PSE&G

Public Service Electric and Gas Company 80 Park Place Newark, N.J. 07101 Phone 201 430-7000

March 3, 1980

Mr. Albert Schwencer, Chief
Operating Reactor Branch #1
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

DEGRADED GRID VOLTAGE PROTECTION (70-90%)
SUPPLEMENTAL INFORMATION
SALEM GENERATING STATION
UNITS NO. 1 AND 2
DOCKET NO. 50-272

The enclosures attached to this letter are submitted in response to your questions about the degraded grid voltage protection at Salem. Since the October, 1979 meeting with the NRC staff, questions about the proposed design for a second level of undervoltage protection have been received and are addressed in Enclosure 1. Enclosure 2 contains related information requested by Mr. W. Ross during the October, 1979 meeting.

If you have any questions, please do not hesitate to contact us.

Very truly yours,

Frank P. Librizzi
General Manager -
Electric Production

Attachments

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ENCLOSURE 1

1. The onsite distribution system for each unit at Salem is arranged so that two vital buses are connected to one station power transformer and the third is connected to the other station power transformer (FSAR figure 8.3.1). The in-feed breakers for each vital bus from the two station power transformers are electrically interlocked to prevent paralleling both sources through a vital bus. The breakers also provide the means for transferring between sources in the event of an interruption of power from one source.

   Undervoltage protection for each vital bus will be provided by two protective relay groups. One group is designed to protect the vital buses if bus supply voltage falls below 70% of its rated value. This group is already installed and operable. The other group will be designed to protect the vital buses if bus supply voltage falls below 91% of its rated value.

   Each undervoltage protection group is/will be comprised of two sets of relays:

   A set for undervoltage transfer, and

   A set for generating "Blackout" signals.

   The 91% group will be comprised of adjustable time delay relays. The protective relays will be connected to the electrical system in the same manner and location as the present undervoltage protection. The new design essentially duplicates the present protective scheme in all regards (Attachment A) with the following exception.

   The 91% relays will be equipped with an administratively controlled lockout which will allow the control room operator to disarm the system during the start of any reactor coolant pump. This feature is required to forestall any unnecessary undervoltage signals due to the voltage transient caused by a reactor coolant pump start. The lack of this manual lockout feature would require that an extended time delay (30 seconds) be used to actuate the 91% relays. The system will be armed by the control room operator upon completion of any RCP start, and will remain armed under all conditions other than a RCP start. The disarming and rearming of the system will become an integral part of the RCP starting procedures used at Salem and an alarm will be provided for the disarmed condition. In addition to manual rearming, a timer will be provided to automatically rearm the system in the event the control room operator neglects to do so after a RCP has been started.

The time delay of the 91% undervoltage transfer relays will be 10.5 seconds when the output of the station power transformers is below 91% of its rated value (Figure 1).

The time delay of the 91% bus "blackout" relays will be 13 seconds when the voltage on the affected bus (or buses) is below 91% of rated value (Figure 1).

In the event the supply voltage to a 4 KV vital bus or buses falls below 91% of its rated voltage, the affected bus or buses will be automatically transferred to the alternate source by the action of the vital bus transfer relay (XET-230, Fig. 1) and the 91% transfer relays after a 10.5 second time delay.

The following conditions must be met before a bus transfer may be accomplished at either low-voltage condition:

a. The bus differential or overload relays have not operated.

b. Voltage on the affected bus or buses is below 35% (this permissive prevents transfer with excessive out-of-phase residual bus voltage).

c. The in-feed breaker of the normal supply is opened.

d. The related diesel-generator circuit breaker is open.

e. The alternate source voltage is above 91%.

f. The SEC (Safeguards Equipment Control) bus undervoltage (blackout) relays have not operated.

For both groups (70% and 91%), the undervoltage and vital bus (XET-230) transfer relays allow the affected bus or buses to be transferred to the remaining station power transformer before the bus blackout relays are tripped.

If the supply voltage to the vital buses falls below 70% of rated voltage and a transfer is not accomplished, the 70% blackout relays will provide a signal to start the diesel-generators. If the supply voltage to the vital buses falls below 91% of rated voltage and a transfer is not accomplished, the 91% bus blackout relays will provide a signal to start the diesel-generators.

Undervoltage signals generated by either set of blackout relays will be combined (through the use of buffer relays) in a 2/3 logic matrix per bus to develop a blackout loading signal for that bus. The buffer relays will be used on each vital bus undervoltage sensor to supply independent signals to each SEC unit to maintain independence among the three buses.

If the output voltage of a station power transformer supplying one vital bus falls to 70% of its rated value and the transfer mechanism fails, the 70% blackout relay for that bus will generate a signal which results in a 1/3 condition at each SEC controller. The Salem design is such that a loss of one vital bus is tolerable for all normal operating conditions; therefore, no automatic equipment actuation will take place for this condition. This design will also apply to the new 91% protective relays. For a postulated LOCA, this criterion will not apply. A postulated LOCA concurrent with an undervoltage condition on one vital bus is discussed in the response to question 5.

2. The proposed design will employ test switches which can be used in conjunction with any external equipment (variable power supply, etc.) necessary for proper calibration and testing.

   Technical specifications similar to those for the existing undervoltage protection will be generated upon the Staff's approval of the proposed design.

3. Since this design is a duplicate of the present undervoltage protection system (except for the administrative controls), it will meet the necessary criteria for protection and control of Class 1E equipment (IEEE 279-1971).

4. If a LOCA concurrent with a voltage degradation which reduces the output of both station power transformers to between 90% and 70% of rated voltage is postulated, the SEC system will react only to the LOCA while the 91% transfer relays are timing out. The time for the relays to actuate will be 10.5 seconds.

   While the relays are timing out, the SEC system will perform the following functions:

   a. Start the diesel-generator units.

   b. Lockout manual control of equipment circuit breakers until the required loads are connected to the vital buses.

   c. Connect all required accident loads.

   The diesel-generators are started automatically so as to be available in the event they are subsequently required. They are not automatically connected to the vital buses.

   The ability of the safeguards motors to start and carry their designated loads under degraded voltage conditions is described in Attachment B. The safeguards motors are capable of withstanding degraded voltage conditions for the times under consideration without suffering any thermal damage.

   When the 91% transfer relays time out (10.5 seconds), the transfer will not take place because the station power transformer potential relays will not generate a permissive. Therefore, the 91% blackout relays will be allowed to time out (in an additional 2.5 seconds), and a blackout signal will be generated. When the blackout signal is generated, the SEC will automatically shift modes from that for a LOCA (Mode I) to that for a LOCA plus blackout (Mode III). The shift of modes will require less time than the recognition and action required to combat only a blackout due to the "ready" status of the diesel-generators.

The above mentioned sequence of operations will take place within the required time limits to successfully mitigate the consequences of a LOCA. A delay time of 15 seconds between the occurrence of the incident and the application of power to the first sequenced safeguards pumps was assumed in the original LOCA analysis.

Although regarded as extremely unlikely, it may be postulated that one station power transformer may suffer a voltage degradation which reduces its output voltage to between 90% and 70% of its rated value while the output of the remaining station power transformer is reduced to just above 91% of rated voltage. Under these conditions, one set of 91% transfer relays will begin timing out while the other set "sees" no abnormal conditions. It may be possible to reduce the output voltage of the "normal" transformer to below 91% of its rated value after the transfer from the affected transformer takes place. Also, the output voltage of the initially affected transformer may rise above 91% of its rated value due to its partial unloading. These voltage changes will not amount to more than 3% for each transformer. Consequently, the 91% transfer relays for the alternate transformer will begin timing out and would effect a subsequent transfer at the end of an additional 10.5 seconds. These conditions would result in a continual flip-flop condition causing intermittent power interruptions on the vital buses.

This action will be prevented by the installation of 91% blackout relays which have a 95% reset setting. The 91% blackout relays began timing out at the same time as the 91% transfer relays on the initially affected transformer. Since their time delay will be 2.5 seconds longer than that of the transfer relays, and if the transfer does not successfully raise the bus voltage above 95%, the bus relays will initiate separation of the bus from both transformers. The reset setting of 95% on the transfer relays will also ensure that the buses do not continually transfer from one source to the other.

The interlocks and permissives utilized in the transfer of buses are described in Item 1.

5. In the event a LOCA occurs concurrent with a voltage level on one vital bus below 90% and above 70% of rated voltage, the SEC response will be the same as that explained in Item 4 while the 91% transfer relays are timing out. Once the relays have timed out, a transfer to the alternate source will take place.

   If the transfer mechanism fails, a blackout signal will be generated for the affected bus and the SEC will automatically shift from a Mode I (LOCA) to a Mode IV (LOCA plus one vital bus undervoltage) condition, whereby only the affected bus is connected to its diesel-generator. The other two buses will remain connected to offsite power.

   If a LOCA occurs concurrent with a degraded voltage condition on two of the three vital buses which reduces the bus voltages to between 90% and 70% of rated voltage, the SEC will react as explained in Item 4 while the 91% transfer relays are timing out. Once the relays time out, the buses will be transferred to their alternate source.

   If the transfer mechanism fails, a blackout signal will be generated and the SEC will automatically shift from a Mode I (LOCA) to a Mode III (LOCA plus blackout) condition, whereby all three vital buses will be shifted to diesel-generator power.

   For both postulated conditions, the safeguards motors on the affected bus or buses will be subjected to degraded voltage conditions for no more than 13 seconds. Their ability to start and maintain operation (or to withstand a postulated voltage degradation which prevents starting) during the period prior to bus transfer, and the acceptability of the time delays involved are explained in Item 4.

6. The characteristics of AC contactors and associated control fuses are described in Attachment B.

7. With regard to Staff's suggestions of utilizing only bus blackout relays in the proposed design (no attempted transfer), the following scenario is presented.

The existing diesel starting and sequence loading logic is located in the Safeguards Equipment Control (SEC) system associated with each bus. The plant design is predicated on each SEC performing the master decision making and resultant actions associated with bus loading. To make use of this existing logic with the design suggested, would require paralleling the existing bus undervoltage inputs and the proposed secondary bus undervoltage relays.

Assuming an initial system configuration of two buses being supplied from one station power transformer (assume #11) and the remaining bus powered by #12 SPT, a degraded voltage condition on #11 SPT side, coupled with a single failure within the bus voltage monitoring logic, could result in the following condition:

Bus "A" operating with degraded voltage due to failure in monitoring logic.

Bus "B" operating with degraded voltage due to lack of required coincident logic in SEC (failure cascaded from failure in Bus "A" circuits).

Bus "C" operating at normal voltage supplied from #12 SPT.

The above scenario assumed that no condition exists which would generate a Safety Injection (SI) signal. If an SI signal were to exist during this occurrence, the following system configuration would result:

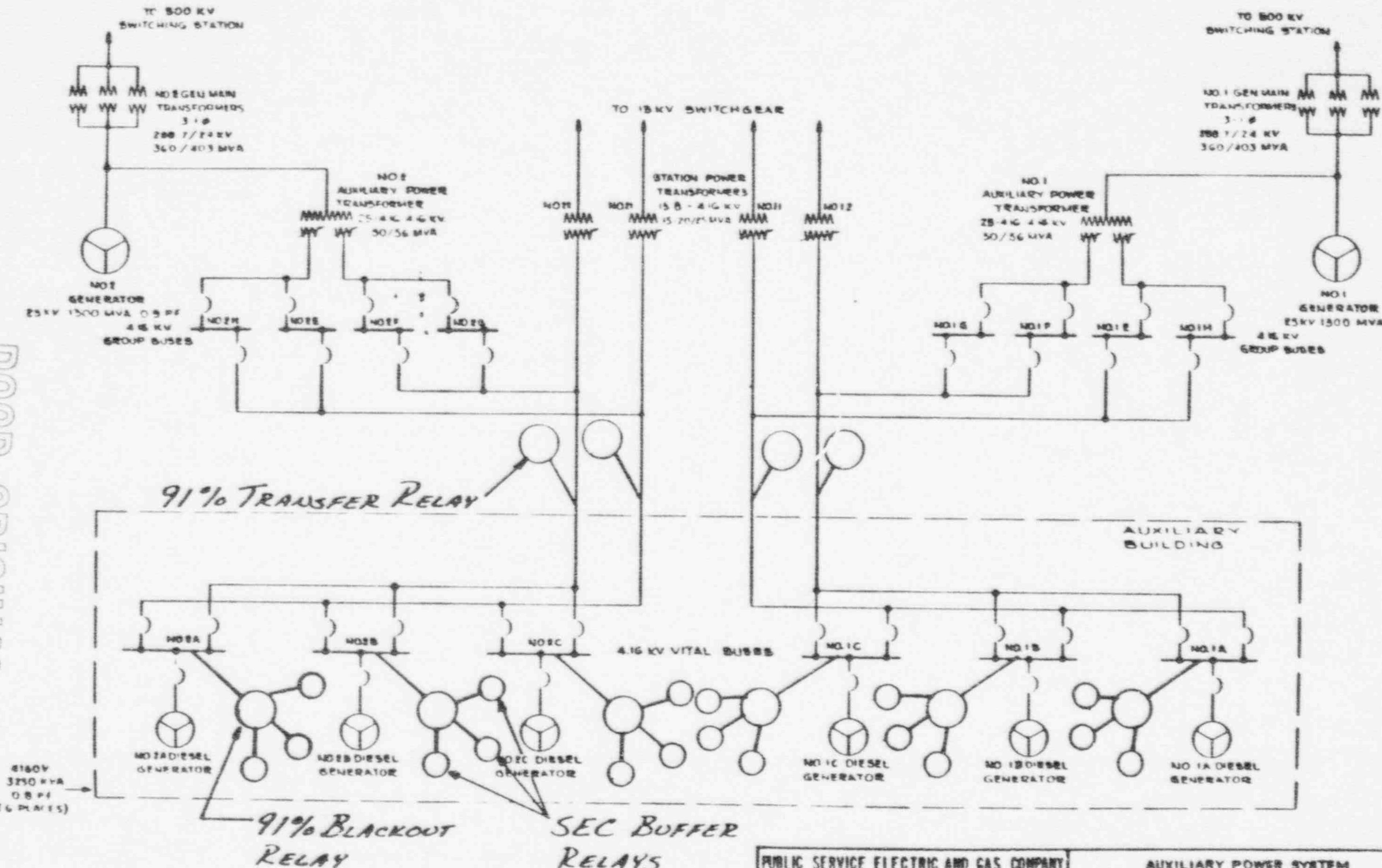
Bus "A" could attempt to block load all ESF loads during a degraded voltage situation. This would most likely result in a further bus voltage degradation to below 70% and cause the diesel to start and commence sequential loading via the SEC.

Bus "B" would follow the sequence of events described in Item 5 for a postulated LOCA concurrent with a voltage degradation on one vital bus.

Bus "C" would "block load" the ESF loads on the normal supply from the #12 SPT.

The sequence described for the case of "No SI Signal" is unacceptable. The proposed design which includes an attempted transfer, precludes that sequence of events and ensures that at least two buses are capable of supplying the needed equipment.

ATTACHMENT A

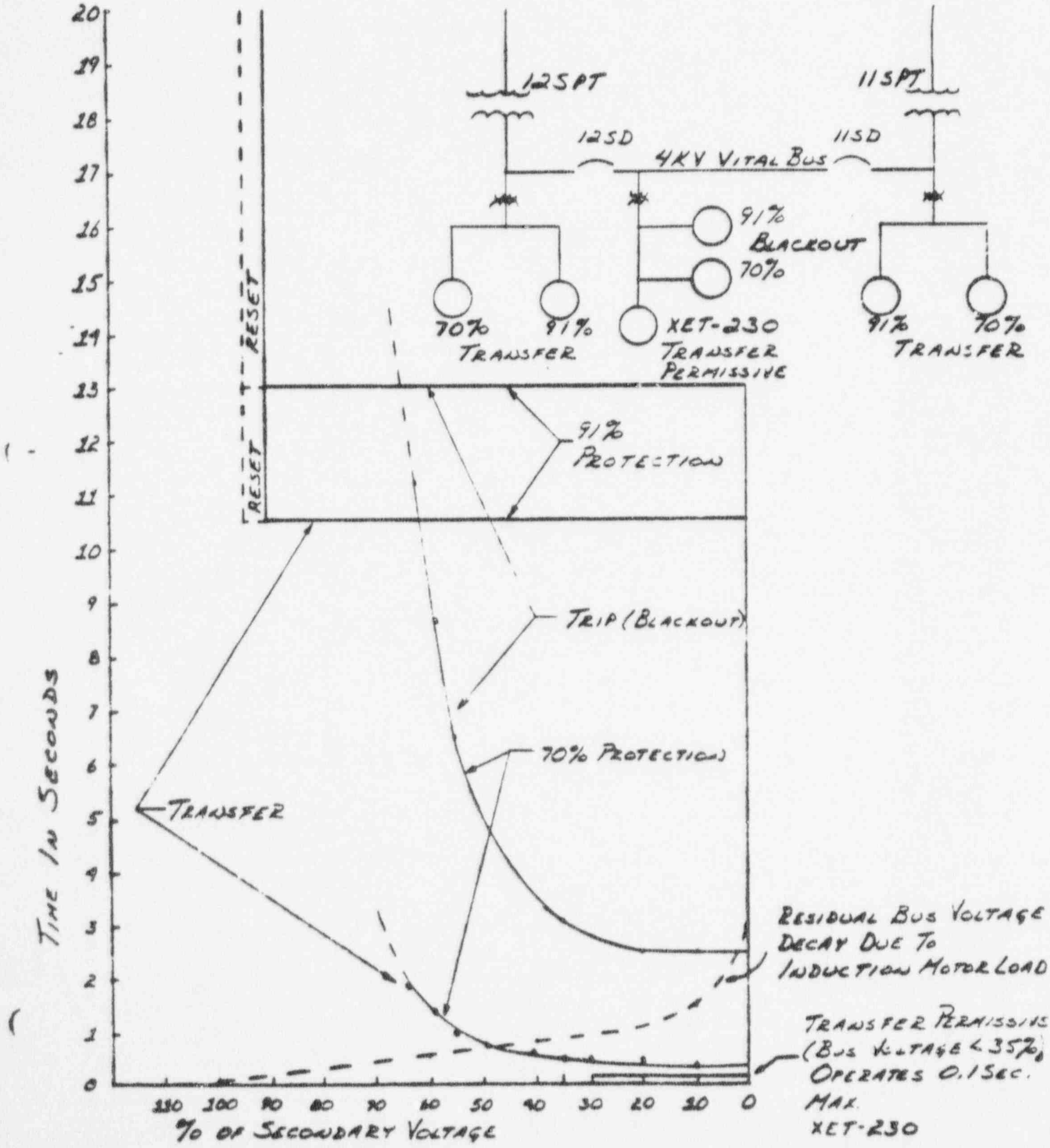


PUBLIC SERVICE ELECTRIC AND GAS COMPANY	AUXILIARY POWER SYSTEM DIAGRAM
SALEM NUCLEAR GENERATING STATION	FSAR FIG. 8.3-1

FIGURE 1

SALEM NUCLEAR GENERATING STATION

4KV VITAL BUS U.V. PROTECTION AND TRANSFER CHARACTERISTIC CURVES



ATTACHMENT B

ELECTRICAL DIVISION
OCT 12 1979

WSR

GENERAL MANAGER-ENGINEERING
Engineering and Construction Dept.
R. R. EAST
OCT 12 1979
RAA RDR JJK GWC WDO FAC PRHL

PSE&G
Public Service Electric and Gas Company

October 10, 1979

Director of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Attention: Mr. William Gammill, Acting Assistant Director
for Operating Reactors Projects
Division of Operating Reactors

Gentlemen:

ADEQUACY OF STATION ELECTRIC DISTRIBUTION
SYSTEM VOLTAGES - SALEM GENERATING STATION
UNITS NOS. 1 AND 2

We have performed the analysis on the Salem Generating Station Units Nos. 1 and 2 electric power system in accordance with NRC letter, Adequacy of Station Electric Distribution System Voltages dated August 8, 1979 and its enclosures.

The analysis demonstrates that the offsite power system and the onsite distribution system is of sufficient capacity and capability to automatically start as well as operate all safety loads within their voltage ratings for all anticipated transients and accidents.

Satisfactory results were obtained as a result of the original design considerations. The Salem Generating Station was designed such that the resulting voltage profile was within component voltage limitations, being +5% of transformer secondary voltage and -10% of motor nameplate voltage under steady-state conditions. The system was also designed such that the inrush current associated with the start of a 6000 horsepower, 4.0 kV motor would not cause the bus voltages to drop below 80%. All motors are designed to accelerate their driven equipment with at least 80% motor nameplate voltage applied to its terminals. This was accomplished by optimum selection of transformer impedances, incorporation of no-load taps on all power and unit substation transformers, and a ± 10% automatic load tap changer on all the 13.8/4.16 station power transformers. All motor starters have a guaranteed drop out voltage of 70%. All starters were bought with 300 VA control power transformers, regardless of NEMA size, to minimize voltage drop at the contactor coil. Further, consideration was given to cable size and length to limit voltage drop in a feeder.

The analysis showed the worse sustained under-voltage condition imposed upon the distribution system occurred with a severely degraded 500kV offsite system simultaneous with a concurrent LOCA on Unit 2 and Unit trip on Unit 1 (or vice versa). This under-voltage condition results from the automatic transfer of the group buses from the auxiliary power transformers to the station power transformer and the automatic start of the required vital bus loads. For this condition the lowest voltages at the 4.16 kV, 460V and 230V loads were .917, .923 and .9% per unit respectively. The above analysis indicates that the onsite distribution system and its components will operate within component voltage limitations. The motors are the limiting component under steady-state conditions as they are designed to run continuously at .9 per unit nameplate voltage.

Transient voltage drops due to the starting of motors were analyzed at each voltage level with no adverse effects. This analysis assumed the prestart voltage to be that corresponding to the degraded 500 kV system and the load in parallel with the motor being started equal to the maximum continuous rating of the transformer to which it is connected less the running load of the motor being started. Further, the impedance of the parallel load was conservatively assumed to decrease as the square of the bus voltage to analytically compensate for the additional current drawn by induction motors upon decrease in voltage. The minimum transient voltages obtained on the 4.16 kV, 460V and 230V levels were .86, .86 and .78 per unit, respectively for a duration of approximately 5 seconds. These transients are within motor and motor starter design capabilities, thereby having no adverse effect on system operation. The results of this analysis were used to reexamine under-voltage protective settings and establish that no spurious separations of the safety buses from offsite power would occur.

The 5 kV power cables that connect the 13.8/4.16 kV station power transformers to the group and vital buses are the load limiting component in the distribution system. The sixteen hour rating of the cable is utilized for the load that results from the concurrent LOCA Unit 2 and Unit trip on Unit 1. There is sufficient margin between the cable rating and the resultant load to allow for implementation of existing station procedures used during the events analyzed and thus, avoid overloading.

As indicated in the NRC letter of August 8, 1979, tests had been previously run to correlate calculations with field conditions. With Salem Units 1 and 2 and the 500 kV system in an existing mode corresponding to a given loading of the plant distribution system, selected system parameters were monitored over a 24-hour period. An analysis was then performed using the actual load and 500 kV system voltage to obtain a calculated voltage profile and compare to actual measurements. The calculations and field measurements correlated within very reasonable accuracy, thus substantiating our assumptions and the method of calculation. The results are given in Attachment 1. Further, a test on a cold 6000 horsepower, 4.0 kV reactor coolant pump motor was conducted. The bus voltage dropped 15% upon start of this motor. No adverse effects were observed on other operating equipment. The results of this test substantiate the original plant design basis.

The electric power system was reviewed to determine if there are any events or conditions which could result in the simultaneous or consequential loss of required circuits to the offsite network that would violate GDC-17. No potential exists for violation of GDC-17.

If you should have any questions, please do not hesitate to contact us.

Very truly yours,

F. P. Librizzi

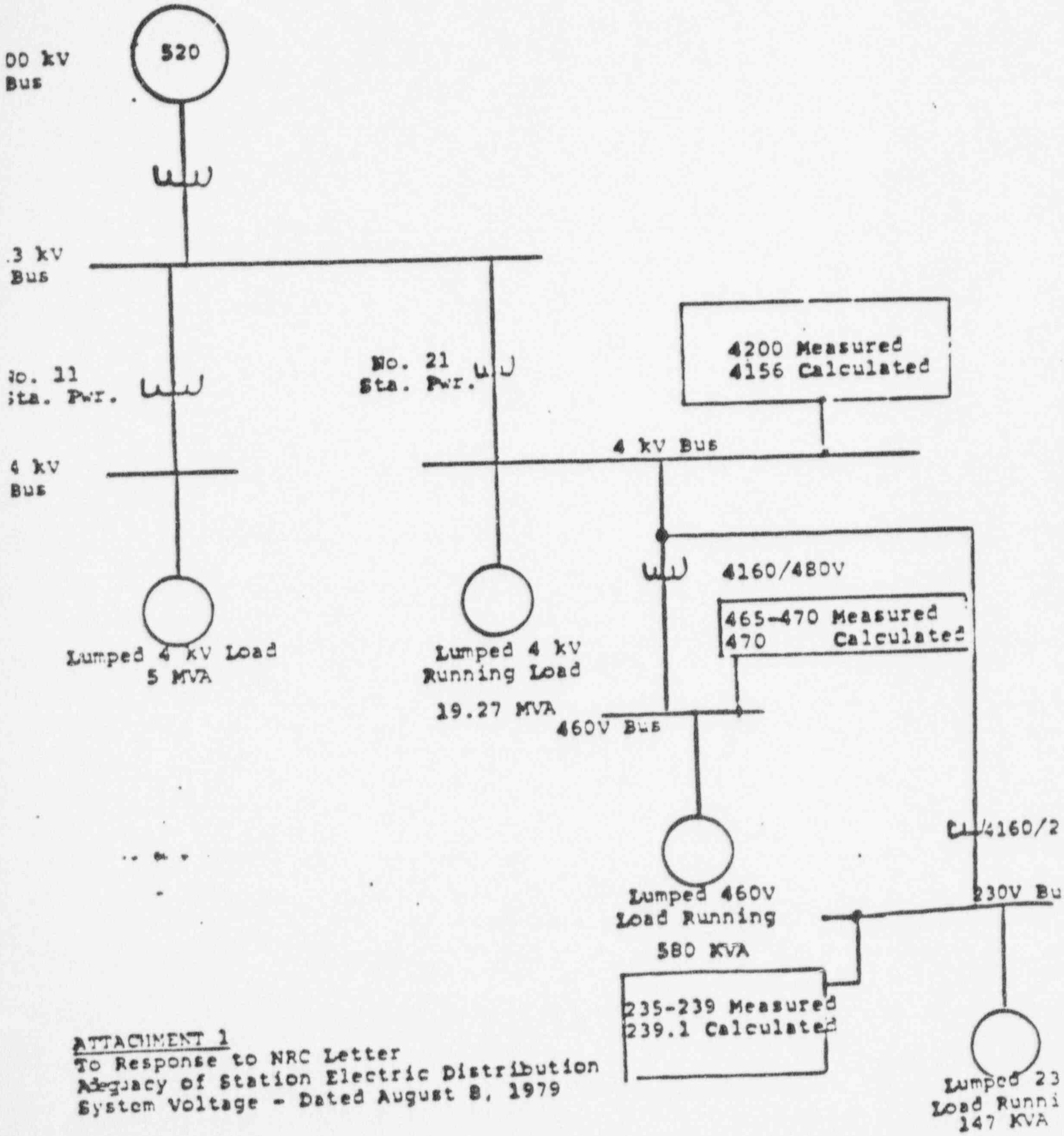
Frank P. Librizzi
General Manager -
Electric Production

GLS:hs

CC Gen'l Mgr. - Engg.
Proj. Licensing Mgr. - Salem
Asst. Gen'l. Solicitor
Mgr. - Nuc. Opers.
Mgr. - Plant Maint.
Mgr. - Salem
SQAE - Salem
EPD-QAE
P. A. Moeller
N. R. Philipp

Attachment

SALEM GENERATING STATION, UNIT 2
VOLTAGE PROFILE
FIELD MEASUREMENTS VS. CALCULATIONS



ATTACHMENT 1
To Response to NRC Letter
Adequacy of Station Electric Distribution
System Voltage - Dated August 8, 1979

Salem 1 & 2
Proposed Design of Degraded
Grid Voltage Protection (70%-90%)

It is our understanding that the proposed design involves addition of UV relays for 90% trip (with appropriate time delays) essentially paralleling the existing 70% loss-of-voltage UV trip scheme. The proposed design, as described during our recent meeting, appears to meet existing criteria. However, we have some concern with its complexity, and particularly with the time delays associated with the automatic bus transfers between the two auxiliary transformers and onto the emergency diesel generators. Therefore, your detailed description of the scheme should specifically include the following:

1) For each relay: the number, type, location in the electrical system, set point, associated time delay, actuation logic(s) and function(s) performed.

2) A description of the testability of the system and the associated Technical Specification requirements.

3) A positive statement regarding conformance with specific applicable criteria.

4) A description of the operation of the UV trip system and the ESF loads assuming a LOCA with concurrent voltage degradation (between 70% and 90%) at the output of both auxiliary (offsite power) transformers; specifically address (1) all interlocks and permissives including the provisions for preventing repetitive auxiliary

bus transfers between auxiliary transformers and transfers with excessive out-of-phase residual bus voltage, and (2) the acceptability of the time delays involved with regard to both accident mitigation and the capability of electrical equipment to operate at degraded voltage for those periods without damage.

5) A description as in item (4) except that voltage degradation is assumed to occur at the output of only one auxiliary power transformer.

6) A description specifically addressing the operability of AC contactors and the associated control fuses under degraded voltage for the time delay intervals involed.

7) The reasons why a less complex design with only one set of UV relays (90% trip with <10 sec. delay) at the emergency buses to initiate trip of offsite power and initiation of the diesels cannot or should not be used instead of the proposed scheme.

ENCLOSURE 2

SYNOPSIS

Analysis was performed on the Salem Station Electric Distribution System in accordance with NRC letter dated August 8, 1979 and its enclosures (Appendix 1). The following summarizes the results of such analyses. This response serves as the discussion to the results.

The analysis were performed with margin to avoid repetition of this calculation to the future changes. The greatest voltage drop imposed upon the distribution system would be with a severely degraded 500 kV system that results in the minimum expected voltage at Salem simultaneous with the load resulting from a unit trip on No. 1 and a LOCA on Unit 2. The analysis was very conservative as discussed herein. Assumptions made in the load and voltage profile are given.

WSR:bm

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CONTENTS

Appendix I

PSE&G

Public Service Electric and Gas Company 80 Park Place Newark, N.J. 07101 Phone 201/430-7000

Follow-up Due By 9/30

August 22, 1979

AUG 27 1979

To the Chief Electrical Engineer
Engineering and Construction Department

WSR

NRC LETTER DATED AUGUST 8, 1979
ADEQUACY OF STATION ELECTRIC
DISTRIBUTION SYSTEMS VOLTAGES

The NRC letter dated August 8, 1979, with the above title, requires that all licensees review the electric power systems at each of their nuclear power plants to determine analytically if the off-site power systems and on-site distribution system is of sufficient capacity and capability to automatically start as well as operate all required safety loads.

Please make the necessary analysis to comply with the letter, copy attached. This response is due to the NRC within sixty (60) days of the date of the letter. Please have your analysis completed and a response sent to us for concurrence by October 1, 1979.

Manager - Plant Maintenance

EMC:kls

CC Mgr. - Nuclear Operations
Electrical Plant Engineer

CENTENNIAL OF LIGHT

MGR.—NUCLEAR OPERATIONS

RECD AUG 20 1979

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

To File Copy
Copy To
Route To
Then To ☐ File ☐ Discard

August 8, 1979

All Power Reactor Licensees (Except Humboldt Bay)

RE: ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEMS VOLTAGES

We are currently reviewing the licensee's submittals in response to the NRC generic letter of June 2, 1977 regarding undervoltage protection of the safety related electric equipment from loss of capability of redundant safety loads, their control circuitry, and associated electrical components required for performing safety functions as a result of sustained degraded voltage from the offsite electric grid system. This generic action was based on the Millstone Event which occurred on July 5, 1976.

The recent event at the Arkansas Nuclear One (ANO) station on September 16, 1978 brought into question the conformance of the station electric distribution system to GDC-17, in two separate regards. Each of two units at the ANO station has a dedicated startup transformer powered through a single shared autotransformer (common source of offsite power) from the station switchyard. Operation of an autotransformer overcurrent relay caused the loss of the two dedicated startup transformers. The station electrical distribution system thus automatically transferred the full auxiliary loads of both units to the backup startup transformer exceeding its rated capacity and degrading the voltage level at the safety buses. Secondly, during our review of the electrical system at the ANO station, the licensee's analysis indicated that the "immediate access offsite power circuit" (dedicated startup transformer) lacked "sufficient capacity and capability" to accommodate the simultaneous starting demands of the emergency loads concurrent with the full house loads, in the event of a loss of coolant accident (LOCA). The condition would result in all safety loads remaining on the dedicated startup transformer with unacceptably degraded voltage. A voltage degradation during the electrical starting condition becomes a safety concern either if the degradation causes the starting condition to be prolonged so as to become a sustained undervoltage or if the voltage degradation causes frequent spurious shedding of the ESF loads from the preferred power source, the offsite electric grid. This event was described in NRC's IE Information Notice No. 79-04. Additional background information is provided in Enclosure 1.

The IE Information Notice No. 79-04 stated that NRC would follow with specific actions to be taken by licensees. This letter identifies those actions.

Based on the ANO event, the NRC has expanded its generic review of the adequacy of the electric power systems for all operating nuclear power facilities. Specifically, we must now confirm the acceptability of the voltage conditions on the station electric distribution systems with regard to both (1) potential overloading due to transfers of either safety or non-safety loads, and (2) potential starting transient problems in addition to the concerns expressed in our June 2, 1977 correspondence with regard to degraded voltage conditions due to conditions originating on the grid.

Based on the experience at ANO, the NRC is requiring all licensees to review the electric power systems at each of their nuclear power plants to determine analytically if, assuming all onsite sources of AC power are not available, the offsite power system and the onsite distribution system is of sufficient capacity and capability to automatically start as well as operate all required safety loads. Within their required voltage ratings in the event of (1) an anticipated transient (such as unit trip) or (2) an accident (such as a LOCA) regardless of other actions the electric power system is designed to automatically initiate and without the need for manual shedding of any electric loads. Protection of safety loads from undervoltage conditions must be designed to provide the required protection without causing voltages in excess of maximum voltage ratings of safety loads and without causing spurious separations of safety buses from offsite power. NRC should be informed of any required sequential loading of any portion of the offsite power system or the onsite distribution system which is needed to assure that power provided to all safety loads is within required voltage limits for these safety loads. Guidance on evaluating the performance of electric power systems with regard to voltage drops is provided in Enclosure 2.

The adequacy of the onsite distribution of power from the offsite circuits shall be verified by test to assure that analysis results are valid. Please provide: (1) a description of the method for performing this verification, and (2) the test results. If previous tests verify the results of the analysis, then test results should be submitted and additional tests need not be performed.

In addition, you are requested to review the electric power systems of your nuclear station to determine if there are any events or conditions which could result in the simultaneous or consequential loss of both required circuits to the offsite network to determine if any potential exists for violation of GDC-17 in this regard. These reviews should be completed, and a copy of the analyses provided to NRC within 60 days of the date of this letter.

In the event that any violation or potential violations of GDC-17 or voltage requirements of safety loads are discovered remedial action should be taken immediately. You should provide the Commission with Prompt Notification with Written Followup pursuant to the reporting requirements of your Technical Specifications.

If the above required reviews have been completed by you as part of your response to our June 2, 1977 request, NRC should be informed within 30 days of the date of this letter. Approved by GAO, B-180225 (R0072), clearance expires 7/31/80. Approval was given under a blanket clearance specifically for identified generic problems.

Sincerely,

W. G. Gammill

William Gammill, Acting Assistant Director
for Operating Reactors Projects
Division of Operating Reactors

Enclosures:
1. Background Information on
ANO Event
2. Guidelines for Voltage Drop
Calculations

cc: Service List

ENCLOSURE 1

BACKGROUND INFORMATION ON ANO EVENT

The event that occurred at the Arkansas Nuclear One station on September 16, 1978, brought into question the conformance of the station electric distribution system design to GDC-17 with regard to the capacity and the capability of the onsite systems.

Each of two units at the ANO station has a dedicated startup transformer connected to a single shared autotransformer (common source of offsite power) from the station switchyard. The incident was initiated by Unit 1 reactor trip concurrent with trip of the unit's turbine-generator. The Unit 1 auxiliary loads were automatically transferred to Startup Transformer 1. The power being supplied to Startup Transformer 3 (Unit 2 dedicated startup transformer), which was feeding Unit 2, and being supplied to Startup Transformer 1 resulted in operation of an autotransformer overcurrent relay and consequent tripping of the incoming circuit breaker of the autotransformer. The autotransformer has the capacity to provide power for both units, but due to an error, the overcurrent relay was still set for the operation of Unit 1 only. Loss of input power to the two Startup transformers automatically transferred the auxiliary loads for both units to the backup Startup Transformer, ST 2. However, this transformer is designed as an alternate supply for one unit and is not designed to carry full auxiliary loads for both units. This overload caused a voltage degradation at the safety buses. The event to this point demonstrated that the design of the offsite power system to the ANO station Units 1 and 2 did not fully meet GDC-17. In the circumstances experienced at ANO the failure of one of the two offsite electric power circuits resulted in failure of the other electric power circuit. GDC-17 requires, in part, that (1) electric power from the transmission network to the onsite distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and environmental conditions and (2) provision shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear unit, or the loss of power from the transmission network. The ANO did not fully meet these requirements.

Initially, the sequence of events on September 16, 1978 did not indicate any problem with the electrical distribution system of Unit 1. However, subsequent analysis by the licensee indicated that in the event of a LOCA at Unit 1 during which time Startup Transformer No. 1 would be required to provide power to both the non-safety auxiliary electrical loads and start the safety loads a voltage degradation would result. The safety loads might not transfer to the Unit 1 diesel-generators but could remain on the startup transformer with unacceptably degraded voltage. Although there is margin in the thermal capability of equipment such a situation could result in thermal damage in the safety equipment and/or blown fuses in control circuits for these safety loads. Either event could result in disabling these loads during a LOCA. GDC-17 requires, in part, that electric power supplies for nuclear power plants provide sufficient capacity and capability to assure that certain limits are not exceeded in the event of anticipated operational occurrences and that the core is cooled and containment integrity and other vital functions are maintained in the event of postulated failures. The ANO design was not capable of providing the electric power of "sufficient capacity and capability."

ENCLOSURE 2

not apply to ...

GUIDELINES FOR VOLTAGE DROP CALCULATIONS

1. Separate analyses should be performed assuming the power source to safety buses is (a) the unit auxiliary transformer; (b) the startup transformer; and (c) other available connections to the offsite network one by one assuming the need for electric power is initiated by (1) an anticipated transient (e.g., unit trip) or (2) an accident, whichever presents the largest load demand situation.

2. For multi-unit stations a separate analysis should be performed for each unit assuming (1) an accident in the unit being anlayzed and simultaneous shutdown of all other units at that station; or (2) an anticipated transient in the unit being analyzed (e.g., unit trip) and simultaneous shutdown of all other units at that station, whichever presents the largest load demand situation.

3. All actions the electric power system is designed to automatically initiate should be assumed to occur as designed (e.g., automatic bulk or sequential loading or automatic transfers of bulk loads from one transformer to another). Included should be consideration of starting of large non-safety loads (e.g., condensate pumps).

4. Manual load shedding should not be assumed.

5. For each event analyzed, the maximum load necessitated by the event and the mode of operation of the plant at the time of the event should be assumed in addition to all loads caused by expected automatic actions and manual actions permitted by administrative procedures.

6. The voltage at the terminals of each safety load should be calculated based on the above listed considerations and assumptions and based on the assumption that the grid voltage is at the "minimum expected value". The "minimum expected value" should be selected based on the least of the following:

   a. The minimum steady-state voltage experienced at the connection to the offsite circuit.

   b. The minimum voltage expected at the connection to the offsite circuit due to contingency plans which may result in reduced voltage from this grid.

   c. The minimum predicted grid voltage from grid stability analysis. (e.g., load flow studies).

   In the report to NRC on this matter the licensee should state planned actions, including any proposed "Limiting Conditions for Operation" for Technical Specifications, in response to experiencing voltage at the connection to the offsite circuit which is less than the "minimum expected value." A copy of the plant procedure in this regard should be provided.

7. The voltage analysis should include documentation for each condition analyzed, of the voltage at the input and output of each transformer and at each intermediate bus between the connection to the offsite circuit and the terminals of each safety load.

8. The analysis should document the voltage setpoint and any inherent or adjustable (with nominal setting) time delay for relays which (1) initiate or execute automatic transfer of loads from one source to another; (2) initiate or execute automatic load shedding; or (3) initiate or execute automatic load sequencing.

