then the cryo pump is pumped down again to cross-over for another cycle if more that one cycle is chosen. The cycles will continue until the duration length is met before the regeneration pressure. If the number of cycles is completed unsuccessfully, an alarm is shown indicating the pressure rose too quickly, and the regeneration mode stops.

Load Lock Full Pump Down Mode

Interlocks required to be met to start an auto load lock full pump down include the air pressure interlock, load lock high vacuum valve closed, load lock gate valve closed, high current feed through water flow, and cryo pump water flow. If any of these interlocks are lost during the mode, the auto sequence is cancelled and the system reverts to no mode, indicating a fault and waiting for further user commands.

If the interlocks are met and the user starts the load lock full auto pump down, the PLC looks at the first sequence of the mode, which is cryo at atmosphere and cryo at temperature. If the cryo temperature is above the cryo pump room temperature setpoint, CTSP3, and the pressure in the cryo is above the cryo pump atmosphere pressure setpoint CG2SP3, the cryo is put through a series of pump and purge cycles. The number of cycles is user setpoint C7, pump / purge cycles setpoint. The purge duration is T7, pump / purge purging duration setpoint. The pumping duration is T20, pump / purge pumping duration setpoint. While pumping, the next purge cycle is triggered by the pumping timer, T20, or the cryo pump crossover pressure setpoint, CG2SP1. All pump and purge cycles are completed before the sequence moves to the next step. If the cryo pump temperature is higher than the cryo pump low temperature setpoint, CTSP1, but lower than the cryo pump room temperature setpoint, CTSP3, an alarm informs the user that cryo pump regeneration is required using a cryo regeneration cycle.
Once the pump and purge cycles are complete, if the cryo pump is at crossover pressure, the cryo pump is turned on, and the cryo pump begins cooling towards the cryo pump low temperature setpoint, CTSP1.

If this mode is selected and the cryo pump is already running, and the cryo pump low temperature setpoint CTSP1 has been met, then the PLC jumps to the next part of the sequence, which is rough pumping the load lock. If the load lock cross-over pressure setpoint LLCGSP1 is met, then the PLC will open up the high vacuum valve between the load lock and the cryo pump for high vacuum pumping. If the cross-over is not met, the rough pump is started and the load lock rough valve is opened. The load lock is then pumped down to the cross-over set point LLCGSP1, and then the rough valve is closed, the rough pump is turned off, and the high vacuum valve is opened.

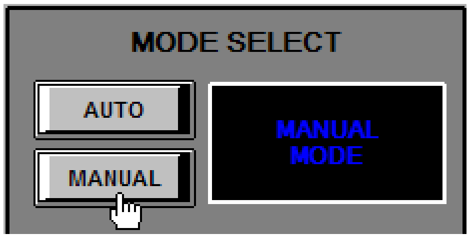
Once the high vacuum valve has opened, the system looks for the load lock base pressure setpoint, LLIGSP1. If the load lock base pressure is not met before the load lock base pressure time delay setpoint, T27 has elapsed, a fault is shown and the system reverts to no mode and the high vacuum valve closes. However, the cryo pump remains on.

Load Lock Auto Vent Cycle

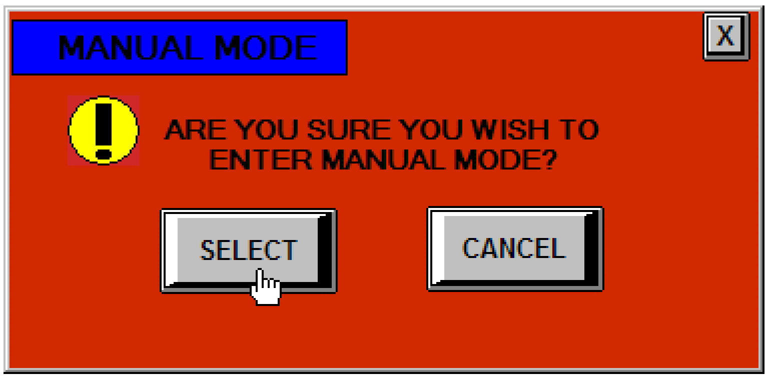
The load lock auto vent cycle is used to vent the load lock to atmosphere from vacuum. Selection of the cycle closes the high vacuum valve and the load lock gate valve. Conditions required to allow a load lock auto vent cycle include the high vacuum valve closed, load lock gate valve closed and the air pressure interlock met so that air can be used to operate the vent valve. When the auto vent is selected and the sequence is started the load lock will be vented by opening up the load lock vent valve. The vent valve will stay opened for the duration of the load lock vent valve timer T25. Once the load lock auto vent is complete the vent valve will close and the system will revert to no mode.

Chapter 4 – Manual Mode

Manual mode is only available to users logged in with supervisor status. Users with operator status can only operate the system using the auto modes. If the user has only operator status, all of the manual controls for the system components will be grayed out and not selectable.
Manual mode is selected by clicking on the manual button in the mode select area. There must not be any alarms present to enter manual mode.



Once this mode is selected, a dialog box asks if you are sure before entering the mode. If a deposition process is running changing modes will stop the process. Entering manual mode stops any auto process as well.



System Components Operation and Interlocks

All of the components available to the user in manual mode still have interlocks. This is designed to prevent even the most experienced user from making a mistake. These interlocks are in place primarily to safeguard the user, and to prevent occurrences that may take a lot of time to correct.

The manual component functions and the interlocks associated with each are outlined in the following section in point form for simplicity.

Vent Valve

To be able to access the manual controls:
- The rough valve must be closed.
- The gate valve must be closed.

To open the vent valve:
- The front door must be closed.
- Conditions to access manual controls must be met as above.

To close the vent valve:
- Conditions to access manual controls must be met.

NOTE: If the front door interlock is lost (the front door is opened or unsealed) the vent valve is closed automatically to prevent the pressurization of the glove box.

Load Lock Vent Valve

To be able to access the manual controls:
- The load lock rough valve must be closed.
- The load lock high vacuum valve must be closed.
- The load lock gate valve must be closed

To open the vent valve:
- Conditions to access manual controls must be met as above.

To close the vent valve:
- Conditions to access manual controls must be met.

Gate Valve

To be able to access the manual controls:
- The vent valve must be closed.
- The rough valve must be closed.

To open the gate valve:
- The purge valve must be closed.
- The foreline valve must be closed.
- The rough valve must be closed.
- Either (A) Atmosphere pressure setpoints for both the cryo and gate valve must be met (cryo CG2SP3 and chamber CG1SP3) i.e. they are both at atmosphere, or (B) the cryo pump low temperature setpoint CTSP1 is met and chamber cross-over pressure setpoint CG1SP2 is met, i.e. the cryo pump is at low temp, and the chamber is at cross-over, ready for high vacuum pumping.

To close the gate valve:

- Conditions to access the manual controls must be met.

NOTE: The gate valve will close automatically if:

- A change in login occurs.
- The PLC is first powered up (first scan closes the gate valve)
- Cryo pump low temperature setpoint CTSP1 is lost (temperature rises above setpoint).
- The chamber cross-over pressure setpoint CG1SP1 is not met (pressure is higher than cross-over)

<u>Load Lock Gate Valve</u>

To be able to access the manual controls:

- The load lock vent valve must be closed.
- The load lock rough valve must be closed.
- Conditions to access Manual controls must be met

To open the load lock gate valve:

- Either (A) Atmosphere pressure setpoints for both the load lock and the chamber must be met (load lock LLCGSP3 and chamber CG1SP3) i.e. they are both at atmosphere, or (B) the load lock crossover pressure setpoint LLCGSP2 is met and chamber cross-over pressure setpoint CG1SP2 is met, i.e. the load lock is at or bellow crossover, and the chamber is at or bellow cross-over.

To close the gate valve:

- Conditions to access the manual controls must be met.
- The magnetic arm must be retracted.

NOTE: The gate valve will close automatically if:

- The chamber or load lock vent valves are selected and the magnetic arm is retracted.

<u>Rough Valve</u>

To be able to access the manual controls:

- The vent valve must be closed.
- The gate valve must be closed.
- The roughing pump must be turned on.

To open the rough valve:

- The chamber crossover pressure setpoint CG1SP1 must not be met (the chamber pressure is higher than the cross-over pressure).
- The chamber door interlock is met (door is in position and sealed to the chamber front face).

To close the rough valve:
- Conditions to access the manual controls must be met.

NOTE: If the rough pump is on and the rough valve is open and the user then turns off the rough pump, the rough valve is automatically closed.

Load Lock Rough Valve

To be able to access the manual controls:
- The load lock vent valve must be closed.
- The load lock high vacuum valve must be closed
- The load lock gate valve must be closed.
- The roughing pump must be turned on.

To open the rough valve:
- The load lock vent valve must be closed
- The load lock gate valve must be closed.
- The roughing pump must be turned on.
- The load lock crossover pressure setpoint LLCGSP1 must not be met (the load lock pressure is higher than the cross-over pressure).

To close the rough valve:
- Conditions to access the manual controls must be met.

NOTE: If the rough pump is on and the load lock rough valve is open and the user then turns off the rough pump, the load lock rough valve is automatically closed.

Purge Valve

To be able to access the manual controls:
- The foreline valve must be closed.
- The cryo pump must be off.
- The gate valve must be closed.
- The cryo pump regeneration temperature setpoint CTSP2 must be met (the cryo temperature must be above this setpoint).

To open and close the purge valve:
- The conditions to access the manual controls must be met.

Foreline Valve

To be able to access the manual controls:
- The purge valve must be closed.
- The cryo pump must be off.

- Gate valve must be closed

To open the foreline valve:
- The cryo pump crossover pressure setpoint CG2SP1 must not be met (pressure is higher than cross-over).
- The purge valve must be closed.
- The cryo pump must be off.

To close the foreline valve:
- The conditions to access the manual controls must be met.

NOTE: If the rough pump is on and the foreline valve is open and the user then turns off the rough pump, the foreline valve is automatically closed.

<u>Chamber Door</u>

NOTE: The user can be logged in as an operator or as a supervisor to access the door controls.

To be able to access the manual controls:
- The chamber atmosphere pressure set point CG1SP3 must be met.

To open and close or seal the front door:
- The conditions to access the manual controls must be met.
- The door must be in position in front of the chamber seal face, as indicated by the door position switch. If the door is out of position the manual control displays that it is, and the door will not seal (close), however it may be opened.

NOTE: In the event that air pressure is lost while the door is out of position, it will move to the seal position. If this occurs, the door should not be slid on the door tracks or damage to the o-ring seal on the door may occur. Once air pressure is restored to the system the door can be opened or moved to the unsealed position, allowing it to slide.

<u>Cryo pump</u>

To be able to access the manual controls:
- The purge valve must be closed.
- The foreline valve must be closed.
- The gate valve must be closed.

To start the cryo pump:
- The cryo pump crossover pressure setpoint CG2SP1 must have been met at least one time. Pressure is allowed to increase after the pump is turned on until the cryo pump regeneration pressure setpoint CG2SP2, at which point the pump is turned off automatically and a fault is shown.

- The cryo pump temperature must be higher than the cryo pump room temperature setpoint, CTSP3 (interlock is met), OR lower than the cryo pump low temperature setpoint, CTSP1 (interlock is met) for the cryo pump to turn on.

To turn the pump off:

- The conditions to access the manual controls must be met.
- The gate valve must be closed.

NOTE: If the temperature in the cryo pump rises above the cryo pump low temperature setpoint CTSP1, the cryo pump will automatically turn off. If this occurs the cryo pump will then need to be left to warm up above the cryo pump room temperature setpoint CTSP3 before it can be started again. You may purge the pump after the temperature has risen higher than the cryo pump regeneration temperature setpoint CTSP2 to speed up the process. Traditionally the user will want to regenerate the cryo pump if the temperature shows much higher than 12 or 13 Kelvin.
The contactor to operate the pump has an overload on it that turns off the pump if it draws excessive current. If the contactor turns off the pump an alarm is shown. The pump current may exceed the overload if it is working to hard and running hot, or if a mechanical problem has occurred such as a motor seizing or a bearing failure.

Rough Pump

To be able to access the manual controls:

- The manual controls are always available in manual mode.

To turn on the rough pump:

- The foreline valve must be closed.
- The rough valve must be closed.

To turn off the rough pump:

- The conditions to access the manual controls must be met.

NOTE: The rough pump has a timer that starts as soon as it is turned on. The timer is hard coded for 2 hours, and then the rough pump is turned off automatically if the user has forgotten to turn it off in manual mode. The timer also closes both the rough valve and the foreline valve if they are open.
The contactor to operate the pump has an overload on it that turns off the pump if it draws excessive current. If the contactor turns off the pump an alarm is shown. The pump current may exceed the overload if it is working to hard and running hot, or if a mechanical problem has occurred such as a motor seizing or a bearing failure.

Chapter 5 – Main Page Items

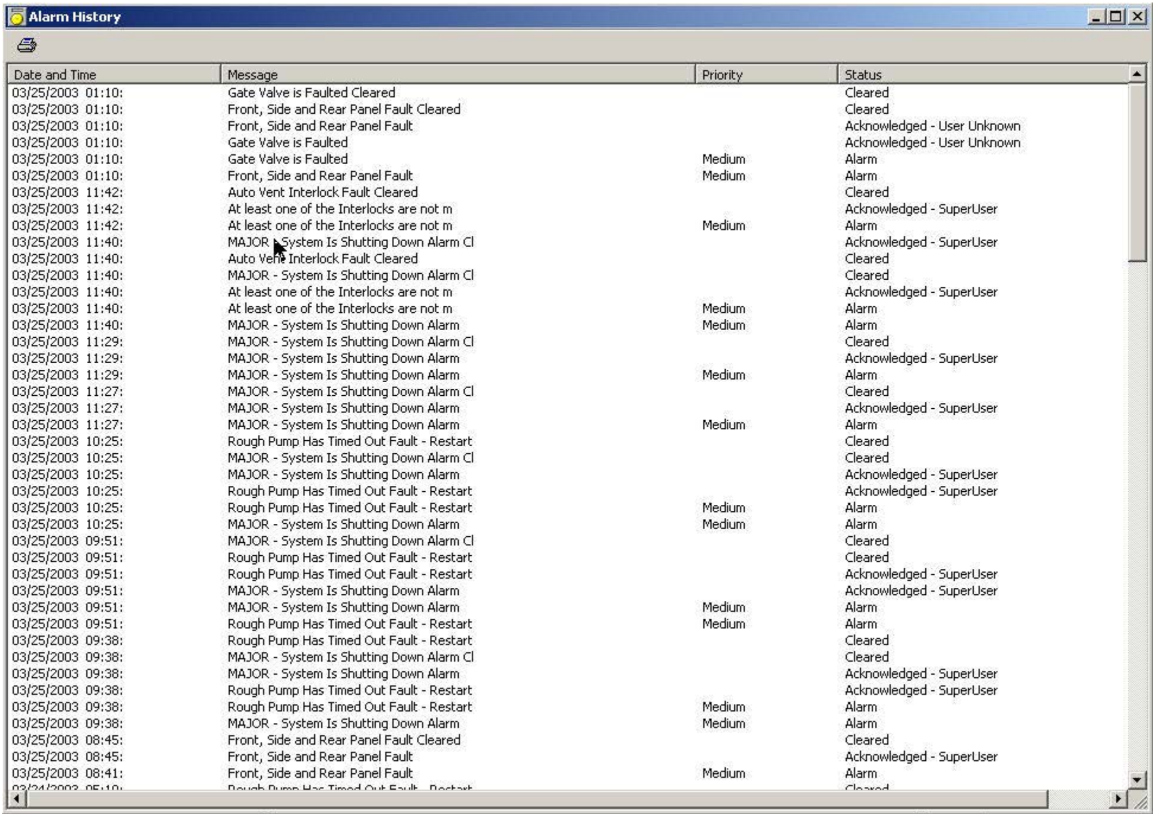
Alarm Window

The alarm window can display up to three active alarms or faults. If an alarm occurs a pop up box will appear in the center of the screen first.

The user needs to acknowledge the alarm, and then resolve it. After the alarm has been resolved, clicking on the reset button will reset the alarm. All alarms must be acknowledged before they can be reset.

All acknowledged alarms are stored in the alarm history as shown below.

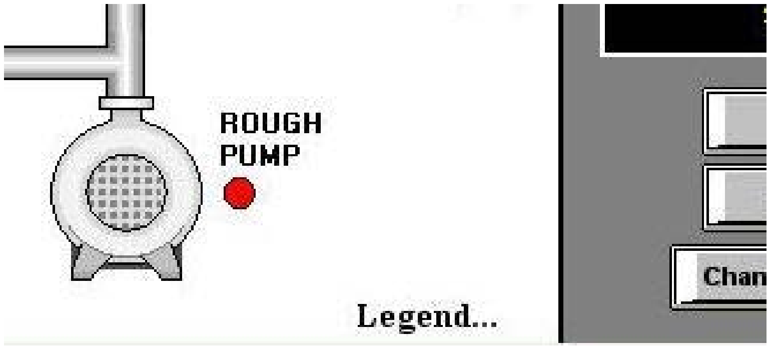
The alarm history page pops up if the alarm history button is clicked on in the alarm bar. All alarms and their status are shown here. Clicking the clear button under the alarm history will clear the alarm history.

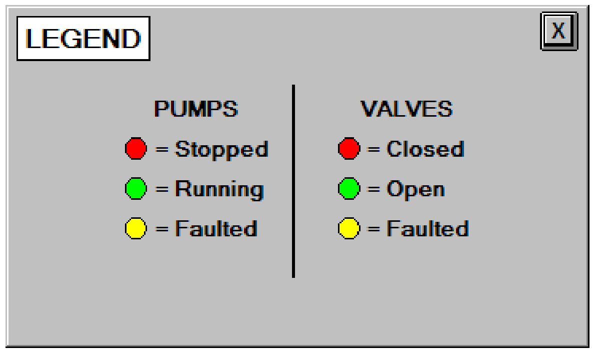

Alarm History

Date and Time	Message	Priority	Status
03/25/2003 01:10:	Gate Valve is Faulted Cleared		Cleared
03/25/2003 01:10:	Front, Side and Rear Panel Fault Cleared		Cleared
03/25/2003 01:10:	Front, Side and Rear Panel Fault		Acknowledged - User Unknown
03/25/2003 01:10:	Gate Valve is Faulted		Acknowledged - User Unknown
03/25/2003 01:10:	Gate Valve is Faulted	Medium	Alarm
03/25/2003 01:10:	Front, Side and Rear Panel Fault	Medium	Alarm
03/25/2003 11:42:	Auto Vent Interlock Fault Cleared		Cleared
03/25/2003 11:42:	At least one of the Interlocks are not m		Acknowledged - SuperUser
03/25/2003 11:42:	At least one of the Interlocks are not m	Medium	Alarm
03/25/2003 11:40:	MAJOR - System Is Shutting Down Alarm Cl		Acknowledged - SuperUser
03/25/2003 11:40:	Auto Vent Interlock Fault Cleared		Cleared
03/25/2003 11:40:	MAJOR - System Is Shutting Down Alarm Cl		Cleared
03/25/2003 11:40:	At least one of the Interlocks are not m		Acknowledged - SuperUser
03/25/2003 11:40:	At least one of the Interlocks are not m	Medium	Alarm
03/25/2003 11:40:	MAJOR - System Is Shutting Down Alarm	Medium	Alarm
03/25/2003 11:29:	MAJOR - System Is Shutting Down Alarm Cl		Cleared
03/25/2003 11:29:	MAJOR - System Is Shutting Down Alarm		Acknowledged - SuperUser
03/25/2003 11:29:	MAJOR - System Is Shutting Down Alarm	Medium	Alarm
03/25/2003 11:27:	MAJOR - System Is Shutting Down Alarm Cl		Cleared
03/25/2003 11:27:	MAJOR - System Is Shutting Down Alarm		Acknowledged - SuperUser
03/25/2003 11:27:	MAJOR - System Is Shutting Down Alarm	Medium	Alarm
03/25/2003 10:25:	Rough Pump Has Timed Out Fault - Restart		Cleared
03/25/2003 10:25:	MAJOR - System Is Shutting Down Alarm Cl		Cleared
03/25/2003 10:25:	MAJOR - System Is Shutting Down Alarm		Acknowledged - SuperUser
03/25/2003 10:25:	Rough Pump Has Timed Out Fault - Restart		Acknowledged - SuperUser
03/25/2003 10:25:	Rough Pump Has Timed Out Fault - Restart	Medium	Alarm
03/25/2003 10:25:	MAJOR - System Is Shutting Down Alarm	Medium	Alarm
03/25/2003 09:51:	MAJOR - System Is Shutting Down Alarm Cl		Cleared
03/25/2003 09:51:	Rough Pump Has Timed Out Fault - Restart		Cleared
03/25/2003 09:51:	Rough Pump Has Timed Out Fault - Restart		Acknowledged - SuperUser
03/25/2003 09:51:	MAJOR - System Is Shutting Down Alarm		Acknowledged - SuperUser
03/25/2003 09:51:	MAJOR - System Is Shutting Down Alarm	Medium	Alarm
03/25/2003 09:51:	Rough Pump Has Timed Out Fault - Restart	Medium	Alarm
03/25/2003 09:38:	Rough Pump Has Timed Out Fault - Restart		Cleared
03/25/2003 09:38:	MAJOR - System Is Shutting Down Alarm Cl		Cleared
03/25/2003 09:38:	MAJOR - System Is Shutting Down Alarm		Acknowledged - SuperUser
03/25/2003 09:38:	Rough Pump Has Timed Out Fault - Restart		Acknowledged - SuperUser
03/25/2003 09:38:	Rough Pump Has Timed Out Fault - Restart	Medium	Alarm
03/25/2003 09:38:	MAJOR - System Is Shutting Down Alarm	Medium	Alarm
03/25/2003 08:45:	Front, Side and Rear Panel Fault Cleared		Cleared
03/25/2003 08:45:	Front, Side and Rear Panel Fault		Acknowledged - SuperUser
03/25/2003 08:41:	Front, Side and Rear Panel Fault	Medium	Alarm

This dialog box opens, and if clear is selected, the alarm history page will now be blank.

Legend





The legend for the status dots beside each component is located at the bottom of the main page.

Ion Gauges

The chamber ion gauge is a Granville-Phillips Series 354 Mini-Ion® vacuum gauge. A second similar gauge measures pressure in the load lock. These gauge modules supply an analog signal representing the pressure. More information on these gauge modules is included in their operation manual, which is included in the appendix of this manual.

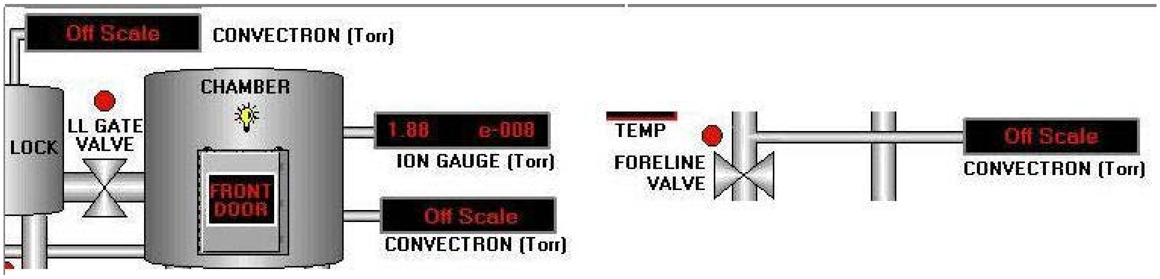
The pressure is displayed on the main control page in Torr. If you click on the pressure display on the main control page the control box pops up. Here a dial displays the analog voltage of the gauge, where 0-10 volts represents the full scale. Also displayed are the degas button, and the manual power (filament on/off) button for the gauge itself.

When the gauge is on, a voltage is displayed, usually between 2 to 7 volts. If the voltage reads 0, the gauge itself is not powered, or possibly disconnected. If a voltage of 10 volts is shown, the gauge is powered, but the filament is off. The gauge is automatically turned on by the PLC when the pressure indicated by the chamber Convectron® gauge is 2.9 x 10^{-3} Torr or less. The ion gauge cannot measure pressure much higher than this value, and the gauge automatically turns itself off to protect the filament at a slightly higher pressure than this. If the gauge turns off, usually due to a sudden burst of pressure in the chamber, the manual power needs to be turned back on to start the filament. The gauge can take up to 10 seconds to come on and register a pressure.

The degas button turns on the gauge filament degas. This cleans the filament and provides more accurate pressure readings at lower pressures (less than 5.0 x 10^{-7} Torr). The degas function is only available if the user is logged in as Supervisor, and the system is in manual mode. When degas is selected, filament power is increased by the gauge module, and pressure values will fluctuate. The degas runs for two minutes, during which time the manual power button is inoperable. It is recommended that the chamber pressure reading be lower than 5.0 X 10^{-6} before degassing the filament. The gauge will automatically turn itself off if the pressure reading goes above 5.5 X 10^{-5} Torr during a degas process. If this occurs, the degas function will stop, and the gauge filament will need to be manually turned on again. You can then try again, or let the chamber pump to a lower pressure before attempting to degas once more. The gauge is factory calibrated to read nitrogen.

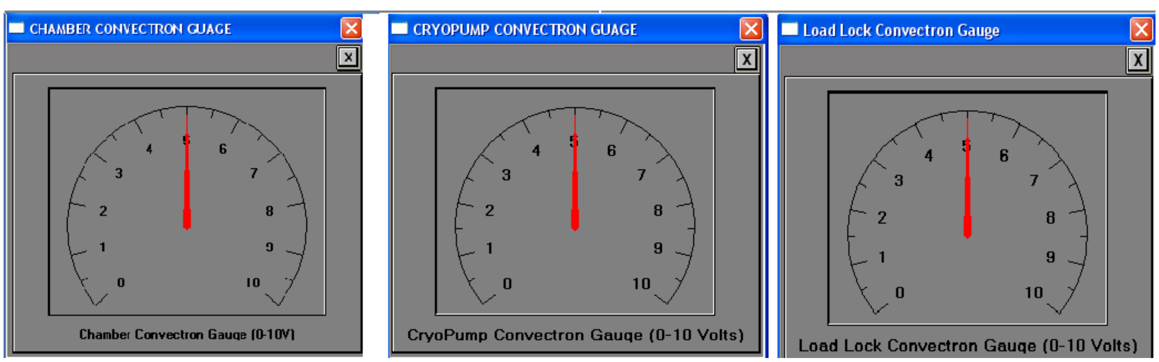
<u>Convectron® Gauges</u>

The chamber Convectron® gauge is a Granville-Phillips Series 275 Mini-Convectron® non-linear analog output module. A second similar gauge measures pressure in the cryo pump. A third similar gauge measures pressure in the load lock. These gauge modules supply an analog signal representing the pressure. This voltage is manipulated by a number of equations, and the resulting pressure values are displayed on the main system screen. More information on these gauge modules is included in their operation manual, which is included in the appendix of this manual.



These gauges measure pressure from atmosphere to 1.0 x 10^{-3} Torr. If the gauge is carefully zeroed, it is capable of measuring pressures down to 1.0 x 10^{-4} Torr. Pressures lower than 1 x 10^{-4} Torr cause the gauge to read off scale, however the gauges are always on.

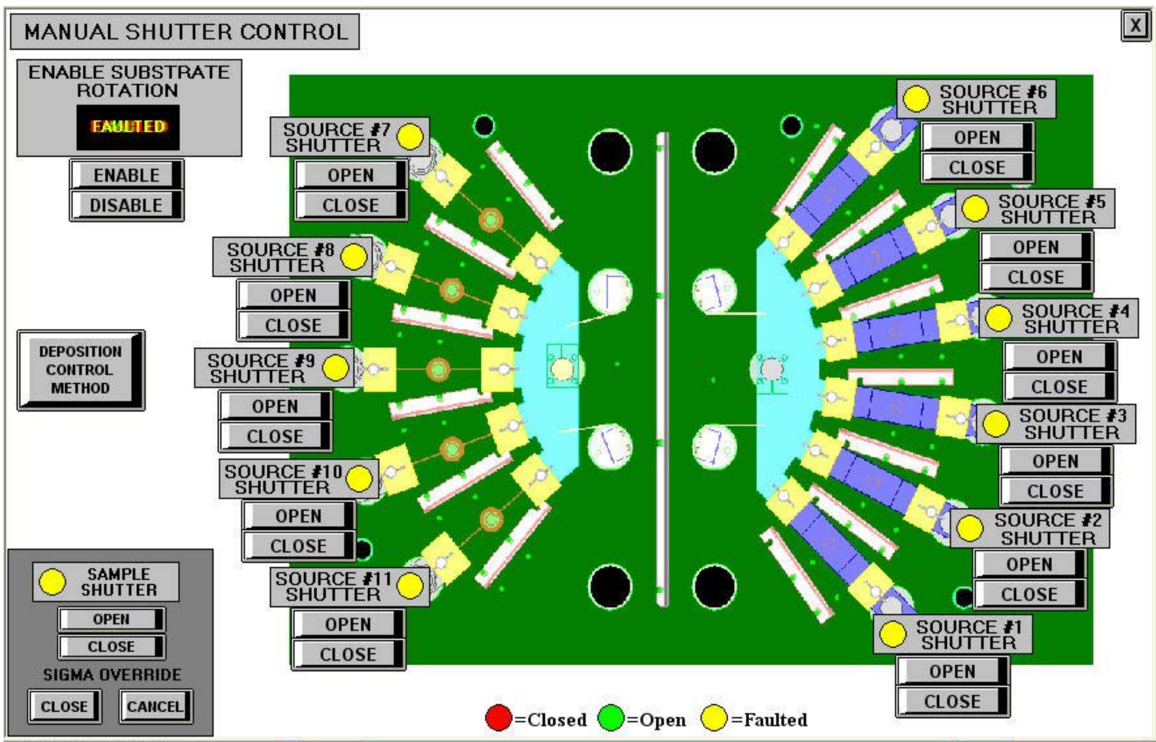
If you click on either of the cryo, chamber or load lock Convectron® pressure displays on the main control page a control box pops up. This display represents the analog output of the gauge as 0-10volts (full scale). A zero voltage would indicate the gauge is disconnected. Voltages greater than .38 are pressure readings. The gauges are factory calibrated to read nitrogen.



Shutter Control & Deposition Control

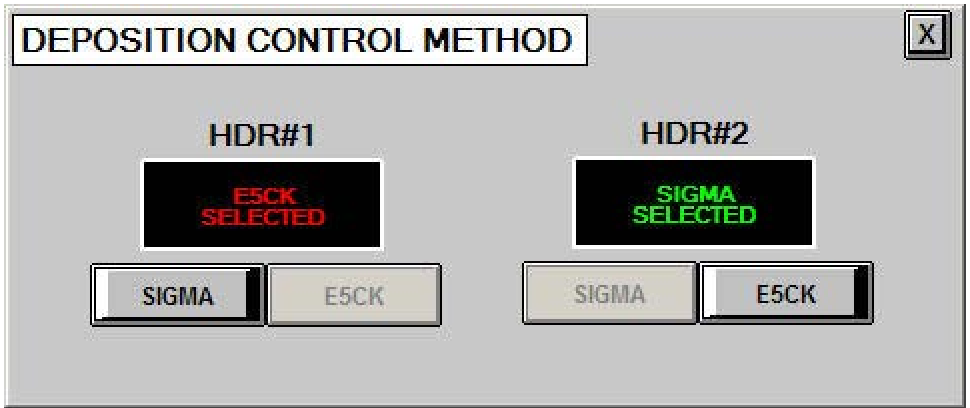
The shutter control and deposition control button is located on the bottom left of the main screen.

This button pops up the manual shutter control page.



When the system is in manual mode, the user can operate the source and substrate shutters and enable the substrate rotation simply by clicking on the open and close buttons for each shutter or the enable and disable buttons for the rotation. This allows for the testing and adjustment of these components, if required it also allows the user to move shutters out of the way to remove and load sources. The Sigma override section of the sample shutter control box allows the user to override the Sigma software control of the sample shutter and keep the sample shutter closed for testing purposes. Click the close button to override Sigma and close the shutter. The shutter will stay closed regardless of whether the Sigma software attempts to open it or not. The cancel button stops the override.

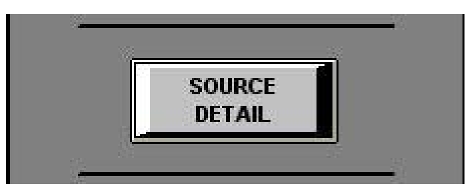
Also displayed on this screen is the deposition control method button. Clicking on the button opens the pop up box shown below.

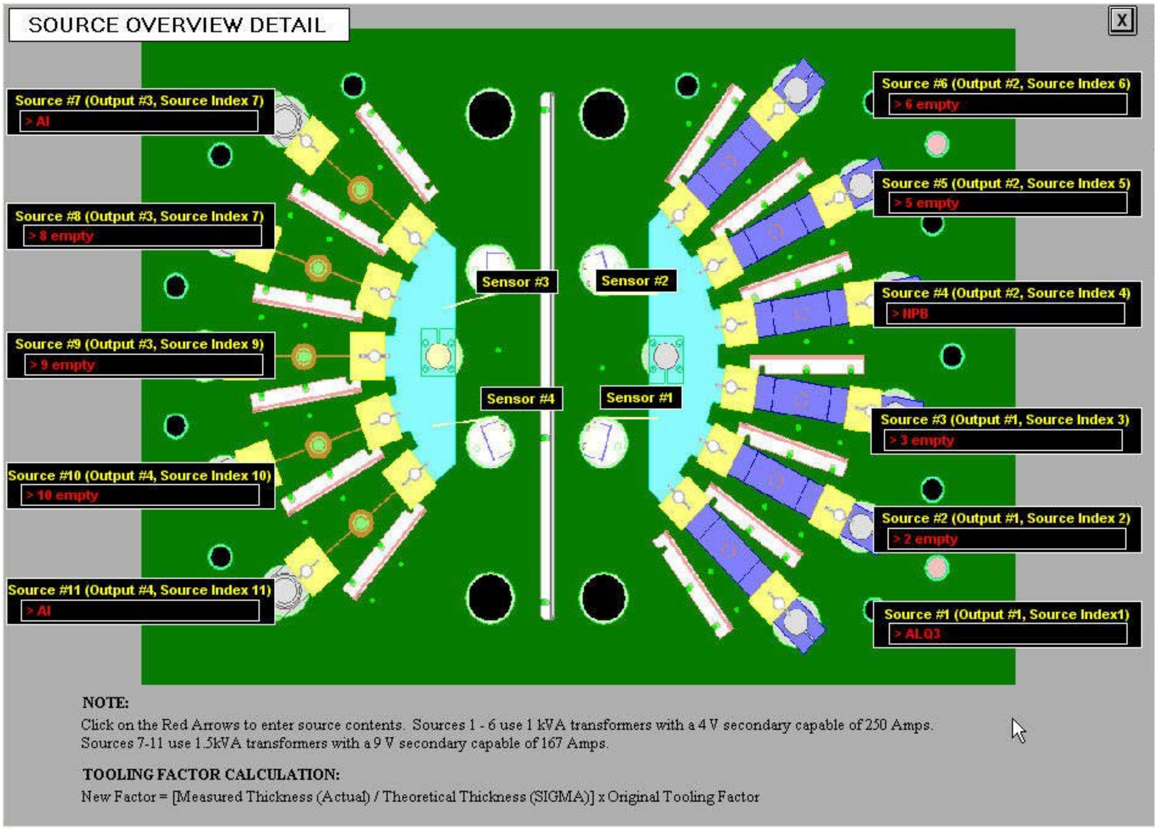


The deposition control method allows the selection between control of any of the organic sources through a manual temperature control using the E5CK temperature controllers or through the Sigma software using the Sigma deposition control software. If the user wishes to control a source using an E5CK, the Sigma software must first be used to select the source. Any process that is assigned to the desired source may be used, and the deposition is actually run in manual mode with no power output. Switching the control to E5CK removes the control signal connection from the Sigma software and replaces it with the control signal from the E5CK. The HDRs are the actual SCR units that control the primary side voltage to the transformers that drive the sources. HDR#1 controls organic sources 1-3, and HDR#2 controls organic sources 4-6. The sources are selected by relays controlled by signals the Sigma software sends to the PLC. Rates will still be shown in the Sigma software when controlling using the E5CKs and a specific thickness can be set and controlled to in the manual mode of the Sigma software. Sigma will end the deposition at the desired thickness if the user wishes. Manual mode will not work unless the user specifies a thickness. A very large thickness can be entered if thickness is not a parameter the user wants to control to while doing an E5CK controlled deposition.

Source Detail

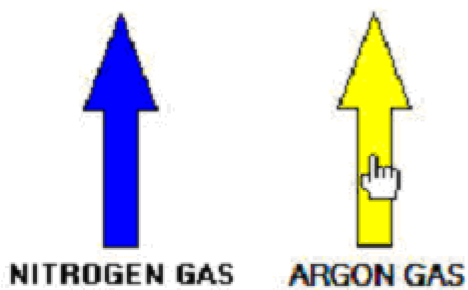
The source detail button displays the source overview detail page.



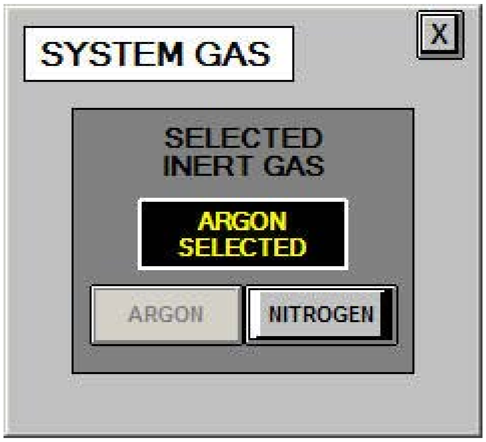


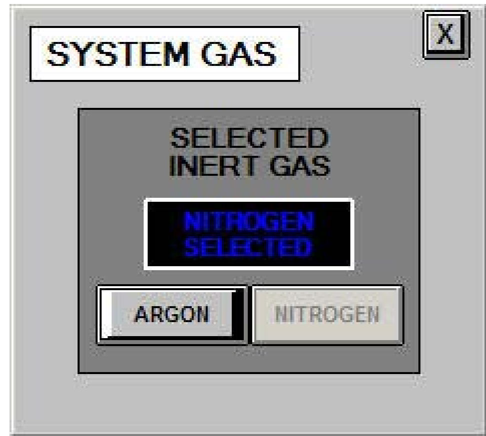
This page primarily helps the users keep track of what material is where at any time. The text in each black text box identifies the material at each location. The text can be modified by clicking on the red arrows. The sensor numbers are noted as well as information for the Sigma software such as source outputs and index numbers. Other notes and the often-used new tooling factor calculation are also noted on the page.

<u>System Gas</u>



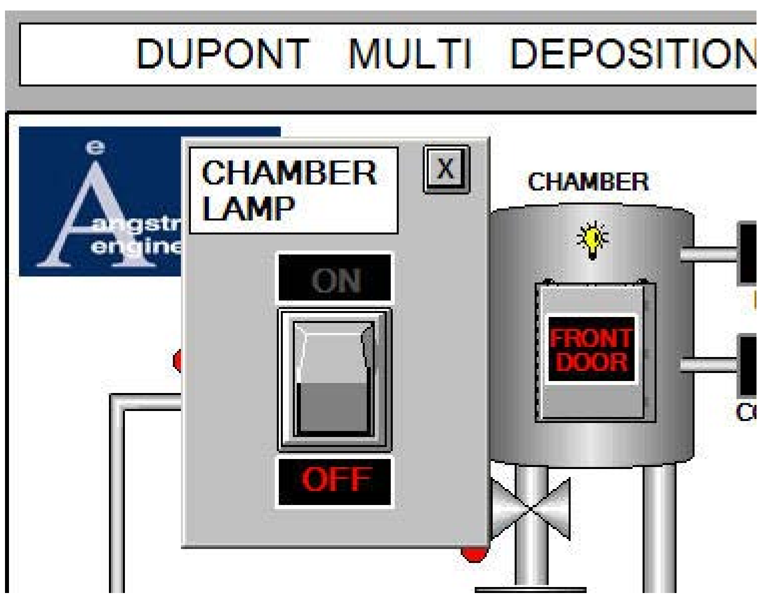
The system gas is selectable in manual mode between argon and nitrogen. Simply click on the gas arrow to display a pop up box with the selection.





When nitrogen is selected the arrow on the main screen is blue, and the gas is noted as nitrogen. Note that all the gauges on the system will be affected globally by the gas selection. The pressure calculations for each gas are entirely different, and incorrect pressures will be displayed if the wrong gas is selected.

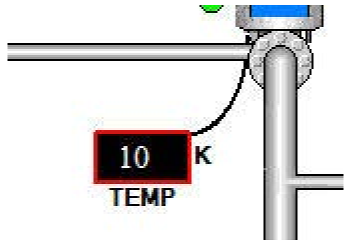
<u>Chamber Light</u>



By clicking on the light bulb on the main chamber the pop up the box above is shown. Clicking on the top or bottom side of the toggle switch turns the light on or off.

Cryo pump Temperature

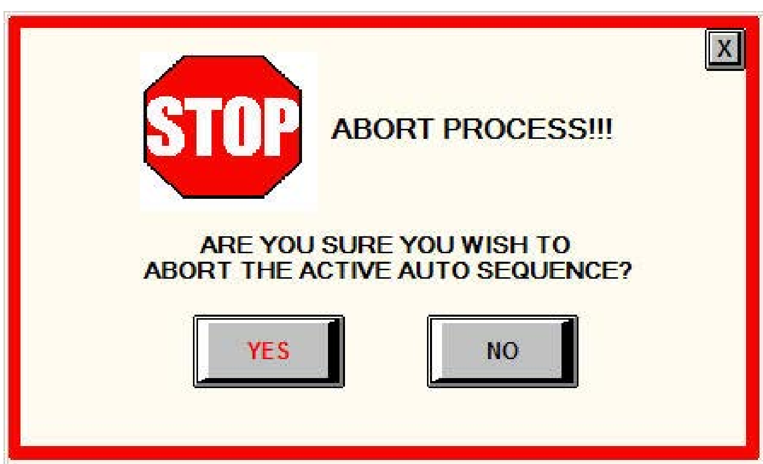
The cryo pump on the system has a diode inside it to measure internal temperature. This diode is wired to a Lakeshore Cryotronics Model 211 temperature monitor. This monitor is mounted in the electrical rack of the system frame where a display shows the current temperature in the cryo pump. More information about this temperature monitor can be found in its equipment manual. A copy of the manual is found in the appendix section. The 211 temperature monitor sends out an analog signal representing the temperature in the cryo pump to the PLC. The SCADA software then also displays the temperature on the main system page.



The temperature is displayed in Kelvin. The cryo pump diode is capable of measuring temperatures down to 10 Kelvin. Room temperature is about 293 K. All of the cryo pump temperature setpoints are interpreted from the analog signal from the 211.

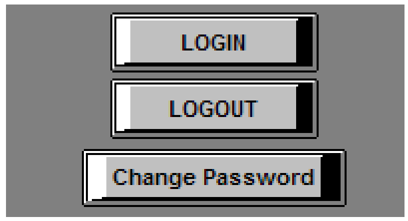
Abort Button

The abort button is used to stop any sequence in case of emergency. Note that this will close all valves including the gate valve, and stop any active deposition process. A confirmation dialog box will pop up if the button is clicked.

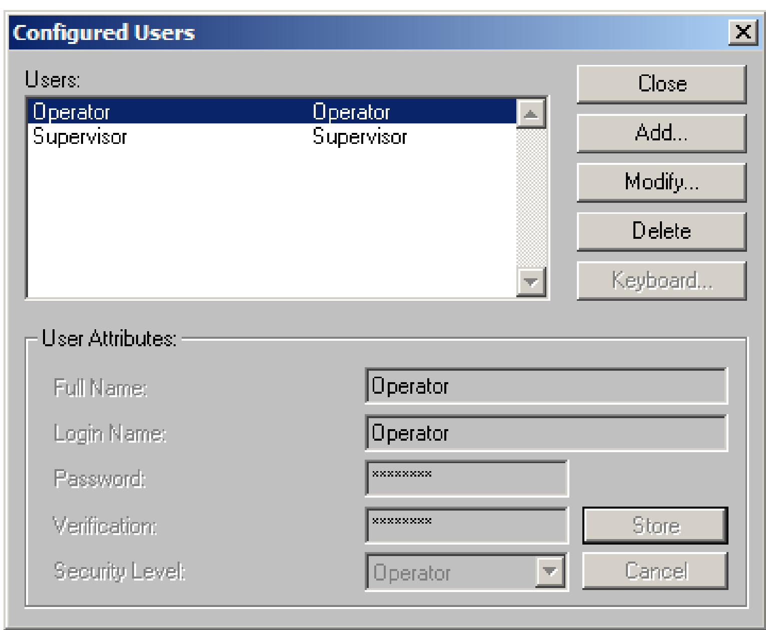


Login / Logout / Change Password

Every time the SCADA software is started the user is required to login. Click on the login button to display the login screen.



There are two levels of user allowed on the system. There are operators and supervisors. Operators do not have access to manual mode. They can only operate the system using auto modes.



Supervisors have access to all the system controls, and they can change operator passwords and add other operators. There is a special password required to change supervisor passwords or add supervisors. There is no need to logout unless you are a supervisor and you want to leave the machine to an operator.

angstrom engineering

SYSTEM COMPONENT INFORMATION

Installations- und
Betriebsanleitung
Installation and
Operating Instructions
Manuel d'installation
et de maintenance

Spiral-Vakuumpumpen Fossa FO 0009 - 0030 A
Scroll Vacuum Pumps Fossa FO 0009 - 0030 A
Pompes à Vide, à Spirales Fossa FO 0009 - 0030 A

Diese Betriebsanleitung hat Gültigkeit für folgende Pumpen:

- FO 0009 A
- FO 0018 A
- FO 0030 A

Diese Vakuumpumpen sind nach dem neuesten Stand der Technik und den anerkannten sicherheitstechnischen Regeln gebaut. Dennoch können bei unsachgemäßer Installation oder nicht bestimmungsgemäßem Betrieb Gefahren und Schäden entstehen.

Diese Betriebsanleitung ist vor der Installation und Inbetriebnahme der Vakuumpumpe unbedingt zu lesen und zu befolgen.

Hersteller:

Ateliers Busch S.A.
Zone industrielle
CH 2906 Chevenez
Schweiz
Telefon: 032/ 4760200
Fax: 032/ 4760399

These installation and operating instructions are valid for the following pumps:

- FO 0009 A
- FO 0018 A
- FO 0030 A

These vacuum pumps have been manufactured according to the latest technical standards and safety regulations. If not installed properly or not used as directed, dangerous situations or damage might occur.

It is mandatory that these operating instructions are read and understood prior to the vacuum pump installation and start-up.

Manufacturer:

Ateliers Busch S.A.
Zone industrielle
CH 2906 Chevenez
Switzerland
Phone: 032/ 4760200
Fax: 032/ 4760399

Ce manuel d'installation et de maintenance est valable pour:

- FO 0009 A
- FO 0018 A
- FO 0030 A

Ces pompes à vide sont fabriquées selon les plus récents standards techniques et règlements de sécurité connus. Une mauvaise installation ou une utilisation non conforme aux recommandations peut être dangereuse ou entraîner des dommages.

Il est impératif que ce manuel d'instructions soit lu et compris avant de mettre en marche la pompe à vide.

Constructeur:

Ateliers Busch S.A.
Zone industrielle
CH 2906 Chevenez
Suisse
Téléphone: 032/ 4760200
Fax: 032/ 4760399

Inhaltverzeichnis

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1. Sicherheit

Diese Vakuumpumpen sind nach dem Stand der Technik und den anerkannten sicherheitstechnischen Regeln gebaut. Dennoch können bei unsachgemäßer Installation oder nicht bestimmungsgemäßem Betrieb Gefahren und Schäden entstehen.

1. Safety

These vacuum pumps have been manufactured according to the technical standards and safety regulations. If not installed properly or not used as directed, dangerous situations or damage might occur.

1. Sécurité

Ces pompes à vide sont fabriquées selon les standards techniques et règlements de sécurité connus. Une mauvaise installation ou une utilisation non conforme aux recommandations peut être dangereuse ou entraîner des dommages.

**Flüssigkeiten und Feststoffe dürfen nicht in die Pumpe gelangen.
Nicht geeignet für aggressive Gase und für zündfähige Gemische.
Im Zweifelsfall unbedingt Rücksprache mit Ihrer örtlichen Busch-Vertretung halten.**

**Liquid and solid particles must not enter the pump.
Not to be used to evacuate aggressive gases or ignitable gas mixtures.
In case of doubt consult your local Busch Agency.**

**Des liquides et des particules solides ne doivent pas entrer dans la pompe.
Ne doit ni être utilisée avec des gaz ou mélanges de gaz agressifs, ni mélanges inflammables.
En cas de doute, veuillez consulter votre Agence Busch locale.**

Sicherheitshinweise
In dieser Installations- und Betriebsanleitung werden jeweils vor den betreffenden Handlungsschritten Sicherheitshinweise genannt. Diese Hinweise sind unbedingt zu beachten.

Anwendung
Diese Vakuumpumpen sind für den Einsatz im Feinvakuumbereich konzipiert. Sie können für das Fördern von sauberem und trockenem Gas verwendet werden.
Andere Medien dürfen nicht gefördert werden. Wenden Sie sich im Zweifelsfall an Ihre örtliche Busch-Vertretung.

Safety advice
In these operating instructions safety measures are stated before each step. It is imperative that these safety precautions are observed.

Application
These vacuum pumps are designed for use in the fields of fine vacuum. They can be used to evacuate dry and neutral gas.

Other agents should not be transported. In case of doubt, please contact your local Busch-Agency

Indications de sécurité
Dans ce manuel d'installation, différentes indications de sécurité sont mentionnées. Il est impératif que ces indications soient suivies.

Application
Ces pompes à vide sont conçues pour une utilisation dans le domaine du vide fin. Elles peuvent être utilisées pour aspirer du gaz sec et neutre.

Certains produits ne doivent pas être aspirés par les pompes; en cas de doute, consulter votre Agence Busch locale.

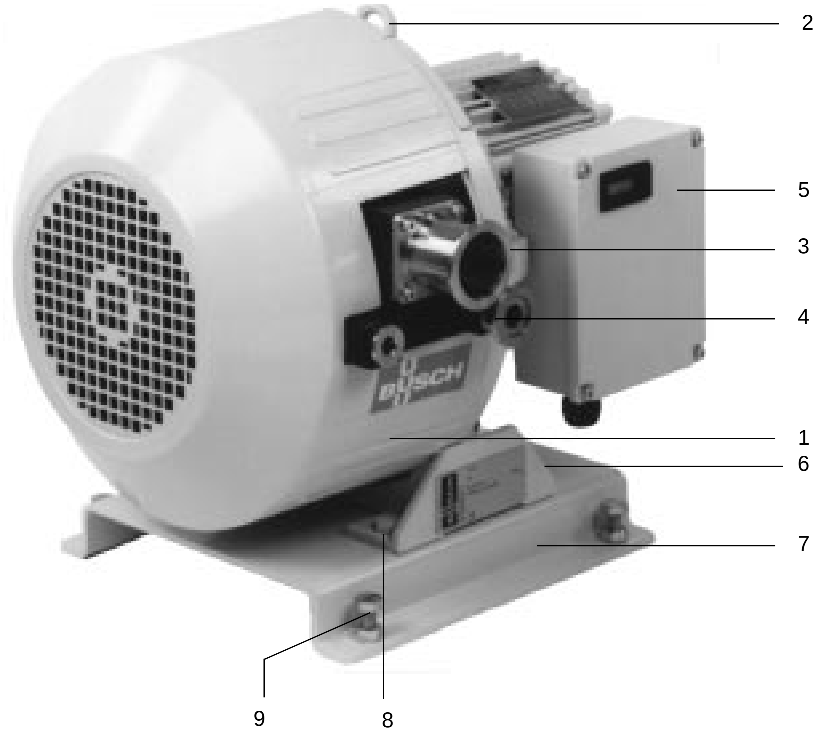
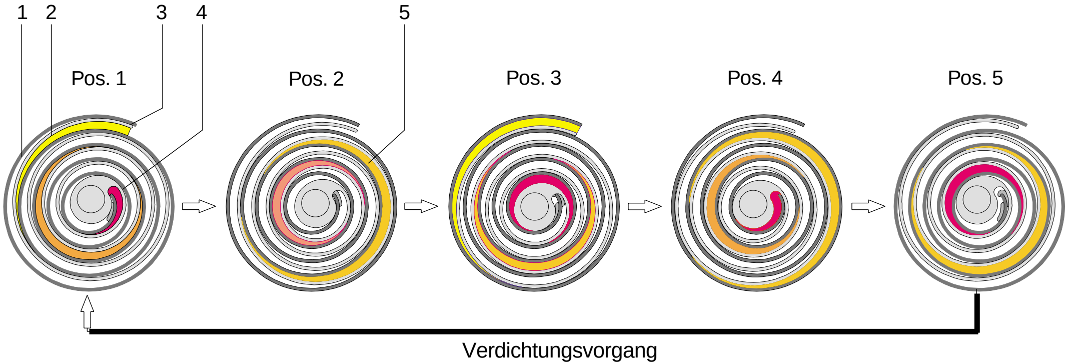


Fig. 4.1 FO 0030 A

1 Haube
2 Ringschraube
3 Einlass
4 Auslass
5 Klemmenkasten mit Betriebsstundenzähler
6 Grundrahmen (FO 0009-0018 A)
7 Grundrahmen (FO 0030 A)
8 Befestigungschrauben (FO 0009-0018 A)
9 Befestigungschrauben (FO 0030 A)

1 Cover
2 Eye bolt
3 Inlet flange
4 Outlet flange
5 Electrical box with an operating hour counter
6 Baseframe (FO 0009-0018 A)
7 Baseframe (FO 0030 A)
8 Fixing screws (FO 0009-0018 A)
9 Fixing screws (FO 0030 A)

1 Capot
2 Anneau de levage
3 Bride d'aspiration
4 Bride de refoulement
5 Boîtier électrique avec compteur horaire
6 Socle de base (FO 0009-0018 A)
7 Socle de base (FO 0030 A)
8 Vis de fixation (FO 0009-0018 A)
9 Vis de fixation (FO 0030 A)



1 Feststehende Spirale
2 Bewegliche Spirale
3 Gaseinlass
4 Gasauslass
5 Gaseinschluss

1 Fixed scroll
2 Rotating scroll
3 Gas inlet
4 Gas outlet
5 Gas pocket

1 Spirale fixe
2 Spirale orbitale
3 Aspiration
4 Refoulement
5 Poche de gaz

Fig. 5.1

2. Funktionsprinzip und Arbeitsweise

Die Spiral-Vakuumpumpe Fossa besteht im wesentlichen aus einer feststehenden und einer beweglichen Spirale. Beide Spiralen greifen während der Drehbewegung ineinander und bilden sichelförmige Gasräume. Dabei wird durch die exzentrisch kreisende Spirale das Gas kontinuierlich verdichtet und zum Zentrum der Spiralen gefördert, wo sich der Gasaustritt befindet.

2. Principle of operation

Fossa scroll vacuum pumps mainly consist of a fixed scroll and a rotating scroll when rotating both scrolls form crescent shaped gas products. By the eccentrically rotating scroll the gas is compressed continuously and conveyed to the center of the spirals and therefore to the gas outlet.

2. Principe de fonctionnement

Le mécanisme de la pompe à spirales Fossa est constitué d'une spirale fixe et d'une spirale orbitale entraînée. Le déplacement orbital de la spirale entraînée compresse continuellement le gaz et le dirige vers le centre de la pompe. L'aspiration se situe à l'extérieur, alors que l'échappement passe par le centre du mécanisme de la pompe.

Fossa Spiral-Vakuumpumpen enthalten keinerlei Schmier-, Dicht- oder Getriebeöl. Nur die Lager und die Wellendichtungen sind gefettet.

Ein Ansaugsieb schützt die Pumpe vor dem Ansaugen von größeren Partikeln (Fig. 15.1).

Der Antriebsmotor ist mit einem Betriebsstundenzähler ausgerüstet.

3. Ausführungen

Die Pumpenkennzeichnung gibt das Nennsaugvermögen und den Konstruktionsstand an:

Beispiel: FO 0018 A

FO = Vakuumpumpe Fossa
0018 = Nennsaugvermögen 18 m^3/h (50 Hz)
A = Konstruktionsstand

Falls Sie Fragen zur Anwendung und Ausführung haben, wenden Sie sich bitte an Ihre örtliche Busch-Vertretung.

4. Transport und Verpackung

Die Vakuumpumpen werden im Werk auf Funktion überprüft und fachgerecht verpackt. Achten Sie bei der Annahme der Pumpe auf Transportschäden.

Fossa scroll vacuum pumps contain neither lubricating, sealing nor gear oil in the pumping chamber. Only bearings and shaft seals are greased.

A mesh is installed at the pump's inlet to prevent bigger particles from entering into the pump (Fig. 15.1).

The pump motor is equipped with an operating hours counter.

3. Versions

The pump description states the nominal flow rate and the construction level:

Example: FO 0018 A

FO = Fossa Vacuum pump
0018 = Nominal suction capacity 18 m^3/h (50Hz)
A = Construction level

If you have any questions about applications and models, please contact your local Busch Agency.

4. Transport and packing

The vacuum pumps pass a rigorous test in the factory and are packed carefully to avoid transport damage. Please check packing on delivery for transport damage.

Les pompes à spirales Fossa ne contiennent aucun fluide d'étanchéité ou de lubrification. Seuls les roulements et les joints d'arbres sont graissés.

La bride d'aspiration de la pompe est équipée d'un tamis qui empêche les grosses particules d'entrer dans la pompe (Fig. 15.1).

Le moteur de la pompe est équipé d'un compteur horaire.

3. Versions

Les indications suivantes définissent le débit de pompage et la génération de la pompe:

Exemple: FO 0018 A

FO = Pompe à vide Fossa
0018 = Débit nominal aspiration 18 m^3/h (50 Hz)
A = Génération

Pour tout renseignement complémentaire concernant l'application ou la version, contacter votre Agence Busch locale.

4. Transport et emballage

Les pompes à vide sont testées et contrôlées dans notre usine avant d'être soigneusement emballées. Veuillez vérifier lors de la réception que l'emballage n'aie pas subi de dommage pendant le transport.

Die Saug- und Abluftanschlüsse sind mit Stopfen verschlossen, damit während des Transportes kein Schmutz in die Pumpe gelangen kann. Diese Stopfen müssen vor Inbetriebnahme der Pumpe entfernt werden.
Die Pumpe kann an der Ringschraube (Fig. 4.1.2) angehoben werden.
Das Verpackungsmaterial ist nach den geltenden Bestimmungen zu entsorgen bzw. wiederzuverwenden.
Diese Betriebsanleitung ist Bestandteil der Lieferung.

5. Inbetriebnahme

Die Einhaltung der Reihenfolge der hier beschriebenen Arbeitsschritte ist für eine sicherheitsgerechte und funktionssichere Inbetriebnahme unbedingt erforderlich.
Die Inbetriebnahme darf nur von geschultem Fachpersonal durchgeführt werden.

5.1 Aufstellung

Die Vakuumpumpe ist komplett auf einen Grundrahmen (Fig. 4.1.6 für FO 0009/ 0018 A,Fig. 4.1.7 für FO 0030 A) montiert. Die Pumpe kann somit entweder überall ohne Befestigung auf waagerechtem Untergrund aufgestellt werden oder mit Befestigungschrauben (Fig. 4.1.8 für FO 0009/ 0018 A, Fig. 4.1.9 für FO 0030 A) fixiert werden.

The inlet and outlet ports are sealed with plugs so that no dust can penetrate during transport. The plugs must be removed before starting the vacuum pump.

The pump can be lifted from the packing using the eye bolt (Fig. 4.1.2).
Packing materials should be disposed of according to environmental regulations.

These operating instructions are part of the consignment.

5. Start-up

It is essential to observe the following instructions step by step to ensure a safe start-up.

Start-up may only be carried out by trained specialists.

5.1 Setting-up

The vacuum pump is delivered with a baseframe (Fig. 2.1.6 for FO 0009/ 0018 A, Fig. 2.1.7 for FO 0030 A; Fig. 1). It can be placed either on an horizontal surface without fixing or locked with fixing screws (Fig. 2.1.8 for FO 0009/ 0018 A, Fig. 2.1.9 for FO 0030 A; Fig. 1).

A la livraison, les brides d'aspiration et de refoulement sont protégées par des bouchons qui évitent la pénétration de saletés pendant le transport. Avant de connecter la pompe à la tuyauterie de vide, enlever ces bouchons.
La manutention de la pompe peut se faire à l'aide d'un anneau de levage (Fig. 4.1.2).
Les matériaux d'emballage doivent être éliminés selon les lois en vigueur ou doivent être réutilisés.

Ce manuel fait partie de notre envoi.

5. Démarrage

Il est impératif de suivre pas à pas les recommandations suivantes pour assurer un démarrage correct de la pompe.

Le démarrage doit être réalisé uniquement par un personnel qualifié.

5.1 Préparation

La pompe est montée sur un socle de base (Fig. 4.1.6 pour FO 0009/ 0018 A, Fig. 4.1.7 pour FO 0030 A). Elle peut être placée directement sur une surface plane et horizontale sans fixations additionnelles ou fixée par 4 vis de fixations (Fig. 4.1.8 pour FO 0009/ 0018 A, Fig. 4.1.9 pour FO 0030 A).

Folgende Umgebungsbedingungen müssen gegeben sein:
Umgebungstemperatur: 5 - 40 °C
Umgebungsdruck = Atmosphäre

Um ein Überhitzen der Pumpe zu vermeiden, ist stets auf genügend Frischluftzufuhr zu achten.

5.2 Drehen der Ansaug- und Austrittanschlüsse

Die Pumpe wird mit waagrechter Anordnung der Ansaug- und Austrittanschlüsse geliefert (siehe Fig. 4.1). Je nach Bedarf des Kunden kann dieser die Ausrichtung der Anschlüsse auf einfache Weise ändern, indem der Rahmen (Fig. 9.1.2) der Pumpe nach folgender Anleitung gedreht wird :

- Die Pumpe seitlich auf die Haube legen (Fig. 4.1.1)
- Die zwei Befestigungsschrauben (Fig. 9.1.1) des Rahmens (Fig. 9.1.2) an der Pumpe entfernen.
- Den Rahmen um 90° drehen, um die Ansaug- und Austrittsanschlüsse in die vertikale Position zu bringen.
- Den Rahmen (Fig. 9.1.2) mit den zwei Befestigungsschrauben (Fig. 9.1.1) wieder an der Pumpe befestigen.
- Die Pumpe wieder aufrichten.

The following operating environment must be observed:
Ambient temperature: 5 - 40 °C
Ambient pressure = Atmosphere

In order to avoid overheating of the pump, an undisturbed freshair-flow to the pump is necessary.

5.2 Change of the inlet and outlet connections position

The pump is delivered with inlet and outlet connections in horizontal position (see Fig. 4.1). Dependant on application the customer can easily change the position of connections by turning the frame (Fig. 9.1.2) according to the following steps:

- Lift pump into vertical position cap side (Fig. 4.1.1), turn it to cap side
- Unscrew and remove the two screws (Fig. 9.1.1) which secure the frame (Fig. 9.1.2) to the body of the pump
- Turn pump through 90°, so that the inlet and outlet connections are in vertical position
- Use the two screws (Fig. 9.1.2) to secure the frame (Fig. 9.1.1) to the pump.
- Turn pump in the horizontal position

La pompe doit fonctionner dans l'environnement suivant:
Température ambiante: 5 - 40 °C
Pression ambiante = pression atmosphérique

Pour éviter un échauffement anormal de la pompe, il faut prévoir une ventilation suffisante.

5.2 Changement de position des brides entrée / sortie

A la livraison de la pompe, les brides d'aspiration et de refoulement sont montées en position horizontale (voir Fig. 4.1). Selon son implantation, le client peut changer avec facilité la position des brides en tournant le socle (Fig. 9.1.2). Procéder comme suit:

- Mettre la pompe en position verticale coté capot (Fig. 4.1.1)
- Dévisser et enlever les deux vis (Fig. 9.1.1) qui fixent le socle (Fig. 9.1.2) au corps de pompe
- Tourner la pompe de 90° pour amener les brides d'aspiration et de refoulement en position verticale
- Utiliser les deux vis (Fig. 9.1.2) pour fixer le socle (Fig. 9.1.1) sur la pompe.
- Reposer la pompe en position horizontale

5.3 Ansaug- und Austrittanschlüsse

Der Anschluss an den Saugflansch kann über einen vakuumdichten, flexiblen Schlauch oder durch Rohrleitungen erfolgen.

Verengungen in den Anschlussleitungen sind zu vermeiden, da sonst die Saugleistung vermindert wird. Die Nennweite der Anschlussleitungen muss mindestens dem Querschnitt des Saugflansches der Pumpe entsprechen.
Achten Sie darauf, dass sich keine Fremdkörper oder Flüssigkeiten in der Ansaugleitung befinden. Diese können die Vakuumpumpe zerstören. Die Abgasleitung immer so anbauen, dass kein Kondensat in die Pumpe gelangen kann (Gefälle, Siphon).
Um den Rücklauf des Prozessgases in den Prozess zu vermeiden, empfehlen wir Ihnen, an der Ansaugseite eine Rückschlagklappe oder ein Absperrorgan einzubauen.

5.3 Inlet and outlet connections

The inlet flange can be connected with a vacuumtight flexible hose or pipe.

Restriction of the pipes must be avoided in order not to decrease the displacement of the pump. The nominal diameter of the pipes has to be at least the same as the diameter of the vacuum pump's inlet flange.
No foreign particles or liquids must enter the inlet line, as they could damage the vacuum pump. Always connect the exhaust pipe in a manner, so that no condensate can enter the pump (slope, siphon).

In order to avoid process gases flowing back into the process, we recommend you insert a non-return valve or a shut-off device must cristalled at the inlet flange.

5.3 Raccordement entrée/sortie

La bride d´aspiration peut être raccordée par une tuyauterie souple ou rigide étanche au vide.

Il faut éviter les restrictions de tuyauterie qui diminuent les performances de la pompe.
Le diamètre nominal doit être au moins égal au diamètre de la bride d'aspiration de la pompe à vide.
Aucune particule solide ou liquide ne doit pénétrer dans la pompe, ce qui pourrait l'endommager. Il faut l'installer de façon à ce qu'aucun condensat ne puisse entrer dans la pompe (siphon, pente).

Pour éviter le retour des gaz du procédé dans le procédé, nous recommandons de monter un clapet anti-retour ou un organe d'arrêt à l'aspiration.

1 Schrauben / Screw / Vis

2 Rahmen / Frame / Cadre

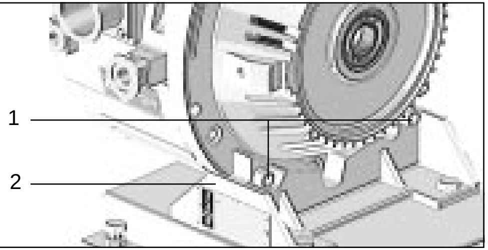


Fig. 9.1

Verschraubung Connection Raccordement	Sauganschluß Inlet connection Bride d'aspiration KF-DIN 28403	Abluftanschluß Outlet connection Bride de refoulement KF-DIN 28403
FO 0009 A	DN 16	DN 10
FO 0018 A	DN 25	DN 16
FO 0030 A	DN 40	DN 16 / DN 25

6. Elektroanschluss

Die Elektroinstallation darf nur von einem Fachmann durchgeführt werden. Bestimmungen nach EMV-Richtlinie 89/ 336/ EWG und Niederspannungs-richtlinie 73/ 23/ EWG, sowie die entsprechenden EN-Normen sind ebenso einzuhalten wie VDE/ EVU-Richtlinien bzw. örtliche oder nationale Vorschriften. Der Betreiber der Vakuumpumpe hat dem Hersteller mitzuteilen, wenn elektrische oder elektromagnetische Störungen aus seinem Netz zu erwarten sind.

1. Die Spannungs- und Frequenzangaben auf dem Motorentypenschild müssen mit der Netzspannung übereinstimmen.

2. Der Antriebsmotor ist nach VDE 0113 gegen Überlastung abzusichern.

3. Zum Anschluss des Motors müssen folgende Schritte beachten werden:
- Den Deckel des Klemmenkastens entfernen (Fig. 4.1.5)
- Die Spannung und Frequenz der Stromversorgung kontrollieren
- Die Elektrokabel durch den Klemmenkasten durchziehen
- Die Kabel gemäß ihrer vorliegenden Spannungsart anschließen (Fig. 11.1 und 12.1)

6. Electrical connection

Electrical installation may only be carried out by a specialist. Regulations following EMV Directive 89/ 336 EEC, low Voltage Directive 73/ 23 EEC, and the appropriate EN Standards have to be applied as well as VDE/ EVU regulations and local or national regulations. The operator of the vacuum pump must inform the manufacturer, if electric or electromagnetic interference from his mains is to be expected.

1.Voltage and frequency on the nameplate of the motor must match the supply voltage.

2. The drive motor must be protected against overloads according to VDE 0113.

3. the following steps must be considered when connecting the motor to the mains:
- Remove cover of the terminal box (Fig. 4.1.5)
- Check supply voltage and frequency
- Pass the electric cable through the terminal box
- Connect phase and earthwires, appropriate to the voltage (see Fig. 11.1 and 12.1)

6. Raccordement électrique

L'installation électrique ne doit être effectuée que par un spécialiste. Les directives 89/ 336/ CEE sur la compatibilité électromagnétique, 73/ 23/ CEE sur la basse tension, ainsi que les directives VDE/ EVU et les réglementations locales doivent être respectées. L'utilisateur de la pompe à vide doit informer le constructeur, si le réseau est susceptible de provoquer des interférences électriques ou électromagnétiques.

1. La tension et la fréquence indiquées sur la plaque signalétique doivent correspondre aux caractéristiques du réseau.

2. Le moteur électrique doit être protégé contre les surcharges conformément à VDE 0113.

3. Pour raccorder l'alimentation du moteur, procéder comme suit:
- Enlever le couvercle du boîtier électrique (Fig. 4.1.5)
- Contrôler la tension et la fréquence d'alimentation
- Passer le câble électrique à travers le boîtier
- Brancher les fils du câble en fonction de la tension d'alimentation (voir Fig. 11.1 et 12.1)

- Den Deckel des Klemmenkastens schließen

4. Zur Prüfung der Drehrichtung (bei Drehstrommotor) Pumpe kurz ein- und ausschalten.
Zur Kontrolle, ob Luft angesaugt wird, kann die Handfläche auf den Ansaugflansch gelegt werden. Eine andere Möglichkeit besteht darin, die Drehrichtung des Motors mit der angegebe-nen Pfeilrichtung zur vergleichen (Fig. 12.1). Von der Motorenseite aus gesehen ist die Drehrichtung nach rechts, im Uhrzeigersinn.
Bei falscher Drehrichtung, bei Drehstrom:
-Zwei der drei Phasen umpolen.

- Close terminal box cover

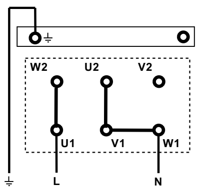
4. To check the pump's direction of rotation (for three-phase motor), switch on the pump for a few seconds. Verify that there is vacuum by putting the palm of your hand on the inlet flange. Another possibility is to compare the direction of rotation of the motor with the direction indicated by the arrow (Fig. 12.1). Looking at the motor fan cover, the direction of rotation is clockwise.
In case of wrong direction of rotation in three-phase current operation:
- reverse polarity of two of the three electrical phases.

- Replacer le couvercle du boîtier électrique

4. Pour vérifier le sens de rotation de la pompe (pour moteur triphasé), la mettre sous tension pendant un court instant.
Contrôler que la pompe aspire en approchant la paume de la main de la bride d'aspiration. Un autre moyen de contrôle est de comparer le sens de rotation du moteur avec le sens de la flèche (Fig. 12.1). Vu du côté moteur, le sens de rotation est à droite (sens horaire).
Si le sens de rotation est faux pour le triphasé:
- inverser deux des trois phases d'alimentation

FO 0009 A, FO 0018 A

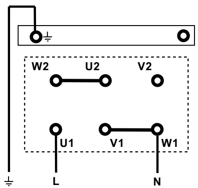
Wechselstromanschluss
Alternative current connection
Connexion monophasée



100 - 115 V

FO 0009 A, FO 0018 A

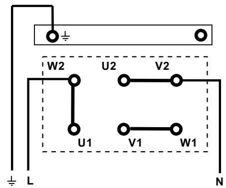
Wechselstromanschluss
Alternative current connection
Connexion monophasée



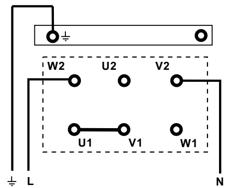
220 - 230 V

FO 0030 A

Wechselstromanschluss
Alternative current connection
Connexion monophasée



100 - 115 V

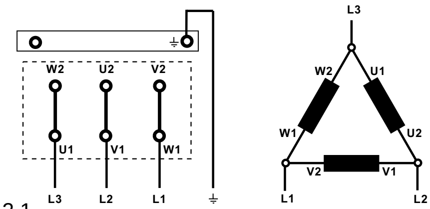


220 - 230 V

Fig. 11.1

FO 0030 A

Dreieckschaltung
Triangle connection
Connexion en triangle



FO 0030 A

Sternschaltung
Star connection
Connexion en étoile

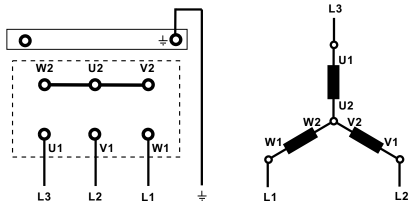


Fig. 12.1

7. Betriebshinweise

Diese Vakuumpumpen sind für das Fördern von sauberen und trockenen Gasen bestimmt, die weder aggressiv noch giftig sind. Nicht geeignet für zündfähige Gemische.
Andere Medien dürfen nicht gefördert werden. Wenden Sie sich im Zweifelsfall an Ihre örtliche Busch-Vertretung.

Flüssigkeiten und Feststoffe dürfen nicht in die Pumpe gelangen.
Nicht geeignet für aggressive Gase und für zündfähige Gemische.

7. Operation advice

These vacuum pumps can be used to evacuate dry and neutral gases, which are not aggressive or poisonous. Not to be used to suck off ignitable gas mixtures.
Other agents must not be transported. In case of doubt, please contact your local Busch Agency.

Liquid and solid particles must not enter the pump.
Not to be used to evacuate aggressive gases or explosive gas mixtures.

7. Conseils d'utilisation

Ces pompes à vide sont conçues pour aspirer du gaz sec et neutre qui n'est pas agressif. Ne pas aspirer de mélanges explosifs.

Certains produits ne doivent pas être aspirés par les pompes. En cas de doute consulter votre Agence Busch locale.

Des liquides et des particules solides ne doivent pas entrer dans la pompe. Ne doit ni être utilisée avec des gaz ou mélanges de gaz agressifs, ni mélanges explosifs.

Vor dem Betreiben mit Prozessgas muss die Vakuumpumpe kurz bei Atmosphärendruck (offener Saugflansch) betrieben werden, um eventuell bei der Inbetriebnahme eingedrungene Staubpartikel aus der Pumpe zu entfernen.
Diese Luftspülung sollte nach Stillstand weitergeführt werden.

8. Wartung

8.1 Reinigung des Siebes (Fig. 15.1)
Das Sieb ist regelmäßig auf Verschmutzungen zu überprüfen. Eine Verschmutzung des Siebes kann das Saugvermögen absenken. Gegebenenfalls muss das Sieb gereinigt werden.

Die vier Schrauben, den Saugflansch und das Sieb entfernen.

Das Sieb mit Druckluft ausblasen und anschließend mit dem Saugflansch wieder einsetzen. Der Sauganschluss muss sauber und luftdicht sein.

8.2 Reinigung des Gasballastventiles (option) (Fig. 15.2, 15.3)
Regelmäßig überprüfen, ob das Gasballast ansaugt. Falls keine Luft oder Stickstoff angesaugt wird, muss das Gasballastventil abmontiert und mit Druckluft ausgeblasen werden.

Before operating with process gases, run shortly the pump at the atmospheric pressure to remove the possible dusts accumulated in the pump during the operation.

Purge the pump with air after use.

8. Maintenance

8.1 Cleaning of sieve (Fig. 15.1)
The mesh should be inspected regularly for dirt. Soiling of the mesh can lower the flow rate. If necessary clean it.

Unscrew the four screws, remove mesh and inlet flange.

Blow mesh with compressed air. Reinstall mesh and inlet flange.
Make sure the connection is in place and tight.

8.2 Cleaning of gas ballast valve (option) (Fig. 15.2, 15.3)
Check regularly if the gas ballast valve works.
If no air or nitrogen enters correctly the gas ballast valve, remove it and blow it out with compressed air.

Avant le fonctionnement de la pompe avec les gaz du procédé, faire tourner la pompe à la pression atmosphérique pendant un court instant afin d'éliminer les éventuelles poussières accumulées pendant le fonctionnement.
Rincer la pompe à l'air après utilisation.

8. Maintenance

8.1 Nettoyage du tamis (Fig. 15.1)
Il faut contrôler régulièrement la propreté du tamis. Un encrassement peut faire descendre le débit d'aspiration. Au besoin, le nettoyer.

Dévisser les quatre vis, enlever la bride d'aspiration et le tamis.

Souffler ce dernier avec de l'air comprimé. Remonter le tamis et la bride en contrôlant que la connexion soit propre et étanche au vide.

8.2 Nettoyage du lest d'air (option) (Fig. 15.2, 15.3)
Contrôler régulièrement que le lest d'air aspire.
Si l'aspiration d'air ou d'azote ne se fait pas correctement, démonter et nettoyer le lest d'air avec de l'air comprimé.

8.3 Weitere Wartungsarbeiten

Um den sicheren Betrieb der Pumpe zu gewährleisten, empfehlen wir, mindestens alle 8000 Betriebsstunden einen Service von Busch durchführen lassen.

Dazu muss die Fossa Vakuumpumpe aus der Anlage des Betreibers ausgebaut werden. Je nach Anwendungsfall muss die Pumpe zuvor mit Stickstoff gespült oder gereinigt werden. Dabei sind alle für das gefördete Medium relevanten Sicherheitsvorschriften einzuhalten.

Der Betreiber muss entweder beim Versand der Vakuumpumpe an die örtliche Busch-Vertretung schriftlich bestätigen, dass die Vakuumpumpe nur mit unbedenklichen Substanzen in Berührung gekommen ist.

Oder er muss eine Unbedenklichkeitsbescheinigung ausfüllen, in der auf eventuelle Gefahren durch das geförderte Medium und auf die geeigneten Schutzvorkehrungen hingewiesen werden muss.

Die Vakuumpumpe ist mit der komplett ausgefüllten Unbedenklichkeitsbescheinigung an die örtliche Busch-Vertretung zu senden.

8.3 Additional maintenance

To guarantee safe operation, we recommend that the pump is serviced by Busch at least every 8000 hours of operation.

For that the pump must be disconnected from your installation. Dependent on application, the pump must be cleaned or purged with nitrogen. All safety precautions concerning the product must be observed.

In case of return please send back with the pump a written form which confirms that the pump only was in contact with harmless substances.

Otherwise you must complete a certificate of no danger in which however any incidental danger and the corresponding safety measures must be indicated.

The vacuum pump and the correctly completed certificate of no danger must be returned to your local Busch Agency

8.3 Maintenance additionnelle

Pour garantir le meilleur fonctionnement de la pompe, nous recommandons d'effectuer un service par la société Busch au minimum toutes les 8000 heures de service.

La pompe doit ainsi être déconnectée de l'installation de l'exploitant. Selon l'application, la pompe doit être avant tout rincée à l'azote ou nettoyée. Les prescriptions de sécurité concernant le médium pompé doivent être respectées.

Avant d'envoyer sa pompe, l'exploitant doit confirmer par écrit à l'Agence Busch locale qu'aucunes substances nocives ne sont entrées en contact avec le pompe.

Dans les autres cas, il doit remplir un certificat d'absence de risque qui informe des dangers éventuels concernant le médium pompé et des dispositions de sécurité à prendre.

La pompe à vide et le certificat d'absence de risque entièrement rempli sont à envoyés à votre Agence Busch locale.

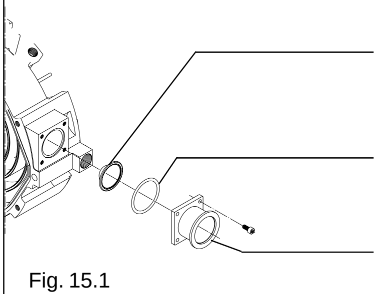


Fig. 15.1

Art.-Nr. Part-no. N° art.	FO 0009 A	FO 0018 A	FO 0030 A
Sieb Mesh Tamis	0534 520 152	0534 520 153	0534 520 151
O-Ring O-Ring Joint torique	0486 000 617	0486 000 673	0486 509 689

Gasballastventil, Standard-Ausführung (option)
Gas ballast valve, standard version (option)
Lest d'air, version standard (option)

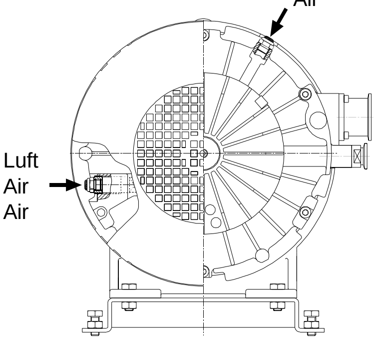


Fig. 15.2

Gasballastventil, Stickstoff-Ausführung (option)
Gas ballast valve, N2 version (option)
Lest d'air, version azote (option)

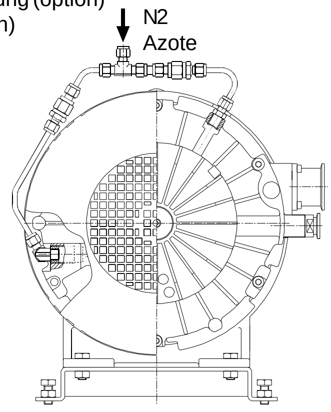


Fig. 15.3

Servicetabelle Service schedule Tableau de maintenance	Wartungsarbeit Service job Type d'intervention		Zeitabstand Interval Périodicité
Sieb Mesh Tamis	Reinigung Cleaning Nettoyage	Pkt. 8.1 Pt. 8.1 Pt. 8.1	nach Anwendungen according to applications selon applications
Gasballastventil (option) Gas ballast valve (option) Lest d'air (option)	Reinigung Cleaning Nettoyage	Pkt. 8.2 Pt. 8.2 Pt. 8.2	ca. monatlich app. monthly env. mensuel
Kompletter Service Complete service Service complet	Nur durch Busch Kundendienst Only by Busch maintenance service engineer Seulement par notre service de maintenance Busch		nach 8000 h after 8000 h après 8000 h

Hauptzubehör Principal accessories Accessoires principaux	Beschreibung Description Description	FO 0009 A	FO 0018 A	FO 0030 A
Gasballastventil, Standard-Ausführung Gas ballast valve, standard version Lest d'air, version standard	um die Kondensation in der Pumpe zu vermeiden in order to avoid the condensation in the pump pour éviter la condensation dans la pompe	-	0916 525 267	0916 525 252
Gasballastventil, Stickstoff-Ausführung Gas ballast valve, N2 version Lest d'air, version azote	um die Kondensation in der Pumpe zu vermeiden in order to avoid the condensation in the pump pour éviter la condensation dans la pompe	-	-	0916 525 251

9. Informationen

Weitere Informationen senden wir Ihnen auf Anfrage gerne zu. Verfügbar ist:

- Typenblatt Fossa FO
- Unbedenklichkeitsbescheinigung

9. Informations

We would be happy to supply further information if needed, as follows:.

- Type sheet Fossa FO
- Certificate of no danger

9. Informations

Sur demande, nous vous ferons volontiers parvenir les documents supplémentaires suivants:

- Documentation commerciale Fossa FO
- Certificat d'absence de risque

Technische Daten Technical data Caractéristiques techniques		FO 0009 A			FO 0018 A			FO 0030 A		
Nennsaugvermögen Nominal displacement Débit nominal	50 Hz 60 Hz	150 l/min 180 l/min	9 m^3/h 11 m^3/h	5,25 cfm 6,5 cfm	300 l/min 360 l/min	18 m^3/h 22 m^3/h	10,5 cfm 13 cfm	500 l/min 600 l/min	30 m^3/h 36 m^3/h	17,5 cfm 21 cfm
Enddruck Ultimate pressure Pression finale		$\leq 7{,}5 \cdot 10^{-2}$ hPa (mbar)			$\leq 2{,}5 \cdot 10^{-2}$ hPa (mbar)			$\leq 1{,}0 \cdot 10^{-2}$ hPa (mbar)		
Enddruck mit Gasballastventil (option) Ultimate pressure with gas ballast valve (option) Pression finale avec lest d'air (option)		–			$< 3{,}2 \cdot 10^{-2}$ hPa (mbar)			$< 1{,}7 \cdot 10^{-2}$ hPa (mbar)		
Motornennleistung Nominal motor rating Puissance nominale du moteur	50/ 60 Hz	0,2 kW / 0,3 hp			0,37 kW / 0,5 hp			0,6 kW / 0,75 hp		
Motornenndrehzahl Nominal motor speed Vitesse de rotation nominale	50 Hz 60 Hz	1500 min^{-1} 1800 min^{-1}			1500 min^{-1} 1800 min^{-1}			1500 min^{-1} 1800 min^{-1}		
Motorspannung Motor supply voltage Tension du moteur		1 x 200-230 V, 50/ 60 Hz 100-115 V, 50/ 60 Hz			1 x 200-230 V, 50/ 60 Hz 100-115 V, 50/ 60 Hz			3 x 200-240/346-415 V, 50 Hz 3 x 200-266/346-460 V, 60 Hz 1x 200-230 V, 50/60 Hz 1x 100-115 V, 50/60 Hz		
Schalldruckpegel (DIN 45635) Sound level (DIN 45635) Niveau sonore (DIN 45635)		≤ 58 dB (A)			≤ 60 dB (A)			≤ 65 dB (A)		
Gewicht ca. Weight approx. Poids approx.		26 kg			32 kg			38 kg		

No	Troubles	Causes/ check items	Actions
1	Evacuation difficulties	▪ Incorrect direction of motor rotation ▪ Suction pipe obstructed ▪ Leakage of suction pipe ▪ Inlet gauge obstructed	▪ Reverse polarity of 2 phases of the power supply ▪ Clean suction pipe ▪ Check suction pipe ▪ Clean or replace inlet gauge
2	Difficulty in obtaining the ultimate vacuum	▪ Leakage in vacuum system ▪ Condensate formation within pump ▪ Defective seals	▪ Check vacuum system ▪ Put pump at atmospheric pressure ▪ Let check the pump by Busch service
3	Overload	▪ The back pressure of pump is too high ▪ Defective bearing ▪ Pump contaminated by process residuals	▪ Check discharge pipe ▪ Let replace bearing by Busch service ▪ Let check the pump by Busch service
4	Heating of pump	▪ Ventilation around the pump is too low ▪ Pump contaminated by process residuals ▪ Discharge pipe obstructed ▪ Motor failure ▪ Ambient temperature is too high	▪ Check the location of pump ▪ Let check the pump by Busch service ▪ Check discharge pipe ▪ Check motor ▪ Check ambient temperature
5	Anormal noise of pump	▪ Discharge pipe obstructed ▪ Incorrect direction of motor rotation ▪ Pump contaminated by process residuals	▪ Check discharge pipe ▪ Reverse polarity of 2 phases of the power supply ▪ Let check the pump by Busch service
6	Condensation within pump	▪ Suction of condensable vapors is too high ▪ Defective gas ballast valve	▪ Check process ▪ Clean or replace gas ballast valve

Mit dieser Konformitätserklärung im Sinne der EG-Maschinenrichtlinie 98/ 37/ EWG Anhang II A erklärt die Firma

In compliance with the EC Machinery Directive 98/ 37/ EEC, appendix II a it is confirmed by

Avec cette déclaration de conformité dans le sens de la Directive Machines 98/ 37/ CEE, annexe II A, l'entreprise

Ateliers Busch S.A.
Zone Industrielle
CH-2906 Chevenez

Reg. N° 10947

dass nachfolgend beschriebene

that following

atteste que les

Vakuumpumpen: FO 0009 - 0030 A

Vacuum pumps: FO 0009 - 0030 A

Pompes à vide: FO 0009 - 0030 A

in Übereinstimmung mit den EG-Maschinenrichtlinie 98/ 37/ EWG , der EG-Niederspannungsrichtlinie 73/ 23/ EWG, mit der Elektromagnetischen Verträglichkeitsrichtlinie 89/ 336/ EWG, sowie den nachfolgend genannten Normen und Vorschriften hergestellt worden ist.

are manufactured in accordance to EC Machinery Directive 98/ 37/ EEC, to EC low voltage standard 73/ 23/ EEC, to the Electromagnetic compatibility Directive 89/ 336/ EEC and all standards listed next page.

ont été fabriquées conformément à la Directive Machines 98/ 37/ CEE , à la Directive Basse Tension 73/ 23/ CEE, à la Directive sur la Compatibilité électromagnétique 89/ 336/ CEE, de même que selon les normes et prescriptions indiquées à la page suivante.

Beauftragter innerhalb EG:

Mandadory within the EC:

Mandataire dans la CE

Dr.- Ing. K. Busch GmbH
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Hersteller / Manufacturer / Fabricant	Beauftragter / Mandatory / Mandataire
René Gigon Geschäftsführer General director Directeur général	**Dr. - Ing. Karl Busch** Geschäftsführer General director Directeur général

Norm Norm Norme	Titel der Norm Title of the norm Titre de la norme
Harmonisierte Normen/ harmonized normes/ normes harmonisées	
EN 292-1 EN 292-2	Sicherheit von Maschinen: Grundbegriffe, allgemeine Gestaltungsleitsätze; Teil 1 und 2 Safety of machinery: Basic concepts, general principles for design; Part 1 and 2 Sécurité des machines; Notions fondamentales, principes généraux de conception; Partie 1 et 2
EN 294	Sicherheit von Maschinen: Sicherheitsabstände gegen das Erreichen von Gefahrenstellen mit den oberen Gliedmaßen Safety of machinery: Safety distances to prevent danger zones being reached by the upper limbs Sécurité des machines, distances de sécurité pour empêcher que les zones de danger soient atteintes par les membres supérieurs
EN 60204-1	Elektrische Ausrüstung von Maschinen; Teil 1 Electrical equipment of machines; Part 1 Equipement électrique des machines; Partie 1
EN 1012-1 EN 1012-2	Kompressoren und Vakuumpumpen; Sicherheitsanforderungen - Teil 1 und 2 Compressors and vacuum pumps; Safety requirements; Part 1 and 2 Compresseurs et pompes à vide; Exigences en matière de sécurité; Partie 1 et 2
EN 50081-1,-2	Elektromagnetische Verträglichkeit; Fachgrundnorm Störaussendung; Teil 1 und 2 Electromagnetic compatibility; Generic emission standard; Part 1 and 2 Compatibilité électromagnétique; Norme générique émission; Partie 1 et 2
EN 50082-1,-2	Elektromagnetische Verträglichkeit; Fachgrundnorm Störfestigkeit; Teil 1 und 2 Electromagnetic compatibility; Generic immunity standard; Part 1 and 2 Compatibilité électromagnétique; Norme générique immunité; Partie 1 et 2

Nationale Normen/ national normes/ normes nationales

DIN 45635-13	Geräuschmessung an Maschinen (Verdränger-, Turbo- und Strahlverdichter) Measurement of airborne noise emitted by machines (Displacement-, turbo- and jet-compressors) Mesure sonore sur les machines (compresseur volumétrique, centrifuge et faisceau)

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CTI-CRYOGENICS
HELIX TECHNOLOGY CORPORATION

Cryo-Torr® 100, 7, 8 and 8F High-Vacuum Pump Installation, Operation, and Service Instructions

8040240
Rev. F (5/99)

HELIX TECHNOLOGY CORPORATION
Mansfield Corporate Center, Nine Hampshire Street, Mansfield, Massachusetts 02048-9171 Telephone (508) 337-5000

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Safety

Introduction

On-Board products have been designed to provide extremely safe and dependable operation when properly used. Safety precautions must be observed during normal operation and when servicing the On-Board system.

NOTE: *Read this manual and follow these safety guidelines before installing, operating, or servicing On-Board products.*

Warnings

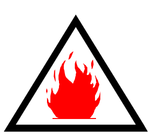
A warning describes safety hazards or unsafe practices which could result in personal injury or loss of life. A warning message is accompanied by a symbol as described in the following paragraphs and is also surrounded by a box to attract your attention.

Toxic, Corrosive, Dangerous Gases, or Liquids

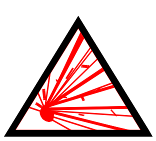
Toxic, corrosive, dangerous gases, or liquids which may be present in an On-Board product could cause severe injury upon contact. Make sure the following precautions are taken when handling toxic, corrosive, or dangerous gases.

1. Always vent toxic, corrosive, dangerous gases, or liquids to a safe location using an inert purge gas.
2. Clearly identify toxic, corrosive, dangerous gases, or liquids on containers used to store or ship equipment after such exposure.

Flammable or Explosive Gases



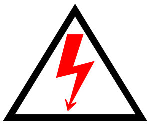
Flammable or explosive gases which may be present in an On-Board product could cause severe injury if ignited. Make sure the following precautions are taken when handling flammable or explosive gases:



1. Always vent flammable or explosive gases to a safe location using an inert purge gas.
2. Do not install a hot filament type vacuum gauge on the high vacuum side of the isolation valve. This could be an ignition source of flammable gases in On-Board products.

High Voltage

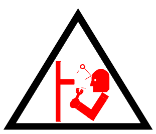
High voltage electric shock can cause severe injury or loss of life. Take the following precautions to prevent high voltage risks:



1. Disconnect the high vacuum pump system from all power sources before making electrical connections between system components or before performing troubleshooting and maintenance procedures.

High Gas Pressure

High gas pressure may be present within high vacuum pump systems and can cause severe injury from propelled particles or parts.

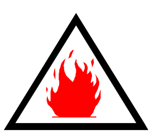


1. Do not modify or remove the pressure relief valves, either on the On-Board pump or within the helium compressor.
2. Always depressurize the adsorber to atmospheric pressure before disposing.
3. Always bleed the helium charge down to atmospheric pressure before servicing or disassembling the self sealing couplings.

Cautions

A caution describes safety hazards or unsafe practices which could result in equipment damage.

Cryopump Oxygen Procedures



WARNING

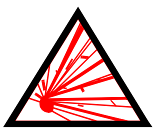
Combustion supported by oxygen in the cryopump could cause severe injury when oxygen is used as a process gas. Special precautions described in the following text should be taken.

When oxygen is used as a process gas, the following precautions should be taken:

1. Insure that there are no sources of ignition (e.g. hot filament vacuum gauges) on the cryopump side of the high vacuum valve operating during the warming or venting of the cryopump.

2. Perform inert gas purge regeneration cycles at flow rates recommended for cryopumps.
3. Regenerate as frequently as practical to minimize the amount of oxidizer present in the cryopump.
4. It is standard practice in the vacuum industry that any system exposed to richer-than-air oxygen levels should be prepared for oxygen service per the manufacturer's recommendations, including use of oxygen service lubricating oils in roughing pumps.

WARNING



Explosion occurring from ozone in the cryopump could cause severe injury. Ozone can be present as a by product of oxygen processes. If ozone is present, special precautions described in the following text must be taken.

Ozone may be unknowingly produced in an ionizing process (e.g. sputtering, etching, glow discharge). Explosive conditions may exist if ozone is present, especially during the warming of the cryopump. Signs of ozone's presence are:

1. Crackling, popping sounds (as in electrical arcing) occurring within the first few minutes of a regeneration cycle.
2. Gas venting from the cryopump during regeneration may have a pungent smell, similar to that present in an arc welding operation or after an electrical storm.

NOTE: *A change in process may increase the amount of ozone present.*

If ozone is present, the following precautions must be taken:

1. All of the above oxygen precautions must be followed. The required regeneration frequency is dependent upon flow and process conditions. Daily regeneration may be required. Call CTI-CRYOGENICS for assistance.
2. Reduce the oxygen mixture to the lowest level the process will allow.

Section 1 - Cryopump Description

Introduction

This manual provides instructions for installing, operating and servicing the Cryo-Torr 100, 7, 8, and 8F Cryopumps. If you are installing or operating a high-vacuum system you should also have the appropriate Compressor manual that applies to your particular system.

The manuals cover two basic components: the cryopump, compressor, and the controller where applicable. Each manual presents information for installation, operation and servicing of that component. A manual is shipped with each system component (cryopump, compressor, and controller). When you purchase a system, you will receive the three manuals necessary for system installation, plus a loose-leaf binder with index tab separators allowing you to compile a complete indexed system notebook.

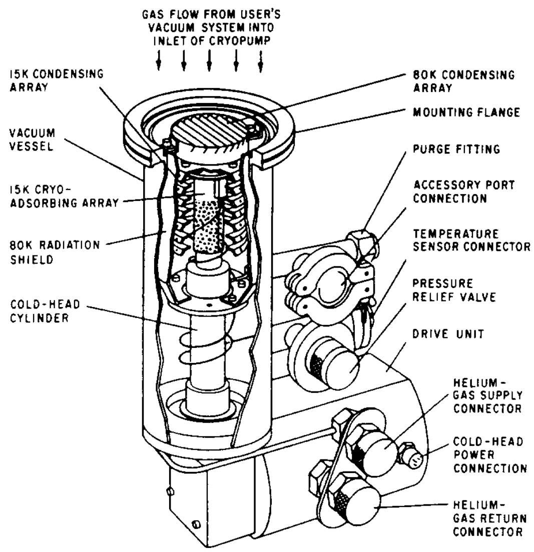
The Cryo-Torr High-Vacuum Pump System provides fast, clean pumping of all gases in the 10^{-3} to 10^{-10} torr range. It operates on the principle that gases can be condensed and held at extremely low vapor pressure, achieving high speeds and throughputs at the cryogenic temperatures of the operating cryopump.

The cryopump is a reliable rugged unit that requires a minimum of servicing. The cryopump exposes no moving parts, operating fluids, or backing pumps to the working vacuum; the possibility of contamination is eliminated.

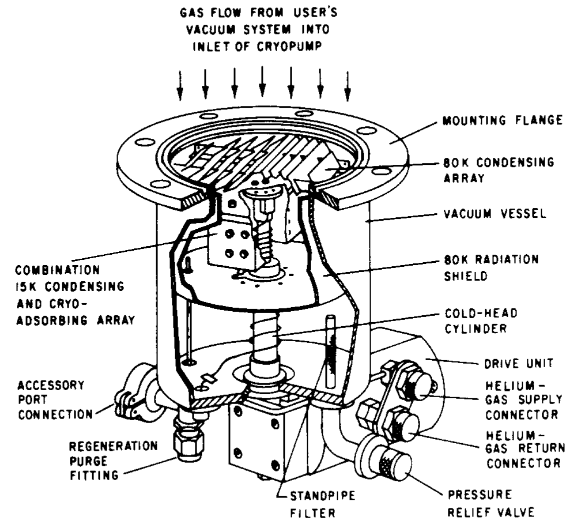
Figure 1-1 shows cutaway views of the cryopumps. The Cryo-Torr 8F cryopump is virtually identical in operation to the Cryo-Torr 8 and is of a flat pump design that offers a dimensional alternative when vertical space is limited. The Cryo-Torr 8F cryopump is available with gas and electrical connectors facing in either a left or right direction to match your piping and electrical interface.

Installation, Operation, and Service Instructions

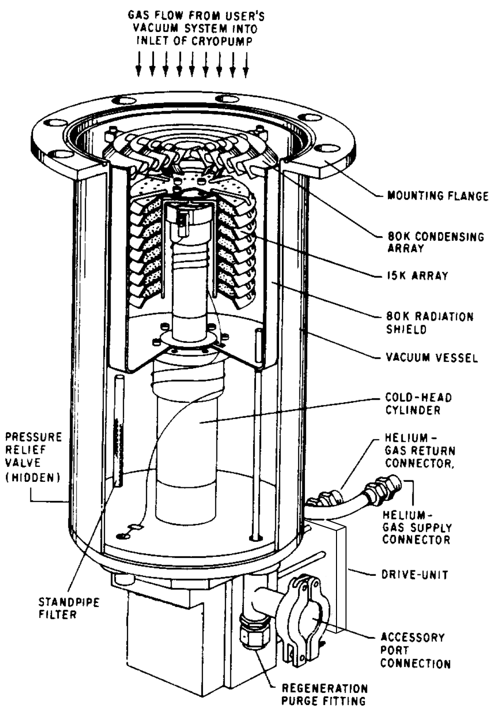
Installation, Operation, and Service Instructions for your Cryo-Torr vacuum pump provide complete and easily accessible information. All personnel with installation, operation, and servicing responsibilities should become familiar with the contents of these instructions to ensure safe, reliable, and efficient cryopump performance.



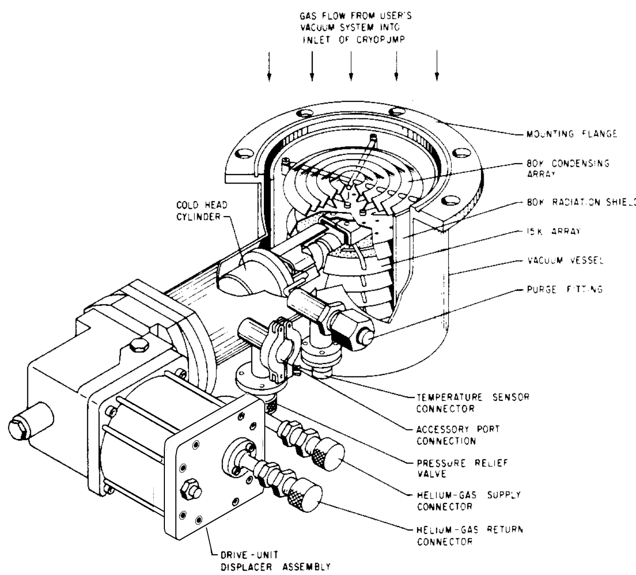
Cryo-Torr 100



Cryo-Torr 7



Cryo-Torr 8



Cryo-Torr 8F

Figure 1-1: Cutaway Views of Cryo-Torr Cryopumps

Table 1-1: Weight (Approximate)

Cryopump	Lbs.	Kg	Shipping Weight	
			Lbs.	Kg
Cryo-Torr 100	22	10	30	11
Cryo-Torr 7	25	11	32	14.5
Cryo-Torr 8	45	20	50	23
Cryo-Torr 8F	42	20	47	21

Table 1-2: Pumping Speeds (Liters/Second)

Cryopump	Water	Air	Hydrogen	Argon
Cryo-Torr 100	1,000	350	480	285
Cryo-Torr 7	3,600	1,000	1,000	850
Cryo-Torr 8	4,000	1,500	2,500	1,200
Cryo-Torr 8F	4,000	1,500	2,200	1,200

Table 1-3: Crossover (Maximum Gas Burst)

Cryopump	Torr-Liters
Cryo-Torr 100	40
Cryo-Torr 7	50
Cryo-Torr 8	150
Cryo-Torr 8F	150

Table 1-4: Condensable Gases Capacity (Argon, Nitrogen, Oxygen, Etc.)

Cryopump	Standard Liters	Torr-Liters
Cryo-Torr 100	90	68,400
Cryo-Torr 7	350	266,000
Cryo-Torr 8	1,000	760,000
Cryo-Torr 8F	1,000	760,000

Table 1-5: Hydrogen Gas Capacity

Cryopump	Hydrogen Partial Pressure (Torr)	Standard Liters	Torr-Liters
Cryo-Torr 100 Cryo-Torr 100	5×10^{-8} 5×10^{-6}	1 2	760 1,520
Cryo-Torr 7 Cryo-Torr 7	5×10^{-8} 5×10^{-6}	2 4	1,520 3,040
Cryo-Torr 8 Cryo-Torr 8	5×10^{-8} 5×10^{-6}	6 12	4,560 9,120
Cryo-Torr 8F Cryo-Torr 8F	5×10^{-8} 5×10^{-6}	4 8	3,040 6,080

Table 1-6: Argon Throughput (Maximum)

Cryopump	SCC/Minute	Torr-Liters/Second
Cryo-Torr 100	75	0.95
Cryo-Torr 7	75	0.95
Cryo-Torr 8	700	8.9
Cryo-Torr F	700	8.9

Interface Connections

Helium Supply and Return Lines

- 10 ft. (3 m) each with 1/2-inch self-sealing couplings (longer lengths, elbows and tees available)

Cold-head Power Cable

- 10 ft. (3 m) (longer lengths available)

Temperature Sensor

- Hydrogen-vapor-pressure gauge
- Diode temperature sensor connector mates with Amphenol P/N 48-16R-10-55/48-23-41

Accessory Port Connection (Roughing)

- Supplied by CTI-CRYOGENICS
- NW-25 ISO-KF flange
- With clamp and blank flange

Regeneration Purge Fitting

- Supplied by CTI-CRYOGENICS
- Parker CPI ULTRASEAL SIZE 6
- With plug and nut

NOTE: *The cryopump may be operated in any position.*

NOTE: *The dimensions in Table 1-7 are basic interfacing dimensions required for cryopump installation. If additional dimensions are required, contact your sales representative or the Order Processing Department to obtain an interface drawing for your particular cryopump.*

Table 1-7: Interface Dimensions

Cryopump	A (in./mm)	B (in./mm)	C (in./mm)	D (in./mm)	E (in./mm)
Cryo-Torr 100					
(Metal Seal)	12.9 (328)	9.4 (152)	6 (152)	3.9 (99)	10 (256)
(ISO)	12.8 (323)	9.3 (235)	5.12 (130)	3.9 (99)	10 (256)
Cryo-Torr 7					
(ISO)	13.25 (337)	9 (229)	9.5 (130)	7.9 (200)	11.8 (300)
(ANSI)	13.25 (337)	9 (229)	11 (279)	7.9 (200)	12.6 (320)
(UHV)	13.25 (337)	9 (229)	10 (254)	7.9 (200)	12 (307)
Cryo-Torr 8					
(ANSI)	20.7 (526)	13.8 (351)	11 (279)	8 (203)	14.5 (370)
(Metal Seal)	20.7 (526)	13.8 (351)	10 (254)	8 (203)	14.5 (370)
(UHV)	20.7 (526)	13.8 (351)	10 (254)	8 (203)	14.5 (370)
(ISO)	20.7 (526)	13.8 (351)	9.5 (240)	8 (203)	14.5 (370)
Cryo-Torr 8F					
(ANSI)	22.6 (574)	15.8 (402)	11 (279)	8 (203)	14.5 (370)
(ISO)	21.8 (555)	15 (381)	9.5 (240)	8 (203)	14.5 (370)

NOTE: *Cryo-Torr 8F depth dimension is 7.1 in. (179.6 mm) approximate.*

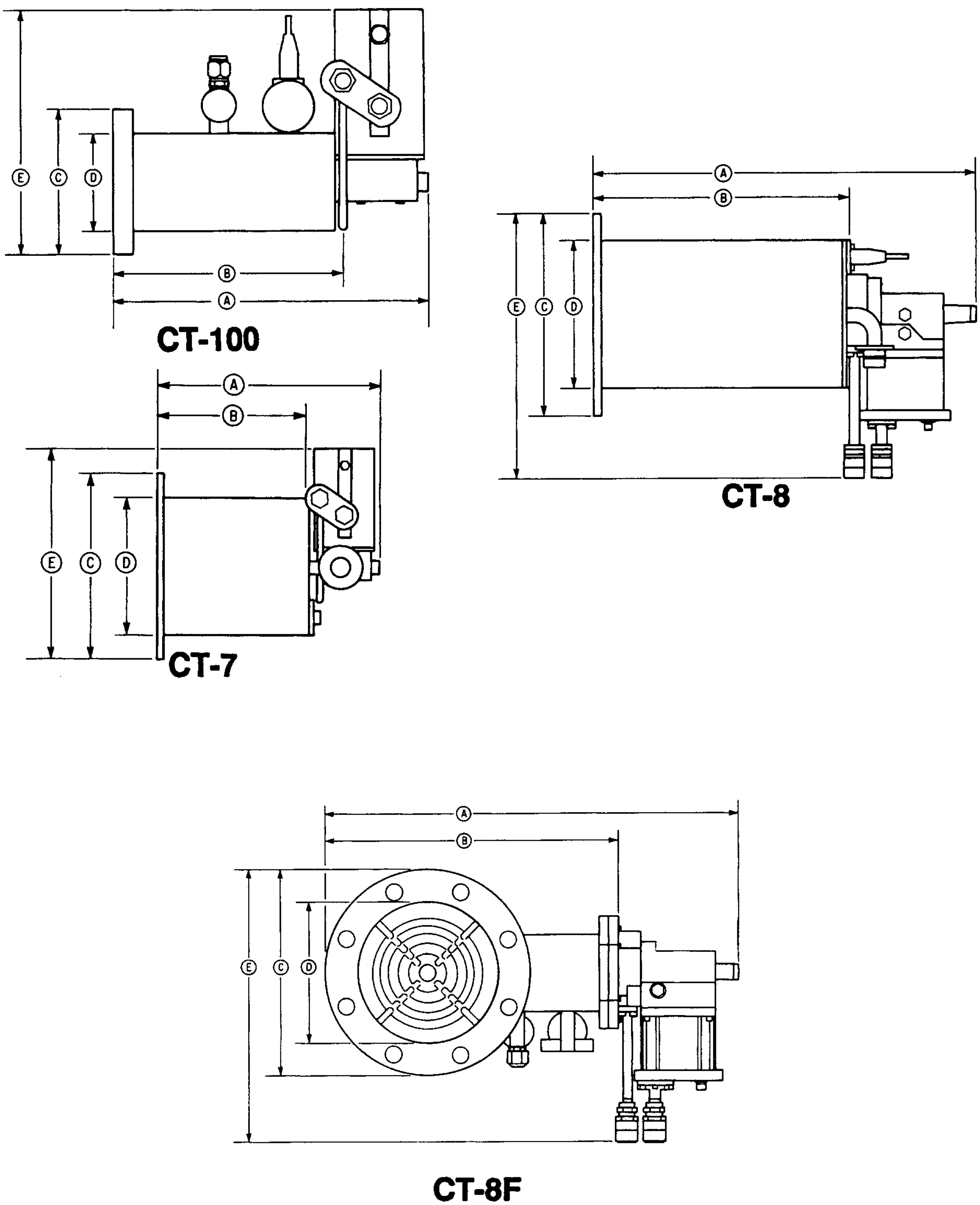


Figure 1-2: Interface Drawings

Section 2 - Inspection

Packaging of the System

A Cryo-Torr High-Vacuum Pump System is packaged in three separate cartons. Table 2-1 lists the contents of each carton, as they relate to these two compressor applications. Note that an Installation, Operation, and Service Manual is included in cartons for the high-vacuum pump, compressor and controller; each manual covers the component packaged in that carton.

When installing a Cryo-Torr High-Vacuum Pump System, CTI-CRYOGENICS recommends that as you unpack a component; then perform an inspection and the necessary tasks for system installation for the component according to the manual (included with the component). Final system installation and operation will be performed following procedures in the cryopump manual (8040240).

The Cryopump

On receipt, remove the cryopump from its shipping carton and inspect the cryopump for evidence of damage. Report any damage to the shipper at once. Also, retain the shipping cartons for use in storage or return shipment.

Inspect the cryopump for damage by examining the following:

1. Overall exterior.
2. Mounting flange and its sealing surfaces after removing the protective cover.
3. Louver assembly of the 80K condensing array. Replace the protective cover.

NOTE: *If you are already familiar with the details of cryopump installation, proceed directly to* ***Section 3 - Quick Installation and Start-up*** *so your cryopump can be made operational quickly. If not, proceed to* ***Section 4 - Installation*** *of this manual for detailed installation procedures.*

Table 2-1: Product Carton Contents

Carton Labels	Compressor Used		Manual Number
	8200	8500	
Cryo-Torr	Cryopump	Cryopump	8040240
Compressor	------ 8200 Compressor ------	------ ------ 8500 Compressor	8040242 8040353 8040251
Accessories	Maintenance Tool Kit and Accessories, P/N 8140000K001	Maintenance Tool Kit and Accessories, P/N 8140000K001	------

Section 3 - Quick Installation and Start-up

Many Users are already familiar with the details of cryopump, controller, and compressor installation, and basic operation. This section presents the installation and start-up steps in summary form so that the cryopump can be made operational quickly. Figures 3-1 and 3-2, present summary procedures for quick installation and start-up. Each step in the table is followed by a reference to the location in the Manual where detailed information is given. Figure 3-3 shows the interconnections between the cryopump and the 8200 Compressor.

This Section is merely designed to get your system *running*. No attempt is made here to present detailed procedures for installing and operating your system. Detailed information is covered in Section 4 and Section 5.

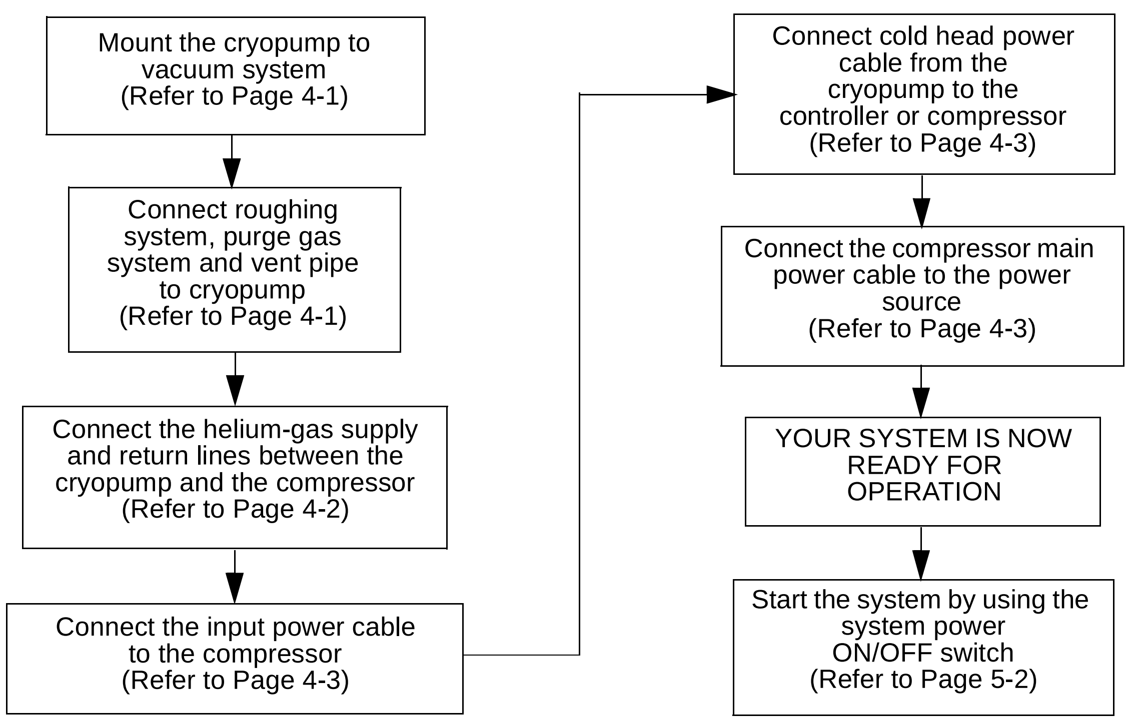


Figure 3-1: Summary of Procedures for Quick Installation and Start-up

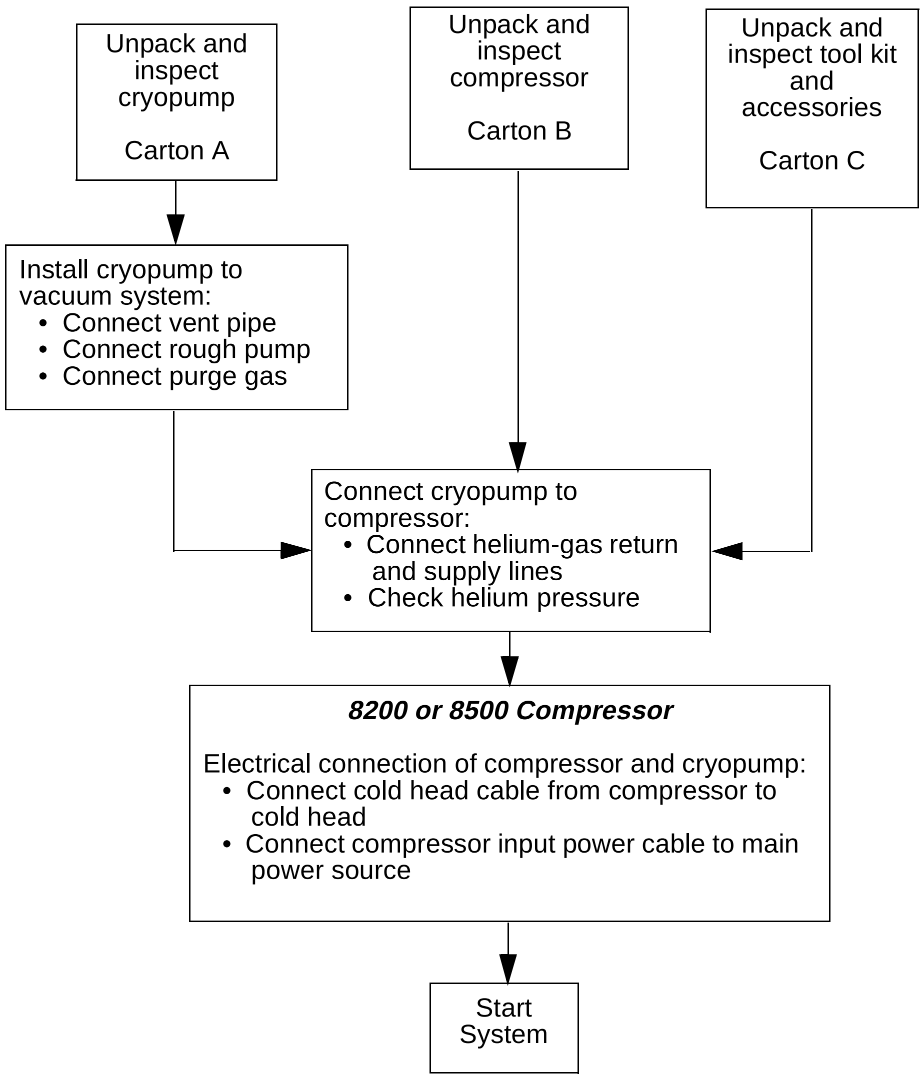


Figure 3-2: Block Diagram for System Installation

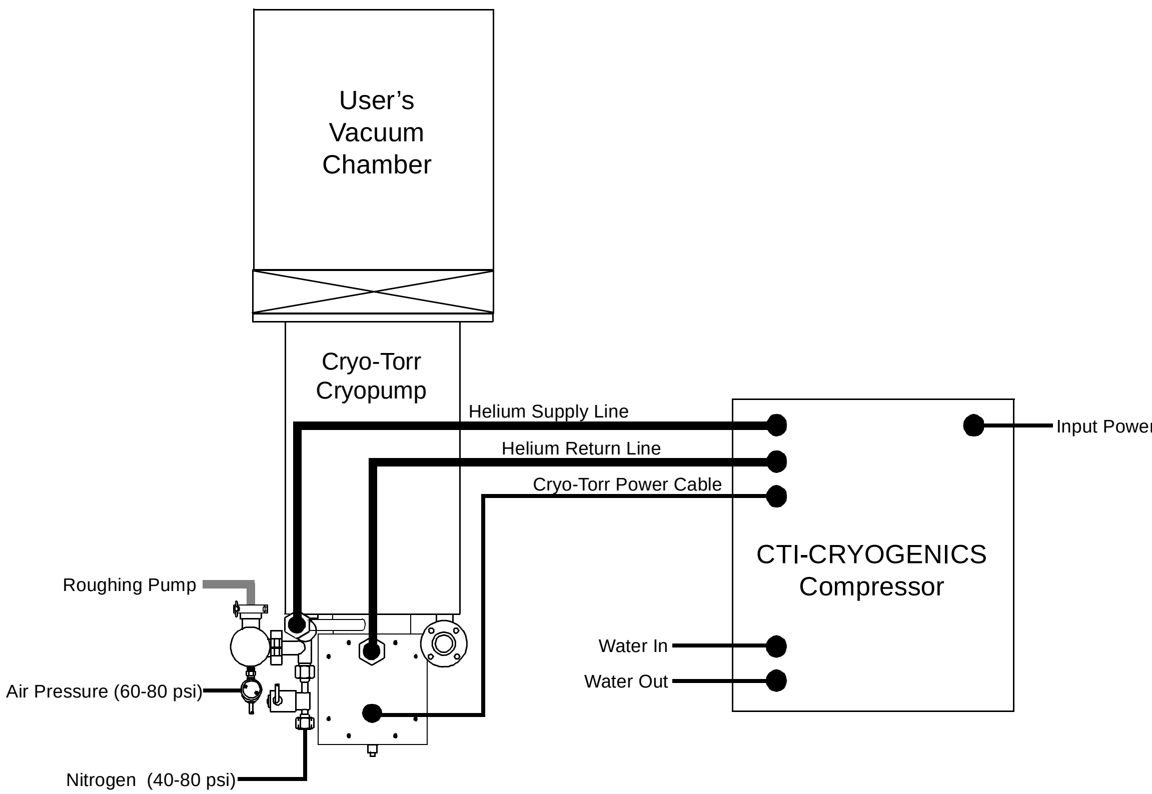


Figure 3-3: Cryopump Interconnection

Section 4 - Installation

Mounting the Cryopump to the Vacuum System

Your cryopump may be installed in any orientation.

Before mounting the cryopump to a vacuum system, an isolation valve (Hi-Vac valve) must be installed between the cryopump and vacuum chamber as a means to isolate the cryopump from the chamber.

To install the cryopump to the vacuum system, refer to Figure 3-3, and proceed as follows:

1. Remove the protective cover from the main flange of the cryopump.
2. Clean all sealing surfaces and install the O-ring or metal seal gasket as appropriate.
3. Mount the cryopump to the Hi-Vac valve or vacuum chamber mounting flange. Be sure all mounting bolts are secure.

Connecting to Roughing Pump

The roughing pump system connects to the cryopump accessory port. The port will accept an ISO NW-25 flange.

Connect the roughing pump system to the accessory port of the cryopump using a roughing line with the largest inside diameter possible to minimize the roughing time required during start-up procedures prior to normal operation.

WARNING

Do not install a hot-filament-type vacuum gauge on the cryopump side of the roughing valve; it could be a source of ignition for flammable gases.

The installation of a DV6M thermocouple (TC) gauge is acceptable providing you install the roughing valve and the TC gauge between the roughing pump system and cryopump. Install the TC gauge and roughing valve as close as possible to the cryopump. A distance of 4 to 6 inches from the cryopump accessory port is desirable.

A molecular sieve roughing trap to minimize oil backstreaming from your roughing pump system may be installed in the roughing pump line near the roughing pump. The trap must be properly maintained.

Connecting Purge Gas

Connect your purge gas supply to the purge gas heater and purge valve. Adjust the supply pressure to operating pressure of 40 psig minimum and a maximum operating pressure of 100 psig maximum; this will allow for the desired purge gas flow rate for the most efficient regeneration.

Connecting a Vent Pipe

The cryopump pressure relief valve (shown in Figure 1-1) may be vented directly into the room or can be connected to a vent pipe.

WARNING

If toxic, corrosive, or flammable gases are pumped, a vent pipe must be connected to the cryopump relief valve and directed to a safe location.

When connecting a vent pipe to your cryopump, a 1.30 inch diameter x 1.38 inch long volume around the relief valve must remain open.

(Vent pipe adapters are available from CTI-CRYOGENICS (P/N 8080250K008).

Connecting the Cryopump to the Compressor

Make the connections between the cryopump and compressor. Refer to Figure 3-3, while making the component interconnections.

1. Remove all dust plugs and caps from the supply and return lines, compressor, and cryopump. Check all fittings.
2. Connect the helium-gas return line from the compressor helium-gas return connector to the helium-gas return connector on the cryopump.
3. Connect the helium-gas supply line from the compressor helium-gas supply connector to the helium-gas supply connector on the cryopump.
4. Attach the supply and return line identification decals (CTI-CRYOGENICS supplied) to their respective connections.

5. Verify proper helium static pressure by confirming that the helium pressure gauge on the compressor reads 245-250 psig (1690-1725 kPa) in an ambient temperature range of 60 to 100°F (16 to 38°C).

If the indicated pressure is higher than 250 psig (1725 kPa), reduce the pressure as follows:

1. Remove the flare cap from the gas charge fitting located on the rear of the compressor.
2. Open the gas charge valve very slowly. Allow a slight amount of helium gas to escape until the helium pressure gauge reads 250 psig (1725 kPa).
3. Close the gas charge valve and reinstall the flare cap.

If the indicated pressure is lower than 245 psig, (1690 kPa), add helium gas as described in **Section 7 - Adding Helium Gas**.

Connecting Power Cables

CAUTION

The power switches on the compressor must be in the OFF position before making any and all electrical connections.

Do not connect the compressor to its power source until all connections have been made between the components of the high-vacuum pump system.

1. Check to ensure the compressor main power cable is properly connected to the compressor.
2. Check to ensure the cold-head power cable is properly connected to the cold head and compressor.
3. Check to ensure the controller or compressor main power cable is properly connected to the main power source.
4. Your system is now ready to operate.

Multi-Cryopump Installation Using 8500 Compressor

NOTE: *Contact the CTI-CRYOGENICS, U.S.A. Application Engineering Department (1-800-447-5007) for specific hardware and gas pressure requirements before installing your multiple cryopumps and the 8200 or 8500 Compressor. If you have installed your cryopumps and desire to establish the static pressure for your system, refer to procedures in this section.*

Installation with 8200 Compressor

To establish the appropriate gas charge pressure of a multiple (2) cryopump (Cryo-Torr-100) and 8200 Compressor installation using interconnecting lines totaling more than 10 feet (on either the supply or return side), proceed as follows:

1. Connect the multiple cryopump system as shown in Figure 4-1. This figure depicts a typical multi-cryopump installation with an 8200 Compressor. Note that the components are helium connected in parallel (all supply fittings piped together).
2. Check the static charge of the system and add or discharge helium gas as required to bring the static pressure to 245-250 psig (1690-1725 kPa). (Follow the procedures as described in **Section 7 - Adding Helium Gas** to add helium or **Connecting the Cryopump to the Compressor** in this section, to discharge helium).
3. Start the system.
4. Approximately 10 minutes after start-up, note the pressure on the return gauge on the helium compressor. Adjust the pressure by adding or discharging helium to 85-95 psig (585-655 kPa).
5. Allow the system to run until both cryopumps have attained a temperature less than 20K.
6. Again adjust the pressure as in step 4 above, until the return gauge in the compressor is reading 105-115 psig (725-780 kPa).
7. Shut off the system and allow it to reach room temperature (approximately 3 hours without regeneration). Note the static pressure in the system. It should not exceed 255 psig (1755 kPa). This then becomes the static pressure of your multiple cryopump installation.

Installation with 8500 Compressor

Figure 4-2 depicts a typical multi-cryopump installation with an 8500 Compressor. As shown in this figure, an electrical power cable is connected from the compressor to each cold head; also, the components are helium connected in parallel (all supply fittings piped together).

Listed below are multiple combinations of Cryo-Torr 100, 7, 8 and 8F high-vacuum pumps that can be driven by the 8500 Compressor.

Table 4-1: 8500 Compressor/Cryopump Combinations

Cryo-Torr 100	Cryo-Torr 7	Cryo-Torr 8/8F	Total
1	-	1	2
2	-	1	3
3	-	1	4
2	-	-	2
3	-	-	3
4	-	-	4
5	-	-	5
-	1	1	2
-	2	1	3
-	3	1	4
-	2	-	2
-	3	-	3
-	4	-	4
-	5	-	5
-	-	2	2
-	-	3	3
1	-	3	3
-	1	2	3

To establish the helium gas charge pressure of a multiple cryopump installation using interconnecting lines longer than ten feet, proceed as follows:

1. Interconnecting the Cryo-Torr high-vacuum pump components.
2. Attach a helium bottle, regulator, and charging line to the compressor.
3. Turn on the system power ON/OFF switch. If the remote energizing feature is installed, place the remote ON/OFF switches to on so the cold heads will run.
4. Note the helium pressure gauge reading immediately after start-up. If should read 50-100 psig (345-690 kPa).
5. If necessary add helium gas, or reduce the helium gas pressure.
6. Allow the cryopumps to operate until a cooldown temperature of 20K or less is reached.

   Adjust the helium pressure if necessary until the helium pressure gauge reads 80-100 psig (550-690 kPa) while the compressor is operating.
7. Shut off the compressor and cryopumps. Allow the system to reach ambient temperature; this usually takes approximately four to five hours.

NOTE: *Record the compressor static pressure in your operating log. This is the static pressure for your particular installation and should be used for checking compressor performance or when troubleshooting the installation.*

8. Ensure that the helium charge valve on the compressor is tightly closed. Then shut off the helium pressure regulator or the helium bottle. Remove the charging line from the male flare fitting and reinstall the flare cap.

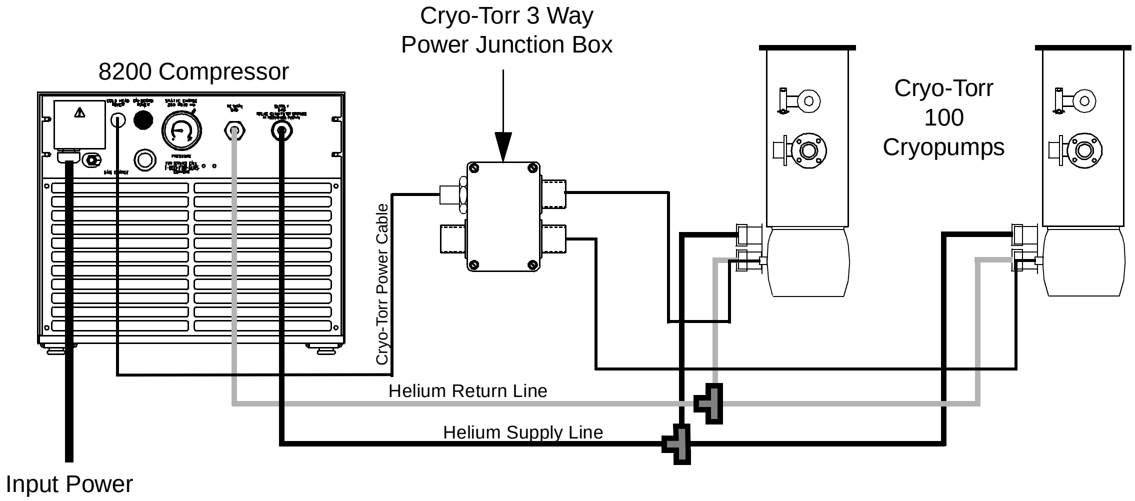


Figure 4-1: Multiple Cryopump Installation with 8200 Compressor

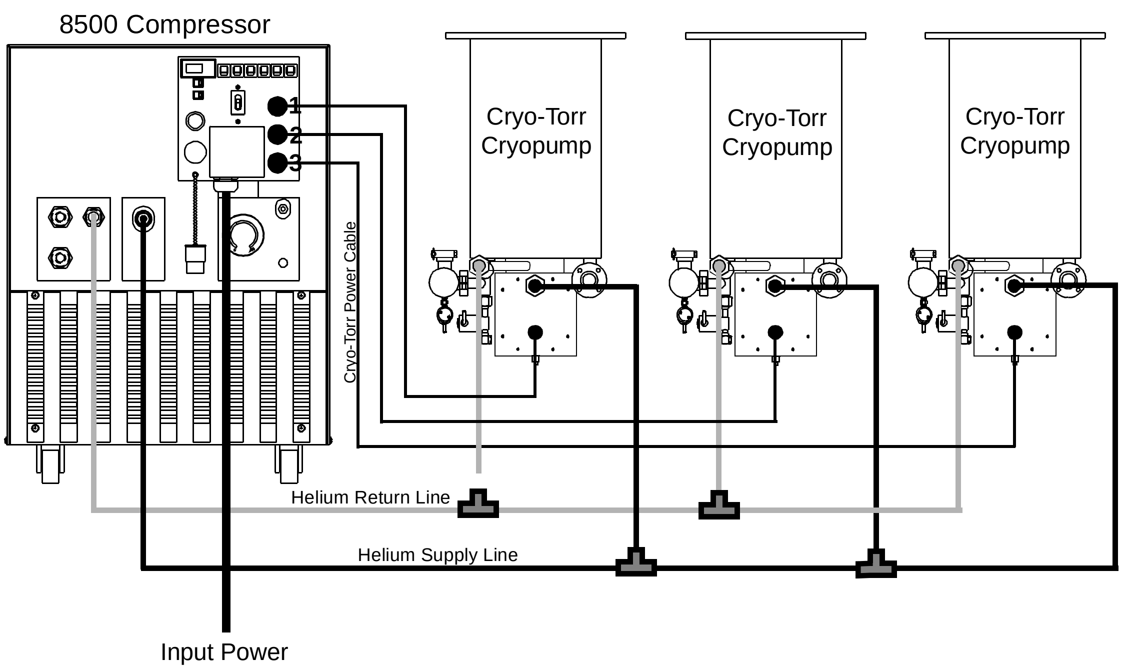


Figure 4-2: Multiple Cryopump Installation with 8500 Compressor

Section 5 - Operation

Before Start-up

Before beginning system operation make certain all the steps in the inspection and installation procedures have been completed and confirmed.

Operating Log

It is advisable to create and maintain an operating log. The record will assist in troubleshooting should problems arise. The log should include as a minimum the following data: the cooldown time to 20K; the roughing time to 50µ; the time to base pressure at crossover; the time between regeneration; and, the compressor pressure reading. These recorded values are useful for future performance reference.

Rough Pumping (Preliminary Vacuum Pumping)

It is not necessary to rough pump the cryopump to very low pressures. Experience has shown that a roughing pressure between 50 and 75 microns is all that is required. This pressure can be measured with a DV-6M thermocouple (TC) gauge mounted as close as possible to the roughing port.

Rate-of-Rise (ROR)

Rate of pressure rise in a newly installed cryopump is an important measure of the tightness of your installation. This is obtained by closing the roughing valve (see Figure 3-3) when the pressure has reached 50-75 microns. Observe the rate of pressure rise over the five-minute period. A rise of less than 10 microns/ minute over a five-minute period (50 microns total) is an indication of the integrity and cleanliness of the cryopump. If the total ROR is greater than 50 microns, repurge the cryopump, check for evidence of leaks, and repeat the roughing cycle and ROR.

NOTE: *Such a procedure may be adapted to quickly check the integrity/ cleanliness of your process chamber.*

Start-up and Cooldown

1. Before start-up confirm the following:
   a. That the Hi-Vac valve to your vacuum chamber is closed.
   b. That the pressure in your cryopump is approximately 100 microns.
2. Turn on the system power ON/OFF switch on the controller/compressor.
3. Note the helium pressure and temperature reading during the initial cooldown. Typical values during cooldown are given in Table 5-1. If the cryopump has not achieved a second stage temperature of 20K or less in the time specified in Table 5-1 with the Hi-Vac valve closed, refer to the **Appendix B - Troubleshooting the Cryopump**.
4. When the cooldown temperature of 20K or less is reached, the cryopump is ready for normal vacuum operation. An additional 30 minutes will often permit the cryopump to reach "bottom-out" temperature.
5. Record the time that was required to reach 20K in your log; also record the compressor return gas pressure at 20K. This value can be useful for future evaluation of cryopump performance.

Table 5-1: Typical Pressure Variations During Cooldown and Normal Operation (All Values Nominal)

Cryopump Model (Qty. Used)	Compressor Model (Controller) Model	Time	Nominal Helium Pressure Psig (kPa)*	Temperature Indicator Reading (k)	H_2V_P Reading (Psia)
CT-100 (1)	8200	Before start-up ***120 mins. after start-up***	250 (1725) 275 (1895)	300 10-20	--- 20
CT-7 (1)	8200	Before start-up ***90 mins. after start-up***	250 (1725) 275 (1895)	300 10-20	--- 20
CT-8 or CT-8F	8200	Before start-up ***90 mins. after start-up***	250 (1725) 280 (1930)	300 10-20	--- 20
Multiple CT-100	8500	Before start-up ***120 mins.***	200 (1380) 65 (450)	300 20	--- 20
Multiple CT-8/CT-8F	8500	Before start-up ***120 mins.***	200 (1380) 95 (655)	300 10-20	--- 20

*Center point of needle swing.

Normal Operation

The Cryo-Torr High-Vacuum pump system is designed to operate without operator assistance.

As an aid to evaluating performance it may be advantageous to record basic parameters at a regularly scheduled period. An ideal time is to coordinate this practice with other maintenance items or whenever regeneration is required. On new systems record this data at least on a monthly basis.

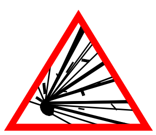
Cryopump Oxygen Procedures

WARNING

Combustion supported by oxygen in the pump could cause severe injury. When oxygen is used as a process gas, special precautions should be taken.

When using oxygen as a process gas, it is strongly recommended that as a minimum, the following precautions be taken.

1. Follow all cryopump operating instructions including:
   - Insure that there are no sources of ignition (e.g., hot filament vacuum gauges) on the cryopump side of the Hi-Vac valve operating during the warming or venting of the pump.
   - Perform inert gas purge regenerations at flow rates recommended for cryopumps.
2. Regenerate as frequently as practical to minimize the amount of oxidizer present in the cryopump.
3. Provide proper and appropriate venting for the cryopump relief valve to vent exhaust gases.
4. Any system exposed to richer-than-air oxygen levels should be prepared for oxygen service per the manufacturer's recommendations, including use of oxygen service lubricating oils in roughing pumps.



WARNING

Explosion occurring from ozone in the pump could cause severe injury. Ozone can be present as a by-product of oxygen processes. If ozone is present, special precautions described in the text below must be taken.

Ozone may be unknowingly produced in an ionizing process (e.g., sputtering, etching, glow discharge). Explosive conditions may exist if ozone is present, especially during warming of the cryopump. Signs of ozone's presence are:

1. Crackling/popping sounds (as in electrical arcing) occurring within the first few minutes of regeneration.
2. Gas venting from the cryopump during regeneration may have a pungent smell, similar to that present in an arc welding operation or after an electrical storm.

NOTE: *A change in process may increase the amount of ozone present.*

If ozone is present, the following precautions must be taken, in addition to those already mentioned.

1. The required regeneration frequency should be increased depending upon flow and process conditions. Daily regeneration may be required. (Call CTI-CRYOGENICS for assistance.)

2. Reduce the oxygen mixture to the absolute lowest level the process will allow.
3. Be sure that the system is properly vented to a scrubber or to a safe area preferably outdoors.

Determining Crossover Pressure

Crossover is that point in time when the pumping of a vacuum chamber is switched from "rough" pumping to "high-vacuum" pumping. Rough pumping brings the vacuum chamber pressure from one atmosphere (760 torr) down to a pressure of about 0.5 torr. At crossover the roughing valve is closed and the high-vacuum valve opened bringing the vacuum chamber down to a pressure typically less than 10^{-6} torr. This momentary "pulse" of gas and water molecules is cryo-condensed on the arrays of the cryopump.

To determine the maximum permissible CROSSOVER PRESSURE (CP) perform the following calculation using the CROSSOVER VALUES (CV) for your Model cryopump shown in the table below and the actual VOLUME OF YOUR CHAMBER (VC).

Table 5-2: Crossover Values (CV)

Cryo-Torr	Torr-Liters
CT-100	40
CT-7	50
CT-8	150
CT-8F	150

Example: (For CT-8/8F)
(Volume of chamber = 100 liters)

$$CP = \frac{CROSSOVER\ VALUE}{VOLUME\ OF\ CHAMBER} = \frac{CV}{VC}$$

$$\text{CP} = \frac{\text{150 torr-liters}}{\text{100 liters}} = \text{1.5 torr}$$

NOTE: *The calculated crossover pressure may not be optimized for your system. To help prevent any backstreaming during the roughing of the vacuum chamber, you should stop roughing at as high a pressure as possible. The optimum crossover pressure for a vacuum chamber should cause a very slight rise in temperature with a rapid recovery. Increase the roughing pressure in small increments (15 to 20%) until this rise in temperature is noted; then drop the value by a small amount (10%), this will be the optimum pressure for that vacuum chamber.*

Determining Cryopump Capacity for Condensable Gases

Cryopump capacity is defined as the total standard liters of a gas that can be accommodated within a cryopump prior to regeneration. The number of hours between regeneration cycles can be easily calculated in the case of a continuous gas flow of a known gas species:

$$A = \frac{16.6 \times C}{B}$$

A = Duration of operation with a continuous gas flow (hours)
B = Gas flow (scc/min.)
C = Cryo-Torr capacity for the particular gas species being flowed (std liters); refer to the following Table.

Table 5-3: Condensable Gases Capacity (Argon, Nitrogen, Oxygen, Etc.)

Cryopump	Standard Liters	Torr-Liters
CT-100	90	68,400
CT-7	350	266,000
CT-8	1,000	760,000
CT-8F	1,000	760,000

Example: (For CT-8/8F)

For a sputtering application of continuously flowing argon gas at 70 scc/min., the duration of continuous operation with this gas flow (between regenerations) would be:

$$A = \frac{16.6 \times 1{,}000 \text{ (std liters)}}{70 \text{ (scc/min.)}} = 237 \text{ hours}$$

Determining the Number of Crossover Cycles

The number of crossover cycles between regenerations can also be easily calculated when the crossover pressure and vacuum chamber volume are known:

$$N = \frac{760{,}000 \text{ torr liters}}{P \times V}$$

N = *Number of crossover cycles*
V = *Volume of vacuum chamber (liters)*
P = *Pressure of vacuum chamber prior to crossover (torr) (roughing pressure)*

Example:

$$\mathrm{N} = \frac{760{,}000 \text{ torr liters}}{1.5 \text{ (torr)} \times 100 \text{ (liters)}} = 5{,}060 \text{ cycles}$$

Cryopump Shutdown Procedures

Typically a cryopump can be left in operation continuously if you are not processing or not using the vacuum chamber, by simply closing the Hi-Vac valve to isolate the cryopump from your vacuum chamber. You are now able to load, unload, repair or replace components in the chamber and the cryopump will be available for restart of the process as necessary.

If you are planning to shut down the cryopump it is recommended that the cryopump be shut off and a gas purge be initiated and continued until the cryopump has reached room temperature. At this point it can be held under positive pressure, and rough pumped prior to start-up.

Cryopump Storage

If the cryopump is stored while still attached to your vacuum system, the cryopump vacuum vessel should be kept at slight positive atmospheric pressure with dry nitrogen or argon.

If the cryopump is removed from your vacuum system, install the protective cover on the mounting flange of the cryopump vacuum vessel inlet before storage.

The remaining components of your Cryo-Torr high-vacuum pump systems are fully protected during storage if kept under positive helium pressure and all component connections left connected. Periodically check the helium supply pressure gauge on the compressor. If the gauge reads below 245 psig (1690 kPa) for 8200/8300 or below 195 psig (1345) for 8500, add helium as described in **Section 7 - Adding Helium Gas**.

Hazardous Materials

WARNING

If the cryopump has been used to pump toxic or dangerous materials, you must take adequate precautions to safeguard personnel. If such a cryopump is shipped to a Product Service Department, clearly mark on all storage cartons the identity of the toxic or dangerous materials to which the cryopump has been subjected. All shipped equipment that contains hazardous/toxic materials must conform to DOT regulations.

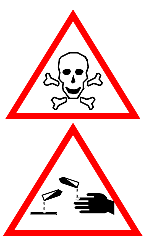
Section 6 - Regeneration

Introduction

The cryopump periodically requires regeneration to return it to its original operating capabilities.

Gases captured from a vacuum chamber and trapped in the cryopump through condensation and cryo-adsorption are held primarily in an ice-like form. Regeneration removes trapped gases through a process similar to defrosting a refrigerator freezer compartment.

During regeneration the cryopump is warmed to room temperature or higher, allowing trapped gases to change from a solid state to a gaseous state and are thereby released from the cryopump through the pressure relief valve to the atmosphere.



WARNING

Toxic, corrosive, or flammable gases must be safely vented to prevent harm to personnel and to avoid equipment damage. If a large amount of oxygen has been cryopumped, refer to **Section 5 - Cryopump Oxygen Procedures.**

When to Regenerate

The need to regenerate the Cryo-Torr high-vacuum pump as a result of saturation is a function of the cryopump capacity and the process gas throughput.

If the cryopump becomes incapable of maintaining a high-vacuum (typically an increase in your vacuum chamber base pressure by a factor greater than 10, even though the cold head and compressor unit are operating satisfactorily), the cryopump requires regeneration.

It is recommended that your cryopump be regenerated on a regular schedule coinciding with system maintenance, weekend system shutdown, etc. A suitable time interval between regenerations can be determined by experience.

Data aiding calculation of gas saturation levels may be obtained in **Section 5 - Determining Cryopump Capacity for Condensable Gases**. Extended loss of electrical power (10 minutes or longer), system vacuum failure, such as venting with a partially open vacuum isolation valve, and operator error may necessitate cryopump regeneration.

NOTE: *Short term electrical outages of up to 10 minutes should not result in the need to regenerate your cryopump.*

Assisted Regeneration

Regeneration incorporating the use of heated dry inert purge gas (nitrogen/argon) is the preferred method of regeneration and will overcome the unassisted regeneration technical difficulties by:

1. Minimizing the required time to bring the condensing and cryo-adsorbing arrays to room temperature.
2. Reducing the time required to rough the cryopump because the dry inert purge gas will minimize the amount of residual water vapor in the 15K array.
3. Diluting hazardous gases and ensuring their removal from the cryopump housing.

Table 6-1: Required Accessories for Assisted Regeneration

Description	Part Number
Purge gas heater	8080250K020
Purge gas solenoid valve	8080250K023

To accomplish assisted regeneration with heated dry purge gas:

1. Close the Hi-Vac isolation valve.
2. Shut off the cryopump using the system power ON/OFF switch on the controller or the compressor.
3. ***Immediately*** introduce heated dry purge gas through the vacuum vessel purge fitting at approximately 150°F (66°C) and at a flow rate of 1-2 cfm. Allow the purge gas to vent through the "poppet" relief valve.
4. Halt the gas purge when the condensing arrays reach 80°F (26°C) (300k).

5. When the condensing arrays reach ambient temperature, rough the cryopump to an initial starting pressure, usually between 50 and 100 microns. After roughing, you can perform a simple check 1) to ensure that your cryopump regeneration has been thorough, and 2) that no air-to-vacuum leaks are present. The check is called a "rate-of-rise" (ROR).

   Upon completion of your roughing cycle (to 50 or 100 microns), close the roughing valve and observe the "rate of pressure rise" (ROR) over a five-minute period. The ROR should be less than 10 microns/minute over a five-minute period (50 microns total). If the ROR is greater than 50 microns, repurge the cryopump, check for evidence of leaks, and repeat the roughing cycle and ROR.
6. Close the cryopump roughing valve and start the cryopump.
7. The cryopump is ready for use when the second stage array reaches a temperature of 20K or lower.

Section 7 - Maintenance Procedures

Scheduled Maintenance

The only scheduled maintenance required on the Cryo-Torr High-Vacuum System is periodic replacement of the compressor adsorber per the following schedule:

Table 7-1: Adsorber Replacement Information

Compressor	Adsorber P/N	Replacement Interval (Years)
8200	8080255K001	1
8500	8080275K001	3

Refer to the appropriate compressor manual for the procedures for removing and replacing the adsorber.

Unscheduled Maintenance

There are several maintenance items that may arise on an unplanned basis. These items generally do not occur frequently but when they do, some specialized procedures are necessary. They are as follows and are listed in their general order of frequency of occurrence.

1. Cleaning or replacing the cryopump arrays.
2. Adding helium gas.
3. Decontaminating the helium circuit.

Suggested Maintenance Equipment

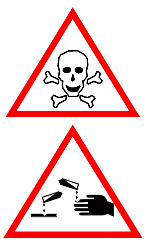
It is advisable to have available the equipment and disposable supplies listed below.

1. Helium, 99.999% pure
2. Indium gasket 0.005-inch thick, 3" x 3" sheet, P/N 3543738P001
3. Maintenance manifold, P/N 8080250K003*
4. Pressure regulator (0-3000/0-400 psig)

5. Helium charging line terminating in a 1/4-inch female flare fitting (P/N 7021002P001)
6. Installation Tool Kit, P/N 8140000K001. Supplied with Cryo-Torr High-Vacuum Pump
7. Lint-free gloves and cloth
8. Oakite or equivalent detergent soap
9. Denatured alcohol
10. Apiezon™ vacuum grease, P/N 579847*
11. Torque wrench, 0 to 30 inch-pounds

*Available from stock; consult the factory or your sales representative.

Cleaning the Cryopump



WARNING

If the cryopump has been used to pump toxic or dangerous materials, you must take adequate precautions to safeguard personnel.

The arrays or other interior surfaces of the cryopump vacuum vessel seldom require cleaning because dust buildup does not affect performance, and the special alloy copper cryo-condensing arrays are nickel plated for corrosion resistance. Cryopump performance in most cases can be recovered by regeneration. In case of a system malfunction, (i.e., backstreaming of a rough pump oil or "dumping" of a process chamber) saturation or contamination of the 15K cryo-adsorbing array (charcoal) may require more than regeneration. The charcoal array, if not severely contaminated, may be recovered by following the vacuum baking procedures in this section.

If you wish to clean the arrays and other interior surfaces, follow the procedures below. Refer to **Appendix C - Illustrated Parts Breakdown**, while performing these disassembly and reassembly procedures.

1. Confirm that an adequate supply of indium gasket material, P/N 3543738P001, is available.
2. Carefully disassemble the components in the vacuum vessel.

3. Clean the components as follows:

CAUTION

Do not clean the 15K cryo-adsorbing array (charcoal) because you will contaminate it in the cleaning process. Use the vacuum baking procedure to recover a 15K cryo-adsorbing array that is not severely contaminated.

   a. Wash each item in strong soap or detergent solution and hot water.
   b. Rinse the items in *clean, hot water.*
   c. Air or oven dry at 150°F (66°C) maximum.

4. To clean a 15K cryo-adsorbing array (charcoal) that is not severely contaminated by oil backstreaming or dust particles covering its surfaces, vacuum bake it at a temperature of 150°F (66°C) for at least 2 hours.

NOTE: *It is good practice to perform this vacuum baking procedure on the 15K array on a regular basis to insure continued efficient cryopump operation.*

5. If the 15K cryo-adsorbing array does not require vacuum baking, the array surfaces may be dusted using a lint-free cloth lightly moistened with denatured alcohol. Allow the array to air dry before assembly.
6. Wearing lint-free gloves, reassemble the cryopump. Replace any indium gasket damaged during disassembly.
7. Hold the torque on all screws that compress indium gaskets for a minimum of 5 seconds to allow proper gasket seating.

Table 7-2: Indium Gasket Mounting Screw Torque Information

Screw Thread	Torque (Inch-Pounds)
No. 4-40	11
No. 6-32	20
No. 10-32	30

Adding Helium Gas

CAUTION

If the compressor helium pressure gauge reads less than 30, decontamination is required. Refer to **Decontamination Procedures** in this section.

There are two conditions that require the addition of helium gas:

1. Compressor not operating; helium pressure gauge reads 245 psig (1690 kPa), or below.
2. Compressor operating; helium pressure reads below that specified in Table 7-3.

Table 7-3: Typical Pressure During Normal Operation (CT-100, 7, 8 and 8F)

Cryopump (No. Used)	Helium Pressure Psig (kPa)*	
	8200 Compressor	8500 Compressor
CT-100 (1) CT-100 (2)	275 (1895) ---	--- 65 (450)
CT-7 (1)	275 (1895)	65 (450)
CT-8 (1) CT-8F (1)	280 (1930)	90 (620)

*Center point of needle swing.

If you need to add helium more than once every 6 months, check for leaks caused by improperly connected self-sealing connections on interconnecting components or any mechanical joint within the compressor.

A User-supplied helium charging line terminating in a 1/4-inch female flare fitting, and a two-stage pressure regulator rated at 0-3000/0-400 psig is required for this operation.

Use only 99.999% pure helium gas.

To add helium gas:

1. Attach a two-stage regulator (0-3000/0-400 psig) and charging line to a helium bottle (99.999% pure). DO NOT OPEN THE BOTTLE AT THIS TIME. Purge the regulator and charging lines as instructed in steps a through d below. Do *not* use helium gas that is *less than 99.999% pure*.
   a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm, then turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.
   b. Slowly open the bottle valve, and purge the regulator and line for 10 to 15 seconds. Turn the regulator knob counter-clockwise until the helium stops flowing.
   c. Loosely connect the charge line to the helium pressure regulator.
   d. Purge the charge line again, as in step a, for 30 seconds, and tighten the charge line flare fitting onto the helium pressure regulator while the helium is flowing.

This procedure is required to ensure that both the regulator and the charging line will be purged of air and that the air trapped in the regulator will not diffuse back into the helium bottle. For best results, CTI-CRYOGENICS suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.

2. Remove the flare cap of the gas charge fitting on the rear of the compressor.
3. Attach the charging line from the helium pressure regulator to the 1/4-inch male flare fitting installed on the helium charge valve.
4. Set the helium pressure regulator to 300 psig (2070 kPa). Depending on the compressor operating state, add helium gas:
   a. If the compressor is running under normal operating conditions, slowly open the helium charge valve on the rear of the compressor. When the helium pressure gauge rises to that specified in the Table above, tightly close the charge valve.
   b. If the compressor is not running, slowly open the helium charge valve. When the helium pressure gauge rises to 245-250 psig (1690-1725 kPa), tightly close the charge valve.

5. Ensure that the helium charge valve on the compressor is tightly closed. Shut off the helium pressure regulator on the helium bottle and remove the charging line from the male flare fitting. Reinstall the flare cap.

Helium Circuit Decontamination

Contamination of the helium-gas circuit is indicated by sluggish or intermittent operation (ratchetting) of the cold head drive mechanism. With severe contamination the cold head drive may seize and fail to operate. One of the major sources of contamination is using helium gas of less than the required purity. When performing the decontamination process, use only 99.999% pure-helium gas, and the regulator and charging line must be properly connected and purged.

This decontamination procedure will remove contaminants from the cold head and/or compressor, thereby restoring system performance. The cold-trapping of contaminants inside the cold head during this procedure also decontaminates the compressor if the contamination is not severe. (Separate decontamination of the compressor is required whenever the compressor has been opened to atmosphere, or the pressure dropped to zero.)

Cryopump Decontamination Procedures

1. Cool down the cryopump and operate it for one to three hours. (If the system will not cool down, proceed to step 2.) Operating the cryopump will isolate the contaminants by coldtrapping them in the cold head. The longer the cryopump is operated beyond the one-hour period, the greater is the amount of contamination that becomes isolated inside the cold head.
2. Shut down the cryopump per **Section 5 - Cryopump Shutdown Procedures**.
3. *Immediately* disconnect the helium-gas supply and helium-gas return lines from the gas-supply and gas-return connectors at the rear of the compressor. Leave them attached to the cold head.
4. Attach the maintenance manifold (P/N 8080250K003) to the disconnected ends of the helium-gas return and helium-gas supply lines.
5. Reduce the pressure in the cold head to a level of 45 psig by using the maintenance manifold.
6. Allow the second stage of the cold head to warm up to room temperature. Warm-up time can be reduced by purging the cryopump with warm dry argon or nitrogen gas. Using the gas heater,

CTI-CRYOGENICS P/N 8080250K020, will reduce warm-up time about 50 percent, and will maintain the gas temperature below the 150°F (66°C) limit.

7. Once the cryopump has reached room temperature, attach a two-stage regulator (0-3000/0-400 psig) and charging line to a helium bottle (99.999% pure). DO NOT OPEN THE BOTTLE AT THIS TIME. Purge the regulator and charging lines as instructed in steps a through d below. Do *not* use helium gas that is *less than 99.999% pure.*

    a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm; then turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.

    b. Slowly open the bottle valve, and purge the regulator and line for 10 to 15 seconds. Turn the regulator knob counter-clockwise until the helium stops flowing.

    c. Loosely connect the charge line to the 1/8-inch valve on the maintenance manifold.

    d. Purge the charge line again, as in step a, for 30 seconds, and tighten the charge line flare fitting onto the valve while the helium is flowing.

This procedure is required to ensure that both the regulator and the charging line will be purged of air. For best results, CTI-CRYOGENICS suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.

8. Perform in sequence:

    a. Backfill the cold head with helium to a static charge pressure of 245-250 psig (1690-1725 kPa), by adjusting the regulator to the required pressure, and opening the valve on the manifold. Close the valve when the pressure is correct.

    b. Depressurize the cold head by *slowly* opening the ball valve and allowing the helium to bleed out slowly. Do *not* reduce the pressure to *less than* 30 psig or the cold head may be further contaminated.

    c. Perform flushing steps a and b three more times.

    d. Pressurize the cold head to the static charge pressure of 245-250 psig (1690-1725 kPa) and run the cold head drive motor for 10 to 30 seconds by actuating the controller ON/OFF switch.

e. Perform steps b through d three more times for a total of 20 flushes and a total of 4 drive-motor runs.

9. Verify that the cold head is pressurized to the static charge pressure of 245-250 psig (1690-1725 kPa).
10. Disconnect the maintenance manifold from the helium-gas return and helium-gas supply lines.
11. Reconnect the helium-gas return and helium-gas supply lines to the return and supply connectors at the rear of the compressor. The cryopump is now ready for operation.

Compressor Decontamination Procedures

The procedure to decontaminate a compressor is similar to the above procedure with certain exceptions.

- There is no need to operate the cryopump before decontaminating the compressor.
- The maintenance manifold and flex lines will be connected to the supply and return fittings on the compressor.

1. Depressurize the compressor (if pressurized) SLOWLY to 30 psig by opening the ball valve on the maintenance manifold and allowing the helium to bleed out.
2. Charge the compressor slowly to approximately 250 psig (1725 kPa) by opening the 1/8-inch valve on the maintenance manifold.
3. Run the compressor for about 30 seconds.
4. Repeat steps 1 and 2, one more time.
5. Disconnect the maintenance manifold from the helium-gas return and helium-gas supply lines.
6. Reconnect the helium-gas return and helium-gas supply lines to the return and supply connectors on the cold head. The compressor is now ready for operation.

NOTE: *After connecting the compressor to the cryopump, and operating the system for a period of time, it may be necessary to decontaminate the cryopump as some residual contamination from the compressor may become trapped in the cold head. If the entire system were reduced to zero psig (a broken flex line for example), then the cryopump and compressor would have to be decontaminated according* ***Decontamination Procedures*** *in this section.*

Appendix A - Customer Support Centers

Introduction

Refer to Table A-1 for the nearest Customer Support Center for technical assistance or service. North American customers may call 1-800-FOR-GUTS (1-800-367-4887) 24 hours a day, seven days a week. All other customers must call their local Customer Support Center.

Please have the following information available when calling so that we may assist you:

- Product Part Number
- Product Serial Number
- Product Application
- Specific Problem Area
- Hours of Operation
- Equipment Type
- Vacuum System Brand/Model/Date of Manufacture

Table A-1: Customer Support Center Locations

United States and Canada Helix Technology Mansfield Corporate Center Nine Hampshire Street Mansfield, Massachusetts 02048, U.S.A. Tel: 508-337-5000 Tel: 800-379-7224 (within USA) Fax: 508-337-5169 Dial 1-800-FOR-GUTS (1-800-367-4887) 24 hours a day, seven days a week.	**United States and Canada** Helix Technology 3350 Montgomery Drive Santa Clara, CA 95054, U.S.A. Tel: 562-592-5940 Tel: 800-379-7224 (within USA) Fax: 408-988-6630 Dial 1-800-FOR-GUTS (1-800-367-4887) 24 hours a day, seven days a week.
United States and Canada Helix Technology 4120 Freidrich Lane, Suite 600 Austin, TX 78744, U.S.A. Tel: 512-912-2800 Tel: 800-324-6445 (within USA) Fax: 512-912-2888 Dial 1-800-FOR-GUTS (1-800-367-4887) 24 hours a day, seven days a week.	**Germany** Helix Technology Haasstrasse 15 D-64293 Darmstadt Germany Tel: 49-6151-959-55 Fax: 49-6151-959-57
France Helix Technology Domaine Technologique de Saclay 4, rue Rene Razel, Bat Apollo F-91892 Orsay Cedex France Tel: 331-6935-2600 Fax: 331-6985-3725	**United Kingdom** Helix Technology Fleming Road Kirkton Campus Livingston, West Lothian Scotland EH54 7BN Tel: 441-506-460017 Fax: 441-506-411122

Table A-1: Customer Support Center Locations (Continued)

Japan Helix Technology K.K. Queens Tower A 14F 3-1, Minatomirai 2-chome Nishi-ku, Yokohama 220-6014 Japan Tel: 81-45-682-5470 Fax: 81-45-682-5475	**Korea** Helix Technology Zeus Company, Ltd. Zeus Building 3-16, Yangjae-Dong, Sochu-Ku Seoul, 137-130 South Korea Tel: 82-2-577-3181 Tel: 82-2-577-3186 Fax: 82-2-576-3199
Taiwan, Hong Kong, and China Helix Technology Challentech International Corporation No. 1, Lane 9, Pateh Road Hsin-Chu 300, Taiwan, R.O.C. Tel: 886-35-614211 Fax: 886-35-614210	**Australia, New Zealand, and Tasmania** Helix Technology AVT Services Pte. Ltd Unit 1, 12 Pioneer Avenue Thornleigh NSW 2120 Sydney, Australia Tel: 612-9-4810748 Fax: 612-9-4810910
Singapore, Malaysia, Philippines, and Indonesia Helix Technology APP Systems Services Pte Ltd.. 2 Corporation Road #06-14 Corporation Place Singapore 2261 Tel: 65-268-2024 Fax: 65-268-6621	

Appendix B - Troubleshooting

Troubleshooting Techniques

The primary indication of trouble in a vacuum pumping system is a rise in the base pressure of your vacuum chamber. A rise in the base pressure may be caused by a leak in the vacuum system or by a fault in the cryopump i.e., saturation of the 15K cryo-adsorbing charcoal array (regeneration may be necessary). If the cryopump temperature is below 20K it must pump at rated capacity; a high base pressure is usually caused by an air-to-vacuum leak in the system.

If you suspect a leak in your vacuum system, isolate the cryopump by closing the Hi-Vac valve and leak check your vacuum chamber. If no leaks are found, a leak may be present below the Hi-Vac valve (cryopump). Leak checking below the Hi-Vac valve should be performed with the cryopump shut off and at room temperature. Leak checking while the cryopump is operating may mask leaks that are present (due to the ability of the cryopump to pump helium). If no leak is found, refer to the cryopump troubleshooting procedures summarized in Table B-1.

The problems presented in the Troubleshooting Table are followed by possible causes and corrective actions. The causes and corresponding actions are listed in their order of probability of occurrence. 1) is most likely, 2) is next most likely, etc.

Maintaining a log of certain parameters during normal operation can be a valuable tool in troubleshooting the cryopump. The parameters included in the log should include as a minimum the following: the cooldown time to 20K; the roughing time to 50μ; the time to base pressure at crossover; the time between regeneration; and the compressor pressure reading.

Technical Inquiries

Please refer to **Appendix A** of this manual for a complete list of the CTI-CRYOGENICS' world wide customer support centers.

Table B-1: Troubleshooting the Cryopump

Problem	Possible Cause	Corrective Action
High base pressure of vacuum system; cryopump temperature *below* 20K.	Air-to-vacuum leak in vacuum system.	Check the following: Vacuum chamber and Hi-Vac valve for leaks. Cryopump for leaks. Cryopump relief valve for leaks.
	High partial pressure of non-condensables (helium, hydrogen, or neon) within the cryopump because the 15K array has reached full capacity.	Regenerate the cryopump.
High base pressure of vacuum system, and a cryopump temperature *above* 20K.	A leak through a roughing valve, purge valve, or other accessory.	Check all valves to insure proper seating.
	Decrease in cryopump cold head performance.	Check compressor gauge for low helium charge pressure. Add gas as necessary.
	High partial pressure of non-condensables (helium, hydrogen, or neon) within the cryopump.	Regenerate the cryopump.
	Excessive thermal load on frontal array.	Reduce the thermal radiation load by: Shielding the cryopump. Lowering the temperature of the radiating surface.

Table B-1: Troubleshooting the Cryopump (continued)

Problem	Possible Cause	Corrective Action
Cryopump fails to cool down to the required operating temperature; takes too long to reach temperature (20K).	Low helium pressure in compressor.	Check compressor gauge for low helium charge pressure. Add gas as necessary.
	Helium-gas supply/return line incorrectly attached; self-sealing couplings not fully tightened.	Check the helium-gas supply line is connected to supply connector and all self-sealing couplings are fully seated.
	Vacuum leak in vacuum system or cryopump.	Check the following: Vacuum chamber and Hi-Vac valve for leaks. Cryopump for leaks. Cryopump relief valve for leaks.
	Incomplete regeneration may not have fully cleaned the adsorbing array. High rate-of-rise.	Regenerate the cryopump.
	Compressor problems.	Refer to compressor troubleshooting procedures in Table A.1 of compressor manual.
The cryopump makes a growling noise (8200 Compressor).	Incorrect position of frequency selector switch or of the voltage selector switch.	Measure and confirm incoming voltages, also confirm correct selector switch settings as described in Section 3 (8200 Compressor Manual).

Table B-2: Basic Operating Information

Cryopump (No. Used)	Helium Pressure Psig (kPa)* (Normal Operation-Steady State)	
	8200 Compressor	8500 Compressor
CT-100 (1) CT-100 (2)**	275 (1895) ---	--- 65 (450)
CT-7 (1)	275 (1895)	65 (450)
CT-8 (1) CT-8F (1)	280 (1930)	90 (619)

*Center point of needle swing.
**Powered by 8002 Controller.

Appendix C - Illustrated Parts Breakdown

Table C-1: Legend for Figure C-1

Item No.	Part No.	Description	No. Req'd
—	—	Cryo-Torr 100 Cryopump	1
1	8080006K001	80K Condensing Array	1
2	—	Cap Screw, Hexagon Socket Type, SSTL, #4-40 x 3/8" Lg.	2
3	—	Lockwasher, Split Type, SSTL, #4	6
4	—	Washer, Flat, SSTL, #4	6
5	8080006K003	15K Condensing Array	1
6	—	Cap Screw, Hexagon Socket Type, SSTL, #4-40 x 1/2" Lg.	4
7	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	7
8	—	Lockwasher, Split Type, SSTL, #6	7
9	—	Washer, Flat, SSTL, #6	7
10	8080006K004	80K Radiation Shield	1
11	—	Screw, Flat Head, SSTL, #4-40 x 3/8" Lg.	3
12	8080006K003	15K Cryo-Adsorbing Array	2
12A	—	Temperature Sensor	1
13	—	Vacuum Vessel	1
14	—	O-Ring, #600-V1, Viton, Parker	1
15	—	Plug	1
16	—	Nut	1
17	—	Centering Ring	1
18	—	O-Ring, Alcatel	1
19	—	Flange, Blank	1
20	—	Clamp	1
21	8080250K045	Pressure Relief Valve	1
22	—	O-Ring, #2-037, Viton, Parker V337-9	1
23	8080250K010	Drive-Unit-Displacer Assembly	1
24	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
25	—	Lockwasher, Split, SSTL, #10	2
26	—	Cover	1
—	505013	Indium Sheet, 3" x 6" x 0.005" Thick	1

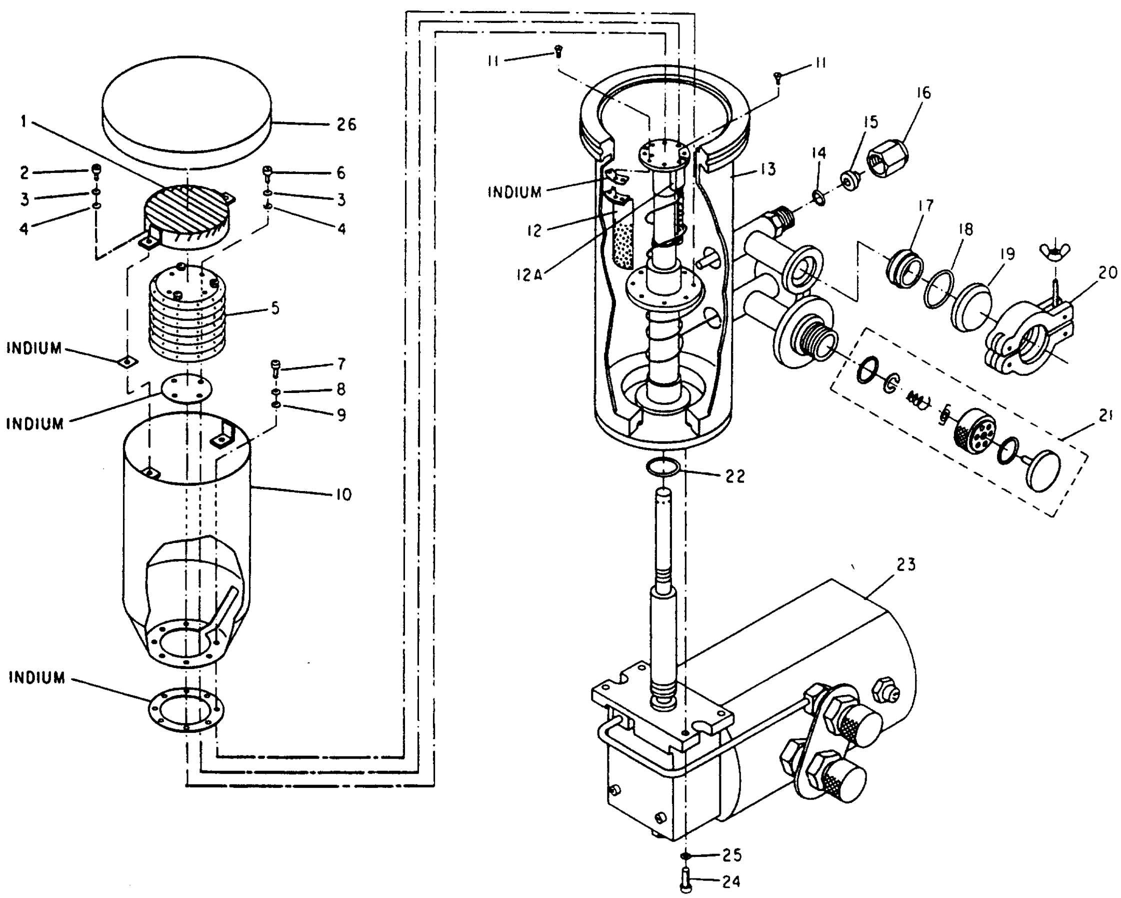


Figure C-1: Exploded View of Cryo-Torr 100 Cryopump

Table C-2: Legend for Figure C-2

Item No.	Part No.	Description	No. Req'd
—	—	Cryo-Torr 7 Cryopump	1
1	8080001K001	80K Condensing Array	1
2	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	14
3	—	Lockwasher, Split Type, SSTL, #6	22
4	—	Washer, Flat, SSTL, #6	22
5	8080001K003	15K Cryo-Adsorbing Array	1
6	—	Screw, Round Head, Brass, #4-40 x 1/2" Lg.	4
7	—	Lockwasher, Split Type, SSTL, #4	4
8	—	Washer, Flat, SSTL, #4	1
9	8080001K004	80K Radiation Shield	1
10*	8080250K006	Hydrogen-Vapor-Pressure Gauge (Optional)	1
11	—	Screw, Flat Head, Brass, #2-56 x 1/8" Lg.	1
12	8080250K045	Pressure Relief Valve	1
13	8080250K004	Accessory Port Cover	1
14	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	8
15	—	O-Ring, #2-20, Viton, Parker, 77-545	2
16	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
17	—	Lockwasher, Split, SSTL, #10	2
18	—	O-Ring, #2-037, Viton, Parker, V337-9	1
19	586441	O-Ring, #2-267, Viton, Parker, V377-9	1
20	—	Vacuum Housing	1
21	—	Cover	1
22	8042033	Diode Temperature Sensor	1
23	8044042G001	Regeneration Purge Fitting	1
24	—	O-Ring, #600-V1, Viton, Parker	1
25	—	Plug	1
26	—	Nut	1
27	—	Centering Ring	1
28	—	O-Ring, Alcatel	1
29	—	Flange, Blank	1
30	—	Clamp	1
31	8080250K010	Drive-Unit-Displacer Assembly	1
—	—	Indium Sheet, 3" x 6" x 0.005"	1

*Not shown in Figure C-2.

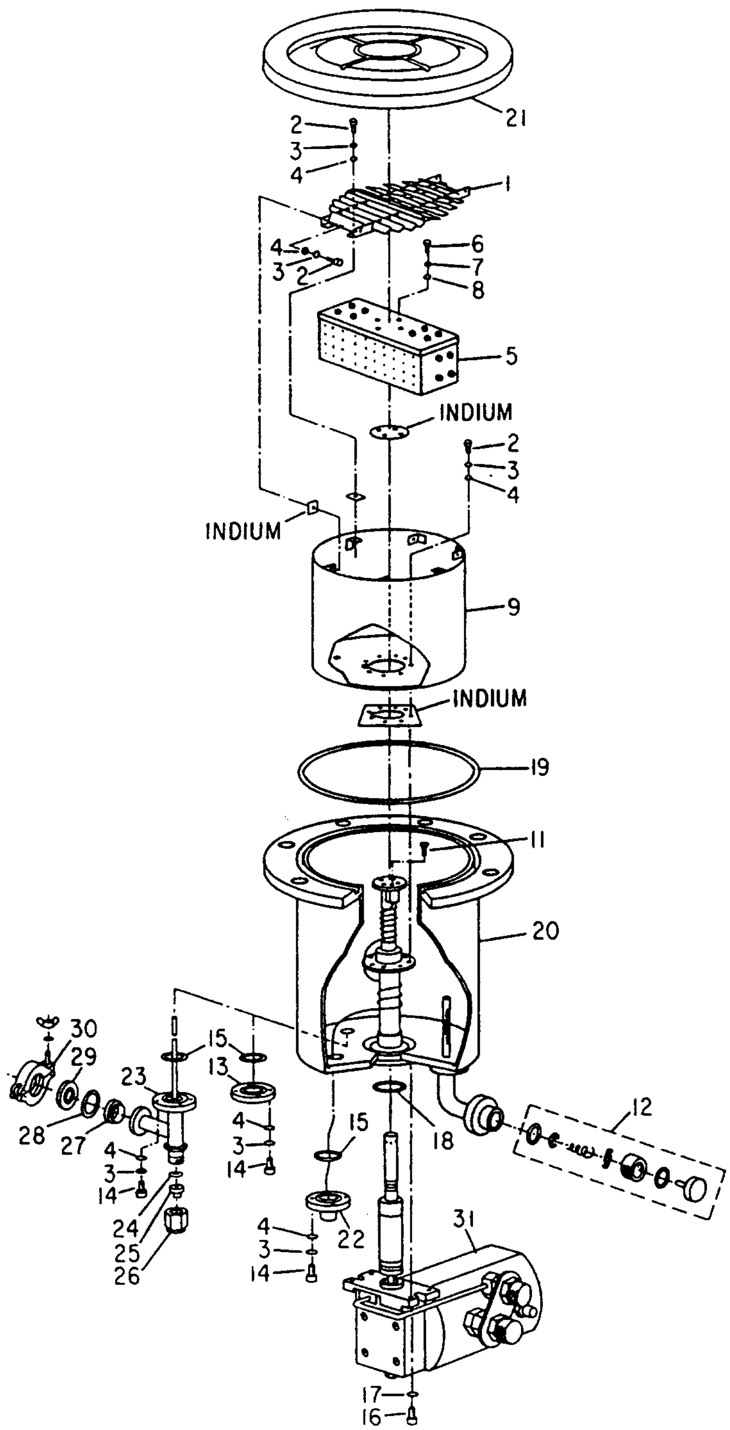


Figure C-2: Exploded View of Cryo-Torr 7 Cryopump

Table C-3: Legend for Figure C-3

Item No.	Part No.	Description	No. Req'd
—	—	Cryo-Torr 8 Cryopump	1
1	8080002K001	80K Condensing Array	1
2	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	12
3	—	Lockwasher, Split Type, SSTL, #6	22
4	8080002K010	15K Array Assembly	1
5	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	10
6	—	Washer, Flat, SSTL, #6	18
7	8080002K004	80K Radiation Shield	1
8	8080250K045	Pressure Relief Valve	1
9	—	O-Ring, #2-20, Viton, Parker V337-9	2
10*	8080250K006	Hydrogen-Vapor-Pressure Gauge	1
11	8080250K009	Diode Temperature Sensor	1
12	8044043G002	Regeneration Purge Fitting	1
13	—	Cap Screw, Hexagon Socket Type, SSTL, #2-56 x 1/2" Lg.	2
14	—	Lockwashers, Split, SSTL, #2	2
15	8080002K005	Drive-Unit-Displacer Assembly	1
16	—	O-Ring, #2-140, Buna-N, Parker N219-7	1
17	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
18	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1-1/4"	4
19	—	Lg.	1
20	586441	Protective Cover	1
21	—	O-Ring, #2-172, Viton, Parker V377-9	1
22	—	Vacuum Housing	1
23	—	O-Ring, #600-V1, Viton, Parker	1
24	—	Plug	1
25	—	Nut	1
26	—	Centering Ring w/O-Ring (Alcatel)	1
27	—	Flange, Blank	1
28	—	Clamp	1
—	—	O-Ring, #2V1-84-8A116, Cryolab	1
		Indium Sheet, 3" x 6" x 0.005" thick	

*Not shown in Figure C-3.

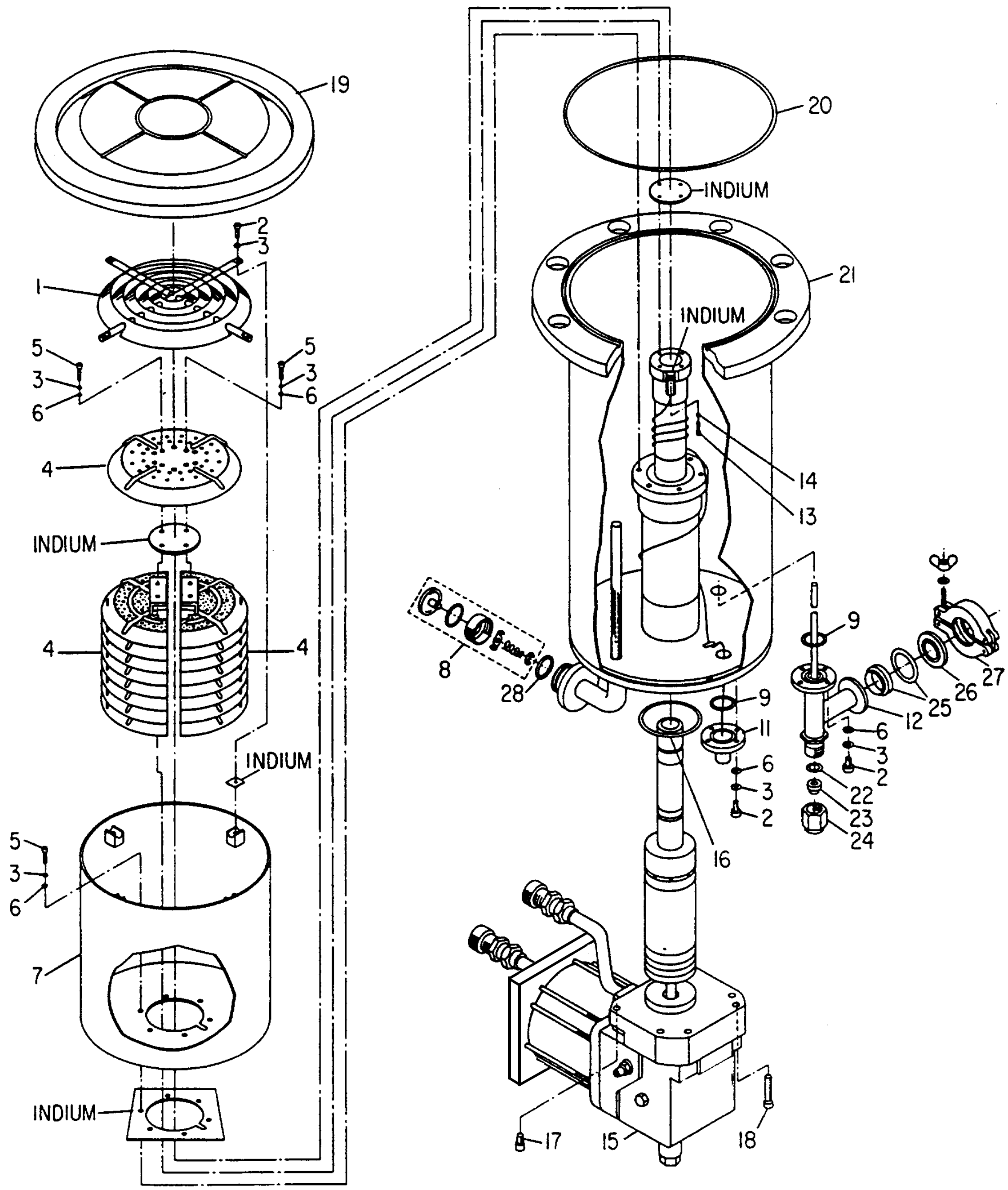


Figure C-3: Exploded View of Cryo-Torr 8 Cryopump

Table C-4: Legend for Figure C-4

Item No.	Part No.	Description	No. Req'd
—	—	Cryo-Torr 8F Cryopump	1
1	8080002K001	80K Condensing Array	1
2	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	8
3	—	Lockwasher, Split Type, SSTL, #6	18
4	—	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	10
5	—	Washer, Flat, SSTL, #6	10
6	8080007K003	15K Array Assembly	1
7	8080007K004	80K Radiation Shield	1
8	—	Vacuum Housing	1
9	—	O-Ring, V747-75, #2-157 Viton	1
10*	—	Cylinder, Refrigerator	1
11	—	O-Ring, #2-140, Buna-N, Parker N674-70	1
12	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1" Lg.	8
13	—	Lockwasher, Split Type, SSTL, #10	8
14	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1-1/4" Lg.	4
15	—	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
16	8080002K005	Drive-Unit-Displacer Assembly	1
17	8080250K045	Pressure Relief Valve	1
18	—	O-Ring	1
19	—	Connector Assembly	1
20	—	Wire, Silicon Diode (72 in. length)	1
21	—	Diode Temperature Sensor	1
22	—	Nut, Hex #4-40	1
23	—	O-Ring, V709-90, 2-020	1
24	—	Clamp	1
25	—	Flange, Blank	1
26	—	Centering Ring with O-Ring	1
27	—	Nut	1
28	—	Plug	1
29	—	O-Ring, #6Q0-V1, Viton, Parker	1
30	—	Protective Cover	1
—	—	Indium Sheet, 3" x 6" x 0.005" thick	1
—	8080250K012	Temperature Sensor Replacement Kit, consisting of:	1
—	—	Wire, Silicon Diode (Item No. 20)	1
—	—	Diode Temperature Sensor (Item No. 21)	1

*Not shown in Figure C-2.

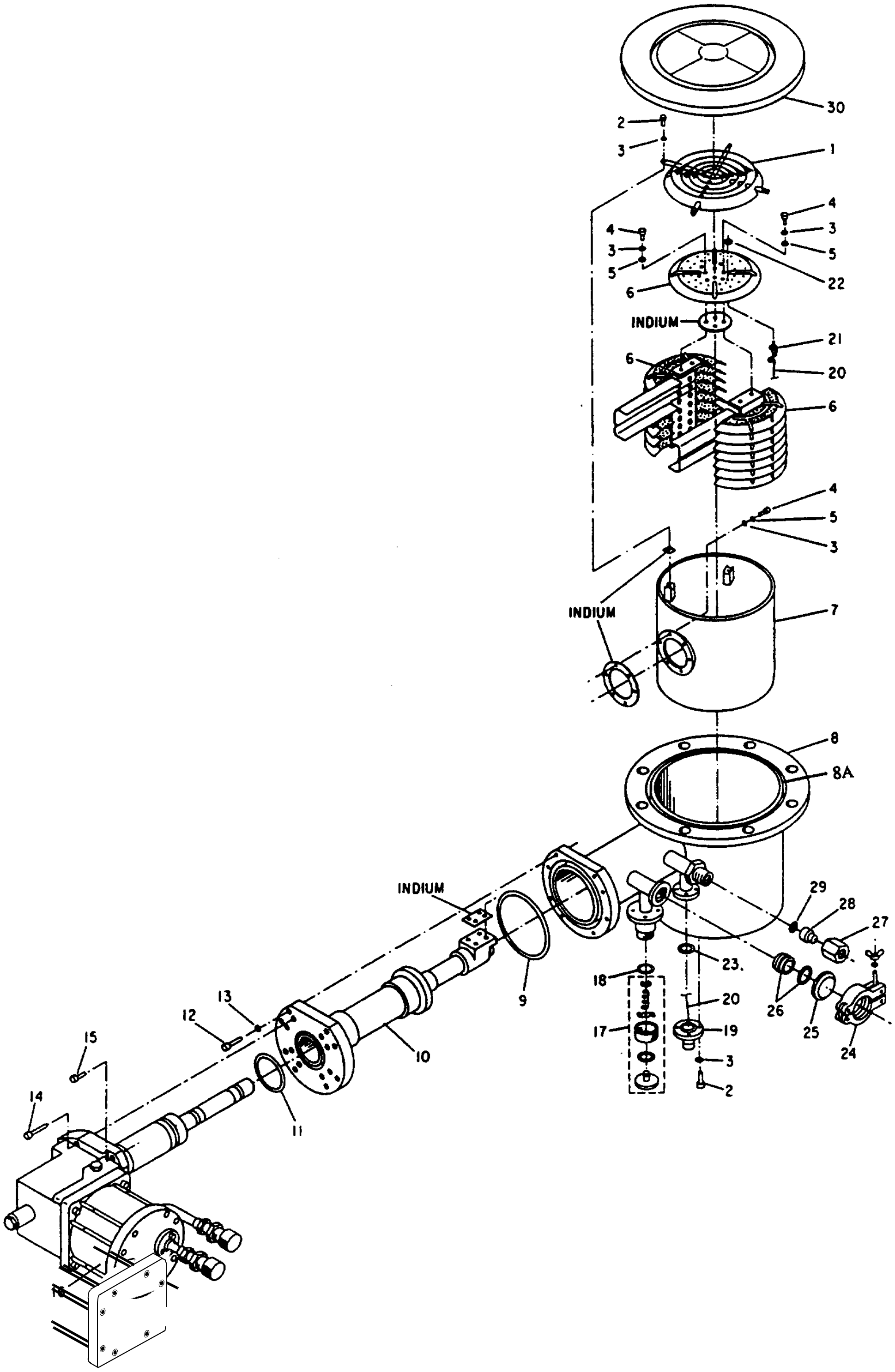


Figure C-4: Exploded View of Cryo-Torr 8F Cryopump

Appendix D - Accessories List for Cryo-Torr High-Vacuum Pumps

Table D-1: Accessory Part Numbers and Description

Part Number	Description
8042001G003	Remote Temperature Indicator (115V, 60 Hz) with Dual Setpoints
8042001G004	Remote Temperature Indicator (208V, 50 Hz) with Dual Setpoints
8044001G001	Automatic Regeneration Controller (115V, 60 Hz)
8044001G002	Automatic Regeneration Controller (208/230V, 60 Hz)
8080250K003	Maintenance Manifold
8080250K020	Purge Gas Heater (110V, 50/60 Hz)
8080250K022	Roughing Valve (110V, 50/60 Hz)
8080250K023	Purge Valve (110V, 50/60 Hz)
8080250K036	Purge Gas Heater (230V, 50/60 Hz)
8080250K037	Rouging Valve (230V, 50/60 Hz)
8080250K017	Purge Valve (230V, 50/60 Hz)

Appendix E - Conversion of Hydrogen-Vapor-Pressure Gauge Readings to Temperature

Use the data given below to convert a reading of the optional hydrogen-vapor-pressure gauge (in psia) to the temperature of the second-stage cold station (in degrees Kelvin). The hydrogen-vapor-pressure gauge should notbe used to measure temperatures higher than 26K.

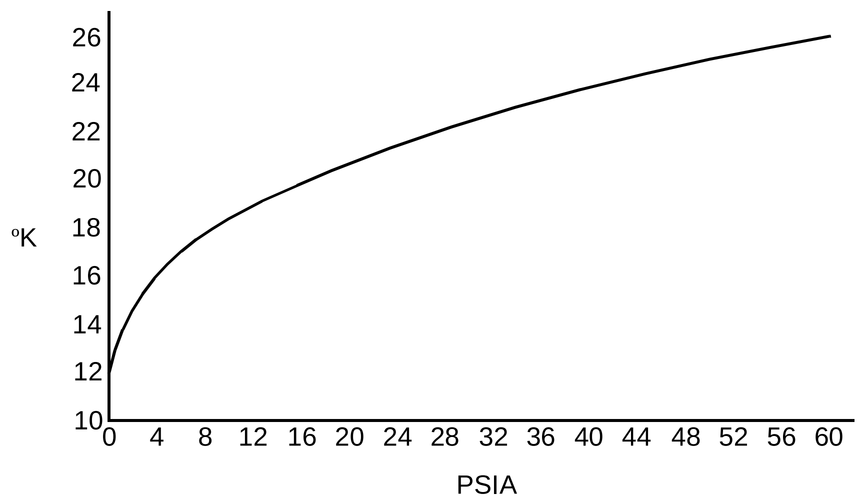


Figure E-1: Temperature versus Hydrogen-Vapor-Pressure

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Table E-1: Hydrogen-Vapor-Pressure versus Temperature

PSIA	K
0	Less than12
1	13.9
2	15.2
3	16.0
4	16.7
5	17.2
6	17.7
7	18.1
8	18.5
10	19.2
12	19.7
15	20.5
18	21.1
21	21.7
24	22.2
27	22.6
30	23.1
35	23.7
40	24.3
45	24.8
50	25.3
55	25.8

CTI-CRYOGENICS
HELIX TECHNOLOGY CORPORATION

8200 Compressor

Installation, Operation and Service Instructions

8040353
Rev. 101 (11/2001)

HELIX TECHNOLOGY CORPORATION
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Section 1 - Introduction

General

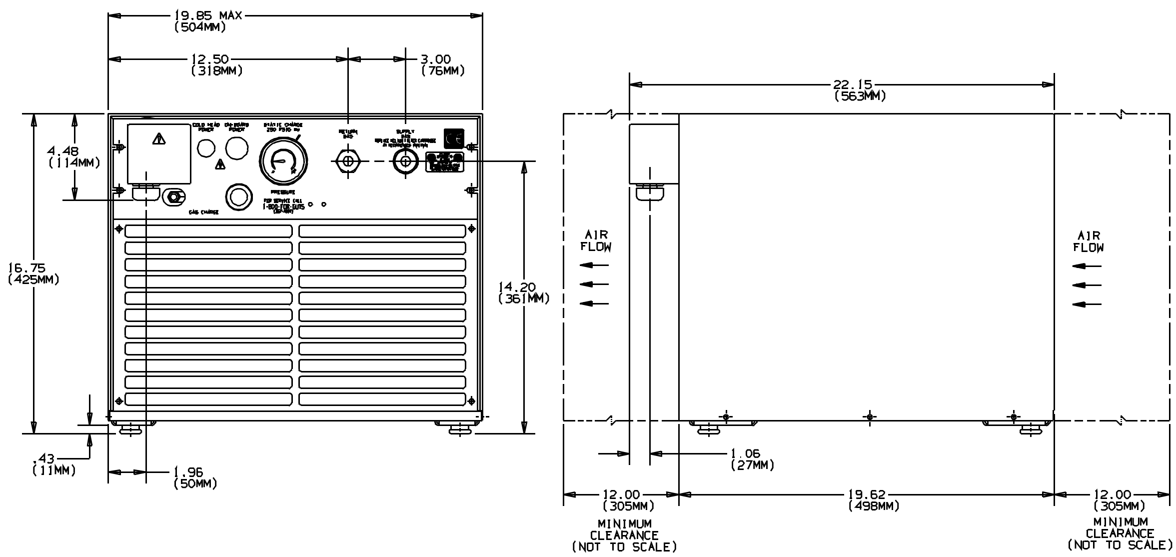
The manual provides instructions for installing, operating and servicing the 8200 Compressor. This compressor is available in two versions: air-cooled, P/N 8032549G001/G002 and water cooled, P/N803255G001/G002.

If you are installing or operating a Cryo-Torr or On-Board System you should also have available the appropriate cryopump or refrigerator.

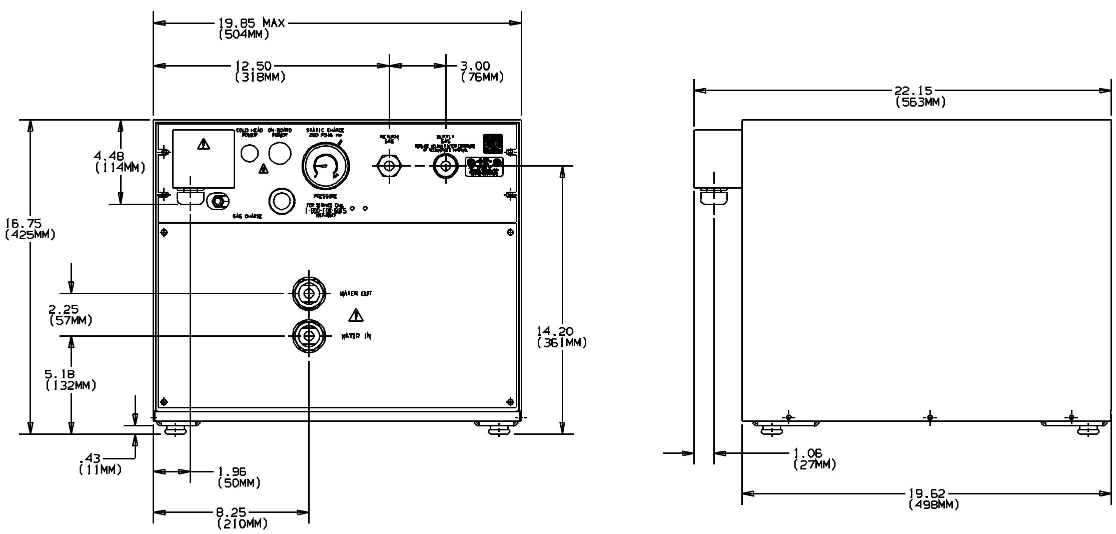
When you purchase a system, you will receive two manuals necessary for system installation, plus a loose- leaf binder with index tab separators, allowing you to compile a complete indexed system notebook.

Installation, Operation and Servicing Instructions

Installation, Operation and Servicing Instructions for your 8200 Compressor provide easily accessible information. All personnel with installation, operation, and servicing responsibilities should become familiar with the contents of these instructions to ensure high quality, safe, reliable performance.

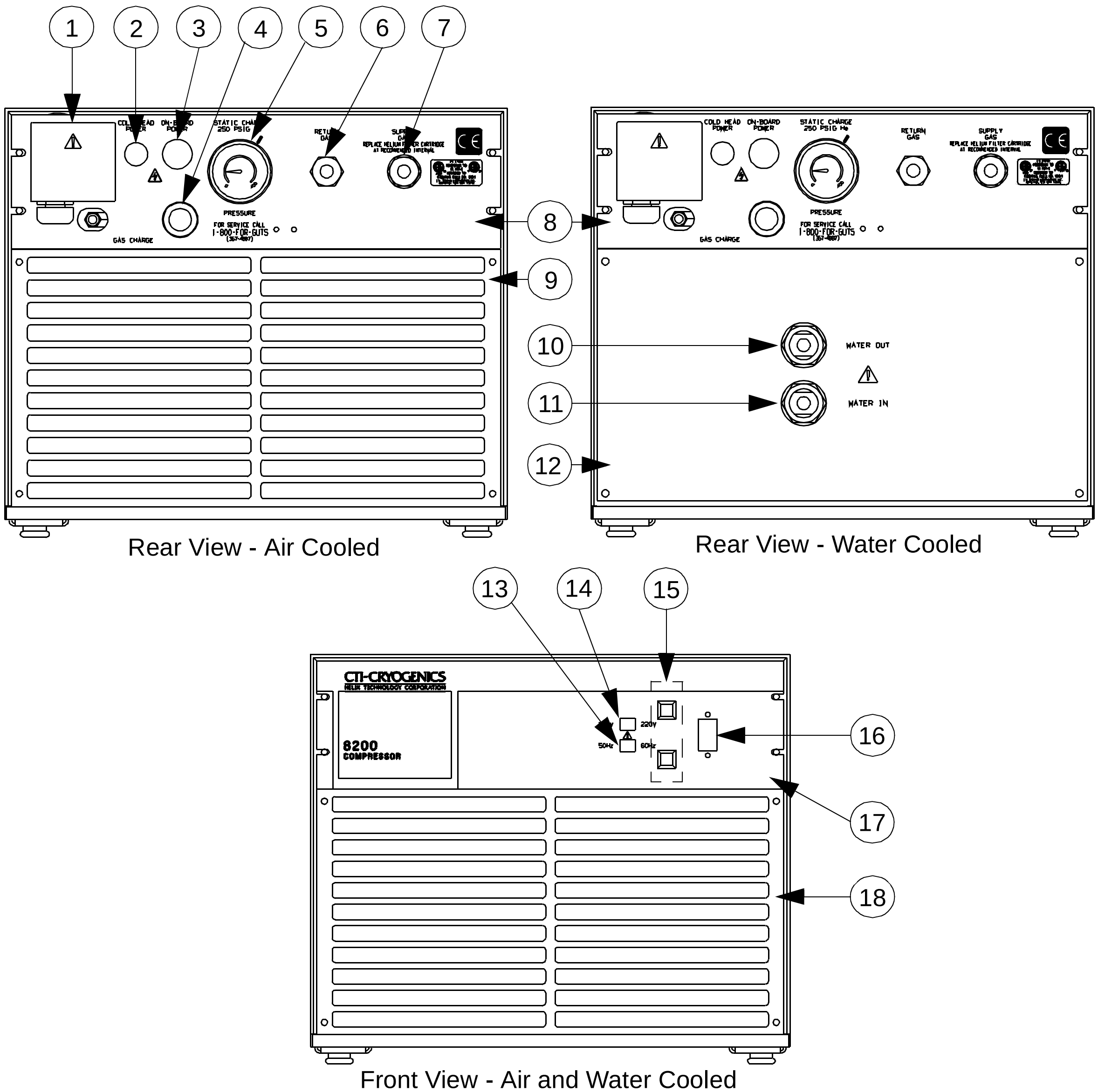


Air Cooled



Water Cooled

Figure 1-1: Air and Water Cooled 8200 Compressor Dimensions



LEGEND

1. Compressor Input Power Block
2. Cold Head Power Receptacle
3. On-Board Power Receptacle
4. Helium Gas Fitting and Charge Valve
5. Helium Supply Pressure Gauge
6. Helium Gas Return Connector
7. Helium Gas Supply Connector
8. Rear Panel
9. Rear Grill
10. Cooling Water Output
11. Cooling Water Input
12. Rear Plate
13. 50/60 Hz Frequency Selector Switch
14. 208/220 Voltage Range Selector Switch
15. Resettable Circuit Breakers
16. Compressor ON/OFF Switch
17. Front Panel
18. Front Grill

Figure 1-2: Component Locations

Table 1-1: Power Requirements (Steady-State Conditions)

Part Number	Cooling	Phase	Hz	Operating Voltage Range	Nominal Operating Current
8032549G001	Air Air	3 3	50 60	180-220 198-250	10A 10A
8032549G002	Air Air	1 1	50 60	180-220 198-250	10A 10A
8032550G001	Water Water	3 3	50 60	180-220 198-250	8.5A 8.5A
8032550G002	Water Water	1 1	50 60	180-220 198-250	8.5A 8.5A

Table 1-2: General Specifications

Specification	Description
Weight	140 lbs (63.5 kg) approximate
Weight (shipping)	145 lbs (70.5 kg) approximate
Power consumption	2.0 kw, nominal operating(water), 2.1 kw nominal operating (air)
Compressor input-power cable (customer-supplied)	Recommended type SO-4 conductor, 600V, neoprene jacket and 14-gauge wire. Install per Figure C-1, Electrical Schematic diagram, ensuring compliance with all national, state and local standards.
Helium pressure	Static: 245-255 psig (1688-1757 kPa) at 70 to 80°F (21 to 27°C) Supply: nominal operation: 270-290 psig (1860-2000 kPa) at operating temperature.
Ambient operating temperature range	50 to 100°F (10 to 38°C)

Table 1-2: General Specifications

Specification	Description
Interface	Cold head power receptacle: Mates with plug on cold head power cable. On-Board power receptacle: Mates with plug on cold-head power cable. Compressor input-power terminal block enclosure: Mates with input power cable, fabricated by customer or available from CTI-CRYOGENICS. Gas-supply connector: 1/2-inch self-sealing coupling Gas-return connector: 1/2-inch self-sealing coupling
Adsorber service schedule	Replace every 12 months.
Cooling water requirements (water cooled only)	100°F (38°C) maximum discharge temperature Refer to Figures 3-5 and 3-6 for parameters.

Section 2 - Inspection

Packaging of the System

A High-Vacuum Pump or Refrigerator System is packaged in separate cartons for each major component. An Installation, Operation, and Servicing Manual is included in the carton for the component packaged in that carton.

The Compressor

On receipt, remove the 8200 Compressor from its shipping carton and inspect the compressor for evidence of damage as described in this Section.

1. Unpack and remove the compressor from its shipping carton.
2. Check the carton contents. It should contain:
   a. 8200 Compressor (air cooled or water cooled).
   b. Compressor Manual P/N 8040353.
3. After unpacking, inspect the compressor for evidence of damage as follows:
   a. Inspect the compressor overall exterior for damage.
   b. Report damage to the shipper at once.
   c. Retain shipping cartons for storage or return shipment.

When installing your system, CTI recommends that as you unpack a component, you perform an inspection and the necessary tasks for system installation for the component according to the manual included with the component. Final system installation and operation will be performed following procedures in the high-vacuum pump or refrigerator manual.

4. Check the helium pressure gauge. The gauge should indicate 250 psig (1725 kPa) minimum at 70°F. If additional gas pressure is required, follow the instructions in **Adding Helium Gas**.

Section 3 - Installation

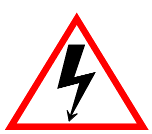
Compressor Installation

Installation of your compressor requires no special tools other than those supplied in the Installation and Scheduled Maintenance Tool Kit.

Preparing the Compressor Input-Power Cable

To supply input power to the 8200 compressor requires the fabrication of a 600-volt power cable that has an SO-4 conductor, 600-volt rating neoprene jacket and 14-gauge or 2.3 mm^2 wire. Proceed as follows:

WARNING



Do not connect the compressor to the power source at this time. All of the preparation must be completed and all panels reinstalled before electrically connecting the compressor.

Unit must be wired by an authorized electrician in accordance with the national Electrical Code, ANSI/NFPA 70-1987, as well as the local codes. This shall include installation of a readily accessible disconnect device into the fixed wiring supplying power.

An insulated earthing conductor that is identical in size, insulation material and thickness to the earth and unearth branch circuit supply conductors, except that it is green with or without one or more yellow stripes is to be installed as part of the branch circuit which supplies the unit or system. The earthing conductor described is to be connected to the earth at the service equipment, or supplied by a separately derived system at the supply transformer or generator.

1. Prepare the input power cable by terminating each of the four conductors with a #10 ring terminal. Follow the terminal manufacturer’s instructions to insure proper crimping.
2. Disassemble the electrical terminal enclosure cover, mounted on the compressor rear panel, as shown in Figure 3-1. Remove the two screws securing the cover and lift it off.
3. If necessary, back off strain relief screws.

4. Thread input power cable end up through the strain relief into the enclosure.
5. Attach the power conductors onto the appropriate terminals of the terminal block.
   a. For three-phase hookups, attach the three power leads to terminals X, Y and Z.
   b. For single-phase hookups, attach the two power leads to terminals X and Y. DO NOT USE TERMINAL Z.
6. Tighten all terminals to 18-22 in.-lbs. torque.
7. Tighten down screws on strain relief.

CAUTION

Ensure that strain relief is tightened down on the outer insulation of the input power cable and that the cable does not slide.

8. Remount the terminal enclosure cover and secure with two screws.
9. Refer to **Final Preparation of Compressor** for correct phasing checkout procedure.

WARNING

Insure that the ground wire is returned to a suitable ground in a non-interrupting manner.

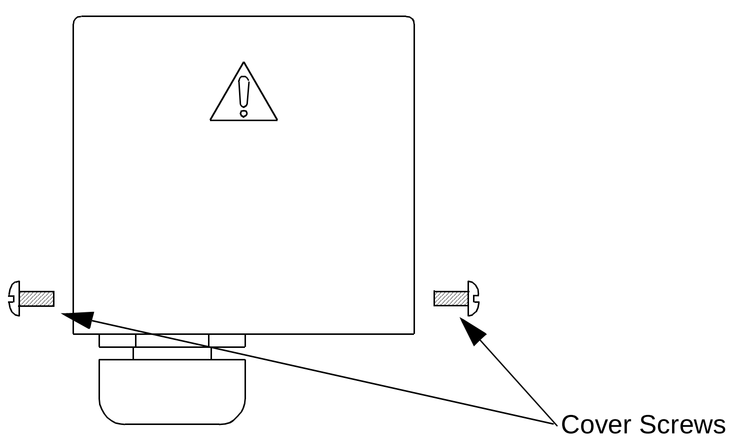


Figure 3-1: Electrical Terminal Enclosure with Cover in Place

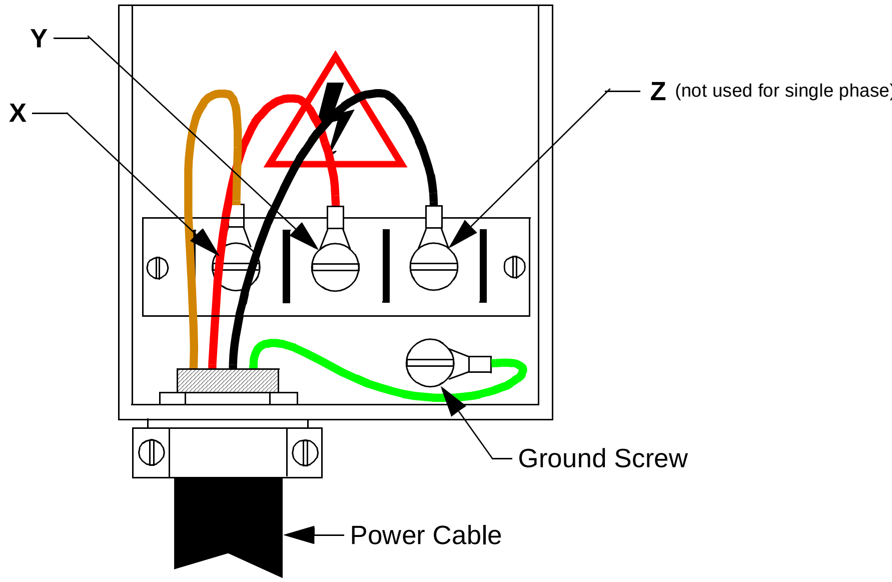


Figure 3-2: Assembly of Conductors to Terminal Block

Cooling Water Requirements (Water-Cooled Compressors Only)

If flexible water hose connections are used, install the barbed fittings supplied with the compressor on the input and output connections:

1. Apply a light coating of standard plumbing thread sealant on the barbed fitting threads.
2. Tighten fittings on 1/2-inch FPT input and 1/2-inch FPT output connections. DO NOT OVERTIGHTEN.
3. Connect flexible hoses to the fittings and secure with hose clamps.

If hard piping is desired, install the water lines directly onto the compressor 1/2-inch FPT input and output connections. DO NOT OVERTIGHTEN.

CAUTION

Check water connections for leaks.

Cooling Water: General Considerations

NOTE: *Adjust your water flow to maintain an optimum discharge water temperature of 85°F with a minimum input pressure of 2 psig. For detailed water requirements, see below.*

1. Cooling water must meet flow and pressure requirements as indicated in the following subsections.
2. Cooling water having a pH value of 6.0 to 8.0 and a calcium-carbonate concentration of less than 75 ppm, the quality of typical municipal drinking water, is acceptable. If the cooling water has a pH value lower than 6.0 or a calcium- carbonate concentration higher than 75 ppm, water conditioning may be required.
3. To conserve water, the cooling water should be shut off when the compressor is not running.

CAUTION

If cooling water below 45°F (7°C) is allowed to run through the compressor while the compressor is not operating, the compressor oil will change viscosity and thicken, causing the compressor to overheat and shut off at startup. In this event, repeatedly restart the compressor and allow it to run until it has shut off several times. The oil temperature will rise and thereby allow continuous compressor operation.

4. Drain and purge water from the compressor before shipping it back to the factory or subjecting it to freezing conditions. Purge water from the compressor by blowing compressed air, regulated to 30 to 40 psig (200 to 275 kPa) into the compressor output connection and allowing water to exit from the water input connection.

Cooling Water: Flow and Pressure Requirements

CAUTION

If your water supply pressure falls below 2 psig due to back pressure, the compressor will overheat and shut down.

Use the two graphs in Figure 3-3, to determine the minimum acceptable cooling water supply pressure at different flow rates and temperatures.

Find the minimum pressure:

1. Determine the temperature variation of the cooling water. Allow a ±10°F to the present water temperature if a variation cannot be ascertained. Plot the high and low temperatures on the vertical axis of the lower graph.

The example describes cooling water that varies between 40°F and70°F.

2. Determine the optimum water flow rate by drawing a horizontal line from the upper temperature variation figure on the lower graph to the upper curve of the allowable operating range indicated by cross-hatching. Draw a line from this intersecting point straight down to the horizontal axis to find the optimal flow rate.

The example shows a solid arrow extending from 70°F and intersecting the allowable operating range. Dashed arrows pointing downward indicate a water flow rate of 0.5 gallons per minute.

3. Determine the cooling water supply pressure drop by drawing a line straight up from the flow rate in the lower graph to the upper graph. At the point at which this line intersects the upper graph, draw a line leftward to the vertical axis and find the water supply pressure drop.

The example shows dashed arrows extending from the lower to the upper graph. On the upper graph the dashed arrows intersect the graph curve at approximately 2.5 psig.

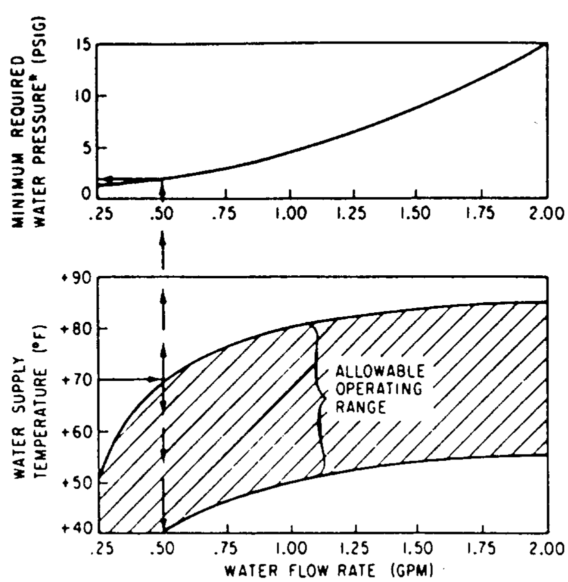


Figure 3-3: 8200 Compressor Cooling Water Flow and Pressure Requirements

Cooling Water: Temperature Rise

CAUTION

The temperature of the cooling water as it leaves the compressor should not exceed 100°F.

Use the graph in Figure 3-4 to determine the rise in cooling water temperature as it passes through the compressor. This information is provided for plant engineering personnel to determine cooling water requirements.

Find the temperature rise:

1. Draw a vertical line upward from the horizontal axis of the graph at the water flow rate determined from the previous section, until it hits the graph curve.

The example shows dashed arrows pointing upward to the graph curve from 0.50 gpm on the water flow rate axis.

2. At the point which the dashed arrows intersect the graph curve, draw a straight line to the left to obtain the increase in output water temperature.

The example shows a temperature increase of 20°F.

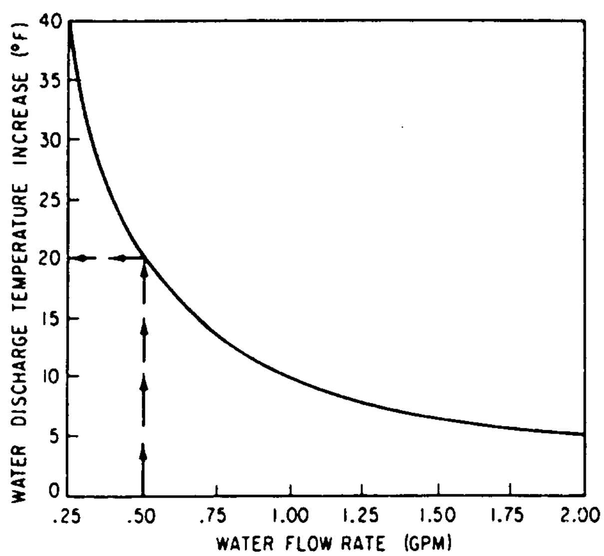


Figure 3-4: 8200 Compressor Water Discharge Temperature Increase (°F)

Final Preparation of Compressor

1. Using a voltmeter, measure the phase-to-phase voltage from the power source. Compare this voltage to the following table and position the voltage range selector switch to the “208V” or “220V” position as required. Also, set the frequency selector switch to the 50 Hz or 60 Hz position, as appropriate. See Figure 1-2 for location of selector switches.

Table 3-1: Voltage Specifications

Operating Voltage Range		Voltage Adjustment Switch S1 Position
60 Hz	50 Hz	
198-212	180-212	208V
213-250	213-220	220V

2. Ensure that water is turned on for the water-cooled compressor.
3. Set the compressor ON/OFF switch (3) to OFF. Connect the input-power cable to the power source Refer to Table 1-1, for electrical power requirements.
4. Turn the compressor switch to the ON position and allow the compressor to run for 15 minutes to stabilize the oil circuit. Make sure that the compressor fan operates freely in the air-cooled compressor.
5. Switch off the compressor and disconnect the input-power cable.
6. Install the compressor in its permanent location on a level surface. Air cooled units must have a minimum clearance of 12 inches at the front and back for adequate airflow.

Connecting the Compressor to the Cold Head

Make the connections between the cryopump and compressor. See Figure 3-5.

1. Remove dust plugs and caps from the supply fittings and return lines, compressor, and cold head. Check all fittings.
2. Connect the helium-gas return line from the gas-return connector on the rear of the compressor to the gas-return connector on the cold head.

3. Connect the helium-gas supply line from the gas-supply connector on the rear of the compressor to the gas-supply connector on the cold head.
4. Attach the supply and return line identification decals (CTI-supplied) to their respective connecting piping ends.
5. Verify proper helium supply static pressure by confirming that the helium pressure gauge reads 245-250 psig (1690-1725 kPa), in an ambient temperature range of 60 to 100°F (16 to 38°C).

WARNING

Do not operate the 8200 Compressor unless a Cryopump or Waterpump is connected to the system.

If the indicated pressure is higher than 250 psig (1725 kPa), reduce the pressure as follows:

a. Remove the flare cap from the gas charge fitting located on the rear of the compressor.
b. Open the gas charge valve very slowly. Allow a slight amount of helium gas to escape until the helium pressure gauge reads 250 psig (1725 kPa).
c. Close the gas charge valve and reinstall the flare cap.

If the indicated pressure is lower than 245 psig (1690 kPa), add helium gas as described in **Adding Helium Gas**.

6. Make the following electrical connections.

WARNING

The compressor ON/OFF power switch on the front of the compressor must be in the OFF position before making any and all electrical connections.

a. Connect the cold head power cable to the rear panel of the compressor and the other end to the electrical power connector on the high-vacuum pump cold head.
b. Connect the compressor input power cable to the power source.
c. Turn on compressor.
d. Your system is now ready for operation.

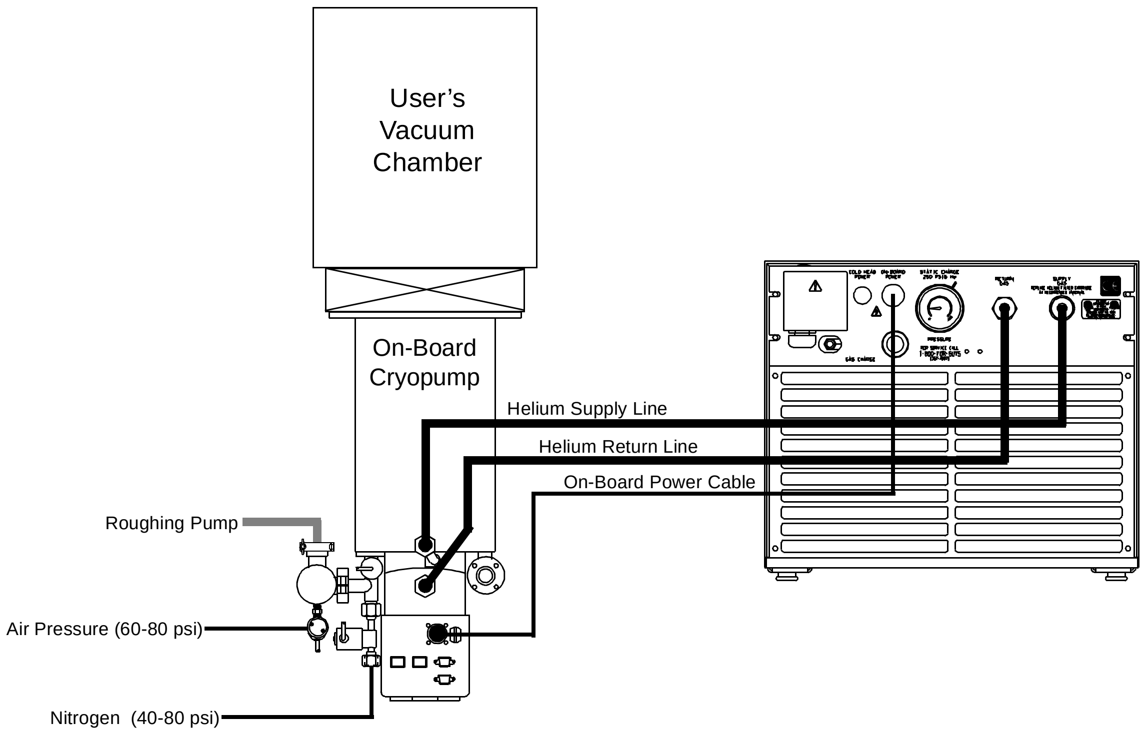


Figure 3-5: Typical 8200 Compressor Installation

Section 4 - Maintenance Procedures

WARNING

Always disconnect the compressor from all sources of electrical power before performing any maintenance procedures.

Scheduled Maintenance

The only scheduled maintenance required on the 8200 Compressor is replacement of the compressor adsorber (P/N 8080255K001) every 12 months.

Removing the Compressor Adsorber

1. Shut down the compressor.
2. Disconnect the compressor input power cable from its electrical power source.
3. Disconnect the flex lines from the gas-return and gas-supply connectors at the rear of the compressor.
4. Remove the screws holding the compressor rear grille, rear panel, front panel and cover (Figure 1-2). Front and rear panels remain in place.
5. Use the two wrenches (supplied) to avoid loosening the body of the coupling from its adapter.
6. Unscrew the two self-sealing coupling halves quickly to minimize gas leakage as shown in Figure 4-1.
7. Disconnect the adsorber-inlet self-sealing coupling as shown in Figure 4-1.
8. Remove the bolts, nuts, and washers that secure the adsorber to the base of the compressor. Save all nuts, bolts, and washers for installing the replacement adsorber.
9. Carefully lift the adsorber inward until the outlet self-sealing coupling clears the rear panel and remove the adsorber as shown in Figure 4-2.
10. Remove the adsorber from the compressor as shown in Figure 4-2.

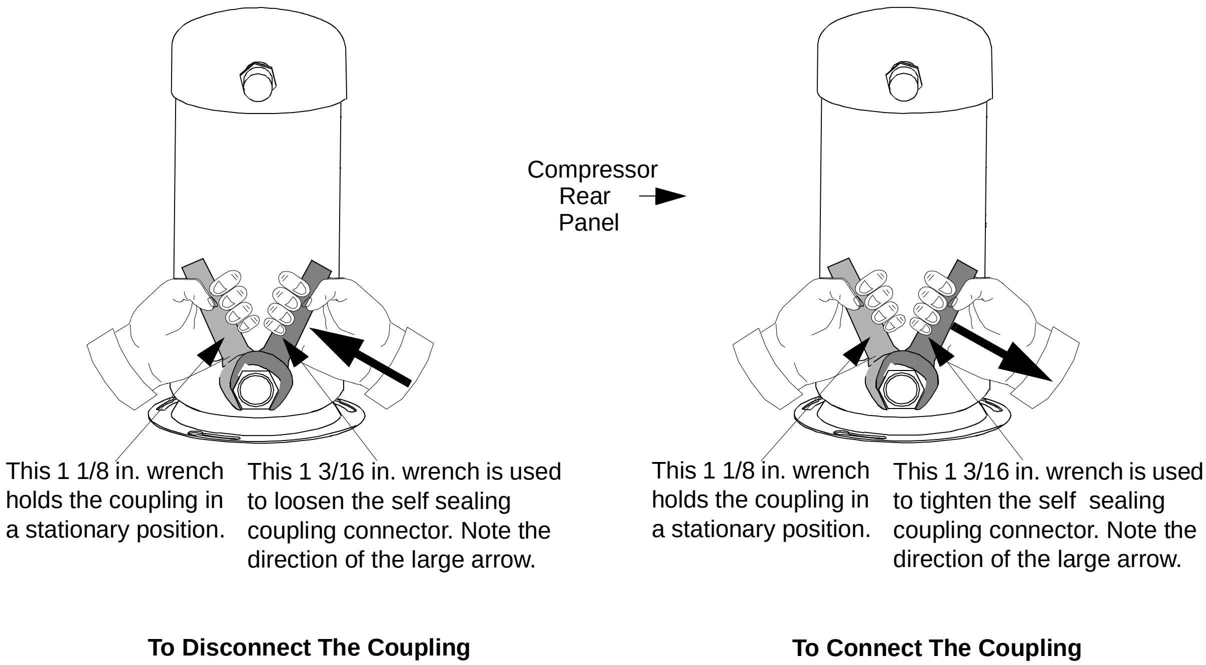


Figure 4-1: Disconnecting/Connecting the Adsorber Self-Sealing Coupling

WARNING

Depressurize the adsorber before disposing of it. Attach the depressurization fitting (included in the Installation and Scheduled Maintenance Tool Kit) to the coupling half at either end of the adsorber and tighten it slowly.

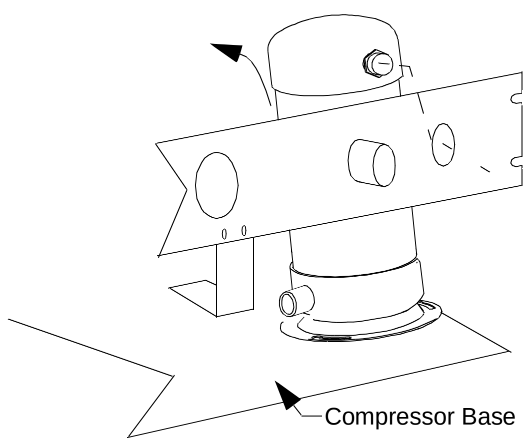


Figure 4-2: Removing the Adsorber from the Compressor

Installing the Compressor Adsorber

1. Install the replacement adsorber as follows:
   a. Remove the dust caps from the self-sealing coupling halves at each end of the replacement adsorber.
   b. Write installation date on the adsorber decal.
   c. Install the replacement adsorber following the steps for compressor adsorber removal in reverse order. Use the hardware saved in step 5 above.
2. Connect the adsorber to the compressor internal piping. Refer to Figure 4-1.
   a. Check the self-sealing connector flat rubber gasket to make sure that it is clean and properly positioned.

CAUTION

Make sure to hold fast on the left coupling nut while tightening the right coupling nut, as shown in Figure 4-1.

   b. Make the first turns by hand and then firmly seal the connection using the two wrenches until the fittings “bottom”. Refer to Figure 4-1, for proper coupling of the self-sealing connection
3. Replace the cover and the front and rear grilles and secure them
4. Ensure that the pressure gauge reads 245-250 psig (1690-1725 kPa). If additional gas pressure is required, follow the instructions in, **Adding Helium Gas**.
5. Reconnect the return and supply flex lines to the compressor.
6. Connect the compressor input power cable to the electrical power source.

Unscheduled Maintenance

Suggested Unscheduled Maintenance Equipment

It is advisable to keep on hand the unscheduled maintenance equipment and disposable supplies listed below.

1. Helium, 99.999% pure.
2. Pressure regulator (0-3000/0-400 psig).
3. Maintenance manifold, P/N 8080250K003*.

4. Helium charging line terminating in a 1/4-inch female flare fitting, P/N 7021002P001.
5. Installation and Scheduled Maintenance Tool Kit, P/N 8032040G004.

*Available from stock; consult the factory or your sales representative.

Adding Helium Gas

Use only 99.999% pure helium gas.

> **CAUTION**
>
> If the compressor helium pressure gauge reads 0, decontamination is required. Refer to decontamination procedures under, **Helium Circuit Decontamination**, or contact the Product Service Department.

1. A User-supplied helium charging line terminating in a 1/4-inch female flare fitting, and a two-stage pressure regulator rated at 0-3000/0-400 psig is required for this operation.
2. If you need to add helium more than once every several months, check for leaks caused by improperly connected self-sealing connections or any mechanical joint within the compressor.

There are two conditions that require the addition of helium gas:

1. Compressor not operating; helium pressure gauge reads 245 psig or below.
2. Compressor operating; helium pressure reads 270 psig, or below.

To add helium gas:

1. Attach a pressure regulator (0-3000/0-400 psig) and charging line to a helium gas (99.999% pure) bottle. DO NOT OPEN THE BOTTLE AT THIS TIME. Purge the regulator and charging lines as instructed in steps a through e below. Do *not* use helium gas that is l*ess than 99.999% pure*.
   a. Open the regulator a small amount by turning the adjusting knob clockwise until it contacts the diaphragm, then turn approximately 1/8 to 1/4 turn more, so that the regulator is barely open.
   b. Slowly open the bottle valve, and purge the regulator for 10 to 15 seconds. Turn the regulator knob counterclockwise until the helium stops flowing.

c. Connect the charge line to the helium pressure regulator.

d. Remove the flare cap of the gas charge fitting on the rear of the compressor. Loosely connect the charge line to the charge fitting.

e. Set the helium pressure regulator to 10 to 25 psig (70-125 kPa). Allow helium gas to flow through the charging line and around the loosened flare fitting for 30 seconds to purge the charging line of air. Then tighten the flare nut at the end of the charge line.

(This procedure is required to ensure that both the regulator and the charging line will be purged of air and that the air trapped in the regulator will not diffuse back into the helium bottle. For best results, CTI suggests a dedicated helium bottle, regulator, and line, which are never separated, for adding helium.)

2. Set the helium pressure regulator to 300 psig (2070 kPa). Depending on the compressor operating state, add helium gas:

   a. If the compressor is running (approximately 2 hours operating time) under normal operating conditions, slowly open the helium charge valve on the rear of the compressor. When the helium pressure gauge rises to 270 - 290 psig (1860 - 2000 kPa) tightly close the charge valve.

   b. If the compressor is not running, slowly open the helium charge valve. When the helium pressure gauge rises to 245 - 255 psig (1688 - 1757 kPa), tightly close the charge valve.

CAUTION

Add helium gas slowly to prevent relief valve blow-off.

3. Ensure that the helium charge valve on the compressor is tightly closed. Shut off the helium pressure regulator on the helium bottle and remove the charging line from the male flare fitting. Shut off the helium gas bottle valve. Reinstall the flare cap.

Helium Circuit Decontamination

Refer to **Section 4 - Maintenance** of the appropriate On-Board Cryopump Installation Operation, and Maintenance manual for information on helium circuit decontamination.

Appendix A - Customer Support Information

Introduction

Refer to Table A-1 for the nearest Customer Support Center for technical assistance or service for CTI-CRYOGENICS products. North American customers may call 800-FOR-GUTS (800-367-4887) 24 hours a day, seven days a week. All other customers must call their local Customer Support Center.

NOTE: *Please contact the Customer Support Center in Mansfield, Massachusetts in the United States of America by dialing 508-337-5599 if a Customer Support office is not located in your area.*

Please have the following information available when calling so that we may assist you:

- Product Part Number
- Product Serial Number
- Product Application
- Specific Problem Area
- Hours of Operation
- Equipment Type
- Vacuum System Brand/Model/Date of Manufacture

For your convenience, you may also e-mail us at:

contact@helixtechnology.com

Visit us at our corporate website:

www.helixtechnology.com

Table A-1: CTI-CRYOGENICS Product Customer Support Centers

United States and Canada **Guaranteed Uptime Support Line GUTS®** Dial: **800-FOR-GUTS** (800-367-4887) (within USA) 508-337-5599 (outside USA) *24 hours a day, seven days a week* **Corporate Headquarters:** 800-379-7224 (within USA) 508-337-5000 (outside USA) **Austin, TX:** 800-324-6445 (within USA) 512-912-2800 (outside USA) **Longmont, CO:** 800-776-6543 (within USA) 303-652-4400 (outside USA) **Santa Clara, CA:** 800-324-6449 (within USA) 408-562-5940 (outside USA)	**Germany, Italy, Denmark, Switzerland, Holland, Norway, The Netherlands** Dial: +(49) 6151-959-55 *24 hours a day, seven days a week*
France, Spain, Portugal, Greece, Belgium, North Africa Dial: +(33) 1-6935-2600 *24 hours a day, seven days a week*	**United Kingdom, Ireland, N. Ireland, Scandinavia** Dial: +(44) 1-506-460017 *24 hours a day, seven days a week*
Japan Dial: +(81) 0120-60-4887 *24 hours a day, seven days a week*	**Korea** Dial: +(82) 2-577-3181 *24 hours a day, seven days a week*
Taiwan Dial: +(886) (3) 516-9022 *24 hours a day, seven days a week*	**China** Dial +(86) 21-6279-1389 *24 hours a day, seven days a week*
Australia, New Zealand, Tasmania Dial: +(612) 9-4810748 *24 hours a day, seven days a week*	**Singapore, Malaysia, Philippines, Indonesia** Dial: +(65) 268-2024 *24 hours a day, seven days a week*
India Dial: +(91) 22-7632906 *24 hours a day, seven days a week*	**Israel** Dial: +(972) 3-9247710 *24 hours a day, seven days a week*

Appendix B - Troubleshooting Procedures

WARNING

Disconnect the compressor before performing any troubleshooting procedures.

The compressor pump is hot after operating. Wait for the pump to cool down before working on the inside of the compressor

Table B-1: Compressor Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
1) System power ON/OFF switch (CB1) and compressor switch (S1) remains in the ON position when switched on but the compressor will not run. Refer to Figure C-1 for identification of all electrical components	1) The thermal protective switch (TS1) is closed, activating the relay-trip coil in the ON/OFF switch (SW1).	1) Test switch (TS1) on air-cooled compressor; test (TS1) and (TS2) on water-cooled compressor. If continuity is found in any switch, contact the Product Service Department.
	2) Incorrect phasing at input power.	2) Correct phase sequence at input power cable.
	3) Excessive current drain has activated the series trip in the compressor ON/OFF switch.	3) Measure and record the current and contact the Product Service Department.
2) System power ON/OFF switch (CB1) remains in the ON position, but the compressor will not run.	1) No power coming from the power source.	1) Check service fuses, circuit breakers, and wiring associated with power source, and repair as needed.
	2) Incorrect or disconnected wiring within the compressor	2) Check the compressor against its electrical schematic, Figure C-1.

Table B-1: Compressor Troubleshooting Procedures

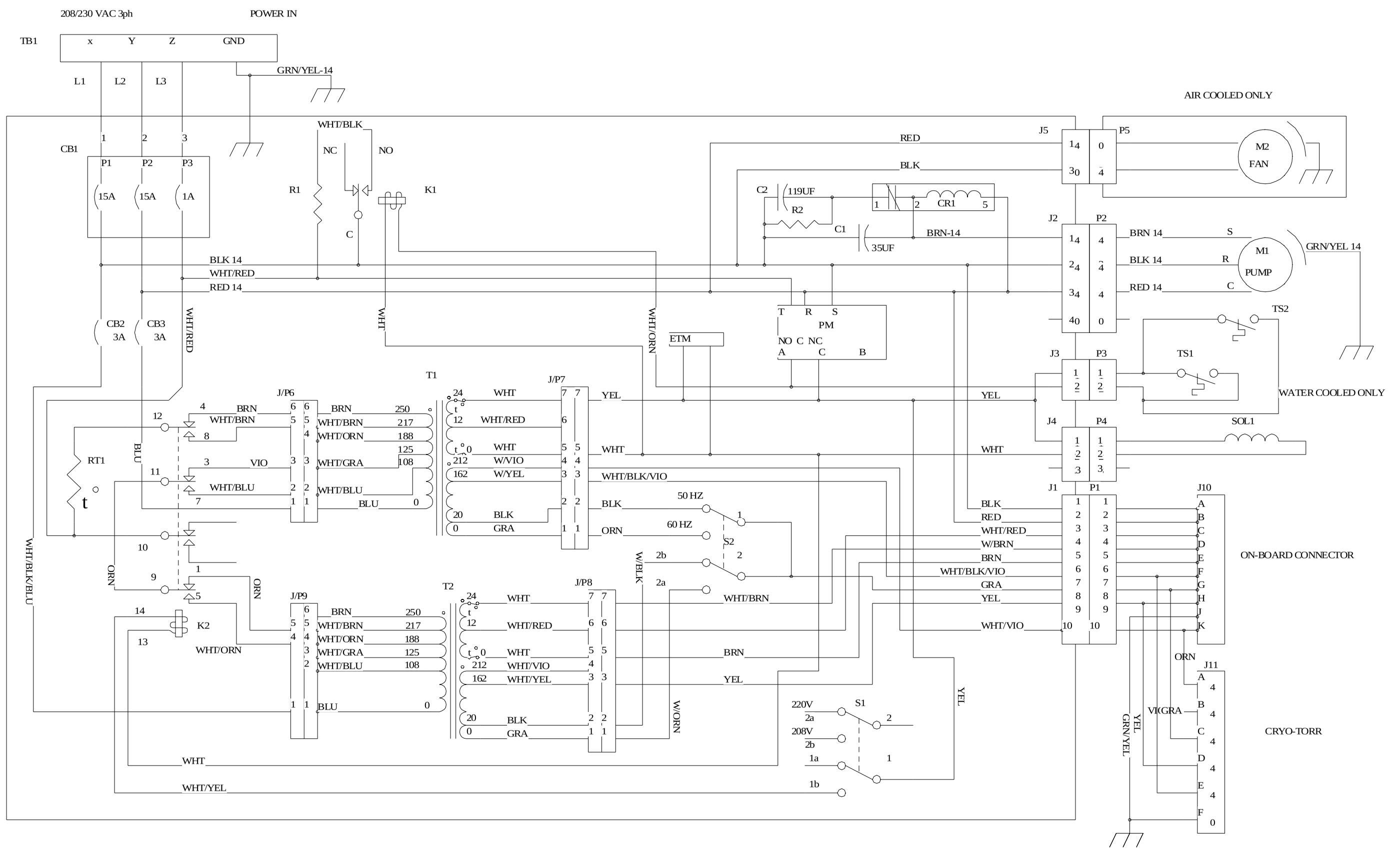
Problem	Possible Cause	Corrective Action
3) Compressor stops after several minutes of operation and remains off.	1) High temperature of the compressor is caused by insufficient cooling water, resulting in the opening of thermal protective switch (water-cooled compressor only).	1) Confirm that cooling water to the compressor is flowing. Confirm that proper cooling water flow rate and pressure exist by referring to Figure 3-3.
	2) After turn-off, very cold cooling water was left running through the compressor. The resulting low oil temperature has caused a restriction of oil flow through the metering orifice during startup.	2) Turn on the compressor and allow it to run until it has stopped several times, allowing the oil temperature to rise and the compressor to operate continuously for one hour minimum.
	3) Very cold cooling water is circulating through the compressor. The resulting low oil temperature causes a restriction of oil flow through the metering orifice during startup.	3) Recheck for proper cooling water temperature per, **Cooling Water Requirements (Water-Cooled Compressors Only)**.
	4) Ambient temperature is unusually high resulting in the opening of the thermal protective switch (air-cooled compressor only).	4) Provide a free flow of air to the compressor. Confirm a 12-inch (30 cm) clearance at the front and back of the compressor. Confirm unobstructed and clean heat exchanger surfaces.
	5) Insufficient helium supply pressure is indicated by the supply pressure gauge.	5) Add helium per, **Unscheduled Maintenance**.
	6) High temperature of the compressed helium in the discharge line from the compressor pump has tripped the thermal protective switch.	6) Confirm that oil is visible in the compressor sight glass (air-compressor only).
	7) Mechanical seizure.	7) Contact the Product Service Department.

Table B-1: Compressor Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
4) Compressor pump stops after several minutes of operating and then switches ON and OFF at short intervals.	1) Intermittent power source voltage.	1) Confirm power source voltage between 198-250V, 60 Hz or 180-220V, 50 Hz and restore if necessary.
5) Compressor operates but cold head motor does not run.	1) Loose or defective cable.	1) Check cold head cable.

Appendix C - Electrical Schematics for 8200 Compressor

C1	RUN CAPACITOR,	35UF
C2	START CAPACITOR,	119UF
CB1	MAIN CIRCUIT BREAKER	
CB2	CIRCUIT BREAKER, 3A	
CB3	CIRCUIT BREAKER, 3A	
CR1	MOTOR START RELAY	
ETM	METER ELAPSED TIME	
J1	COLDHEAD CONNECTOR	
J2	PUMP CONNECTOR	
J3	THERMOSTAT CONNECTOR	
J4	SOLENOID CONNECTOR	
J5	FAN CONNECTOR	
J/P6	TRANSFORMER CONNECTOR	
J/P7	TRANSFORMER CONNECTOR	
J/P8	TRANSFORMER CONNECTOR	
J/P9	TRANSFORMER CONNECTOR	
K1	OVERTEMPERATURE TRIP RELAY	
K2	VOLTAGE SELECTOR RELAY	
M1	PUMP MOTOR	
M2	FAN MOTOR, AIR COOLED ONLY	
PM	PHASE MONITOR	
J10	ON-BOARD CONNECTOR	
J11	CRYO-TORR CONNECTOR	
R1	OVERTEMPERATURE RESISTOR	
R2	BLEED RESISTOR	
RT1	CURRENT LIMITER	
S1	VOLTAGE SELECTOR SWITCH	
S2	FREQUENCY SELECTOR SWITCH	
SOL1	SOLENOID	
T1	TRANSFORMER	
T2	TRANSFORMER	
TB1	TERMINAL BLOCK, INCOMING VOLTAGE	
TS1	THERMOSTAT	
TS2	THERMOSTAT, FOR WATER COOLED USE TS1 AND TS2	



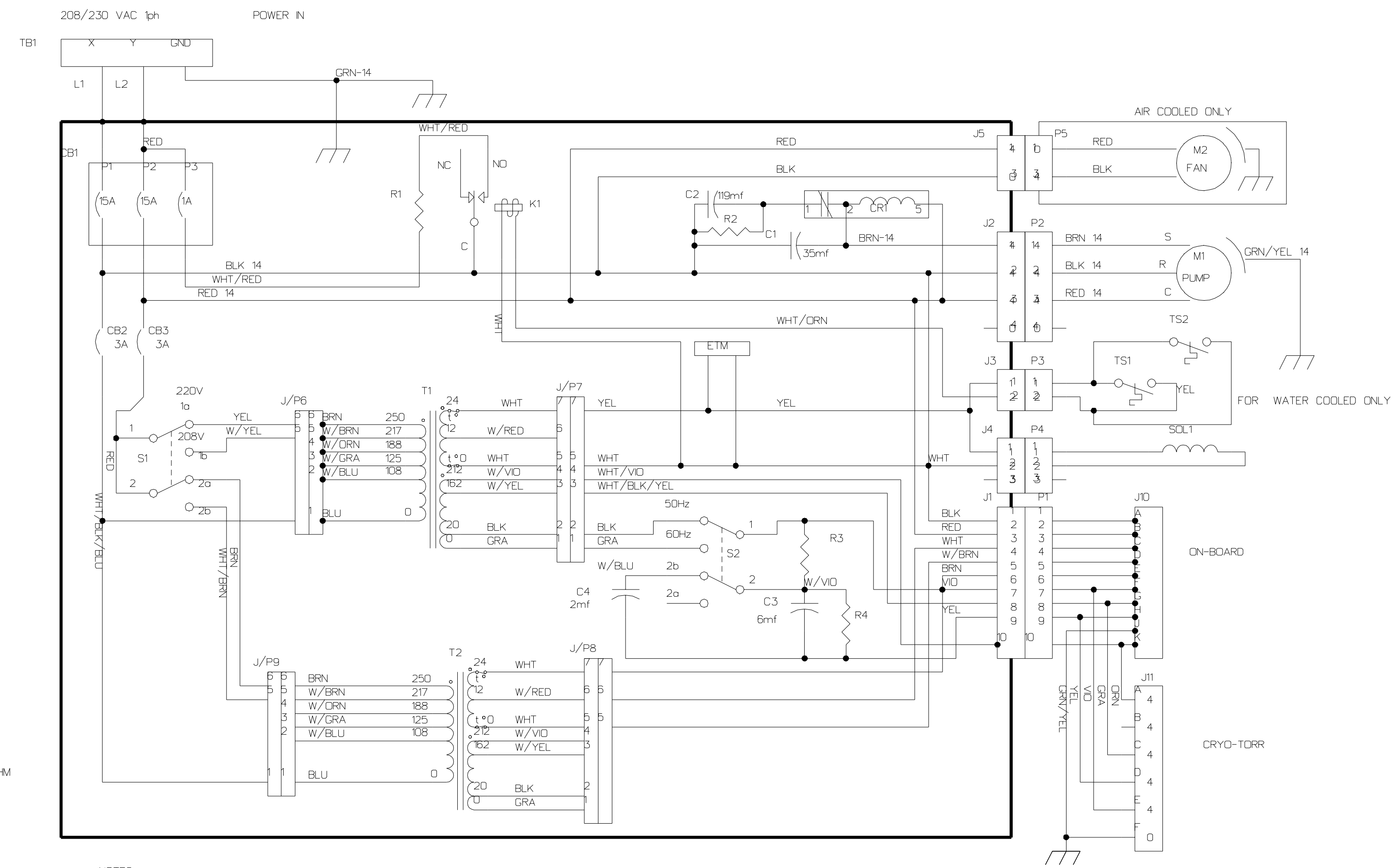
NOTES:

1. VOLTAGE SELECTION:

FREQUENCY	LINE VOLTS	S1	S2	CH VOLTS	CONTROL VOLTS
50 Hz	180 - 212	208V	50 Hz	118 - 139	19.9 - 23.5
	213 - 220	220V	50 Hz	121 - 125	20.5 - 21.2
60 Hz	198 - 212	208V	60 Hz	148 - 159	21.9 - 23.5
	213 - 250	220V	60 Hz	138 - 162	20.5 - 24.0

Figure C-1: 8200 Compressor Electrical Schematic P/N 8032563P001 Rev. 100

C1 RUN CAPACITOR, 35UF
C2 START CAPACITOR, 119UF
C3 RUN CAPACITOR, 6UF
C4 RUN CAPACITOR, 2UF
CB1 MAIN CIRCUIT BREAKER
CB2 CIRCUIT BREAKER, 3A
CB3 CIRCUIT BREAKER, 3A
CR1 MOTOR START RELAY
ETM METER ELAPSED TIME
J/P1 COLDHEAD CONNECTOR
J/P2 PUMP CONNECTOR
J/P3 THERMOSTAT CONNECTOR
J/P4 SOLENOID CONNECTOR
J/P5 FAN CONNECTOR
J/P6 TRANSFORMER CONNECTOR
J/P7 TRANSFORMER CONNECTOR, 8 PIN
J/P8 TRANSFORMER CONNECTOR
J/P9 TRANSFORMER CONNECTOR
K1 RELAY, TRIP RELAY
M1 PUMP MOTOR
M2 FAN MOTOR, AIR COOLED ONLY
J10 ON-BOARD CONNECTOR
J11 CRYO-TORR CONNECTOR
R1 OVERTEMPERATURE RESISTOR 100 OHM
R2 BLEED RESISTOR, 15K
R3 COLDHEAD PHASE-SHIFTING RESISTOR 150 OHM
R4 BLEED RESISTOR, 100K, 2W
S1 VOLTAGE SELECTOR SWITCH
S2 FREQUENCY SELECTOR SWITCH
SOL1 SOLENOID
T1 TRANSFORMER
T2 TRANSFORMER
TB1 TERMINAL BLOCK, INCOMING VOLTAGE
TS1 THERMOSTAT
TS2 THERMOSTAT, FOR WATER COOLED USE TS1 AND TS2



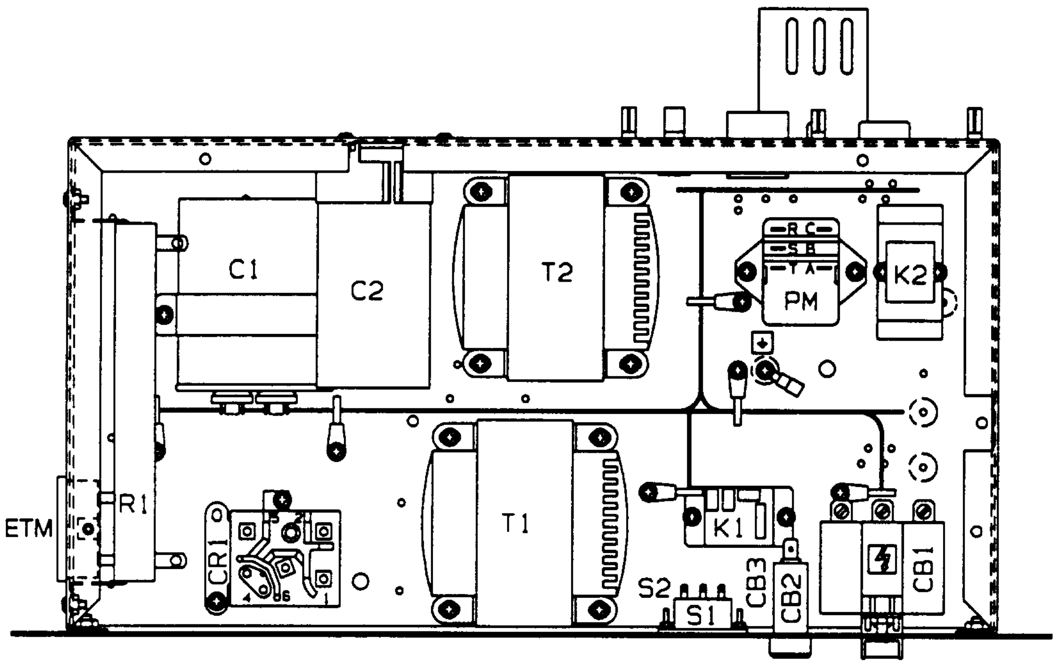
NOTES:

1 VOLTAGE SELECTION:

FREQUENCY	LINE VOLTS	S1	S2	CH VOLTS	CONTROL VOLTS
50 Hz	180 - 212	208V	50 Hz	118 - 139	199 - 235
	213 - 220	220V	50 Hz	121 - 125	205 - 212
60 Hz	198 - 212	208V	60 Hz	148 - 159	219 - 235
	213 - 250	220V	60 Hz	138 - 162	205 - 240

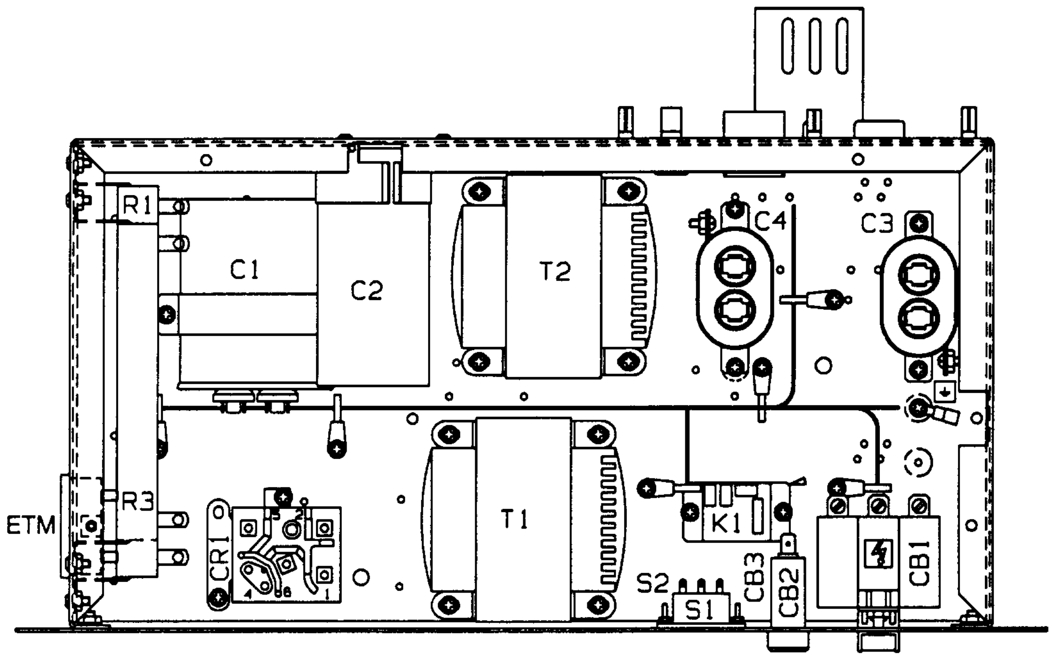
Figure C-2: 8200 Compressor Electrical Schematic P/N 8032564P001 Rev. D

Appendix D - Components in the Electrical Control Module of the 8200 Compressor



1.	Overtemperature Resistor	R1	9.	Circuit Breaker, 3A	CB3
2.	Run Capacitor, 35 µf	C1	10.	Voltage Selector Switch	S1
3.	Start Capacitor, 119 µf	C2	11.	Frequency Selector Switch	S2
4.	Transformer	T2	12.	Overtemperature Trip Relay	K1
5.	Phase Monitor	PM	13.	Transformer	T1
6.	Voltage Selector Relay	K2	14.	Motor Start Relay	CR1
7.	Main Circuit Breaker	CB1	15.	Meter, Elapsed Time	ETM
8.	Circuit Breaker, 3A	CB2			

Figure D-1: Components in the Electrical Control Chassis of the 8200 Compressor Three-Phase Scott-T Configuration



1.	Coldhead Phase-Shifting Resistor	R3	9.	Circuit Breaker, 3A	CB2
2.	Overtemperature Resistor	R1	10.	Circuit Breaker, 3A	CB3
3.	Run Capacitor, 35 µf	C1	11.	Voltage Selector Switch	S1
4.	Start Capacitor, 119 µf	C2	12.	Frequency Selector Switch	S2
5.	Transformer	T2	13.	Relay, Trip Relay	K1
6.	Run Capacitor, 2 µf	C4	14.	Transformer	T1
7.	Run Capacitor, 6 µf	C3	15.	Motor Start Relay	CR1
8.	Main Circuit Breaker	CB1	16.	Meter, Elapsed Time	ETM

Figure D-2: Components in the Electrical Control Chassis of the 8200 Compressor - Single-Phase RC Configuration

Appendix E - Flow Diagrams for 8200 Air-Cooled and Water-Cooled Compressors

Compressor Gas and Oil Flows

Refer for Figure E-1 or Figure E-2 while reviewing this subsection.

Helium returning from the cold head enters the compressor, and a small quantity of oil is injected into the gas stream, thereby overcoming helium low specific head and inability to carry heat produced during compression. Helium is then compressed and passed through a heat exchanger for removal of compression-caused heat. The helium flows through a bulk oil separator, oil-mist separator, and helium filter cartridge, where oil and contaminants are removed.

A differential pressure relief valve in the compressor limits the operating pressure differential between the helium supply and return lines, thereby allowing compressor operating without cold head operation. When cold head operation reaches a steady-state condition, further pressure regulation is unnecessary.

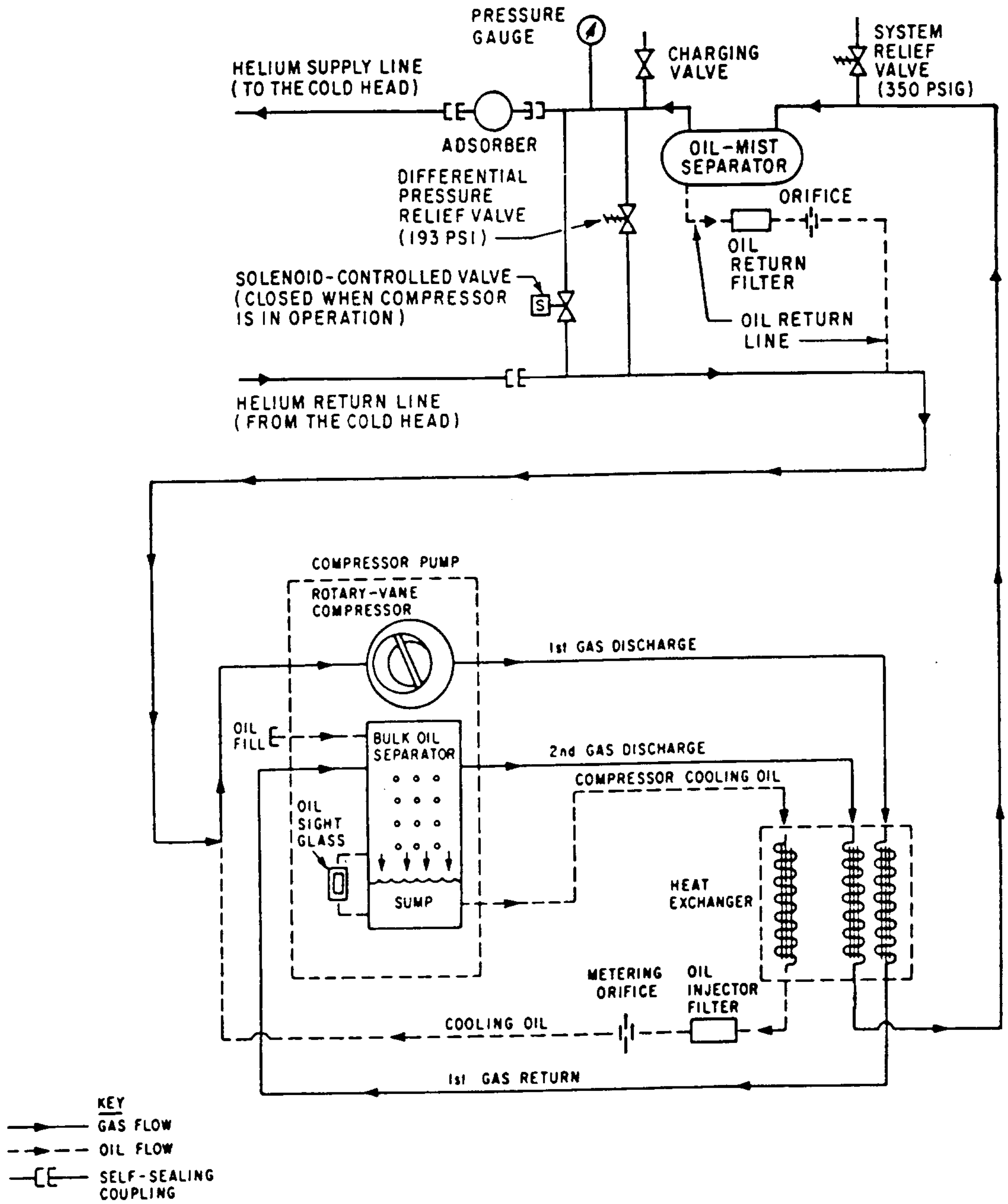


Figure E-1: Flow Diagram of the 8200 (Air-Cooled) Compressor

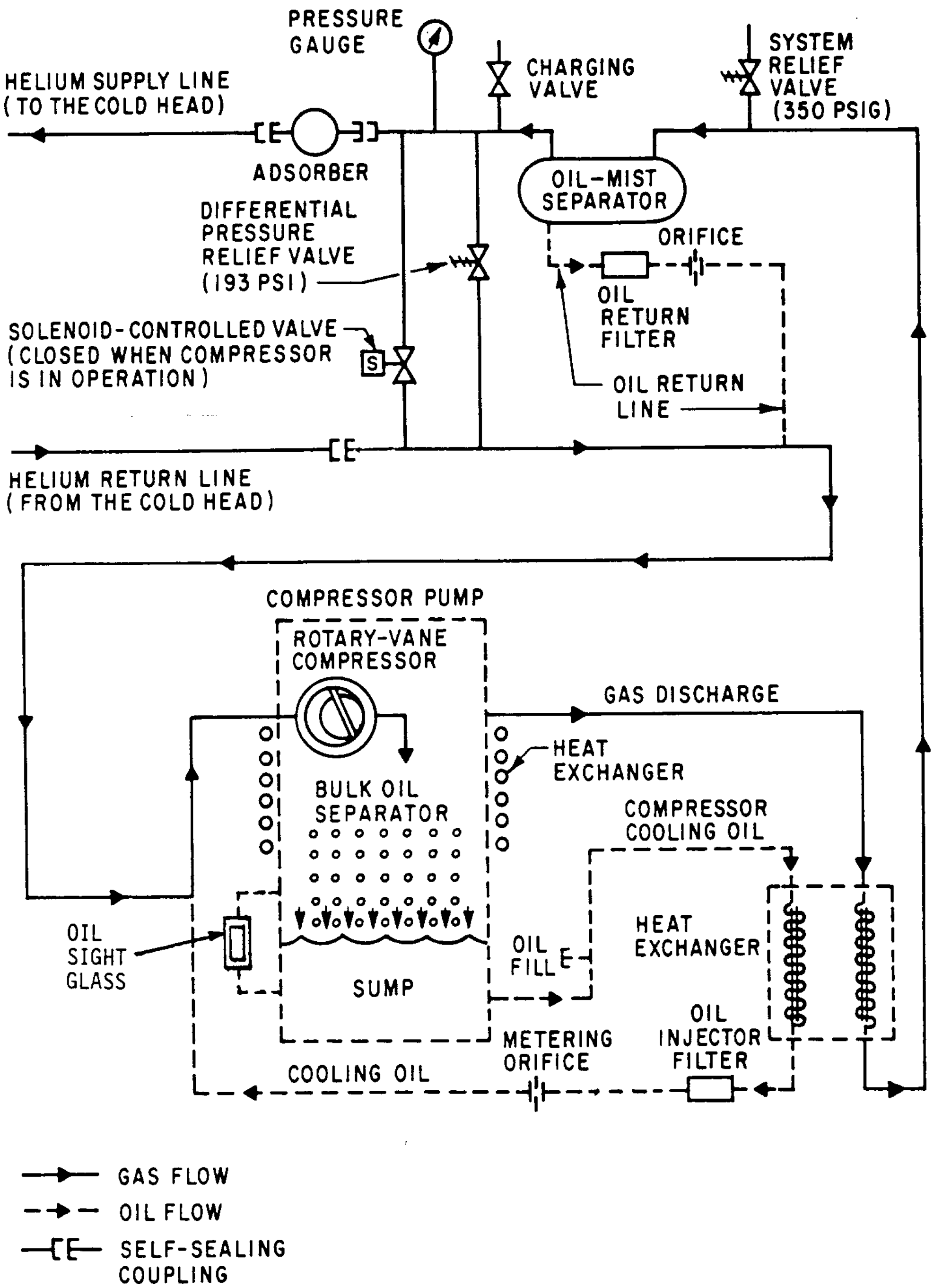


Figure E-2: Flow Diagram of the 8200 (Water-Cooled) Compressor

Flow Set Point Switching – RFS Types

- Combines visual confirmation of flow with dynamic, electronic switch operation
- Easy, adjustable switch point calibration: a local LED signals when set point is reached

RotorFlow® Switches build an extra level of reliability and protection into your equipment. By principle of operation, the rotor cannot be deceived into indicating a positive flow situation when no flow actually exists. Once set to a desired actuation point, RotorFlow will switch to a "no-flow" condition should the rotor stop for any reason.

Typical Applications

Protect expensive electronic equipment from coolant flow failure on...

- Semiconductor Processing Equipment
- Lasers • Medical Equipment
- X-Ray and Other High Power Tubes
- Robotic Welding Equipment

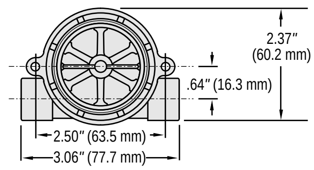
File No. E45168

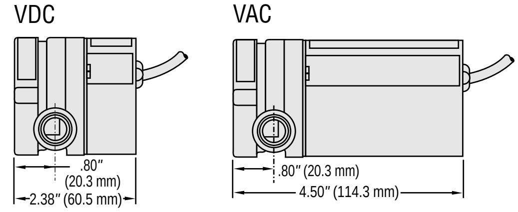
Specifications

Wetted Materials	
Body	Brass, Stainless Steel or Polypropylene (Hydrolytically Stable, Glass Reinforced)
Rotor Pin	Ceramic
Rotor	PPS Composite, Black
Lens	Polysulfone
O-Ring	Viton® (Alloy Bodies); Buna N (Polypropylene Body)
Low Flow Adaptor	Glass Reinforced Polypropylene
Operating Pressure, Maximum	
Brass or Stainless Steel Body	200 PSIG @ 70°F
Polypropylene Body	100 PSIG @ 70°F, 40 PSI Max. @ 180°F
Operating Temperature,	
Brass or Stainless Steel Body	-20°F to 212°F (-29°C to 100°C)
Polypropylene Body	-20°F to 180°F (-29°C to 82°C)
Electronics	150°F (65°C) Ambient
Viscosity, Maximum	200 SSU
Input Power	24 VDC or 110 VAC
Relay Contact Ratings (SPDT)	1 Amp, 24 VDC Resistive; 0.3 Amp, 110 VAC
Repeatability	2% Maximum Deviation
Set Point Accuracy (Factory Set)	± 5%
Set Point Differential	15% Maximum
Electrical Termination	20 AWG PVC-Jacketed, 24″ Cable. Color Codes: Red = +VAC/VDC, Black = Ground, White = N.O. Contact, Brown = N.C. Contact, Green = Common

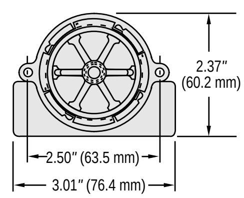
Dimensions

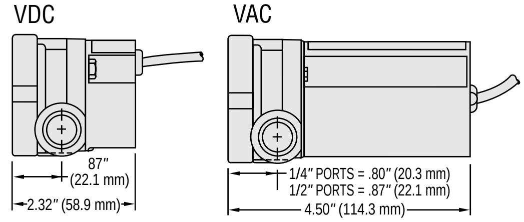
Polypropylene Bodies



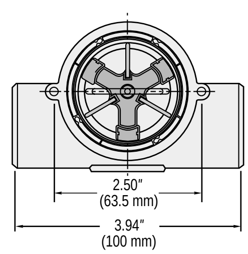


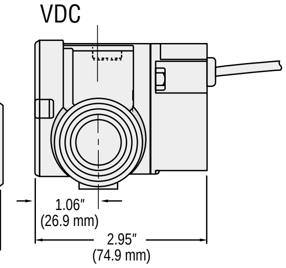
Brass and Stainless Steel Bodies - .25″ and .50″ Port

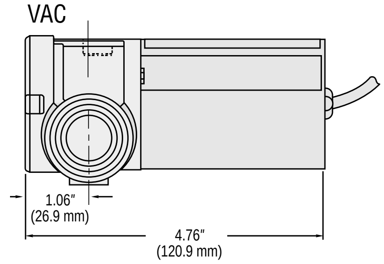




Brass and Stainless Steel Bodies - .75″ and 1.00″ Port



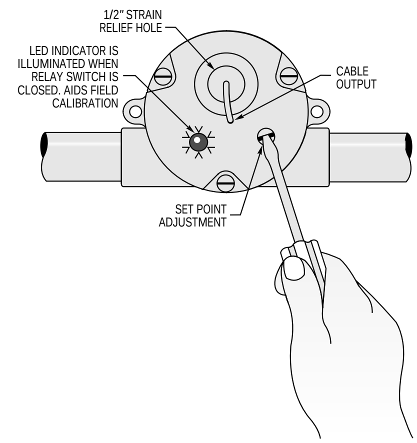




Switch Set Point Calibration With LED Signal (RFS Type)

With the unit installed in the line and power supplied, complete the following steps to calibrate switch actuation point with proper flow rate. A small flat-blade screwdriver is the only tool required.

1. Adjust liquid flow in the line to the rate at which switch actuation is desired.
2. Insert screwdriver into opening on backside of housing and fit blade into the potentiometer adjustment screw inside.
3. If LED is not illuminated, slowly turn screwdriver counterclockwise and stop as soon as LED illuminates.
4. If LED is illuminated, turn screwdriver clockwise until LED light goes out. Then, slowly turn screwdriver counterclockwise and stop as soon as LED illuminates.



How To Order

Specify Part Number based on desired body material, port size and input power rating.

Body Material	Port Size NPT	Flow Ranges – GPM Low Range*	Flow Ranges – GPM Standard Range	Input Power	Part Number
Polypropylene	.25″	0.1 to 1.0	0.5 to 5.0	24 VDC	**155425** ⚡
				110 VAC	**155876** ⚡
	.50″	1.5 to 12.0	4.0 to 20.0	24 VDC	**155485** ⚡
				110 VAC	**155886** ⚡
Brass	.25″	0.1 to 1.0	0.5 to 5.0	24 VDC	**156265** ⚡
				110 VAC	**156266** ⚡
	.50″	1.5 to 12.0	4.0 to 20.0	24 VDC	**156268** ⚡
				110 VAC	**156269** ⚡
	.75″	–	5.0 to 30.0	24 VDC	**180395** ⚡
				110 VAC	**180396** ⚡
	1.00″	–	8.0 to 60.0	24 VDC	**181688** ⚡
				115 VAC	**181689** ⚡
Stainless Steel	9/16-18**	0.1 to 1.0	0.5 to 5.0	24 VDC	**165073** ⚡
				110 VAC	**165074**
	.50″	1.5 to 12.0	4.0 to 20.0	24 VDC	**165077** ⚡
				110 VAC	**165078** ⚡
	.75″	–	5.0 to 30.0	24 VDC	**181691**
				115 VAC	**181692**
	1.00″	–	8.0 to 60.0	24 VDC	**181693**
				115 VAC	**181694**

* With use of Low Flow Adapter supplied. See Page J-7 for more information.
** Straight thread with O-ring seal.
⚡ – Stock Items.

Special Requirements:

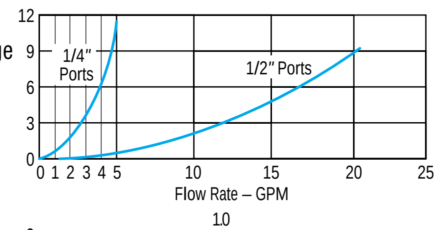
GEMS caters to OEM needs with special configurations for potable water and enhanced chemical capabilities. Consult factory for further details.

High Resolution Black Rotor

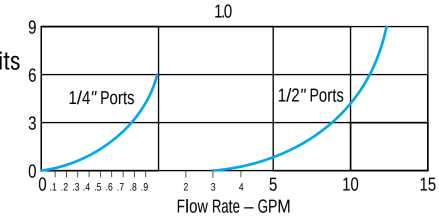
PPS composite. Each of the six rotor arms is magnetized.

Pressure Drop-Typical

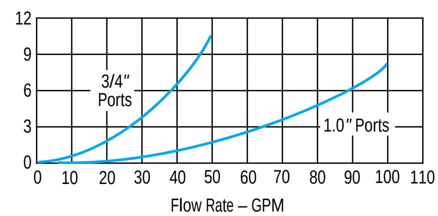
Standard Flow Range Units



Low Flow Range Units



High Flow Units



User’s Manual

Model 211
Temperature Monitor

LakeShore®

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Rev. 1.0 P/N 119-035 **2 April 2002**

LIMITED WARRANTY

Lake Shore Cryotronics, Inc. (henceforth Lake Shore), the manufacturer, warrants this product to be free from defects in material and workmanship for a period of 12 months from the date of shipment. During the warranty period, under authorized return of instruments or component parts to Lake Shore freight prepaid, the company will repair, or at its option replace, any part found to be defective in material or workmanship, without charge to the Owner for parts, service labor, or associated customary shipping cost. Replacement or repaired parts will be warranted for only the unexpired portion of the original warranty or 90 days (whichever is greater)

All products are thoroughly tested and calibrated to published specifications prior to shipment. Calibration Certifications are offered for 12-month periods only. Where such documentation must be updated, a re-certification service is offered by Lake Shore at a reasonable cost.

LIMITATION OF WARRANTY

This warranty is limited to Lake Shore products purchased and installed in the United States, or Internationally through our approved distribution agents. This same protection will extend to any subsequent owner during the warranty period. It does not apply to damage resulting from improper or inadequate maintenance, unauthorized modification or misuse, or operation outside of the environmental specifications. It does not apply to damage caused by accident, misuse, fire, flood, or acts of God, or from failure to properly install, operate, or maintain the product in accordance with the printed instruction provided.

This warranty is in lieu of any other warranties, expressed or implied, including merchantability or fitness for a particular purpose, which are expressly excluded. The owner agrees that Lake Shore’s liability with respect to this product shall be set forth in this warranty, and incidental or consequential damages are expressly excluded.

CERTIFICATION

Lake Shore certifies that this product has been inspected and tested in accordance with its published specifications and that this product met its published specifications at the time of shipment. The accuracy and calibration of this product at the time of shipment are traceable to the United States National Institute of Standards and Technology (NIST); formerly known as the National Bureau of Standards (NBS), or to a recognized natural standard.

FIRMWARE LIMITATIONS

Lake Shore has worked to ensure that the Model 211 firmware is as free of errors as possible, and that the results you obtain from the instrument are accurate and reliable. However, as with any computer-based software, the possibility of errors exists.

In any important research, as when using any laboratory equipment, results should be carefully examined and rechecked before final conclusions are drawn. Neither Lake Shore nor anyone else involved in the creation or production of this firmware can pay for loss of time, inconvenience, loss of use of the product, or property damage caused by this product or its failure to work, or any other incidental or consequential damages. Use of our product implies that you understand the Lake Shore license agreement and statement of limited warranty.

FIRMWARE LICENSE AGREEMENT

The firmware in this instrument is protected by United States copyright law and international treaty provisions. To maintain the warranty, the code contained in the firmware must not be modified. Any changes made to the code is at the user’s risk. Lake Shore assumes no responsibility for damage or errors incurred as result of any changes made to the firmware.

Under the terms of this agreement you may only use the Model 211 firmware as physically installed in the instrument. Archival copies are strictly forbidden. You may not decompile, disassemble, or reverse engineer the firmware. If you suspect there are problems with the firmware, return the instrument to Lake Shore for repair under the terms of the Limited Warranty specified above. Any unauthorized duplication or use of the Model 211 firmware in whole or in part, in print, or in any other storage and retrieval system is forbidden.

TRADEMARK ACKNOWLEDGEMENT

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Cryo-Gloves® is a trademark of Tempshield.
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CHAPTER 1

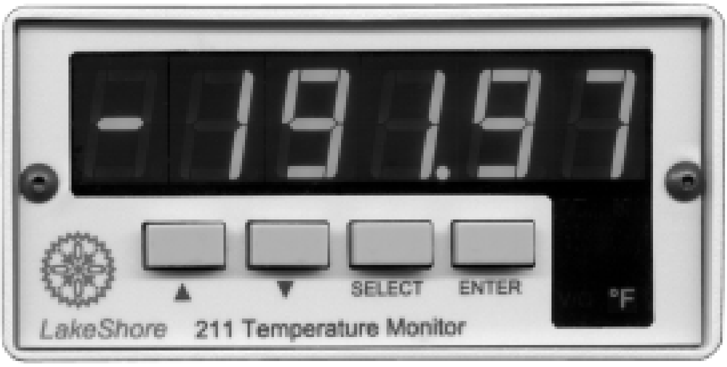
INTRODUCTION

1.0 GENERAL

This chapter provides an introduction to the Model 211 Temperature Monitor. The Model 211 was designed and manufactured in the United States of America by Lake Shore Cryotronics. A general description is provided in Paragraph 1.1, specifications in Paragraph 1.2, safety summary in Paragraph 1.3, and safety symbols in Paragraph 1.4.

1.1 DESCRIPTION

The Lake Shore single-channel Model 211 Temperature Monitor provides the accuracy, resolution, and interface features of a benchtop temperature monitor in an easy to use, easily integrated, compact instrument. With appropriate sensors, the Model 211 measures temperature from 1.4 to 800 K and in difficult sensing conditions, including high vacuum and magnetic fields. Alarms, relays, user-configurable analog voltage or current output, and a serial interface are standard features on the Model 211. Backed by the Lake Shore tradition of excellence in cryogenic and precision temperature measurement for science and industry, the Model 211 is a good choice for liquefied gas storage/monitoring, cryopump control, cryo-cooler, and materials science applications, and for applications that require greater accuracy than thermocouples allow.



211_LED_Front.bmp

Figure 1-1. Model 211 Front Panel

General Description (Continued)

The Model 211 Temperature Monitor supports diode temperature sensors and resistance temperature detectors (RTDs). The Model 211 can be configured for the type of sensor in use from the instrument front panel. Four-lead differential measurement and 24-bit analog-to-digital conversion ensure high accuracy and 5-digit measurement resolution. Temperature data can be read up to seven times per second over computer interface; the display is updated twice each second.

The Model 211 converts voltage or resistance to temperature units based on temperature response curve data for the sensor in use. Standard temperature response curves for silicon diodes and platinum RTDs are included in instrument firmware. The Model 211 also provides non-volatile memory for one 200-point temperature response curve which can be entered via the serial interface. Measurements are available in temperature units K, °C, °F, or sensor units V or Ω.

With an RS-232C serial interface and other interface features, the Model 211 is valuable as a stand-alone monitor and is easily integrated into other systems. Setup and every instrument function can be performed via serial interface or the front panel of the Model 211. High and low alarms can be used in latching mode for error limit detection and in non-latching mode in conjunction with relays to perform simple on-off control functions. The analog output can be configured for either 0 to 10 V or 4 to 20 mA output.

Table 1-1. Temperature Range of Typical Lake Shore Sensors *

Diodes	***Model***	***Useful Range***
Silicon Diodes	DT-670	1.4 – 500 K
GaAlAs Diode	TG-120	1.4 – 475 K
Positive Temperature Coefficient (PTC) RTDs		
100 Ω Platinum RTD	PT-100, 250 Ω full scale	30 – 675 K
100 Ω Platinum RTD	PT-100, 500 Ω full scale	30 – 800 K
Rhodium-Iron RTD	RF-800-4	1.4 – 400 K
Negative Temperature Coefficient (NTC) † RTDs		
Germanium RTD	GR-200A-1000	2 – 100 K
Germanium RTD	GR-200A-250	1.2 – 40 K
Carbon-Glass™ RTD	CGR-1-500	3 – 325 K
Cernox™ RTD	CX-1050 AA or SD	3.5 – 325 K
Cernox™ RTD	CX-1030 AA or SD	2 – 325 K
High-Temperature Cernox™ RTD	CX-1030-SD-HT	2 – 420 K
Rox™ Ruthenium Oxide RTD	RX-102A	2 – 40 K
Rox™ Ruthenium Oxide RTD	RX-202A	3 – 40 K

* Sensors sold separately.

† Single excitation current may limit the low temperature range of NTC resistors.

1.2 SPECIFICATIONS

Thermometry

Number of Inputs: 1
Measurement Type: 4-lead differential
Excitation: Constant current, 10 µA or 1 mA
Isolation: Measurement is not isolated from chassis ground
A/D Resolution: 24 bit
Input Accuracy: Sensor dependent. Refer to Table 1-2
Measurement Resolution: Sensor dependent. Refer to Table 1-2
Maximum Update Rate: 7 readings per second
Supported Sensors: Diodes: Silicon, GaAlAs;
RTDs: 100 Ω Platinum, 1000 Ω Platinum, Cernox, Carbon Glass, ROX
Standard Curves: DT-470, DT-670, CTI Curve C, PT-100, PT-1000
User Curve: One, 200 point CalCurve or User curve in non-volatile memory
Settings: Sensor Type, Sensor Curve
Input Connector: DB-25

Front Panel

Display Type: 5 digit LED
Display Units: K, °C, °F, V, Ω
Display Update Rate: Twice per second
Temperature Display Resolution: 0.001° between 0 – 99.999°,
0.01° between 100 – 999.99°, 0.1° above 1000°
Sensor Units Display Resolution: Sensor dependent, to 5 digits
Display Annunciators: K, °C, °F, V/Ω
Keys: Select, Enter, ▲ (Up Arrow), ▼ (Down Arrow)
Front Panel Features: Display Units, Display Brightness,
Keypad Lockout, Instrument Reset

Interface

Serial Interface:
Format: RS-232C
Baud Rate: 9600 BAUD
Reading Rate: To 7 readings per second
Special Features: User Curve Entry, LabView Driver
Connector: DE-9
Alarms:
Number: 2, High and Low
Settings: High Setpoint, Low Setpoint, Dead band,
Latching or Non-Latching, Alarm On/Off
Actuators: Display message, relays

Interface Specifications (Continued)

Relays:

Number: 2

Contacts: Normally Open (NO), Normally Closed (NC), and Common (C)

Contact Rating: 30 VDC at 1 A

Settings: manually off, manually on, follows alarms

Connector: DB-25 (shares input connector)

Analog Output:

Isolation: Output is not isolated from chassis ground

Update Rate: 7 readings per second

	Voltage	Current
Range:	0 – 10 V	4 – 20 mA
Resolution:	0.15 mV	0.3 µA
Accuracy:	±1.25 mV	±2.5 µA
Minimum Load Resistance:	500 Ω (short-circuit protected)	NA
Compliance Voltage:	NA	10 V
Load Regulation	NA	±0.02% RDG 0 to 500 Ω

Scales:

Temperature	Sensor Units (Fixed by type)
0 – 20 K 0 – 100 K 0 – 200 K 0 – 325 K 0 – 475 K 0 – 1000 K	Diodes: 1 V = 1V 100 Ω Platinum: 1 V = 100 Ω 1000 Ω Platinum: 1 V = 1000 Ω NTC Resistor: 1 V = 1000 Ω

Settings: Voltage or current, scale
Connector: DB-25 (shares input connector)

General

Ambient Temperature: 15 – 35 °C (59 – 95 °F) at rated accuracy,
10 – 40 °C (50 – 104 °F) at reduced accuracy

Power Requirement: Regulated +5 VDC @ 300 mA, +15 VDC @ 75 mA,
–15 VDC @ 15 mA, 5 pin DIN

Size: 96 mm W × 48 mm H × 166 mm D (3.8 × 1.9 × 6.5 inches)

Mounting: Panel mount into 91 mm W × 44 mm H (3.6 × 1.7 inch) cutout

Weight: 0.65 kilograms (1.5 pounds)

Approval: CE Mark (consult factory)

Ordering Information

Model

211	Model 211 only (without power supply)
211-UN	Model 211 with 100 – 250 V (universal input), 17 VA power supply (P/N 109-012)

Power Options (Model 211-UN only)

VAC-120	Includes U.S. line cord
VAC-220	Includes European line cord

Accessories included with the Model 211 Temperature Monitor

106-253	Sensor input mating connector (DB-25)
106-264	Shell for sensor input mating connector
MAN-211	User's manual

NOTE: Panel mount hardware installed at factory.

Calibration Options

8000	CalCurve, floppy disk. Consists of a calibrated sensor breakpoint table on a floppy disk in ASCII format for customer download.
8001-211	CalCurve, factory installed. Consists of a calibrated sensor breakpoint table factory-installed into non-volatile memory.
CAL-211	Instrument calibration with certificate.
CAL-211DATA	Instrument calibration with certificate and data.

Accessories Available

2111	Single ¼ DIN panel mount adapter (see Figure 2-5).
2112	Dual ¼ DIN panel mount adapter (see Figure 2-5).

Table 1-2. Sensor Input Performance Chart

Sensor Type	Silicon Diode	GaAlAs Diode
Temperature Coefficient	Negative	Negative
Sensor Units	Volts (V)	Volts (V)
Input Range	0 – 2.5 V	0 – 7.5 V
Sensor Excitation (Constant Current)	10 µA ±0.01%	10 µA ±0.01%
Display Resolution (Sensor Units)	100 µV	100 µV
Example LSCI Sensor	DT-670-SD-13 with 1.4H Cal.	TG-120SD with 1.4H Cal.
Temperature Range	1.4 – 475 K	1.4 – 475 K
Standard Sensor Curve	DT-670	Requires Calibration
Typical Sensor Sensitivity	–31.6 mV at 4.2 K –1.73 mV at 77 K –2.3 mV at 300 K –2.12 mV at 500 K	–180 mV/K at 10 K –1.25 mV/K at 77 K –2.75 mV/K at 300 K –2.75 mV/K at 475 K
Measurement Resolution: Sensor Units Temperature Equivalence	 20 µV 0.6 mK at 4.2 K 11.6 mK at 77 K 8.7 mK at 300 K 9.4 mK at 500 K	 20 µV 1 mK at 10 K 16 mK at 77 K 10 mK at 300 K 10 mK at 475 K
Electronic Accuracy: Sensor Units Temperature Equivalence	 ±160 µV ±0.01% RDG ±10 mK at 4.2 K ±152 mK at 77 K ±94 mK at 300 K ±80 mK at 500 K	 ±160 µV ±0.02% RDG ±6 mK at 10 K ±300 mK at 77 K ±150 mK at 300 K ±110 mK at 475 K
Temperature Coefficient	±10 µV ±5 PPM of reading per °C	±20 µV ±5 PPM of reading per °C
Temperature Accuracy including electronic accuracy, CalCurve™ and calibrated sensor	±31 mK at 4.2 K ±267 mK at 77 K ±154 mK at 300 K ±140 mK at 500 K	±21 mK at 10 K ±390 mK at 77 K ±140 mK at 300 K ±210 mK at 475 K
Magnetic Field Use	Recommended for T $\geq$ 60 K & B $\leq$ 3 T	Recommended for T > 4.2 K & B $\leq$ 5 T

Table 1-2. Sensor Input Performance Chart (Continued)

100 Ω Platinum RTD 500 Ω Full Scale	1000 Ω Platinum RTD	Cernox™ RTD
Positive	Positive	Negative
Ohms (Ω)	Ohms (Ω)	Ohms (Ω)
0 – 500 Ω	0 – 5000 Ω	0 – 7500 Ω
1 mA ±0.3%	1 mA ±0.3%	10 µA ±0.01%
10 mΩ	100 mΩ	100 mΩ
PT-103 with 14J Cal.	PT-1001 * with 1.4J Cal.	CX-1050-SD with 4L Cal.
30 – 800 K	30 – 800 K	3.5 – 400 K
DIN 43760	Scaled from DIN 43670	Requires calibration
0.19 Ω/K at 30 K 0.42 Ω/K at 77 K 0.39 Ω/K at 300 K 0.35 Ω/K at 675 K 0.33 Ω/K at 800 K	1.9 Ω/K at 30 K 4.2 Ω/K at 77 K 3.9 Ω/K at 300 K 3.3 Ω/K at 800 K	–770 Ω/K at 4.2 K –1.5 Ω/K at 77 K –0.1 Ω/K at 300 K
2 mΩ 10.6 mK at 30 K 10 mK at 77 K 10 mK at 300 K 10 mK at 675 K 10 mK at 800 K	20 mΩ 10.6 mK at 30 K 10 mK at 77 K 10 mK at 300 K 10 mK at 800 K	50 mΩ 1 mK at 4.2 K 33.3 mK at 77 K 500 mK at 300 K
±0.004 Ω ±0.02% RDG ±25 mK at 30 K ±18 mK at 77 K ±70 mK at 300 K ±162 mK at 675 K ±187 mK at 800 K	±0.06 Ω ±0.04% RDG ±40 mK at 30 K ±33 mK at 77 K ±135 mK at 300 K ±370 mK at 800 K	±0.1 Ω ±0.04% RDG ±1 mK at 4.2 K ±88 mK at 77 K ±1.144 K at 300K
±0.2 mΩ ±5 PPM of reading per °C	±2.0 mΩ ±5 PPM of reading per °C	±20 mΩ ±15 PPM of reading per °C
±45 mK at 30 K ±38 mK at 77 K ±105 mK at 300 K ±262 mK at 675 K ±287 mK at 800 K	±60 mK at 30 K ±53 mK at 77 K ±170 mK at 300 K ±470 mK at 800 K	±9 mK at 4.2 K † ±138 mK at 77 K † ±1.284 K at 300K †
Recommended for T > 40 K & B ≤ 2.5 T	Recommended for T > 40 K & B ≤ 2.5 T	Recommended for T > 2 K & B ≤ 19 T

* No longer available from Lake Shore.

† Specified accuracy includes no effects of thermal EMF voltages. An error of 3 mΩ results from each 1 µV of thermal EMF voltage. In well-designed systems, thermal EMF voltage should be <10 µV.

1.3 SAFETY SUMMARY

Observe these general safety precautions during all phases of instrument operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended instrument use. Lake Shore Cryotronics assumes no liability for Customer failure to comply with these requirements.

The Model 211 protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument.

The Model 211 is designed for indoor use only. Improper use of the instrument may pose a hazard to the operator and surrounding area.

The power supply included with the Model 211-UN meets or exceeds the International Safety Standard for Information Technology Equipment, IEC 60950.

Ground The Instrument

To minimize shock hazard, the optional instrument power supply is equipped with a 3-conductor AC power cable. Plug the power cable into an approved three-contact electrical outlet or use a three-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Do Not Operate In An Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Keep Away From Live Circuits

Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

Safety Summary (Continued)

Do Not Substitute Parts Or Modify Instrument

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized Lake Shore Cryotronics representative for service and repair to ensure that safety features are maintained.

Cleaning

Do not submerge instrument. Clean only with a damp cloth and mild detergent. Exterior only.

1.4 SAFETY SYMBOLS

Direct current (power line).

Alternating current (power line).

Alternating or direct current (power line).

Three-phase alternating current (power line).

Earth (ground) terminal.

Protective conductor terminal.

Frame or chassis terminal.

On (supply).

Off (supply).

Equipment protected throughout by double insulation or reinforced insulation (equivalent to Class II of IEC 536 - see Annex H).

Caution: High voltages; danger of electric shock. Background color: Yellow; Symbol and outline: Black.

Caution or Warning - See instrument documentation. Background color: Yellow; Symbol and outline: Black.

Fuse.

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CHAPTER 2

INSTALLATION

2.0 GENERAL

This chapter provides general installation instructions for the Model 211 Temperature Monitor. To ensure the best possible performance and to maintain operator safety, please read the entire chapter before installing and operating the instrument. Refer to Chapter 3 for operating instructions. Refer to Chapter 4 for computer interface installation and operation.

2.1 INSPECTION AND UNPACKING

Inspect shipping containers for external damage before opening. Photograph any container that has significant damage before opening it. If there is visible damage to the contents of the container, contact the shipping company and Lake Shore immediately, preferably within 5 days of receipt of goods. Keep all damaged shipping materials and contents until instructed to either return or discard them.

Open the shipping container and keep the container and shipping materials until all contents have been accounted for. Check off each item on the packing list as it is unpacked. Instruments may be shipped as several parts. The items included with the Model 211 are listed as follows.

Items Included with Model 211 Temperature Monitor:

- Model 211 Instrument
- Model 211 User's Manual
- Input/Output Mating Connector and Shell
- Panel Mount Hardware Installed at Factory

Items Also Included with Model 211-UN Option:

- Universal Input Power Supply
- Line Power Cord

Contact Lake Shore immediately if there is a shortage of parts or accessories. Lake Shore is not responsible for any missing items if not notified within 60 days of shipment.

INSPECTION AND UNPACKING (Continued)

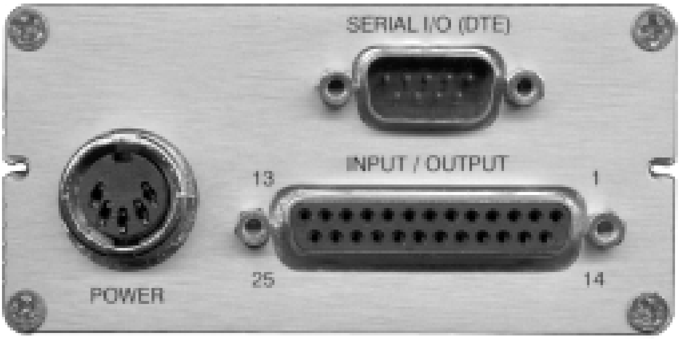
Inspect all items for both visible and hidden damage that occurred during shipment. If damage is found, contact Lake Shore immediately for instructions on how to file a proper insurance claim. Lake Shore products are insured against damage during shipment but a timely claim must be filed before Lake Shore will take further action. Procedures vary slightly with shipping companies. Keep all shipping materials and damaged contents until instructed to either return or discard them.

If the instrument must be returned for recalibration, replacement or repair, a returned goods authorization (RGA) number must be obtained from a factory representative before it is returned. The Lake Shore RGA procedure is given in Paragraph 5.2.

2.2 REAR PANEL DEFINITION

This paragraph describes the connectors on the rear panel of the Model 211. See Figure 2-1. Readers are referred to paragraphs that contain installation instructions and connector pin-outs for each feature. A summary of connector pin-outs is provided in Paragraph 5.6.

CAUTION: Only make rear panel connections with the power supply disconnected.



211_Rear.bmp

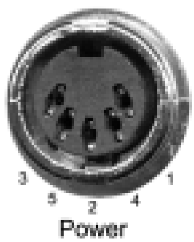
		Description	*Details*
1	POWER 5-pin DIN	Paragraph 2.3	Figure 5.2
2	SERIAL I/O (DTE) DE-9	Paragraph 4.1.1	Figure 5.4
3	INPUT/OUTPUT DB-25	Paragraphs 2.4 – 2.6	Figure 5.3

Figure 2-1. Model 211 Rear Panel

2.3 POWER INPUT CONNECTOR

Power is supplied to the Model 211 through a 5-pin DIN connector located on the rear panel of the instrument. There is no power switch on the instrument, so it is off when not plugged in, or on when plugged in. Make sensor connections before applying power to the instrument. The instrument requires +5 V at 300 mA, +15 V at 75 mA, and –15 V at 15 mA. Refer to Figure 2-2 for pin out descriptions.

WARNING: To prevent electrical fire or shock hazards, do not expose this instrument, or its power supply, to rain or excess moisture.



Pin	Description
1	Ground
2	Ground
3	+5V
4	–15V
5	+15V

Figure 2-2. Power Connector

2.4 EXTERNAL POWER SUPPLY (Model 211-UN Only)

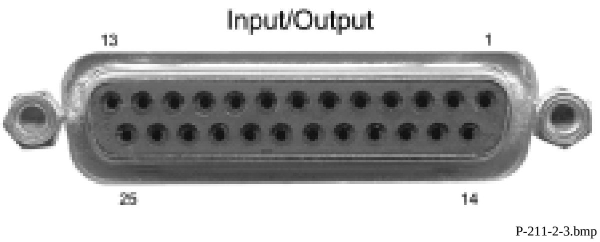
The Model 211-UN comes with the optional universal input power supply, Lake Shore P/N 109-012. This power supply can accept input voltages from 100 to 240 VAC (±10%), 50 to 60 Hertz. It has an IEC 320-C14 line cord receptacle for input power and a 5-pin DIN connector for the output. It can output +5 V at 1 A, +15 V at 400 mA, and –15V at 400 mA. One power supply can provide power for up to three Model 211's with a user supplied adapter cable. The power supply is CE Certified and meets or exceeds the following safety standards: UL 1950, CSA C22.2, and IEC 60950.

2.5 SENSOR INPUT

This paragraph details how to connect diode and resistor sensors to the Model 211 input. Refer to Paragraph 3.5 to configure the input. Sensor installation instructions are provided in the Lake Shore Temperature Measurement and Control Catalog.

2.5.1 Input/Output Connector

Sensors are connected to the Model 211 through the Input/Output connector on the rear panel of the instrument. The Input/Output connector is also used for the analog output and relay connections. Refer to Figure 2-3 for pin descriptions.



Pin	Description	Pin	Description
1	No Connection	—	—
2	Shield	14	Shield
3	I+	15	I–
4	V+	16	V–
5	Shield	17	Shield
6	Analog Output Signal	18	Analog Output Ground
7	No Connection	19	No Connection
8	Low Alarm COM	20	Low Alarm N.O.
9	Low Alarm N.C.	21	No Connection
10	No Connection	22	No Connection
11	High Alarm COM	23	High Alarm N.O.
12	High Alarm N.C.	24	No Connection
13	No Connection	25	No Connection

Figure 2-3. Input/Output Connector

2.5.2 Sensor Lead Cable

The sensor lead cable used outside the cooling system can be much different from what is used inside. Between the instrument and vacuum shroud, heat leak is not a problem, but errors from noise pick up need to be minimized. Larger conductor, 22 to 28 AWG stranded copper wire is recommended because it has low resistance yet remains flexible when several wires are bundled in a cable. The arrangement of wires in a cable is also important. For best results, twist voltage leads, V+ and V– together and twist current leads I+ and I– together. Cover the twisted pairs of voltage and current leads with a braided or foil shield connected to the shield pin of the instrument. This type of cable is available through local electronics suppliers. Instrument specifications are given assuming 10 feet of sensor cable. Longer cables, 100 feet or more, can be used but environmental conditions may degrade accuracy and noise specifications.

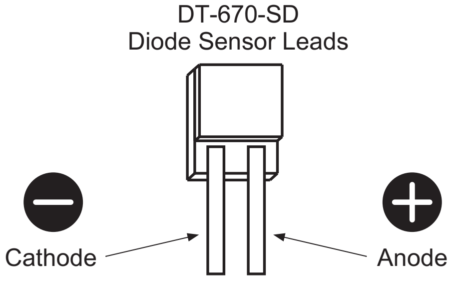
2.5.3 Grounding and Shielding Sensor Leads

The sensor input circuitry is NOT isolated from earth ground. Do not ground sensor leads outside of the instrument.

Shielding the sensor lead cable is important to keep external noise from entering the measurement. A shield is most effective when it is near the measurement potential, so the Model 211 offers a shield that stays close to the measurement. Connect the sensor cable shield to the input connector shield pin. Do not terminate the shield at the opposite end or ground loops may be formed.

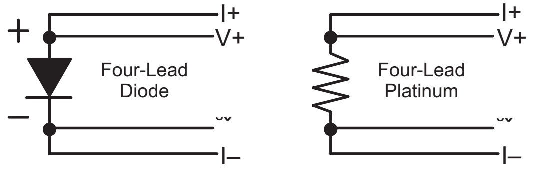
2.5.4 Sensor Polarity

Lake Shore sensors ship with instructions that indicate which sensor leads are which. It is important to follow these instructions for plus and minus leads (polarity) as well as voltage and current when applicable. Diode sensors do not operate in the wrong polarity. They look like an open circuit to the instrument. Two-lead resistors can operate with any lead arrangement and the sensor instructions may not specify polarity. Four-lead resistors may depend more on lead arrangement. Follow any specified lead assignment for four lead resistors. Mixing leads could give a reading that appears correct, but is not the most accurate.



2.5.5 Four-Lead Sensor Measurement

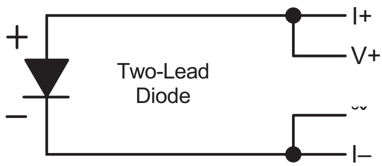
All sensors, including both two-lead and four-lead can be measured with a four-lead technique. Four-lead measurement eliminates the effect of lead resistance on the measurement. If it is not taken out, lead resistance is a direct error when measuring a sensor.



In a four lead measurement, current leads and voltage leads run separately to the sensor. With separate leads, there is little current in the voltage leads so their resistance does not enter into the measurement. Resistance in the current leads will not change the current as long as the voltage compliance of the current source is not reached. When two lead sensors are used in four lead measurements, the short leads on the sensor have an insignificant resistance.

2.5.6 Two-Lead Sensor Measurement

Sometimes a crowded cryogenic system forces users to read sensors in a two-lead configuration because there are not enough feedthroughs or room for lead wires. If this is the case, plus voltage to plus current and minus voltage to minus current leads are attached at the back of the instrument or at the vacuum feedthrough.



The error in a resistive measurement is the resistance of the lead wire run with current and voltage together. If the leads contribute 2 or 3 Ω to a 5 kΩ reading, the error can probably be tolerated. When measuring voltage for diode sensors the error in voltage can be calculated as the lead resistance times the current, typically 10 µA. For example: a 10 Ω lead resistance times 10 µA results in a 0.1 mV error in voltage. Given the sensitivity of a silicon diode at 4.2 K the error in temperature would be only 3 mK. At 77 K the sensitivity of a silicon diode is lower so the error would be close to 50 mK. Again, this may not be a problem for every user.

2.5.7 Lowering Measurement Noise

Good instrument hardware setup technique is one of the least expensive ways to reduce measurement noise. The suggestions fall into two categories: (1) Do not let noise from the outside enter into the measurement, and (2) Let the instrument hardware features work to their best advantage.

- Use 4-lead measurement whenever possible.
- Do not connect sensor leads to chassis or earth ground.
- Use twisted shielded cable outside the cooling system.
- Attach the shield pin on the sensor connector to the cable shield.
- Do not attach the cable shield at the other end of the cable, not even to ground without taking precautions to prevent ground loops.
- Run different inputs and outputs in their own shielded cable.
- Use twisted wire inside the cooling system.
- Use a grounded receptacle for the instrument power cord.
- Consider ground strapping the instrument chassis to other instruments or computers.

2.6 ANALOG OUTPUT

The Analog Output available on the rear panel of the Model 211 can be configured as either a voltage or current output that can be used for monitor and control applications. Its most basic function is a temperature monitor where it puts out a voltage or current that is proportional to temperature. Refer to Paragraph 3.8 to configure the analog output.

In voltage mode the analog output can vary from 0 – 10 V with a resolution of 0.15 mV or 0.0015% of full scale. The output can drive a resistive load of no less than 500 Ω. The output is short-circuit protected so the instrument is not harmed if the load resistance is too small. However, this practice is not recommended as the additional load on the instrument power supply causes noise on internal circuits.

In current mode, the analog output can vary from 4 to 20 mA with a resolution of 0.3 μA or 0.0015% of full scale. The output is limited by a 10 V compliance voltage so the largest resistive load that the output can drive in current mode is 500 Ω.

The output for the analog output is available from Pins 6 and 18 of the Input/Output connector. See Figure 2-3. The terminal marked analog output signal is the output voltage terminal, the terminal marked analog output ground is the ground and is attached to chassis ground inside the instrument.

It is not recommended to attach the analog output ground to a ground outside the instrument. The output should be read by an instrument with an isolated or differential input wherever possible. Connecting to an external ground can cause noise in the analog output voltage or the sensor input measurement. If this cannot be avoided, try to keep the chassis of the two instruments at the same potential with a ground strap.

2.7 RELAYS

The Model 211 has two relays, labeled high and low. The relays are most commonly associated with the alarm feature. The relays can also be placed in manual mode and controlled directly by the user from the front panel or over the computer interface. Refer to Paragraph 3.7 and the RELAY command in Chapter 4.

Normally Open (N.O.), Normally Closed (N.C.), and Common (COM) contacts are available for each relay. All contacts (including common) are isolated from the measurement and chassis grounds of the instrument. If a relay is inactive (Off), it will be in its normal state of open or closed. When the relay is active (On), it will be in the opposite state. Relay connections are available on the Input/Output connector. See Figure 2-3.

2.8 PANEL MOUNTING

The Model 211 can be easily panel mounted using the panel mount brackets included. The Model 211 fits in a 91 × 44 mm (3.6 × 1.7 inch) cutout. To panel mount the instrument, unplug the unit and then use a $^{1}/_{16}$ inch hex wrench to remove the 2 set screws holding the brackets in place. Remove the 2 panel mount brackets by sliding them towards the rear of the unit. Then place the unit into the panel cutout. Slide the two panel mount brackets back into the case of the instrument. Reinstall the 2 set screws and tighten them until the instrument is secure.

The Model 211 can also be purchased with either of two panel mount adapters. The Model 2111 or 2112 will mount 1 or 2 Temperature Monitors in a ¼ DIN cutout measuring 105 mm Wide × 132 mm High (4.1 × 5.2 inches). See Figure 2-5.

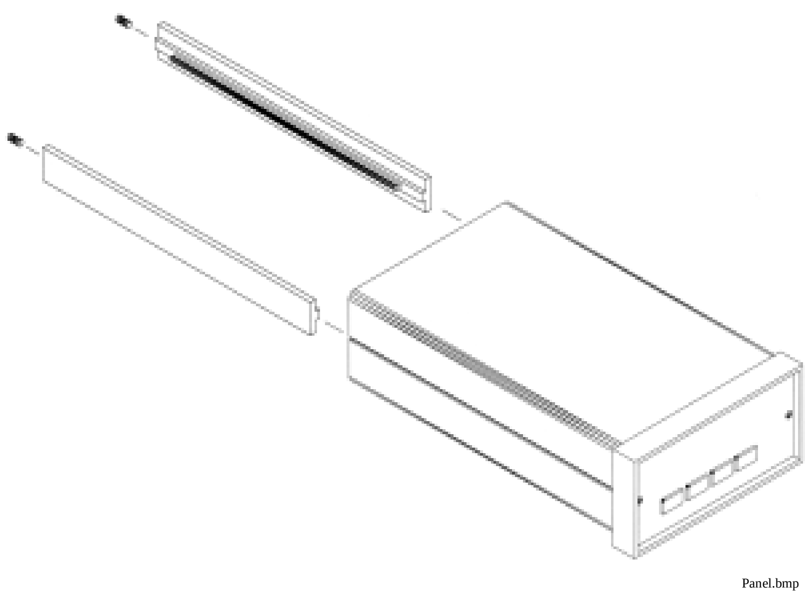
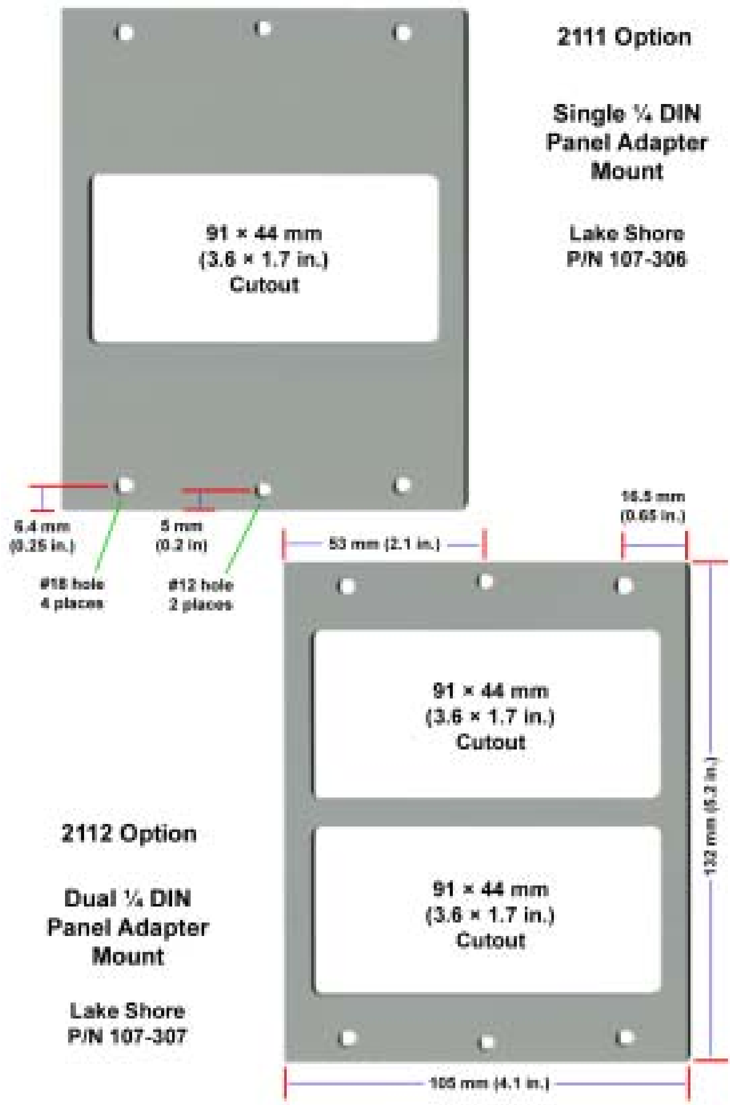


Figure 2-4. Panel Mounting Details



Cutout_Panels.bmp

Figure 2-5. 2111 and 2112 Panel Mount Adapters

CHAPTER 3

OPERATION

3.0 GENERAL

This chapter provides operating instructions for most features of the Model 211 Temperature Monitor. Corresponding computer interface instructions for these features are provided in Chapter 4.

3.1 INSTRUMENT POWER

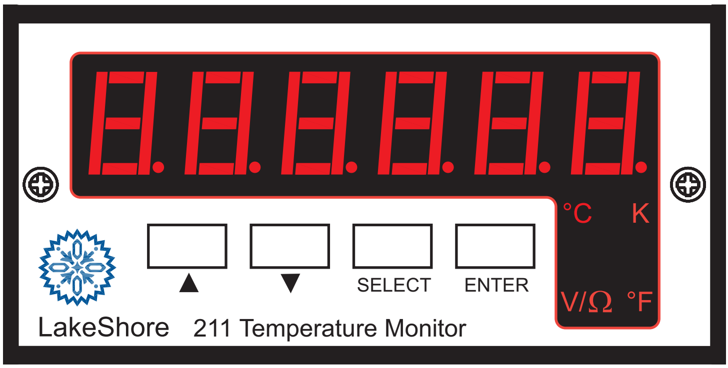
The Model 211 is powered on by plugging in the power supply. There is no power switch on the instrument. When the Model 211 is powered on every segment on the display will illuminate for a few seconds to indicate instrument initialization. Most of the instrument setup parameter values are retained when powered off with one exception. The latching alarm will reset itself on power-up. When the instrument is powered on for the first time parameter values are set to their defaults, listed in Table 3-6.

When initialization is complete the instrument will begin its normal reading cycle and temperature or sensor units readings should appear on the display. Messages will appear in the reading location on the display if the measurement input has not been fully configured. Messages listed in Paragraph 5.3.1, Instrument Hardware Errors, are related to the instrument hardware and may require help from Lake Shore service. The messages listed in Paragraph 5.3.2, Limit Errors, do not indicate a problem with the instrument and will disappear when input setup is complete.