9. The calculated voltages at the terminals of each safety load should be compared with the required voltage range for normal operation and starting of that load. Any identified inadequacies of calculated voltage require immediate remedial action and notification of NRC.

10. For each case evaluated the calculated voltages on each safety bus should be compared with the voltage-time settings for the under-voltage relays on these safety buses. Any identified inadequacies in undervoltage relay settings require immediate remedial action and notification of NRC.

11. To provide assurance that actions taken to assure adequate voltage levels for safety loads do not result in excessive voltage, assuming the maximum expected value of voltage at the connection to the offsite circuit, a determination should be made of the maximum voltage expected at the terminals of each safety load and its starting circuit. If this voltage exceeds the maximum voltage rating of any item of safety equipment immediate remedial action is required and NRC shall be notified.

12. Voltage-time settings for undervoltage relays shall be selected so as to avoid spurious separation of safety buses from offsite power during plant startup, normal operation and shutdown due to startup and/or operation of electric loads.

13. Analysis documentation should include a statement of the assumptions for each case analyzed.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
ENGINEERING AND CONSTRUCTION DEPARTMENT

DATE: October 4, 1979
RESPONSE DUE:

TO: F. P. Librizzi
General Manager - Electric Production

FROM: R. R. Bast
General Manager - Engineering

SUBJECT: RESPONSE TO NRC LETTER
ADEQUACY OF STATION ELECTRIC DISTRIBUTION
SYSTEM VOLTAGES DATED AUGUST 8, 1979

We have performed the analysis on the Salem Generating Station Units Nos. 1 and 2 electric power system in accordance with NRC letter, Adequacy of Station Electric Distribution System Voltages dated August 8, 1979 and its enclosures.

The analysis demonstrates that the offsite power system and the onsite distribution system is of sufficient capacity and capability to automatically start as well as operate all safety loads within their voltage ratings for all anticipated transients and accidents.

Satisfactory results were obtained as a result of the original design considerations. The Salem Generating Station was designed such that the resulting voltage profile was within component voltage limitations, being +5% of transformer secondary voltage and -10% of motor nameplate voltage under steady-state conditions. The system was also designed such that the inrush current associated with the start of a 6000 horsepower, 4.0 kV motor would not cause the bus voltages to drop below 80%. All motors are designed to accelerate their driven equipment with at least 80% motor nameplate voltage applied to its terminals. This was accomplished by optimum selection of transformer impedances, incorporation of no-load taps on all power and unit substation transformers, and a ± 10% automatic load tap changer on all the 13.8/4.16 station power transformers. All motor starters have a guaranteed drop out voltage of 70%. All starters were bought with 300 VA control power transformers, regardless of NEMA size, to minimize voltage drop at the contactor coil. Further, consideration was given to cable size and length to limit voltage drop in a feeder.

2-02

The analysis showed the worse sustained under-voltage condition imposed upon the distribution system occurred with a severely degraded 500 kV offsite system simultaneous with a concurrent LOCA on Unit 2 and Unit trip on Unit 1 (or vice versa). This under-voltage condition results from the automatic transfer of the group buses from the auxiliary power transformers to the station power transformer and the automatic start of the required vital bus loads. For this condition the lowest voltages at the 4.16 kV, 460V and 230V loads were .917, .923 and .91 per unit respectively. The above analysis indicates that the onsite distribution system and its components will operate within component voltage limitations. The motors are the limiting component under steady-state conditions as they are designed to run continuously at .9 per unit nameplate voltage.

Transient voltage drops due to the starting of motors were analyzed at each voltage level with no adverse effects. This analysis assumed the prestart voltage to be that corresponding to the degraded 500 kV system and the load in parallel with the motor being started equal to the maximum continuous rating of the transformer to which it is connected less the running load of the motor being started. Further, the impedance of the parallel load was conservatively assumed to decrease as the square of the bus voltage to analytically compensate for the additional current drawn by induction motors upon decrease in voltage. The minimum transient voltages obtained on the 4.16 kV, 460V and 230V levels were .86, .86 and .78 per unit, respectively, for a duration of approximately 5 seconds. These transients are within motor and motor starter design capabilities, thereby having no adverse effect on system operation. The results of this analysis were used to re-examine under-voltage protective settings and establish that no spurious separations of the safety buses from offsite power would occur.

The 5 kV power cables that connect the 13.8/4.16 kV station power transformers to the group and vital buses are the load limiting component in the distribution system. The sixteen hour rating of the cable is utilized for the load that results from the concurrent LOCA Unit 2 and Unit trip on Unit 1. There is sufficient margin between the cable rating and the resultant load to allow for implementation of existing station procedures used during the events analyzed and thus, avoid overloading.

As indicated in the NRC letter of August 8, 1979, tests had been previously run to correlate calculations with field conditions. With Salem Units 1 and 2 and the 500 kV system in an existing mode corresponding to a given loading of the plant distribution system, selected system parameters were monitored over a 24-hour period. An analysis was then performed using the actual load and 500 kV system voltage to obtain a calculated voltage profile and compare to actual measurements. The calculations and field measurements correlated within very reasonable accuracy, thus substantiating our assumptions and the method of calculation. The results are given in Attachment 1. Further, a test on a cold 6000 horsepower, 4.0 kV reactor coolant pump motor was conducted. The bus voltage dropped 15% upon start of this motor. No adverse effects were observed on other operating equipment. The results of this test substantiate the original plant design basis.

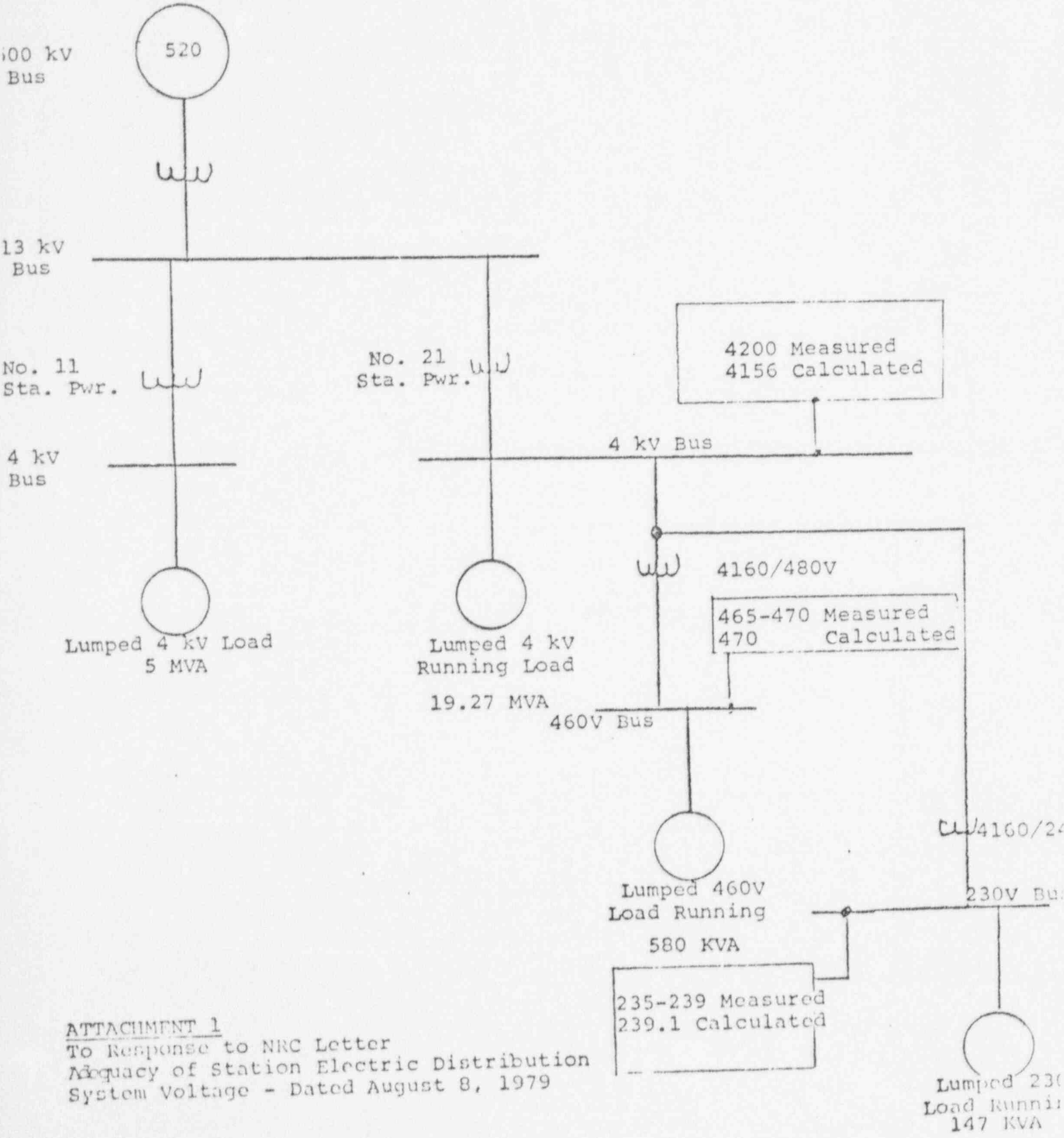
The electric power system was reviewed to determine if there are any events or conditions which could result in the simultaneous or consequential loss of required circuits to the offsite network that would violate GDC-17. No potential exists for violation of GDC-17.

ORIGINAL SIGNED
R. R. BAST

WSR:vlf
Attach:

CC R. L. Mittl
D. J. Jagt

SALEM GENERATING STATION, UNIT 2
VOLTAGE PROFILE
FIELD MEASUREMENTS VS. CALCULATIONS



ATTACHMENT 1
To Response to NRC Letter
Adequacy of Station Electric Distribution
System Voltage - Dated August 8, 1979

Appendix II

LOAD TABULATION

PURPOSE:

The purpose of the load tabulation is to arrive at a load that reflects the greatest plant loading for use in calculation of the voltage profile.

RESULTS:

The load profile is attached. The greatest load results with a simultaneous LOCA on Unit 2 and unit trip on Unit 1. In addition to initiating loading of the vital buses in Unit 2, the event(s) also initiate transfer of the group bus loads to the station power transformers.

The load limiting component was identified as the 5 kV power cables. Comparison of this to be load profile shows the cable to be within rating with adequate margin.

Further discussion is contained in PSE&G response to NRC 8/22/79 request and may be found in Appendix I.

3Q1 16A

LOAD TABULATION

METHOD AND ASSUMPTIONS

1. Using actual 4 kV motor data from PSBP 140032, 111059, 112305, 112653, 119349, 140042, 124584, 140041, 135633, 135634, 140040 and 112698 and one lines 203001, 203062, 203061, 203002 and 203004 motor quantities, full load horsepower, efficiency and power factor were obtained to calculate motor KVA using the relationship.

$$KVA = \frac{(HP)\ (.746)}{(pf)\ (eff)}$$

2. Pump BHP (brake horsepower) was used rather than motor nameplate HP if the former was well defined. Actual running data was used to determine a conservative reactor coolant pump BHP.

3. The attached sheets entitled Motor Operational Information was used as a reference.

4. Individual load KVA was conservatively assumed to be additive.

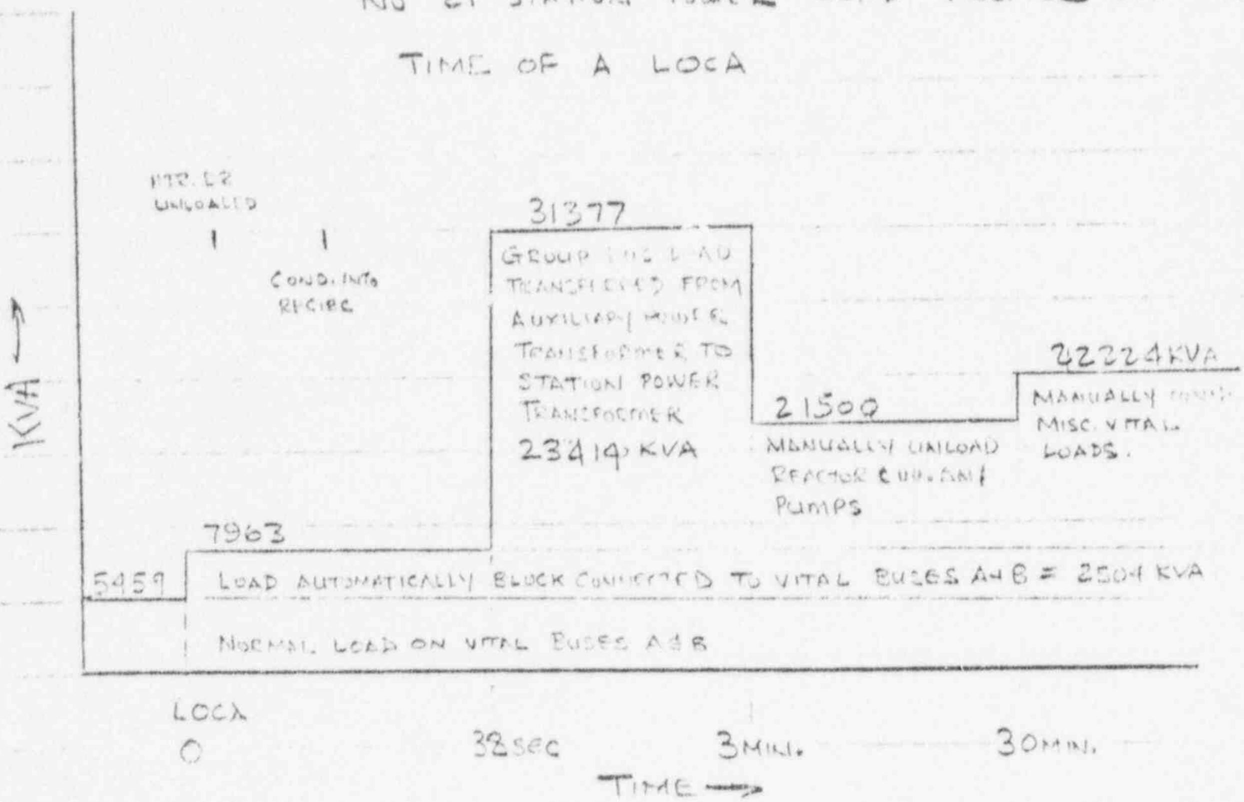
5. The attached one line shows the switching arrangement.

6. To arrive at a conservative maximum loading it was assumed that No. 1 station power was carrying 4 of 6 vital buses (normal switching it would carry 3) and that the 4 kV loads were aligned to give the maximum.

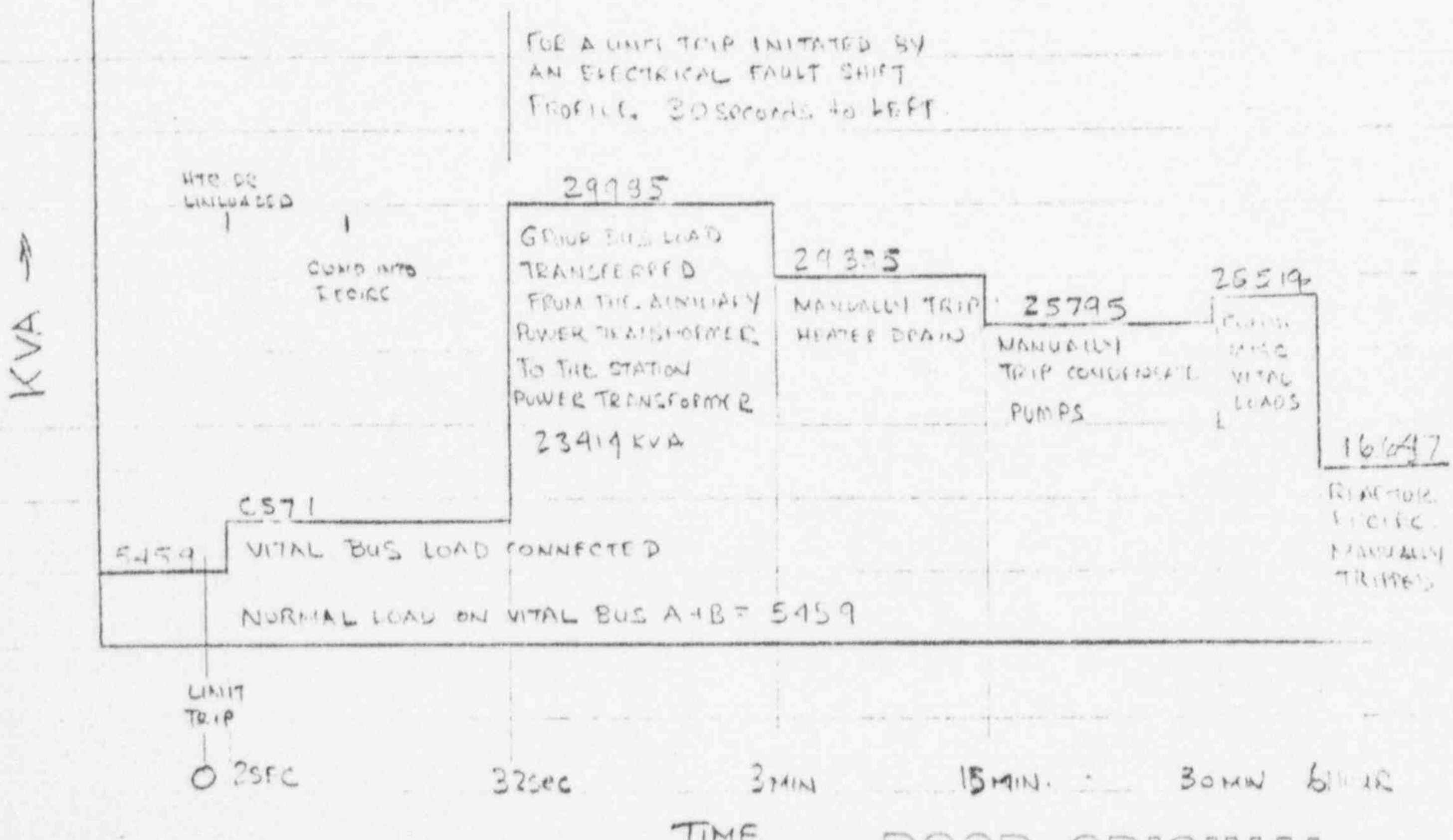
3Q1 17A

LOAD PROFILE

NO 21 STATION POWER LOAD PROFILE AT THE TIME OF A LOCA



NO 11 STATION POWER LOAD PROFILE FOLLOWING A UNIT TRIP

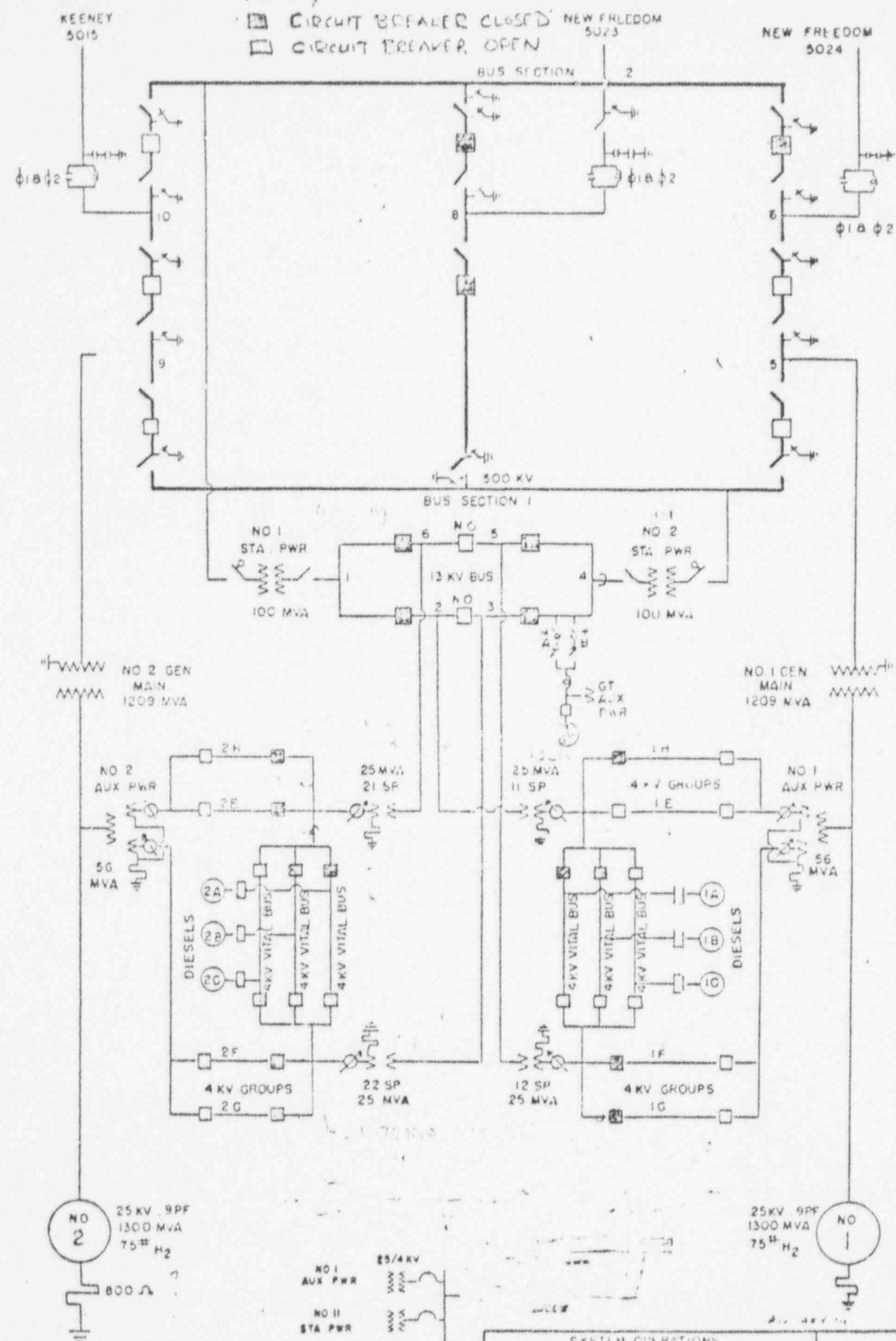


Components Load Limitations

The limiting component in the Salem distribution system are the 5kV power cables which are connected between 13.8/4.16 station power transformers and the group and vital buses. Six (6) 1250 MCM cables are connected per phase and are rated as follows:

Time	Rating
Up to 2 Hrs.	40 MVA
Up to 16 Hrs.	33.5 MVA
Up to 24 Hrs.	30 MVA
Continuous	25 MVA

SWITCHING ARRANGEMENT (5)



SYSTEM OPERATIONS

SALEM GEN. STATION

PUBLIC SERVICE ELECTRIC & GAS COMPANY

ELECTRIC PRODUCTION DEPARTMENT

REV 6-9-77

POOR ORIGINAL

MOTOR OPERATIONAL INFORMATION

1. Circulating water pump motor. Six at 2000 Hp each.

   Pump BHP under normal full load conditions is 1511 Hp. Run all six during startup, full load, shutdown and LOCA with offsite power. 70% starting voltage.

2. Condensate pump motors. Three at 3000 Hp each.

   During startup use one initially and add others as it is desired to buildup feedwater pressure. Run three at full load. Ten seconds after the unit trip pumps go into recirculation automatically for which BHP is 1900 Hp. Operator takes out of service about 15 minutes after unit trip. 70% starting voltage.

3. Heater drain pump motor. Three at 1000 Hp each.

   Use when at load. Connect when at approximately 30% load coming up. Unload automatically two seconds following a unit trip for which BHP is approximately 720 Hp. Operator takes out of service about 3 minutes after unit trip. 70% starting voltage.

4. Turbine auxiliary cooling pump motors. Three at 400 Hp each.

   One runs most of the time. Run three with unit at full load. Can run two but with additions to TAC system the former is the case. Run at least two approximately 4 hours after a unit trip. 70% starting voltage.

5. Air compressor motor. Three at 1000 Hp.

   This is a common system between Units 1 and 2. One run continuously per unit with the other motor in automatic standby. 70% starting voltage. BHP is approximately 800 Hp.

WMR

6. Reactor coolant pump motor. Four at 6000 Hp.

   Run all four on startup, full load and shutdown. After a LOCA, operator trips all four when reactor pressure drops to 1550 psi. When initially started BHP is approximately 7200. As the water heats up the horsepower drops off to normal running BHP. Normal running BHP used in calculation was 5600 Hp corresponding to the maximum current on No. 13 reactor coolant pump from field test of 11/30-12/1, 1976. 80% starting voltage.

7. Service water pump motor. Six at 1000 Hp.

   Three are required for full operation but plant usually runs four for startup, full load and unit trip. Minimum of three, one per vital bus for LOCA. Impeller has been changed from original design. BHP during normal full load operation and is approximately 950 Hp.

6. (Reactor coolant supplement.)

   ~~Following a LOCA~~, RCP's are tripped when reactor pressure reaches ~~1550 psi (E.I. I-4.0)~~. Following a unit trip pumps are operated as follows: 4 (Tav 547-400); 3 (Tav 400 to 350F); 2 (350 to 250F) and 11&14 or 12 and 13; ≥ 250°F run 1, 13 or 11 (OI I-3.6). See attach P, T vs I and Tech Spec Fig. 4.9.1a, 4.4.4.2.

WJR

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
ENGINEERING AND CONSTRUCTION DEPARTMENT

THE FOLLOWING: MOTOR LOAD AND VITAL SYSTEMS INFORMATION

REACTIVITY CONTROLS SYSTEMS
(Re: SA-1 Tech Spec 3/4.1-1 628)

One charging pump shall be operable during shutdown. Two charging pumps shall be operable during reactor operation. One boric acid tranfser pump shall be operable during the shutdown period. Two boric acid transfer pumps shall be operable during reactor operation.

EMERGENCY CORE COOLING SYSTEMS
(Re: SA-1 Tech Spec 3/4.4-1634)

ECCS Subsystems - T Average greater than or equal to 350°F

Two separate and independent ECCS Subsystems shall be operable with each Subsystem comprised of:

A. One operable centrifugal charging pump

B. One operable safety injection pump

C. One operable residual heat removal pump

ECCS Subsystems - T Average less than 350°F, one ECCS Subsystem comprised of the following shall be operable:

Same as AB&C above.

Containment Cooling System (Re: 3/4.6-15)

Three separate and independently powered groups of containment cooling fans shall be operable with two fans systems to each of two groups and one fan system comprising of the third group. If one group of cooling fans is inoperable, either restore the inoperable fan group to operable status within 48 hours or be in hot shutdown within the next 12 hours.

WSR

Auxiliary Feedwater Pumps (Re: 3/4.7-5)

The Auxiliary Feedwater System in each unit is equipped with two parallel pumping systems for redundancy. The first system is composed of two AC motor driven feedwater pumps each of which is sized to supply cool down water to two of the four steam generators. The second system is composed of one steam turbine driven pump. This pump is sized to supply cool down water to all four steam generators. The unit has to be shutdown with one auxiliary feedwater pump motor out of service.

At least three generator auxiliary feedwater pumps shall be operable with two motor driven feedwater pumps, one steam turbine feedwater pump.

Component Cooling Water (Re: 3/4.7-12)

Three component cooling pumps are provided to circulate the component cooling water. Two independent component cooling water loops shall be operable as a limiting condition for operation.

Service Water System (Re: 3/4.7-15)

Two independent service water loops shall be operable.

Four out of six service water pump motor will be sufficient to run the unit at 100% capacity. We have to lose three motors to require shutdown of the plant.

Control Room Emergency Air Conditioning System (Re: 3/4.7-16)

The Control Room Emergency Air Conditioning System shall be operable.

Auxiliary Building Exhaust Air Filtration System (Re: 3/4.7-19)

Three separate and independent auxiliary building exhaust air HEPA filter trains, one charcoal absorber train and three exhaust fans shall be operable. With one auxiliary building exhaust air filter train or one exhaust fan inoperable, restore the inoperable train to operable status within seven days or be in cold shutdown.

WSR

Refueling Operations Coolant Circulation

A minimum of one residual heat removal pump shall be operable.

Residual Heat Removal System

The residual heat removal system consists of two independent loops, two residual heat removal pumps rated at 400 HP. Two separate and independent ECCS Subsystems shall be operable within each subsystem comprised of one operable residual heat removal pump. With one ECCS Subsystem inoperable restore the inoperable to operable status within 48 hours or be in hot shutdown within the next 12 hours.

Reactor Coolant System

Four reactor coolant loops are in service during normal operation with one reactor coolant loop and associated pump not in operation reduced thermal power level to 76% of rated thermal power.

Fuel Handling Area Ventilation

Fuel Handling Area Ventilation System should be operable during either fuel movement within the spent fuel storage pool or crane operation with loads over the spent fuel storage pool. Fuel Handling Area Ventilation System shall be operable whenever the irradiated fuel is in the storage pool. Only one supply air unit provided.

Switchgear Room Ventilation System

Three supply air fans to supply air to switchgear room which are located on the elevation 84 and 64 of the Auxiliary Building. Normally two of the three supply fans are operated with the third in standby. Three fans on elevation 84 and the three fans on elevation 64 operate to exhaust switchgear rooms to the return duct.

WSR

48t

Control Air Conditioning System

Normal system consists of three fans, two normally operating and one standby. Emergency system operates upon actuation of safeguard system consisting of two fans, (one standby).

Safety Injection Pump

SIS this design is to insure that the following minimum SIS equipment per unit operates in the event of an S signal:

One out of two centrifugal charging/safety injection and one out of two safey injection pumps.

WSR:cm

11/14/79

5K2 39/42-A

WSR

GROUP BUS LOAD TABULATION

	Motor	QTY	Full load HP (BHP)	Full load eff	Full load p.f.	KVA	Running KVA: F.L	Running KVA: Unit Trip	Running KVA: LOCA and Unit Trip [illegible]
1.	COND	3	3000	.95	.916	2581	7743	7743	7743
2.	HTR DR	3	1000	.936	.913	873	2619	2619	2619
3.	CIRC. WTR	6	2000 (1511)	.935	.916	(1646)	9876	9876	9876
4.	R.C.P.	4	6000 (5600)	.93	.91	(4936)	19745	19745	19745
5.	TAC	3	400	.925	.915	353	1059	706	706
6.	COMP AIR	1	1000	.957	.906	874	874	874	874
7.	UNIT SUBS:								
	a. E, EP, G, GP		1000				3400	3400	3400
	b. F, H		1333				2666	2666	2666
	c. CIRC WTR, FL, HL		750						
	F(750), H(750)								
	SWYD, BOAT						3375	3375	3375
						TOTAL	47982	47629	47629

NOTES

1. ( ) Brake horsepower
2. (7a.) KVA totals arrived at by adding 1000 for E, 1800 for EP & GP and 600 for G.

   (7b.) KVA total arrived at by adding 1333 + 1333.

   (7c.) " " " " " " 750 for F, H and 375 for FL, HL circ. wtr, swyd and ferry boat.
3. If BHP used to calculate KVA p.f. and eff at actual BHP was also used.

VITAL BUS LOAD TABULATION.

						RUNNING KVA		
MOTOR	QTY	Full load HP (BHP)	Full load eff p.f.		KVA	F.L.	UNIT TRIP	LOCA AND UNIT TRIP
1. SER WTR	6	1000 (950)	.941	.887	(850)	3400	3400	3400
2. COMP CLG	3	300	.927	.877	276	552	552	552
3. RHR	2	400 (410)	.94	.9	(362)	0	0	724
4. SIS	2	400 (375)	.902	.891	337	0	0	674
5. CONT SP	3	400 (375)	.936	.904	(331)	0	0	662
6. AUX FD	2	600 (450)	.94	.9	(396)	0	792	792
7. CHARG. PP	2	600 (650)	.942	.901	(557)	533	1144	1144
8. UNIT SUBS:								
(a) 750	2					1000	1000	1000
b 300	3					900	900	900
c 1000	1					900	900	900
						7285	8673	10748

NOTES:

1. ( ) indicates BHP

LOAD FLOW

GROUP BUS LOAD FLOW

(21)

11 STATION PWR CARRIES E+H GP. BUSES

= 2 COND, 1 HTR DR, 3 CIRC, 1 AIR COMP, 1 TAC, 2 RCP

UNIT SUBS HL, SWYD, H(400), H(230), E, IEP

= 2581(2) + 873 + 1646(3) + 874 + 353 + 4936(2)

+ 375 + 375 + 1333 + 750 + 1000 + 1000 +

= 25259 KVA

auto unload (2581 - 1770)2 + (873 - 650) = 1845

25259 - 1845 = 23414

(22)

12 STATION PWR CARRIES F+G GR. BUSES

= COND, 2 HTR DR, 3 CIRC, 2 TAC, 2 RCP

UNIT SUBS FL, BOAT, F(400), F(230), CW, G, GP

= 2581 + 873(2) + 1646(3) + 353(2) + 4936(2)

+ 375 + 200 + 1333 + 750 + 375 + 1000 + 800

= 24676 KVA

LOAD FLOW

VITAL BUS LOAD FLOW

NORMAL FULL LOAD

A: COMP CLG, 2 SER WTR, UNIT SUBS

276 + 2(850) + 750 + 300 = 3026 KVA

B: SER WTR + CHRG PP + UNIT SUBS

850 + 533 + 750 + 300 = 2433 KVA

C: SER WTR + UNIT SUBS

850 + 1000 + 300 = 2150 KVA

3026
2433
5459

UNIT TRIP.

A COMP CLG, 2 SER WTR, UNIT SUBS + + AUX FD

276 + 2(850) + 750 + 300 + 337 + = 3422

B. SER WTR, CHRG PP, UNIT SUBS, COMP CLG, AUX FD

850 + 577 + 750 + 300 + 276 + 396 = 3149

3422
3149
6571

C SER WTR + UNIT SUBS, CHRG PP, SIS

850 + 1000 + 300 + 577 + = 2727

LOCA:

A: UNIT TRIP + RHR + CONT SP

3759 + 362 + 331 = 4452 KVA

B: UNIT TRIP + RHR

3149 + 362 = 3511 KVA

C UNIT TRIP + CONT SP.

3064 + 331 = 3395 KVA.

Appendix III

VOLTAGE PROFILE

General Discussion

The voltage profile with a given plant must be examined for both steady, state and transient conditions.

This voltage profile is largely depended upon two variables, those being the system voltage regulation at the terminals of the plant and the plant load regulation. The steady state profile can be most readily examined by analyzing the end points. The lowest possible steady voltage will result with the lowest attainable system voltage coupled with the greatest plant load. The highest voltage possible will be with the highest attainable system voltage and the least amount of plant load. All other voltage profiles resulting from other plant loads or system conditions would lie between these two points. The resultant profiles must then fall within the component voltage limitations which will be discussed later.

The greatest voltage drop resulting from transient conditions usually results from the start of the largest motor at each voltage level, coupled with the greatest plant load and the lowest system voltage. Bus transfer should also be examined.

WSR:pd

2Q2 39

SUMMARY OF RESULTS

1. The greatest sustained voltage drop results with the 500 kV system degraded to .978 per unit with a simultaneous unit trip on Unit 1 and a LOCA on Unit 2. For this condition the 13.8 kV bus drops to .903 per unit, Units 2, 4.16 kV vital and group buses dropped to .9226 per unit with the voltage at the 4.16 kV, 460 V and 230 V loads dropping to .917, .923, and .91 per unit respectively. This condition lasts for approximately three minutes until the reactor coolant pumps are tripped after which the profile improves. This profile is summarized on page ____. The LTC will also move to improve this condition in 5/8% increments and 30 seconds per increment. (No credit was taken for the LTC action at this time.)

2. The highest voltage results with the 500 kV system voltage at 1.06 per unit and hypothetical loads on each bus.

3. The greatest transient drop on the 4.16 kV vital system results upon the start of a 6,000 hp reactor coolant pump motor. This transient is worse than correction of the vital loads upon the occurrence of a LOCA. Postulating a prestart condition corresponding to the 500 kV voltage degraded to .978, Unit 1, 4.16 kV loaded to the maximum continuous full load rating of the 13.8/4.16 kV station power transformer and the reactor coolant pump motor being started against a transformer which is loaded to its maximum full load rating less the KVA corresponding to the RCP, the voltage on the 4.16 kV group and vital buses drops to .8692 per unit. The voltages at te 460, 230 volt loads dropped to .8692 and .8543 per unit respectively. The 460 volt and 230 volt loads selected were those with the greatest circuit impedance and horsepower representing the greatest drop. This condition lasts for approximately 25 seconds.

4. The transient analyzed on the 460 volt vital bus was upon the simultaneous start of the chiller, auxiliary building supply and vent fans and the switchgear room supply fans which results upon a LOCA signal. This corresponds to 255 Hp. The prestart condition was with the 4.16 kV sustained voltage condition in 1 above and the 460 volt load hypothetically postulated at the maximum continuous rating of the transformer less the KVA of the motors being started. This transformer also has the greatest per unit impedance of all the 460 volt vital transformers. The resulting 460 bus voltage was .8608 per unit. Individual motor starting times are approximately 5 seconds.

5. The transient analyzed on the 230 volt vital bus was the start of a 30 hp motor on feeder 2B3Y. This load was found to be the largest load on the smallest cable, the greatest distance from the source corresponding to the greatest circuit impedance and result in drop (see page 31). The prestart conditions correspond to the sustained 4.16 kV voltage conditioned in 1 above with the transformer upons which the load was being started equal to the maximum rating of the transformer. The resultant MCC voltage was .8739 and .7854 at the load.

WSR:aec

3L1 03/04C

Discussion of Results

The results must be viewed in view of the component voltage limitations which are summarized on the attached sheet.

The calculations were done with a great deal of conservatism.

Conservative factors were:

1. The 500 KV system minimum steady state voltage is under an extremely unlikely combination of circumstances.

2. Credit was not taken for the action of the 13.8/4.10KV station power transformer load tap changer after the event.

3. Margin was added to the actual load KVA.

4. The resultant voltage profile at each voltage level is for the limiting case.

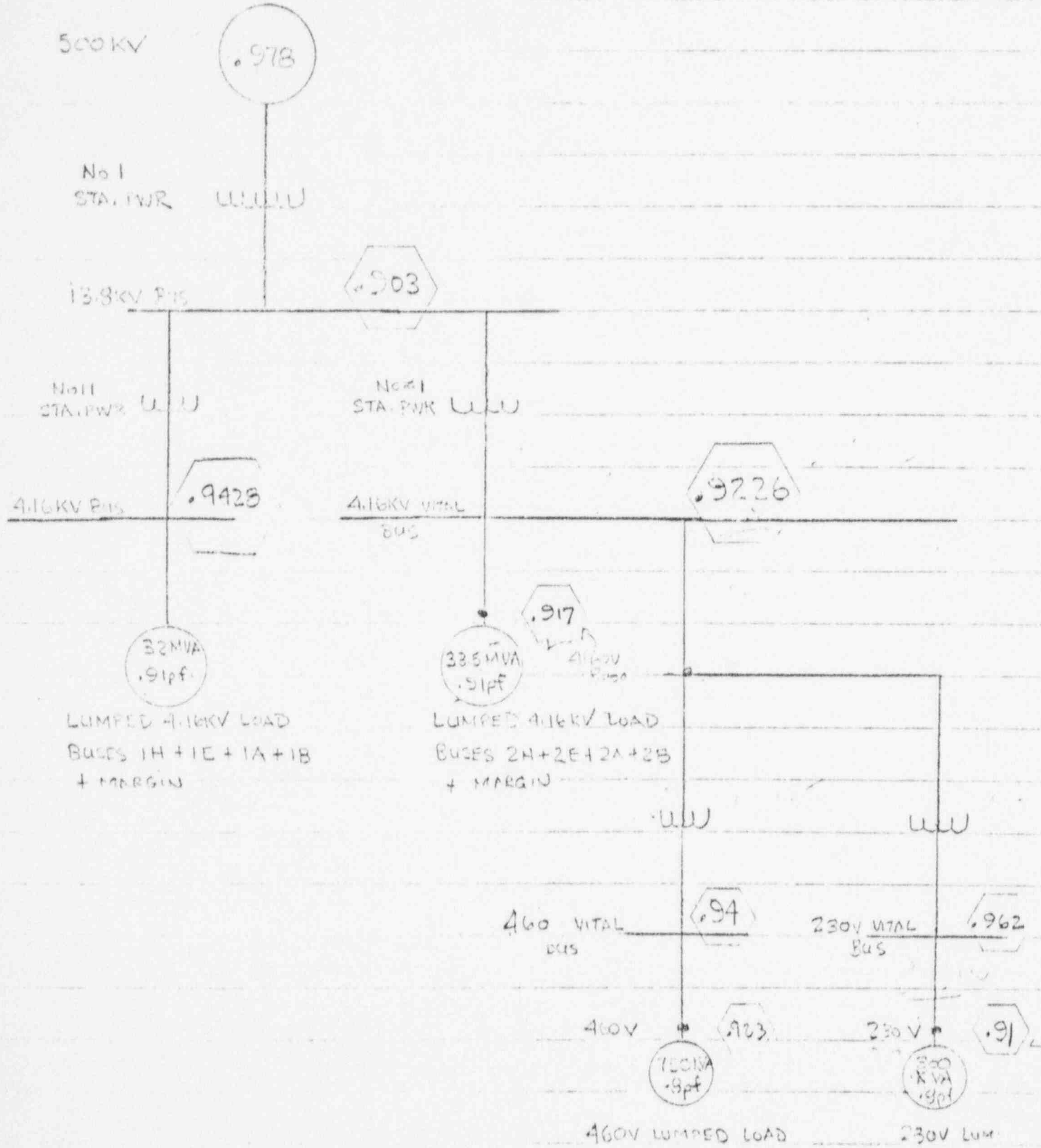
The PSE&G response serves as discussion of the results.

Component Voltage Limitations

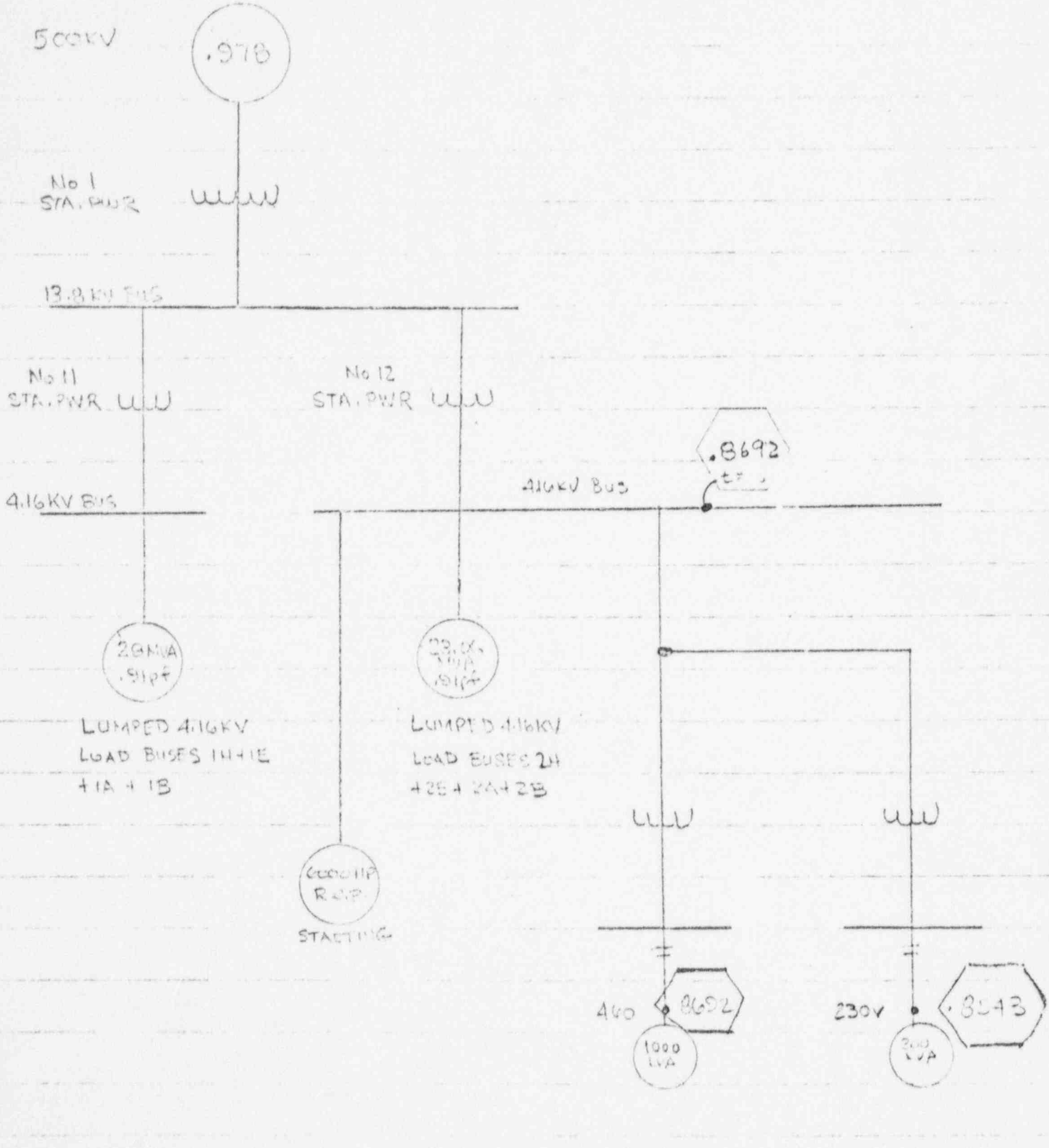
1. Transformers:
   - A. Plus 10% secondary nameplate voltage at no load.
   - B. Plus 5% secondary nameplate voltage at load.
2. Motors:
   - A. ± 10% nameplate voltage
   - B. Motor breakdown torques minimum of 175% full load torque.
3. Contactors: All contactors are made by GE which have the following characteristics:
   - A. Dropout: 32-58% in 7-12 MS, guarantee 70%.
   - B. Pullin: 56-87% in 13-35MS, guarantee 85%.

VOLTAGE PROFILE

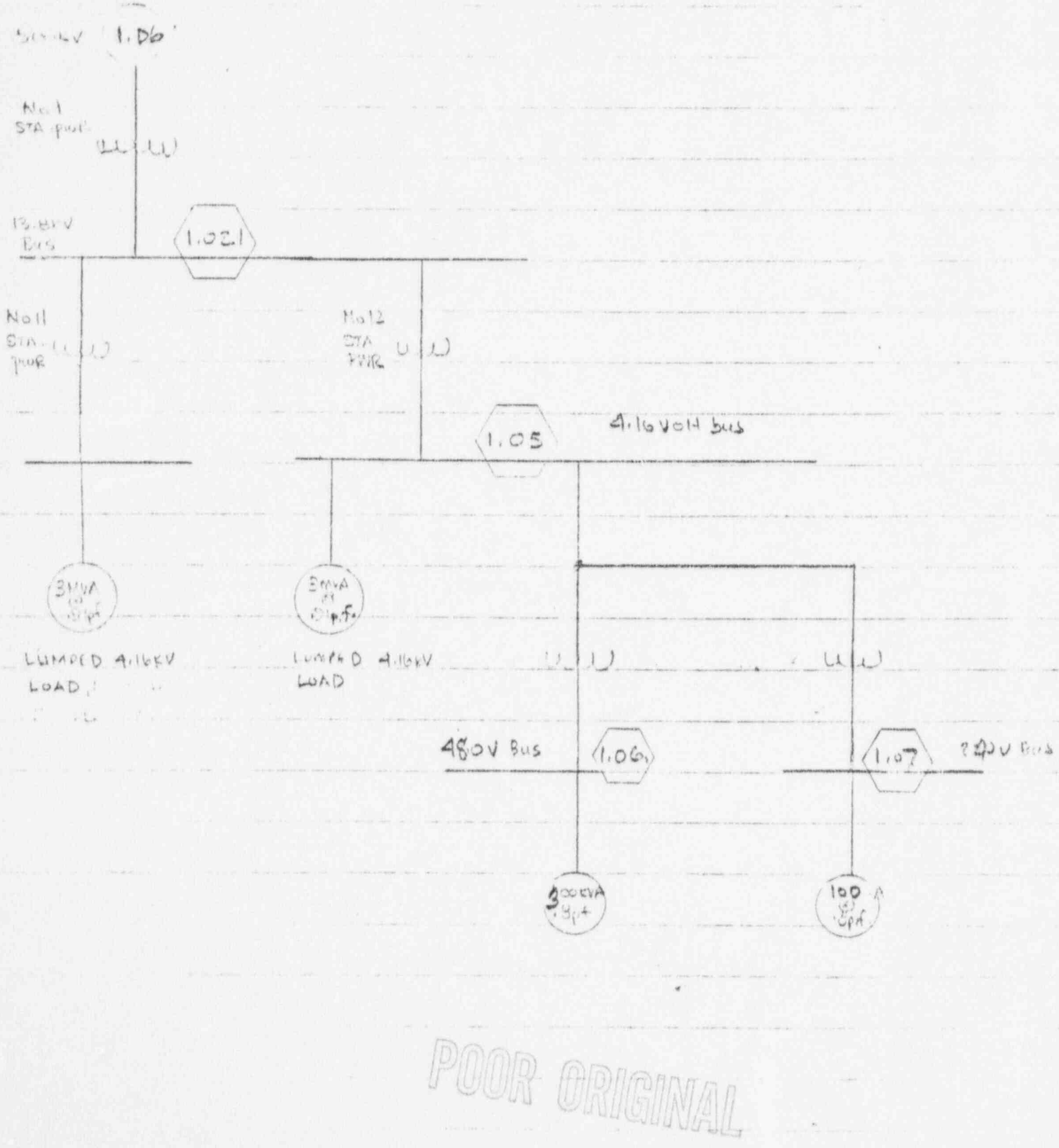
CORRESPONDING TO MAXIMUM LOAD DURING A LOCA ON UNIT 2 AND UNIT TRIP ON UNIT 1 AND SUSTAINED 500KV GRID DEGRADATION. DURATION IS APPROXIMATELY 3 MINUTES.



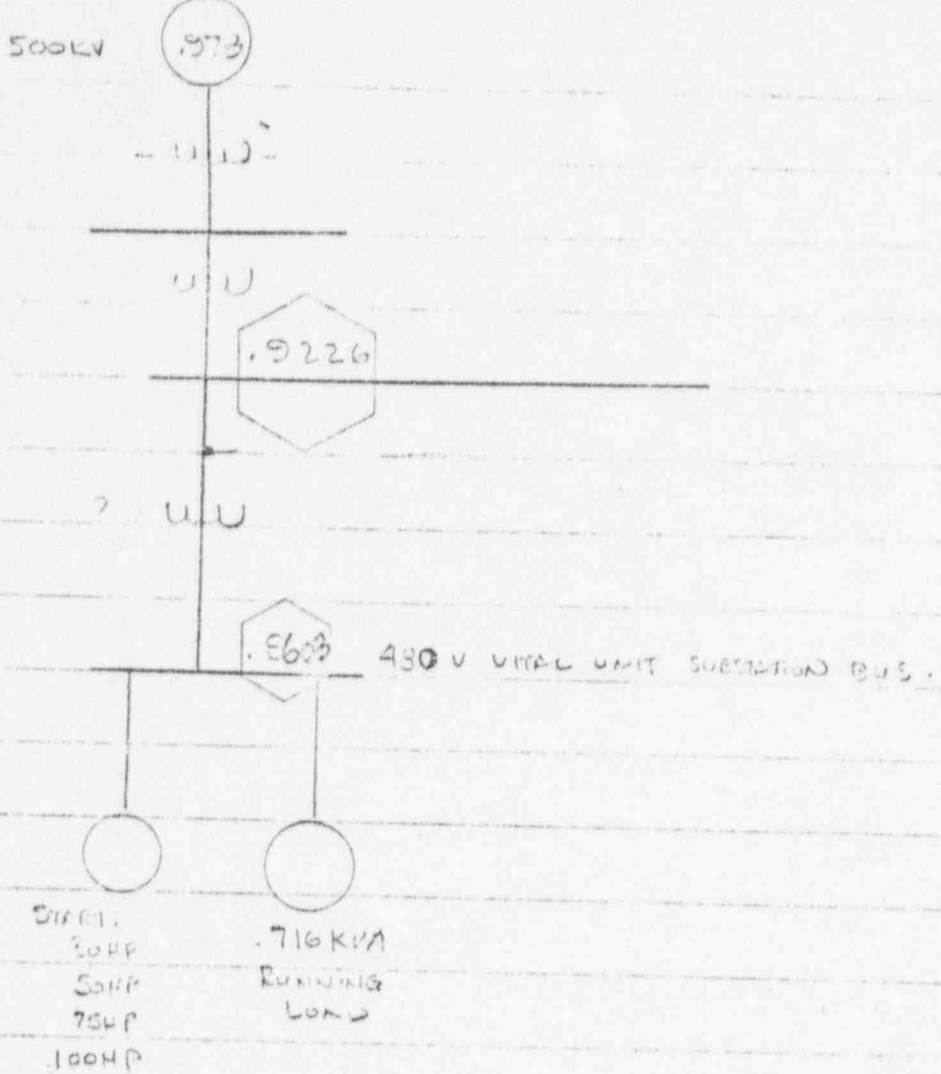
TRANSIENT
VOLTAGE PROFILE
REACTOR COOLANT PUMP MOTOR START UNDER
ADVERSE SYSTEM AND PLANT CONDITIONS



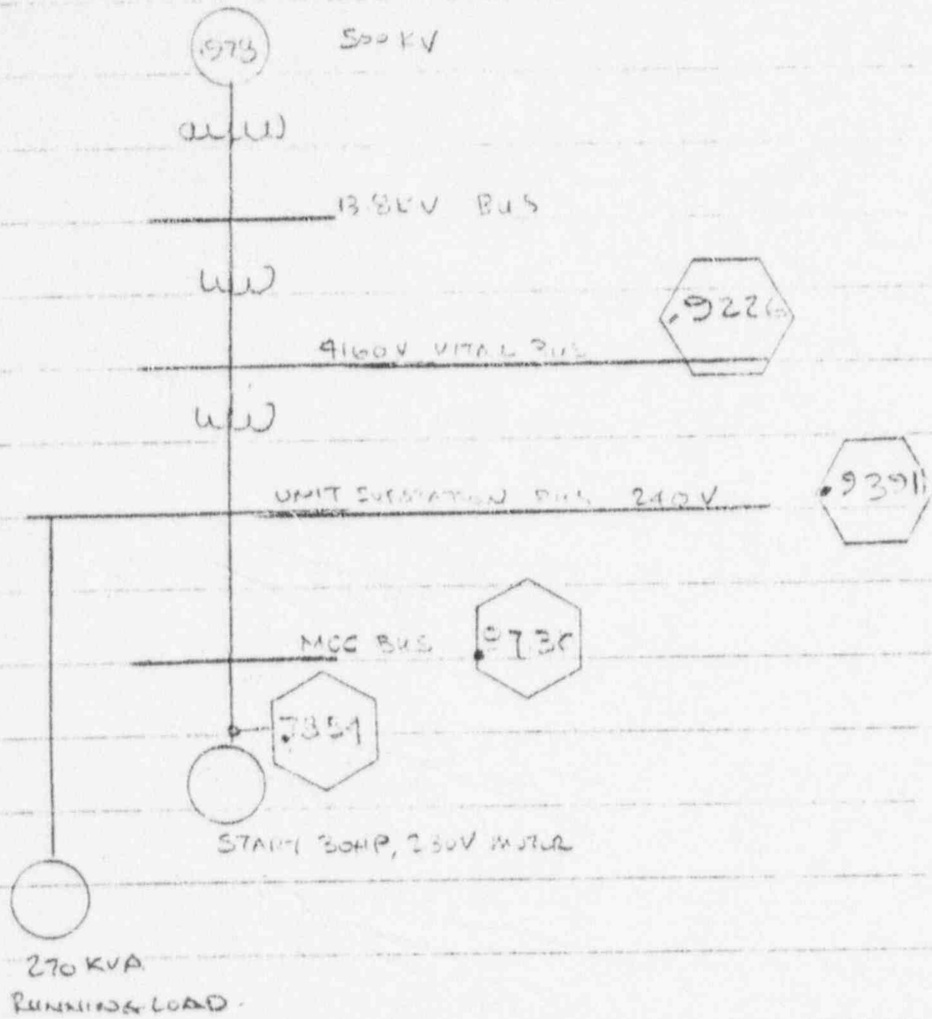
STEADY STATE
VOLTAGE PROFILE
LIGHT LOAD AND OPTIMUM 500KV VOLTAGE



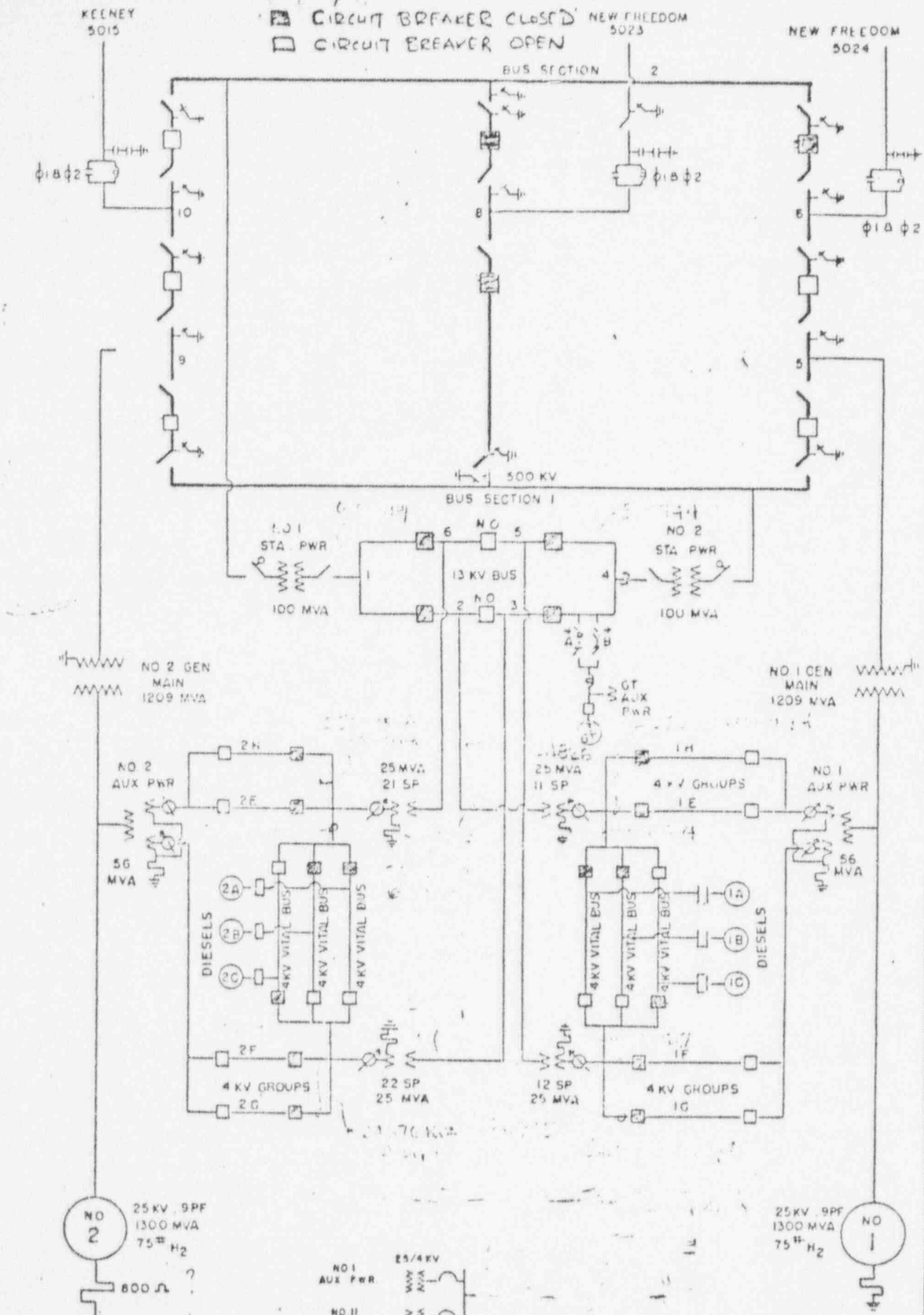
TRANSIENT
VOLTAGE PROFILE
BLOCK LOADING OF 4160V VITAL BUS.



TRANSIENT
VOLTAGE PROFILE ON
230V VITAL BUS



SWITCHING ARRANGEMENT



SYSTEM OPERATIONS

SALEM GEN. STATION

PUBLIC SERVICE ELECTRIC & GAS COMPANY

ELECTRIC PRODUCTION DEPARTMENT

REV 6-9-77

4160 V VOLTAGE PROFILE

METHOD AND ASSUMPTIONS

1. One line (attached) shows switching arrangement.
2. All transformer impedance was assumed to be reactive.
3. All transformer impedances were obtained from the transformer nameplates. The greatest impedance of a group of identical transformers were used.
4. Calculations were worked in per unit on a 1 MVA, 500 kV base.
5. Okonite Cable Bulletin was used as a reference to obtain cable impedance data.
6. 4 kV loads were assumed at .91 p.f. This allows some margin.
7. Approximately 2 MVA was added to the loads on 11 and 21 station power transformer for margin.
8. Cable impedances were used.
9. PSE&G memorandum dated 10/31/78, part IV was used to obtain lowest system voltage. This memorandum makes very conservative assumptions of its own. The increase in the load flow into Salem at 500 kV has an insignificant effect on the final result. This memorandum may be found in Appendix.
10. The 500 kV system which is a minimum of approximately 5000 MVA represents a negligible impedance (i.e. 1/5000 = .0002 against final circuit impedance of [illegible].017) loading on No. 1, 11, 21 station power transformer.

3Q1 18A

VOLTAGE STUDY.

PER-UNIT DEVELOPMENT

Work on 1MVA, 500KV base.

1. No 1,2 STAT. PWR. 500/13.8KV on no load tap 512.5KV

$Z = 10.79\%$ on 60MVA (Transformer nameplate)

Z_{pu} $\frac{.1079}{60} = j.001798$

2. No 11, 12, 21, 22 STA. PWR 13.8/4.16KV on no load tap 13.455KV

Greatest impedance of 4 is 5.8% on 15MVA (Transformer NP)

$Z_{p.u} = {.058}/{15} = j.00386$

3. MAXIMUM LOADS (Reference load profile and add KVA for margin)

Load on 21 STA. PWR 33,500 KVA @ .91 p.f (assumed p.f.) (~2100KVA marg

$= \frac{1}{33.5}(.91 + j.414) = .0271 + j.0123 = .0297 \angle 24.41$

Load on 11 STA. PWR 32,000KVA @ .91 p.f (assumed p.f.) (~2000KVA margin

$= \frac{1}{32}(.91 + j.414) = .0284 + j.0129 = .03125 \angle 24.41$

4. CABLES

13KV: 1750MCM, 150', 15" spac. Per Okonite Bulletin 721, p. 8 and 10

$X = .074\,\Omega/1000' = .033\,\Omega$ for 150'

POOR ORIGINAL

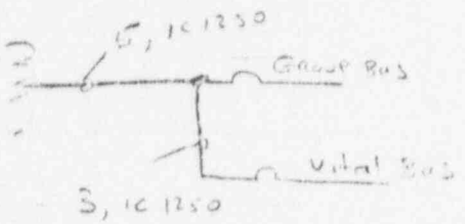
VOLTAGE STUDY
PER UNIT DEVELOPMENT CONTINUED

R = .00604 Ω/1000′ = .0027

$Z_{p.u.} = \frac{Z_\Omega (KVA_{base})}{10 (KV)^2\ 100} = \frac{Z_\Omega (1000)}{1000 (13.8)^2} = Z_\Omega (.00525)$

$Z_{p.u.} = (.0027 + j.033).00525 = \underline{.000014 + j.00017}$

4KV cables: Consists of 6 1/C 1250 MCM in parallel / φ running 350′ and 3 1/C 1250 MCM in parallel / φ running 250′



Using Okonite Bulletin 721, p. 3 & 10

R = .00846 Ω/1000′

X = j.024 Ω/1000′

$Z = (.00846 + j.024).35 = .0029 + j.0084 = .0089\angle 71$

$Z_{p.u.} = .0089\angle 71^\circ (1/4.16^2) = .0089\angle 71^\circ (.0577) = .0005 \angle 71^\circ$

6 in parallel = $.0001\angle 71 = .000032 + j.000094$

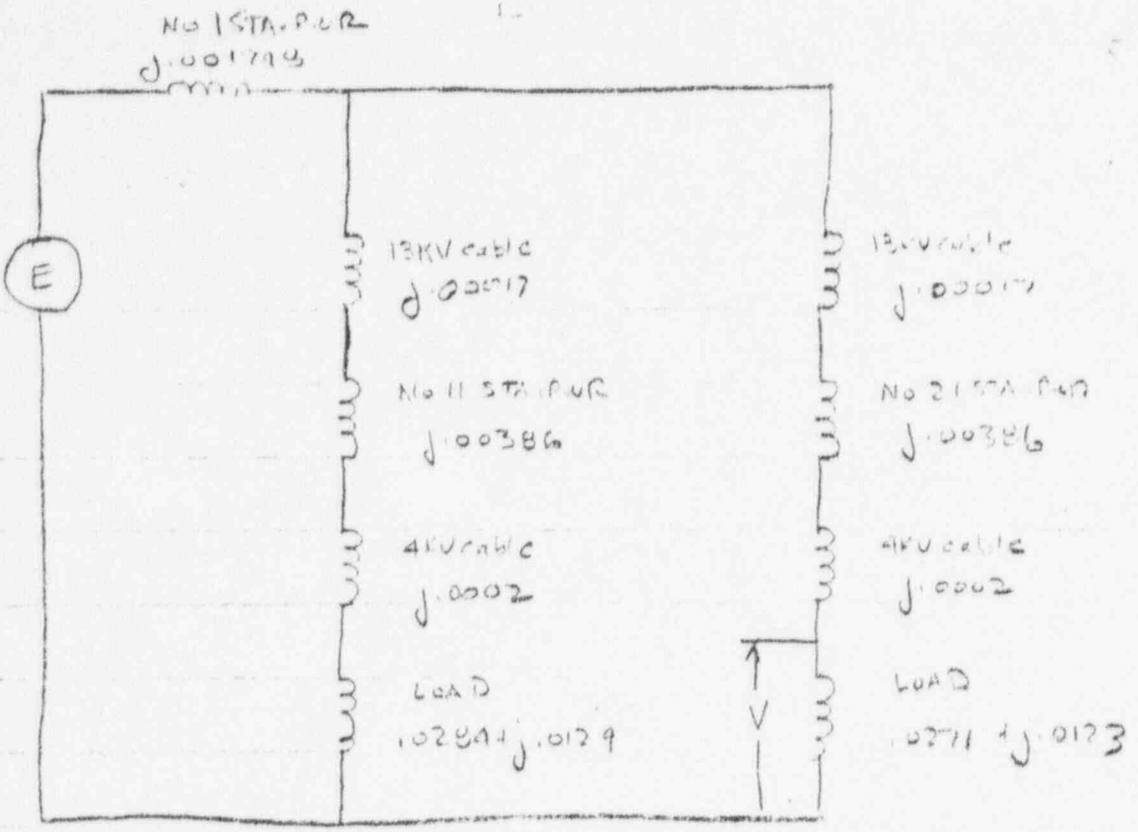
$Z_{p.u.} = (.00846 + j.024)(.25)(.0577) = .000122 + j.00034 = .00036\angle 71$

3 in parallel = $.000119\angle 70.2 = .000039 + j.00011$

$\underline{Z_{TOTAL} = .000071 + j.000204}$

POOR ORIGINAL

Using per unit impedances the following one line is developed



Reducing the one line:

$j.00017 + j.00386 + j.0002 + .0284 + j.0129 = .0284 + j.01713 = .0331 \angle 31.09$

$j.00017 + j.00386 + j.0002 + .0271 + j.0123 = .0271 + j.01653 = .0317 \angle 31.38$

$$\frac{[.0331 \angle 31.09][.0317 \angle 31.38]}{(.0284 + .0271) + j(.01713 + .01653)} = .01616 \angle 31.24 = .0138 + j.0083$$

$.0138 + j.0083 + j.001793 = .0138 + j.01 = .0170 \angle 35.92$

$$|V| = |E| \frac{.01616(.0297)}{.0170(.0317)} = .9505(.9369) = (.8905)$$

Taking N.L. TAPS in ACCOUNT MULTIPLY BY $\left(\frac{500}{512.5}\right)\left(\frac{13.8}{13.455}\right) = 1.0$
thus they are offsetting

POOR ORIGINAL

From PSEG memo dated 10/31/78, part IV the lowest voltage is 97.8% on a 500KV Base

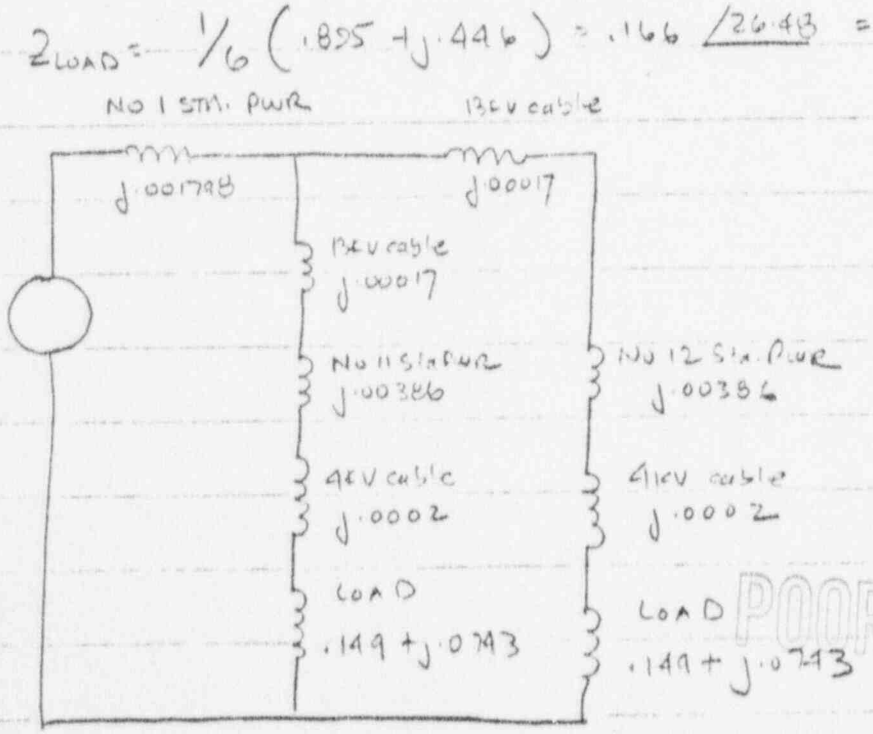
$|V| = .978(.8905) = .8709$

The LTC on the 13.8/4.16 Station Power transformers will provide and additional 10% correction. The resultant voltage would therefore be $(1.1)(.8709) = .958$ on a 4.16KV base. LTC would be on R16.

However this represents the final voltage after the LTC has had a chance (time) to correct.

It is needed to know the tap that the LTC w...
(11)
the event. The load on 21 STA. PWR was
at .895 p.f. Using 6.0 MVA @ .895 p.f. to allow
the tap can be found as follows.

$$Z_{LOAD} = \frac{1}{6}(.895 + j.446) = .166\,\angle 26.48 = (.149 + j.074)$$



This circuit reduces as follows.

$j.00017 + j.00386 + j.0002 + .149 + j.0743 = .149 + j.0803 = .1692\angle 28.3$

$.1692\angle$ in parallel with $.1692\angle = .0846\angle 28.32 = .0745 + j.0402$

$.0745 + j.0402 + j.001798 = .0745 + j.0419 = .0855\angle 29.35°$

Apply system voltage of .978 and referencing initial circuit reduction

$$|V| = .978\left(\frac{.0846}{.0855}\right)\left(\frac{.1666}{.1692}\right) = .974$$

LTC is set to maintain 124 V on a 4200/120V potential transformer. Conservatively use 123 V due to Bandwidth tolerance. The tap will be

$$\frac{4200}{120} \times \frac{123}{4160} = 1.0348 \text{ p.u. voltage}$$

$\therefore$ a correction of $\frac{1.0348}{.974}$ or 1.0624 is required

LTC moves in 5/8 % increment so corresponding tap is on R9-R10.

Apply this result the initial voltage at the instant of the transfer is $.8709(1.06) = \underline{\underline{.9226}}$ on a 4160V base.

Note; that this is the initial voltage and every 30 seconds the LTC will move 5/8 % to further correct voltage. We will not take credit for this at this time. Use .9226

The 13KV voltage is

$$|V_{13.8}| = .979\left(\frac{.01616}{.017}\right)\left(\frac{500}{512.5}\right) = .979(.9505)(.975)$$

$$= .903$$

The 4KV voltage on 1 std. pur is

$$= .979\ \frac{.01616}{.017}\left(\frac{.03125}{.0331}\right)$$

$$= .8974$$

Similarly LTC on R9 level set @ 1.124 V

$$= .8974(1.0624) = .9978$$

.95

The voltages at the loads is evaluated as follow:

All the 4KV vital motor loads are connected with 2/0 cable. The longest run (1219') and greatest load (124 Amps) is the service water pump motors. Using the Okonite Cable Bulletin for 2/0

R = .0795 AC/DC = 1.001 O.D = 2.2 1' spacing X = .1

$Z_{3700} = (.0795(1.001) + j.1)\frac{1219}{1000} = .097 + j.2 = .15\angle\Omega$

Volt drop = .15 (124) = 18.6 volts or .44% on 4160V

∴ use .5% on vital bus loads.

RCP START

1. Actual motor data was used.

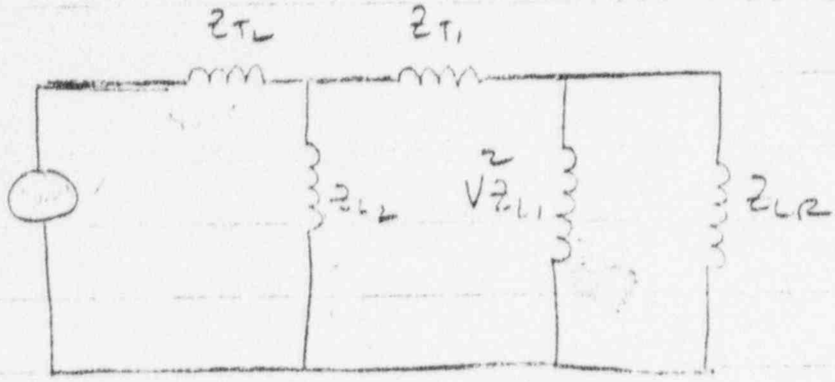
2. In order to achieve a conservative result the following method was utilized. (Ref. one line.)

   The greatest drop would be obtained when the 500 kV system is at its lowest attainable voltage and the other load running at the time of the RCP start is the greatest. The latter can be attained by assuming this load to be the maximum rating of the station power transformer less the load of the RCP. The running load on the other 13.8/4.16 station transformer is taken as its maximum rating.

   Further when starting a large motor which results in a significant bus voltage drop there is an increase in the current drawn by the running motors due to reduction in the torque developed by the motor and slight speed reduction. The results in an additional drop. This relationship is slightly greater than one for one. We have very conservatively assumed that the running load impedance decreases as the square of the bus voltage to analytically model this occurrence.

3Q1 19A

RCP Start



RCP data   Locked rotor = 4800A @ .17 p.f.

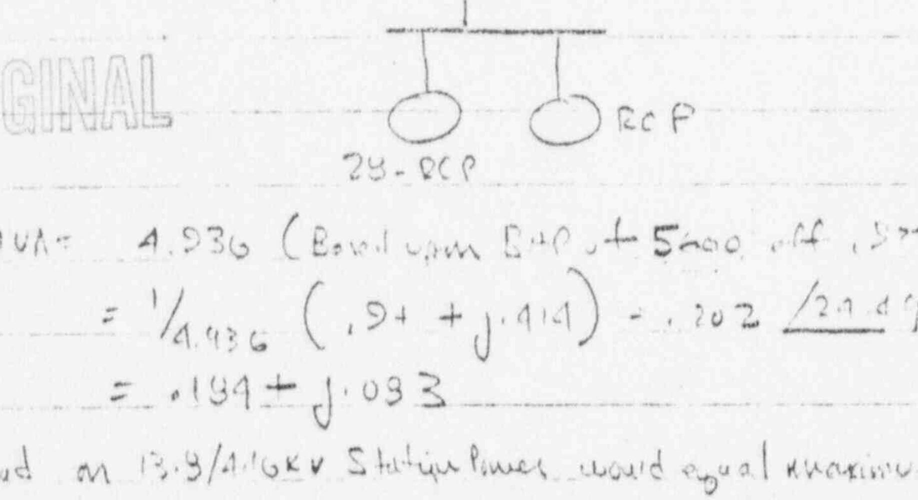
MVA_{LR} = 4800 × .4 × 1.732 = 26.36 MVA

@ .176 p.f. and correct for 4160V base

$$Z_{LR} = \frac{1}{26.36}(.176 + j.9849)\left(\frac{4160}{4000}\right)^2 = .04255 \angle 79.86^\circ$$

$$= .0072 + j.0403$$

Pre-start load



RCP running MVA = 4.936 (Based upon BHP of 5400, eff .975, pf .91)

$$= \frac{1}{4.936}(.91 + j.414) = .202 \angle 24.47$$

$$= .184 + j.083$$

Maximum load on 13.8/4.16KV Station Power would equal maximum continuous rating of the transformer less the RCP.

$= 28 - 4.936 = 23.064$ MVA @ .91 pf

$Z_{L1} = 1/23.064\,(.91 + j.414) = .0394 + j.0179 = .0433 \angle 24.49$

Assume other transformer fully loaded @ 28MVA @ .91pf.

$Z_{L2} = 1/28\,(.91 + j.414) = .0321 + j.0147 = .0357 \angle 24.49$

$Z_{T1} = .058/15 = j.00386$

$Z_{T2} = .1079/60 = j.001798$

Reducing:

$$\frac{(.04255)(.0433)\ \angle 24.49 + 79.86}{(.0072 + .0394) + j(.0179 + .0403)} = .0249 \angle 53.09 = .0149 + j.0198$$

$.0149 + j.0198 + j.00386 = .0149 + j.02366 = .0279 \angle 57.79$

$$\frac{(.0279)(.0357)\ \angle 57.79 + 24.49}{(.0149 + .0321) + j(.0147 + .02366)} = .0164 \angle 43.06 = .01198 + j.0119$$

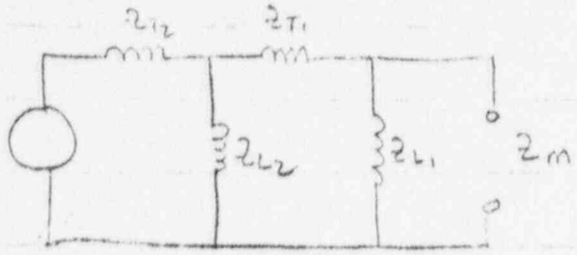
$.01198 + j.0119 + j.001798 = .01198 + j.01298 = .01766 \angle 47.29$

$$|V| = |E|\left(\frac{.0164}{.01766}\right)\left(\frac{.0249}{.0279}\right) = E(.9286)(.8889) = |E|(.8254)$$

$(|V| \ldots$ [illegible]

POOR ORIGINAL

PRIOR TO START 4KV LTC IS ON TAP!



23.06MVA $\underbrace{.0394 + j.0179}_{Z_{L1}} + \underbrace{j.00386}_{Z_{T1}} = .0394 + j.0208 = .045 \angle 28.84$

$$\frac{(.045)(.0377)\angle 28.84 + 24.49}{(.0394 + .0321) + j(.0217 + .0147)} = .02 \angle 26.98 = .0178 + j.009$$

$.0178 + j.009 + j.001795 = .0178 + j.0108 = .0208 \angle 31.24$

$$|V| = |E| \frac{.02}{.0208} \frac{.0435}{.045} = |E|(.961)(.9672) = |E|(.9246)$$

$I_f = |E| = .978$ $|V| = .904$

Correct for No load tap = $1.025(.975) = 1$

LTC set to maintain 124V, ∴ will have run out of LTC ~~R16~~

$.904(1.1) = \underline{.9944}$

Therefore since LTC is on R16 prior to start

$|V| = .978(.8254)(1.1) = .8879$ on a 4160V base.

POOR ORIGINAL

But the load current to the transformer will vary as the voltage varies i.e. if the volt. drops the current will increase or impedance decrease.