The Model 211 should be allowed to warm up for a minimum of 30 minutes to achieve rated accuracy.

3.2 DISPLAY DEFINITION

The Model 211 has a 6-digit LED display capable of showing both numeric and character data. In normal operation the display shows the current sensor reading in sensor units or temperature units. The four annunciators below the right hand side of the display indicate what units the display is reading in. Other display configurations appear during parameter setting and data entry operations. These displays are illustrated in their individual operation paragraphs.



211_Display.eps

Figure 3-1. Model 211 Display

3.3 LED ANNUNCIATORS AND DISPLAY MESSAGES

The display units are indicated using LED annunciators below the right side of the main display.

LED Annunciators

°C	The display units are in degrees Celsius.
K	The display units are in Kelvin.
°F	The display units are in degrees Fahrenheit.
V/Ω	The display units are in sensor units, either volts or ohms depending on input type.

Alarm messages are displayed alternately with the reading when an alarm condition exists. If both a high and low alarm condition exists (can only happen when latching alarms are active), then the display will alternate between the current reading and the alarm high and alarm low messages. Other display messages are described in Paragraph 5.3.

Alarm Messages

ALA H	Indicates that the high alarm is active.
ALA L	Indicates that the low alarm is active.

3.4 KEYPAD DEFINITION

The Model 211 has 4 keys on the front panel to setup instrument functions. A list of front panel setup operations is shown in the Model 211 Menu Structure located on the inside back cover of this manual.

3.4.1 Key Descriptions

▲	The up arrow serves two functions: to choose between parameters during setting operations and to increment numerical data. Holding the button in while setting numerical data increases setting speed.
▼	The down arrow serves two functions: to choose between parameters during setting operations and to decrement numerical data. Holding the button in while setting numerical data increases setting speed.
Select	Places the instrument into settings mode where all instrument parameters can be setup. When pressed while in the settings mode, it terminates the settings mode without changing the existing parameter value. Press and hold to display code revision date.
Enter	Completes setting function storing any changes to the parameter value. Press and hold to lock or unlock the keypad.

3.4.2 General Keypad Operation

The Model 211 has two keypad operations: setting selection and data entry.

Setting Selection: Allows the user to select from a finite list of parameter values. During setting selection the ▲ and ▼ keys are used to select a parameter value. **Enter** is used to accept the change and advance to the next parameter. **Select** will cancel the change to that parameter and return to the normal display.

Data Entry: Allows the user to enter numeric parameter values using the ▲ and ▼ keys. Press the ▲ key to increase the value of the setting, or press the ▼ key to decrease its value. Holding either key down for a few seconds will cause the number to change at a faster rate. Once the correct parameter value is entered press **Enter** to accept the change and advance to next parameter. Pressing **Select** will cancel the change to that parameter and return to the normal display.

Related setting selection and data entry sequences are often chained together under a single setting sequence. To skip over a parameter without changing its value press **Enter** before pressing an arrow key. To return to the normal display in the middle of a setting sequence press **Select** before pressing an arrow key. Changes "entered" before **Select** is pressed are kept.

3.5 INPUT SETUP

3.5.1 Input Type

The Model 211 supports a variety of temperature sensors sold by Lake Shore and other manufactures. An appropriate sensor type must be selected for the input. Refer to Table 3-1 for a list of common sensor types. If a particular sensor is not listed in the Input Type selection, look at Table 3-1 to find a sensor with similar range and excitation. For additional details on sensors, refer to the Lake Shore Temperature Measurement and Control Catalog or visit our website at www.lakeshore.com.

To select sensor type, press the **Select** key, use the ▲ or ▼ keys to select " InPUt," then press the **Enter** key. Use the ▲ or ▼ keys to cycle through the sensor types shown in Table 3-1. When the desired type appears, press the **Enter** key. Proceed to Paragraph 3.5.2 to select a temperature curve or press the **Select** key to return to the normal display.

Table 3-1. Sensor Input Types

Display Message	Input Type	Excit-ation	Sensor Type	Curve Format	Coef-ficient	Lake Shore Sensors *
Si	2.5 V	10 µA	Silicon Diode	V/K	Neg.	DT-470, DT-670
GAALAS	7.5 V	10 µA	Gallium-Aluminum-Arsenide Diode	V/K	Neg.	TG-120 Series
250 Pt	250 Ω	1 mA	100 Ω Plat. RTD <675K; Rhodium-Iron RTD	Ω/K	Pos.	PT-100 Series Platinum, RF-800 Rhodium-Iron
500 Pt	500 Ω	1 mA	100 ΩPlat. RTD >675K			
1000Pt	5000 Ω	1 mA	1000 ΩPlat. RTD	Ω/K	Pos.	—
ntcrtd	7500 Ω	10 µA	Negative Temperature Coefficient (NTC) RTD	log R/K	Neg.	Cernox, High-Temp Cernox, Carbon Glass, Germanium, Rox, and Thermox

* Refer to the Lake Shore Temperature Measurement and Control Catalog for complete details on all Lake Shore Temperature Sensors.

3.5.2 Curve Selection

The Model 211 supports a variety of temperature sensors sold by Lake Shore and other manufacturers. After the appropriate sensor type is selected for the input (Paragraph 3.5.1), an appropriate temperature response curve may be selected. The Model 211 can use curves from several sources. Standard curves are included with every instrument and numbered 1 thru 7. A single user curve can be loaded via the serial interface when a sensor does not match a standard curve. CalCurve option can be stored as the user curve at the factory or by the customer. The complete list of standard curves built in to the Model 211 is provided in Table 3-2. Curve tables are listed in Appendix A of this manual.

During normal operation, only the curves related to the input type selected are displayed. If the curve you wish to select does not appear in the selection sequence make sure the curve format matches the recommended format for the input type selected. Refer to Table 3-1.

NOTE: The sensor reading can always be displayed in sensor units. If a temperature response curve is selected for an input, its readings may also be displayed in temperature.

To select a curve, continue from the input type selection (Paragraph 3.5.1) or press the **Select** key, use the ▲ or ▼ key to select " InPUt," then press the **Enter** key twice. The display will show the curve currently assigned to the input. If no curve is attached "nonE" will be displayed. Use the ▲ or ▼ keys to cycle through the temperature response curves. When the desired type appears, press the **Enter** key. Proceed to Paragraph 3.5.3 to select the display units or press the **Select** key to return to the normal display.

Table 3-2. Standard Curves

Curve No.	Display Name	Sensor Type	Lake Shore Sensor	Curve Name	Temperature Range
0	nonE	None	None	None	None
1	dt470	Silicon Diode	DT-470	Curve 10	1.4–475 K
2	dt670	Silicon Diode	DT-670	DT-670	1.4–500 K
3	Ct i	Silicon Diode	N/A	CTI Curve C	10–320 K
6	Pt 100	100 Ω Platinum RTD	PT-100	DIN 43760	30–800 K
7	Pt 1000	1000 Ω Platinum RTD	N/A	DIN 43760	30–800 K
21	USEr	User defined	—	User defined	User defined

3.5.3 Display Units Selection

The Model 211 has a 6-character LED display. During normal operation it can display the senor reading in temperature (Kelvin, Celsius, or Fahrenheit) or sensor units (V or Ω). The LEDs to the right of the keys indicate what units are being displayed.

To select display units, continue from input curve selection (Paragraph 3.5.2) or press the **Select** key, use the ▲ or ▼ key to select " InPUt," then press the **Enter** key three times. The display shows "Un itS" and a LED shows the selected display units. Use the ▲ or ▼ key to cycle through the display units. When the desired unit is highlighted, press the **Enter** key.

3.6 ALARM SETUP AND OPERATION

The input of the Model 211 has high and low alarm capability. Temperature reading data in Kelvin can be compared to the alarm setpoint values. A reading higher than the high setpoint or off the high end of the temperature curve triggers the high alarm and a reading lower than the low alarm setpoint or off the low end of the temperature curve triggers the low alarm.

NOTE: Alarm setpoints are always set in K, but the alarm feature will still operate if the instrument displays °C or °F. If no temperature response curve is chosen, the alarm function will not operate. Refer to Paragraph 3.5.2 for curve selection.

If an alarm activates for the input, the display flashes between the current reading and "ALA H" or "ALA L" for high and low alarms respectively. The two relays can also be tied to alarm functions as described in Paragraph 3.7.

Latching Alarms. Often used to detect faults in a system or experiment that require operator intervention. The alarm state remains visible to the operator for diagnostics even if the alarm condition is removed. Relays often signal remote monitors or for added safety take critical equipment off line. Pressing the **Select** key clears latched alarms.

Non-Latching Alarms. Often tied to relay operation to control part of a system or experiment. The dead band parameter can prevent relays from turning on and off repeatedly when the sensor input reading is near an alarm setpoint. **Example:** If the high alarm setpoint = 100 K and the dead band = 1 K, the high alarm triggers when sensor input temperature increases to 100 K, and it will not deactivate until temperature drops to 99 K.

To begin alarm setup press the **Select** key and use the ▲ or ▼ key to select "ALA" and press the **Enter** key. Use the ▲ or ▼ key to turn the alarm function on or off. If the alarm function is powered on, the alarm will continue with alarm setup otherwise no other settings need to be made and the display will return to normal operation.

Alarm Setup and Operation (Continued)

The next setting is the high alarm point indicated by a "H" on the left of the display. The high alarm setpoint is always set in units of Kelvin. Use the ▲ or ▼ key to set the high alarm setpoint. Holding the button in will increase the rate of change. The minimum value is 0 K and the highest is 999.9 K. Press the **Enter** key to store the high alarm setpoint.

The next setting is the low alarm setpoint indicated by a "L" on the left of the display. Its setting is similar to the high alarm setpoint listed above. Press the **Enter** key to store the low alarm setpoint.

The next setting is the alarm deadband indicated by a "d" on the left of the display. Its setting is similar to the high and low alarm point settings except that the maximum value that can be set is 99.9 K. Press the **Enter** key to store the alarm deadband.

The final setting is alarm latching. The display will show "LtCH" along with the setting, 0 indicating that the latch function is turned off and a 1 indicating that it is turned on. Use the ▲ or ▼ key to set the alarm latching status. Press the **Enter** key to store the alarm latching status. The display will return to normal operation.

3.7 RELAY SETUP

There are two relays on the Model 211 numbered 1 and 2. They are most commonly thought of as alarm relays, but they may be manually controlled. The relays are rated for 30 VDC and 1 A. The terminals are in the Input/Output connector on the Model 211 rear panel. See Figure 2-3.

When using relays with alarm operation, set up the alarms first (Paragraph 3.6). Relay 1 is tied to the low alarm operation and relay 2 is tied to the high alarm operation.

To begin relay setup press the **Select** key and use the ▲ or ▼ key to select "rELAY" and press the **Enter** key. Relay 1 will be setup first indicated by the "r1" on the left of the display. Use the ▲ or ▼ key to select the function of relay 1 from manually off (r1 oFF), manually on (r1 on), or following the low alarm (r1 ALA). If the relay is set to follow the alarm, it will turn on when the temperature drops below the low alarm setpoint. Press the **Enter** key to store the relay setting.

The next setting is the relay 2 setup indicated by the "r2" on the left of the display. Use the ▲ or ▼ key to select the function of relay 2 from manually off (r2 oFF), manually on (r2 on), or following the high alarm (r2 ALA). If the relay is set to follow the alarm, it will turn on when the temperature goes above the high alarm setpoint. Press the **Enter** key to store the relay setting. The display will return to normal operation.

3.8 ANALOG OUTPUT SETUP

The Model 211 has a single analog output. It is normally configured to provide an analog signal proportional to temperature to a strip chart recorder or separate data acquisition system. Pins 6 and 18 on the DB-25 Input/Output connector are used for the analog output. See Figure 2-3.

The analog output is front panel configurable to be either a variable DC voltage or current source. In voltage mode, the analog output can vary from 0 to 10 V with a resolution of 0.15 mV or 0.0015% of full scale. The output can drive a resistive load of no less than 500 Ω. The output is short-circuit protected so the instrument is not harmed if the load resistance is too small. However, this practice is not recommended as the additional load on instrument power supplies causes noise on internal circuits.

In current mode the analog output can vary from 4 to 20 mA with a resolution of 0.2 µA or 0.0015% of full scale. The output is limited by a 10 V compliance voltage so the largest resistive load that the output can drive in current mode is 500 Ω.

The analog output has two modes, voltage and current, and six ranges. The ranges are listed in Table 3-3. The low output is the temperature that produces zero output (0 V or 4 mA) and the high output is the temperature that produces full output (10 V or 20 mA).

If no curve is selected for the input, the analog output range is fixed to output a signal proportional to sensor units. Refer to Table 3-4.

NOTE: When a curve is selected for the input, the analog output always works in units of Kelvin no matter what units are displayed.

To begin analog output setup press the **Select** key and use the ▲ or ▼ key to select "OUtPUt" and press the **Enter** key. Analog output mode will be set up first. Use the ▲ or ▼ key to choose between voltage mode or current mode. Press the **Enter** key to store the analog output mode.

The next setting is analog output range. Refer to Table 3-3 and use the ▲ or ▼ key to select a range for the analog output. Press the **Enter** key to store the analog output range. The display will return to normal operation.

Table 3-3. Analog Output Range Scales

Range Number	Low Output	High Output
0	0 K	20 K
1	0 K	100 K
2	0 K	200 K
3	0 K	325 K
4	0 K	475 K
5	0 K	1000 K

Table 3-4. Analog Output Scales In Sensor Units

Input Type	Low Output	High Output
Silicon Diode	0 V	10 V
GaAlAs Diode	0 V	10 V
PT-100, 250 Ω	0 Ω	1 kΩ
PT-100, 500 Ω	0 Ω	1 kΩ
PT-1000	0 Ω	10 kΩ
NTC RTD	0 Ω	10 kΩ

3.9 ANALOG OUTPUT TO TEMPERATURE CONVERSION

The output current or voltage is directly proportional to the temperature reading. For the 4 – 20 mA output, the following formula converts output current to temperature:

$$T = A + B \times I_{OUT}$$

where T = temperature in Kelvin, I_{OUT} = output current in mA, and A and B are constants from Table 3-5.

For the 0 – 10 V output, the following formula converts output voltage to temperature:

$$T = C \times V_{OUT}$$

where T = temperature in Kelvin, V_{OUT} = output voltage, and C is a constant from Table 3-5.

Table 3-5. Conversion Parameters for Temperature in K

		4 – 20 mA		0 – 10 V
RANGE	**TEMP. (K)**	**A (K)**	**B (K/mA)**	**C (K/V)**
0	0 – 20	–5.00	1.2500	2.0
1	0 – 100	–25.00	6.2500	10.0
2	0 – 200	–50.00	12.5000	20.0
3	0 – 325	–81.25	20.3125	32.5
4	0 – 475	–118.75	29.6875	47.5
5	0 – 1000	–250.00	62.5000	100.0

3.10 LOCKING AND UNLOCKING THE KEYPAD

The keypad lock feature prevents accidental changes to parameter values. When the keypad is locked, only the alarm reset function of the **Select** key still functions. All other key functions are ignored.

To lock the keypad, press and hold the **Enter** key for 10 seconds. The display will show "LOC" indicating the keypad is now locked. Release the **Enter** key and the display will return to normal operation.

To unlock the keypad, press and hold the **Enter** key for 10 seconds. The display will show "UnLOC" indicating the keypad is now unlocked. Release the **Enter** key and the display will return to normal operation.

3.11 RESETTING THE MODEL 211 TO DEFAULT VALUES

It is sometimes necessary to reset instrument parameters that are stored in nonvolatile memory called EEPROM. The default values of the Model 211 are shown below in Table 3-6. Resetting to default values does not affect the user curve or the calibration data.

To reset the Model 211 to default values, press and hold both the ▲ or ▼ keys for 10 seconds. All of the LED digits will illuminate when the memory has been reset. Release the buttons and the display will return to normal operation.

Table 3-6. Model 211 Default Values

Parameter	Default	Parameter	Default
Input Type	Silicon Diode	Alarm Latch	Off
Input Curve	DT-470	Analog Mode	Voltage
Display Units	K	Analog Range	5
Alarm Function	Off	Relay 1 Mode	Off
Alarm High	0 K	Relay 2 Mode	Off
Alarm Low	0 K	Keypad Lock	Unlocked
Alarm Deadband	0 K	Display Brightness	8

3.12 CHECKING CODE DATE REVISION

To check revision date of the firmware code, press and hold the **Select** key until the display shows the code date. It is in the format of MMDDYY, where MM is the month, DD is the day, and YY is the year of the code. Release the key and the display returns to normal operation.

3.13 CURVE ENTRY AND STORAGE

The Model 211 has standard curve locations numbered 1 thru 20. At present, not all locations are occupied by curves; the others are reserved for future updates. Standard curves can not be changed by the user, and reserved locations are not available for user curves.

The Model 211 has one user curve location. The user curve can only be entered using the serial interface. Refer to Paragraph 4.2 for the serial interface curve commands. The user curve location can hold from 2 to 200 data pairs (breakpoints) including a value in sensor units and a corresponding value in Kelvin.

3.13.1 Curve Header Parameters

Each curve has a set of parameters that are used for identification and to allow the instrument to use the curve effectively. The parameters must be set correctly before a curve can be used for temperature conversion.

Curve Number: 1 – 21. Location 21 is for the user curve.

Name: Up to a 15-character name can be entered.

Serial Number: Up to a 10-character sensor serial number consisting of both numbers and letters.

Format: The format parameter tells the instrument what breakpoint data format to expect. Different sensor types require different formats. Formats for Lake Shore sensors are:

V/K: Volts vs. Kelvin for Diode sensors.

Ω/K: Resistance vs. Kelvin for platinum RTD sensors.

Log Ω/K: Log Resistance vs. Kelvin for NTC resistive sensors.

Limit: Temperature limit in Kelvin for the curve. Default is 375 K. This limit is not used in this instrument but is left in to be compatible with Lake Shore temperature controllers.

Temperature Coefficient: The unit derives the temperature coefficient from the first two breakpoints. The coefficient sent by the user is ignored. If it is not correct when the curve header is queried, check for proper entry of those points. A positive coefficient (**P**) indicates that the sensor signal increases with increasing temperature. A negative coefficient (**N**) indicates that the sensor signal decreases with increasing temperature. The power must be cycled or the *RST command issued for the instrument to calculate the temperature coefficient after curve points have been entered.

3.13.2 Curve Breakpoints

Temperature response data of a calibrated sensor must be reduced to a table of breakpoints before entering it into the instrument. Each breakpoint consists of one value in sensor units and one temperature value in Kelvin. Linear interpolation is used by the instrument to calculate temperature between breakpoints. From 2 to 200 breakpoints can be entered as a curve. The instrument will show an error message on the display if the sensor input is outside the range of the breakpoints. No special endpoints are required. Sensor units are defined by the format setting in Table 3-7.

Breakpoint setting resolution is six digits in temperature. Most temperature values are entered with 0.001 resolution. Temperature values of 1000 K and greater can be entered to 0.01 resolution. Temperature values below 10 K can be entered with 0.0001 resolution. Temperature range for curve entry is 1500 K.

Setting resolution is also 6 digits in sensor units. The curve format parameter defines the range and resolution in sensor units as shown in Table 3-7. The sensor type determines the practical setting resolution. Table 3-7 lists recommended sensor units resolutions. For most sensors, additional resolution is ignored.

The breakpoints should be entered with the sensor units value increasing as point number increases. There should not be any breakpoint locations left blank in the middle of a curve. The search routine in the Model 211 interprets a blank breakpoint as the end of the curve.

Table 3-7. Recommended Curve Parameters

Type	Typical Lake Shore Model	Unit	Format	Limit (K)	Coefficient	Recommended Sensor Resolution
Silicon Diode	DT-470	V	V/K	475	Negative	0.00001 (V)
GaAlAs Diode	TG-120	V	V/K	325	Negative	0.00001 (V)
Platinum 100	PT-100	Ω	Ω/K	800	Positive	0.001 (Ω)
Platinum 1000	PT-100	Ω	Ω/K	800	Positive	0.01 (Ω)
Rhodium-Iron	RF-100	Ω	Ω/K	325	Positive	0.001 (Ω)
Carbon-Glass	CGR-1-1000	Ω	logΩ/K	325	Negative	0.00001 (logΩ)
Cernox	CX-1030	Ω	logΩ/K	325	Negative	0.00001 (logΩ)
Germanium	GR-200A-100	Ω	logΩ/K	325	Negative	0.00001 (logΩ)
Rox	RX-102A	Ω	logΩ/K	40	Negative	0.00001 (logΩ)

CHAPTER 4

REMOTE OPERATION

4.0 GENERAL

The Model 211 is equipped with an RS-232C serial computer interface. The interface allows computer automation of instrument setup and temperature measurement data collection. Nearly every feature of the instrument can be accessed through the computer interface. Interface capabilities including setup information and example programs are provided in Paragraph 4.1. Interface commands including a command summary are described in Paragraph 4.2.

4.1 SERIAL INTERFACE OVERVIEW

The serial interface used in the Model 211 is commonly referred to as an RS-232C interface. RS-232C is a standard of the Electronics Industries Association (EIA) that describes one of the most common interfaces between computers and electronic equipment. The RS-232C standard is quite flexible and allows many different configurations. However, any two devices claiming RS-232C compatibility cannot necessarily be plugged together without interface setup. The remainder of this paragraph briefly describes the key features of a serial interface that are supported by the instrument. A customer supplied computer with similarly configured interface port is required to enable communication.

4.1.1 Physical Connection

The Model 211 has a 9 pin D-Subminiature plug on the rear panel for serial communication. The original RS-232C standard specifies 25 pins but both 9- and 25-pin connectors are commonly used in the computer industry. Many third party cables exist for connecting the instrument to computers with either 9- or 25-pin connectors. Paragraph 5.6 gives the most common pin assignments for 9- and 25-pin connectors. Please note that not all pins or functions are supported by the Model 211.

The instrument serial connector is the plug half of a mating pair and must be matched with a socket on the cable. If a cable has the correct wiring configuration but also has a plug end, a "gender changer" can be used to mate two plug ends together.

Physical Connection (Continued)

The letters DTE near the interface connector stand for Data Terminal Equipment and indicate the pin connection of the directional pins such as transmit data (TD) and receive data (RD). Equipment with Data Communications Equipment (DCE) wiring can be connected to the instrument with a straight through cable. As an example, pin 3 of the DTE connector holds the transmit line and pin 3 of the DCE connector holds the receive line so the functions complement.

It is likely both pieces of equipment are wired in the DTE configuration. In this case pin 3 on one DTE connector (used for transmit) must be wired to pin 2 on the other (used for receive). Cables that swap the complementing lines are called null modem cables and must be used between two DTE wired devices. Null modem adapters are also available for use with straight through cables. Paragraph 5.6.1 illustrates suggested cables that can be used between the instrument and common computers.

The instrument uses drivers to generate the transmission voltage levels required by the RS-232C standard. These voltages are considered safe under normal operating conditions because of their relatively low voltage and current limits. The drivers are designed to work with cables up to 50 feet in length.

4.1.2 Hardware Support

The Model 211 interface hardware supports the following features. Asynchronous timing is used for the individual bit data within a character. This timing requires start and stop bits as part of each character so the transmitter and receiver can resynchronized between each character. Half duplex transmission allows the instrument to be either a transmitter or a receiver of data but not at the same time. The serial output supports a communication speed of 9600 baud.

Hardware handshaking is not supported by the instrument. Handshaking is often used to guarantee that data message strings do not collide and that no data is transmitted before the receiver is ready. In this instrument appropriate software timing substitutes for hardware handshaking. User programs must take full responsibility for flow control and timing as described in Paragraph 4.1.5.

4.1.3 Character Format

A character is the smallest piece of information that can be transmitted by the interface. Each character is 10 bits long and contains data bits, bits for character timing and an error detection bit. The instrument uses 7 bits for data in the ASCII format. One start bit and one stop bit are necessary to synchronize consecutive characters. Parity is a method of error detection. One parity bit configured for odd parity is included in each character.

ASCII letter and number characters are used most often as character data. Punctuation characters are used as delimiters to separate different commands or pieces of data. Two special ASCII characters, carriage return (CR 0DH) and line feed (LF 0AH), are used to indicate the end of a message string.

Table 4-1. Serial Interface Specifications

Connector Type: 9-pin D-style plug
Connector Wiring: DTE
Voltage Levels: EIA RS-232C Specified
Transmission Distance: 50 feet maximum
Timing Format: Asynchronous
Transmission Mode: Half Duplex
Baud Rate: 9600
Handshake: Software timing
Character Bits: 1 Start, 7 Data, 1 Parity, 1 Stop
Parity: Odd
Terminators: CR(0DH) LF(0AH)
Command Rate: 20 commands per second maximum

4.1.4 Message Strings

A message string is a group of characters assembled to perform an interface function. There are three types of message strings commands, queries and responses. The computer issues command and query strings through user programs, the instrument issues responses. Two or more command or query strings can be chained together in one communication but they must be separated by a semi-colon (;). The total communication string must not exceed 64 characters in length.

Message Strings (Continued)

A command string is issued by the computer and instructs the instrument to perform a function or change a parameter setting. The format is <command mnemonic><space><parameter data><terminators>. Command mnemonics are listed in Paragraph 4.2. Parameters necessary for each one are described in Paragraph 4.2.1. Terminators must be sent with every message string.

A query string is issued by the computer and instructs the instrument to send a response. The query format is <query mnemonic><?><space><parameter data><terminators>. Query mnemonics are often the same as commands with the addition of a question mark. Parameter data is often unnecessary when sending queries. Query mnemonics are listed in Paragraph 4.2. Parameter data if necessary is described in Paragraph 4.2.1. Terminators must be sent with every message string. The computer should expect a response very soon after a query is sent.

A response string is the instruments response or answer to a query string. The response can be a reading value, status report or the present value of a parameter. Response data formats are listed along with the associated queries in Paragraph 4.2.1. The response is sent as soon as possible after the instrument receives the query. Typically it takes 10 ms for the instrument to begin the response. Some responses take longer.

4.1.5 Message Flow Control

It is important to remember that the user program is in charge of the serial communication at all times. The instrument can not initiate communication, determine which device should be transmitting at a given time, or guarantee timing between messages. This is the responsibility of the user program.

When issuing commands only the user program should:

- Properly format and transmit the command including terminators as one string.
- Guarantee that no other communication is started for 50 ms after the last character is transmitted.
- Not initiate communication more than 20 times per second.

When issuing queries or queries and commands together the user program should:

- Properly format and transmit the query including terminators as one string.
- Prepare to receive a response immediately.
- Receive the entire response from the instrument including the terminators.
- Guarantee that no other communication is started during the response or for 50 ms after it completes.
- Not initiate communication more than 20 times per second.

Message Flow Control (Continued)

NOTE: The serial interface will not function during front panel setup operations. Do not use the front panel during serial communications.

Failure to follow these rules may result in inability to establish communication with the instrument or intermittent failures in communication.

4.1.6 Serial Interface Basic Programs

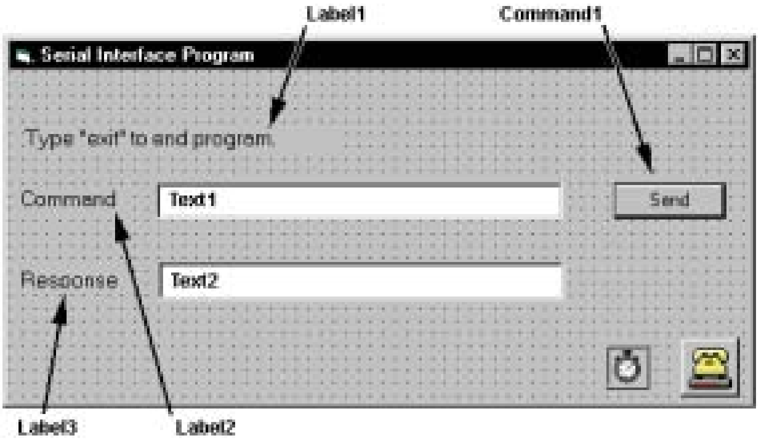
Two BASIC programs are included to illustrate the serial communication functions of the instrument. The first program was written in Visual Basic. Refer to Paragraph 4.1.6.1 for instructions on how to setup the program. The Visual Basic code is provided in Table 4-3. The second program was written in Quick Basic. Refer to Paragraph 4.1.6.2 for instructions on how to setup the program. The Quick Basic code is provided in Table 4-4. Finally, a description of operation common to both programs is provided in Paragraph 4.1.6.3. While the hardware and software required to produce and implement these programs not included with the instrument, the concepts illustrated apply to almost any application where these tools are available.

4.1.6.1 Visual Basic Serial Interface Program Setup

The serial interface program (Table 4-3) works with Visual Basic 6.0 (VB6) on an IBM PC (or compatible) with a Pentium-class processor. A Pentium 90 or higher is recommended, running Windows 95 or better, with a serial interface. It uses the COM1 communications port at 9600 Baud. Use the following to develop the Serial Interface Program in Visual Basic.

1. Start VB6.
2. Choose Standard EXE and select Open.
3. Resize form window to desired size.
4. On the Project Menu, click Components to bring up a list of additional controls available in VB6.
5. Scroll through the controls and select Microsoft Comm Control 6.0. Select OK. In the toolbar at the left of the screen, the Comm Control will have appeared as a telephone icon.
6. Select the Comm control and add it to the form.
7. Add controls to form:
   a. Add three Label controls to the form.
   b. Add two TextBox controls to the form.
   c. Add one CommandButton control to the form.
   d. Add one Timer control to the form.
8. On the View Menu, select Properties Window.

Visual Basic Serial Interface Program Setup (Continued)



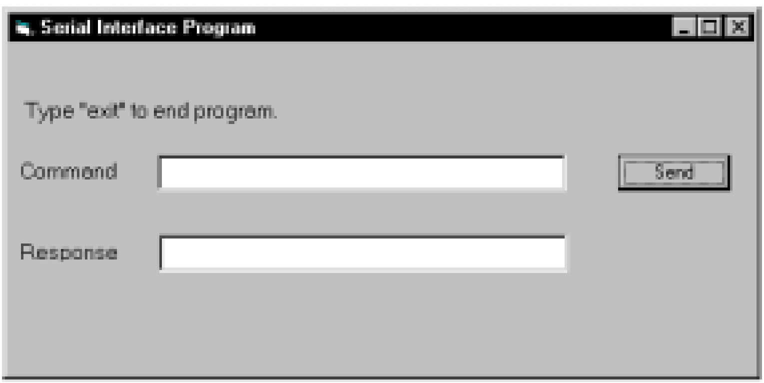
9. In the Properties window, use the dropdown list to select between the different controls of the current project.
10. Set the properties of the controls as defined in Table 4-2.
11. Save the program.

Table 4-2. Serial Interface Program Control Properties

Current Name	Property	New Value
Label1	Name Caption	lblExitProgram Type "exit" to end program.
Label2	Name Caption	lblCommand Command
Label3	Name Caption	lblResponse Response
Text1	Name Text	txtCommand <blank>
Text2	Name Text	txtResponse <blank>
Command1	Name Caption Default	cmdSend Send True
Form1	Name Caption	frmSerial Serial Interface Program
Timer1	Enabled Interval	False 10

Visual Basic Serial Interface Program Setup (Continued)

12. Add code (provided in Table 4-3).
    a. In the Code Editor window, under the Object dropdown list, select (General). Add the statement: Public gSend as Boolean
    b. Double Click on cmdSend. Add code segment under Private Sub cmdSend_Click( ) as shown in Table 4-3.
    c. In the Code Editor window, under the Object dropdown list, select Form. Make sure the Procedure dropdown list is set at Load. The Code window should have written the segment of code: Private Sub Form_Load( ). Add the code to this subroutine as shown in Table 4-3.
    d. Double Click on the Timer control. Add code segment under Private Sub Timer1_Timer() as shown in Table 4-3.
    e. Make adjustments to code if different Com port settings are being used.
13. Save the program.
14. Run the program. The program should resemble the following.



15. Type in a command or query in the Command box as described in Paragraph 4.1.6.3.
16. Press Enter or select the Send button with the mouse to send command.
17. Type Exit and press Enter to quit.

Table 4-3. Visual Basic Serial Interface Program

```
Public gSend As Boolean                       'Global used for Send button state

Private Sub cmdSend_Click()                   'Routine to handle Send button press
   gSend = True                               'Set Flag to True
End Sub

Private Sub Form_Load()                                 'Main code section
   Dim strReturn As String                              'Used to return response
   Dim strHold As String                                'Temporary character space
   Dim Term As String                                   'Terminators
   Dim ZeroCount As Integer                             'Counter used for Timing out
   Dim strCommand As String                             'Data string sent to instrument

   frmSerial.Show                                       'Show main window
   Term = Chr(13) & Chr(10)                             'Terminators are <CR><LF>
   ZeroCount = 0                                        'Initialize counter
   strReturn = ""                                       'Clear return string
   strHold = ""                                         'Clear holding string
   If frmSerial.MSComm1.PortOpen = True Then    'Close serial port to change settings
      frmSerial.MSComm1.PortOpen = False
   End If
   frmSerial.MSComm1.CommPort = 1                       'Example of Comm 1
   frmSerial.MSComm1.Settings = "9600,o,7,1"            'Baud,Parity,Data,Stop
   frmSerial.MSComm1.InputLen = 1                       'Read one character at a time
   frmSerial.MSComm1.PortOpen = True                    'Open port

  Do
   Do                                                   'Wait loop
   DoEvents                                             'Give up processor to other events
   Loop Until gSend = True                              'Loop until Send button pressed
   gSend = False                                        'Set Flag as false

   strCommand = frmSerial.txtCommand.Text               'Get Command
   strReturn = ""                                       'Clear response display

   strCommand = UCase(strCommand)                       'Set all characters to upper case
   If strCommand = "EXIT" Then                          'Get out on EXIT
      End
   End If
```

Program continues on the next page...

Table 4-3. Visual Basic Serial Interface Program (Continued)

```
   frmSerial.MSComm1.Output = strCommand & Term  'Send command to instrument
   If InStr(strCommand, "?") <> 0 Then              'Check to see if query
      While (ZeroCount < 20) And (strHold <> Chr$(10))    'Wait for response
         If frmSerial.MSComm1.InBufferCount = 0 Then
                                                    'Add 1 to timeout if no character
            frmSerial.Timer1.Enabled = True
            Do
            DoEvents                                'Wait for 10 millisecond timer
            Loop Until frmSerial.Timer1.Enabled = False
            ZeroCount = ZeroCount + 1               'Timeout at 2 seconds
         Else
            ZeroCount = 0                           'Reset timeout for each character
            strHold = frmSerial.MSComm1.Input   'Read in one character
            strReturn = strReturn + strHold         'Add next character to string
         End If
      Wend                                          'Get characters until terminators

      If strReturn <> "" Then                       'Check if string empty
         strReturn = Mid(strReturn, 1, InStr(strReturn, Term) - 1)  'Strip terminators
      Else
         strReturn = "No Response"                  'Send No Response
      End If
      frmSerial.txtResponse.Text = strReturn        'Put response in textbox on main
form
      strHold = ""                                  'Reset holding string
      ZeroCount = 0                                 'Reset timeout counter
   End If
  Loop
End Sub
```

```
Private Sub Timer1_Timer()                          'Routine to handle Timer interrupt
   frmSerial.Timer1.Enabled = False                 'Turn off timer
End Sub
```

4.1.6.2 Quick Basic Serial Interface Program Setup

The serial interface program (Table 4-4) works with QuickBasic 4.0/4.5 or Qbasic on an IBM PC (or compatible) running DOS or in a DOS window with a serial interface. It uses the COM1 communication port at 9600 Baud. Use the following procedure to develop the Serial Interface Program in Quick Basic.

1. Start the Basic program.
2. Enter the program exactly as presented in Table 4-4.
3. Adjust the COM port in the program as necessary.
4. Lengthen the "TIMEOUT" count if necessary.
5. Save the program.
6. Run the program.
7. Type a command query as described in Paragraph 4.1.6.3.
8. Type "EXIT" to quit the program.

4.1.6.3 Program Operation

Once either program is running, try the following commands and observe the response of the instrument. Input from the user is shown in **bold** and terminators are added by the program. The word [term] indicates the required terminators included with the response.

`ENTER COMMAND?` **`*IDN?`** — Identification query. Instrument will return a string identifying itself.

`RESPONSE: LSCI,MODEL211,2110000,032502[term]`

`ENTER COMMAND?` **`KRDG?`** — Kelvin reading query. Instrument will return a string with the present Kelvin reading.

`RESPONSE: +12.345[term]`

`ENTER COMMAND?` **`INTYPE 0`** — Input type command. Instrument will change the input type to silicon diode. No response will be sent.

`ENTER COMMAND?` **`INTYPE?`** — Input type query. Instrument will return a string with the present input type setting.

`RESPONSE: 0[term]`

`ENTER COMMAND?` **`INTYPE 0;INTYPE?`** — Input type command followed by input type query. Instrument will change the input type to silicon diode then return a string with the present input type setting.

`RESPONSE: 0[term]`

Table 4-4. Quick Basic Serial Interface Program

```
      CLS                                          'Clear screen
      PRINT " SERIAL COMMUNICATION PROGRAM"
      PRINT
      TIMEOUT = 2000                               'Read timeout (may need more)
      BAUD$ = "9600"
      TERM$ = CHR$(13) + CHR$(10)                  'Terminators are <CR><LF>
      OPEN "COM1:" + BAUD$ + ",O,7,1,RS" FOR RANDOM AS #1 LEN = 256

LOOP1: LINE INPUT "ENTER COMMAND (or EXIT):"; CMD$
                                                   'Get command from keyboard
      CMD$ = UCASE$(CMD$)                          'Change input to upper case
            IF CMD$ = "EXIT" THEN CLOSE #1: END         'Get out on Exit
      CMD$ = CMD$ + TERM$
      PRINT #1, CMD$;                              'Send command to instrument

      IF INSTR(CMD$, "?") <> 0 THEN                'Test for query
            RS$ = ""                               'If query, read response
            N = 0                                  'Clr return string and count

            WHILE (N < TIMEOUT) AND (INSTR(RS$, TERM$) = 0)
                                                   'Wait for response
                  IN$ = INPUT$(LOC(1), #1)         'Get one character at a time
                  IF IN$ = "" THEN N = N + 1 ELSE N = 0
                                                   'Add 1 to timeout if no chr
                  RS$ = RS$ + IN$                  'Add next chr to string
            WEND                                   'Get chrs until terminators

            IF RS$ <> "" THEN                      'See if return string is empty
                  RS$ = MID$(RS$, 1, (INSTR(RS$, TERM$) - 1))
                                                   'Strip off terminators
                  PRINT "RESPONSE:"; RS$           'Print response to query
            ELSE
                  PRINT "NO RESPONSE"              'No response to query
            END IF
      END IF                                       'Get next command
      GOTO LOOP1
```

Program Operation (Continued)

The following are additional notes on using either Serial Interface program.

- If you enter a correctly spelled query without a "**?**," nothing will be returned. Incorrectly spelled commands and queries are ignored. Commands and queries and should have a space separating the command and associated parameters.
- Leading zeros and zeros following a decimal point are not needed in a command string, but they will be sent in response to a query. A leading "**+**" is not required but a leading "**–**" *is* required.

4.1.7 Trouble Shooting

New Installation

1. Make sure transmit (TD) signal line from the instrument is routed to receive (RD) on the computer and vice versa. (Use a null modem adapter if not).
2. Always send terminators
3. Send entire message string at one time including terminators. (Many terminal emulation programs do not.)
4. Send only one simple command at a time until communication is established.
5. Be sure to spell commands correctly and use proper syntax.

Old Installation No Longer Working

1. Power instrument off then on again to see if it is a soft failure.
2. Power computer off then on again to see if communication port is locked up.
3. Check all cable connections.

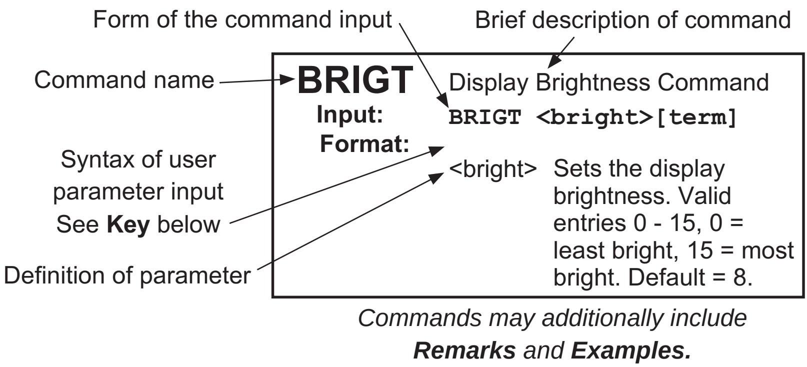
Intermittent Lockups

1. Check cable connections and length.
2. Increase delay between all commands to 100 ms to make sure instrument is not being over loaded.
3. Do not use the front panel keys during serial communication.

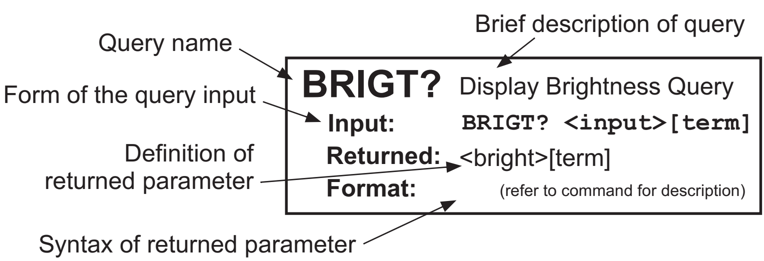
4.2 SERIAL INTERFACE COMMAND SUMMARY

This paragraph provides a summary of the Serial Interface Commands. The Interface Commands are detailed in Paragraph 4.2.1. A list of all commands is provided in Table 4-5.

Serial Interface Command Summary (Continued)



Command.eps



Query.eps

Key:

✱	Begins common interface command.
?	Required to identify queries.
aa…	String of alpha numeric characters.
nn…	String of number characters that may include a decimal point.
[term]	Terminator characters.
<…>	Indicated a parameter field, many are command specific.
<state>	Parameter field with only On/Off or Enable/Disable states.
<value>	Floating point values can have a varying resolution depending on the type of command or query issued.

Table 4-5. Interface Commands (Alphabetical Listing)

Command	Function	Page
✱IDN?	Identification Query	15
✱RST	Reset Instrument Command	15
ALARM	Input Alarm Parameter Command	15
ALARM?	Input Alarm Parameter Query	16
ALMRST	Alarm Reset Status Command	16
ANALOG	Analog Output Parameter Command	16
ANALOG?	Analog Output Parameter Query	16
AOUT?	Analog Output Data Query	16
BRIGT	Display Brightness Command	17
BRIGT?	Display Brightness Query	17
CRDG?	Celsius Reading Query	17
CRVDEL	Curve Delete Command	17
CRVHDR	Curve Header Command	17
CRVHDR?	Curve Header Query	18
CRVPT	Curve Data Point Command	18
CRVPT?	Curve Data Point Query	18
DFLT	Factory Defaults Command	19
DISPFLD	Displayed Field Command	19
DISPFLD?	Displayed Field Query	19
FRDG?	Fahrenheit Reading Query	19
INCRV	Input Curve Number Command	19
INCRV?	Input Curve Number Query	20
INTYPE	Input Type Parameter Command	20
INTYPE?	Input Type Parameter Query	20
KEYST?	Keypad Status Query	20
KRDG?	Kelvin Reading Query	20
LOCK	Front Panel Keypad Lock Command	21
LOCK?	Front Panel Keypad Lock Query	21
RDGST?	Input Reading Status Query	21
RELAY	Relay Control Parameter Command	21
RELAY?	Relay Control Parameter Query	22
SRDG?	Sensor Units Input Reading Query	22

4.2.1 Interface Commands (In Alphabetical Order)

***IDN?** Identification Query

Input: ***IDN?[term]**

Returned: <manufacturer>,<model>,<serial>,<date>[term]

Format: aaaa,aaaaaaaa,aaaaaaa,mmddyy

<manufacture>	Manufacturer ID
<model>	Instrument model number
<serial>	Serial number
<date>	Instrument firmware revision date

Example: **LSCI,MODEL211,1234567,013001**

***RST** Reset Instrument Command

Input: ***RST[term]**

Remarks: Sets instrument parameters to power-up settings.

ALARM Input Alarm Parameter Command

Input: **ALARM <off/on>, <high value>, <low value>, <deadband>,<latch enable>[term]**

Format: n, +nnn.n, +nnn.n, +nn.n,n

<off/on>	Determines whether the instrument checks the alarm for input where 0 = off and 1 = on.
<high value>	Sets the value the temperature is checked against to activate the high alarm.
<low value>	Sets the value the temperature is checked against to activate low alarm.
<deadband>	Sets the value that the temperature must change outside of an alarm condition to deactivate an unlatched alarm.
<latch enable>	Specifies a latched alarm (remains active after alarm condition correction) where 0 = off (no latch) and 1 = on.

Remarks: Configures the alarm parameters for the input.

Example: **ALARM 1,270.0,0,0,1[term] –** Turns on alarm checking for the input, activates high alarm if Kelvin reading is over 270, and latches the alarm when Kelvin reading falls below 270.

ALARM? Input Alarm Parameter Query

Input: `ALARM?[term]`

Returned: <off/on>, <high value>, <low value>, <deadband>, <latch enable> [term]

Format: n,+nnn.n,+nnn.n,+nn.n,n (Refer to command for description)

ALMRST Reset Alarm Status Command

Input: `ALMRST[term]`

Remarks: Clears both the high and low status of the alarm, including latching alarm.

ANALOG Analog Output Parameter Command

Input: `ANALOG <mode>, <range>[term]`

Format: n,n

<mode> Specifies mode in which analog output operates where 0 = voltage mode and 1 = current mode.

<range> Sets temperature range that analog output uses as full scale.

0 = 0 – 20 K	3 = 0 – 325 K
1 = 0 – 100 K	4 = 0 – 475 K
2 = 0 – 200 K	5 = 0 – 1000 K

Example: **ANALOG 0,1[term]** – Sets analog output to voltage mode (0–10V) 100.0 K at +100% output (+10.0 V) and 0.0 K at 0% output (0.0 V).

ANALOG? Analog Output Parameter Query

Input: `ANALOG?[term]`

Returned: <mode>, <range> [term]

Format: n,n (Refer to command for definition)

AOUT? Analog Output Data Query

Input: `AOUT?[term]`

Returned: <analog output>[term]

Format: +nnn.nn

Remarks: Returns the percentage of output of the analog output.

BRIGT Display Brightness Command

Input: **`BRIGT <bright>[term]`**

Format: nn

<bright> Sets display brightness. Valid entries: 0–15, 0 = least bright, 15 = most bright. Default = 8.

BRIGT? Display Brightness Query

Input: **`BRIGT?[term]`**

Returned: <bright>[term]

Format: nn (Refer to command for description)

CRDG? Celsius Reading Query

Input: **`CRDG?[term]`**

Returned: <temp value>[term]

Format: ±nnnnnn

Remarks: Also see the RDGST? command.

CRVDEL Curve Delete Command

Input: **`CRVDEL <curve>[term]`**

Format: nn

<curve> Specifies user curve to delete. Only valid entry is 21. (Curve number is used to retain compatibility with existing instrument line. Curve number 21 must be sent with the command or else the command will be ignored.)

CRVHDR Curve Header Command

Input: **`CRVHDR <curve>, <name>, <SN>, <format>, <limit value>, <coefficient>[term]`**

Format: nn,aaaaaaaaaaaaaaa,aaaaaaaaaa,n,+nnn.nnn,n

<curve> Specifies user curve. Valid entry: 21.

<name> Curve name. Limited to 15 characters.

<SN> Curve serial number. Limited to 10 characters.

<format> Curve data format. Valid entries: 2 = V/K, 3 = Ω/K, 4 = log Ω/K.

<limit value> Curve temperature limit in Kelvin (Unused).

<coefficient> Curves temperature coefficient. Valid entries: 1 = negative, 2 = positive.

Remarks: Configures the user curve header.

Curve Header Command (Continued)

Example: **CRVHDR 21,DT-470,00011134,2,325.0,1[term]** – Configures User Curve 21 with a name of DT-470, serial number of 00011134, data format of volts versus Kelvin, upper temperature limit of 325 K, and negative coefficient.

CRVHDR? Curve Header Query

Input: `CRVHDR? <curve>[term]`

Format: nn

<curve> Valid entries: 1 – 21.

Returned: <name>,<SN>,<format>,<limit value>,<coefficient>[term]

Format: aaaaaaaaaaaaaaa,aaaaaaaaaa,n,+nnn.nnn,n (Refer to command for description)

Remarks: Returns a standard or user curve header.

CRVPT Curve Data Point Command

Input: `CRVPT <curve>, <index>, <units value>, <temp value>[term]`

Format: nn,nnn,±nnnnnnn,+nnnnnnn

<curve> Specifies which curve to configure. Valid entry: 21.

<index> Specifies curve points index. Valid entries: 1 – 200.

<units value> Specifies sensor units for point to 6 digits.

<temp value> Specifies the corresponding temperature in Kelvin for this point to 6 digits.

Remarks: Configures a user curve data point. To finalize curve entry, send the *RST command or cycle the instrument power after all the curve points have been entered.

Example: **CRVPT 21,2,0.10191,470.000[term] –** Sets User Curve 21 second data point to 0.10191 sensor units and 470.000 K.

CRVPT? Curve Data Point Query

Input: `CRVPT? <curve>, <index>[term]`

Format: nn,nnn

<curve> Specifies which curve to query: 1 – 21.

<index> Specifies the points index in the curve: 1 – 200.

Returned: <units value>, <temp value>[term]

Format: ±nnnnnnn,+nnnnnnn (Refer to command for description)

Remarks: Returns a standard or user curve data point.

DFLT Factory Defaults Command

Input: `DFLT 99[term]`

Remarks: Sets all configuration values to factory defaults and resets the instrument. The "99" is included to prevent accidentally setting the unit to defaults.

DISPFLD Displayed Field Command

Input: `DISPFLD <source>[term]`

Format: n

<source> Specifies input data to display. Valid entries: 0 = Kelvin, 1 = Celsius, 2 = sensor units, 3 = Fahrenheit.

Example: **DISPFLD 1[term]** – Displays Kelvin reading for the input.

DISPFLD? Displayed Field Query

Input: `DISPFLD?[term]`

Returned: <source>[term]

Format: n (Refer to command for description)

FRDG? Fahrenheit Reading Query

Input: `FRDG?[term]`

Returned: <temp value>[term]

Format: ±nnnnnn

Remarks: Also see the RDGST? command.

INCRV Input Curve Number Command

Input: `INCRV <curve number>[term]`

Format: nn

<curve number> Specifies which curve the input uses. If specified curve parameters do not match the input, the curve number defaults to 0. Valid entries: 0 = none, 1 – 20 = standard curves, 21 = user curve.

Remarks: Specifies curve the input uses for temperature conversion.

Example: **INCRV 21[term]** – The input User Curve 21 for temperature conversion.

INCRV? Input Curve Number Query

Input: **INCRV?[term]**

Returned: <curve number>[term]

Format: nn (Refer to command for description)

INTYPE Input Type Parameter Command

Input: **INTYPE <sensor type>[term]**

Format: n

<sensor type> Specifies input sensor type. Valid entries:

0 = Silicon Diode	3 = 100 Ω Platinum/500
1 = GaAlAs Diode	4 = 1000 Ω Platinum
2 = 100 Ω Platinum/250	5 = NTC RTD

Example: **INTYPE 0[term]** – Sets input sensor type to silicon diode.

INTYPE? Input Type Parameter Query

Input: **INTYPE?[term]**

Returned: <sensor type>[term]

Format: n (Refer to command for description)

KEYST? Keypad Status Query

Input: **KEYST?[term]**

Returned: <keypad status>[term]

Format: n 1 = key pressed, 0 = no key pressed.

Remarks: Returns keypad status since the last KEYST?. KEYST? returns 1 after initial power-up.

KRDG? Kelvin Reading Query

Input: **KRDG?[term]**

Returned: <Kelvin value>[term]

Format: +nnnnnn

Remarks: Also see the RDGST? command.

LOCK Front Panel Keypad Lock Command

Input: **`LOCK <state>[term]`**

Format: n

<state> 0 = Unlocked, 1 = Locked

Remarks: Locks out all front panel entries. Refer to Paragraph 3.10.

Example: **LOCK 1[term] –** Enables keypad lock.

LOCK? Front Panel Keypad Lock Query

Input: **`LOCK?[term]`**

Returned: <state>[term]

Format: n (Refer to command for description)

RDGST? Input Reading Status Query

Input: **`RDGST?[term]`**

Returned: <status bit weighting>[term]

Format: nnn

Remarks: Integer returned represents sum of bit weighting of the input status flag bits. "000" indicates a valid reading is present.

Bit	***Bit Weighting***	***Status Indicator***
1	2	A/D not responding
2	4	Alarm low
3	8	Alarm high
4	16	Temperature under range
5	32	Temperature over range
6	64	Sensor units zero
7	128	Sensor units over range

RELAY Relay Control Parameter Command

Input: **`RELAY <relay number>, <mode>[term]`**

Format: n,n

<relay number> Specifies which relay to configure: 1 = low alarm relay, 2 = high alarm relay.

<mode> Specifies relay mode. 0 = Off, 1 = On, 2 = Alarms.

Example: **RELAY 1,2[term]** – Low alarm relay activates when low alarm activates.

RELAY? Relay Control Parameter Query

Input: `RELAY? <relay number>[term]`

Format: n

<relay number> Specifies which relay to query: 1 = low alarm relay, 2 = high alarm relay.

Returned: n (Refer to command for description)

SRDG? Sensor Units Input Reading Query

Input: `SRDG?[term]`

Returned: <sensor units value>[term]

Format: ±nnnnnn

Remarks: Also see the RDGST? command.

CHAPTER 5

SERVICE

5.0 GENERAL

This chapter provides basic service information for the Model 211 Temperature Monitor. Customer service of the product is limited to the information presented in this chapter. Factory trained service personnel should be consulted if the instrument requires repair.

5.1 CONTACTING LAKE SHORE

If a Lake Shore product was purchased through a dealer or representative, please use that resource for prompt sales or service information. When contacting Lake Shore directly, please specify the name of a department if you do not know the name of an individual. Questions regarding product applications, price, availability and shipments should be directed to sales. Questions regarding instrument calibration or repair should be directed to instrument service. **Do not return a product to Lake Shore without a Return Goods Authorization (RGA) number**. Refer to Paragraph 5.2. Contact information may change periodically but current contact information can always be found on the Lake Shore web site: www.lakeshore.com.

When contacting Lake Shore please provide your name and complete contact information including e-mail address if possible. It is often helpful to include the instrument model number and serial number (located on the rear panel of the instrument) as well as the firmware revision information as described in Paragraph 3.12.

Mailing Address:	Lake Shore Cryotronics, Inc. Instrument Service Department 575 McCorkle Blvd. Westerville, OH USA 43082-8888	
E-mail Address:	sales@lakeshore.com service@lakeshore.com	Sales Instrument Service
Telephone:	614-891-2244 614-891-2243 ext. 131	Sales Instrument Service
Fax:	614-818-1600 614-818-1609	Sales Instrument Service

5.2 RETURNING PRODUCTS TO LAKE SHORE

If it is necessary to return the Model 211 or accessories for recalibration, repair or replacement, an RGA number must be obtained from a factory representative or from the Lake Shore web site. **Do not return a product to Lake Shore without an RGA number**. The following information must be provided to Lake Shore in order to obtain an RGA number.

1. Instrument model and serial number.
2. User name, company, address, phone number, and e-mail address.
3. Malfunction symptoms.
4. Description of the system in which the product is used.

If possible, the original packing material should be retained for reshipment. If not available, a minimum of three inches of shock adsorbent packing material should be placed snugly on all sides of the instrument in a sturdy corrugated cardboard box. Include the RGA number on the mailing label or written prominently on the outside of the box. Include a copy of the customer contact information and RGA number inside the box. Consult Lake Shore with questions regarding shipping and packing instructions.

5.3 ERROR MESSAGES

The following messages appear on the instrument display when it identifies a problem during operation. The messages are divided into two groups. Instrument hardware messages are related to the instruments internal circuits or non-volatile memory. If one of these messages persists after power is cycled the instrument requires repair or recalibration. Limit messages are most often associated with over voltage conditions caused by an improperly selected range or excessive noise on the measurement leads. If these messages persist after the input or output is configured properly the instrument may require repair.

5.3.1 Instrument Hardware Errors

Err 01 Indicates that there is a hardware problem in the instrument memory. This error is not correctable by the user and the factory should be consulted.

Err 02 Indicates there is a soft error in the instrument memory. This error can be corrected reinitializing memory. Reinitializing memory sets the instrument to defaults and erases the user curve. To reinitialize the memory after an Error 02, press both the ▲ and ▼ keys simultaneously. The display will blank for about 5 seconds while the memory is initialized.

Instrument Hardware (Continued)

Err 03 Indicates the instrument has lost its calibration. To continue using the instrument in an uncalibrated state, press the Enter key after the Error 03 message appears. The Error 03 message is not cleared and will be displayed again on power up until the unit is calibrated.

Err 04 Indicates that the A/D converter is not communicating with the microprocessor. This error is not correctable by the user. Please contact the factory for instrument return information.

5.3.2 Limit Errors

Err 05 Input is at or under zero output.

Err 06 Input is at or over full-scale.

Err 07 Temperature conversion is off the low end of the curve

Err 08 Temperature conversion is off the high end of the curve

Err 09 No curve is selected for the input.

5.4 OPENING THE ENCLOSURE

WARNING: To avoid potentially lethal shocks, disconnect the power cord from the instrument before performing this procedure. Only qualified personnel should perform this procedure.

REMOVAL

1. Disconnect the power cord from rear of unit.
2. If attached, remove from panel mount.
3. Use a Phillips screwdriver to remove the four flat-head screws from the corners of the rear panel.
4. Slide out the PC board assembly. The rear panel is attached to the PC board.

INSTALLATION

1. Slide the PC board assembly in from the rear of the chassis making sure the keypad aligns with the holes in the front panel.
2. Use a Phillips screwdriver to install four flat-head screws in the corners of the rear panel.
3 If required, replace the instrument in the panel mount opening.
4. Connect power cord to rear of the unit.

5.5 FIRMWARE REPLACEMENT

There is one integrated circuit (IC) that may potentially require replacement. See Figure 5-1 for IC location.

Firmware Microcontroller (U1) – Contains the software that runs the entire instrument. Has a sticker on top labeled "M211F.HEX" and a version number or date. Use the following procedure to replace this IC.

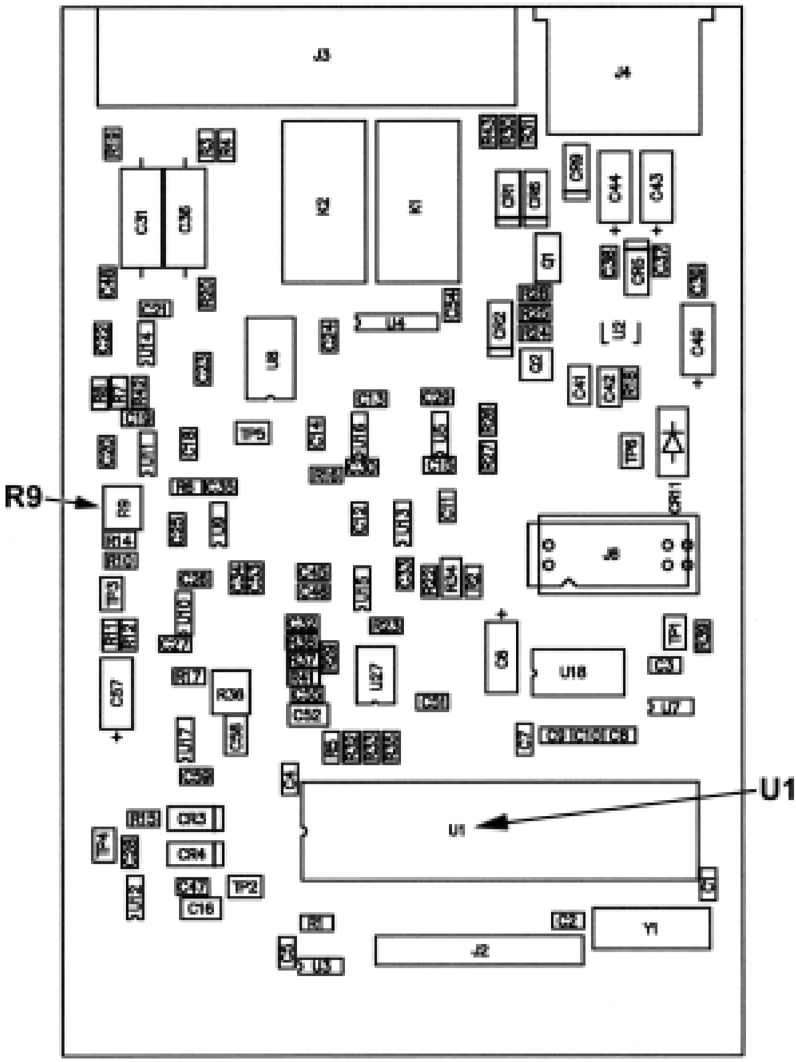
1. Follow the enclosure *REMOVAL* procedure in Paragraph 5.4.
2. Locate the IC on the main circuit board. See Figure 5-1. Note orientation of existing IC.

CAUTION: The IC is an Electrostatic Discharge Sensitive (ESDS) device. Wear shock-proof wrist straps (resistor limited to <5 mA) to prevent injury to service personnel and to avoid inducing an Electrostatic Discharge (ESD) into the device.

3. Use IC puller to remove existing IC from the socket.
4. Noting orientation of new IC, use an IC insertion tool to place new device into socket.

IC_Notch.bmp

5. Follow the opening the enclosure *INSTALLATION* procedure in Paragraph 5.4.

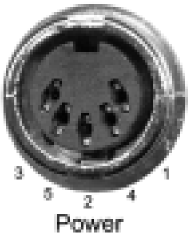


211_PCB.bmp

Figure 5-1. Model 211 Main PCB Layout

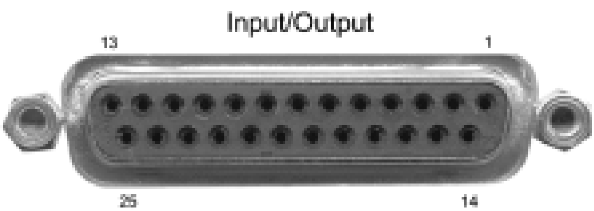
5.6 CONNECTOR DEFINITIONS

The POWER, INPUT/OUTPUT, and RS-232 (DTE) connectors are defined in Figures 5-2 thru 5-4.



Pin	Description
1	Ground
2	Ground
3	+5V
4	–15V
5	+15V

Figure 5-2. Power Connector



Pin	Description	Pin	Description
1	No Connection	—	—
2	Shield	14	Shield
3	I+	15	I–
4	V+	16	V–
5	Shield	17	Shield
6	Analog Output Signal	18	Analog Output Ground
7	No Connection	19	No Connection
8	Low Alarm COM	20	Low Alarm N.O.
9	Low Alarm N.C.	21	No Connection
10	No Connection	22	No Connection
11	High Alarm COM	23	High Alarm N.O.
12	High Alarm N.C.	24	No Connection
13	No Connection	25	No Connection

Figure 5-3. Input/Output Connector

Serial Connector.bmp

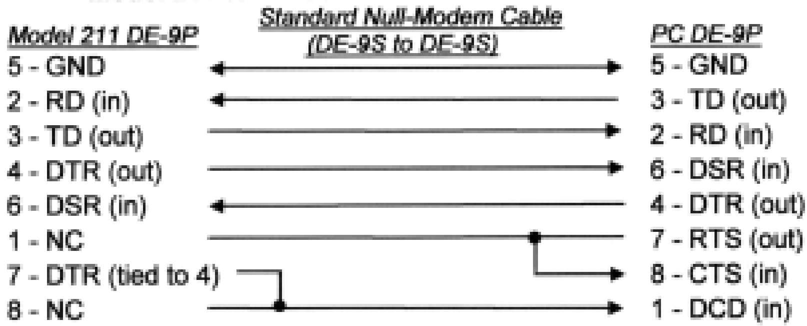
Model 211Temperature Monitor		Typical Computers			
DE-9P (DTE)		DB-25P (DTE)		DE-9P (DTE)	
Pin	**Description**	**Pin**	**Description**	**Pin**	**Description**
1	No Connection	2	TD (out)	1	DCD (in)
2	Receive Data (RD in)	3	RD (in)	2	RD (in)
3	Transmit Data (TD out)	4	RTS (out)	3	TD (out)
4	Data Terminal Ready (DTR out)	5	CTS (in)	4	DTR (out)
5	Ground (GND)	6	DSR (in)	5	GND
6	No Connection	7	GND	6	DSR (in)
7	Data Terminal Ready (DTR out) (tied to 4)	8	DCD (in)	7	RTS (out)
8	No Connection	20	DTR (out)	8	CTS (in)
9	No Connection	22	Ring in (in)	9	Ring in (in)

Figure 5-4. RS-232 (DTE) Connector

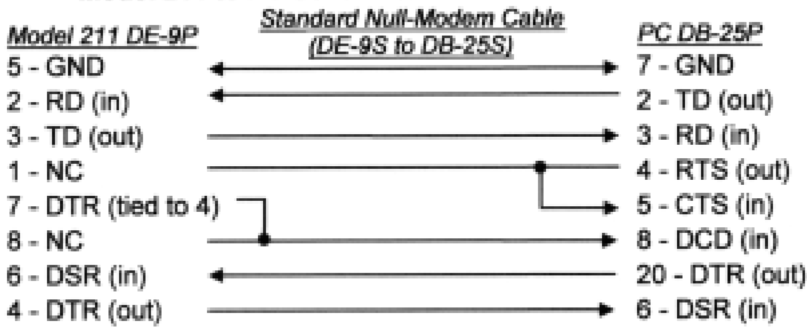
5.6.1 Serial Interface Cable Wiring

The following are suggested cable wiring diagrams for connecting the Model 211 Serial Interface to various Customer Personal Computers (PCs).

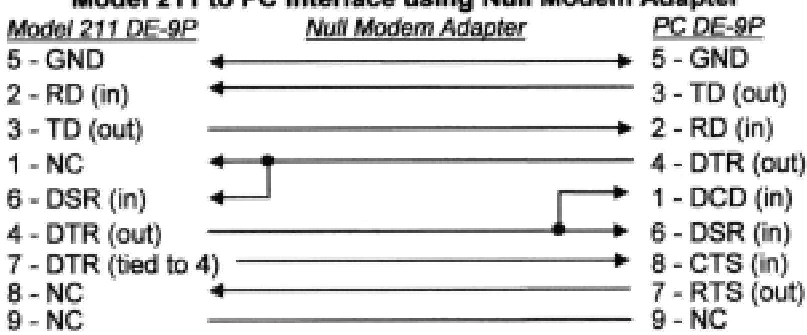
Model 211 to PC Serial Interface – PC with DE-9P



Model 211 to PC Serial Interface – PC with DB-25P



Model 211 to PC Interface using Null Modem Adapter



NOTE: Same as null modem cable design except PC CTS is provided from the Model 211 on DTR.

5.7 CALIBRATION PROCEDURE

The Model 211 requires calibration of both the sensor input and analog output to operate within the specification published in Paragraph 1.2 of this manual. None of the other circuits require calibration. Refer to Paragraph 5.7.4 for details on calibration specific interface commands.

WARNING: Only qualified personnel should perform this procedure.

5.7.1 Equipment Required for Calibration

PC and Interface

- PC with software loaded providing serial command line communication. (Example program in Paragraph 4.1.6 is ideal for this purpose.)
- Serial interface cable.

Test and Measurement Equipment

- Digital Multimeter (DMM) with minimum of 6-digits resolution. DMM DC voltage and 4-lead resistance specifications to be equivalent to or better than Agilent 34401 specifications.
- Cable to attach resistor standards to input.

Resistor Standards

- Resistor standards with the following nominal values. If standards are not available, ¼ W, 25 ppm/°C, metal film resistors can be used. Resistors should have connectors for 4-lead measurement.
- 0 Ω (short), 100 Ω, 250 Ω, 500 Ω, 2.5 kΩ, 5 kΩ, 7.5 kΩ, 100 kΩ, 250 kΩ.

5.7.2 Diode/Resistor Sensor Input Calibration

The sensor input contains a current source which can supply 10 µA or 1 mA of current, but only the 10 µA current source is adjusted during calibration. It is calibrated by adjusting the pot on the Model 211 main board. The sensor input contains multiple gain stages to accommodate the various sensors the Model 211 supports. The input gain and 1 mA circuitry is not adjusted during calibration. Instead calibrated resistors are attached to the input and mathematical calibration constants are calculated and programmed into the Model 211 to compensate for input offset and gain errors.

5.7.2.1 Sensor Input Calibration Setup and Serial Communication Verification

1. Allow the 211 to warm up for at least 1 hour with the input configured for Silicon diode and a 250 kΩ resistor standard attached to the input.
2. Connect the 211 to the PC via the serial port.
3. Verify operation of serial communication by sending the *IDN? command and receiving the proper response from the 211.

5.7.2.2 10 µA Current Source Calibration and 1 mA Current Source Verification

Purpose

To calibrate the 10 µA current source to be within the specified tolerance and verify operation of the 1 mA current source.

Process

1. Configure the input for the Silicon Diode input type.
2. Accurately determine the value of the 250 kΩ resistor using the DMM. Determine the calibration value by multiplying the actual resistance of the 250 kΩ resistor by 10×10^{-6}.
3. Attach the 250 kΩ resistor to the 211 input using proper 4-lead connection techniques, configure the DMM to read VDC and attach across the voltage terminals of the resistor.
4. Remove the four screws on the rear panel of the instrument. Slide the PC board assembly out enough to expose R9.
5. Adjust the current source calibration pot, R9, on the 211 main board until the DMM reads the value calculated in Step 2 to ±0.0002 VDC.
6. Slide the PC board back into the enclosure and replace the four screws on the rear panel.
7. Configure the input for the 1 kΩ Platinum input type.
8. Accurately determine the value of the 1 kΩ resistor using the DMM. Determine the verification value by multiplying the actual resistance of the 1 kΩ resistor by 1×10^{-3}.
9. Attach the 1 kΩ resistor to the 211 input using proper 4-lead connection techniques, configure the DMM to read VDC and attach to the resistor.
10. Measure voltage across resistor and verify it is within ±0.3% of the value calculated in Step 8.

5.7.2.3 Input Gain Calibration

Purpose

To determine the input offset and gain errors when the input is configured for each of the input types and provide offset and gain calibration constants back to the 211. Refer to the CALZ and CALG commands in Paragraph 5.7.4.

Process

1. Configure the input for the type to be calibrated.

Input Ranges Calibration (Continued)

2. Reset the calibration constants to their default values using the **CALZ** and **CALG** commands.

   Example:

   Input Type: GaAlAs Diode
   Zero Offset Reset Command: **CALZ 1,1,0**
   Gain Reset Command: **CALG 1,1,1**
3. Attach the 0 Ω (short) resistor standard to the input.
4. Via the interface obtain the input reading using the **CALREAD?** command and record this number.
5. Program the offset calibration by providing the inverse of the value read in the previous step using the **CALZ** command.

   Example:

   Input Type: GaAlAs Diode
   CALREAD? Reading: 0.00005
   Calibration Command: **CALZ 1,1,-0.00005**
6. Select resistor standard for the range being calibrated from Table 5-1 and accurately determine value of the resistor to the tolerance shown.
7. Attach the resistor standard to the 211 sensor input. Be sure to connect the resistor using proper 4-lead connection techniques.
8. Via the interface obtain the input reading using the **CALREAD?** command and record this number.
9. Program the gain calibration by dividing the actual resistance of the calibration resistor by the value read in the previous step and provide the result using the **CALG** command. Note that the gain calibration constant will always be within 5% of 1.00000.

Table 5-1. Calibration Table for Resistive Ranges

Input Type	Calibration Resistor Nominal Value	Resistor Value Known to	Cal. Command Type Number
Silicon Diode	250 kΩ	±20.5 Ω	0
GaAlAs Diode	250 kΩ	±20.5 Ω	1
Platinum 250 Ω	250 Ω	±0.027 Ω	2
Platinum 500 Ω	500 Ω	±0.052 Ω	3
Platinum 1000 Ω	5 kΩ	±1.03 Ω	4
NTC RTD	7.5 kΩ	±1.55 Ω	5

Input Ranges Calibration (Continued)

Example:

Input Type: 100 Ω Plat/250
Measured Value of Calibration Resistor: 250.025 Ω
CALREAD? Reading: 250.145
Constant Calculation: 250.025 / 250.145 = 0.99952
Calibration Command: **CALG 1,2,0.99952**

10. Repeat for all input ranges.
11. Send the **CALSAVE** command to finalize the calibration.

5.7.3 Analog Output Calibration and Verification

The 211 has one analog output which requires calibration. Both the voltage and current modes of the output need to be calibrated separately. Zero offset and gain errors are calibrated out by programming offset and gain constants to the instrument. Reference the CALZ and CALG commands and the extended version of the ANALOG command in Paragraph 5.7.4.

5.7.3.1 Analog Output Voltage Mode Calibration

Purpose

To determine the analog output voltage mode offset and gain errors and provide offset and gain calibration constants back to the 211.

Process

1. Reset the calibration constants to their default values using the **CALZ** and **CALG** commands.
   Example:
   Zero Offset Reset Command: **CALZ 2,0,0**
   Gain Reset Command: **CALG 2,0,1**
2. Connect the 100 kΩ resistor standard to the analog output using only the two voltage leads. Connect the positive lead of the DMM to the analog output positive terminal, the negative lead is connected to the analog output negative terminal.
3. Set the analog output to manual mode, manual output of 0%.
   Example:
   Manual Zero Voltage Command: **ANALOG 4,0**
4. Read the output voltage with the DMM and record this zero output (ZERO) value.
5. Set the analog output to +100%.
   Example:
   Manual + FS Voltage Command: **ANALOG 4,2**
6. Read the output voltage with the DMM and record this positive full scale (+FS) value.

Analog Output Voltage Mode Calibration (Continued)

7. Determine the offset calibration constant by dividing the ZERO value by the difference of the +FS value and the ZERO value and then inverting the result. Offset constant = –[ZERO / (+FS – ZERO)].
8. Use the **CALZ** command to send the offset calibration constant.

   Example:

   ZERO DMM Reading: –0.05632
   +FS DMM Reading: 10.0135
   Offset Constant Calculation:
   –(–0.05632 / (10.0135 –(–0.05632))) = 0.00559
   Calibration Command: **CALZ 2,0,0.00559**
9. Determine the gain calibration constant by adding the +FS reading to the inverse of the ZERO reading obtained in step 3 and dividing that number into 10. Gain constant = 10 / (+FS – ZERO).
10. Use the **CALG** command to send the gain calibration constant.

    Example:

    ZERO DMM Reading: –0.05632
    +FS DMM Reading: 10.0135
    Gain Constant Calculation: 10 / (10.0135 – (–0.05632)) = 0.99307
    Calibration Command: **CALG 2,0,0.99307**

5.7.3.2 Analog Output Current Mode Calibration

Purpose

To determine the analog output current mode offset and gain errors and provide offset and gain calibration constants back to the 211.

Process

1. Reset the calibration constants to their default values using the CALZ and CALG commands.

   Example:

   Zero Offset Reset Command: **CALZ 2,1,0**
   Gain Reset Command: **CALG 2,1,1**
2. Accurately determine the value of the 250 Ω resistor using the DMM.
3. Connect the 250 Ω resistor standard to the analog output with the two current leads. Connect the DMM to the two voltage leads of the resistor standard.
4. Set the analog output to manual mode, manual output of 0% (4 mA).

   Example:

   Manual Zero Current Command: **ANALOG 3,0**

Analog Output Current Mode Calibration (Continued)

5. Read the output voltage with the DMM. Divide this number by the measured resistor value and record this zero output (ZERO) value.
6. Set the analog output to +100% (20 mA).

   Example:

   Manual +FS Current Command: **ANALOG 3,2**
7. Read the output voltage with the DMM. Divide this number by the measured resistor value and record this positive full scale (+FS) value.
8. Determine the offset calibration constant by subtracting the ZERO value from the zero current point of 4 mA and divide that by the difference of the +FS value and the ZERO value.
   Offset constant = (4e–3 – ZERO) / (+FS – ZERO).
9. Use the **CALZ** command to send the offset calibration constant.

   Example:

   ZERO DMM Reading: 4.03974e–3
   +FS DMM Reading: 20.0674e–3
   Offset Constant Calculation: (4e-3 – 4.03974e-3) /
   (20.0674e-3 – 4.03974e-3) = –0.00248
   Calibration Command: **CALZ 2,1,–0.00248**
10. Determine the gain calibration constant by adding the +FS reading to the inverse of the ZERO reading obtained in step 5 and dividing that number into 16 mA. Gain constant = 16e–3 / (+FS – ZERO).
11. Use the **CALG** command to send the gain calibration constant.

    Example:

    ZERO DMM Reading: 4.03974e-3
    +FS DMM Reading: 20.0674e-3
    Gain Constant Calculation:
    16e-3 / (20.0674e-3 – 4.03974e-3) = 0.99827
    Calibration Command: **CALG 2,1,0.99827**
12. Send the **CALSAVE** command to finalize the calibration.

5.7.4 Calibration Specific Interface Commands

ANALOG Analog Output Parameter Command

Input: **ANALOG <mode>, <range>[term]**

Format: n,n

<mode> Specifies analog output voltage mode, current mode, voltage calibration mode, or current calibration mode.
- 0 = Voltage mode
- 1 = Current mode
- 3 = Current calibration mode
- 4 = Voltage calibration mode

<range> Specifies analog output range. Valid entries are:
- 0 = 0 – 20K or 0% output calibration mode
- 1 = 0 – 100K or 50% output calibration mode
- 2 = 0 – 200K or 100% output calibration mode
- 3 = 0 – 325K
- 4 = 0 – 475K
- 5 = 0 – 1000K

Remarks: Allows manual setting of analog output values for calibration purposes.

ANALOG? Analog Output Parameter Query

Input: **ANALOG?[term]**

Returned: <mode>, <range>[term]

Format: n,n (Refer to command for description)

CALG Gain Calibration Constant Command

Input: **`CALG <input>, <type>, <value>[term]`**

Format: n,n,+n.nnnnn

<input> Specifies input or analog output the gain calibration constant will be provided to. Valid entries are 1 for input and 2 for the analog output.

<type> Specifies the input sensor type. Valid entries are:

0 = Silicon Diode or Analog Output Voltage Mode
1 = GaAlAs Diode or Analog Output Current Mode
2 = 100Ω Plat/250
3 = 100Ω Plat/500
4 = 1000Ω Plat
5 = NTC RTD

<value> Gain calibration constant value.

Remarks: Provides the gain calibration constant for the selected input or analog output.

CALG? Gain Calibration Constant Query

Input: **`CALG? <input>, <type>[term]`**

Returned: <mode>, <range>[term]

Format: n,n

<input> 1, or 2

<type> 0 – 5

Returned: <value>[term]

Format: +n.nnnnn (Refer to command for description.)

CALREAD? 6-Digit Input Reading Query

Input: **`CALREAD? [term]`**

Returned: <value>[term]

Format: ±nnnnnnn

Remarks: Returns 6-digit value of selected input reading. Used for CALZ and CALG functions.

CALSAVE Calibration Save Command

Input: **CALSAVE[term]**

Remarks: Finalizes the calibration procedure. This command calculates and stores a checksum of the calibration memory. This checksum is used on power up to determine if the instrument is calibrated properly. If this command is not sent after a calibration, the instrument will display an "Err 03" on power up. Refer to Paragraph 5.3.1.

CALZ Zero Offset Calibration Constant Command

Input: **CALZ <input>, <type>, <value>[term]**

Format: n,n,±nnnnnnn

<input> Specifies the input or analog output the zero offset calibration constant will be provided to. Valid entries are 1 for input and 2 for the analog output.

<type> Specifies the input sensor type. Valid entries are:
- 0 = Silicon Diode or Analog Out Voltage Mode
- 1 = GaAlAs Diode or Analog Out Current Mode
- 2 = 100 Ω Plat/250
- 3 = 100 Ω Plat/500
- 4 = 1000 Ω Plat
- 5 = NTC RTD

<value> Zero offset calibration constant value.

Remarks: Provides the zero offset calibration constant for the input or analog output.

CALZ? Zero Offset Calibration Constant Query

Input: **CALZ? <input>, <type>[term]**

Format: n,n

<input> 1, or 2

<type> 0 – 5

Returned: <value>[term]

Format: ±nnnnnnn (Refer to command for description)

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CHAPTER 6

OPTIONS AND ACCESSORIES

6.0 GENERAL

This chapter provides lists of models, options, accessories, sensors, wires, and special equipment available for the Model 211.

6.1 MODELS

A list of the available Temperature Monitor models are as follows:

Model	Description
211	Model 211 Temperature Monitor without power supply.
211-UN	Model 211 Temperature Monitor with 100 – 250 V (universal input) 17 VA power supply. **Power Options:** VAC-120 Includes U.S. line cord VAC-220 Includes European line cord

6.2 ACCESSORIES

A list of accessories available for the Model 211 are as follows:

Model	Description of Accessory
106-253*	Sensor input mating connector (DB-25)
106-264*	Shell for sensor input mating connector
2111	Panel mount adapter for one Model 211 into 105 mm Wide × 132 mm High (4.1 × 5.2 inches) mounting plate. See Fig. 2-4.
2112	Panel mount adapter for two Model 211s into 105 mm Wide × 132 mm High (4.1 × 5.2 inches) mounting plate. See Fig. 2-4.
8000	CalCurve™, floppy disk. Consists of a calibrated sensor breakpoint table on a floppy disk in ASCII format for customer download
8001-211	CalCurve™, factory installed. Consists of a calibrated sensor breakpoint table factory-installed into nonvolatile memory
MAN-211*	User's manual

* Included with Model 211.

6.3 WIRES

Common cryogenic wire available from Lake Shore. Other wire and installation accessories are also available.

P/N	Cable Description
9001-005	**Quad-Twist™ Cryogenic Wire.** Two twisted pairs, phosphor-bronze wire, 36 AWG, 0.127 mm (0.005 inch) diameter.
9001-006	**Duo-Twist™ Cryogenic Wire.** Single twisted pair, phosphor-bronze wire, 36 AWG, 0.127 mm (0.005 inch) diameter.
9001-007	**Quad-Lead™ Cryogenic Wire**. Phosphor-bronze wire, flat, 32 AWG, 0.203 mm (0.008 inch) diameter.
9001-008	**Quad-Lead™ Cryogenic Wire**. Phosphor-bronze wire, flat, 32 AWG, 0.127 mm (0.005 inch) diameter.

6.4 SENSORS

Silicon Diode sensors available from Lake Shore. Other sensors are also available.

Sensor No.	Sensor Description
Series DT-420	The smallest silicon diode Temperature Sensor available. For installation on flat surfaces. Sensor incorporates the same type of silicon chip used in the Series DT-470 and DT-471.
Series DT-450	Silicon Diode Miniature Temperature Sensor. Same silicon chip used in the DT-470 configured for installation in recesses as small as 1.6 mm diameter by 3.2 mm deep.
Series DT-470	Silicon Diode Temperature Sensor. Interchangeable, repeatable, accurate, wide range customized for cryogenics.
Series DT-471	An economical version of the DT-470 for applications where temperature measurements below 10 K are not required.
Series DT-670	Lake Shore DT-670 diode temperature sensors offer the best accuracy across the widest useful temperature range – 1.4 to 500 K – of any silicon diode sensor in the industry. Sensors within the DT-670 series are interchangeable to the Curve DT-670.

APPENDIX A

CURVE TABLES

A1.0 GENERAL

The following curve tables are applicable to the Model 211 Temperature Monitor.

Table A-1. Lake Shore DT-470 Silicon Diode (Curve 10)

Break-point	Temp. (K)	Volts	Break-point	Temp. (K)	Volts	Break-point	Temp. (K)	Volts
1	475.0	0.09062	30	170.0	0.82405	59	031.0	1.10476
2	470.0	0.10191	31	160.0	0.84651	60	030.0	1.10702
3	465.0	0.11356	32	150.0	0.86874	61	029.0	1.10945
4	460.0	0.12547	33	145.0	0.87976	62	028.0	1.11212
5	455.0	0.13759	34	140.0	0.89072	63	027.0	1.11517
6	450.0	0.14985	35	135.0	0.90161	64	026.0	1.11896
7	445.0	0.16221	36	130.0	0.91243	65	025.0	1.12463
8	440.0	0.17464	37	125.0	0.92317	66	024.0	1.13598
9	435.0	0.18710	38	120.0	0.93383	67	023.0	1.15558
10	430.0	0.19961	39	115.0	0.94440	68	022.0	1.17705
11	420.0	0.22463	40	110.0	0.95487	69	021.0	1.19645
12	410.0	0.24964	41	105.0	0.96524	70	019.5	1.22321
13	400.0	0.27456	42	100.0	0.97550	71	017.0	1.26685
14	395.0	0.28701	43	095.0	0.98564	72	015.0	1.30404
15	380.0	0.32417	44	090.0	0.99565	73	013.5	1.33438
16	365.0	0.36111	45	085.0	1.00552	74	012.5	1.35642
17	345.0	0.41005	46	080.0	1.01525	75	011.5	1.38012
18	330.0	0.44647	47	075.0	1.02482	76	010.5	1.40605
19	325.0	0.45860	48	070.0	1.03425	77	009.5	1.43474
20	305.0	0.50691	49	065.0	1.04353	78	008.5	1.46684
21	300.0	0.51892	50	058.0	1.05630	79	007.5	1.50258
22	285.0	0.55494	51	052.0	1.06702	80	005.2	1.59075
23	265.0	0.60275	52	046.0	1.07750	81	004.2	1.62622
24	250.0	0.63842	53	040.0	1.08781	82	003.4	1.65156
25	235.0	0.67389	54	039.0	1.08953	83	002.6	1.67398
26	220.0	0.70909	55	036.0	1.09489	84	002.1	1.68585
27	205.0	0.74400	56	034.0	1.09864	85	001.7	1.69367
28	190.0	0.77857	57	033.0	1.10060	86	001.4	1.69818
29	180.0	0.80139	58	032.0	1.10263			

Table A-2. Lake Shore DT-670 Silicon Diode

Break-point	Temp. (K)	Volts	Break-point	Temp. (K)	Volts	Break-point	Temp. (K)	Volts
1	500.0	0.090570	26	87.0	1.01064	51	20.2	1.19475
2	491.0	0.110239	27	81.0	1.02125	52	17.10	1.24208
3	479.5	0.136555	28	75.0	1.03167	53	15.90	1.26122
4	461.5	0.179181	29	69.0	1.04189	54	14.90	1.27811
5	425.5	0.265393	30	63.0	1.05192	55	14.00	1.29430
6	390.0	0.349522	31	56.4	1.06277	56	13.15	1.31070
7	346.0	0.452797	32	49.0	1.07472	57	12.35	1.32727
8	320.0	0.513393	33	38.7	1.09110	58	11.55	1.34506
9	298.5	0.563128	34	35.7	1.09602	59	10.75	1.36423
10	279.0	0.607845	35	33.3	1.10014	60	10.00	1.38361
11	261.0	0.648723	36	31.2	1.10393	61	9.25	1.40454
12	244.0	0.686936	37	29.6	1.10702	62	8.50	1.42732
13	228.0	0.722511	38	28.3	1.10974	63	7.75	1.45206
14	213.0	0.755487	39	27.3	1.11204	64	6.80	1.48578
15	198.5	0.786992	40	26.5	1.11414	65	5.46	1.53523
16	184.5	0.817025	41	25.8	1.11628	66	4.56	1.56684
17	171.5	0.844538	42	25.2	1.11853	67	4.04	1.58358
18	159.5	0.869583	43	24.7	1.12090	68	3.58	1.59690
19	148.0	0.893230	44	24.3	1.12340	69	3.18	1.60756
20	137.5	0.914469	45	24.0	1.12589	70	2.62	1.62125
21	127.5	0.934356	46	23.7	1.12913	71	2.26	1.62945
22	118.0	0.952903	47	23.3	1.13494	72	1.98	1.63516
23	109.0	0.970134	48	22.8	1.14495	73	1.74	1.63943
24	100.5	0.986073	49	22.0	1.16297	74	1.53	1.64261
25	93.5	0.998925	50	21.3	1.17651	75	1.40	1.64430

Table A-3. CTI Curve C Silicon Diode

Breakpoint	Temp. (K)	Volts
1	320.0	0.2968
2	305.0	0.3382
3	295.0	0.3640
4	285.0	0.3911
5	280.0	0.4050
6	270.0	0.4341
7	250.0	0.4896
8	195.0	0.6408
9	165.0	0.7255
10	140.0	0.7971
11	130.0	0.8245
12	125.0	0.8376
13	115.0	0.8625
14	110.0	0.8769
15	100.0	0.9049
16	95.0	0.9184
17	90.0	0.9314
18	85.0	0.9440
19	77.4	0.9626
20	65.0	0.9958
21	60.0	1.0100
22	36.0	1.0747
23	20.0	1.1162
24	19.0	1.1290
25	18.0	1.1500
26	14.0	1.3161
27	12.0	1.3656
28	11.0	1.3850
29	10.0	1.4000

Table A-4. Lake Shore PT-100/-1000 Platinum RTD Curves

Break-point	PT-100		PT-1000	
	Temp. (K)	Ohms (Ω)	Temp. (K)	Ohms (Ω)
1	030.0	3.820	030.0	38.20
2	032.0	4.235	032.0	42.35
3	036.0	5.146	036.0	51.46
4	038.0	5.650	038.0	56.50
5	040.0	6.170	040.0	61.70
6	042.0	6.726	042.0	67.26
7	046.0	7.909	046.0	79.09
8	052.0	9.924	052.0	99.24
9	058.0	12.180	058.0	121.80
10	065.0	15.015	065.0	150.15
11	075.0	19.223	075.0	192.23
12	085.0	23.525	085.0	235.25
13	105.0	32.081	105.0	320.81
14	140.0	46.648	140.0	466.48
15	180.0	62.980	180.0	629.80
16	210.0	75.044	210.0	750.44
17	270.0	98.784	270.0	987.84
18	315.0	116.270	315.0	1162.70
19	355.0	131.616	355.0	1316.16
20	400.0	148.652	400.0	1486.52
21	445.0	165.466	445.0	1654.66
22	490.0	182.035	490.0	1820.35
23	535.0	198.386	535.0	1983.86
24	585.0	216.256	585.0	2162.56
25	630.0	232.106	630.0	2321.06
26	675.0	247.712	675.0	2477.12
27	715.0	261.391	715.0	2613.91
28	760.0	276.566	760.0	2765.66
29	800.0	289.830	800.0	2898.30

Model 211 Menu Structure

InPUt			**Input Setup Settings**
	—		*Input Type*
		Si	Si (Silicon Diode)
		GAALAS	GaAlAs (Gallium Aluminum Arsenide Diode)
		250 Pt	250 Pt (PT-100, 250 Ω Range)
		500 Pt	500 Pt (PT-100, 500 Ω Range)
		1000Pt	1000 Pt (PT-1000, 5 kΩ Range)
		ntdrtd	NTCRTD (Neg. Temp. Coefficient RTD)
	—		*Input Curve (Selections depend on input type)*
		nonE	None
		dt470	DT-470
		dt670	DT-670
		Ct i	DT-670
		Pt 100	PT-100
		Pt 1000	PT-1000
		USEr	User
	Un itS		*Display Units (front panel LEDs)*
		—	°C (Celsius)
		—	°F (Fahrenheit)
		—	K (Kelvin)
		—	V/Ω (Sensor Units)
OUtPUt			**Analog Output Settings**
	—		*Analog Output Mode*
		voLt	Voltage
		CUr	Current
	—		*Analog Output Range*
		rnG 0	0 = 0 to 20 K
		rnG 1	0 = 0 to 100 K
		rnG 2	0 = 0 to 200 K
		rnG 3	0 = 0 to 325 K
		rnG 4	0 = 0 to 475 K
		rnG 5	0 = 0 to 1000 K
ALA			**Alarm Settings**
	—		*Alarm Mode*
		AL OFF	Off
		AL On	On
	H		*High Setpoint*
	L		*Low Setpoint*
	d		*Deadband*
	—		*Latching*
		Ltch 0	0 = Off
		Ltch 1	1 = On
rELAY			**Relay Settings**
	—		*Relay 1 Mode*
		r1 OFF	Off
		r1 On	On
		r1 ALA	Alarms
	—		*Relay 2 Mode*
		r2 OFF	Off
		r2 On	On
		r2 ALA	Alarms

Lake Shore

is a technology leader in the development of cryogenic temperature sensors, precision low temperature measurement and control instrumentation, and magnetic measurement and test systems. Since 1968, Lake Shore physicists, material scientists, and engineers have dedicated themselves to the development of tomorrow’s technology today. Lake Shore serves a worldwide network of Customers including university and national laboratories, aerospace and other industries, as well as many of the premier companies around the world.

Series 275

MINI-CONVECTRON®
Nonlinear Analog Output Modules

Installation, Operation, and Maintenance Instructions

This manual is for use only with the following catalog numbers:

One Setpoint		Two Setpoints	
275800-EU	275806-EU	275867-EU	275875-EU
275801-EU	275807-EU	275870-EU	275876-EU
275802-EU	275808-EU	275871-EU	275877-EU
275803-EU	275809-EU	275872-EU	275878-EU
275804-EU	275863-EU	275873-EU	275879-EU
275805-EU		275874-EU	

For assistance in using or servicing this instrument contact:

Granville-Phillips Customer Service Department
5675 Arapahoe Avenue
Boulder, Colorado 80303 U.S.A.
Telephone (303) 443-7660
FAX (303) 443-2546
email: custserv@granville.com

Any comments or questions? Call Us!

Your comments on how these instructions could be made more useful to you will help us to improve our capabilities for satisfying your requirements. Call 1-303-443-7660 (1-800-776-6543 toll-free in the U.S.A.) or email us at custserv@granville.com

Instruction Manual Catalog No. 275511

GRANVILLE-PHILLIPS
HELIX TECHNOLOGY CORPORATION

Printed: November 1999

Table of Contents

Safety Instructions

START BY READING THESE IMPORTANT SAFETY INSTRUCTIONS AND NOTES collected here for your convenience and repeated with additional information at appropriate points in these instructions.

> **These safety alert symbols in this manual or on the Product rear panel, mean caution - personal safety, property damage or danger from electric shock. Read these instructions carefully.**

In these instructions the word "product" refers to the 275 *MINI-CONVECTRON*® Module and all of its approved parts and accessories.

NOTE: These instructions do not and cannot provide for every contingency that may arise in connection with the installation, operation, or maintenance of this product. Should you require further assistance, please contact Granville-Phillips (G-P) at the address on the title page of this manual.

This product has been designed and tested to offer reasonably safe service provided it is installed, operated, and serviced in strict accordance with these safety instructions.

> **Failure to comply with these instructions may result in serious personal injury, including death, or property damage.**

These safety precautions must be observed during all phases of operation, installation, and service of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Granville-Phillips disclaims all liability for the customer's failure to comply with these requirements.

> **The service and repair information in this manual is for the use of Qualified Service Personnel. To avoid shock, do not perform any procedures in this manual or perform any servicing on this product unless you are qualified to do so.**

- *Read Instructions* – Read all safety and operating instructions before operating the product.
- *Retain Instructions* – Retain the Safety and Operating Instructions for future reference.
- *Heed Warnings* – Adhere to all warnings on the product and in the operating instructions.
- *Follow Instructions* – Follow all operating and maintenance instructions.
- *Accessories* – *Do not* use accessories not recommended in this manual as they may be hazardous.

> **To reduce the risk of fire or electric shock, do not expose this product to rain or moisture.**

> **Objects and Liquid Entry - Never push objects of any kind into this product through openings as they may touch dangerous voltage points or short out parts that could result in a fire or electric shock. Be careful not to spill liquid of any kind onto the products.**

Do not substitute parts or modify instrument.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to a service facility designated by Granville-Phillips for service and repair to ensure that safety features are maintained. Do not use this product if it has unauthorized modifications.

Damage Requiring Service

Disconnect the product from all power sources and refer servicing to Qualified Service Personnel under the following conditions:

a. When any cable or plug is damaged.

b. If any liquid has been spilled onto, or objects have fallen into, the product.

c. If the product has been exposed to rain or water.

d. If the product does not operate normally even if you follow the operating instructions. Adjust only those controls that are covered by the operation instructions. Improper adjustment of other controls may result in damage and will often require extensive work by a qualified technician to restore the product to its normal operation.

e. If the product has been dropped or the enclosure has been damaged.

f. When the product exhibits a distinct change in performance. This indicates a need for service.

Replacement Parts - When replacement parts are required, be certain to use the replacement parts that are specified by G-P, or that have the same characteristics as the original parts. Unauthorized substitutions may result in fire, electric shock or other hazards.

Safety Check - Upon completion of any service or repairs to this product, ask the Qualified Service Person to perform safety checks to determine that the product is in safe operating order.

Finite Lifetime - After ten years of normal use or even non-use, the electrical insulation in this product may become less effective at preventing electrical shock. Under certain environmental conditions which are beyond the manufacturer's control, some insulation material may deteriorate sooner. Therefore, periodically inspect all electrical insulation for cracks, crazing, or other signs of deterioration. Do not use if the electrical insulation has become unsafe.

Be aware that when high voltage is present in any vacuum system, a life threatening electrical shock hazard may exist unless all exposed conductors are maintained at earth ground.

This hazard is not peculiar to this product.

Be aware that an electrical discharge through a gas may couple dangerous high voltage directly to an ungrounded conductor almost as effectively as would a copper wire connection. A person may be seriously injured or even killed by merely touching an exposed ungrounded conductor at high potential.

This hazard is not unique to this product.

Install suitable devices that will limit the pressure to the level that the vacuum system can safely withstand. In addition, install suitable pressure relief valves or rupture disks that will release pressure at a level considerably below the pressure that the system can safely withstand.

Overpressure

Series 275 Gauges should not be used above 1000 Torr true pressure.

Series 275 instruments are furnished calibrated for N_2. They also measure the pressure of air correctly within the accuracy of the instrument. Do not attempt to use a Series 275 Gauge calibrated for N_2 to measure or control the pressure of other gases such as argon or CO_2, unless accurate conversion data for N_2 to the other gas is properly used.

If accurate conversion data is not used, or is improperly used, a potential overpressure explosion hazard can be created under certain conditions.

A pressure relief valve should be installed in the system should the possibility of exceeding 1000 Torr (1333 mbar) exists.

Suppliers of pressure relief valves and pressure relief disks are listed in the Thomas Register under **Valves, Relief** and **Discs, Rupture**.

Confirm that these safety devices are properly installed before installing the product. In addition, check that:

(1) the proper gas cylinders are installed,

(2) gas cylinder valve positions are correct on manual systems, and

(3) the automation is correct on automated gas delivery systems.

Proper Grounding:

All components of a vacuum system used with this or any similar high voltage product must be maintained at earth ground for safe operation. The power cord of this product shall be connected only to a properly grounded outlet. Be aware, however, that grounding this product does not guarantee that other components of the vacuum system are maintained at earth ground.

Complying with the usual warning to connect the power cable only to a properly grounded outlet is necessary but not sufficient for safe operation of a vacuum system with this or any similar high voltage producing product.

Verify that the vacuum port to which the *MINI-CONVECTRON* Gauge is mounted is electrically grounded. It is essential for personnel safety as well as proper operation that the envelope of the gauge be connected to a facility ground. Use a ground lug on a flange bolt if necessary.

Vacuum gauges with compression fittings may be forcefully ejected if the vacuum system is pressurized.

Using the N_2 calibration to pressurize a vacuum system above about 1 Torr with certain other gases can cause dangerously high pressures which may cause explosion of the system. See Section 3.2 on page 3-1 before using with other gases.

Warning - If used improperly, *MINI-CONVECTRON* Gauges can supply misleading pressure indications that can result in dangerous overpressure conditions within the system.

Do not operate in an explosive atmosphere.

Do not operate the product in the presence of flammable gases or fumes.

Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Do not use the product to measure the pressure of explosive or combustible gases or gas mixtures. The sensor wire of the *MINI-CONVECTRON* Gauge normally operates at only 125 °C, but it is possible that Controller malfunction can raise the sensor temperature above the ignition temperature of combustible mixtures.

Danger of explosion or inadvertent venting to atmosphere exists on all vacuum systems which incorporate gas sources or involve processes capable of pressurizing the system above safe limits.

It is the installer's responsibility to ensure that the automatic signals provided by the product are always used in a safe manner. Carefully check manual operation of the system and the set point programming before switching to automatic operation.

Where an equipment malfunction could cause a hazardous situation, always provide for fail-safe operation. As an example, in an automatic backfill operation where a malfunction might cause high internal pressures, provide an appropriate pressure relief device.

The fumes from solvents such as trichloroethylene, perchloroethylene, toluene, and acetone can be dangerous to health if inhaled. Use only in well ventilated areas exhausted to the outdoors. Acetone and toluene are highly flammable and should not be used near an open flame or energized electrical equipment.

Certification

Granville-Phillips certifies that this product met its published specifications at the time of shipment from the factory. Granville-Phillips further certifies that its calibration measurements are traceable to the National Institute of Standards and Technology to the extent allowed by the Institute's calibration facility. See also CE Declaration of Conformity inside envelope for CE tests performed.

Limited Warranty

Granville-Phillips (G-P) warrants Series 275 Modules and Series 275 Gauges for one year from date of shipment against defects in materials and workmanship, provided that the installation, operating and preventive maintenance procedures specified in their instruction manuals have been followed. G-P warrants that the software and hardware designated by G-P for use with these products will execute their programming instructions, but does not warrant the operation of the product, software, or hardware will be uninterrupted or error free. G-P will, at its option, repair, replace or refund the selling price of a product if it proves to be in breach of this limited warranty during the warranty period, provided the item is returned to G-P together with a written statement of the problem in reasonable detail.

The foregoing warranties shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or hardware or interfacing, unauthorized modification, misuse, mechanical damage, operation outside of the environmental specifications for the product, or improper site preparation or maintenance. In addition, the foregoing warranty shall not apply to transducers that are visibly contaminated. G-P specifically disclaims any responsibility for product performance related to applications that adversely affect performance.

THE WARRANTY SET FORTH ABOVE IS EXCLUSIVE. G-P EXPRESSLY DISCLAIMS ANY OTHER WARRANTIES, WHETHER EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. UNDER NO CIRCUMSTANCES SHALL GRANVILLE-PHILLIPS BE LIABLE FOR CONSEQUENTIAL OR OTHER DAMAGES RESULTING FROM A BREACH OF THIS LIMITED WARRANTY OR OTHERWISE.

For warranty service or repair, this product must be returned to a service facility designated by G-P. Buyer shall prepay shipping charges to the designated service facility and the service facility shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes incoming and outgoing for products returned to G-P from any country other than the U.S.A.

Some states or provinces do not allow limitations on how long an implied warranty lasts, so such limitation or exclusion may not apply. However, any implied warranty of merchantability or fitness is limited to the duration of this written warranty.

Service Guidelines

Some minor problems are readily corrected on site. If the product requires service, please contact our Customer Service Department at 1-303-443-7660 for troubleshooting help over the phone. If the product must be returned for service, request a Return Authorization (RA) from G-P. See the Service Form at the end of Chapter 6. Do not return products without first obtaining an RA.

Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

When returning equipment to Granville-Phillips, please use the original packing material whenever possible. Otherwise, contact your shipper or Granville-Phillips for safe packaging guidelines. Circuit boards and modules separated from the controller chassis must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Granville-Phillips will supply return packaging materials at no charge upon request.

FCC Verification

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio or television technician for help.

Canadian Users

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numerique de la classe B respecte toutes les exigences du Reglement sur le material broilleur du Canada.

Chapter 1

System Components

Series 275 Nonlinear Analog Output *MINI-CONVECTRON* Modules have single or dual process control setpoints. These adjustable setpoints allow you to control which valves to switch, alarms to signal, or controls to engage. An analog output signal of the indicated pressure can be used for a remote display or input to a computer.

1.1 Modules

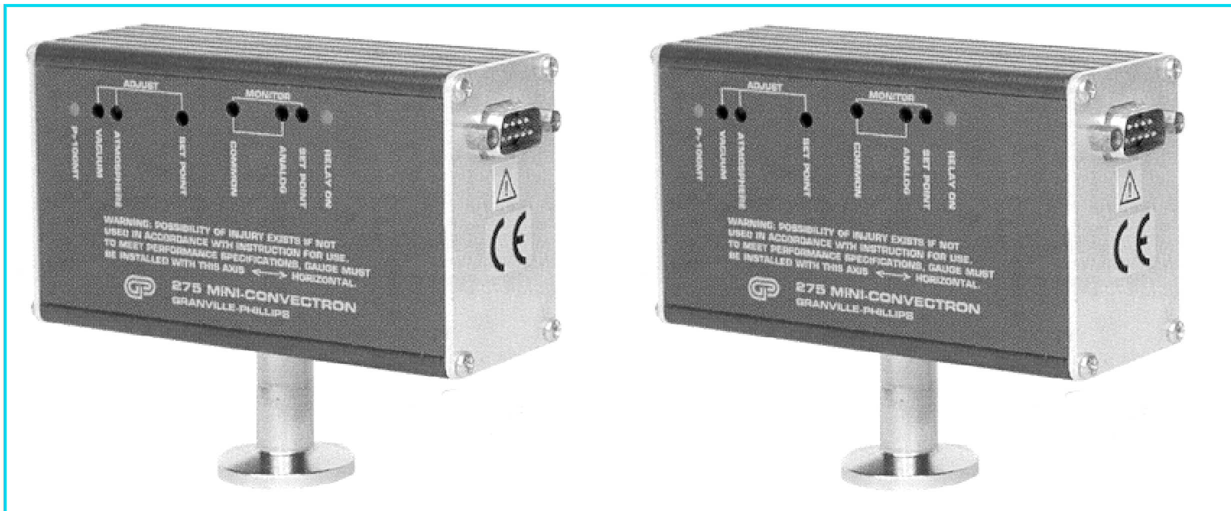


Figure 1-1 *Series 275 Nonlinear Analog Output MINI-CONVECTRON Modules. Left—One Process Control Setpoint. Right—Two Process Control Setpoints.*

Each Series 275 Nonlinear Analog Output *MINI-CONVECTRON* Module contains a *CONVECTRON* Gauge tube. (See Figure 1-2.)

Each Series 275 Nonlinear Analog Output *MINI-CONVECTRON* Module is shipped with an electrical mating connector and a screwdriver. (See Figure 1-3.)

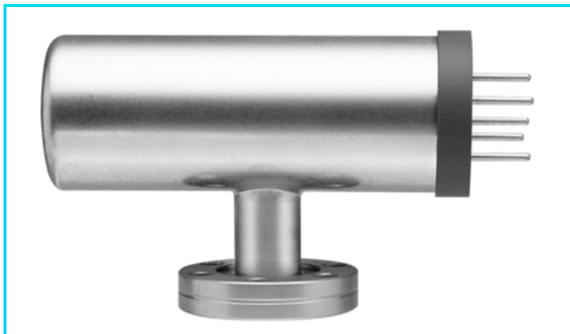


Figure 1-2 *CONVECTRON Gauge Tube.*

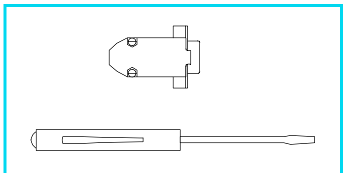


Figure 1-3 *Electrical Mating Connector, Screwdriver.*

1.2 Specifications

Table 1-1 Specifications.

Modules	
Pressure Range for N_2/Air	1 x 10^{-3} Torr to 1,000 Torr (1 x 10^{-3} mbar to 1,333 mbar) (1 x 10^{-1} Pa to 133 kPa) Operation down to 1 x 10^{-4} Torr (mbar) possible using analog output, but requires periodic checking of zero by reducing system pressure to below 1 x 10^{-5} Torr (mbar)
Operating Temperature	+4 °C to +50 °C ambient, noncondensing
Bakeout Temperature	+85 °C, nonoperating
Input Voltage/Power	11.5 Vdc to 26.5 Vdc @ 0.1 Adc. Protected against reversals, transients, or over-voltages
Analog Output	0.375 Vdc to 5.659 Vdc non-linear corresponding to 0 to 1000 Torr for N_2 (output impedance 120 ohms)
Weight (with fitting)	0.33 kg (12 oz)
CE Compliant	EN50081-1, EN50081-2, EN50082-1, EN50082-2, EN61010-1
Process Control Options	
Relay configuration	Single-pole, double-throw relay(s) (SPDT), silver-alloy, gold-clad contacts
Contact rating	1 A, 30 Vdc, resistive load, or ac non-inductive
Adjustment range	1 mTorr to 1000 Torr
***CONVECTRON* Gauge**	
Sensor material	Gold-plated tungsten
Mounting orientation	Gauge axis must be horizontal to provide accurate measurement above about 1 Torr
Operating temperature	+15 °C to 50 °C ambient, noncondensing
Internal volume	40 cm^3 (2.5 $in.^3$)
Bakeout temperature	150 °C maximum, nonoperating, removed from module

1.3 Pinout Diagrams

1.3.1 One Setpoint Connector

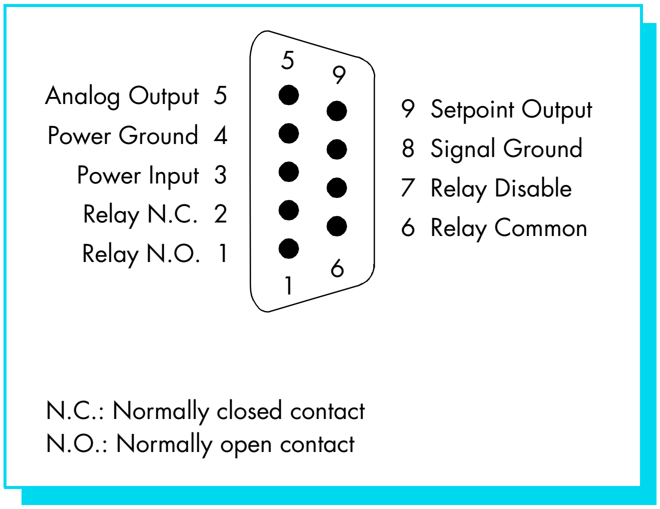


Figure 1-4 *One Setpoint Connector.*

1.3.2 Two Setpoint Connector

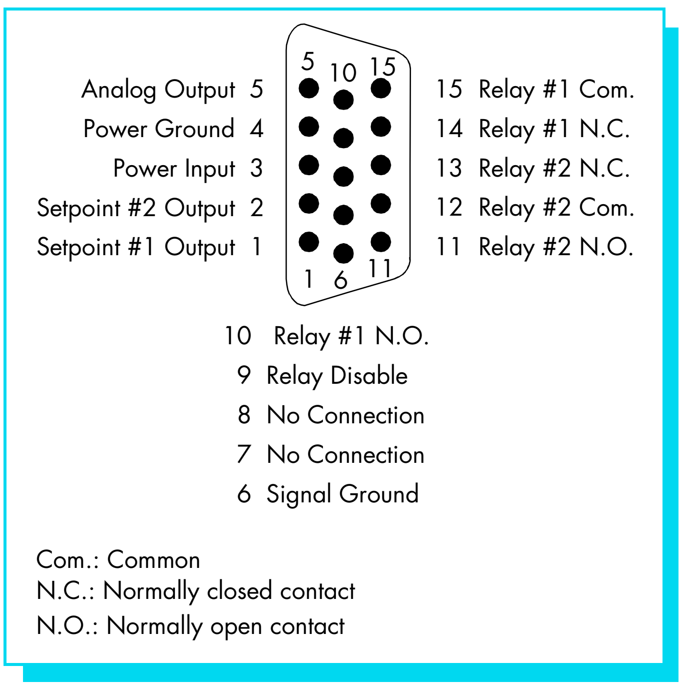
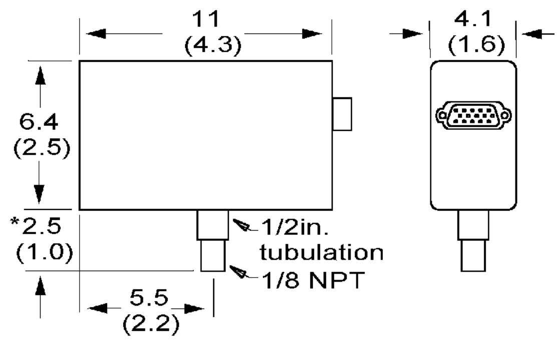


Figure 1-5 *Two Setpoint Connector.*

1.4 Dimensions

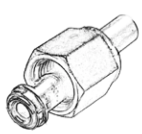
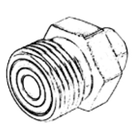
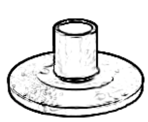
Dimensions are in cm (in.).



* Dimension H, see Table 1-2

Figure 1-6 *Dimensions.*

Table 1-2 *Vacuum Connections.*

Fitting	Description	Dimension H
 1/8 NPT pipe thread / 1/2 inch compression fitting	1/8 NPT pipe thread / 1/2 inch quick connect/weld	2.5 cm (1.0 in.)
 VCR-type female fitting	1/4 inch VCR-type female fitting 1/2 inch VCR-type female fitting	3.0 cm (1.2 in.) 3.6 cm (1.4 in.)
 VCO-type male fitting	3/8 inch VCO-type male fitting	4.8 cm (1.9in.)
 ConFlat-type flange	1.33 inch (NW16CF) ConFlat-type 2.75 inch (NW35CF) ConFlat-type	3.8 cm (1.5 in.) 3.8 cm (1.5 in.)
 KF flange	NW10KF flange NW16KF flange NW25KF flange NW40KF flange NW50KF flange	3.3 cm (1.3 in.) 3.3 cm (1.3 in.) 3.3 cm (1.3 in.) 3.8 cm (1.5 in.) 3.8 cm (1.5 in.)

All dimensions are nominal. For tolerances, contact G-P.

Chapter 2

Initial Setup Procedures

2.1 Pre-Installation Considerations

The purpose of this chapter is to guide you through the basic setup procedures for the Series 275 Nonlinear Analog Output *MINI-CONVECTRON* Modules. You will find information on mounting *MINI-CONVECTRON* Gauges and fabricating and connecting the gauge cable.

Table 2-1 *Factory Defaults for Options.*

Process Control	Factory Default Settings
Setpoint Relay	Pressure Setpoint Polarity (–): Relay pulls in below Setpoint. (0.0)

2.2 Mounting *CONVECTRON* Gauges

- Cleanliness pays. Keep the port cover in place until moments before installation.
- For proper operation above about 1 Torr, install *MINI-CONVECTRON* Modules with the gauge axis horizontal (see Figure 2-1). Although the gauge will read correctly below 1 Torr when mounted in any position, erroneous readings will result at pressures above 1 Torr if the gauge axis is not horizontal.
- Vibration causes convection cooling of the sensor and will result in high pressure readings. Mount *MINI-CONVECTRON* Modules where they will not vibrate excessively.

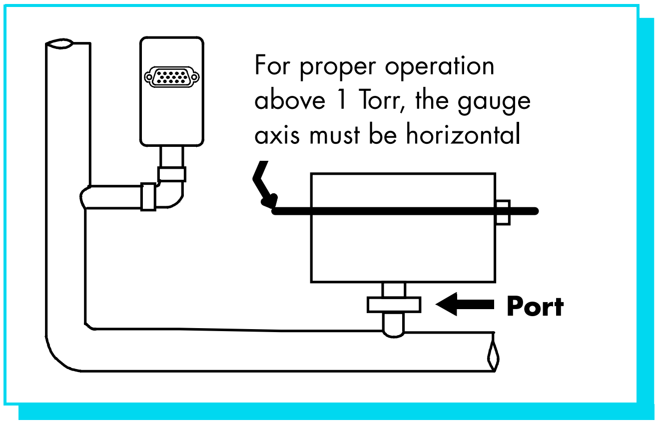


Figure 2-1 *MINI-CONVECTRON Module Installation.*

- Orient the gauge to prevent condensation of process vapors on the internal surfaces through line-of-sight access to its interior. If vapor condensation is likely, orient the port downward to help liquids drain out (see Figure 2-1).

2.2.1 Environment

To minimize temperature effects, locate pressure gauges away from internal and external heat sources, in an area where the ambient temperature is reasonably constant.

2.2.2 Location

Where you mount the gauge is critical to obtaining reliable pressure measurements. Long tubing or other constrictions can cause large errors in pressure readings. If you mount the gauge near the pump, the pressure in the gauge may be considerably lower than in the rest of the system. If you place the gauge near a gas inlet or other source of contamination, the pressure in the gauge may be much higher than in the rest of the system.

2.2.3 Grounding

> **When high voltage is present, all exposed conductors of a vacuum must be maintained at earth ground.**

Under certain conditions, dangerously high voltage can be conducted through a gas directly to an ungrounded conductor almost as effectively as through a copper wire. The ability of an electric current to flow through a gas under certain circumstances poses a serious risk. Do not touch the exposed pins on any gauge installed on a vacuum system when high voltage is present.

The *CONVECTRON* Gauge envelope may not be reliably grounded through its vacuum connection. For safety, you must either:

- add a separate ground wire, or
- shield the envelope to prevent human contact. Ground the gauge envelope by using a metal hose clamp on the gauge connected by a #12 AWG (minimum size) copper wire to the grounded vacuum chamber.

2.3 Gauge Mounts

2.3.1 Compression Mount/Quick Connect

Do not use for positive pressure applications. The gauge may be forcefully ejected. The gauge port is designed to fit a standard $^1/_2$ in. compression/quick connect mounting such as an Ultra-Torr®[1] fitting. Insert the gauge tube port into the compression fitting and finger-tighten the press ring. A light film of vacuum grease, such as APIEZON[2], will ensure sealing.

2.3.2 1/8 NPT Mount

Fits standard $^1/_8$ NPT female fitting. Wrap the threads of the gauge port with TEFLON®[3] tape and hand tighten. Do not use a wrench or tool. Tighten only enough to achieve a seal.

2.3.3 VCR/VCO Mount

Remove the plastic or metal bead protector cap from the bead. When using a gasket, place it into the female nut where applicable. Assemble the components and snug finger-tight. While holding a back-up wrench stationary, tighten the female nut $^1/_8$ turn past finger-tight for 316 stainless steel and nickel gaskets; or $^1/_4$ turn past finger-tight for copper and aluminum gaskets.

2.3.4 NW10KF, NW16KF, NW25KF, NW40KF, or NW50KF Flange Mount

The KF mounting system requires O-rings and centering rings between mating flanges. Tightening the wing nut will hold the flanges and the aluminum flange clamp together. Maximum pressure for this style of mounting system is 1000 Torr absolute.

2.3.5 ConFlat Flange Mount

To minimize the possibility of leaks with ConFlat[4] flanges, use high strength stainless steel bolts and a new, clean OFHC copper gasket. Avoid scratching the seal surfaces. To avoid contamination, do not use nonmetal gaskets.

Finger tighten all bolts. Use a wrench to continue tightening $^1/_8$ turn at a time in crisscross order, e.g., 1, 4, 2, 5, 3, 6, 4 until all flanges are in contact. After contact, further tighten each bolt about $^1/_{16}$ turn.

1. Ultra-Torr, VCR, and VCO are registered trademarks of Cajon Co.
2. APIEZON is a trademark of James G. Biddle Co.
3. TEFLON is a registered trademark of DuPont.
4. ConFlat is a registered trademark of Varian Associates

2.4 Fabricating the Gauge Cable

Attach the electrical mating connector shipped with the Series 275 Nonlinear Analog Output *MINI-CONVECTRON* Module to your own cable. The connector pins for single and dual process control setpoint modules are shown in Figure 2-2 and Figure 2-3.

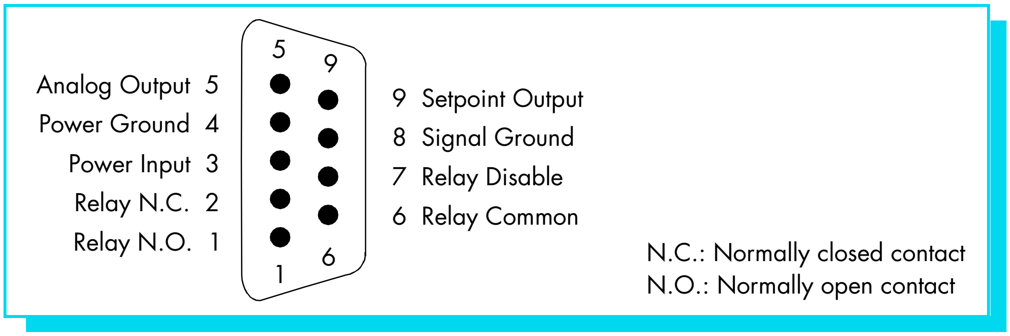


Figure 2-2 *Pins for 1 Process Control Setpoint.*

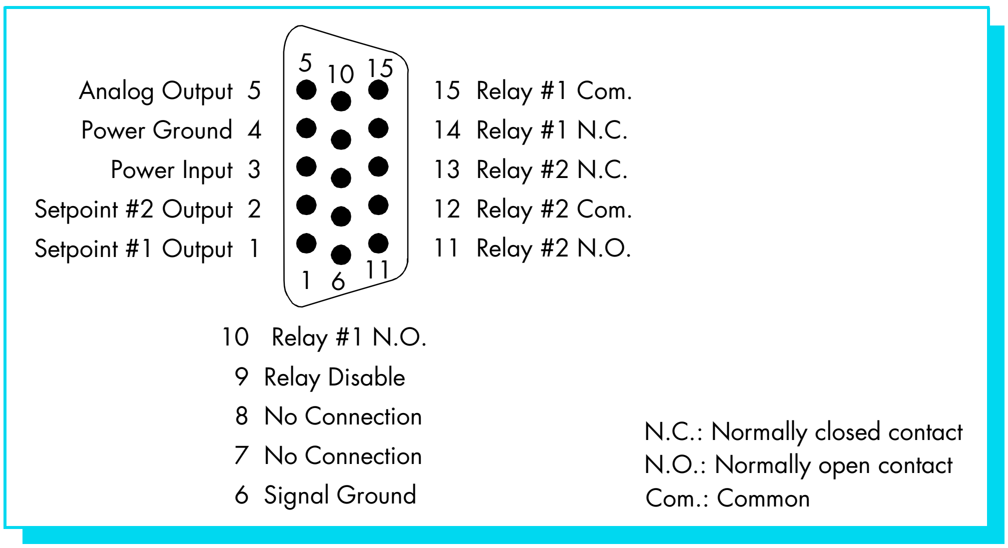


Figure 2-3 *Pins for 2 Process Control Setpoints.*

2.5 Connecting the Cable

Never touch the connector pins on any vacuum gauge if high voltages are present in the vacuum system. An electrical discharge or plasma may couple high voltage to the pins.

1. Connect the *MINI-CONVECTRON* Module cable to the gauge and to power.

2. **Before you turn on and operate the system**, adjust the process control relay setpoint to operate at a predetermined pressure (Section 4.4 on page 4-4). Attempting automatic operation with process control before the controls are properly set can be dangerous and can cause costly damage to the system.

NOTES

Chapter 3

Preparing the MINI-CONVECTRON for Operation

3.1 Preparing for Pressure Measurement

The steps in this chapter assume:

- Your Series 275 Nonlinear Analog Output *MINI-CONVECTRON* Module has been properly installed per the instructions in Chapter 2.
- The gas in your vacuum system is air, N_2. If you are using other gases you <u>must</u> follow the instructions in Section 3.6 on page 3-2.
- That you are reasonably familiar with the general theory of operation of thermal conductivity gauges.

  We recommend you consult a good textbook if you are unfamiliar with vacuum technology or if you require more information on the general theory behind operating a thermal conductivity gauge. We recommend the following books and believe you will find them to be extremely useful reference volumes.

  - Dushman, S., Lafferty, J. M., *Scientific Foundations Of Vacuum Technique,* John Wiley & Sons, Inc., Second Edition, New York, 1962.
  - Redhead, P. A., et. al., *Ultrahigh Vacuum,* Chapman and Hall, London, 1968.
  - O'Hanlon, J. F., *A User's Guide To Vacuum Technology,* John Wiley & Sons, New York, 1980.

3.2 Gas Type

The *MINI-CONVECTRON* Gauge is calibrated for N_2 unless otherwise labeled on the front panel for custom applications.

Warning - If used improperly, *MINI-CONVECTRON* Gauges can supply misleading pressure indications that can result in dangerous overpressure conditions within the system.

3.3 Long Cable Operation

There is no restriction on cable length since the control circuitry is located right at the sensor. This is true as long as the input voltage remains within the range of +11.5 Vdc to +26.5 Vdc.

3.4 Power

The *MINI-CONVECTRON* is in operation anytime that the +11.5 Vdc to +26.5 Vdc input voltage is applied. The sensor of the gauge runs at a temperature of approximately 120 °C. Gauge life is not affected by hours of operation.

3.5 Preparing for *CONVECTRON* Gauge Operation

Install pressure limiting devices calibrated to a level that the vacuum system can safely withstand. In addition, install pressure relief valves or rupture disks that will release pressure at a level considerably below the maximum safe pressure level of the system.

Using the N_2 calibration to pressurize a vacuum system above about 1 Torr with certain other gases can cause dangerously high pressures which may cause explosion of the system. See Section 3.6, page 3-2, before using with other gases.

Suppliers of pressure relief valves and pressure relief disks are listed in the Thomas Register under **Valves, Relief** and **Discs, Rupture**.

Confirm that these safety devices are properly installed before installing the Series 275 *MINI-CONVECTRON* Module. In addition, check that:

(1) the proper gas cylinders are installed,

(2) gas cylinder valve positions are correct on manual systems, and

(3) the automation settings are correct on automated gas delivery systems.

NOTE: Vacuum gauges with compression fittings may be forcefully ejected if the vacuum system is pressurized.

3.6 Understanding *CONVECTRON* Gauge Pressure Measurement in Gases Other Than Nitrogen (or Air)

CONVECTRON Gauges are Pirani type thermal conductivity gauges. These gauges measure the heat loss from a heated sensor wire maintained at constant temperature. For gases other than nitrogen or air, the heat loss varies at any given true pressure and can result in inaccurate pressure readings.

It is important to understand that the pressure indicated by a *CONVECTRON* Gauge depends on the type of gas, the orientation of the gauge axis, and on the gas density in the gauge. *CONVECTRON* Gauges are normally factory calibrated for N_2 (air has approximately the same calibration). With proper precautions, the *CONVECTRON* Gauge may be used for pressure measurement of certain other gases.

NOTE: The information in this section applies only when the CONVECTRON Gauge is calibrated for N_2 and the CONVECTRON Gauge is mounted with its gauge axis horizontal.

At pressures below a few Torr, there is no danger in measuring pressure of gases other than N_2 and air, merely inaccurate readings. A danger arises if the N_2 calibration is used without correction to measure higher pressure levels of some other gases. For example, N_2 at 24 Torr causes the same heat loss from the *CONVECTRON* sensor as argon will at atmospheric pressure. If the pressure indication of the *CONVECTRON* Gauge is not properly corrected for argon, an operator attempting to fill a vacuum system with 1/2 atmosphere of argon would observe a pressure reading of only 12 Torr when the actual pressure had risen to the desired 380 Torr. Continuing to fill the system with argon to 760 Torr would result in a 24 Torr pressure reading.

Depending on the pressure of the argon gas source, the chamber could be dangerously pressurized while the display continued to read about 30 Torr of N_2 equivalent pressure.

3.7 Adjustment of CONVECTRON Gauge Zero and Atmospheric Pressure Indications

Using the N_2 calibration to pressurize a vacuum system above about 1 Torr with certain other gases can cause dangerously high pressures which may cause explosion of the system. See Section 3.6 before using with other gases.

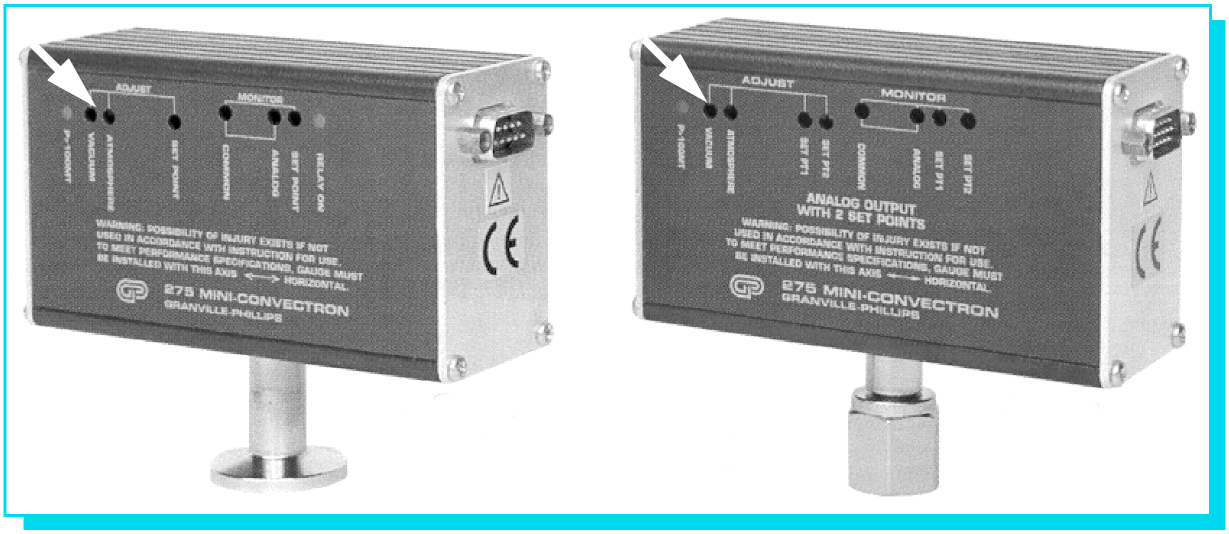


Figure 3-1 *Front Panels Showing Vacuum and Atmospheric Adjustment Potentiometers.*

Each *MINI-CONVECTRON* Gauge is individually computer calibrated for N_2. Zero adjustment of the gauge should not be necessary unless readout accuracy is required below 1 x 10^{-3} Torr or the gauge has been contaminated. Adjustment of the atmospheric indication should not be necessary unless compensating for long cables, variations in mounting orientation, or contamination.

If adjustments are necessary, the vacuum and atmosphere adjustments must be made in the following order for accurate readout:

1. **VACUUM** adjustment

- **a.** Evacuate the system to a pressure less than 10^{-4} Torr.
- **b.** While monitoring the analog output voltage, adjust the **ADJUST VACUUM** potentiometer for a reading of +0.375 Vdc.

2. **ATMOSPHERE** adjustment

- **a.** Allow the system pressure to rise to atmospheric pressure of air.
- **b.** While monitoring the analog output, adjust the **ADJUST ATMOSPHERE** potentiometer for a voltage corresponding to the absolute pressure corresponding to your location. Refer to Table 3-1 on page 3-4 for typical altitude/Torr/voltage relationships.

Table 3-1 *Altitude/Torr/Voltage Relationships.*

Altitude in Feet Above Sea Level	Pressure in Torr (N_2, Air)	Analog Output Voltage Vdc
0	760	5.534
1,000	733	5.513
2,000	707	5.493
3,000	681	5.473
4,000	656	5.454
5,000	632	5.435
6,000	609	5.417
7,000	586	5.399
8,000	564	5.382
9,000	543	5.366
10,000	523	5.350

3.7.1 Special Considerations for *CONVECTRON* Gauge Use Below 10^{-3} Torr

During a fast pumpdown from atmosphere, thermal effects will prevent the *CONVECTRON* Gauge from tracking pressure accurately below 10^{-3} Torr. After waiting about 15 minutes, indications in the 10^{-4} range will be valid and response will be rapid. Zero adjustment at vacuum may be performed at this time (or sooner if readings in the 10^{-4} range are not needed). In the 10^{-4} Torr range, the indication is resolved to about 0.1 millitorr provided the instrument has been carefully zeroed at vacuum. For accurate use in the 10^{-4} range, zeroing should be repeated frequently.

Chapter 4

Process Control

Process control provides a convenient method of organizing and establishing automatic control of vacuum system operations. Control is based on configuring pressure setpoints to activate relays.

4.1 Process Control Factory Default Settings

Table 4-1 lists the default settings for process control option.

Table 4-1 *Default Settings.*

Feature	Default Setting
Setpoints 1 and 2	Setpoint,— 0.0 Relay Polarity—Relay activation below pressure setpoint; (–) Returning Pressure Hysteresis—2% (not changeable)

4.2 Front Panels

4.2.1 One-Setpoint *MINI-CONVECTRON*

Adjustment potentiometers, monitor jacks, and LED indicators for the Series 275 Nonlinear Analog Output *MINI-CONVECTRON* Module with one process control setpoint are shown in Figure 4-1 and described in Table 4-2.

Figure 4-1 *1 Setpoint MINI-CONVECTRON Front Panel Showing Indicators and Adjustments.*

4.2.2 Two-Setpoint *MINI-CONVECTRON*

Adjustment potentiometers, monitor jacks, and LED indicators for the Series 275 Nonlinear Analog Output *MINI-CONVECTRON* Module with two process control setpoints are shown in Figure 4-2 and described in Table 4-2.

Figure 4-2 *2 Setpoint MINI-CONVECTRON Front Panel Showing Indicators and Adjustments.*

4.2.3 Front Panel Features

Table 4-2 *Series 275 Nonlinear Analog Output MINI-CONVECTRON Front Panel Features.*

Feature	Description
P > 100 mTorr LED	A red light emitting diode (LED) is used as a rough pressure indicator. The LED will be OFF below 100 mTorr and gradually turn on as pressure increases.
Adjust: Vacuum Potentiometer	Adjustment is provided to restore accuracy of the analog output voltage at low pressures.
Adjust: Atmosphere Potentiometer	Adjustment is provided to set the analog output voltage to correspond to known atmospheric pressure.
Adjust: Setpoint Potentiometer(s)	Adjustment is provided to set the setpoint voltage to correspond to a desired analog output voltage.
Monitor: Common Jack	Used in conjunction with the analog or setpoint monitor test jacks.
Monitor: Analog Test Jack	Provides the same analog output voltage with respect to common as furnished to pin 5 of the I/O connector.
Monitor: Setpoint Test Jack(s)	Provides the analog output voltage at which the corresponding process relay will activate.
Relay On LED	(For models with one setpoint.) A green LED is used to indicate the status of the process relay.

4.3 Process Control Setup

1. Even if the control logic is simple and obvious, we recommend that you develop a logic diagram of the process control function.
2. Prepare a specification table that lists the proposed pressure setting, system measurement point, and relay status for each process control setpoint.
3. Draw a circuit schematic which specifies exactly how each piece of system hardware will be connected to the process control relays.
4. Do not exceed the relay ratings shown below:

Relay Configuration	Form C – NC, C, NO (Normally Closed, Common, Normally Open)
Relay Contact Rating	1 A, 30 Vdc or AC non-inductive

5. Attach a copy of the process control circuit diagram to this manual for future reference and troubleshooting.
6. If you desire application assistance, please contact a G-P Application Engineer at the number listed on the title page of this manual.

4.4 Process Control Relay Setup

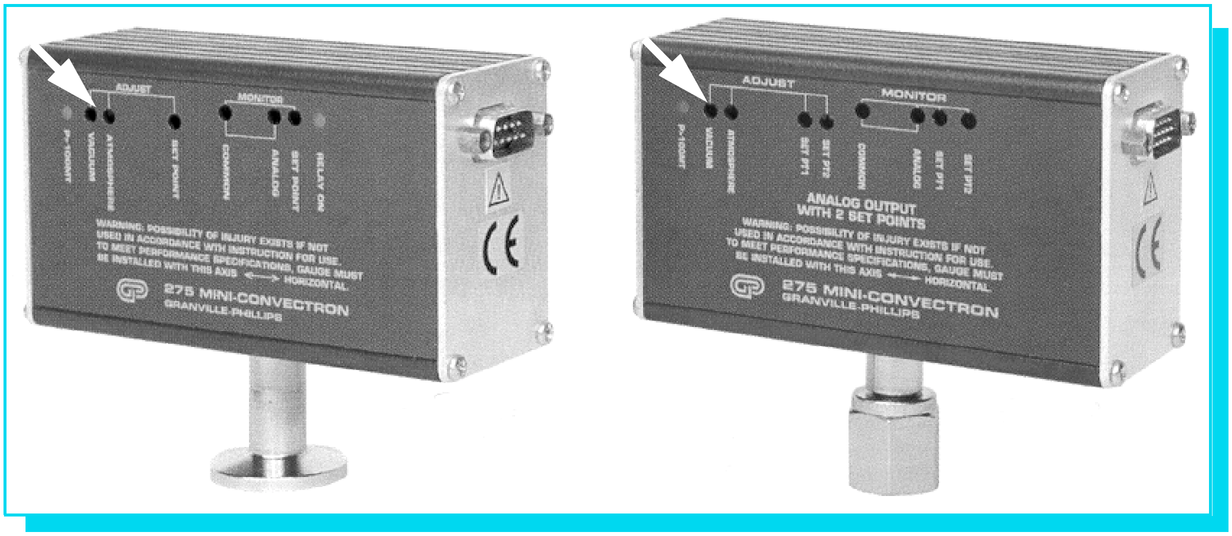


Figure 4-3 *Front Panels Showing Adjustment Potentiometers.*

4.4.1 Method 1

The use of a digital voltmeter (DVM) is required in order to adjust the process control relay setpoint to operate at a predetermined pressure.

1. From the graphs of Figure 4-4 on page 4-6 and Figure 4-5 on page 4-7, or the data from Table 4-3 on page 4-8, determine the analog output voltage corresponding to the setpoint for the type of gas being used.
2. Using the DVM, measure the setpoint voltage using the **MONITOR COMMON** and **MONITOR SETPOINT** test jacks.
3. Using a small screwdriver, adjust the **ADJUST SETPOINT** potentiometer for the desired trip voltage.

Pin-out information for the process relay contacts is shown in Figure 2-2 on page 2-3 and Figure 2-3 on page 2-3. In order to prevent oscillation around the trip point, there is a built in hysteresis band of approximately 2%.

4.4.2 Method 2

To adjust the process control relay without using a DVM, proceed as follows.

1. With the vacuum system in operation, establish pressure at the desired trip point value.
2. Start with the **ADJUST SETPOINT** potentiometer fully CCW (relay de-energized). Slowly rotate the potentiometer CW until the relay energizes (relay on, LED on). This completes the adjustment.

4.5 Analog Output Signal

Table 4-3 on page 4-8 shows the analog output voltage for various gases. The impedance of this output is 120 ohms. This output is normalized for 0.375 Vdc at vacuum and 5.659 Vdc at 1000 Torr for N_2 or air. Should this output drop to approximately 0.10 Vdc, an open sensor in the gauge is a distinct possibility. Should it drop to 0.0 Vdc, the input power of +11.5 Vdc to +26.5 Vdc should be investigated.

Figure 4-4 and Figure 4-5 show the relationship of true pressure for N_2 (air) - vs - analog output voltage. This graph was plotted using the data taken from Table 4-3 on page 4-8, which is the analog output voltage versus true pressure for various gases. This data can be used in your application by performing a curve fit for the gas involved with your process. It can also be plotted out on the graphs of Figure 4-4 and Figure 4-5 if you desire to see how it compares with N_2 or air.

For gases not listed in Table 4-3 on page 4-8, or for a mixture of gases, it will be necessary to generate your own calibration curve using an acceptable gas independent transfer standard such as a capacitance manometer. The maximum usable analog voltage output will depend upon the power supply input voltage used. Subtract 4 Vdc from VIN to determine the maximum analog voltage output. This will determine the highest readable pressure for the gas involved.

The equations for calculating pressure (Torr) as a function of voltage (V) for the *MINI-CONVECTRON* Gauge are given in Table 4-4 on page 4-9.

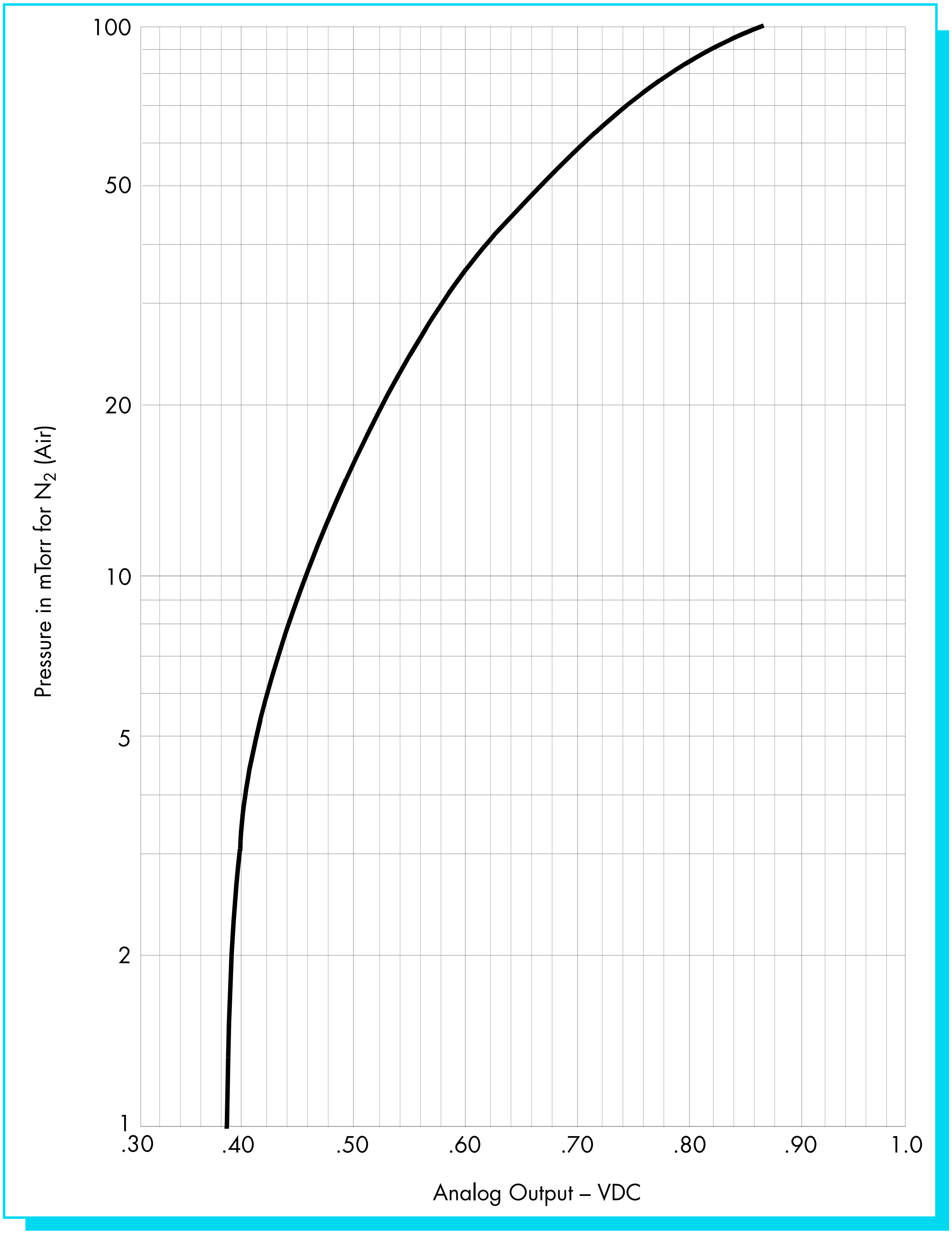


Figure 4-4 *Output Voltage vs. Indicated Pressure.*

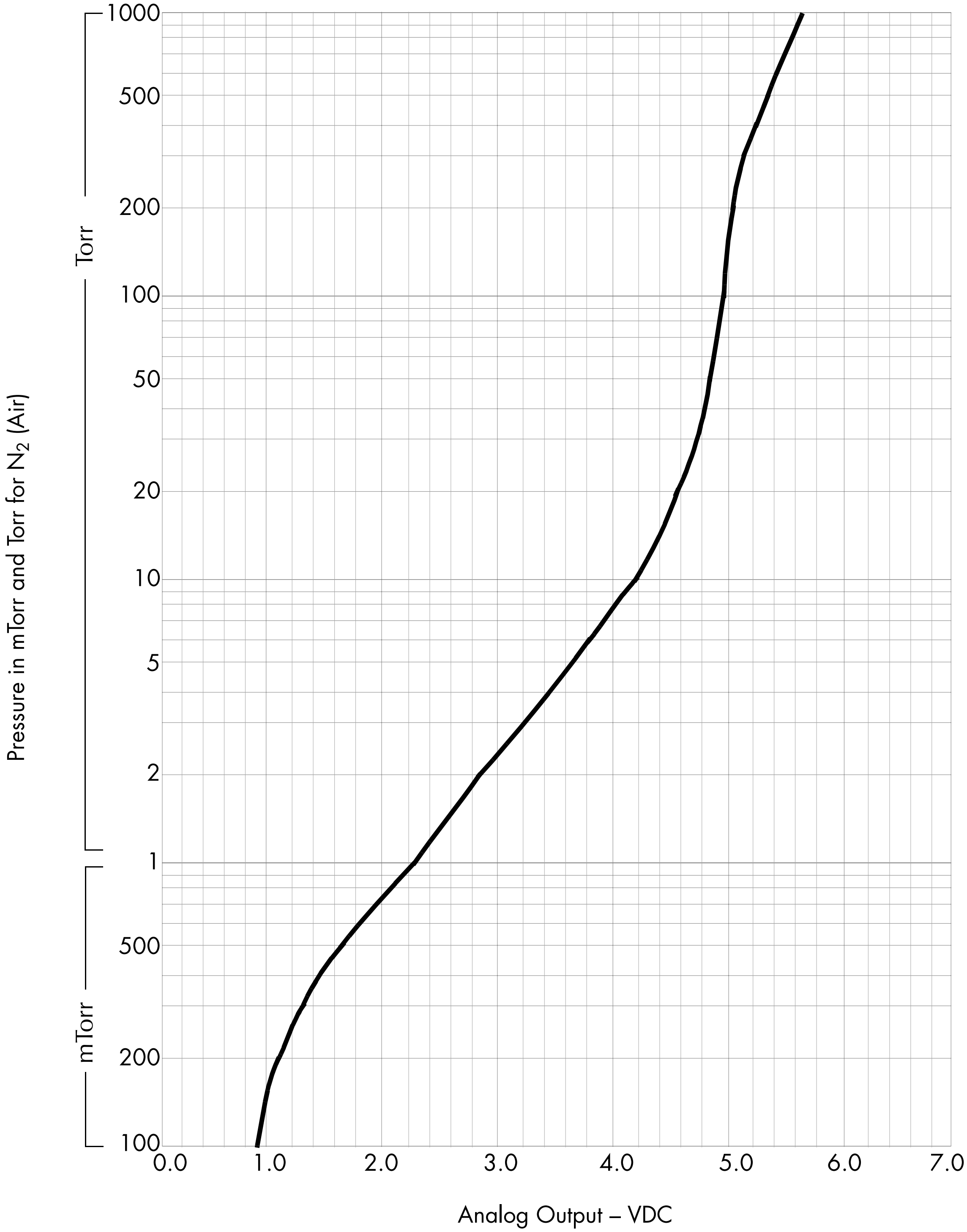


Figure 4-5 *Output Voltage vs. Indicated Pressure.*

4.5.1 Analog Output

Table 4-3 *Bridge Analog Output Voltages (Vdc) for Various Gases.*

True Pressure Torr/mTorr	N2 (Air)	Argon	Helium	O_2	CO_2	KR	Freon12	Freon22	D2	Ne	CH_4
0	.375	.375	.375	.375	.375	.375	.375	.375	.375	.375	.375
.1 mTorr	.376	.3757	.3755	.376	.376	.3755	.376	.376	.376	.3757	.3766
.2 mTorr	.377	.376	.3765	.377	.377	.3768	.378	.378	.377	.3763	.3780
.5 mTorr	.379	.378	.379	.380	.381	.3772	.382	.381	.381	.3782	.3825
1 mTorr	.384	.381	.382	.384	.385	.379	.388	.388	.386	.381	.3896
2 mTorr	.392	.387	.389	.392	.395	.384	.401	.400	.396	.388	.403
5 mTorr	.417	.403	.409	.417	.412	.395	.437	.432	.425	.405	.438
10 mTorr	.455	.429	.441	.453	.462	.415	.488	.480	.470	.433	.492
20 mTorr	.523	.477	.497	.521	.536	.451	.581	.566	.549	.484	.584
50 mTorr	.682	.595	.637	.679	.705	.544	.778	.764	.727	.608	.796
100 mTorr	.878	.745	.814	.868	.900	.668	1.009	.990	.944	.768	1.053
200 mTorr	1.155	.962	1.068	1.141	1.179	.847	1.315	1.291	1.265	1.002	1.392
500 mTorr	1.683	1.386	1.589	1.664	1.668	1.194	1.826	1.805	1.914	1.469	2.014
1 Torr	2.217	1.818	2.164	2.195	2.172	1.536	2.257	2.247	2.603	1.976	2.632
2 Torr	2.842	2.333	2.939	2.814	2.695	1.921	2.647	2.666	3.508	2.631	3.313
5 Torr	3.675	3.028	4.387	3.672	3.316	2.429	3.029	3.090	5.059	3.715	-
10 Torr	4.206	3.480	5.774	4.225	3.670	2.734	3.204	3.330	6.361	4.605	4.699
20 Torr	4.577	3.801	7.314	4.620	3.903	2.966	3.308	3.414		5.406	5.172
50 Torr	4.846	4.037		4.916	4.071	3.075	3.430	3.509		6.159	5.583
100 Torr	4.945	4.122		5.026	4.154	3.134	3.618	3.660		6.483	5.720
200 Torr	5.019	4.192		5.106	4.336	3.269	3.827	3.883		6.661	5.860
300 Torr	5.111	4.283		5.200	4.502	3.384	3.938	4.005		6.726	-
400 Torr	5.224	4.386		5.315	4.621	3.466	4.016	4.088		6.767	6.103
500 Torr	5.329	4.477		5.422	4.708	3.526	4.076	4.151		6.803	-
600 Torr	5.419	4.550		5.515	4.775	3.573	4.124	4.203		6.843	6.342
700 Torr	5.495	4.611		5.592	4.830	3.613	4.166	4.247		6.890	-
760 Torr	5.534	4.643		5.633	4.860	3.632	4.190	4.271		6.920	-
800 Torr	5.558	4.663		5.658	4.877	3.645	4.203	4.286		6.942	6.519
900 Torr	5.614	4.706		5.713	4.919	3.674	4.237	4.321		7.000	-
1000 Torr	5.659	4.745		5.762	4.955	-	4.270	4.354		7.056	6.642

Table 4-4 *Equations for Pressure (Torr) as a Function of Voltage (V) for the MINI-CONVECTRON Gauge.*

Segment	Range (V)	Equation	Parameter Values	
1	0.376 - 2.842	$y = a+bx+cx^2+dx^3+ex^4+fx^5+gx^6+hx^7$	a	-3.3114122859E-02
			b	9.1225738708E-02
			c	-1.0902742405E-01
			d	3.4313981420E-01
			e	-2.2851221698E-01
			f	9.4706717562E-02
			g	-2.0686516159E-02
			h	2.0209521035E-03
2	2.842 - 4.945	$y = (a+cx+ex^2) / (1+bx+dx^2+fx^3)$	a	1.0311295434E-01
			b	-3.9860638710E-01
			c	-2.3222519703E-02
			d	7.4382021328E-02
			e	7.2294948746E-02
			f	-6.8656810268E-03
3	4.945 - 5.659	$y = a+bx+cx^2+dx^3+ex^4+fx^5+gx^6$	a	3.6181600534E+08
			b	-4.1329782247E+08
			c	1.9655307114E+08
			d	-4.9816080153E+07
			e	7.0970331066E+06
			f	-5.3888777795E+05
			g	1.7039048857E+04

NOTES

Chapter 5

Service and Maintenance

5.1 Service Guidelines

If a Qualified Service Person makes repairs at the component level, repairs properly made with equivalent electronic parts and rosin core solder do not void the warranty.

If the product requires service, please contact our Customer Service Department at 1-800-776-6543 for troubleshooting help over the phone. If the product must be returned for service, request a Return Authorization (RA) from G-P. See the Service Form at the end of this chapter. Do not return products without first obtaining an RA.

When returning equipment to G-P, please use the original packing material whenever possible. Otherwise, contact your shipper or G-P for safe packaging guidelines. G-P will supply return packaging materials at no charge upon request. Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

Because the *MINI-CONVECTRON* Gauge contains static-sensitive electronic parts, the following precautions must be followed when troubleshooting:

- Use a grounded, conductive work surface. Wear a high impedance ground strap for personal protection.
- Use conductive or static dissipative envelopes to store or ship static sensitive devices or printed circuit boards.
- Do not operate the product with static sensitive devices or other components removed from the product.
- Do not handle static sensitive devices more than absolutely necessary, and only when wearing a ground strap.
- Do not use an ohmmeter for troubleshooting MOS circuits. Rely on voltage measurements.
- Use a grounded, electrostatic discharge safe soldering iron.

NOTE: This product has been designed and tested to offer reasonably safe service provided it is installed, operated, and serviced in strict accordance with these safety instructions.

The service and repair information in this manual is for the use of Qualified Service Personnel. To avoid shock, do not perform any procedures in this manual or perform any servicing on this product unless you are qualified to do so.

Do not substitute parts or modify product.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to a service facility designated by G-P for service and repair to ensure that safety features are maintained. Do not use this product if it has unauthorized modifications.