$Z_{L} = .0333(.8878)^2 \angle 24.49 = .03379 \angle 24.49 = .0311 + j.0141$

2nd Iteration

Reducing $\dfrac{(.03379)(.04255)\angle 24.86 + 24.49}{(.0311 + .0076) + j(.0403 + .0141)} = .0216 \angle 49.43$

$= .014 + j.0164$

$= .014 + j(.0164 + .00386) = .014 + j.0203 = .0246 \angle 55.90$

$\dfrac{(.0246)(.0357)\angle 55.90 + 24.09}{(.0147 + .0321) + j(.0147 + .0203)} = .015 \angle 47.53 = .011 + j.0101$

$.011 + j.0101 + j.001798 = .011 + j.01188 = .0162 \angle 47.20$

$|V| = |E| \dfrac{.015}{.0162} \dfrac{.0216}{.0246} = (.9259)(.878)|E| = E(.8129)$

Correcting for LTC by 1.1 and E = .978

$|V| = (.978)(1.1)(.8129) = .874$

3rd. Iteration

$Z_{L_1} = .0433(.874)^2 \angle 24.49 = .0330 \angle 24.49 = .03 + j.0136$

Reducing $\dfrac{(.04255)(.033) \angle 24.49 + 79.86}{(.0072 + .03) + j(.0403 + .0136)} = .0214 \angle 48.96 = .01405 + j.016$

$.01405 + j(.016 + .00386) = .01405 + j.01986 = .0243 \angle 54.72$

$\dfrac{(.0243)(.0337) \angle 24.49 + 54.72}{(.01405 + .321) + j(.0147 + .01986)} = .01506 \angle 42.39 = .0111 + j.0105$

$= .0111 + j(.0105 + .00178) = .0111 + j.0123 = .01656 \angle 47.93$

$|V| = |E| \left(\dfrac{.01506}{.01656}\right)\left(\dfrac{.0214}{.0243}\right) = (.9099)(.88)|E| = .8008 |E|$

Correct for LTC by 1.1 and E: .. 978

$V = .978(1.1)(.8008) = \underline{\underline{.8692}}$

4th Iteration

$Z_{L_1} = .0433(.8692)^2 \angle 24.44 = .0327 \angle 24.49 = .0297 + j.0135$

Reducing: $\dfrac{(.04255)(.0327) \angle 24.49 + 72.3}{(.0072 + .0297) + j(.0135 + .1403)} = .0213 \angle 48.6 = .014 + j.016$

$.014 + j(.016 + .00386) = .014 + j.01986 = .0243 \angle 54.81$

approaching same magnitude and angle
as last iteration

With full load on the 4160/480V unit substation the voltage would drop to:

$|E| = .8692$

$|V|_{480} = |E|(.954)(1.025) = .8692(.954)(1.025) = .8499$

$|V|_{460} = \frac{480}{460}(.8499) = .8868$ less cable drop of .017

$= .8698$

With full load on the 4160/240V unit substation the voltage would drop to

$E = .8692$

$|V|_{240} = (E)(.975)(1.025) = .8692(.975)(1.025)$

$|V|_{240} = .8686$

$|V|_{230} = \frac{240}{230}(.8686) = .9063$ less cable drop of .052

$= .8543$

460 V VOLTAGE PROFILE

The 460V voltage profile was approached so as to allow margins as follows:

1. B vital bus was selected as typical. Of the 3, 480 V vital buses A&B represent the greatest per unit impedance as they are 750 KVA, 5.75% where as C is 1000 KVA, 5.75%.

2. The load assumed connected to the 480V bus was equal to the maximum continuous rating of its transformer. i.e. B is rated 750/1000 KVA AA/FA. 1000 KVA was used and assumed at .8 p.f.

3. The cable voltage drop was approached as follows. List all the B bus loads with their full load amps, cable length and size, and determine the individual drops. From this select the greatest drop and apply in all cases. Thus for any feeder where the voltage drop is examined further, we can obtain less drop by refering to this calculation (i.e. the RMS was looked at further applying the 8V drop. Had we had trouble we could have used the actual drop of 1.41.)

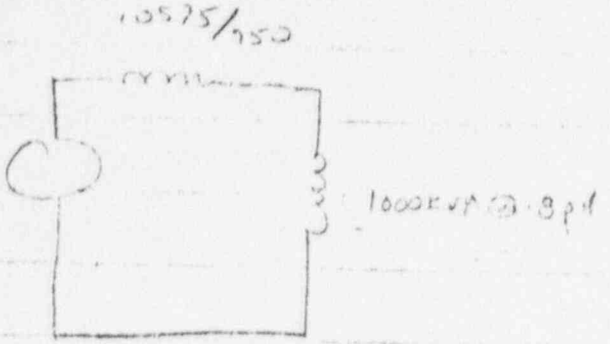
4. The worst transient was with the simultaneous connection of the safety related loads that are block loaded. The transient was analyzed similarly to the 4160 V, that is, using the running load prior to the start of this block connected load as the maximum continuous rating of the transformer to which it is connected. The 4160 V prestart voltage was that corresponding to the degraded 500 kV system condition.

5. The motor locked rotor currents were assumed equal to 5 time full load amps and a .2 p.f.

480V FEEDER VOLTAGE DROP

BKR. Position	LOAD	FULL LOAD AMPS	cable length and size	Impedance /1000'	actual Z	volt drop.
2B2X	CONT FAN	206A	140' of 350	.0539	.01[illegible]	2.28
2B4X		333A	200' of 500	.0551	.011	3.66
2B5X	22 FUEL HDL	25	240 of 6	.513	.129	3.1
2B9X	HT TRANS	70	190 of 6	.513	.097	6.79
2B10X	SUGR FN	30.7	65 of 2/0	.11	.007	.25
2B11X	22AB SUP FN	65	220 of 6	.513	.112	7.28 —
2B12X	22AB EX FN	96	205 of 2	.207	.042	4.03
2B13X	Chiller	116	175 of 2	.207	.036	4.17
2B14X	sp. fuel pump	114	150 of 2	.207	.031	3.53
2B15X	H_2 Rec	94	50 of 2/0	.11	.005	.47
2B16X	RMS	94	140 of 2/0	.11	.015	1.41

7.28 volts is greatest drop. Use 8 volts as feeder drop.



Z_L 1/1 (.8+j.6) =

Z_T = j.0575/750 = j.0766

Z = .8+j.676 = 1.04

$|V| = |E| \frac{1.0}{1.04} = .954(E)$

Correct for tap position and system voltage E = .922

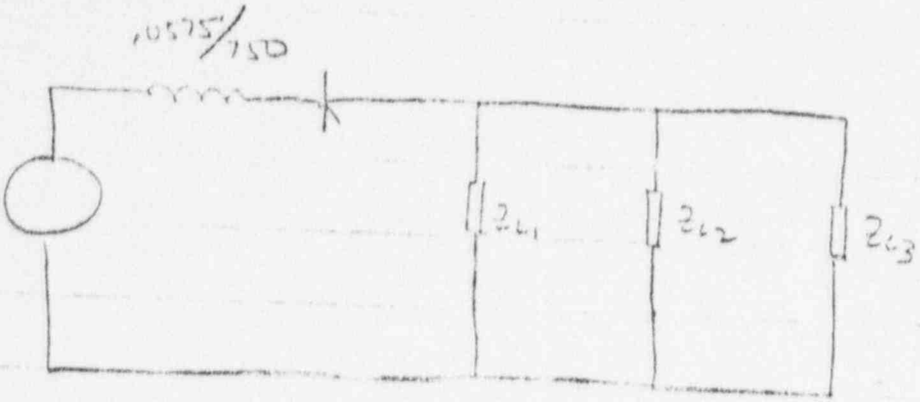
$|V| = 1.025(.922)(.954) = .901$

on 460V base = $.901\left(\frac{480}{460}\right) = .94$

This allows .04(460) 18.4V drop which is more than required.

Actual maximum is 7.78 use 8 or 8/460 = .017%

.94 − .017 = **.923**



Worse transient would be on start of 2 Containment Fan Coil Units would be simultaneous start of assuming they were not running previously

Switchgear rm. exh. fan	30HP, 36.7A	=	$\frac{30(.751)}{.8(.85)}$ =	33.26 KVA
" " supply fan	50HP, 65A	=	$\frac{50(.751)}{.8(.85)}$	55.5 KVA
aux. bldg exhaust fan	75HP, 96A	=	$\frac{75(.751)}{.8(.85)}$	83.25 KVA
chiller	100HP, 116A	=	$\frac{100(.751)}{.8(.85)}$	111 KVA

Motor Z @ LR equal 5(FLA) $\sqrt{3}$ (460) assume starting pf = .2

36.7(1.732)(460)(5) = .146 MVA, $Z = \frac{1}{.146}(.2+j.979) = 1.36+j6.70$

65(1.732)(460)5 = .259 MVA, $Z = \frac{1}{.259}(.2+j.979) = .772+j3.77$

96(1.732)(460)5 = .382 MVA, $Z = \frac{1}{.382}(.2+j.979) = .523+j2.56$

116(1.732)(460)5 = .462 MVA, $Z = \frac{1}{.462}(.2+j.979) = .432+j2.119$

Combining = .6381 $\angle 78.46^0$ = .127 + j.624

Assume 750kva is fully loaded less these motors at start

Pre-started load

$1000 - 33.26 - 55.5 - 83.25 - 111 = 716.99$

$1/.717\,(.8 + j.6) = 1.394\,(.8 + j.6) = 1.115 + j.8364$

Reducing

$$\frac{(.6391)(1.394)\angle 38.84 + 78.46}{(.127 + 1.115) + j(.8564 + .624)} = .463\angle 65.69 = .1906 + j.421$$

$Z_T = .0575/750 = j.0766$

$Z_T = .1906 + j(.421 + .0766) = .1906 + j.497 = .53\angle$

$|V| = |E|\,\frac{.463}{.53} = |E|(.873)$

E = .922 and correct for tap ~ @ 1.025

$|V| = .825$

on 460 v base $|V| = \frac{480}{460}(.825) = .86$

230 V VOLTAGE PROFILE

The 230V voltage profile was approached so as to allow margins as follows:

1. B vital bus was selected as typical.

2. The following data was compiled as follows for each MCC feed: The actual cable size and length, the connected load (assumed all MCC feeders closed and no diversity), the cable impedance/1000' from which the actual cable impedance was determined. The actual impedance was multiplied by the connected load amps to determine the voltage drops between the unit substation and MCC. The greatest voltage drop between the MCC and the load was determined for each MCC in the same manner. These two drops were then arithmetically added to arrive at the worse case voltage drop.

3. The load connected to the 230 V bus was assumed to be equal to the maximum continuous rating of its transformer or 300 KVA. A .8 p.f. was also assumed.

4. The worse transient was with the start of a 30 HP motor. The transient was analyzed similarly to the 4160 V, that is using the running load prior to the start of this block connected load as the maximum continuous rating of the transformer to which it is connected. The 4160 V pre-start voltage was that corresponding to the degraded 500 kV system condition. Motor locked rotor was assumed equal to 6X F.L. at .2 p.f.

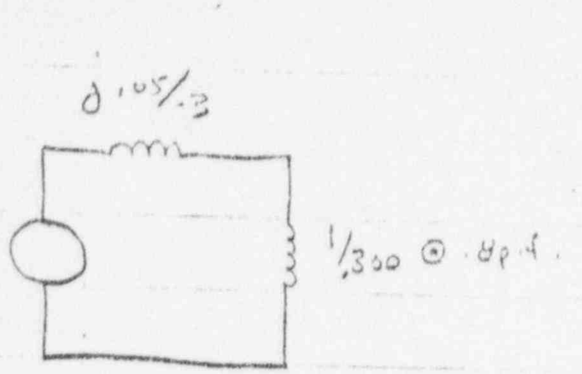
MCC to LOAD VOLTAGE DROPS

2B8Y	[illegible]	5HP, 15.2A	3C12 - 50'	1.62 (.05)(15.2) = 1.23V
2B7Y	2B A/C	25HP, 72A	3C2 85'	.207 (.285)(72) = 4.24V
2B4Y	2B Diesel	1½HP, 6.7A	3C12 - 110'	6.7 (1.62)(.11) = 1.19
2B3Y	Vlvs. West	22SJ49 41A, 3C2 244'		= 41 (.207)(.244) = 2.07
	Vlvs. East	22SI54 59A, 3C2 250+105 =		59 (.207)(.341) = 4.4
	-	21BFI3 34.8, 3C6 450'		= 34.8 (.5113)(.45) = 8.02
2B13Y	2B Vent & A/C	10HP, 27.2A	3C6, 129+97	= 27.2 (.513)(.226) = 3.15
		7½HP, 22A, 3C6, 506' =		22 (.513)(.506) = 5.71V
2B15Y	2B2 SW	1, 3.2A, 3C12, 150'		3.2 (1.62)(.15) = .77
		2SW26 16A, 3C6, 75'		16 (.513)(.075) = .61

VOLT DROP - UNIT SUBSTATION TO MCC.

UNIT SUB. TO MCC FOR.	Cable size and actual length	Connected amps	Cable Z /1000'	Z actual	UNIT SUB to MCC Volt Drop	MCC to load drop
2B3Y	3T350 261'	255	.0539	.014	3.57	
	3T350 - 283'	269	.0539	.015	3.96	8.03
2B4Y	3T350 - 474'	216	.0539	.025	5.4	1.19
2B7Y	3T00 - 325'	149	.11	.035	5.2	4.24
2B8Y	3T00 - 1185'	22	.11	.13	2.86	1.23
2B13Y	3T00 - 325'	131.8	.11	.035	4.61	5.71
2B15Y	4C00 - 1099'	38	.11	.120	4.56	.77

Greatest drop is 12V.



$Z_T = .05/.3 = j.166$

$Z_L = 1/.3\,(.8+j.6) = 3.33(.8+j.6) = 2.66 + j2.0$

Z_{total} $2.66 + j2.16 = 3.42$

$|V| = |E| \frac{3.33}{3.42} = |E|\,(.975)$

If E = .922 and correct for tap

$|V| = .922(1.025)(.975) = .922$ on xfmr base

$= .962$ on motor base + 6.230V

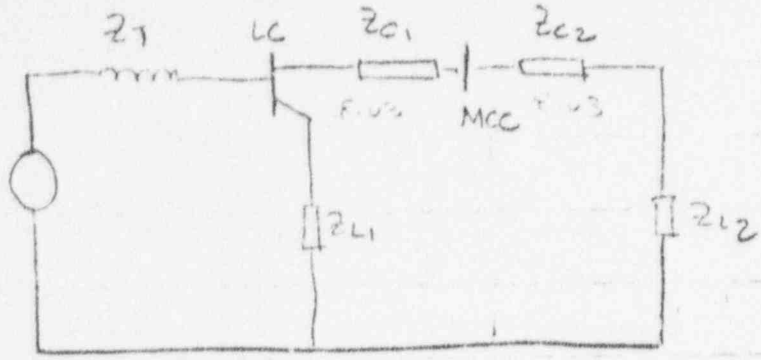
Max Voltage drop between unit sub bus and load is 17V or 5.2%

i.e. still have margin

$.962 - .052 = .91$

230V VOLTAGE PROFILE - 30HP MOTOR START   53

BASED ON FDR 2B34



$Z_T = .05/.3 = j.1666$

$Z_{C1} = Z_{C\ 3T350} = .0378 + .0373\ \Omega/1000'$

$Z_{p.u.} = \frac{Z_\Omega}{(.24)^2} = 17.36\ Z_\Omega$

$Z_{pu} = 17.36\left(\frac{.288}{1000}\right)(.0378 + .0373) =$

$= .189 + j.186$

Z_{C2} 285' of 3C2

$17.36\left(\frac{285}{1000}\right)(.202 + j.0148) = .998 + j.073$

$Z_{L1} =$ 270KVA @ .8pf $= 1/.27\ (.8 + j.6) = 3.7\angle 36.86 = 2.96 + j2.22$

Z_{L2}: $\frac{30HP \times .754KW/HP}{.8 \times .85} = 33.26 \times 6 = 199.56KVA$ @ .2pf

$Z_{L2} = 1/199.56\ (.2 + .979) = 5.01\angle 78.41 = 1.002 + j4.90$

Reducing $Z_{C1} + Z_{C2} + Z_{L2} = .188 + j.186 + .999 + j.023 + 1.002 + j4.90$

$= 2.188 + j5.109 = 5.999\angle 66.81$

POOR ORIGINAL

Reducing

$$\frac{(5.444)(3.7)\ \angle 63.81 + [illegible]}{2.188 + 2.46 + j(2.22 + 5.104)} = 2.48\ \angle 48.76 = 1.631 + j1.869$$

$$1.631 + j1.869 + j.156 = 1.63 + j2.03 = 2.60\ \angle$$

$$|V| = |E|\left(\frac{2.48}{2.60}\right)\left(\frac{5.01}{5.444}\right) = |E|(.954)(.835) = |E|(.796)$$

If E = .9226 and correct of drop 1.025

$$|V| = .7527 \text{ on } 240V = .7527\left(\frac{240}{230}\right) = .7854$$

MCC bus = $Z_{L_2} + Z_{LT}$ = $1.002 + j4.90 + .998 + j.023$

= $2 + j4.923 = 5.313$

$$\frac{5.313}{[illegible]} = .8856(1.025)(.9226) = .837$$

on 230V base = .8374 $\left(\frac{240}{230}\right)$

.8374

= .8738

LIGHT LOAD

The voltage profile was also examined to ascertain that the distribution system voltage profile was within upper voltage limitations. This was done by making the following conservative assumptions.

1. All cable impedance was neglected.

2. The 500 kV system practicable upper voltage limitation was determined to be 1.06 p.u. at the Salem terminals.

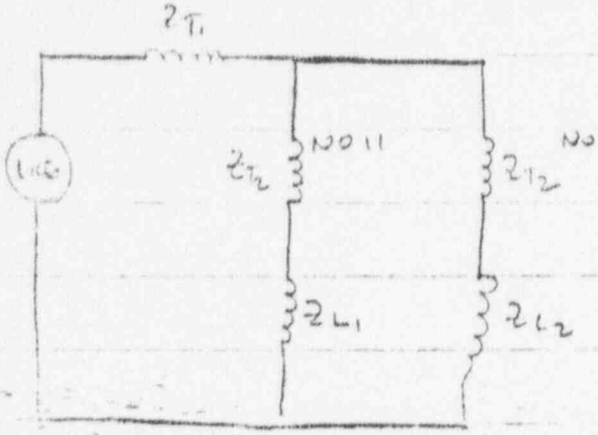
3. The loads on the 4.16 kV, 460 V and 230 V levels were assumed at 3 MVA, .91 p.f.; 300 KVA @ .8 p.f. and 100 KVA @ .8 p.f. respectively.

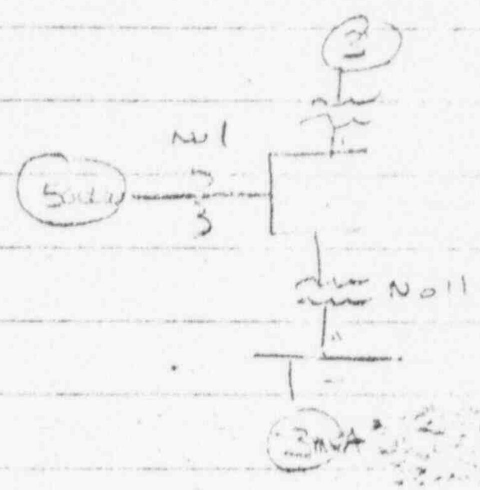
4. The upper tolerance of the 13.8/4.16 kV B.W. adjustment was assumed.

3Q1 22A

LIGHT LOAD

Neglect all cable Z, account only for load and transformer Z.





No 1 Station Pwr $Z_{T_1} = j.001793$

No 11 (21) Station Pwr $Z_{T_2} = j.00386$

Assumed @ 3MVA load

$Z_{L_1} = Z_{L_2} = \frac{1}{3}(.91 + j.414) = .30 + j.136$

Reducing

$.33 + j.136 + j.00386 = .33 + j.1398 = .3584 \angle 22.95°$

Combining

$.1792 \angle 22.95 = .165 + j.0698 = .1791 \angle$

$.165 + j.0699 + j.001793 = .165 + j.0716 = .1798 \angle$

$|V| = |E| \left(\frac{.1791}{.1798}\right)\left(\frac{.333}{.3584}\right) = |E| (.9961)(.9291) = E\ .9255$

Correction for NL Taps $1.025(.975) = 1$

If $|E|$ maximum = 1.06 p.u.

V = .981

LTC set to maintain 124 V ... $= 125 \times \frac{4200}{110} = 4375$ or 1.051 p.u.

1.051
.981
.070

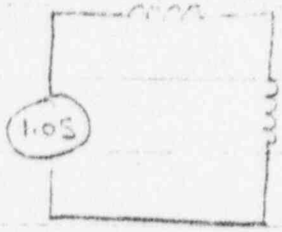
∴ LTC will must correct .07

$.07/.00625 = 11.2$ L11-L12

at 460V.

1.998
.0766
2.0746

j.0575/7.5 = j.0766



Assume 300 KVA load

$\frac{1}{.3}(.8+j.6) = 2.66+j1.99$

4+j3

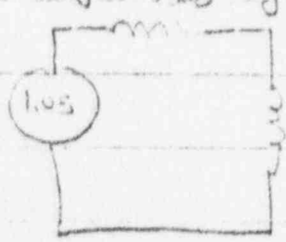
4+3.0766

Reducing 2.66+j1.998 j.0766 = 2.66+j2.0746 = 3.373∠

$|V| = (E)\frac{3.333}{3.373}(1.025) = 1.012|E| = 1.012(1.05) = 1.06$ on bus.

at 230V

j.05/.300 = j.1666



Assume 100 KVA load

$\frac{1}{.1}(.8+j.6) = 8+j6$

Reducing 8 j6 j.1666 = 8+j6.1666 = 20.10

$|V| = |E|\frac{20}{20.1}(1.025)(1.05) = 1.07$ on bus.

RCP STARTING TIME

PURPOSE:

The purpose of this calculation is to determine the reactor coolant pump starting times with the pump load under cold and hot conditions. Actual RCP cold start times are available for comparison of results.

METHOD & ASSUMPTIONS:

1. Actual motor and pump speed torque curves were used (attached).

2. The starting interval was divided into ten increments and the mean of each increment used in the analysis. The results of each increment were then summed.

3. Based upon previous analysis the motor terminal voltage was assumed at 85% at 4160 V for 95% of the total starting time.

RESULTS:

A RCP cold accelerating time was 25.46 seconds and hot was 18.33 seconds. Test results indicated an RCP starting times of 22-26 seconds.

3Q1 24A

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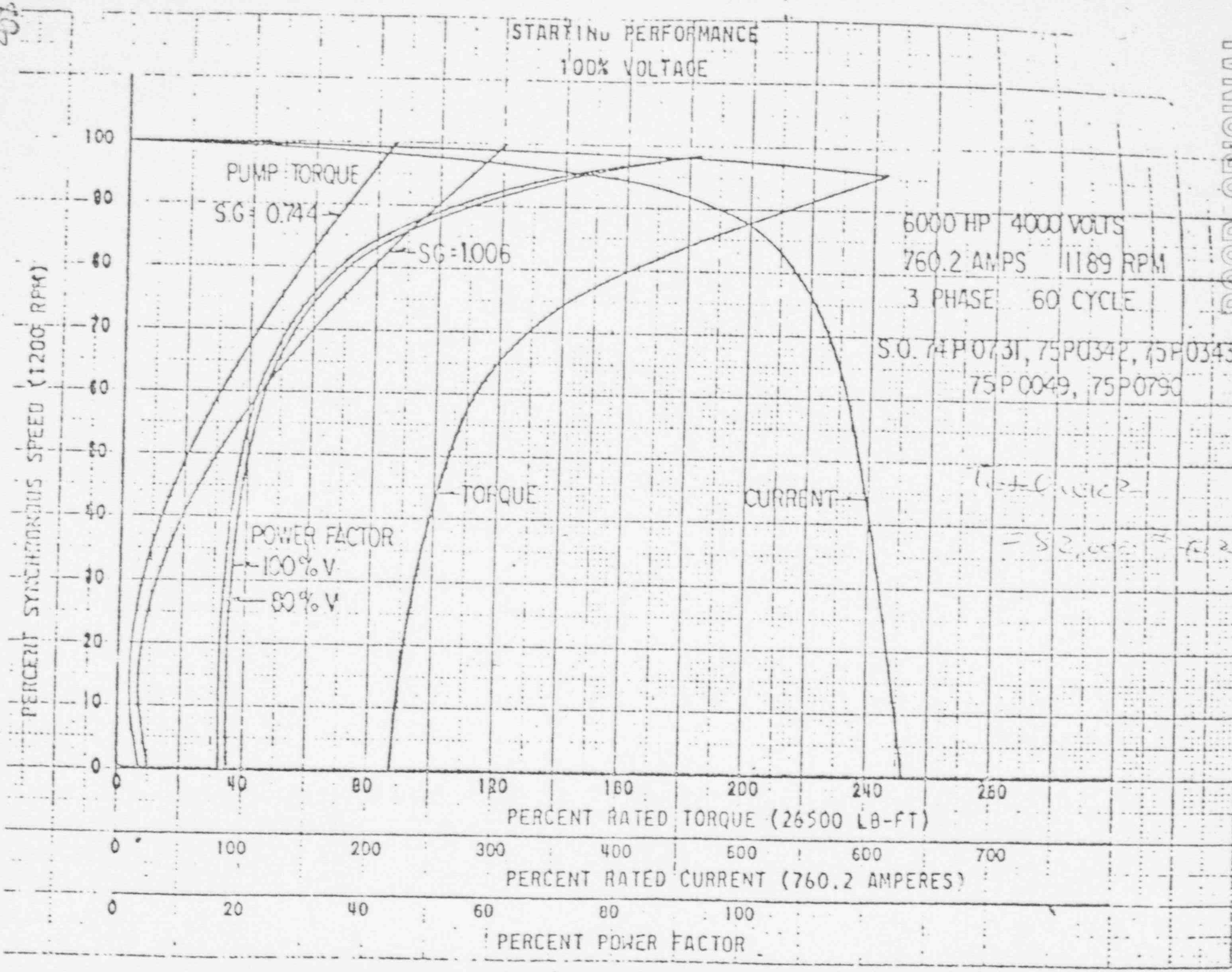
RCP STARTING TIME

(1) Increment %	(2) Motor Volts %	(3) P.U. Motor T	(4) #-ft Motor T	(5) P.U. Load Cold	(6) #-ft Load	(7) (4-6) ΔT_c	(8) t
0-10	85	.90	17231	.08	2120	15111	1.0[illegible]
10-20	85	.92	17614	.06	1590	16024	1.9
20-30	85	.94	17997	.08	2120	15877	2.0
30-40	85	.98	18763	.14	3710	15053	2.[illegible]
40-50	85	1.02	19529	.26	6890	12639	2.5
50-60	85	1.08	20677	.38	10070	10607	3.0
60-70	85	1.2	22975	.54	14310	8665	3.[illegible]
70-80	85	1.44	27570	.7	18550	9020	3.[illegible]
80-90	85	1.90	36377	.9	23850	12527	2.5
90-95	85	2.30	44036	1.06	28090	15946	[illegible]
95-100	90	1.80	33463	1.18	31270	3193	2.[illegible]
							25.[illegible]

1. $\#$-ft motor T = $(.85)^2(26,500) = .7225(26,500)$
2. $WK^2 = 82,000$ #-ft^2
3. use attached Ⓦ curve - columns 1, 3, 4, 5, 6
4. 1200 rpm
4. $t = \dfrac{rpm \times WK^2}{308\ \Delta T}$ - column 8

(9) P.U. Load Hot	(10) #-ft Load Hot	(11) ΔT_H	(12) t
.06	1590	15641	1.02
.04	1060	16559	1.92
.06	1590	16407	1.95
.10	2650	16113	1.98
.18	4770	16879	1.89
.26	6890	13789	2.32
.38	10070	12905	2.47
.5	13250	14320	2.23
.62	16430	19997	1.60
.74	19610	24426	.33
.82	21730	12733	.62
			16.33



STARTING PERFORMANCE
100% VOLTAGE
6000 HP 4000 VOLTS
760.2 AMPS 1189 RPM
3 PHASE 60 CYCLE
S.O. 74P0731, 75P0342, 75P0343
75P0049, 75P0790
PUMP TORQUE
SG = 0.744
SG = 1.006
TORQUE
CURRENT
POWER FACTOR
100% V
80% V
PERCENT SYNCHRONOUS SPEED (1200 RPM)
PERCENT RATED TORQUE (26500 LB-FT)
PERCENT RATED CURRENT (760.2 AMPERES)
PERCENT POWER FACTOR

CORRELATION OF FIELD TEST DATA AND CALCULATIONS

PURPOSE:

The purpose of those calculations was to use actual 500 kV system voltage and plant load data in the calculation of a plant load profile. The same procedure applied in the previous calculations was utilized. The results of this calculation were then composed with actual measurements.

METHOD & ASSUMPTIONS:

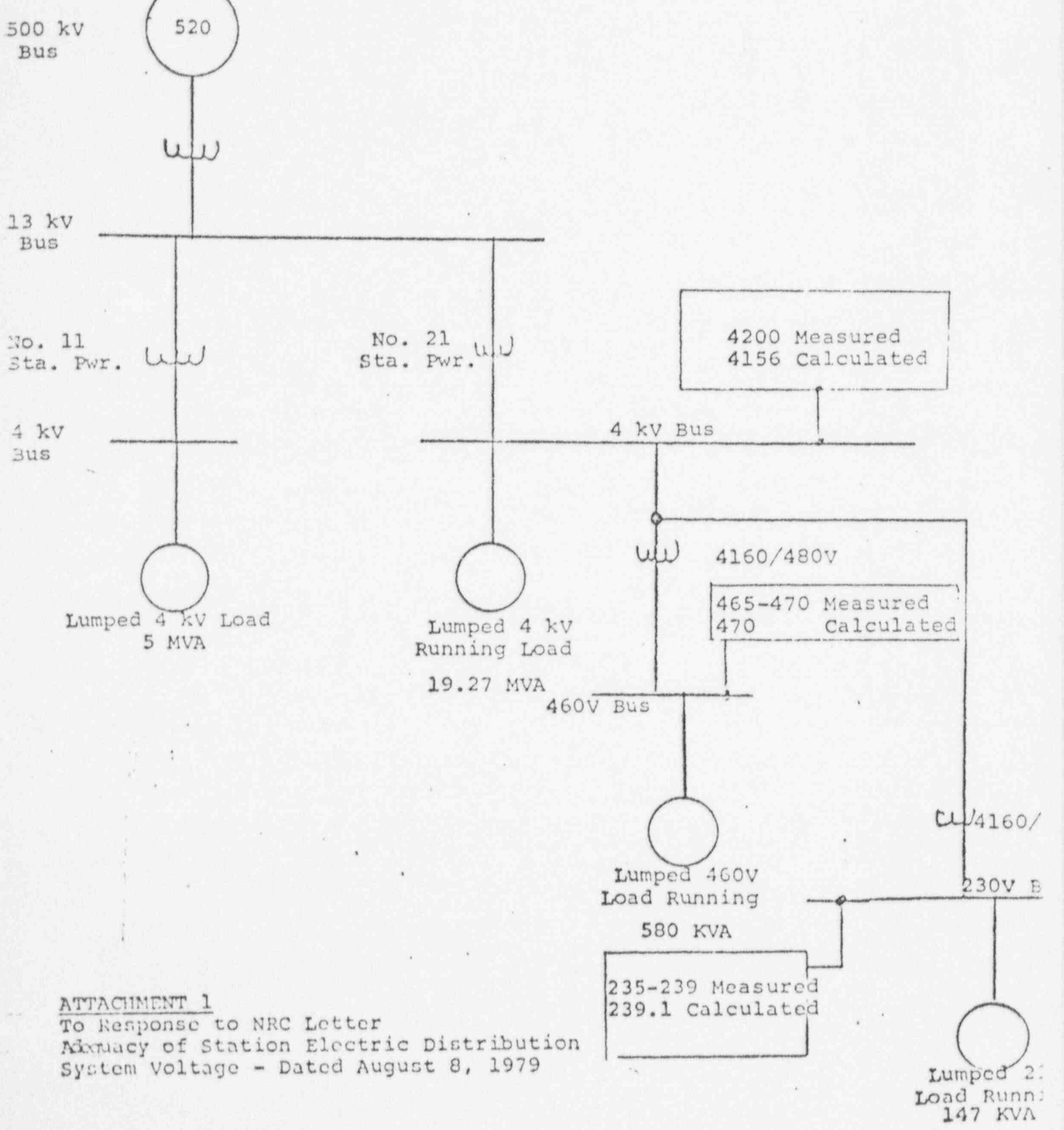
The field data was monitored over a 24 hour period by Maplewood Laboratory personnel and is attached. Readings at 1600 hours were arbitrarily selected to use in the calculations.

RESULTS:

As shown on the attached sheet, the results of measured and calculated compare favorably.

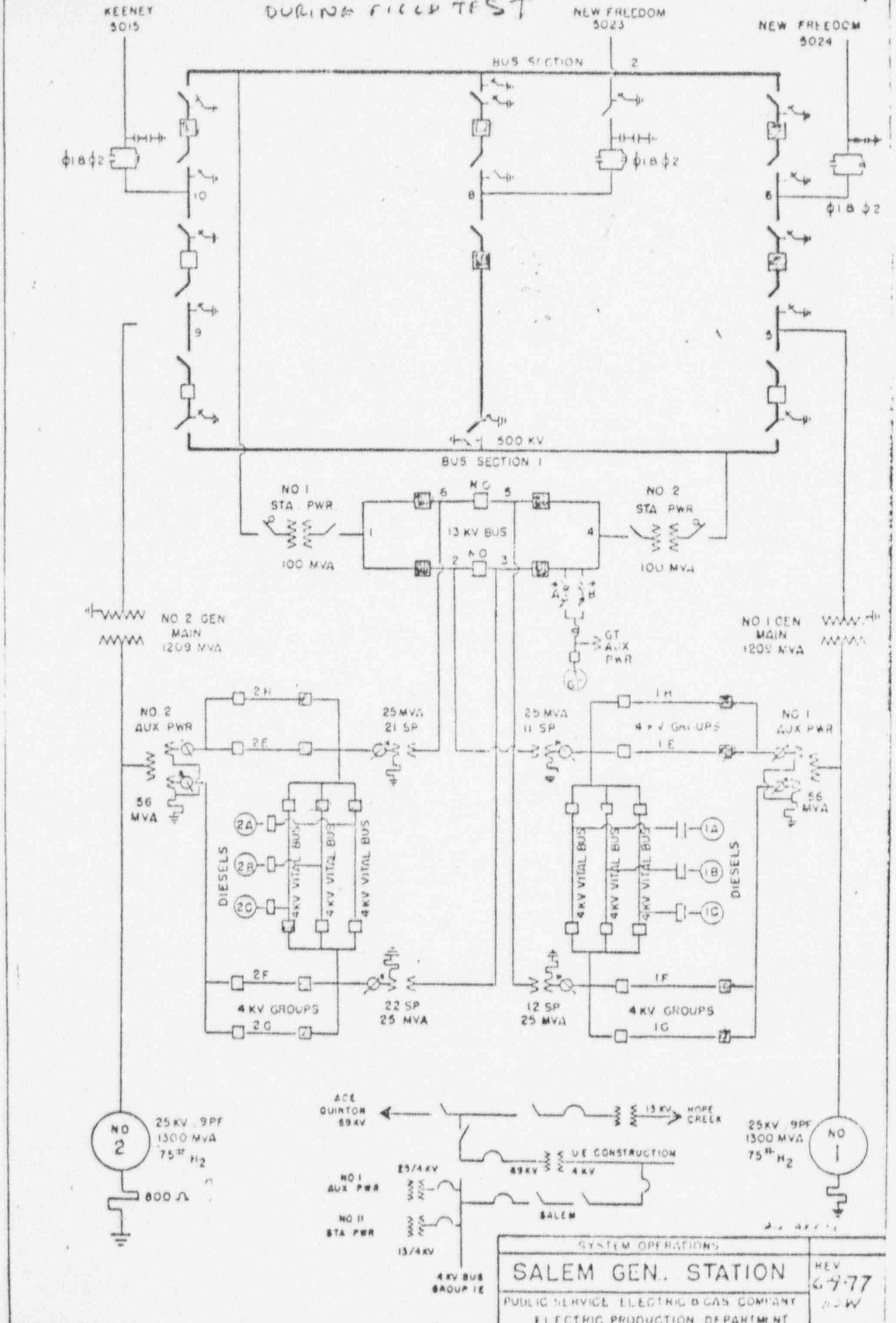
3Q1 23A

SALEM GENERATING STATION, UNIT 2
VOLTAGE PROFILE
FIELD MEASUREMENTS VS. CALCULATIONS



ATTACHMENT 1
To Response to NRC Letter
Adequacy of Station Electric Distribution
System Voltage - Dated August 8, 1979

ONE LINE OF PLANT
DURING FIELD TEST



ECSchwarda
RGMcLean

SALEM NUCLEAR GEN STA

No 2 GEN - Control Room Metering

Date	Time hrs	No 21 Sta Pwr Xfmr Load Tap Position	No 21 Amperes	No 21 Megawatts	No 22 Sta Pwr Xfmr Load Tap Position	No 22 Amperes	No 22 Megawatts
12-6-78	1000	3 Raise	2600	16.2	1 Lower	2000	12.5
	1100	3 Raise	2600	16.5	1 Lower	2000	12.4
	1200	3 Raise	2620	16.4	1 Lower	2050	12.8
	1300	3 Raise	2600	16.4	1 Lower	2030	12.8
	1400	3 Raise	2500	16.1	1 Lower	2020	12.8
	1500	3 Raise	2650	16.5	1 Lower	2050	12.8
→	1600	3 Raise	2650	16.5	1 Lower	2100	13.0
	1700	3 Raise	2650	16.4	1 Raise	2050	13.0
	1800	3 Raise	2650	16.5	1 Raise	2080 *	13.0 **
	1900	3 Raise	2600	16.3	1 Lower	2030 *	13.0 **
	2000	3 Raise	2600	16.2	1 Lower	2060 *	13.0 **
	2100	3 Raise	2600	16.2	1 Lower	2060 *	13.0 **
	2200	3 Raise	2600	16.3	1 Lower	2000	12.7
	2300	3 Raise	2620	16.3	1 Lower	2020	12.7
MID	2400	3 Raise	2600	16.3	1 Lower	2070 *	13.0 **
12-7-78	0100	3 Raise	2610	16.3	1 Lower	2010	12.7
	0200	3 Raise	2600	16.3	1 Lower	2000	12.6
	0300	1 Raise	2400	15.0	1 Lower	2000	12.6
	0400	1 Raise	2390	15.0	1 Lower	2000	12.5
	0500	1 Raise	2400	15.0	1 Lower	2000	12.6
	0600	2 Raise —	2600	16.1	1 Lower	2000	12.5
	0700	0	2590	16.0	1 Lower	2000	12.6
	0800	3 Raise	2550	16.1	0	2050 *	12.6 **
	0900	3 Raise	2570	16.2	1 Lower	2000	12.6
	1000	2 Raise	2550	16.2	2 Lower	2020	12.5
	1100	2 Raise	2560	16.1	2 Lower	2020	12.7

* Sharp changes from 2000 Amperes to Maximum as indicated above.
* Sharp changes from 12.6 Megawatts to Maximum as indicated above.

SALEM NUCLEAR GEN STA

No 2 GEN - Control Room Metering

EC Schwarsky
RC McLean

Date	Time	(Reactor) 5015	13KV Sect 1	13KV Sect 4	4KV 2B	4KV 2C	4KV 2G	4KV 2H
12-6-78	1515	522	13.3	13.5	4.19	4.23	4.20	4.20
→	1600	520	13.3	13.5	4.20	4.22	4.20	4.20
	1700	515	13.4	13.3	4.19	4.25	4.20	4.20
	1800	523	13.5	13.4	4.20	4.27	4.20	4.20
	1900	523	13.6	13.5	4.20	4.25	4.20	4.21
	2000	525	13.6	13.4	4.22	4.28	4.22	4.24
	2100	524	13.5	13.4	4.21	4.27	4.21	4.22
	2200	525	13.6	13.5	4.22	4.28	4.22	4.25
	2300	521	13.5	13.4	4.20	4.26	4.20	4.20
Mid	2400	525	13.3	13.5	4.21	4.27	4.20	4.21
12-7-78	0100	522	13.3	13.6	4.20	4.26	4.20	4.22
	0200	524	13.4	13.5	4.21	4.28	4.22	4.22
	0300	522	13.4	13.5	4.20	4.26	4.21	4.20
	0400	522	13.4	13.5	4.20	4.27	4.21	4.20
	0500	523	13.4	13.5	4.20	4.26	4.21	4.20
	0600	522	13.4	13.5	4.20	4.25	4.21	4.20
	0700	520	13.3	13.4	4.20	4.25	4.21	4.20
	0800	520	13.3	13.5	4.18	4.25	4.20	4.20
	0900	523	13.4	13.6	4.20	4.26	4.21	4.22
	1000	525	13.4	13.5	4.21	4.27	4.20	4.20
	1100	525	13.4	13.6	4.21	4.26	4.20	4.20

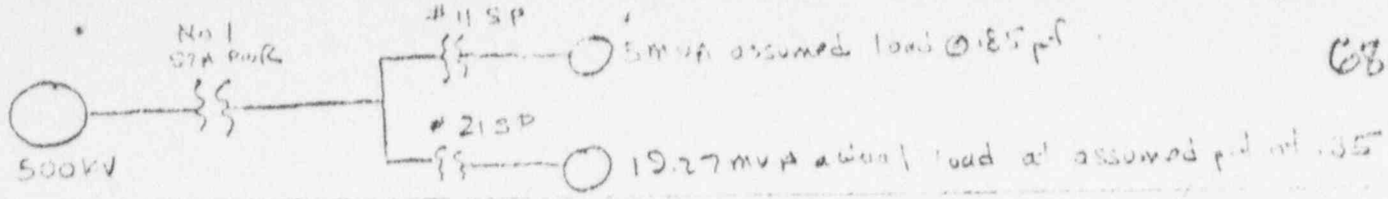
E.C. Schwaster
R.G. McLean
12-6-75

DATA

SALEM NUCLEAR GEN STA

No 2 GEN - Vital & Group Bus Measurements

Tap Positions		2G	2C	2B	2B	2H	
		460V	230V	230V	460V	460V	
21 Sta Pwr	22 Sta Pwr	Gp Bus	Vital	Vital	Vital	Gp Bus	
3 Raise	1 Lower	* 480V	*237V	*239V	*470V	*480V	* ØA-B or Ø1-2
3 Raise	1 Raise	480v	237v	237v	470v	475v	
3 Raise	1 Lower	480v	237v	238v	470v	478v	
1 Raise	1 Lower	480v	239v	235v	467v	475v	
2 Raise	1 Lower	0	238v	235v	465v	475v	
0	1 Lower	0	238v	237v	467v	478v	
3 Raise	0	0	237v	238v	467v	477v	
3 Raise	1 Lower	0	237v	238v	467v	477v	
Raise	2 Lower	0	238v	237v	469v	478v	



At 1600 hrs.