5.2 Damage Requiring Service

Disconnect this product from the wall outlet and any other power sources, and refer servicing to Qualified Service Personnel if any the following conditions exist:

- The gauge cable, power-supply cord, or plug is damaged.
- Liquid has been spilled onto, or objects have fallen into, the product.
- The product has been exposed to rain or water.
- The product does not operate normally even if you have followed the Operation Instructions. Adjust only those controls that are covered in the instruction manual. Improper adjustment of other controls may result in damage and require extensive work by a qualified technician to restore the product to its normal operation.
- The product has been dropped or the enclosure has been damaged.
- The product exhibits a distinct change in performance. This may indicate a need for service.

Replacement Parts - When replacement parts are required, be certain to use the replacement parts that are specified by G-P, or that have the same characteristics as the original parts. Unauthorized substitutions may result in fire, electric shock or other hazards.

Safety Check - Upon completion of any service or repairs to this product, ask the Qualified Service Person to perform safety checks to determine that the product is in safe operating order.

5.3 Symptoms and Possible Causes

Table 5-1 *General Symptoms/Possible Causes.*

Symptom	Possible Causes
Unit will not power-up, no response to power.	Power interconnect cable improperly connected.
Pressure reading is higher than expected.	Poor conductance in gauge's vacuum connection to chamber. Gas source in plumbing to gauge, such as leak or contamination. Chamber pressure high because of leak, contamination, or pump failure. Faulty gauge or power cable.
Pressure reading grossly in error.	Module out of calibration. Unknown gas type. Gauge not mounted horizontally (see Section 2.2 on page 2-1). Sensor damaged (e.g., by reactive gas) or dirty. Extremes of temperature or mechanical vibration.
Analog output voltage indicating a pressure in system is vastly different than the voltage being observed by supporting gauges.	Gas composition on the system is not what the user believes it to be. This can be caused by a selective gas pumping process in use, outgassing of product, etc.

Symptom	Possible Causes
Process relay LED indicator on, but process not functioning.	Defective relay contacts. Check that the load is within specified rating or relay and that it is non-inductive.
Process relay will not energize.	Ground is being applied on the Relay Disable (L) input of the I/O connector. Circuit problem. Sensor of gauge tube is open and analog output is below 0.10 volts.

5.4 *MINI-CONVECTRON* Disassembly

For most troubleshooting procedures it will be required that the printed circuit board and gauge tube be removed from the enclosure. To accomplish this, proceed as follows.

1. Remove the two screws holding on the enclosure cover.
2. Remove the cover.
3. Pull up on the edge of the PC board and remove the board with gauge tube attached.
4. To remove the gauge tube from the PC board, unplug the tube from the four sockets on the board.
5. For assembly, reverse this procedure.

5.5 *CONVECTRON* Gauge Test Procedure

The small diameter sensor wire can be damaged by even small voltages. Do not perform electrical continuity tests with instruments applying in excess of 0.1 volt when the gauge is at vacuum, or 2 volts when at atmospheric pressure.

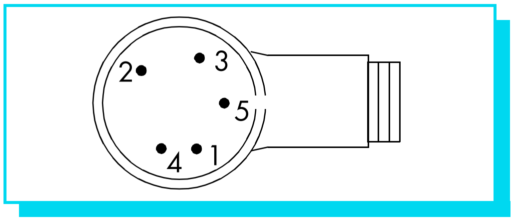


Figure 5-1 *CONVECTRON Gauge Base.*

The *CONVECTRON* Gauge should show the resistances listed in Table 5-2 (pin numbers are embossed on the gauge base). If not, replace the gauge tube.

Table 5-2 *CONVECTRON Gauge Resistances.*

Pressure Range	Overpressure Point (Torr)
Pins 1 to 2	20 to 30 ohms
Pins 2 to 3	50 to 60 ohms
Pins 1 to 5	175 to 190 ohms

NOTE: If the resistance from pin 1 to 2 is about 800 ohms, the sensor wire is open.

5.6 Cleaning Contaminated *CONVECTRON* Gauges

The fumes from solvents such as trichloroethylene, perchloroethylene, toluene, and acetone can be dangerous to health if inhaled. If used, use only in well-ventilated area exhausted to the outdoors. Acetone and toluene are highly flammable and should not be used near an open flame or energized electrical equipment.

All materials have been chosen for ultra high vacuum service, corrosion resistance, and bakeability. The envelope is type 304 stainless steel. All metallic joints in the envelope are TIG welded. No solder is used within the envelope. The following materials are exposed to the vacuum: Type 304 stainless steel, Carpenter Alloy 52, Kovar, Kapton, gold plated tungsten, borosilicate glass, and Dow-Corning 9015 glass. The blue trim cover is rated at 150 °C.

The *CONVECTRON* Gauge may be baked to 150 °C non-operating while under vacuum with the Connector removed.

When the small sensor wire is contaminated with oil or other films, its emissivity or its diameter may be appreciably altered and a change of calibration will result. Cleaning with trichloroethylene, perchloroethylene, toluene, or acetone is possible but it must be done very carefully so as not to damage the sensor.

1. Hold the gauge with the main body horizontal and the port projecting upward at a 45° angle.
2. Slowly fill the port with solvent using a standard wash bottle with the spout inserted in the port to the point where it touches the screen. Let the solvent stand in the gauge for at least ten minutes.

   Do not shake the gauge. Shaking the gauge with liquid inside can damage the sensor wire.
3. To drain the gauge, position it horizontally with the port facing downward. Slightly warming the gauge will help dry the gauge.
4. Allow the gauge to dry overnight with the port vertically downward and uncapped. Before re-installing the gauge on the system, be certain no solvent odor remains.

5.7 Process Control Troubleshooting

The setpoints are read from non-volatile memory into RAM when the unit powers up.

If a setpoint is found to contain incorrect data which cannot be interpreted as a valid setpoint, it will be set to 0 and polarity set to (–).

5.8 Service Form

Please photocopy this form, fill it out, and return it with your equipment:

RA No.___________________ Contact Granville-Phillips Customer Service at **1-303-443-7660**, or **1-800-776-6543 in the USA**; or email: **custserv@granville.com**

Model No.______________________ Serial No._____________________ Date_______________________

Name ____ Phone No.____________________________

Company____

Address

____

City____ State_____________________ Zip____________________

Please help Granville-Phillips continue to provide the best possible service by furnishing information that will help us determine the cause of the problem, as well as protect our analysis and calibration equipment from contamination.

Problem description:____

____

____

____

____

Application description:____

____

____

____

____

Has this product been used with high vapor pressure or hazardous materials? ❑ Yes ❑ No

If Yes, please list the types of gas, chemicals (common names, specific chemical,) biological materials, or other potentially contaminating or harmful materials exposed to the product during its use.

____

____

____

NOTE: PRODUCTS EXPOSED TO RADIOACTIVE MATERIAL CANNOT BE ACCEPTED BY GRANVILLE-PHILLIPS UNDER ANY CIRCUMSTANCES.

Corporate Officer signature: ____

Contact Name____ Phone No.________________________

NOTES

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Series 354

Granville-Phillips Micro-Ion®
Vacuum Gauge Module

Installation, Operation, and Maintenance Instructions

Micro-Ion Modules with either dual yttria-coated iridium or dual tungsten filaments and 1 V/decade analog output

Instruction Manual Catalog No. 354004-03

This manual is for use only with the following catalog numbers:

354001	20354007
354002	20354014
354025	20354015
354047	20354019

For assistance in using or servicing this instrument contact:

Helix Technology Corporation
Colorado Operations
Customer Service Department
6450 Dry Creek Pkwy
Longmont, Colorado 80503-9501 USA
Telephone (303) 652-4400
FAX (303) 652-2844
email: salesco@helixtechnology.com

Any comments or questions? Call Us!

Your comments on how these instructions could be made more useful to you will help us to improve our capabilities for satisfying your requirements. Call 1-303-652-4400 (1-800-776-6543 toll-free in the U.S.A.) or email us at salesco@helixtechnology.com

GRANVILLE-PHILLIPS
HELIX TECHNOLOGY CORPORATION

Revised: November 2001

Table of Contents

Safety

Safety Instructions

START BY READING THESE IMPORTANT SAFETY INSTRUCTIONS AND NOTES collected here for your convenience and repeated with additional information at appropriate points in these instructions.

These safety alert symbols in this manual or on the Product rear panel, mean caution - personal safety, property damage or danger from electric shock. Read these instructions carefully.

In these instructions the word "product" refers to the 354 Micro-Ion Vacuum Gauge Module and all of its approved parts and accessories.

NOTE: These instructions do not and cannot provide for every contingency that may arise in connection with the installation, operation, or maintenance of this product. Should you require further assistance, please contact Helix Technology at the address on the title page of this manual.

This product has been designed and tested to offer reasonably safe service provided it is installed, operated, and serviced in strict accordance with these safety instructions.

Failure to comply with these instructions may result in serious personal injury, including death, or property damage.

These safety precautions must be observed during all phases of operation, installation, and service of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Helix Technology disclaims all liability for the customer's failure to comply with these requirements.

The service and repair information in this manual is for the use of Qualified Service Personnel. To avoid shock, do not perform any procedures in this manual or perform any servicing on this product unless you are qualified to do so.

- *Read Instructions* – Read all safety and operating instructions before operating the product.
- *Retain Instructions* – Retain the Safety and Operating Instructions for future reference.
- *Heed Warnings* – Adhere to all warnings on the product and in the operating instructions.
- *Follow Instructions* – Follow all operating and maintenance instructions.
- *Accessories – Do not* use accessories not recommended in this manual as they may be hazardous.

To reduce the risk of fire or electric shock, do not expose this product to rain or moisture.

Objects and Liquid Entry - Never push objects of any kind into this product through openings as they may touch dangerous voltage points or short out parts that could result in a fire or electric shock. Be careful not to spill liquid of any kind onto the products.

Do not substitute parts or modify instrument.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to a service facility designated by Helix Technology for service and repair to ensure that safety features are maintained. Do not use this product if it has unauthorized modifications.

Damage Requiring Service

Disconnect the product from all power sources and refer servicing to Qualified Service Personnel under the following conditions:

- **a.** When any cable or plug is damaged.
- **b.** If any liquid has been spilled onto, or objects have fallen into, the product.
- **c.** If the product has been exposed to rain or water.
- **d.** If the product does not operate normally even if you follow the operating instructions. Adjust only those controls that are covered by the operation instructions. Improper adjustment of other controls may result in damage and will often require extensive work by a qualified technician to restore the product to its normal operation.
- **e.** If the product has been dropped or the enclosure has been damaged.
- **f.** When the product exhibits a distinct change in performance. This indicates a need for service.

Replacement Parts - When replacement parts are required, be certain to use the replacement parts that are specified by Helix Technology, or that have the same characteristics as the original parts. Unauthorized substitutions may result in fire, electric shock or other hazards.

Safety Check - Upon completion of any service or repairs to this product, ask the Qualified Service Person to perform safety checks to determine that the product is in safe operating order.

Finite Lifetime - After ten years of normal use or even non-use, the electrical insulation in this product may become less effective at preventing electrical shock. Under certain environmental conditions which are beyond the manufacturer's control, some insulation material may deteriorate sooner. Therefore, periodically inspect all electrical insulation for cracks, crazing, or other signs of deterioration. Do not use if the electrical insulation has become unsafe.

Be aware that when high voltage is present in any vacuum system, a life threatening electrical shock hazard may exist unless all exposed conductors are maintained at earth ground.

This hazard is not peculiar to this product.

Be aware that an electrical discharge through a gas may couple dangerous high voltage directly to an ungrounded conductor almost as effectively as would a copper wire connection. A person may be seriously injured or even killed by merely touching an exposed ungrounded conductor at high potential.

This hazard is not unique to this product.

Proper Grounding:

All components of a vacuum system used with this or any similar high voltage product must be maintained at earth ground for safe operation. Be aware that grounding this product does not guarantee that other components of the vacuum system are maintained at earth ground.

Verify that the vacuum port to which the Micro-Ion Module is mounted is electrically grounded. It is essential for personnel safety as well as proper operation that the envelope of the gauge be connected to a facility ground. Use a ground lug on a flange bolt if necessary.

All conductors in, on, or around the vacuum system that are exposed to potential high voltage electrical discharges must either be shielded at all times to protect personnel or must be connected to earth ground at all times.

Danger, High Voltage – The high voltages present within the Power Supply are capable of causing injury or death. To avoid electric shock, wait 3 minutes after power is removed before touching any component within the Power Supply. This will permit charged capacitors to discharge.

Danger, high voltage – 180V is present in the Power Supply, on the cable, and at the ion gauge when the gauge is turned on. Voltages as high as 250V peak are present during degas.

Install suitable devices that will limit the pressure to the level that the vacuum system can safely withstand. In addition, install suitable pressure relief valves or rupture disks that will release pressure at a level considerably below the pressure that the system can safely withstand.

Suppliers of pressure relief valves and pressure relief disks are listed in the *Thomas Register* under "Valves, Relief", and "Discs, Rupture".

Confirm that these safety devices are properly installed before installing the product. In addition, check that:

(1) the proper gas cylinders are installed,

(2) gas cylinder valve positions are correct on manual systems, and

(3) the automation is correct on automated gas delivery systems.

Vacuum gauges with compression fittings may be forcefully ejected if the vacuum system is pressurized.

Caution: If the overpressure shutdown point is increased from the factory settings, an excess pressure rise may go undetected—resulting in possible gauge and/or vacuum system damage. Consult the factory if in doubt.

It is the installer's responsibility to ensure that the automatic signals provided by the product are always used in a safe manner. Carefully check the system programming before switching to automatic operation.

Where an equipment malfunction could cause a hazardous situation, always provide for fail-safe operation. As an example, in an automatic backfill operation where a malfunction might cause high internal pressures, provide an appropriate pressure relief device.

The fumes from solvents such as trichloroethylene, perchloroethylene, toluene, and acetone can be dangerous to health if inhaled. Use only in well ventilated areas exhausted to the outdoors. Acetone and toluene are highly flammable and should not be used near an open flame or energized electrical equipment.

Warranty Information

Helix Technology Corporation provides an eighteen (18) month warranty from the date of shipment for new Granville-Phillips Products. The Helix Technology Corporation General Terms and Conditions of Sale provides the complete and exclusive warranty for Helix Technology Corporation's products. This document may be located on our web site at *www.helixtechnology.com*, or may be obtained by contacting Helix Technology Corporation's Customer Service Representatives.

Service Guidelines

Some minor problems are readily corrected on site. If the product requires service, please contact our Customer Service Department at 1-303-652-4400 for troubleshooting help over the phone. If the product must be returned for service, request a Return Authorization (RA) from Helix Technology (see the Service Form on page 3-7). Do not return products without first obtaining an RA number.

Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

When returning equipment to Helix Technology, please use the original packing material whenever possible. Otherwise, contact your shipper or Helix Technology for safe packaging guidelines. Circuit boards and modules separated from the controller chassis must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Helix Technology will supply return packaging materials at no charge upon request.

FCC Verification

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio or television technician for help.

Canadian Users

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numerique de la classe B respecte toutes les exigences du Reglement sur le material broilleur du Canada.

Chapter 1

Installation

The 354 Micro-Ion Gauge measures pressures from less than 1 x 10^{-9} Torr to 5 x 10^{-2} Torr, N_2 equivalent (or air). Pressure readout is via a logarithmic analog voltage on the I/O connector on all models and digital readout for models with that option. Filament selection is via a selector switch adjacent to the "D" connector.

The 354 Micro-Ion Gauge is a modular instrument intended for computer control only with no external controls or adjustments. The power supply voltage required for operation is 24 Vdc, ±15%, 12 watts.

1.1 Mounting

The 354 Micro-Ion Gauge can be mechanically mounted anywhere in a system in any attitude. It should be mounted in a location with free air flow and ambient temperature less than 40 °C.

The 354 Micro-Ion Gauge is mounted to the vacuum system by the flange only. Reasonable care should be taken to install the device where it is protected from physical damage.

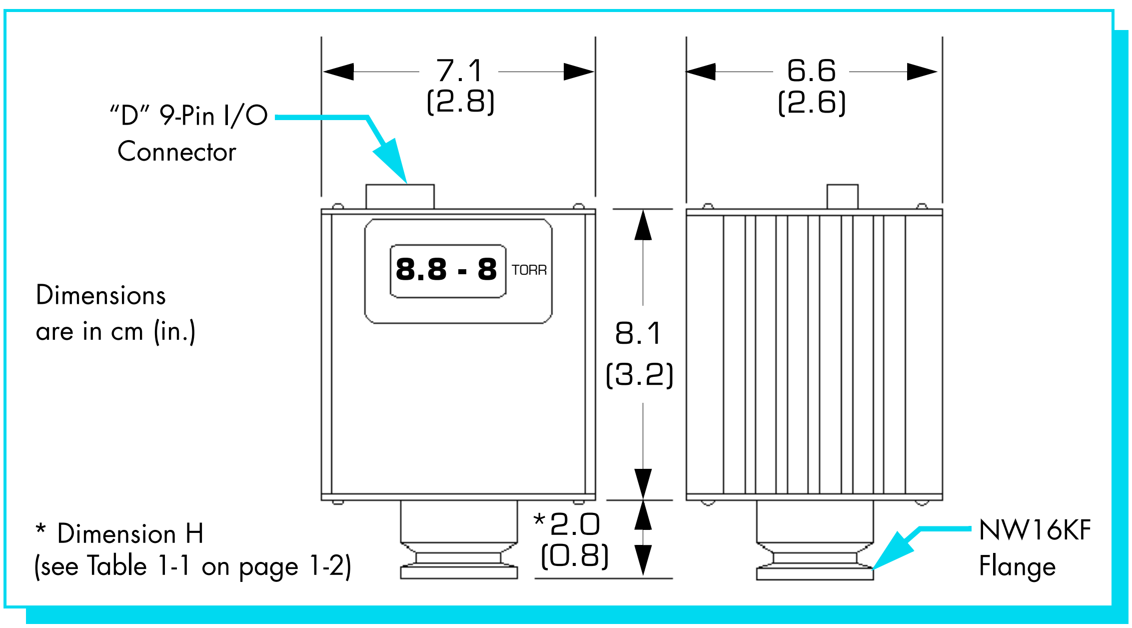
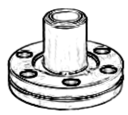
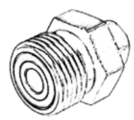


Figure 1-1 *354 Micro-Ion Gauge Dimensions.*

1.2 Fittings

Table 1-1 *Fittings for 354 Micro-Ion Gauge.*

Fitting	Description	Dimension H
	NW16KF flange NW25KF flange NW40KF flange	2.0 cm (0.8 in.) 2.0 cm (0.8 in.) 2.0 cm (0.8 in.)
	1.33 in. (NW16CF) ConFlat-type flange 2.75 in. (NW35CF) ConFlat-type flange	4.3 cm (1.7 in.) 4.3 cm (1.7 in.)
	1/2 inch VCR-type male	5.8 cm (2.3 in.)

All dimensions are nominal. For tolerances, contact Helix Technology Corporation.

1.3 Grounding

The 354 Micro-Ion Gauge converts the input power to +180 Vdc for the grid supply (+250 Vdc during degas). For safety the outer housing of the gauge must be grounded to the vacuum chamber. This is accomplished by the use of a metal flange clamp for the NW16KF and NW25KF flanges. Due to the “O” ring seal, grounding cannot be assumed through the fitting. The groove in the KF flange of the 354 Micro-Ion Gauge has been designed to prevent the use of a non-metallic type of flange clamp. Do not alter the groove or a non-metallic flange clamp to attempt usage.

VCR, VCO are registered trademarks of Cajon Co.; Conflat is a registered trademark of Varian Associates

1.4 I/O Cable Connections

The I/O connector is used to operate the 354 Micro-Ion Gauge and output the analog voltage corresponding to pressure.

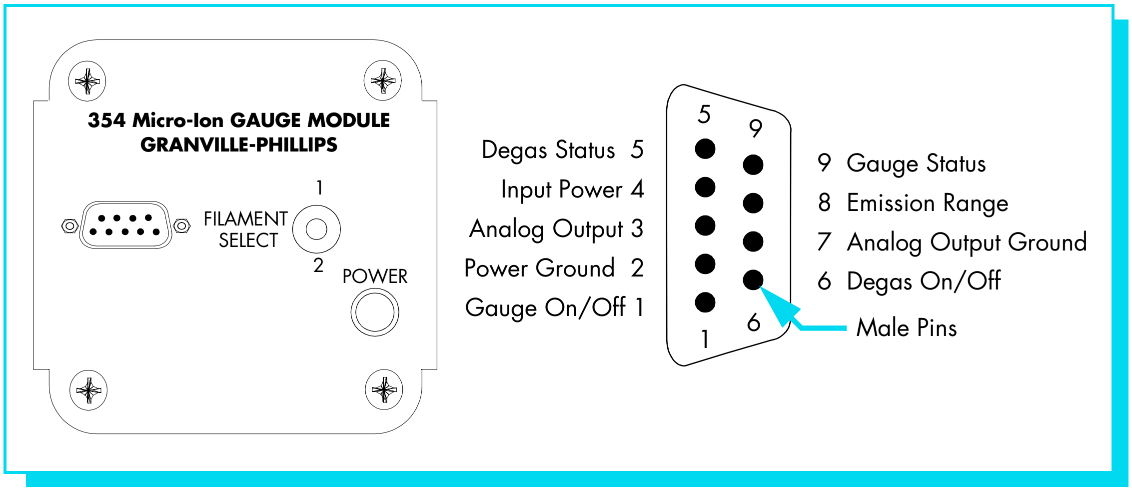


Figure 1-2 *354 Micro-Ion Gauge Analog Connector.*

Table 1-2 *I/O Connector Pin Descriptions.*

Pin	Function
1	Gauge On/Off. The application of a continuous ground is required for an "ON" condition. Removal of the ground turns the gauge off.
2	Power Ground. Use for input power return, IG ON/OFF, Degas ON/OFF, and status outputs.
3	Analog Output.
4	Input Power. +24 Vdc ±15%, 12 watts max. Protected against reversal and overvoltage.
5	Degas Status. Open collector transistor (grounded emitter) rated at 40 V max. VCE, 50 mA max. Transistor off = degas off, transistor on = degas on.
6	Degas ON/OFF. Same as Gauge ON/OFF.
7	Signal Ground. Use in conjunction with the analog output only.
8	Emission Current. Application of a ground increases emission current from 100 µA to 4 mA.
9	Gauge Status. Same as Degas Status.

NOTES

Operation

2.1 Theory of Operation

The functional parts of a typical ionization gauge are the filament (cathode), grid (anode) and ion collector, which are shown schematically in Figure 2-1. These electrodes are maintained by the gauge controller at +30, +180, and 0 volts, relative to ground, respectively.

The filament is heated to such a temperature that electrons are emitted, and accelerated toward the grid by the potential difference between the grid and filament. All of the electrons eventually collide with the grid, but many first traverse the region inside the grid many times.

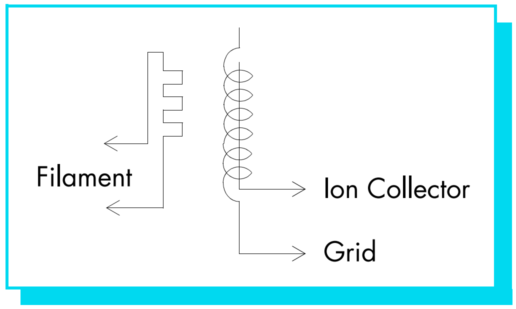


Figure 2-1 *Ion Gauge Schematic.*

When an energetic electron collides with a gas molecule an electron may be dislodged from the molecule leaving it with a positive charge. Most ions are then accelerated to the collectors. The rate at which electron collisions with molecules occur is proportional to the density of gas molecules, and hence the ion current is proportional to the gas density (or pressure, at constant temperature).

The amount of ion current for a given emission current and pressure depends on the ion gauge design. This gives rise to the definition of ion gauge "sensitivity", frequently denoted by "K":

K = ion current/(emission current x pressure)

Micro-Ion Gauges have a sensitivity of 20/Torr when used with nitrogen or air.

The ion gauge controller varies the heating current to the filament to maintain a constant electron emission, and measures the ion current to the collector. The pressure is then calculated from these data.

Ion gauge degas is accomplished by increasing the emission current to 15 mA and raising the grid bias to 250 Vdc resulting in an increased temperature of the grid to drive off absorbed gases.

2.2 Emission Current

There are two ranges of emission current available. Either 100 microamperes or 4 milliamperes are available as determined by the status of pin 8 of the I/O connector. While either range can be used continuously, the following guidelines are suggested. For operation in the higher pressure ranges with a clean system 100 microamperes emission is satisfactory. For operation in the lower pressure ranges the 4 milliampere range should be used to give a more accurate pressure reading. Internal circuitry corrects the analog output voltage to pressure relationship curve for the emission current selected.

There is a problem with all ion gauges when used in systems which have the potential for diffusion pump oil vapor to enter the gauge volume. This oil vapor deposits on the grid forming an insulator and preventing emission resulting in higher and higher filament power being required and ultimate inability to control emission. In this situation, the 4 milliampere position is recommended.

2.3 Analog Output

This signal is proportional to the logarithm of the pressure with 0 volts at 1 x 10^{-10} Torr. The equation is: Pressure = $10^{(volts-10)}$. When the Micro-Ion Gauge is turned OFF, the output will switch to slightly over +10 Vdc. Refer to Figure 2-2 for complete details.

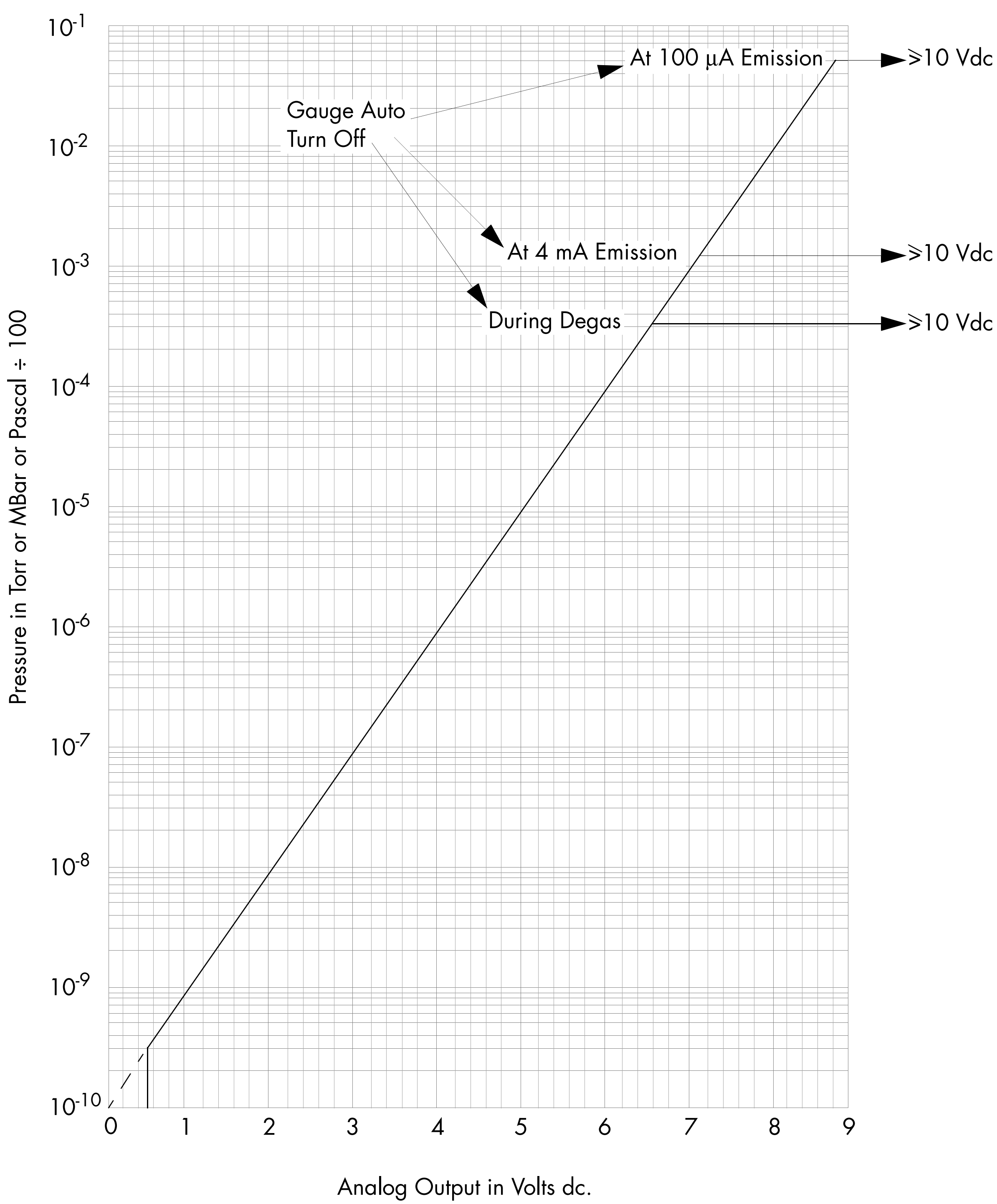


Figure 2-2 *Analog Output.*

2.4 Gas Sensitivity Correction

The 354 Micro-Ion Gauge is calibrated to read pressure for nitrogen or air. If used with gases other than this, it will be required that the analog output voltage to pressure reading be corrected for the gas in use. Table 1.1 gives some typical sensitivity ratios. To correct the analog output to pressure curve reading, divide the indicated pressure reading by the sensitivity ratio.

Ion gauge sensitivity ratios, r, derived from data obtained by NASA Technical Note TND5285, “Ionization Gauge Sensitivities as Reported in the Literature,” by Robert L. Summers, Lewis Research Center, National Aeronautics and Space Administration are shown in Table 2-1.

Table 2-1 *Ion Gauge Sensitivity Ratios (r).*

Gas	He	Ne	D_2	H_2	N_2	Air	O_2	CO
r	0.18	0.30	0.35	0.46	1.00	1.00	1.01	1.05

Gas	H_2O	NO	Ar	CO_2	Kr	SF_6	Xe	Hg
r	1.12	1.16	1.29	1.42	1.94	2.50	2.87	3.64

2.4.1 Example

The analog output voltage is measured and found to be 4.69 Vdc which, for air or nitrogen, indicates a pressure of 5 x 10^{-5} Torr. If the gas type in the system is known to be neon, then

$$\frac{5 \times 10^{-5}\ \text{Torr}}{0.30} = 1.67 \times 10^{-4}\ \text{Torr of neon.}$$

2.5 Overpressure Shutdown

The 354 is preset by fixed component values to shut down the ion gauge should pressure rise above 5 x 10^{-2} Torr of nitrogen at 100 microamperes emission or 1.3 x 10^{-3} Torr of nitrogen at 4 milliamperes emission.

2.6 Gauge ON/OFF

To turn the gauge ON, it is required that pin 1 be grounded to pin 2 of the I/O connector. To turn the gauge OFF, remove the ground. Note that the application of the ground will only try to turn the gauge ON once. If, for any reason, this is not successful, it will be required that the input be recycled back to OFF and then ON again.

Possible reasons for an unsuccessful turn-on to happen include:

1. Slow voltage rise from the power supply to the unit. Try again.
2. Attempt made to turn on the gauge at a pressure where emission could not be established.
3. An overpressure shutdown where system pressure exceeded the overpressure shutdown level.

2.7 Very-High and Ultra-High Vacuum Measurement

For best results when measuring vacuum pressures below 1 x 10^{-7} Torr:

- Use only all-metal vacuum fittings.
- Degas the grid. See degas instructions following this section.
- A chamber bake to 100 to 150 ^{o}C is often required. When baking the chamber, be sure the temperature of the tube and the vacuum plumbing to the tube is raised at least as much as the chamber. The electronics module must be removed from the gauge if the bake-out temperature exceeds 70 ^{o}C. This can be done without breaking vacuum by removing the four screws

securing the front plate to the aluminum extrusion enclosure. Pull the module away from the plate after the 4 screws are removed. The plate will stay attached to the tube (see Figure 3-1 on page 3-4). Do not exceed 200 ^oC.

After baking, re-install the electronics module by reversing the above procedure, being careful that the gauge pins line up with the sockets on the PC board.

2.8 Degas

Degassing of the gauge tube is accomplished by electron bombardment (EB) heating of the grid. Pressure reading during degas is provided. Note that in order to activate the degas circuit, the IG ON circuit must be first activated. This assures that there is a vacuum in the system prior to degas. Also note that the degas circuit will turn off if the IG ON circuit is turned off. Power during degas is approximately 4 watts above operating power and is turned off automatically after a two minute period.

2.9 Filament Selection

The 354 Micro-Ion Module is equipped with a filament select switch adjacent to the I/O connector which allows the user to switch between the two filaments of the gauge tube. It is recommended that the gauge be turned off before switching to the other filament.

2.10 Specifications for 354 Micro-Ion Gauges

Table 2-2 *Specifications for the 354 Micro-Ion Gauge.*

Performance	
Measurement Range	1×10^{-9} to 5×10^{-2} Torr for N_2 or air. For use below 1×10^{-7} Torr the use of a Conflat flange or other type metal seal is recommended.
Analog Output	Logarithmic, 1 Vdc/decade.
Digital Display Update Rate	0.5 sec.
Overpressure Protection	Gauge tube turns off if pressure rises above 5×10^{-2} Torr at 100 microamperes or 1.3×10^{-3} Torr at 4 milliampere emission.
Emission Current	2 ranges: 100 μA, 4 mA.
Operating Voltage & Power	+24 Vdc, ±15%, 12 watts max.
Degas	Electron bombardment, approximately 4 watts with 2 minute timer.
Filament Selection	2 position switch.
Physical	
Vacuum Connection	NW16KF flange, NW25KF flange, NW40KF flange, 1-5/16 in. Conflat, 2-3/4 in. Conflat or 1/2 in. 8-VCR male fitting.
Electrical Connection	9 pin “D” connector.
Weight	13 oz.
Case Material	Aluminum extrusion.
Gauge Tube Replacement	Field replaceable using only Phillips type screwdriver.
Electrical Safety	Metal enclosure which houses 180 V supply will require use of a metal flange clamp to assure ground continuity to system.
Operating Temperature Range	0 ^oC to 40 ^oC.
Non-operating Temperature Range	-40 ^oC to 70 ^oC.

Chapter 3

Service and Maintenance

3.1 Service Guidelines

Some minor difficulties are readily corrected in the field.

If a Qualified Service Person makes repairs at the component level, repairs properly made with equivalent electronic parts and rosin core solder do not void the warranty.

Because the 354 Micro-Ion Module contains static-sensitive electronic parts, the following precautions must be followed when troubleshooting:

- Use a grounded, conductive work surface. Wear a high impedance ground strap for personnel protection.
- Use conductive or static dissipative envelopes to store or ship static sensitive devices or printed circuit boards.
- Do not operate the product with static sensitive devices or other components removed from the product.
- Do not handle static sensitive devices more than absolutely necessary, and only when wearing a ground strap.
- Do not use an ohmmeter for troubleshooting MOS circuits. Rely on voltage measurements.
- Use a grounded, electrostatic discharge safe soldering iron.

NOTE: This product has been designed and tested to offer reasonably safe service provided it is installed, operated, and serviced in strict accordance with these safety instructions.

Danger, High Voltage – The high voltages present within the Power Supply are capable of causing injury or death. To avoid electric shock, wait 3 minutes after power is removed before touching any component within the Power Supply. This will permit charged capacitors to discharge.

The service and repair information in this manual is for the use of Qualified Service Personnel. To avoid shock, do not perform any procedures in this manual or perform any servicing on this product unless you are qualified to do so.

Do not substitute parts or modify instrument.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to a service facility designated by Helix Technology for service and repair to ensure that safety features are maintained. Do not use this product if it has unauthorized modifications.

3.2 Damage Requiring Service

Disconnect this product from all power sources, and refer servicing to Qualified Service Personnel if any the following conditions exist:

- The gauge cable, power-supply cord, or plug is damaged.
- Liquid has been spilled onto, or objects have fallen into, the product.
- The product has been exposed to rain or water.
- The product does not operate normally even if you have followed the Operation Instructions. Adjust only those controls that are covered in the instruction manual. Improper adjustment of other controls may result in damage and require extensive work by a qualified technician to restore the product to its normal operation.
- The product has been dropped or the enclosure has been damaged.
- The product exhibits a distinct change in performance. This may indicate a need for service.

Replacement Parts - When replacement parts are required, be certain to use the replacement parts that are specified by Helix Technology, or that have the same characteristics as the original parts. Unauthorized substitutions may result in fire, electric shock or other hazards.

Safety Check - Upon completion of any service or repairs to this product, ask the Qualified Service Person to perform safety checks to determine that the product is in safe operating order.

Finite Lifetime - After ten years of normal use or even non-use, the electrical insulation in this product may become less effective at preventing electrical shock. Under certain environmental conditions which are beyond the manufacturer's control, some insulation material may deteriorate sooner. Therefore, periodically inspect all electrical insulation for cracks, crazing, or other signs of deterioration. Do not use if the electrical insulation has become unsafe.

3.3 Troubleshooting

Table 3-1 *General Symptoms/Possible Causes.*

Symptom	Possible Causes
Power indicator does not light.	Power supply disconnected, off, or inadequate for load. A switching supply may shut down from the current surge upon power-up. If a switching power supply is used, size current limit to two times working load. See Table 2-2 on page 2-4 for power requirements. The connector may be wired wrong. See Section 1.4 I/O Cable Connections on page 1-3. Blown fuse. This could be caused by wrong wiring. Replace the fuse with the following fuse: 1 ampere, slow blow, 2AG, Granville-Phillips P/N 012084 (see Fuse Replacement on page 3-6).
Ion gauge will not stay on.	Overpressure condition. 50 milliTorr at 100 µA emission, 1.3 milliTorr at 4mA emission. Emission control failure. Causes include gauge failure due to broken filament, contamination, or pressure over 1 Torr. High voltage power to gauge failure. Causes include gauge failure due to mechanical damage or leakage due to contamination.
Inaccurate pressure reading.	Organic seals. If the ion gauge connection to the vacuum system is sealed with an organic O-ring, the gauge will not read accurately below 1e-7 Torr. Use a metal seal. Mechanical damage. If the unit is dropped or excessive force is applied to the vacuum connection during installation, gauge elements may be damaged or pin leaks may occur. Replace the ion gauge tube. Contamination. Pump oil and other organic compounds, or metal coating from a sputtering process can cause electrical current leakage between ion gauge elements. Degas the ion gauge by connecting Pin 6 (Degas On/Off) on the I/O connector to Pin 2 (Power Ground) (see Figure 1-2 on page 1-3). Degas will operate for up to two minutes. Disconnect Pin 6 from Pin 2 in order to allow another degas cycle.

3.4 Ion Gauge Continuity Test

To prevent electrical shock, turn OFF electrical power before servicing the Micro-Ion Module. Do not touch any gauge pins while the gauge tube is under vacuum or connected to a controller.

This test should only be performed while the ion gauge is exposed to atmospheric pressure and the 354 electronics is removed from the gauge. If a problem with pressure measurement is traced to the Micro-Ion Module, the gauge may be tested with an ohm meter. This test can detect open filaments or shorts between gauge elements. This test may not detect inaccurate pressure measurement due to gauge contamination or vacuum leaks.

1. Turn OFF power to the module.

2. Remove the I/O connector from the module.

3. Remove the Micro-Ion Module from the vacuum system.

4. Remove the four Phillips head screws from the gauge collar plate as shown in Figure 3-1.

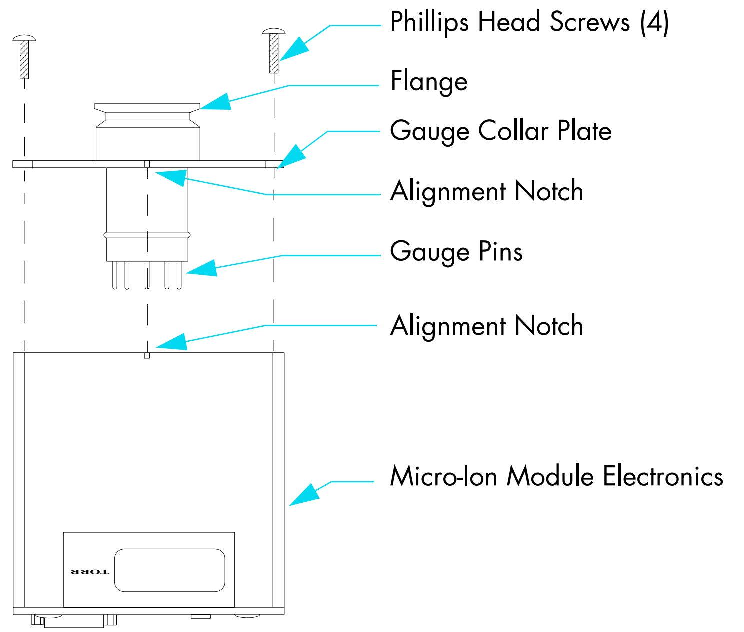


Figure 3-1 *354 Micro-Ion Gauge Removal.*

5. While holding the flange, *gently* pull the Micro-Ion Vacuum Gauge Module away from the gauge collar plate as shown in Figure 3-1. The gauge tube and plate will disconnect from the module.

6. Using a digital multimeter, measure the resistance of the left filament and the right filament between filament pins as shown in Figure 3-2 on page 3-5. The reading should be approximately 0.2 Ω.

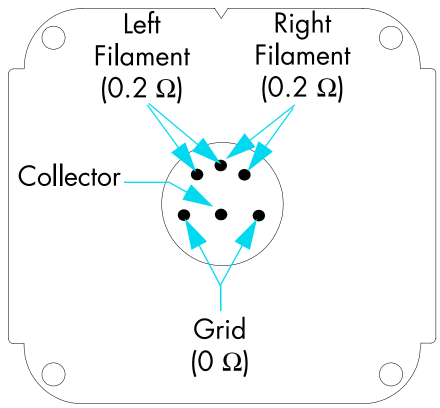


Figure 3-2 *354 Micro-Ion Gauge Pin Identification.*

7. Measure the resistance of filament pins to any other pin or gauge case as shown in Figure 3-2. The reading should be infinity.

8. Measure the resistance between Grid pins as shown in Figure 3-2. The reading should be approximately 0 Ω.

9. Measure the resistance of Grid pins to any other pin or gauge case as shown in Figure 3-2. The reading should be infinity.

10. Measure the resistance of Collector pin to any other pin or gauge case as shown in Figure 3-2. The reading should be infinity.

NOTE: If the readings obtained during this procedure are not within the values specified, the gauge should be replaced. Contact Helix Technology Customer Service to order a replacement gauge.

11. Once the replacement 354 Micro-Ion Gauge has been received, refer to Chapter 1, Installation on page 1-1, within this manual to install the gauge.

3.5 Fuse Replacement

Use the following procedure to replace the fuse in the Micro-Ion module.

> **To prevent electrical shock, turn OFF electrical power before servicing the Micro-Ion Module.**

1. Turn OFF power to the Micro-Ion Module.
2. Disconnect the I/O cable from the connector.
3. Remove the I/O cable connector jack posts from the connector.
4. Remove the four screws from the Micro-Ion Module top cover and remove the cover.
5. Locate the defective fuse as shown in Figure 3-3 and replace it with a new 1 amp, slow blow fuse.

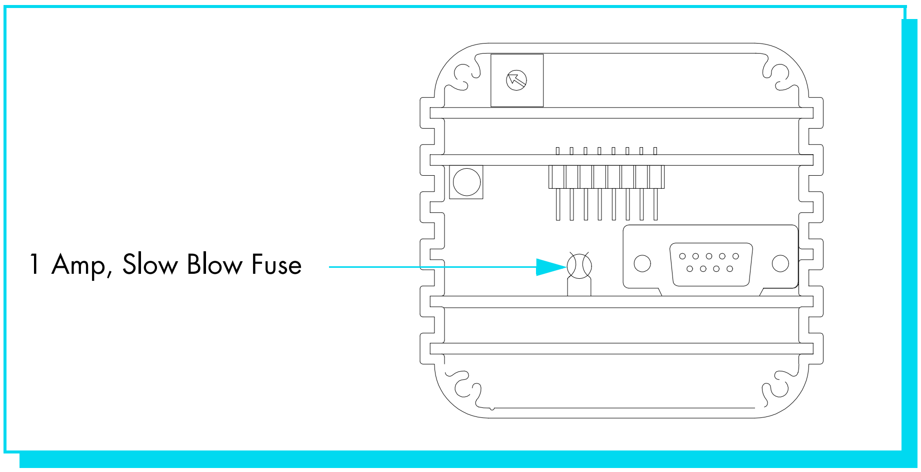


Figure 3-3 *Position of 1 Amp, Slow Blow Fuse.*

6. Install the Micro-Ion Module top cover with the previously removed four screws.
7. Install the I/O cable connector jack posts on the connector.
8. Connect the I/O cable to the connector.
9. Turn ON power to the Micro-Ion Module. It is now ready to be used.

3.6 Service Form

Please photocopy this form, fill it out, and return it with your equipment:

RA No.____________________

Contact Helix Technology Customer Service at **1-303-652-4400**, or **1-800-776-6543 in the USA**; FAX: **1-303-652-2844**, or email: **salesco@helixtechnology.com**

Model No.______________________ Serial No.____________________ Date________________________

Name ____ Phone No.____________________________

Company____

Address____

____

City____ State____________________ Zip_________________

Please help Helix Technology continue to provide the best possible service by furnishing information that will help us determine the cause of the problem, as well as protect our analysis and calibration equipment from contamination.

Problem description:____

____

____

____

____

Application description:____

____

____

____

Has this product been used with high vapor pressure or hazardous materials? ❑ Yes ❑ No

If Yes, please list the types of gas, chemicals (common names, specific chemical,) biological materials, or other potentially contaminating or harmful materials exposed to the product during its use.

____

____

____

NOTE: PRODUCTS EXPOSED TO RADIOACTIVE MATERIAL CANNOT BE ACCEPTED BY HELIX TECHNOLOGY UNDER ANY CIRCUMSTANCES.

Signature: ____

Printed Name____ Phone No.________________________

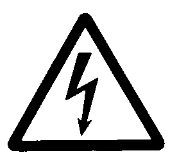
NOTES

Index

INSTALLATION, OPERATION and MAINTENANCE MANUAL

MODEL PF1 15, 25, 40 & 70 AMP
SINGLE PHASE
SOLIDSTATE RELAY (SSR) POWER CONTROLS

UL/Cul FILE NUMBER – E151547
CE – See last page of manual for CE Declaration of Conformity



HDR POWER SYSTEMS, INC.
3563 INTERCHANGE ROAD
COLUMBUS, OHIO 43204

TEL: 614-308-5500
TOLL FREE: 1-888-PWR-CNTL (797-2685)
FAX: 614-308-5506

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All of our employees are dedicated to your success. If you have any questions, comments or concerns, please call me toll free at 1-888-PWR-CNTL (797-2685).

Sincerely,

HDR POWER SYSTEMS, INC.

George A Sites

George A. Sites
Vice President

GAS/be

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REVISION PAGE

Page	Change	Revision	Date
2	1	"@ 3VA. . . " in Paragraph 3 Added	5/5/92
3	1	"The 24VAC must be. . . " Paragraph 3-1	5/5/92
4	1	"NOTE: The control power transformer. . . "	5/5/92
8	1	"NOTE: The control power transformer. . . "	5/5/92
9	1	"NOTE: Use a RMS voltmeter. . . "	5/5/92
10	1	"Erratic Output. . . "	5/5/92
Many	2	Added 70A Rating. . . "	4/14/93
Many	3	Totally Revised	12/01/95
Many	4	Revised for Scanner	10/96
Many	5	Rewritten for CE	8/00
17	6	Added EMC to CE Declaration	11/00

NOTE: SPECIFICATIONS SUBJECT TO CHANGE WITHOUT PRIOR NOTICE.

TABLE OF CONTENTS

TABLES, ILLUSTRATIONS & DRAWING LIST

TABLES

ILLUSTRATIONS

DRAWING LIST

NOTE: If full size drawings are required, contact HDR inside sales and request the required drawing by the drawing number listed above

1-1 MODELS COVERED

This manual covers the PF1 models rated 15, 25, 40 & 70 amperes and its options.

1-2 GENERAL DESCRIPTION

The PF1 is a solid-state, single-phase, phase fired (PF) SCR power control which will operate on line voltages up to 600 VAC. It accepts most all standard process command signals and regulates the output voltage. Zero and Span Multi-turn potentiometers are provided to ease calibration. The PF1 utilizes an isolated base Solid-State-Relay (SSR) Module which contains two SCRs connected back to back. The firing circuit is based on a common phase firing integrated circuit which includes soft-start for loads which are inductive or have a large resistance change due to temperature or start-up. Terminals are provided to ease installation.

1-3 APPLICATIONS

The PF1 provides infinitely variable firing angles for precise control of single-phase power to resistive or loads with large resistance change (cold to hot). The PF1 may also be used on straight resistive loads as well, but the lower power factor and higher harmonics may present a problem to other equipment mounted nearby. A zero fired model would be a better choice. It is not recommended for use with transformer coupled loads. PF1's/SHPF1's with dual SCR modules (not SSRs) should be used.

1-4 SPECIFICATIONS

Specifications for the PF1 SCR Power Control are given in Table 1.

Table 1
Specifications for the PF1 15, 25, 40 & 70 Amp Models

CONTROL METHOD - Phase firing of back to back SCRs.
VOLTAGE RATING - Up to 600 VAC, 1 Ph., 50/60 Hz.
CURRENT RATING - 15, 25, 40 & 70 Arms.
COMMAND SIGNAL - 4-20 ma, 0-5 VDC/0-10 VDC,Manual Control
ISOLATION - 2500 Vrms from line/load to command signal to ground.
LINEARITY - RMS output voltage is linear to command signal.
ADJUSTMENTS - Zero and Span, multi-turn.
AMBIENT TEMPERATURE - Operating, 0 - 50 °C; Storage, -10 - 70 °C.
AGENCY LISTING - UL/cUL Listed, CE Compliant

1-5 OPTIONS

Five options are available for the PF1 models: A fuse Kit, a 24 VAC Control Transformer, a Current Limit, an Overcurrent Trip and Heatsink Thermostats.

The Fuse Kit (Option FK) consists of a Semi-Conductor Fuse and a fuse block. It is the user's responsibility to mount this fuse kit.

The PF1 requires 24 VAC @ 3VA control power. Appropriate sized transformers (Option TX) are available with 120, 240, 400, 480 or 600 VAC primaries.

Current Limit (Option CL) is available for those loads that decrease in resistance with time.

Overcurrent Trip (Option OC) can be used on loads which have instantaneous shorts that are self healing; or, in some cases, it may be used as an "Electronic Fuse".

Heatsink Thermostats (Option NO or NC) provide a dry contact (either Normally Open (NO) or Normally Closed (NC).

1-6 OPERATION

The PF1 controls power by the switching action of two SCRs connected in a back to back configuration. The gating of these SCRs is synchronized with the line frequency (either 50 or 60 HZ) by the Phase Control Integrated Circuit and the 24 VAC control voltage. This IC provides timing pulses along with a soft-start feature. The output may be adjusted by the on-board potentiometers or by a voltage or current signal from a process controller. Zero and Span controls allow the user to calibrate the SCR unit's output to the process command signal. Terminals are also available for connection a remote manual potentiometer.

WARNING
Hazardous voltages exist at the power controller heat sinks and at the load at all times when the input voltage is connected. This condition exists even when the controller is set to delivery zero output.

NOTE: The 24 VAC control power <u>must be</u> of the same phase relationship as the power being controlled.

Table 2 shows the % output voltage at various input command signal levels. The PF1 will maintain as constant a power level to the heating elements as possible.

TABLE 2 % OUTPUT VOLTAGE AT VARIOUS INPUT COMMAND LEVELS	
Ma Input	**% Output Voltage**
4	0
5	10
6	30
7	41
8	53
9	59
10	64
11	68
12	71
13	76
14	80
15	85
16	88
17	91
18	95
19	98
20	100

NOTE: The % output voltage for any given command signal is affected by the exact setting of the zero and span potentiometers. Table 2 is intended to be used only as a comparative example.

2-1 MOUNTING

Prior to mounting, verify the voltage and current rating of the PF1, the information is provided on the nameplate. Determine the mounting dimensions from the outline drawing located in Figures 2 & 3. Mount the PF1 with line/load terminals to the top so that airflow is upward through the heat sink fins. Ensure that airflow is unrestricted and mount the 24 VAC control transformer close by. The 24VAC must be phase referenced to the same power as the PF1.

2-2 LINE/LOAD POWER WIRING

Connect the line/load using appropriately sized and insulated wire/cable per NEC based on the voltage and current rating of the PF1. Torque the line/load power connections to 25 in-lbs. min. Refer to Fig. 1 for all additional connections.

NOTE: 75 °C rated wire is required by UL for all power connections to the PF1.

WARNING

Branch circuit overcurrent protection is required to be provided in Accordance with the national and/or local code of the inspecting Authority or equivalent. If it is desired to protect the SCRs, fast Clearing semiconductor fuses must be added to the system. Table 3 Shows the fuse voltage, fuse current, fuse maximum 12T rating and Conditional short circuit current (CSCA) rating for each of the power Control's ratings.

TABLE 3

UNIT CURRENT	FUSE VOLTAGE	FUSE CURRENT	FUSE I2T	CSCA
15	700	20	157	200,000
25	700	30	427	200,000
40	700	50	950	200,000
70	700	80	4085	200,000

NOTE: The Conditioned Short Circuit Current (CSCA) rating is thee maximum current the fuse can safely clear and this rating must be higher than the current the branch circuit can supply.

2-3 SAFETY ISSUES

The rated operational voltage of each power controller is shown on it's nameplate,i.e. 120V, 240V, 400V, 480V, or 575V. The power controller is designed to operate between +10% and –15% of this rated operational voltage in an Over Voltage Category III environment.

WARNING

Power control units are not suitable to provide isolation due to the use of semiconductors and other components that allow a small current to flow from line to load even when the unit is in the non-conducting mode.

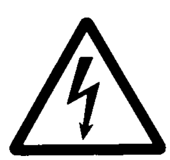
The minimum operational current and the maximum off state current for eqch unit is shown in Table 4.

The power controls described in this instruction manual are designed to operate in a pollution degree 2 environment.

TABLE 4

UNIT CURRENT (A)	**MINIMUM OPERATING CURRENT (ma)**	**MAXIMUM OFF CURRENT (ma)**
15	100	15
25	100	15
40	100	15
70	100	15

HAZARDS EXIST



DANGEROUS VOLTAGES EXIST

2-4 OPTIONS

If the PF1 was ordered with either the Current Limit or the Overcurrent Trip option then it should be mounted at this time. The Current Transformer should be mounted so the input line wire/cable passes through it and it is close enough for the plug-in cable assembly to reach the firing circuit.

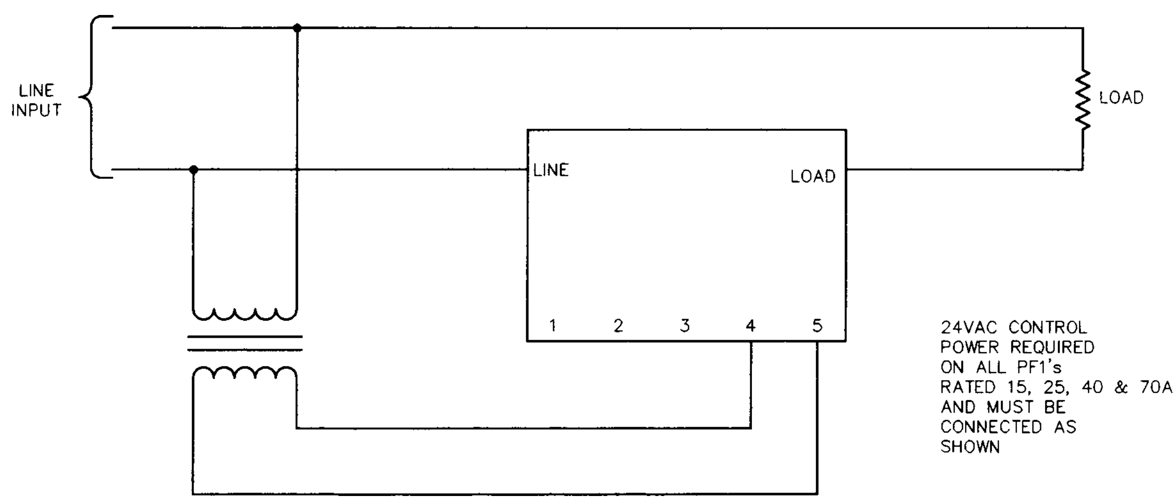
Refer to Figures 4 & 5 for dimensional information.

NOTE: Do not connect the Current Limit or the Overcurrent Trip plug-in cable to the firing circuit until the Zero and Span controls have been adjusted.

Both the Current Limit and the Overcurrent Trip options have been factory adjusted for nominal ratings. You may want to adjust these for your individual requirements. The Current Limit is adjustable from 50 to 125% of the unit's rating while the Overcurrent Trip is adjustable from 25 to 200% of its rating.

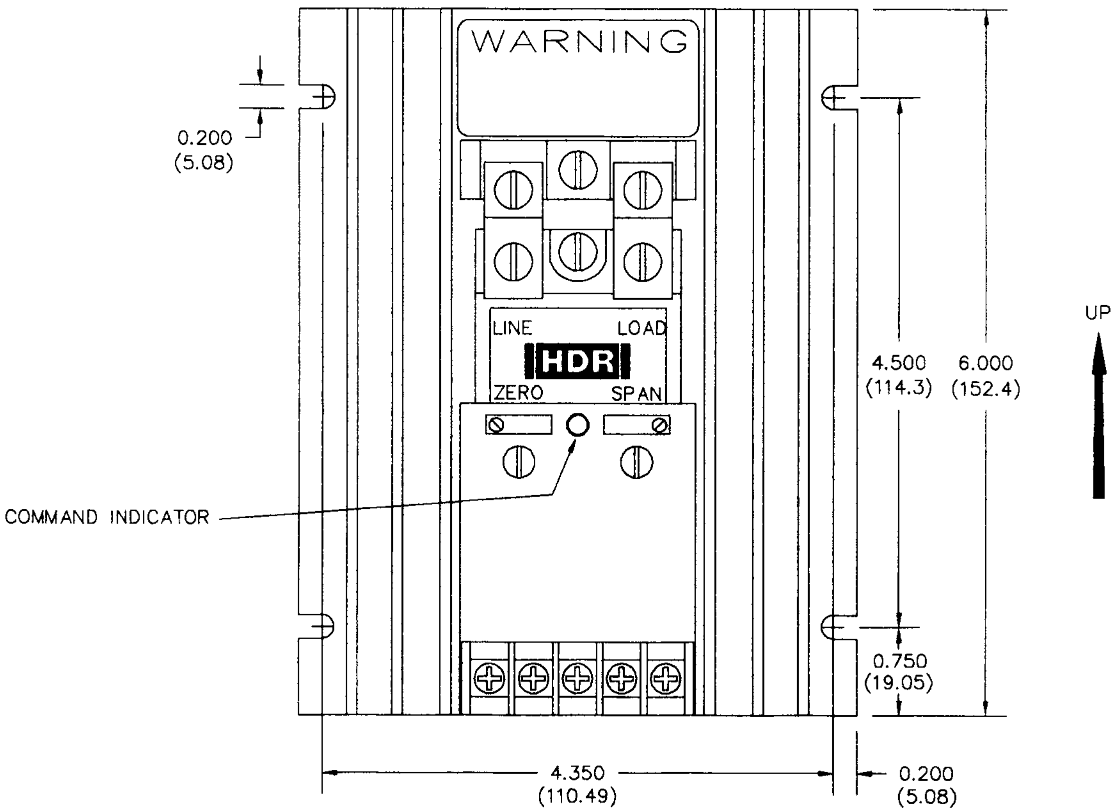
The Overcurrent Trip has a Form C relay output and provisions for a remote overcurrent reset push button. A momentarily closed contact resets the trip.

Figure 1 – LINE/LOAD POWER WIRING



NOTE: the control transformer must be referenced to the same phases as the PF1.

Figure 2 - OUTLINE AND MOUNTING DIMENSIONS - 15, 25 & 40A



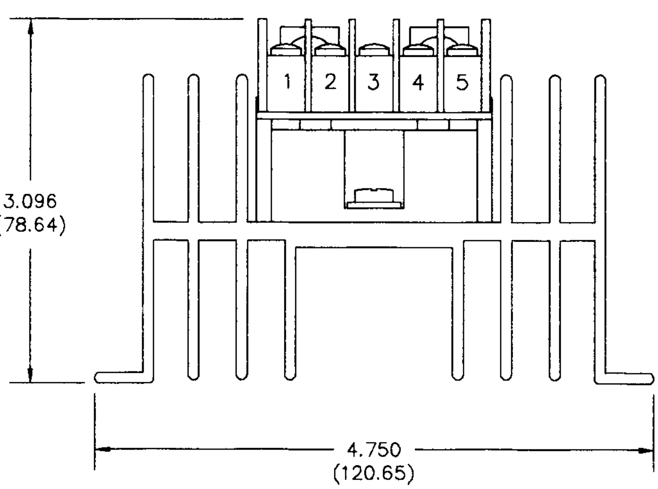


Figure 3 - OUTLINE AND MOUNTING DIMENSIONS - 70A

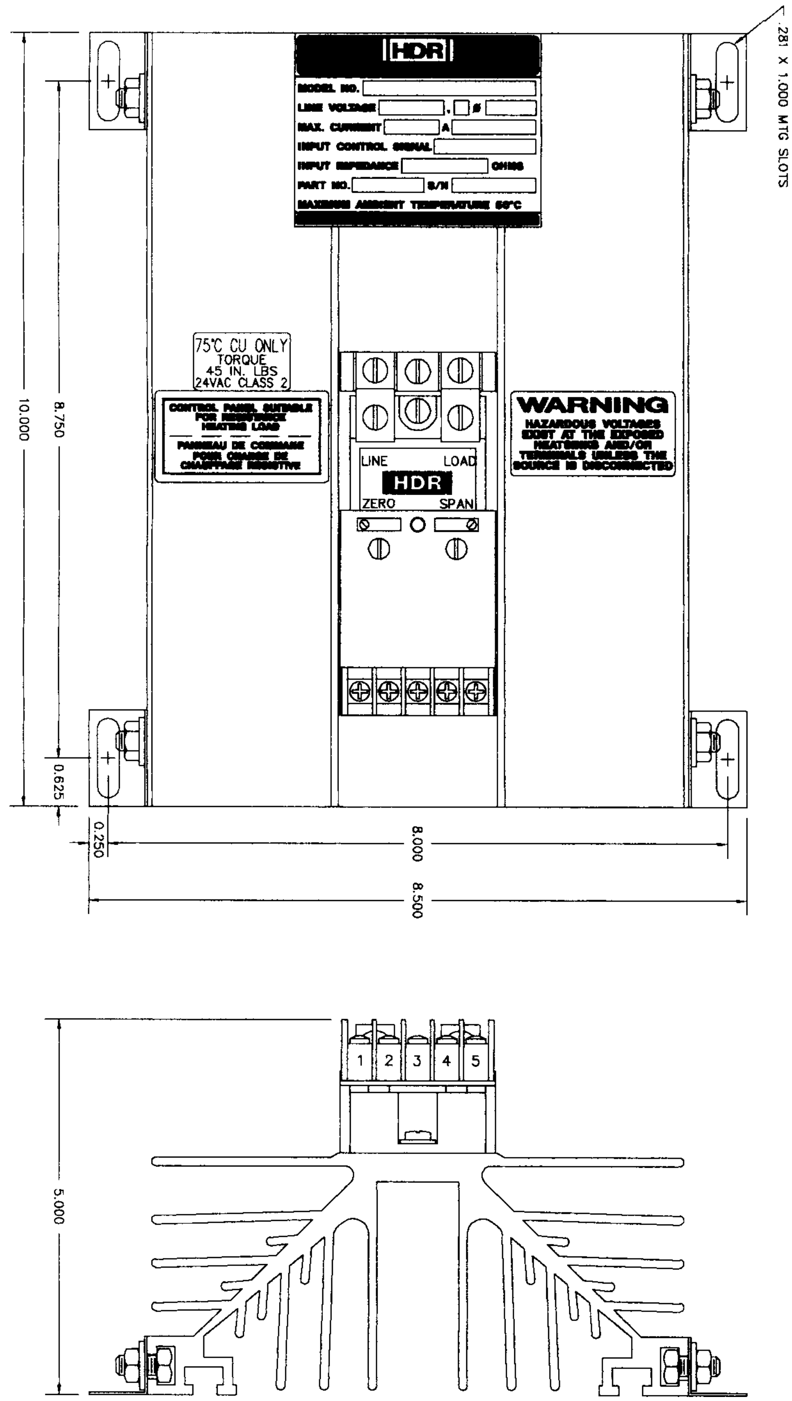


Figure 4 - OUTLINE AND MOUNTING - CURRENT LIMIT

Figure 5 - OUTLINE AND MOUNTING - OVERCURRENT TRIP

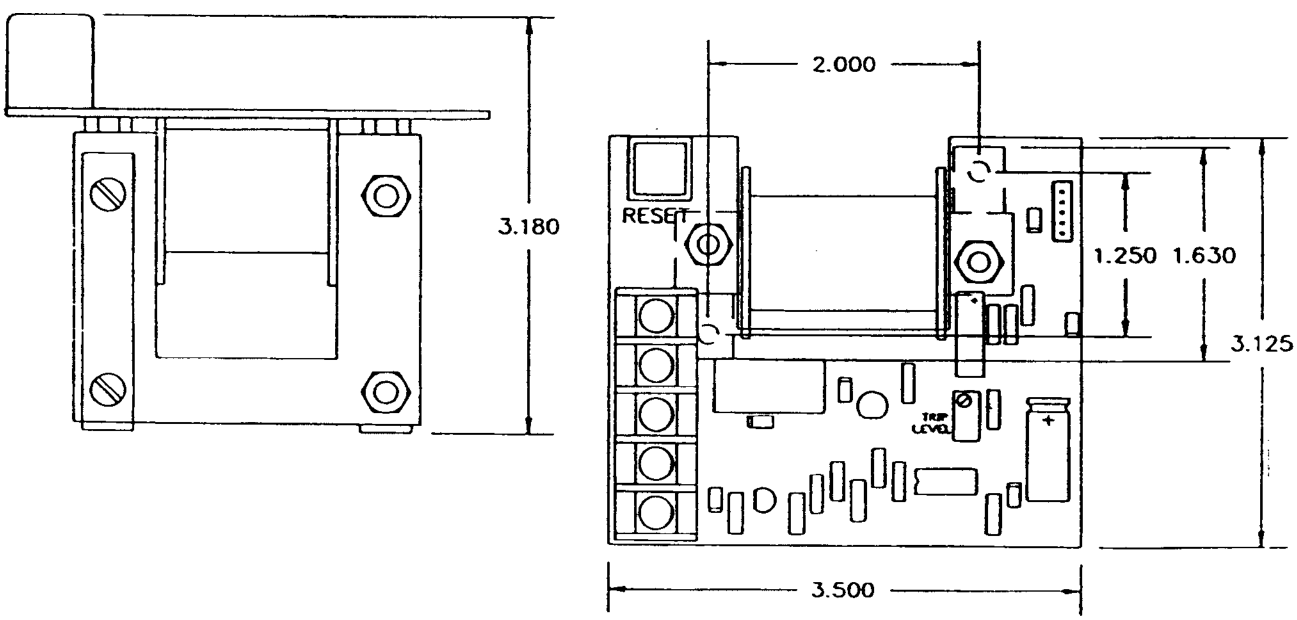


Figure 6 – 24 Vac TRANSFORMER

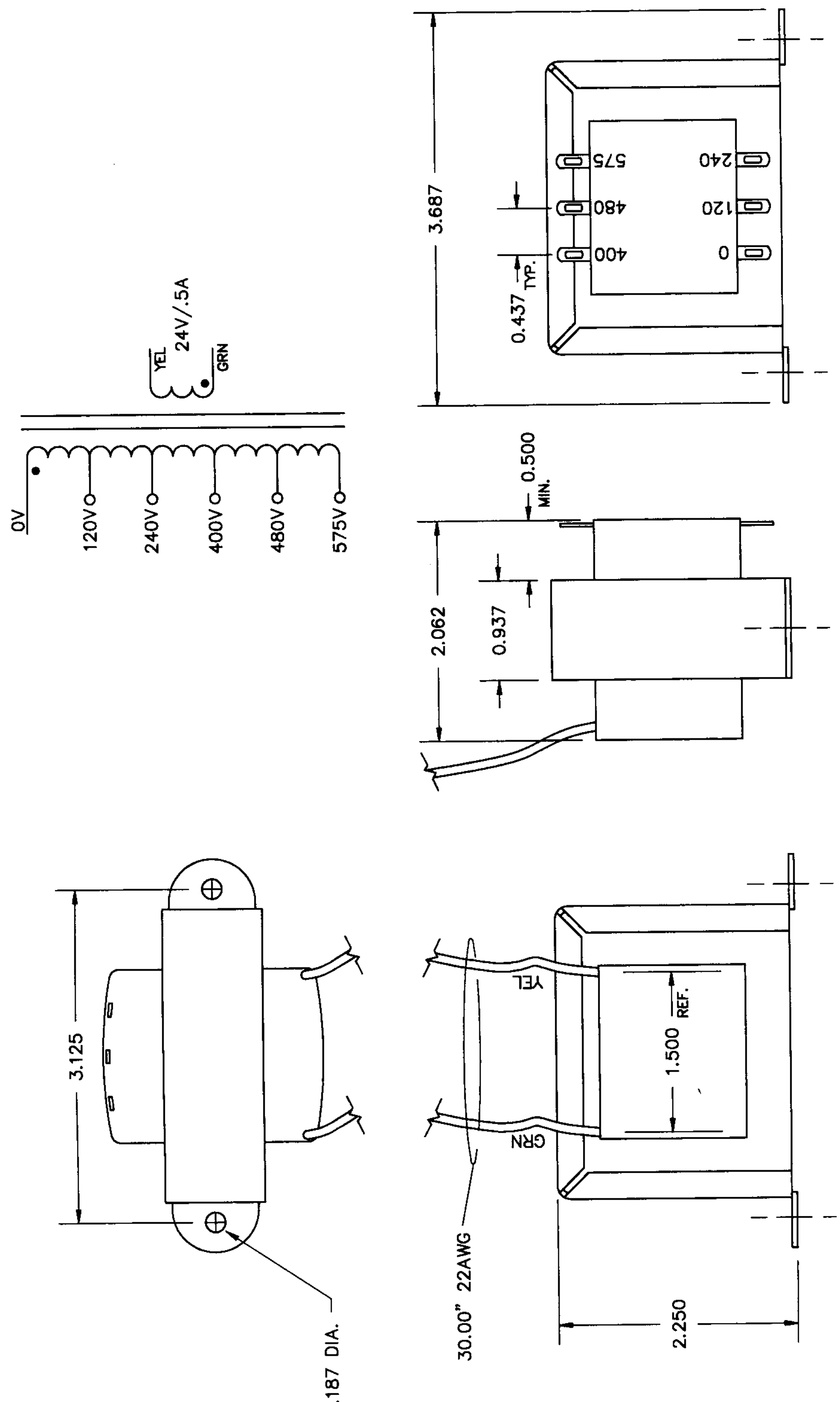
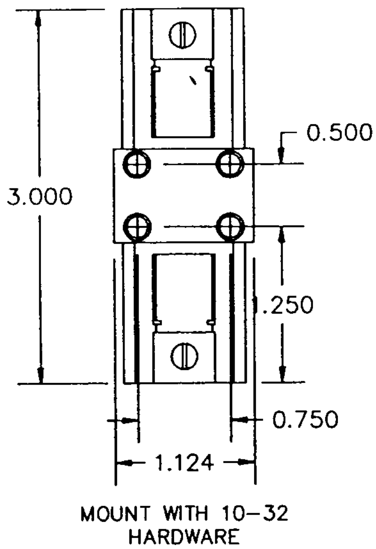
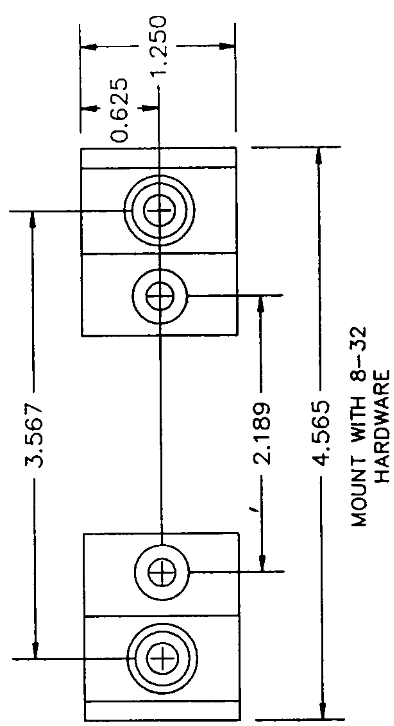


Figure 7 – FUSE BLOCK DIMENSIONS



15/25 AMP



40/70 AMP

3-1 ZERO AND SPAN ADJUSTMENTS

The Zero potentiometer has both positive and negative voltages available making it usable as a manual or zero control. By turning the Zero control clockwise the unit's output voltage will increase proportionally to the adjustment. Turning it counter-clockwise will decrease or zero the output for any non-zero based command signal.

The Span potentiometer is used to adjust the maximum output. It will adjust for either a remote manual control or a command signal input. Clockwise adjustment increases the output while counter-clockwise adjustment decreases the output. Due to some interaction between controls, it may be necessary to repeat these adjustments.

3-2 COMMAND INDICATOR

The Command Indicator is a green Light Emitting Diode (LED) located between the Zero and Span controls. The intensity of this LED will vary with the output of the unit. The intensity will be brighter with higher outputs and dimmer with lower outputs.

3-3 REMOTE MANUAL CONTROL

Start with the Zero Control set approximately at mid rotation and the Span Control set at minimum (counter-clockwise). Connect a 5K ohm remote manual control to terminals 1 (CCS), 2 (Wiper) and 3 (CW). With the unit energized and the manual control fully counter-clockwise, adjust the Zero Control until the unit is just off. Next turn the manual control fully clockwise and adjust the Span Control until the desired output voltage is reached. This procedure may have to be repeated since some interaction between the Zero and Span Controls exist.

3-4 PROCESS COMMAND SIGNAL

This procedure is similar to the Remote Manual Control procedure. Start with the Zero Control set approximately at mid rotation and the Span Control set at minimum. Connect the Command Signal to terminals 1 (-) and 2 (+) and then energize the unit. With the Command Signal at minimum, adjust the Zero Control so the unit is just off (zero output voltage) then with the Command Signal at full output, adjust the Span Control so the output voltage is at the desired level. Repeating this procedure may be necessary due to some interaction between the Zero and Span Controls.

NOTE: The Zero and Span Controls should be adjusted prior to connecting or adjusting either the Current Limit or the Overcurrent Trip. The Current Limit and Overcurrent Trip options have been factory set, if the adjustments have not been changed, then the following adjustments may not be needed. The current transformer may need more than one (1) primary turn. See note below.

4-1 CURRENT LIMIT (OPTION CL)

Prior to energizing the PF1, adjust the Current Limit control fully clockwise. Next with the PF1 operating at full output and the proper load connected turn the Current Limit control counter-clockwise until the desired maximum output is attained.

NOTE: Current transformer wiring:
15A unit requires 3 primary turns.
25A unit requires 2 primary turns.
40A unit requires 1 primary turn.
70A unit requires 1 primary turn.

4-2 OVERCURRENT TRIP (OPTION OC)

As with the Current Limit, insure that the Overcurrent Trip control is fully clockwise. With the PF1 operating at full current adjust the Overcurrent Trip control counter-clockwise until the unit shuts off. Readjust the control clockwise a small amount and press the Reset button. The Overcurrent Trip should be adjusted properly at this point.

The Overcurrent relay output (Form C) and a remote reset input is included on the overcurrent trip option. The normally open (N.O.) contact is on terminals 2 & 3 and the normally closed (N.C.) contact is on terminals 1 & 2. A remote reset pushbutton (N.O.) may be connected to terminals 4 & 5.

NOTE: Make the following changes:
15A unit remove R1 & R2.
25A unit remove R2.
40A unit no change.
70A unit no change.

NOTE: Use a RMS ammeter to monitor the output current. Some load must be present when making adjustments.

5-1 ENVIRONMENTAL CONCERNS

Always verify that the PF1 is mounted in a clean, dust free environment. Clean the heat sink and printed circuit board periodically so no dust and/or dirt accumulates on the unit. Dust and/or dirt on the heat sink fins can prevent proper airflow causing overheating of the semiconductors. Conductive dust and/or dirt can cause shorts or arcing which can cause damage to the unit.

5-2 LINE/LOAD POWER CONNECTIONS

Periodically turn the power off to the PF1 and check for corrosion and tightness of the power connections. If any corrosion is evident, clean the cable and connector and reconnect making sure to tighten to 25 in-lbs.

5-3 TROUBLESHOOTING TYPICAL SYMPTOMS

Any one of the following symptoms usually indicate a problem with the PF1:

1. **Symptom** - No output.
   Cause - Open fuse or no 24 VAC control power.
   Solution - Disconnect the input power and check the fuse, replace the fuse if faulty. If the fuse checks ok, verify the 24 VAC control power on terminals 4 & 5. If neither of these solve the problem, contact the factory.

2. **Symptom** - Full output regardless of command signal input.
   Cause - Shorted SSR module or defective firing circuit.
   Solution - Readjust the zero and span controls. If this does not help, disconnect the input power and remove the firing circuit. Re-energize, if the output is on full, replace the SSR module. If the output is off, then most likely the firing circuit is defective. Consult the factory.

3. **Symptom** - The unit is not variable fro 0 to full output.
   Cause - Defective firing circuit.
   Solution - If neither of the first two symptom/solutions are the answer, order a replacement firing circuit from the factory.

6-1 CUSTOMER SERVICE

If you have operational problems which cannot be resolved using this manual, please contact the Service Department at HDR. Our normal work hours are 8 a.m. to 3:30 p.m., U.S.A. EASTERN TIME ZONE, Monday through Friday.

TELEPHONE: 1-888-PWR-CNTL (797-2685) OR 614-308-5500.
Our answering machine at 614-308-5500 will answer after hours and we will return your call the next working day.

FAX: 614-308-5506. 24 hours per day automatic answering.

6-2 SPARE PARTS

Inside Sales should be contacted for any spare parts orders whether routine or emergency during normal working hours. All after hours requirements should be called in on our 614-308-5500 answering machine. Please have as much information available as possible pertaining to the model number, serial number, order number and parts required. A purchase order number should be available.

6-3 WARRANTY

HDR warrants that the equipment delivered will be free from defects in workmanship and material for a period of five years from the date of shipment. HDR will repair or replace, at HDR's option, any part found defective during proper and normal use, provided that written notice of the nature of the defect is received by HDR within the five year warranty period and that the customer returns the part to HDR freight paid both ways. This warranty is not transferrable by the initial end user.

HDR MAKES NO OTHER WARRANTIES, EXPRESSED OR IMPLIED (INCLUDING, WITHOUT LIMITATION, MERCHANTABILITY, FITNESS FOR PURPOSE, OR AGAINST INFRINGEMENT OF ANY PATENT) EXCEPT AS EXPRESSLY PROVIDED HEREIN.

THE REMEDY OF REPAIR OR REPLACEMENT IS CUSTOMER’S SOLE AND EXCLUSIVE REMEDY AND WILL SATISFY ALL OF HDR’S LIABILITIES, WHETHER BASED ON CONTRACT, NEGLIGENCE, TORT, PRODUCT LIABILITY, STRICT LIABILITY, OR OTHERWISE. IN NO WAY WILL HDR BE LIABLE FOR INCIDENT OR CONSEQUENTIAL DAMAGES, NOR IN ANY EVENT SHALL HDR’S LIABILITY EXCEED THE UNIT PRICE OF ANY DEFECTIVE PRODUCT OR PART.

HDR Power Systems, Inc.

EC DECLARATION OF CONFORMITY

WE: **HDR POWER SYSTEMS, INC.**
3563 Interchange Road
Columbus, Ohio 43204 - USA

Declare under our sole responsibility that the products listed below and bearing the CE label:

Type: SCR power controllers with the following model designations and current ratings:

ZF1, ZF2, ZF3, PF1, PF3 - 15, 25, 40, 60, 70, 90, 120, 180, 225, 350, 500, 650, 800, 1000 and 1200A.
SHZF1, SHPF1 - 15, 30, 40, 60, 70, 90 and 120A
SHZF2, SHZF3, SHPF3 - 15, 25, 30, 60, 90, 120, 180 and 225A
SCZF1, SCPF1 - 15, 25, 40 and 65A
All applicable options

To which this declaration relates is in conformity with the technical requirements of the following documents:

Title:	Low-voltage switchgear and controlgear	***No.*** IEC 947-5-1	***Year:*** 1990-03
	Low Voltage Directive	***No.*** IEC 73/23/EEC	***Year:*** 1973-02
	Degrees of protection provided by enclosures (IP Code):	***No.*** IEC 529-2nd Edition	***Year:*** 1989-11
	Electromagnetic Compatibility (EMC)	***No.*** IEC 89/336/EEC	***Year:*** 1989-05

Warning
All phase-fired (PF) controllers will require line filters and possibly shielded cables to meet the EMC requirements.

(Environmental protection classification IP00 - for mounting inside an enclosure)

Note: Characteristics are according to mfg specifications.

Name: George A. Sites

Title: Vice President

Date: November 10, 2000

George A Sites

Signature:

E5CK Process Controller

User Manual

Cat. No. H78-E3-2

Notice:

OMRON products are manufactured for use according to proper procedures by a qualified operator and only for the purposes described in this manual.

The following conventions are used to indicate and classify precautions in this manual. Always heed the information provided with them. Failure to heed precautions can result in injury to people or damage to the product.

DANGER! Indicates information that, if not heeded, is likely to result in loss of life or serious injury.

⚠ WARNING Indicates information that, if not heeded, could possibly result in loss of life or serious injury.

⚠ Caution Indicates information that, if not heeded, could result in relatively serious or minor injury, damage to the product, or faulty operation.

OMRON Product References

All OMRON products are capitalized in this manual. The word “Unit” is also capitalized when it refers to an OMRON product.

The abbreviation “Ch,” which appears in some displays and on some OMRON products, often means “word” and is abbreviated “Wd” in documentation in this sense.

The abbreviation “PC” means Programmable Controller and is not used as an abbreviation for anything else.

Visual Aids

The following headings appear in the left column of the manual to help you locate different types of information.

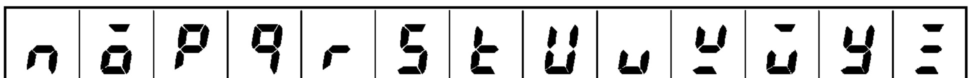
Note Indicates information of particular interest for efficient and convenient operation of the product.

1, 2, 3... 1. Indicates lists of one sort or another, such as procedures, checklists, etc.

How to Read Display Symbols

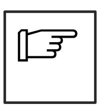
The following tables show the correspondence between the E5CK display symbols and alphabet characters.

A	B	C	D	E	F	G	H	I	J	K	L	M



N	O	P	Q	R	S	T	U	V	W	X	Y	Z

The *Reference* Mark



This mark indicates that extra, useful information is being provided, such as supplementary explanations and how to apply functions.

Contents

SECTION 1
Introduction

SECTION 2
Preparations

SECTION 3
Preparations

SECTION 4
Applied Operation

SECTION 5
Parameters

SECTION 6
Using the Communications Function

SECTION 7
Troubleshooting

APPENDIX

About this Manual:

To ensure correct use, thoroughly read and understand this manual before using the E5CK.

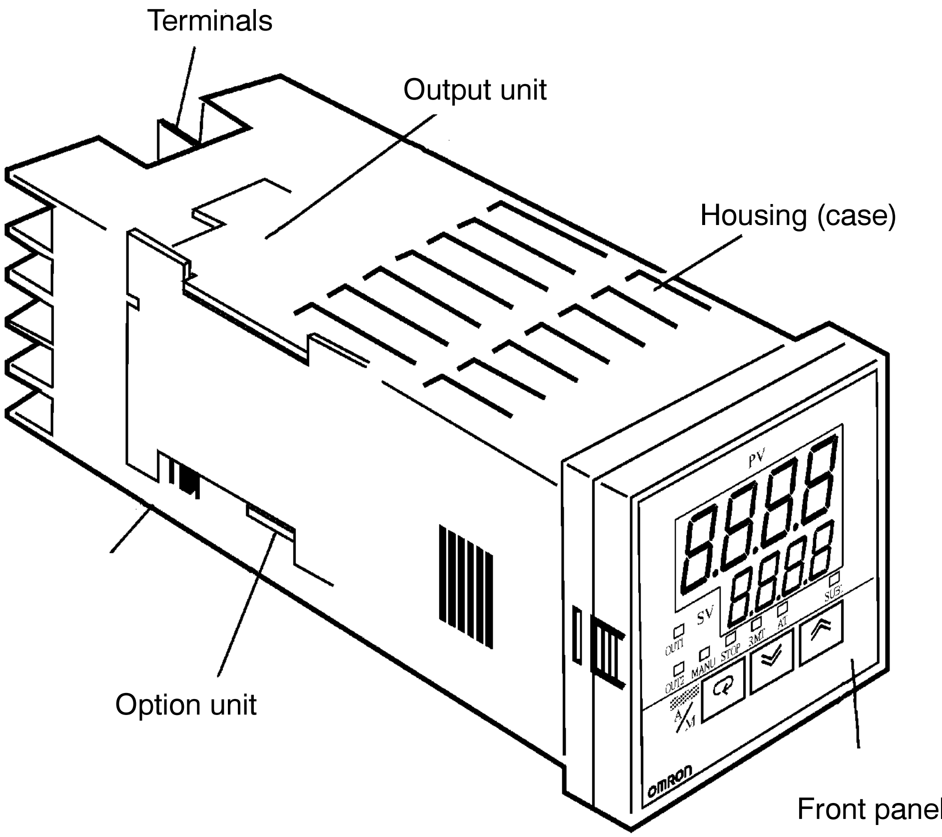
Topic	*Manual Location*	*Type of Information*
Features of the E5CK	*Section 1 – Introduction*	Features of the E5CK, names of parts, and typical functions.
Set Up	*Section 2 – Preparations*	Operations such as installation, wiring and switch settings you must do before using the E5CK.
Basic E5CK Operations	*Section 3 – Basic Operation* *Section 5 – Parameters*	How to use the front panel keys and how to view the display when setting the parameters of the major E5CK functions.
Applied E5CK Operations	*Section 4 – Applied Operation* *Section 5 – Parameters*	Important functions of the E5CK and how to use the parameters for full use of the E5CK.
Communications with a Host Computer	*Section 6 – Using the Communications Function*	Communications commands, and program examples.
Calibration	*Section 4 – Applied Operation*	How the user should calibrate the E5CK.
Troubleshooting	*Section 7 – Troubleshooting*	What to do if any problems occur.

SECTION 1
Introduction

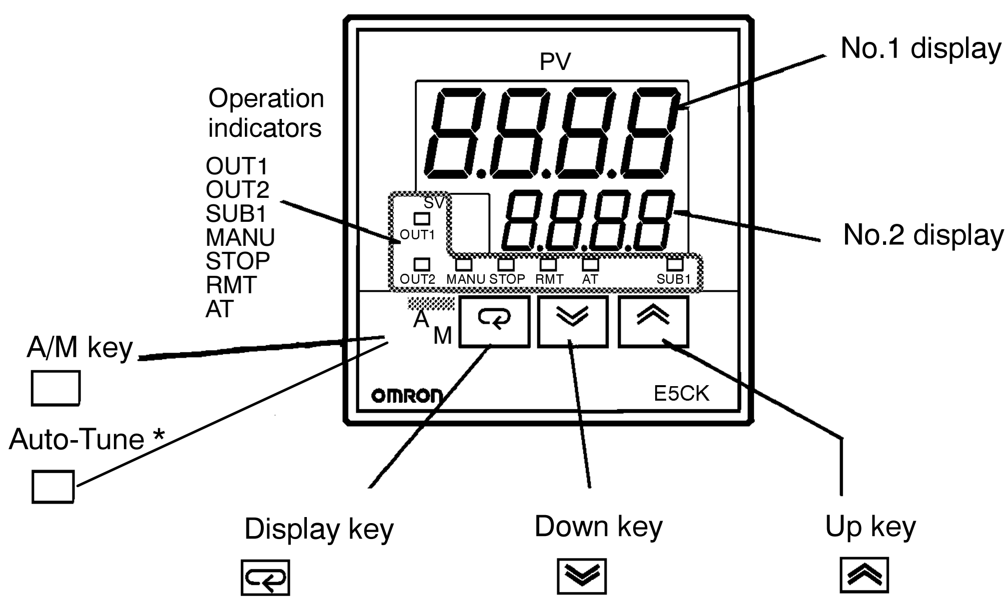
This Section introduces the E5CK. For details on how to use the controller and how to work with parameter settings, refer to Section 2 and subsequent Sections.

1-1 Nomenclature

1-1-1 Main Parts



1-1-2 Front Panel



* E5CK-AA1-302 model displays an auto-tune button instead of the ☐ key

1–1–3 About the E5CK

- Select from many types of temperature and analog input (multiple input)
- Select output functions such as control output or alarm (output assignment)
- Use two set points (multi-SP function)
- Monitor the control loop by LBA (Loop Break Alarm)
- Use the communications function
- Calibrate input or transfer output
- Rely on the E5CK water-tight construction (NEMA 4: equivalent to IP66)

1–1–4 E5CK Displays

No.1 Display

Displays the process value or parameter symbols.

No.2 Display

Displays the set point, manipulated variable or parameter settings.

Operation Indicators

- OUT 1 Lit when ***control output 1*** is ON.
- OUT2 Lit when ***control output 2*** is ON.
- SUB1 Lit when the output function assigned to ***auxiliary output 1*** is ON.
- MANU Lit when the manual operation mode is being used.
- STOP Lit when control operation has been stopped.
- RMT Lit during remote operation.
- AT Flashes during auto-tuning.

1–1–5 Basic Operations Using Keys

key
key

Each press of this key switches between the auto and manual operations.
Note: E5CK-AA1-302 models do not have the key. Instead, they feature an auto-tune key. (controls are in place within the programming.)

key

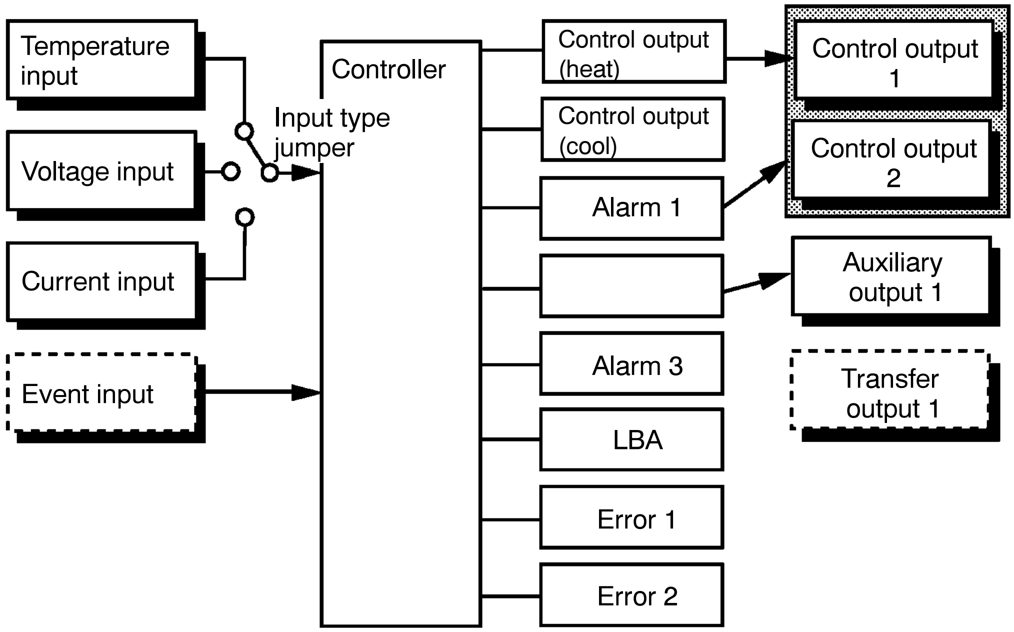
The functions of this key change according to how long it is pressed. Pressing this key for less than one second, lets you scroll through the parameters within the mode. Pressing this key for one second or more, brings up the the menu display and allows you to select which mode you need to adjust. In key operations from here on, ***press the key*** indicates that you must press the key for ***less*** than one second. For details on parameter switching and menu display items, refer to Parameters and Menus in Section 1.

key

Each press of the key increments or advances the values or settings on the No.2 display, while each press of the key decrements or returns the values or settings on the No.2 display.

Some keys have more than one use. For example, when the key is held down simultaneously with the display key, or a key is held down continuously. For details, see Selecting Modes in Section 1. Also, refer to examples (using various key combinations) in Sections 3 and 4.

1-2 Input and Output



1-2-1 Input

The E5CK supports four different types of inputs.

Temperature Input/Voltage Input/Current Input

Only one of these inputs can be selected and connected to the controller:

- Temperature input
- Voltage input
- Current input

Note: The above figure shows temperature input connected to the controller.

The following input sensors can be connected for temperature input:

- Thermocouple: K, J, T, E, L, U, N, R, S, B, W, PLII
- Platinum resistance thermometer: JPt100, Pt100

The following currents can be connected for current input:

- 4 to 20 mA, 0 to 20 mA

The following voltages can be connected for voltage input:

- 1 to 5 VDC, 0 to 5 VDC, 0 to 10 VDC

Event Input

When using event input, add on the Input Unit E53-CKB.
Select from the following five event inputs:

- Multi-SP
- Run/Stop
- Auto/Manual

1-2-2 Output

The E5CK supports these four outputs.

- Control output 1
- Control output 2
- Auxiliary output 1
- Transfer output

When using control outputs 1 and 2, set the output unit (sold separately). Eight output units are available to suit the output circuit configuration.

When using transfer output, add on the Transfer Output Option Board E53-CKF.

Note: The output functions of the E5CK do not operate for five seconds after the E5CK is turned ON.

Output Assignments

The E5CK supports the following eight output functions.

- Control output (heat)
- Control output (cool)
- Alarms 1 to 3
- LBA
- Error 1 (input error)
- Error 2 (A/D converter error)

Assign these output functions to control outputs 1 and 2 and auxiliary output 1. *Two guidelines are:*

- Only control output (heat), control output (cool), alarms 1 to 3, and LBA can be assigned to control outputs 1 and 2.
- Only alarms 1 to 3, LBA, and errors 1 and 2 can be assigned to auxiliary output 1.

In the example given in Section 1-2 (previous page), control output (heat) is assigned to control output 1; alarm 1 is assigned to control output 2; and, alarm 2 is assigned to auxiliary output 1. In this configuration, heating control output is connected to control output 1; and, alarm output is connected to control output 2 and auxiliary output 1.

In a heating and cooling control, assign control output (cool) to either control output 1 or control output 2.

Transfer Output

The E5CK supports the following five transfer outputs.

- Set point
- Set point during SP ramp
- Process value
- Heating side manipulated variable
- Cooling side manipulated variable

These transfer outputs can be output after being scaled. Reverse scaling is also possible because setting an upper limit value smaller than the lower limit value is allowed.

1-3 Parameters and Menus

1-3-1 Parameter Types

E5CK parameters are distributed between the following nine modes.

- Protect mode
- Manual mode
- Level 0 mode
- Level 1 mode
- Level 2 mode
- Setup mode
- Expansion mode
- Option mode
- Calibration mode

The settings of parameters in each of seven modes (excluding the protect mode and manual mode) can be checked and modified by selection on the menu display.

Protect Mode

Limits use of the Menu and $\boxed{}$ Keys.
The protect function prevents unwanted modification of parameters and can also be used to prevent switching between the auto and manual operation.

Manual Mode

Sets the controller to manual operation mode.
You can only manually adjust the manipulated variable (MV) in this mode.

Level 0 Mode

For normal operation.
Change: the set point during operation, and start or stop Controller operation; and, (only in this mode) monitor the process value, ramp SP, and manipulated variable.

Level 1 Mode

For adjusting primary control parameters.
Execute: AT (auto-tuning); set alarm values; set the control period; and, set PID parameters.

Level 2 Mode

For adjusting secondary control parameters.
Set parameters for: limiting the manipulated variable and set point; switch

between the remote and local modes; set the loop break alarm (LBA), alarm hysteresis, and the digital filter value of inputs.

Setup Mode

For setting the basic specifications.
Set parameters for: input type, scaling, output assignments and direct/reverse operation.

Expansion Mode

For setting expanded functions.
Set: ST (self-tuning), SP setting limiter. Select: advanced PID or ON/OFF control. Specify the standby sequence resetting method. Initialize parameters; and, set the time for automatic return to the monitoring display.

Option Mode

For setting option functions.
Set: the communications conditions; transfer: output and event input parameters to match the type of Option Board installed in the Controller. *This mode will be accessible only when an option board is installed in the controller.*

Calibration Mode

For calibrating inputs and transfer output.
Calibrate the selected input type. *Transfer output can be calibrated only when the Transfer Output Option Board E53-CKF has been installed in the Controller.*

Menu Display

To select the menu display in any of the above modes (excluding the protect mode and manual mode), press the ⏎ key for 1 second minimum. If you select the desired mode using the ▲ or ▼ keys and press the ⏎ key, the top parameter in the specified mode is displayed.

When you have selected the menu display, the previous mode is selected. For example, if you selected the menu display while in the level 0 mode, the No.2 display changes to [Lu-0] as shown on the left.

Protected modes cannot be selected. Also, the menu display does not appear when modes are protected up to the level 1 mode.

Level 0 to 2 Modes

If you select [Lu-0] [Lu-1] or [Lu-2] in the menu display, the level 0, level 1 and level 2 modes, respectively, are selected.

These modes are selected with control still continuing.

Setup Mode
Expansion Mode
Option Mode
Calibration mode

If you select [SEt] [EXt] [oPt] or [CLb] in the menu display, the setup, expansion, option and calibration modes, respectively, are selected. When these modes are selected, the control is reset. So, control outputs and auxiliary output are turned OFF. When another mode is selected while in these modes, *reset is canceled*.

Protect Mode

To set the controller to the protect mode or to return to the level 0 mode from the protect mode, simultaneously press the key and key for 1 second minimum.

Manual Mode

To set the controller to the manual mode, press the key for 1 second minimum in levels 0, 1 and 2. To return to the level 0 mode from the manual mode, press the key for 1 second minimum.

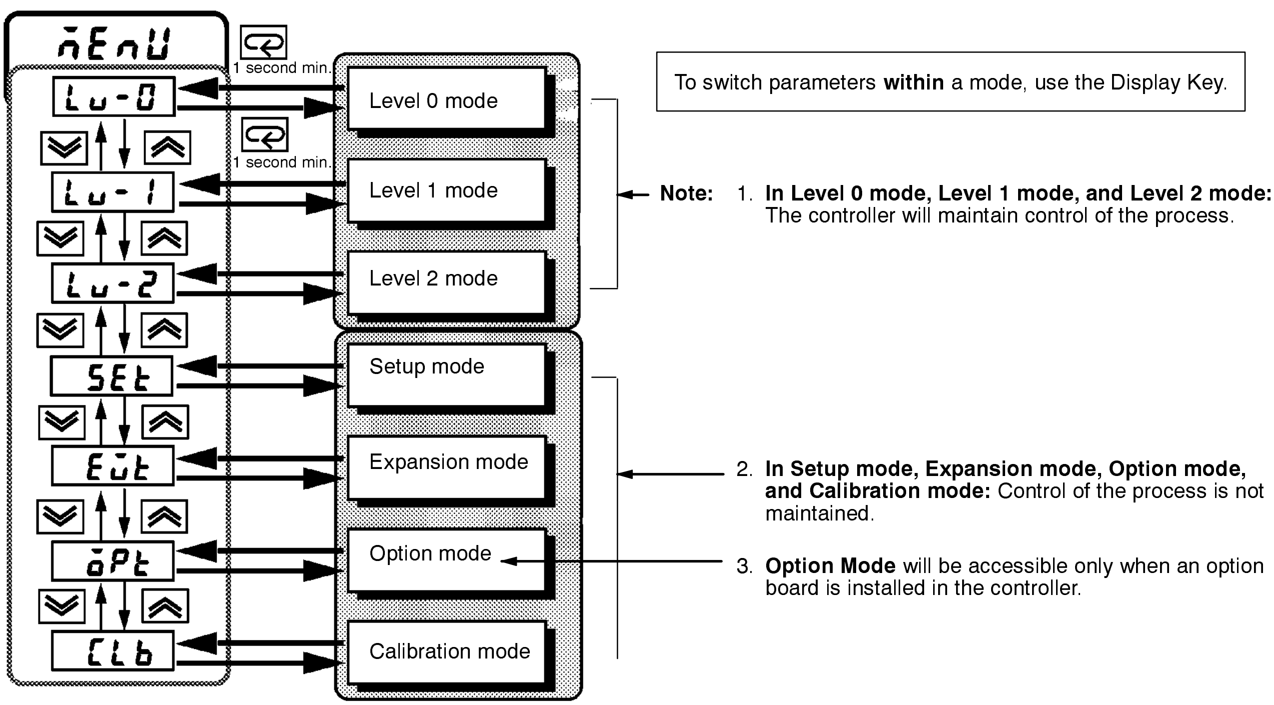
1-3-2 Selecting Modes

Operating Parameters

Mode Selection. Press the Display Key for 1 sec. minimum to switch to modes other than the manual or protect mode.

The figure below (Menu Display) shows all parameters in the order that they are displayed. Some parameters are not displayed, depending on the protect mode setting and the option boards used.

Menu Display



To Access *Protect Mode.* Press and hold the A/M Key and the Display Key for more than 1 second.

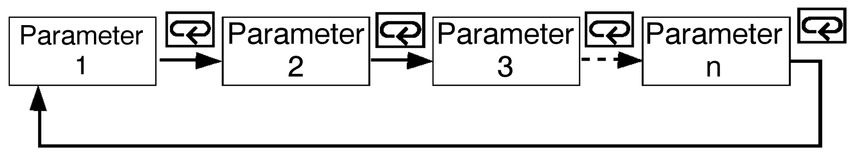
To Return to the Main PV/SP Display. To Return to the Main PV/SP Display from the Protect Mode by pressing the A/M Key and the Display Key for more than 1 second.

To Access *Manual Mode.* Press and hold the A/M Key for more than 1 second.

1–3–3 Selecting Parameters

When not in the manual mode, press the key (less than one second) to switch the parameter.

If you press the key when at the final parameter, the display returns to the first parameter.



1–3–4 Writing the Settings to Memory

When you have changed a parameter setting, specify the parameter using the or keys, and either leave the setting for at least two seconds or press the key. This writes the setting to memory.

When another mode is selected, the content of the parameters before the mode was selected is written to memory.

When turning the power OFF, you must first write the settings and parameter contents to memory (by pressing the key or selecting another mode). The settings and parameter contents are sometimes not changed by simply pressing the or keys.

1–4 Communications Function

The E5CK can be provided with a communications function that allows you to check and set controller parameters from a host computer. If the communications function is required, add on the communications unit.
For details on the communications function, refer to Section 6.

RS-232C

When using the communications function on the RS-232C interface, add on the Communications Unit E53-CK0.

RS-485

When using the communications function on the RS-485 interface, add on the Communications Unit E53-CK03.

1-5 Calibration

The E5CK controller is calibrated before shipment from the factory. So, the user need not calibrate the E5CK controller during regular use.

However, if you must calibrate the E5CK controller, use the parameters provided for user to calibrate temperature input, analog input (voltage, current) and transfer output.
Also, note that calibration data is updated to the latest value each time the E5CK controller is calibrated.

Note: If you alter the factory-set calibration, you cannot automatically return to factory calibration settings.

Calibrating Inputs

The input type selected in the parameter is the item to be calibrated. The E5CK is provided with the following four calibration parameters.

- Thermocouple
- Platinum resistance thermometer
- Current input
- Voltage input

Note: Two parameters are provided for thermocouple and voltage input.

Calibrating Transfer Output

Transfer output can be calibrated when the Transfer Output Option Board E53-CKF is added on.

Registering Calibration Data

To calibrate these items, the user must prepare separate measuring devices and equipment. For details, refer to Section 4. For details on handling these measuring devices and equipment, refer to the respective manuals.

SECTION 2
Preparations

This section describes the operations you must do before turning ON the E5CK.

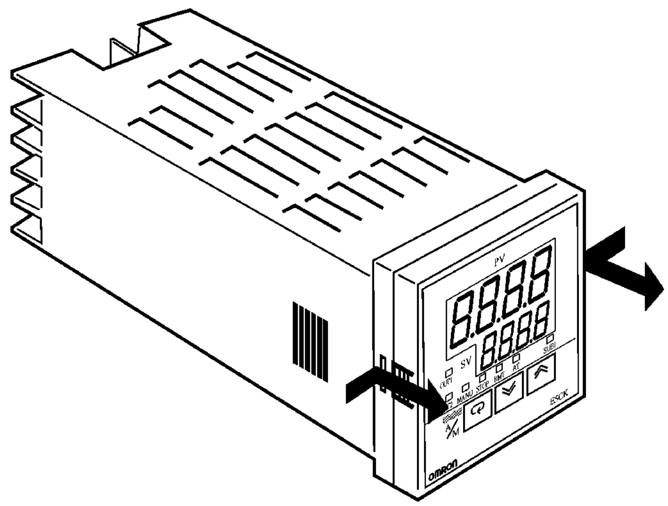
2-1 Setting Up

Information is provided on how to set the input-type jumper, and how to set up the output unit or option unit.

2-1-1 Remove Internal Mechanism from the Housing

First, pull the internal mechanism from the housing:

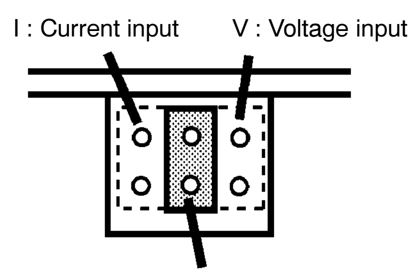
1, 2, 3...
1. While pressing the hooks on the left and right sides of the front panel, pull out the internal mechanism.
2. Hold both sides of the front panel as you pull the internal mechanism out toward you.



2-1-2 Setting the Input Type

For details on the jumper connector location, refer to Nomenclature in Section 1.

1, 2, 3...
1. Set the input type jumper connector to a temperature input, voltage input or current input matched to the sensor connected to the input terminal.



Note: The factory setting is "TC/PT (temperature input)."

Note: When removing or inserting the jumper connector, do not touch the pins with your fingers. Pull it out gently with a needle-nose pliers.

2. When you have set the jumper connector, insert the internal mechanism into the housing.

3. When inserting the internal mechanism, push in until you hear the hooks on the front panel click into place.

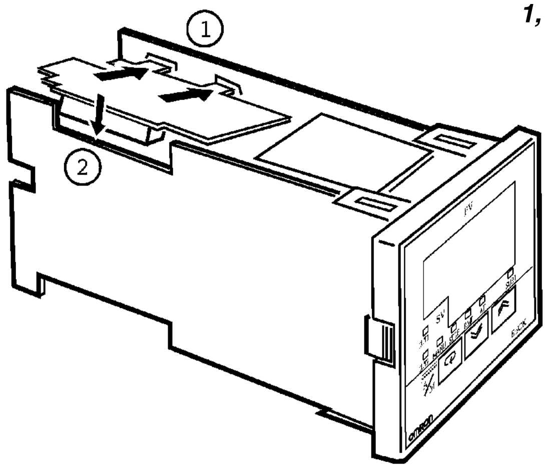
2-1-3 Setting Up the Output Unit

Output Unit List

The output units that can be set in the E5CK controller are listed here:

Model	Specifications (control output 1/control output 2)
E53-R4R4	Relay/Relay
E53-Q4R4	Voltage (NPN)/Relay
E53-Q4HR4	Voltage (PNP)/Relay
E53-C4R4	4 to 20 mA/Relay
E53-C4DR4	0 to 20 mA/Relay
E53-V44R4	0 to 10 V/Relay
E53-Q4Q4	Voltage (NPN)/Voltage (NPN)
E53-Q4HQ4H	Voltage (PNP)/Voltage (PNP)

Setup



1, 2, 3...
1. Two rectangular slots are provided on the power board (on right side of controller). Fit the two protrusions on the output unit into these two slots.
2. With the output unit fitted into the power board, fit the output unit into the connector on the control board (on left side of controller).

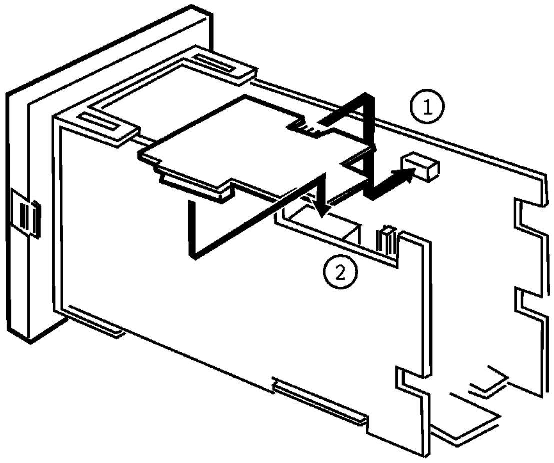
2-1-4 Setting Up the Option Unit

Option Unit List

The Option Units (or Option Boards) that can be connected to the E5CK controller are listed here:

Unit	Model	Specifications
Communications Unit	E53-CK01	Communications (RS-232C)
Communications Unit	E53-CK03	Communications (RS-485)
Input Unit	E53-CKB	Event input: 1 input
Transfer Output Option Board	E53-CKF	Transfer output: 4 to 20 mA

Setup



, 3... 1. Place the controller with the bottom facing up and fit the board horizontally into the connector on the power board (on right side of controller).
2. With the power board connected, fit the board vertically into the connector on the control board (on left side of controller).

2-2 E5CK Installation

2-2-1 Before Installing the E5CK

If you remove the controller from its case, never touch or apply shock to the electronic parts inside.

Do not cover the top and bottom of the controller. (Ensure sufficient space around the controller to allow heat to escape.)

Use a voltage (100 to 240 VAC at 50 to 60 Hz). At power ON, the prescribed voltage level must be attained within two seconds.

When wiring input or output lines to your controller, keep the following points in mind to reduce the influence from inductive noise:

- Allow adequate space between the high voltage/current power lines and the input/output lines.
- Avoid parallel or common wiring with high voltage sources and power lines carrying large currents.
- Using separating pipes, duct, and shielded line is also useful in protect ing the controller, and its lines form inductive noise.

Allow as much space as possible between the controller and devices that generate a powerful, high frequency (high-frequency welders, high-frequency sewing machines, and so forth) or surge. These devices may cause malfunctions.

If there is a large power-generating peripheral device and any of its lines, attach a surge suppressor or noise filter to the device to stop the noise affecting the controller system. In particular, motors, transformers, solenoids and magnetic coils have an inductance component, and therefore can generate very strong noises.

When mounting a noise filter, be sure to first check the filter's voltage and current capacity; then mount the filter as close as possible to the controller.

Do not use the controller in places where icing, condensation, dust, corrosive gas (especially sulfurized gas or ammonia gas), shock, vibration, splashing liquid, or oil atmosphere occur. Also, avoid places where the controller is exposed to intense heat radiation (from a furnace, for example) or sudden temperature changes.

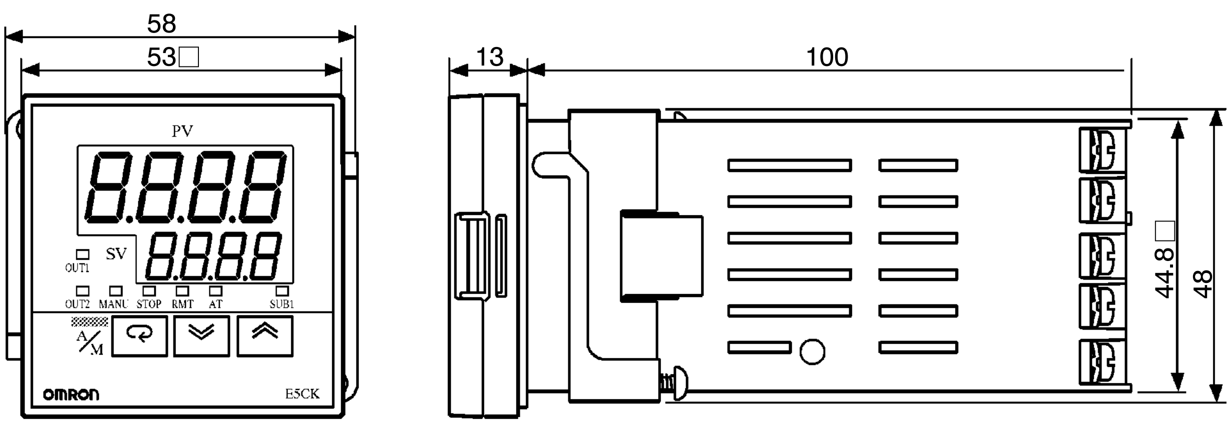
Ambient temperature must be kept between -10°C and 55°C (14°F to 131°F). Ambient humidity must be kept between 35%RH to 85%RH (with no icing or condensation). If the controller is installed inside a control board, the ambient temperature must be kept under 55°C, including the temperature around the controller. If the controller is subjected to heat radiation, use a fan to cool the surface of the controller to under 55°C.

Store the controller at an ambient temperature between -25°C and 65°C (-13°F to 149°F). The ambient humidity must be between 35%RH to 85%RH (with no icing or condensation).

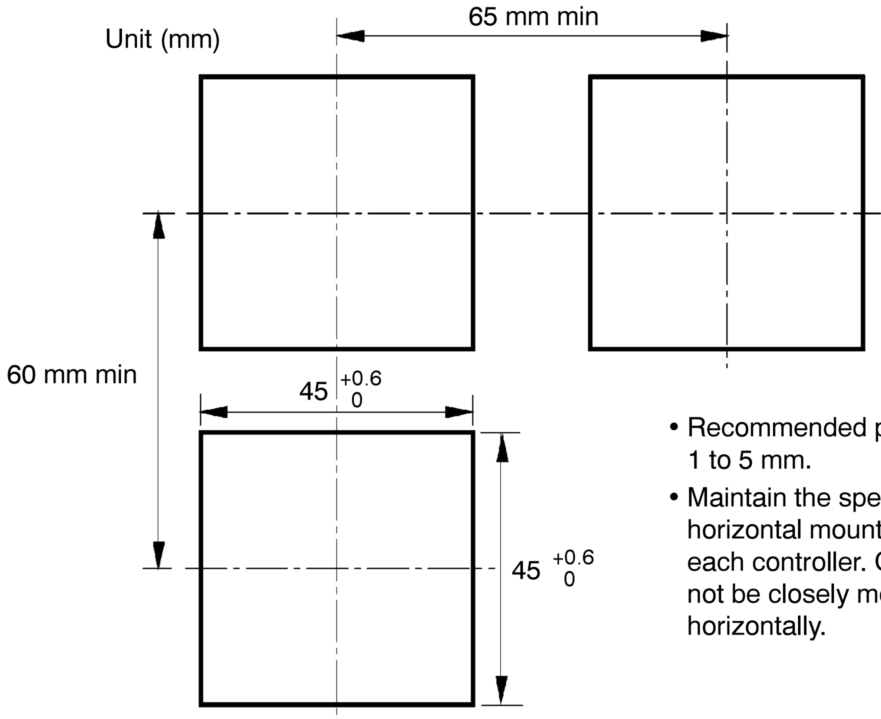
Never place heavy objects on the controller or apply pressure to the controller. This could cause the controller to deform or deteriorate.

Do not use the controller in places near a radio, television set, or wireless installation. These devices can cause radio disturbances which adversely affect the performance of the controller.

2-2-2 Dimensions

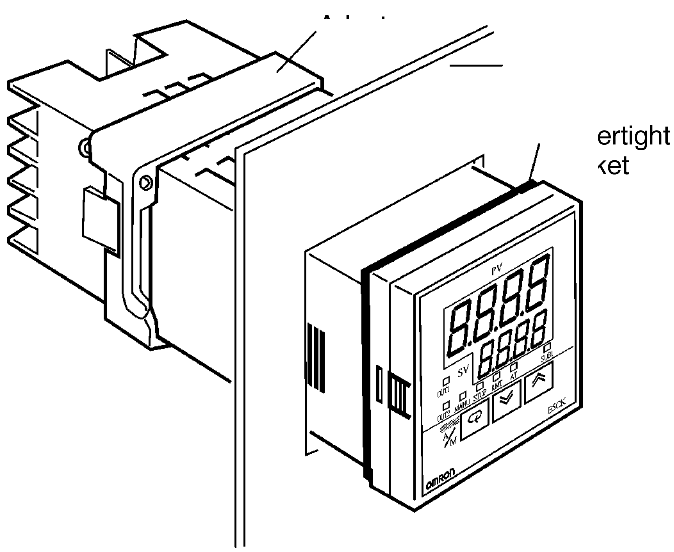


2–2–3 Panel Cutout



- Recommended panel thickness is: 1 to 5 mm.
- Maintain the specified vertical and horizontal mounting space between each controller. Controllers must not be closely mounted vertically or horizontally.

2–2–4 Installation Procedure



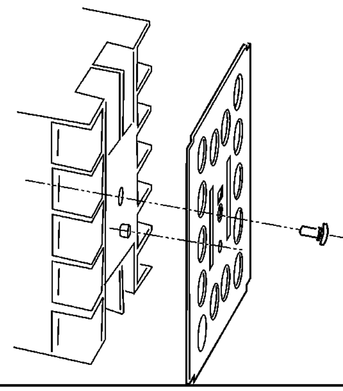
1, 2, 3... 1. Insert the E5CK controller into the mounting hole in the panel at the position shown in the figure above.

2. Push the adapter along the controller body from the terminals up to the panel and fasten temporarily.

3. Tighten the two mounting screws on the adapter. When tightening screws, tighten the two screws alternately keeping the torque to approximately 0.29 to 0.39 N·m, or 3 to 4 kgf·cm.

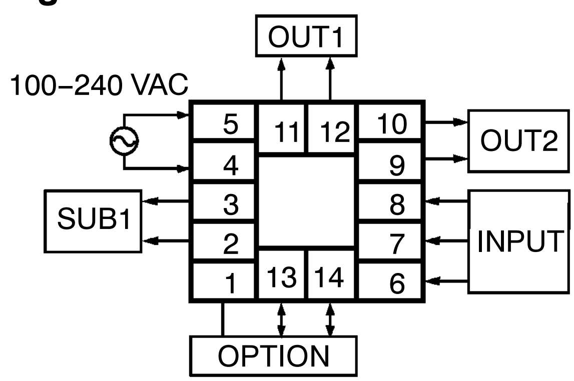
About the Terminal Cover

E5CK-AA1-500 controller is provided with a terminal cover (E53-COV07). Fasten the terminal cover by using the snap pin. Refer to the figure below.



2–3 Wiring Terminals

2–3–1 Terminal Arrangement



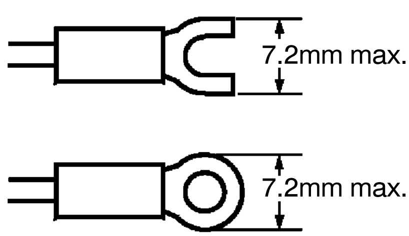
2–3–2 Wiring Precautions

Use wire ducts to separate input leads and power lines in order to protect the controller and its lines from external noise.

We recommend using solderless terminals when wiring the controller.

Do not tighten the terminal screws too tightly: tighten the terminal screws using a torque no greater than 0.78 N·m, or 8 kgf·cm max.

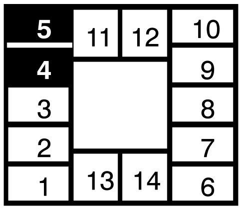
Use the following type of solderless terminals for M3.5 screws.



2-3-3 Wiring Procedure

In the following wiring diagrams, the left side of the terminal Nos. indicates the inside of the controller

Power Supply

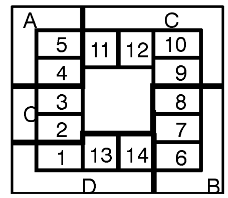


Input power to terminal Nos. 4 and 5. Power specifications are:
100 to 240VAC, 50/60Hz, approximately 15VA.

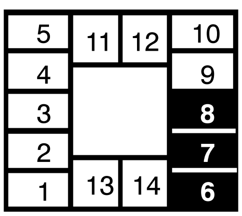
About the power blocks

The E5CK has independent power supplies for each of the terminal blocks shown on the right. However, that the power supplies for blocks C (exclude relay output) and D are the same whether you have installed the option unit E53-CKB or E53-CKF.

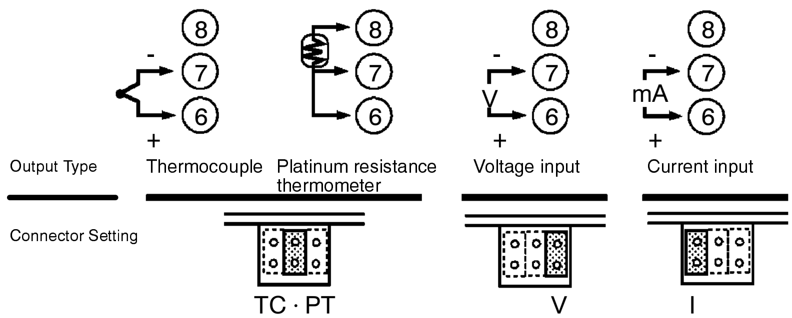
Note: You can install only one option unit at a time in the controller.



Input

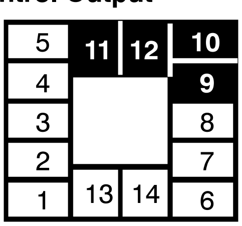


Connect the input to terminal Nos. 6 to 8 as follows according to the input type.

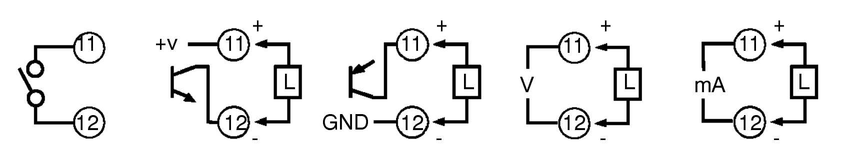


Match the inputs with the internal jumper settings for each input type. For thermocouple or platinum resistance thermometer inputs, set the inputs to a common position (TC/PT) as the temperature input. For details on jumper connector positions, refer to *Setting the Input Type* in Section 2.

Control Output

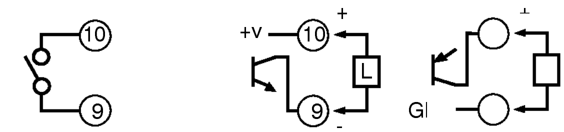


Terminal Nos. 11 and 12 are for control output 1 (OUT1). The five output types and internal equalizing circuits are available according to output unit:



Output Type	Relay	NPN	PNP	0 to 10V	4 to 20mA/0 to 20mA
Part No.	E53-R4R4	E53-Q4R4 E53-Q4Q4	E53-Q4HR4 E53-Q4HQ4H	E53-V44R4	E53-C4R4 E53-C4DR4

Terminal Nos. 9 and 10 are for control output 2 (OUT2). The three output types and internal equalizing circuits are available according to output unit:

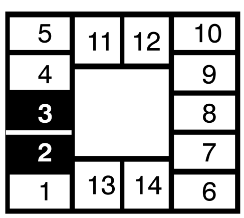


Output Type	Relay	NPN	PNP
Part No.	E53-R4R4 /E53-V44R4 E53-Q4R4 /E53-C4R4 E53-Q4HR4/E53-C4DR4	E53-Q4Q4	E53-Q4HQ4H

The specifications for each output type are provided here:

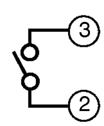
Output Type	Specifications
Relay	250VAC, 3 A, SPST-NO
Voltage (NPN)	12VDC, 20 mA (with short-circuit protection)
Voltage (PNP)	12VDC, 20 mA (with short-circuit protection)
0 to 10V	0 to 10VDC, Permissible load impedance: 1 kΩ min., Resolution: 11 Bit
4 to 20mA	4 to 20 mA, Permissible load impedance: 500 Ω max., Resolution: 11 Bit
0 to 20mA	0 to 20 mA, Permissible load impedance: 500 Ω max., Resolution: 11 Bit

Auxiliary Output 1



Terminal Nos. 2 and 3 are for auxiliary output 1 (SUB1).

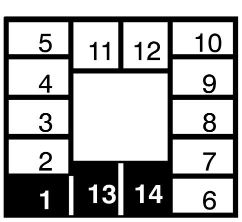
The internal equalizing circuit for auxiliary output 1 is as follows:



Relay specifications are as follows:

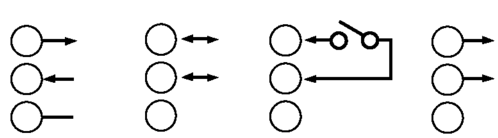
SPST-NO, 250VAC, 1A

Option



Terminal Nos. 1, 13 and 14 are valid only when the option unit is set in the controller.

The following four connections are possible depending on the type of option unit.



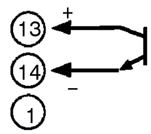
Output Type	RS-232C	RS-485	Event input	Transfer output
Part No.	E53-CK01	E53-CK03	E53-CKB	E53-CKF

For details on RS-232C and RS-485 communications functions, refer to *Using the Communications Function* in Section 6.

Use event inputs under the following conditions

Contact input	ON: 1 kΩ max., OFF: 100 kΩ min.
No-contact input	ON: residual voltage 1.5V max., OFF: leakage current 0.1mA max.

Polarities during no-contact input are:



Transfer output specifications are:
4 to 20 mA, Load 500 Ω max.; resolution: 11 bit.

SECTION 3
Preparations

This Section describes an actual example for understanding the basic operation of the E5CK.

3-1 Control Example

To facilitate understanding basic E5CK controller operation, this Section describes the following control example.

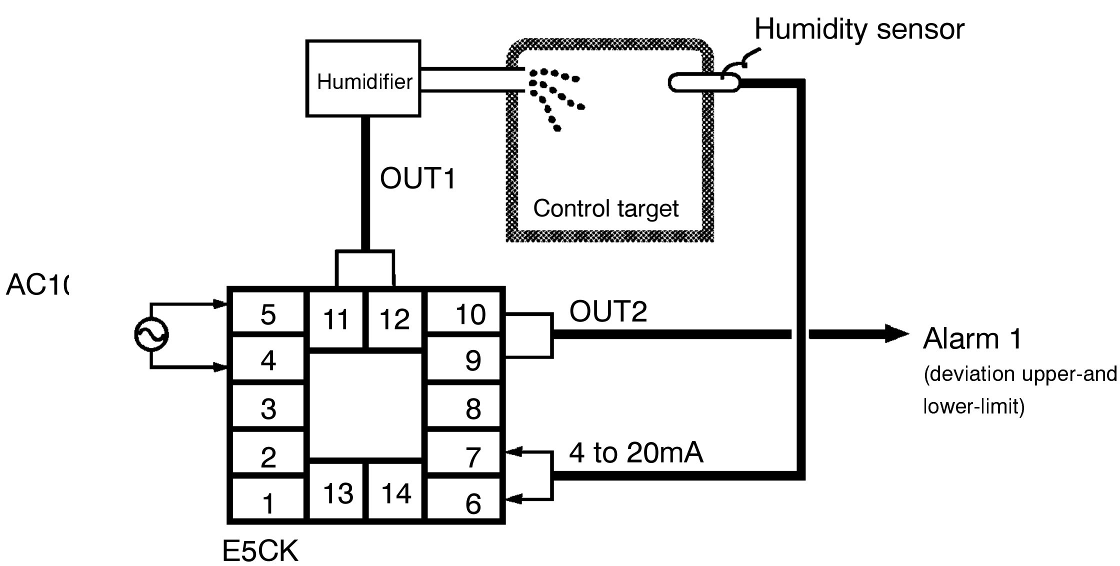
In this example, we assume that the controller is operated under the following conditions.

- A humidity sensor of output 4 to 20 mA is connected to the controller. The measuring range of the humidity sensor is set to 10 to 95%.
- A humidifier is controlled by pulse output to maintain humidity at a constant 60%.
- An alarm is output when the humidity exceeds the upper limit value (70%) or lower limit value (50%).

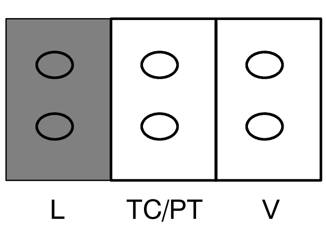
3-1-1 Setup

Output unit: relay/relay type (E53-R4R4)

Input type jumper connector: "I (current input)"



3-1-2 Input Type Connector



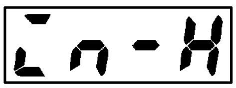
3–2 Setting Input Specifications

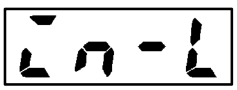
3–2–1 Input Type

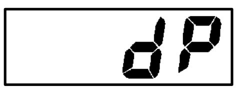
Set the type No. (0 to 21) in the *input type* parameter. The factory setting is **2: K1 (thermocouple)**.

For details on input types and setting ranges, refer to *Setup Mode – Input Type* in Section 5.

3–2–2 Scaling





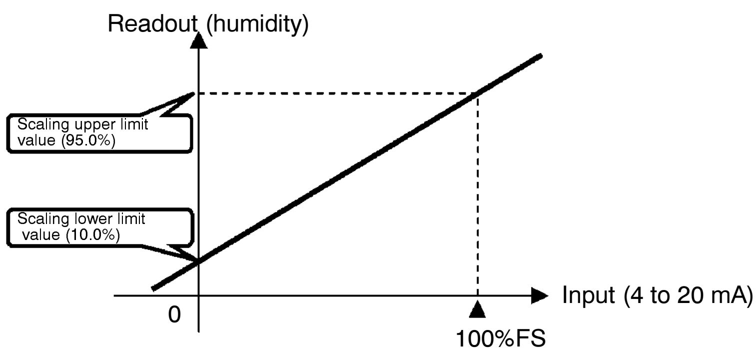


When the voltage input and current input are selected, scaling matched to the control is required.

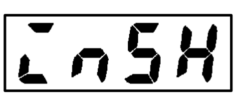
The *scaling upper limit*, *scaling lower limit* and *decimal point* parameters (setup mode) are used for scaling.

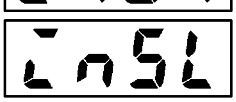
The *scaling upper limit* parameter sets the physical quantity to be expressed by the upper limit value of input, and the *scaling lower limit* parameter sets the physical quantity to be expressed by the lower limit value of input. The *decimal point* parameter sets the number of digits past the decimal point.

The following figure shows scaling example of 4 to 20 mA input. After scaling, the humidity can be directly read. In this case, the *decimal point* parameter is set to **1**.



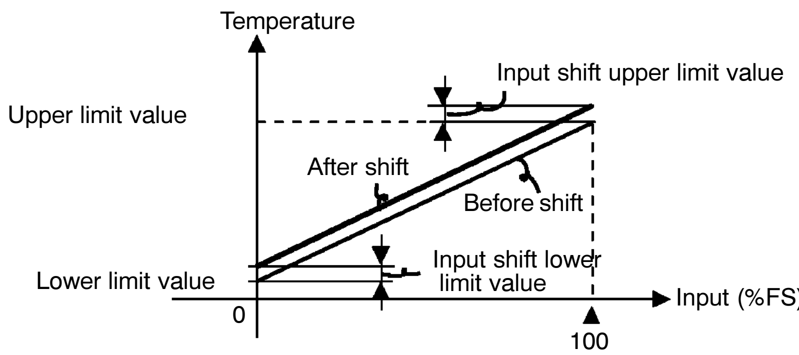
3–2–3 Input Shift



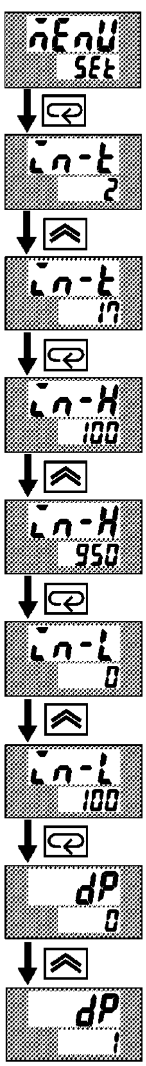


When temperature input is selected, scaling is not required. This is because temperature inputs are matched to the input type. However, note that the upper and lower limit values of the sensor can be shifted. For example, if both the upper and lower limit values are shifted by 1.2°C, the process value (before shift) is regarded as 201.2°C after shift when input is 200°C before shift.

To set input shift, set shift values in the *input shift upper limit* and *input shift lower limit* parameters (level 2 mode).



Setting Example



In this example, let's set the parameters as follows:

- *input type* = ***17 (4 to 20 mA)***
- *input type* = **17 (4 to 20 mA)**
- *scaling upper limit value* = **950**
- *scaling lower limit value* = **100**
- *decimal point* = **1**

(1) Press the key for more than one second to get the menu display, and select [SEt] (setup mode) using the or keys.

(2) Press the key to enter the setup mode. The top parameter in the setup mode [in-t] *input type* is displayed. The parameter default is **2**.

(3) Press the key until the display indicates **17**.

(4) Press the key to fix the set value. The display changes to [in-H] (*scaling upper limit value* parameter). The parameter default is **100**.

(5) Press the key until the display indicates **950**.

(6) Press the key to fix the set value. The display changes to [in-L] (*scaling lower limit value* parameter). The parameter default is **0**.

(7) Press the key until the display indicates **100**.

(8) Press the key to fix the set value. The display changes to [dP] (*decimal point* parameter). The parameter default is **0**.

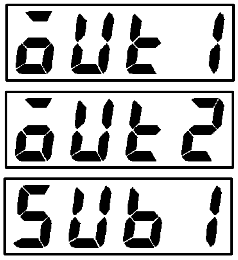
(9) Press the key until the display indicates **1**.

(10) Return the controller to level 0, PV/SP display.

The controller has been set up so the display will read **between 100.0 and 950.0**.

3–3 Setting Output Specifications

3–3–1 Output Assignments



Eight different output types are supported. The eight output types are shown in the table that follows.

- control output (heat)
- control output (cool)
- alarm output 1
- alarm output 2
- alarm output 3
- LBA, and
- error 1 (input error)
- error 2 (A/D converter error).

These functions are assigned to control outputs 1 and 2, and auxiliary output 1. Restrictions on assignment destination are placed on some of the outputs. The following table shows where outputs may be assigned.

Assignment Destination / Output Function	Control Output		Auxiliary Output
	1	2	1
Control output (heat)	●	●	
Control output (cool)	●	●	
Alarm 1	●	●	●
Alarm 2	●	●	●
Alarm 3	●	●	●
LBA	●	●	●
Error 1; input error			●
Error 2; A/D converter error			●

Heating and cooling control is carried out when control output (cool) is assigned, and standard control is carried out when output is not assigned. For details on heating and cooling control, refer to Selecting the Control Method in Section 4.

Factory settings are shown here:

Function	Rear Terminals
Control output (heat) =	Control output 1
Alarm 1 =	Control output 2
Alarm 2 =	Auxiliary output 1.

Output assignments are set in the *control output 1 assignment*, *control output 2 assignment* and *aux output 1 assignment* parameters (setup mode).

3-3-2 Direct/Reverse Operation

ōrEv

Reverse operation (or heating) refers to control where the manipulated value (MV) increases as the PV increases. In other words, as the value of the set point rises, the MV must also rise to attain the new SP. Thus, reverse operation involves an increasing MV and an increasing PV. In direct (or cooling) operation, the MV will still increase, but it will have the opposite effect on the PV. As the PV goes down, the MV must increase to lower the PV.

Direct/reverse operation is set in the [ōr-r] *direct/reverse operation* parameter (setup mode).

Reverse operation:	ōr-r
Direct operation:	ōr-d

3-3-3 Control Period

CP

When the output unit is a pulse output such as relay, SSR, or voltage output, set the pulse output cycle (control period). *When the output unit is relay* – though a shorter pulse period provides better control performance, the control period should be set taking the life expectancy of the output unit into consideration.

The control period is set in the *control period (heat)* parameter (level 1 mode). Factory setting is **20 seconds**.

Note: For control periods less than five seconds, an SSR or a voltage output is recommended.

The *control period* represents a period of time. This period of time is directly related to how long the output will be on.

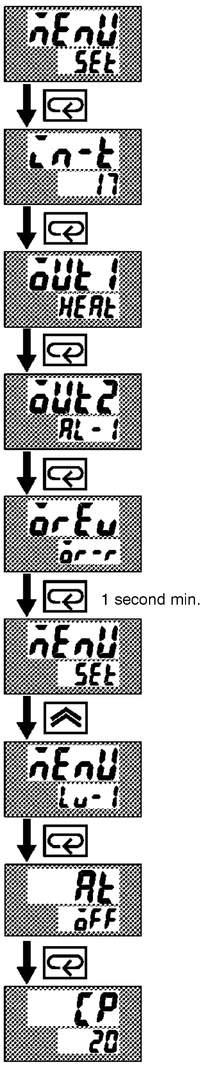
Example: If the manipulated variable (MV) is at 50% with a control period of 20 seconds, the output will turn ON and OFF (cycling) until the output has been ON for a total of 10 seconds within the 20 second control period. The MV = 25%. The output will be ON for 5 seconds within the 20 second period.

Setting Example

In this example, set the parameters as follows:

- *control output 1 assignment* = **control output (heat)**
- *control output 2 assignment* = **alarm output 1**
- *direct/reverse operation* = **reverse (heating) operation**
- *control period* = **20 secs**

All of the above settings in this example are factory settings. So, in this example, we are only going to check the parameter settings.



(1) Press the key (display key) for more than one second, to access the menu display. Select [SEt] (setup mode) using the or keys.

(2) Press the key for more than one second to enter the setup mode. The top parameter in the setup mode [in-t] "input type" is displayed. In this example, the parameter setting is **17 (4 to 20 mA)**.

(3) Press the key until [oUt 1] ("control output 1 assignment" parameter) is displayed. Verify that the current setting is [HEAt].

(4) As the setting in this example is to be left as it is, press the key. The display changes to [oUt2] (*control output 2 assignment* parameter). Verify that the current setting is [AL - 1].

(5) The setting in this example is to be left as it is, so press the key until [orEu] ("direct/reverse operation" parameter) is displayed. Press the key for more than one second to return to the menu display. Verify that the current setting is is [or - r] (reverse or heating).

(6) Press the key for more than one second, to access the menu display. Select [Lu- 1] (level 1 mode).

(7) Press the key for more than one second to enter the level 1 mode. The top parameter in the level 1 mode [At] *AT execute/cancel* is displayed.

(8) Press the key until [CP] (*control period* parameter) is displayed. Verify that the current setting is **20**.

(9) Access the menu display again and return the controller to Level 0.

The controller is now ready to run the process.

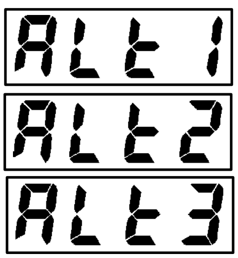
3-4 Setting Alarm Type

Three alarm outputs are supported: alarms 1 to 3. Of these, only the alarms assigned to an output can be used.

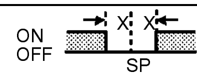
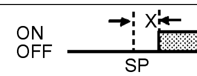
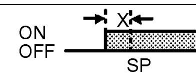
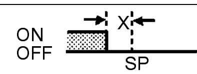
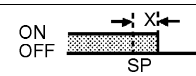
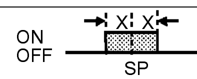
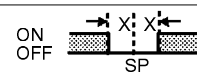
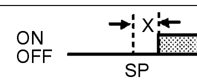
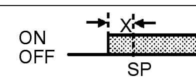
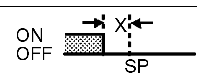
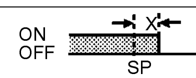
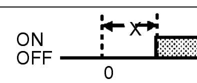
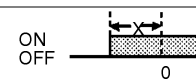
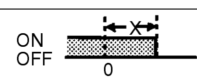
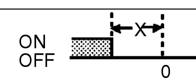
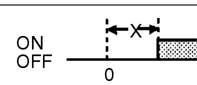
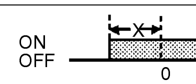
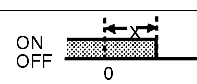
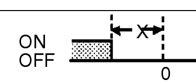
Alarm output conditions are determined according to the combination of the *alarm type*, *alarm value* and *alarm hysteresis* parameter settings.

The contact conditions when alarm output is ON can be set to *open* or *closed* in the *close in alarm/open in alarm* parameter.

3-4-1 Alarm type



The following table shows the alarm types supported by the E5CK controller and the operations for each.

Alarm Type		Alarm Output Operation	
		When X is positive	When X is negative
1	Upper-and lower-limit alarm (deviation)		Always ON
2	Upper-limit alarm (deviation)		
3	Lower-limit alarm (deviation)		
4	Upper-and lower-limit range alarm (deviation)		Always OFF
5	Upper-and lower-limit alarm with standby sequence (deviation)		Always OFF
6	Upper-limit alarm with standby sequence (deviation)		
7	Lower-limit alarm with standby sequence (deviation)		
8	Absolute-value upper-limit alarm		
9	Absolute-value lower-limit alarm		
10	Absolute-value upper-limit alarm with standby sequence		
11	Absolute-value lower-limit alarm with standby sequence		

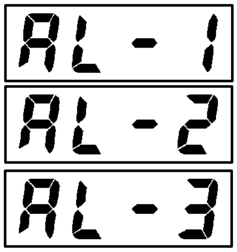
Note:

1.) A deviation is: deviation from SP.

2.) An absolute alarm is defined as a fixed value **X** with reference to **0**.

Alarm types are set independently for each alarm in the *alarm 1 to 3* parameters (setup mode). Factory setting is **2: Upper-limit alarm (deviation)**.

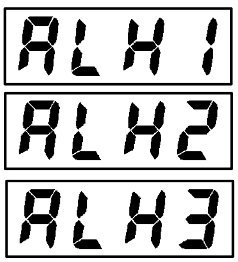
3-4-2 Alarm Value



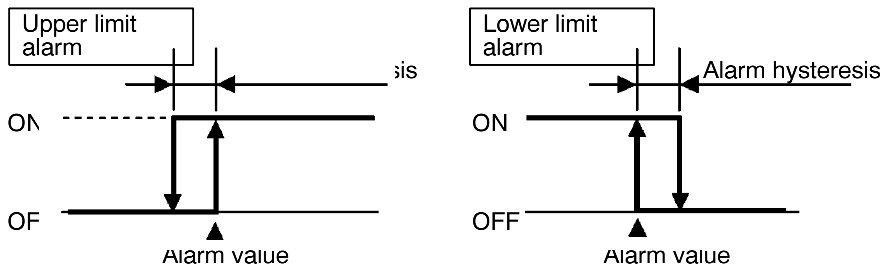
Alarm values are indicated by **X** in the table above. Alarm output operation differs according to whether the value of the alarm is positive or negative.

Alarm values are set independently for each alarm in the *alarm value 1 to 3* parameters (level 1 mode). Factory setting is **0**.

3-4-3 Alarm Hysteresis



The hysteresis of alarm outputs when alarms are switched ON/OFF can be set as follows.

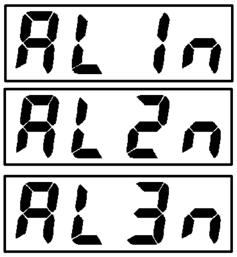


Alarm hysteresis is set independently for each alarm in the *alarm 1 to 3 hysteresis* parameters (level 2 mode). Factory setting is **0.02: 0.02%FS**.

Standby Sequence

Alarm functions with *standby sequence* suppress nuisance alarms when the controller is first powered up. The alarm output is suppressed until the temperature exceeds the alarm band or alarm limit one time.

3–4–4 Close In Alarm/Open In Alarm



When the controller is set to *close in alarm*, the status of the alarm output function is output normally. When set to *open in alarm*, the status of the alarm output function is output inverted.

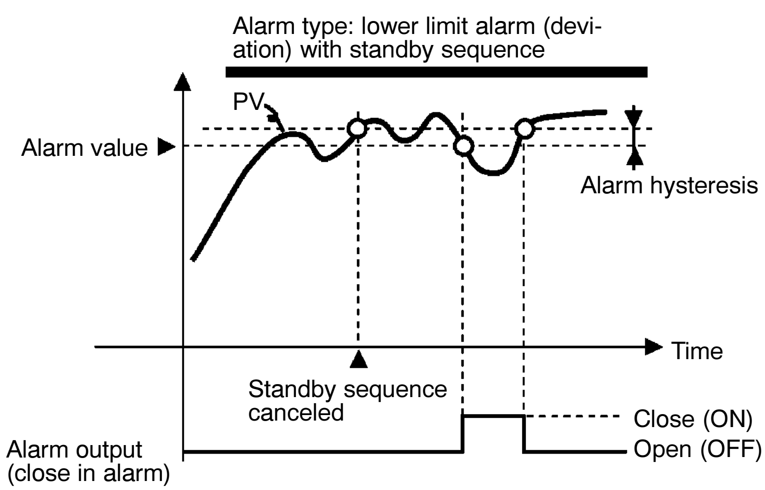
	Alarm	Output	Output LED
Close in alarm	ON	ON	Lit
	OFF	OFF	Not lit
Open in alarm	ON	OFF	Lit
	OFF	ON	Not lit

Alarm type and ***close in alarm/open in alarm (normally open/normally close)*** can be set independently for each alarm.

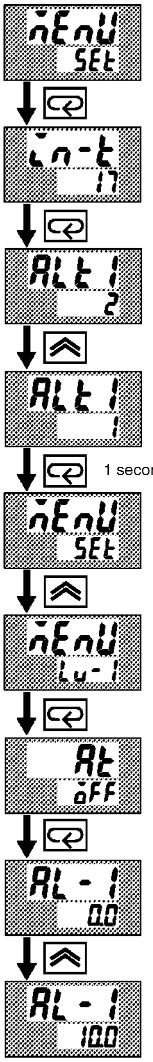
Close in alarm/open in alarm is set in the *alarm 1 to 3 open in alarm* parameters (setup mode). Factory setting is [n - ō] *close in alarm*.

Summary of Alarm Operations

The figure below visually summarizes the above description of alarm operations, when alarm type is set to *lower limit alarm (deviation)*:



Setting Example



When a set point for a temperature exceeds ±10%, alarm1 will be output.
In this example, let's set the parameters as follows:

- *alarm type 1* = **1: (deviation upper-and lower-limit)**
- *alarm value 1* = **10**
- *alarm hysteresis* = **0.20**
- *close in alarm/open in alarm* = **n-o: close in alarm**

Meanings of parameters, *alarm hysteresis* and *open in alarm/close in alarm* are the same settings at the shipment, so settings for operations are omitted.

(1) Press the (display) key for more than one second, to access the menu display. Select [SEt] (setup mode) using the or keys.

(2) Press the key (for more than one second) to enter the setup mode. The top parameter in the setup mode [in-t] *input type* is displayed. In this example, the parameter setting is **17: 4 to 20 mA**.

(3) Press the key until [ALt 1] (*alarm type 1* parameter) is displayed. Verify that the current setting is **2**: *deviation upper limit*.

(4) Press the key to return to **1**: *deviation lower limit*.

(5) Press the key (for more than one second) to access the menu display. Select [Lv-1] (level 1 mode) using the or keys.

(6) Press the key (for more than one second) to enter the level 1 mode. The top parameter in the level 1 mode [At] *AT execute/cancel* is displayed.

(7) Press the key until [AL-1] (*alarm value 1* parameter) is displayed.

(8) In this example, the parameter setting is **10.0;** so, press the key until **10.0** is displayed.

(9) Return the controller to Level 0 using the menu display.

The controller's alarm values have now been set for proper operation when the controller is in RUN mode.

About the Decimal Point of the Alarm Value

The decimal point of the alarm value conforms to the setting of the decimal point parameter (setup mode). In this example, the decimal point parameter is set to ***1****. (During temperature input, the decimal point of the alarm value conforms to the sensor selected.)*

3–5 Protect Mode

3–5–1 Security

This parameter allows you to protect (until start of operation) parameters that do not change during operation to prevent unwanted modification.

The set value of the *security* (protect) parameter specifies the range of protected parameters.

When this parameter is set to **0**, parameters are not protected.

When this parameter is set to **from 1 to 3**, the number of modes that can be displayed on the menu display is limited.
When set to **1**, levels 0 to 2, setup, expansion and option modes only can be selected. When set to **2**, only levels 0 to 2 modes can be selected. When set to **3**, only levels 0 and 1 modes can be selected.

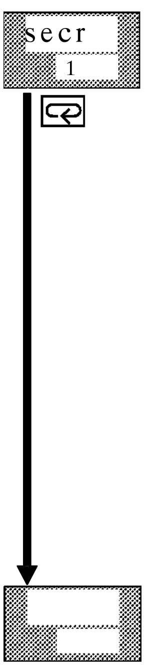
When this parameter is set to **4** to **6**, operations in only the level 0 mode can be selected, and the mode is not displayed on the menu display.

When this parameter is set to **5**, only the *PV/SP* parameter can be used.

When this parameter is set to **6**, only the *PV/SP* parameter can be used. (The set point can not change.)

Default is **1**.

Understanding the Security Parameter



Using the Security-Level Table:
Any mode marked with an **X** is displayed in the Security Level indicated.

Example: Selecting Security Level 2:
Displays these modes: Level 0, Level 1 and Level 2 only.
Does NOT display these modes: Setup, Expansion, Option, Calibration

Mode ↓	Set value						
	0	1	2	3	4	5	6
Calibration	x						
Option	x	x					
Expansion	x	x					
Setup	x	x					
Level 2	x	x	x				
Level 1	x	x	x	x			
Level 0	x	x	x	x	x	x	

⇐ **Security Level**

⇑ Lowest Security Level (first column)

⇑ Highest Security Level (last column)

When the set value is **5:**
Only the **PV/SP monitor** and **set point** parameter can be used.

When the set value is **6**:
Only the **PV/SP monitor** parameter can be used.

3–5–2 A/M Key Protect

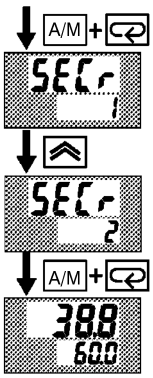
This parameter disables use of the key during operation. For example, if you protect use of the key by the *A/M key protect* parameter (protect mode) during auto operation, the controller cannot be set to the manual mode, preventing manual operation of the controller during operation.

Note: E5CK-AA1-302 has this feature built into the programming.

Setting Example

For this example protect the setup, expansion, option and calibration modes. Set the parameters as follows:

security setting = **2 (Usable only in level 0 to 2 modes)**

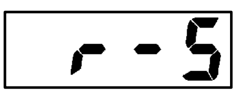


(1) Press the and keys simultaneously for 1 second minimum; the controller enters the protect mode.

(2) In the protect mode, the top parameter in the protect mode *security* is displayed. The parameter default is **1**. Press the key to change the parameter setting to **2**.

(3) Press for 1 second minimum the and keys simultaneously; the display changes to the *PV/SP monitor* parameter (level 0 mode).

3–6 Starting and Stopping Operation



You can start and stop operation by changing the setting of the *RUN/STOP* parameter (level 0 mode).

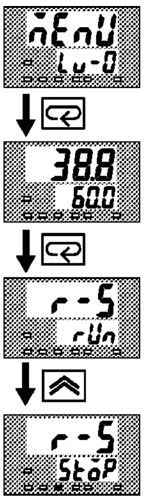
To stop operation, set the *run/stop* parameter to **[StoP]** (stop). In a stop state, the *STOP* LED lights.

3–6–1 Manipulated Variable at Stop

To set a specific output level during a stop, specify the manipulated variable (-5.0 to 105.0%) in the *MV at stop* parameter (level 2 mode). Factory setting is **0.0%**.

Setting Example

The following example describes the procedure to follow to stop control during operation of the controller.



(1) Press the (display) key for more than one second to access the menu display. Select [Lu-0] (level 0 mode) using the or keys.

(2) Press the key (for more than one second) to enter the level 0 mode. The PV and SP are displayed.

(3) Press the key until [r-S] (*run/stop* parameter) is displayed.

(4) Press the key to select [StoP] (stop). The STOP LED lights, and operation stops.

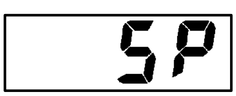
(5) Press the key until the PV, SP are displayed again.

To resume operation, follow the above procedure to select [rUn] (RUN). The STOP LED goes out, and operation starts.

3–7 Adjusting Control Operation

3–7–1 Changing the Set Point

You can change the set point in the *set point* parameter in level 0 mode (default screen).

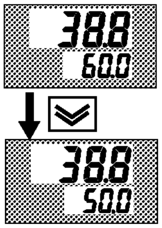


However, note that you cannot change the set point when the *security* parameter (protect mode) is set to **6**.

To change the set point, press the or keys to select the desired value. If you leave the setting for two seconds, the set point is updated to the new setting.

Setting Example

In the following example, let’s change the temperature set point from 60°C to 50°C.



(1) Select the PV/SP monitor display (default screen at power on).

(2) Press the key to change the setting to: **50°C**.

3–7–2 Manual Operation

To set manual operation and manually set the manipulated variable, press for 1 second minimum the key. The controller enters the manual mode.

The manipulated variable is displayed on the No.2 display. To change the manipulated variable, press the or keys. After two seconds, the manipulated variable is updated to the new setting.