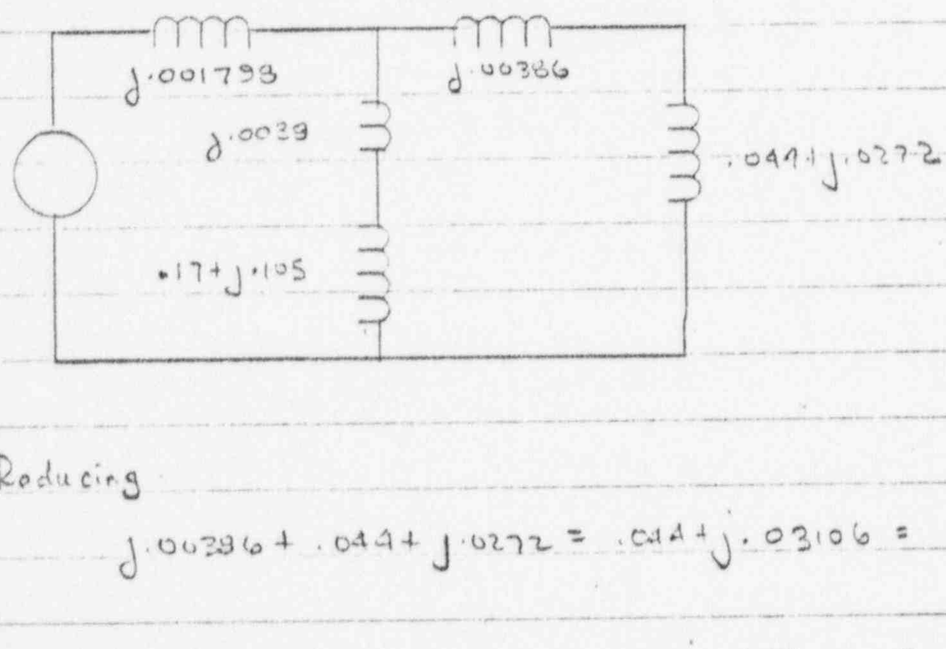
I = 2650A V = 4.2

KVA = 19.277 @ .85 pf or .85 + j .5267

Assume Unit 1, No 11 SP @ 5 MVA @ (.85 + j .567)

$\frac{1}{19.27}(.85 + j.5267) = .0518(.85 + j.5267) = .04403 + j.0272 = .0517 \angle$

$\frac{1}{5}(.85 + j.5267) = .2(.85 + j.5267) = .17 + j.105$



Reducing

$j.00386 + .044 + j.0272 = .044 + j.03106 = .05385 \angle 35.21^\circ$

$j.0038 + .17 + j.105 = .17 + j.1088 = .2018 \angle 32.61^\circ$

$\frac{(.05385)(.2018)\angle 35.21 + 32.61}{(.044 + .17) + j(.03106 + .1088)} = \frac{.0108}{.214 + j.13986} = \frac{.0108}{.25 \tan^{-1} .6535}$

$= .0432 \frac{\angle 67.82}{\angle 33.2} = .0432 \angle 34.62^\circ \quad .0432(.8231 + j.5678)$

$= .0355 + j.0245$

Using chart 500KV voltage & existing NL and LTC tap settings

$$E_{13.8} = \frac{118}{115} \times \frac{500}{512.5} \times \frac{.0432}{.0355 + j(.0245 + .001798)} = 13.42 KV$$

$$E_{4160} = \left(\frac{13.42}{13.8}\right)\left(\frac{4238}{4160}\right)\left(\frac{13.8}{13.455}\right)\left(\frac{.0517}{.0535}\right) = 4076 \text{ volts}$$

Chart 4160 measurement was 4090 volts.

Using meter 500KV voltage & existing NL & LTC tap settings

$$E_{13.8} = \frac{520}{500}\left(\frac{500}{512.5}\right)\left(\frac{.0432}{.0355 + j(.0245 + .001798)}\right) = 13.68 KV$$

$$E_{4160} = \frac{13.68}{13.8}\left(\frac{4238}{4160}\right)\left(\frac{13.8}{13.455}\right)\left(\frac{.0517}{.0535}\right) = 4156 \text{ volts}$$

Meter 4160 reading was 4190 to 4200 volts.

2B 460V UNIT SUB

	connected	est. running
H_2 Recomb	94	–
Sp. Fuel pp	119	–
22 Chiller	116	116
22 Aux Bldg Ex Fn	71.6	71.6
Aux Bldg Sup. Fn	46.5	46.5
Swgr. Rm Sup. Fn	36.7	36.7
Ht. Ht. Trac. Xfmr	141	70
22 Fuel Hdl. Ex Fn	25	25
24 Fn CC	333	333
22 Fn CC	333	–
	1310	698.8

Load = 698.8 × 1.732 × 480 = 580 KVA.

$Z_L = 1000/580 = 1.724$ $Z_T = .0575 \frac{1000}{750} = .0766$

$\text{Load Reg} = \frac{1.724}{1.724 + .0766} = .957$

$V_{480} = V_{4160}\left(\frac{480}{4160}\right)(1.025)(.957) = V_{4160}(.1131)$

Using previous calculated V_{4160} = 4076 & 4156 corresponding to chart of meter 500KV voltages.

$V_{480} = (.1131)4076 = 461V$

$V_{480} = (.1131)(4156) = 470V$

Measured voltages were 465-470

2B 230V UNIT SUB LOADING.

	connected	estimated running
2B Diesel	155.9 A	30 A
2B1 S.W.	26.0	20
2B2 S.W	38.0	30
2B vent	131.8	100
2B A.C.	149.0	125
2B E. Valves	262	25
2B W. Valves	239	25
	1091 amps	355 amps

Actual KVA @ transf rated = 355 x 1.732 x 240 = 147 KVA

use 150 KVA

Load $Z_L = 1000/150 = 6.66$; Transf. $Z_T = .05 \times \frac{1000}{300} = .1666$

Load Reg

$$\frac{6.66}{6.66 + .1666} = .9755$$

$$V_{240} = V_{4160} \times \frac{240}{4160} \times 1.025\ (.9755) = V_{4160}\ (.0576)$$

Using previous calculated V_{4160} = 4076 and 4156 corresponding to chart and metered 500KV voltages

V_{4160} = 4076(.0576) = 235.1 V

V_{4160} = 4156(.0576) = 239.4 V

Measured voltages were 235-239 on all three phases

APPENDIX IV

RELAY COORDINATION

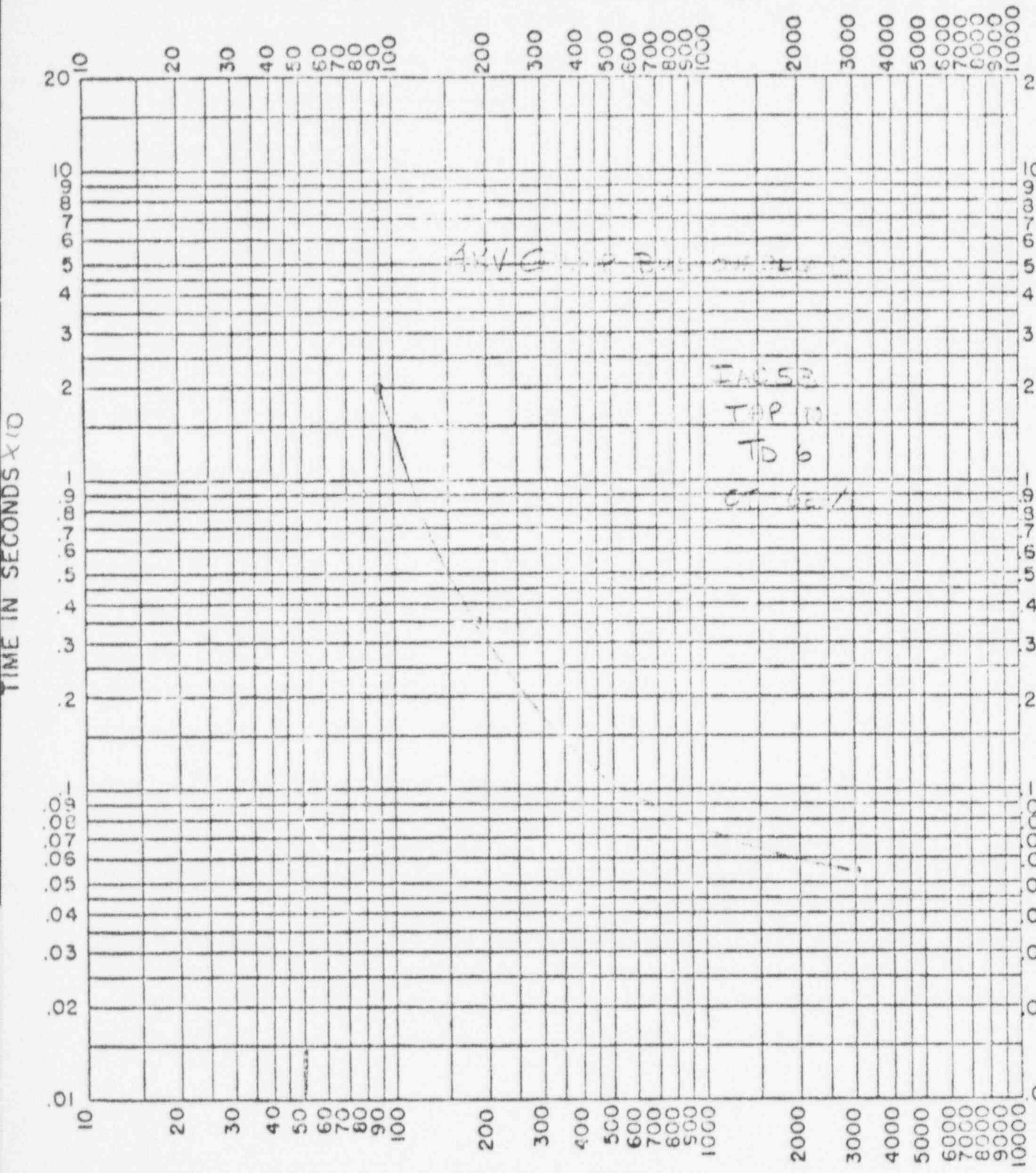
The attached overload protective devices show that there were no spurious trips due to overload.

The existing under voltage protection is shown and also shows no spurious trips. (Second level of undervoltage protection will follow under separate cover.)

Relays setting sheets and characteristic relay curves were used to plot due attachments.

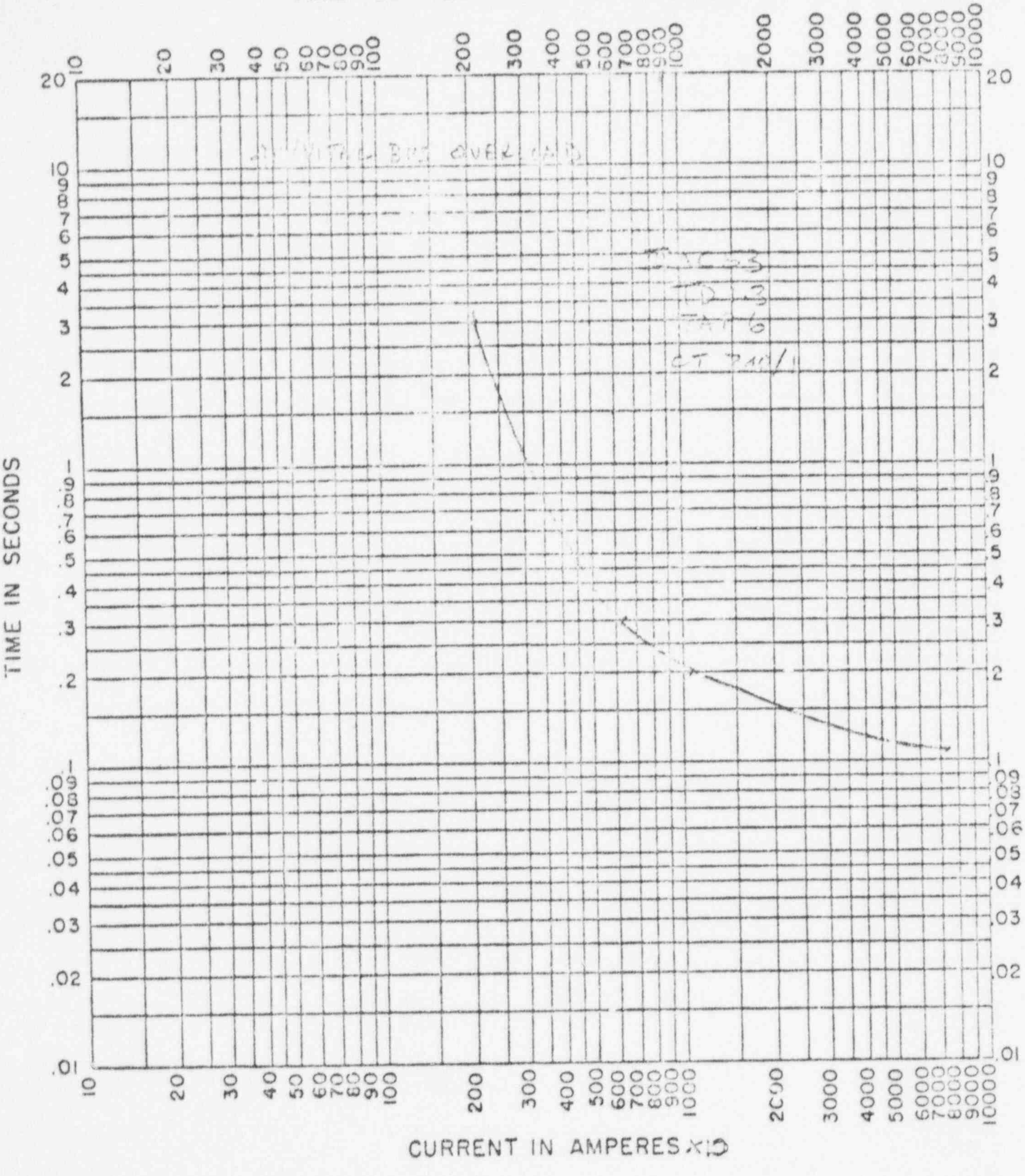
FORM EE-124

TIME-CURRENT CHARACTERISTICS



FORM LE-124

TIME-CURRENT CHARACTERISTICS



4KV Vital Bus O.L. IAC53 Tap 6 TD 1.3 use curve for TD 1

CT 240/1 Ref. Dwg. 203117 BL 4T7

Relay	T	1440
1.5	3	2160
4.5	.3	6480
7	.2	10080
50	.11	72000

4KV Group Bus O.L. IAC53 Tap 10 TD 6

CT 600/1 Ref Dwg 203123, 222756

Relay	T	6000
1.5	20	9000
3	3.5	18000
10	.9	60000
50	.55	300000

6

3.2

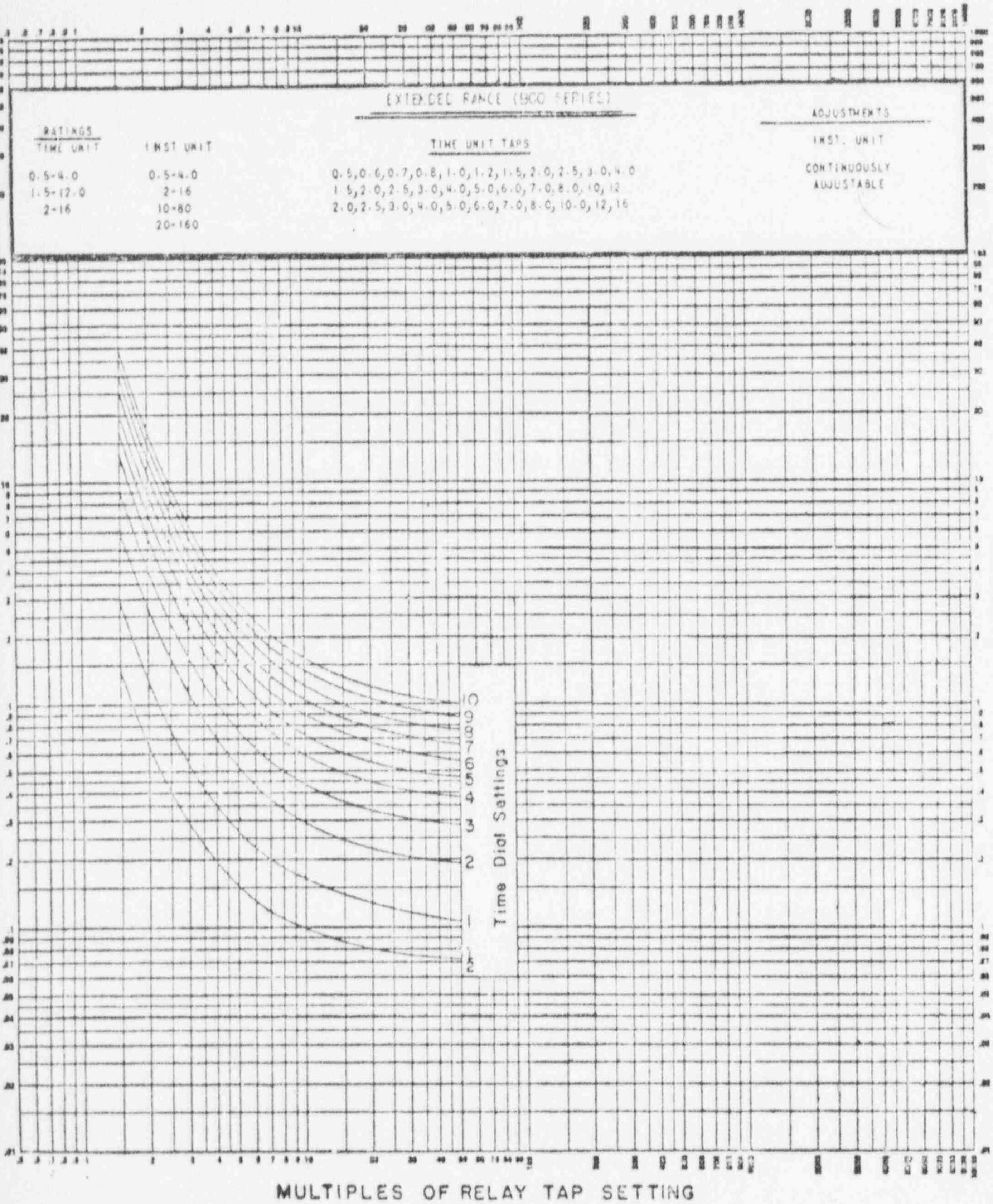
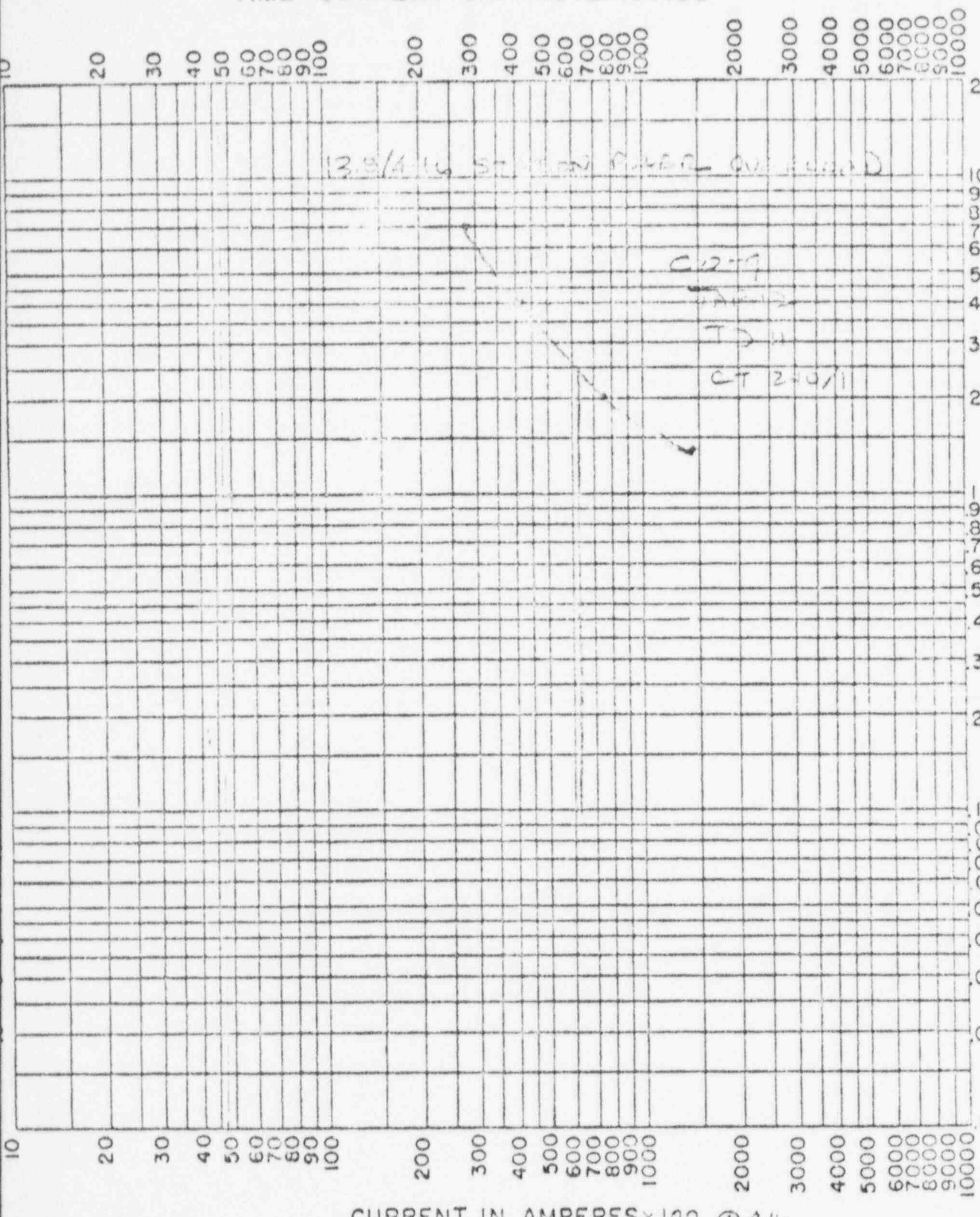


FIG. 9 (088B0270-3) 60HZ-TIME CURRENT CHARACTERISTICS FOR THE TYPES IAC53 AND IAC54 RELAYS

TIME-CURRENT CHARACTERISTICS



CURRENT IN AMPERES x 100 @ 4.16

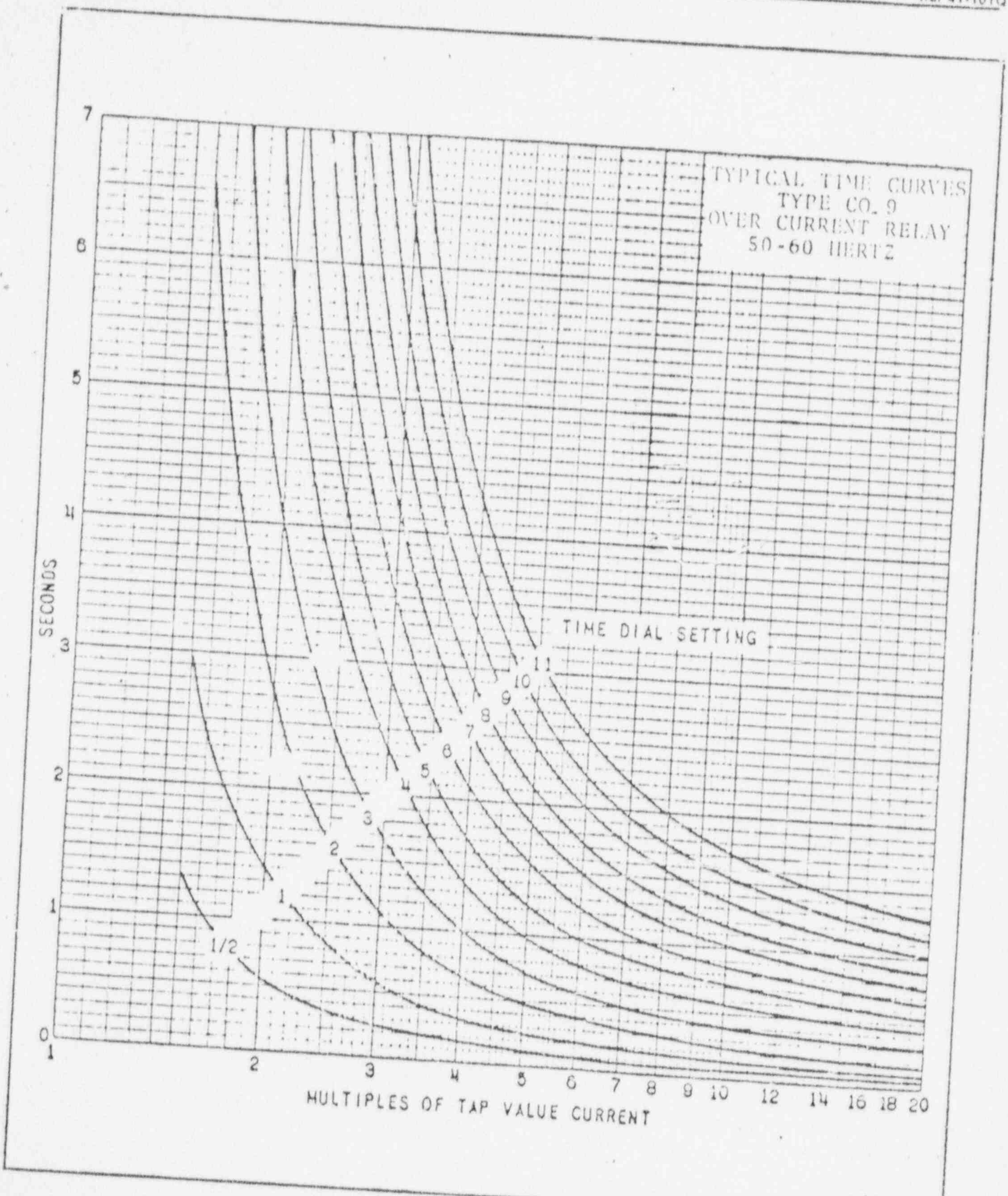


Fig 12. Typical Time Curves of the Type CO-9 Relay.

CO-9

Tap 12, TD-11

CT = 240/1 , Station Pwr Transf 13.8/4.16

4.16KV amps = (Relay)(12)(240)(13.8/4.16) = 9553A

Tap Value	Time	× 9553
3.1	7	29614
4.3	4	41077
8	2	76424
15	1.4	143295
20	1.3	

Inst. 80/12 × 9553 = 63686

11, 12, 21 Same

71 5M 10-71

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

ELECTRIC DISTRIBUTION DEPARTMENT

RELAY TEST ORDER

THE DIVISION SUPERINTENDENT CAMDEN DIVISION DATE Feb. 3, 1976

PLEASE DO THE FOLLOWING WORK AT SALEM GEN. STATION ON #22 STATION POWER TRANSF. LINE TO AT 13.8/4.16 KV

REGULAR RELAYS X BACK UP RELAYS

CT RATIO				RELAY DATA				SETTING DATA												
								TAP							TEST			VOLTS CURRENT		TIME
PRI	SEC	TERT	AUX	RELAY	STOCK CODE	RANGE	ELEMENT ZONE	CONDITION	1Z	θ	CURRENT	VOLTS	WATTS / SLOPE	%R CALC	CURRENT	VOLTS	Ø ANGLE °LEAD	PICK UP	DROP OUT	SEC
5/1				BDD				∅			3.5									
5/1											3.5									
	1000/1										5.0									
													25% - SLOPE TAP							
5/1				CO-9		4-12		∅			12.0				6.0 (11 DIAL)					[illegible]
						20-80 INST.												80		
	100/1			CO-8		0.5-2.5		⏚			1.0				10.0 (4 TIME)					[illegible]
								13KV BREAKER FAILURE												
5/1				CHC		2-?		BUS SECT. 3-4										2.0		
				TD-5																15.[illegible]

REASON FOR SETTING CHANGE:

IMPEDANCE CHANGE ☐ NEW INSTALL. ☐ REARRANGEMENT

Increased the pick up of the CO-8 ground relay to coordinate with the feeder relays

LOADABILITY LINE: 2 HR WINTER RATING: ______ AMPS LOADABILITY ______ MVA ______ AMPS

TRANSFORMER: ______ MVA ON ______ TRF BANKS ______ MVA ON ______ TRF BANKS MVA ON TRF BANKS

GENERAL SUPERINTENDENT OF DISTRIBUTION:

GENERAL SUPERINTENDENT OF DISTRIBUTION:

675 Furnished [illegible]

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

81

REFER TO

SUBJECT

FILE

ESTIMATE

PREPARED BY

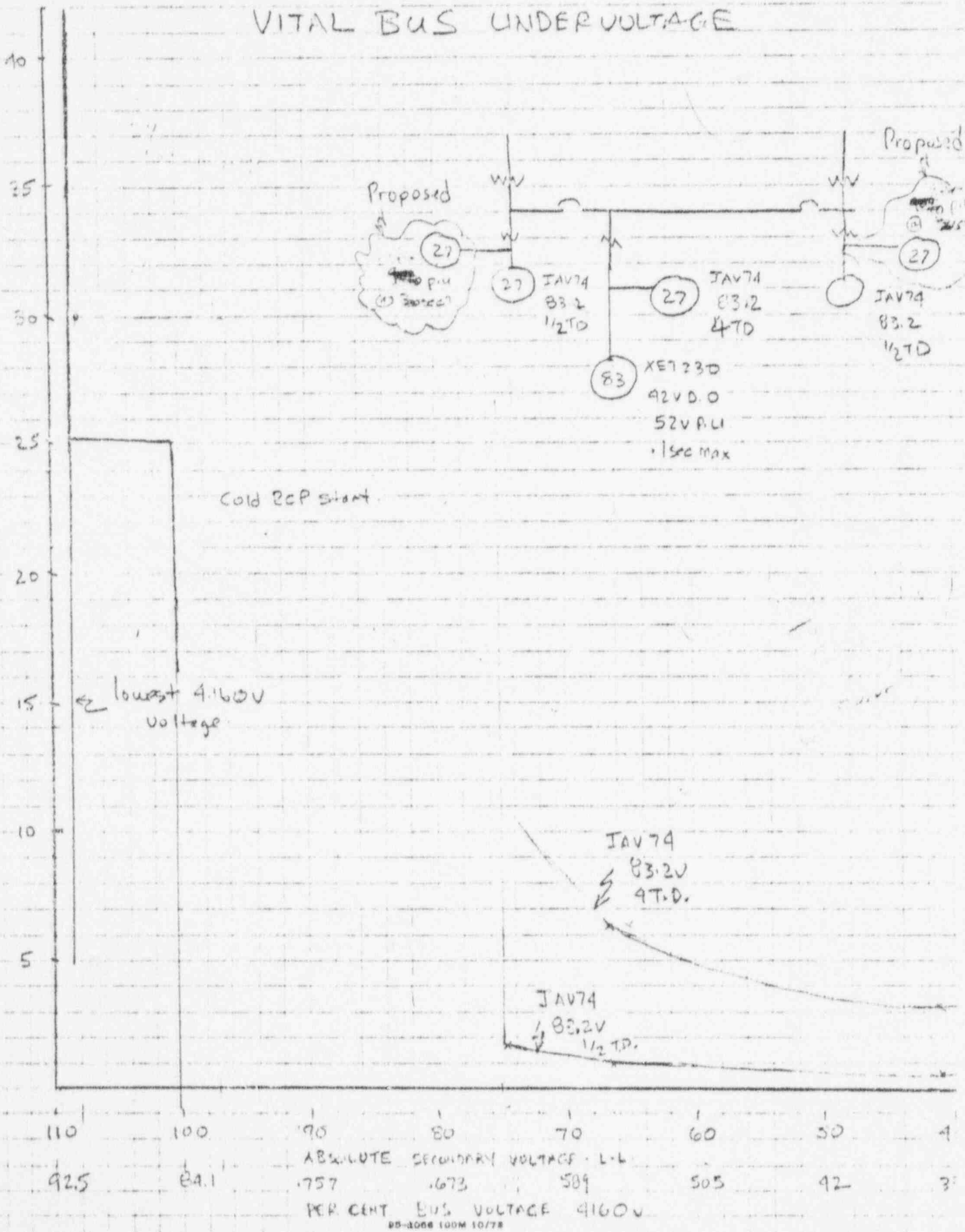
DATE

CHECKED BY

DATE

COMPUTATION SHEET

VITAL BUS UNDERVOLTAGE



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PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO

SUBJECT

FILE

ESTIMATE

COMPUTATION SHEET

PREPARED BY

DATE

CHECKED BY

DATE

PT ratio = 4200/120 = 35/1

IAV74 1/2 TD.

x83.2	%V	1/2	4
0	0	.5	2.4
41.6	50	.6	3.2
66.56	80	1	6.6
74.88	90	1.6	11.4

PT ratio 4200/120 = 35

Bus voltage 1.0 pu = 4160 ÷ $\frac{4160}{35}$ = 118.85 = 100%

V	%
110	.925
100	.841
90	.757
83.2	.70
80	.673
70	.589
60	.505
50	.42
40	.337

106.2 .90

95.08 80

101.02 85

53

INSTRUCTIONS

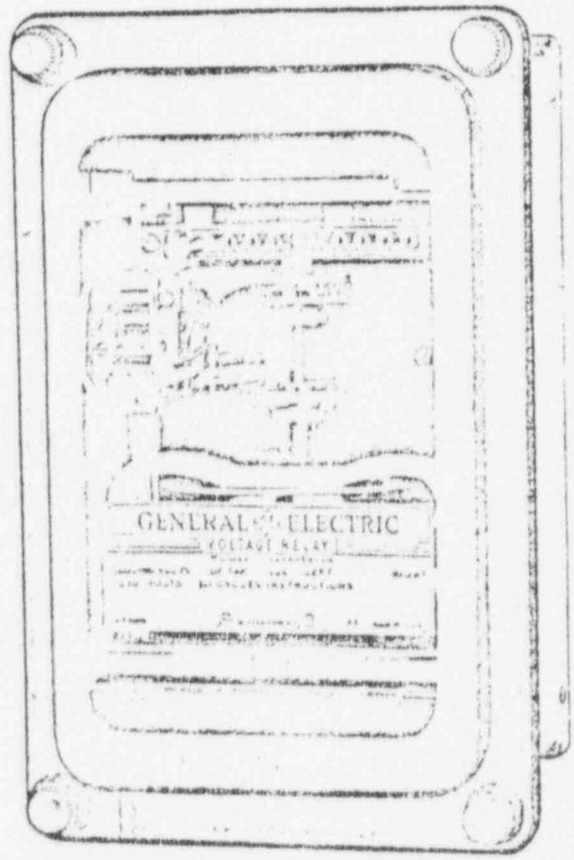
GEH-1768B
Supersedes GEH-1768A

UNDERVOLTAGE RELAYS

Types

IAV54E

IAV54F	IAV55F
IAV54H	IAV55H
IAV55C	IAV55J



POWER SYSTEMS MANAGEMENT DEPARTMENT
GENERAL ELECTRIC
PHILADELPHIA, PA.

84

UNDERVOLTAGE RELAYS

TYPE IAV

INTRODUCTION

These relays are of the induction-disk construction. The disk is actuated by a potential operating coil on a laminated U-magnet. The disk shaft carries the moving contact which completes the trip or alarm circuit when it touches the stationary contact or contacts. The disk shaft is restrained by a spiral spring to give the proper contact-closing voltage and its motion is retarded by permanent magnets acting on the disk to give the correct time delay.

There is a seal-in unit mounted to the left of the shaft as shown in Fig. 1. This unit has its coil in series and its contacts in parallel with the main contacts such that when the main contacts close, the seal-in unit picks up and seals in. When the seal-in unit picks up, it raises a target into view which latches up and remains exposed until released by pressing a button beneath the lower-left corner of the cover.

The relays are all mounted in single-unit double-end cases. The case has studs for external connections at both ends. The electrical connections between the relay and the case are made through stationary molded inner and outer blocks between which rests a removable connecting plug which completes the circuits. The molded outer blocks carry the studs for the external connections while the inner blocks carry the terminals for the internal connections. The operating coil is connected in parallel with both the upper and the lower inner molded blocks while the trip circuit is connected in series with these blocks. In this way, insertion of either the upper or lower connecting plug will energize the operating coil but the trip circuit will not be completed until the second connecting plug is inserted. For relays which have contacts closed when the relay is de-energized but open under normal operating conditions, the double connecting plug feature allows the relay contacts to open before the trip circuit is completed, thus minimizing the possibility of incorrect tripping when returning the relay to service after tests and inspection.

APPLICATION

These relays are protective devices designed to close trip or alarm circuits whenever the voltage applied to their operating coils reaches some predetermined value. The functions are described in greater detail in the following paragraphs.

OPERATING CHARACTERISTICS

The Type IAV54E relay has a single circuit-closing contact which closes when the voltage is reduced to some predetermined value. Thus, the contacts are closed at zero volts. This relay is a time undervoltage relay with inverse time characteristics which are shown in Fig. 2.

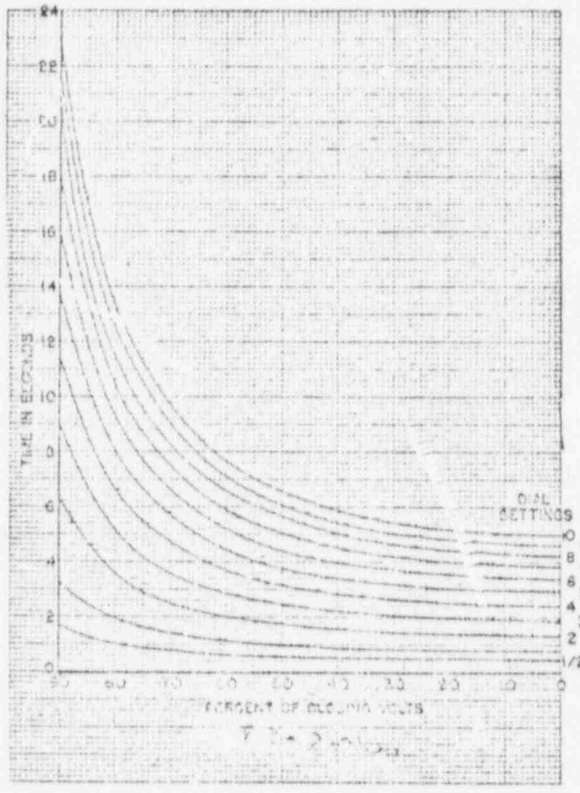


Figure 2. (362A648-0) Time-Voltage Curves for Relay Types IAV54E and IAV55C

The Type IAV54F relay is similar to the Type IAV54E relay except that it has a longer operating time. The time characteristics are shown in Fig. 3.

The Type IAV54H relay is also similar to the Type IAV54F relay except that it has much longer operating time than either the Type IAV54E or the Type IAV54F relays. The time characteristics are shown in Fig. 4.

The Type IAV55C relay is similar to the Type IAV54E relay except that it has two circuit-closing contacts.

The Type IAV55F relay is similar to the Type IAV54F relay except that it has two circuit-closing contacts.

The Type IAV55H relay is similar to the Type IAV54H relay except that it has two circuit-closing contacts.

The Type IAV55J relay is similar to the Type IAV55H relay except that it is provided with two separate seal-in units; one for each set of normally closed contacts.

(8307476) Cover

VOLTAGE SETTINGS

The voltage at which the contacts operate may be changed by changing the position of the tap plug in the tap block at the top of the relay. The range of this adjustment is from 55 to 140 volts on the 115 volt ratings, 110 to 280 volts on the 230 volt ratings, and 220 to 560 volts on the 460 volt ratings. Screw the tap plug firmly into the tap marked for the desired voltage (above which the relay is not to operate).