Other modes cannot be selected while in the manual mode. To select other modes, press the key for 1 second minimum. The manual mode is quit.

The automatic return of display function does not work while in the manual mode.

When switching between manual and auto operation, the manipulated variable is subject to balance-less, bumpless operation.

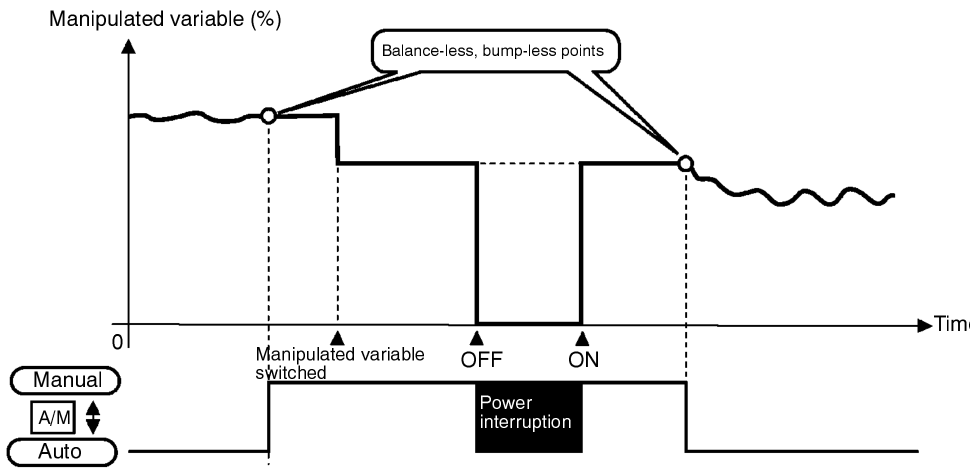
If the power is interrupted during manual operation, manual operation is resumed at the manipulated variable at power interruption when the power is reset.

You can switch the AUTO/MANUAL function up to 100,000 times.

Balance-less, Bumpless Operation

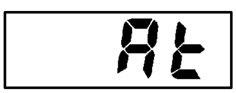
To prevent sudden changes in the manipulated variable when switching between manual and auto operation, operation is resumed using the value that was active immediately before operation was switched, and the value is brought gradually closer to the value immediately after operation was switched.

The following diagram summarizes manual operation.



3–7–3 Auto-tuning

AT (auto-tuning) cannot be executed when the auto-tuning operation is canceled, or during ON/OFF control, or when the controller is in STOP operation.



When you execute auto-tuning, the optimum PID parameters are automatically set by forcibly changing the manipulated variable to calculate the characteristics of the control target (called the *limit cycle method*). During auto-tuning, the AT LED flashes.

There are two types of auto-tuning available: 40% (AT-1) or 100% (AT-2). At AT-1, the MV will cycle 0 to 40% around the set point. At AT-2, the MV will cycle between fully ON and fully OFF (level 1 mode).

During heating and cooling control, only 100% AT can be executed. (So, [At - 1] (40% AT) will not be displayed.)

To cancel AT execution, specify [oFF] (*AT cancel*). In addition to AT, the

E5CK is also provided with fuzzy self-tuning (ST) that allows automatic calculation of the PID parameters suited to the control target. However, note that the ST function operates only during standard control by temperature input. For further information on the ST, please refer to *Expansion Mode* in Section 5.

The controller has completed auto–tuning when the AT LED stops flashing.

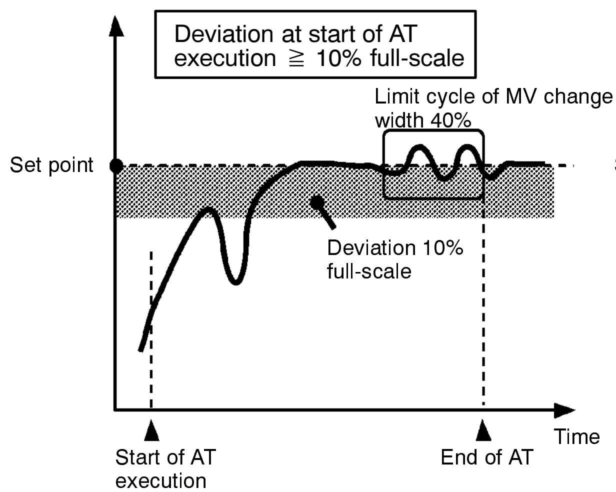
Note: E5CK-AA1-302 has the auto-tune feature on the front panel for easy and quick use.

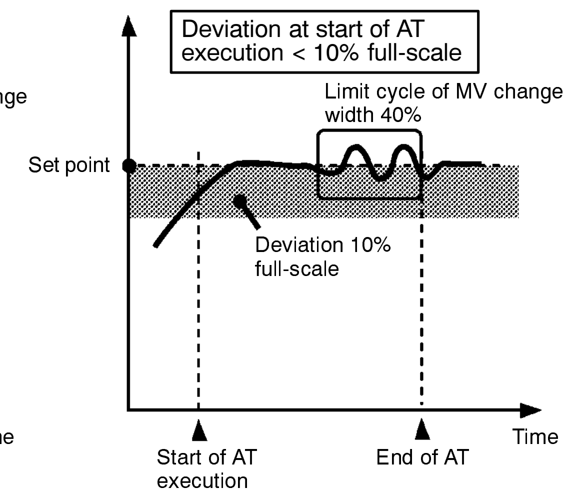
40% AT

To set the limit cycle of MV change width to 40%, select 40% AT to execute auto-tuning while fluctuations in the process value are kept to a minimum.

Note: Auto-tuning takes longer to execute compared with 100%AT.

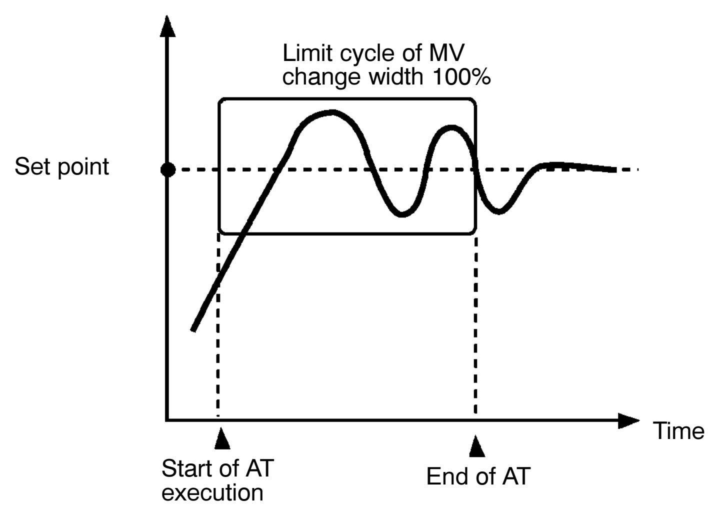
The timing by which limit cycles are generated varies according to whether or not the deviation (DV) at the start of AT execution is 10% full-scale or less.





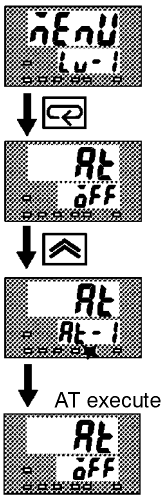
100% AT

In order to set the limit cycle of MV change width to 100%, select 100% AT to shorten the AT execution time without worrying about fluctuations in the process value.



Setting Example

In this example, execute 40% AT.



(1) Press the (Display) Key (for more than one second) to access the display menu. Select [Lu- 1] (level 1 mode) using the or keys.

(2) Press the key (for more than one second) to enter the level 1 mode. The top parameter in the setup mode [At] *AT execute/cancel* is displayed. In this example, the parameter setting is [oFF] *AT cancel.*

(3) Press the key to specify [At - 1].

(4) The AT LED flashes, and AT execution starts. When the AT LED goes out (end of AT execution), the parameter automatically returns to [oFF] (*AT cancel*).

About PID Parameters

When control characteristics are already known, the PID parameters can be set directly to adjust control.
PID parameters are set in the proportional band (P), integrated time (I) and derivative time (D) parameters (level 1 mode).
For details on the setting ranges of these parameters, refer to Level 1 Mode in Section 5.

SECTION 4
Applied Operation

This section describes each of the parameters required when making full use of the E5CK features. As you read this section, refer to the parameter descriptions provided in Section 5.

4–1 Selecting the Control Method

When selecting the control method, set the parameters according to the following table.

Note: Parameters are factory-set to heating control.

Parameter / Control Method	Control output 1 assignment	Control output 2 assignment	Direct/Reverse operations
Heating control (Standard)	Control output (heat)	–	Reverse operation
Cooling control (Standard)	Control output (heat)	–	Direct operation
Heating and cooling control	Control output (heat)	Control output (cool)	Reverse operation

For details on how to assign outputs, refer to Setting Output Specifications in Section 3.

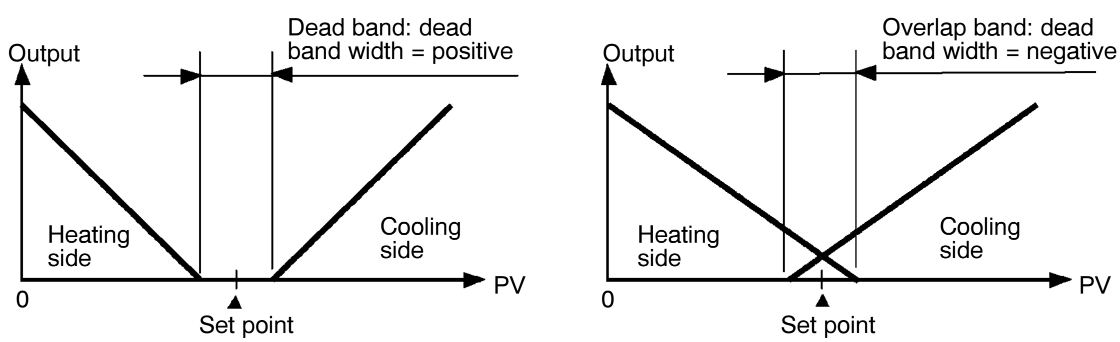
4–1–1 Heating and Cooling Control

When heat/cool control is selected, the *dead band* and *cooling coefficient* parameters can be used.

Note: If heat/cool control is not selected, dead band and cooling coefficient will not be visible.

Dead band

The dead band is set with the set point as its center. The dead band width is the set value of the *dead band* parameter (level 1 mode). Setting a positive value produces a dead band; setting a negative value produces an overlap band.



Cooling Coefficient

If the heating and cooling characteristics of the control target differ greatly, preventing satisfactory control characteristics from being obtained by the same PID parameters, adjust the proportional band (P at cooling side) using the cooling coefficient to balance control between the heating and cooling sides. In heating and cooling control, P at the heating or cooling side is calculated by the following formula:

Heating side P = P; Cooling side P = cooling coefficient $\times$ P

Manipulated Variable at Stop

In heating and cooling control, the manipulated variable output that is output when controller operation is stopped is dependent on the set value of the *MV at stop* parameter (level 2 mode) in the same way as for standard control.

However, note that in heating and cooling control, the manipulated variable at the cooling side is treated as a negative value for the sake of convenience. When the manipulated variable at STOP is a negative value, the manipulated variable is output to only the cooling side; when a positive value, the manipulated variable is output to only the heating side. The factory setting is **0**. If the controller is operated using the factory setting, the manipulated variable is not output to either the heating or the cooling sides.

Switching with Manual Operation

When the overlap band is set, the bumpless function that operates when switching between manual and automatic operation may not work.

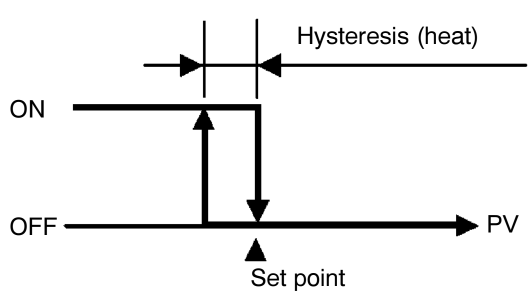
4–1–2 ON/OFF Control

Switching between advanced PID control and ON/OFF control is carried out by the *PID or ON/OFF* parameter (expansion mode). When this parameter is set to [PID], advanced PID control is selected, and when set to [ONOF], ON/OFF control is selected. Default is [PID].

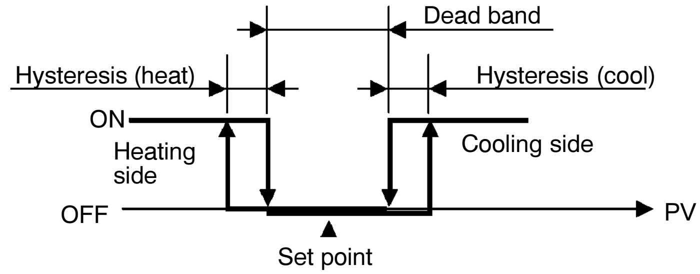
Hysteresis

In ON/OFF control, hysteresis is provided in the program when switching between ON and OFF to stabilize operation. The hysteresis width provided during ON/OFF control is simply referred to as *hysteresis*. Control output (heat) and control output (cool) functions are set in the *hysteresis (heat)* and *hysteresis (cool)* parameters, respectively.

In standard control (heating or cooling control), hysteresis can be set only for the heating side.



In heating and cooling control, a dead band can be set. So, 3-position control is made possible.



Parameters

Symbol	Parameter Name: Mode	Description
oUt1	Control output 1 assignment : Setup	For specifying control method
oUt2	Control output 2 assignment : Setup	For specifying control method
orEv	Direct/Reverse operation : Setup	For specifying control method
C-db	Dead band : Level 1	Heating and cooling control
C-SC	Cooling coefficient : Level 1	Heating and cooling control
mv-S	MV at stop : Level 2	Manipulated variable when control operation is stopped
HYS	Hysteresis (heat) : Level 1	ON/OFF control
CHYS	Hysteresis (cool) : Level 1	ON/OFF control
CntL	PID / ON/OFF : Expansion	ON/OFF control

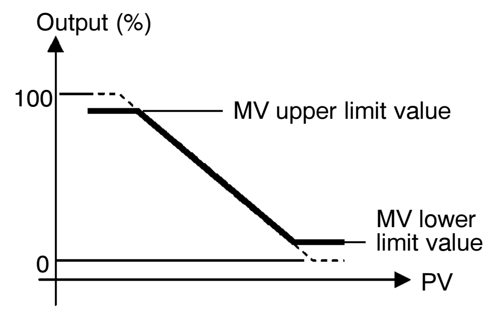
4–2 Operating Condition Restrictions

4–2–1 Manipulated Variable Restrictions

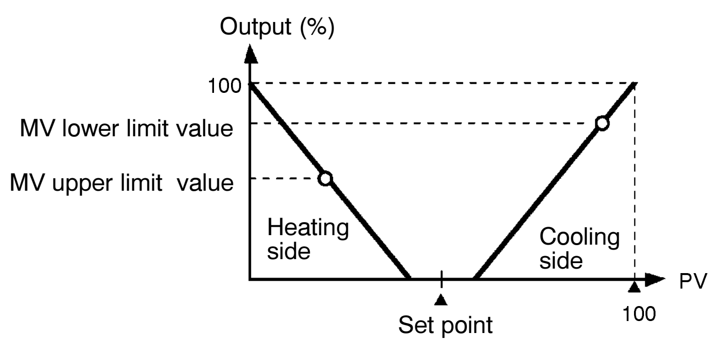
The upper-and lower-limit values of the manipulated variable can be restricted by the MV limiter, and the change rate of the manipulated variable can be restricted by the MV change rate limiter.

MV Limiter

The upper-and lower-limit values of the manipulated variable are set in the *MV upper limit* and *MV lower limit* parameters (level 2 mode). When the manipulated variable calculated by the E5CK is outside the range of the MV limiter, actual outputs are dependent on the set value of these parameters.

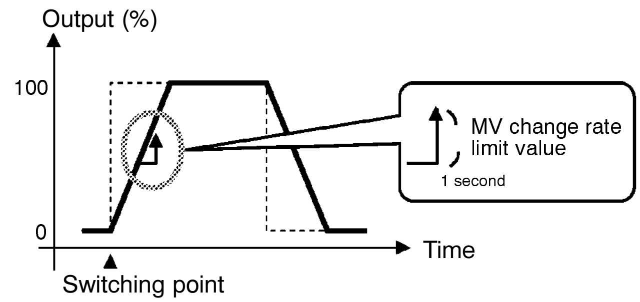


In heating and cooling control, the manipulated variable at the cooling side is treated as a negative value for convenience. The upper limit is set for the heating side (positive value), and the lower limit is set for the cooling side (negative value), as shown in the following figure.



MV Change Rate Limiter

The *MV change rate limit* parameter (level 2 mode) sets the maximum permissible change width per second of the manipulated variable. If a change in the manipulated variable exceeds this parameter setting, the value calculated by the E5CK is reached by changing the value by the per-second value set in this parameter.



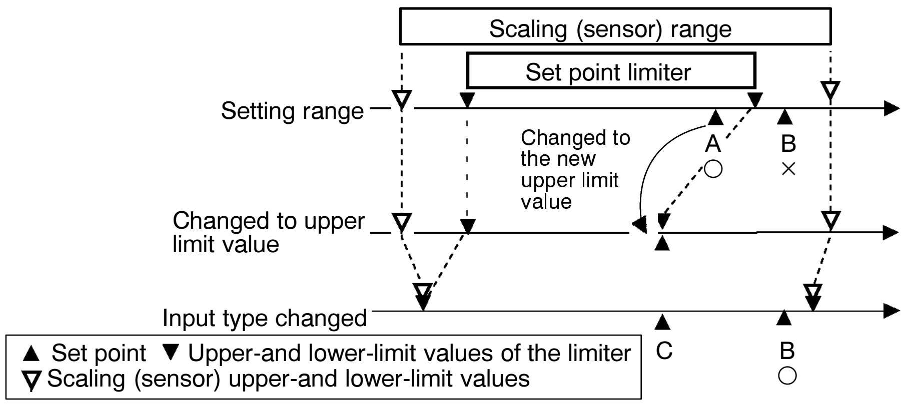
Limit Operation Conditions

The limiters are invalid or cannot be set when any of the following conditions occurs:

- During ON/OFF control
- During ST execution
- During AT execution (only by MV change rate limiter)
- During manual operation
- When operation is stopped
- When an error has occurred

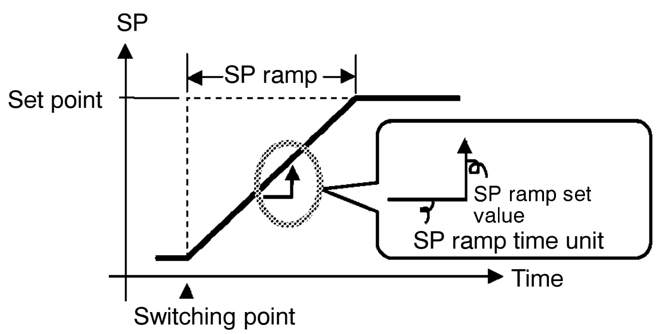
4-2-2 Set Point Limiter

The setting range of the set point is limited by the set point limiter. The upper-and lower-limit values of this set point limiter are set in the *Set point upper limit* and *Set point lower limit* parameters (expansion mode), respectively. Note that when the set point limiter is reset, the set point is forcibly changed to the upper-or lower-limit value of the set point limiter if the set point is out of the limiter range. Also, when the input type, temperature unit and scaling (sensor) range are changed, set point limiter is forcibly reset to the scaling (sensor) range.



4-2-3 SP Ramp

With the SP ramp function, the controller operates according to the value (set point during SP ramp) limited by a change rate, instead of the changed set point when set point is changed. The interval in which the set point during SP ramp is limited is referred to as the *SP ramp*.

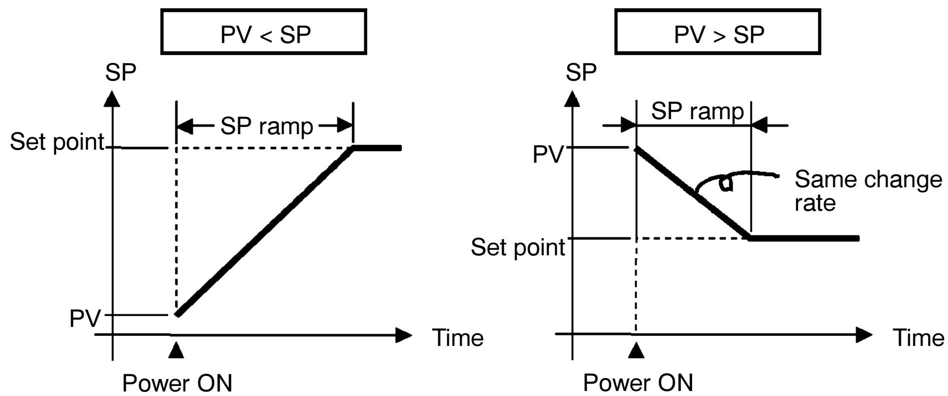


The change rate during the SP ramp is specified by the SP ramp set value and SP ramp time unit parameters. At the SP ramp set value default **0**, the SP ramp function is disabled.
The set point changing in SP ramp can be monitored in the Set point during SP ramp parameter (level 0 mode).

Operation at Start

The limiters are invalid or cannot be set when any of the following conditions occurs:

If the SP ramp function is enabled when the power is turned ON, and when STOP is switched to RUN process value may reach the set point after SP ramp in the same way as when the set point is changed. In this case, operation is carried out with the process value regarded as the set point before the change was made.
The direction of the SP ramp changes according to the relationship between the process value and the set point.



Restrictions During SP Ramp

Execution of auto-tuning starts after the end of SP ramp.

When the controller is switched to the manual mode, the set point changes continuously until SP ramp ends.

When an error occurs, the SP ramp function becomes invalid.

Parameters

Symbol	Parameter Name: Mode
oL-H	MV upper limit : Level 2
oL-L	MV lower limit : Level 2
orL	MV change rate limit : Level 2
SL-H	SP setting upper limit: Expansion
SL-L	SP setting lower limit: Expansion
SPrt	SP ramp set value : Level 2
SPrU	SP ramp time unit : Level 2

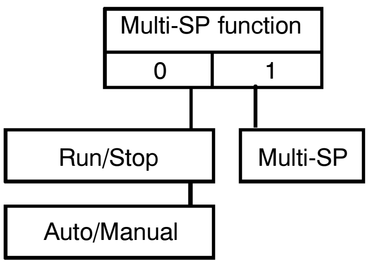
4-3 Using Option Functions

For details on the communications function, refer to *Using the Communications Function* in Chapter 6.

4-3-1 Event Input

When using event input, add on the Input Unit E53-CKB.

Input Assignments



You can choose from the following three event inputs:

- RUN/STOP
- Auto/Manual
- Multi-SP

When selecting an option function, first determine whether or not the multi-SP function is to be used. You can select two of the remaining option functions only when the multi-SP function is not in use.

When using the multi-SP function, set the *multi-SP function* parameter (option mode) to **1: ON**. When using other functions, set this parameter to **0: OFF**.

When specifying event input other than the multi-SP function, specify event input in the *event input assignment 1* parameter (option mode). The following table shows the relationship between parameter settings and event input functions.

Setting	Function
StoP	ON : Stop /OFF : Run
mAn	ON : Manual /OFF : Auto

RUN/STOP

When event input is set to ON, controller operation is stopped and the STOP LED lights. The content of event input is reflected in the RUN/STOP parameter (level 0 mode).

Auto/Manual

When event input is set to ON, the controller is switched for manual operation, and the MANU LED lights.

Turn event input ON/OFF while the controller is ON.

Multi-SP

The set points set to the **set point 0** and **set point 1** parameters (level 1 mode) can be switched for use. Note that these parameters cannot be set when the multi-SP function is not selected.

The set point can be switched up to 100,000 times.

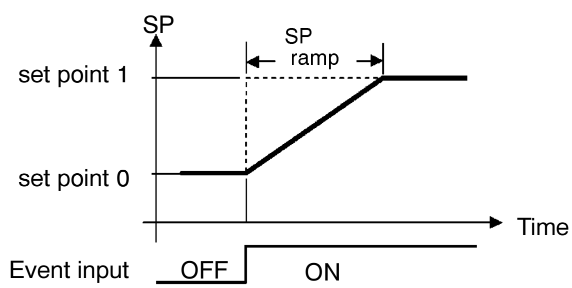
When event input is OFF, set point 0 is used, and when ON set point 1 is used.

When you have changed the set point, the set point of the currently selected parameter is changed.

When you have switched between set point 0 and set point 1, the SP ramp function works if the SP ramp function is enabled. The following examples shows how the set point changes when you switch from set point 0 and set point 1.

About the event input and key operation

There is no order of priority when inputting events and operating the keys. However, because event input of run/stop or auto/manual must be carried out in either of the physical ON/OFF states, parameters ultimately conform to event input even if an attempt is made to switch the setting by key operation.



4-3-2 Transfer Output

When using transfer output, add on the Transfer Output Option Board E53-CKF.

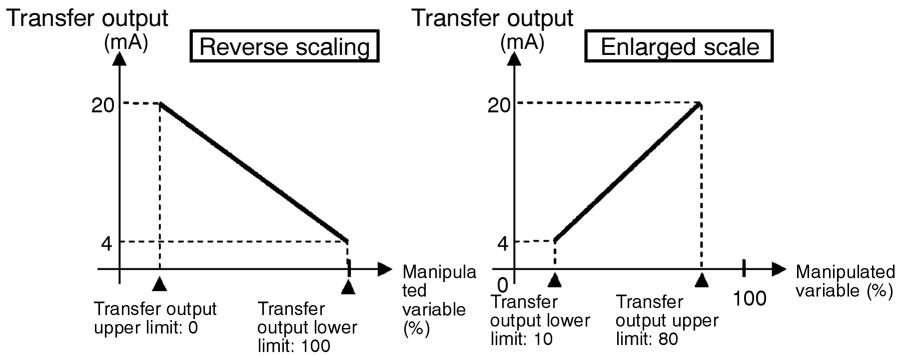
You can select the following data items in the transfer output type parameter (option mode) as the transfer outputs:

- Set point
- Set point during SP ramp
- Process value
- Manipulated variable (heat)
- Manipulated variable (cool)

These transfer outputs can be scaled according to the settings of the *transfer output upper limit* and *transfer output lower limit* parameters before output.

Note: Setting of an upper limit value smaller than the lower limit value is allowed, so reverse scaling can also be carried out.

Also, the scale can be enlarged by the upper-and lower-limit width specified for each data item. The following example shows scaling of the reading side manipulated variable.



Parameters

Symbol	Parameter Name: Mode	Application
Ev-m	Multi-SP function : Option	Event input functions
Ev-1	Event input assignment 1 : Option	Event input functions
SP-0	Set point 0 : Level 1	Multi-SP
SP-1	Set point 1 : Level 1	Multi-SP
tr-t	Transfer output type : Option	Transfer output designation
tr-H	Transfer output upper limit : Option	Transfer output scaling
tr-L	Transfer output lower limit : Option	Transfer output scaling

4–4 LBA

The LBA (Loop Break Alarm) function can be used only when assigned to an output. Also, the LBA function does not work when a memory error or A/D converter error occurs.

LBA (Loop Break Alarm) is a function for judging that an error has occurred somewhere on the control loop and creating an alarm when the process value does not change with the manipulated variable at a maximum or minimum state. The LBA function can be used as a means for detecting a malfunctioning control loop.

LBA Detection Time

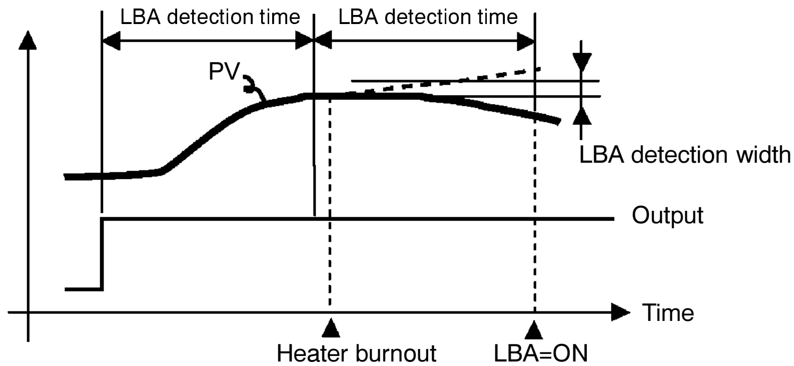
Normally, when output is set to maximum or minimum, the process value rises or falls after the dead time has elapsed. LBA is output if the process value does not change in the predicted direction after a fixed amount of time has elapsed. This fixed amount of time is the *LBA detection time*.

LBA Detection Width

LBA operation sometimes becomes unstable when the process value fluctuates considerably due to the control characteristics. The LBA detection width is provided so that changes with respect to output can be correctly detected. Changes smaller than the detection width, due to LBA detection timing, are not regarded as changes.

LBA Detection Example

The following example describes what happens when a heater burnout at maximum output.



LBA judgment is carried out at each LBA detection time from the point of maximum output. In above figure, the process value (PV) is changing greatly at the 1st judgment timing, so LBA remains OFF.

At the 2nd judgment timing, the process value increases as indicated by the broken line of the process value is normal. This means that the change width exceeds the LBA detection width, and LBA output remains OFF.

If the heater burns out at the point shown in the above figure, the process value *decreases*. Accordingly, it is judged that *the process value is not changing in the increasing direction* at the 2nd judgment timing and the LBA output becomes ON.

Setting the LBA Detection

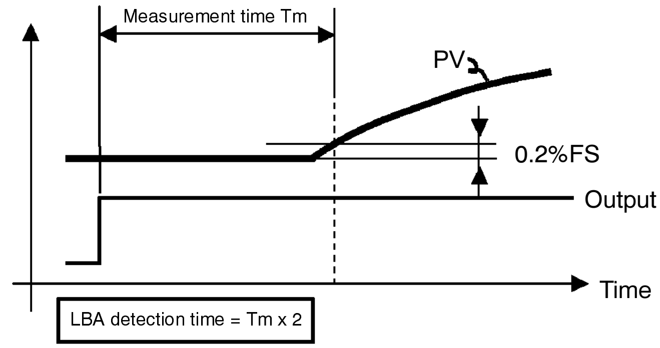
The LBA detection time is automatically set by auto-tuning (except in heating and cooling control).

If the optimum LBA detection time cannot be obtained by auto-tuning, set the time in the *LBA detection time* parameter (level 2 mode).

Determining the LBA Detection Time

Calculate the LBA detection time as follows:

1, 2, 3...
1. Set output to maximum.
2. Measure the time it takes for the input change width to reach the LBA detection width (default: 0.2 % full-scale).
3. Take a value twice that of the measurement time as the LBA detection time.



4. In the case of ON/OFF operation, set the LBA detection time to a value longer than the control period.

Parameters

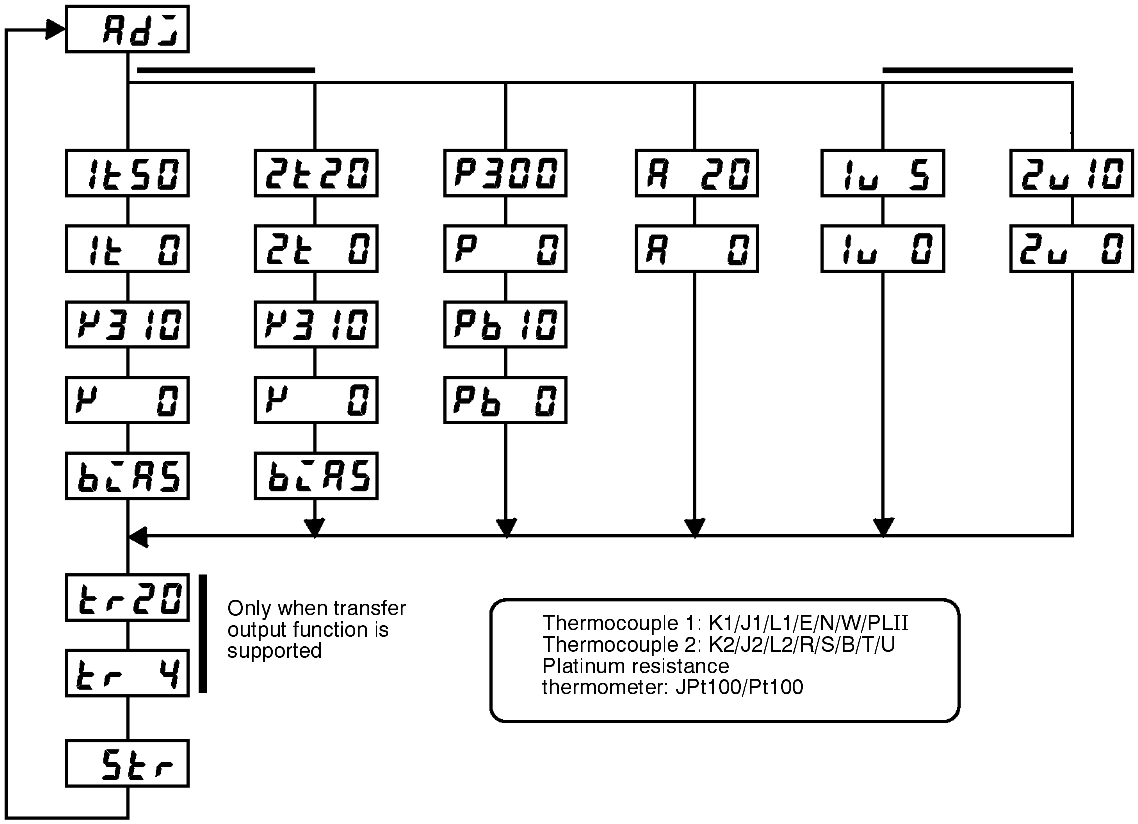
Symbol	Parameter Name: Mode	Application
At	AT Execute/Cancel : Level 1	Automatic setting of LBA detection time
LbA	LBA detection time : Level 2	Setting of LBA detection time
LbAb	LBA detection width : Expansion	Changing of LBA detection width

4–5 Calibration

To calibrate the E5CK controller, select [CLb] in the menu display to select the calibration mode. [AdJ] is displayed.

Note that [CLb] may not be displayed on the menu display unless the *security* parameter (in protect mode) has been changed to **0**.

The parameters in the calibration mode are configured as shown in the following figure.



To select the desired parameter, press the [key] key. Parameters are displayed in this order:

- Calibration of inputs
- Calibration of transfer output
- Saving of calibration data

If the E5CK controller does not support the transfer output function, calibration of transfer output is automatically deleted from the calibration procedure as follows:

- Calibration of inputs → Saving of calibration data

Only inputs that have been set in the input type parameter (setup mode) can be calibrated. To temporarily save data for each of the calibration parameters, press the [key] key for 1 second.

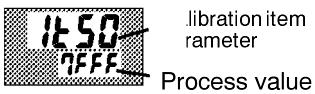
Transfer output can be calibrated only when the Transfer Output Option Board E53-CKF is set in the controller. To adjust data items, press the [key] or [key] keys.

The data save menu is displayed only when all calibration items have temporarily been saved.

After calibrating input, you must always check indication accuracy. For further details, refer to *Checking Indication Accuracy* later in this section.

Calibration Item Menu

Parameters are displayed on the No.1 display, and the process value is displayed in Hexadecimal on the No.2 display.

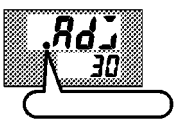


Normally, the process value changes by several digits. The process value flashes, for example, when a sensor error causes the process value to stray from the calibration target range.

When the process value display is flashing, the process value is not saved as data even if the [▼] key is pressed.

Calibration Save Mark

Once the E5CK controller has been calibrated by the user, [Adj] is preceded by the "." mark when the calibration mode is selected.

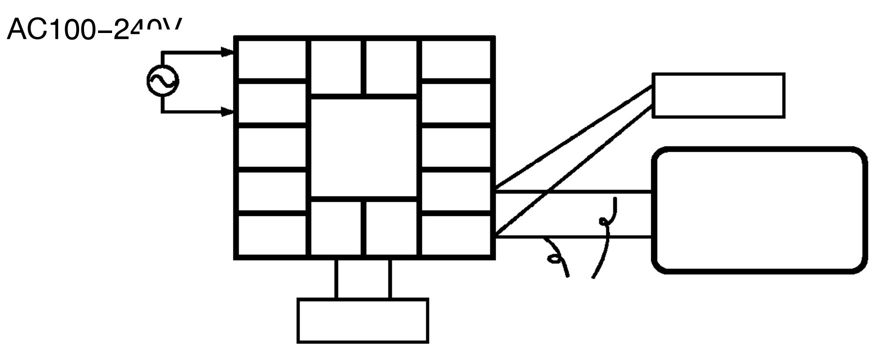


4–5–1 Calibrating Thermocouple

Calibrate according to the type of thermocouple, thermocouple 1 group (K1, J1, L1, E, N, W, PLII) and thermocouple 2 group (K2, J2, L2, R, S, B, T, U).

When calibrating, do not cover the bottom or top of the controller. Also, do not touch the input terminals (Nos. 6 and 7) and compensating conductor on the E5CK controller.

Preparations



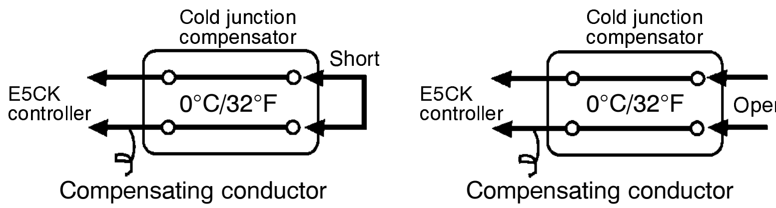
Set the cold junction compensator to 0°C. However, make sure that internal thermocouples are disabled (tips are open).

In the above figure, STV refers to a standard DC current/voltage source, and DMM refers to a precision digital multimeter.

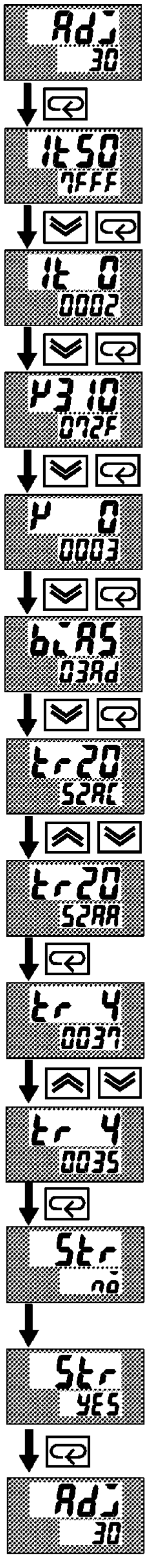
Use the compensating conductor selected thermocouple. However, note that when thermocouple R, S, E, B, W or PLII is used, the compensating conductor can be substituted with the compensating conductor for thermocouple K.

Connecting the Cold Junction Conductor

Correct process values cannot be obtained if you touch the contact ends of the compensating conductor during calibration of a thermocouple. Accordingly, short (enable) or open (disable) the tip of the compensating conductor inside the cold junction compensator as shown in the figure below to create a contact or non-contact state for the cold junction compensator.



Calibrating Thermocouple 1



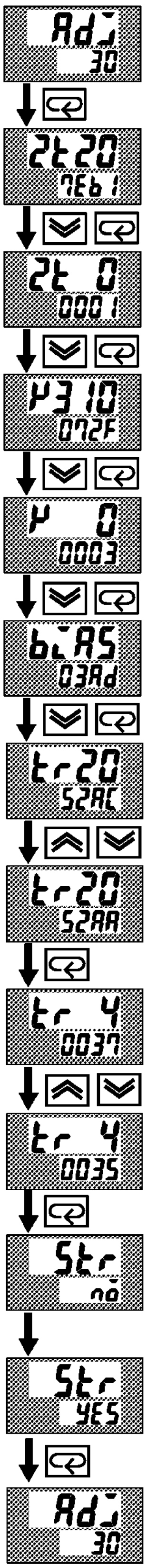
This example describes how to calibrate a thermocouple when the transfer output function is supported. If the transfer output function is not supported, skip steps 7 to 10.

1, 2, 3...

1. When [Adj] is displayed, the 30-minute timer is displayed on the No.2 display and counts down. This timer serves as a guide for the aging time when aging is required.
2. First, calibrate the main input. Press the [⟲] key to display [it50] (50mV calibration display). Set STV output to 50mV. When the value on the No.2 display has stabilized (changes of several digits max.), press the [▼] key to temporarily save the calibration data.
3. Press the [⟲] key to display [it 0] (0mV calibration display). Set STV output to 0mV. When the value on the No.2 display has stabilized (changes of several digits max.), press the [▼] key to temporarily save the calibration data.
4. Next, calibrate the cold junction compensator. Press the [⟲] key to display [P310] (310mV calibration display). Set STV output to 310mV. When the value on the No.2 display has stabilized (changes of several digits max.), press the [▼] key to temporarily save the calibration data.
5. Press the [⟲] key to display [P 0] (0mV calibration display). Set STV output to 0mV. When the value on the No.2 display has stabilized (changes of several digits max.), press the [▼] key to temporarily save the calibration data.
6. Finally, calibrate the bias compensation value. Disconnect the STV, and enable the thermocouple of the cold junction compensator. When doing this, make sure that the wiring on the STV is disconnected.
   Make sure that the cold-junction compensator is set to 0°C and press the [⟲] key. The display changes to [biAS] (calibration display for the bias compensation value). When the value on the No.2 display has stabilized (changes of several digits max.), press the [▼] key to temporarily save the calibration data.
7. Next, calibrate the transfer output function. If the transfer output function is not supported, skip to step 11. Press the [⟲] key. The display changes to [tr20] (20mA calibration display).
8. Set the output to 20mA by the [▼] or [▲] keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **20mA**.
9. Press the [⟲] key. The display changes to [tr 4] (4mA calibration display).
10. Set the output to 4mA by the [▼] or [▲] keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **4mA**.
11. Press the [⟲] key until the display changes to the data save display. Press the [▲] key. The No.2 display changes to [yES], and two seconds later the calibration data is saved to internal memory. If you press the [⟲] key when the No.2 display reads [no], the calibration data is invalidated.

12. This completes calibration of the thermocouple 1 group. Press the ↩ key to return the display to [Adj].

Calibrating Thermocouple 2



This example describes how to calibrate a thermocouple when the transfer output function is supported. If the transfer output function is not supported, skip steps 7 to 10.

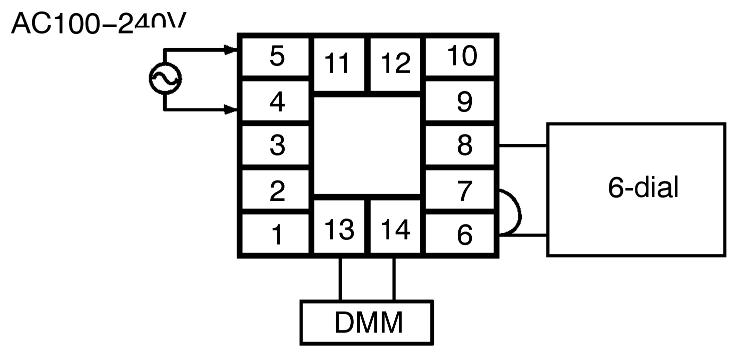
1, 2, 3...

1. When [Adj] is displayed, the 30-minute timer is displayed on the No.2 display and counts down. This timer serves as a guide for the aging time when aging is required.
2. First, calibrate the main input. Press the ↩ key to display [2t20] (20mV calibration display). Set STV output to 20mV. When the value on the No.2 display has stabilized (changes of several digits max.), press the ▼ key to temporarily save the calibration data.
3. Press the ↩ key to display [2t 0] (0mV calibration display). Set STV output to 0mV. When the value on the No.2 display has stabilized (changes of several digits max.), press the ▼ key to temporarily save the calibration data.
4. Next, calibrate the cold junction compensator. Press the ↩ key to display [P310] (310mV calibration display). Set STV output to 310mV. When the value on the No.2 display has stabilized (changes of several digits max.), press the ▼ key to temporarily save the calibration data.
5. Press the ↩ key to display [P 0] (0mV calibration display). Set STV output to 0mV. When the value on the No.2 display has stabilized (changes of several digits max.), press the ▼ key to temporarily save the calibration data.
6. Finally, calibrate the bias compensation value. Disconnect the STV, and enable the thermocouple of the cold junction compensator. When carrying this out, make sure that the wiring on the STV is disconnected. Make sure that the cold-junction compensator is set to 0°C and press the ↩ key. The display changes to [biAS] (calibration display for the bias compensation value). When the value on the No.2 display has stabilized (changes of several digits max.), press the ▼ key to temporarily save the calibration data.
7. Next, calibrate the transfer output function. If the transfer output function is not supported, skip to step 11. Press the ↩ key. The display changes to [tr20] (20mA calibration display).
8. Set the output to 20mA by the ▼ or ▲ keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **20mA**.
9. Press the ↩ key. The display changes to [tr 4] (4mA calibration display).
10. Set the output to 4mA by the ▼ or ▲ keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **4mA**.

11. Press the key until the display changes to the data save display. Press the key. The No.2 display changes to [yES], and two seconds later the calibration data is saved to internal memory. If you press the key when the No.2 display reads [no], the calibration data is invalidated.
12. This completes calibration of the thermocouple 2 group. Press the key to return the display to [Adj].

4–5–2 Calibrating Platinum Resistance Thermometer

Preparation

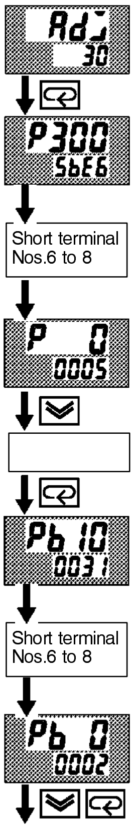


Use leads of the same thickness when connecting to the platinum resistance thermometer.

In the above figure, 6-dial refers to a precision resistance box, and DMM stands for a digital multimeter. However, note that the DMM is required only when the transfer output function is supported.

Connect (short) the leads from terminal Nos. 6 and 7.

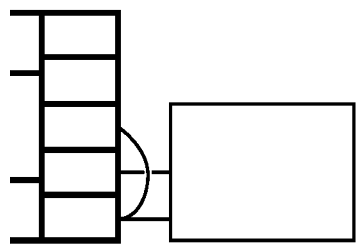
Calibration

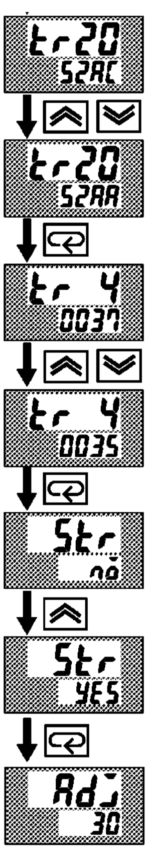


This example describes how to calibrate a platinum resistance thermometer when the transfer output function is supported. If the transfer output function is not supported, skip steps 7 to 10.

1, 2, 3...

1. When [Adj] is displayed, the 30-minute timer is displayed on the No.2 display and counts down. This timer serves as a guide for the aging time when aging is required.
2. First, calibrate the main input. Press the key to display [P300] (300Ω calibration display). Set the 6-dial to 300Ω. When the value on the No.2 display has stabilized (changes of several digits max.), press the key to temporarily store the calibration data.
3. Press the key to switch [P 0] (0Ω calibration) display. Short terminal No.6 to 8. When the value on the No.2 display has stabilized (changes of several digits max.), press the key to temporarily store the calibration data.
4. Next, calibrate the B-B' input. Change the wiring as shown in the following diagram. Make the connection across terminals 6 and 7 and the 6-dial as short as possible. Short terminals 6 and 8.



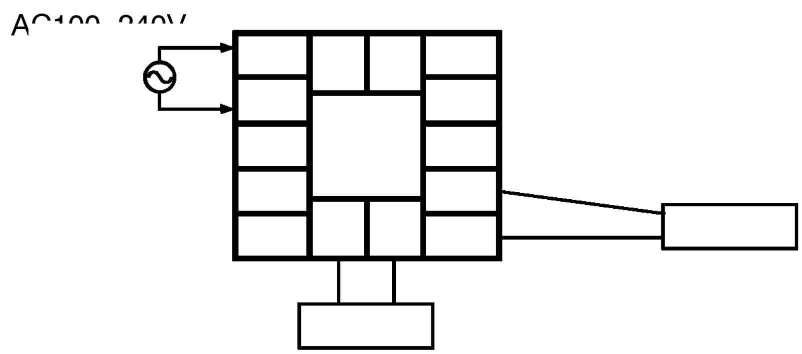


5. Press the key to display [Pb 10] (10Ω calibration display). Set the 6-dial to 10Ω.. When the value on the No.2 display has stabilized (changes of several digits max.), press the key to temporarily store the calibration data.
6. Press the key to display [Pb 0] (0Ω calibration display). Set the 6-dial to 10Ω.. When the value on the No.2 display has stabilized (changes of several digits max.), press the key to temporarily store the calibration data.
7. Next, calibrate the transfer output function. *If the transfer output function is not supported, skip to step 11.* Press the key. The display changes to [tr20] (20mA calibration display).
8. Set the output to 20mA by the or keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **20mA**.
9. Press the key. The display changes to [tr 4] (4mA calibration display).
10. Set the output to 4mA by the or keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **4mA**.

11. Press the key until the display changes to the data save display. Press the key. The No.2 display changes to [YES], and two seconds later the calibration data is saved to internal memory. If you press the key when the No.2 display reads [no], the calibration data is invalidated.
12. This completes calibration of the platinum resistance thermometer. Press the key to return the display to [Adj].

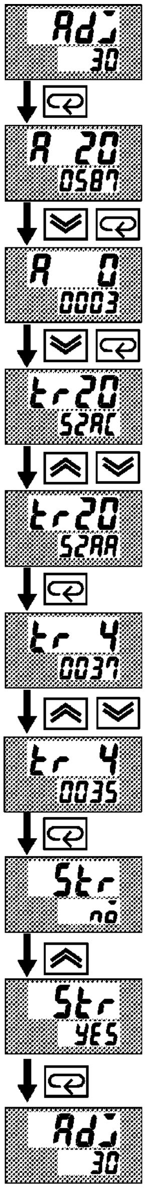
4–5–3 Calibrating Current Input

Preparation



In the above figure, STV refers to a standard DC current/voltage source, and DMM refers to a precision digital multimeter. However, note that the DMM is required only when the transfer output function is supported.

Calibration



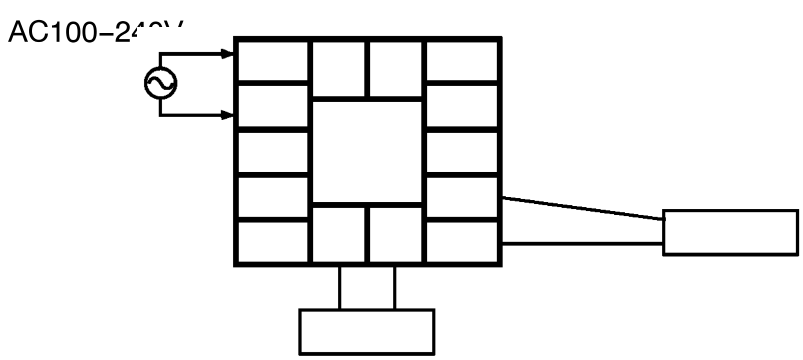
This example describes how to calibrate a current input when the transfer output function is supported. If the transfer output function is not supported, skip steps 4 to 7.

1, 2, 3...

1. When [Adj] is displayed, the 30-minute timer is displayed on the No.2 display and counts down. This timer serves as a guide for the aging time when aging is required.
2. Press the [key] key. The display changes to [A 20] (20mA calibration display). Set the STV output to 20mA. When the value on the No.2 display has stabilized (changes of several digits max.), press the [key] key to temporarily store the calibration data.
3. Press the [key] key. The display changes to [A 0] (0mA calibration display). Set the STV output to 0 mA. When the value on the No.2 display has stabilized (changes of several digits max.), press the [key] key to temporarily store the calibration data.
4. Next, calibrate the transfer output function. If the transfer output function is not supported, skip to step 8. Press the [key] key. The display changes to [tr20] (20mA calibration display).
5. Set the output to 20mA by the [key] or [key] keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **20mA**.
6. Press the [key] key. The display changes to [tr 4] (4mA calibration display).
7. Set the output to 4mA by the [key] or [key] keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **4mA**.
8. Press the [key] key until the display changes to the data save display. Press the [key] key. The No.2 display changes to [yES], and two seconds later the calibration data is saved to internal memory. If you press the [key] key when the No.2 display reads [no], the calibration data is invalidated.
9. This completes calibration of voltage input. Press the [key] key to return the display to [Adj].

4-5-4 Calibrating Voltage Input

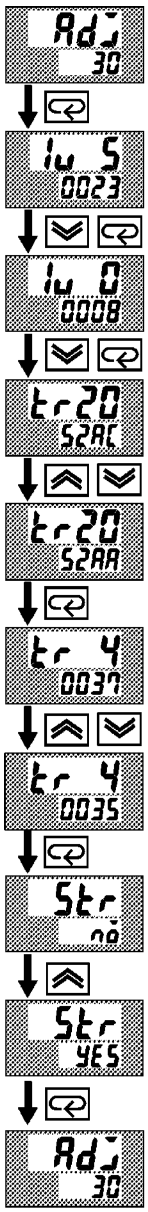
Preparation



In the above figure, STV refers to a standard DC current/voltage source, and DMM refers to a precision digital multimeter. However, note that the DMM is required only when the transfer output function is supported.

Calibration: 0 to 5 V, 1 to 5 V

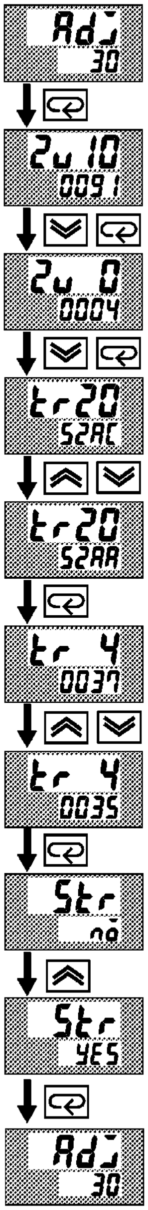
This example describes how to calibrate voltage input when the transfer output function is supported. If the transfer output function is not supported, skip steps 4 to 7.



1, 2, 3...
1. When [AdJ] is displayed, the 30-minute timer is displayed on the No.2 display and counts down. This timer serves as a guide for the aging time when aging is required.
2. Press the ↩ key. The display changes to [iu 5] (5 V calibration display). Set the STV output to 5V. When the value on the No.2 display has stabilized (changes of several digits max.), press the ▼ key to temporarily store the calibration data.
3. Press the ↩ key. The display changes to [iu 0] (0V calibration display). Set the STV output to 0V. When the value on the No.2 display has stabilized (changes of several digits max.), press the ▼ key to temporarily store the calibration data.
4. Next, calibrate the transfer output function. If the transfer output function is not supported, skip to step (8). Press the ↩ key. The display changes to [tr20] (20mA calibration display).
5. Set the output to 20mA by the ▼ or ▲ keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **20mA**.
6. Press the ↩ key. The display changes to [tr 4] (4mA calibration display).
7. Set the output to 4mA by the ▼ or ▲ keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **4mA**.
8. Press the ↩ key until the display changes to the data save display. Press the ▲ key. The No.2 display changes to [YES], and two seconds later the calibration data is saved to internal memory. If you press the ↩ key when the No.2 display reads [no], the calibration data is invalidated.
9. This completes calibration of voltage input (0 to 5V, 1 to 5V). Press the ↩ key to return the display to [AdJ].

Calibration: 0 to 10V

This example describes how to calibrate voltage input when the transfer output function is supported. If the transfer output function is not supported, skip steps 4 to 7.



1, 2, 3...

1. When [Adj] is displayed, the 30-minute timer is displayed on the No.2 display and counts down. This timer serves as a guide for the aging time when aging is required.
2. Press the ⟲ key. The display changes to [2v 10] (10V calibration display). Set the STV output to 10V. When the value on the No.2 display has stabilized (changes of several digits max.), press the ▼ key to temporarily store the calibration data.
3. Press the ⟲ key. The display changes to [2v 0] (0V calibration display). Set the STV output to 0V. When the value on the No.2 display has stabilized (changes of several digits max.), press the ▼ key to temporarily store the calibration data.
4. Next, calibrate the transfer output function. If the transfer output function is not supported, skip to step 8. Press the ⟲ key. The display changes to [tr20] (20mA calibration display).
5. Set the output to 20mA by the ▼ or ▲ keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **20mA**.
6. Press the ⟲ key. The display changes to [tr 4] (4mA calibration display).
7. Set the output to 4mA by the ▼ or ▲ keys while monitoring the voltage on the digital multimeter. In the example on the left, the display indicates that the value two digits smaller than before calibration is **4mA**.
8. Press the ⟲ key until the display changes to the data save display. Press the ▲ key. The No.2 display changes to [YES], and two seconds later the calibration data is saved to internal memory. If you press the ⟲ key when the No.2 display reads [no], the calibration data is invalidated.
9. This completes calibration of voltage input (0 to 10V). Press the ⟲ key to return the display to [Adj].

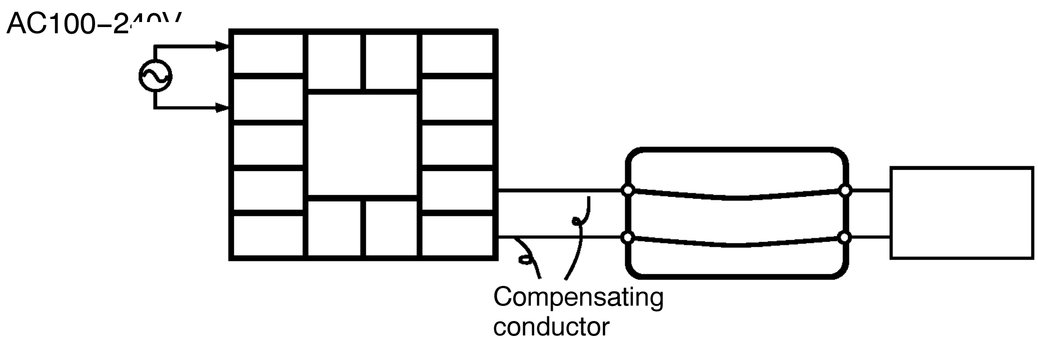
4–5–5 Checking Indication Accuracy

After calibrating input, check indication accuracy to make sure that the E5CK controller has been correctly calibrated.

- Operate the E5CK controller in the PV/SP monitor mode (level 0).
- Check the indication accuracy at the upper and lower limits and midpoint.

Thermocouple

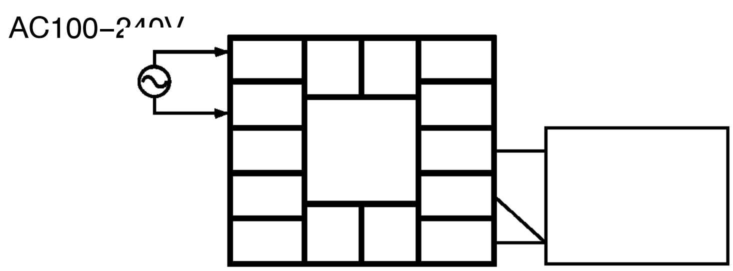
Preparation. The following figure shows the required device connection. Make sure that the E5CK controller and cold junction compensator are connected by a compensating conductor for the input type that is to be used during actual operation.



Operation. Set the cold junction compensator at 0°C, and set STV output to the voltage equivalent to the starting power of the check value.

Platinum Resistance Thermometer

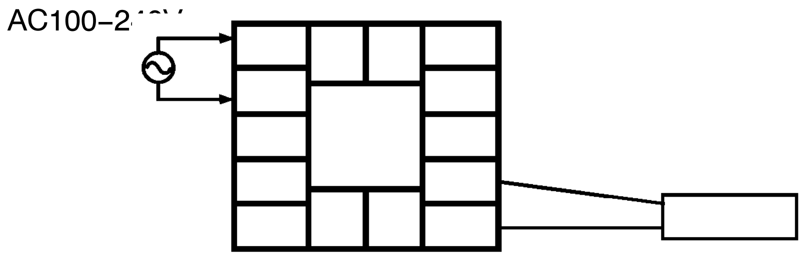
Preparation. The following figure shows the required device connection.



Operation. Set the 6-dial to the resistance equivalent to the check value.

Current or Voltage Input

Preparation. The following figure shows the required device connection.



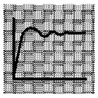
Operation. Set the STV to the current or voltage value equivalent to the check value.

SECTION 5
Parameters

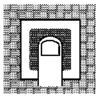
This section describes the parameters of the E5CK. Use this section as a reference guide.

Conventions Used in Section 5

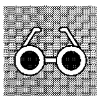
Icons used in this chapter:


Function

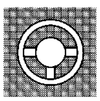
Indicates the functions of the parameter.


Comment

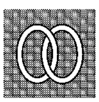
Indicates the range and defaults of the parameter setting.


Monitor

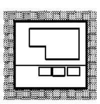
Indicates monitor-dedicated parameters.
Describes the range of the monitor values.


Example of use

Indicates a procedure using parameters in operating instructions.


See

Indicates related parameters and items.


Model

Indicates models of the E5CK supporting the parameter being described.

About parameter display:

On the E5CK controller, only parameters that can be used are displayed. These parameters are displayed only when the *Conditions of Use* on the right of the parameter heading are satisfied. However, note that the settings of protected parameters are still valid and are not displayed, regardless of the conditions of use.

At **AT Execute/cancel**

Conditions of Use
The controller must be in operation.

5-1 Protect Mode

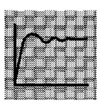
The protect mode is for disabling (protecting) the functions of the menu key or key. Before changing parameters in this mode, first make sure that protecting the key will not cause any problems in operation.

To select this mode, press the key and key simultaneously for 1 second minimum. To exit this mode, press the key and key down again simultaneously for 1 second minimum.

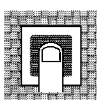
The following table shows the parameters supported in this mode.

Symbol	Parameter Name
SECr	Security
kEYP	[A/M] key protect

SECr Security



Function

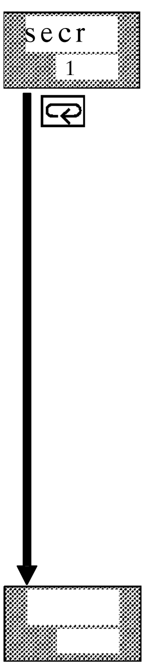


Comment

This parameter specifies which parameters are protected. However, note that the protect mode and manual mode cannot be protected.

Understanding the Security Parameter

Using the Security-Level Table (shown below). Any mode marked with an **X** is displayed in the Security Level indicated.



Mode ↓	Set value						
	0	1	2	3	4	5	6
Calibration	x						
Option	x	x					
Expansion	x	x					
Setup	x	x					
Level 2	x	x	x				
Level 1	x	x	x	x			
Level 0	x	x	x	x	x	x	

⇑ **Lowest Security Level (first column)**

⇑ **Highest Security Level (last column)**

⇐ **Security Level**

When the set value is **5:**
Only the **PV/SP monitor** and **set point** parameter can be used.

When the set value is **6**:
Only the **PV/SP monitor** parameter can be used.

Example:

Selecting Security Level 2 displays these modes:
Level 0, Level 1 and Level 2 only.

Selecting Security Level 2 does NOT display these modes:
Setup, Expansion, Option, Calibration

Default is **1**. Only the calibration mode is protected.

See

Related information:
Refer to *Protect Mode in Section 3.*

KEYP [A/M] key protect

Function

Invalidate the function of the key. In other words, you cannot switch between the auto and manual operations by key operation.

Comment

[on] : key protect ON

[oFF] : key protect canceled

Default = [oFF]

See

Related information:
Refer to *Protect Mode in Section 3.*

5-2 Manual Mode

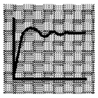
In this mode, manual operations are possible, and the MANU LED lights.

When this mode is selected, the manipulated variable that was active immediately before the mode was switched to the output. When changing the manipulated variable, change it using the or keys.

To select this mode when in the level 0 to 2 modes, press the key for 1 second minimum. To exit this mode, press the key for 1 second minimum. The mode changes to the level 0 mode.

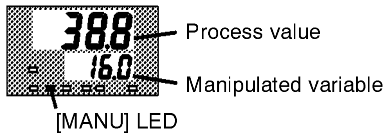
Manual MV is the only parameter available in this mode.

Manual MV

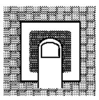

Function

Set the manipulated variable for manual operation.

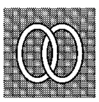
The process value is displayed on the No.1 display, and the manipulated variable is displayed on the No.2 display. Change the manipulated variable using the or keys.



The manual manipulated variable is held when the power is interrupted.


Comment

Control Method	Setting Range	Unit	Default
Standard	-5.0 to 105.0	%	0
Heating and cooling	-105.0 to 105.0	%	0


See

Related information:
Refer to: *Adjusting Control Operation* in Section 3.

5-3 Level 0 Mode

The parameters in this mode can be used only when the security parameter (protect mode) is set at **0 to 4**.

This mode is used for monitoring the process value (PV), set point (SP) and manipulated variable (MV) during operation and for checking and setting the SP setting value. It is also used for starting and stopping controller operation.

To select this mode when in the levels 1 and 2, setup, expansion, option and calibration modes, press the key for 1 second minimum. The display changes to the menu display. If you select [Lu-0] then press key for 1 second minimum, the controller enters the level 0 mode.

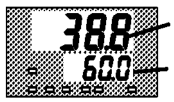
To select parameters in this mode, press the key. To change parameter settings, use the or keys.

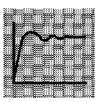
The following table shows the parameters supported in this mode.

Symbol	Parameter Name
	PV/SP
SP-M	Set point during SP ramp
O	MV monitor (heat)
C-O	MV monitor (cool)
r-S	Run/Stop

PV/SP

The process value is displayed on the No.1 display, and the set point is displayed on the No.2 display. The set point can be set.



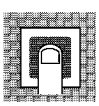

Function

When the multi-SP function is in use, the value of whichever is set, set point 0 or 1, is linked.

The decimal point position is dependent on the selected sensor during temperature input and on the results of scaling during analog input.

The process value is displayed on the No.1 display, and the set point is displayed on the No.2 display.

The decimal point position is dependent on the selected sensor during temperature input and on the results of scaling during analog input.


Comment

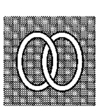
Process value

Monitor Range	Unit
Scaling lower limit -10%FS to scaling upper limit +10%FS	EU

During temperature input, the range of the currently selected sensor is taken as the monitor range.

Set point

Setting Range	Unit	Default
SP setting lower limit to SP setting upper limit	EU	0

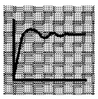

See

Related information:
Refer to: *Adjusting Control Operation* in Section 3.

Related parameters:
Input type, Scaling upper limit, Scaling lower limit, Decimal point (setup mode), SP setting upper limit, SP setting lower limit (expansion mode)

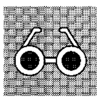
Set point during SP ramp

Conditions of Use
The SP ramp function must be enabled.



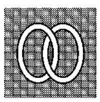
Function

Sets the set point.



Monitor

Monitor Range	Unit	Default
SP setting lower limit to SP setting upper limit	EU	0



See

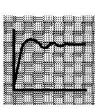
Related information:
Refer to *Adjusting Control Operation*, in Section 3.

Related parameters:
PV/SP (level 0 mode,)
SP ramp time unit, SP ramp set value (level 2 mode),
Set point upper limit, Set point lower limit (expansion mode)

Related parameters:
SP setting upper limit, SP setting lower limit (expansion mode),
Multi-SP function (option mode),
Set point 0, Set point 1 (level 1 mode)

MV monitor (heat)

MV monitor (cool)



Function

This parameter cannot be set.

Monitors the manipulated variable on the heating or cooling side.

The manipulated variable in a standard control system is checked in the *MV monitor (heat)* parameter.

Monitor

The *MV monitor (cool)* parameter can be used only during heating and cooling control.

MV monitor (heat)

Control	Monitor Range	Unit
Standard	-5.0 to 105.0	%
Heating and cooling	0.0 to 105.0	%

MV monitor (cool)

Control	Monitor Range	Unit
Heating and cooling	0.0 to 105.0	%

r-S Run/Stop

Function

This parameter is used for checking the operating status of the controller, and for specifying start and stop of operation.

When the RUN/STOP function is assigned to event input, STOP is set when event input is ON, and RUN is set when event input is OFF. There is no order of priority in key operations.

Example of use

To start operation, set this parameter to [rUn] press the [Up] or [Down] keys.

To stop operation, set this parameter to [StoP]. When operation is stopped, the STOP LED lights.

Default is [rUn]

See

Related information:
Refer to *Starting and Stopping Operation* in Section 3.

5–4 Level 1 Mode

The parameters in this mode can be used only when the “security” parameter (protect mode) is set to **0** to **3**.

This mode contains the main parameters for adjusting control. These parameters include parameters for executing AT (auto-tuning), setting the alarm values, setting the control period, and setting PID parameters.

To select this mode when in the levels 0 and 2, setup, expansion, option and calibration modes, press the key for 1 second minimum. The display changes to the menu display. If you select [Lu-1] then press the key for 1 second minimum, the controller enters the level 1 mode.

To select parameters in this mode, press the key. To change parameter settings, use the or keys.

The following table shows the parameters supported in this mode.

Symbol	Parameter Name
At	AT Execute/Cancel
SP-0	Set point 0
SP-1	Set point 1
AL-1	Alarm value 1
AL-2	Alarm value 2
AL-3	Alarm value 3
P	Proportional band
I	Integral time
d	Derivative time
C-SC	Cooling coefficient
C-db	Dead band
oF-r	Manual reset value
HYS	Hysteresis (heat)
CHYS	Hysteresis (cool)
CP	Control period (heat)
C-CP	Control period (cool)

At

AT Execute/Cancel

Conditions of Use

The controller must be in operation, control must be advanced PID control, and ST must be set to OFF.

Note: Model E5CK-AA1-302 has the auto-tune feature on the front panel.

The [ ] key has been placed within the programming modes.

Function

Selects the limit cycle of MV change width (40% or 100%) for execution. After AT execution, the PID and the LBA detection time (LBA: Loop Break Alarm) parameters are set automatically.

During heating and cooling control, only 100% AT can be executed.

Example of use

When this parameter is selected, the setting becomes [oFF].

To execute 40%AT, select [At - 1], and to execute 100% AT, select [At - 2]. During execution of auto-tuning, the AT LED flashes. However, note that during heating and cooling control, [At - 1] is not displayed.

When AT execution ends, the parameter setting automatically returns to [oFF].

See

Related information
Refer to *Adjusting Control Operation* in Section 3.

Related parameters:
Run/Stop (level 0 mode),
Proportional band, Integral time, Derivative time (level 1 mode),
LBA detection time (level 2 mode)

SP-0

Set point 0

SP-1

Set point 1

Conditions of Use

The multi-SP function must be in operation.

Function

When event input is OFF, *the set point 0* parameter is used, and when ON, the *set point 1* parameter is used.

When the *set point* parameter has been changed, the setting of whichever is selected in event input, set point 0 or set point 1, is linked and changed.

The decimal point position is dependent on the selected sensor during temperature input and on the results of scaling during analog input.

Comment

Setting Range	Unit	Default
Scaling lower limit to Scaling upper limit	EU	0

See

Related information:
Refer to *How to Use Option Functions in Section 4.*

Related parameters:
Multi-SP function (option mode),
Set point (level 0 mode),
Input type, Scaling upper limit, Scaling lower limit,
Decimal point (setup mode)

AL-1

Alarm value 1

AL-2

Alarm value 2

AL-3

Alarm value 3

Conditions of Use

Alarms must be assigned as outputs. For example, if alarm outputs 1 and 2 only are assigned as outputs, the “alarm value 3” parameter cannot be used.

Function

This parameter is used for monitoring or changing the alarm values of alarm outputs 1 to 3.

During temperature input, the decimal point position is dependent on the currently selected sensor, and during analog input on the results of scaling.

Comment

Setting Range	Unit	Default
-1999 to 9999	EU	0

See

Related information:
Refer to *Adjusting Control Operation* in Section 3.

Related parameters:
Input type, Scaling upper limit, Scaling lower limit, Decimal point, Control output 1 assignment, Control output 2 assignment, Auxiliary output 1 assignment, Alarm 1 type, Alarm 2 type, Alarm 3 type, Alarm 1 open in alarm,

Alarm 2 open in alarm, Alarm 3 open in alarm (setup mode,)
Alarm 1 hysteresis, Alarm 2 hysteresis, Alarm 3 hysteresis (level 2 mode),
Standby sequence reset method (expansion mode)

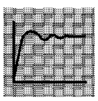
Proportional band

Integral time

Derivative time

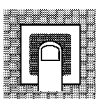
Conditions of Use

Control must be advanced PID control, and ST must be set to OFF.



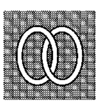
Function

Sets the PID parameters. However, note that the PID parameter settings are changed to optimum values when auto-tuning is executed, and self-tuning is selected.



Comment

Parameter	Setting Range	Unit	Default
Proportional band	0.1 to 999.9	%FS	10.0
Integral time	0 to 3999	Second	233
Derivative time	0 to 3999	Second	40



See

Related parameter:
AT Execute/Cancel (level 1 mode)

C-SC Cooling coefficient

Conditions of Use
The control must be either heating and cooling control, or advanced PID control.

Function

In heating and cooling control, P at the cooling side is calculated by the following formula:
Cooling side P = cooling coefficient × P

Comment

Setting Range	Unit	Default
0.01 to 99.99	None	1.00

See

Related information
Refer to *Selecting the Control Method* in Section 4.

Related parameter
Proportional band (level 1 mode)

C-db Dead band

Conditions of Use
The control system must be heating and cooling control.

Function

Sets the output dead band width in a heating and cooling control system. A negative setting sets an overlap band.

Comment

Setting Range	Unit	Default
-19.99 to 99.99	%FS	0.00

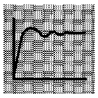
See

Related information:
Refer to *Selecting the Control Method* in Section 4.

Manual reset value

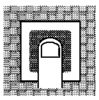
Conditions of Use

The control must be either standard control or advanced PID control, ST must be set to OFF, and the *integral time* parameter must be set to 0.



Function

Sets the required manipulated variable to remove offset during stabilization of P or PD control.



Comment

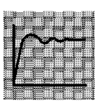
Setting Range	Unit	Default
0.0 to 100.0	%	50.0

Hysteresis (heat)

Hysteresis (cool)

Conditions of Use

The control system must be ON/OFF control.

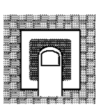


Function

Sets the hysteresis for ensuring stable operation at ON/OFF switching.

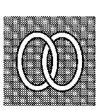
In standard control, use the *hysteresis (heat)* parameter. The *hysteresis (cool)* parameter cannot be used.

In heating and cooling control, the hysteresis can be set independently for heating and cooling. Use the hysteresis (heat) parameter to set the heating side hysteresis, and use the hysteresis (cool) parameter to set the cooling side hysteresis.



Comment

Parameter	Setting Range	Unit	Default
Hysteresis (heat)	0.01 to 99.99	%FS	0.10
Hysteresis (cool)	0.01 to 99.99	%FS	0.10



See

Related information:
Refer to *Selecting the Control Method* in Section 4.

Related parameters:
Control output 1 assignment, Control output 2 assignment (setup mode), PID/ON/OFF (expansion mode)

CP — Control period (heat)

C-CP — Control period (cool)

Conditions of Use

Relay or voltage output must be set as the outputs, and the control must be set to advanced PID control.

Function

Sets the pulse output period. Set the control period taking the control characteristics and life expectancy of the controller into consideration.

In standard control, use the *control period (heat)* parameter. The *control period (cool)* parameter cannot be used.

In heating and cooling control, the control period can be set independently for heating and cooling. Use the control period (heat) parameter to set the heating side control period, and use the control period (cool) parameter to set the cooling side control period.

Comment

Parameter	Setting Range	Unit	Default
Control period (heat)	1 to 99	Second	20
Control period (cool)	1 to 99	Second	20

See

Related information:
Refer to *Setting Output Specifications in Section 3.*

Related parameters:
Control output 1 assignment, Control output 2 assignment (setup mode)

5–5 Level 2 Mode

The parameters in this mode can be used only when the “security” parameter (protect mode) is set to **0** to **2**.

This mode contains the auxiliary parameters for adjusting control. These parameters include parameters for limiting the manipulated variable and set point, parameters for switching between remote and local operation, and parameters for setting the LBA (Loop Break Alarm), alarm hysteresis, and input digital filter values.

To select this mode when in the levels 0 and 1, setup, expansion, option and calibration modes, press the key for 1 second minimum. The display changes to the menu display. If you select [Lu-2] using the key then press the key for 1 second minimum, the controller enters the level 2 mode.

To select parameters in this mode, press the key. To change parameter settings, use the or keys.

The parameters supported in this mode are:

Symbol	Parameter Name
r-L	Remote/Local
SPrU	SP ramp time unit
SPrt	SP ramp set value
LbA	LBA detection time
mV-S	MV at stop
mV-E	MV at PV error
oL-H	MV upper limit
oL-L	MV lower limit
orL	MV change rate limit
inF	Input digital filter
ALH1	Alarm 1 hysteresis
ALH2	Alarm 2 hysteresis
ALH3	Alarm 3 hysteresis
inSH	Input shift upper limit (temperature)
inSL	Input shift lower limit (temperature)

r-L

Remote/Local

Conditions of Use
The communications function must be in use.

Function

Switches between remote and local operation.

To change the parameter setting during remote operation, use the communications function. To change the parameter setting during local operation, change the setting on the E5CK controller.

You can check the parameter setting by both communications and on the E5CK controller regardless of whether the controller is switched to remote or local operation.

Comment

Setting Range	Default
[rmt]: remote / [LCL]: local	[LCL]

SPrU

SP ramp time unit

SPrt

SP ramp set value

Conditions of Use
ST must be set to OFF.

Function

Specifies the change rate during SP ramp operation. Set the maximum permissible change width per unit of time (minute or hour) as the *SP ramp set value*. However, note that when set to **0**, the SP ramp function is disabled.

The time unit and SP ramp set value are independent of each other. For example, when setting 30 per minute, set the SP ramp set value parameter to **30** and the *SP ramp time unit* parameter to [m] (minute). However, if you change the time unit only to [H] (hour), the set time becomes 30 per hour.

During temperature input, the decimal point position of the SP ramp set value is dependent on the currently selected sensor, and during analog input on the results of scaling.

Comment

Parameter	Setting Range	Unit	Default
SP ramp time unit	[m]: minute/ [H]: hour	None	m
SP ramp set value	0 to 9999	EU	0

During temperature input, the range of the currently selected sensor is taken as the setting range for the *SP ramp set value* parameter.

See

Related information:
Refer to *Operating Condition Restrictions* in Section 4.

Related parameters:
Input type, Scaling upper limit, Scaling lower limit, Decimal point (setup mode)

LbA

LBA (Loop Break Alarm) detection time

Conditions of Use
The LBA (Loop Break Alarm) function must be assigned as an output.

Function

This parameter is automatically set by AT execution (excluding AT execution in a ON/OFF control).

The LBA is output if the change width of the process value falls below 0.2 %full-scale of the time preset to this parameter when the manipulated variable is set in the *MV upper limit* or *MV lower limit* parameters.

The LBA function is disabled when this parameter is set to “0”.

Comment

Setting Range	Unit	Default
0 to 9999	Second	0

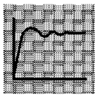
See

Related information:
Refer to *LBA* in Section 4.
How to Use Error Output in Section 7.

Related parameters:
AT Execute/Cancel (level 1 mode),
Control output 1 assignment, Control output 2 assignment, Auxiliary output 1 assignment (setup mode)

MV at stop

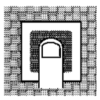
MV at PV error



Function

The *MV at stop* parameter sets the manipulated variable when operation stops.

The *MV at PV error* parameter sets the manipulated variable when an input error occurs.

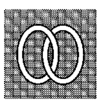


Comment

The setting ranges during standard control and heating and cooling control are different.

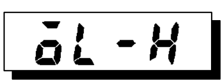
The manipulated variable at the cooling side during heating and cooling control is expressed as a negative value.

Control Method	Setting Range	Unit	Default
Standard	-5.0 to 105.0	%	0
Heating and cooling	-105.0 to 105.0	%	0



See

Related information:
MV at stop: Refer to *Starting and Stopping Operation* in Section 3.
MV at PV error: Refer to *How to Use the Error Display* in Section 7.

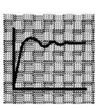


MV upper limit

MV lower limit

MV change rate limit

Conditions of Use
The control must be advanced PID control, and ST must be set to OFF.



Function

The *MV upper limit* and *MV lower limit* parameters set the upper and lower limits of the manipulated variable. When the manipulated variable calculated by the E5CK controller is outside of the upper-and lower-limit range, the upper limit or lower limit set to these parameters is output, respectively.

The *MV change rate limit* parameter sets the maximum permissible change width per second of the manipulated variable. If a change in the manipulated variable causes this parameter setting to be exceeded, the calculated value is reached while changing the value by the per-second value set in this parameter.

Comment

MV upper limit

The setting ranges during standard control and heating and cooling control are different. Also, the manipulated variable at the cooling side during heating and cooling control is expressed as a negative value.

Control Method	Setting Range	Unit	Default
Standard	MV lower limit +0.1 to 105.0	%	105.0
Heating and cooling	0.0 to 105.0	%	105.0

MV lower limit

The setting ranges during standard control and heating and cooling control are different. Also, the manipulated variable at the cooling side during heating and cooling control is expressed as a negative value.

Control Method	Setting Range	Unit	Default
Standard	-5.0 to MV upper limit -0.1	%	-5.0
Heating and cooling	-105.0 to 0.0	%	-105.0

MV change rate limit

Setting Range	Unit	Default
0.0 to 100.0	%	0.0 : OFF

See

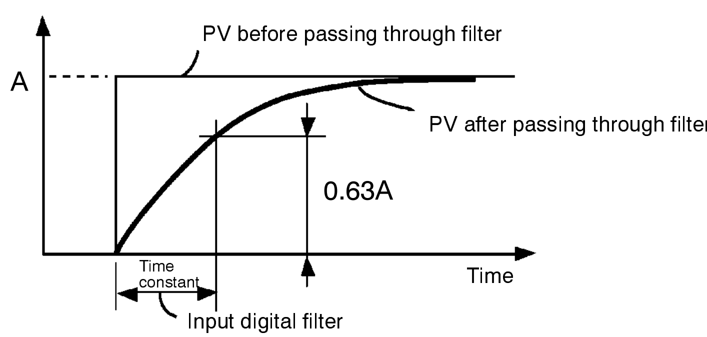
Related information:

Refer to *Operating Condition Restrictions* in Section 4.

inF Input digital filter

Function

Sets the time constant of the input digital filter. The following figures shows the effect on data after passing through the digital filter.



Comment

Setting Range	Unit	Default
0 to 9999	Second	0

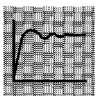
ALH1
Alarm 1 hysteresis

ALH2
Alarm 2 hysteresis

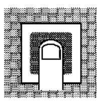
ALH3
Alarm 3 hysteresis

Conditions of Use

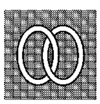
Alarms must be assigned as outputs. For example, if alarm outputs 1 and 2 only are assigned as outputs, the *alarm 3 hysteresis* parameter cannot be used.


Function

This parameter is for setting the hysteresis of alarm outputs **1** to **3**.


Comment

Setting Range	Unit	Default
0.01 to 99.99	%FS	0.02


See

Related information:
Refer to *Setting Alarm Type* in Section 3.

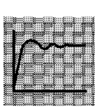
Related parameters:
Alarm 1 type, Alarm 2 type, Alarm 3 type, Alarm 1 open in alarm, Alarm 2 open in alarm, Alarm 3 open in alarm (setup mode),
Alarm value 1, Alarm value 2, Alarm value 3 (level 1 mode)

INSH
Input shift upper limit

INSL
Input shift lower limit

Conditions of Use

The input type must be set to temperature input (thermocouple or platinum resistance thermometer).


Function

Sets each of the shift amounts for the input shift upper and lower limit values.

Comment

Setting Range	Unit	Default
-199.9 to 999.9	°C or °F	0.0

See

Related information:
Refer to *Setting Input Specifications* in Section 3.

Related parameter:
Input type (setup mode)

5-6 Setup Mode

The parameters in this mode can be used only when the *security* parameter (protect mode) is set to **0** and **1**.

This mode contains the parameters for setting the basic specifications of the E5CK controller. These parameters include parameters for specifying the input type, scaling, output assignments, and direct/reverse operation.

To select this mode when in the levels 0 to 2, expansion, option and calibration modes, press the ↵ key for 1 second minimum. The display changes to the menu display. If you select [SEt] using the ▲ ▼ key then press the ↵ key for 1 second minimum, the controller enters the setup mode.

To select parameters in this mode, press the ↵ key. To change parameter settings, use the ▲ or ▼ keys.

The following table shows the parameters supported in this mode.

Symbol	Parameter Name
in-t	Input type
in-H	Scaling upper limit
in-L	Scaling lower limit
dP	Decimal point
d-U	°C/°F selection
init	Parameter initialize
oUt1	Control output 1 assignment
oUt2	Control output 2 assignment
SUb1	Auxiliary output 1 assignment
ALt1	Alarm 1 type
AL1n	Alarm 1 open in alarm

Symbol	Parameter Name
ALt2	Alarm 2 type
AL2n	Alarm 2 open in alarm
ALt3	Alarm 3 type
AL3n	Alarm 3 open in alarm
oREu	Direct/Reverse operation

in-t Input type

Function

Match the setting (software) of this parameter with the setting (hardware) of the input type jumper connector.

Set the input types to be connected to terminal Nos. 6 to 8 by the input type codes in the table below.

Comment

Set the code according to the following table. Default is **2: K1 thermocouple**.

Set value	Input Type				Jumper Position
0	JPt	-199.9 to 650.0 (°C)	/-199.9 to 999.9 (°F)	Platinum resistance thermometer	TC·PT
1	Pt	-199.9 to 650.0 (°C)	/-199.9 to 999.9 (°F)		
2	K1	-200 to 1300 (°C)	/-300 to 2300 (°F)	Thermocouple	TC·PT
3	K2	0.0 to 500.0 (°C)	/0.0 to 900.0 (°F)		
4	J1	-100 to 850 (°C)	/-100 to 1500 (°F)		
5	J2	0.0 to 400.0 (°C)	/0.0 to 750.0 (°F)		
6	T	-199.9 to 400.0 (°C)	/-199.9 to 700.0 (°F)		
7	E	0 to 600 (°C)	/0 to 1100 (°F)		
8	L1	-100 to 850 (°C)	/-100 to 1500 (°F)		
9	L2	0.0 to 400.0 (°C)	/0.0 to 750.0 (°F)		
10	U	-199.9 to 400.0 (°C)	/-199.9 to 700.0 (°F)		
11	N	-200 to 1300 (°C)	/-300 to 2300 (°F)		
12	R	0 to 1700 (°C)	/0 to 3000 (°F)		
13	S	0 to 1700 (°C)	/0 to 3000 (°F)		
14	B	100 to 1800 (°C)	/300 to 3200 (°F)		
15	W	0 to 2300 (°C)	/0 to 4100 (°F)		
16	PLII	0 to 1300 (°C)	/0 to 2300 (°F)		
17	4 to 20mA			Current input	I
18	0 to 20mA				
19	1 to 5V			Voltage input	V
20	0 to 5V				
21	0 to 10V				

See

Related information:
Refer to *Setting Input Specifications* in Section 3.

Related parameters:
When input type is set to temperature input:
°C/°F selection (setup mode)
When input type is set to voltage input or current input:
Scaling upper limit, Scaling lower limit, Decimal point (setup mode)

in-H
Scaling upper limit

in-L
Scaling lower limit

dP
Decimal point

Conditions of Use

The input type must be set to analog input (voltage or current input).

Function

This parameter can be used only when voltage input or current input is selected as the input type.

When voltage input or current input is selected as the input type, scaling is carried out. Set the scaling upper limit in the *scaling upper limit* parameter and the scaling lower limit in the s*caling lower limit* parameter.

The *decimal point* parameter specifies the decimal point position of parameters (set point, etc.) whose unit is set to EU (Engineering Unit).

Comment

Scaling upper limit, Scaling lower limit

Parameter	Setting Range	Unit	Default
Scaling upper limit	Scaling lower limit +1 to 9999	EU	100
Scaling lower limit	-1999 to scaling upper limit -1	EU	0

Decimal point: default :0

Set Value	Example
0	1234
1	123.4
2	12.34
3	1.234

See

Related information:
Refer to *Setting Input Specifications* in Section 3.

Related parameter:
Input type (setup mode)

init Parameter initialize

Function

Returns parameter settings to their defaults. However, note that the following parameters are not affected by execution of this parameter:
input type, scaling upper limit, scaling lower limit, decimal point and °C/°F selection.

Example of use

When this parameter is selected, [no] (no) is first displayed. To initialize parameters, press the [up] key to specify [YES] (“yes”).

d-u °C/°F selection

Conditions of Use
The input type must be set to temperature input (thermocouple or platinum resistance thermometer).

Function

This parameter can be used when thermocouple or platinum resistance thermometer is selected as the input type.

Set the temperature input unit to either of “°C” or “°F”.

Comment

Setting Range	Default
C : °C / F : °F	C

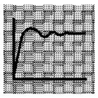
See

Related information:
Refer to *Setting Input Specifications* in Section 3.

Related parameter:
Input type (setup mode)

oUt1 Control output 1 assignment

oUt2 Control output 2 assignment



Function

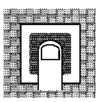
Assigns the output functions to either of control output 1 or 2.

The following six output functions can be assigned as outputs: Control output (heat), Control output (cool), Alarms 1 to 3, and LBA.

Errors 1 and 2 cannot be assigned as outputs.

When the output function assigned to control output 1 is ON, the OUT1 LED lights. However, note that the OUT1 LED does not light when control output (heat) or control output (cool) are assigned to linear outputs such as current and voltage.

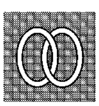
When the output function assigned to control output 2 is ON, the OUT2 LED lights.



Comment

Symbol	HEAt	CooL	AL-1	AL-2	AL-3	LbA
Function	Control output (heat)	Control output (cool)	Alarm 1	Alarm 2	Alarm 3	LBA

Defaults:
Control output 1 = [HEAt], *Control output 2* = [AL-1]

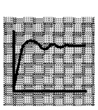


See

Related information
Refer to *Setting Output Specifications* in Section 3.

Related parameters:
Alarm-related parameters
Heating and cooling related parameter
LBA detection time (level 2 mode)

SUb1 Auxiliary output 1 assignment



Function

Assigns output functions to auxiliary output 1. The following six output functions can be assigned as outputs: Alarms 1 to 3, LBA, Error 1 (input error), and Error 2 (A/D converter error).

Control output (heat) and control output (cool) cannot be assigned as outputs.

When the output function assigned to auxiliary output 1 is ON, the SUB1 LED lights.

Comment

Symbol	AL-1	AL-2	AL-3	LbA	S.Err	E333
Function	Alarm 1	Alarm 2	Alarm 3	LBA	Error 1	Error 2

Defaults: [AL-2]

See

Related information
Refer to *Setting Output Specifications* in Section 3.

Related parameter
Alarm-related parameter. LBA detection time (level 2 mode).

ALt1
Alarm 1 type

ALt2
Alarm 2 type

ALt3
Alarm 3 type

Conditions of Use

Alarms must be assigned as outputs. For example, if alarm outputs 1 and 2 only are assigned as outputs, the *alarm 3 type* parameter cannot be used.

Function

Alarm 1 to 3 type parameters specify the operation of the alarm by the one of the set values in the following table. For details of operation at an alarm, refer to Section 3.

Comment

Set Value	Settings	Set Value	Settings
1	Upper-and lower-limit alarm (deviation)	7	Lower-limit alarm with standby sequence (deviation)
2	Upper-limit alarm (deviation)	8	Absolute-value upper-limit alarm
3	Lower-limit alarm (deviation)	9	Absolute-value lower-limit alarm
4	Upper-and lower-limit range alarm (deviation)	10	Absolute-value upper-limit alarm with standby sequence
5	Upper-and lower-limit alarm with standby sequence (deviation)	11	Absolute-value lower-limit alarm with standby sequence
6	Upper-limit alarm with standby sequence (deviation)		

Defaults: Deviation upper limit

See

Related information:
Refer to *Setting Alarm Type, in Section 3*

Related parameters:
Alarm value 1, Alarm value 2, Alarm value 3 (level 1 mode),
Alarm 1 hysteresis, Alarm 2 hysteresis, Alarm 3 hysteresis (level 2 mode),
Alarm 1 open in alarm, Alarm 2 open in alarm, Alarm 3 open in alarm, Control output 1 assignment, Control output 2 assignment (setup mode)

AL1n
Alarm 1 open in alarm

AL2n
Alarm 2 open in alarm

AL3n
Alarm 3 open in alarm

Conditions of Use

Alarms must be assigned as outputs. For example, if alarm outputs 1 and 2 only are assigned as outputs, the *alarm 3 open in alarm* parameter cannot be used.

Function

Selects the output states of alarms 1 to 3.

When the controller is set to *close in alarm*, the status of the alarm output function is output as it is. When set to *open in alarm*, the status of the alarm output function is output inverted. The following table shows the relationship between alarm output functions, output and output LEDs.

	Alarm	Output	Output LED
Close in alarm	ON	ON	Lit
	OFF	OFF	Not lit
Open in alarm	ON	OFF	Lit
	OFF	ON	Not lit

Comment

Setting Range	Default
n-o: Close in alarm/ n-c :Open in alarm	n-o

See

Related information:
Refer to *Setting Output Specifications* in Section 3.

Related parameters:
Alarm value 1, Alarm value 2, Alarm value 3 (level 1 mode),
Alarm 1 hysteresis, Alarm 2 hysteresis, Alarm 3 hysteresis (level 2 mode),
Alarm 1 open in alarm, Alarm 2 open in alarm, Alarm 3 open in alarm,
Control output 1 assignment, Control output 2 assignment (setup mode)

orEu Direct/Reverse operation

Function

Direct operation (or normal operation) refers to control where the manipulated variable is increased according to the increase in the process value. Alternatively, *reverse operation* refers to control where the manipulated variable is increased according to the decrease in the process value.

Comment

Setting Range	Default
or-r : Reverse operation/ or-d :Direct operation	or-r

See

Related information:
Refer to *Setting Output Specifications* in Section 3.

5–7 Expansion Mode

The parameters in this mode can be used only when the *security* parameter (protect mode) is set to **0** and **1**.

This mode contains the parameters for setting expanded functions. These parameters include parameters for setting ST (self-tuning), setting the SP setting limiter, selecting advanced PID and ON/OFF control, specifying the standby sequence reset method, resetting the parameters, and automatic return of display mode.

To select this mode when in the levels 0 to 2, setup, option and calibration modes, press the [↵] key for 1 second minimum. The display changes to the menu display. If you select [Eūt] using the [▲] [▼] key then press the [↵] key for 1 second minimum, the controller enters the expansion mode.

To select parameters in this mode, press the [↵] key. To change parameter settings, use the [▲] or [▼] keys.

The parameters supported in this mode are:

Symbol	Parameter Name
SL-H	SP setting upper limit
SL-L	SP setting lower limit
CntL	PID / ON/OFF
St	ST
St-b	ST stable range
ALFA	α
At-G	AT calculated gain
rESt	Standby sequence reset method
rEt	Automatic return of display mode
At-H	AT hysteresis
LbAb	LBA detection width

SL-H Set point upper limit

SL-L Set point lower limit

Function

Limits the upper and lower limits of the set point. When the set point exceeds the settings of the *Set point upper limit* and *Set point lower limit* parameters, the E5CK controller regards the settings of the Set point upper limit and Set point lower limit parameters as the set points.

When the input type is changed to temperature input, the set point upper and lower limits are changed to the upper and lower limits of the currently selected sensor. And when the input type is changed to analog input, the set point upper and lower limits are changed to the scaling upper and lower limits.

During temperature input, the decimal point position is dependent on the currently selected sensor, and during analog input on the results of scaling.

Comment

Parameter	Setting Range	Unit	Default
SP setting upper limit	SP setting lower limit +1 to scaling upper limit	EU	1300
SP setting lower limit	Scaling lower limit to SP setting upper limit -1	EU	-200

During temperature input, the range becomes the range of use of the selected sensor instead of the scaling upper and lower limit values.

See

Related information:
Refer to *Operating Condition Restrictions* in Section 4.

Related parameters:
Input type, Scaling upper limit, Scaling lower limit, Decimal point (setup mode)

CntL PID / ON/OFF

Function

Selects advanced PID control or ON/OFF control.

Comment

Setting Range	Default
PId : advance PID/ onoF :ON/OFF	PId

See

Related information:
Refer to *Selecting the Control Method* in Section 4.

Related parameters:
Hysteresis (heat), Hysteresis (cool) (level 1 mode)

St

ST

St-b

ST stable range

Conditions of Use

The input type must be set to temperature input, and the control must be either standard control or advanced PID control.

Function

When the ST parameter is set to ON, the self-tuning (ST) function is active. During operation of the ST function, the power on the load side connected to the control output must be turned ON at the same time or before start of E5CK operation.

The *ST stable range* parameter sets the stable range width during self-tuning. However, note that this parameter cannot be used when the ST parameter is set to OFF.

Comment

Parameter	Setting Range	Unit	Default
ST	oFF : ST function OFF/ on : ST function ON	None	oFF
ST stable range	0.1 to 999.9	°C or °F	15.0

See

Related information:
Refer to *Fuzzy self-tuning* in Appendix A.

Related parameters:
Input type (setup mode)
PID/ON/OFF (expansion mode)

ALFA α

Conditions of Use

The control must be advanced PID control, and ST must be set to OFF.

Function

Sets advanced PID-control parameter α.

Comment

Setting Range	Unit	Default
0.00 to 1.00	None	0.65

See

Related parameter:
PID/ON/OFF (expansion mode)

At-G AT calculated gain

Conditions of Use

The control must be advanced PID control, and ST must be set to OFF.

Function

Sets the gain when adjusting the PID parameters by auto-tuning. To give priority to response, decrease the set value of this parameter. To give priority to stability, increase the set value of this parameter.

Comment

Setting Range	Unit	Default
0.1 to 10.0	None	1.0

See

Related parameters:
AT Execute/Cancel (level 1 mode),
PID/ON/OFF (expansion mode)

rESt Standby sequence reset method

Function

Selects the conditions for enabling reset after the standby sequence of the alarm has been canceled.

Condition A:
Control started (including power ON), and set point, alarm value or input shift value changed

Condition B:
Power ON

Comment

Setting Range	Default
0: Condition A / 1: Condition B	0

See

Related parameters:
Alarm 1 type, Alarm 2 type, Alarm 3 type (setup mode)

rEt Automatic return of display mode

Function

If you do not operate any of the controller keys for the time set in this parameter when in levels 0 to 2 modes, the display automatically returns to the PV/SP display.

When this parameter is set to **0**, this function is disabled.

This parameter is invalid while the menu is displayed.

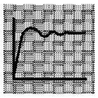
Comment

Setting Range	Unit	Default
0 to 99	Second	0

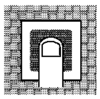
AT hysteresis

Conditions of Use

The control must be advanced PID control, and ST must be set to OFF.


Function

The levels of limit cycle operations during AT execution are given hysteresis at event ON/OFF switching. This parameter sets this hysteresis width.

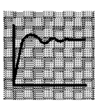

Comment

Setting Range	Unit	Default
0.1 to 9.9	%FS	0.2

LBA detection width

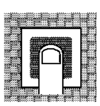
Conditions of Use

The LBA (Loop Break Alarm) function must be assigned as an output.


Function

This parameter can be used when LBA is assigned as an output.

When the change width of the manipulated variable is below the width set in this parameter, the controller regards this as detection of an LBA.


Comment

Setting Range	Unit	Default
0.0 to 999.9	%FS	0.2

5–8 Option Mode

The parameters in this mode can be used only when the s*ecurity* parameter (protect mode) is set to **0** and **1**.

You can select this mode only when the option unit is set in the controller: E53-CK01; E53-CK03; E53-CKB; E53-CKF. In this mode, you can set the communications conditions, transfer output and event input parameters to match the type of option unit set in the controller.

To select this mode when in the levels 0 to 2, setup, expansion and calibration modes, press the ↩ key for 1 second minimum. The display changes to the menu display. If you select [oPt] using the ⋀ ⋁ key then press the ↩ key for 1 second minimum, the controller enters the option mode.

To select parameters in this mode, press the ↩ key. To change parameter settings, use the ⋀ or ⋁ keys.

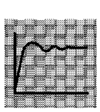
The following table shows the parameters supported in this mode.

Symbol	Parameter Name
Ev-m	Multi-SP function
Ev-1	Event input assignment 1
Sbit	Communication stop bit
LEn	Communication data length
PrtY	Communication parity
bPS	Communication baud rate
U-no	Communication unit No.
tr-t	Transfer output type
tr-H	Transfer output upper limit
tr-L	Transfer output lower limit

Ev-m Multi-SP function

Conditions of Use

The event input function must be in use.



Function

This parameter specifies the number of set points (SP) when using the multi-SP function. When set to **0**, the multi-SP function cannot be used.

Comment

Setting Range	Unit	Default
0 to 1	None	0

See

Related information:
Refer to *How to Use Option Functions* in Section 4.

Related parameter:
Event input assignment 1 (option mode)

Model

Option unit:
Event Input Unit E53-CKB

Ev-1 Event input assignment 1

Conditions of Use

Event input must be specified when the event input function is in use.

Function

This parameter specifies event input other than the multi-SP function. The following two functions can be specified: RUN/STOP and Manual/Auto.

Event input is disabled while the menu is displayed.
It is also disabled in set up, expansion, option and calibration modes.

Comment

Symbol	Function	Event Input Operation
StoP	Run/Stop	ON: Stop, ON : Run
mAn	Manual/Auto	ON: Manual, OFF : Auto

See

Related information:
Refer to *How to Use Option Functions* in Section4.

Related parameter:
Event input assignment 1 (option mode)

Model

Option unit:
Event Input Unit E53-CKB

SbIt **Communication stop bit**

LEn **Communication data length**

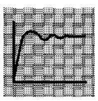
PrtY **Communication parity**

bPS **Communication baud rate**

U-no **Communication unit No.**

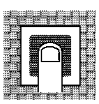
Conditions of Use

The communications function must be in use.


Function

These parameters set the communications conditions. Make sure that the stop bit, data length, parity and baud rate of the host computer and the E5CK controller are matching. These parameters are valid when the power is turned ON again or when level 0 to 2 modes are switched.

When connecting two or more E5CK controllers to the host computer, set unit Nos. that will not conflict with the unit Nos. of other controllers.


Comment

Communication stop bit parameter

Setting Range	Unit	Default
1, 2	Bits	2

Communication data length parameter

Setting Range	Unit	Default
7, 8	Bits	7

Communication parity parameter

Setting	Default
nonE : None/ EuEn :Even/ odd :Odd	EuEn

Communication baud rate parameter

Setting Range	Unit	Default
1.2, 2.4, 4.8, 9.6, 19.2	kbps	9.6

Communication unit No. parameter

Setting Range	Unit	Default
0 to 99	None	0

See

Related information:
Refer to *How to Use Option Features* in Section 4.

Related parameter:
Remote/Local (level 2 mode)

Model

Option unit:
RS-232C Unit E53-CK01, RS-485 Unit E53-CK03

tr-t **Transfer output type**

tr-H **Transfer output upper limit**

tr-L **Transfer output lower limit**

Conditions of Use
The transfer output function must be in use.

Function

These parameters set the transfer output conditions.

The *transfer output type* parameter selects one of the following as the transfer output type, and assigns this to transfer output:
Set point, Set point during SP ramp, Process value, Manipulated variable (heat), and Manipulated variable (cool).
However, note that *manipulated variable (cool)* can be selected only during heating and cooling control.

The *transfer output upper limit* and *transfer output lower limit* parameters are used for scaling of transfer output. The setting range varies according to this output data. Also, a lower limit value larger than the upper limit value may be set.

During temperature input, the decimal point position of the set point, set point during SP ramp or process value is dependent on the currently selected sensor, and during analog input on the results of scaling.

Comment

Transfer Type		Transfer Output Lower Limit to Transfer Output Upper Limit
SP	Set point	Set point lower limit value to Set point upper limit value
SP-m	Set point during SP ramp	Set point lower limit value to Set point upper limit value

Transfer Type		Transfer Output Lower Limit to Transfer Output Upper Limit
Pv	Process value	Scaling lower limit to scaling upper limit
o	Manipulated variable (heat)	-5.0% to 105.0%
C-o	Manipulated variable (cool)	0.0% to 105.0%

The output ranges of the set point, set point during SP ramp or process value when temperature input is selected are the ranges supported by the selected sensor.

When you have selected the *manipulated variable (heat)* parameter, the transfer output lower limit during heating and cooling control becomes **0.0**.

See

Related information:
Refer to *How to Use Option Functions* in Section 4.

Model

Option unit:
Transfer Output Option Board E53-CKF

5-9 Calibration Mode

The parameters in this mode can be used only when the *security* parameter (protect mode) is set to **0**. When selecting this mode for the first time after the E5CK has left the factory, return the security parameter to **0**.

This mode contains the parameters for user calibration of inputs and outputs. Only parameters relating to input types specified in the *input type* parameter (setup mode) can be used. Also, related output parameters can be used only when the Transfer Output Option Board E53-CKF is added on.

To select this mode when in the levels 0 to 2, setup, expansion and option modes, press the key for 1 second minimum. The display changes to the menu display. If you select [CLb] using the key then press the key for 1 second minimum, the controller enters the calibration mode.

For details on parameters in the calibration mode, refer to *Calibration* in Section 4.

SECTION 6
Using the Communications Function

This section explains communications with a host computer and communications commands.

6–1 Outline of the Communications Function

6–1–1 Outline

The communications function allows you to monitor and set E5CK parameters by a program prepared and running on a host computer connected to the E5CK controller. This chapter describes operations as viewed from the host computer.

When using the communications function, the option unit for RS-232C or RS-485 communications must be added on. The E5CK communications function allows you to:

- Read/write parameters
- Do operating instructions
- Selecting the setting level

The communications function assumes the following conditions:

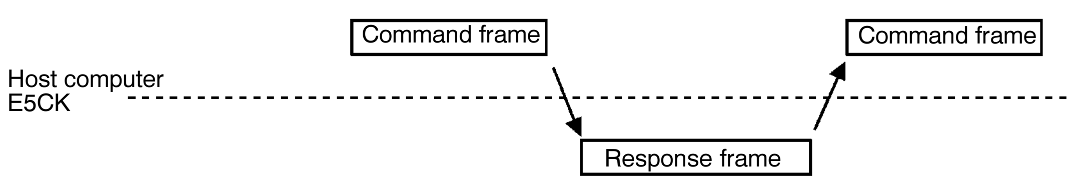
- Writing of parameters is possible in during remote operation. Also, parameters cannot be written during execution of auto-tuning;
- Writing parameters are provided with a setting level. Writing conditions are as follows depending on the setting level:
  Setting level 1: No restrictions
  Setting level 0: Writing of parameters in the setup and expansion modes only is prohibited.

For details on switching between setting levels. refer to Issuing Special Commands, within Section 6-4-1.

The *RUN/STOP*, *remote/loca*l and *AT execute/cancel* parameters are set aside from other parameters as special commands for instructing operations.

6–1–2 Transfer Procedure

The host computer sends a *command frame* to the controller, and the controller returns a *response frame* corresponding to the content of the command sent by the host computer. In other words, a response frame is returned for each command frame sent.
The following diagram shows command frame/response frame operations.



6–1–3 Interface

The host computer carries out communications conforming to the RS-232C or RS-485 interface specifications. Option units supporting the RS-232C and RS-485 specifications are as follows:

- Option units
  E53-CK01 (RS-232C)
  E53-CK03 (RS-485)

6–2 Preparing for Communications

For details on wiring when using the communications, see Chapter 2 Preparations.

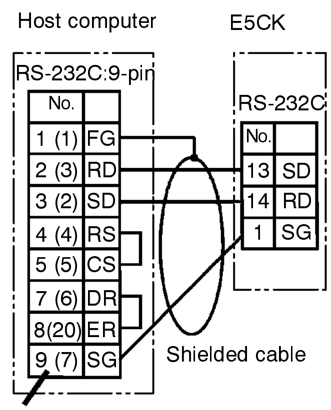
6–2–1 Cable Connections

RS-232C

Only one controller can be connected to the host computer.

The cable length should not exceed 15 meters.

Use shielded twisted-pair cables (AWG28 or more) for the cables.



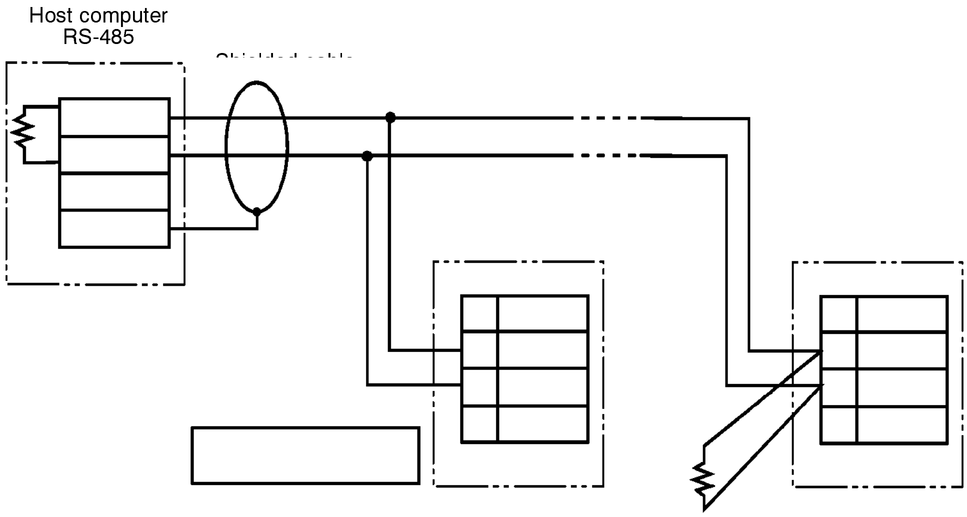
Figures in parentheses "( )" shows No. for 25–pin connector.

RS-485

Up to 32 controllers, including a computer, can be connected to the host computer.

The total cable length should not exceed 500 meters. Use shielded twisted-pair cables (AWG28 or more) for the cables.

Attach terminators to the controllers at both ends of a series of controllers connected in an open configuration. For example, in the above configuration, connect the terminator to the host unit and the unit No.30, and do not connect terminators to unit Nos.0 to 29. Use terminators having a resistance of 120Ω (1/2 W). The total resistance of both ends should be at least 54Ω .



6–2–2 Setting the Communications Specifications

Match the communications specifications of the host computer and E5CK controller. When two or more controllers are connected to the host computer, make sure that the communications specifications of all controllers are the same.

This section describes how to set the communications specifications of the E5CK controller. For details on the host computer, see the relevant manual supplied with the host computer.

Communications Parameters

Set the communications specifications of the E5CK in the controller's communications parameters. The communications parameters are set on the front panel of the E5CK controller.

The following table shows the communications parameters provided on the E5CK controller and their respective settings.

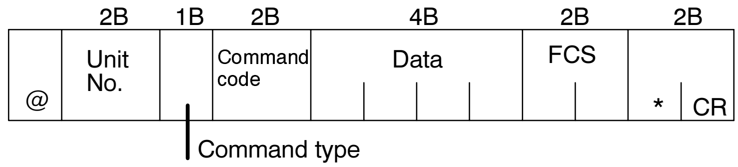
Parameter/Symbol		Setting	Set Value
Unit No.	U-no	0 to 99	[illegible] to 99
Baud rate	bPS	1.2/2.4/4.8/9.6/19.2 (kbps)	1.2/2.4/4[illegible] /19.2
Bit length	LEn	7/8 (bit)	[illegible] /8
Parity	PrtY	None/even/odd	nonE / EuEn odd
Stop bit	Sbit	1/2	[illegible] 1/

Inverted items are factory-settings.

6–3 Command Configuration

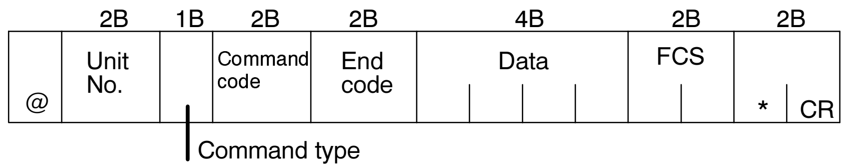
Command configuration is as follows:

Command



Response

Command configuration – paired with a response:



"@"
The start character. This character must be inserted before the leading byte.

Unit No.
Specifies the "unit No." of the E5CK. If there are two or more transmission destinations, specify the desired destination using "unit No."

Command type
Specifies the command type by codes "1" to "3": parameter read, parameter write and special commands.

Command code
Specifies the command for each command type. With parameter read/write commands, this becomes the parameter No.

Data
Specifies the set value or setting content. In the parameter read command, set dummy data "0000". In the response, this is inserted only when the end code is "00".

End code
Sets the communication results. For details on the types and meanings of end codes, see 6.5 How to Read Communications Error Information (page 6-10).

FCS (Frame Check Sequence)
Set the frame check results from the start character to the data section. For details on the frame check, see 6.6 Program Example (page 6-12).

"*" "CR (Carriage Return) code"
Indicates the end (terminator) of the command or response block.

6–4 Commands and Responses

This section describes commands and response in detail. The conventions used in this section and data restrictions are as follows:

1, 2, 3...
1. Data is expressed in 1-byte units and in ASCII code.
2. When the read or write data is a numerical value, the data to be set must conform to these conditions:

- The decimal point [.] is not indicated in fractions.
- The leftmost bit of minus numerical data must be expressed as given in this example:
  10.0=[0100], -150.0=[A500], -15=[F015]

6–4–1 Reading/Writing Parameters

Reading parameters

Command

	2B		2B	4B	2B	2B
@	Unit No.	1	Parameter No.	X X X X	FCS	* CR

X: Any value acceptable

Response

	2B		2B	2B	4B	2B	2B
@	Unit No.	1	Parameter No.	End code	Read data	FCS	* CR

Writing parameters

Command

	2B		2B	4B	2B	2B
@	Unit No.	2	Parameter No.	Write data	FCS	* CR

Response

	2B		2B	2B	4B	2B	2B
@	Unit No.	2	Parameter No.	End code	Write data	FCS	* CR

Reading or writing of the parameters of a specified controller is executed.

- Writing is possible only during remote operation.
- Reading is impossible during executing auto-tuning.
- The following are set aside as special commands.

  RUN/STOP

  remote/local

  AT execute/cancel

Writing the Set Value

With X format "MA" and "ME" commands (see Appendix), you can select non-volatile RAM or RAM as the memory for the set value. The limit for the number of times that non-volatile RAM can be written to is 100,000 times. When the number of times that the set point is written exceeds this limit, set RAM write mode as the memory.

Parameter No.	Parameter	Data Setting and Monitor Range	Mode
00	PV monitor (see note *1)	Scaling lower limit -10% to scaling upper limit +10% (see note *2)	Level 0
86	SP monitor during SP ramp (see note *1)	Set point lower limit to set point upper limit	
04	MV monitor (heat) (see note *1)	–5.0 to 105.0 (see note *3)	
42	MV monitor (cool) (see note *1)	0.0 to 105.0	
01	Set point	Set point lower limit to set point upper limit	
02	Alarm value 1	–1999 to 9999	Level 1
03	Alarm value 2	–1999 to 9999	
41	Alarm value 3	–1999 to 9999	
19	Proportional band	0.1 to 999.9	
20	Integral time	0 to 3999	
21	Derivative time	0 to 3999	
22	Cooling coefficient	0.01 to 99.99	
09	Dead band	–19.99 to 99.99	
23	Manual reset value	0.0 to 100.0	
06	Hysteresis (heat)	0.01 to 99.99	
43	Hysteresis (cool)	0.01 to 99.99	
07	Control period (heat)	1 to 99	
08	Control period (cool)	1 to 99	
44	SP ramp time unit	0: Minutes, 1: Hours	Level 2
45	SP ramp set value	0 to 9999	
46	LBA detection time	0 to 9999	
47	MV at stop	–5.0 to 105.0 (see note *4)	
48	MV at PV error	–5.0 to 105.0 (see note *4)	
50	MV upper limit	MV lower limit +0.1 to 105.0	
49	MV lower limit	–5.0 to MV upper limit –0.1 (see note *5)	
51	MV change rate limit	0.0 to 100.0	
56	Input digital filter	0 to 9999	
25	Alarm 1 hysteresis	0.01 to 99.99	
26	Alarm 2 hysteresis	0.01 to 99.99	
52	Alarm 3 hysteresis	0.01 to 99.99	
53	Input shift upper limit	–999.9 to 999.9	
54	Input shift lower limit	–999.9 to 999.9	

*1 Possible only during reading

*2 During temperature input, the range becomes the range of use of the selected sensor.

*3 During heating and cooling control, the range becomes 0.0 to 105.0.

*4 During heating and cooling control, the range becomes -105.0 to 105.0.

*5 During heating and cooling control, the range becomes -105.0 to MV upper limit -0.1.

About invalid parameters

Currently, if a command is used for invalid parameters (parameters that do not satisfy the conditions of use in Section 5), the "undefined" error (end code: 1C) is output.

Parameter No.	Parameter	Data Setting Range	Mode
57	Input type	0 to 21 (see note *1)	Setup
59	Scaling upper limit	Scaling lower limit +1 to 9999	
58	Scaling lower limit	–1999 to scaling upper limit –1	
60	Decimal point	0 to 3	
30	°C/°F selection	0 : °C, 1 : °F	
61	Control output 1 assignment	0 to 4, 6 (see note *2)	
62	Control output 2 assignment	0 to 4, 6 (see note *2)	
63	Auxiliary output 1 assignment	2 to 4, 6 to 8 (see note *3)	
65	Alarm 1 type	1 to 11 (see note *4)	
66	Alarm 1 open in alarm	0: closed in alarm, 1: open in alarm	
67	Alarm 2 type	1 to 11 (see note *4)	
68	Alarm 2 open in alarm	0: closed in alarm, 1: open in alarm	
69	Alarm 3 type	1 to 11 (see note *4)	
70	Alarm 3 open in alarm	0: closed in alarm, 1: open in alarm	
71	Direct/Reverse operation	0: Reverse operation, 1: Direct operation	
28	Set point upper limit (see note *5)	Set point lower limit +1 to scaling upper limit	
27	Set point lower limit (see note *5)	Scaling lower limit to Set point upper limit –1	Expansion
72	PID / ON/OFF	0: Advanced PID, 1: ON/OFF	
73	ST	0 : OFF, 1 : ON	
34	ST stable range width	0.1 to 999.9	
35	α	0.00 to 1.00	
85	AT calculated gain	0.1 to 10.0	
37	Standby sequence reset method	0, 1 (see note *6)	
36	Automatic return of display mode	0 to 99	
93	AT hysteresis	0.1 to 9.9	
55	LBA detection width	0.0 to 999.9	

*1 See Section 5.
*2 0: Control output (heat), 1: Control output (cool), 2: Alarm 1, 3: Alarm 2, 4: Alarm 3, 6: LBA.
*3 2: Alarm 1, 3: Alarm 2, 4: Alarm 3, 6: LBA, 7: Error 1, 8: Error 2
*4 See Section 5.
*5 During temperature input, the range becomes the range of use of the selected sensor.
*6 See Section 5.

Reading the status

To read the E5CK controller status, use the X format “RX” command. For details, see X Format Head List in the Appendix.

Issuing Special Commands

Command

	2B		2B	4B	2B	2B
@	Unit No.	3	Command code	Instruction code	FCS	* CR

X: Any value acceptable

Response

	2B		2B	2B	4B	2B	2B
@	Unit No.	3	Command code	End code	Instruction code	FCS	* CR

The following functions are issued as special commands.

Run/Stop
Runs or stops programs. This command cannot be issued in setting level 1.

Remote/Local
Selects remote operation or local operation.

AT Execute/Cancel
Executes or cancels auto-tuning. This command cannot be issued in setting level 1.

Move to setting level 1
Issue this command when writing parameters in setup and expansion modes.

Software reset
A response is not returned to this command. Also, communications with the E5CK cannot be carried out for five seconds after reset.

These special commands are available on the E5CK controller:

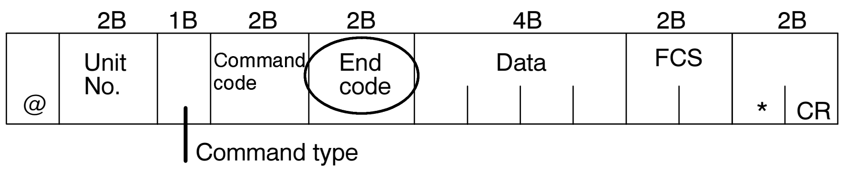
Command No.	Command	Instruction Code
00	Run/Stop	0000: Run, 0001: Stop
02	Remote/Local	0000: Local, 0001: Remote
07	AT Execute/Cancel	0000: Cancel, 0001: 40%AT execution, 0002: 100% AT execution
09	Move to setting level 1	0000
11	Software reset	0000

About Setting Levels

To return to setting level 0 from setting level 1, issue the software reset command. If the parameter write command is issued for the setup and expansion modes in setting level 0, an error occurs, and the end code (OD = Command cannot be executed) is returned.

6-5 How to Read Communications Error Information

The result of communications on the E5CK can be checked by the end code in the response frame. Use this end code to remedy errors that may occur.



End code	00	Code name	Normal end

Description

Communications ended normally without a transmission error or any other error being generated.

End code	0D	Code name	Command cannot be executed

Description

Writing was carried out during local operation.

Writing was carried out during executing auto-tuning.

An attempt was made to execute 40% AT during heating and cooling control.

An attempt was made to switch run/stop in setting level 1.

An attempt was made to execute AT in setting level 1.

Action

Issue the parameter read or write commands in conditions other than above.

End code	10	Code name	Parity error

Description

Parity check error was detected in the received data.

Action

Check the communications condition. If the communications condition of the host computer and E5CK controller match, then a probable cause is a problem in the communications circuit of one or both of the host computer and E5CK controller.

End code	11	Code name	Framing error

Description

Stop bit cannot be detected.

Action

Check the communications condition. If the communications condition of the host computer and E5CK controller match, then a probable cause is a problem in the communications circuit of one or both of the host computer and E5CK controller.

About the Unit No. *Responses are not returned unless the target unit for communications and the unit No. in the command match.*

End code	12	Code name	Overrun error

Description

The receive buffer overflowed.

Action

Check the communications condition. If the communications condition of the host computer and E5CK controller match, then a probable cause is a problem in the communications circuit of one or both of the host computer and E5CK controller.

End code	13	Code name	FCS error

Description

The FCS (Frame Check Sequence) do not match.

Action

Check the FCS program.

End code	14	Code name	Format error

Description

The received command length does not match the length defined in the frame format.

Description
Action

Check the communications condition. If the communications condition of the host computer and E5CK controller match, then a probable cause is a problem in the communications circuit of one or both of the host computer and E5CK controller.

End code	15	Code name	Setting range error

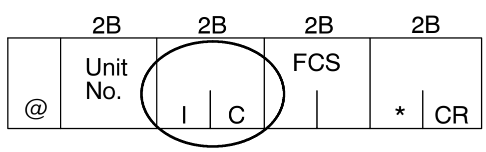
Description

Numerical values or code values in the data are not within the setting range.

Action

Check the parameter and read or write data of special commands.

Undefined Error



Description

An undefined header code has been received.

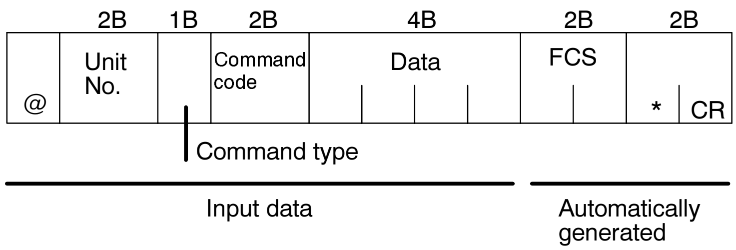
A currently invalid parameter (e.g. the scaling command during temperature input) has been received.

Action Check the parameter No.

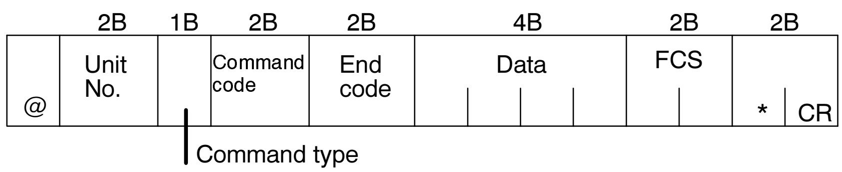
6-6 Program Example

6-6-1 How to Use Programs

The program described below is for obtaining corresponding response frame data when some of the command frame data is input.
The input format is as follows. The FCS and terminator are automatically generated and need not be input.



The output format is as follows. The content of the response frame is displayed as it is.



Procedure

1, 2, 3...
1. Read the program.
2. Enter *RUN*.
3. When *send data*: is displayed, enter the command data (from @ to the command string).
4. The content of the response frame is displayed following *receive data:*.

Conditions When Running a Program

Set the communications condition as follows:

- Baud rate: 9600 bps
- Bit length: 7 bits
- Parity : Even
- Stop bit: 2
- Make sure that the communications cable is properly connected.

6–6–2 Program List (Language: IBM PC COMPATIBLE MACHINE)

```
1000 ' ---------------------------------------------------------------------------------------
1010 ' PROGRAM : E5CK Communication Program
1020 ' ----------------------- For IBM PC COMPATIBLE MACHINE
1030 ' VERSION  :  1.00
1040 ' Copyright (C) 1995 OMRON Corporation All Rights Reserved.
1050 ' ---------------------------------------------------------------------------------------
1060 ' ----- RS-232C SPEED: 9600BPS, PARITY: EVEN, DATA: 7, STOP: 2 ---------------------------
1070  OPEN "COM: 9600, E, 7, 2, CD0, CS0, DS0, RB256, RS "FOR RANDAM AS #1 LEN=256
1080  REPEAT
1090 ' ----------- Make Command
1100  PRINT "send data : " ;
1110  INPUT SEND$
1110 ' ----------- FCS calculation -----------------------------------------------------------
1130  FCS=0
1140  FOR IFCS=1 TO LEN (SEND$)
1150  FCS=FCS XOR ASC (MID$ (SEND$, IFCS, 1))
1160  NEXT
1170  FCS$=RIGHT$ ("0"+HEX$ (FCS), 2)
1180 ' ----- Send data to communication port -----------------------------------------------
1190  PRINT #1, SEND$+FCS$+"*"
1200 ' ----- Receive data from communication port ------------------------------------------
1210  RECCNT=0: TMP$=""
1220  DRECLOOP:
1230  IF LOC (1) <> 0 THEN DREC1
1240  RECCNT=RECCNT+1
1250  IF RECCNT=5000 THEN *DRECERR ELSE DRECLOOP
1260  'DREC1
1270  TMP$=TMP$+INPUT$ (LOC (1), #1)
1280  IF RIGHT$ (TMP&, 1)=CHR$ (13) THEN DRECEND
-----    ELSE RECCNT=0: GOTO DRECLOOP
1290  DRECERR:
1300  TMP$="No response !!"
1310  DRECEND:
1320  RECV$=TMP$
1330  PRINT "response: "; RECV$
1340 ' ----- Repeat to make Command --------------------------------------------------------
1350  GOTO REPEAT
1360 ' ----- END ---------------------------------------------------------------------------
1370  CLOSE #1
1380  END
```

6–6–3 Examples of Use

Set the Unit No. to "00"

- In the following examples, data is shown in individual blocks to make the examples easier to understand. However, when actually creating programs, do not leave spaces between frame items. Also, response are displayed without spaces between frame items.

Set the Set Point to "300.0"

- Input data

@ 00 2 01 3000

- 3000: 300.0
- 01: Set point
- 2: Write parameter

- Response

@ 00 2 01 00 3000 (FCS) *

- 00: Normal end

Start Running

- Input data

@ 00 3 00 0000

- 0000: Run
- 00: Run/Stop
- 3: Special command

- Response

@ 00 3 00 00 0000 (FCS) *

- 00: Normal end

Monitor Process Value

- Input data

@ 00 1 00 0000

- 0000: Dummy data
- 00: Monitor process value
- 1: Read parameter

- Response

@ 00 1 00 00 2000 (FCS) *

- 2000: Process value = 2000
- 00: Normal end

SECTION 7
Troubleshooting

This section explains how to determine and remedy E5CK troubleshooting problems.

7-1 Initial Checks

If trouble occurs, first of all check the following.

1, 2, 3...
1. **Power supply**
   Make sure that the power supply is ON. Also, make sure that the power supply is within the rated voltage range.
2. **Input type jumper connectors**
   Make sure that the jumper connectors are at their correct positions. The following table shows the operations when the jumper connector positions do not match the input type parameter settings.

Jumper Connector	Parameter	Operation
TC • PT	Current (0 to 20mA)	Fixed at scaling lower limit value
	Current (4 to 20mA)	S.Err
	Voltage (0 to 10V, 0 to 5V)	Fixed at scaling lower limit value
	Voltage (1 to 5V)	S.Err
I	Temperature input	S.Err
	Voltage (0 to 10V, 0 to 5V)	Fixed at scaling lower limit value
	Voltage (1 to 5V)	S.Err
V	Temperature input	S.Err
	Current (0 to 20mA)	Fixed at scaling lower limit value
	Current (4 to 20mA)	S.Err

3. **Wiring**
   Make sure that all cables are properly connected.
4. **Communications condition**
   When communicating using the RS-232C or RS-485 communications interfaces, make sure that the baud rate and other communications condition settings on the host computer and E5CK controller are matching, and are within the permissible ranges.

If there appears to be nothing wrong after checking the E5CK controller, and the same phenomenon continues, check the controller in more detail, for example, on the error display.

7-2 How to Use Error Display

When an error has occurred, the No.1 display alternately indicates error codes together with the current display item.
This section describes how to check error codes on the display, and the actions you must be taken to remedy the problem.

S.Err Input error

Meaning

Input is in error.

Action

Check the wiring of inputs, disconnections, and shorts, and check the input type and the input type jumper connector.

Operation at error

For control output functions, output the manipulated variable matched to the setting of the *MV at PV error* parameter (level 2 mode). Alarm output functions are activated when the upper limit is exceeded.

E111 Memory error

Meaning

Internal memory operation is in error.

Action

First, turn the power OFF then back ON again. If the display remains the same, the E5CK controller must be repaired. If the display is restored to normal, then a probable cause can be external noise affecting the control system. Check for external noise.

Operation at error

Control output functions turn OFF (2mA max. at 4 to 20mA output, and output equivalent to 0% in case of other outputs). Alarm output functions turn OFF.

E333 A/D converter error

Meaning

Internal circuits are in error.

Action

First, turn the power OFF then back ON again. If the display remains the same, the E5CK controller must be repaired. If the display is restored to normal, then a probable cause can be external noise affecting the control system. Check for external noise.

Operation at error

Control output functions turn OFF (2mA max. at 4 to 20mA output, and output equivalent to 0% in case of other outputs). Alarm output functions turn OFF.

A.Err Calibration data error

This error is output only during temperature input, and is displayed for two seconds when the power is turned ON.

Meaning

Calibration data is in error.

Action

Must repair.

Operation at error

Both control output functions and alarm output functions operate. However, note that readout accuracy is not assured.

cccc / ɔɔɔɔ Display range over

Meaning

Though not an error, this is displayed when the process value exceeds the display range when the control range (setting range ±10%) is larger than the display range (–1999 to 9999).

- When less than **-1999** [cccc]
- When greater than **9999** [ɔɔɔɔ]

Operation

Control continues, allowing normal operation.

ɔɔɔ Overflow error

When shown on the Temp Controller’s display, this signifies an “overflow” error. The user’s system temperature has risen above the maximum display scale range. Check the thermocouple or output device. Also perform the “bare wire test.” Remove the thermocouple sensor and apply a bare wire jumper/short between the two terminals. If the temperature controller displays the existing ambient temperature, the controller is fine. If not, the controller has malfunctioned, and a replacement is needed.

7–3 How to Use Error Output

The E5CK controller allows you to assign error output to terminals as outputs.
For details on output assignments, see Setting Output Specifications in Section 3.

LBA

LBA (Loop Break Alarm) can be used as a means for detecting loop breaks when the control loop is not functioning normally. For details, see Section 4.

LBA allows you to detect the following errors:

- Heater burnout
- Output error (contact weld, damaged transistors, etc.)
- Sensor error (constant input values, etc.)

If you use the LBA function, set the loop break detection time matched to the control characteristics in the *LBA detection time* parameter (level 2 mode).

Input errors

If you assign error 1 as the output, an error can be output when input is in error. When this error occurs, remedy by following the description for *Input error* in this section.

A/D converter error

If you assign error 2 as the output, an error can be output when the A/D converter is in error. When this error occurs, remedy by following the description for *A/D converter error* in this section.

7-4 Checking Operation Restrictions

With the E5CK controller, auto-tuning or self-tuning sometimes do not operate depending on the way functions are combined. The table below summarizes the main operating restrictions.
If the E5CK controller is not operating properly, first check whether operating conditions violate the restrictions in this table.

Restriction	Inoperable or Invalid Functions			
	ST Execution	AT Execution	Limiter Function	Other
At analog input	×			
At heating and cooling control	×	Not possible only with 40%AT		
At ON/OFF control	×	×	Manipulated variable MV change rate	
ST = ON	–	×	Manipulated variable MV change rate	SP ramp function
At AT execution	–	–	MV change rate	Parameter setting
At stop	×	×	Manipulated variable MV change rate	

Note: Items marked by a **X** indicates combinations of conditions not acceptable during ST or AT execution.
Items marked by **–** are impossible combinations.

APPENDIX

Specifications

Ratings

Supply Voltage	AC100−240V, 50/60 Hz
Operating Voltage Range	85% to 110% of rated supply voltage
Power Consumption	Approx. 15VA
Input	Thermocouple : K, J, T, E, L, U, N, R, S, B, W, PLII *1, *2 Platinum resistance thermometer : JPt100, Pt100 Voltage input : 4 to 20mA, 0 to 20mA Current input : 1 to 5V, 0 to 5V, 1 to 10V
Control Output	According to output unit (see *Output Unit Ratings and Characteristics*)
Auxiliary Output	SPST-NO, 1A at 250 VAC (resistive load)
Control Method	Advanced PID or ON/OFF control
Setting Method	Digital setting using front panel keys
Indication Method	7-segment digital display and LEDs
Other Functions	According to option unit (see *Option Unit Ratings and Characteristics*)
Ambient Temperature	Operating : -10°C to 55°C (with no icing)/3-year warranty period: -10°C to 50°C Storage : -25°C to 65°C (with no icing)
Ambient Humidity	35% to 85% RH

*1 Thermocouple W is W/Re5-26.
*2 The following table shows the setting ranges and indication ranges for each of the inputs.

Setting No.	Input*	Setting Range	Indication Range
0	JPt100	−199.9 to 650.0(°C) /−199.9 to 999.9(°F)	−199.9 to 735.0(°C) /−199.9 to 999.9(°F)
1	Pt100	−199.9 to 650.0(°C) /−199.9 to 999.9(°F)	−199.9 to 735.0(°C) /−199.9 to 999.9(°F)
2	K1	−200 to 1300(°C) /−300 to 2300(°F)	−350 to 1450(°C) /−560 to 2560(°F)
3	K2	0.0 to 500.0(°C) /0.0 to 900.0(°F)	−50.0 to 550.0(°C) /−90.0 to 990.0(°F)
4	J1	−100 to 850(°C) /−100 to 1500(°F)	−195 to 945(°C) /−260 to 1660(°F)
5	J2	0.0 to 400.0(°C) /0.0 to 750.0(°F)	−40.0 to 440.0(°C) /−75.0 to 825.0(°F)
6	T	−199.9 to 400.0(°C) /−199.9 to 700.0(°F)	−199.9 to 460.0(°C) /−199.9 to 790.0(°F)
7	E	0 to 600(°C) /0 to 1100(°F)	−60 to 660(°C) /−110 to 1210(°F)
8	L1	−100 to 850(°C) /−100 to 1500(°F)	−195 to 945(°C) /−260 to 1660(°F)
9	L2	0.0 to 400.0(°C) /0.0 to 750.0(°F)	−40.0 to 440.0(°C) /−75.0 to 825.0(°F)
10	U	−199.9 to 400.0(°C) /−199.9 to 700.0(°F)	−199.9 to 460.0(°C) /−199.9 to 790.0(°F)
11	N	−200 to 1300(°C) /−300 to 2300(°F)	−350 to 1450(°C) /−560 to 2560(°F)
12	R	0 to 1700(°C) /0 to 3000(°F)	−170 to 1870(°C) /−300 to 3300(°F)
13	S	0 to 1700(°C) /0 to 3000(°F)	−170 to 1870(°C) /−300 to 3300(°F)
14	B	100 to 1800(°C) /300 to 3200(°F)	−70 to 1970(°C) /10 to 3490(°F)
15	W	0 to 2300(°C) /0 to 4100(°F)	−230 to 2530(°C) /−410 to 4510(°F)
16	PLII	0 to 1300(°C) /0 to 2300(°F)	−130 to 1430(°C) /−230 to 2530(°F)
17 18 19 20 21	4 to 20mA 0 to 20mA 1 to 5V 0 to 5V 0 to 10V	One of following ranges depending on results of scaling and decimal pt. selection. −1999 to 9999 −199.9 to 999.9 −19.99 to 99.99 −1.999 to 9.999	-10 to 110% of setting range. Note, however that max. value is -1999 to 9999

*Grounded

Characteristics

Indication Accuracy		Thermocouple: (0.3% of indication value or 1°C, whichever greater) 1 digit max. (*1) Platinum resistance thermometer: (0.2% of indication value or 0.8°C whichever greater) 1 digit max. Analog input: 0.2% 1 digit max.
Hysteresis		0.01 to 99.99%FS (in units of 0.1%FS)
Proportional Band (P)		0.1 to 999.9% FS (in units of 0.1%FS)
Integral (reset) Time (I)		0 to 3999 s (in units of 1 second)
Derivative (rate) Time (D)		0 to 3999 s (in units of 1 second)
Control Period		1 to 99 s (in units of 1 second)
Manual Reset Value		0.0 to 100.0% (in units of 0.1%)
Alarm Setting Range		-1999 to 9999 or -199.9 to 999.9 (decimal point position dependent on input type)
Sampling Period		Temperature input: 250 ms, Analog input: 100 ms
Insulation Resistance		20 MΩ min. (at 500 VDC)
Dielectric Strength		2000 VAC, 50/60Hz for 1 min (between terminals of different polarities)
Vibration Resistance	Malfunction	10 to 55 Hz, 10 m/s^2 (1G) for 10 min each in X, Y, and Z directions
	Mechanical	10 to 55 Hz, 20 m/s^2 (2G) for 2hrs each in X, Y, and Z directions
Shock Resistance	Malfunction	200 m/s^2 min. (20G), 3 times each in 6 directions (100 m/s^2 (10G) applied to the relay)
	Mechanical	300 m/s^2 min. (30G), 3 times each in 6 directions
Weight		Approx. 170 g, adapter: approx. 10 g
Enclosure Ratings		Front panel: NEMA4 for indoor use (equivalent to IP66) Rear case: IEC standard IP20 Terminals: IEC standard IP00
Memory Protection		Non-volatile memory (Write operation : 100000 max.)

*1 The indication accuracy of the K1, T, and N thermocouples at a temperature of -100°C or less is ±2°C ±1 digit maximum. The indication accuracy of the U, L1 and L2 thermocouples at any temperature is ±2°C ±1 digit maximum.
The indication accuracy of the B thermocouple at a temperature of 400°C or less is unrestricted.
The indication accuracy of the R and S thermocouples at a temperature of 200°C or less is ±3°C ±1 digit maximum.
The indication accuracy of the W thermocouple is ±1 digit max. of whichever is the greater of ±0.3% or ±3°C of the indicated value.
The indication accuracy of the PLII thermocouple is ±1 digit max. of whichever is the greater of ±0.3% or ±2°C of the indicated value.

Output Unit Ratings and Characteristics

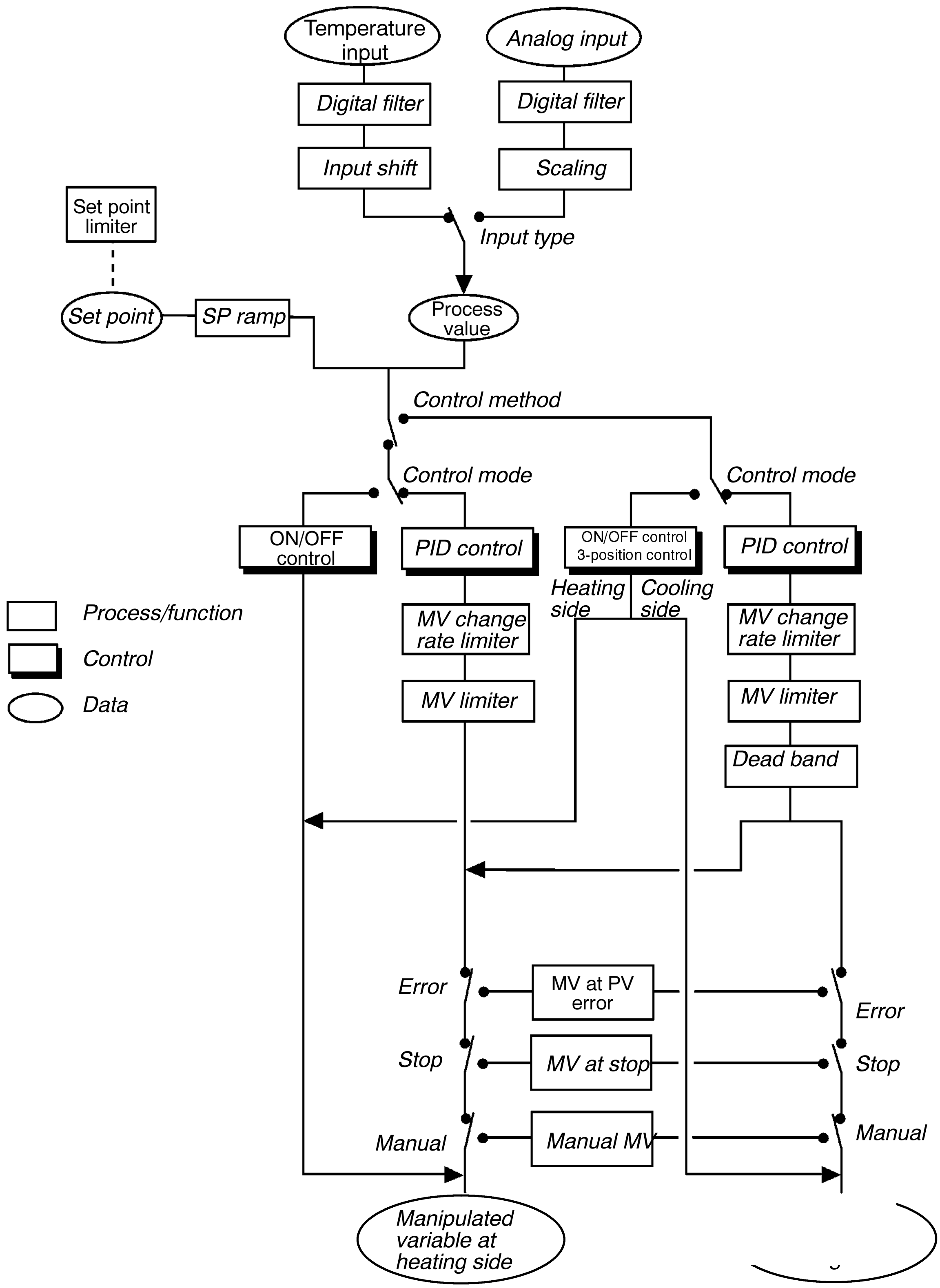
Relay output*	SPST, 250 VAC, 3A (resistive load) Mechanical life expectancy: 10,000,000 operations min Electrical life expectancy: 100,000 operations min
Voltage Output (NPN)	NPN, 12 VDC, 20 mA (with short-circuit protection)
Voltage Output (PNP)	PNP, 12 VDC, 20 mA (with short-circuit protection)
Linear Voltage Output	0 to 10 VDC, Permissible load impedance: 1 kΩ min., Resolution: Approx. 2600
Linear Current Output	4 to 20 mA, Permissible load impedance: 500 Ω max., Resolution: Approx. 2600
	0 to 20 mA, Permissible load impedance: 500 Ω max., Resolution: Approx. 2600

*If a relay output is used, the Control Period should not be less than 5 seconds.

Option Unit Ratings and Characteristics

Event inputs	Contact input	ON: 1 kΩ max., OFF: 100 kΩ min.
	No-contact input	ON: residual voltage 1.5 V max., OFF: leakage current 0.1 mA max.
Communications	Interface :RS-232C or RS-485 Transmission method :Half-duplex Synchronization method :Start-stop synchronization (asynchronous method) Baud rate :1.2/2.4/4.8/9.6/19.2 kbps	
Transfer output	4 to 20 mA, Permissible load impedance: 500 Ω max. Resolution: Approx. 2600	

Control Block Diagram

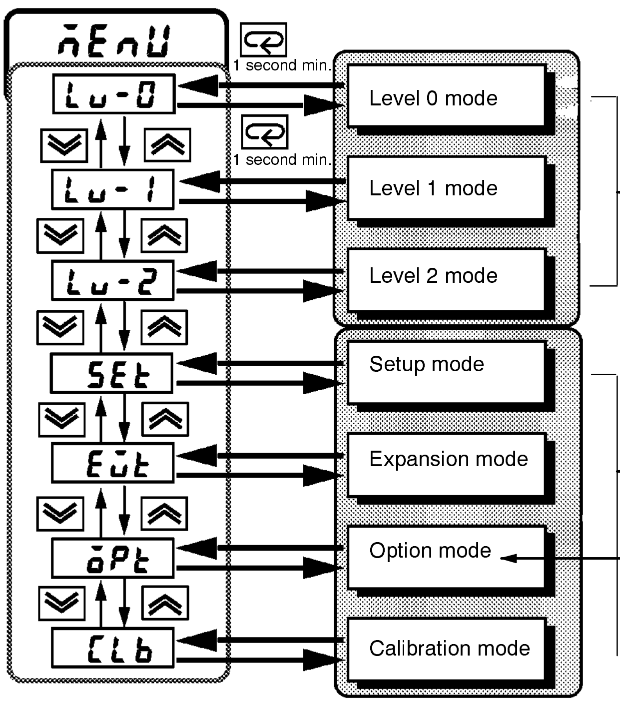


Parameter Operations List

Switching to modes other than manual or protect mode is carried out by mode selection in the menu display.

The figure below shows all parameters in the order that they are displayed. Some parameters are not displayed depending on the protect mode setting and conditions of use.

Menu Display



To switch parameters **within** a mode, use the Display Key.

Note:

1. **In Level 0 mode, Level 1 mode, and Level 2 mode:** The controller will maintain control of the process.
2. **In Setup mode, Expansion mode, Option mode, and Calibration mode:** Control of the process is not maintained.
3. **Option Mode** will be accessible only when an option board is installed in the controller.

To Access *Protect Mode.* Press and hold the A/M Key and the Display Key for more than 1 second.

To Return to the Main PV/SP Display. To Return to the Main PV/SP Display from the Protect Mode by pressing the A/M Key and the Display Key for more than 1 second.

To Access *Manual Mode.* Press and hold the A/M Key for more than 1 second.

NOTE: For E5CK-AA1-302 models, the A/M option can be accessed through Level 1. It has replaced the Auto-tune.

Fuzzy Self-Tuning

Fuzzy self-tuning is a function that enables the E5CK to calculate the most suitable PID constants for the controlled object.

Features

The E5CK determines by itself when to perform fuzzy self-tuning.

At the time of fuzzy self-tuning, the E5CK does not output any signal that disturbs the temperature or output value.

Fuzzy Self–tuning Function

The fuzzy self-tuning function has three modes.

In SRT(step response tuning) mode, the PID constants are tuned using a step response method at the time the set point is changed. In DT(disturbance tuning) mode, the PID constants are amended so that the controlled temperature will be within the target range set in advance when there is external disturbance.
In HT(hunting tuning) mode, when hunting occurs, the PID constants are amended to suppress the hunting.

Note: Be sure to turn on the power supply to the load either before or simultaneously with the start of Temperature Controller operation. Dead time will be measured from the time the Temperature Controller starts operating. If a load such as a heater is turned on after the Temperature Controller is turned on, dead time longer than the actual value will be measured and inappropriate PID constants will be obtained. If an extremely large amount of dead time is measured, the control amount will be set to 0% for a short period of time before being returned to 100%, and the constants will then be returned. Retuning is performed only for large amounts of dead time, so be sure to follow the precaution given above when starting operation.

Startup Conditions of SRT

SRT will start if all of conditions 1 to 4 or condition 5 are satisfied when the set point is changed or the E5CK is turned ON.

(1) The new set point is different from the set point used at the time SRT was executed last.

(2) The difference between the new set point and the last set point is larger than the value obtained from the calculation: present proportional band value(P) x approximately 1.27+4.(When the E5CK is turned on, the difference be-

tween the process value and set point is regarded as the set point changing range.)

(3) The temperature is stable before changing the set point or the temperature is balanced while the E5CK is turned on before any output is obtained.

(4) The set point is changed in the direction that the controlled amount increases (i.e., the control amount is in the upper direction at the time of reverse operation and in the lower direction at the time of normal operation).

(5) SRT has not been carried out even once with the current set point.

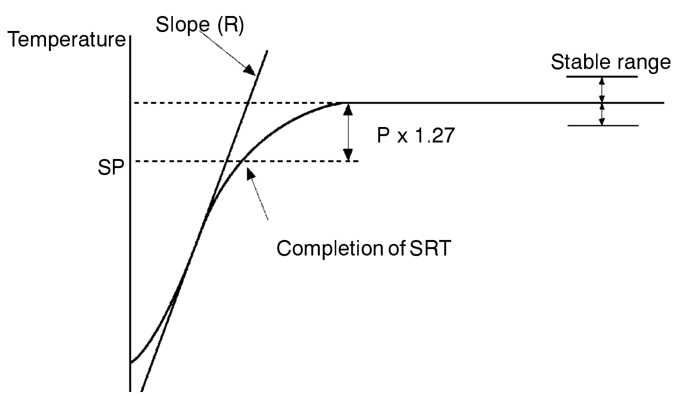
In the following cases, SRT will not be executed accurately. Therefore the E5CK must be tuned in DT or HT mode.

(1) The maximum temperature slope(R) is not obtained before the process value reaches the value obtained from the calculation: present proportional band value(P) x approximately 1.27(i.e., the maximum temperature slope(R) is not obtained before the SRT is finished). If the proportional band, obtained before SRT is finished, is larger than the previous proportional band, however, the PID constants will be renewed so that their values will be more accurate.

(2) The set point is changed during SRT and the SRT completion conditions are satisfied, in which case no PID constant will be renewed.

Stable Temperature Status

If the temperature is within the stable range for a specified period, it is deemed that the temperature is stable.



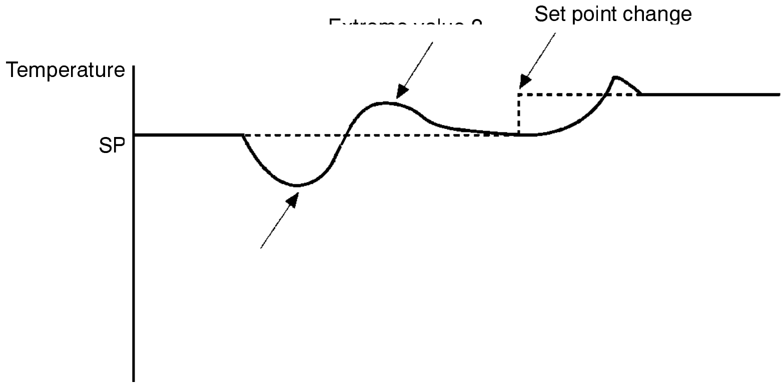
Balanced Status

If the process value is within the stable range for 60s when there is no output, it is deemed that the temperature is balanced.

Startup Conditions of DT

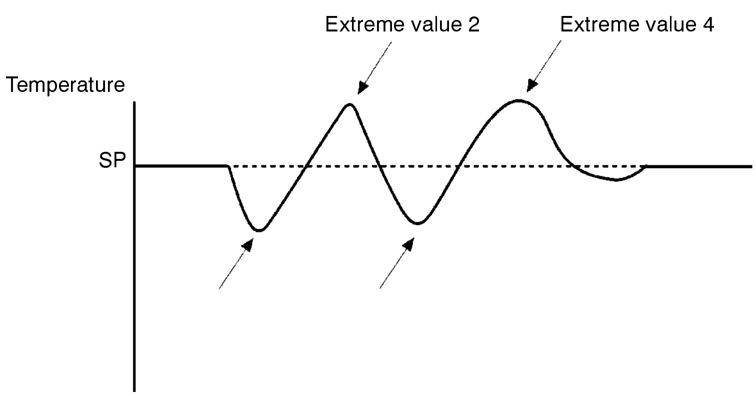
(1) DT will start if the temperature that has been stable varies due to external disturbance and the deflection of the temperature exceeds the stable range, and then the temperature becomes stable, provided that the number of maximum temperature values is less than four.

(2) DT will start if the set point is changed under the condition that SRT does not start and the temperature becomes stable, provided that the number of maximum temperature values is less than four. If there are four or more maximum temperature values, HT will start.



Startup Conditions of HT

HT will be ON when there is hunting with four or more maximum temperature values (extreme values) while SRT is not being executed.



Note: In specific applications where temperature varies periodically due to disturbance, internal parameters need to be adjusted.

Model List

Description	Type Name	Specification
Base unit	E5CK-AA1-500	Base unit
	E5CK-AA1-302	Base unit
Output unit	E53-R4R4	Relay/relay
	E53-Q4R4	Pulse (NPN)/relay
	E53-Q4HR4	Pulse (PNP)/relay
	E53-C4R4	Linear (4 to 20mA)/relay
	E53-C4DR4	Linear (0 to 20mA)/relay
	E53-V44R4	Linear (0 to 10V)/relay
	E53-Q4Q4	Pulse (NPN)/pulse (NPN)
	E53-Q4HQ4H	Pulse (PNP)/pulse (PNP)
Option unit	E53-CK01	RS-232C
	E53-CK03	RS-485
	E53-CKB	Event input : 1 point
	E53-CKF	Transfer output (4 to 20mA)
Terminal cover	E53-COV07	Terminal cover for E5CK

The output unit is required for E5CK-AA1. When adding an Option Unit, refer to Section 2.

X Format

Format

The E5CK controller supports communications in the X format which is used in other Omron controllers such as ES100, E5AJ/EJ and E5AX/EX. Commands are structured as follows and are paired with a response.

Command

	2B	2B	2B		2B	2B
@	Unit No.	Header code	Data code	Data	FCS	* CR

Response

	2B	2B	2B		2B	2B
@	Unit No.	Header code	End code	Data	FCS	* CR

“@”
The start character. This character must be inserted before the leading byte.

Unit No.
Specifies the “unit No.” of the E5CK. If there are two or more transmission destinations, specify the desired destination using “unit No.”

Header Code/Data Code
Specifies the command type. For details on the command type, see page A-12.

Data
Specifies the set value or setting content. The data length varies according to the command.

End Code

Sets the communication results. For details on the types and meanings of end codes, see 6.5 How to Read Communications Error Information (page 6-10).

FCS (Frame Check Sequence)

Set the frame check results from the start character to the data section. For details on the frame check, see 6.6 Program Example (page 6-12).

"*" "CR (Carriage Return) Code"

Indicates the end (terminator) of the command or response block.

X FORMAT HEAD LIST

Header Code	Data Code	Command Content	R/W	Data	Remarks
IC	01	Undefined error	-	None	Error response
MB	01	Remote/Local	Write	4B	
MA	01	RAM write mode	Write	None	
ME	01	Backup mode			
MW	01	RAM data batch save			
R%	01	Alarm value 1 read	Read	4B	
	02	Alarm value 2 read			
	03	Alarm value 3 read			
RB	01	Proportional band read			
RN	01	Integrated time read			
RV	01	Derivative time read			
RC	01	Cooling coefficient read	Read	4B	During heating and cooling control
RD	01	Dead band read			
RI	01	Input shift upper limit read	Read	4B	
	02	Input shift lower limit read			
RL	01	SP setting limit read	Read	8B	Upper-and lower-limit batch read
RO	01	Manipulated variable read	Read	4B	
RS	01	Set point read			
RX	01	Process value read	Read	8B	with status
W%	01	Alarm value 1 write	Write	4B	
	02	Alarm value 2 write			
	03	Alarm value 3 write			
WB	01	Proportional band write			
WN	01	Integrated time write			
WV	01	Derivative time write			
WC	01	Cooling coefficient write	Write	4B	During heating and cooling control
WD	01	Dead band write			
WI	01	Input shift upper limit write	Write	4B	
	02	Input shift lower limit write			
WS	01	Set point write			

RX (process value read) command status

Command

	2B					2B	2B
@	Unit No.	R 1	X		0	FCS	* CR

Response

	2B			2B	4B	4B	2B	2B
@	Unit No.	R	X	End code	Process value	Status	FCS	* CR

Bit	Content	“1”	“0”
0	Run/Stop	Stop	Run
1	Setting level	1	0
2	Input error	ON	OFF
3	A/D converter error	ON	OFF
4	LBA	ON	OFF
5			
6			
7	EEP	RAM≠EEP	RAM=EEP
8	Alarm 1	ON	OFF
9	Alarm 2	ON	OFF
10	Alarm 3	ON	OFF
11	AT	AT execution	OFF
12	RAM mode	RAM mode	Backup mode
13	Auto/Manual	Manual	Auto
14			
15	Remote/Local	Remote	Local

ASCII Code List

Upper 4 bits

Hex		0	1	2	3	4	5	6	7
	Bin	0000	0001	0010	0011	0100	0101	0110	0111
0	0000			SP	0	@	P		p
1	0001			!	1	A	Q	a	q
2	0010			”	2	B	R	b	r
3	0011			#	3	C	S	c	s
4	0100			$	4	D	T	d	t
5	0101			%	5	E	U	e	u
6	0110			&	6	F	V	f	v
7	0111			’	7	G	W	g	w
8	1000			(	8	H	X	h	x
9	1001			)	9	I	Y	i	y
A	1010			*	:	J	Z	j	z
B	1011			+	;	K	[	k	{
C	1100			,	<	L	¥	l	¦
D	1101			-	=	M	]	m	}
E	1110			.	>	N	^	n	~
F	1111			/	?	O	_	o	DEL

Lower 4 bits

Setting List

Mode	Parameter Name		Setting Range	Unit	Default	Remarks	Setting
Protect	SECr	Security	0 to 6	None	1		
	PEYP	[A/M] key protect	ON/OFF	None	OFF		
Manual		Manual MV	-5.0 to 105.0 *1	%	0.0		
Level 0	SP	Set point	Set point lower limit to Set point upper limit	EU	0		
	r-S	Run/Stop	Run/Stop	None	RUN		
Level 1	At	AT Execute/Cancel	OFF/AT-1/AT-2	None	OFF	During running	
	SP-0	Set point 0	Set point lower limit to Set point upper limit	EU	0	Multi-SP	
	SP-1	Set point 1	Set point lower limit to Set point upper limit	EU	0	Multi-SP	
	AL-1	Alarm value 1	-1999 to 9999	EU	0		
	AL-2	Alarm value 2	-1999 to 9999	EU	0		
	AL-3	Alarm value 3	-1999 to 9999	EU	0		
	P	Proportional band	0.1 to 999.9	%FS	10.0		
	I	Integral time	0 to 3999	sec	233		
	d	Derivative time	0 to 3999	sec	40		
	C-SC	Cooling coefficient	0.01 to 99.99	None	1.00	At heating and cooling control	
	C-db	Dead band	-19.99 to 99.99	%FS	0.00	At heating and cooling control	
	oF-r	Manual reset value	0.0 to 100.0	%	50.0		
	HYS	Hysteresis (heat)	0.01 to 99.99	%FS	0.10		
	CHYS	Hysteresis (cool)	0.01 to 99.99	%FS	0.10	At heating and cooling control	
	CP	Control period (heat)	1 to 99	sec	20		
	C-CP	Control period (cool)	1 to 99	sec	20	At heating and cooling control	
Level 2	r-L	Remote/Local	RMT/LCL	None	LCL		
	SPrU	SP ramp time unit	M(Minutes) / H(Hours)	None	M		
	SPrt	SP ramp set value	0 to 9999	EU	0		
	LbA	LBA detection time	0 to 9999	Sec	0		
	mv-S	MV at stop	-5.0 to 105.0 *1	%	0.0		
	mv-E	MV at PV error	-5.0 to 105.0 *1	%	0.0		
	oL-H	MV upper limit	MV lower limit + 0.1 to 105.0 *2	%	105.0		
	oL-L	MV lower limit	-5.0 to MV upper limit -0.1 *3	%	-5.0		
	orL	MV change rate limit	0.0 to 100.0	%/sec	0.0		
	InF	Input digital filter	0 to 9999	sec	0		
	ALH1	Alarm 1 hysteresis	0.01 to 99.99	%	0.02		
	ALH2	Alarm 2 hysteresis	0.01 to 99.99	%	0.02		
	ALH3	Alarm 3 hysteresis	0.01 to 99.99	%	0.02		
	InSH	Input shift upper limit	-199.9 to 999.9	°C	0.0	Temperature input	
	InSL	Input shift lower limit	-999.9 to 999.9	°C	0.0	Temperature input	

**1 During heat and cooling control, the lower limit becomes -105.0%.*
**2 During heat and cooling control, the setting range becomes 0.0 to 105.0%.*
**3 During heat and cooling control, the setting range becomes -105.0 to 0.0%.*

NOTE: E5CK-AA1-302 has Auto-tune [A/T] on front panel, and placed the auto-manual key [A/M] in Level 1.

Mode	Parameter Name		Setting Range	Unit	Default	Remarks	Setting
Setup	in-t	Input type	0 to 21	None	2		
	in-H	Scaling upper limit	Scaling lower limit +1 to 9999 *4	EU	-100	Analog input	
	in-L	Scaling lower limit	-1999 to SP setting upper limit -0.1 *4	EU	0	Analog input	
	dP	Decimal point	0 to 3	None	0	Analog input	
	d-U	°C/°F selection	°C/°F	None	°C	Temperature input	
	init	Parameter initialize	Yes/No	None	NO		
	oUt1	Control output 1 assignment	Heat/Cool/Alarm 1/Alarm 2/Alarm 3/LBA	None	HEAT		
	oUt2	Control output 2 assignment	Heat/Cool/Alarm 1/Alarm 2/Alarm 3/LBA	None	AL-1		
	SUb1	Auxiliary output 1 assignment	Alarm 1/Alarm 2/Alarm 3/LBA/S.ERR/ E333	None	AL-2		
	ALt1	Alarm 1 type	0 to 11	None	2	Output assignment needed	
	AL1n	Alarm 1 open in alarm	N-O/N-C	None	N-O	Output assignment needed	
	ALt2	Alarm 2 type	0 to 11	None	2	Output assignment needed	
	AL2n	Alarm 2 open in alarm	N-O/N-C	None	N-O	Output assignment needed	
	ALt3	Alarm 3 type	0 to 11	None	2	Output assignment needed	
	AL3n	Alarm 3 open in alarm	N-O/N-C	None	N-O	Output assignment needed	
	orEu	Direct/Reverse operation	OR-R/OR-D	None	OR-R		
Expan- sion	SL-H	Set point upper limit	Set point lower limit +1 to scaling upper limit *2	None	1300 *4		
	SL-L	Set point lower limit	Scaling upper limit to Set point lower limit -1 *2	None	-200 *4		
	CntL	PID/ON/OFF	PID / ON/OFF	None	PID		
	St	ST	OFF/ON	None	OFF		
	St-b	ST stable range	0.1 to 999.9	°C/°F	15.0	ST=ON	
	ALFA	α	0.01 to 1.00	None	0.65		
	At-G	AT calculated gain	0.1 to 10.0	None	1.0		
	rESt	Standby sequence reset setting method	0/1	None	0		
	rEt	Automatic return of display mode	0 to 99	Sec	0		
	At-H	AT hysteresis	0.1 to 9.9	%FS	0.2		
	LbAb	LBA detection width	0.0 to 999.9	%FS	0.2		
Option	Eu-m	Multi-SP function	0/1	None	0		
	Eu-1	Event input assignment 1	STOP/MAN	None	STOP		
	Sbit	Communication stop bit	1/2	bits	2		
	LEn	Communication data length	7/8	bits	7		
	PrtY	Communication parity	None/Even/Odd	None	EVEN		
	bPS	Communication baud rate	1.2/2.4/4.8/9.6/19.2	kbps	9.6		
	U-no	Communication unit No.	0 to 99	None	0		
	tr-t	Transfer output type	SP/SP-M/PV/O/C-O	None	SP		
	tr-H	Transfer output upper limit	*5	*5	*5		
	tr-L	Transfer output lower limit	*5	*5	*5		

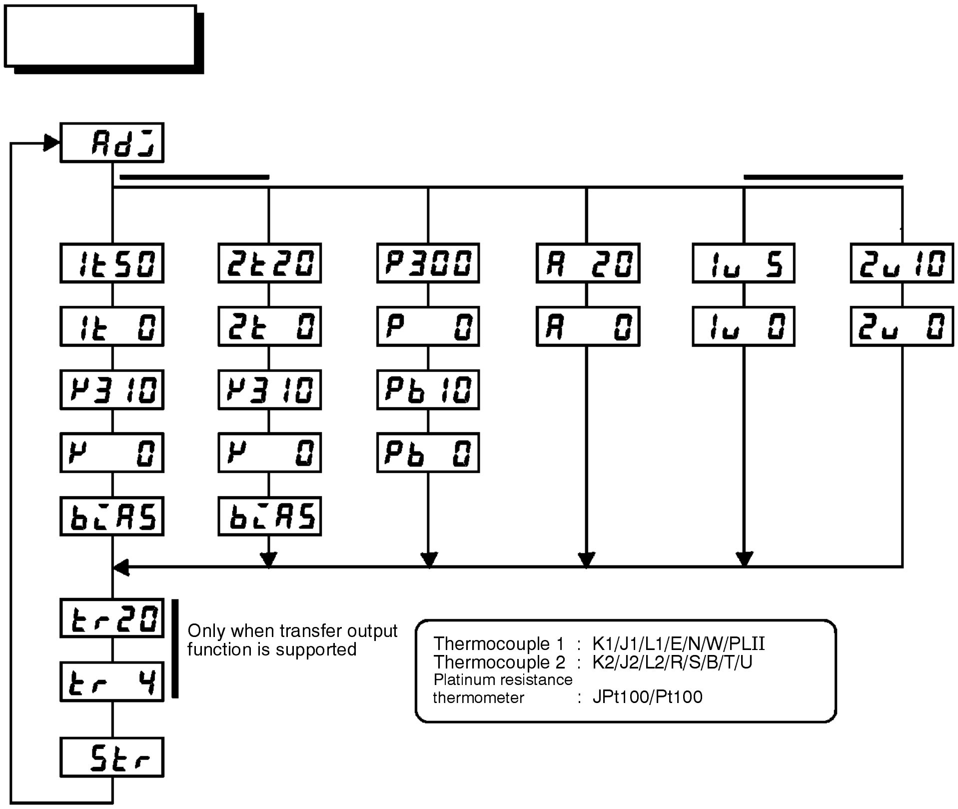
*4 *When temperature input is selected, the sensor range selected in the “input type” parameter (setup mode) corresponds to the scaling upper and lower limit value.*

*5 *Set the transfer output type parameter according to the following table.*

Transfer Output Type		Transfer Output Lower Limit to Transfer Output Upper Limit
SP	:Set point	Set point lower limit to Set point upper limit
SP-M	:Set point during SP ramp	Set point lower limit to Set point upper limit
PV	:Process value	Scaling lower limit to scaling upper limit
O	:Manipulated variable (heat)	-5.0 to 105.0%
C-O	:Manipulated variable (cool)	0.0 to 105.0%

- *The output ranges of the SP setting, set point or process value when temperature input is selected are the ranges supported by the selected sensor.*
- *When the heating side manipulated variable or cooling side manipulated variable is selected, the transfer output lower limit in a heating and cooling control becomes “0.0”.*

Calibration Mode



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Revision History

E5CK Process Controller

User Manual

A manual revision code appears as a suffix to the catalog number on the front cover of the manual.

Cat. No. H078-E3-2

Revision code

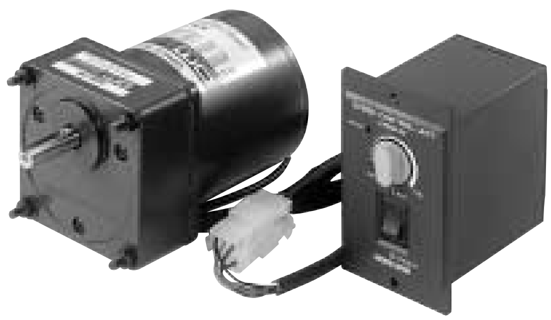
The following table outlines the changes made to the manual during each revision. Page numbers refer to previous version.

Revision code	Date	Revised content
E1-1	September 1995	Original Production of the Source Document
E3-1	January 1996	Original Production in USA
E3-2	April 1998	**Page 2, 3, 33, 36, 74, 133, and 142:** Information added regarding E5CK-AA1-302. This model displays auto-tune (AT) key instead of A/M key. **Page 107**: Section 6–2–1, RS-232C cable connection corrected. **Page 113:** Section 6–4–1, Instruction code corrected for command number 02. **Page 137:** Model E5CK-AA1-302 added to model list.

Speed Control Motors

US *Series*

The US series combines a speed control motor and a control unit. The capacitor and the potentiometer have been integrated into one compact control unit. The series is designed for applications where remote control of the motor speed and easy hook-up are required.



Gearhead shown in the photograph is sold separately.

EASY WIRING | GEAR | SAFETY STD.

Features

- Control units combine the control pack, potentiometer and the capacitor in one device. Capacitors for **US560** and **US590** types are externally fitted with leads and capacitor caps. Connection between motor and control unit is simplified by a special connector.
- Use of the optional extension cable allows for remote control of the motor from a distance of up to 15.6 feet.(4.75m).
- Variable speed range is 90r/min ~ 1400r/min (50Hz), 90r/min~ 1600r/min (60Hz).

Safety Standards and CE Marking

Motor

Standards	Certification Body	Standards File No.	CE Marking
UL1004 UL519 (US206 type) UL547 (US315, US425, US540, US560, US590 type)	UL	E64199 (US206 type) E64197 (US315, US425, US540, US560, US590 type)	Low Voltage Directive
CAN/CSA-C22.2 No.100 CAN/CSA-C22.2 No.77			
EN60950	VDE	114919ÜG (US206 type) 6751ÜG (US315, US425, US540, US560, US590 type)	
EN60034-1 EN60034-5 IEC60034-11	Conform to EN/IEC Standards (EN/IEC certifications are scheduled.)		

Control Unit

Standards	Certification Body	Standards File No.	CE Marking
UL508	UL	E91291	Low Voltage Directive
CAN/CSA-C22.2 No.14			
EN60950	Conform to EN/VDE Standards (EN/IEC certifications are scheduled.)		

• For installations for EN/IEC standards, see page D-2.

Product Number Code

US 5 60 -5 0 1 U

Provided Capacitor
U: 110V/115V
E: 220V/230V

Voltage
1: Single-Phase 110V/115V, 4 Poles
2: Single-Phase 220V/230V, 4 Poles

Motor type
0: Induction motor (Continuous rating)

Shaft type
0: Round shaft
4: **GN** pinion shaft (for use with **GN** type gearhead)
5: **GU** pinion shaft (for use with **GU** type gearhead)

Output Power
06: 6W **40**: 40W
15: 15W **60**: 60W
25: 25W **90**: 90W

Motor Frame Size
2: 2.36 inch sq.(60mm sq.)
3: 2.76 inch sq.(70mm sq.)
4: 3.15 inch sq.(80mm sq.)
5: 3.54 inch sq.(90mm sq.)

US series

Note : The "**U**" and "**E**" at the end of the model number indicate that the unit includes a capacitor. These two letters are not listed on the motor nameplate.

Product Line

●Single-Phase 110V/115V

Output Power HP	W	Model Pinion shaft	Round shaft
1/124	6	**US206-401U**	**US206-001U**
1/50	15	**US315-401U**	**US315-001U**
1/30	25	**US425-401U**	**US425-001U**
1/18.5	40	**US540-401U**	**US540-001U**
1/12.5	60	**US560-501U**	**US560-001U**
1/8	90	**US590-501U**	**US590-001U**

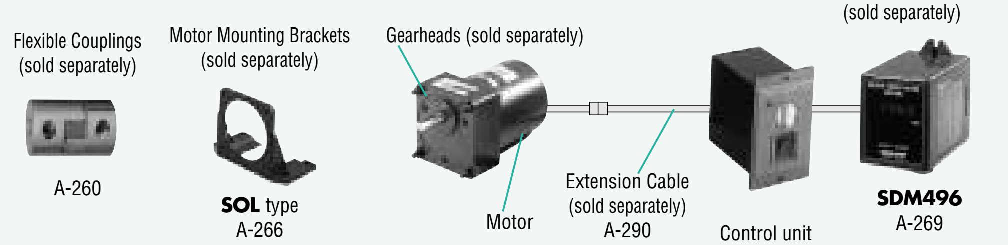
●Single-Phase 220V/230V

Output Power HP	W	Model Pinion shaft	Round shaft
1/124	6	**US206-402E**	**US206-002E**
1/50	15	**US315-402E**	**US315-002E**
1/30	25	**US425-402E**	**US425-002E**
1/18.5	40	**US540-402E**	**US540-002E**
1/12.5	60	**US560-502E**	**US560-002E**
1/8	90	**US590-502E**	**US590-002E**

●Gearheads

Motor Model	Gearhead Model
US206	**2GN3KA** ~ **2GN180KA** **2GN10XK** (Decimal Gearhead)
US315	**3GN3KA** ~ **3GN180KA** **3GN10XK** (Decimal Gearhead)
US425	**4GN3KA** ~ **4GN180KA** **4GN10XK** (Decimal Gearhead)
US540	**5GN3KA** ~ **5GN180KA** **5GN10XK** (Decimal Gearhead)
US560, **US590**	**5GU3KA** ~ **5GU180KA** **5GU10XKB** (Decimal Gearhead)

Construction



List of Motor/Control Unit Packages

Model numbers for motor/control unit packages are shown below.

●Single-Phase 110V/115V

Output Power HP	W	Packages Model	Motor Model	Control Unit Model
1/124	6	**US206-401U** **US206-001U**	USM206-401W USM206-001W	USP206-1U
1/50	15	**US315-401U** **US315-001U**	USM315-401W USM315-001W	USP315-1U
1/30	25	**US425-401U** **US425-001U**	USM425-401W USM425-001W	USP425-1U
1/18.5	40	**US540-401U** **US540-001U**	USM540-401W USM540-001W	USP540-1U
1/12.5	60	**US560-501U** **US560-001U**	USM560-501W USM560-001W	USP560-1U
1/8	90	**US590-501U** **US590-001U**	USM590-501W USM590-001W	USP590-1U

●Single-Phase 220V/230V

Output Power HP	W	Packages Model	Motor Model	Control Unit Model
1/124	6	**US206-402E** **US206-002E**	USM206-402W USM206-002W	USP206-2E
1/50	15	**US315-402E** **US315-002E**	USM315-402W USM315-002W	USP315-2E
1/30	25	**US425-402E** **US425-002E**	USM425-402W USM425-002W	USP425-2E
1/18.5	40	**US540-402E** **US540-002E**	USM540-402W USM540-002W	USP540-2E
1/12.5	60	**US560-502E** **US560-002E**	USM560-502W USM560-002W	USP560-2E
1/8	90	**US590-502E** **US590-002E**	USM590-502W USM590-002W	USP590-2E

Product Specifications

Specifications (Motor) — Continuous Rating

Model: Pinion shaft	Model: Round shaft	Maximum Output Power HP	Maximum Output Power W	Voltage V	Frequency Hz	Speed Range r/min	Permissible Torque 1200r/min oz-in	Permissible Torque 1200r/min mN•m	Permissible Torque 90r/min oz-in	Permissible Torque 90r/min mN•m	Starting Torque oz-in	Starting Torque mN•m	Current A	Power Consumption W
ZP **US206-401U**	**US206-001U**	1/124	6	110	60	90~1600	6.9	50	4.2	30	4.9	35	0.24	24
				115	60	90~1600	6.9	50	4.2	30	4.9	35	0.25	28
ZP **US206-402E**	**US206-002E**	1/124	6	220	60	90~1600	6.9	50	4.0	29	3.7	27	0.13	27
				230	50	90~1400	6.9	50	4.0	29	4.0	29	0.13	28
				230	60	90~1600	6.9	50	4.0	29	4.0	29	0.13	28
TP **US315-401U**	**US315-001U**	1/50	15	110	60	90~1600	17.4	125	6.2	45	7.6	55	0.47	44
				115	60	90~1600	17.4	125	6.2	45	7.6	55	0.50	44
TP **US315-402E**	**US315-002E**	1/50	15	220	60	90~1600	11.8	85	4.9	35	7.2	52	0.18	39
				230	50	90~1400	17.4	125	4.9	35	7.5	54	0.21	43
				230	60	90~1600	14.6	105	4.9	35	7.6	55	0.22	47
TP **US425-401U**	**US425-001U**	1/30	25	110	60	90~1600	27.8	200	6.9	50	14.6	105	0.74	70
				115	60	90~1600	27.8	200	6.9	50	14.6	105	0.74	73
TP **US425-402E**	**US425-002E**	1/30	25	220	60	90~1600	18.1	130	6.0	43	11.1	80	0.31	59
				230	50	90~1400	26.4	190	6.5	47	12.1	87	0.35	62
				230	60	90~1600	18.1	130	6.0	43	12.1	87	0.31	60
TP **US540-401U**	**US540-001U**	1/18.5	40	110	60	90~1600	36.1	260	9.7	70	25.0	180	1.1	102
				115	60	90~1600	36.1	260	9.7	70	25.0	180	1.1	105
TP **US540-402E**	**US540-002E**	1/18.5	40	220	60	90~1600	31.9	230	8.7	63	17.4	125	0.55	98
				230	50	90~1400	41.7	300	8.7	63	19.4	140	0.53	90
				230	60	90~1600	31.9	230	8.7	63	19.4	140	0.55	100
TP **US560-501U**	**US560-001U**	1/12.5	60	110	60	90~1600	68.0	490	27.8	200	39.6	285	2.0	178
				115	60	90~1600	68.0	490	27.8	200	39.6	285	2.1	186
TP **US560-502E**	**US560-002E**	1/12.5	60	220	60	90~1600	62.5	450	22.2	160	29.2	210	0.86	159
				230	50	90~1400	68.0	490	19.4	140	33.3	240	0.89	154
				230	60	90~1600	62.5	450	22.2	160	33.3	240	0.88	165
TP **US590-501U**	**US590-001U**	1/8	90	110	60	90~1600	101.4	730	27.8	200	56.2	405	2.6	230
				115	60	90~1600	101.4	730	27.8	200	56.2	405	2.6	246
TP **US590-502E**	**US590-002E**	1/8	90	220	60	90~1600	101.4	730	36.1	260	50.0	360	1.2	221
				230	50	90~1400	101.4	730	31.9	230	55.5	400	1.2	201
				230	60	90~1600	101.4	730	36.1	260	55.5	400	1.2	227

- The **US206** type is impedance protected. The other types contain a built-in thermal protector. When a motor overheats for any reason, the thermal protector is opened and the motor stops. When the motor temperature drops, the thermal protector closes and the motor restarts. Be sure to turn off the power before inspecting.
- The speed ranges shown are under no load condition.
- The "**U**" and "**E**" at the end of the model number indicate that the unit includes a capacitor. These two letters are not listed on the motor nameplate.

General Specifications

Item	Specifications
Insulation Resistance	100MΩ or more when 500V DC is applied between the windings and the frame after rated motor operation under normal ambient temperature and humidity.
Dielectric Strength	Sufficient to withstand 1.5kV at 50Hz and 60Hz applied between the windings and the frame after rated motor operation under normal ambient temperature and humidity.
Temperature Rise	144°F (80°C) or less measured by the resistance change method after rated operation of motor with connecting a gearhead or equivalent heat radiation plate.
Overheating Protection Device	**US206** type is impedance protected. All others have built-in thermal protector (Automatic return type) Operating temperature, open: 266°F±9°F (130°C±5°C) Close: 179.6°F±27°F (82°C±15°C)
Insulation Class	Class B (266°F [130°C])
Ambient Temperature Range	14°F~104°F (−10°C~+40°C)
Ambient Humidity	85% maximum (non condensing)
Degree of protection	**US206**, **US315**, **US425**, **US540** type: IP20 **US560**, **US590** type: IP40

See page A-36 for equivalent heat radiation plate sizes.

Control Unit General Specifications

Item	Specifications
Insulation Resistance	100MΩ or more when 500V DC is applied between the windings and the frame.
Dielectric Strength	Sufficient to withstand 2.3kV (Single phase 220, 230V: 3.0kV) at 60Hz applied between all the pins and the frame for 1 minute.
Ambient Temperature Range	32°F~104°F (0°C~40°C)
Ambient Humidity	85% maximum (noncondensing)
Degree of protection	IP10

Speed Range when Gearhead is Attached

Unit = r/min

Gear Ratio		3	3.6	5	6	7.5	9	12.5	15	18	25	30	36	50	60	75	90	100	120	150	180
High Speed	50Hz	466	388	280	233	186	155	112	93	77	56	46	38	28	23	18	15	14	11	9	7
	60Hz	533	444	320	266	213	177	128	106	88	64	53	44	32	26	21	17	16	13	10	8.8
Low Speed		30	25	18	15	12	10	7.2	6	5	3.6	3	2.5	1.8	1.5	1.2	1	0.9	0.75	0.6	0.5

Permissible Torque when Gearhead is Attached

The permissible torque with decimal gearheads are as follows.

2GN□KA/2GN10XK 26 lb-in / 3N·m **3GN□KA/3GN10XK** 43 lb-in / 5N·m
4GN□KA/4GN10XK 69 lb-in / 8N·m (Gear Ratio 25~36 52 lb-in / 6N·m)
5GN□KA/5GN10XK 87 lb-in / 10N·m **5GU□KA/5GU10XKB** 174 lb-in / 20N·m

Right-Angle gearheads may be connected to **US425**, **US540**, **US560** and **US590** types. See page [A-216] for more information.

● Single-Phase 115V

Unit = Upper values: lb-in/Lower values: N·m

Model	Gear Ratio	3	3.6	5	6	7.5	9	12.5	15	18	25	30	36	50	60	75	90	100	120	150	180
US206-401U / 2GN□KA	1200r/min	1	1.3	1.7	2.1	2.6	3.1	4.4	5.2	6.3	7.9	9.4	11	14	17	21	26	26	26	26	26
		0.12	0.15	0.2	0.24	0.3	0.36	0.51	0.61	0.73	0.91	1.1	1.3	1.7	2	2.5	3	3	3	3	3
	90r/min	0.64	0.77	1.1	1.3	1.6	1.9	2.7	3.2	3.8	4.8	5.7	6.9	8.7	10	13	16	17	21	26	26
		0.073	0.087	0.12	0.15	0.18	0.22	0.3	0.36	0.44	0.55	0.66	0.79	0.99	1.2	1.5	1.8	2	2.4	3	3
US315-401U / 3GN□KA	1200r/min	2.6	3.2	4.4	5.3	6.6	7.9	11	13	16	20	24	29	36	43	43	43	43	43	43	43
		0.3	0.36	0.51	0.61	0.76	0.91	1.3	1.5	1.8	2.3	2.7	3.3	4.1	5	5	5	5	5	5	5
	90r/min	0.94	1.1	1.6	1.9	2.4	2.8	3.9	4.7	5.6	7.1	8.5	10	13	15	19	23	26	31	38	43
		0.11	0.13	0.18	0.22	0.27	0.33	0.46	0.55	0.66	0.82	0.99	1.2	1.5	1.8	2.2	2.7	3	3.6	4.5	5
US425-401U / 4GN□KA	1200r/min	4.2	5.1	7	8.4	11	13	18	21	25	32	38	46	57	69	69	69	69	69	69	69
		0.49	0.58	0.81	0.97	1.2	1.5	2	2.4	2.9	3.7	4.4	5.3	6.6	7.9	8	8	8	8	8	8
	90r/min	1	1.3	1.7	2.1	2.6	3.1	4.4	5.2	6.3	7.9	9.4	11	14	17	21	26	28	34	43	51
		0.12	0.15	0.2	0.24	0.3	0.36	0.51	0.61	0.73	0.91	1.1	1.3	1.7	2	2.5	3	3.3	4	5	5.9
US540-401U / 5GN□KA	1200r/min	5.5	6.6	9.1	11	14	16	23	27	33	41	49	59	74	87	87	87	87	87	87	87
		0.63	0.76	1.1	1.3	1.6	1.9	2.6	3.2	3.8	4.7	5.7	6.8	8.6	10	10	10	10	10	10	10
	90r/min	1.5	1.8	2.5	2.9	3.7	4.4	6.1	7.4	8.8	11	13	16	20	24	30	36	40	48	60	72
		0.17	0.2	0.28	0.34	0.43	0.51	0.71	0.85	1	1.3	1.5	1.8	2.3	2.8	3.5	4.2	4.6	5.5	6.9	8.3
US560-501U / 5GU□KA	1200r/min	10	12	17	21	26	31	39	47	56	70	84	101	140	168	174	174	174	174	174	174
		1.2	1.4	2	2.4	3	3.6	4.5	5.4	6.4	8.1	9.7	12	16	19	20	20	20	20	20	20
	90r/min	4.2	5.1	7	8.4	11	13	16	19	23	29	34	41	57	69	77	92	103	123	154	174
		0.49	0.58	0.81	0.97	1.2	1.5	1.8	2.2	2.6	3.3	4	4.8	6.6	7.9	8.9	11	12	14	18	20
US590-501U / 5GU□KA	1200r/min	15	18	26	31	39	46	58	69	83	105	125	151	174	174	174	174	174	174	174	174
		1.8	2.1	3	3.5	4.4	5.3	6.7	8	9.6	12	14	17	20	20	20	20	20	20	20	20
	90r/min	4.2	5.1	7	8.4	11	13	16	19	23	29	34	41	57	69	77	92	103	123	154	174
		0.49	0.58	0.81	0.97	1.2	1.5	1.8	2.2	2.6	3.3	4	4.8	6.6	7.9	8.9	11	12	14	18	20

- Gearheads and decimal gearheads are sold separately.
- Enter the gear ratio in the box □ within the model number. A colored background indicates gear shaft rotation in the same direction as the motor shaft; a white background indicates rotation in the opposite direction.
- Values for permissible torque are calculated by taking permissible torque at high speed (1200r/min) and low speed (90r/min) and multiplying by gear ratio and gearhead efficiency.

● Single-Phase 220V/230V

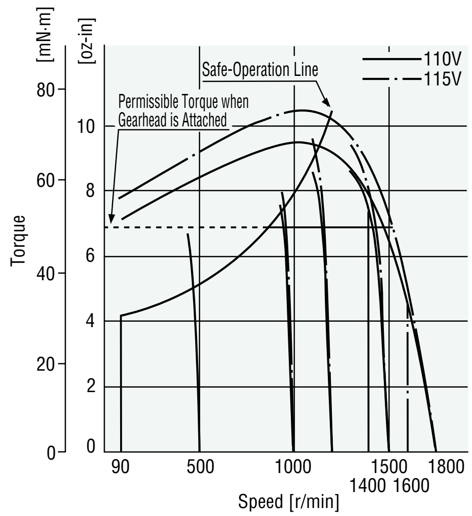
Unit = Upper values: lb-in/Lower values: N·m

Model	Gear Ratio		3	3.6	5	6	7.5	9	12.5	15	18	25	30	36	50	60	75	90	100	120	150	180
US206-402E / 2GN□KA	1200r/min		1	1.3	1.7	2.1	2.6	3.1	4.4	5.2	6.3	7.9	9.4	11	14	17	21	26	26	26	26	26
			0.12	0.15	0.2	0.24	0.3	0.36	0.51	0.61	0.73	0.91	1.1	1.3	1.7	2	2.5	3	3	3	3	3
	90r/min		0.61	0.73	1	1.2	1.5	1.8	2.5	3	3.6	4.6	5.5	6.6	8.3	9.9	12	15	17	20	25	26
			0.07	0.085	0.12	0.14	0.18	0.21	0.29	0.35	0.42	0.53	0.64	0.76	0.96	1.1	1.4	1.7	1.9	2.3	2.9	3
US315-402E / 3GN□KA	1200r/min	230V	2.6	3.2	4.4	5.3	6.6	7.9	11	13	16	20	24	29	36	43	43	43	43	43	43	43
		50Hz	0.3	0.36	0.51	0.61	0.76	0.91	1.3	1.5	1.8	2.3	2.7	3.3	4.1	5	5	5	5	5	5	5
		230V	2.2	2.7	3.7	4.4	5.5	6.7	9.2	11	13	17	20	24	30	36	43	43	43	43	43	43
		60Hz	0.26	0.31	0.43	0.51	0.64	0.77	1.1	1.3	1.5	1.9	2.3	2.8	3.5	4.2	5	5	5	5	5	5
	90r/min		0.74	0.89	1.2	1.5	1.9	2.2	3.1	3.7	4.5	5.6	6.7	8	10	12	15	18	20	24	30	36
			0.085	0.1	0.14	0.17	0.21	0.26	0.35	0.43	0.51	0.64	0.77	0.92	1.2	1.4	1.7	2.1	2.3	2.8	3.5	4.2
US425-402E / 4GN□KA	1200r/min	230V	2.7	3.3	4.6	5.5	6.9	8.2	11	14	16	21	25	30	37	45	56	67	69	69	69	69
		60Hz	0.32	0.38	0.53	0.63	0.79	0.95	1.3	1.6	1.9	2.4	2.8	3.4	4.3	5.1	6.4	7.7	8	8	8	8
		230V	4	4.8	6.7	8	10	12	17	20	24	30	36	43	54	65	69	69	69	69	69	69
		50Hz	0.46	0.55	0.77	0.92	1.2	1.4	1.9	2.3	2.8	3.5	4.2	5	6.3	7.5	8	8	8	8	8	8
	90r/min	230V	0.91	1.1	1.5	1.8	2.3	2.7	3.8	4.6	5.5	6.8	8.2	9.9	12	15	19	22	25	30	37	45
		60Hz	0.1	0.13	0.17	0.21	0.26	0.31	0.44	0.52	0.63	0.78	0.94	1.1	1.4	1.7	2.1	2.6	2.8	3.4	4.3	5.1
		230V	0.99	1.2	1.6	2	2.5	3	4.1	4.9	5.9	7.4	8.9	11	13	16	20	24	27	32	40	48
		50Hz	0.11	0.14	0.19	0.23	0.29	0.34	0.48	0.57	0.69	0.86	1	1.2	1.6	1.9	2.3	2.8	3.1	3.7	4.7	5.6
US540-402E /5GN□KA	1200r/min	230V	4.8	5.8	8.1	9.7	12	15	20	24	29	36	44	52	66	79	87	87	87	87	87	87
		60Hz	0.56	0.67	0.93	1.1	1.4	1.7	2.3	2.8	3.4	4.2	5	6	7.6	9.1	10	10	10	10	10	10
		230V	6.3	7.6	11	13	16	19	26	32	38	48	57	68	86	87	87	87	87	87	87	87
		50Hz	0.73	0.87	1.2	1.5	1.8	2.2	3	3.6	4.4	5.5	6.6	7.9	9.9	10	10	10	10	10	10	10
	90r/min		1.3	1.6	2.2	2.6	3.3	4	5.5	6.6	7.9	9.9	12	14	18	22	27	32	36	43	54	65
			0.15	0.18	0.26	0.31	0.38	0.46	0.64	0.77	0.92	1.1	1.4	1.7	2.1	2.5	3.1	3.7	4.2	5	6.2	7.5
US560-502E / 5GU□KA	1200r/min	230V	9.5	11	16	19	24	28	36	43	51	64	77	93	129	155	173	174	174	174	174	174
		60Hz	1.1	1.3	1.8	2.2	2.7	3.3	4.1	4.9	5.9	7.4	8.9	11	15	18	20	20	20	20	20	20
		230V	10	12	17	21	26	31	39	47	56	70	84	101	140	168	174	174	174	174	174	174
		50Hz	1.2	1.4	2	2.4	3	3.6	4.5	5.4	6.4	8.1	9.7	12	16	19	20	20	20	20	20	20
	90r/min	230V	3.4	4	5.6	6.7	8.4	10	13	15	18	23	27	33	46	55	61	74	82	98	123	147
		60Hz	0.39	0.47	0.65	0.78	0.97	1.2	1.5	1.8	2.1	2.6	3.2	3.8	5.3	6.3	7.1	8.5	9.4	11	14	17
		230V	2.9	3.5	4.9	5.9	7.4	8.8	11	13	16	20	24	29	40	48	54	64	72	86	107	129
		50Hz	0.34	0.41	0.57	0.68	0.85	1	1.3	1.5	1.8	2.3	2.8	3.3	4.6	5.5	6.2	7.4	8.3	9.9	12	15
US590-502E / 5GU□KA	1200r/min		15	18	26	31	39	46	58	69	83	105	125	151	174	174	174	174	174	174	174	174
			1.8	2.1	3	3.5	4.4	5.3	6.7	8	9.6	12	14	17	20	20	20	20	20	20	20	20
	90r/min	230V	5.5	6.6	9.1	11	14	16	21	25	30	37	45	54	74	89	100	120	133	160	174	174
		60Hz	0.63	0.76	1.1	1.3	1.6	1.9	2.4	2.8	3.4	4.3	5.1	6.2	8.6	10	12	14	15	18	20	20
		230V	4.8	5.8	8.1	9.7	12	15	18	22	26	33	39	47	66	79	88	106	118	141	174	174
		50Hz	0.56	0.67	0.93	1.1	1.4	1.7	2.1	2.5	3	3.8	4.6	5.5	7.6	9.1	10	12	14	16	20	20

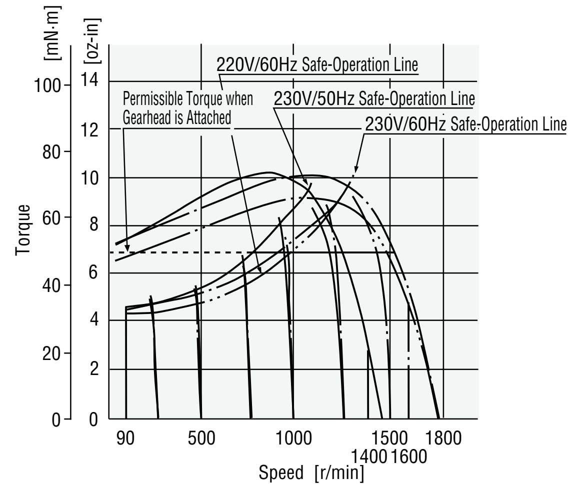
- Gearheads and decimal gearheads are sold separately.
- Enter the gear ratio in the box □ within the model number. A colored background indicates gear shaft rotation in the same direction as the motor shaft; a white background indicates rotation in the opposite direction.
- Values for permissible torque are calculated by taking permissible torque at high speed (1200r/min) and low speed (90r/min) and multiplying by gear ratio and gearhead efficiency.

Torque-Speed Characteristics

US206-401U
US206-001U



US206-402E
US206-002E



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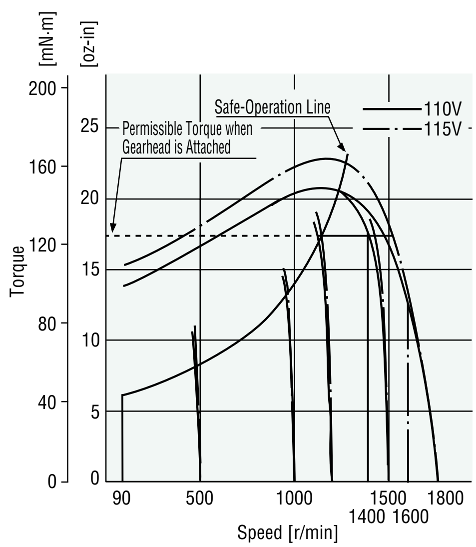
US315-001U



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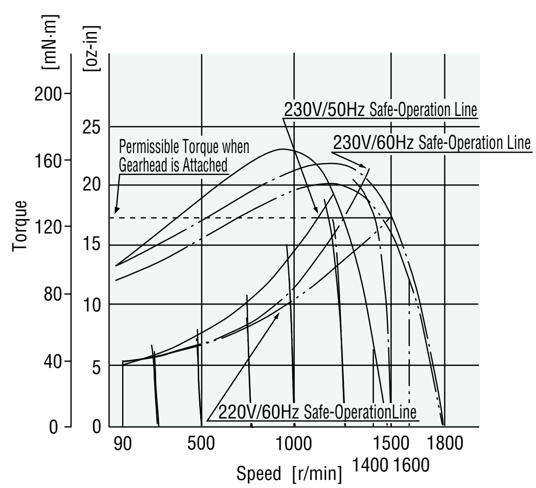
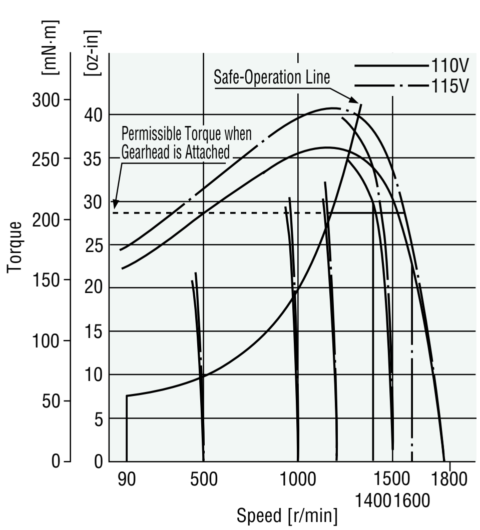


US425-401U
US425-001U



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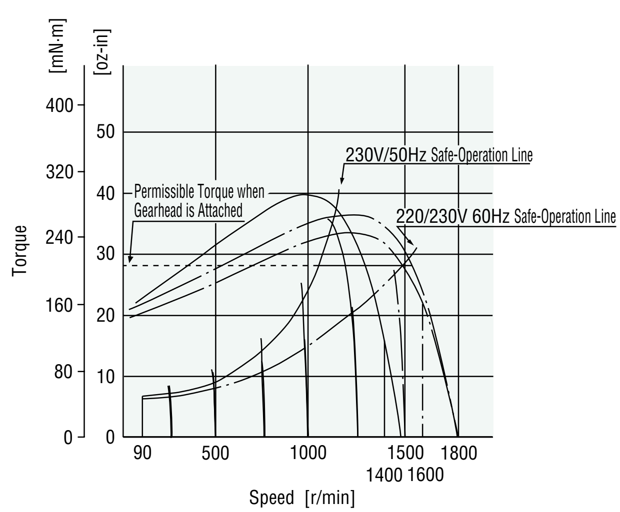
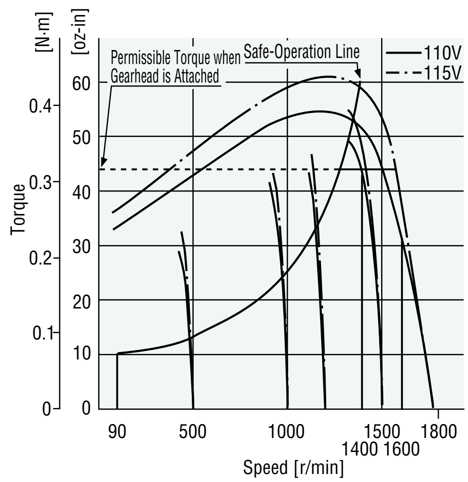


US540-401U
US540-001U



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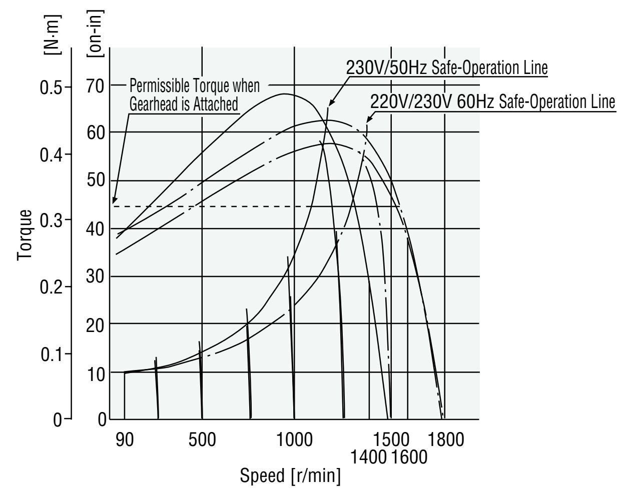
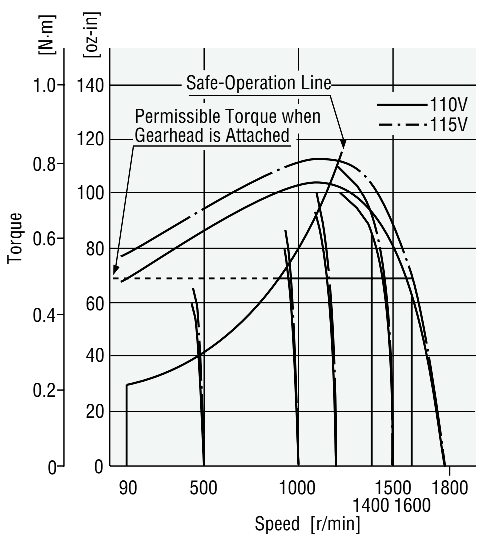
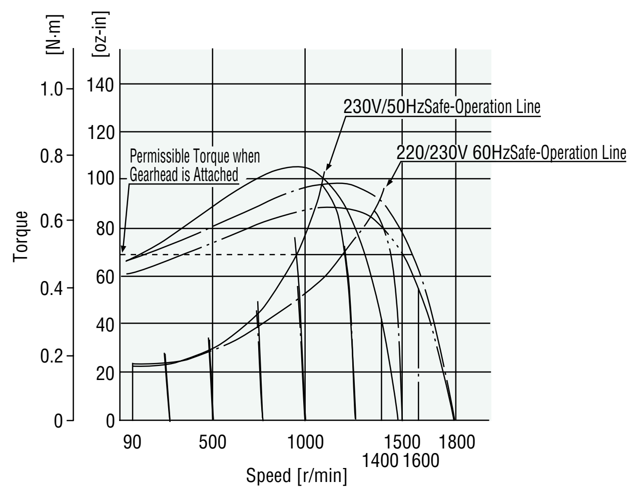
US540-002E



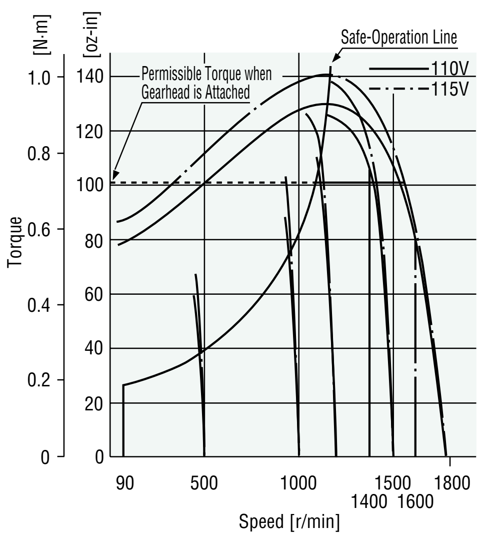
US560-501U
US560-001U



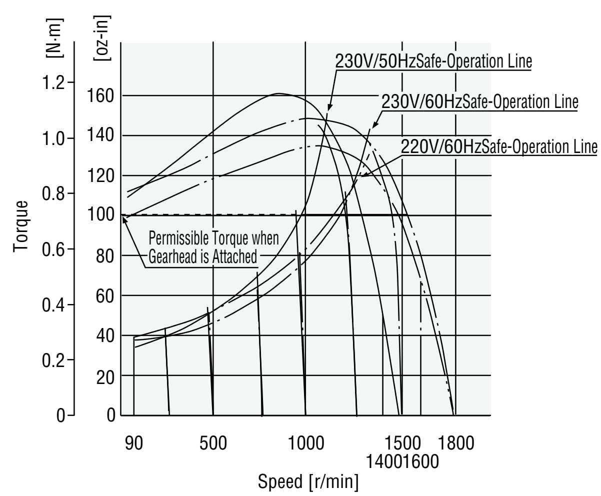
US560-502E
US560-002E



US590-501U
US590-001U



US590-502E
US590-002E



Operation of Speed Control Motor US series

■ Operation

●Rotation

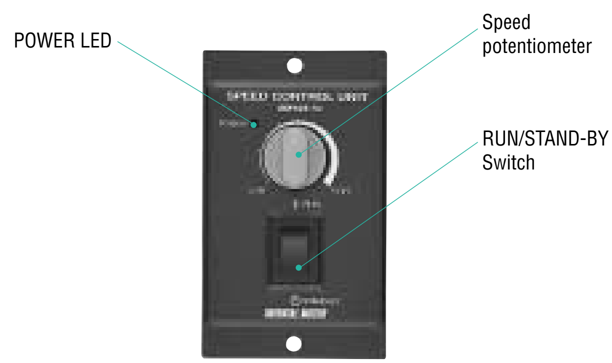
US206, US315, US425 and US540 types

Connect the motor lead wire connectors to the control unit. Then connect the power cord to the power supply. When the RUN/STAND-BY switch of the control unit is flipped to RUN, the motor rotates in the clockwise (CW) direction as seen from the motor shaft.
(Control units are set for clockwise rotation at shipment. The direction of rotation for the gearhead output shaft may be the reverse of the direction of the motor shaft depending on the gear ratio.)

●US560 and US590 types

Connect the control unit and the motor, and attach the capacitor wire leading from the control unit to the capacitor. Next, plug in the power supply cord into an AC power supply. When the RUN/STAND-BY switch located on the control unit is flipped to RUN, the motor will rotate in the direction set by the connection of the capacitor.
(Control units are set for clockwise rotation at shipment. The direction of rotation for the gearhead output shaft may be the reverse of the direction of the motor shaft depending on the gear ratio.)

Control Unit Front Panel



●Changing Speed

When the potentiometer located on the front surface of the control unit is turned in the clockwise direction, motor speed increases; when turned in the opposite direction, motor speed decreases.
Motor speed can be set and adjusted over a range of 90r/min-1600r/min.

●Stopping

When the RUN/STAND-BY switch on the control unit is set to STAND-BY, the motor stops. This switch is not a power ON/OFF switch. When the motor is to be stopped for a long time, a separate power ON/OFF switch should be installed.

●Changing the Direction of Rotation

US206, US315, US425 and US540 types

(Capacitor is attached to the control unit.)

Uni-directional Rotation

When the direction of motor rotation needs to be reversed for reasons relating to transmission mechanisms such as gearheads, change the terminal used for attaching the power cord, located at the back of control unit, from terminal N (CW) to terminal N (CCW). The power cord connections are located at terminals L and N (CW) when shipping. See the diagram to the right.
(This should always be done with the power OFF.)

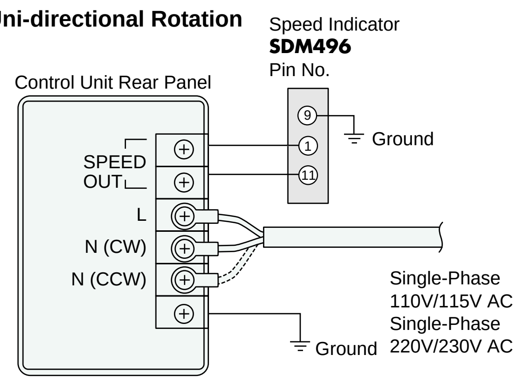
Bi-directional Rotation

Install an additional power switch (SW1) and CW/CCW switch (SW2) as shown in the diagram to the right, and use these switches to change the direction of rotation. (Motor cannot be reversed instantaneously. Turn SW1 off and wait until the motor has come to a complete stop before switching SW2.) See the diagram to the right.

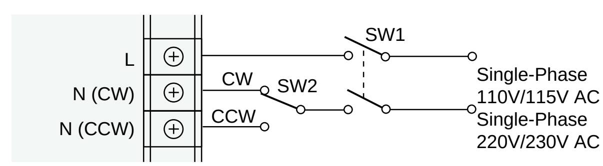
Connecting the Speed Indicator

Connect terminals ① and ⑪ of the **SDM496**, (a digital speed indicator), to the SPEED OUT terminals of control unit.

Uni-directional Rotation



Bi-directional Rotation



Switch Specification
Single-Phase 110V/115V: AC250V 5A Min.
Single-Phase 220V/230V: AC400V 5A Min.

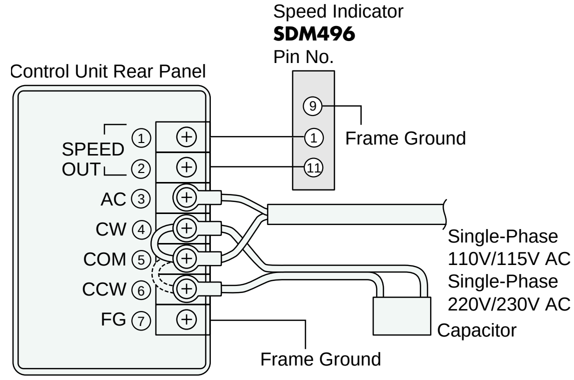
US560 and **US590** types
(Connection of capacitor is necessary.)

Uni-directional Rotation
When the direction of motor rotation needs to be reversed, change the terminal used for attaching the power cord, located at the back of control unit, from terminals ④ - ⑤ (CW - COM) to terminals ⑤ - ⑥ (COM - CCW). The power cord connections are located at terminals ④ - ⑤ when shipping. See the diagram to the right.
(This should always be done with the power OFF.)

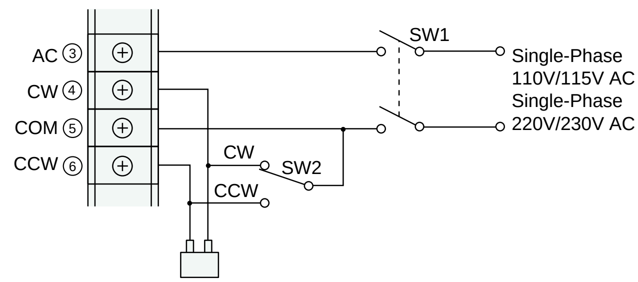
Bi-directional Rotation
Install an additional power switch (SW1) and CW/CCW switch (SW2) as shown in the diagram to the right, and use these switches to change the direction of rotation. (Motor cannot be reversed instantaneously. Turn SW1 off and wait until the motor has come to a complete stop before switching SW2.)
See the diagram to the right.

Connecting The Speed Indicator
Connect terminals ① and ⑪ of the SDM496, (a digital speed indicator), to the SPEED OUT terminals ① and ② of control unit.

Uni-directional Rotation



Bi-directional Rotation

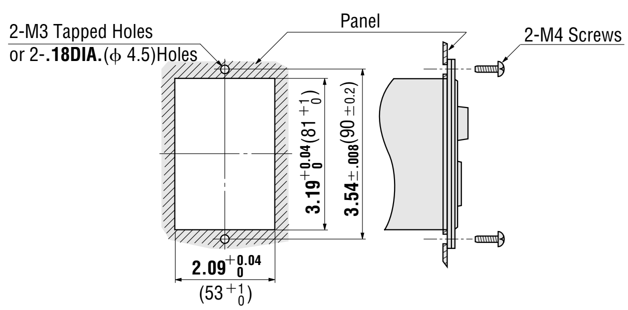


Switch Specification : AC250V 5A Min.
Single-Phase 110V/115V : AC250V 5A Min.
Single-Phase 220V/230V : AC400V 5A Min.

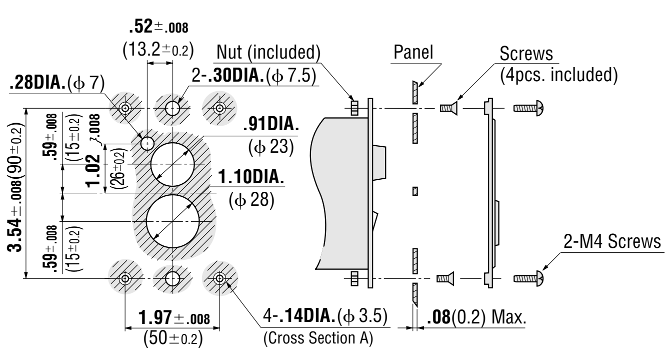
Installation Hole for Control Unit

The control unit can be installed from either the front or back of the panel. In either case, the installation hole shown below is required.

1. Installation from front of panel



2. Installation from back of panel



Extension Cable (Sold separately)

When installing the motor and control unit in different locations, an extension cable can be used (sold separately). This enables remote operation at a distance of up to 15.7 feet.(4.75m).
See page [A-270] for details.

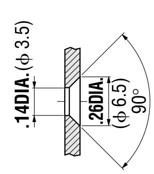
●**US206**,**US315**,**US425**,**US540** types

Model	Length		Weight	
	ft.	(m)	lb.	(kg)
CC01SS052	3.3	(1)	0.22	(0.10)
CC02SS052	6.6	(2)	0.44	(0.20)
CC03SS052	9.8	(3)	0.57	(0.26)
CC04SS052	13.1	(4)	0.77	(0.35)

●**US560**, **US590** types

Model	Length		Weight	
	ft.	(m)	lb.	(kg)
CC01SS2	3.3	(1)	0.37	(0.17)
CC02SS2	6.6	(2)	0.68	(0.31)
CC03SS2	9.8	(3)	1.01	(0.46)
CC04SS2	13.1	(4)	1.28	(0.58)

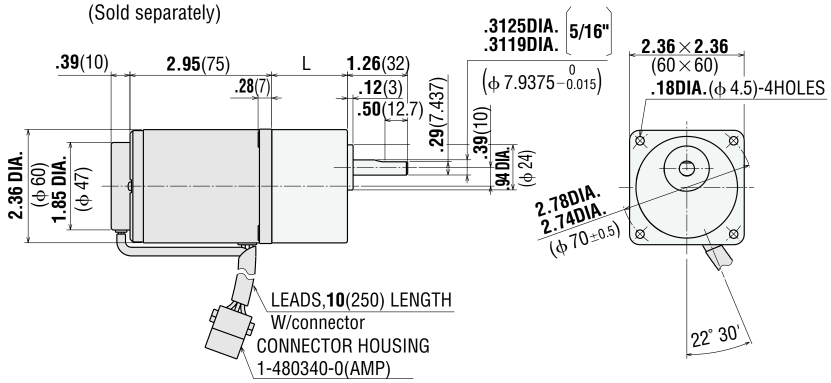
Cross Section A



■ Dimensions Scale 1/4, Unit =**inch** (mm)

US206-401U
US206-402E

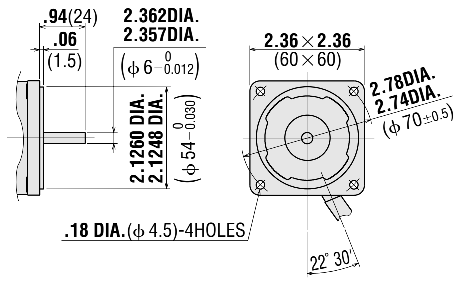
Motor USM206-401W Weight (Mass): 1.8 lb. (0.8 kg)
USM206-402W
Gearhead **2GN□KA** Weight (Mass): 0.88 lb. (0.4 kg)
(Sold separately)



L = **1.18**(30) **2GN3KA~18KA**
L = **1.57**(40) **2GN25KA~180KA**

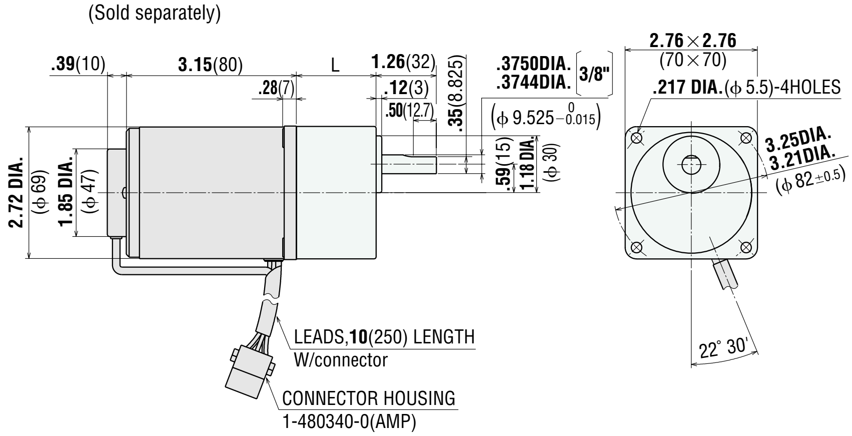
US206-001U Round shaft
US206-002E

Motor USM206-001W Weight (Mass): 1.8 lb. (0.8 kg)
USM206-002W



US315-401U
US315-402E

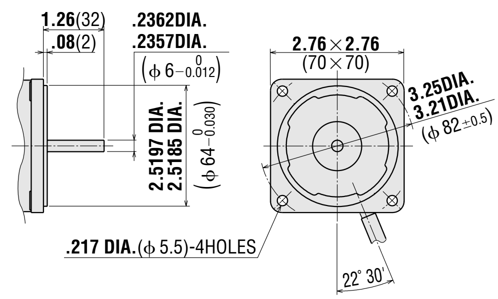
Motor USM315-401W Weight (Mass): 2.6 lb. (1.2 kg)
USM315-402W
Gearhead **3GN□KA** Weight (Mass): 1.21 lb. (0.55 kg)
(Sold separately)



L = **1.26**(32) **3GN3KA~18KA**
L = **1.65**(42) **3GN25KA~180KA**

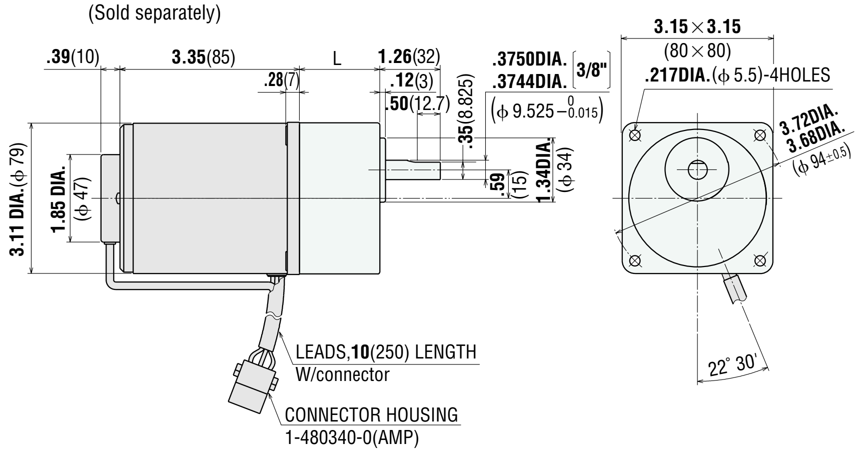
US315-001U Round shaft
US315-002E

Motor USM315-001W Weight (Mass): 2.6 lb. (1.2 kg)
USM315-002W



US425-401U
US425-402E

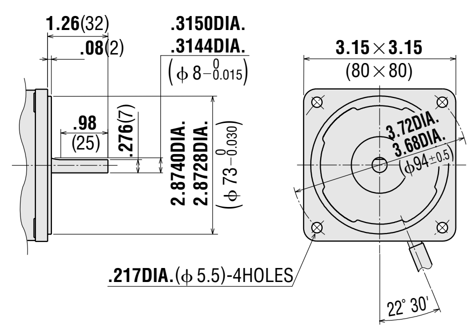
Motor USM425-401W Weight (Mass): 3.5 lb. (1.6 kg)
USM425-402W
Gearhead **4GN□KA** Weight (Mass): 1.43 lb. (0.65 kg)
(Sold separately)



L = **1.26**(32) **4GN3KA~18KA**
L = **1.67**(42.5) **4GN25KA~180KA**

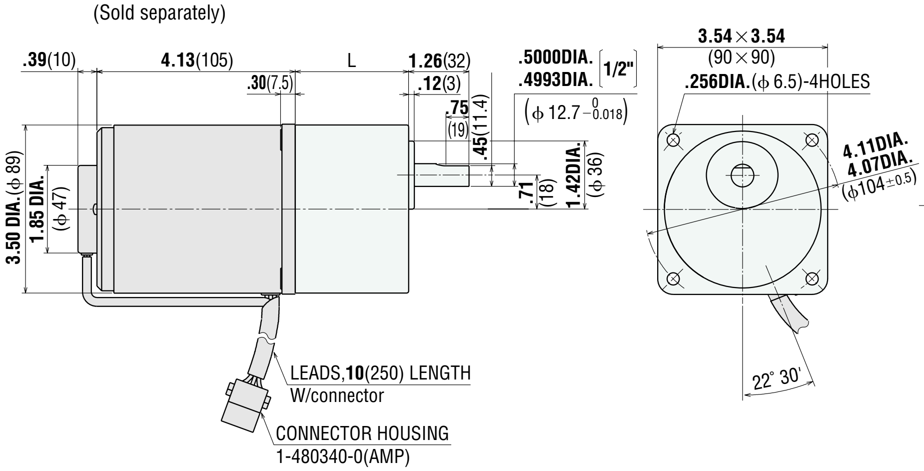
US425-001U (Round shaft)
US425-002E

Motor USM425-001W Weight (Mass): 3.5 lb. (1.6 kg)
USM425-002W



US540-401U
US540-402E

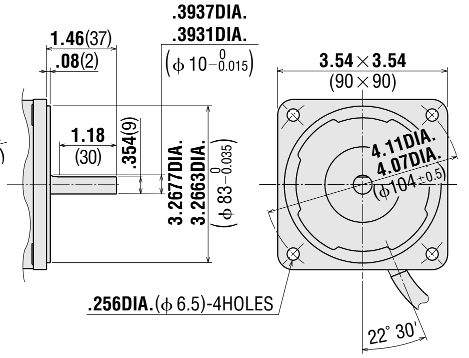
Motor USM540-401W Weight (Mass): 5.7 lb. (2.6 kg)
USM540-402W
Gearhead **5GN□KA** Weight (Mass): 3.3 lb. (1.5 kg)
(Sold separately)



L = **1.65**(42) **5GN3KA~18KA**
L = **2.36**(60) **5GN25KA~180KA**

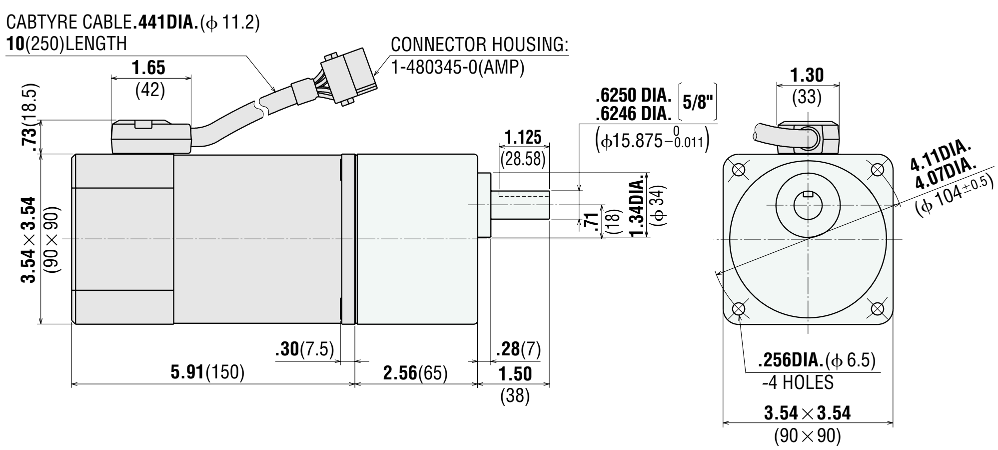
US540-001U (Round shaft)
US540-002E

Motor USM540-001W Weight (Mass): 5.7 lb. (2.6kg)
USM540-002W



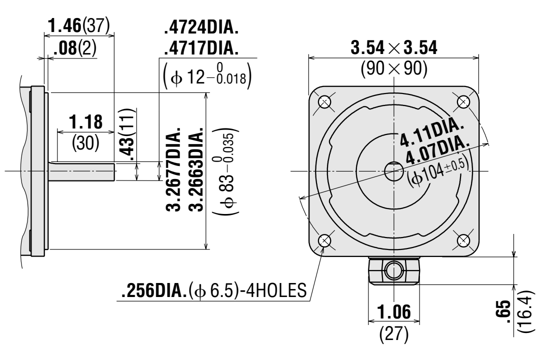
US560-501U
US560-502E

Motor USM560-501W Weight (Mass): 6.2 lb. (2.8 kg)
USM560-502W
Gearhead **5GU□KA** Weight (Mass): 3.3 lb. (1.5 kg)
(Sold separately)



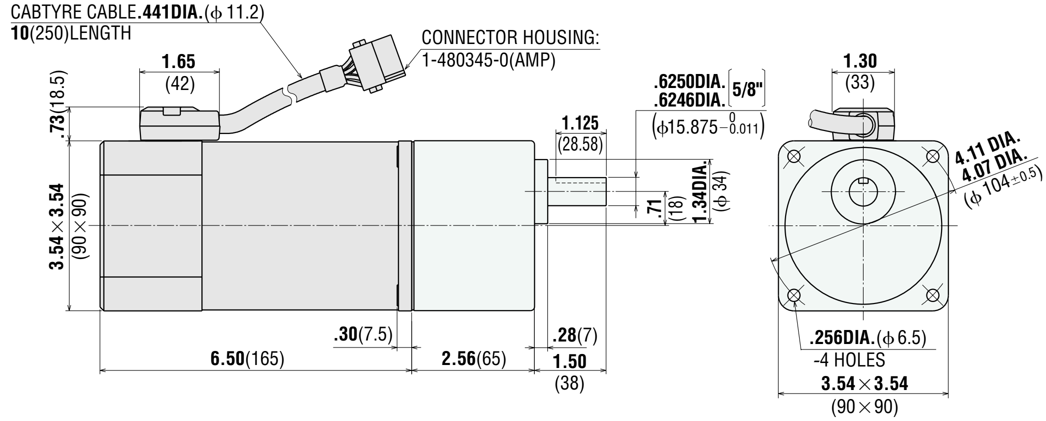
US560-001U (Round Shaft)
US560-002E

Motor USM560-001W Weight (Mass): 6.2 lb. (2.8kg)
USM560-002W



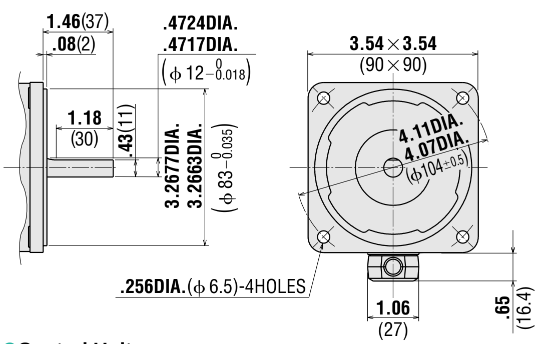
US590-501U
US590-502E

Motor USM590-501W Weight (Mass): 7.9 lb. (3.6 kg)
USM590-502W
Gearhead **5GU□KA** Weight (Mass): 3.3 lb. (1.5 kg)
(Sold separately)

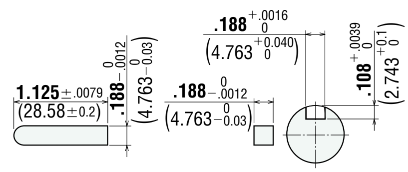


US590-001U (Round shaft)
US590-002E

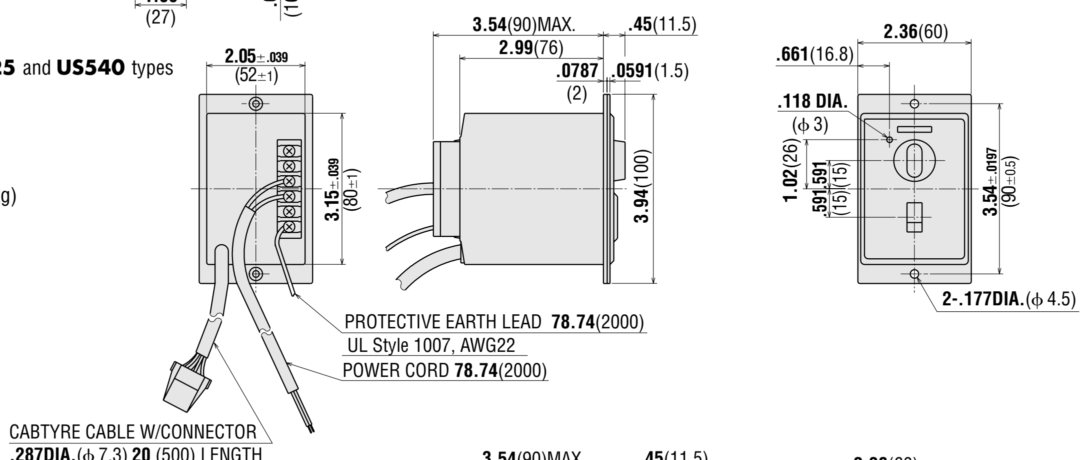
Motor USM590-001W Weight (Mass) : 7.9 lb. (3.6kg)
USM590-002W



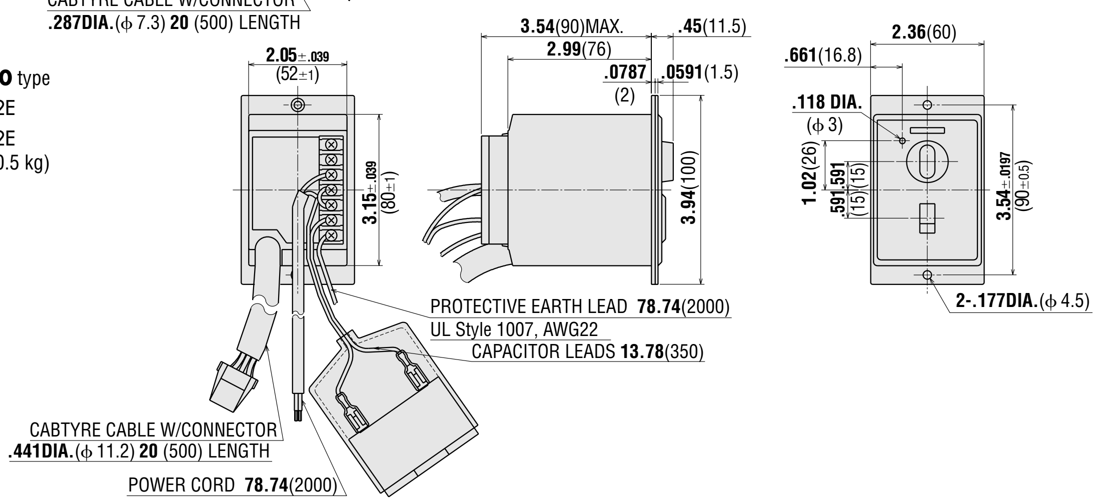
●**Key and Key Slot** (Scale 1/2)
(included)
5GU□KA



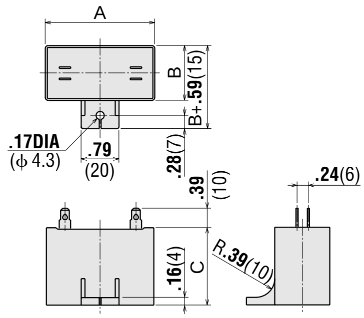
●**Control Unit**
for **US206, US315, US425** and **US540** types
USP206-1U, USP206-2E
USP315-1U, USP315-2E
USP425-1U, USP425-2E
USP540-1U, USP540-2E
Weight (Mass): 1.0 lb. (0.45kg)



●**Control Unit**
for **US560** and **US590** type
USP560-1U, USP560-2E
USP590-1U, USP590-2E
Weight (Mass): 1.1 lb. (0.5 kg)



●Capacitor (included with the motor)



Capacitor Dimensions Unit = inch (mm)

Unit Model	Capacitor Model	A	B	C	Weight(Mass) oz (g)
US560-☐01U	CH180CFAUL	2.28 (58)	0.93 (23.5)	1.46 (37)	2.47 (70)
US560-☐02E	CH40BFAUL	2.28 (58)	0.93 (23.5)	1.46 (37)	2.47 (70)
US590-☐01U	CH200CFAUL	2.28 (58)	1.14 (29)	1.61 (41)	3.35 (95)
US590-☐02E	CH60BFAUL	2.28 (58)	1.14 (29)	1.61 (41)	3.00 (85)

Capacitor cap is provided with the capacitor.

■ Right-Angle Gearheads (Sold separately)

The right-angle gearhead provides an output shaft at a right angle to the motor's output shaft. See page[A-216] for specifications and more information.

■ Accessories (Sold separately)

● Motor Mounting Brackets

Optional die-cast aluminum mounting brackets are available.
They can be used to install motors without gearheads.
See page[A-266] for the dimensions.

Motor	Model
for 6W type	**SOL2U08**
for 15W type	**SOL3U10**
for 25W type	**SOL4U10**
for 40W, 60W, 90W type	**SOL5UA**

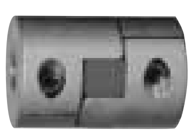
● Speed Indicator

To check the speed of speed control motors,connect the speed indicator.
See page [A-267] for more information.

Model: **SDM496**

● Flexible Couplings

Optional flexible couplings are available.
See page [A-260] for more information.



● Extension Cable

Extension cable for connecting motor and control unit.
See page[A-270] for the dimensions.

SID-242
Thin Film Deposition Controller

SQS-242
Deposition Control Software

SQM-242
Deposition Control Card

Version 3.23

User's Guide

Σ Sigma instruments

Safety Information

Read this manual before installing, operating, or servicing equipment. Do not install substitute parts, or perform any unauthorized modification of the product. Return the product to Sigma Instruments for service and repair to ensure that safety features are maintained.

Safety Symbols

WARNING: Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

CAUTION: Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

Refer to all manual Warning or Caution information before using this product to avoid personal injury or equipment damage.

Hazardous voltages may be present.

Earth ground symbol.

Chassis ground symbol.

Equipotential ground symbol.

Warranty Information

Hardware Warranty: This Sigma Instruments product is warranted against defects in material and workmanship for a period of 2 years from the date of shipment, when used in accordance with the instructions in this manual. During the warranty period, Sigma will, at its option, either repair or replace products that prove to be defective.

Software Warranty: Sigma Instruments warrants that the media on which this software is supplied will be free from defects for a period of 90 days from the date of shipment. Sigma Instruments does not warrant that 1) the software and any updates will be free from defects, 2) the software will satisfy all of your requirements, 3) the use of the software will be uninterrupted or error free.

Limitation of Warranty

Defects from, or repairs necessitated by, misuse or alteration of the product, or any cause other than defective materials or workmanship are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. UNDER NO CIRCUMSTANCES SHALL SIGMA INSTRUMENTS BE LIABLE FOR CONSEQUENTIAL OR OTHER DAMAGES RESULTING FROM A BREACH OF THIS LIMITED WARRANTY, OR OTHERWISE.

Return Policy

The purchaser may return this product in new condition within 30 days after shipment for any reason. In case of return, purchaser is liable and responsible for all freight charges in both directions.

Sigma Instruments
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Fort Collins, CO 80524 USA
970-416-9660
970-416-9330 (fax)

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Chapter 1 Introduction

Chapter 2 Quick Start

Chapter 3 SQS-242 Software

Chapter 3 SQS-242 Software (continued)

Chapter 4 SQM-242 PC Card

Chapter 5 Digital I/O

Chapter 6 Computer Interface

Appendix

1.0 Introduction

This manual covers both the hardware and software associated with the SID-242 Thin Film Deposition Controller. The SID-242 consists of four main elements, integrated into a complete deposition control system:

SRC Series Rack-mount Computer
SQM-242 PC Card(s)
SQS-242 Windows CoDeposition Software
PLC for Digital I/O (option)

While the focus of this manual is on the SID-242 Controller package, it also covers each of these components separately. If you have purchased only the SQS-242 Software and/or the SQM-242 Card, we suggest that you also review Chapters 1 and 2 of this manual for important information.

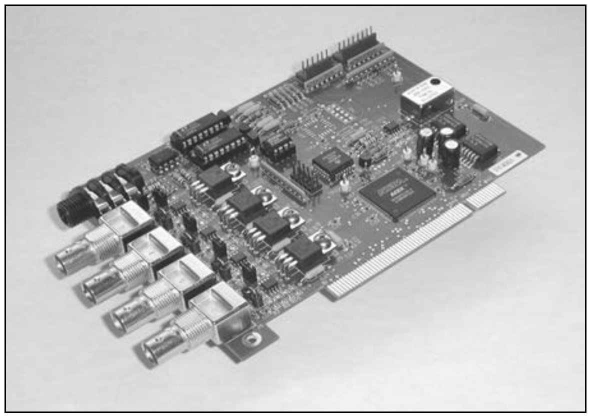
1.1 SRC Series Computer

Sigma's SRC Series computers are Celeron (or better) class computers running the Microsoft Windows® operating system. SRC computers use standard off-the-shelf components and Sigma's custom rack-mount chassis to provide a compact, flexible, yet low cost instrument.

Included in the 5.25" high rack-mount chassis are an LCD Display, a TouchPad pointing device, a setting Knob, and six SoftKeys. A standard keyboard is provided; an optional rack-mount keyboard is also available.

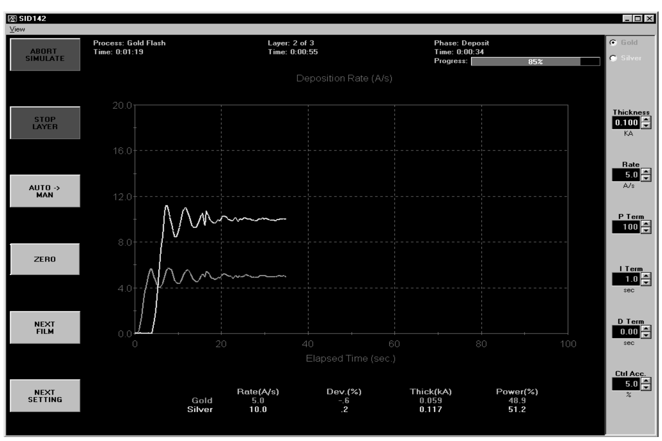
1.2 SQM-242 Deposition Control Card

Sigma's SQM-242 is a PCI expansion card for use in computers running the Microsoft Windows® operating system. Each card measures up to four quartz sensors via BNC inputs, and supplies the control signal for two evaporation sources via a ¼" stereo phone plug. Up to six SQM-242 cards can be installed in a computer. A single SAM-242 piggyback card with four analog inputs and two control outputs can also be installed.



Consult the separate SQM-242 card User's Guide for detailed information on installing SQM-242 and SAM-242 cards.

1.3 SQS-242 CoDeposition Control Software



Included with the SID-242 is Sigma's SQS-242 software, a Windows-based program that provides all of the functions required for an eight sensor, six output, CoDeposition controller. It is optimized for use with the Setting Knob and six SoftKeys of our SID-242 controller. However, it will run on any Win98 or later system with our SQM-242 and SAM-242 cards installed.

The six SoftKeys provide easy access to the common operating functions. A single tabbed dialog box provides all of the settings required for a thin film process. Material parameters, sensor/source setup, pre/post conditioning, and error conditions are all visible on a single screen. Process settings, numeric data, and graphical displays are displayed during all phases of deposition.

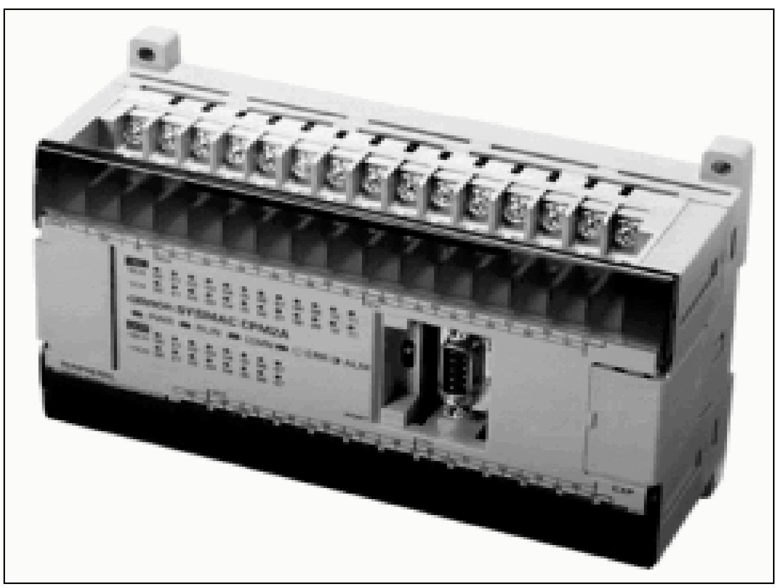
The SQS-242 software stores process parameters in a Microsoft Access compatible database. This provides virtually unlimited access to desktop tools for building and analyzing thin film processes.

The SQS-242 software can be controlled from another computer using the RS-232 or Ethernet command protocol.

1.4 Digital I/O

Digital I/O for the SID-242 is provided through an inexpensive, external, programmable logic controller (PLC). This allows the PLC, and the associated I/O wiring, to be placed in a convenient location in a wiring cabinet. A single, serial communications cable runs to the SID-242 computer. The PLC provides electrical isolation, fail-safe operation, and extensive I/O processing capabilities through its ladder logic programming.

See Chapter 5 for more information on digital I/O capabilities.



2.0 Introduction

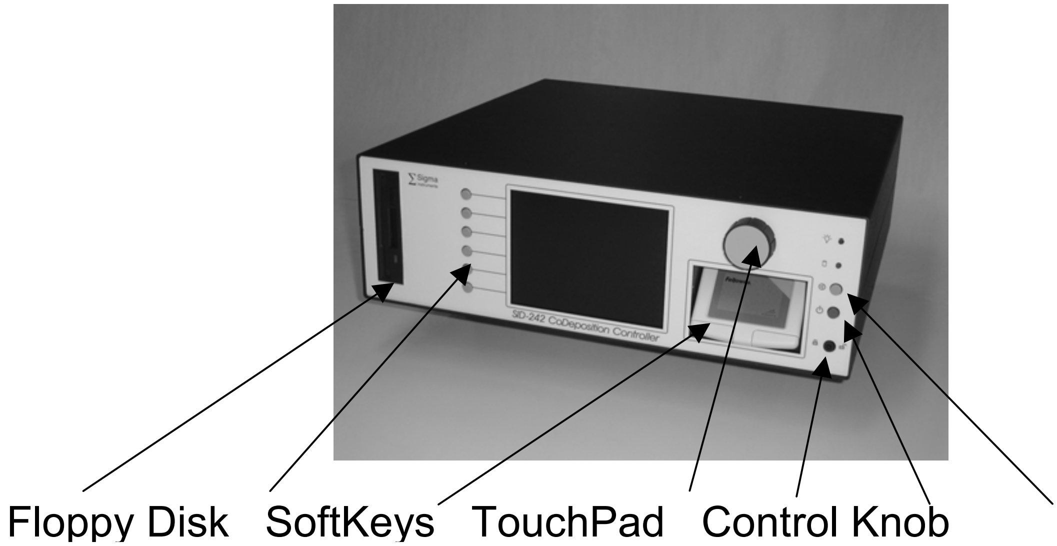
This section covers the minimum system connections and initial setup required to run the SID-242 Deposition Controller. Consult later chapters of this manual for more detailed setup and operational instructions.

2.1 Installation

WARNING: Care should be exercised to route SID-242 cables as far as practical from other cables that carry high voltages or generate noise. This includes other line voltage cables, wires to heaters that are SCR-controlled, and cables to source power supplies that may conduct high transient currents during arc down conditions.

Rack Installation	The SID-242 occupies a 5.25" high (4U) rack space. Install the unit in a 19" rack with the supplied hardware.
Power Connection	***WARNING***: Verify that the 120/240 Voltage Selector Switch, next to the power switch, matches your mains supply voltage. ***WARNING***: Verify that the power cable provided is connected to a properly grounded mains receptacle.
Sensor Input Connections	Connect the BNC cables and oscillators from your vacuum chamber feedthrough to the desired SQM-242 Card Input(s). Refer to Chapter 4 for detailed instructions on system hookup to the SQM-242 card(s).
Source Output Connections	Connect the dual phone plug from the SQM-242 output jack to your evaporation supply control input. Refer to Chapter 4 for detailed instructions on wiring the SQM-242 output phone plug.
Digital I/O Connections	Digital I/O is not required for initial operation of the SID-242. Perform initial setup and checkout of the SID-242 before connecting your digital I/O. Refer to Chapter 5 for detailed information on wiring the SID-242 for digital I/O.
Keyboard Connection	A keyboard is supplied for initial user setup of Windows. Attach the keyboard to the keyboard input jack on the rear of the SID-242.

2.2 Front Panel



Front Panel Controls

KeyLock Power Reset	Insert key and turn clockwise to enable the power (red) and reset (gray) buttons. Turn key counterclockwise to disable the power and reset buttons.
SoftKeys	Provide basic instrument operations within the SQS-242 deposition program. The SoftKeys are functional only in programs written specifically for the SRC computer.
TouchPad	Provides mouse functions in all Windows programs, including the SQS-242 software. Move your index finger along the TouchPad surface to move the cursor. Press the left or right buttons below the TouchPad surface to “click.”
Control Knob	Used to adjust values within the SQS-242 software. Pushing the control knob stores the current setting, and moves to the next setting. Functional only in programs written specifically for the SRC computer.
Floppy Disk	1.44 MB floppy disk for upgrades, backup, and data storage/transfer.
Keyboard (not shown)	Required for Windows data entry, and useful during initial SID-242 setup. The F1 through F6 keys on the keyboard provide the same functions as the six SoftKeys on the front panel.

2.3 Program Startup

This section will start the SID-242 and run the SQS-242 deposition control program.

Power On the Computer

Insert the and turn clockwise to enable the power and reset buttons. Push the power button to start the computer.

Start the Program

The SID-242 will boot Windows from the internal disk and start the SQS-242 deposition program. If the SQS-242 program does not start automatically, use the TouchPad to double-click the desktop icon.

Note: If you are prompted to register the software, just click Cancel for now. The SID-242 ships with one pre-assigned user. The user name is Super, with no Password.

User Login Screen

The SID-242 displays a progress bar during program startup, then a User Login screen. Select a User Name from the drop down box, enter the Password, then click OK. See Chapter 3 for more information on users, passwords, access levels, and registration.

Process Database

The SID-242 normally starts with the last active process displayed. If that process is not found, a Database Open dialog is displayed. Use the TouchPad to select the SQS242 database.

Main Display

As you operate the SID-242, the six SoftKey labels along the left of the screen will change to display appropriate functions.

Along the top of the display is a menu of less commonly used functions. This menu is available only when the SID-242 is stopped (i.e. not running a deposition process).

Simulate Mode

Simulate mode allows you to familiarize yourself with SID-242 operation, and test process recipes. Simulate Mode will be used for the remainder of this chapter.

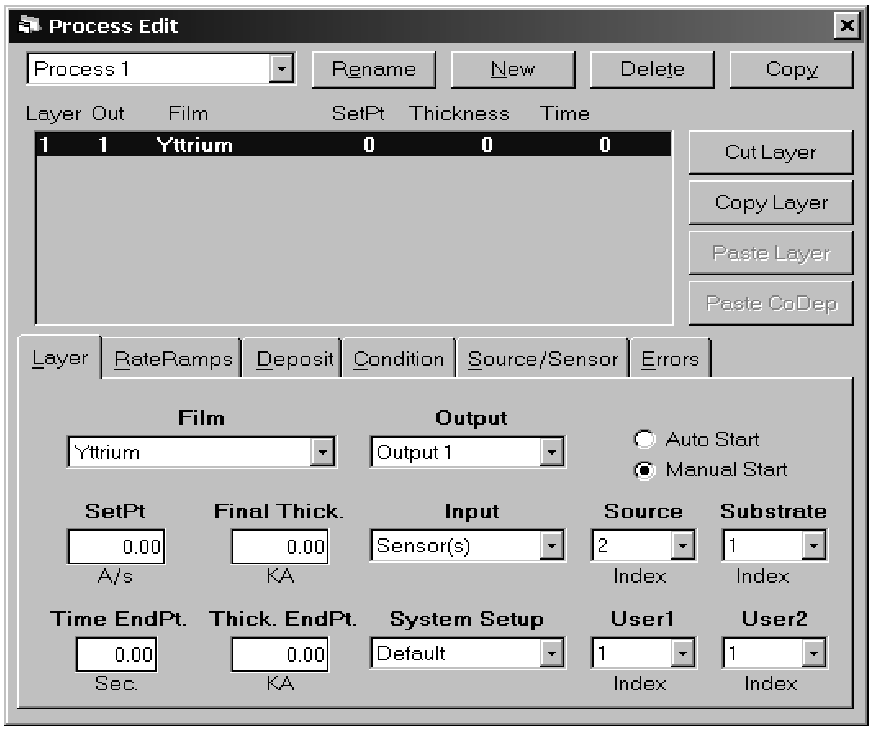
If the first SoftKey is labeled “START SIMULATE” then the Simulate mode is active. Otherwise, click the “Edit” menu selection along the top of the display, then click “System.” On the Card tab, click the Simulate button. Select the “Close” SoftKey to activate Simulate mode.

2.4 Single-Layer Process Setup

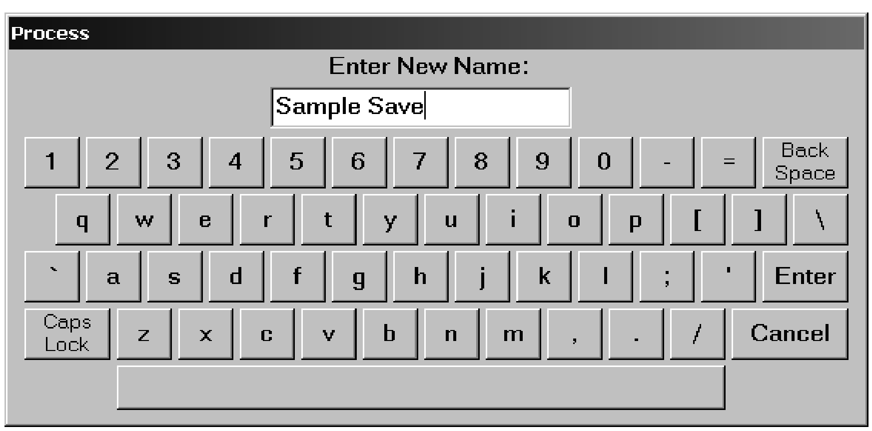
We will build a simple single-layer process as an introduction.

Create a New Process

Click the "Edit" menu selection along the top of the display, then click "Process." The Process Edit dialog will display the setup data for the active process. To create a new process, click the "New" button at the top of the Process Edit dialog box.

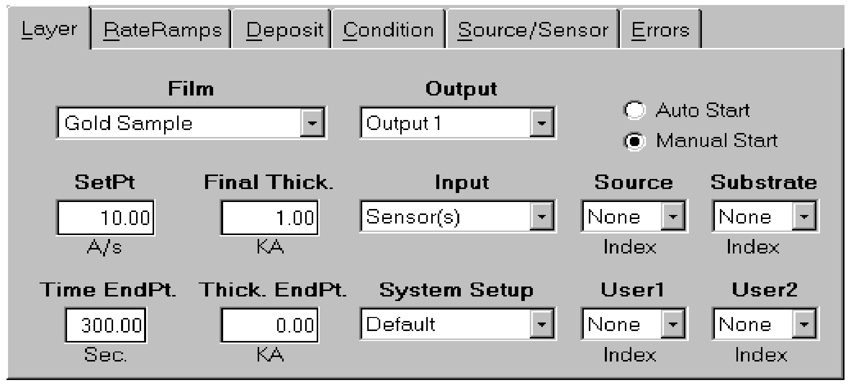


Type a new process name using your keyboard, or the touchpad and on-screen keyboard. Click "Enter" to save the new process name.



Edit Layer Parameters

Click the “Layer” tab to display the layer parameters.



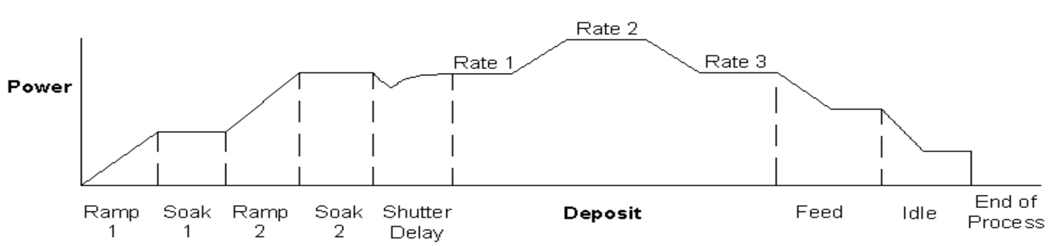
A Film is basically a material, plus the settings that will control its deposition. Select “Gold Sample” in the Film dropdown box. We will be simulating a quartz sensor input that is controlling the deposition rate of Output 1. Select Output 1 in the Output dropdown and Sensor(s) in the Input dropdown.

Click the SetPt setting, and then use the Control Knob or your keyboard to adjust the rate setpoint to 10 Å/s. Adjust the “Final Thickness” to 1.000 kÅ. Time and Thickness Endpoints won’t be used for this example.

System Setup determines the physical inputs and outputs that are used and displayed on the screen. For now use the Default system setup.

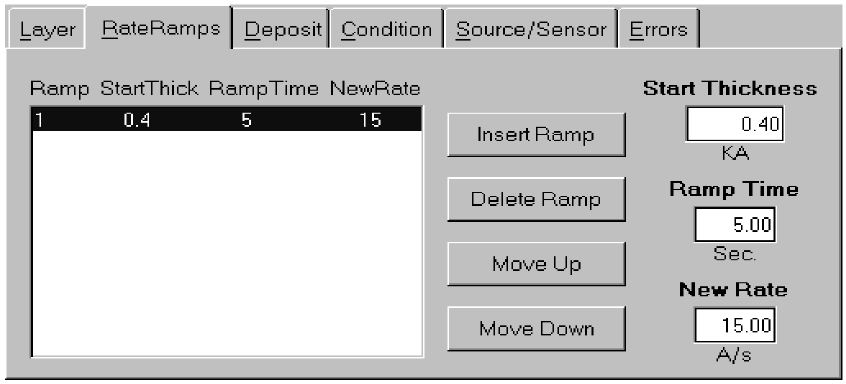
Manual Start causes this layer to wait for user input before beginning. We won’t use any indexers for this example, so select None.

A thin-film deposition process consists of one or more layers of material evaporated onto a substrate The diagram below illustrates a complete deposition cycle for a single layer. Refer to this diagram as we set the remaining parameters.



Edit Rate Ramps

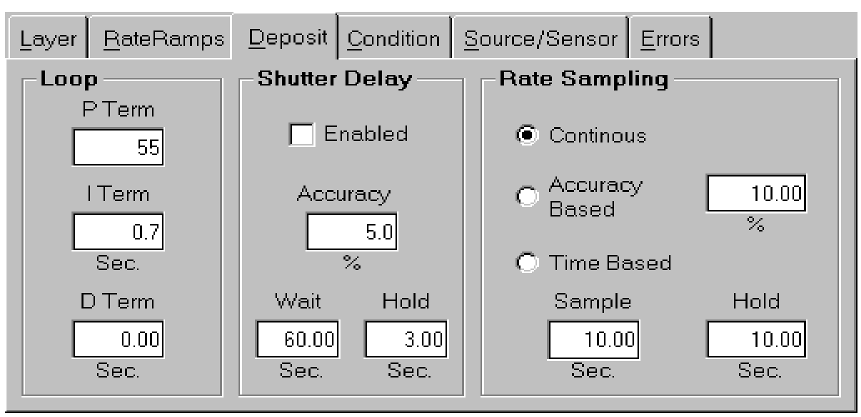
It may be desirable to vary the deposition rate during a layer. For example, to deposit slowly at first, then more quickly once the initial material is deposited. Click the “Rate Ramps” tab, then click “Insert Ramp.” Adjust the “Start Thickness” to 0.400 kÅ, “Ramp Time” to 5 seconds, and “New Rate” to 15 Å/s.



***Note**: Settings on the Layer and Rate Ramp tabs must be set for each layer in a process. Settings on the remaining four tabs (Deposit, Condition, Source/Sensor, and Errors) correspond to the Film that was selected on the Layers tab. This allows a Film’s settings to be used in a number of layers, without the need to individually adjust each layer.*

Edit Deposition

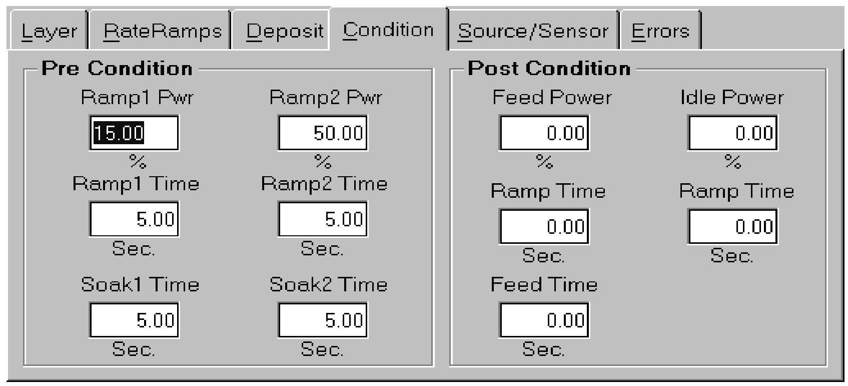
Select the “Deposit” tab. This tab establishes the gain (P Term), time constant (I Term), and dead time (D Term) for your process. Set these values to 55, .7, and 0 respectively.



Be sure Shutter Delay Enabled is <u>not</u> selected. Select Continuous for Rate Sampling.

Edit Pre/Post Conditioning

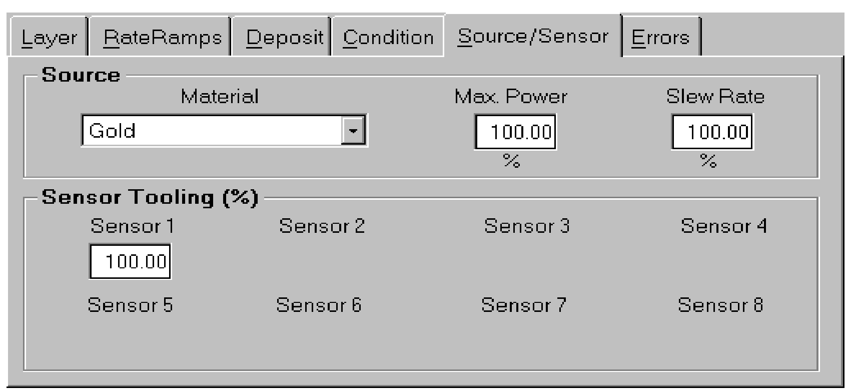
Before deposition begins, the source material is often brought to a ready state by slowly raising the evaporation source power. Select the “Condition” tab and set each parameter to the values shown below.



Edit Source/Sensor

Select the “Source/Sensor” tab. Select the proper material for this film, “Gold.” Set the maximum power and slew rate that should be used for the selected material.

Sensor Tooling adjusts for differences in the substrate deposition and that measured by each sensor. Select 100% for now.

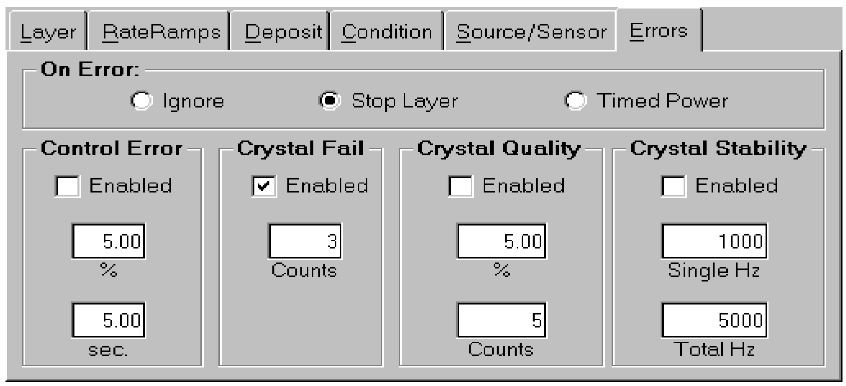


Edit Errors

Select the “Errors” tab to control the actions taken when a sensor or deposition control error occurs.

You can elect to ignore errors (unlikely), stop deposition for this layer, or continue deposition at a fixed power level. Select Stop Layer for this example.

Until a process is well established, it is best to enable only the Crystal Fail error checking. Uncheck the remaining error conditions.



Save Edits

Select the “Close Form” SoftKey to save this one-layer process. If you are prompted “Do you want to change….,” answer Yes to make this the current process.

Your new single-layer process is now the active process in the main window. Notice the process, layer, and time information above the graph.

2.5 Single-Layer Process Simulation

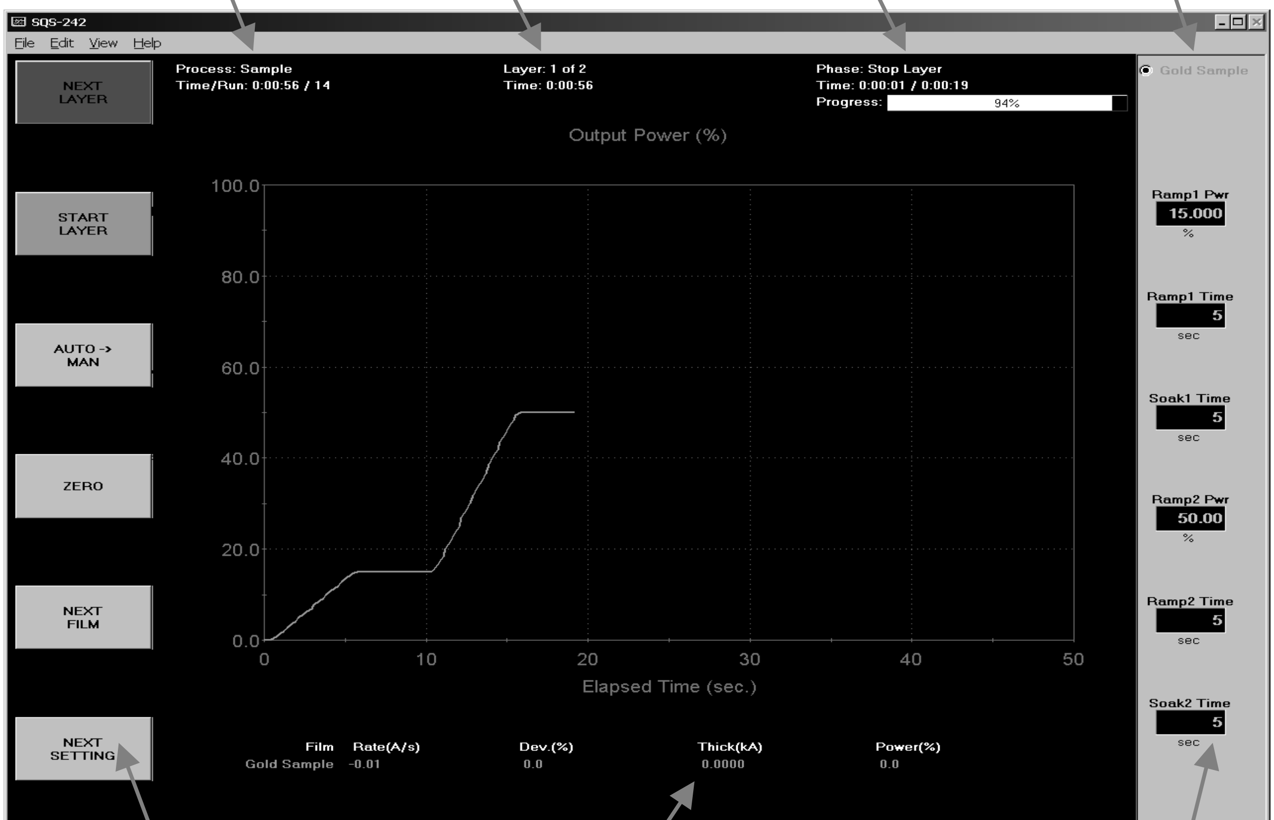
If you have followed this chapter, you are ready to simulate a deposition process. First, take a look at the information provided on the main screen.

Process
Name,
Elapsed Time,
Run Number

Layer
Number
Elapsed Time

Phase
Name
Time Elapsed/Remain
Percent Complete

Film(s)



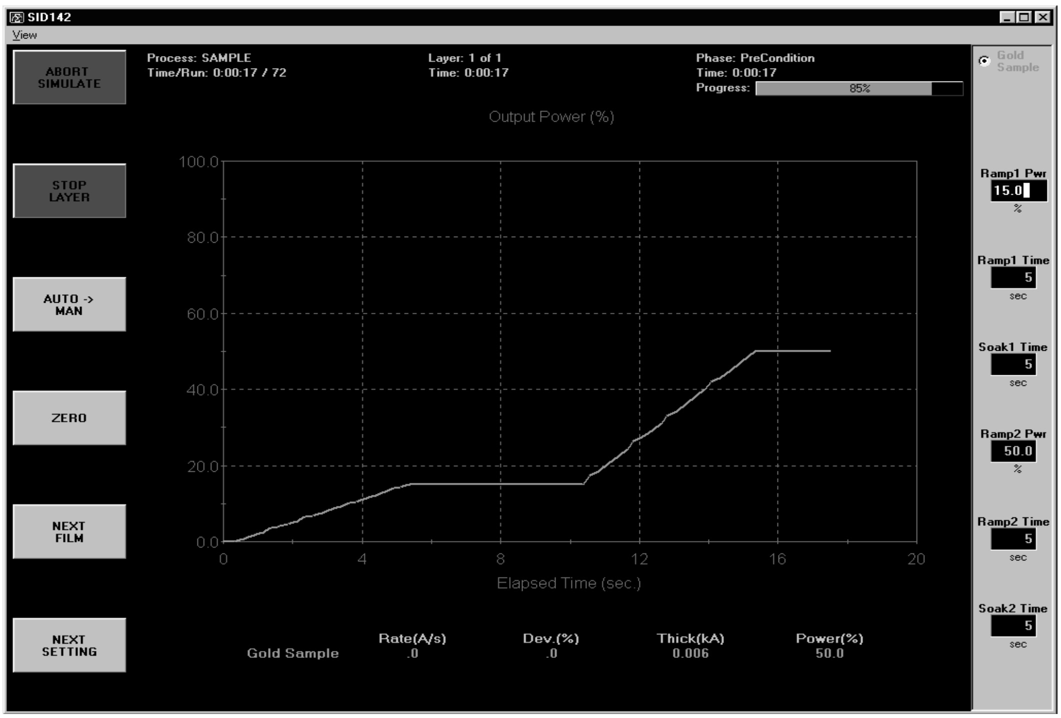
Operating SoftKeys **Film Measurements** **Film Settings**

Setup Displays Click the "View" menu and assure that these options are selected: Film Settings, Film Readings, and Automatic. Note that the settings "ribbon" along the right side of the screen displays the pre-conditioning parameters you entered in the previous section.

Start Process Verify that the top SoftKey label displays "START SIMULATE." If "START PROCESS" is displayed, follow the instructions at the end of Section 2.3 to enable simulate mode. Press the "START SIMULATE" SoftKey to start the process.

The process will start with preconditioning (i.e. Ramp1, Soak1, Ramp2, Soak2) as shown below. Once preconditioning is complete, the process will enter the Deposit phase.

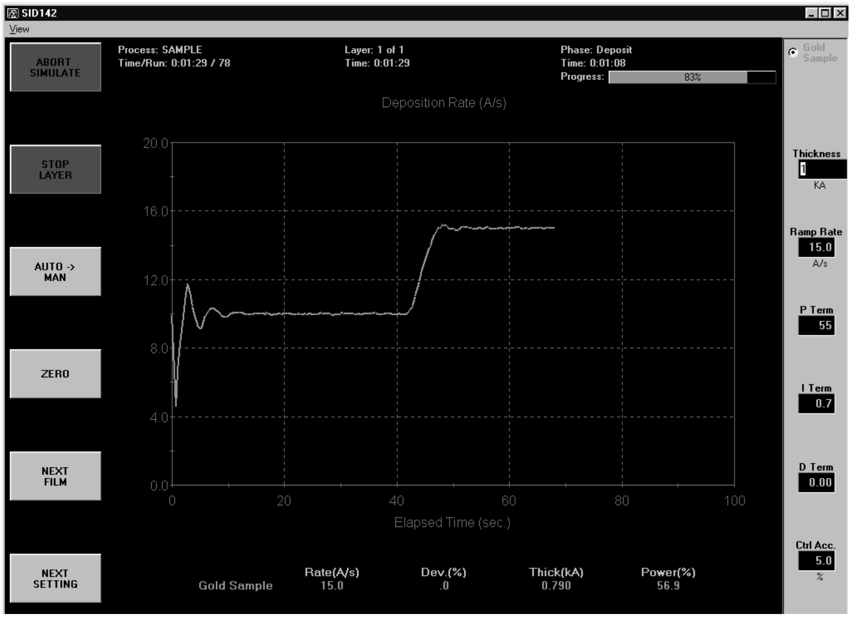
You may want to select “ABORT SIMULATE,” then “START SIMULATE” several times to familiarize yourself with the on-screen displays during preconditioning. You may also want to use the settings ribbon to adjust parameters while the process is running.



Preconditioning Phases

Because we selected “Automatic” in the View menu, the graph displays Output Power during preconditioning, then switches to Rate during the deposition phase.

As shown below, the initial deposition rate was 10 Å/s until a thickness of .400 kÅ. Then the deposition rate was ramped up to 15 Å/s, and held until the desired final thickness of 1.000 kÅ was achieved. At this point, this single-layer process is finished.



<u>Deposition Phase with one Rate Ramp</u>

You should adjust the PID parameters on the setting ribbon, then Start/Stop the process several times to become familiar with their effect on control loop response.

<u>Note</u>*: In Simulate Mode, a deposition rate is not “measured” until the output power exceeds 50%.*

2.6 SoftKey Functions

As you have seen, the SoftKey functions remain constant during deposition. Spend a few minutes to become familiar with each of these SoftKey functions.

START PROCESS	Starts the first layer of a process when START is pushed. If AUTO->MAN is shown on the third SoftKey (AUTO mode) the process starts PreConditioning. If MAN->AUTO is shown on the third SoftKey (MANUAL mode) the process immediately starts in the Deposition phase.
ABORT PROCESS	Aborts the process. The process can only restart at the first layer.
START LAYER	Starts a stopped layer, or a layer that has been designated “Manual Start” in the process database. Starts the layer based on the state of the AUTO->MAN SoftKey as described above.
STOP LAYER	Stops the current layer. Also changes the function of the first SoftKey to NEXT LAYER.
NEXT LAYER	Abandons the current layer and moves to the next layer in the process. If it is the last layer of a process, the same as pushing ABORT PROCESS.
AUTO->MAN	When AUTO->MAN is pushed, the source output is set to manual control. You may adjust the output using the settings ribbon. Because the PID loop is not running, you can manually set the output power to different levels and observe the associated deposition rate.
MAN->AUTO	Returns the output to PID loop control. If the process is running (ABORT PROCESS and STOP LAYER shown on the first two SoftKeys) deposition continues. If the process is stopped, sets the output to zero and awaits a start command.
ZERO	Resets the thickness reading to zero.
NEXT FILM	Sequences the setting ribbon through each Film in a codeposition layer.
NEXT SETTING	When the settings ribbon is shown, sequences the setting knob action through each of the displayed parameters.

2.7 Multi-Layer CoDeposition Process

Our final example builds on the previous sections. If you have modified the setup of your process, return to Section 2.4 and adjust the process to those values. When your single-layer process matches Section 2.4, complete these steps:

Duplicate a Layer

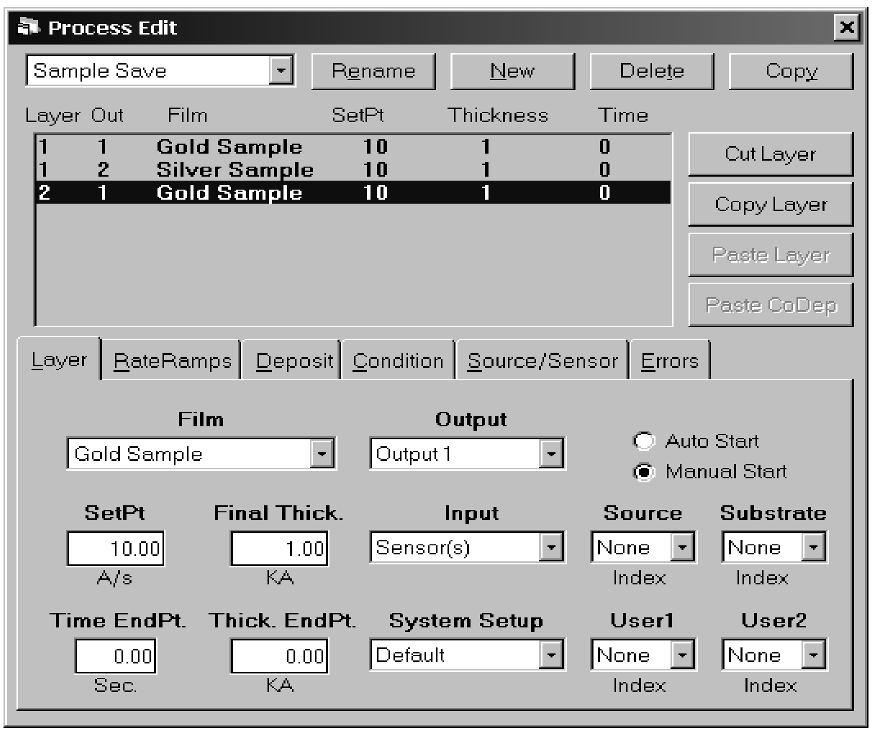
Open the Edit Process dialog. Click on Layer 1, click the "Layer" tab, then click "Copy Layer." Now click "Paste Layer." A duplicate Gold Sample film will be added as Layer 2. Click "Paste Layer" again to add a third Gold Sample layer.

Select a CoDep Film

Select Layer 3 in the layers list. Now select "Silver Sample" in the Films dropdown and Output 2 in the Output dropdown. The layers list will update to show the new Silver Sample film assigned to Layer 3.

Add a CoDep Layer

Select Layer 3 in the layers list, then click "Cut Layer." Now select Layer 1. Click "Paste CoDep." The Silver Sample film will be added below Gold Sample as a codeposition layer. (Your setup should match the picture below.)



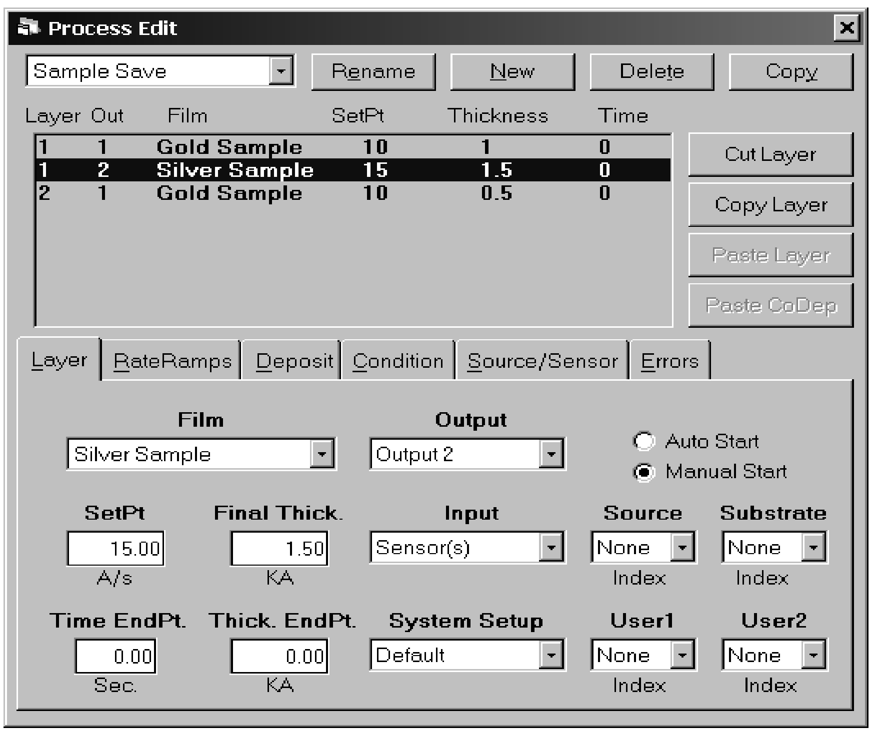
We now have two layers in our process. Layer 1 has Gold being deposited from source Output 1 and Silver is being codeposited on Output 2. Layer 2 is Gold alone.

Hint: *It's easiest to copy a layer, then paste several temporary layers of that type as additional layers. Next, assign the films and outputs that you want to each of these additional layers. Now use "Cut Layer" on the temporary layers, and "Paste CoDep" to assign the film to the desired codeposition layers. Remember that each film in a codeposited layer must be assigned to a different source output! Review this example until you are comfortable with these concepts.*

Edit Layer 1 Rate & Thickness — Click Silver Sample in the list of layers. Set "Initial Rate" to 15 Å/s, "Final Thickness" to 1.500 kÅ. Click the Rate Ramps tab and adjust "Start Thickness" to 0.400 kÅ, "Ramp Time" to 15 seconds, and "New Rate" to 0 Å/s.

Edit Layer 2 Rate & Thickness — Click the Layer Tab, then click Layer 2 Gold Sample. Set Final Thickness to .5000 kÅ.

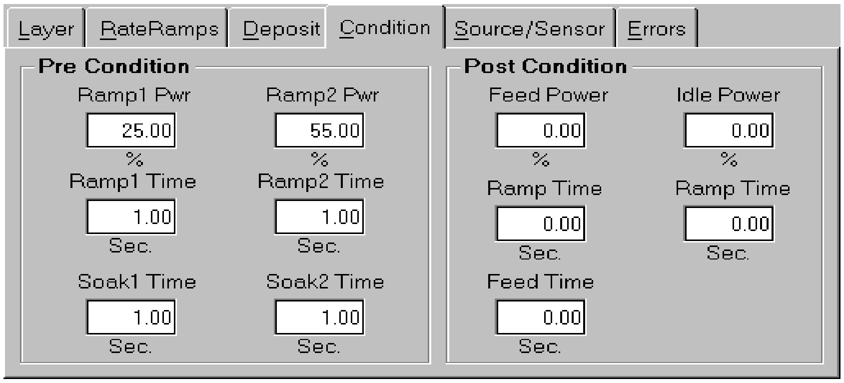
Set Layers to Auto Start — At the end of deposition, you may choose to have the next layer wait for a Start Layer command, or to start automatically. Select each Layer in the layers list, then click Auto to set that layer to start automatically.



Verify that your process matches the one shown above.

Edit Silver Conditioning

Select the “Condition” tab and the Silver Sample layer. Set each parameter to the values shown below.



Save Edits

Click “Close Form” or press the first SoftKey to save this two-layer codeposition process. Answer Yes if it displays the “Do you want to change….” message box to make this the current process.

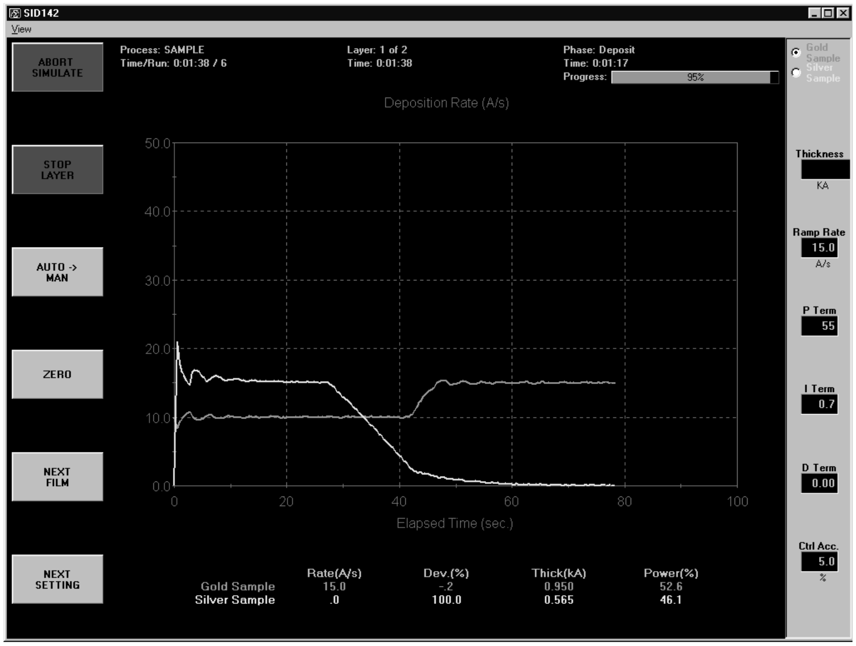
Start Process

Press the “START SIMULATE” SoftKey to start the first layer preconditioning phases. Note that two outputs are displayed for this codeposition layer.

Preconditioning of the two materials is entirely independent. If the preconditioning of one layer takes longer than the other, the start times are adjusted so that the end times coincide.

When preconditioning ends, codeposition of the two materials begins.

Your response should be similar to the graph shown below (your vertical scale may be slightly different). The slight ringing on the waveforms indicates some further tuning may be desired. However, this is an example of a reasonably well tuned loop.



At .400kÅ thickness, the Silver Sample deposition rate ramps down from 15Å/s to 0. Similarly, at .400 kÅ thickness the Gold Sample film ramps to a higher deposition rate of 15Å/s. Because the initial rate for Gold was set lower than the initial rate for Silver, Gold reached its .400 kÅ thickness rate ramp trigger later in the deposition cycle.

Try a P Term in the 25-30 range (less gain) for both Gold and Silver to decrease the loop susceptibility to noise. Increasing the I Term a little, say toward 1.0, will lessen overshoot during rate changes. The D term can be thought of as a “dead band” term. Most systems require little or no D term.

2.8 Conclusion

Once again, spend some time with this process to become familiar with its setup, and the effect of changes on deposition performance.

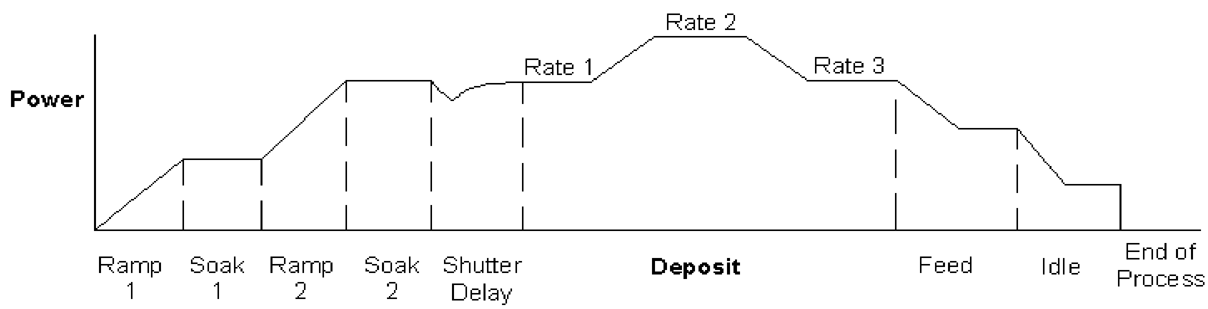
Because we selected Simulate Mode at the beginning of this Quick Start session, the SQM-242 card is “faking” an actual process. You can use the Simulate feature at any time to become familiar with SID-242 operation, and the effect of various settings on process performance. It is also a very useful feature for pre-testing your process setups. Return to the Edit menu, then select System and set the Mode to Normal to begin running your process with the SID-242 controller.

3.0 Introduction

The SQS-242 Deposition Control Software works with Sigma Instrument's SQM-242 Card to provide a powerful, PC based Thin Film Deposition Controller that can:

- Measure up to eight quartz crystal sensors simultaneously
- Control up to six deposition source supplies simultaneously (CoDeposition)
- Provide PreConditioning, multiple rate ramps, and feed/idle phases
- Graph deposition rate, rate deviation, or power output
- Store process, film and material parameters in Microsoft Access® database
- Provide flexible and reliable digital I/O using an inexpensive PLC

A typical deposition cycle for a thin film is shown below. The cycle can be broken into three distinct phases: pre-conditioning (ramp/soak), deposition, and post-conditioning (feed/idle).



During pre-conditioning, power is applied to prepare the source material for deposition. The first ramp/soak preconditioning phase is used to bring the material to a uniform molten state. The second ramp/soak phase is typically set to a power that is near the desired deposition rate.

When pre-conditioning ends, PID rate control of deposition begins. Initially, the substrate material may remain shuttered until the desired deposition rate is achieved (shutter delay). Once the control loop achieves the desired rate, the shutter opens and deposition begins. Multiple deposition rates (rate ramps) can be programmed.

When the desired thickness is reached, the evaporation source is set to feed or idle power. At this point the process may be complete, or deposition of another film layer may begin. Up to six separate films can be codeposited within a single layer. There is no practical limit to the total number of processes, layers, or materials that can be stored in the process database.

3.1 Installation and Registration

The SQM-242 card can be installed before or after the SQS-242 software. Consult the separate SQM-242 card User's Guide for installation information.

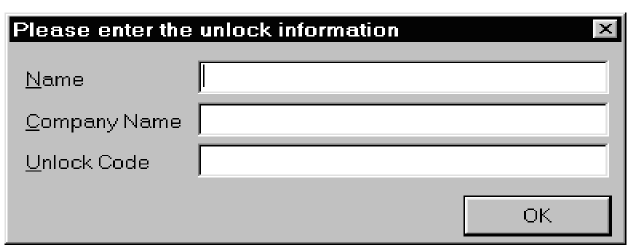
Note: *CD-ROM installation on the SID-242 rack mount computer can be accomplished with an external USB CDROM, or by copying the CD-ROM "Disk" folder to 3 ½" diskettes. It is also possible to use the SID-242 Ethernet connection to install the software over a network.*

To install the program, insert the disk or CD-ROM. Click Start, then Run, then type <d>:Setup (where <d> is the drive you are using). Click OK to begin installation, and follow the on-screen prompts. When installation is complete, you may be prompted to restart the computer.

To start the SQS-242 program, click Start, Programs, Sigma Instruments, then SQS-242. Until the software is registered, this Registration "nag" screen will appear.

Note: *You may select **Cancel** for a maximum of 30 unregistered runs. After 30 runs you must contact Sigma Instruments to start the program. There is no work-around!*

Press **OK** to show the unlock screen. Unlock codes are in the SQS-242 CDROM sleeve. If a valid User ID and Unlock Code are entered, the program will start normally. Otherwise, after three tries the program will start in unregistered mode.

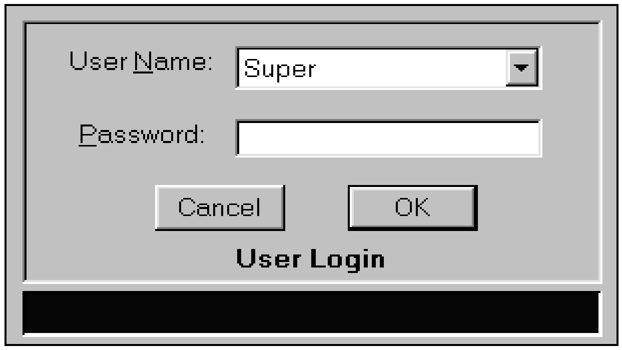


Note: *If you enter a name of DEMO and Unlock Code of 5A8CAC8E5586268 the software will be placed in Demo mode. All features of the software are permanently available, except that readings from the SQM-242 card are only simulated. The Demo mode can be disabled later by entering a valid User ID and Unlock Code.*

3.2 Operation

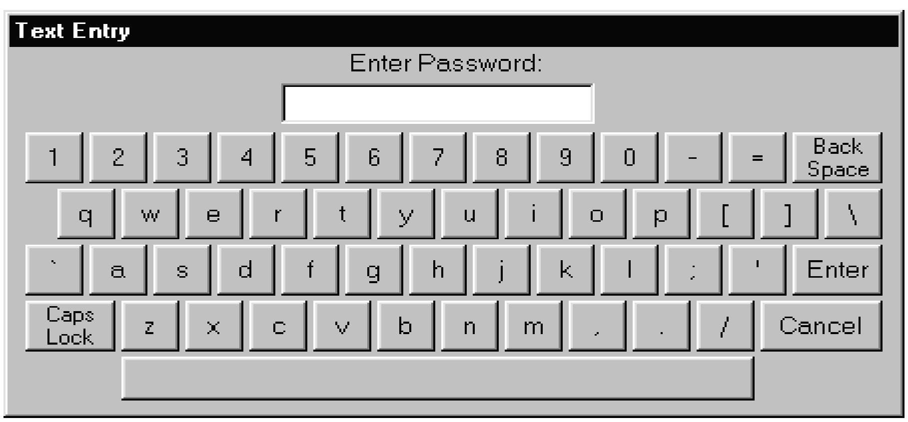
The SID-242 displays a progress bar during startup, then a User Login screen.

Note: The SQS-242 software ships with one pre-assigned user. The user name is Super, with no Password. Do not confuse this with the registration Name and Unlock Code discussed in the previous section.



Select a User Name from the drop down box, type in the Password, then click **OK** to start the program.

If your software is configured for keyboardless operation, an on-screen keyboard will appear as shown below. You can use your normal keyboard or mouse/TouchPad to "type" the password, then click Enter. See System Setup, SQM-242 Setup later in this chapter to enable or disable the on-screen keyboard.



An Access Level is associated with each User Name. The Access Level controls which software functions are available to each user. For example, only users with an Access Level of Supervisor can add new users. See the Security section of this chapter for information on setting up users.

The remainder of this chapter covers the purpose and operation of each software function, arranged by menu selections. For a more “operational” approach, consult the previous Quick Start chapter.

Menus: The menus along the top of the main screen provide access to functions for building deposition processes, configuring the hardware for your vacuum system, and data display.

SoftKeys: The six switches to the left of the display are used for the normal operation of the instrument, and to navigate the setup programs (see below for the individual switch functions). Normally, you press the button that is adjacent to the labels on the SID-242 screen, but you can also use the mouse. Just move the cursor over the key label on screen and single click the mouse. You can also use the keyboard F1 to F6 function keys to simulate the front panel function switches. The SoftKeys change during operation to address different user input requirements.

Setting Knob: The knob to the right of the display is used by the SID-242 to set numeric data. The keyboard +/- keys, or the on-screen up/down arrows can also be used.

TouchPad: On the SID-242, a TouchPad is located below the setting knob. The TouchPad serves the same function as a normal mouse. Use the TouchPad or mouse to access the menus, and for functions not available from the six function keys.

3.3 File Menu

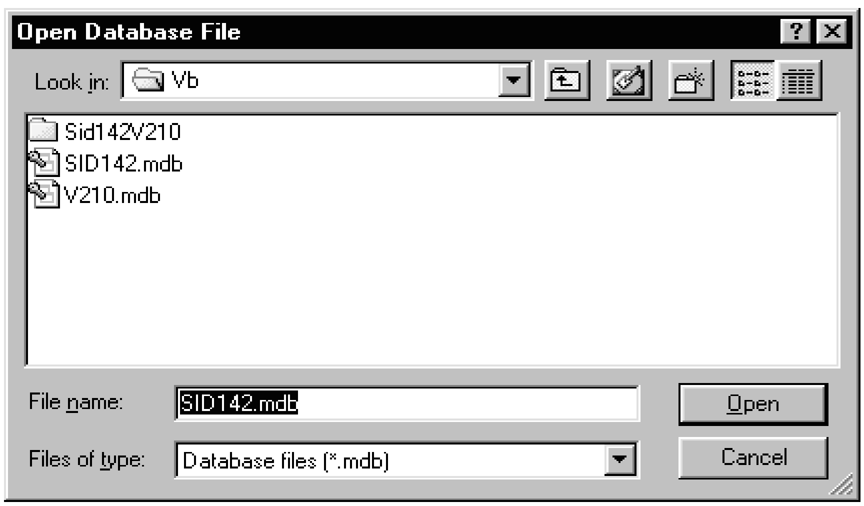
***Note**: The current process must be stopped for the File menu to be available.*

3.3.1 File: Process

Used to select a process from a list of all processes in the current database. If the process selected is different than the current process, you are prompted to confirm the change.

3.3.2 File: Open and Save Database

Open Database: Selects a process database to be used for deposition. Remember, a single process database may contain an unlimited number of processes, films, and materials.



***Note**: A read-only demo database (VER_DEMO.MDB) is included with each release. To use this database, use Windows Explorer to make a copy, then right click the new file and uncheck the read only property.*

Save Database As: Saves the current process database to disk under a different name. This is useful for saving the process database to floppy disk (for backup!), or for making trial changes without affecting your working database. Process databases are saved in Microsoft Access format.

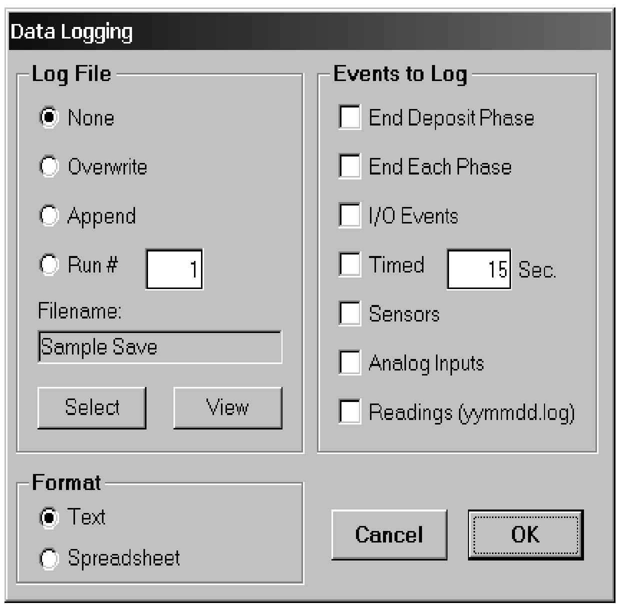
Once again, a pop-up keyboard may appear. If you want to browse, just select Cancel from the pop-up keyboard.

3.3.3 File: Data Logging

Logs data from a deposition process to a disk .LOG file. There are four options for file naming and logging.

Log File: Select "None" to disable data logging. If “Overwrite” is selected, the last run of the process is saved as FileName.LOG (where FileName is the name shown in the FileName text box). Subsequent runs overwrite the log file. If “Append” is selected, each run is appended to FileName.LOG. If “Run#” is selected, each run of the process is saved as a separate file under the format FileName_Run#.LOG.

Changing Run# on this screen will also change the Run# displayed at the top of the main program screen.



Normally, the log file is saved to the folder where the program is installed. If desired, you can click **Select** and navigate to a different folder. Log files can be viewed in Notepad by clicking the **View** button.

Note: *To avoid delays in data acquisition DO NOT log data to a floppy disk file. Instead, save to the hard disk, and transfer the files to a floppy disk later.*

Events to Log: A number of “events” can trigger a data entry in the log file. “End Deposit Phase” records process data (rate, thickness, time, etc.) at the end of each layer’s deposit phase. Similarly, “End Each Phase” logs data at the end of each phase (conditioning, depositing, etc.). “I/O Events” logs data each time an external digital input or output changes.

“Timed” logging records data at the selected time intervals throughout the process.

Click the Sensors box to include individual sensor data in addition to the normal film based data. Click Analog Inputs to also log that data.

Finally, click “Readings” to log every reading from the SQM-242 card(s). The file will be saved in the application directory with a name in yymmdd.log format. That is, readings logged on January 15, 2004 will be saved as 040115.log.

***Note**: This file can grow quite large and cause Windows to slow significantly. Typically, the “Timed” option is a better choice unless you must record every reading. When “Readings” is selected, a reminder screen appears each time the SQS-242 program is started.*

Format: There are two formats for writing data. If “Spreadsheet” is selected, each entry is a comma-delimited line of data. If “Text” is selected, the data is formatted for easy reading. The first few lines of the LOG file is a heading that illustrates the file format and content.

***Note**: If you wish to use a different delimiter than a comma, change the SQS242.INI file so that under the [DataLog] section, the LogDelimit= entry shows the charcater you wish to use. To use a <TAB> charcter, type the word Tab.*

3.3.4 File: Print

Print Process: Prints the parameters for the current process to the system printer. Select “Print to File” in the Printer Setup Menu to print the data to a file.

Print Setup: Selects and modifies the current system printer.

3.3.5 File: User Login

Displays the User Login screen so that a different user may log in. The existing user is logged off automatically. The user Access Level changes immediately to that of the new user. See the Edit, Security section for more information on Users, Passwords, and Access levels.

3.3.6 File: Exit

Exits the SQS-242 deposition control program and saves the current data.

3.4 Edit Menu

3.4.1 Edit: Process

A process is a sequence of thin film layers. Multiple films deposited in the same layer are known as CoDeposition. The Edit Process dialog provides the functions needed to develop a thin film deposition process from the database of existing films and materials.

Controls along the top of the Process Edit dialog box apply to the entire process:

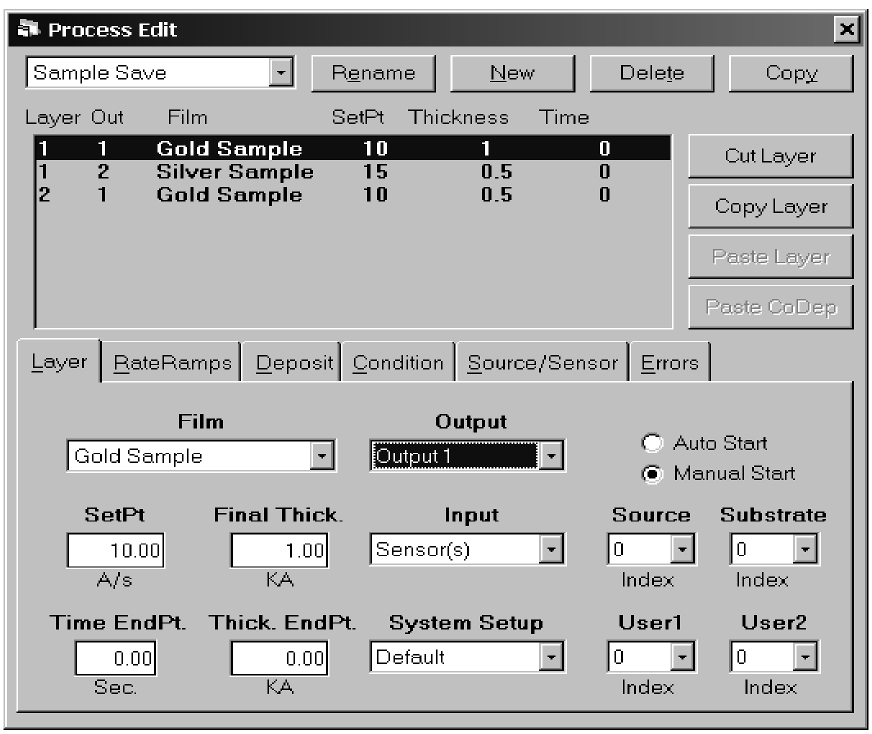
Process: A dropdown box that selects the process to be edited. Defaults to the current process. Below the process dropdown, a listing of each layer assigned to the Process. CoDeposition layers are listed with the same layer number, but a different output.

Rename: Edits the name of the selected process.

New: Creates a new process. Since every process must have at least one film, the first film of the currently selected process is used.

Delete: Deletes the selected process from the database. *There is no undelete!*

Copy: Creates a duplicate of the currently selected process.



Layers List: To select a process layer, click on it in the Layers list.

Cut/Copy/Paste the selected layer as described below:

Cut Layer: Removes the selected layer from the process and places the layer on the clipboard.

Copy Layer: Places the layer selected in the Layers list box on the clipboard, without removing it from the process.

Paste Layer: Inserts the clipboard layer above the currently selected layer in the Layers list box. Existing layers are shifted down.

Paste CoDep: Pastes the clipboard layer as a CoDeposition layer at the currently selected layer number. Attempting to paste a layer that uses an output already assigned to the selected layer generates an error message.

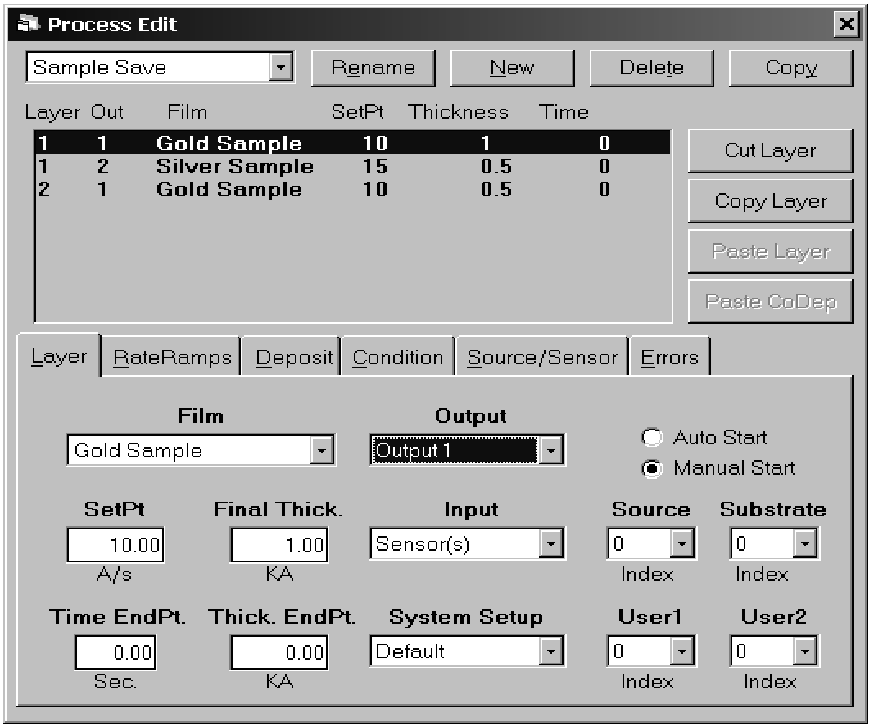
Hint: To add layers to a process, it is easiest to select an existing layer in the layers list, then click Copy. Click Paste repeatedly to insert several temporary layers. Next, assign the proper film and layers parameters to each of these temporary layers.

To change one of the temporary layers to a CoDep layer, highlight the temporary layer and click “Cut Layer.” Next click the layer desired for CoDep and click “Paste CoDep” to assign the selected layer. The Multi-Layer CoDeposition Process section of Chapter 2 illustrates this concept.

Controls in the tabbed control apply to the layer selected above, in the Layers list. The Layer and Rate Ramp tabs assign layer-specific parameters to the selected layer. Note that captions on the Layer tab may change, depending on the input and output selections. The remaining tabs provide access to the film assigned to the selected layer.

Note*: Edits to the Deposition, Condition, Source/Sensor, and Error tabs will affect all processes and layers that use the selected film!*

Layer Tab



Film DropDown Box: Assigns a film to the selected layer. A film is basically a Material, plus the other settings shown on the Deposit, Condition, Source/Sensor, and Error tabs.

Output DropDown Box: Selects the output that is used for deposition of the selected layer's film. A particular film often uses the same output (i.e. a thermal boat or EBeam pocket).

Note: *Due to the way outputs are stored in the process database, the physical output number (not its name) is listed in the layers listing. Outputs 1 and 2 refer to the first SQM-242 card outputs. Outputs 3 and 4 refer to the second SQM-242 card outputs (if installed). Outputs 13 and 14 are the SAM 242 card outputs (if installed).*

Input DropDown Box: Selects the input used to measure and control deposition of the selected layer. The combination of an output and its input defines the deposition "control loop" for the selected layer. The Input selection can significantly alter operation of the deposition phase, as described in the following discussion on the SetPt parameter.

SetPt: The function of the setpoint parameter depends on the Input dropdown. If Sensor(s) are used as the input, the setpoint is Rate (in A/s). This sets the initial Rate setpoint for the selected layer. Rate is controlled by the PID parameters for the film assigned to the layer. If no rate ramps are defined for the layer, this is the rate setpoint for the entire layer.

If the Input selected is Timed Power, the setpoint is shown as % Power. This sets a fixed % output Power during deposition. In Timed Power the Time Endpoint establishes the length of time for the deposition cycle. The layer will end when either the time endpoint is reached, or when the Final Thickness is reached, whichever occurs first.

If one of the SAM-242 analog inputs are selected, the setpoint is in volts (or the analog input's corresponding user-defined units). The layer will end when either Time Endpoint or Final Thickness is reached, whichever occurs first. See the Analog Inputs section later in this chapter for a discussion of programming for analog inputs.

Final Thickness: Sets the endpoint thickness for the selected layer. When final thickness is reached, deposition is stopped for that layer and the feed/hold phase is entered.

Time EndPoint: Sets an arbitrary time, after deposition begins, when the time setpoint relay is activated. During % Power and Analog Input deposition, it also sets the length of the deposition cycle.

Thickness EndPoint: Sets an arbitrary thickness that activates the thickness limit relay.

***Note**: The following parameters on the Layer tab are common to all of the co-deposited films in a particular layer. In the previous screen shot for this section, both layer 1.1 and 1.2 would share common values for the following parameters. Layer 2.1 could have different values.*

System Setup: System setup assigns outputs to their controlling sensors (called sensor mapping). It also determines which physical sensor and output connections are displayed on the main screen. See Edit, System for detailed System Setup information.

Auto/Manual Start: Determines whether a layer begins automatically upon completion of the previous layer. If Manual Start is selected, the previous layer ends at its idle power and waits for the user to push the Start Layer switch.

Source Index: Assigns each film to a specific source indexer pocket (one of 16 values). Each of the six possible outputs is associated with a unique source indexer. These values are sent to the digital I/O (PLC) at the beginning of each layer.