The tap settings indicate voltage values at which the contacts will close. A spring adjusting ring is provided for a sensitive adjustment of the relay operation. If the factory adjustment has been disturbed; the desired operating value may be obtained by inserting a tool in the notches around the edge of the ring (see Fig. 9) and turning the ring to the desired position. This adjustment also permits any desired setting between the taps. The relay has been adjusted at the factory to close its contacts, from any time-dial position, at a voltage within 5 per cent of the tap-plug setting. For example: If the tap plug setting is 55 volts, the contacts will close when the voltage is reduced from a higher value down to 55 volts. The relay contacts will open at 110 per cent of the tap setting. For the 55 volt tap setting, the contacts will open when the voltage is increased approximately 61 volts.

TIME SETTINGS

The time of operation of the relay is determined primarily by the setting of the time dial. Further adjustment is obtained by moving the permanent magnet along its supporting shelf; moving the magnet in toward the back of the relay decreases the time while moving it out increases the time.

Figs. 2, 3, and 4 show the time-voltage characteristics of the various relays with the time-dial settings for obtaining each characteristic. To make time settings, set the time dial to the number required (to give the desired characteristics) by turning it until the number lines up with the notch in the adjacent frame. The time indicated by the curves is the time required to close the relay contacts when the voltage is suddenly decreased from operating value or above to the value on the curve.

The time voltage curves are plotted in per cent thus making them applicable for all tap settings.

INSPECTION

At the time of installation, the relay should be inspected for tarnished contacts, loose screws, or other imperfections. If any trouble is found, it should be corrected in the manner described under MAINTENANCE.

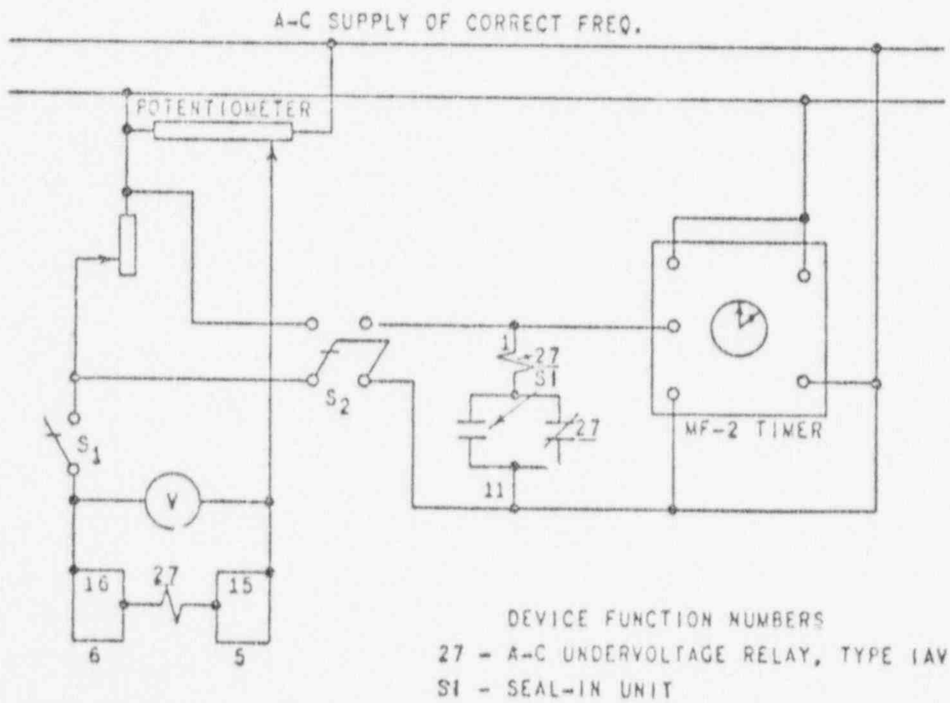


Figure 9. (0154392-5) Connections for Testing Relay Types IAV54 and IAV55

OPERATION

Before the relay is put in service, it should be given a partial check to determine that factory adjustments have not been disturbed. On relays which have time dials, the dials will be set at zero before the relay leaves the factory. It is necessary to change this setting so that the relay contacts may be opened.

The drop-out voltage should be checked on one or more taps making certain that the contacts close.

The time voltage curves should be checked for one or more settings.

Recommended test connections for the above tests are shown in Fig. 8.

The relay may be tested while mounted on the panel, either from its own or another source of power, by inserting separate testing plugs in place of the connecting plugs. Or, the cradle can be drawn out and replaced by another which has been laboratory tested.

MAINTENANCE

These relays are adjusted at the factory and it is advisable not to disturb the adjustments. If for any reason, they have been disturbed, the following points should be observed in restoring them:

DISK AND BEARINGS

The lower jewel may be tested for cracks by exploring its surface with the point of a fine needle. The jewel should be turned up until the disk is centered in the air gap, after which it should be locked in position by the set screw provided for the purpose.

CONTACT CLEANING

For cleaning fine silver contacts, a flexible burnishing tool should be used. This consists of a flexible strip of metal with an etched roughened surface, resembling in effect, a superfine file. The polishing action is so delicate that no scratches are left, yet corroded material will be removed rapidly and thoroughly. The flexibility of the tool insures the cleaning of the actual points of contact. Sometimes an ordinary file cannot reach the actual points of contact because of some obstruction from some other part of the relay.

Fine silver contacts should not be cleaned with knives, files, or abrasive paper or cloth. Knives or files may leave scratches which increase arcing and deterioration of the contacts. Abrasive paper or cloth may leave minute particles of insulating abrasive material in the contacts and thus prevent closing.

The burnishing tool described above can be obtained from the factory.

RENEWAL PARTS

It is recommended that sufficient quantities of renewal parts be carried in stock to enable the prompt replacement of any that are worn, broken, or damaged.

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, specifying the quantity required and describing the parts by catalogue numbers as shown in Renewal Parts Bulletin No. GEF-3897.

POOR ORIGINAL

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

ELECTRIC TRANSMISSION AND DISTRIBUTION DEPARTMENT

RELAY TEST ORDER

File Copy 5-1-79-17 FILE COPY

TO THE DIVISION SUPERINTENDENT CAMDEN DIVISION DATE OCT. 19, 1978

PLEASE DO THE FOLLOWING WORK AT SALEM GEN STATION ON #1A VITAL BUS LINE TO AT 4 KV

☐ REGULAR RELAYS ☐ BACK UP RELAYS

CT/PT RATIO PRI	SEC	TERT	AUX / ASSIST	RELAY	STOCK CODE 93-	RANGE	COND / ZONE	TAP CURRENT	TAP VOLTS	S / IZ	%	WATTS / SLOPE	% R CALC	TEST CURRENT	TEST VOLTS	Ø ANGLE °LEAD	VOLTS CURRENT PICK UP	DROP OUT	TIME SEC.
						VITAL BUS OVERLOAD AND GROUND													
2400/1	11ASD			IAC53A	3624	4-16		6.0						16					1.0
				IAC54A	3639	0.1-0.4		0.4						2					[illegible]
				IAV74A	3643	55-140			82 (ADJUST FOR 83.2V DROP OUT)						55				[illegible]
				TD-5	6902														12 cyc.
						VITAL BUS UV TRANSF. - VITAL BUS U.V. TRIP													
																	52	42	
	1AAD			XET-230	7561														
				IAV74A	3643	55-140			82 (ADJUST FOR 83.2V DROP OUT)						74.5				2.[illegible]
						VITAL BUS OVERLOAD AND GROUND													
2400/1	12ASD			IAC53A	3624	4-16		6.0						16					1.5
				IAC54A	3639	0.1-0.4		0.4						2					0.5
				IAV74A	3643	55-140			82 (ADJUST FOR 83.2V DROP OUT)						55				0.7
				TD-5	6902														12 cyc.
						AUXILIARY FEED PUMP MOTOR													
400/1	1AAD			IAC66B	3012	2.5-5		3.5						11.5					15
						10-40	INST										23		
				IAC55A	3009	1.5-6		2.5						12					5 [illegible]

REASON FOR SETTING CHANGE: ☐ CT RATIO CHANGE ☐ UPDATE SETTING ☐ IMPEDANCE CHANGE ☐ NEW INSTALL. ☐ REARRANGEMENT

11ASD, 12ASD & 1AAD IAV74 RELAY SETTING CHANGES PER DCR-1EC-0396

LOADABILITY:

TRANSFORMER:

_____ MVA ON _____ TRF BANKS
_____ MVA ON _____ TRF BANKS
_____ MVA ON _____ TRF BANKS

LINE: 4 HR RATING _____ AMPS
30 MIN RATING _____ AMPS
LOADABILITY _____ MVA _____ AMPS

TO GENERAL MANAGER—ELECTRIC TRANSMISSION AND DISTRIBUTION:

GENERAL MANAGER—ELECTRIC TRANSMISSION AND DISTRIBUTION

WORK COMPLETED: SIGNED ML/[signature] DATE 4/26/79 BY [signature]

APPENDIX II

FORM 3516 REV. 1/74

86

CALL FROM/TO

DATE

TIME

SUBJECT DATA

JOB NO.

ORDER NO.

Station Power Transformers	No 1,	No 2	No 21 -	No 2[illegible]
Rating - Base	60	60	15	15
Voltage Ratio	500/13.8	500/13.8	13.8/4.16	13.8/4.1[illegible]
Impedance	10.79%	10.54%	5.8%	5.7[illegible]%
No load position	#2 (512.5)	#2 (512.5)	#4 (13,455)	#4 (13,4[illegible])
(p.u Z - 1MVA)	.001798	.001756	.00386	.003[illegible]

Unit Substation Transformers

xfmr	2HL	2H-460	2H-230	2A-460	2A-230
Rating - Base	750	1000	750	750	300
Voltage Ratio	4160/208	4160/480	4160/240	4160/480	4160/240
Impedance	5.8%	5.34%	6.59%	5.75%	5%
Tap					
(p.u Z 1MVA)	.0773				

xfmr	2FL	2F-460	2F-230	2C-460	2C-230
Rating - Base	750	1000	750		
Voltage Ratio	4160/208	4160/480	4160/240		
Impedance	5.78%	5.46%	6.71%	5.41%	5%
Taps					

FORM 3516 REV. 1/74

CALL FROM/TO ____________________ DATE 12/4/78

TIME

SUBJECT DATA. JOB NO.

ORDER NO.

XFMR	NLTC	LTC tap	Drag needle range	Bal	BW	TD	R	Counter	Z on 15,00
11	4	4R	16R to 16L	124	~2.2	30L 30R	0	11348	5.8%
12	4	1R	12L to 16R	124	2	30	0	10726	5.7%
21	4	2R	16L to 16R	120	2	30	0	3201	5.8%
22	4	3L	5R to 16L	120	·2	30	16	3005	5.7%

← (lab runs up & down to do ratios)

NLTC = 13,455 volts. 1L = 4.134 1R = 4.186

No 1 NLTC = 2 10.79% on 69,000 NLTC = 512500

No 2 NLTC = 2 10.54% on 69,000

ACTUAL MEASUREMENTS FROM METERING (NO 2 CR)

	CR		
Keeney Line	520 KV	1.8 A	300 MW
No 21 Sta. Pwr	-	2600	16.2
22 Sta Pwr	-	1700	10.8
13 KV	13.4		
vitals	4200±	4100 (Local)	
group	4180±	4100±(Local)	

Note CR meters agree the LTC setting

SWITCHING ARR

500KV - all closed but 9-10, 1-9

13 KV - normal

4KV: 21 carrying E, H, A, B

22 carrying G, F, C

W Rayfley 12-4-78

Notes of Meeting

Attendees: J. Hebson
B. Daley
W. Raughley
J. Popvich - System Planning

Per our request System Planning ran studies to find the maximum 500 kV voltage at Salem.

The maximum practicable voltage on the 500 kV at Salem is 1.06 p.u. For this condition Salem 1 & 2 are on line with a 450 MVAR/Unit output. This condition will occur when system is going from a light load condition to a high load condition. This is done by boosting the VAR output of the base load units and putting the other units on line. Such a condition usually exists on late Sunday night-early Monday morning when the system is being built up. Otherwise, the highest voltage is 1.04 p.u.

WSR:aec

3Q1 25

IV. SALEM GENERATING STATION MINIMUM EXPECTED STEADY-STATE VOLTAGE CONDITIONS

Salem unit #2, scheduled for service in May, 1979, will be connected to the 500-kV transmission system as shown in Exhibit 4, including transmission line impedance data. Of concern in this section is the minimum steady-state voltage condition at Salem for the most critical yet extremely unlikely combination scheduled and sudden outage situation. Exhibit 5 is a power flow transcription of an all in peak load condition simulating a PSE&G capacity emergency power import level. Exhibit 6 is a condition which simulates the maintenance outage of Salem unit #1 along with the New Freedom-Deans 500-kV line.

In Exhibit 7, in addition to the previously described maintenance outages a sudden loss of the Salem-Keeney 500-kV line complicated with a stuck breaker at Salem, causes Salem unit #2 to trip leaving the auxiliary load of 44 MW at Salem to be fed radially from the New Freedom 230-kV bus. The resulting voltage shows a total reduction by 5.8% from the initial 103.6% on the 500-kV at Salem.

The attached calculation looks at the voltage transient resulting from connection of vital loads following a LOCA. This transient is not as severe as would be obtained under restart of an RCP under the event analyzed.

Start SI, charging, RHR, CS

B&C bus worse loading

1000
750
1810

375 + 650 + 410 + 375 = 1810 HP

Assume .91 pf. .93 eff

$$KVA = \frac{1810(.746)}{.91(.93)} = 1595\ KVA$$

assume .2 p.f.

$$Z = \frac{1}{1595}(.2 + j.9797) = .6269(.2 + j.9797) = .6269\angle 78.4$$

$$= .1253 + j.614$$

other load = 6 MVA @ .895 p.f.

$$= \frac{1}{6}(.855 + j.446) = .166\angle 26.48 = (.149 + j.079)$$

Reducing

$$\frac{(.6269)(.166)(\angle 78.46 + 26.48)}{(.1253 + .149) + j(.074 + .614)} = \frac{.104\angle 104.94}{.274 + j.688} = \frac{.104}{.7405}\angle 104.9 - 68.2$$

$$= .1404\angle 36.74 = .1125 + j.0839$$

plus transformer Z and cable Z

$$.1125 + j.0839 + j.0002 + j.0036 + j.0017$$

$$= .1125 + j.0882 = .1429\angle 38.09$$

assume same dies tapping on other end

$$.0715\angle 38.09 = .0562 + j.0441$$

$.0562 + j.0441 + j.001798 = .0562 + j.0458 = .0725 \angle$

$V = E\left(\frac{.0715}{.0725}\right)\left(\frac{.1404}{.1429}\right) = E(.9862)(.9825) = E(.9689)$

If system @ .978, taps offsetting

$V = .978(.9689) = \underline{.9476}$

Taking into account LTC which is set @ 1.0348 p.u.
Setting corresponding to preload is ~ R9-R10 ∴
$.9476(1.0624) = 1.006$.

During normal operation, the Safety Injection Pumps, Residual Heat Removal Pumps and Containment Spray Pumps are not operating except for tests. Up to five fan coolers are operating, depending upon the needs of the moment. At least one component cooling pump is operating.

During normal operation, an "S" signal may be generated in error. As soon as it is discovered that the "S" signal is false, the operator must defeat the signal and secure operation of the pumps to limit or prevent lifting of the pressurizer relief valves and eventual release of reactor coolant to the containment. The operator is locked out for performing any action for up to 2 minutes following receipt of the "S" signal until the start sequence is completed.

3.2 Abnormal Conditions

General

The design of the Salem Safeguard System includes the requirements that the station must be safely shut down during the occurrence of a loss of coolant accident (LOCA) and a coincident loss of offsite power (blackout). All electrical equipment needed during a LOCA is powered by the vital AC system which can be energized by standby diesel generator. The Safeguards Equipment Control (SEC) provides the necessary logic capable of initiating proper actions for any accident conditions (with possible continuation of events) assumed by the design of the station.

The SEC system is comprised of three independent control systems for each unit which determines the need for accident and/or blackout safety equipment, and start and load this equipment on the vital electrical system. Each SEC is independent and isolated from the others, and is associated with its own diesel generator. Rev. 3

Each SEC can control safety loads according to four modes of operation described below:

3.2.1 Injection Phase

3.2.1.1 Mode 1 LOCA (with Off-Site Power Available)

Should a LOCA occur, the Solid State Protection System (SSPS) will send safety injection ("S") signal to the SEC system. The SEC initiates the following actions automatically:

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a) Lock/out manual control of safety-related loads.

b) Start diesel generators (the diesels are not connected to tje bus since off-site power is available).

c) Automatically load all the following safety related loads to the vital bus.

- 240-480V Breaker (230V Control Center Loads)
- 800 2(400) Start SI Charging Pumps 70
- 1200 2(600) Start Safety Injection Pumps
- 800 2(400) Start Residual Heat Removal Pumps
- Start Containment Spray Pumps (If the "P" signal-high pressure in containment occur)
- Running — Start service water pumps (alternate SW pump if the other fails to start)
- Start at least four Containment Fan Coolers (low speed operation) (20TD. from HS to LS — Rev.
- Start Auxiliary Feedwater Pumps
- 460V — Start Chillers
- Start Emergency Control Air Compressors
- Start Aux. Bldg. Supply and Exhaust Fans
- Start Swgr. Room Supply Fans

The following valves will be operted to prepare for Emergency Core Cooling:

- The motor-operated valves at the inlet to (SJ 4 and 5) and discharge from (SJ 12 and 13) the Boron Injection Tank will be opened.
- The motor-operated valves in the normal charging paths (CV 139 and 140; CV 68 and 69; CV 40 and 41) will be closed; those in the seal water return line from the reactor coolant pump seals will be left open. Seal water return will be isolated on a "P" signal indicating high containment pressure.

BRC

- The valves on the line from the RWST to the Centrifugal Charging/Safety Injection Pump suction (SJ 1 and 2) will be ooened.

- The valves in the concentrated boric acid circulating lines from the CVCS (SJ 108, SJ 78 and 70) will be closed.

- Any closed accumulator valves (SJ 54) will be opened.

3.2.1.2 Mode II - Blackout

If power should be lost to the 4 kV vital busses, each SEC receives inputs from undervoltage relays on each vital bus. The undervoltage signals are combined in a two-out-of-three logic matrix in each SEC. If an accident has not occurred, the SEC performs the following logic sequence summarized below:

a) Trip all 460 V and 4160 V vital bus breakers.

b) Start diesel generators.

c) Lockout manual control of all bus loads until the automatic loading sequence is complete

Rev. 3

d) Close tne diesel generator ACB

e) Sequence the loading of safeguard equipment required for blackout conditions as shown below:

- 240-480V Breaker (230V Control Center Loads)
- Start SI Charging Pumps
- Start Component Cooling Water Pumps
- Start Auxiliary Feedwater Pumps
- Start Service Water Pumps (Alternate SW pump if previous fails to operate)
- Start Emergency Control Air Compressor
- Start Chillers
- Start Aux. Bldg. Supply and Exhaust Fans
- Start Swgr. Rooms Supply Fans

OPERATING INSTRUCTION
I-3.6
HOT STANDBY TO COLD SHUTDOWN

1.0 PURPOSE

1.1 This instruction outlines the sequence in which systems are placed in service for plant cooldown from Hot Standby (Mode 3) to Cold Shutdown (Mode 5). Specific operating details and valve lineups are found in the referenced operating instructions.

1.2 In the event plant conditions require a delay during some part of this procedure, the Senior Shift Supervisor/Shift Supervisor shall retain the check off sheets until the procedure is continued or terminated.

1.3 If the instruction is terminated prior to completion, the Senior Shift Supervisor/Shift Supervisor shall note the reason, time and date of the termination on each check off sheet which has been started. He will then file these check off sheets in the normal manner.

1.4 All steps of this instruction, with an asterisk, are to be signed off on the appropriate check off sheets.

1.5 Procedural steps must be completed, initial conditions may be satisfied in any order.

2.0 INITIAL CONDITIONS

*2.1 The plant is in Hot Standby with the control rods banks completely inserted and shutdown rod banks position and RCS boron concentration as specified in Fig. 20(b) of the Reactor Engineering Manual.

2.2 System temperature is being maintained approximately at the no-load T_{avg} (547°F) by use of the Steam Dump System in the MAIN STEAM PRESS CONT mode or by use of the Atmospheric's Steam Relief (MS10) Valves.

*2.3 Steam Generator water levels are being maintained at ~ 33% by operating the Auxiliary Feedwater System.

2.4 Four (4) Reactor Coolant Pumps are in operation to provide circulation through the core and minimize temperature differentials among the loops.

*2.5 At least one Source Range Channel is operational and the SR HIGH FLUX AT SHUTDOWN alarm is operational and is not BLOCKED.

3.0 PRECAUTIONS

3.1 Temperatures and Pressures.

POOR ORIGINAL

3.1.1 The residual heat removal loop must not be placed in service until the reactor coolant temperature is below 350°F and the pressure is $\leq$ 375 psig.

3.1.2 The Reactor Coolant Pumps must not be operated when the RCS pressure is not enough to maintain a differential pressure greater than 200 psid across the RCP's No. 1 Seal or when the Volume Control Tank pressure is less than 15 psig.

3.1.3 When the RCS is solid and under control of Letdown Pressure Control Valve 1CV18, an increase in RCS pressure should be expected whenever an RHR Pump is stopped. Likewise, a decrease in pressure will result from starting an RHR Pump.

3.1.4 When starting an RHR Pump with the RCS solid and at least one RCP in operation, special attention must be given the precautions in OI II-6.3.2, "Initiating Residual Heat Removal", to prevent decreasing the RCS pressure below the minimum required for RCP operation (RCS Solid).

3.1.5 The reactor core should always be supplied with a flow of water for cooling, and reliable temperature indications; therefore, when the Reactor Coolant System temperature is below 350°F, at least one Residual Heat Removal Pump or one Reactor Coolant Pump should be operation.

NOTE

Under abnormal conditions, when coolant cannot be supplied to the reactor core, a backup means of temperature detection is available in the in-core thermocouples.

3.1.6 When starting a Reactor Coolant Pump, special attention must be given the precautions in OI II-1.3.1, "Reactor Coolant Pump Operation", to prevent overpressurization of the RHR System or the RCS.

3.1.7 The Reactor Coolant Pump No. 1 Seal bypass valve, 1CV114, must be closed when the RCS pressure has been decreased to 100 psig.

3.1.8 The Reactor Coolant Pump seal water temperature must not exceed 140°F.

3.1.9 Component Cooling to the Reactor Coolant Pumps must be supplied any time a Reactor Coolant Pump is operating and should not be secured to an idle pump until the RCS has been cooled below 150°F and the pump has been idle for at least 1/2 hour.

3.1.10 The Pressurizer sprays must not be used, if the temperature differential between the Pressurizer and the spray fluid is greater than 320°F.

3.1.11 The RCS temperature should be maintained at least 50°F lower than the Pressurizer during cooldown.

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3.1.12 Plot on Operations Log No. 4, the RCS cooldown rate on at least a 30 minute interval maintaining the cooldown rate ≤ 100°F/hour and within the limits of the pressure - temperature curve to satisfy Technical Specification Surveillance 4.4.9.1.a.

3.1.13 Plot on Operations Log No. 5, the Pressurizer cooldown rate on at least a 30 minute interval maintaining the cooldown rate ≤ 200°F/hour to satisfy Technical Specification Surveillance 4.4.9.2.

3.1.14 Do not remove the Rod Drive Vent Fans from service while the control rod drive mechanisms are energized.

3.1.15 Do not remove the Reactor Shield Ventilation Fans or the Nozzle Support Fans from service until the RCS temperature is < 145°F.

3.1.16 During cooldown of the RCS from 547°F to less than 250°F, the number of running RCP's is as follows:

RCS TEMP.	RCP's IN-SERVICE
547°F TO 400°F	4
400°F TO 350°F	3
350°F TO 250°F	(2) 11 RCP and 14 RCP OR 12 RCP and 13 RCP
LESS THAN 250°F	(1) 11 RCP or 11 RCP OR NO RCP's RUNNING AND RHR IN-SERVICE

NOTES

1. No. 11 or No. 13 RCP should be operated to maintain pressurizer spray.
2. Operation of RCP's, other than specified above, can result in uneven RCS temperatures among the loops and create conditions in the S/G's leading to inadvertent safety injections created by S/G differential pressures.

3.1.17 Maintain at least one Reactor Coolant Pump in service during the degasing and borating operations.

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3.1.18 DO NOT exceed the 1600 psi ΔP limit across the Steam Generator tube sheets.

3.1.19 When in the Hot Standby condition, the rate of feedwater addition to a Steam Generator is limited to $\leq 2.2 \times 10^4$ gpm/hr whenever the S/G level is $\leq$10% narrow range.

3.1.20 When the RCS temperature (as indicated by Loop 11 or Loop 12) decreases to 312°F and the RCS pressure is reduced to less than 375 psig, the Pressurizer Overpressure Protection System (POPS) must be armed.

3.1.21 During the cooldown of the RCS, avoid the use of the Atmospheric Relief Valves when the condenser is available.

NOTE

Use of the Atmospheric Relief Valves warrants close operator monitoring of 11-14 steam generator pressures (observed on the S/G Protection Channels) in order to avoid S/G differential pressures resulting in inadvertent safety injections.

3.2 Chemistry

3.2.1 The flow rate of reactor coolant shall be greater than 3000 gpm whenever a change in Reactor Coolant System boron concentration is being made.

3.2.2 When changing RCS boron concentration, Pressurizer sprays should be utilized to minimize the differential between Pressurizer and loop boron concentration. The use of spray flow should continue until this difference is less than 50 ppm.

3.2.3 Before placing the RHR System in service, its boron concentration must be such that if the RCS was at that concentration, the minimum Shutdown Margin requirements would be met.

3.2.4 The hydrogen concentration in the reactor coolant should be reduced to less than 5 cc/kg prior to being opened for refueling or repair.

3.3 Reactivity Control

3.3.1 A minimum of one Source Range Channel shall be in operation any time the reactor is shutdown.

3.3.2 The RCS must be borated, prior to start of cooldown, to insure the minimum SDM is maintained. Refer to Fig. 20(a) of the Reactor Engineering Manual for the RCS boron concentration required for cold shutdown mode of operation.

NOTE

Approximately 46,000 gallons (> 19.5%) of primary water (30,000 gallons above Low Level Alarm) and 1,000 gallons of concentrated boric acid (in excess of the 5106 gallons required by the Technical Specifications) must be available for cooldown makeup.

3.3.3 The Audio Count Rate Channel should be in operation any time the reactor is shutdown.

4.0 CHECK OFF SHEETS

4.1 Plant Cooldown

5.0 PROCEDURE

5.1 If the Reactor Coolant System is to be opened for repair [illegible]ing, increase the purification rate to its maximum rate, however, do not exceed 120 gpm.

*5.2 If required, begin the degassing of the RCS IAW OI II-3.3.11, "Volume Control Tank Degassification".

NOTE

Degassing and cooldown may be accomplished concurrently.

cold shut-down concentration

*5.3 Borate the RCS to a concentration determined from Figure 20(a) of the Reactor Engineering Manual. Borate IAW OI II-3.3.6, "Boron Concentration Control". Perform a shutdown Margin Calculation IAW the Reactor Engineering Manual prior to entering Mode 5 for the above conditions.

*5.4 De-energize all Pressurizer heaters after the Pressurizer boron concentration has been verified to be within 50 ppm of the concentration in the reactor coolant loops.

NOTE

If outage is going to be of short duration and the bubble maintained in the Pressurizer, the following steps pertaining to Pressurizer cooldown are to be marked N/A (not applicable) on Check Off Sheet 4.1: Steps 5.4, 5.12, 5.27, 5.28 and 5.30.

*5.5 Notify Technical Supervisor-Chemistry of impending plant cooldown and the need to sample the RCS per the Chemistry Department requirements.

WILL BE IN AUTO WHEN CR IS EVACUATED – CANT ADJUST BLEND LOCALLY

→ *5.6 Place the Make-Up Mode Selector in AUTO and adjust the blend.

5.7 Verify that a normal level in the Volume Control Tank is being maintained during the cooldown, except during degassing operations.

5.8 Slowly increase the rate of steam dump by lowering the pressure setpoint of the main steam dump pressure controller, or place the main steam dump pressure controller in MANUAL and periodically adjust the dumping of steam to maintain the desired cooldown rate. If the condenser is unavailable for dumping steam, the use of the 11-14 MS10 Atmospheric Relief Valve in AUTO or MANUAL is authorized. Plot on Operations Log #4 the cooldown rate on at least 30 minute intervals maintaining the cooldown rate ≤100°F/hr and within the limits of the pressure-temperature curve.

CAUTION

→ Cooldown of the RCS via the 11-14 MS10 Atmospheric Relief Valves requires close operator monitoring of the S/G pressure so that S/G ΔP inadvertent safety injections will not occur. TOO BAD!

5.8.1 Maintain Steam Generator levels in the normal operating range. (33%)

*5.9 Maintain four (4) RCP's in service when the RCS temperature is between 547°F and 400°F.

5.10 When the RCS temperature reaches the setpoint of the P-12 Permissive (543°F) as indicated by the LOW T_{avg} (2/4 Low-Low T_{avg}) Light on the RP4 Status Panel:

CAN'T DO

*5.10.1 Depress the TRAIN "A" and TRAIN "B" STEAMLINE PRESSURE SI BLOCK pushbuttons to block the High Steam Flow coincident with Low Steam Pressure or Low-Low T_{avg} safety injection signal.

*5.10.2 Depress the STEAM DUMP INTLK TR A and TR B BYPASS T AVG pushbuttons to bypass the Low-Low T_{avg} Steam Dump block to allow the cooldown to continue.

SI WILL CAUSE MAJOR VALVE REALIGNMENT IN PLANT AND SAFEGUARDS PUMPS TO START

CAUTION

These blocks will automatically reset above 543°F, should temperature then decrease below 543°F the actions described above must be repeated.

MANUAL CONTROL OF CHARGING USING CV55

5.11 As cooldown progresses, adjust charging flow to gradually increase Pressurizer level to approximately 70%.

NOTE

Readjust No. 13 Charging Pump low speed stop to maintain minimum seal injection flow as pressure is decreased.

HOW?

5.12 Transfer the controllers for the spray valves to MANUAL and slowly open the spray valves to begin the cooldown and depressurization of the Pressurizer. Observe precaution 3.1.10. Plot on Operations Log No. 5 the cooldown rate on at least a 30 minute interval maintaining the cooldown rate ≤ 100°F/hour.

*5.? When the RCS pressure has been reduced below 1915 psig, manually block the Low Pressure Pressure coincident with Low Pressurizer Level safety injection signal by depressing the TRAIN "A" and TRAIN "B" PRESSURIZER PRESSURE SI BLOCK pushbuttons.

CAUTION

The Low Pressurizer Pressure coincident with Low Pressurizer Level safety injection signal will automatically reset should pressure increase above 1915 psig and must be reblocked when pressure once again decreases below 1915 psig.

WESTINGHOUSE SAYS WE MAY NOT HAVE TO DO THIS IF LOWER ADD. BRG TEMPERATURE STAYS DOWN (<200°F?

*5.14 When the seal leakoff from any operating Reactor Coolant Pump No. 1 Seal decreases to 1 gpm or the RCS pressure is ≤ 1500 psig, open Reactor Coolant Pump Seal Bypass Valve 1CV114. Record valve status in Valve Deviation List.

5.15 Open additional letdown orifice isolation valves, as necessary, to maintain letdown flow rate. ch

5.16 When the Steam Generator's pressure has decreased to ≈ 500 psig (T_{avg} ≈ 475°F) the Condensate Pumps may be used to maintain Steam Generator levels and for continuing the cooldown (the Auxiliary Feed Pumps maybe secured at this time).

.17 When the RCS pressure decreases below 1000 psig, close Accumulator Outlet Valves 11, 12, 13 and 14SJ54, and C&T the electrical supplies to the valve motors. SHUT MANUALLY @ VALVE CONTR. Record valve status in Valve Deviation List.

*5.18 When the RCS temperature has been reduced below 400°F, reduce the running RCP's to three (3). No. 11 RCP or 13 RCP should remain in operation to provide pressurizer spray flow. ~~Upon stopping of each RCP verify the respective RCP breaker open status light on RP4 Status Panel energizes.~~

*5.19 When the RCS temperature has been reduced below 350°F and pressure is <375, place the RHR System in service IAW OI II-6.1.2, "Initiating Residual Heat Removal".

5.20 When the RCS temperature is below 350°F. done? @ SI INITIATION (OR NEED SI BLOCKS)

*5.20.1 C&T the electrical supplies to both Safety Injection Pumps: rack the 4KV breakers out and turn off the DC Control Power. Close 11 and 12SJ134 and 1SJ135. Record the position change in the Valve Deviation List for OI II-4.3.1, "SIS Normal Operation".

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*5.20.2 C&T the electrical supply to one Centrifugal Charging Pump; rack the 4KV breaker out and turn off the DC Control Power.

NOTE

A minimum of one Centrifugal Charging Pump must remain operable as a part of an ECCS subsystem until RCS temperature is below 200°F as required by the Technical Specifications. *

*5.20.3 C&T the electrical supplies to both motor driven Auxiliary Feedwater Pumps; rack the 4KV breakers out and turn off the DC Control Power.

NOTE

If it is necessary or desirable to use the Auxiliary Feed Pump(s) to maintain Steam Generator levels, clearing and tagging may be deferred until the pump(s) is no longer required.

*5.20.4 Close and C&T 11 and 12MS45, the steam supply valve to No. 11 Auxiliary Feedwater Pump. Record valve status in the Valve Deviation List.

5.20.5 Reduce the running RCP's to two (2) in the following combinations:

a) 11 RCP and 14 RCP

OR

b) 12 RCP and 13 RCP

~~Upon stopping of each RCP verify the respective RCP Breaker Open status light on RP4 Status Panel energizes.~~

~~*5.20.6 Test the POPS IAW OI II-2.3.4, "Pressurizer Overpressure Protection - Operability Check of PR1 and PR2".~~ (?)

*5.21 When the RCS temperature reaches 312°F (as indicated by Loop 11 or Loop 12 Wide Range T_c) reduce RCS pressure to less than 375 psig (as indicated by ~~PT403 and PT405~~) (?). With RCS pressure less than 375 psig and RCS temperature at 312°F, arm the POPS by depressing Channel I and II pushbuttons to the "ON" position (?)

~~*5.22 When the RCS temperature reaches 230°F and water chemistry has been adjusted, place the Steam Generators in "Wet Layup" IAW OI III-9.3.3, "Filling and Venting the Steam Generators".~~

NOTE

~~If the outage is to be of short duration, placing the Steam Generators in "Wet Layup" is not required.~~

5.22.1 With the RCS temperature ≤250°F, the number of running RCP's can be reduced to one (1). No. 13 RCP should remain in service to provide Pressurizer spray flow. Upon stopping of each RCP verify the respective RCP Breaker Open status light on RP4 Status Panel energizes.

5.23 When steam dump is no longer required, break vacuum and remove the Turbine Gland Sealing System from service, as desired.

5.24 If the S/G's will not be put in "Wet Layup", open wide 11-14MS10 Atmospheric Relief Valves to facilitate S/G heat removal.

5.25 When the RCS temperature is below 200°F:

*5.25.1 C&T the electrical supplies to both Contaiment Spray Pumps: rack the 4kV breakers out and turn off the DC Control Power.

*5.25.2 C&T the electrical supply to remaining Centrifugal Charging Pump: rack the 4kV breaker out and turn off the DC Control Power. If the other Centrifugal Charging Pump has not been made inoperable, C&T its electrical supply, rack the 4kV breaker out and turn its DC Control Power off.

5.26 If the shutdown is to be of long duration, degas the Generator IAW OI IV-2.3.2, "Generator Gas System - Normal Operation".

*5.27 If the Pressurizer is to be filled solid, establish a continuous bleed through the sample system IAW PD-3.5.004, "Pressurizer Steam Space Sampling", to vent off non-condensable gases. Take the Reactor Coolant System solid IAW OI II-1.3.4, "Filling and Venting the RCS".

*5.28 When the Pressurizer is solid, slowly open 1PS1 and/or 1PS2, Pressurizer Spray Valves to obtain a uniform cooldown of the Pressurizer.

*5.29 When the Cold Shutdown, Mode 5, RCS temperature has been achieved, continue operation in Mode 5 with:

5.29.1 One RCP in service
5.29.2 Pressurizer bubble exists
5.29.3 POPS "ON"
5.29.4 RHR System in service for temperature control.

NOTE

This is the normal, preferred operation of the RCS for cold shutdown, Mode 5. Possibility of a RCS overpressurization is minimized. The RCS accumulators may remain pressurized above their MPT limit of 70°F (Refer to OI II-4.3.4). Planned deviations from the above must be authorized by the Chief Engineer or Station Operating Engineer.

*5.30 To continue the cooldown of the pressurizer as required by maintenance or refueling outage:

5.30.1 Open Pressurizer Auxiliary Spray Stop Valve 1CV75.
Record valve status in the Valve Deviation List.

5.30.2 Close Charging Line Stop Valve 1CV77. Record valve status in the Valve Deviation List.

5.30.3 Adjust the Reciprocating Charging Pump speed to obtain the desired cooldown of the Pressurizer.

5.30.4 Continue to circulate through the auxiliary spray line until the Pressurizer temperature has been reduced to the desired temperature.

5.31 Prior to reducing the RCS pressure below 100 psig close the RCP Seal Bypass Valve 1CV114.

5.32 Prior to reducing RCS pressure less than 25 psig:

5.32.1 Open 1PR1 or 1PR2 to the PRT.
5.32.2 Drain the PRT below the sparger (approx. 20%).
5.32.3 Continue cooldown of the pressurizer to the desired temperature using auxiliary spray flow.

NOTE

Nitrogen makeup to the PRT with 1PR1 or 1PR2 open will occur to maintain the RCS at a positive pressure (≥8psig).

CAUTION

Abnormal or sudden pressurizer level increases are indicative of vacuum formation.

5.32.4 If the RCS is to be drained below the level range of the Pressurizer Cold Calibrated Channel, refer to OI II-1.3.6, "Draining the RCS".

*5.32.5 If the RCS is to be drained IAW OI II-1.3.6, "Draining the RCS", C&T the electrical power to 1RH1 and 1RH2 and limit RHR pump operation to one (1).

5.33 Maintain RCS temperature >50°F unless tension is relieved from reactor head studs.

Prepared by E. P. Cruchnicki

SORC Meeting No. 50-78

H. J. Midura
Manager - Salem Generating Station

Date 3/14/78

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CHECK OFF SHEET 4.1

PLANT COOLDOWN

STEP	ITEM	SIGNATURE	DATE
2.1	Hot Standby Mode of Operation		
2.3	S/G Level at ~ 33%		
2.4	Four RCP's In Service		
2.5	Source Range Channel Operable		
5.2	Degas RCS		
5.3	RCS Borated for K_{eff} <.99		
5.4	Pressurizer Heaters Off	*	
5.5	Commenced RCS Sampling		
5.6	CVCS - Makeup Control in AUTO		
5.9	Four RCP's In Service (547°F to 400°F)		
5.10.1	Steamline Pressure SI Block (P-12)		
5.10.2	Steam Dump Interlock BYPASS T_{avg}		
5.11	Pressurizer Level Increased to ~70%	*	
5.12	Pressurizer Spray Valves MANUAL OPEN		
5.13	Pressurizer Pressure SI Block (P-11)		
5.14	RCP Seal Bypass Valve Open		
5.17	Accumulator Outlet Valves Closed		
5.18	Three (3) RCP's In Service (≤400°F)		
5.19	Initiate RHR		
5.20.1	C&T Safety Injection Pumps		
5.20.2	C&T Centrifugal Charging Pump		
5.20.3	C&T Motor Driven Auxiliary Feedwater Pumps		
5.20.4	11 & 13MS45 Closed and C&T		
5.20.5	Two (2) RCP's In Service (≤350°F)		
5.20.6	Test POPS		
5.21	POPS "ON"		
5.22	S/G's in Wet Layup	*	
5.22.1	One (1) RCP In Service (≤250°F)		
5.23.1	C&T Containment Spray Pumps		

*NOTE: If the bubble is to be maintained in the Pressurizer, these steps may be marked N/A

NOTE: If the outage is of short duration, this step may be marked N/A (Not Applicable).

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CHECK OFF SHEET 4.1

PLANT COOLDOWN

STEP	ITEM	SIGNATURE	DATE
5.25.2	C&T Remaining Centrifugal Charging Pump	________	________
5.2"	Vent Pressurizer, Take RCS Solid	________*	________
5.28	Commence Pressurizer Cooldown	________*	________
5.29	Pzr. Bubble, Mode 5, One RCP Operation	________	________
5.30	Complete Pressurizer Cooldown	________*	________
5.22.5	C&T 1RH1 and 1RH2	________*	________

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*NOTE: If the bubble is to be maintained in the Pressurizer, these steps may be marked N/A.