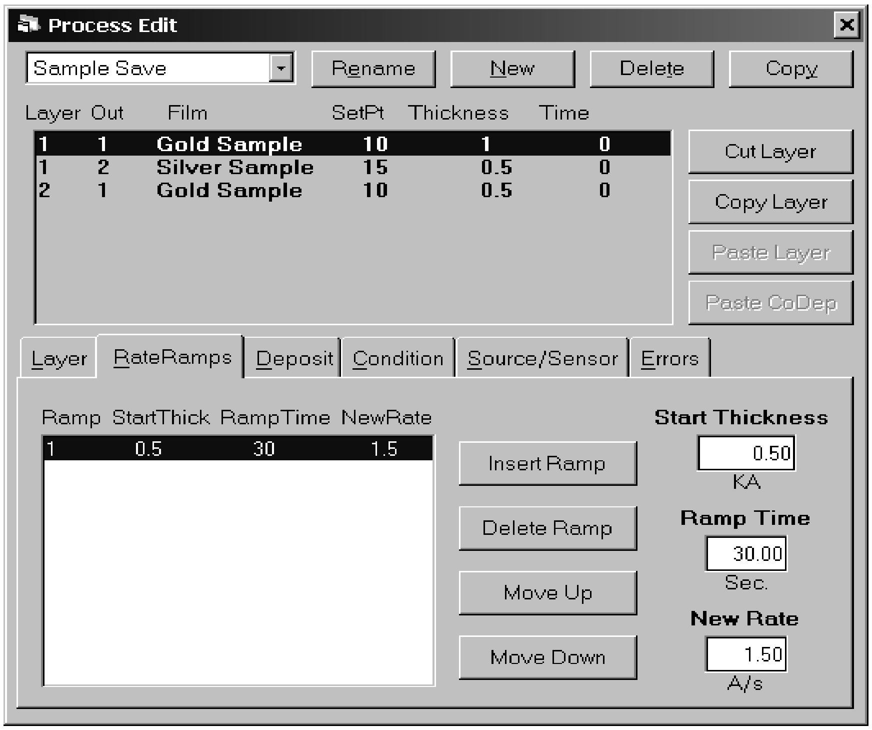
Substrate Index: If using a substrate indexer, assigns the substrate to one of 16 possible values. These values are set at the beginning of each layer.

User1/User2 Index: These additional values are output to the PLC for use as needed. Common applications are to select external equipment configurations.

***Note**: The Index names, and the range of values (0 to 15, or 1 to 16), can be customized by editing entries in the SQS242.INI file.*

Rate Ramps Tab

Rate ramps cause changes to the deposition rate over time under PID control. Each rate ramp has a starting thickness, an elapsed time to ramp to the new rate, and a new rate setpoint. Each process layer can have an unlimited number of rate ramps.



Insert Ramp: Inserts a new rate ramp for the selected layer, at the selected position in the rate ramps list. Existing rate ramps are shifted down.

Delete Ramp: Deletes the selected rate ramp.

Move Up: Shifts the selected rate ramp up one position.

Move Down: Shifts the selected rate ramp down one position.

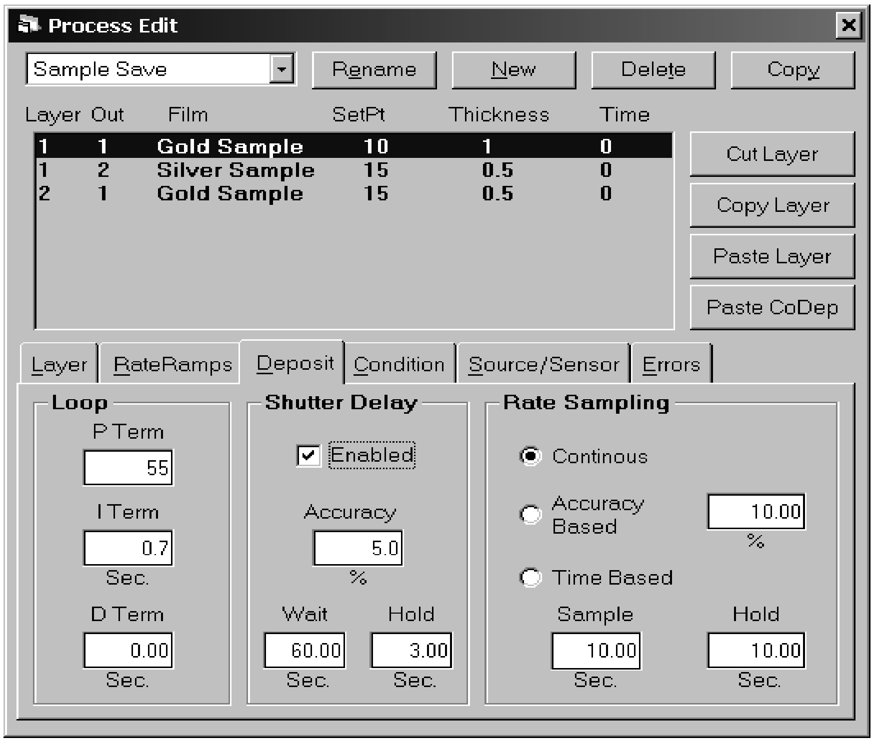
Start Thickness: The thickness that triggers a timed ramp to a new rate. (Start thickness should be greater for each subsequent ramp, and less than the final layer thickness, otherwise the rate ramp is ignored.)

Ramp Time: The time (in seconds) to ramp to the new rate. If the rate ramp is too fast, a PID control error may be generated.

New Rate: The new deposition rate setpoint for the selected layer.

Deposition Tab

The deposition tab contains parameters that directly affect the deposition phase of the process cycle.



P Term: Sets the gain of the control loop. High gains yield more responsive, but potentially unstable loops. Try a value of 25, then gradually increase/decrease the value to respond to step changes in rate setpoint.

I Term: The integral term controls the time constant of the loop response. A small I term, say 1 to 3 seconds, will smooth the response of most loops.

D Term: The differential term causes the loop to respond quickly to changes. Use 0 or a very small value (.1 x I Term) to avoid oscillations.

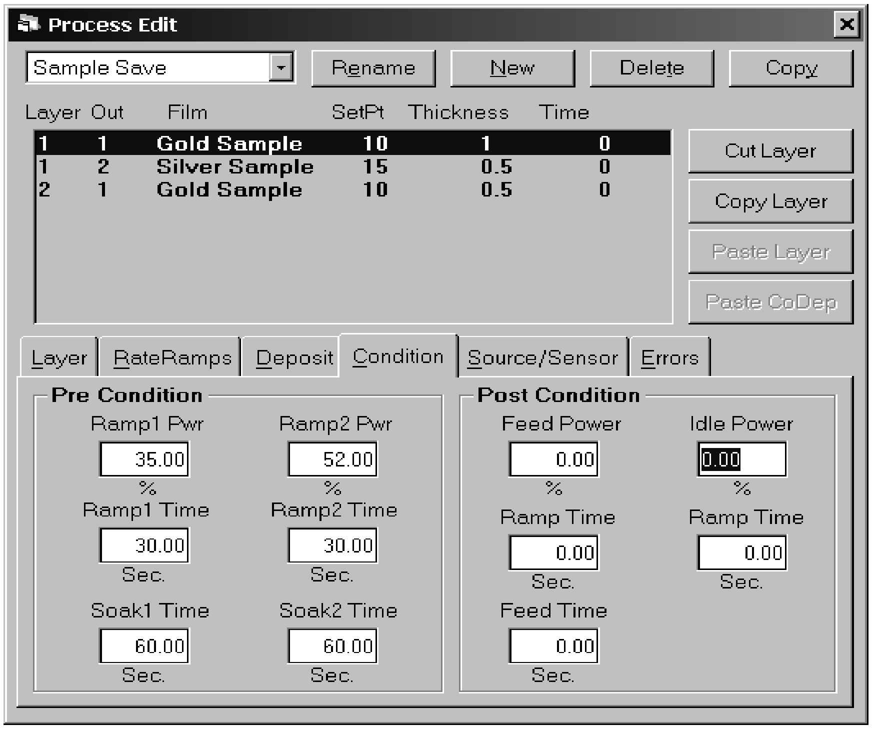
See the Appendix B for loop tuning tips.

Shutter Delay: It is often desirable to assure stable process control before the substrate shutter opens. Enabling shutter delay requires that the system reach the programmed shutter delay Accuracy, and maintain that accuracy before deposition begins. If the accuracy is not reached within Wait seconds, the process halts. If accuracy is achieved, and maintained for Hold seconds, then the substrate shutter opens and deposition begins. The Thickness reading is zeroed at the end of the shutter delay period.

Rate Sampling: Rate sampling can extend the life of crystals. With rate sampling, the deposition rate is sampled for a period of time, then the sensor shutter is closed. Power is then held at the same level as the final power setting during the sample period. Continuous selects no sampling; the sensor shutter remains open during deposition. Accuracy Based sampling opens and closes the shutter at the rate required to maintain the desired accuracy during the hold phase. Time Based sampling opens the shutter for a fixed period of time then closes it for a fixed time.

Condition Tab

Before deposition begins, it is often necessary to PreCondition the source material. This places the system at the proper power level to achieve rapid PID control when deposition begins.



Ramp 1: Ramp power sets the power level that is desired at the end of the ramp phase, in % of full scale. Ramp time sets the time to ramp with a linear rate from the initial power to the Ramp power. Soak time sets the time the output remains at the ramp power level.

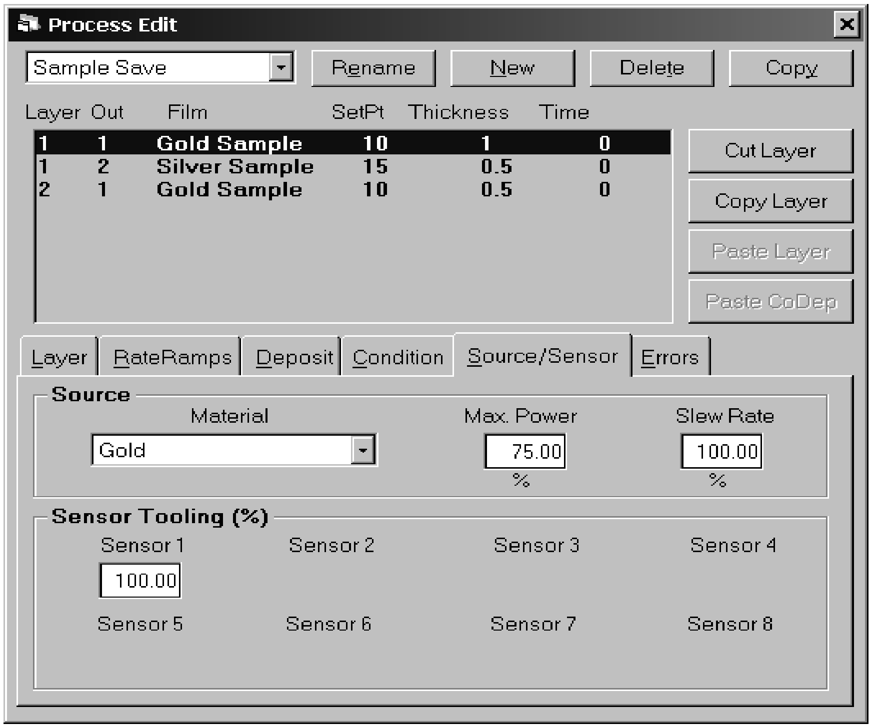
Ramp 2: Ramp 2 functions are the same as Ramp 1. Typically, Ramp 2 power is set near the power level required to match the desired initial deposition rate.

Feed: The feed phase begins immediately after deposition is complete. It holds output power at the level and time required to wire feed new material.

Idle: The Idle phase follows the Feed phase.

Source/Sensor Tab

The Source/Sensor tab controls the physical setup of the deposition system.

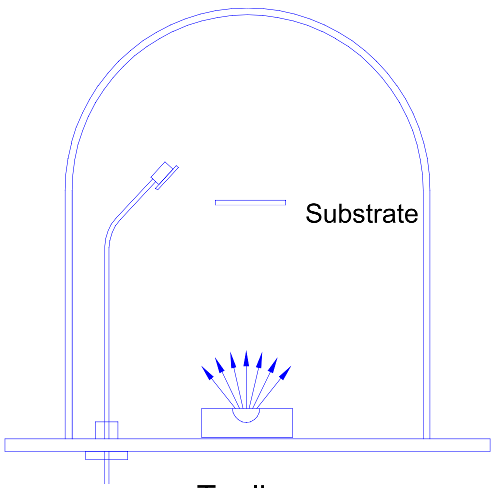


Material: Selects the physical deposition material for the film selected on the Layers tab. Selecting a material sets the Density and Z Factor, as defined in the Edit Materials dialog box.

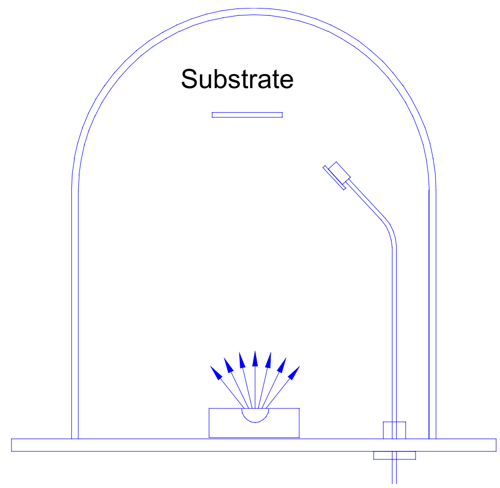
Max Power: The maximum output power allowed for the selected output. The full scale output voltage is a function of the deposition power supply input specifications, and is set in the Edit System menu, Outputs tab. Max Power controls the maximum % of the full scale power that can be used by this film in all phases (PreConditioning, Deposition, and Feed/Idle).

Slew Rate: The maximum power change allowed on an output, per second. If rate ramps or PID power requirements exceed this value, an error will occur.

Sensor Tooling: Adjusts for sensor measured deposition rates that differ from the substrate deposition rate. A higher tooling value yields higher rates. For example, if the sensor sees only 50% of the substrate rate, set the value to 200%. Setting Tooling to 0% causes a sensor to be ignored for this film.



Tooling
Over 100%



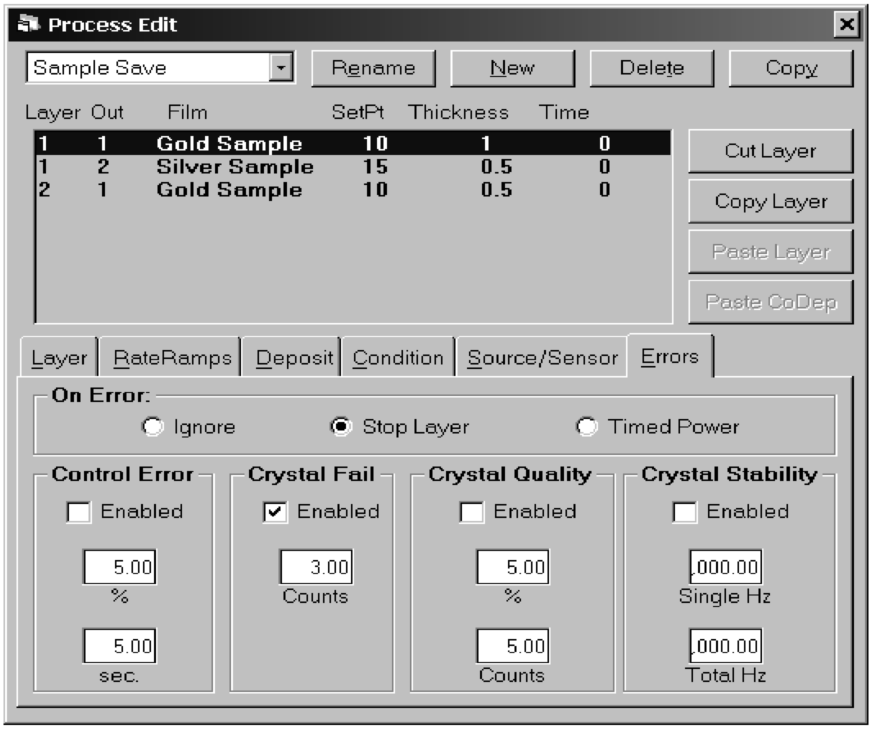
Tooling
Under 100%

The System Setup selection on the Layer tab establishes which sensor(s) are visible. Only those sensors “mapped” to the layer’s output are visible.

Errors Tab

Several source or sensor error conditions are possible during deposition. This tab establishes the program's response to errors.

Note: *It is best to leave all error settings, except Crystal Fail, disabled until you are confident of the stability and repeatability of your process.*



Control Error: If the control loop cannot maintain the desired deposition rate (due to loss of source material, excessively high rate ramps, or equipment malfunction) a control error occurs. Control error % is the accuracy that must be exceeded for the specified time (in seconds) to trigger a control error. Use shutter delay accuracy to assure adequate process control before entering the deposition phase.

Crystal Fail: Establishes the number of bad readings (i.e. 0 Hz) from a sensor that generates a Crystal Fail condition. If a crystal fails, the PID loop will send the source supply to max power. Therefore, it is unlikely you will ever want to disable this error.

Crystal Quality: Each time the rate deviation for this film exceeds the % value, a counter is incremented. Each time the rate deviation is within the % value, the counter is decremented (to zero minimum). If the counter exceeds the Counts value during the entire layer deposition, an error occurs.

Crystal Stability: When material is being deposited, a crystal's frequency normally drops. At the end of crystal life, sensor frequency may briefly "mode hop" to higher frequencies. Single Hz is the largest single positive frequency shift allowed. Total Hz is the sum of positive shifts allowed during a film's deposition.

On Error: When an error condition occurs, three actions are possible. Ignore the error and let the PID loop attempt to maintain rate control. Stop the layer and allow the user to fix or manually control deposition. The last choice, Timed Power, uses the last good Rate/Power settings to "estimate" rate and thickness.

In Timed Power, the output is set to the power level that last yielded a rate reading within the Control Error % deviation setting (10% deviation if Control Error is disabled). The program then calculates the estimated thickness based on that rate and the deposition elapsed time. When the calculated thickness reaches thickness setpoint, deposition stops.

Analog Inputs

Normally the SQS-242 software uses SQM-242 card quartz sensor inputs to measure or control rate and thickness. The SAM-242 analog input card extends this capability to allow measurement and control on DC voltage-based process variables, such as temperature transmitters, pressure/flow controllers.

Analog input based control is treated, for the most part, identically to quartz sensor based control. Considerations for using an analog input are discussed below.

Layers Tab: In the Inputs dropdown, select one of the Analog inputs. In the Outputs dropdown, select the output that is to be controlled. Enter the desired setpoint. Normally this setpoint is in Volts, but can be converted to other units (e.g. degrees or PSI) in the Edit, System, Analog screen.

Use Time Endpoint to stop the analog layer after a set time. Otherwise, a Sensor input, programmed as a Codep layer, can control the layer endpoint. Final Thickness and Thickness Endpoint settings have no effect for an analog input.

Rate Ramps Tab: Setpoint ramps can also be programmed for an analog signal.

Deposition Tab: The PID and Shutter Delay controls operate the same as a Sensor input. Rate sampling is not possible for analog inputs.

Condition Tab: Conditioning is identical to that of a Sensor input with one significant exception. If all Ramp/Soak/Feed times are set to zero, the analog input controls to its programmed Layer Setpoint through all of the Ramp/Soak/Feed phases. This allows temperature or pressure control (for example) to be maintained through all phases of the layer. If Stop Layer is selected, control is still maintained at setpoint. Pressing Abort Process will set the output to zero.

Source/Sensor Tab: Only Max Power and Slew Rate are functional.

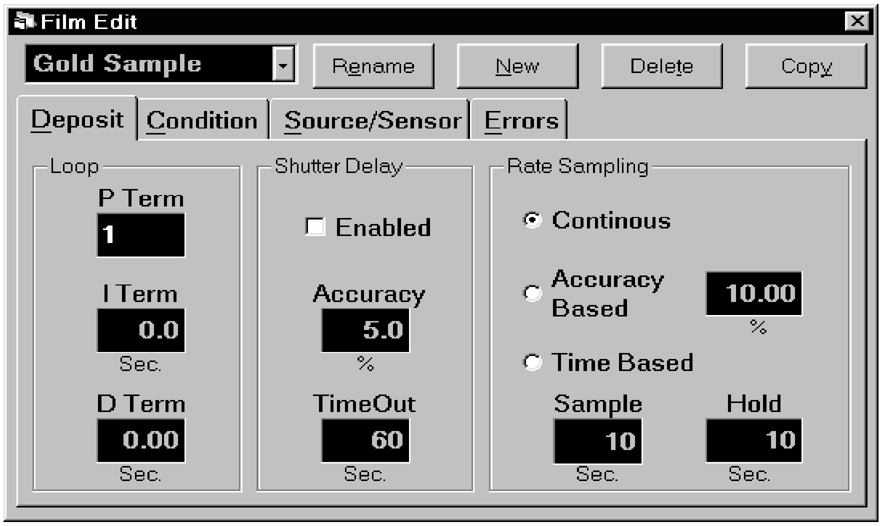
Errors: Only Control Error applies.

The Analog Input’s measured value (converted to the defined units) and deviation from setpoint are shown below the graph. The analog input values are NOT shown on the normal Rate graph (the values could lead to poor rate resolution on the graph). Instead the analog input voltages are shown on the View, Analog graph. Volts are displayed on this graph, rather than the scaled units (again, to maintain adequate graph resolution).

3.4.2 Edit: Films

The Edit Films dialog box allows you to rename, delete, and copy films. The functions in the tabbed control are identical to those for this film on the Edit Processes dialog.

***Note**: Edits to a Film will affect all processes and layers that use that film!*



Film: A dropdown box that selects the film parameters displayed in the edit film dialog box.

Rename: Edits the name of the selected film.

New: Creates a new film.

Delete: Deletes the currently selected film from the database. A film cannot be deleted if it is used in ANY process! To delete a film, you must first delete the film from each process where it is used.

Copy: Creates a duplicate of the currently selected film.

The function of each Edit Films tab, and its associated controls, are identical to those detailed in the Edit Processes section. Please consult Section 3.4.1 for that information.

3.4.3 Edit: Materials

The Edit Material dialog box provides the functions needed to build a materials database. In addition to the functions listed below, the main screen SoftKeys provide capabilities to add/edit/delete materials.

Note: *See the Appendix for a list of standard Material Density and Z-Factor.*

Material: Selects a material to edit.

Density: Sets the density for this material. Material density has a significant impact on deposition calculations.

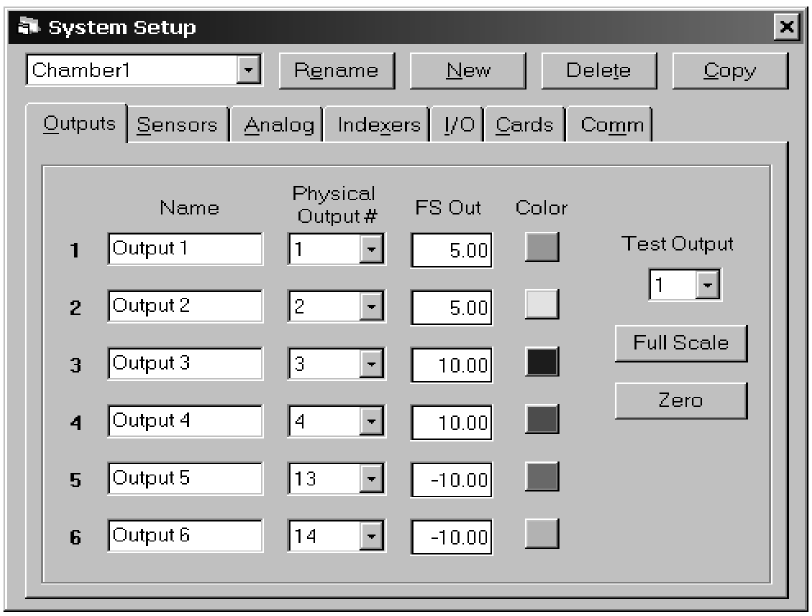
Z-Factor: Sets the Z-factor, a measure of a material's effect on quartz crystal frequency change. Z factor has no effect on measurements when using a new crystal. If the Z Factor for your material is not known, using crystals with >80% life will eliminate the effect of the Z Factor term.

3.4.4 Edit: System

The System Setup dialog box configures the SQS-242 software to the physical setup of your deposition system. Several settings that control the overall operation of the program are also accessed in System Setup.

The combination of sensor input and control output assignments, known as a System Setup, are stored in the SQS-242 database. Most systems will have a single setup that applies to all processes. However, complex systems may use several different system setups within a single process.

***Note**: Settings on the Outputs, Sensors, Analog, and Cards tabs are unique for each System Setup. Settings on the Indexers, I/O, and Comm tabs apply to all System Setups. Output colors are also common to all setups.*



Controls along the top of the System Setup dialog box apply to the selected system setup:

System Setup: A dropdown box that selects the setup to be edited. Defaults to the current setup.

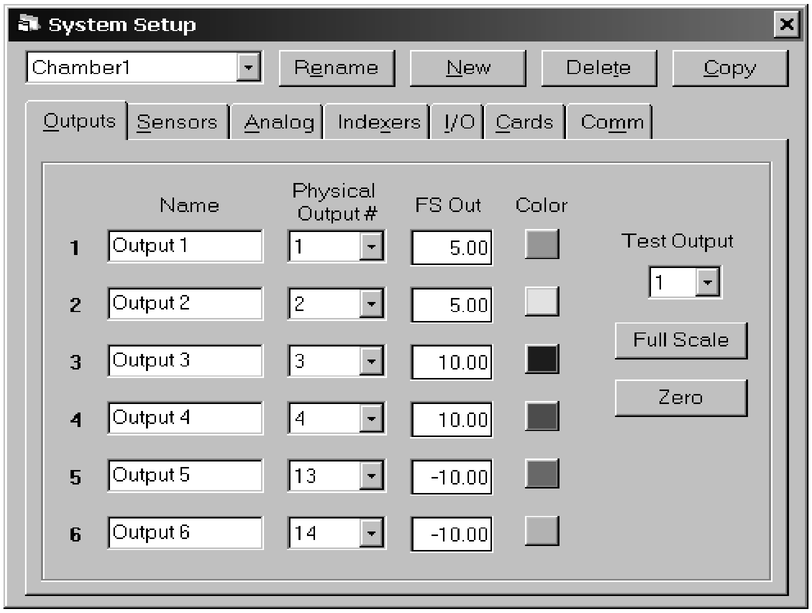
Rename: Edits the name of the selected setup.

New: Creates a new system setup, based on the existing default setup.

Delete: Deletes the currently selected setup from the database. If the setup is used in a process, an error message is displayed.

Copy: Creates a duplicate of the currently selected system setup.

Outputs Tab



Name: Assigns a name to each displayed output. For clear display, keep the name to less than 8 characters.

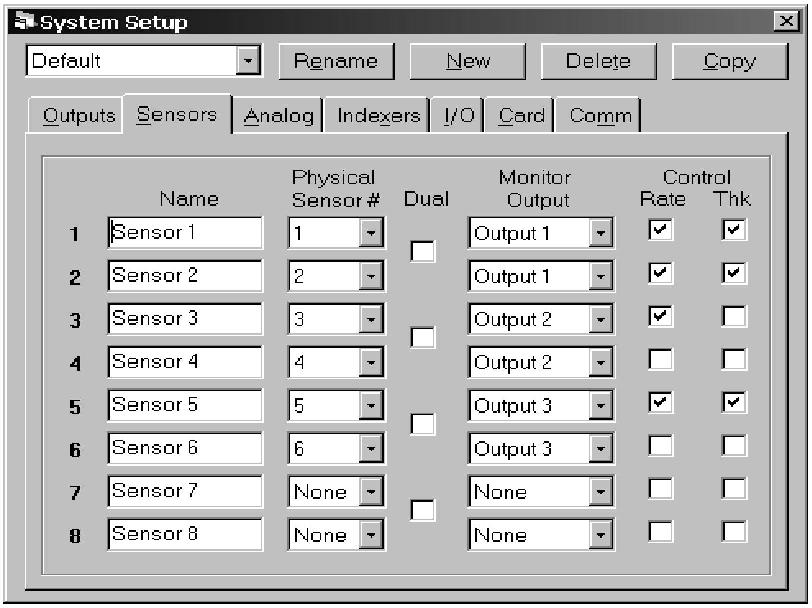
Physical Output: Up to six SQM-242 cards (physical outputs 1 to 12) and a single SAM-242 card (physical outputs 13 and 14) may be installed in a computer. However, the SQS-242 software can display and control a maximum of 6 outputs simultaneously. Use this dropdown to assign a “physical” output to a “display” output.

FS Out: The input voltage required by the deposition source power supply to produce 100% output power. Positive or negative full scale values are possible.

Color: Selects the color used to graph and display output data.

Test Output: Useful for testing output wiring and Full Scale voltage settings. Select an output, then click Full Scale to set the SQM-242 card output to its Full Scale voltage. Click Zero to return the selected output to 0 volts.

Sensors Tab



Name: A meaningful name assigned to each sensor. For clear display, keep the name to less than 8 characters.

Physical Sensor: Up to six SQM-242 cards (physical sensors 1 to 24) may be installed in a computer. However, the SQS-242 software can display a maximum of 8 sensors simultaneously. Use this dropdown to assign a "physical" sensor to a "display" sensor.

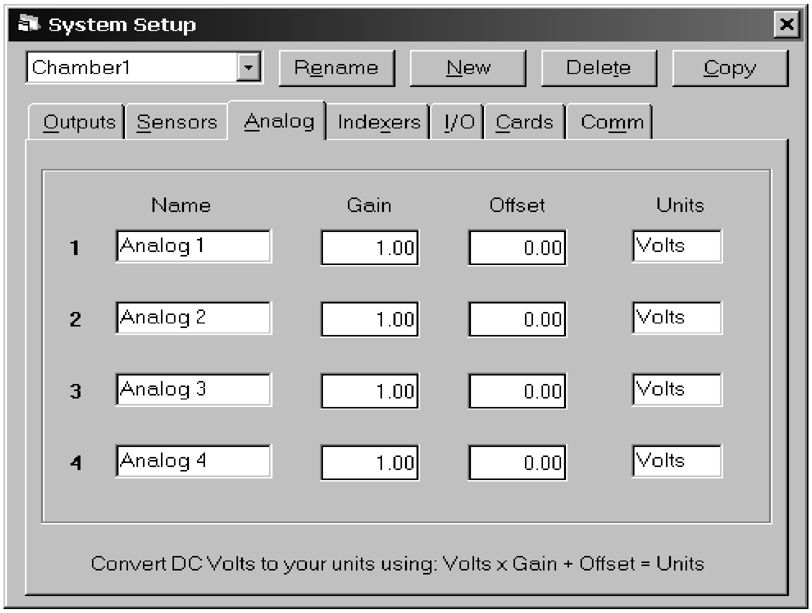
Dual: Indicates that a pair of sensors is set up as primary/secondary duals. When a primary sensor fails, the SQS-242 switches to the secondary sensor.

Monitor Output: Select the output that each sensor is positioned to measure. The rate and thickness displayed by the sensor will be calculated based on the material assigned to the selected output.

Control Checkboxes: Click Rate to assign the sensor to the PID rate control loop for the assigned output during deposition. Click Thk to use the sensor for Thickness endpoint detection. Typically you will check both boxes so that the sensor controls to rate setpoint and detects the thickness endpoint. If multiple sensors are assigned to control the same output, the sensor readings are averaged when calculating rate and thickness.

Uncheck both boxes to have a sensor monitor an output, without controlling deposition rate or stopping when final thickness is reached.

Analog Tab



The SAM-242 analog input card measures DC voltages in the +/-10 volt range. These voltages may represent temperature, flow, or any other process variable. The analog tab allows you to modify the display to show values in the desired units, using a linear (y = mx + b) transformation.

For example, assume you have a temperature transmitter that sends 0V at 0°C and 1V at 100°C. To display temperature in °F, set the Gain to 180, Offset to 32, and Units to DegF. The SQM-242 will display setpoints and measurements associated with the analog input in degrees F.

To leave the analog input display in Volts, set Gain = 1 and Offset = 0.

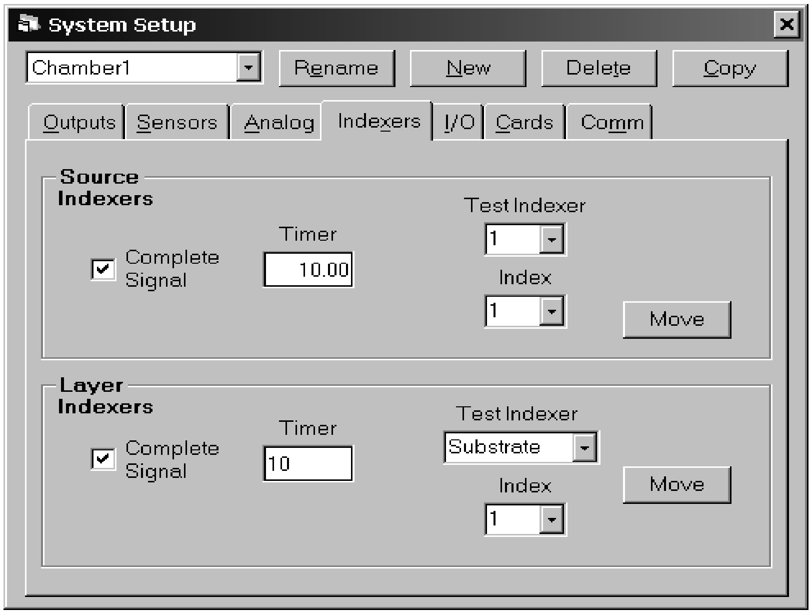
Name: A meaningful name assigned to each analog input. For clear display, keep the name to less than 8 characters.

Gain: The gain term for transforming voltage to measured units. This is the m term in y = mx + b.

Offset: The offset term for transforming voltage to measured units. This is the b term in y = mx + b.

Units: The units that you wish to display for the analog input.

Indexers Tab



Source Indexers:

Complete Signal: Check this box if your source indexers send a signal indicating that the move is complete.

Timer: If Complete Signal is checked, the process will halt if a move complete signal is not received within this timeout period. If Complete Signal is not checked, the process waits for this fixed time period before starting a layer.

Test: Useful for testing source indexer functions manually. Select a source indexer, then an index (pocket). Click Move to move to the selected index.

Layer Indexers:

Complete Signal: Check this box if your indexers send a signal indicating a move is complete.

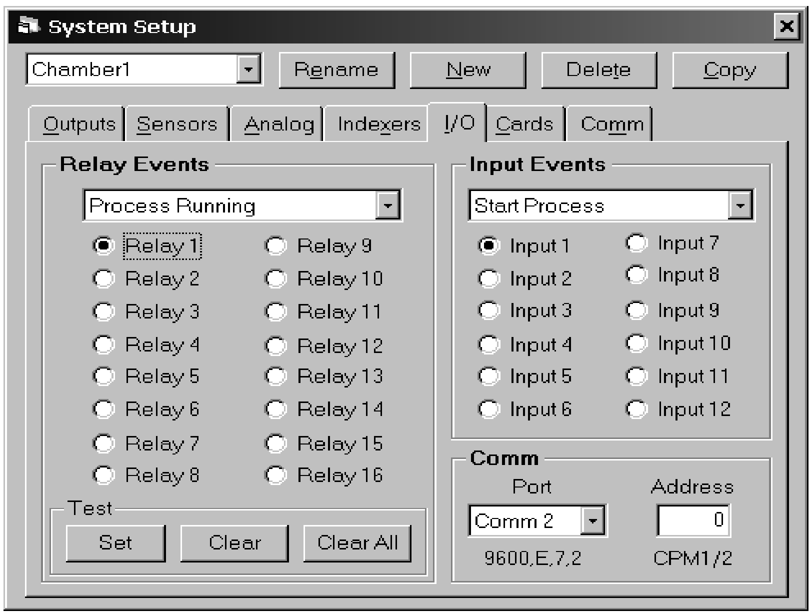
Timer: If Complete Signal is checked, the process will halt if a move complete signal is not received within this timeout period. If Complete Signal is not checked, the process waits for this fixed time period before starting a layer.

Test: Useful for testing indexer functions manually. Select a layer indexer, then an index (pocket). Click Move to move to the selected index. Layer indexers are typically named Substrate, User 1, and User 2. Layer indexer names can be edited in the SQS242.INI file.

I/O Tab

The SID-242 uses an inexpensive PLC to provide digital I/O capabilities. The I/O tab assigns deposition events (i.e. open shutter, start deposit, final thickness, etc.) to the physical relays and inputs on the PLC.

Note: *Omron CPM series PLCs number relays from 10.00 to 10.07, then 11.00 to 11.07. These correspond to Relays 1 to 16 on the I/O tab. Similarly, inputs 0.00 to 0.11 on the Omron PLC correspond to inputs 1 to 12 on this screen.*



Relay Events: The relay events dropdown box lists the deposition events that can cause a relay output to be activated. To assign a deposition event to a relay, click the Relay #, then select the desired event from the dropdown box. As you click each Relay#, the dropdown will change to show its currently assigned event. A description of each relay (output) event follows:

Source Shutter 1 to 6

These relays control the Shutter that covers your deposition source. At the beginning of the deposit phase the relay will close its contacts. When the deposit phase finishes the shutter relay contacts open.

Sensor Relays 1 to 8

These relays control sensor shutters. Their function depends on whether you have single or dual sensors.

If Dual Sensor is not selected (i.e. a single sensor), the relay contacts are closed when you are in a layer with the sensor enabled. As an example, let’s say you have sensors

1 and 3 enabled for Film 1 and sensors 2 and 4 enabled for Film 2. When you start Film 1, the contacts for Sensor Relays 1 and 3 will close. When you start Film 2, these contacts open and the contacts for Sensor Relays 2 and 4 will close.

If the software is configured for dual sensors, the relay operation is considerably different. Dual sensors use pairs of sensors, i.e. Sensor 1 and 2, or Sensor 3 and 4. With Sensors 1 or 3 selected, the associated relay contacts are open. If a Crystal Fail is detected, the relay contacts for the failed sensor will close to select the second sensor in the Dual Sensor assembly for the duration of the film.

Xtal All Good and Xtal All Fail Relays

These two relays provide an indication of the general health of your sensors. If the Xtal All Good Relay is closed, then all enabled sensors are returning a valid reading. If the Xtal All Fail Relay is closed, none of the enabled sensors are returning a valid reading.

Process Stopped and Running Relays

These relays indicate the overall status of the process. The Process Running relay closes as soon as Start Process is selected (by front panel or digital input), and opens when Abort Process is selected. Even if a layer is stopped within a process, the Process Running relay remains closed until the last film of a process has finished. The Process Stopped relay contacts behave in the inverse manner.

Layer Stopped and Running Relays

The Layer Running relay closes as soon as Start Layer is selected (by front panel or digital input), and opens when Stop Process is selected. The Layer Stopped relay contacts behave in the inverse manner.

Deposit Phase Relay

This relay indicates that you are in the deposit phase of a film. It is like having the two Source Shutter Relays connected in parallel. If you have shutter delay enabled, this relay will wait until the end of the shutter delay before going active.

Pre-Cond Phase Relay

This relay closes for the preconditioning phases (Ramp1, Soak1, Ramp2, Soak2) of a film.

Soak Hold Phase Relay

This relay closes for the Soak and Hold phases after deposition.

Process Active Relay

This relay action is similar to the Process Running relay, except it will open if the process is temporarily halted for any reason, e.g. a Manual Start layer.

Manual Mode Relay

Closes when the program is placed in Manual mode.

Max Power Relay

Closes when any control voltage output is at the programmed maximum power level.

Thickness Setpoint Relay

This relay will become active when the Thickness Setpoint is reached. This is a programmable process parameter.

Time Setpoint Relay

This relay will become active when the Time Setpoint has been reached. This is measured from the beginning of the deposit phase, and is a programmable parameter.

Test: The Test section provides a simple means of testing I/O wiring. To close a relay, select the desired relay button, then click Set. Click Clear to open the relay contacts.

Input Events: The input events dropdown box lists the deposition events that can be caused by an external digital input. To assign a deposition event to an input, click the Input #, then select the desired event from the dropdown box. As you click each Input #, the dropdown will change to show its currently assigned event. A brief description of each input event follows:

Start Process Input

Triggering this input is the same as pushing the Start Process button.

Abort Process Input

Triggering this input will abort the process.

Start Layer Input

Triggering this input will start or restart the current layer.

Stop Layer Input

Triggering this input will stop the current layer.

Start Next Layer Input

Triggering this input will skip the current layer and start the next layer.

Zero Thickness Input

This will zero the thickness. It is identical to pressing the Zero button.

Force Final Thickness Input

Triggering this input has the same effect as reaching Final Thickness setpoint.

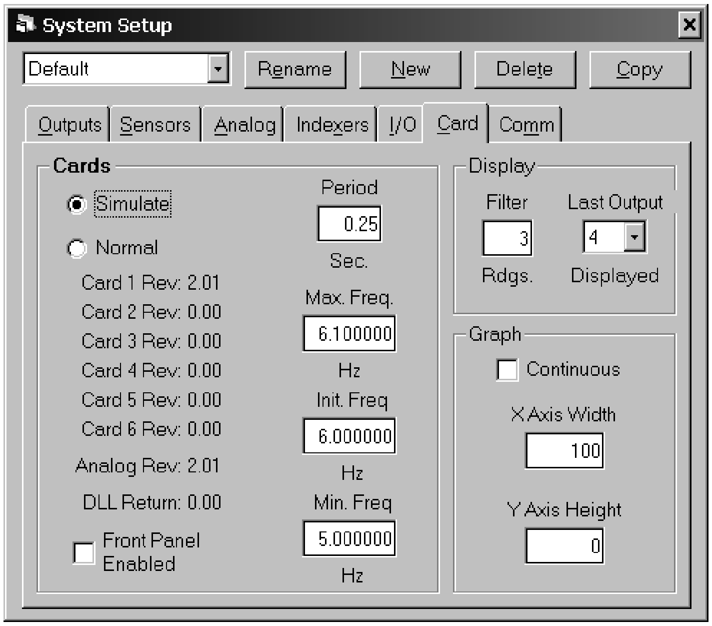
Comm Port: Selects the serial port used to communicate with the PLC. The Comm Port dropdown lists available ports. However, some ports may be used by other devices (modem, mouse, etc.). Select Disabled to prevent I/O from using the PLC.

The communications paramaters (baud, parity, bits, stop) are shown below the Comm Port dropdown. The baud rate can be changed in the SQS242.INI file.

Address: Several PLCs can be controlled from a single computer Comm Port by connecting their expansion ports. The slave address of each such PLC is usually set by a rotary or dip switch, and must be unique. Single PLC systems usually use Address 0. Consult your PLC User Manual.

If the PLC is found at the selected Comm Port and Address, the COMM LED on the PLC will flash continuously. The PLC model is displayed below the address.

Cards Tab



Mode: In Normal mode, the SQS-242 gets readings from the SQM-242 card(s). In Simulate mode, the SQS-242 generates simulated readings even if a card is not installed. This is useful for testing new processes and learning the software.

The firmware revisions of the installed SQM-242 cards are listed below the mode buttons. A value of 0 indicates the card is not installed. Analog Rev refers to the revision of an SAM-242,card if installed. DLL Return is the status of the SQM-242 card's Windows drivers. DLL return values of 9XX indicate a card installation error (see the SQM-242 Card Manual for card installation instructions).

Front Panel Enabled: When used with the SRC series computer, enables/disables the SQS-242 software to read the SoftKeys and setting knob.

Period: Sets the measurement period between .2 seconds (5 readings per second) and 2 seconds. A longer period gives higher reading accuracy, especially at low rates.

Max/Init/Min Frequency: The frequency values for the quartz crystal sensors used as inputs to the SQM-242. Typical values are Max=6.1, Init=6.0, Min=5.0. Sensor readings outside the min/max values cause a Sensor Fail error.

Filter: Sets the number of readings used in the reading filter. A low setting gives rapid response to process changes, high settings give smoother graphs.

Last Output: Limits the maximum number of outputs shown on the main screen.

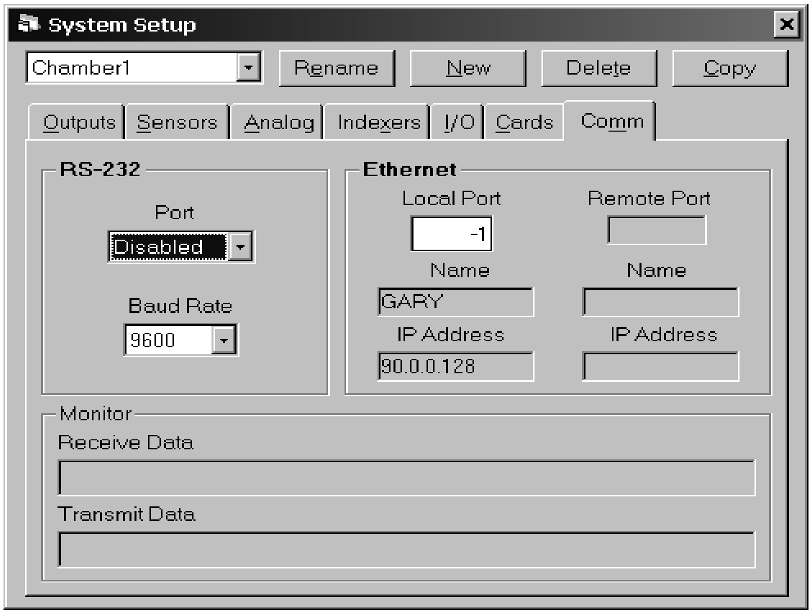
Continuous: Check this box to have the graph continuously display data for each phase of the deposition cycle. Uncheck this box to clear the graph at the end of the preconditioning, deposition, and post conditioning phases.

Graph X Axis: Sets the width of the X axis during deposition, normally 100 seconds. Whatever width is selected, the graph automatically scrolls the X axis as required. Due to screen resolution, setting a width of more than 10 minutes (600 seconds) may cause some data points to not be plotted.

Graph Y Axis: Sets the Y axis Rate graph maximum value during deposition. Setting the value to 0 causes the Y axis to automatically scale to the highest rate displayed.

Comm Tab

The SQS-242 software can be controlled by another computer through an RS-232 or Ethernet connection. See Chapter 6 for a complete discussion.



RS-232 Port: Selects the comm port used for serial communications with another computer. The Comm Port dropdown box lists available ports.

Baud Rate: Sets the baud rate used for serial communications.

Ethernet Ports: Local Port sets the TCP/IP port used by the SQS-242 software for Ethernet communications (1001 is a typical value, -1 for no Ethernet). When communications is established, Remote Port displays theTCP/IP port of the remote computer communicating with the SQS-242 software.

Ethernet Name: Displays the name of the local and remote computers, as set in their Windows, My Computer dialog box.

Ethernet IP Address: Displays the IP address (xxx.xxx.xxx.xxx) of the local and remote computers.

Receive Data: Displays the Query and Update requests received from the Comm and Ethernet port. See Appendix B for a description of the serial communications protocol.

Transmit Data: Displays the response to Query and Update requests received from the Comm and Ethernet port.

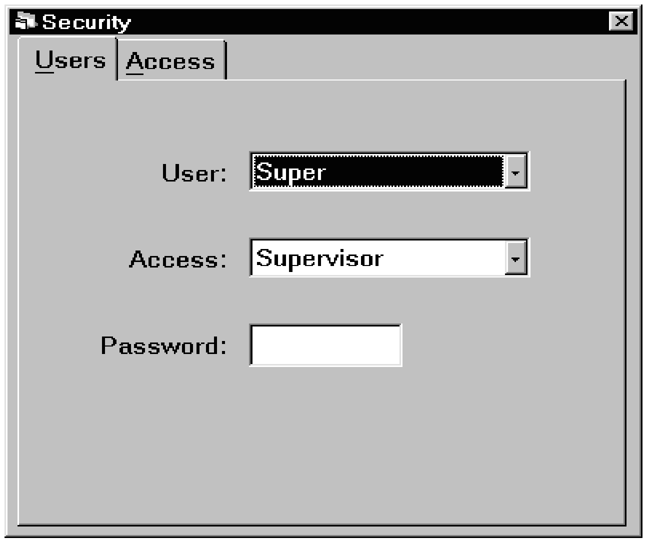
Note: *The Comm tab does not monitor communications with the PLC.*

3.4.5 Edit: Security

The Security menu assigns Users, their Password, and their Access Level. It also provides a flexible way to assign program functions to different Access Levels.

Note: The Security dialog box is available only to users with Supervisor Access.

Users Tab



User: Dropdown box used to select an existing user, to edit their Access or Password. It is not possible to edit or add a user name in the User dropdown. Use the New SoftKey to create a new User. Use the Delete SoftKey to delete the selected user.

Access: Assigns a program access level to the selected user. Generally speaking, Supervisor (SUPV) provides access to all program functions. Technicians (TECH) have access to a subset of functions. While User level access (USER) has access to only those functions needed to run deposition processes. See the Access Tab section to assign SUPV, TECH, and USER program capabilities.

Password: Each user will typically have his/her own password. When a password is entered, a second box will appear for password confirmation. If the Password box is left blank, no Password is needed for that user to login.

Note: User names and passwords are limited to A-Z, 0-9, _, -, and space. Passwords are a maximum of 8 characters.

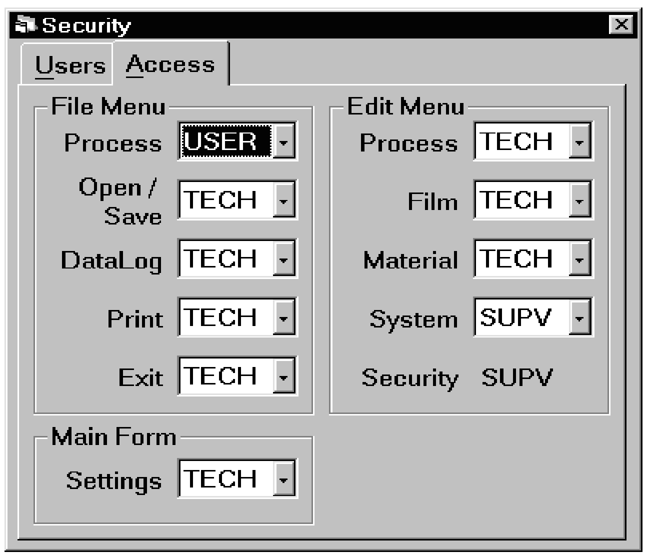
Access Tab

The Access tab allows Supervisors to assign which program functions are available to each of the three Access Levels. When a program function is assigned to a particular access level, it is automatically available to higher access levels.

In the example below, every user has access to the File Process menu and the File Exit menu. Only Supervisors have access to the Edit System and Edit Security menus. The remaining menus are assigned TECH access. They will be available to TECH and SUPV users, but not to USER access users.

The settings along the right side of the Main Form can be viewed by any user, but values can only be edited by TECH or higher access.

Those who login with USER access can select and run processes, but they cannot edit process parameters. TECHs can also select and run processes (because those functions are assigned to a lower level access). However, TECHs can also edit process parameters. Only Supervisors can change System Setup or Security assignments.



3.5 View Menu

The View menu controls the appearance of the main display.

Film Settings: Displays/hides a ribbon of commonly accessed process settings along the right of the screen. Additional process parameters are available in the Edit menu. When displayed, the settings ribbon allows the user to easily modify process settings during deposition without leaving the main screen. Changes are made to the current process and the process database immediately. In CoDeposition, first click on the desired film to display its parameters.

Film Readings: Displays/hides film deposition readings along the bottom of the screen. Readouts of Film, Rate, Deviation, Thickness, and Power are displayed simultaneously for each of the active outputs. The rate, deviation, and thickness readings displayed represent an average of the quartz sensors assigned to each film.

Sensor Readings: Displays/hides a pop-up window of sensor rate, thickness, remaining life, and frequency readings. Unlike the main screen's Film Readings, this display is the raw data coming from each sensor. In addition, the output (i.e. PID control loop) that each sensor is assigned to is displayed. Sensor assignments are established on the Sensor tab of System dialog box.

A (P) in the Control column indicates the sensor is the primary sensor of a dual sensor pair. (S) indicates a secondary sensor. An (R) in the Control column indicates that the sensor is being used only for rate control. A (T) indicates the sensor is used only for Final Thickness endpoint detection. An (M) indicates the sensor is being used to monitor, but not control, the output. These options are selected on the Sensor tab of System dialog box

Note: *The Sensor Readings dialog box can be sized to also show SAM-242 card analog input readings and digital I/O information. The digital I/O information is useful for troubleshooting I/O problems during setup.*

Rate Graph: Fixes the main graph to deposition rate. Deposition rate is useful during the shutter delay, rate ramp, and deposition phases. During other phases, the power output graph is usually more useful.

Deviation Graph: Fixes the main graph to display percent deviation from the rate setpoint. Rate deviation is useful for fine tuning the PID control loop.

Power Graph: Fixes the main graph to output power. Output power is directly adjusted during the PreConditioning, feed, and hold phases. Output power is also useful during the deposition phases to detect error conditions, which cause oscillations. Be sure the Full Scale voltage is set properly in the SQM-242 Setup menu.

Sensors Graph: Normally the graph displays output, or film-based information. The Sensors Graph selection displays the rate readings from each individual sensor assigned to a system setup. It is a graphical display of the Rate column of the Sensor Readings screen.

Analog Graph: If an SAM-242 analog input card is installed, this graph shows the voltage readings from each analog input assigned to a system setup.

Automatic: Changes the main graph to display the most pertinent information for each deposition phase. During preconditioning, output power is displayed. During shutter delay, rate ramps, and deposition, the main graph displays deposition rate. During feed and hold phases, the graph reverts to output power.

Note: *The appearance of each of the graphs has been pre-set for best viewing on the Color LCD display of Sigma's SID-142 rack mount computer. To alter the appearance of a graph, right-click anywhere on the graph. Use the Graph Property Page dialog box to alter the graph to your preferences. To permanently save the changes, click the Control tab, the General tab, then the Save button. Save the graph setup to the appropriate .OC2 file for the graph you are modifying.*

High Resolution: When this option is checked, rate is displayed to .01 A/s, and thickness to .1kA. This can be useful for low rate applications, but annoying for moderate rates. The SQM-242 card resolution for PID control is unchanged.

3.6 Software Specifications

Display

Graphs... Rate, Deviation, Power
Readouts .... Rate,Dev,Thick,Power

Process Parameters

Name.. 12 characters
Processes... Unlimited
Layers... Unlimited
Films... Unlimited
Rate Ramps... Unlimited
Sensors (Dual).. 1 to 8 (4 Dual)
Sources .... 1 to 6

Layer Parameters

Film.. Any defined
Output.. 1 to 6
Input .... Sensor(s)
Timed Power
Analog Input
SetPoint... 0.00 to 999.99 Å/sec.
0.00 to 100.00% Power
0.00 to10.00 VDC
Final Thickness.. 0.0 to 999.9 kÅ
Time EndPoint .... 0 to 30000 sec.
Thickness EndPoint... 0.0 to 999.9 kÅ
Start Mode... Auto/Manual
Source Indexers .... 6, Index 1-16
Layer Indexers... 3, Index 1-16
Rate Ramp Start.. 0.0 to 999.9 kÅ
Rate Ramp Time .... 0 to 1000 sec.
New Rate... 0.00 to 999.99 Å/sec.

Film Parameters

Name.. 12 characters
Ramp Time (1,2).. 0 to 30000 sec.
Soak Power (1,2)... 0.0 to 100.0 %
Soak Time (1,2)... 0 to 30000 sec.
Shutter Delay Time.. 0 to 200 sec.
Shutter Delay Error.. 0.0 to 30.0 %
P Term... 1 to 9999
I Term .... 0 to 999.9 sec.
D Term .... 0 to 99.9 sec.
Control Error .... Ignore/Stop/Hold

Control Error Set... 0 to 30.0 %
Feed Ramp Time... 0 to 30000 sec.
Feed Power.. 0.0 to 100.0 %
Feed Time.. 0 to 30000 sec.
Idle Ramp Time.. 0 to 30000 sec.
Idle Power.. 0.0 to 100.0 %
Tooling (Sensor 1 to 8)... 10.0 to 999.0
Max Power.. 0.0 to 100.0 %
Slew Rate... 0.0 to 100.0 %/sec.
Source Index (Pocket)... 0 to 15

Material Parameters

Name.. 12 characters
Density... .0.40 to 99.99 gm/cm^3
Z-Factor.. 0.100 to 9.900

Digital Inputs *(available only with PLC option)*

Start Process...
Stop Process...
Start Layer..
Stop Layer
Start Next Layer..
Zero Thickness..
Force Final Thickness ....
Substrate Index Complete..
Source Index Complete..

Relay Outputs *(available only with PLC option)*

Source Shutter.. 1 to 6
Sensor Shutter.. 1 to 8
All Crystal Fail...
All Crystal Good...
Process Running..
Process Stopped..
Process Active...
Deposit Phase...
Pre-Cond Phase...
Feed/Idle Phase...
Manual Mode...
Max Power...
Thickness Setpoint..
Time Setpoint...
Final Thickness..
Substrate Index Select.. 0 to 15
Source Index (Pocket) Select.. 0 to 15

Security

User Name .... 16 characters
Password... 8 characters
Access... 3 levels

Computer Interface

Type .... RS-232, Ethernet, ActiveX

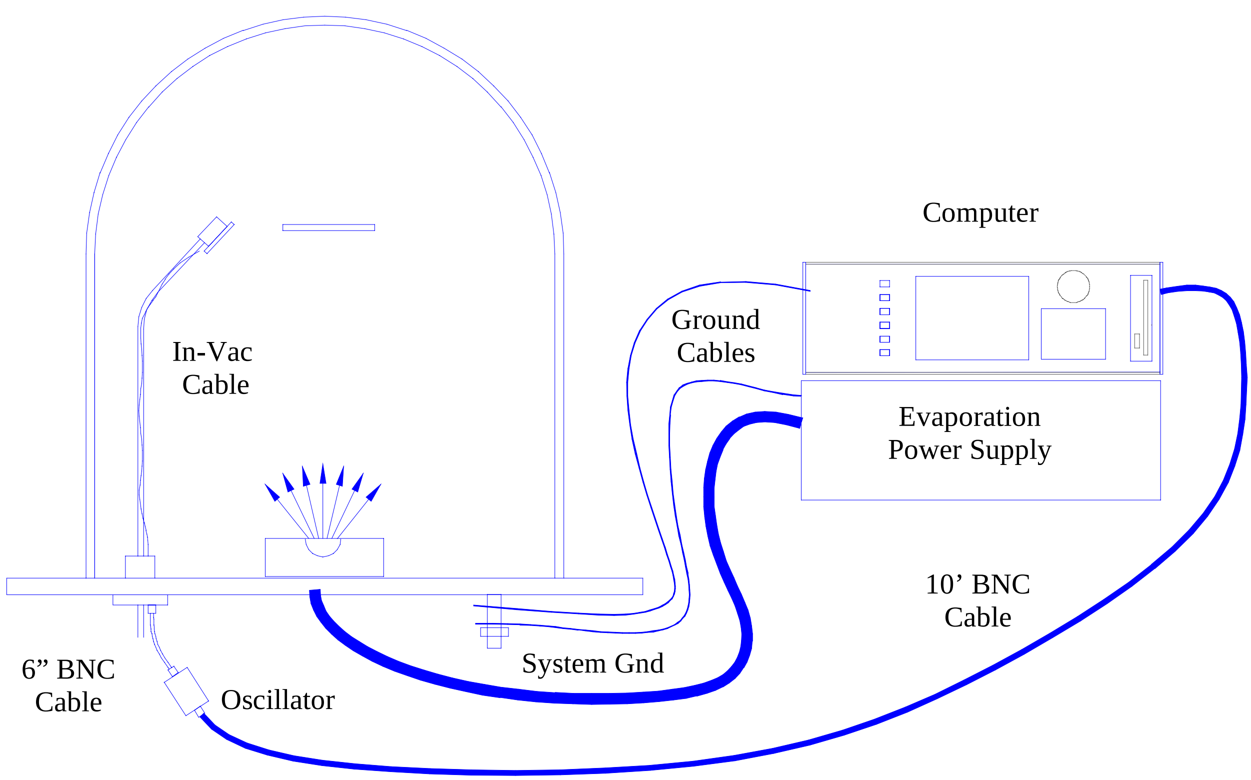
4.0 Introduction

This section is an overview of installation and operation of SQM-242 card. More detailed and current information is available in the SQM-242 User's Guide.

The SQM-242 is a deposition controller on a PC card. Each SQM-242 card has four 1-10MHz quartz sensor inputs, and two 0-10V control outputs. Up to six cards can be installed in a computer.

The diagram below shows a typical single-sensor deposition system. The SQM-242 receives sensor inputs via a BNC cable from each sensor oscillator. It supplies a control voltage to the evaporation power supply (this connection is not shown in this diagram). The SQM-242's internal circuitry measures the sensor inputs, calculates the measured deposition rate against the desired rate, and updates the output voltage based on its PID control loop calculations. The evaporation supply adjusts power to the evaporation source based on the control voltage input.

Visual Basic and LabView demonstration programs allow easy setup and operation. A Windows DLL also provides user-written programs access to SQM-242 setup and readings.

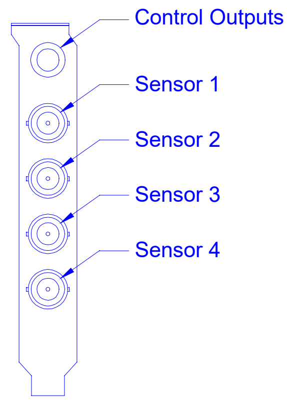


4.1 Installation

Consult the SQM-242 Card User's Guide for driver installation and card jumper instructions.

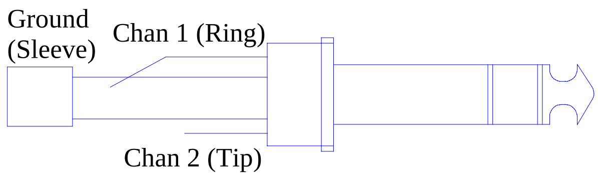
4.2 Sensor Connections

Once the SQM-242 is installed in the PC, connect the cable from the sensor oscillator to the BNC jack on the SQM-242 card. Refer to the drawing in Section 4.0. Avoid running the sensor wires near high voltage or noisy lines.



4.3 Power Supply Connection

The connection to your evaporation power supply is done through a 1/4" Stereo Phone Jack on the SQM-242 card. There are 2 control voltages on this connector, as shown in the figure below. The ground is common to both channels. Power supply input connectors vary. Consult your power supply manual.



4.4 Troubleshooting

Defective crystals or improper software setup causes most SQM-242 problems. Follow the procedures below to identify and correct common problems.

4.4.1 No Readings, or Erratic Readings from Sensors:

Disconnect the deposition source supply. This eliminates the possibility that a noisy source, or poor loop tuning, are causing an unstable PID loop. Verify that the sensors, oscillator and cabling are connected as shown in Section 4.0.

Replace the quartz crystal. Crystals sometimes fail unexpectedly, or exhibit erratic frequency shifts before total failure. Depending on the material, crystals may fail well before the typical 5MHz value. If you find that crystals consistently fail early, you may want to set Min Frequency (see below) to a value higher then 5 MHz.

In the SQS-242 software Edit, System menu, assure that Simulate Mode is OFF, and Frequency Min/Max are set properly for your crystals (typically Min=5.0 MHz, Max=6.0 MHz). Some manufacturer's crystals exceed 6MHz when new. Setting Frequency Max to 6.1 Hz will correct that problem, with no effect on measurement accuracy. Assure that the proper sensors are enabled, and assigned to the desired output.

Close the Edit, System menu and select View, Sensors to show sensor frequency and % Life. While not depositing, observe the % Life display for each active sensor. The value should be stable, between 20% and 100%.

If the % Life reading is zero or unstable: Recheck the wiring from the sensor to the SQM-242, and verify that the system is properly grounded. Also check that the crystal is seated properly in the sensor head. Move the sensor to another SQM-242 input. If both SQM-242 inputs show zero or unstable readings, the problem is almost certainly a wiring or sensor problem.

If the % Life is less than 50%: Replace the crystal and assure that % Life is near 100%, very stable. If % Life is not near 100%, check the Frequency Min/Max limits.

If the problem is not corrected: Referring to Section 4.0, disconnect the 6” M/F BNC cable from the feedthrough. A test crystal and BNC barrel adapter is supplied with each Sigma oscillator. Attach the test crystal to the 6” BNC cable as shown below.

The Sensor Readings display should show 5.5 MHz, very stable. If not, contact Sigma Instruments technical support.

When a stable frequency reading is achieved with the test oscillator, reconnect the sensor and verify a stable reading.

When stable sensor readings are achieved without deposition, reconnect the source supply. Start the deposition process in Manual mode with 0% output. The % Life readings should remain stable.

Slowly raise the % Output until a rate reading is displayed in Sensor Readings. As material is deposited on the crystal, the % Life reading should remain stable, or drop slowly and consistently. If not, check your source supply for erratic output. Also assure that the sensor is not too close to the source (particularly in sputtering).

4.4.2 Incorrect Rate or Thickness Measurement:

First, complete the procedures in Section 4.4.1 to assure reliable sensor operation.

Set Tooling as described in the Edit Process section of Chapter 3. Incorrect Tooling values will cause consistently low or high rate/thickness values for a material.

Verify that the Material Density and Z-Factor values match those in the Materials Parameters Appendix. If the material is not listed, check a materials handbook. Density has a significant effect on rate/thickness calculations.

Z-Factor corrects for stresses as a crystal is coated. If readings are initially accurate, but deteriorate as crystal life drops below 60-70%, you need to adjust the Z-Factor or replace crystals more frequently. The relationship between Z-Factor and Acoustic Impedance is discussed in the Materials Appendix.

4.4.3 Poor Rate Stability:

First, be sure that a stable rate can be achieved in Manual mode, as explained in Section 4.4.1. Once a stable rate is achieved in Manual mode, follow the Loop Tuning procedures of Section 4.5.

5.0 Introduction

Digital I/O for the SQS-242 software is handled by an inexpensive Omron CPM2 series PLC. It is not necessary, however, to use external I/O with the SQS-242 software.

There are several benefits to using an inexpensive external PLC for I/O. First, noisy high voltage wiring can be placed near the control sources, rather than routed into the controller's equipment rack. Only a single serial cable runs from the PLC to the controller. The PLC also provides electrical isolation for the process controller. And finally, the PLC's ladder logic programming provides fail-safe process protection and allows I/O to be easily tailored to each end user's installation.

5.1 PLC Installation

Caution: *The Omron PLC uses a special RS-232 cable as shown below. Do not use a standard serial cable. Damage to the SID-242 or the PLC could result.*

SID-142 Serial Port

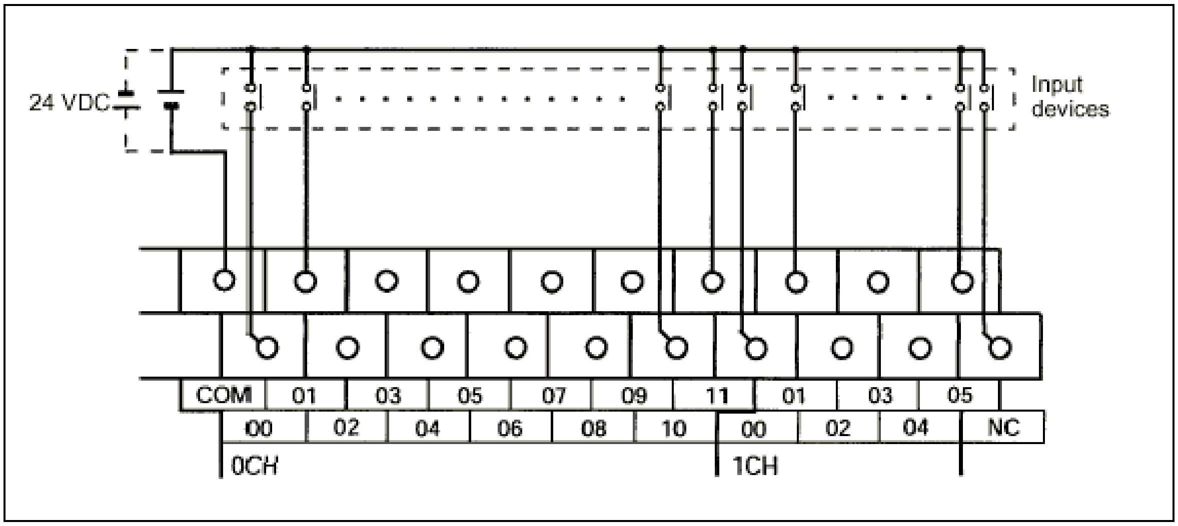
Signal	Pin No.
CD	1
RD	2
SD	3
ER	4
SG	5
DR	6
RS	7
CS	8
CI	9

PLC Port

Pin No.	Signal
1/Cover	FG
2	SD
3	RD
4	RS
5	CS
6	--
7	--
8	--
9	SG

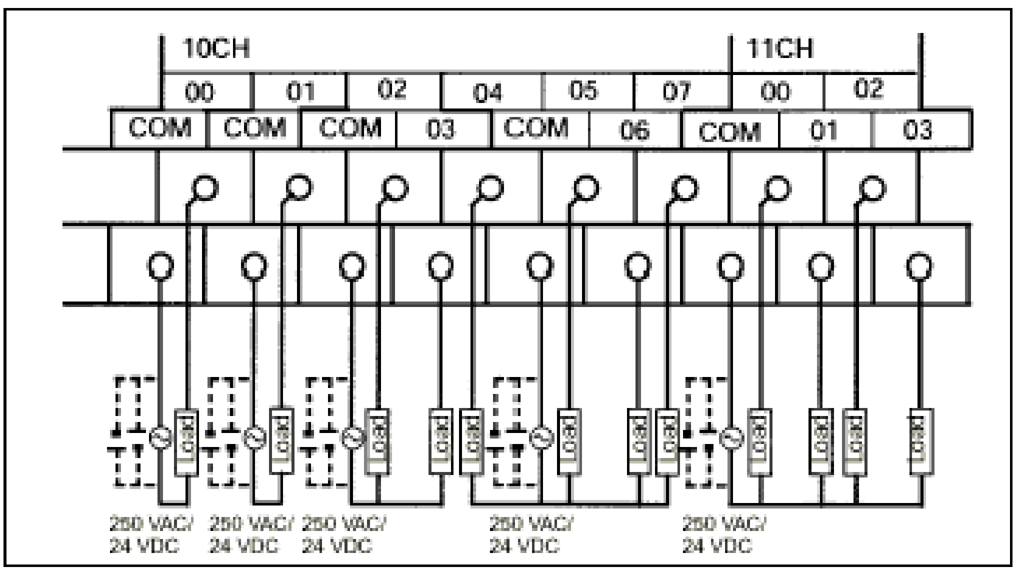
Mount the PLC controller near the devices it is controlling and sensing. Connect the PLC to a properly grounded power source. See the PLC User Manual on the SQS-242 CD-ROM for detailed PLC mounting and connection information. Connect the serial cable supplied from the PLC serial port to your computer serial port.

Input Wiring: The 0.0 to 0.11 inputs on Omron PLCs correspond to Inputs 1 to 12 in the SQS-242 software. Omron PLC input wiring is shown below.



Output Wiring: The PLC output relays are mapped to output events using the SQS-242 software's Edit, System dialog, I/O Events tab.

***Note**: Relays 1 to 8 in the SQS-242 software correspond to relays 10.00 to 10.07 on the PLC. Relays 9 to 12 correspond to Omron relays 11.00 to 11.03.*



Omron PLC output wiring is illustrated above. Notice that some relays (i.e. 02/03 and 04/05/06/07 share a common terminal).

***Note**: The internal 24VDC, .3A supply of the Omron PLC is NOT adequate to serve as the supply shown in the diagram above.*

Other Digital I/O: Depending on the PLC model used, additional relay and input pins are available for other functions (i.e. source indexer operation).

PLC Model	**PLC Terminals**	**SQS-242 Function**
CPM2A-30	Output 11.00-11.03	Source Index 1, Pockets 1-4
	Input 1.00	Source Index 1 Done
CPM2A-40	Output 11.00-11.03	Source Index 1, Pockets 1-4
	Output 11.04-11.07	Source Index 2, Pockets 1-4
	Input 1.01	Source Index 2 Done
900-004-8ER	Output 12.00-12.07	Relays 9 to 16

5.2 PLC Setup and Test

In the SQS-242 software select Edit, System, then the I/O tab. Set the Address to match the PLC Address (usually 0). Set the Comm Port to the serial port you are using. The COMM LED on the PLC should flash several times a second when the Address and Comm Port are set properly.

The Test section of the I/O tab provides a means of testing your PLC communications and digital I/O wiring. To set a relay on the PLC, go to the Digital I/O tab and find which I/O event is assigned to that relay. On the PLC tab, select the same event in the test dropdown, then click Set. The assigned Relay# should close. Click Clear to open the relay.

The Indexers tab of the Edit System dialog box allows you to move a source or substrate indexer. Select the index (i.e. pocket) to activate, then click the appropriate move button.

5.3 PLC Programming

The PLC runs a small ladder logic program that communicates with the SQS-242 software. This program transfers external relay and input states from the PLC connecting block to internal PLC registers. The SQS-242 software reads/writes to those registers.

The preset functions of the SQS-242 software will be adequate for most applications. If you need to perform additional logic functions, they can be programmed using Omron's CX-Programmer software. Contact Sigma Instruments for more information on programming your PLC.

The functions of the internal PLC registers used by the standard SQS-242 program are shown below.

PLC Register	SQS-242 Function
200	Layer/Phase Register Bits 0-9 are BCD layer number running Bits 10-15 are BCD Phase# as shown below

00	Application Startup	09	ShutterDelay Phase
01	Program Initializing	10	Deposit Phase
02	Not Used	11	Layer Stopped
03	Not Used	12	Layer Starting
04	Process Stopped	13	Not Used
05	Ramp1 Phase	14	Feed Ramp Phase
06	Soak1 Phase	15	Feed Hold Phase
07	Ramp2 Phase	16	Idle Ramp Phase
08	Soak2 Phase	17	Idle Phase

PLC Register	SQS-242 Function
201	Sensors/Outputs 1-4 Register (updated each layer) Bits 0-7 are sensors used (1=used, 0=unused) Bits 12-15 are outputs used, 12 is Out1, 13 is Out2, etc.
202	Analog/Outputs 5-6 Register (updated each layer) Bits 0-3 are analog inputs used (1=used, 0=unused) Bits 4-5 outputs used, 4 is Out5, 5 is Out6 Bits 8-11 are BCD of Output source index Bits 12-15 are BCD of Output 6 source index
220	Source Index Register (updated each layer) Bits 0-3 are BCD of Output 1 source index Bits 4-7 are BCD of Output 2 source index Bits 8-11 are BCD of Output 3 source index Bits 12-15 are BCD of Output 4 source index

221 Source Indexer Done Flag
- Bit 0 is Source Indexer 1 (1= Indexer Done, 0=Not Done)
- Bit 1 is Source Indexer 2
- Bit 2 is Source Indexer 3
- Bit 3 is Source Indexer 4
- Bit 4 is Source Indexer 5
- Bit 6 is Source Indexer 6

222 Relays 1-16
- Bit 0 is Relay 1, etc.

224 Inputs 1-12
- Bit 0 is Input 1, etc.

225 Layer Index Register
- Bits 0-3 are BCD of Layer Indexer 1
- Bits 4-7 are BCD of Layer Indexer 2
- Bits 8-11 are BCD of Layer Indexer 3

226 Layer Indexer Done Flag
- Bit 0 is Layer Indexer 1 (1= Indexer Done, 0=Not Done)
- Bit 1 is Layer Indexer 2
- Bit 2 is Layer Indexer 3

6.0 Introduction

The computer interface capabilities of the SQS-242 program allow operation from an external computer via Ethernet or RS-232 serial communications and a simple ASCII command set. Programs running on the same computer, can also control the SQS-242 program using ActiveX and the same ASCII command set.

Parameters may be read (Query commands) while the process is running, but can only be changed (Update commands) while the process is stopped. Changes to the “structure” of a process (e.g. add or delete layers) are not allowed from the computer interface.

6.1 Serial Interface

Connect a serial cable from the SID-242 serial port to a computer serial port. The cable required is a DB9 female to female with pins 2 and 3 crossed, commonly referred to as a null modem cable.

In the SQS-242 program select the Edit, System menu, then the Comm tab. Set the Comm Port to match the serial port the cable is connected to on the SID-242. Set the baud rate to match the baud rate of the host computer that will be connected to the SID-242. Communications format is No Parity, 8 bits, 1 stop bit.

6.2 Ethernet Interface

Connect a cable from the Ethernet card to your Ethernet network. In the SQS-242 program select the Edit, System menu, then the Comm tab. Set the Ethernet Port to 1001, and the Ethernet name to the Network name, or IP Address of the computer you wish to communicate with. Enter a –1 for the Ethernet Port to disable the Ethernet functions.

6.3 ActiveX (COM) Interface

Any program that supports Microsoft’s COM (Active X) interface (i.e. LabView, Wonderware, etc.) can communicate with the SQS-242 program. A small ActiveX interface program, SQS242X.EXE, provides receive data and transmit data entry points to the global cComm242 class. Contact Sigma Instruments for examples in other languages, and detailed technical information.

The SQS242 Comm demo program discussed in the next section provides a Visual Basic example of using another program to control the SQS-242 program.

6.4 SQS-242 Comm Program

SQS-242 Comm, found on the SQS-242 CDROM, is a simple Windows program to demonstrate SQS-242 communications concepts. With SQS-242 Comm you can easily send commands to, and read the responses returned by the SQS-242 program. SQS-242 Comm is written in Visual Basic, and the source code is included as an example of programming concepts for computer interfacing.

Setup for RS-232 or Ethernet:

In the SQS-242 program, select Edit, System and set the RS-232 or Ethernet settings as detailed in the previous sections.

Load the Comm program on a computer (the host), and connect an Ethernet or RS-232 cable between the host and the computer running the SQS-242 program. Start the Comm program on the host computer, then select the Utility tab. Set the Comm Port and Baud Rate for the host computer, or select Ethernet and set the Ethernet Port (typically 1001).

Setup for Active X Control:

Load the Comm program on the same computer that is running the SQS-242 program. Start the Comm program, then select Active X on the Utility tab.

Start the SQS-242 program but minimize it, or bring the Comm program to the foreground.

Communicating with the SQS-242 Program:

In the Comm program, Utility tab, click the Version button under the SID-242 Controller heading. Click Send to send the query to the computer running the SQS-242 program.

The response from the SQS-242 program should show in the Comm program Response window. A typical response is @QU;ACK;3.0.2;32, which indicates software version 3.02. The next section describes the Query/Update and Response strings in detail.

The transmissions to and from the Comm program will also show in the SQS-242 Edit, System, Comm, Receive Data and Transmit Data windows.

6.5 Protocol

SQS-242 commands fall into two categories:

Query commands request data from the SQS-242 program.
Update commands update a setting or instruct the program to take an action.

The SQS-242 responds to both Query and Update commands with a response that indicates the results of the command request. The SQS-242 program never initiates communications. It only responds to commands from the host.

Query Command Format:

@<command>;<param1>;…;<paramn>;<Chksum><CR>

Example: Software Version Query

@QU;11;44<CR>

where:

@	Message start character
;	Separator
QU	Query Utility command
;	Separator
11	Parameter 11 (SID242 Software Version)
;	Separator
44	Checksum (see section that follows on checksums)
<CR>	Carriage Return (ASCII 13)

Example: Response to Software Version Query

@QU;<ACQ>;2.1.6;??<CR> (Response to Software Version query)

where:

@;QU;<ACQ>;	Query Acknowledged (ASCII 06)
2.1.6	Message (Software Version)
;	Separator
0C	Checksum (actual checksum varies with different versions)
<CR>	Carriage Return (ASCII 13)

Update Command Format:

@<command>;<param1>;...;<paramn>;<data>;<Chksum><CR>

Example: Set Process Update

@UP;11;MyProcess;44<CR>

where:

@;UP;	Update Process command
;	Separator
01	Parameter 01 (Set Process)
;	Separator
MyProcess	Data
;	Separator
??	Checksum
<CR>	Carriage Return (ASCII 13)

Example Response: Set Process Update Succeeded

@UP;<ACQ>;??<CR>

Example Response: Set Process Update Failed

@UP;<NAK>;<ERR>;??<CR>

Where:

01	Illegal Command
02	Illegal Parameter
03	Illegal Format
04	Checksum Error
05	Request Denied
06	Unknown Error

Checksum Calculation

The sample code below calculates the FCS checksum of a string of characters.
In the code, Message is a string that has been stripped of terminator and checksum characters before being passed to this routine.

```
' XOR ASCII codes
For i = 1 To Len(Message)
    FCS = Asc(Mid$(Message, i, 1)) Xor FCS
Next i

' Convert FCS to two character hex string
If Len(Hex$(FCS)) = 1 Then
    CalcChkSum = "0" & Hex$(FCS)
Else
    CalcChkSum = Hex$(FCS)
```

Note: *While checksums "may" be useful for RS-232 communications, they are not needed for Ethernet or ActiveX. If you don't want to use a checksum, replace the checksum in each command with "00" (two ASCII zero (Hex 30) characters). The program response will contain two checksum characters, which you can just ignore.*

6.6 Command Summary

Note: *Update commands (except UP02-UP10) are only valid in Stop Mode.*

Query Process: @QP;<param1> where <param1> is:

01 Process Name
Example Query: @QP;01
Example Response: @QP;06;MyProc (Process is MyProc)

02 Process Time (mm:ss)
03 Active Layer #
04 Layer Time (mm:ss)
05 Phase # (where phase numbers returned are)

00	Application Startup	09	ShutterDelay Phase
01	Program Initializing	10	Deposit Phase
02	Not Used	11	Layer Stopped
03	Not Used	12	Layer Starting
04	Process Stopped	13	Not Used
05	Ramp1 Phase	14	Feed Ramp Phase
06	Soak1 Phase	15	Feed Hold Phase
07	Ramp2 Phase	16	Idle Ramp Phase
08	Soak2 Phase	17	Idle Phase

06 Phase Time (mm:ss)
07 Run #
08 All Process Names (comma delimited list)
1n Source Shutter Status, n=1 to 6 (0=Open, 1=Close)
2n Sensor Shutter Status , n=1 to 8 (0=Open, 1=Close)
30 All Crystal Good Status (0=False, 1=True)
3n Crystal n Good, n=1 to 8 (0=False, 1=True)
39 All Crystal Fail (0=False, 1=True)
4n Sensor to Output Map, n=1 to 8

Update Process: @UP;<param1>;<data> where <param1> is:

01 Set Process
Example Update @UP;01;MyProc (Select MyProc)
Example Response: @UP;06;

02 Start Process
03 Stop Process
04 Start Layer
05 Stop Layer
06 Start Next Layer
07 Auto Mode (all films in layer)
08 Manual Mode (all films in layer)
09 Zero Thickness (all films in layer)
10 Set Run #
11 Set Active Layer #
2n Output n (1 to 6) Power (Manual Mode Only)
4n Map Sensor n to Output #

Query/Update Layer: **@QL;<param1>;<layer>;<output>**
@UL<param1>;<layer>;<output>

where <param1> is:

01	Film Name	
	Example: @UL;01;1MyFilm,New Film (set Layer 1, MyFilm to NewFilm)	
02	Setpoint	A/s, V, or % Power
03	Start Thickness	kA
04	Time SP	mm:ss
05	Thickness SP	kA
06	Start Mode	0/1
07	Substrate Index (obsolete)	0 to 15
08	# Layers in Process (query)	
1n	Ramp n Start Thickness, n=1 to 9	kA
2n	Ramp n Ramp Time, n=1 to 9	mm:ss
3n	Ramp n New Rate, n=1 to 9	A/s
41	Layer Indexer 1 Index	0 to 15
42	Layer Indexer 2 Index	0 to 15
43	Layer Indexer 3 Index	0 to 15
44	Source Indexer Index	0 to 15
45	Input Type (Sensors=0, TimedPower=1, Analog1-4 = 2-5)	
46	System Configuration	
47	Source Indexer Done	0/1
48	Layer Indexer 1 Done	0/1
48	Layer Indexer 2 Done	0/1
48	Layer Indexer 3 Done	0/1

Query/Update Film: **@QF;<param1>;<layer>;<output>**
@UF;<param1>;<layer>;<output>;<value>

Note: <layer>=0 is active layer

where <param1> is:

01	P Term
02	I Term
03	D Term
04	Shutter Delay Status (0/1)
05	Shutter Timeout
06	Shutter Accuracy
07	Control Error Status (0/1/2)
08	Control Error Accuracy
09	Rate Sampling Status (0/1/2)
10	Sample Accuracy
11	Sample Time
12	Sample Hold
13	Ramp 1 Power
14	Ramp 1 Time
15	Soak 1 Time
16	Ramp 2 Power
17	Ramp 2 Time
18	Soak 2 Time
19	Feed Power
20	Feed Ramp Time
21	Feed Time
22	Idle Power
23	Idle Ramp Time
24	Output (1-6)
25	Source Index (obsolete)
26	Max Power
27	Slew Rate
28	Material
3n	Tooling n (n=1 to 8)

Query Utility: @QU;<param1>

01	SQM242 DLL Version
02	SQM242 Mode (0/1)
03	SQM242 Period
04	SQM242 Filter
05	SQM242 Number of Cards Installed
06	Front Panel Enabled (0/1)
07	Application Visible (0/1)
11	SID242 Software Version
12	SID242 Operating System
13	SID-242 Computer Name

Update Utility: @QU;<param1>;<Index>

02	SQM242 Mode (0/1)
03	SQM242 Period
04	SQM242 Filter
06	Front Panel Enabled (0/1)
07	Application Visible (0/1)
08	Full Scale Output (Index=1 to 6)
14	Application On Top (0/1)

Query Measurement: @QM;<param1>

1n	Output n Power (n=1 to 6)
2n	Output n Rate
3n	Output n Thickness
4n	Output n Deviation
5n	Sensor n Rate (n=1 to 8)
6n	Sensor n Thickness
7n	Sensor n Frequency
8n	Sensor n % Life
9n	Analog Input n Voltage

Query Register: @QR;<param1>

0	Layer/Phase Register
1	Sensor/Output Register
2	Analog/Output Register
20	Source Index Register
21	Source Index Done Register
22	Relay Register
24	Input Register
25	Layer Index Register
26	Layer Index Done Register

A. Material Parameters

Material	Density	ZFactor
Aluminum	2.73	1.08
Aluminum Oxide	3.97	1
Antimony	6.62	0.768
Arsenic	5.73	0.966
Barium	3.5	2.1
Beryllium	1.85	0.543
Bismuth	9.8	0.79
Bismuth Oxide	8.9	1
Boron	2.54	0.389
Cadmium	8.64	0.682
Cadmium Selenium	5.81	1
Cadmium Sulfide	4.83	1.02
Cadmium Teluridium	5.85	0.98
Calcium	1.55	2.62
Calcium Fluoride	3.18	0.775
Carbon Diamond	3.52	0.22
Carbon Graphite	2.25	3.26
Cerium Fluoride	6.16	1
Cerium Oxide	7.13	1
Chromium	7.2	0.305
Chromium Oxide	5.21	1
Cobalt	8.71	0.343
Copper	8.93	0.437
Copper Sulfide	4.6	0.82
Copper Sulfide B	5.8	0.67
Copper Sulfide A	5.6	0.69
Dysprosium	8.54	0.6
Erbium	9.05	0.74
Gadolinium	7.89	0.67
Gallium	5.93	0.593
Gallium Arsenide	5.31	1.59
Germanium	5.35	0.516
Gold	19.3	.381
Hafnium	13.1	0.36
Hafnium Oxide	9.63	1
Holnium	8.8	0.58
Indium	7.3	0.841
Indium Intimnide	5.76	0.769
Indium Oxide	7.18	1
Iridium	22.4	0.129
Iron	7.86	0.349
Lanthanum	6.17	0.92
Lanthanum Fluoride	5.94	1
Lanthanum Oxide	6.51	1
Lead	11.3	1.13
Lead Sulfide	7.5	0.566
Lithium	0.53	5.9
Lithium Fluoride	2.64	0.774
Magnesium	1.74	1.61

Material	Density	ZFactor
Magnesium Fluoride	3	1
Manganese	7.2	0.377
Manganese Sulfide	3.99	0.94
Mercury	13.46	0.74
Molybdenum	10.2	0.257
Neodymium Fluoride	6.506	1
Neodymium Oxide	7.24	1
Nickel	8.91	0.331
Niobium	8.57	0.493
Niobium Oxide	4.47	1
Palladium	12	0.357
Platinum	21.4	0.245
Potassium Chloride	1.98	2.05
Rhenium	21.04	0.15
Rhodium	12.41	0.21
Samarium	7.54	0.89
Scandium	3	0.91
Selenium	4.82	0.864
Silicon	2.32	0.712
Silicon Dioxide	2.2	1.07
Silicon Oxide	2.13	0.87
Silver	10.5	0.529
Silver Bromide	6.47	1.18
Silver Chloride	5.56	1.32
Sodium	0.97	4.8
Sodium Chloride	2.17	1.57
Sulfur	2.07	2.29
Tantalum	16.6	0.262
Tantalum Oxide	8.2	0.3
Tellurium	6.25	0.9
Terbium	8.27	0.66
Thallium	11.85	1.55
Thorium Fluoride	6.32	1
Tin	7.3	0.724
Titanium	4.5	0.628
Titanium Oxide	4.9	1
Titanium Oxide IV	4.26	0.4
Tungsten	19.3	0.163
Tungsten Carbide	15.6	0.151
Uranium	18.7	0.238
Vanadium	5.96	0.53
Ytterbium	6.98	1.13
Yttrium	4.34	0.835
Yttrium Oxide	5.01	1
Zinc	7.04	0.514
Zinc Oxide	5.61	0.556
Zinc Selenide	5.26	0.722
Zinc Sulfide	4.09	0.775
Zirconium Oxide	5.6	1.001

The equation governing all quartz crystal thin film monitors and controllers is:

$$T_f := \frac{N_q \cdot D_q}{\pi \cdot D_m \cdot F_c \cdot Z} \cdot \operatorname{atan}\left[Z \cdot \tan\left[\frac{\pi \cdot (F_q - F_c)}{F_q}\right]\right]$$

where the constant terms for the quartz crystal are:

AT crystal constant: $N_q := 1.668 \cdot 10^{13} \cdot \frac{Hz}{m^{-10}}$

Density of Quartz: $D_q := 2.648 \cdot \frac{gm}{cm^3}$

For example, a material and sensor frequency change of:

Density of material: $D_m := 2.700 \cdot \frac{gm}{cm^3}$

Z-Factor of material: $Z := 1.00$

Starting Frequency: $F_q := 6000000 \cdot Hz$

Ending Frequency: $F_c := 5999995 \cdot Hz$

Yields a Thickness (in Angstroms) of: $T_f \cdot m^{-10} = 2.272$

Z-Factor is used to match the acoustic impedance of the deposited material (Z_m) to that of the base quartz material (Z_q=8.83) of the sensor crystal:

$$\text{Z-Factor} = Z_q / Z_m$$

For example, the acoustic impedance of gold is Z=23.18, so:

Gold Z-Factor = 8.83 / 23.18 = .381

Finally, Z Factor can be calculated using the Shear Modulus of quartz (U_q) and the deposited material (U_m):

$$Z := ((D_q * U_q)/(D_m * U_m))^{1/2}$$

where U_q ~ 32GPa

B. Loop Tuning

This section will help you adjust your control loop PID parameters to achieve a stable deposition process. Keep in mind that there is no "best" way to determine PID parameters, and no one set of settings that are "best."

Setup System Parameters: Be sure that the output Full Scale voltage and crystal Min/Max Frequency parameters are accurate for your system. All Tooling parameters are best set to 100% for now. A Period of .25 seconds is also a good starting point. Simulate should be OFF.

Create a One-Layer Test Process: Create a new process that has a single film as its only layer, and select it as the current process. Set the film's Initial Rate to your desired rate and Final Thickness to a large value, say 10X your desired Final Thickness. Select the proper Sensor(s), Output, and Material. Set Max Power to 100% and Slew rate to 100%. Disable all errors except Crystal Fail. Set On Error to Stop Layer.

Test the Setup: Press Auto/Manual to start the layer in Manual mode. Slowly turn the control knob to a power of 10%, and verify that your power supply output is about 10% of full scale. Continue to turn the control knob until a Rate(A/s) above 0 is shown. Again, verify that the power supply output agrees with the SID-242 Power(%) reading. If the readings don't agree, check your wiring and process setup. In particular, verify that the System, Outputs, Full Scale voltage agrees with your power supply input specifications.

Determine Open Loop Gain: Slowly adjust the control knob until the Rate(A/s) reading approximately matches your Initial Rate setting. Record the Power(%) reading as PWR_{DR} (power @ desired rate). Slowly lower the power until the Rate(A/s) reading is just at (or near) zero. Record the zero rate Power(%) reading as PWR_{0R}.

Determine Open Loop Response Time: Calculate 1/3 of your desired rate ($RATE_{1/3}$), and 2/3 of the desired rate ($RATE_{2/3}$) for this layer. Slowly increase the power until Rate(A/s) matches $RATE_{1/3}$. Get ready to record the loop's response to an input change. Quickly adjust Power(%) to PWR_{DR}. Measure the time for the Rate (A/s) reading to reach $RATE_{2/3}$. You may want to do this several times to get an average response time reading. Displaying the Rate graph will also help. <u>Twice</u> the measured time is the step response time, $TIME_{SR}$. $TIME_{SR}$ is typically .7 to 1.5 seconds for E-Beam evaporation, 5 to 20 seconds for thermal evaporation.

Press Abort Process, then Manual/Auto to return to Auto mode. Follow these steps to set the loop PID parameters:

Set PID Values: In the Edit Process, Deposition tab set P=25, I= $TIME_{SR}$, D=0. Assure that all Conditioning values are set to zero. Save the values and close the Edit Process dialog. Press Start Process and observe the Power graph. The power should rise from 0%, and stabilize near PWR_{DR} with little ringing or overshoot. If there is more than about 10% overshoot, lower the P Term. If the time to reach PWR_{DR} is very slow, increase the P Term. A lower I Term will increase response time, a higher value will eliminate ringing and setpoint deviations. It is unlikely you will need any D Term.

Continue to Start the process and adjust PID until steady-state response is smooth and the step response is reasonably controlled. You don't need to totally eliminate ringing during the step if the steady-state response is smooth. Preconditioning will minimize step changes.

Set Preconditioning: The power level you recorded as PWR_{0R} is the power where deposition just begins. That's a good value for Ramp 1 power. PWR_{DR}, or slightly less, is a good value for Ramp 2 Power. This will eliminate a large step change when entering the deposition phase.

Once PID terms are established for a material, they will typically be similar for other materials. Only the P Term and preconditioning power levels may need adjustment.

Transfer Engineering and Manufacturing Inc.
Model DBLOP, Linear-Only
Precision Magnetic Manipulator
Users Manual

Table Of Contents

DBLOP-12/00

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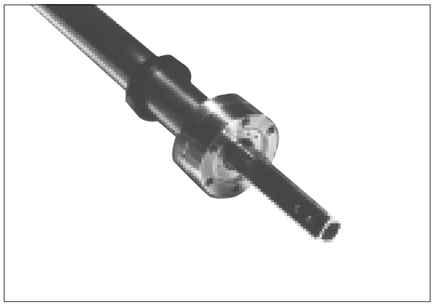
Transfer Engineering and Manufacturing, Inc.

Purpose and Scope



This document is a users manual for the Transfer Engineering and Manufacturing Model DBLOP-XX magnetically-coupled manipulators. This family of products includes a wide variety of unique overall sizes (footprints) which have common set-up and operational principles. This manual contains information on the theory of operation as well as instructions for installation, alignment, and maintenance of these magnetic manipulators.

Theory of Operation

The Model DBLOP-XX, linear-only, magnetically-coupled manipulator (commonly referred to as a sample transporter) is a device which allows for the movement of substrates or other samples within a vacuum system through a welded stainless steel tube. Powerful magnets outside the vacuum system maintained within a housing (magnet carriage) interact with magnetic material inside the vacuum system to allow the motion outside the vacuum to be transferred within. The mechanism inside

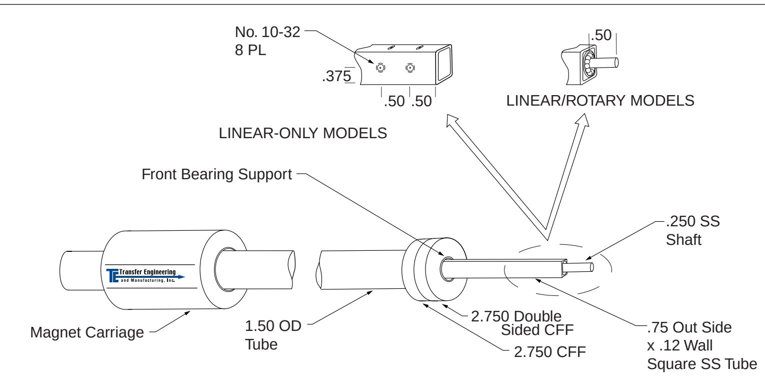
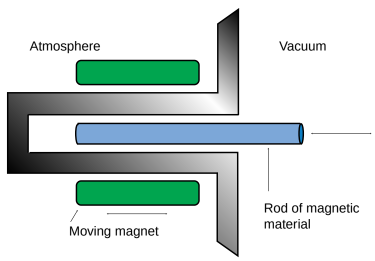


Diagram 1. Linear Only and Linear/Rotary Precision Magnetic Manipulator

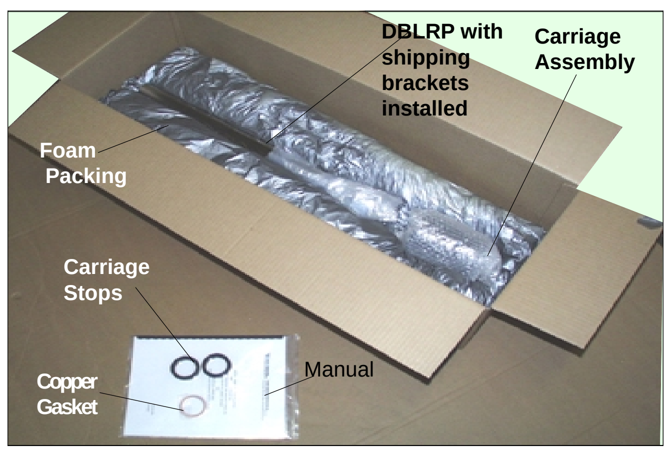
the vacuum system (follower assembly) travels in parallel with the outer magnet case supported by bearings which ride along the inside diameter of the tube and center the square tube at the front flange providing linear motion. Diagram 1 is a schematic representation of a Model DBLOP/DBLRP-XX with labelling for the major sub-assemblies.



These manipulators are covered under U.S. Patent Number 5,105,932.

Unpacking

The manipulators are shipped in corrugated cardboard boxes firmly packed in foam to protect the product during shipment. In some instances, including overseas shipments, this box will be housed within a wooden crate.

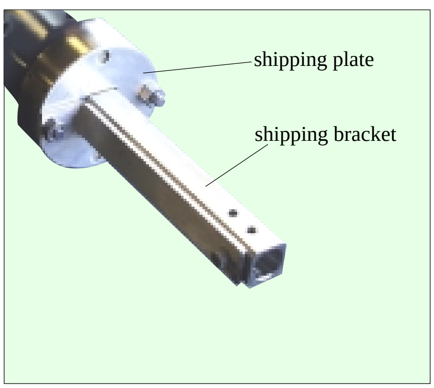


Inspect the box and/or crate for damage which may have occurred during shipment. If it is apparent that the outer wall of the box has been broken through, take a picture of the damage to the box before unpacking and call Transfer Engineering, at 510-651-3000, immediately.

Each box will contain the manipulator outer tube assembly with front bearing assembly attached and internal follower assembly supported by shipping fixtures. The magnet carriage will be individually wrapped, and a bag containing the manual and carriage stops is included. In many instances, accessory devices which mount to the magnetic manipulator will also be included in the box.

NOTE: It is strongly recommended that the box that the item is shipped in is saved for future use. In cases where periodic maintenance is necessary, or damage during use occurs, there may be a requirement to return the unit to the factory.

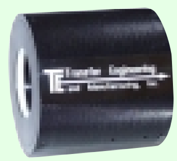
Once the items listed above have been removed from the shipping container, the unit is normally ready to be installed onto the vacuum system. In some specific instances, there may be accessories to be added to the manipulator follower assembly before installation of the manipulator onto the vacuum system.



Before installation, remove the two shipping brackets and the hardware which attach them, and store them in a safe place for possible reuse should this unit need to be shipped in the future. Please refer to the **SHIPPING INSTRUCTIONS** section (page 12) of the manual for instructions on proper procedures to ship this product.

System Assembly

The magnet carriage can be installed and oriented on the manipulator before or after the unit is attached to the vacuum system. In many cases, it is awkward and cumbersome to have this on the tube assembly during installation, and it may be desirable to install this part later. Please



DBLOP Carriage Assembly

refer to the **CARRIAGE INSTALLATION AND REMOVAL** section of this manual (page 7) for further instructions before proceeding.

The product is shipped with a new copper gasket in place between the front bearing and tube assemblies, and a new copper gasket is provided. In instances where the manipulator is shipped as part of a MASCOT Loadlock™, or some other application where a copper gasket is not required, Viton gaskets will be used.

NOTE: The magnetic manipulator must be oriented correctly with respect to the forces being exerted on it. In most cases, the operation of the system is hortizontal with respect to the floor, and this load is the follower assembly itself and the sample, and the force acting on it is gravity. For vertical applications, please call the factory if there is a specific load direction. The following instructions for orientation refer to the most common case, horizontal to floor, mentioned above.

These manipulators are designed with two specific bolt hole patterns into the front bearing assembly for cases where the manipulator is attached to a fixed flange. Please review Diagram 2 for these two bolt hole orientations. In cases where the vacuum system flange is rotatable, this point is irrelevant. When a purchase order is placed, hole pattern A or B can be requested. If no request has been made, the system will be shipped in bolt hole pattern A. The following process must be followed to change from hole pattern A to B. This reconfigures the front bearing assembly 30° from the shipped orientation. Use UHV handling practices and procedures with appropriate tools and clean workspace. Refer to the following diagrams for visual assistance.

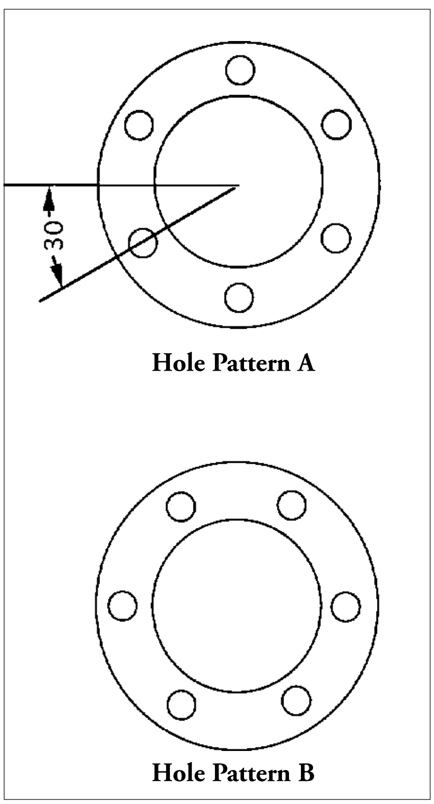
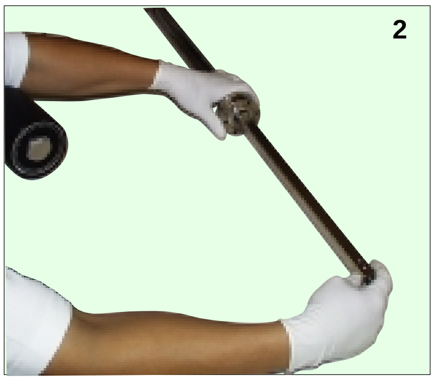


Diagram 2 - Two Hole Patterns
for Front Bearing Assemblies

Steps to Changing Front Bearing Assembly Hole Pattern

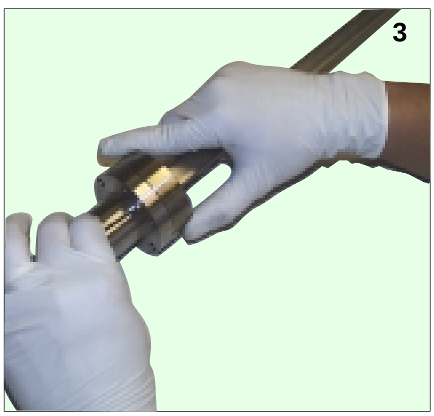
1 With the PMM on a clean stable workbench or table top, de-couple and remove the carriage assembly, if it has been installed.

CAUTION: The coupling force between the carriage and follower assembly is significant, therefore it may require more force than anticipated to de-couple the carriage.

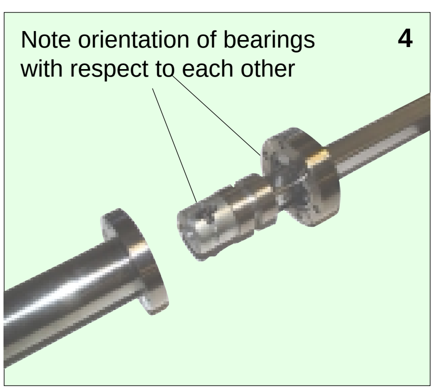


2 With the front bearing assembly still in place, pull the follower assembly so that it is fully extended.

NOTE: Leaving the front bearing assembly in place as the follower is extended centers the follower and prevents damage to the inside wall of the tube assembly.

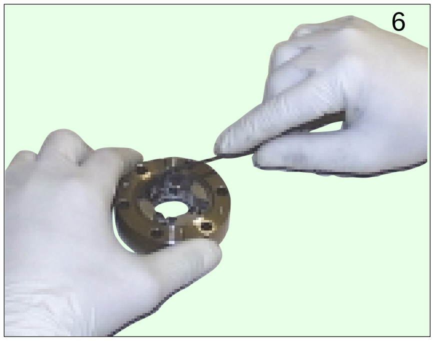


3 Remove the two 4-40 X 5/8" socket cap screws which attach the front bearing assembly to the tube assembly.

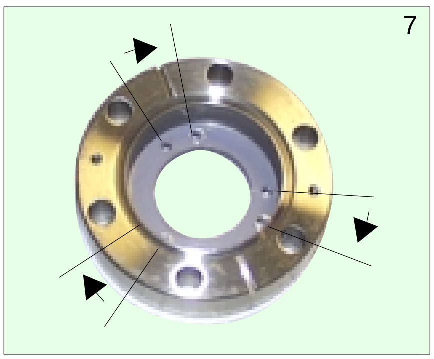


4 Remove the follower assembly from the inside of the tube assembly with the front bearing still in contact with the square tube. Take notice of the orientation of the bearings on the follower assembly with respect to the bearings on the front bearing assembly since that orientation will need to be re-established once the re-orientation is complete. Slide the front bearing assembly off of the square tube.

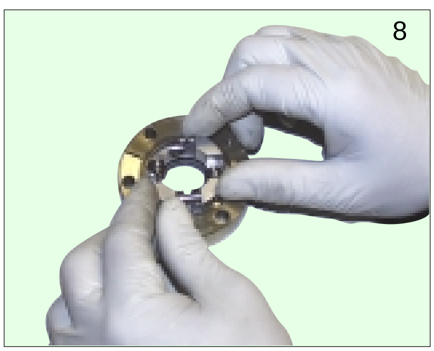
5 Place the front bearing assembly, bearing side up, on a tabletop or other workspace.



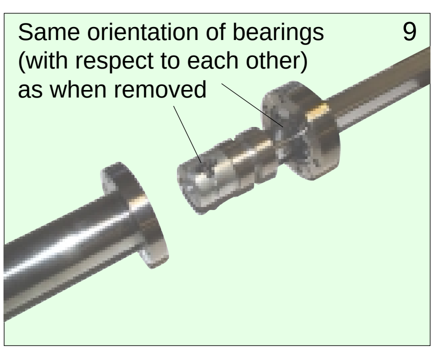
6 Remove the three 4-40 X 3/16" microsealed socket cap screws and lockwashers. This may require that the assembly inside the flange be lifted out as the lower screw is removed. Be careful not to lose the small spacers located between the front bearing frame and the flange, which provide venting between the two flat surfaces.



7 Place the spacers over the holes which are 30° clockwise from the holes that they were located over.



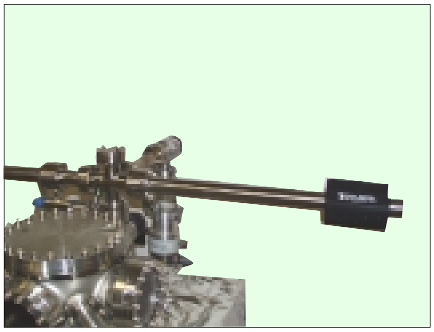
8 Place the front bearing frame assembly back into the flange, also rotated 30° clockwise, and tighten down the screws which attach it to the flange.



9 The front bearing assembly must now be slid back over the square tube of the follower assembly in the **<u>same orientation that it was removed.</u>**

10 Insert the follower assembly into the tube until the front bearing flange mates with the tube assembly flange. Attach the two together with the 4-40 screws removed in step 3, then slide the follower assembly entirely into the tube. Be sure that there is a new gasket or O-ring in place between the two flanges before installing the manipulator on the vacuum system.

The orientation has now been modified to match hole pattern B.



Install the manipulator onto the vacuum system using standard UHV or HV practices where applicable, with the **flange edge scribed with a “T” at the top**. Face-to-face tightening of the bolts is a safe practice for good sealing where torque specifications are not available.

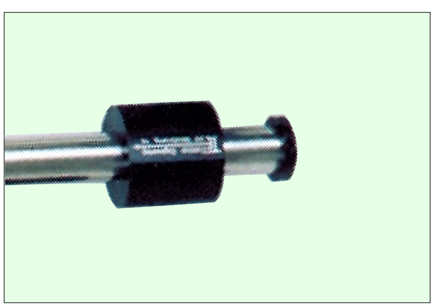
Once the tube and front bearing assemblies have been installed onto the vacuum system, the magnet carriage can be installed, if that process has not yet occurred.

Installation of Carriage Assembly

The installation of the carriage may occur either before or after the manipulator is mounted to the vacuum system.

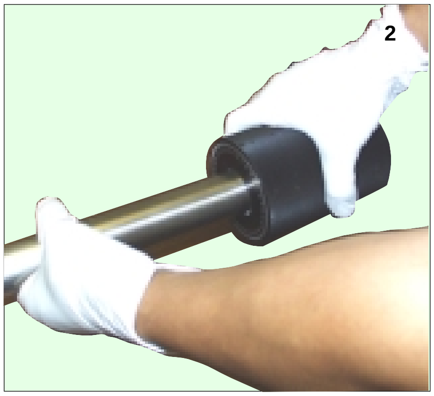
CAUTION: The coupling force between the carriage and follower is significant, and as the process takes place, the follower will accelerate quickly to couple with the carriage. Therefore, delicate devices or samples should not be mounted to the manipulator end when this takes place or possible damage may occur.

Installation of the carriage assembly involves sliding the carriage onto the tube assembly and then coupling the carriage to the follower assembly. The coupling referred to here is the interaction between the magnetic field of the carriage assembly magnets with the magnetic material inside the tube assembly.

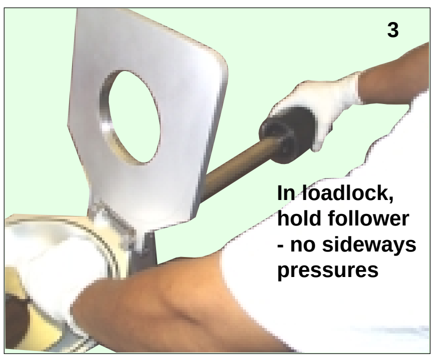


There is **only one correct orientation**, of the carriage assemblies onto the magnetic manipulators even though there are stable magnetic couplings in several different locations. The following process will allow for the correct coupling and see the diagram provided for assistance.

1 Slide the end of the carriage assembly with the two ring magnets onto the end of the tube first. This end will arrive from the factory labelled "*This end on tube first*".

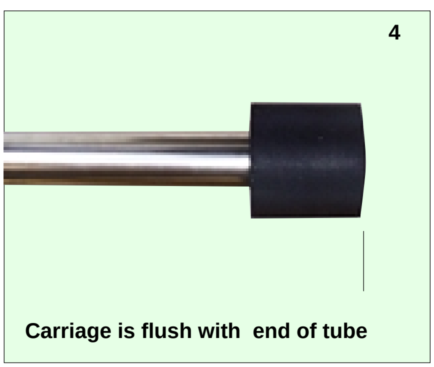


2 Slowly slide the magnet carriage forward until the second polymer sleeve slides over the tube. If the follower assembly is fully retracted, it will jump to the first coupling position and the interaction will be apparent.



3 For applications where the follower can be gripped, with a gloved hand, hold the follower assembly in place, exerting no side forces on it. Side forces on the internal follower assembly can damage the bearings in the front bearing assembly.

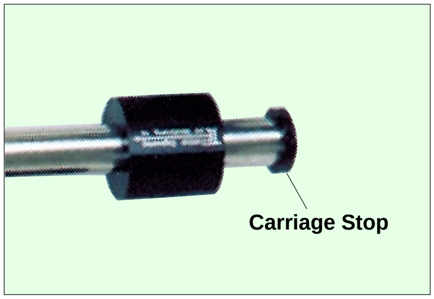
For applications where the follower cannot be gripped, the follower assembly must be allowed to push against some object like a gate valve.



4 Push the carriage farther onto the tube. This will exert a linear force on the follower, which must be held in place. The carriage will break the coupling with the first magnet, then jump to the next coupling point.

The carriage will fit snugly onto the tube with only a small amount of play. As the manipulator is operated, the polymer rings which ride along the outside diameter of the tube will wear, increasing the free play of the carriage.

To check that the manipulator is correctly coupled to the follower assembly, retract the manipulator to



is least extended position, and check the dimension shown in the photo 4 which shows the distance between the rear surface of the carriage and the end of the tube. For DBLOP-XX manipulators, the carriage is flush with the end of the tube. Most users place a carriage stop at the end.

Removal of Carriage Assembly

To remove the carriage assembly, the manipulator must first be in its' fully retracted position. That position is defined as the position where the manipulator is in its' least extended position, and the follower assembly inside the tube is pulled up against the inside surface of the tube cap.

Removing the carriage requires a force of approximately 30 lbs., and the release is a quick motion. Pull the magnet case off the tube being careful not to exert any side motions on the case.

Bakeout

WARNING: The maximum bakeout temperature is 250°C. The carriage assembly must be removed.

REMOVE Carriage before baking.

The carriage assembly **must be removed in order to bake** the entire manipulator. Please read the "*Removal of Carriage Assembly*" section above for instructions before beginning. Bakeout of the manipulator with the magnet case in place can occur, but the magnet carriage itself must not exceed 70° C or permanent loss of magnetism to the unit will occur and the warranty will be void. The manipulator will need to return to the factory for repair.

With the carriage assembly removed, the DBLOP-XX manipulators are constructed entirely of non-polymeric materials, so they can be kept at temperature as long as desired. For maximum removal of water vapor (the most prevalent gas to be pumped away), a 24 hr. bakeout at 220°C is recommended.

COOL FOR
24 HOURS
AFTER BAKEOUT

WARNING: The manipulator must be allowed to cool a minimum of 24 hours after removal of heat before operation. Due to the fact that the internal assembly cools at a very slow rate, a temperature differential will exist soon after heat is removed. Even though the tube assembly may be cool to the touch, the internal parts may be near the bakeout temperature, and the expansion of the follower could cause damage to the tube if the unit is operated.

Maintenance

IMPORTANT: Periodic adjustment of the sleeves on the DBLOP magnetic manipulator is absolutely required for proper operation and prolonged life of this device. Adjustment procedures follow. Use the photos provided for assistance in the adjustment.

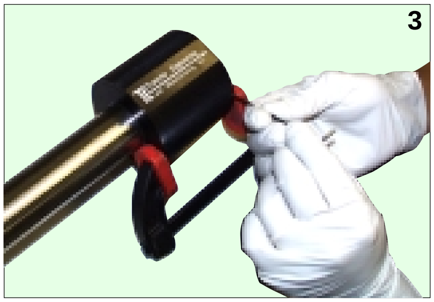
Model DBLOP-XX , Linear-Only Precision Magnetic Manipulator

1 Remove one of the 4-40 x 1/4" socket cap screws that holds the end cap to the magnet carriage.

1

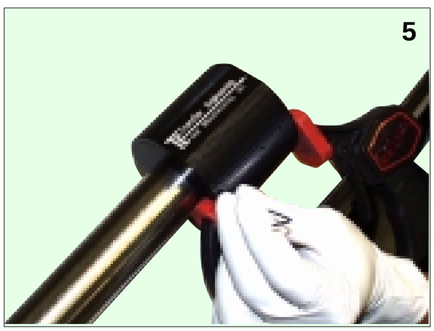
NOTE: For the end cap on the end of the carriage that contains the ring magnetics, the magnetic force will tend to push the end cap out of the recess where it resides. Use of a clamp to hold the end cap in place is needed for this adjustment.

2 Insert the 0.050” allen wrench into the hole exposed by the removed screw, and slightly tighten down on the remaining screw. This screw pushes against the teflon sleeve which rides along the tube assembly



3 Following this adjustment, reinsert the 4-40 socket cap screw.

4 Move to the next hole on that end of the magnet carriage, and repeat the steps above. Repeat the process on the last hole at that end of the carriage.



5 Once one end of the magnet case has been adjusted, move to the other end of the carriage and repeat the process.

IMPORTANT

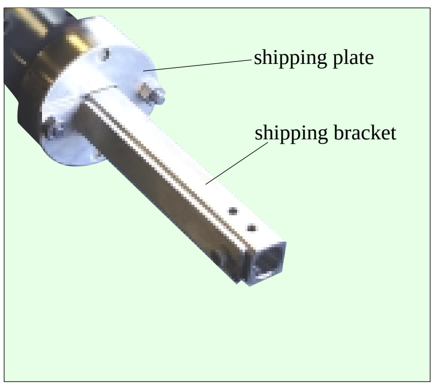
For proper operation and long life of the manipulator, adjusting the magnet carriage evenly, so that it is concentric with the tube, is critical. This may require some fine adjusting by following the process above several times in order to get it adjusted correctly. Observing the exposed section of teflon ring within the end cap against the tube while rotating the magnet case is the best way to determine the concentricity of the magnet case on the tube assembly.

NOTE: The use of a light lubricant like WD-40 on the outside surface of the tube assembly will reduce wear on the teflon rings, and allow operation with less force. Before any bake-out is to take place, this lubricant should be cleaned off of the surface.

Shipping Instructions

The Precision Magnetic Manipulator is a fine tuned, delicate instrument which must be carefully packaged for any shipment. If possible, it is a good idea to retain the box and foam that the manipulator arrives in, or if that is not available, the manipulator should be packaged in a manner similar to the way it arrived from the factory.

Proper packaging consists of 4-6 " of appropriate density foam surrounding the manipulator tube and carriage assembly, with the carriage assembly removed, wrapped and separated from the manipulator by at least 4-6". Corrugated cardboard boxes of appropriate strength rating are adequate.



The manipulator requires installation of the two shipping brackets that it arrived with to prevent damage to the bearings. The carriage must be removed. See the photo to the left for proper installation of the shipping brackets. **Shipping the unit without the shipping brackets will void the warranty.**

Please call Transfer Engineering if a unit needs to be returned for a Return Material Authorization number, and the shipping brackets if they have not been retained.

Shipping checklist:

- ❑ Remove magnet carriage from manipulator
- ❑ Install shipping brackets correctly
- ❑ Package securely
    - Sufficient padding
    - Securely separate carriage from tube
- ❑ Call factory for RMA Number — 510.651.3000
- ❑ Shipping Address:

  Transfer Engineering and Manufacturing, Inc.
  2199 Warm Springs Court, Suite 1
  Fremont, CA 94539

Other Cautions

The carriage assembly contains several strong rare-earth magnets which can cause damage to any devices sensitive to strong magnetic fields — computer disk drives, monitors, floppy disks, credit cards, etc. Care must be taken when the carriage is handled, as magnetic materials will be strongly attracted to this assembly when it is off the unit. Magnetic fields at the carriage are in the order of 20-30 gauss, but drop to the level of the Earth's field at about 1 foot from the unit.

The tube assembly is fabricated from relatively thin-wall stainless steel tubing which is easily damaged by unnecessary pressures exerted on it. This includes squeezing or leaning on the tube. Any distortion of the tube wall will cause the failure of the unit.

The follower assembly contains miniature precision ball bearings which can easily fail with the introduction of any foreign materials. This includes materials flaking from the manipulator tube which have been deposited there during sputtering, or other sample related materials which could enter the tube assembly during the retraction of the manipulator.

Please call Transfer Engineering and Manufacturing with any questions involving the performance, installation or maintenance of the magnetic manipulators described in this manual. We can be reached at 510. 651.3000 or by e-mail at team@transferengineering.com.

Warranty Statement

Basic Warranty

Except as otherwise provided herein, the Seller warrants to Buyer that the equipment sold hereunder, whether it is new equipment or remanufactured (reconditioned) equipment, is, at the time of shipment, as Buyer's sole exclusive remedy under this warranty Seller agrees either to repair or replace, at Seller's sole option and free of part charge to Buyer, any part or parts of such equipment which, under proper and normal conditions of use provide to be defective within twelve (12) months from the date of shipment by the Buyer. Warranty period for equipment requiring installation by Seller will commence on completion of standard installation services. If customer delays installation beyond forty-five (45) days after delivery, the warranty period will commence to run forty-five (45) days after delivery. After installation, any realignment, readjustment, recleaning, or recalibration, provided they do not relate to a proven defect in material or workmanship, shall be performed only at Seller's then current rates for service.

Exclusions and Limitations.

(i) It is recognized that some parts by their nature (expendable items), may not function one year, therefore, exclusined from the foregoing warranty are parts mentioned in the applicable operating manual.

(ii) The foregoing warranty excludes certain major items or accessories specifically indicated on applicable price lists or quotations, as to which Seller passes to the Buyer whatever warranty is provided to Seller by the Manufacturer or the specific warranty indicated by the price list or quotation.

(iii) This warranty does not cover loss, damage, or defects resulting from transportation to the buyer's facility, improper or inadequate maintenance by Buyer, buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the equipment or improper site preparation and maintenance.

Product Service

(i) All claims must be brought to attention of Seller within thirty (30) days of the failure to perform.

(ii) Seller at his option may require the product to be returned to the factory, transportation prepaird, for repair.

Refund of Purchase Price

(i) In lieu of the foregoing, Seller may at anytime elect, in its sole discretion, to discharge its warranty by accepting the return of such equipment and refunding any portion of the purchase price paid by Buyer.

Transfer Engineering and Manufacturing, Inc.
2199 Warm Springs Court, Suite 1
Fremont, CA 94539
Tel: (510)651-3000
Fax: (510)651-3090

Transfer Engineering welcomes feedback from customers. If you have suggested modifications/additions or a comment to this manual or TEAM product, please do not hesitate to FAX or e-mail us. You can also contact us through our web site: www.transferengineering.com.

FAX FAX FAX FAX FAX FAX FAX FAX FAX FAX

To:	Customer Service
Organization:	Transfer Engineering and Manufacturing, Inc.
Fax No:	510-651-3090
E-mail:	team@transferengineering.com
Date:	______________________________
Sender:	______________________________
Organization:	______________________________
Fax or E-mail:	______________________________

Message:

ELECTRICAL SCHEMATICS

FILE NUMBER	DRAWING DESCRIPTION	REV
1107-000-EA-000	Drawing Index	–
1107-000-EA-005	BILL OF MATERIAL #1	–
1107-000-EA-006	BILL OF MATERIAL #2	–
1107-000-EA-007	BILL OF MATERIAL #3	–
1107-000-EA-008	BILL OF MATERIAL #4	–
1107-000-EA-009	BILL OF MATERIAL #5	–
1107-000-ED-000	208 VAC Distribution	–
1107-000-ED-005	208 VAC Distribution	–
1107-000-ED-006	208 VAC Distribution	–
1107-000-ED-007	208 VAC Distribution	–
1107-000-ED-008	208 VAC Distribution	–
1107-000-ED-009	208 VAC Distribution	–
1107-000-ED-020	120 VAC Distribution	–
1107-000-ED-021	120 VAC Distribution	–
1107-000-ED-022	120 VAC Distribution	–
1107-000-ED-025	120 VAC Distribution	–
1107-000-ED-026	120 VAC Distribution	–
1107-000-ED-040	24 VDC Distribution	–
1107-000-ED-041	24 VDC Distribution	–
1107-000-EF-000	PLC Rack 0 Slot 0 & 1	–
1107-000-EF-001	PLC Rack 0 Slot 2 & 3	–
1107-000-EF-002	PLC Rack 0 Slot 4 & 5	–
1107-000-EF-003	PLC Rack 0 Slot 6 & 7	–
1107-000-EF-004	PLC Rack 0 Slot 8 & 9	–
1107-000-EG-000	Bottom Mounting Plate	–
1107-000-EG-001	Vertical Mounting Plate	–

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N2R 1K3 TELEPHONE: (519) 893-6413
FAX: (519) 748-9156
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Angstrom Engineering
00382 ASU Source Deposition System
Drawing Index

DESIGN G.O.	DATE Dec 6/04	JOB# 1107		REV –	
DRAWN G.O.	DATE Dec 6/04	SEC. A	SUB. SEC.	SHEET No. 000	
CHECKED –	DATE –	FILE No. 1107-000-EA-000			

QTY	CATALOG	MFG	DESCRIPTION	TAGS
17	100-C09DJ01	AB	CONTACTOR BULLETIN 100-C/104-C 3-POLE DC-OPERATED 24 VDC COIL AC-3 9A 3 MAIN CONTACTS 1NC	M-2/00 M-2/01 M-5/00 M-5/01 M-5/02 M-5/03 M-5/04 M-5/05 M-5/06 M-5/07 M-5/08 M-5/09 M-5/10 M-5/11 M-5/12 M-5/13 M-5/14
1	100-C85D01	AB	CONTACTOR BULLETIN 100-C/104-C 3-POLE DC-OPERATED 120 VAC COIL AC-3 85A 3 MAIN CONTACTS 1NC	MCR-02130
18	100-FA22	AB	AUXILIARY CONTACTS BULLETIN 100-C/104-C 2 NO 2 NC	M-2/00 M-2/01 M-5/00 M-5/01 M-5/02 M-5/03 M-5/04 M-5/05 M-5/06 M-5/07 M-5/08 M-5/09 M-5/10 M-5/11 M-5/12 M-5/13 M-5/14 MCR-02130
1	100-FSV136	AB	SURGE SUPPRESSOR BULLETIN 100-C/104-C 56..136V AC 78..180V DC	MCR-02130
17	1492-H4	AB	SINGLE-CIRCUIT FUSEABLE TERMINAL BLOCK WITH INDICATOR FUSE HOLDER 300AC/DC CSA 12A WORKING VOLTAGE 100 .. 300 AC/DC	FU-00054 FU-00060 FU-00612A FU-00633 FU-00635 FU-00712A FU-00733 FU-00735 FU-00833 FU-00835 FU-00933 FU-00935 FU-02002 FU-02028 FU-02042 FU-02102 FU-02130
1	1492-H5	AB	SINGLE-CIRCUIT FUSEABLE TERMINAL BLOCK WITH INDICATOR FUSE HOLDER 300AC/DC CSA 12A WORKING VOLTAGE 10 .. 57 AC/DC	FU-02030
3	1492-N49	AB	SINGLE-CIRCUIT FUSEABLE TERMINAL BLOCK SIDE JUMPER	FU-00054
1	193-EA1DB	AB	BULLETIN 193-EA/193-ES OVERLOAD 1.0 .. 2.9 A MANUAL RESET	OL-00514
1	193-EA1FB	AB	BULLETIN 193-EA/193-ES OVERLOAD 3.7 .. 12 A MANUAL RESET	OL-00504
1	194E-E100-1753	AB	IEC DISCONNECT SWITCH 600 VAC 250 VDC 100 A	DS-00008
1	194L-HE8N-175	AB	BULLETIN 194E OPERATING HANDLE IP65 FOR 194E-40..100A	DS-00008
5	700-HLT1Z24	AB	700HL SERIES INTERPOSING/ISOLATION RELAY TYPE HL SPDT 24 VDC COIL 250V MAX AC/DC SPDT	CR-2/14 CR-2/15 CR-3/14 CR-3/15 CR-4/15
2	800E-2X01	AB	800E CONTACT BLOCK 22.5mm IEC STYLE 2NC	PB-02106A

QTY	CATALOG	MFG	DESCRIPTION	TAGS
1	800E-2X10	AB	800E CONTACT BLOCK 22.5mm IEC STYLE 1NO	PB-02106A
1	800E-A2L	AB	800E MOUNTING LATCH – 2 ACROSS 22.5mm IEC STYLE 2 ACROSS MOUNTING LATCH	PB-02106A
1	800E-A6PR5	AB	800E PLASTIC GUARD 22.5mm IEC STYLE	PB-02106A
1	800ES-MP24	AB	PUSH BUTTON – PUSH-PULL MUSHROOM 22.5mm IEC STYLE RED 40mm (STYLE A) MUSHROOM PLASTIC OPERATOR w 2 ACROSS MTG (2 NC)	PB-02106A
1	30VB6	CORCOM	LINE FILTER 120 VAC 30A	LF-00013
4	AGC1	EDISON	FUSE 1/4" x 1-1/4" FAST ACTING 250 VAC/VDC 1A	FU-00612A FU-00712A FU-02102 FU-02130
8	AGC1/4	EDISON	FUSE 1/4" x 1-1/4" FAST ACTING 250 VAC/VDC 1/4A	FU-00633 FU-00635 FU-00733 FU-00735 FU-00833 FU-00835 FU-00933 FU-00935
2	AGC10	EDISON	FUSE 1/4" x 1-1/4" FAST ACTING 250 VAC/VDC 10A	FU-02002 FU-02030
2	AGC2	EDISON	FUSE 1/4" x 1-1/4" FAST ACTING 250 VAC/VDC 2A	FU-00054 FU-02042
1	AGC3	EDISON	FUSE 1/4" x 1-1/4" FAST ACTING 250 VAC/VDC 3A	FU-00060
1	AGC6	EDISON	FUSE 1/4" x 1-1/4" FAST ACTING 250 VAC/VDC 6A	FU-02028
3	MEN12	EDISON	FUSE MIDGET 1-1/2" x 13/32" MIDGET TIME DELAY 250 VAC 12A	FU-00504
1	MEN15	EDISON	FUSE MIDGET 1-1/2" x 13/32" MIDGET TIME DELAY 250 VAC 15A	FU-00030
1	MEN30	EDISON	FUSE MIDGET 1-1/2" x 13/32" MIDGET TIME DELAY 250 VAC 30A	FU-00013
3	MEN4	EDISON	FUSE MIDGET 1-1/2" x 13/32" MIDGET TIME DELAY 250 VAC 4A	FU-00514
8	MEN5	EDISON	FUSE MIDGET 1-1/2" x 13/32" MIDGET TIME DELAY 250 VAC 5A	FU-00605 FU-00606 FU-00612 FU-00619 FU-00705 FU-00706 FU-00712 FU-00719
7	MEN8	EDISON	FUSE MIDGET 1-1/2" x 13/32" MIDGET TIME DELAY 250 VAC 8A	FU-00805 FU-00806 FU-00812 FU-00819 FU-00905 FU-00906 FU-00912

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FAX: (519) 748-9156
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REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-

Angstrom Engineering
00382 ASU Source Deposition System
BILL OF MATERIAL #1

DESIGN G.O.	DATE Dec 6/04	JOB# 1107	REV –		
DRAWN G.O.	DATE Dec 6/04	SEC. A	SUB. SEC.	SHEET No. 005	
CHECKED –	DATE –	FILE No. 1107-000-EA-005			

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QTY	CATALOG	MFG	DESCRIPTION	TAGS
17	USM1I	GOULD	ULTRASAFE FUSE HOLDER MIDGET 1-1/2" x 13/32" 600 VAC 30A	FU-00013 FU-00030 FU-00605 FU-00606 FU-00612 FU-00619 FU-00705 FU-00706 FU-00712 FU-00719 FU-00805 FU-00806 FU-00812 FU-00819 FU-00905 FU-00906 FU-00912
2	USM3I	GOULD	ULTRASAFE FUSE HOLDER MIDGET 1-1/2" x 13/32" 600 VAC 30A	FU-00504 FU-00514
1	1584H6A1	HAMMOND	POWER BAR 6 OUTLETS 120 VAC 15 A	RECPT-0003 0
5	ANGSTROM 1.5KVA	HAMMOND	1.5KVA	XF-00806 XF-00812 XF-00819 XF-00906 XF-00912
6	ANGSTROM 1K	HAMMOND	1KVA	XF-00606 XF-00612 XF-00619 XF-00706 XF-00712 XF-00719
4	ANGSTROM 25VA	HAMMOND	3400023 25 VA	XF-00634 XF-00734 XF-00834 XF-00934
4	PF1 40	HDR	SOLID STATE RELAY 40A	HDR-00604 HDR-00704 HDR-00804 HDR-00904
1	HBL2420CN	HUBBELL	TWIST LOCK RECEPTACLE 20A 3PH 250V	MOT-00515
1	HBL2421CN	HUBBELL	TWIST LOCK PLUG 20A 3PH 250V	MOT-00515
1	HBL2720CN	HUBBELL	TWIST LOCK RECEPTACLE 30A 3PH 250V L15-30 PATTERN	MOT-00505
1	HBL2721CN	HUBBELL	TWIST LOCK PLUG 30A 3PH 250V L15-30 PATTERN	MOT-00505
52	SLU-175	ILSCO	POWER LUGS COPPER MECHANICAL LUGS WITH OFFSET 1/0 TO 4/0 MCM	XF-00606 XF-00612 XF-00619 XF-00706 XF-00712 XF-00719 XF-00806 XF-00812 XF-00819 XF-00906 XF-00912
2	1403401	MARATHON	POWER DISTRIBUTION BLOCK 3 POLE 175 AMP 1x 2/0-#14 AWG LINE 6x #4-#14 AWG LOAD	PDB-00015 PDB-00044
1	1421570	MARATHON	POWER DISTRIBUTION BLOCK 1 POLE 175 AMP 1x 2/0-#14 AWG LINE 4x #4-#14 AWG LOAD	PDB-00005
2	CC1403	MARATHON	POWER DISTRIBUTION BLOCK COVER 3 POLE COVER COVER FOR 1403	PDB-00015 PDB-00044
1	CC1421	MARATHON	POWER DISTRIBUTION BLOCK COVER 1 POLE COVER COVER FOR 1421	PDB-00005
1	CJ1G-CPU44H	OMRON	CJ1 SEREIS PROCESSOR 64 K WORDS (DM: 32 KWORDS, EM: 32 K WORDS X 3 BANKS) PROGRAM STEP CAPACITY 30K	R00/PLC
1	CJ1W-AD081-V1	OMRON	ANALOG INPUT 8 POINT INPUT +/- 10V, 0-10V, 0-5V, 1-5V, 4-20mA	R0/S6
2	CJ1W-ID211	OMRON	DIGITAL INPUT 16 POINT INPUT 24 VDC	R0/S0 R0/S1

QTY	CATALOG	MFG	DESCRIPTION	TAGS
4	CJ1W-OC211	OMRON	RELAY OUTPUT 16 POINT OUTPUT 24 VDC	PLC-02 PLC-42 R0/S4 R0/S5
1	CJ1W-PA205R	OMRON	CJ1-SERIES POWER SUPPLY (WITH RUN OUTPUT) OUTPUT CAPACITY: 5A AT 5 VDC, 0.8A AT 24 V	PLC-02050
7	LY2N-D2-DC24	OMRON	GENERAL PURPOSE DPDT 24 VDC COIL LED INDICATOR AND DIODE SURGE SUPRESSION 10 A 250 VAC 125 VDC	CR-4/01 CR-4/02 CR-4/03 CR-4/04 CR-4/05 CR-4/06 CR-5/15
2	LY4N-D2-DC24	OMRON	GENERAL PURPOSE 4PDT 24 VDC COIL LED INDICATOR AND DIODE SURGE SUPRESSION 7 A 250 VAC 125 VDC	CR-4/08 CR-4/09
7	PTF08A-E	OMRON	GENERAL PURPOSE RELAY BASE DPDT	CR-4/01 CR-4/02 CR-4/03 CR-4/04 CR-4/05 CR-4/06 CR-5/15
2	PTF14A-E	OMRON	GENERAL PURPOSE RELAY BASE 4PDT	CR-4/08 CR-4/09
5	CX09B25	ORION ELECTRONICS	MALE TO FEMALE DB9 25FT	CBL-04003 CBL-04024 CBL-04044 CBL-04105 CBL-04126
8	16 62 52 8	PHOENIX	SACC-M12MS-4CON-PG 7-M M12 4-WIRE PLUG CONNECTOR UNSHIELDED, MALE, M 12 A-CODED, 4-POS	LS-0/00 LS-0/01 LS-0/02 LS-0/07 LS-0/07A LS-0/07B LS-0/07C LS-1/00
8	16 81 12 7	PHOENIX	SACC-M12FS-4CON-PG7-M M12 4-WIRE SOCKET CONNECTOR UNSHIELDED, FEMALE, M 12 A-CODED, 4-POS	LS-0/00 LS-0/01 LS-0/02 LS-0/07 LS-0/07A LS-0/07B LS-0/07C LS-1/00
1	29 38 60 4	PHOENIX	24 VDC POWER SUPPLY 120 VAC 1PH 24 VDC 10A QUINT-PS-100-240AC/24DC/10	PS-02028
1	774 316	PILZ	MONITORING RELAY 3 NO 1 NC SAFETY RELAY 120 VAC, 60Hz COIL	MCR-02102
1	PK9GTA	SQD	GROUND BAR KIT 600 VAC	PDB-00003
51	163205	WEIDMULLER	RAIL MOUNTED TERMINAL BLOCKS FEED-THROUGH 35 A #22...10 AWG BEIGE SPRING CLAMP	120VAC 24V 24VDC
96	165036	WEIDMULLER	ZVL 1.5 PE DISTRIBUTOR STRIP 250 V 17.5A BLUE	24VDC
96	165037	WEIDMULLER	ZVL 1.5 PE DISTRIBUTOR STRIP 250 V 17.5A BROWN	24VDC
96	165198	WEIDMULLER	ZVL 1.5/3L-1 S SENSOR BLOCK 3-WIRE 250 V 17.5A BEIGE	24VDC
1	991549	WEIDMULLER	RECEPTACLE 120 VAC DUPLEX OUTLET 15A	RECPT-0200 2

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00382 ASU Source Deposition System
BILL OF MATERIAL #2

DESIGN G.O.	DATE Dec 6/04	JOB# 1107	REV –		
DRAWN G.O.	DATE Dec 6/04	SEC. A	SUB. SEC.	SHEET No. 006	
CHECKED –	DATE –	FILE No. 1107-000-EA-006			

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QTY	CATALOG	MFG	DESCRIPTION	TAGS
96	165036	WEIDMULLER	ZVL 1.5 PE DISTRIBUTOR STRIP 250 V 17.5A BLUE	24VDC:0/00 24VDC:0/01 24VDC:0/02 24VDC:0/03 24VDC:0/04 24VDC:0/05 24VDC:0/06 24VDC:0/07 24VDC:0/08 24VDC:0/09 24VDC:0/10 24VDC:0/11 24VDC:0/12 24VDC:0/13 24VDC:0/14 24VDC:0/15 24VDC:1/00 24VDC:1/01 24VDC:1/02 24VDC:1/03 24VDC:1/04 24VDC:1/05 24VDC:1/06 24VDC:1/07 24VDC:1/08 24VDC:1/09 24VDC:1/10 24VDC:1/11 24VDC:1/12 24VDC:1/13 24VDC:1/14 24VDC:1/15 24VDC:2/00 24VDC:2/01 24VDC:2/02 24VDC:2/03 24VDC:2/04 24VDC:2/05 24VDC:2/06 24VDC:2/07 24VDC:2/08 24VDC:2/09 24VDC:2/10 24VDC:2/11 24VDC:2/12 24VDC:2/13 24VDC:2/14 24VDC:2/15 24VDC:3/00 24VDC:3/01 24VDC:3/02 24VDC:3/03 24VDC:3/04 24VDC:3/05 24VDC:3/06 24VDC:3/07 24VDC:3/08 24VDC:3/09 24VDC:3/10 24VDC:3/11 24VDC:3/12 24VDC:3/13 24VDC:3/14 24VDC:3/15 24VDC:4/00 24VDC:4/01 24VDC:4/02 24VDC:4/03 24VDC:4/04 24VDC:4/05 24VDC:4/06 24VDC:4/07 24VDC:4/08 24VDC:4/09 24VDC:4/10 24VDC:4/11 24VDC:4/12 24VDC:4/13 24VDC:4/14 24VDC:4/15 24VDC:5/00 24VDC:5/01 24VDC:5/02 24VDC:5/03 24VDC:5/04 24VDC:5/05 24VDC:5/06 24VDC:5/07 24VDC:5/08 24VDC:5/09

QTY	CATALOG	MFG	DESCRIPTION	TAGS
				24VDC:5/10 24VDC:5/11 24VDC:5/12 24VDC:5/13 24VDC:5/14 24VDC:5/15

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REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE
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Angstrom Engineering
00382 ASU Source Deposition System
BILL OF MATERIAL #3

DESIGN	G.O.	DATE	Dec 6/04	JOB#	1107	REV	-
DRAWN	G.O.	DATE	Dec 6/04	SEC.	A	SUB. SEC.	SHEET No. 007
CHECKED	-	DATE	-	FILE No.	1107-000-EA-007		

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QTY	CATALOG	MFG	DESCRIPTION	TAGS
96	165037	WEIDMULLER	ZVL 1.5 PE DISTRIBUTOR STRIP 250 V 17.5A BROWN	24VDC:0/00 24VDC:0/01 24VDC:0/02 24VDC:0/03 24VDC:0/04 24VDC:0/05 24VDC:0/06 24VDC:0/07 24VDC:0/08 24VDC:0/09 24VDC:0/10 24VDC:0/11 24VDC:0/12 24VDC:0/13 24VDC:0/14 24VDC:0/15 24VDC:1/00 24VDC:1/01 24VDC:1/02 24VDC:1/03 24VDC:1/04 24VDC:1/05 24VDC:1/06 24VDC:1/07 24VDC:1/08 24VDC:1/09 24VDC:1/10 24VDC:1/11 24VDC:1/12 24VDC:1/13 24VDC:1/14 24VDC:1/15 24VDC:2/00 24VDC:2/01 24VDC:2/02 24VDC:2/03 24VDC:2/04 24VDC:2/05 24VDC:2/06 24VDC:2/07 24VDC:2/08 24VDC:2/09 24VDC:2/10 24VDC:2/11 24VDC:2/12 24VDC:2/13 24VDC:2/14 24VDC:2/15 24VDC:3/00 24VDC:3/01 24VDC:3/02 24VDC:3/03 24VDC:3/04 24VDC:3/05 24VDC:3/06 24VDC:3/07 24VDC:3/08 24VDC:3/09 24VDC:3/10 24VDC:3/11 24VDC:3/12 24VDC:3/13 24VDC:3/14 24VDC:3/15 24VDC:4/00 24VDC:4/01 24VDC:4/02 24VDC:4/03 24VDC:4/04 24VDC:4/05 24VDC:4/06 24VDC:4/07 24VDC:4/08 24VDC:4/09 24VDC:4/10 24VDC:4/11 24VDC:4/12 24VDC:4/13 24VDC:4/14 24VDC:4/15 24VDC:5/00 24VDC:5/01 24VDC:5/02 24VDC:5/03 24VDC:5/04 24VDC:5/05 24VDC:5/06 24VDC:5/07 24VDC:5/08 24VDC:5/09

QTY	CATALOG	MFG	DESCRIPTION	TAGS
				24VDC:5/10 24VDC:5/11 24VDC:5/12 24VDC:5/13 24VDC:5/14 24VDC:5/15

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Angstrom Engineering
00382 ASU Source Deposition System
BILL OF MATERIAL #4

DESIGN G.O.	DATE Dec 6/04	JOB# 1107	REV –		
DRAWN G.O.	DATE Dec 6/04	SEC. A	SUB. SEC.	SHEET No. 008	
CHECKED –	DATE –	FILE No. 1107-000-EA-008			

QTY	CATALOG	MFG	DESCRIPTION	TAGS
96	165198	WEIDMULLER	ZVL 1.5/3L-1 S SENSOR BLOCK 3-WIRE 250 V 17.5A BEIGE	24VDC:0/00 24VDC:0/01 24VDC:0/02 24VDC:0/03 24VDC:0/04 24VDC:0/05 24VDC:0/06 24VDC:0/07 24VDC:0/08 24VDC:0/09 24VDC:0/10 24VDC:0/11 24VDC:0/12 24VDC:0/13 24VDC:0/14 24VDC:0/15 24VDC:1/00 24VDC:1/01 24VDC:1/02 24VDC:1/03 24VDC:1/04 24VDC:1/05 24VDC:1/06 24VDC:1/07 24VDC:1/08 24VDC:1/09 24VDC:1/10 24VDC:1/11 24VDC:1/12 24VDC:1/13 24VDC:1/14 24VDC:1/15 24VDC:2/00 24VDC:2/01 24VDC:2/02 24VDC:2/03 24VDC:2/04 24VDC:2/05 24VDC:2/06 24VDC:2/07 24VDC:2/08 24VDC:2/09 24VDC:2/10 24VDC:2/11 24VDC:2/12 24VDC:2/13 24VDC:2/14 24VDC:2/15 24VDC:3/00 24VDC:3/01 24VDC:3/02 24VDC:3/03 24VDC:3/04 24VDC:3/05 24VDC:3/06 24VDC:3/07 24VDC:3/08 24VDC:3/09 24VDC:3/10 24VDC:3/11 24VDC:3/12 24VDC:3/13 24VDC:3/14 24VDC:3/15 24VDC:4/00 24VDC:4/01 24VDC:4/02 24VDC:4/03 24VDC:4/04 24VDC:4/05 24VDC:4/06 24VDC:4/07 24VDC:4/08 24VDC:4/09 24VDC:4/10 24VDC:4/11 24VDC:4/12 24VDC:4/13 24VDC:4/14 24VDC:4/15 24VDC:5/00 24VDC:5/01 24VDC:5/02 24VDC:5/03 24VDC:5/04 24VDC:5/05 24VDC:5/06 24VDC:5/07 24VDC:5/08 24VDC:5/09

QTY	CATALOG	MFG	DESCRIPTION	TAGS
				24VDC:5/10 24VDC:5/11 24VDC:5/12 24VDC:5/13 24VDC:5/14 24VDC:5/15
1	991549	WEIDMULLER	RECEPTACLE 120 VAC DUPLEX OUTLET 15A	RECPT-0200 2

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00382 ASU Source Deposition System
BILL OF MATERIAL #5

DESIGN	G.O.	DATE	Dec 6/04	JOB#	1107	REV	–
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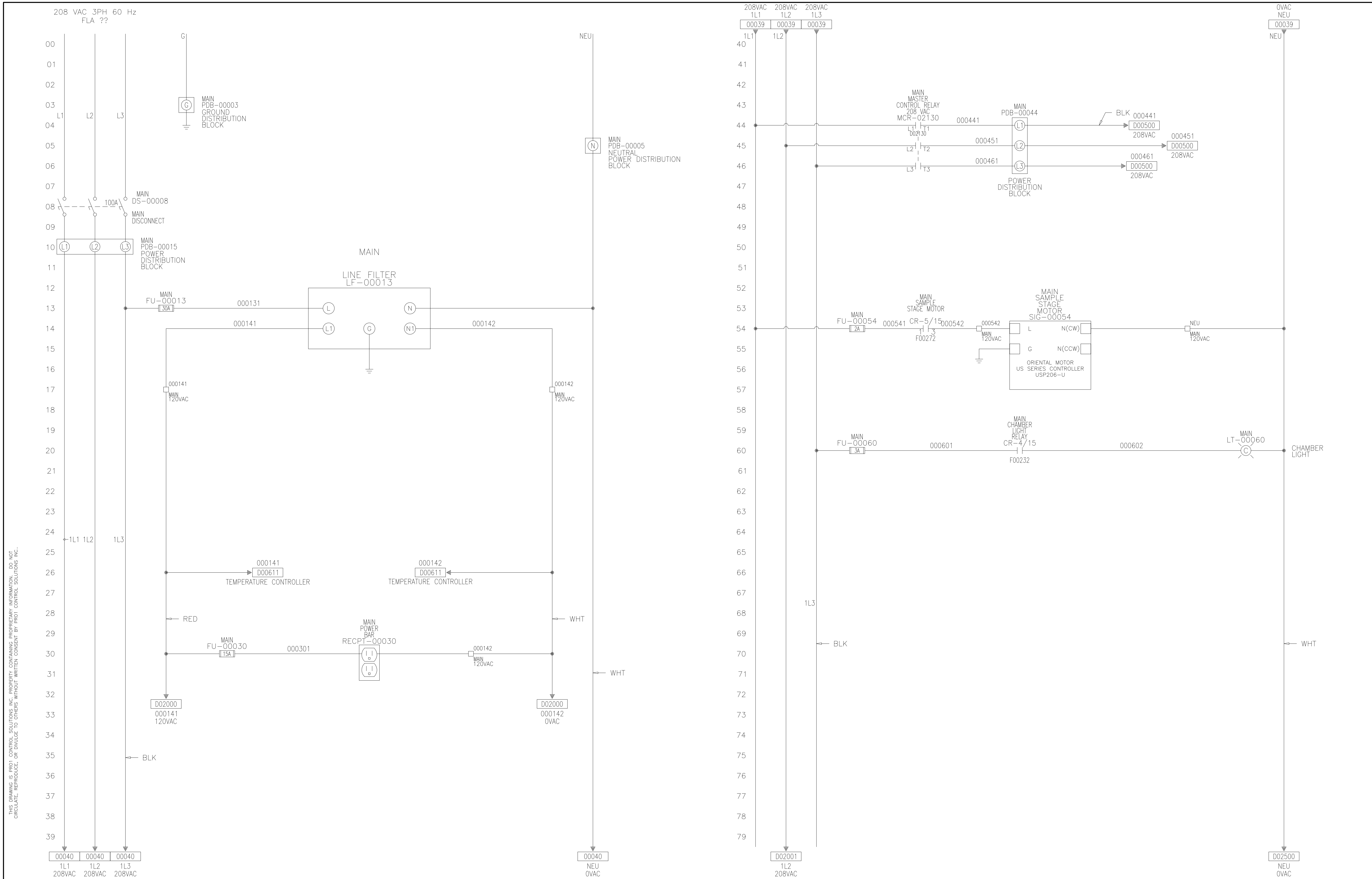

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Angstrom Engineering
00382 ASU Source Deposition System
208 VAC Distribution

DESIGN G.O.	DATE Dec 6/04	JOB# 1107	REV -		
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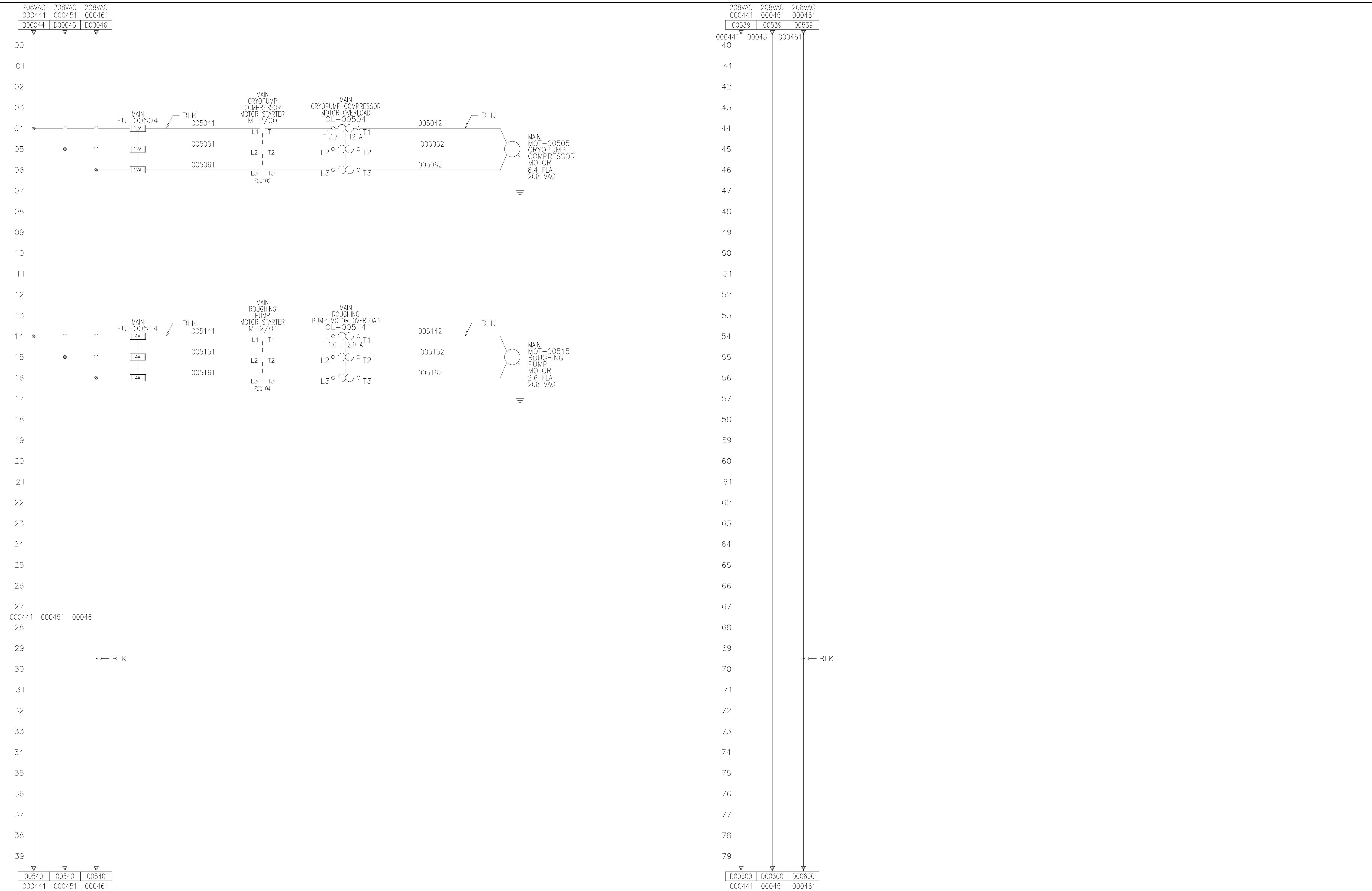

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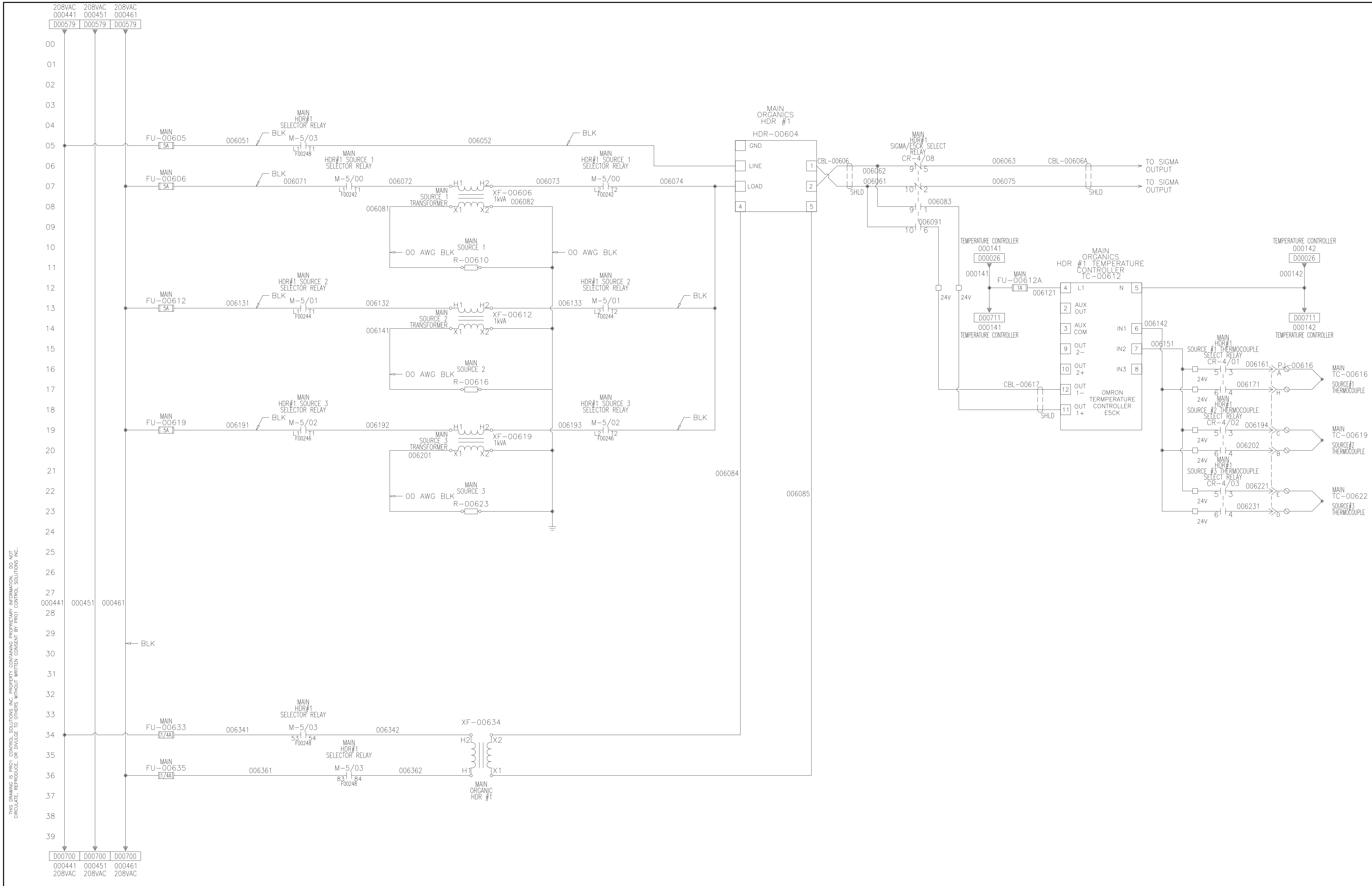

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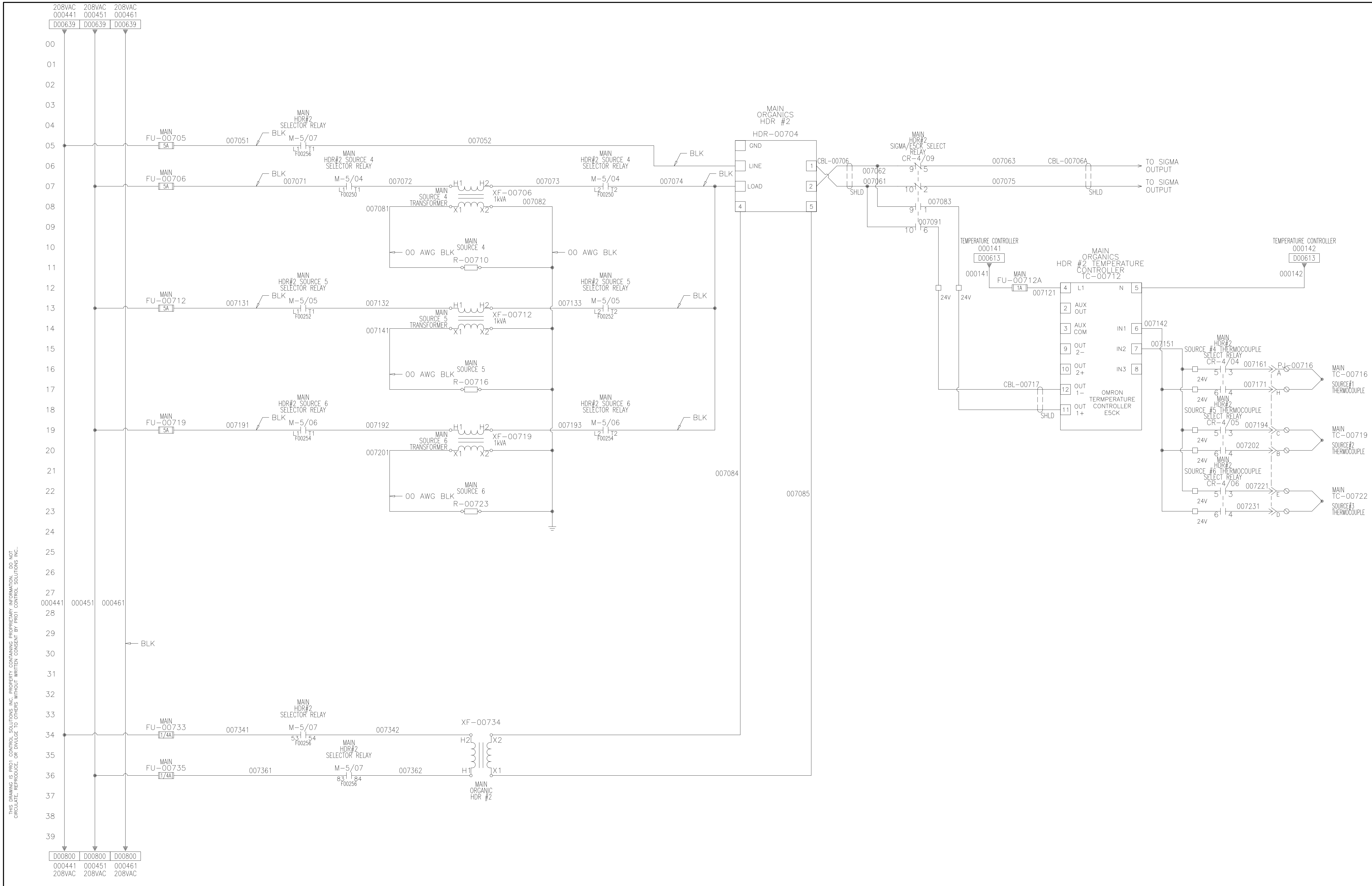

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DESIGN G.O.	DATE Dec 6/04	JOB# 1107	REV -
DRAWN G.O.	DATE Dec 6/04	SEC. D	SUB. SEC.	SHEET No. 007
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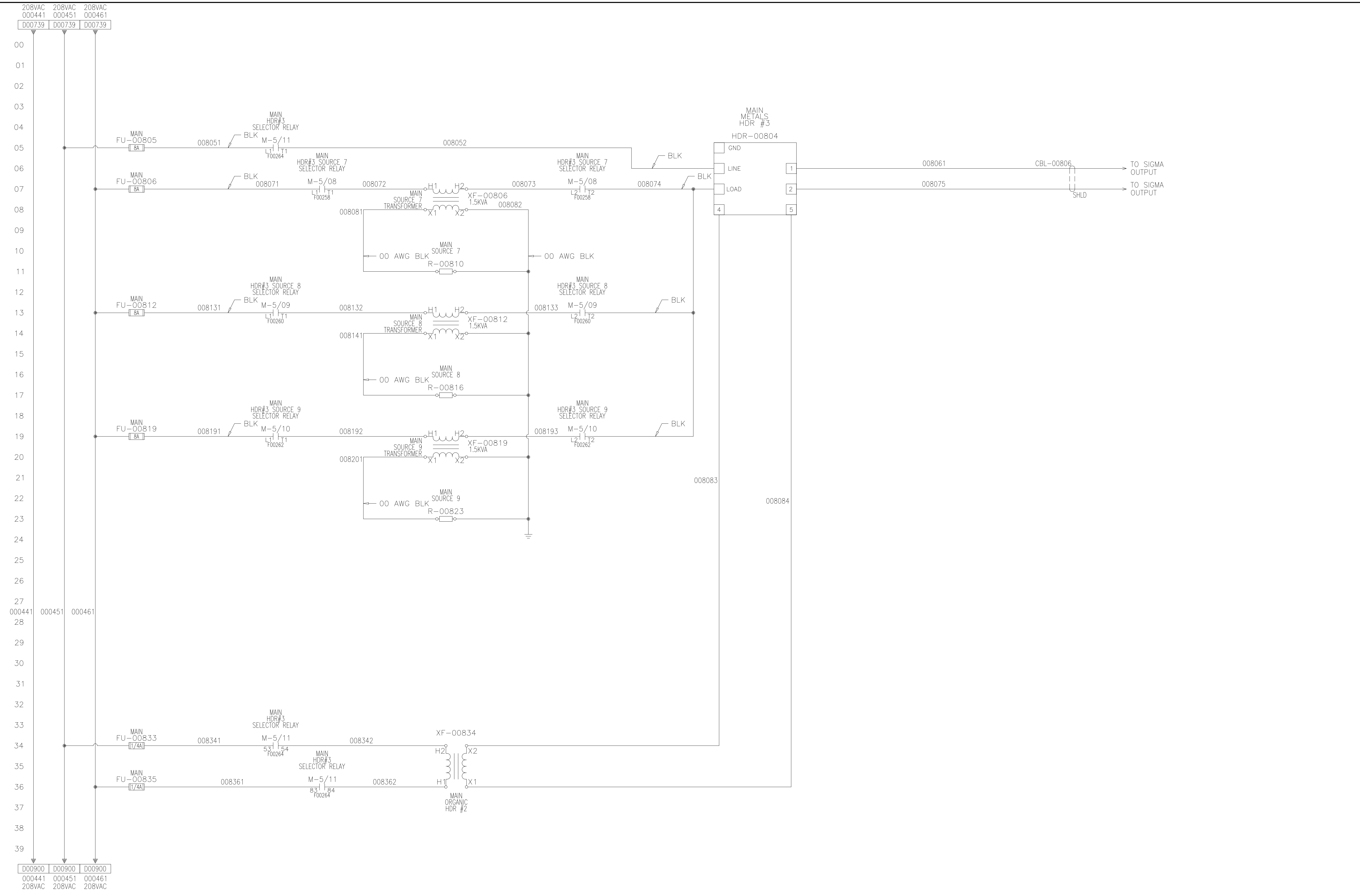

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REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE
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Angstrom Engineering
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208 VAC Distribution

DESIGN	G.O.	DATE	Dec 6/04	JOB#	1107	REV	–
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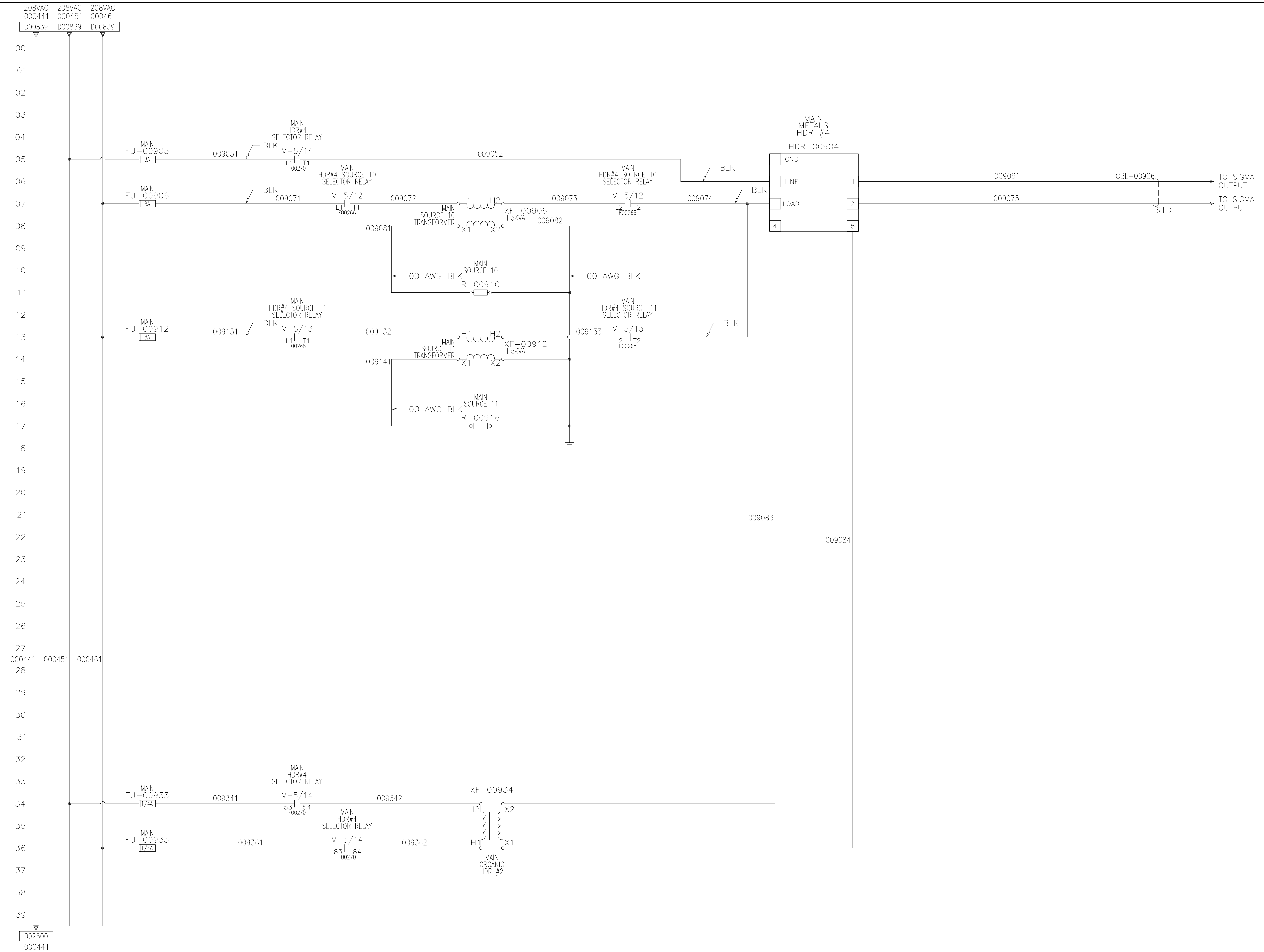

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Angstrom Engineering
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208 VAC Distribution

DESIGN G.O.	DATE Dec 6/04	JOB# 1107	REV -		
DRAWN G.O.	DATE Dec 6/04	SEC. D	SUB. SEC.	SHEET No. 009	
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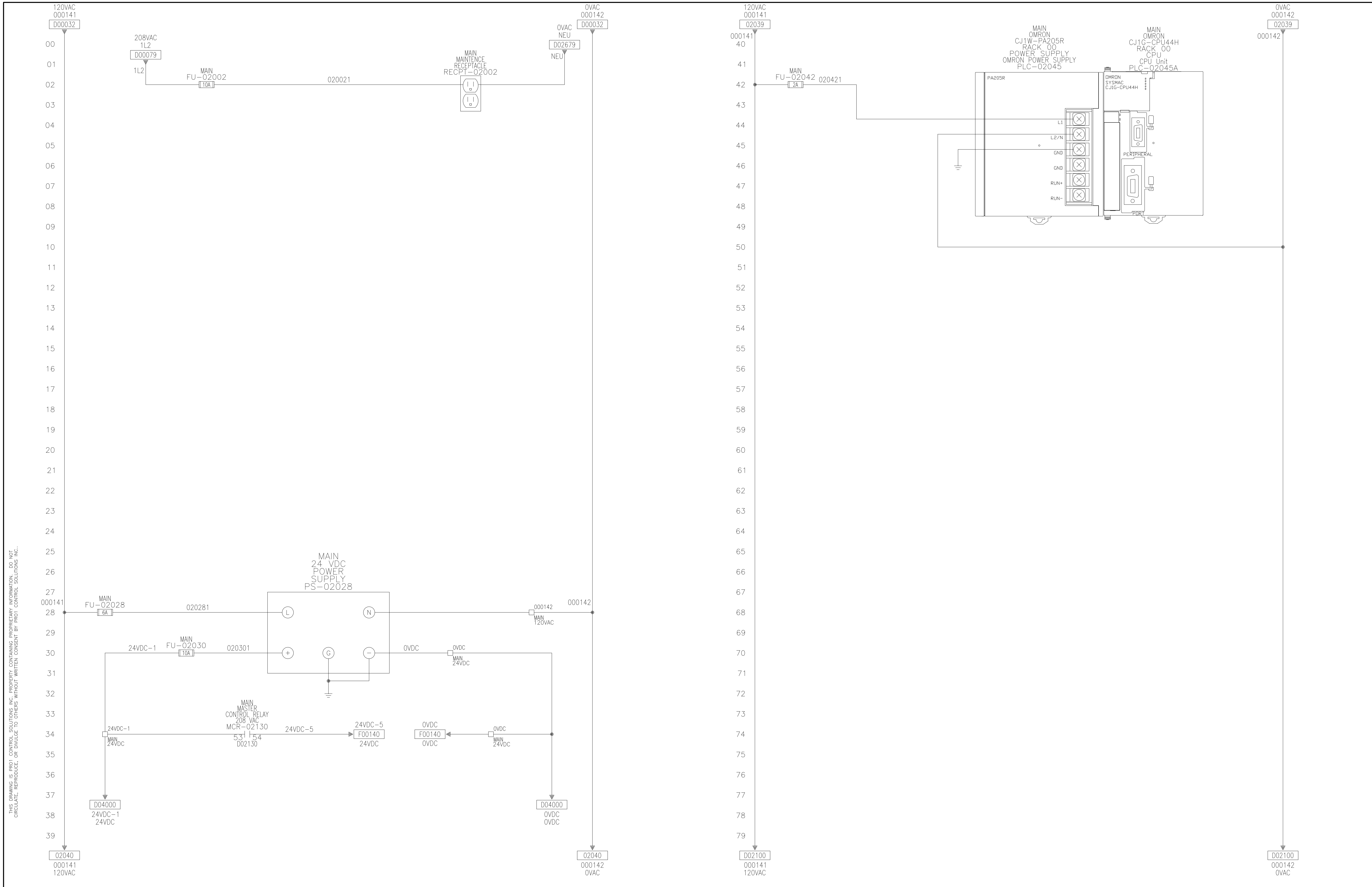

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REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE
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120 VAC Distribution

DESIGN G.O.	DATE Dec 6/04	JOB# 1107	REV -		
DRAWN G.O.	DATE Dec 6/04	SEC. D	SUB. SEC.	SHEET No. 020	
CHECKED -	DATE -	FILE No. 1107-000-ED-020			

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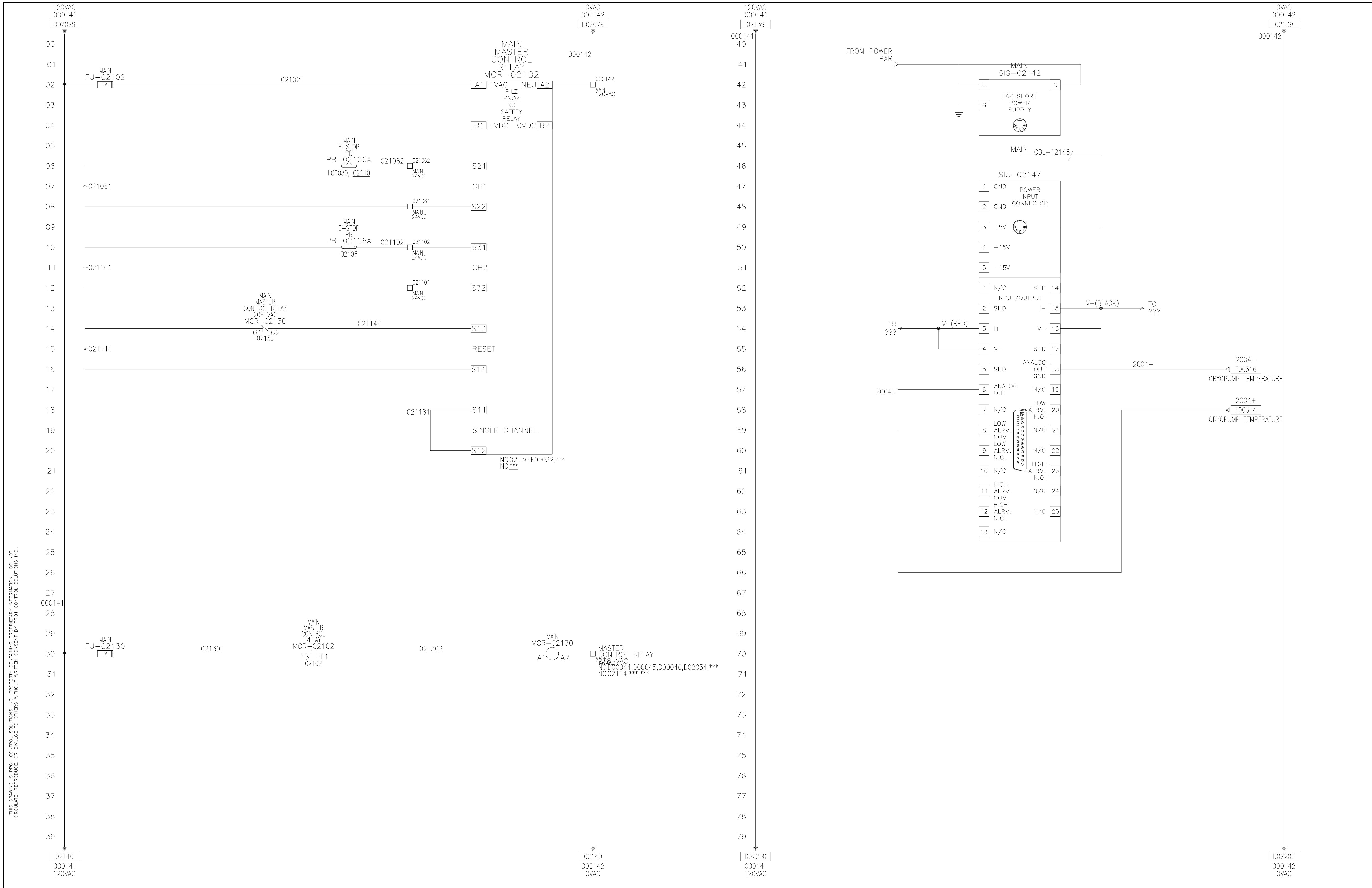

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REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE
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Angstrom Engineering
00382 ASU Source Deposition System
120 VAC Distribution

DESIGN	G.O.	DATE	Dec 6/04	JOB#	1107	REV	-
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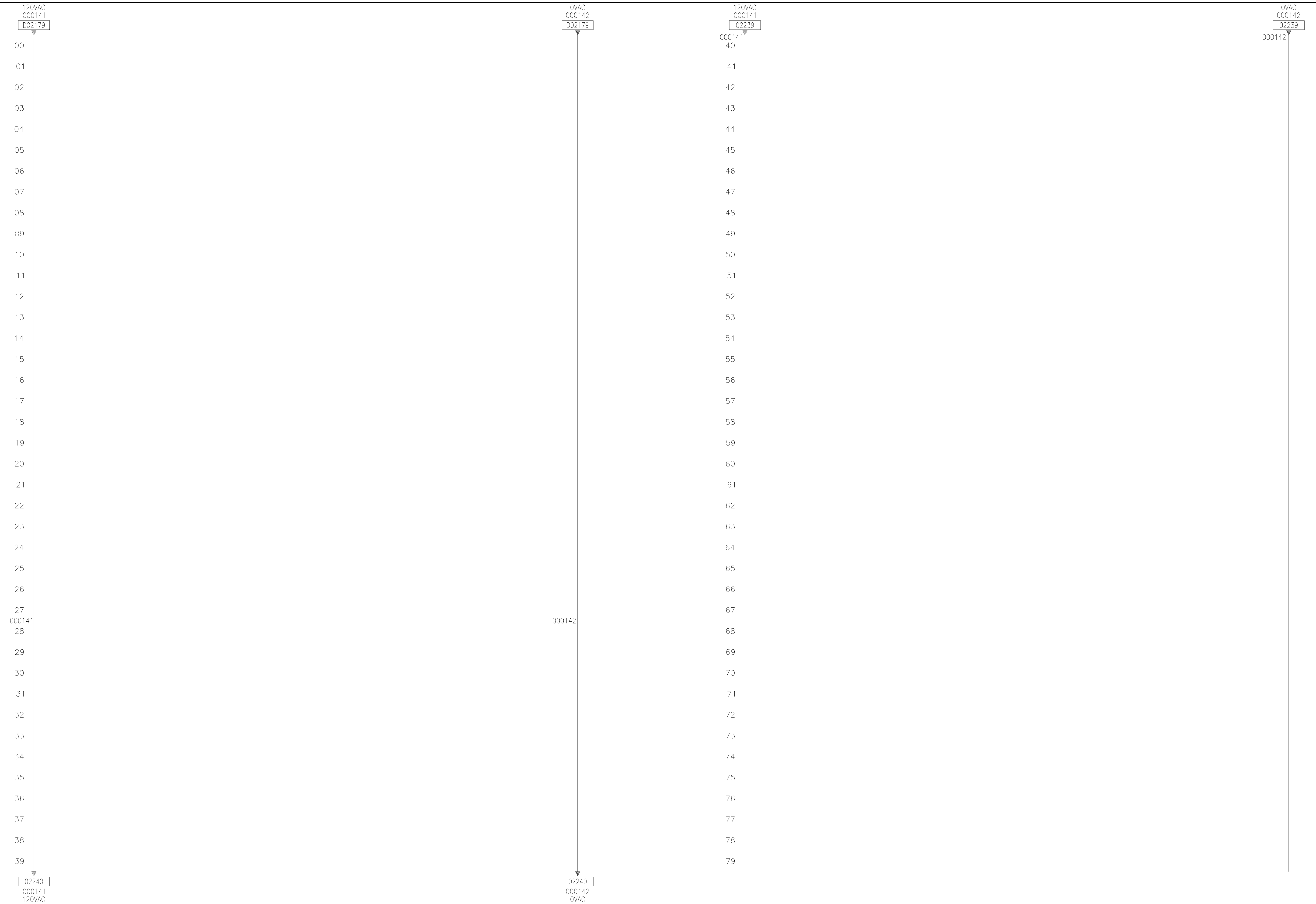

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REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE
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Angstrom Engineering
00382 ASU Source Deposition System
120 VAC Distribution

DESIGN G.O.	DATE Dec 6/04	JOB# 1107	REV –		
DRAWN G.O.	DATE Dec 6/04	SEC. D	SUB. SEC.	SHEET No. 022	
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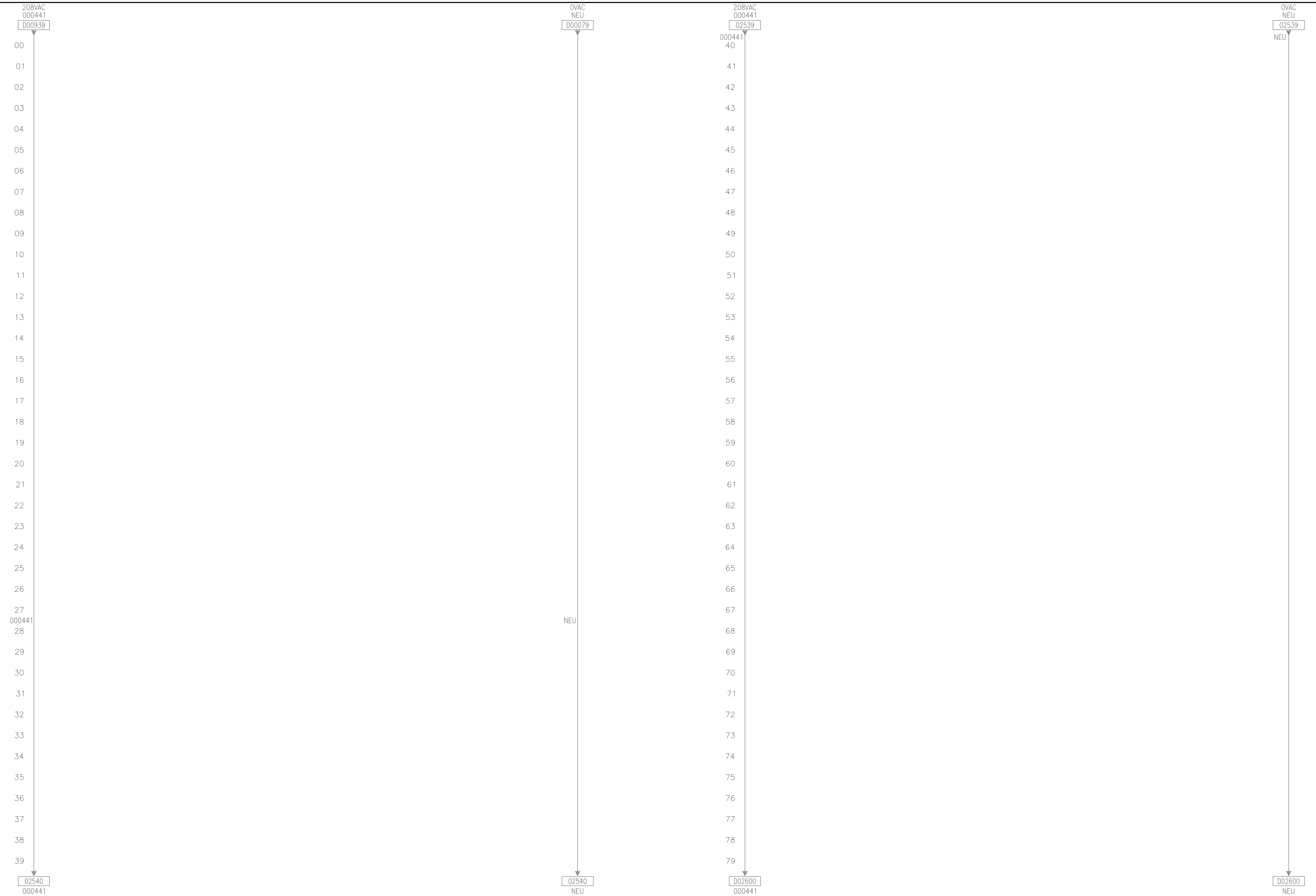

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REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE
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120 VAC Distribution

DESIGN G.O.	DATE Dec 6/04	JOB# 1107	REV –		
DRAWN G.O.	DATE Dec 6/04	SEC. D	SUB. SEC.	SHEET No. 025	
CHECKED –	DATE –	FILE No. 1107-000-ED-025			

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208VAC
000441
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000441 NEU

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208VAC

02640
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REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE	REV	CHANGE	BY	DATE
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Angstrom Engineering
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120 VAC Distribution

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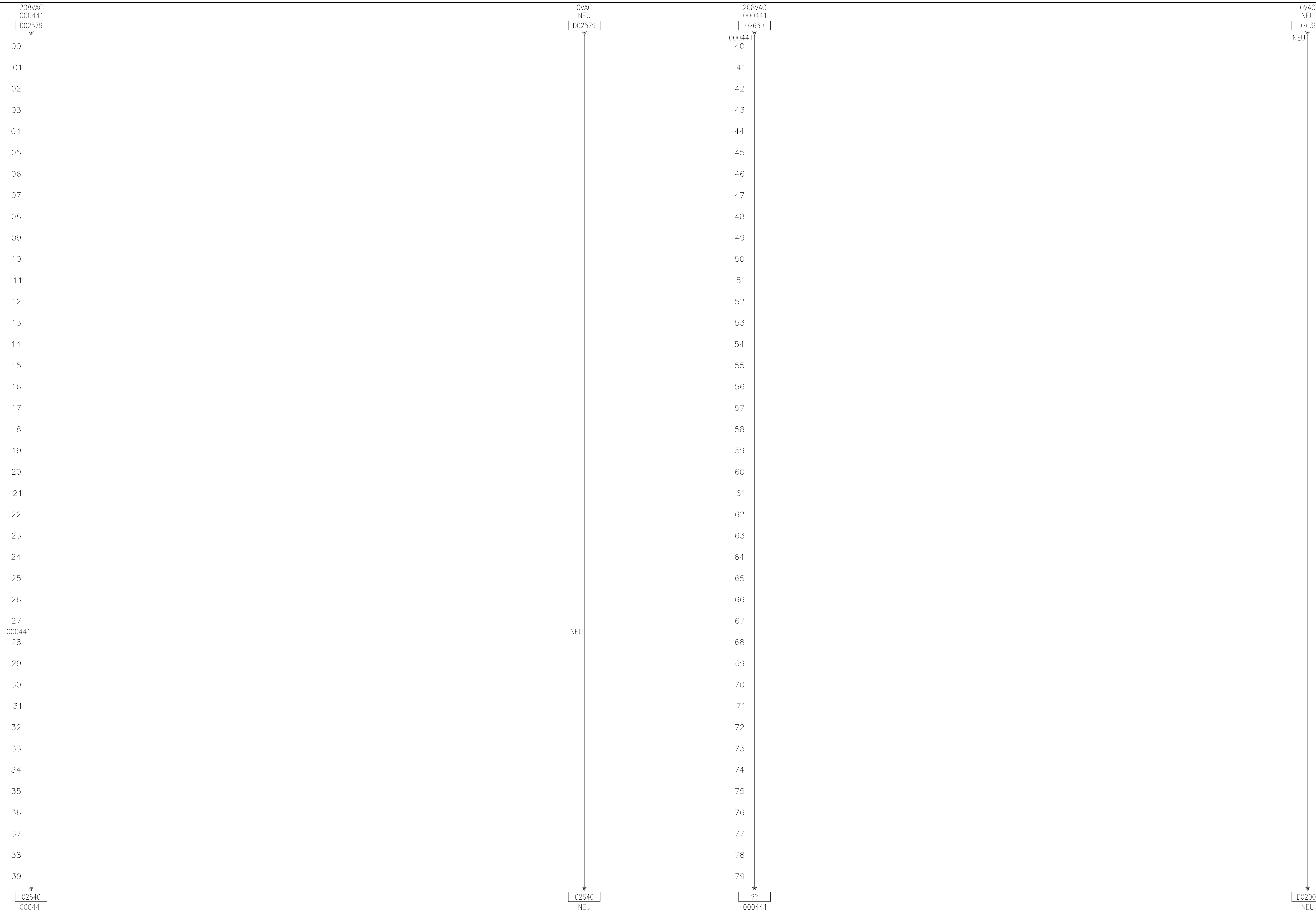

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Angstrom Engineering
00382 ASU Source Deposition System
120 VAC Distribution

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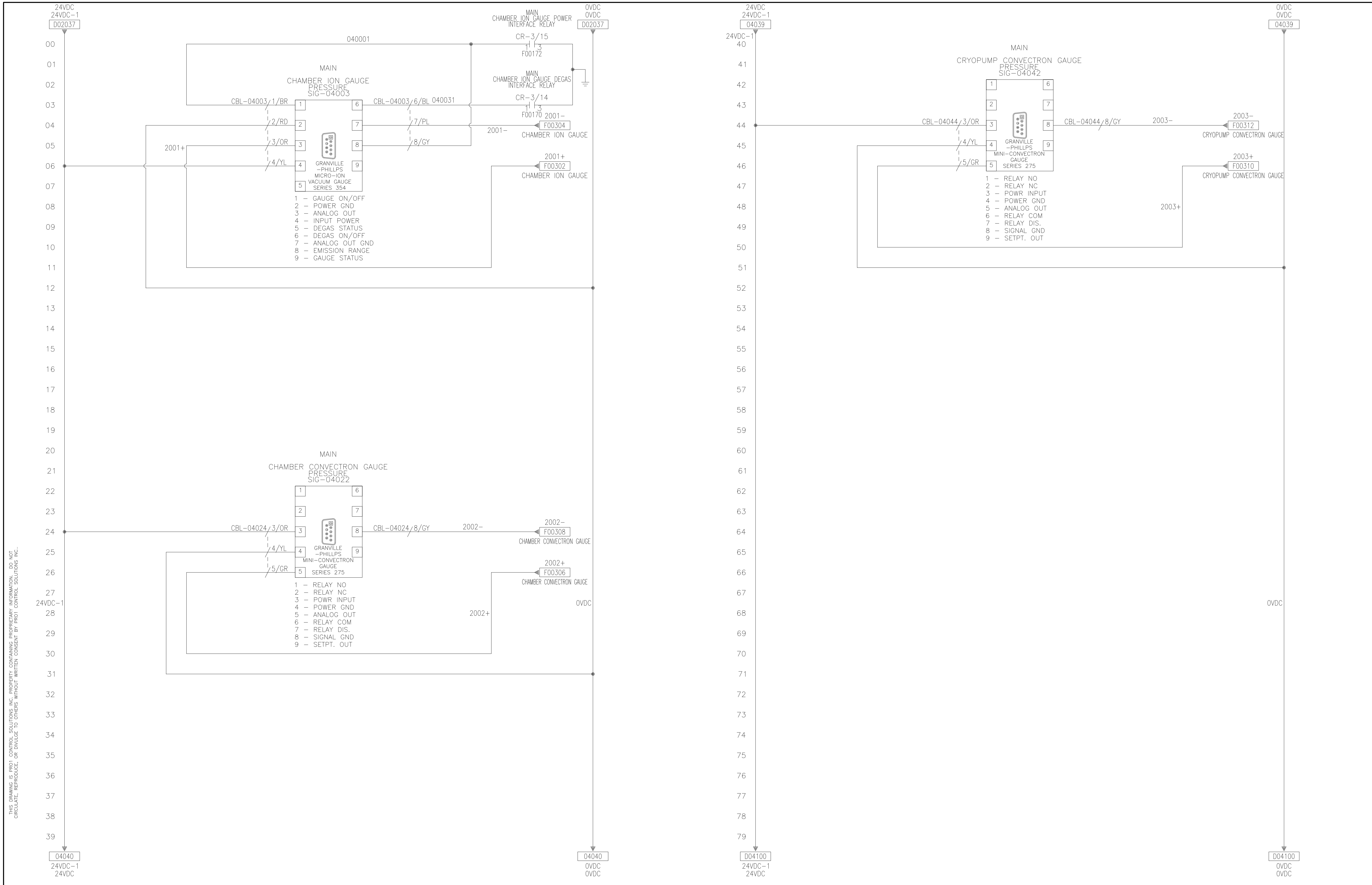

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Angstrom Engineering
00382 ASU Source Deposition System
24 VDC Distribution

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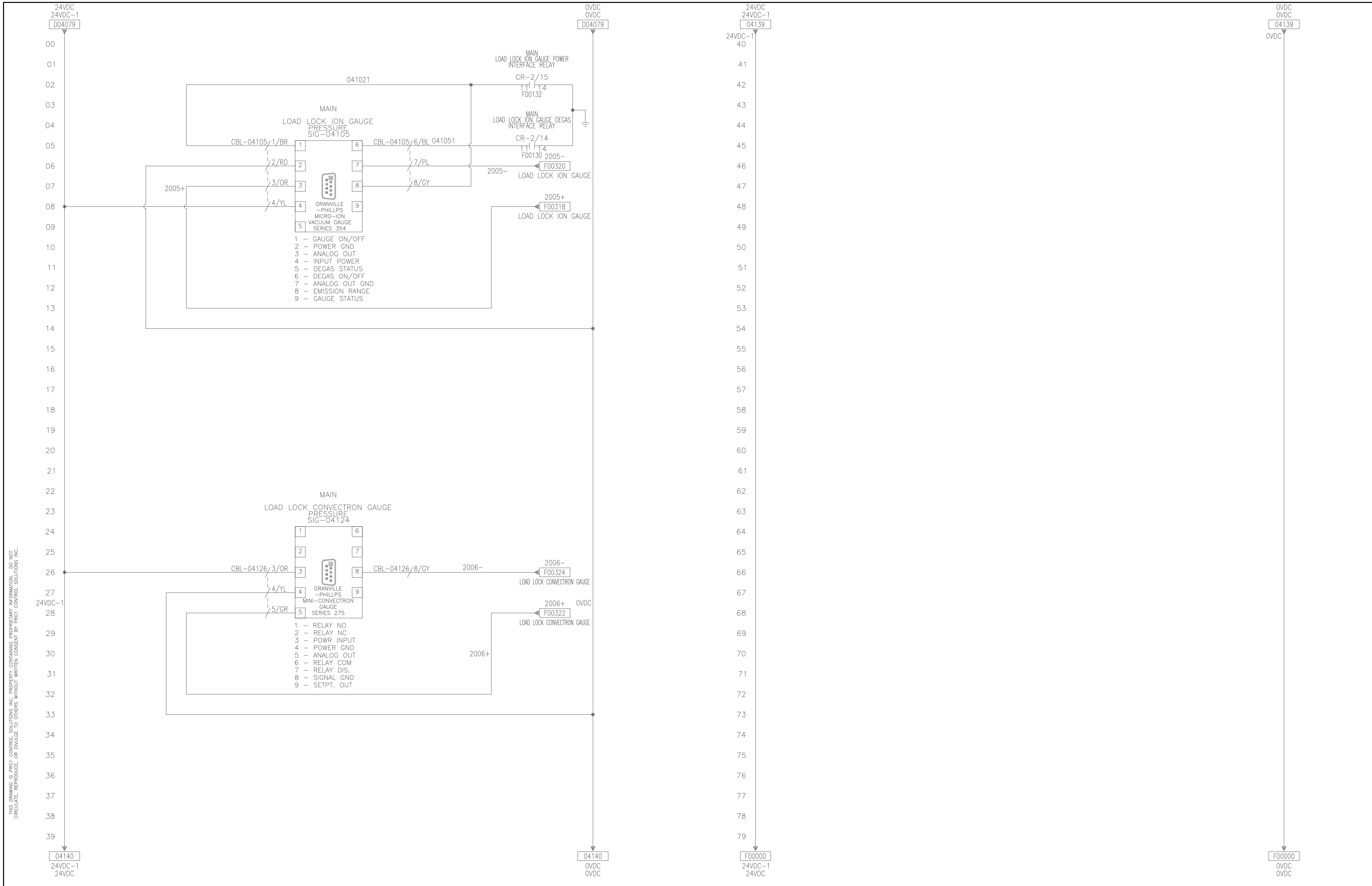

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24 VDC Distribution

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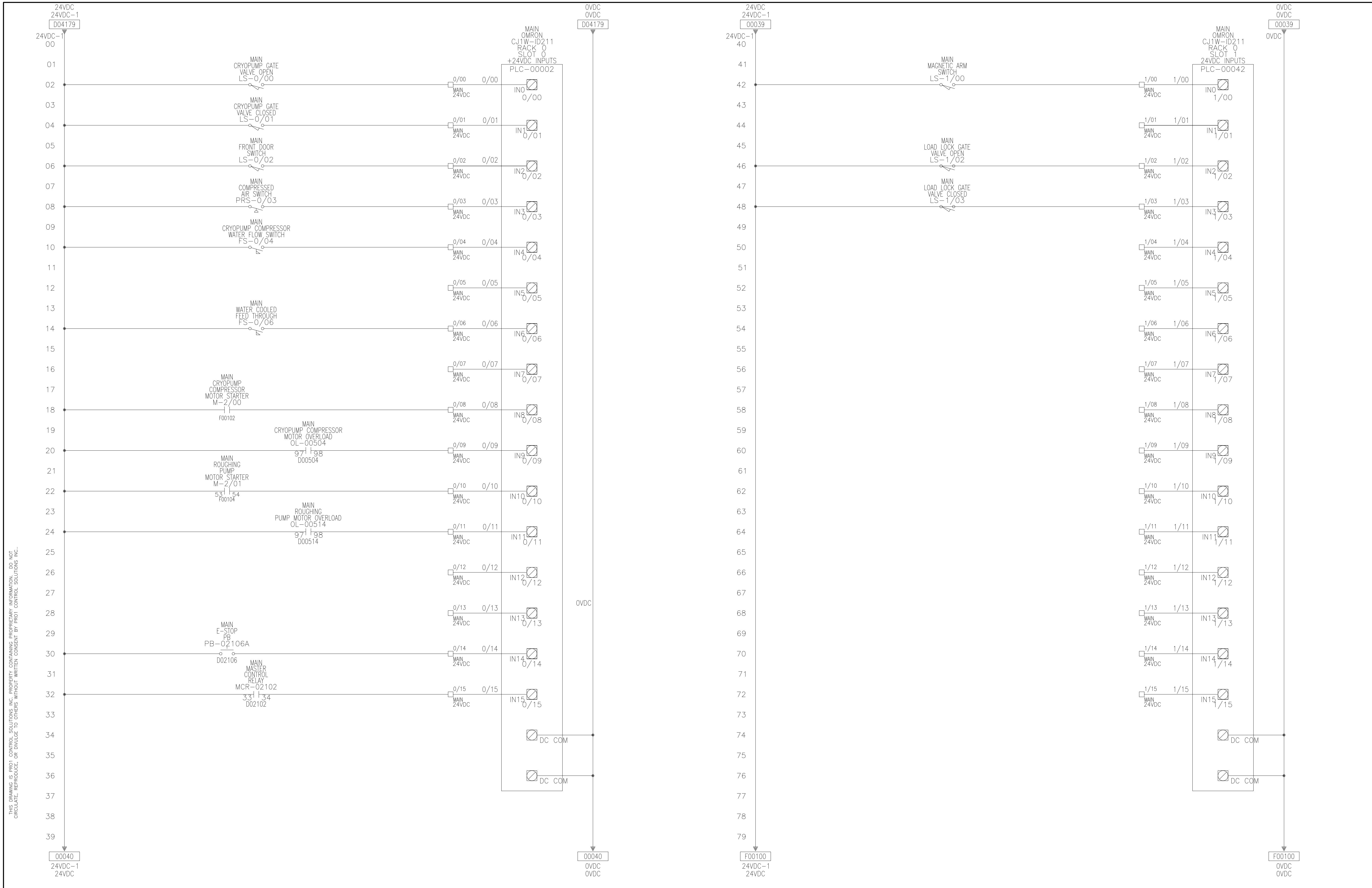

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Angstrom Engineering
00382 ASU Source Deposition System
PLC Rack 0 Slot 0 & 1

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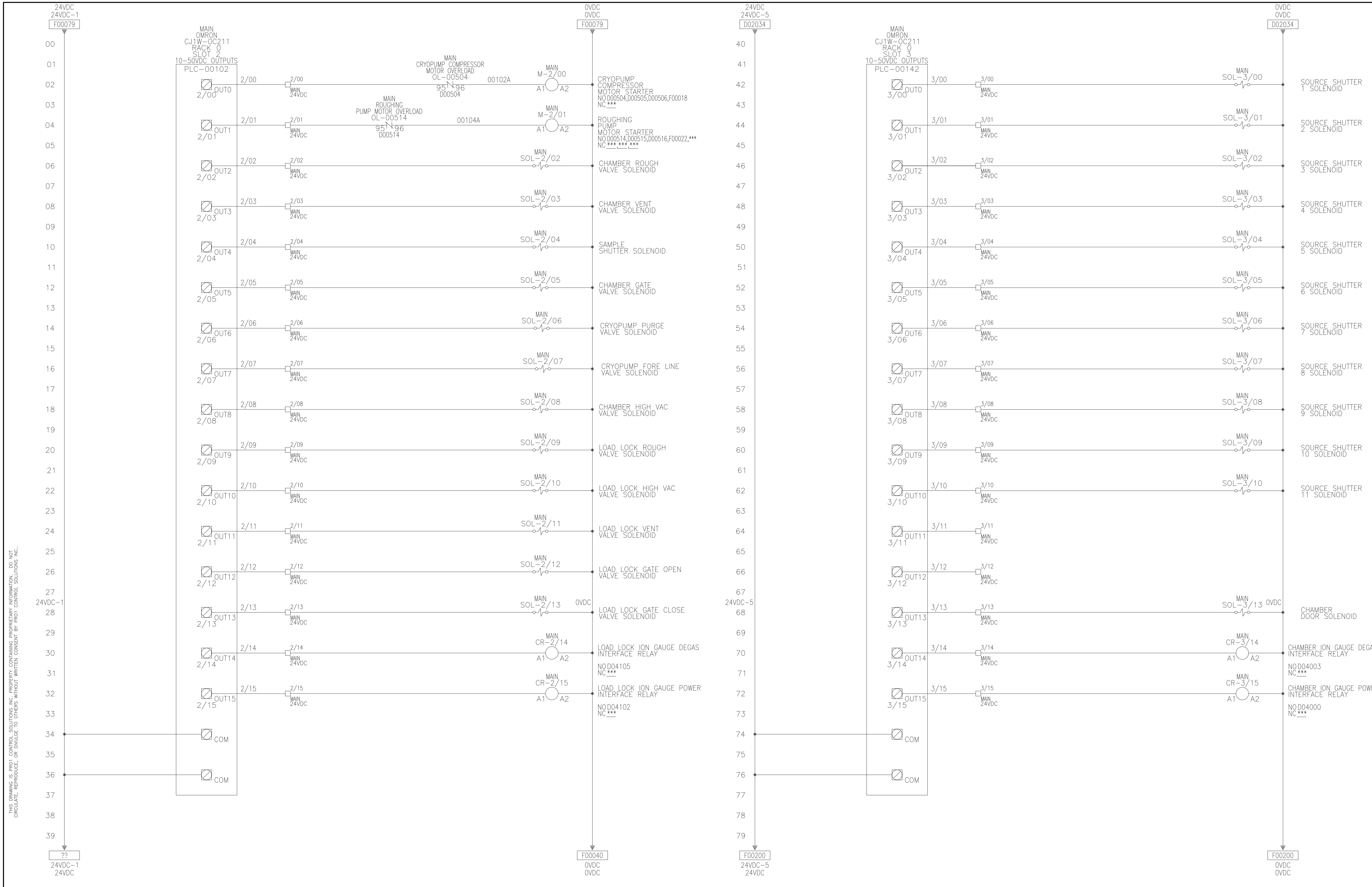

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Angstrom Engineering
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PLC Rack 0 Slot 2 & 3

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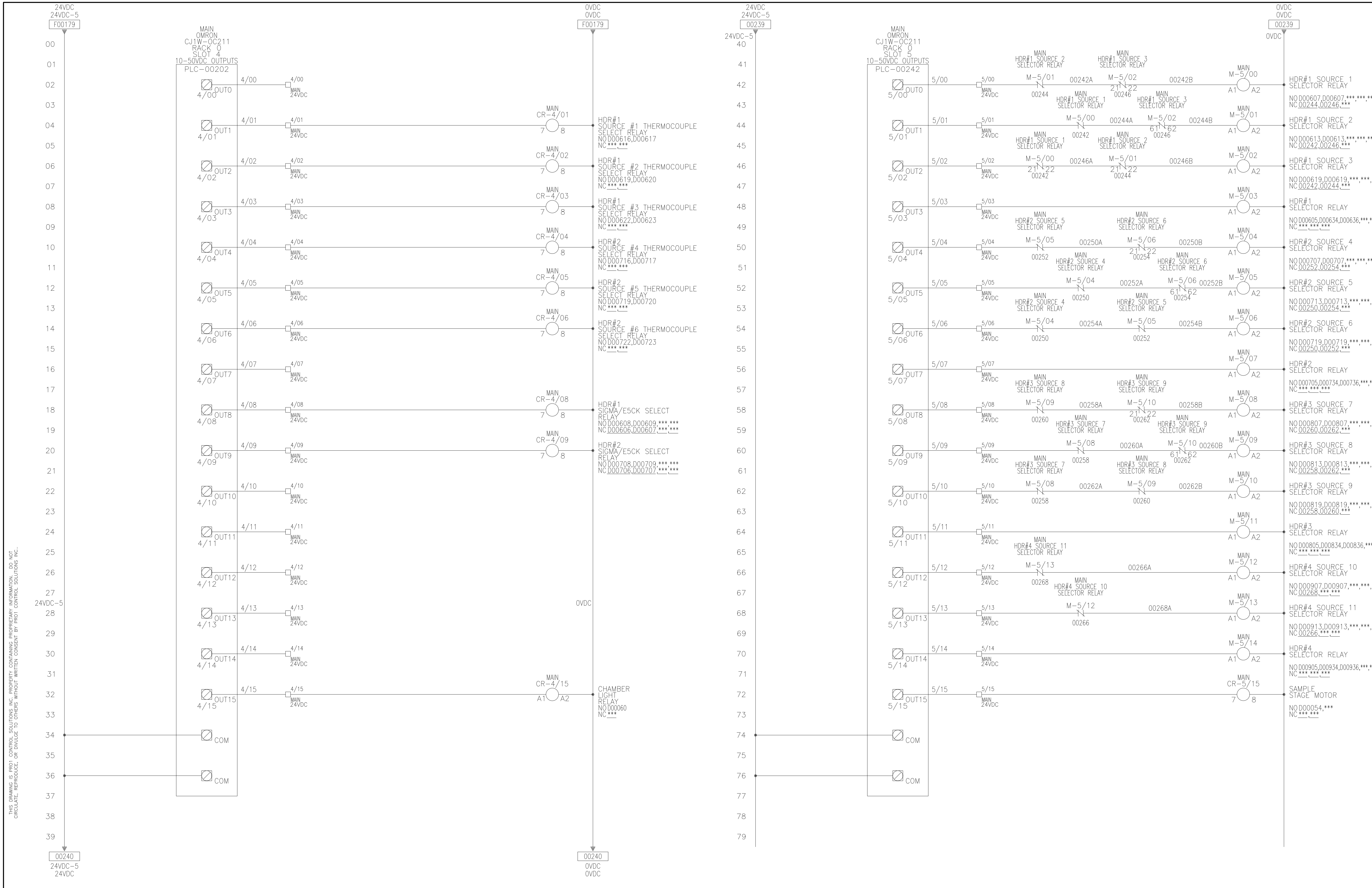

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Angstrom Engineering
00382 ASU Source Deposition System
PLC Rack 0 Slot 4 & 5

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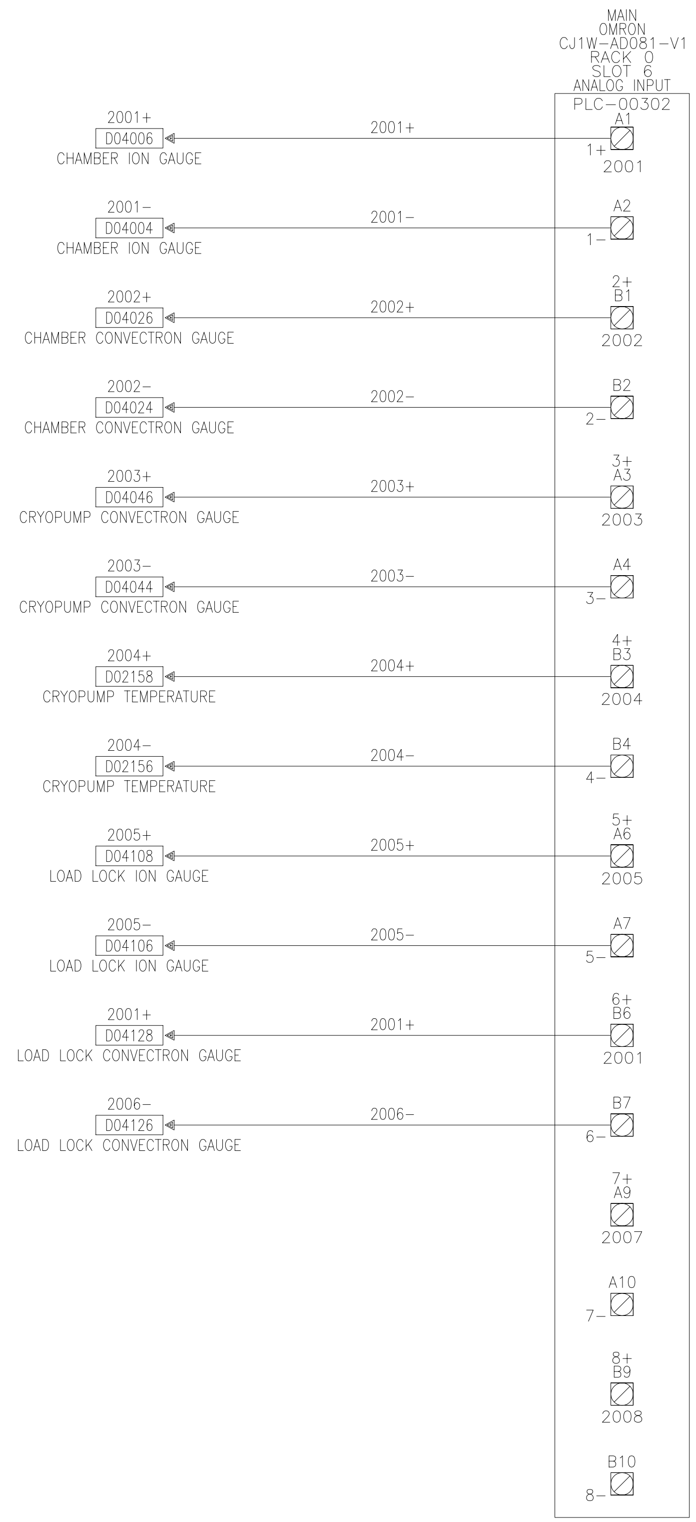

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00382 ASU Source Deposition System
PLC Rack 0 Slot 6 & 7

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Angstrom Engineering
00382 ASU Source Deposition System
PLC Rack 0 Slot 8 & 9

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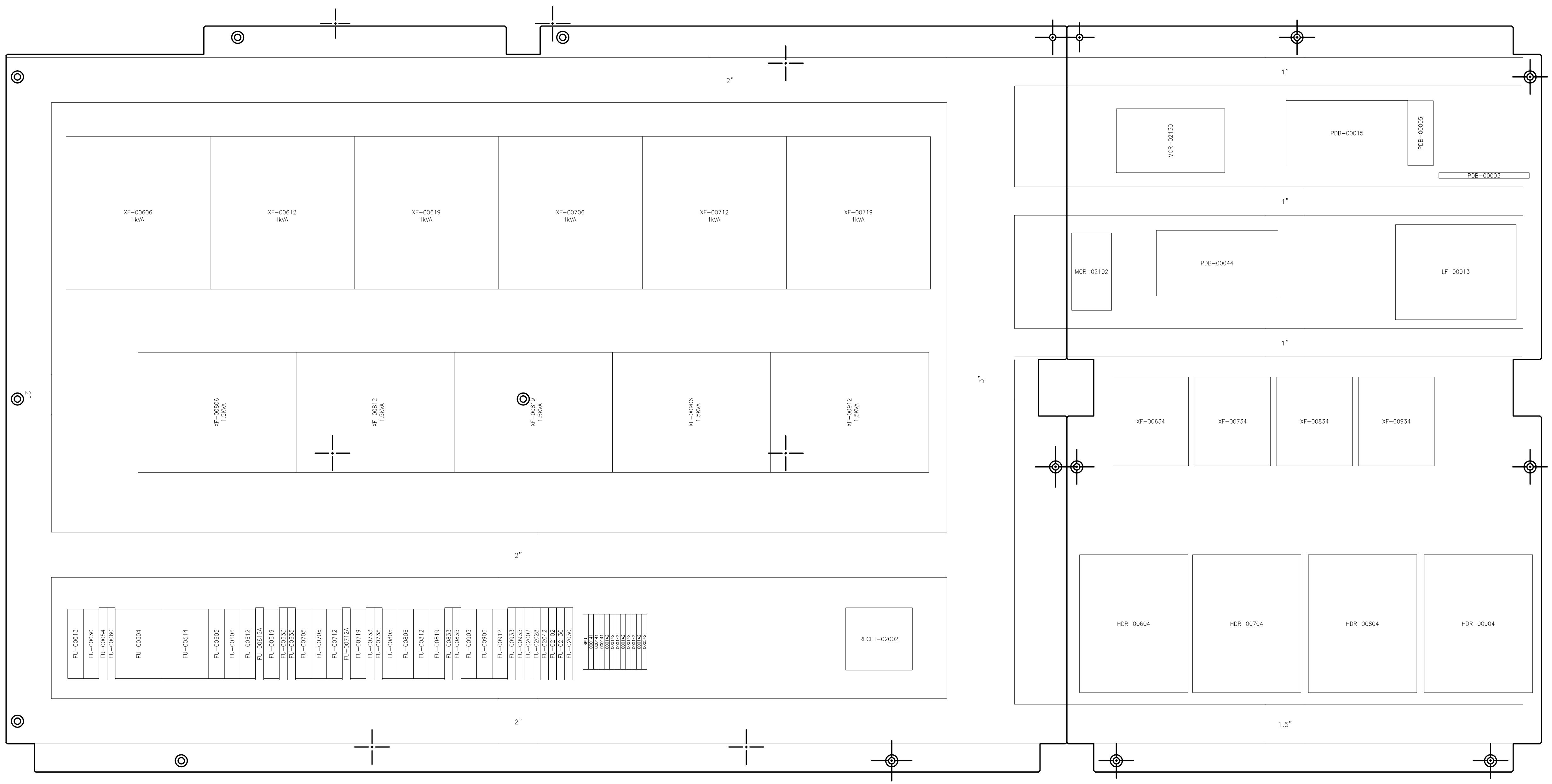

BOTTOM MOUNTING PLATES

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Angstrom Engineering
00382 ASU Source Deposition System
Bottom Mounting Plate

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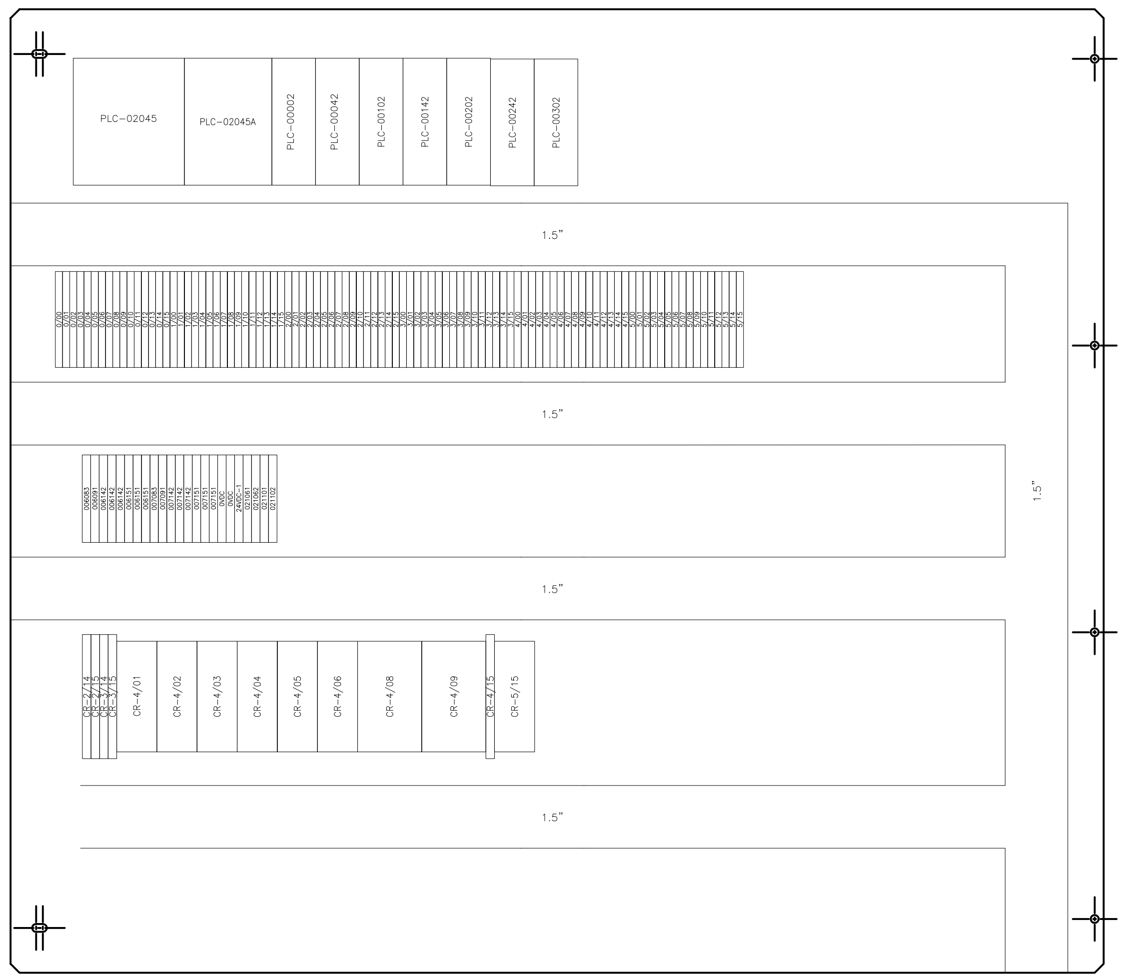
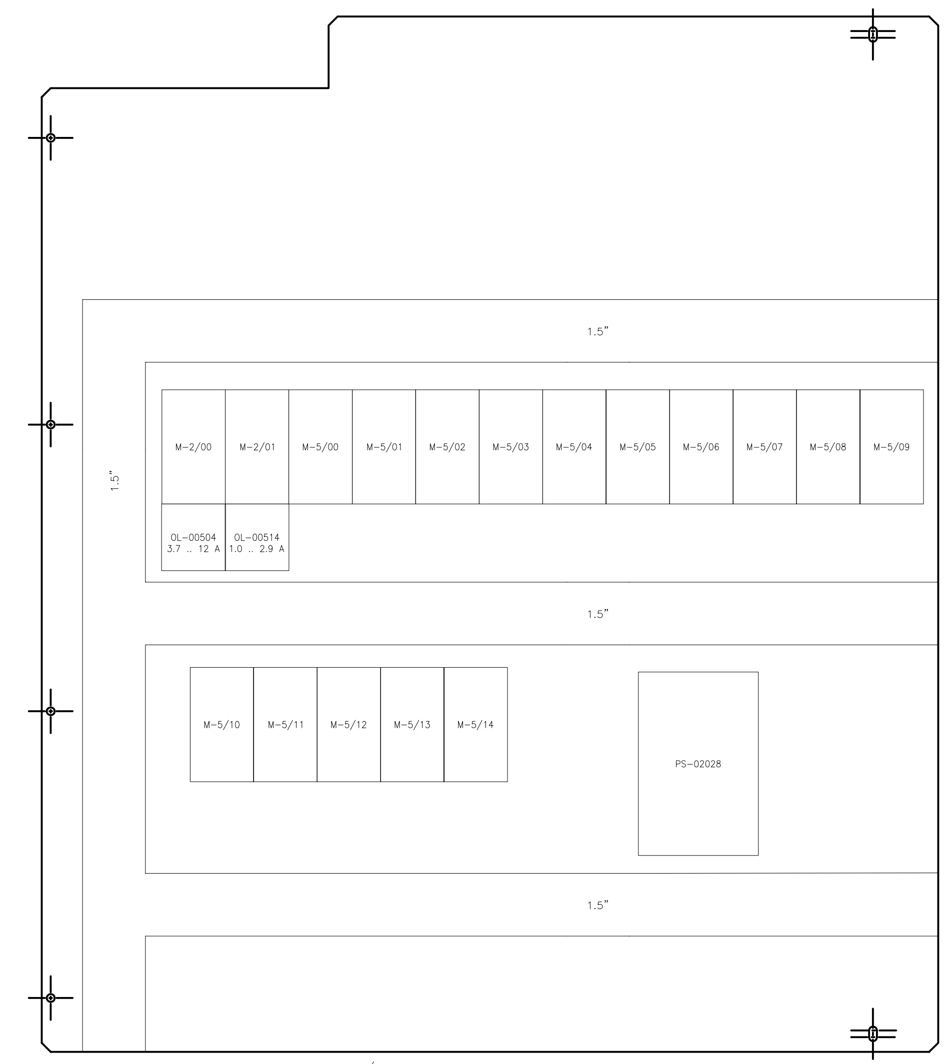


LEFT VERTICAL MOUNTING PLATE



BACK/REAR VERTICAL MOUNTING PLATE

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Angstrom Engineering
00382 ASU Source Deposition System
Vertical Mounting Plate

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APPENDIX

Appendix: Omron E5CK Temperature Controller Settings

Below are the settings that were entered at Angstrom Engineering's facility prior to the shipment of the system. Both of the E5CK's have the same values listed. Refer to the Omron manual for additional information on the parameters listed below.

Level 0 Mode

Setting	Temp Control 1/2
Set Point During SP Ramp	0
Manipulated Variable (MV) Monitor for Heat	0.0
Run / Stop	run

Level 1 Mode

Setting	Temp Control 1/2
AT Execute / Cancel	off
Alarm Value 1	0
Alarm Value 2	0
Proportional Band	auto tune value
Integral Time	auto tune value
Derivative Time	auto tune value
Control Period	20

Auto tune was performed at 250 ^{o}C to determine PID values

Level 2 Mode

Setting	Temp Control 1/2
SP Ramp Time Unit	minutes
SP Ramp Set Value	0
Manipulated Variable (MV) at Stop	0.0
MV at PV Error	0.0
MV Upper Limit	100.0 %
MV Lower Limit	0 %
MV Change Rate Limit	0.0
Input Digital Filter	0
Alarm 1 Hysteresis	0.02
Alarm 2 Hysteresis	0.02
Input Shift Upper Limit	0.0
Input Shift Lower Limit	0.0

Setup Mode

<u>Setting</u>	<u>Temp Control 1/2</u>
Input Type	2
^{o}C / ^{o}F Selection	^{o}C
Parameter Initialize	no
Control Output 1 Assignment	heat
Control Output 2 Assignment	alarm 1
Auxiliary Output 1 Assignment	alarm 2
Alarm 1 Type	2
Alarm 1 Open in Alarm	no
Alarm 2 Type	2
Alarm 2 Open in Alarm	no
Direct / Reverse Operation	reverse (heating)

Expansion Mode

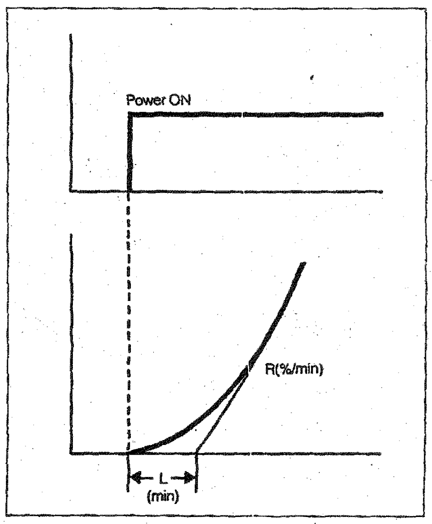
<u>Setting</u>	<u>Temp Control 1/2</u>
SP Setting Upper Limit	800
SP Setting Lower Limit	0
PID / ON / OFF	PID
Adaptive Tuning (Self Tuning)	off
α	0.65
AT Calculated Gain	1.0
Alarm Standby Sequence Reset Method	0
Automatic Return of Display Mode	0
AT Hysteresis	0.2

Step Response Method (by Ziegler Nichols)

To obtain the PID constants by the step response method, observe the following procedure.

1) Establish the heat balance of the controlled system.
2) Manually turn on all heaters and record the characteristics of the control with a recorder.
3) From the response curves recorded by the recorder determine the response speed (R) and the idle time (L).
4) Then the PID constants can be obtained from the following equations.

P = 83RL (%)
I = 2L (min)
D = 0.5L (min)

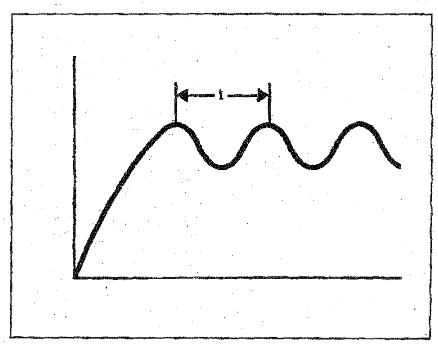


Ultimate Sensitivity Method (by Ziegler Nichols)

To obtain the PID constants by the ultimate response method, observe the following procedure.

1) Test the temperature controller by actually performing only P action with both reset (I) time and rate (D) time set to 0.
2) Operate the control system with the proportional band widened and record the characteristics of the control.
3) Gradually narrow the proportional band and observe the point at which the response being recorded by the recorder begins to vibrate at a fixed cycle.
4) Observe the proportional band and the cycle (t) at which the waveform vibrates.
5) The PID constants can be obtained by the following equations.

P = 1.7PB (%)
I = 0.5t (min)
D = 0.125t (min)

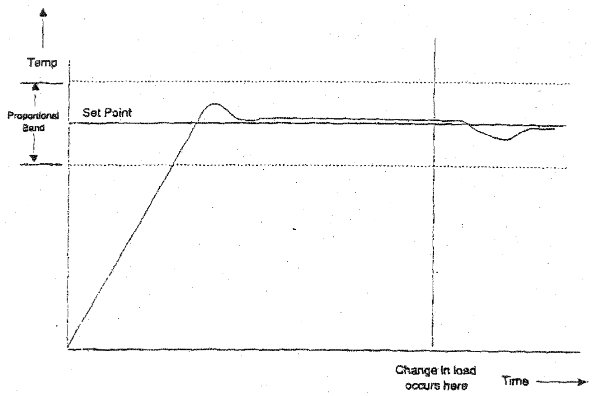


c) <u>Proportional Derivative *(PD)* Control.</u>

The optimum width of the proportional band in its dual role of minimizing overshoot and providing smooth control, is entirely dependant upon the thermal time constants of the system to be controlled.

The addition of the "**derivative**" or "**Rate**" term enables the proportional band to be narrowed, without the otherwise attendant risks of increasing overshoot and hunting. **(See Figure 4).**

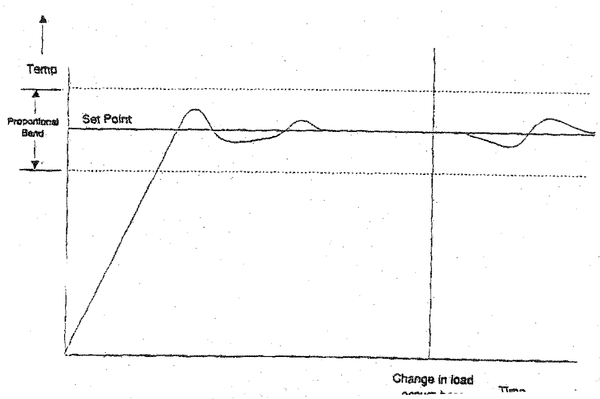
Figure 4



d) <u>Proportional Integral Derivative *(PID)* Control.</u>

The addition of the "**integral**" term means that, providing the thermal time constants of a given system are known and correctly set, the controller will automatically, over a period of minutes, drive out the offset error and control at precisely the temperature which has been set. (This is sometimes known as "**automatic reset"). (See Figure 5).**

Figure 5

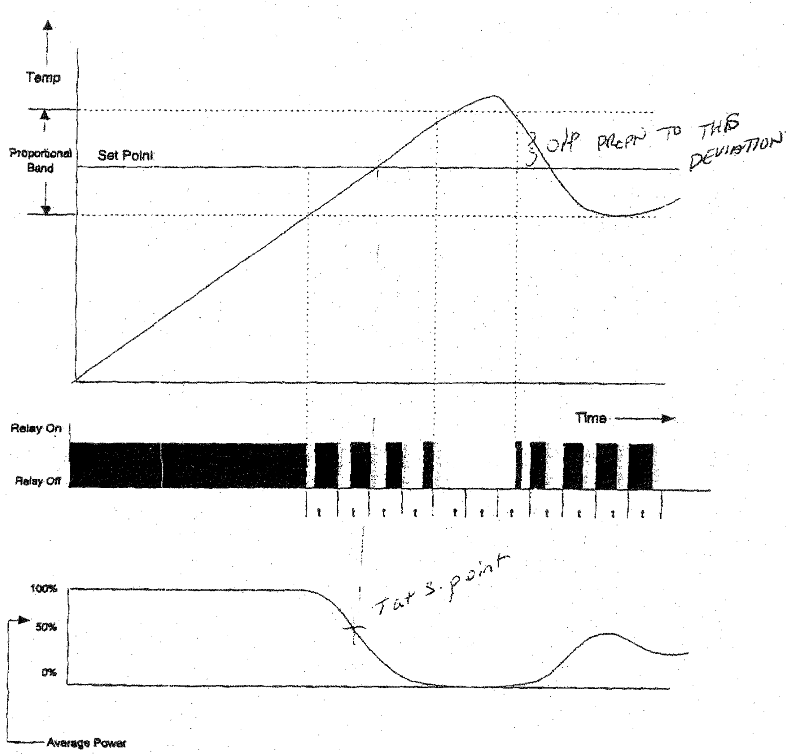


This method is effective where the system time constants are long, compared with the designed switching frequency of the controller.

A typical proportional band may be 20° wide and, until the system temperature reaches the start of this threshold, the controller will allow full (100%) power to pass to the heater by keeping the output relay closed.

As the system temperature enters the "proportional band", the controller output will begin to cycle at a fixed frequency, known as the proportional period, or control period, or duty cycle (typically 20 seconds) with increasingly longer "off" times, until a point is reached where the heat input exactly matches the losses, and the temperature stabilizes. **(See Figure 3b)**.

Figure 3b



On any given system, this point will lie somewhere between the 100% and 0% power requirement, and it is important to note that many manufacturers calibrate their controllers on the assumption that this will represent 50% of the available power. (eg. 10 seconds "on" and 10 seconds "off".

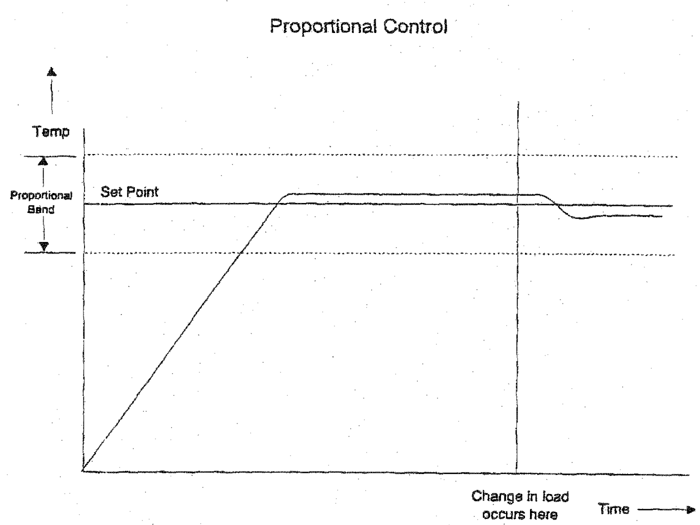
It follows therefore, that if the system requires more, or less, power than 50% in order to maintain its losses, the final settling temperature will be respectively lower, or higher, than the ideal set-point. **(See 3c).**

The difference between the ideal set-point and the actual settling temperature is termed the **"offset"**, and in absolute worst case conditions with a proportional band of 20°, could amount to +/- 10°.

On many instruments, it is possible to tune out this "offset" by means of a **"manual reset"** adjustment. This operation is sometimes referred to as "load matching".

It will be apparent that where a process temperature has to be maintained in both an idling and a running condition, the change in power requirement from one condition to the other will cause a change in offset. For the same reason, so will a change in process temperature because, on any given system, the higher the set temperature, the greater the losses, and more power will be required to maintain the desired temperature.

Figure 3c



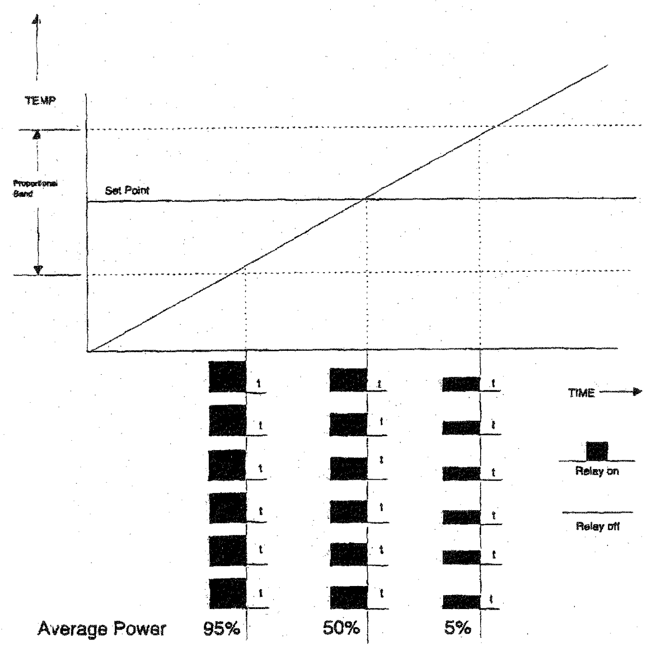
b) <u>Proportional (P) Control.</u>

Where more stable control is required, it is necessary to slow down the rate of rise of temperature when approaching the set-point in order to avoid overshoot; and so by modifying the switching pattern, the peaks and troughs are smoothed out, thus maintaining a stable temperature.

This is achieved by creating levels around the set-point temperature, within which the controller will switch power to the heater by an amount "**proportional**" to the difference (also known as the "error") between the system temperature and the set-point. This is termed the "**proportional band**".

With relay output units, it is possible to regulate the **average** output power to the heater from 100% down to 0%, by modifying the on:off ratio by the appropriate amount. **(See Figure 3a)**

Figure 3a



4. SUMMARY OF CONTROL TYPES.

A) On/Off Control.

Overshoots and continually hunts about the set-point. The amplitude of the oscillation can be restricted by having a small switching differential so long as a fast switching rate can be tolerated, but this is only suitable for processes with long thermal time constants of about ½ °C per minute or greater.

B) Proportional Control.

Virtually eliminates overshoot and gives good, smooth control, but the process temperature may settle 1% or 2% above or below the set-point due to offset, and take longer to reach it. The offset will change if the conditions alter.

C) Proportion + Derivative Control.

As for proportional control, but the possible offset and changes in offset due to external disturbances will be much reduced.

D) Proportional + Integral + Derivative Control.

May give large overshoot on warm-up from cold. Smooth control. Offset, or changes in offset, will be gradually corrected.

5. CHANGING PARAMETERS.

a) Altering the Proportional Band

A wide proportional band has the advantage that the heat output is controlled sooner, thus reducing the risk of overshoot; but the major disadvantage of a wide proportional band is an increased offset, along with a slower response. The attendant risk of a narrow proportional band is that of increased overshoot and possible hunting.

b) Altering the Derivative Term

Decreasing the derivative time will increase the speed that the controller responds to a rapid change of temperature. If too short a time is entered, then the controller will overshoot the set-point and hunt.

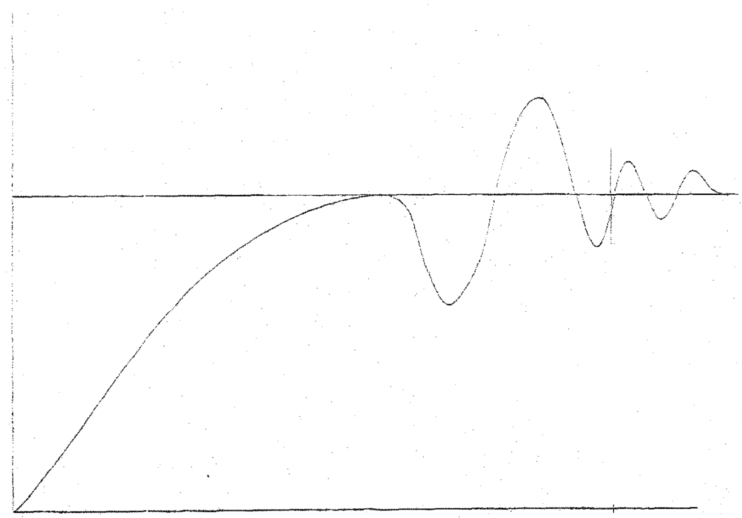
c) Altering the Integral Term

The integral term is the time required to change the temperature from the offset to the set-point. Therefore, a shorter integral time would result in a more intense control. Making the term too short would result in hunting. Making the term longer slows the response.

d) Altering the Proportioning Period (Duty Cycle)

Generally, a shorter duty cycle gives tighter temperature control, but reduces the life of the output relay. Below about 2 seconds duty cycle, solid state switching should be used.

D) Overshoot after temperature change.



Countermeasures:-

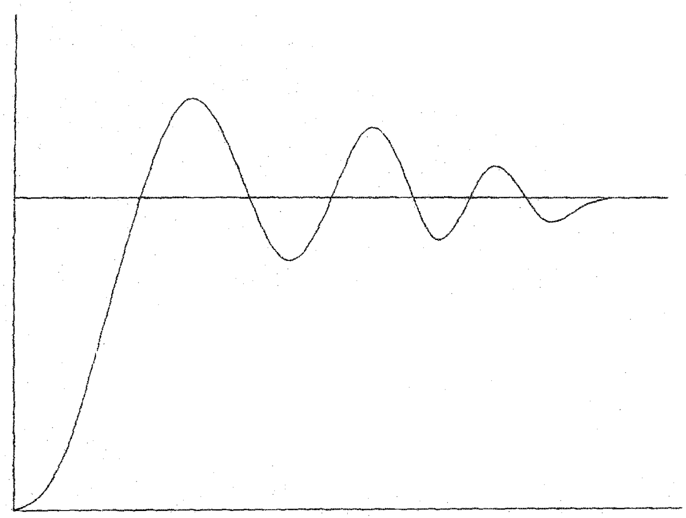
Increase the "P" band

Reduce the "D" time

Increase the "I" time

8. TYPICAL SCENARIOS.

A) Overshoot at start-up.



Countermeasures:-

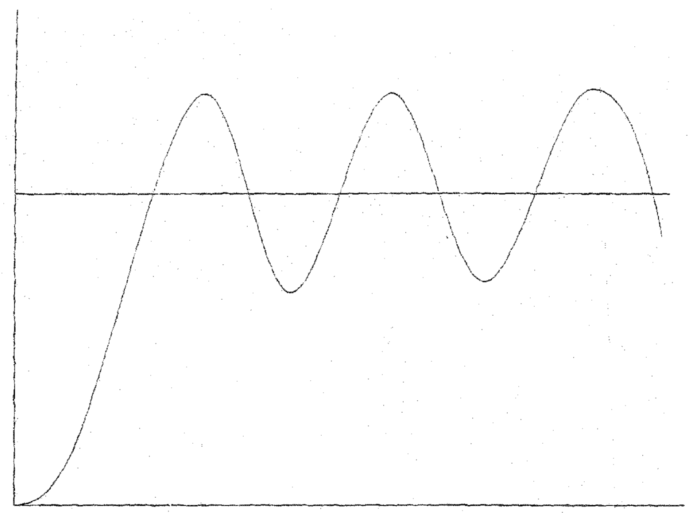
Increase the "P" band

Increase the "D" time

Increase the "I" time

Reduce the "ARW" value

B) Hunting.



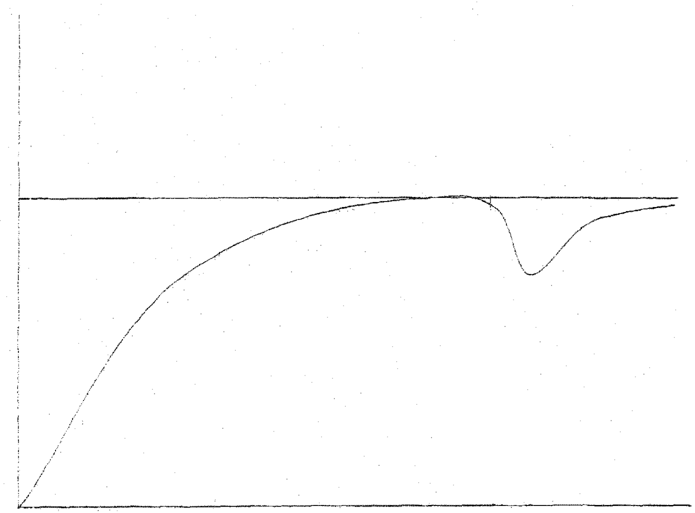
Countermeasures:-

Increase the "P" band

Reduce the "D" time

Increase the "I" time

C) Slow response to temperature change.



Countermeasures:-

Reduce the "P" band

Increase the "D" time

Reduce the "I" time

The inclusion of the integral term may actually increase the possibility of overshoot during initial warm-up, and most manufacturers offer additional circuitry known as **anti-reset-windup** to minimize this problem by decreasing the integral term by a set amount until the temperature passes through the set-point for the first time, then allowing the full value of the integral term to be applied.

With controllers of this degree of complexity, it was usual to consult the manufacturers before installation, as an incorrectly adjusted controller, not matched to the system, may give poor control. Nowadays, most PID controllers offer automatic tuning of parameters.

PID TUNING

When tuning the PID on your system, at times the values that you are entering may seem very high but below you will see the reason for this.

First it is important to determine what output voltage setting you will be running your system at. If you will be running the system with a 0-10V full-scale voltage then you will be using P values that seem normal 35-100. However, if you are going to be running the system with a limited voltage such as 5 or even 2.5 there is one thing to remember. For each factor that you decrease the output voltage you have to multiply the PID by that same factor. For example if you were running 35 for a P value at 10V you will now be running 70 for a P value at 5V.

When setting the PID up on your system you do not have to go through the long process for each material. If you select a material that you know runs like most other organics or metals then you can tune for that material and then you will have the ball park values for tuning of the other materials.

PID is most difficult to set up with these evaporative systems because of the delay that occurs due to the way that the systems work. As power is applied the response in temperature is not instantaneous as the boat and material has to physically heat up. In the same manor it will not cool instantly either. With this in mind you have to remember that there will be a minimum 5-20 second delay in response depending on the size of boat and amount of material used.

For the above reason a material that requires higher power to run is easier to tune the PID for. This is because the source will be running a lot hotter and therefore will respond to change a lot faster as the temperature changes will be greater with each power change either up or down. Generally materials such as Aluminum and Lithium Fluoride will use a higher P value and a lower I value.

PID will not always react the way that you think it will. This means that dropping the I term by one will sometimes quicken the response but other times it may make the response slower. This is because the P and the I work together. The P determines how much drive the source will have and the I determines how fast it will allow the P to react and drive. In essence the I works to slow down the P. Remember that simply removing P to limit overshoot may not work as it may not have enough drive to push the power back down in this situation. You have to remember that the P not only drives the power up but also has to drive the power back down.

Setting up PID is a trial and error process. There are no values that will work all of the time for every material and every system. The following pointers are designed to be a set of guidelines to follow to help you to narrow down the settings faster and with a minimal waste of material.

If possible try to do the PID tuning when you will have few or no interruptions as you can get into the PID train of thought and go with it until it has been set up.

As a general rule setup tuning of PID values could take around 4 hours and about 25 runs for the first material if starting with unknown values.

Below are the steps and thoughts that have been found useful in setting up PID on a system. The values that were arrived at may work very well on your own system and it is Angstrom Engineering's advice that you try them before changing any variables.

The following values were used successfully with Organic materials, including TPD, NPB and ALQ3.

These steps are required when starting a run from 0 with no pre-condition. Although it is not Angstrom Engineering's recommendation to do this, these steps should help you to tune the PID to allow you to do so.

"*Angstrom Engineering recommends that for the best system function you should pre-condition your runs so that you come in to the deposit phase on or near the desired rate*".

A precondition with zero for the time and a power of just below the required power to start the material depositing would help with the initial dead band when the system is just ramping up the power.

However, initially tuning PID to work from a zero start will ensure that your system will respond very quickly and accurately when running with a pre-condition in later runs.

<u>Step 1:</u>Select a source and fill the boat so that you will be confident that you will not run out of material during this setup. In setting up PID you may go through thousands of Angstroms of material before you get it right. (If you have some older material that you are not planning on using for devices now would be a good time to use it.)

<u>Step 2:</u> Set your ramp times and percent powers to 0 and also turn off the Shutter delay. This will ensure that you will be starting your run in deposition mode. Also set your final thickness to a high number so that SIGMA will not end the run before you have seen the results of your tuning. Set your rate for the rate that you will normally run the material. This is not critical but you may see more overshoot if you tune the PID for a rate of 1A/s and then run it at 3A/s. This is because the Drive will be a lot further to get it to the desired rate. (Note: it is not necessary to watch a whole run when tuning your PID settings as after a couple of oscillations you will be able to see a pattern and get an idea of what setting you want to try next.)

<u>Step 3:</u> If you are using new material (One that has not been melted or heated to deposition yet) you should do a run in manual first to deposit at least 200 Angstroms so that you can be sure that the material will react nicely to the PID control. (Note: Once

you have the PID set up this will not be necessary every time you change materials. However, with unused material you may see more overshoot on your first PID controlled run)

Step 4: If you are comfortable with trying the values that have been determined before on another customers system then put in *P 400, I 12 and D 0 with a power output voltage of 2.5*. Remember that if you are running at 5V output power it will be 200, 6, 0 and at 10V output power it is 100, 3, 0. Then start the run and watch to see what happens.

a) Initially you should see the power climb rather quickly as the amount of deviation from the setpoint is very big.
b) It will start to deposit within 20 – 50 seconds. When this happens it will appear to be shooting up way to fast. However, if you watch the power should be drastically dropping. It will overshoot, but should not deviate from the setpoint by more than 50 – 60%. (It will shoot up a lot faster than it falls back down.)
c) Once this initial overshoot starts to happen you should now see the output power dropping very quickly as the deviation from the setpoint is now getting smaller. It may even drop to 0.
d) With this drop you will see the rate start to fall.
e) As the rate gets closer to the desired rate you will now see the power start to rise as it is getting closer to the rate again.
f) You should have no undershoot and the rate should now be stable.
g) This whole process should take about 50 – 80 seconds from the time you hit start to the time it is stable.

Step 5: If this run has been satisfactory then you now have to try it on your other sources and see how it reacts.

Possible Results:

Changing any of the values in these PID settings may make the source run differently than is outlined here. If a change does not do what the possible result said it would then refer to other possible results to determine what type of change may now be required.

1 – If you did the run and you saw that it took more than 1 oscillation to level off then you will have to increase both the P and the I. If you started with P 200 and I 5 then try P250 and I 5. See what this does and then determine whether it was better or worse. If it was worse then try increasing only the I and leaving the P this will tell you which direction you should take in the remaining setup runs.

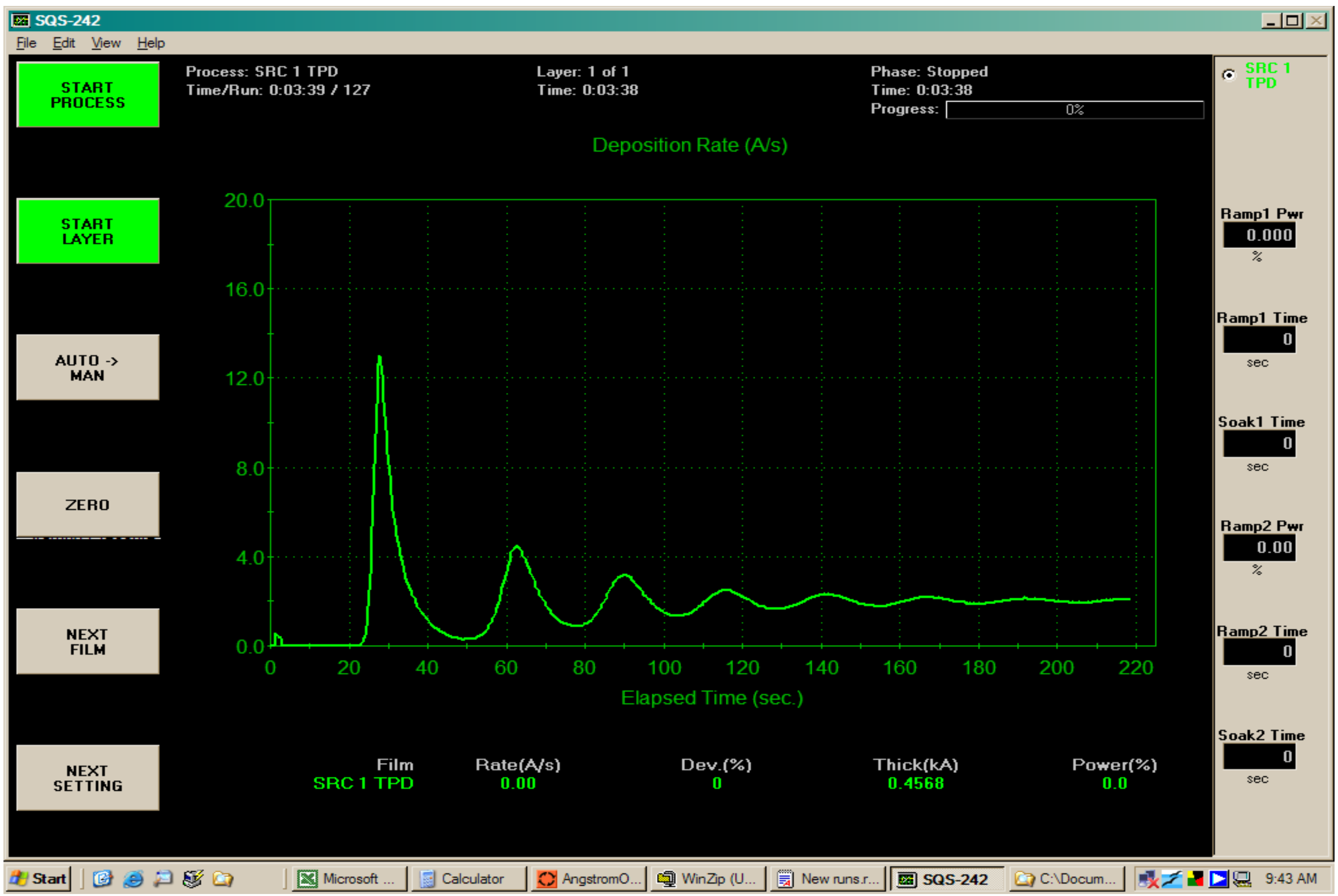
Below is a run that was done that yielded typical results and the values that were used.

TPD in Source location 1 Test run

This is a run to see if the PID can control the source from a 0 start. With no ramp or soak.

Starting Pressure 5.2x10-8

Sensor 1 only used
Z-stage at 0"
Tooling factor 27.2 (chart)
Source to substrate distance 10.104" (chart)
Ran in auto
PID 200,5, 0
All output voltages are at 2.5.
Period 0.5 and filter 3
Angstrom Thurs Test 1 SRC1 TPD.log
Ran at 2Å/s /500Å
Pressure at the end of the run was 6.8 x10-7

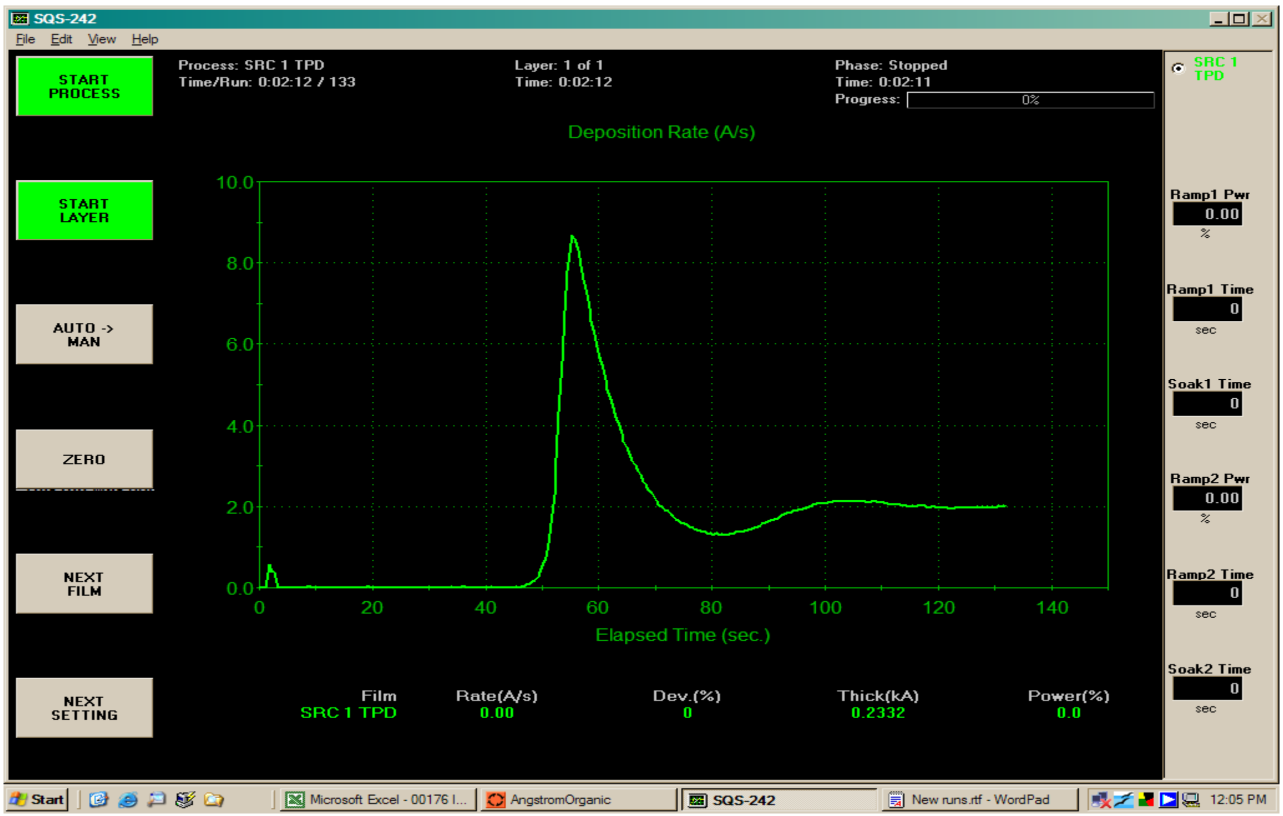


2 - If you did the run and you saw that the power rose at a good speed but the overshoot was more than 50 or 60% and then it fell back down quickly but also had some undershoot and then leveled off this means that the P is allowed to drive the power too hard. You should leave the P and raise the I. You could try raising I from 5 to 6. Then do the run again and see if you have fixed the overshoot. If it does the same thing but to less of an extent then try raising the I again. Note that raising the I may result in the system being too slow. If this occurs then the P will have to be raised to compensate.

<u>TPD in Source location 1 Test run</u>

This is a run to see if the PID can control the source from a 0 start. With no ramp or soak.

Starting Pressure 5.7x10-8
Sensor 1 only used
Z-stage at 0"
Tooling factor 27.2 (chart)
Source to substrate distance 10.104" (chart)
Ran in auto
PID 300,12, 0
Output voltage is set to 2.5
Period 0.5 and filter 3
Angstrom Test 1 SRC1 new wire TPD.log
Ran at 2Å/s /500Å



3 – If you ran it and the power rose very slowly and then overshot more than 50 – 60% and then took a long time to level out (i.e. The power didn't fall very quickly or at all) but did not undershoot then you have to lower the I. This is because you are allowing the P to drive it hard but are also not allowing the I to react fast enough for it to realize that it is above the setpoint. In this case you could start with an I value of 10. Do the run again and see if it is fixed. If it now rises quickly and then overshoots the right amount and then has no undershoot and then levels off nicely but seems to take a long time to start to deposit and also get back to the required rate then you should try lowering the I more and see if it gets faster. Lower it only 1 at a time as changing the I term can make the system very

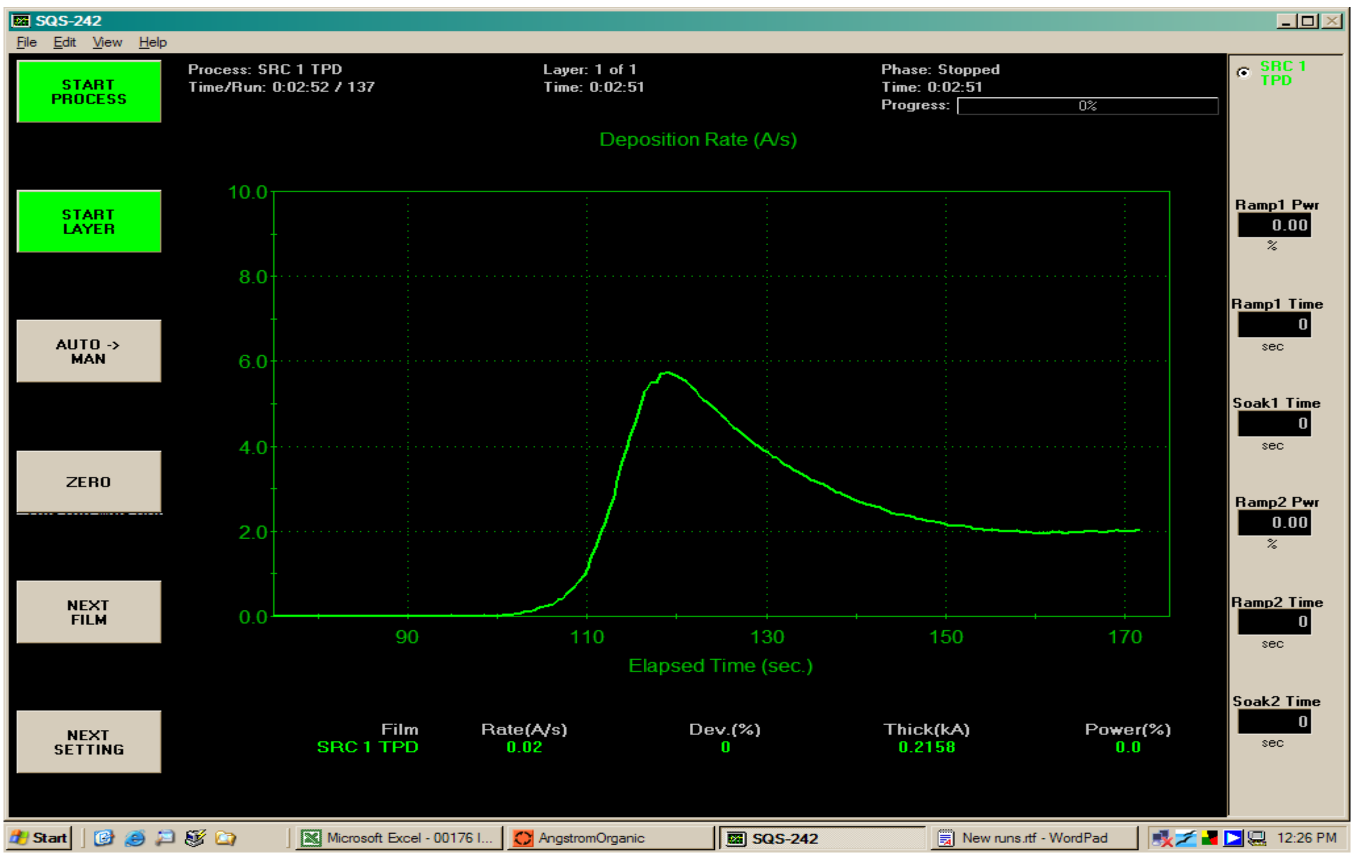
unstable. If lowering the I stops making a positive difference then try leaving the I as it is and increasing the P by 25 at a time. This will allow you to see a change right away.

Run 10 - TPD in Source location 1 Test run

This is a run to see if the PID can control the source from a 0 start. With no ramp or soak.

Starting Pressure 6.4x10-8
Sensor 1 only used
Z-stage at 0"
Tooling factor 27.2 (chart)
Source to substrate distance 10.104" (chart)
Ran in auto
PID 300,10, 0
Output voltage is set to 2.5
Period 0.5 and filter 3
Angstrom Test 1 SRC1 new wire TPD.log
Ran at 2Å/s /500Å

It got slower but the I was too high so it was too slow to react on the way up.



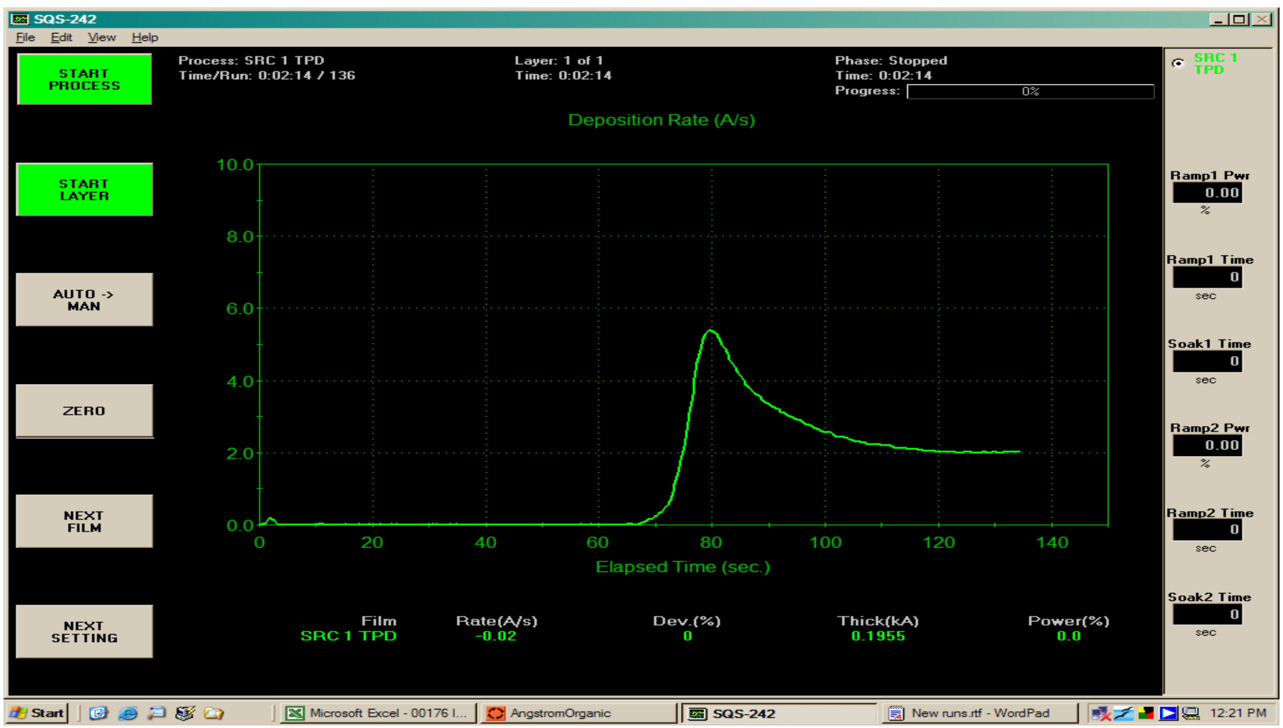
4 – If the power rose at a good speed and then the rate overshot more than 50-60% and then came back down at a good speed then your I value is most likely very close to being right. You then have to increase the P value to drive the system both up and down faster to reduce the overshoot.

TPD in Source location 1 Test run

This is a run to see if the PID can control the source from a 0 start. With no ramp or soak.

Starting Pressure 7.8x10-8
Sensor 1 only used
Z-stage at 0"
Tooling factor 27.2 (chart)
Source to substrate distance 10.104" (chart)
Ran in auto
PID 345,12, 0
Output voltage is set to 2.5
Period 0.5 and filter 3
Angstrom Test 1 SRC1 new wire TPD.log
Ran at 2Å/s /500Å

Less overshoot because the I is controlling it. The I slows it down but you still need the P to drive it.

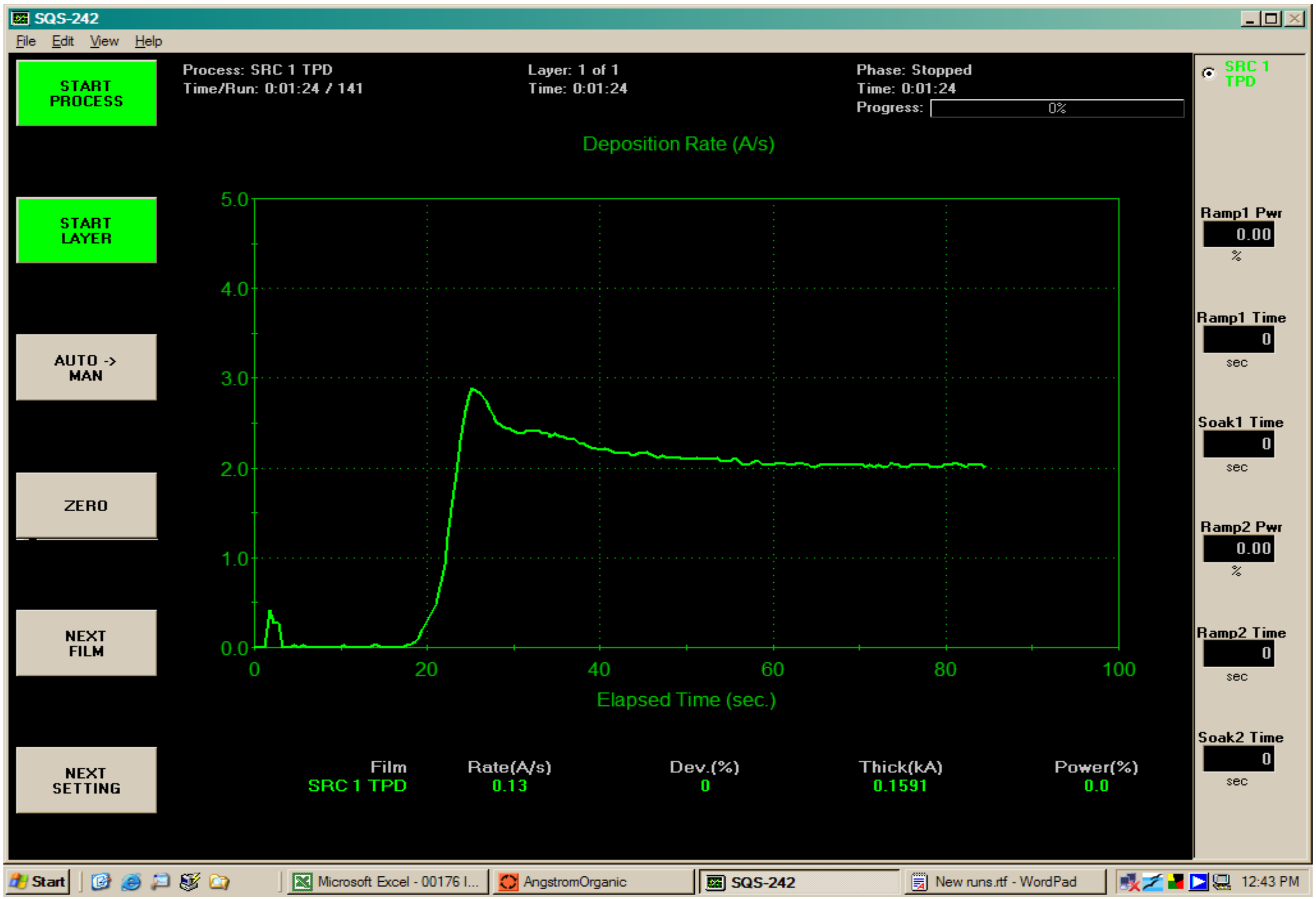


TPD in Source location 1 Test run

This is a run to see if the PID can control the source from a 0 start. With no ramp or soak.

Starting Pressure 7.8x10-8
Sensor 1 only used
Z-stage at 0"
Tooling factor 27.2 (chart)
Source to substrate distance 10.104" (chart)
Ran in auto
PID 400,12, 0
Output voltage is set to 2.5
Period 0.5 and filter 3
Angstrom Test 1 SRC1 new wire TPD.log
Ran at 2Å/s /500Å

Less overshoot because the I is controlling it. The I slows it down but you still need the P to drive it.



Tuning the system to run a new material with predetermined PID values

The following runs were carried out after an initial set of PID values had been determined for another material in the same system. It should be noted that these same values are also used on another system created by Angstrom Engineering and yield the same results as seen here.

Note that comments made about each run will be made in Italic at the bottom of the picture as it will be easier to decipher comments made while doing the runs from the new comments this way.

If you are looking for a completely stable run once Sigma hits deposit phase you can run with a longer shutter delay and make the deviation smaller. For example if you made the shutter delay 120 seconds and the percent deviation 1% then you would be able to have the shutter open only after the deposition rate is completely stable. These tests were run with shutter delay and pre-condition. If you wanted to set the new PID to work as above you would just remove the delay and pre-condition and adjust from there.

Run: Src1 Chamber 1 CBP

Manual run to determine starting points etc.
%Power level to start deposition: 24%
%Power level to maintain rate: 20%

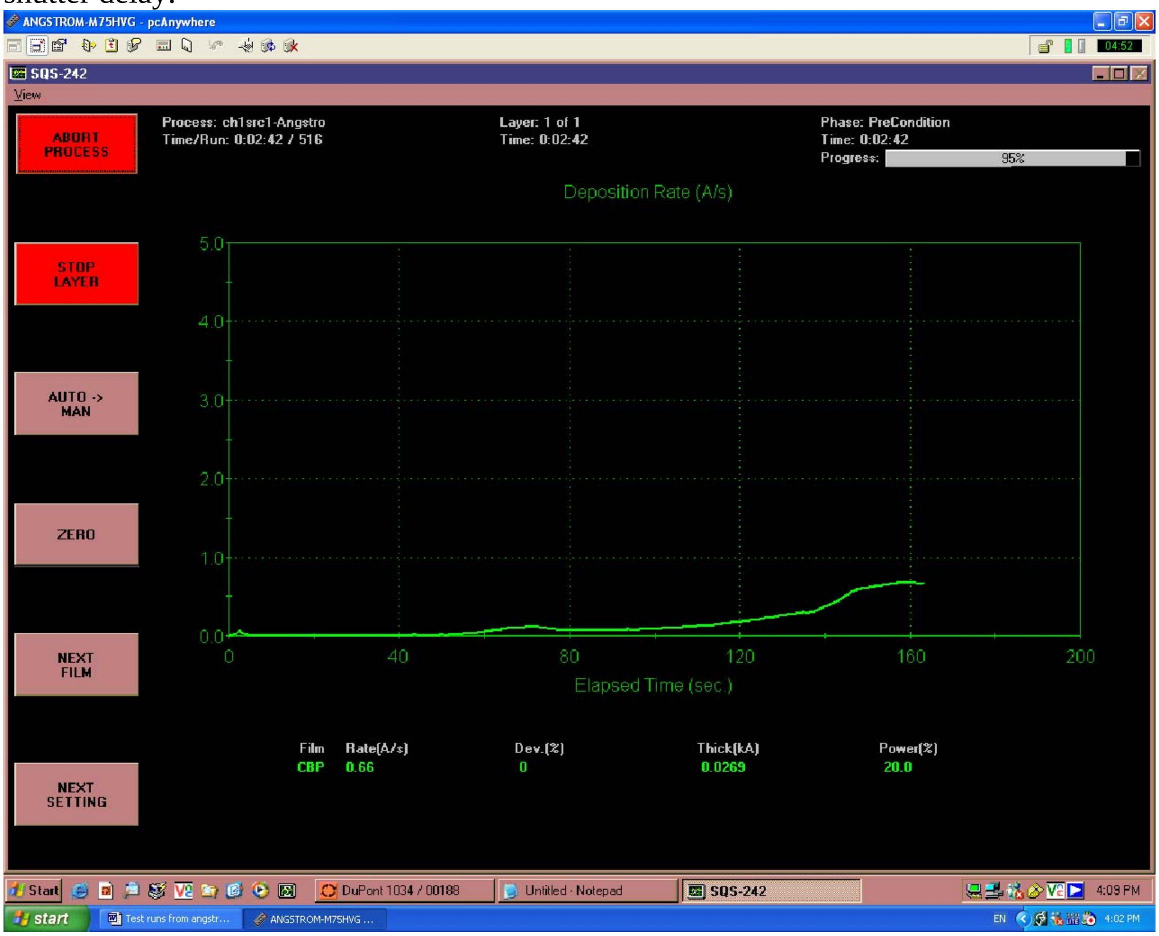
Manual run carried out to determine starting/-running power for the material & source. The above figures obtained will be put into the precondition for the first fully auto PID run carried out with this material. All the other control settings etc will be left the same as the source 2 material ran previously.

This run also serves to pre-melt the material and also allow it to outgas so that it will not run erratically while tuning the PID. If the PID values have already been determined this step could be skipped but it should be remembered that the first run of a new material would not run smoothly or as expected.

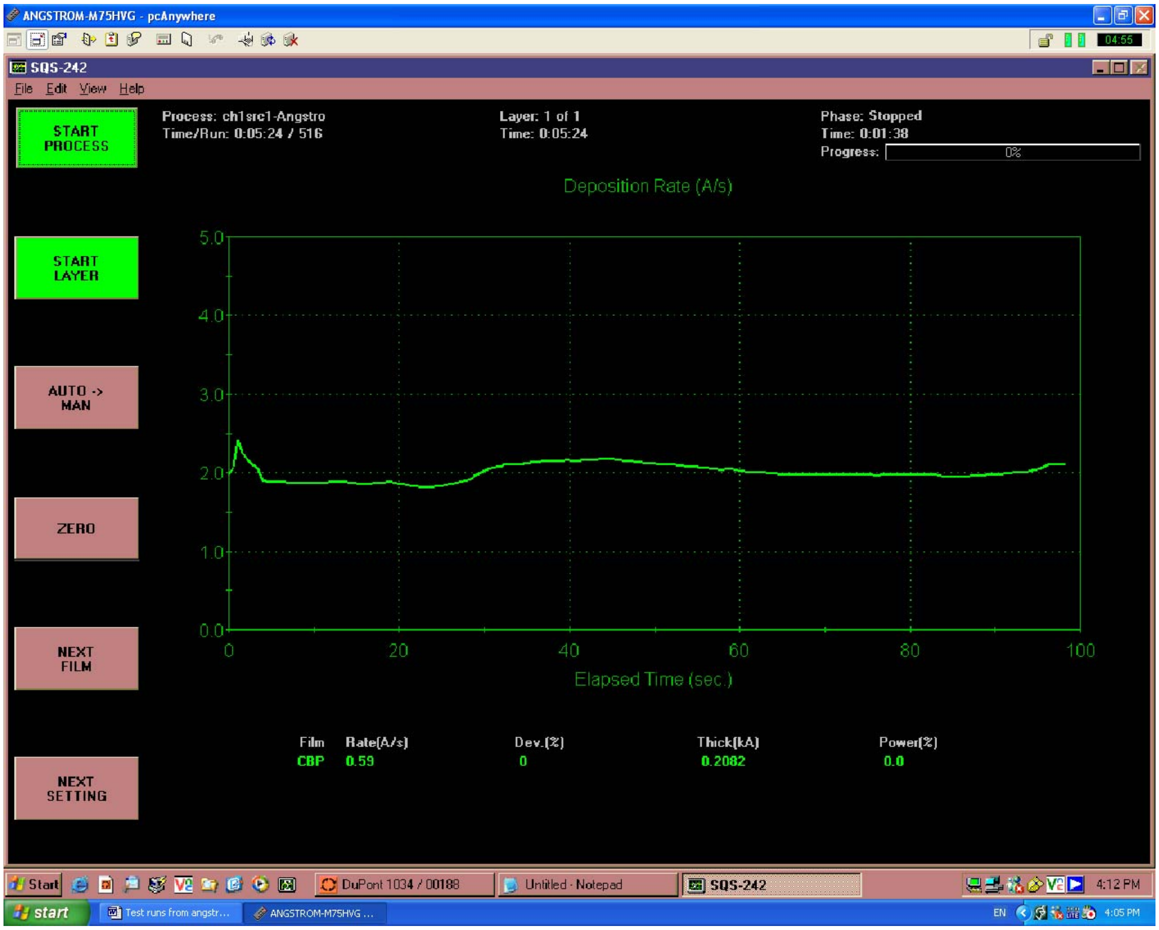
Run: Src1 Chamber 1 CBP

Rate: 2.0A/s
PID values: 400, 12, 0
Period and Filter: 0.5, 6.00
Output voltage: 5V
Preconditioned at: ramp 1 24% for 60sec and ramp 2 20% for 100sec
2% shutter delay
Lower sensor used: Lower Sensor #4

First run precondition – it came in a little low before shutter delay but recovered during shutter delay.



Here you can see that the pre-condition is finished and the rate is still over 1Angstrom from where it is supposed to be. This can be fixed by adjusting the precondition values.

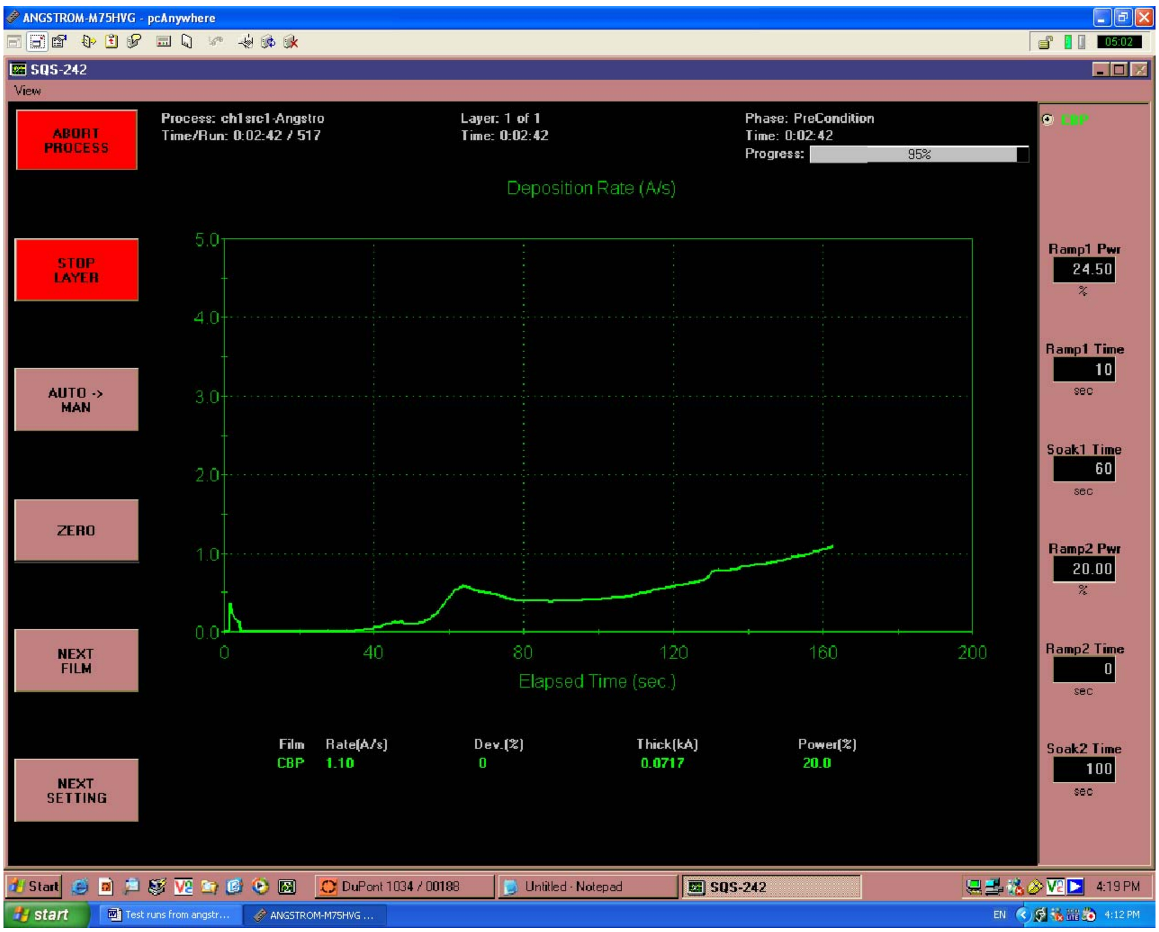


You can also see here that although the precondition did not bring the rate up to the desired rate the shutter delay was able to do so with no trouble and when the shutter was opened after shutter delay was successful the substrate was exposed to a relatively steady rate.

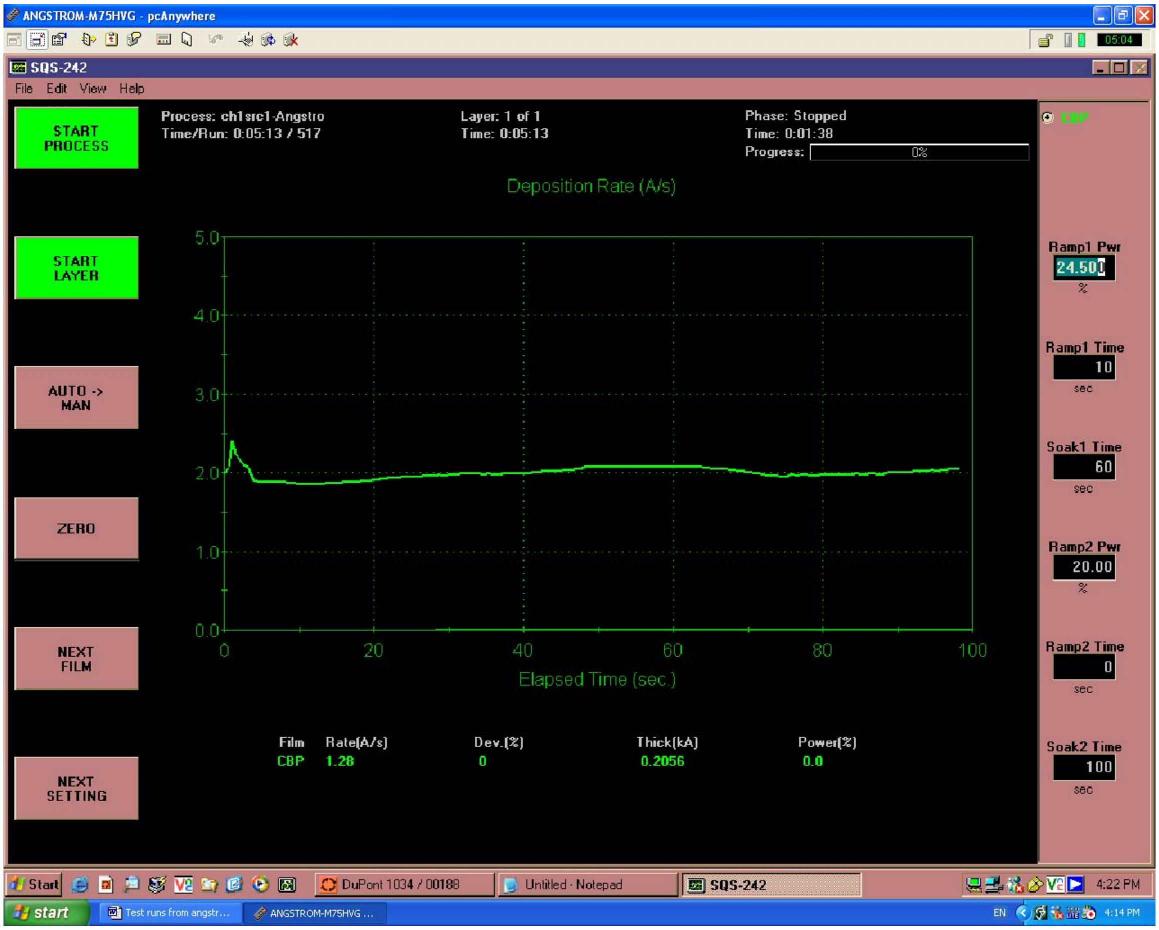
Run: Src1 Chamber 1 CBP

Rate: 2.0A/s
PID values: 350, 12, 0
Period and Filter: 0.5, 6.00
Output voltage: 5V
Preconditioned at: ramp 1 24.5% for 60sec and ramp 2 20% for 100sec
2% shutter delay
Lower sensor used: Lower Sensor #4

Precondition first ramp power changed from 24 – 24.5%. and P value reduced to 350



The rate went into shutter delay a little lower than half the desired rate. Control was good after shutter delay

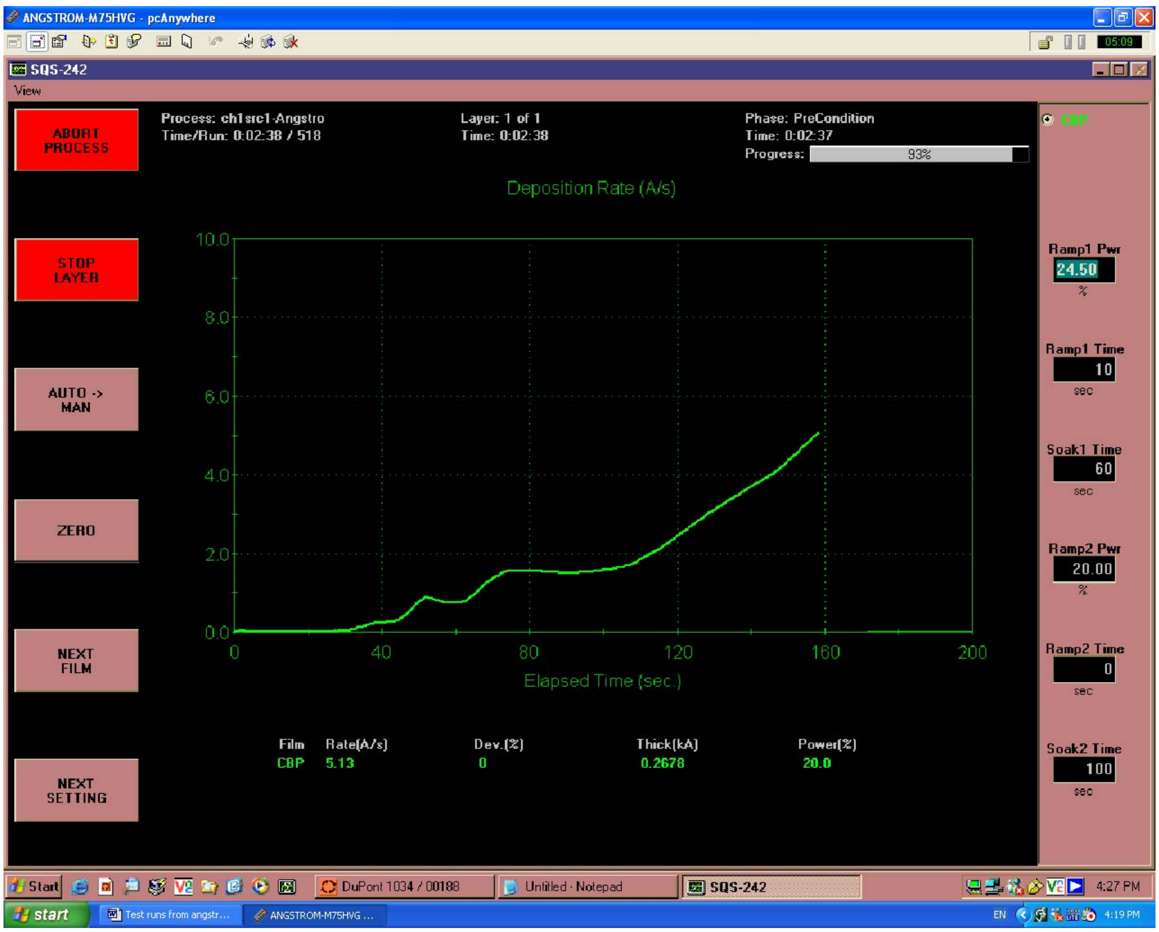


With a lower P term here you can see that the oscillation when it comes out of shutter delay is lessened. This is because when the PID has to work in a tighter range you do not want it to drive so hard. To limit the drive you lower the P term.

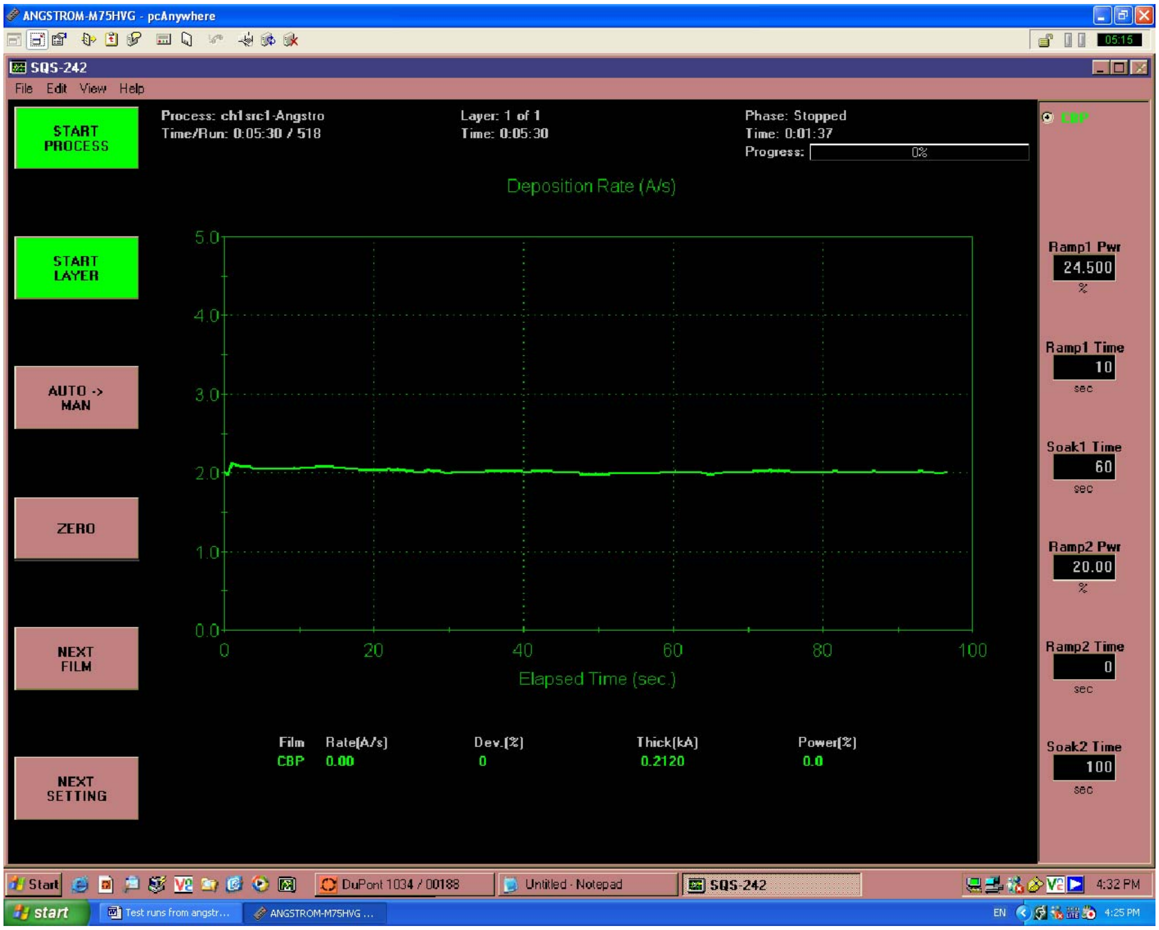
Run: Src1 Chamber 1 CBP

Rate: 2.0A/s
PID values: 350, 12, 0
Period and Filter: 0.5, 6.00
Output voltage: 5V
Preconditioned at: ramp 1 24.5% for 60sec and ramp 2 20% for 100sec
2% shutter delay
Lower sensor used: Lower Sensor #4

Same run as last time, material took off a bit during precondition and went up to 5 angstroms /sec. But this was recovered very easily during shutter delay.



It is possible that the reason that the material took off in this way is that it was already warm from the previous run.



After the deposition started the run was flawlessly smooth.

The finding of the initial settings and running of the last 3 tests were all completed within half of an hour. It is seen from the results that by using the pre-conditioning and shutter delay you can get a reproducible result which can be transferred without too much difficulty between sources and materials.

Appendix: Sigma SQS-242 Deposition Control Software Settings

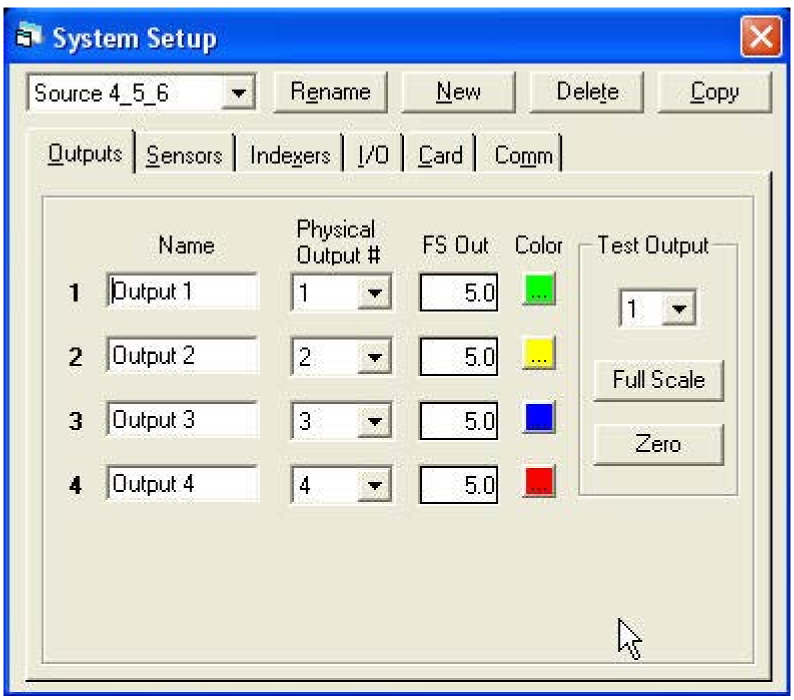
Version 3.23

To access any of the Sigma System Settings select the **Edit: System** menu.

Below are the settings that were entered at Angstrom Engineering's facility prior to the shipment of the system. See the Sigma Instruments SQS-242 Deposition Control Software Manual in the System component information section of this manual for further information.

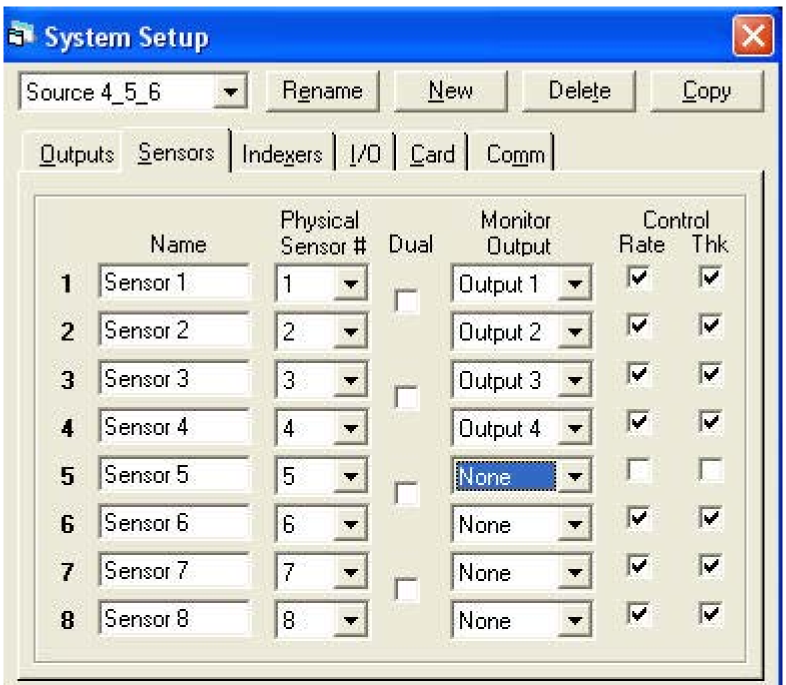
Outputs tab

Name	Full Scale (V)	
Output 1	5.0	Sources 1,2,3
Output 2	5.0	Sources 4,5,6
Output 3	5.0	Sources 7,8,9
Output 4	5.0	Sources 10,11



Sensors tab

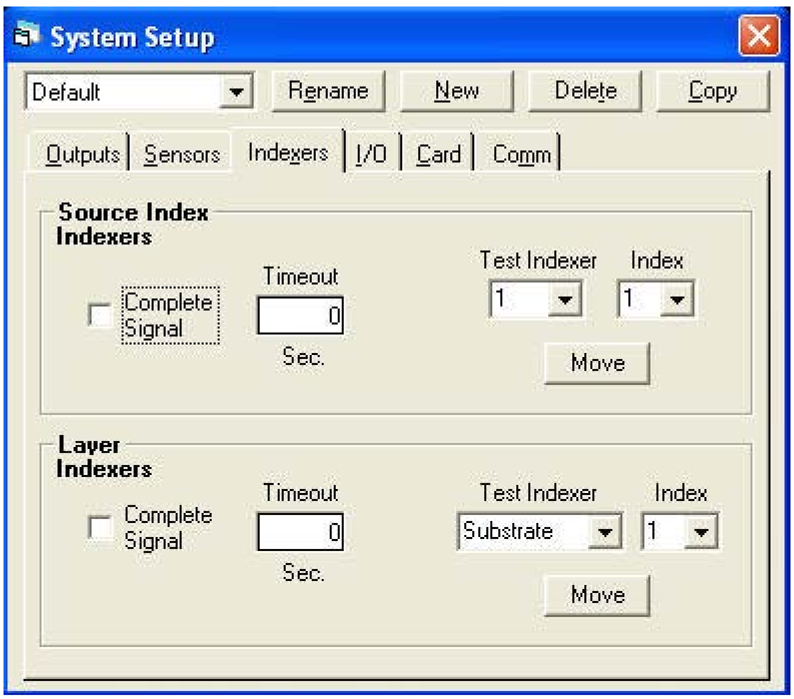
Sensor Name	**Output**
Sensor 1	1
Sensor 2	2
Sensor 3	3
Sensor 4	4
Sensor 5	Monitor



Sensor Frequency (MHz)

Maximum	6.100
Minimum	5.000
Initial	6.000

Indexers Tab



I/O tab

Note: Changing any of the relay assignments listed below will render the Sigma software unable to control depositions.

Relay Events

Relay 1	Process Running
Relay 2	Process Active
Relay 3	Pre-Condition Phase
Relay 4	Deposit Phase
Relay 5	Soak Hold Phase
Relay 6	Final Thickness
Relay 7	All Crystals Fail
Relay 8	Not Assigned
Relay 9	Not Assigned
Relay 10	Not Assigned
Relay 11	Manual Mode
Relay 12	Time Set point
Relay 13	Thickness Set point
Relay 14	Sensor 1 Shutter
Relay 15	Sensor 2 Shutter
Relay 16	Sensor 3 Shutter

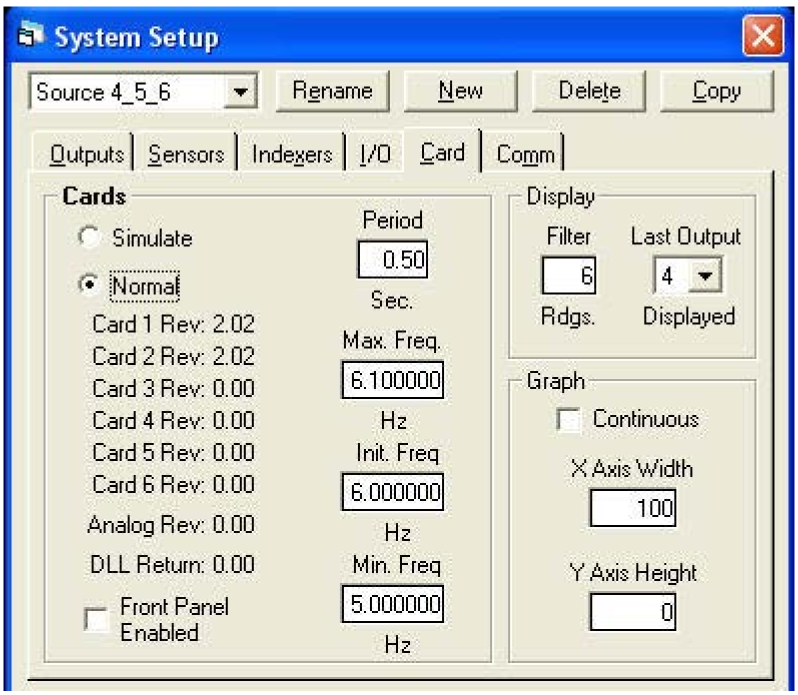
Input Events

Input 1	Start Process
Input 2	Abort Process
Input 3	Start Layer
Input 4	Stop Layer
Input 5	Next Layer
Input 6	Force Final Thickness
Input 7	Zero Thickness
Input 8	Zero Time
Input 9 – 12	Not Assigned

Communication Port 3
Address 0

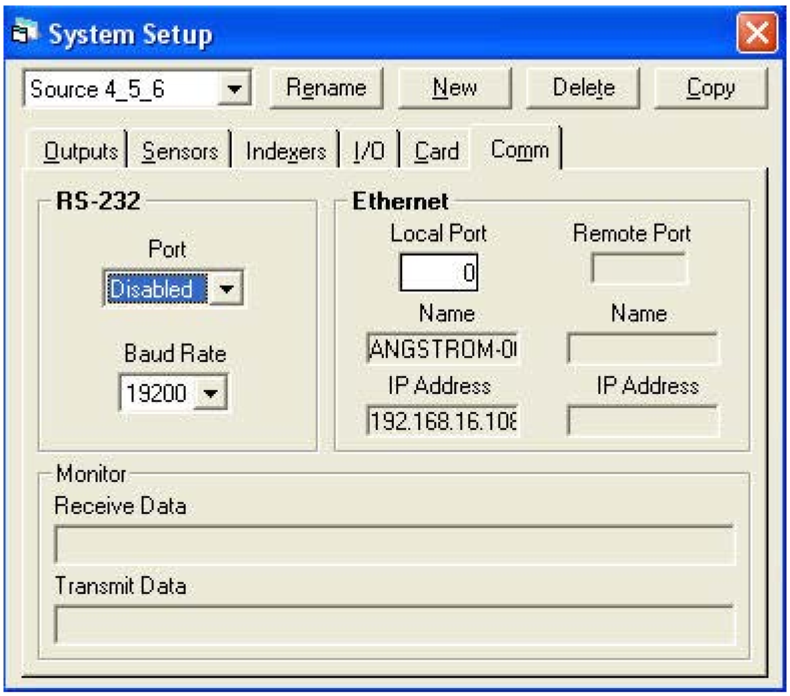
Card Tab

Ensure that the software is not in simulation mode if you wish to run a deposition. In simulate mode all Sigma relays and communications function, but the output signal voltages do not.



***Note: The period and filter have been increased from the default values of .25 and 3 to increase the rate resolution. This helps the software control at lower rates of deposition (rates less than 1 Å/s).**

Comm Tab



Appendix: Lakeshore 211 Temperature Monitor Setup

The Lakeshore temperature monitor has been set up at our facility to accurately read, display, and re-transmit the temperature in the cryo pump. The temperature is read by a silicon diode temperature sensor mounted inside the pump. The cryo pump temperature is re-transmitted from the Lakeshore unit to the PLC, where the temperature value is used as a set point. The temperature is also displayed on the main system page. Detailed instructions on how to view and change the settings in the Lakeshore temperature monitor can be found in this manual in the System Components Information section under Lakeshore Model 211 Temperature Monitor. The information is in the Operation section (Chapter 3).
Note that the display may be locked to prevent accidental changing of the parameters. Press and hold the Enter key on the unit until 'UnLOC' is shown on the display. The display buttons may be locked out again by pressing and holding down the Enter key again until the word 'LOC' appears on the display.

Below are the settings that were entered at Angstrom Engineering's facility prior to the shipment of the system.

Input Menu

Input type: **Si**
Curve selection: **User**
Display units selection: **K**
Note: None of the alarms or relays are used.

Output Menu

Analog output mode: **Volt**
Output range scale: **Rng 3**

Note: Changing any of the factory settings may cause the unit to display or transmit the incorrect temperature, and may cause the system to not operate correctly.

Appendix: Angstrom Contact Information

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Company President
Andrew Bass
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Phone Ext.: 101

Appendix: Customer Software Authorization Numbers

Below is a list of supplied software and the corresponding serial numbers. These will be needed for product support with the manufacturer and for installation of the software.

Program	User ID	Authorization Number
Microsoft Windows XP Professional	N/A	JXJVX-73V87-PY2FC-X98WR-CF8Y3

PC Anywhere 10.5.1 Build 505

CX Programmer Version 5.00, Using CX-Server version 2.2 Registration #: 651VZ1U22HPR9B1FQS

CX Supervisor Version 1.2(12), Product Code: 65ivziuxpmyv069, Communications CX Server Version 2.2

Sigma Inst. Deposition Control SQS 242 v. 3.23, 30/11/2004