*NOTE: If the outage is of short duration, this step may be marked N/A (Not Applicable)

Reviewed by ______________________________ Date ______________
Senior Shift Supervisor / Shift Supervisor

EMERGENCY INSTRUCTION

I-4.0

SAFETY INJECTION INITIATION

1.0 PURPOSE

1.1 This instruction is provided to present the immediate automatic and manual actions required to be performed on the receipt of any Safety Injection actuation, regardless of the cause.

1.2 This instruction contains the information required to direct the operator to the appropriate Emergency Instruction to cope with the existing plant conditions.

2.0 INITIAL CONDITIONS

2.1 Safety Injection has initiated.

3.0 IMMEDIATE ACTIONS

3.1 Verify the following automatic actions have occurred.

3.1.1 Reactor trip by verifying all control rods are fully inserted by checking the individual rod position indications and rod bottom lights.

1. If any control rods do not indicate full insertion, initiate a manual reactor trip.

3.1.2 Accident loading of the Safeguards Equipment has taken place and the following equipment is running by observing the indicating lights on the status panel on RP-4 and by observing the control bezels for each of the following:

1. Centrifugal Charging Pumps
2. Safety Injection Pumps
3. Residual Heat Removal Pumps
4. Auxiliary Feedwater Pumps (Motor Driven)
5. Service Water Pumps
6. Containment Fan Coil Units in slow speed
7. Diesel Generators

3.1.3 Reactor Coolant temperature is decreasing to or being maintained at 547°F by either steam dump or atmosheric steam relief.

3.1.4 Within two minutes reduce Auxiliary Feedwater Flow to the Steam Generators to limit the rate of rise to <1.2 in/min by monitoring the wide range level recorders (<0.2%/min on the wide range until the level is > 10% on the narrow range indication for all Steam Generators not affected by the failure. Then re-establish maximum Auxiliary Feedwater Flow.

NOTE

This limitation applies to Unit 1 only.

3.1.5 Turbine trip by verifying the following:

1. Unit Trip light on the EH Console
2. Turbine speed decreasing

If the turbine does not indicate a tripped condition, initiate a manual trip from the control console.

3.1.6 Main Feed Pumps tripped by observing the indications on the control bezel. If either pump has not tripped, trip it manually.

3.1.7 Feedwater isolation by observing the indicating lights on the Feedwater section of RP4.

3.2 Verify Safety Injection Pump flow to the Cold Legs from the operating Safety Injection Pump(s) by observing the discharge flow meters on the control console. When RCS pressure decreases to $\leq$1550 psig as read on the Wide Range Indicators on the control console, stop all Reactor Coolant Pumps.

3.3 Verify Containment Phase A isolation has taken place by observing the indicating lights on the status panel RP-4.

3.4 Announce over the Station PA System twice: UNIT 1(2) REACTOR TRIP, SAFETY INJECTION.

4.0 SUBSEQUENT ACTIONS

4.1 Verify Safety Injection is in progress by checking each of the following. If any equipment or valve is not in the desired condition or position attempt to establish the desired condition at the individual bezel on the control console.

CAUTION

DO NOT attempt to reset the Safety Injection or SEC in order to place equipment in the desired condition. System design is such that sufficient redundancy is provided to overcome single failures.

4.1.1 Verify, utilizing console and/or 1(2)RP4 status panel indications, that the loads listed on Table I have been loaded onto the vital busses.

4.1.2 Verify that the Containment Fan Coolers meet the following conditions upon starting:

a. Fan Coolers have decreased speed
b. Fan Coolers service water flow has increased from 700 gpm to 2500 gpm
c. Roughing filter dampers have closed
d. HEPA inlet dampers have opened
e. HEPA outlet dampers have opened

4.1.3 Check that the following valves have opened by observing the status panel. If any valve fails to open, attempt to manually open from the control console

1(2)SJ4	Boron Injection Tank Inlet Valve
1(2)SJ5	Boron Injection Tank Inlet Valve
1(2)SJ12	Boron Injection Tank Outlet Valve
1(2)SJ13	Boron Injection Tank Outlet Valve

1(2)SJ1 Charging Pump Suction From RWST
1(2)SJ2 Charging Pump Suction from RWST

4.1.4 Check that the following valves have closed. If any valve fails to close, attempt to close the valve from the control console.

1(2)SJ78	Recirc to Boric Acid Tank
1(2)SJ79	Recirc to Boric Acid Tank
1(2)SJ108	Recirc to Boron Injection Tank
1(2)CV68	Charging System Stop Valve
1(2)CV69	Charging System Stop Valve
1(2)CV139	Charging Pump Disch to SWHX
1(2)CV140	Charging Pump Disch to SWHX
1(2)CV40*	Volume Control Tank Discharge Valve
1(2)CV41*	Volume Control Tank Discharge Valve
1(2)CV3	Orifice Isolation Valve (Letdown)
1(2)CV4	Orifice Isolation Valve (Letdown)
1(2)CV5	Orifice Isolation Valve (Letdown)
1(2)CV7	CVCS Letdown Line
1(2)CV116	Reactor Coolant Pump Seal Water Discharge
1(2)CV284	Reactor Coolant Pump Seal Water Discharge
11(21)SW20	Turbine Generator Area Supply Valve
11(21)SW20	Turbine Generator Area Supply Valve
1(2)SW26	Turbine Generator Area Isolation Valve

NOTE

*These valves will not close until either 1(2)SJ1 or 1(2)SJ2 is fully open.

4.2 Verify that Phase "A" Containment Isolation has taken place by checking that the valves listed in Table II are closed. Should a valve fail to close, attempt to close it from the control console.

4.3 Verify that Feedwater Isolation has taken place due to the Safety Injection.

4.3.1 Check that the following valves have closed by observing the status panel and/or the console bezel. If any valve has failed to close, attempt to close it from the control console.

11(21)BF13	Feedwater Inlet Stop Valve
11(21)BF19	Feedwater Control Valve
11(21)BF40	Feedwater Bypass Valve
12(22)BF13	Feedwater Inlet Stop Valve
12(22)BF19	Feedwater Control Valve
12(22)BF40	Feedwater Bypass Valve

13(23)BF13 Feedwater Inlet Stop Valve
13(23)BF19 Feedwater Control Valve
13(23)BF40 Feedwater Bypass Valve
14(24)BF13 Feedwater Inlet Stop Valve
14(24)BF19 Feedwater Control Valve
14(24)BF40 Feedwater Bypass Valve

4.4 Verify that the 4160 V Group Busses have transferred from the No. 1(2) Auxiliary Power Transformer to No. 11(12) and No. 12(22) Station Power Transformers.

4.4.1 Check that the following 4160 V breakers have opened and acknowledge them on the appropriate control console bezel:

1(2)BGGD
1(2)BFGD
1(2)AEGD
1(2)AHGD

4.4.2 Check that the following 4160 V breakers have closed and acknowledge them on the appropriate console bezel:

12(22)GSD
12(22)FSD
11(21)ESD
11(21)HSD

4.5 Verify the following fans have stopped by observing the indications as noted. If any fans are still running, attempt to stop them manually.

No. 11 & 12 (21 & 22) Iodine Removal, Control Console
No. 11, 12 , 13 , 14 (21, 22, 23,24) Nozzle Support, Control Console
No. 11 & 12 (21 & 22) Reactor Shield, Control Console
No. 11, 12, 13, 14 (21, 22, 23, 24) Control Rod Drive, Control Console
No. 11 & 12 (21 & 22) RHR Pump Room Coolers, RP2
No. 11 & 12 (21 & 22) Charging Pump Room Coolers, RP2
No. 11 & 12 (21 & 22) Containment Spray Pump Room Coolers, RP2

4.6 Verify Control Area Air Conditioning has shifted to the ACCIDENT - INSIDE AIR mode of operation and the following actions have occurred by observing the status panel on RP2. If any actions do not occur, manually initiate them IAW OI II-17.3.2, "Control Room Ventilation Operation", Section 5.3.

NOTE

Control Room Ventilation Isolation of Unit No. 1(2) will also isolate Unit No. 2(1) Control Room, however, its green NORMAL mode indicator will remain illuminated.

4.6.1 No. 11, 12, 13 (21, 22, 23) Chillers are running.

4.6.2 No. 11 & 12 (21 & 22) Chilled Water Pumps are running

4.6.3 No. 11, 12, 13 (21, 22, 23) Control Area Supply Fans are running

4.6.4 No. 11 & 12 (21 & 22) Emergency Control Area Supply Fans are running.

4.6.5 Battery Exhaust Fan has stopped.

4.6.6 Control Valves 1(2)CH30 and 1(2)CH151 close to isolate the Adminstrative Building.

4.6.7. Control Area Dampers positioned as follows:

CAA1 - Closed	CAA4 - Closed	CAA17 - Open	CAA20 - Closed	CAA33 - Closed
CAA2 - Closed	CAA5 - Open	CAA18 - Closed	CAA31 - Closed	
CAA3 - Closed	CAA14 - Closed	CAA19 - Closed	CAA32 - Closed	

5.0 IDENTIFICATION OF FOLLOW-UP ACTIONS

5.1 If RCS Pressure decreased rapidly with no other indications of primary or secondary leakage, verify the following are closed or isolated at their individual control bezels.

5.1.1 Pressurizer Spray Valves (PS-1&3)

1. If PS1 or PS3 is open and will not close, trip the Reactor Coolant Pump in the associated loop.

   1(2)PS1 - Trip 11(21) RCP
   1(2)PS3 - Trip 13(23) RCP

5.1.2 Pressurizer Power Operated Relief Valves (PR1 & 2)

5.1.3 Pressurizer Overpressure Protection Valves (PR 47 & 48 on Unit 2 only)

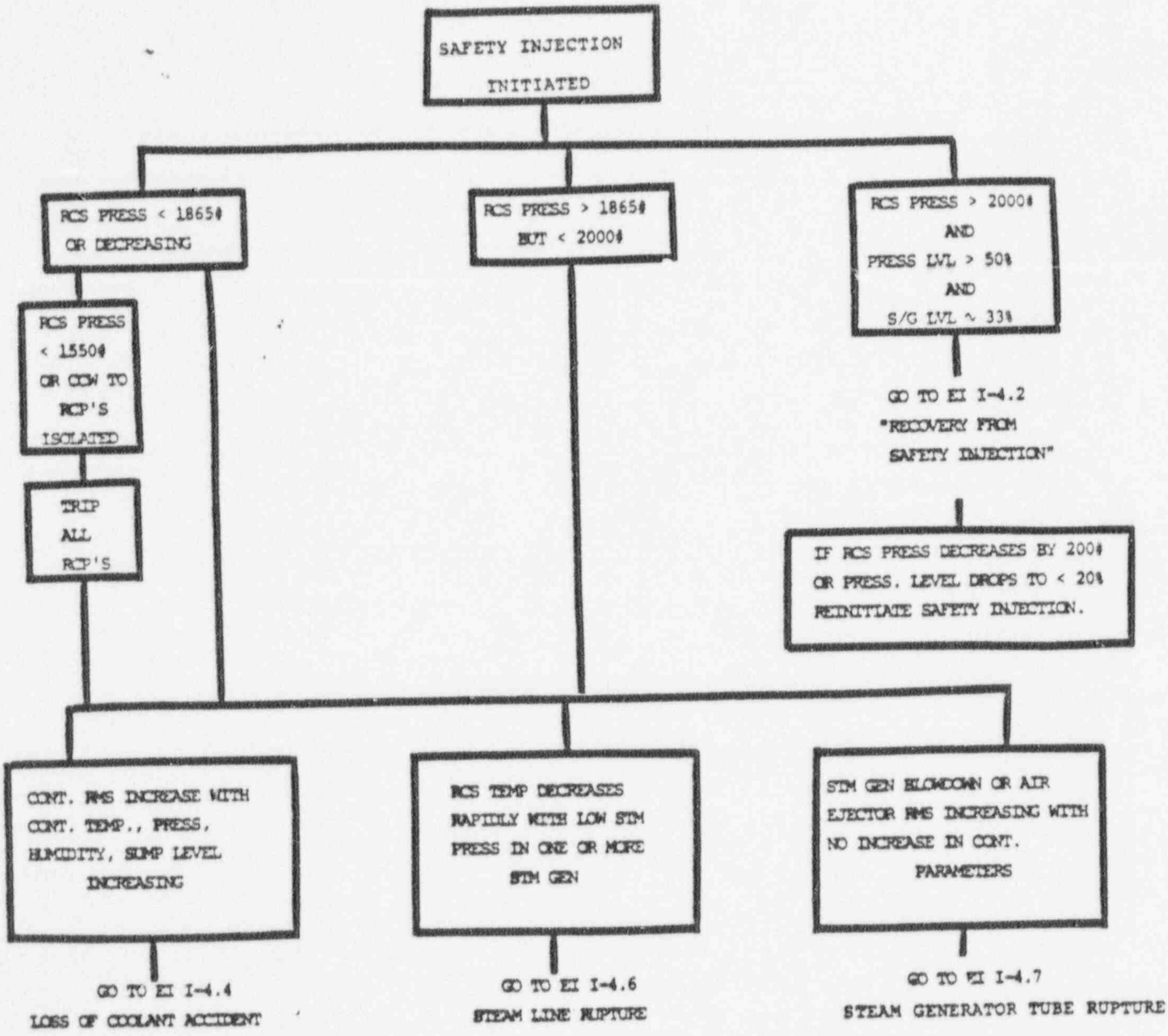
5.2 If RCS Pressure has stabilized after the initial decrease which initiated Safety Injection and Containment Isolation, the problem may be in an area or system which has been subsequently isolated. Investiate the following:

5.2.1 Auxiliary Building for:

1. Increases in Radiation
2. Unexplained accumulations of water

5.2.2 Pressurizer Auxiliary Spray Valve (CV75). Ensure it is closed.

5.3 Utilize the following matrix in order to determine which subsequent Emergency Instruction to follow.



Prepared by J.V. Bailey

Reviewed by J.M. Zupko

SORC Meeting No. 56-79

Manager - Salem Generating Station

Date 7/6/79

"BLACKOUT WITH SAFETY INJECTION" LOADING SEQUENCE

#11(21) DIESEL GENERATOR 1(2)A	#12(22) DIESEL GENERATOR 1(2)B	#13(23) DIESEL GENERATOR 1(2)C
240/480V Breaker	240/480V Breaker	240/480V Breaker
11(21) SI Pump	11(21) Charging Pump	12(22) Charging Pump
11(21) RHR Pump	12(22) RHR Pump	12(22) SI Pump
15(21) SW Pump or* 16(22) SW Pump	14(24) SW Pump or* 13(23) SW Pump	11(25) SW Pump or* 12(26) SW Pump
11(21) Containment Fan (Low Speed)	12(22) Containment Fan (Low Speed)	13(23) Containment Fan (Low Speed)
11(21) Auxiliary Feed Pump	14(24) Containment Fan (Low Speed)	15(25) Containment Fan (Low Speed)
11(21) Auxiliary Building Exhaust Fan	12(22) Auxiliary Feed Pump	Emergency Air Compressor
11(21) Chiller	12(22) Auxiliary Building Supply Vent Fan	11(21) Auxiliary Building Supply Vent Fan
11(21) SWGR Room Supply Fan	12(22) Auxiliary Building Exhaust Fan	13(23) Auxiliary Building Exhaust Fan
	12(22) Chiller	13(23) Chiller
	12(22) SWGR Room Supply Fan	13(23) SWGR Room Supply Fan

NOTE

This sequence is initiated on any Safety Injection actuation with or without a blackout, only in a blackout condition will the Diesel Generator breakers close after first stripping the bus and the loads will then be sequenced onto the bus. This sequence is also initiated with a Safety Injection coincident with undervoltage on one 4kV vital bus.

*NOTE

Only the lead Service Water Pump will start, however, if the lead pump fails to start the backup pump breaker will close.

TABLE I
Page 1 of 1

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TABLE II
PHASE "A" ISOLATION

1. Waste Disposal System

1(2)WL12	RCDT PUMP DISCHARGE
1(2)WL13	RCDT PUMP DISCHARGE
1(2)WL16	CONTAINMENT SUMP PUMP DISCHARGE
1(2)WL17	CONTAINMENT SUMP PUMP DISCHARGE
1(2)WL96	GAS ANALYZER FROM RCDT
1(2)WL97	GAS ANALYZER FROM RCDT
1(2)WL98	RCDT VENT
1(2)WL99	RCDT VENT
1(2)WL108	N_2 SUPPLY TO RCDT

2. Sampling System

1(2)SS27	ACCUMULATOR SAMPLE
1(2)SS33	HOT LEG SAMPLE
1(2)SS49	SAMPLE FROM PZR WATER SPACE
1(2)SS64	SAMPLE FROM PZR STEAM SPACE
1(2)SS103	ACCUMULATOR SAMPLE
1(2)SS104	HOT LEG SAMPLE
1(2)SS107	SAMPLE FROM PZR WATER SPACE
1(2)SS110	SAMPLE FROM PZR STEAM SPACE
11(21)SS94	SAMPLE FROM NO. 11(21) STM GEN BLOWDOWN
12(22)SS94	SAMPLE FROM NO. 12(22) STM GEN BLOWDOWN
13(23)SS94	SAMPLE FROM NO. 13(23) STM GEN BLOWDOWN
14(24)SS94	SAMPLE FROM NO. 14(24) STM GEN BLOWDOWN

3. Component Cooling

1(2)CC113	EXCESS LETDOWN HEAT EXCHANGER COOLING WATER OUTLET
1(2)CC215	EXCESS LETDOWN HEAT EXCHANGER COOLING WATER INLET

4. Steam Generator Drains and Blowdown

11(21)GB4	STEAM GEN OUTLET NO. 11(21)
12(22)GB4	STEAM GEN OUTLET NO. 12(22)
13(23)GB4	STEAM GEN OUTLET NO. 13(23)
14(24)GB4	STEAM GEN OUTLET NO. 14(24)

5. Pressurizer Relief Tank

1(2)WR80	PRIMARY WATER SUPPLY TO PRT
1(2)PR17	GAS ANALYZER FROM PRT
1(2)PR18	GAS ANALYZER FROM PRT
1(2)NT25	N_2 SUPPLY TO PRT

6. Accumulators

1(2)NT32	ACCUMULATOR N_2 SUPPLY

7. Containment Ventilation

1(2)VC1	PURGE SUPPLY
1(2)VC2	PURGE SUPPLY
1(2)VC3	PURGE EXHAUST
1(2)VC4	PURGE EXHAUST
1(2)VC5	CONT PRESS VAC RELIEF ISOLATION VALVE
1(2)VC6	CONT PRESS VAC RELIEF ISOLATION VALVE
1(2)VC7	CONTAINMENT RADIATION SAMPLE OUTLET
1(2)VC8	CONTAINMENT RADIATION SAMPLE OUTLET
1(2)VC11	CONTAINMENT RADIATION SAMPLE INLET
1(2)VC12	CONTAINMENT RADIATION SAMPLE INLET

8. Demineralized Water

1(2)DR29	DM WATER TO FLUSHING CONNECTIONS

9. Fire Protection

1(2)FP147	FIRE PROTECTION WATER SUPPLY

10. Safety Injection

1(2)SJ123	ACCUM TEST STOP VALVE
1(2)SJ60	ACCUM DISCH TEST STOP
1(2)SJ53	SJ HDR TEST STOP VALVE

11. Control Air

11(21)CA330	A HDR ISOLATION VALVE
12(22)CA330	B HDR ISOLATION VALVE

12. Containment Ventilation - the following sample valves receive no automatic isolation signal, however, they should be verified closed.

1(2)VC9	Containment Radiation Sample Outlet Backup
1(2)VC10	Containment Radiation Sample Outlet Backup
1(2)VC13	Containment Radiation Sample Inlet Backup
1(2)VC14	Containment Radiation Sample Inlet Backup

EMERGENCY INSTRUCTION
I-4.3
REACTOR TRIP

1.0 PURPOSE

1.1 A reactor trip is initiated automatically by the Reactor Protection System if unsafe operating conditions are approached. It may also be initiated manually from the control console. This instruction provides the actions required to ensure the reactor is in a safe shutdown condition.

1.2 In addition to de-energizing the shutdown and control rod drive mechanisms, a reactor trip signal will initiate a turbine trip and, in conjunction with a low T_{avg} (554°F) initiate a feedwater isolation signal. This instruction delineates the actions required to ensure both of these have occurred.

2.0 INITIAL CONDITIONS

2.1 Any of the following conditions will lead to a reactor trip and to an automatic plant shutdown. The condition causing the trip will be back lighted in red on the first out overhead annunciator panel (Section F).

	REACTOR TRIP	SETPOINT	COINCIDENCE	INTERLOCK
1.	Manual	None	1/2	None
2.	Pwr. Range, High Neutron Flux	Low Setpoint - 25% of rated thermal pwr.	2/4	P-10
		High Setpoint - 109% of rated thermal pwr.	2/4	None
3.	Pwr. Range, High Flux Rate Trip	± 5% of rated thermal pwr. in 2 sec.	2/4	None
4.	Intermediate Range, High Neutron Flux	Current equivalent to 25% of full pwr.	1/2	P-10
5.	Source Range, High Neutron Flux	10^5 counts per sec.	1/2	P-6 Interlocked with P-10
6.	Overtemperature ΔT	Variable Setpoint	2/4	None
7.	Overpower ΔT	Variable Setpoint	2/4	None
8.	Low Reactor Coolant Pressure	1865 psig	2/4	P-7
9.	High Reactor Coolant Pressure	2385 psig	2/4	None
10.	High Pressurizer	92% Level	2/3	P-7
11.	Low Reactor Coolant Flow	90% of Normal Flow	2/3/Loop	P-7 & P-8
12.	Reactor Coolant Pump Under Voltage	75% of Normal Voltage with a 0.2 sec. time delay	1/2 Taken Twice	P-7
13.	Reactor Coolant Pump Under Frequency	56.5 Hertz with a 0.1 second time delay	1/2 Taken Twice	P-7
14.	Reactor Coolant Pump Breaker Open	10% Pwr. 2 Bkr. Open 36% Pwr. 1 Bkr. Open	1/Pump	P-7 & P-8
15.	Low Feedwater Flow	1.4 X 10^6 Stm. Flow greater than feedwater flow & 25% S/G level	1/2 Flow Mismatch, in coincidence with 1/2 low wtr level, per loop.	None

	REACTOR TRIP	SETPOINT	COINCIDENCE	INTERLOCK
16.	Low-Low Steam Generator Wtr. Lvl.	5% Level per S/G	2/3 per S/G	None
17.	Turbine-Generator Trip	45 psig Auto Stop Oil Pressure or all four Stop Valves Closed	2/3 4/4	P-7
18.	Safety Injection (Actuation)	1. Manual	1/2	None
		2. Pressurizer at 1765 psig	2/3	None
		3. Containment at 4.7 psig	2/3 High Containment pressure	None
		4. Any one S/G 100 psig lower than any other two S/G's	1/2 Steam Pressure on any S/G Lower than 1/2 Steam Pressures on 2/3 of the other loops.	None
		5. Variable: Steam line flow 1.4 X 10^6 #/hr. 0-20% load, increasing to 4.0 X 10^6 #/hr at 100% pwr. in coincidence with Low TAVG 543°F or Low Stm. Press. 500 psig.	1/2 High Steamflow on 2/4 Steam Gen. in coincidence with 2/4 LOW TAVG or 2/4 low steam line pressure.	None
19.	General Alarm	Logic Train "A" & Train "B" in test simultaneously.		

NOTE

The General Alarm trip is not alarmed on the first out annunciator.

20.	Trip Bypass Bkrs.	Racking in, or attempting to rack in, both Reactor Trip Bypass Bkrs at the same time.		

NOTE

The Bypass Breaker trip is not alarmed on the first out annuncia .

3.0 IMMEDIATE ACTIONS

3.1 Automatic

3.1.1 Reactor Trip

3.1.2 Turbine Trip

3.1.3 Generator Trip

3.2 Manual

3.2.1 Verify that a reactor trip has taken place:

1) Check that all full length rods are fully inserted by checking individual rod position indicators and rod bottom lights.

2) If any full length control rod does not indicate fully inserted, manually initiate a reactor trip.

3) If all full length control rods are not then fully inserted, RAPID BORATE by 150 ppm (approximately 8 minutes) for each rod not inserted IAW OI II-3.3.8, "Rapid Boration".

3.2.2 Verify turbine trip by checking the following:

1) UNIT TRIP light on E/H console illuminated.
2) Turbine Stop Valves, Governor Valves, Interceptor Valves and Reheat Stop Valves closed.
3) Turbine speed decreasing.

3.2.3 Within 2 minutes reduce Aux. Feedwater Flow to each Steam Generator to approximately 2.3×10^4 lb/hr.

NOTE

This limination applies to Unit No. 1 only.

3.2.4 Verify that T_{avg} is decreasing toward or is being maintained at 547°F by either steam dump or atmospheric steam relief.

3.2.5 Verify that Feedwater Isolation has taken place when T_{avg} decreases to 554°F.

3.2.6 Announce over the plant PA system twice: UNIT NO. 1(2) REACTOR TRIP.

4.0 SUBSEQUENT ACTIONS

4.1 Check that nuclear power is decreasing by observing the nuclear instrumentation.

4.1.1 Check that the Source Range high voltage is reinstated below 5×10^{-11} amps on both Intermediate Range Channels. This should normally occur in approximately 15-18 minutes on a trip from the power range.

1) If the Source Range high voltage does not energize automatically, manually depress the RESET SOURCE RANGE "A" and RESET SOURCE RANGE "B" pushbuttons on the control console.

4.1.2 Switch the Nuclear Power Recorder (NR-45) to read one Intermediate Range channel and one Source Range Channel.

4.1.3 Notify the Performance Department that a reactor trip has occurred and that the compensating voltage on the Intermediate Range detectors should be adjusted. This adjustment is desirable but is not required.

4.2 Verify that the Pressurizer pressure and level are within limits, and under control.

4.3 Verify that the 4160V Group Busses have transferred from the No. 1(2) Auxiliary Power Transformer to No. 11(12) & No. 12(22) Station Power Transformers.

4.3.1 Check that the following 4160V breakers have opened and acknowledge them on the appropriate control console bezel:

1(2) BGGD
1(2) BFGD
1(2) AEGD
1(2) AHGD

4.3.2 Check that the following 4160V breakers have closed and acknowledge them on the appropriate control console bezel:

12(22) GSD
12(22) FSD
11(21) ESD
11(21) HSD

4.4 Verify that T_{avg} is decreasing toward or is being maintained at 547°F due to steam dump operation.

4.4.1 Check the following steam dump indication:

1) Steam dump valve indication
2) Steam dump demand meter.

4.4.2 Transfer steam dump control from the AVERAGE TEMPERATURE CONTROL mode to the MAIN STEAM PRESSURE CONTROL mode. Ensure that the MAIN STEAM PRESSURE SP (setpoint) is set to maintain the reactor coolant temperature at a no load T_{avg} temperature of 547°F. (Approxiametly 1005 psig steam pressure).

NOTE

If condenser steam dump is not availiable, atmospheric steam relief must be used for the removal of residual heat.

4.5 Verify that Feedwater Isolation has taken place due to the reactor trip in coincidence with low T_{avg} (554°F).

4.5.1 Check that the following valves have closed by observing their appropriate bezel indication:

11(21)BF19 Feedwater Control Valve
12(22)BF19 Feedwater Control Valve
13(23)BF19 Feedwater Control Valve
14(24)BF19 Feedwater Control Valve
11(21)BF40 Feedwater Bypass Valve
12(22)BF40 Feedwater Bypass Valve
13(23)BF40 Feedwater Bypass Valve
14(24)BF40 Feedwater Bypass Valve

4.6 Return the levels in the Steam Generators to normal (~ 33%) as follows:

4.6.1 Limit the rate of rise to less than 1.2 in/min whenever level is below 10% on the Narrow Range.

4.6.2 Monitor the following computer points and maintain the rate of rise to < 0.8%/Min on the narrow range and < 0.2%/min. on the wide range.

S/G	Narrow Range	Wide Range
11(21)	L0400A or L0401A or L0402A	L0403A
12(22)	L0420A or L0421A or L0422A	L0423A
13(23)	L0440A or L0441A or L0442A	L0443A
14(24)	L0460A or L0461A or L0462A	L0463A

NOTE

If the computer is not available, monitor the narrow range indication on the Control Console and the Wide range recorders on RP-4.

4.6.3 Control Flow to the Steam Generators as required by controlling the following valves.

1. 11-14(12-24)AF11 if No. 13(23) Auxiliary Feedwater Pump is in operation.

2. 11-14 (21-24)AF21 if No. 11 & 12 (21 & 22) Auxiliary Feedwater Pumps are in operation.

4.7 Establish and maintain the Hot Standby condition IAW OI I-3.5, "Minimum Load to Hot Standby" and OI I-3.8, "Maintaining Hot Standby".

4.8 If Rx trip was from >15% Rx Power, have the Chem. Dept. perform an I^{131}, I^{133}, I^{135} Isotopic analysis between 2 and 6 hours following the Rx trip.

4.9 Obtain a sample of the Reactor Coolant System and determine boron concentration. Adjust boron concentration as required IAW OI II-3.3.6, "Boron Concentration Control".

4.10 As per Administrative Procedure No. 5:

4.10.1 Notify the Station Operating Engineer or Chief Engineer of the reactor trip and;

4.10.2 Initiate an Operational Incident Report IAW AP-6 and forward it to the station Operating Engineer.

4.11 If, at this time, it becomes necessary, take the plant to the Cold Shutdown Condition IAW OI I-3.6, "Hot Standby to Cold Shutdown".

4.12 As authorized by AP-5, withdraw the shutdown banks as follows:

4.12.1 Reset the flux rate trip by momentarily taking the RATE MODE switches, on each NIS POWER RANGE A drawer, to the RESET position.

4.12.2 Depress the CLOSE pushbutton, on the control console, for REACTOR TRIP BKR A, verifying the breaker doese close.

4.12.3 Depress the CLOSE pushbutton, on the control console, for REACTOR TRIP BKR B, verifying the breaker does close.

4.12.4 Depress the STARTUP pushbutton, on the control console, and verify each Shutdown and Control Rod Step Counter resets to zero.

4.12.5 Commence withdrawing Shutdown Bank A, B, C and D, in that order, to their fully withdrawn position.

4.13 When the cause of the trip has been determined and corrected, obtain the permission of the Station Operating Engineer or the Chief Engineer, IAW AP-5, to take the reactor critical.

4.14 With Steam Generator levels within their normal operating bands and just prior to commencing the recovery startup, perform the following:

4.14.1 Place the Steam Generator Feedwater Controls in MANUAL and run the valve demand to zero.

4.14.2 Reset the Feedwater Isolation signal by depressing the Train "A" and Train "B" FEEDWATER ISOLATION RESET pushbuttons on the control console.

4.14.3 Maintain Steam Generator levels within their normal operating bands by manually controlling Feedwater Bypass Valves 11, 12, 13 and 14 (21, 22 23 and 24) BF40.

4.14.4 Return the Auxiliary Feedwater System to its normal at power lineup IAW OI III-10.3.1, "Auxiliary Feedwater System Operation".

4.15 Return to Power Operation IAW OI I-3.3, "Hot Standby to Minimum Load", and OI I-3.4, "Power Operation".

Prepared by J.V. Bailey

H. J. Midura
Manager - Salem Generating Station

Reviewed by J.P. Kovacsofsky

SORC Meeting No. 56-79

Date 7/16/79

125

Frederick W. Schneider
Vice President
Production

Public Service Electric and Gas Company

SALEM

August 29, 1979

SO, AE file/follow

Mr. Boyce H. Grier, Director
U.S. Nuclear Regulatory Commission
Office of Inspection and Enforcement
Region 1
631 Park Avenue
King of Prussia, Pennsylvania 19406

OM-24
issued 8/30/79

Dear Mr. Grier:

NRC IE BULLETIN NO. 79-06C
NO. 1 UNIT
SALEM GENERATING STATION

Pursuant to the subject bulletin, we hereby, submit the following response:

Short-Term Actions

Item 1

A. Station Emergency Procedures have been revised such that Reactor Coolant Pumps are immediately tripped upon Reactor Trip with initiation of Safety Injection caused by low reactor coolant system pressure.

B. A station operating memo has been issued requiring the presence of two licensed operators in the control room during operation in Modes 1, 2 and 3.

Item 2

A series of Loss of Coolant Accident (LOCA) analyses for a range of break sizes and a range of time lapses between initiation of break and pump trip applicable to the 2, 3 and 4 loop plants has been performed by the Westinghouse Owners' Group. A report summarizing the results of the analysis of delayed Reactor Coolant Pump trip during small loss of coolant accidents for Westinghouse NSSS will be submitted to Mr. D. F. Ross by Mr. Cordell Reed on August 31, 1979. In the report, maximum PCT's for each break size considered and pump shutoff times have been provided. The report concludes that if the reactor coolant pumps are tripped prior to the reactor coolant system pressure reaching 1250 psia, the resulting peak clad temperatures are less than or equal to those reported in the FSAR. In addition, it is shown that there is a finite range of break sizes and RCP trip times in all cases 10 minutes or later, which will result in PCT's in excess of 2200°F as calculated with conservative Appendix K models. The operator in any event would have at least 10 minutes to trip the RCP's following a small break LOCA, especially in light of the conservatisms in the calculations. This is appropriate for manual rather than automatic action, based on the guidelines for termination of RCP operation presented in WCAP-9600.

Item 3

The Westinghouse Owners' Group has developed guidelines which were submitted to the NRC in Section 6 and Appendix A of WCAP 9600. The analyses provided as the response to Item 2 are consistent with the guidelines in WCAP 9600. No changes to these guidelines are needed for both LOCA and non-LOCA transients.

Item 4

The Owners' Group effort to revise emergency procedures covers many issues, including operation of the Reactor Coolant Pumps. The action taken in response to item 1 is sufficient as an interim measure in regards to these pumps. The expected schedule for revising the LOCA, steamline break and steam generator tube rupture emergency procedures is the following:

Mid-October: Guidelines which have been reviewed by the NRC will be provided to each utility. Appropriate utility personnel associated with writing procedures will meet with the Owners' Group Subcommittee on Procedures and Westinghouse to provide the background for revising their emergency procedures.

1 to 2 months from: Mid-October.	Plant specific procedures will be revised.
1 to 4 months from: Mid-October	Revised procedures will be implemented and operators trained.

Item 5 Analyses related to inadequate core cooling and definition of conditions under which a restart of the RCP's should be attempted will be performed. Resolution of the requirements for the analyses and an acceptable schedule for providing the analyses and guidelines and procedures resulting from the analyses will be arrived at between the Westinghouse Owners' Group and the NRC staff.

Long Term Actions

As discussed in our response to short-term item 2, we do not believe that automatic tripping of the RCP's is a required function based on the analyses that have been performed and the guidelines that have been developed for manual RCP tripping. We propose that this item be discussed with the NRC staff following their review of the Owners' Group Submittal.

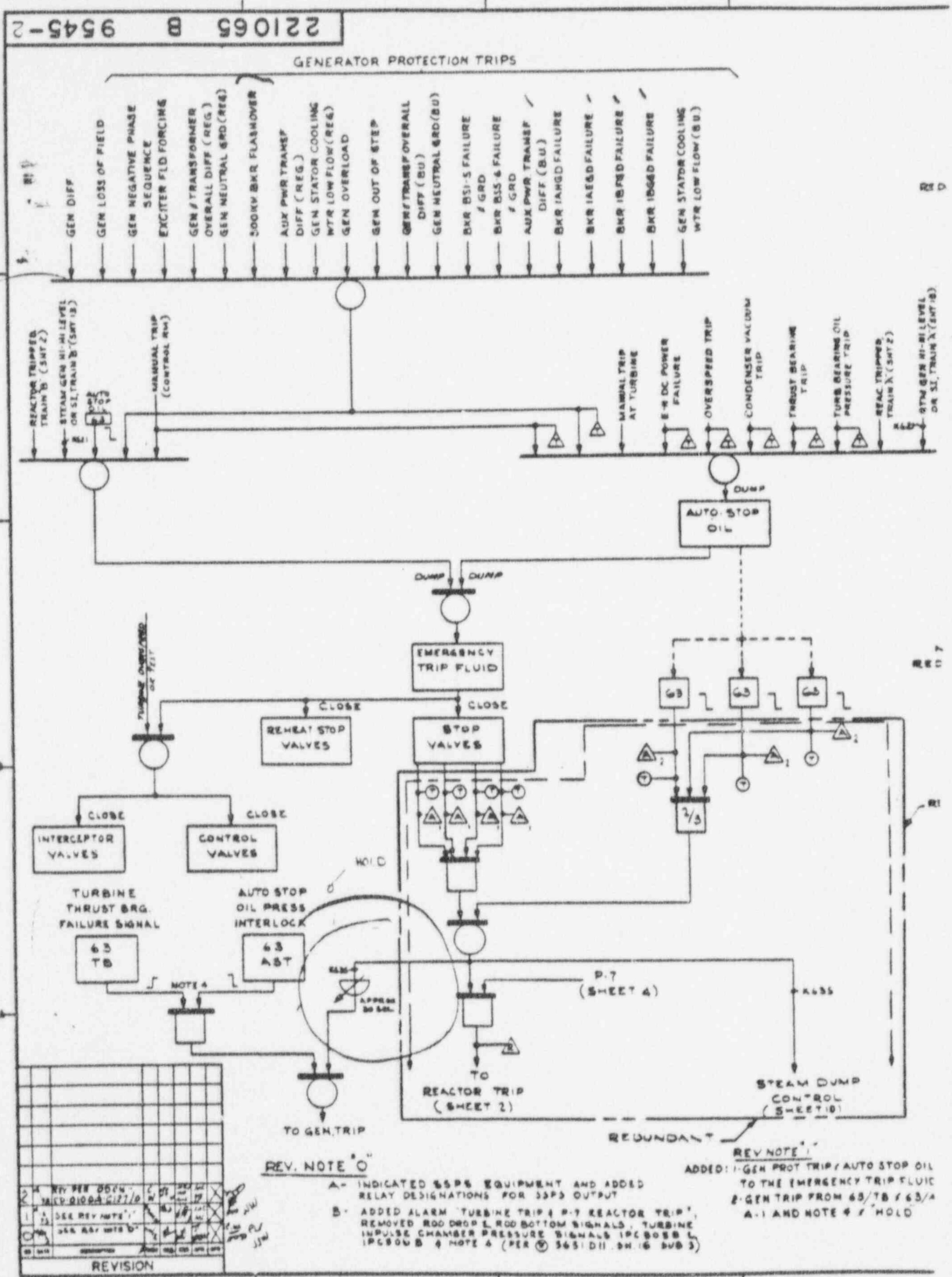
If you have any further questions on this matter we will be pleased to discuss them with you.

Sincerely,

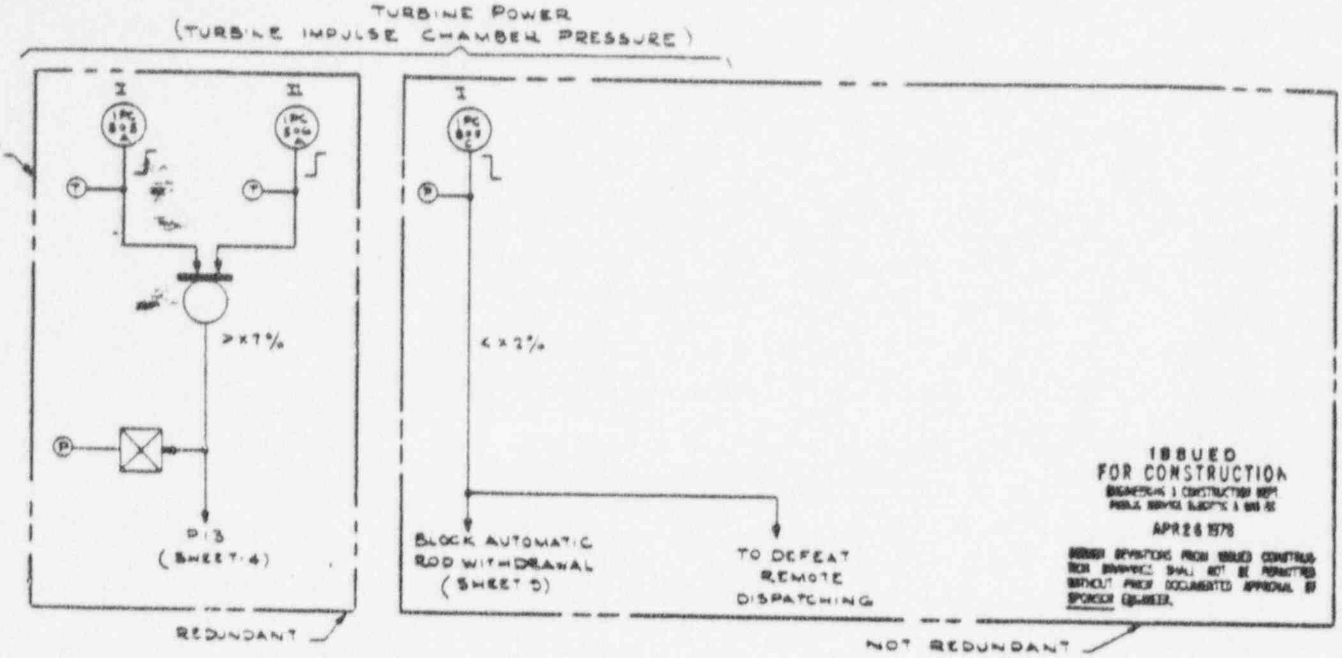
RWB:hs

CC: Director, Office of Inspection
and Enforcement
USNRC
Washington, DC 20555

Director, Office of Nuclear Reactor Regulation
USNRC
Washington, DC 20555



221065 B 9545-2
GENERATOR PROTECTION TRIPS
GEN DIFF
GEN LOSS OF FIELD
GEN NEGATIVE PHASE SEQUENCE
EXCITER FLD FORCING
GEN / TRANSFORMER OVERALL DIFF (REG)
GEN NEUTRAL GRD (REG)
500KV BKR FLASHOVER
AUX PWR TRANSF DIFF (REG)
GEN STATOR COOLING WTR LOW FLOW (REG)
GEN OVERLOAD
GEN OUT OF STEP
GEN / TRANSF OVERALL DIFF (BU)
GEN NEUTRAL GRD (BU)
BKR BS1-5 FAILURE / GRD
BKR BS5-6 FAILURE / GRD
AUX PWR TRANSF DIFF (B.U.)
BKR 1AHGD FAILURE
BKR 1AE&D FAILURE
BKR 1BF&D FAILURE
BKR 1BG&D FAILURE
GEN STATOR COOLING WTR LOW FLOW (B.U.)
REACTOR TRIPPED TRAIN 'B' (SHT 2)
STEAM GEN HI-HI LEVEL OR SI, TRAIN 'B' (SHT 13)
MANUAL TRIP (CONTROL RM)
MANUAL TRIP AT TURBINE
E-H DC POWER FAILURE
OVERSPEED TRIP
CONDENSER VACUUM TRIP
THRUST BEARING TRIP
TURB BEARING OIL PRESSURE TRIP
REAC TRIPPED TRAIN 'A' (SHT 2)
STM GEN HI-HI LEVEL OR SI, TRAIN 'A' (SHT 13)
DUMP
AUTO STOP OIL
DUMP DUMP
EMERGENCY TRIP FLUID
TURBINE OVERSPEED OR TEST
CLOSE
REHEAT STOP VALVES
CLOSE
STOP VALVES
63 63 63
2/3
CLOSE
INTERCEPTOR VALVES
CLOSE
CONTROL VALVES
HOLD
TURBINE THRUST BRG. FAILURE SIGNAL
63 TB
AUTO STOP OIL PRESS INTERLOCK
63 AST
NOTE 4
P-7 (SHEET 4)
K635
TO GEN. TRIP
TO REACTOR TRIP (SHEET 2)
STEAM DUMP CONTROL (SHEET 10)
REDUNDANT
REV. NOTE "O"
A- INDICATED SSPS EQUIPMENT AND ADDED RELAY DESIGNATIONS FOR SSPS OUTPUT
B- ADDED ALARM 'TURBINE TRIP & P-7 REACTOR TRIP', REMOVED ROD DROP & ROD BOTTOM SIGNALS, TURBINE IMPULSE CHAMBER PRESSURE SIGNALS IPC 8058 & IPC 8508 & NOTE 6 (PER 3651 D11 SH.16 SUB 3)
REV NOTE "1"
ADDED: 1-GEN PROT TRIP / AUTO STOP OIL TO THE EMERGENCY TRIP FLUID
2-GEN TRIP FROM 63/TB & 63/A
A-1 AND NOTE 4 & HOLD
SEE REV NOTE "1"
SEE REV NOTE "O"
REVISION



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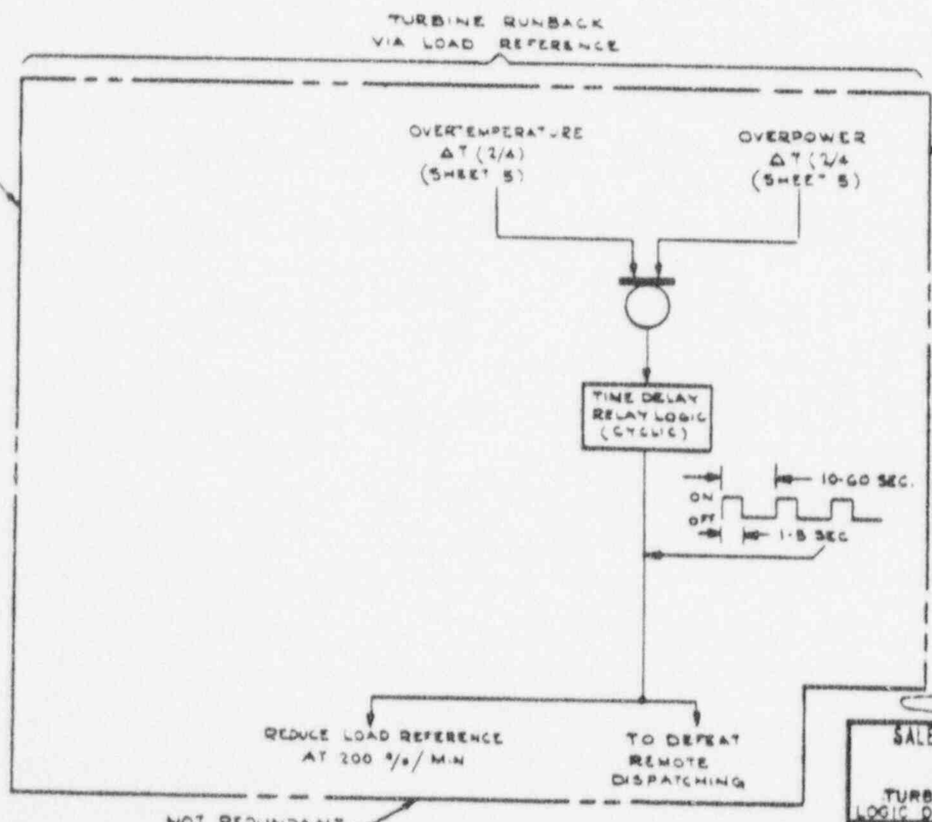
FOR CONSTRUCTION
ENGINEERING & CONSTRUCTION DEPT
PUBLIC SERVICE ELECTRIC & GAS CO
APR 26 1978
DEVIATIONS FROM ISSUED CONSTRUCTION DRAWINGS SHALL NOT BE PERMITTED WITHOUT PRIOR DOCUMENTED APPROVAL OF SPONSOR ENGINEER.



NOTES:

1- THESE SIGNALS INDICATE THE CLOSING OF THE STOP VALVES POSITION DETECTION IS ACCOMPLISHED BY 2 SWITCHES PER STOP VALVE, ONE FOR EACH TRAIN
2- REDUNDANCY IS INDICATED IN REGARDS TO Ⓦ REQUIREMENTS ONLY.
3- THIS SHEET IS IDENTICAL FOR UNITS 1&2 EXCEPT FOR THE TAG NUMBERS WHICH ARE PRECEDED BY 1 OR 2 FOR UNIT 1 OR 2 RESPECTIVELY (HERE INDICATED FOR UNIT 1 ONLY)
4- THE 'AND' LOGIC AND THE ASSOCIATED PRESSURE SWITCHES (63/TB AND 63/AST) MUST BE TESTED PERIODICALLY WHILE ON LINE AT POWER WITHOUT PLANT TRIP. TEST VALVES AND TEST LIGHTS ARE REQUIRED TO PROVIDE THOROUGH TESTING AND TO VERIFY PRESSURE SWITCH CONTACT STATUS.

R100

SALEM NUCLEAR GENERATING STATION
NO 1 & 2 UNITS
REACTOR PROTECTION SYSTEM
TURBINE TRIP, RUNBACKS & OTHER SIGNALS
LOGIC DIAGRAM SH. 16 CONTROLS

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
ELECTRIC ENGINEERING DEPARTMENT
NEWARK, N.J.

AUTH A-62671

221065 B 9545-2

GENERAL NOTES
THIS DRAWING ... SHEET 1 OF 1 SHEETS

Part 12

TESTS AND PERFORMANCE AC FRACTIONAL- AND INTEGRAL-HORSEPOWER MOTORS

MG 1-12.30 Test Methods

Tests to determine performance characteristics shall be made in accordance with the following:

1. For single-phase motors—IEEE Std 114, *Test Procedure for Single-phase Induction Motors.*
2. For polyphase induction motors—IEEE Std 112, *Test Procedure for Polyphase Induction Motors and Generators.*

NEMA Standard 7-7-1965.

MG 1-12.30.a Performance Characteristics

When performance characteristics are provided, they should be expressed as follows:

1. Current in amperes or percent of rated current.
2. Torque in pound-feet, pound-inches, ounce-feet, ounce-inches or percent of full-load torque.
3. Output in horsepower or percent of rated horsepower.
4. Speed in revolutions per minute or percent of synchronous speed.
5. Efficiency in percent.
6. Power factor in percent.
7. Voltage in volts or percent of rated voltage.
8. Input power in watts or kilowatts.

NOTE—If SI units are used, they should be in accordance with ISO Publication No. R-1000.

Authorized Engineering Information 5-12-1975.

MG 1-12.31 Torque Characteristics of Single-phase General-purpose Induction Motors

A. Breakdown Torque

The breakdown torque of general-purpose single-phase fractional- and integral-horsepower induction motors shall be the higher figure in each torque range as given in the table in MG 1-10.33, subject to tolerances in manufacturing and all other conditions given in MG 1-10.33.

B. Locked-rotor Torque of Fractional-horsepower Motors

The locked-rotor torque of single-phase general-purpose fractional-horsepower motors, with rated voltage and frequency applied, shall be not less than the following:

	Minimum Locked-rotor Torque, Ounce-feet					
	60-hertz Speed, Rpm			50-hertz Speed, Rpm		
Hp	3600 3450	1800 1725	1200 1140	3000 2850	1500 1425	1000 950
1/8	..	24	32	..	29	39
1/6	15	33	43	18	39	51
1/4	21	46	59	25	55	70
1/3	26	57	73	31	69	88
1/2	37	85	100	44	102	120
3/4	50	119	...	60	143	...
1	61	...	...	73	...	...

C. Locked-rotor Torque of Integral-horsepower Motors

The locked-rotor torque of single-phase general-purpose integral-horsepower motors, with rated voltage and frequency applied, shall be not less than the following:

	Minimum Locked-rotor Torque, Pound-feet		
Hp	3600	Rpm 1800	1200
3/4	...	...	8.0
1	...	9.0	9.5
1½	4.5	12.5	13.0
2	5.5	16.0	16.0
3	7.5	22.0	23.0
5	11.0	33.0	...
7½	16.0	45.0	...

D. Pull-up Torque of Integral-horsepower Motors

The pull-up torque of single-phase general-purpose alternating-current integral-horsepower motors, with rated voltage and frequency applied, shall be not less than the rated load torque.

NEMA Standard 11-11-1948, revised 6-24-1949, 5-17-1953; 11-11-1965; 11-16-1967.

MG 1-12.32 Locked-rotor Current of Single-phase Fractional-horsepower Motors

A. The locked-rotor current of 60-hertz, single-phase motors shall not exceed the values given in the following table:

2-, 4-, 6- AND 8-POLE, 60-HERTZ MOTORS, SINGLE PHASE

Hp	Locked-rotor Current, Amperes			
	115 Volts		230 Volts	
	Design O	Design N	Design O	Design N
1/6 and smaller	50	20	25	12
1/4	50	26	25	15
1/3	50	31	25	18
1/2	50	45	25	25
3/4	..	61	..	35
1	..	80	..	45

B. The locked-rotor currents of single-phase general-purpose fractional-horsepower motors shall not exceed the values for Design N motors.

NEMA Standard 10-29-1943, revised 11-14-1957; 5-21-1962; 11-12-1964; 11-21-1968.

MG 1-12.33 Locked-rotor Current of Single-phase Integral-horsepower Motors, Designs L and M

The locked-rotor current of single-phase, 60-hertz, Design L and M motors of all types, when measured with rated voltage and frequency impressed and with the rotor locked, shall not exceed the following values:

Hp	Locked-rotor Current, Amperes		
	Design L Motors		Design M Motors
	115 Volts	230 Volts	230 Volts
1/2	45	25	...
3/4	61	35	...
1	80	45	...
1 1/2	..	50	40
2	..	65	50
3	..	90	70
5	..	135	100
7 1/2	..	200	150
10	..	260	200
15	..	390	300
20	..	520	400

NEMA Standard 8-7-1947; revised 1-23-1951; 11-21-1968.

MG 1-12.34 Locked-rotor Current of 3-phase 60-hertz Integral-horsepower Squirrel-cage Induction Motors Rated at 230 Volts

The locked-rotor current of single-speed, 3-phase, constant-speed induction motors rated at 230 volts, when measured with rated voltage and frequency impressed and with rotor locked, shall not exceed the following values:

Hp	Locked-rotor Current, Amperes*	Design Letters
1/2	20	B, D
3/4	25	B, D
1	30	B, D
1 1/2	40	B, D
2	50	B, D
3	64	B, C, D
5	92	B, C, D
7 1/2	127	B, C, D
10	162	B, C, D
15	232	B, C, D
20	290	B, C, D
25	365	B, C, D
30	435	B, C, D
40	580	B, C, D
50	725	B, C, D
60	870	B, C, D
75	1085	B, C, D
100	1450	B, C, D
125	1815	B, C, D
150	2170	B, C, D
200	2900	B, C
250	3650	B
300	4400	B
350	5100	B
400	5800	B
450	6500	B
500	7250	B

* The locked-rotor current of motors designed for voltages other than 230 volts shall be inversely proportional to the voltages.

Suggested Standard for Future Design 7-7-1965, revised 8-20-1966; 11-17-1966, NEMA Standard 11-21-1968.

MG 1-12.35 Locked-rotor Current of 3-phase 50-hertz Integral-horsepower Squirrel-cage Induction Motors Rated at 380 Volts

The locked-rotor current of single-speed, 3-phase, constant-speed induction motors rated at 380 volts, when measured with rated voltage and frequency impressed and with rotor locked, shall not exceed the values shown in Table 12-1.

NEMA Standard 11-21-1968, revised 7-16-1969.

MG 1-12.36 Torque Characteristics of Polyphase Fractional-horsepower Motors

The breakdown torque of a general-purpose polyphase squirrel-cage fractional-horsepower motor, with rated voltage and frequency applied, shall be not less than 140 percent of the breakdown torque of a single-phase general-purpose fractional-horsepower motor of the same horsepower and speed rating given in MG 1-12.31.

NOTE—The speed at breakdown torque is ordinarily much lower in fractional-horsepower polyphase motors than in fractional-horsepower single-phase motors. Higher breakdown torques are required for polyphase motors so that polyphase and single-phase motors will have interchangeable running characteristics, rating for rating, when applied to normal single-phase motor loads.

NEMA Standard 6-4-1948, revised 6-24-1949; 11-13-1969.

TABLE 12-1 (SEE MG 1-12.35)

Hp	Locked-rotor Current, Amperes*	Design Letters	Hp	Locked-rotor Current, Amperes*	Design Letters
1 or less	20	B, D	30	289	B, C, D
1½	27	B, D	40	387	B, C, D
2	34	B, D	50	482	B, C, D
3	43	B, C, D	60	578	B, C, D
5	61	B, C, D	75	722	B, C, D
7½	84	B, C, D	100	965	B, C, D
10	107	B, C, D	125	1207	B, C, D
15	154	B, C, D	150	1441	B, C, D
20	194	B, C, D	200	1927	B, C
25	243	B, C, D			

* The locked-rotor current of motors designed for voltages other than 380 volts shall be inversely proportional to the voltages.

MG 1-12.37 Locked-rotor Torque of Single-speed Polyphase Squirrel-cage Integral-horsepower Motors with Continuous Ratings

A. The locked-rotor torque of Design A and B, 60- and 50-hertz, single-speed, polyphase squirrel-cage motors, with rated voltage and frequency applied. shall be in accordance with the following values which are expressed in percent of full-load torque and represent the upper limit of the range of application for these motors. For applications involving higher torque requirements, see the locked-rotor torque values for Design C and D motors.

Hp	Synchronous Speed, Rpm							
	60 hertz	3600	1800	1200	900	720	600	514
	50 hertz	3000	1500	1000	750	...	...	...
½		...	...	...	140	140	115	110
¾		...	...	175	135	135	115	110
1		...	275	170	135	135	115	110
1½		175	250	165	130	130	115	110
2		170	235	160	130	125	115	110
3		160	215	155	130	125	115	110
5		150	185	150	130	125	115	110
7½		140	175	150	125	120	115	110
10		135	165	150	125	120	115	110
15		130	160	140	125	120	115	110
20		130	150	135	125	120	115	110
25		130	150	135	125	120	115	110
30		130	150	135	125	120	115	110
40		125	140	135	125	120	115	110
50		120	140	135	125	120	115	110
60		120	140	135	125	120	115	110
75		105	140	135	125	120	115	110
100		105	125	125	125	120	115	110
125		100	110	125	120	115	115	110
150		100	110	120	120	115	115	...
200		100	100	120	120	115	...	...
250		70	80	100	100	...	...	...
300		70	80	100	...	...	...	...
350		70	80	100	...	...	...	...
400		70	80	...	...	...	...	...
450		70	80	...	...	...	...	...
500		70	80	...	...	...	...	...

(*Continued*)

B. The locked-rotor torque of Design C, 60- and 50-hertz, single-speed, polyphase squirrel-cage motors, with rated voltage and frequency applied, shall be in accordance with the following values which are expressed in percent of full-load torque and represent the upper limit of the range of application for these motors:

	Synchronous Speed, Rpm			
	60 hertz	1800	1200	900
Hp	50 hertz	1500	1000	750
3		...	250	225
5		250	250	225
7.5		250	225	200
10		250	225	200
15		225	200	200
20–200, inclusive		200	200	200

C. The locked-rotor torque of Design D, 60- and 50-hertz, 4-, 6- and 8-pole, single-speed, polyphase squirrel-cage motors rated 150 horsepower and smaller, with rated voltage and frequency applied, shall be 275 percent, expressed in percent of full-load torque, which represents the upper limit of application for these motors.

NEMA Standard 8-7-1947, revised 6-24-1949; 11-17-1955; 11-17-1966; 7-16-1969.

MG 1-12.38 Breakdown Torque of Single-speed Polyphase Squirrel-cage Integral-horsepower Motors with Continuous Ratings

A. The breakdown torque of Design A* and B, 60- and 50-hertz, single-speed, polyphase squirrel-cage motors, with rated voltage and frequency applied, shall be in accordance with the following values which are expressed in percent of full-load torque and represent the upper limit of the range of application for these motors:

	Synchronous Speed, Rpm							
	60 hertz	3600	1800	1200	900	720	600	514
Hp	50 hertz	3000	1500	1000	750	...	...	...
½		...	...	...	225	200	200	200
¾		...	...	275	220	200	200	200
1		...	300	265	215	200	200	200
1½		250	280	250	210	200	200	200
2		240	270	240	210	200	200	200
3		230	250	230	205	200	200	200
5		215	225	215	205	200	200	200
7½		200	215	205	200	200	200	200
10–125, inclusive		200	200	200	200	200	200	200
150		200	200	200	200	200	200	...
200		200	200	200	200	200	...	...
250	.75✓	175	175	175	175	...	...	...
300–350		175	175	175	...	...	...	...
400–500, inclusive		175	175	...	...	...	...	...

* Design A values are in excess of values shown above.

B. The breakdown torque of Design C, 60- and 50-hertz, single-speed, polyphase squirrel-cage motors, with rated voltage and frequency applied, shall be in accordance with the following values which are expressed in percent of full-load torque and represent the upper limit of the range of application for these motors:

	Synchronous Speed, Rpm			
	60 hertz	1800	1200	900
Hp	50 hertz	1500	1000	750
3		...	225	200
5		200	200	200
7½–200, inclusive		190	190	190

NEMA Standard 1-26-1948, revised 6-24-1949; 11-17-1955; 11-17-1966; 7-16-1969.

Part 20

LARGE APPARATUS—INDUCTION MOTORS

RATINGS

MG 1-20.05 Basis of Rating

Induction motors covered by this Part 20 shall be rated on a continuous-duty basis unless otherwise specified. The output rating shall be expressed in horsepower available at the shaft at a specified speed, frequency and voltage.

NEMA Standard 5-20-1974.

MG 1-20.10 Horsepower and Speed Ratings

Horsepower ratings and synchronous speed ratings shall be as follows:

Hp Ratings					
100	600	2500	9000	19000	45000
125	700	3000	10000	20000	50000
150	800	3500	11000	22500	55000
200	900	4000	12000	25000	60000
250	1000	4500	13000	27500	65000
300	1250	5000	14000	30000	70000
350	1500	5500	15000	32500	75000
400	1750	6000	16000	35000	80000
450	2000	7000	17000	37500	90000
500	2250	8000	18000	40000	100000

Synchronous Speed Ratings, Rpm at 60 hertz*			
3600	720	400	277
1800	600	360	257
1200	51[illegible]	327	240
900	450	300	225

* At 50 hertz, the speeds are 5/6 of the 60-hertz speeds.

NOTE—It is not practical to build motors of all horsepower ratings at all speeds.

NEMA Standard 11-15-1956, revised 7-13-1967.

MG 1-20.10.a Horsepower Ratings of Multispeed Motors

The horsepower ratings of multispeed motors shall be selected as follows:

A. Constant Horsepower

The horsepower rating for each rated speed shall be selected from MG 1-20.10.

B. Constant Torque

The horsepower rating for the highest rated speed shall be selected from MG 1-20.10. The horsepower rating for each lower speed shall be determined by multiplying the horsepower rating at the highest speed by the ratio of the lower synchronous speed to the highest synchronous speed.

C. Variable Torque

The horsepower rating for the highest rated speed shall be selected from MG 1-20.10. The horsepower rating for each lower speed shall be determined by multiplying the horsepower rating at the highest speed by the square of the ratio of the lower synchronous speed to the highest synchronous speed.

NEMA Standard 7-17-1974.

MG 1-20.11 Voltages

Voltages shall be 200, 230, 460, 575, 2300, 4000, 4600, 6600 and 13200 volts. These voltage ratings apply to 60-hertz circuits only.

NOTE—It is not practical to build motors of all horsepower ratings for all of these voltages.

NEMA Standard 11-15-1956, revised 7-13-1967; 7-16-1969.

MG 1-20.12 Frequencies

The frequencies shall be 50* and 60 hertz.

* For export.

NEMA Standard 5-17-1955.

MG 1-20.13 Service Factor

When operated at rated voltage and frequency, induction motors covered by this Part 20 and having a rated temperature rise in accordance with MG 1-20.40 shall have a service factor of 1.0.

NEMA Standard 7-13-1967.

In those applications requiring an overload capacity, the use of a higher horsepower rating as given in MG 1-20.10 is recommended to avoid exceeding the temperature rises for the class of insulation used and to provide adequate torque capacity.

Authorized Engineering Information 5-24-1960.

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TESTS AND PERFORMANCE

MG 1-20.40 Temperature Rise

The observable temperature rise under rated-load conditions of each of the various parts of the induction motor, above the temperature of the cooling air, shall not exceed the values given in the following table. The temperature of the cooling air* is the temperature of the external air as it enters the ventilating openings of the machine, and the temperature rises given in the table are based on a maximum temperature or 40 °C for this external air. Temperatures shall be determined in accordance with the latest revision of IEEE Std 112, *Test Procedure for Polyphase Induction Motors and Generators.*

Item	Machine Part	Method of Temperature Determination	Temperature Rise, Degrees C — Class of Insulation System A	B	F	H
1	Insulated windings					
	a. All horsepower ratings	Resistance	60	80	105	125
	b. 1500 horsepower and less	Embedded detector†	70	90	115	140
	c. Over 1500 horsepower					
	(1) 7000 volts and less	Embedded detector†	65	85	110	135
	(2) Over 7000 volts	Embedded detector†	60	80	105	125
2	Cores, squirrel-cage windings and mechanical parts, such as collector rings and brushes, may attain such temperatures as will not injure the machine in any respect.					

* For totally-enclosed water-air-cooled machines, the temperature of the cooling air is the temperature of the air leaving the coolers. See Note I

† Embedded detectors are located within the slot of the machine and can be either resistance elements or thermocouples. For motors equipped with embedded detectors, this method shall be used to demonstrate conformity with the standard.

NOTE I—Totally-enclosed water-air-cooled machines are normally designed for the maximum cooling water temperature encountered at the location where each machine is to be installed. With a cooling water temperature not exceeding that for which the machine is designed:

a. On machines designed for cooling water temperatures up to 30 °C—the temperature of the air leaving the coolers shall not exceed 40 °C.
b. On machines designed for higher cooling water temperatures—the temperature of the air leaving the coolers may exceed 40 °C provided the temperature rises of the machine parts are then limited to values less than those given in the table by the number of degrees that the temperature of the air leaving the coolers exceeds 40 °C.

NOTE II—For motors which operate under prevailing barometric pressure and which are designed not to exceed the specified temperature rise at altitudes from 3300 feet (1000 meters) to 13000 feet (4000 meters), the temperature rises, as checked by tests at low altitudes, shall be less than those listed in the foregoing table by 1 percent of the specified temperature rise for each 330 feet (100 meters) of altitude in excess of 3300 feet (1000 meters).

Suggested Standard for Future Design 5-24-1960, revised 11-15-1962, NEMA Standard 11-11-1965, revised 8-20-1966; 7-16-1969; 11-8-1973.

NOTE III—Temperature rises in the foregoing table are based upon a reference ambient temperature of 40 °C. However it is recognized that induction motors may be required to operate in an ambient temperature higher than 40 °C. For successful operation of the motors in ambient temperatures higher than 40 °C, it is recommended that the temperature rises of the motors given in the foregoing table be reduced, as indicated below, for the ranges of ambient temperature given. (Exception—for totally-enclosed water-air-cooled machines, see NOTE I.)

Ambient Temperature, Degrees C	Values by which Temperature Rises in the Foregoing Table Should be Reduced, Degrees C
Above 40 up to and including 50	10
Above 50 up to and including 60	20

Authorized Engineering Information 5-24-1960; revised 11-8-1973.

MG 1-20.41 Torques

The torques*, with rated voltage and frequency applied, shall be not less than the following:

Torques*	Percent of Rated Full-load Torque
Locked rotor	60
Pull-up	60
Breakdown	175

In addition, the developed torque at any speed up to that at which breakdown torque occurs, with rated voltage and frequency applied, shall be at least 1.3 times the torque obtained from a curve that varies as the square of the speed and is equal to 100 percent of rated full-load torque at rated speed.

* See Part 1 for definitions.

NEMA Standard 11-15-1962, revised 11-12-1970; 5-12-1975.

HORIZONTAL INDUCTION MOTORS—FRAMES 143-405

3-PHASE • TRI/CLAD 700 LINE

Type K Standard Motor Data④

Dripproof and Totally Enclosed Fan-cooled

OPERATING CHARACTERISTICS

NEMA Design B, 60 Hertz, 460 Volts, Normal Starting Torque, Continuous, 40C Ambient

Horsepower	Full-load RPM ① DP	Full-load RPM ① TEFC	Amperes at 460 Volts Full-load ① DP	Amperes Full-load ① TEFC	NEMA Locked Rotor (Max)	NEMA Code	Torque Full-load lb-ft	NEMA Starting, % Full-load (Min)	NEMA Breakdown, % Full-load (Min)	Efficiency ① Dripproof Full-load	Dripproof ¾-load	Dripproof ½-load	TEFC Full-load	TEFC ¾-load	TEFC ½-load	Power Factor ① Dripproof Full-load	Dripproof ¾-load	Dripproof ½-load	TEFC Full-load	TEFC ¾-load	TEFC ½-load	Max. Correction Capacitor KVAR ③ DP	TEFC
¾	3400	1140	1.55	1.20	13.5	P	3.40	175	275	72.5	71.0	65.5	72.5	71.0	66.5	63.5	54.5	40.0	65.5	54.6	40.0		
1	1730	1730	1.7	1.7	16.0	M	3.07	275	300	74.0	73.5	67.0	74.0	73.5	67.0	75.4	66.5	80.5	74.5	60.5	80.5		
	1140	1140	1.9	1.9	15.0	M	4.60	170	265	73.0	71.5	66.0	73.0	71.5	66.0	60.0	57.5	66.0	60.0	57.5	60.0		
1½	3455	3455	2.2	2.2	20.0	M	2.27	175	230	76.0	75.5	71.5	76.0	75.5	71.5	84.0	75.5	60.5	84.0	75.5	60.5		
	1720	1720	2.5	2.5	20.0	M	4.34	250	280	77.0	76.0	72.0	77.0	76.0	72.0	80.5	73.5	62.0	80.5	73.5	62.0		
	1160	1160	2.6	2.6	20.0	M	6.79	165	230	76.5	73.5	71.0	76.5	73.5	71.0	70.5	62.0	50.0	70.5	63.0	50.0		
2	3495	3495	2.8	2.8	25.0	L	3.00	170	240	79.0	76.5	73.0	79.0	76.5	75.0	85.5	80.0	69.5	85.5	80.0	69.5		
	1725	1725	3.1	3.1	25.0	L	6.09	225	270	81.0	76.5	73.0	81.0	76.5	73.0	73.5	66.5	55.0	75.5	66.5	55.0		
	1135	1135	3.3	3.3	25.0	L	9.00	160	240	78.5	77.5	74.0	78.5	77.5	74.0	71.5	64.0	53.0	71.5	66.0	53.0		
3	3470	3500	4.2	4.6	32.0	K	4.50	160	220	78.5	79.0	76.5	73.5	73.5	66.0	85.5	80.5	70.0	91.0	78.5	60.5		
	1755	1755	4.6	4.6	32.0	K	8.97	215	230	80.5	79.0	74.5	80.5	79.0	74.5	75.5	66.0	55.5	75.5	60.0	55.5		
	1160	1160	5.0	5.0	32.0	K	13.6	185	230	76.0	74.0	70.0	75.0	70.0	57.0	79.0	70.0	57.0	79.0	70.0	57.0	2	2
5	3510	3510	7.1	7.3	46.0	J	7.3	130	215	81.0	80.5	77.5	78.5	77.0	73.0	81.5	76.0	60.5	80.0	77.0	67.5		
	1745	1745	7.1	7.1	46.0	J	13.0	185	225	83.0	82.0	81.0	82.0	83.0	81.0	81.5	73.0	65.0	81.5	73.0	66.0		
	1160	1160	8.1	8.1	46.0	J	22.6	130	215	79.0	78.0	75.0	76.5	67.5	54.5	76.5	67.5	54.5	76.5	67.5	54.5	3	3
7½	3495	3390	9.4	10.3	63.5	H	11.3	140	200	84.0	84.5	83.0	79.0	79.0	75.0	87.0	85.5	77.5	80.0	82.0	74.0		3
	1745	1745	10.5	10.5	63.5	H	22.3	175	215	81.0	81.0	80.0	82.5	83.5	81.5	84.0	74.0	67.0	84.5	79.5	67.5	3	3
	1165	1165	10.5	10.5	63.5	H	33.7	180	205	84.5	84.5	82.5	81.0	74.0	61.0	81.0	74.0	61.0	81.0	74.0	61.0	3	5
10	3515	3515	13.1	12.7	81.0	H	14.9	185	200	84.5	84.5	85.5	82.5	82.0	81.0	86.0	83.0	74.0	90.5	87.5	78.5	3	3
	1740	1745	13.4	12.8	81.0	H	30.1	165	200	83.0	84.0	84.0	82.5	82.0	73.0	86.0	82.0	73.0	89.5	84.0	74.0	4	4
	1160	1160	14.2	14.2	81.0	H	45.0	190	200	84.0	84.0	83.0	80.5	74.5	61.5	80.5	74.5	61.5	80.5	74.5	61.5	4	4
15	3530	3540	18.0	20.0	116.0	G	22.4	130	200	86.0	86.0	86.0	82.0	82.0	80.0	90.0	87.0	80.0	86.0	83.0	76.0	4	5
	1755	1755	19.9	20.1	116.0	G	44.7	140	200	86.5	86.5	85.5	86.5	86.5	85.5	86.5	86.5	85.5	82.0	74.0	66.0	5	5
	1170	1175	20.2	20.2	116.0	G	67.1	140	200	85.0	85.0	85.0	87.0	87.0	87.0	80.5	74.5	62.5	80.5	74.5	62.5	5	5
20	3530	3530	26.0	26.5	145.0	G	29.6	130	200	87.0	87.0	86.0	86.0	85.0	85.0	85.5	81.5	73.5	91.0	90.0	86.0	5	5
	1755	1755	23.5	23.0	145.0	G	59.7	150	200	87.5	87.5	87.5	87.5	86.5	86.5	84.0	80.0	78.0	85.5	80.0	73.0	7.5	5
	1170	1170	26.1	24.9	145.0	G	89.7	135	200	87.0	87.0	87.0	85.0	91.0	73.0	80.0	81.0	73.0	80.0	81.0	73.0	7.5	5
25	3540	3540	30.0	30.6	182.5	G	37.0	130	200	87.0	86.0	86.0	82.5	84.0	81.0	87.5	84.5	77.5	90.0	89.0	82.0	5	5
	1760	1760	27.3	31.5	182.5	G	74.4	180	200	86.0	86.0	86.0	86.0	89.0	89.0	86.0	80.0	80.0	86.0	85.0	79.0	7.5	5
	1170	1170	33.5	33.9	182.5	G	111.0	135	200	86.5	86.5	86.5	85.0	86.0	86.0	81.0	77.0	66.0	81.0	78.0	60.0	10	10
30	3540	3540	36.6	34.9	217.5	G	44.4	130	200	87.0	87.0	86.0	86.5	85.5	84.5	89.0	89.0	87.0	90.0	90.0	86.0	7.5	5
	1765	1760	37.0	36.0	217.5	G	89.3	150	200	89.0	90.0	90.0	87.5	89.5	89.5	89.5	89.1	89.1	86.0	87.0	83.0	7.5	5
	1170	1170	38.5	38.1	217.5	G	134.5	130	200	88.5	88.5	88.5	89.0	89.0	89.0	83.0	79.0	70.0	83.0	81.0	74.0	10	10
40	3540	3555	46.0	48.7	290.0	G	59.3	130	200	88.0	88.0	88.0	86.5	86.5	87.5	90.0	87.0	81.0	91.0	91.0	88.0	7.5	10
	1770	1770	51.0	49.0	290.0	G	118.5	140	200	88.5	90.5	90.5	90.5	90.5	89.5	90.5	90.5	89.5	88.0	83.0	76.0	15	10
50	3555	3555	59.5	61.5	362.0	G	73.8	120	200	89.0	89.0	89.0	88.0	88.0	85.0	88.0	85.0	79.0	91.0	91.0	88.0	10	10
	1770	1770	63.1	66.6	362.0	G	147.5	140	200	89.5	89.5	89.5	91.5	91.5	91.5	83.0	79.0	70.0	86.0	84.0	76.0	15	10
60	3555	3565	70.0	70.5	435.0	G	88.5	120	200	90.0	90.0	89.0	89.9	88.0	85.0	89.1	86.5	79.5	89.5	88.0	88.0	10	10
	1780	1780	73.9	73.9	435.0	G	177.0	140	200	91.0	92.0	92.0	91.0	91.5	91.0	83.5	80.5	72.5	88.5	83.5	76.0	15	15
75	3560	3565	86.5	86.0	542.0	G	110.5	100	200	91.0	91.5	91.0	90.5	90.0	86.0	91.0	90.0	85.5	91.5	90.5	87.5	15	10
	1775	1780	91.0	89.5	542.0	G	221.0	140	200	91.5	92.5	92.0	93.5	93.0	92.0	86.5	82.5	73.5	86.5	82.5	75.5	15	20
100	3560	3565	112.0	113.0	725.0	G	147.0	100	200	91.5	92.0	92.0	91.5	91.0	89.5	91.5	90.5	90.5	87.5	89.5	84.5	15	20
	1780	1780	118.4	117.0	725.0	G	296.0	125	200	92.5	93.0	93.0	93.0	93.0	92.5	86.5	85.5	76.5	86.5	85.0	76.0	25	20
125	3560	3565	144.0	140.0	907.0	G	184.0	100	200	91.5	92.0	91.0				88.0	87.0	81.5				25	30
	1780	1780	147.0	143.0	907.5	G	369.0	130	200	92.5	93.5	93.5				86.0	85.5	77.0				30	30

①Average expected values—do not use as guaranteed values.
②For Type K Standard Severe-duty Motor Data (TEFC) see page 102.
③Recommended maximum standard capacitor rating (commercially available) when capacitor and motor are switched as a unit.
④For unlisted data, refer to General Purpose Motor Dept., Fort Wayne, Indiana.

0075

POOR ORIGINAL

Data changed or added since July 21, 1975 issue

3874220 GENERAL ELECTRIC CO. 69A 10906 A-47x19-03

CHARACTERISTICS

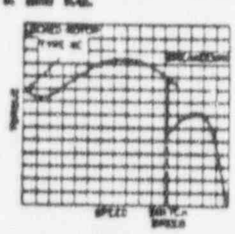
Amps Full Torque F.L. Breakdown

PERFORMANCE DATA—Type K (NEMA design B) 3-phase, 60 Hz

½	3515	3515	.84	.84	10.0	S	.75	200	300
	1740	1740	1.0	1.0	10.0	S	1.51	275	300
	1165	1165	1.0	1.0	10.0	S	2.29	210	300
	860	860	1.33	1.33	10.0	S	3.09	140	225
¾	3530	3370	1.3	1.3	12.5	P	1.15	300	300
	1740	1740	1.4	1.4	12.5	P	2.26	275	300
	1160	1160	1.55	1.55	12.5	P	3.43	175	275
	850	850	1.9	1.9	12.5	P	4.63	125	220
1	3410	3310	1.6	1.6	15.0	N	1.50	300	300
	1730	1730	1.7	1.7	15.0	N	3.03	275	300
	1160	1160	1.9	1.9	15.0	N	5.00	170	265
	870	870	2.4	2.4	15.0	N	6.03	135	215
1½	3455	3455	2.2	2.2	20.0	M	2.27	170	280
	1730	1730	2.3	2.3	20.0	M	4.56	230	280
	1160	1160	2.6	2.6	20.0	M	6.79	165	280
	865	865	3.1	3.1	20.0	M	9.10	130	210
2	3495	3495	2.8	2.8	25.0	L	3.00	170	240
	1725	1725	3.1	3.1	25.0	L	6.09	225	270
	1135	1135	3.3	3.3	25.0	L	9.09	160	240
	870	870	4.3	4.3	25.0	J	12.0	130	210
3	3475	3300	4.1	4.4	32.0	K	4.50	160	230
	1755	1755	4.4	4.6	32.0	K	8.97	215	250
	1160	1160	5.0	5.0	32.0	K	13.5	135	230
	865	865	5.9	5.9	32.0	H	18.1	130	205
5	3500	3300	6.7	6.9	46.0	J	7.5	180	215
	1745	1745	7.1	7.1	46.0	J	15.0	185	225
	1160	1160	8.1	8.1	46.0	J	22.6	130	215
	865	865	9.0	9.0	46.0	G	30.3	130	205
7½	3507	3370	9.8	10.7	63.5	H	11.2	140	200
	1745	1745	10.3	10.3	63.5	H	22.3	175	215
	1165	1165	11.0	11.0	63.5	H	33.7	130	205
	855	855	11.8	11.8	63.5	F	45.9	125	200
10	3515	3515	12.7	12.6	81.0	H	14.9	130	200
	1740	1745	13.4	13.3	81.0	H	30.1	165	200
	1160	1160	14.3	14.3	81.0	H	45.0	130	200
	870	870	15.1	15.1	81.0	G	60.3	125	200
15	3370	3540	19.0	20.0	116.0	[illegible]	22.4	130	200
	1755	1755	21.0	21.0	116.0	[illegible]	44.7	140	200
	1170	1173	20.6	20.3	116.0	[illegible]	67	140	200
	865	873	21.5	21.6	116.0	[illegible]	90.9	125	200
20	3530	3530	26.0	24.6	145.0	G	29.6	130	200
	1755	1755	27.0	24.5	145.0	G	59.7	130	200
	1170	1170	26.1	24.9	145.0	G	89.7	135	250
	860	860	28.6	28.6	145.0	G	119.0	125	200
25	3540	3540	30.7	29.8	182.5	G	37.0	130	200
	1760	1760	32.3	31.7	182.5	G	74.4	130	200
	1170	1170	33.3	32.9	182.5	G	111.9	125	200
	880	880	33.3	33.3	182.5	G	149.0	125	200

30	3545	3545	34.6	34.9	217.5	G	44.4	[illegible]	[illegible]
	1765	1760	37.0	36.0	217.5	G	89.2	[illegible]	[illegible]
	1170	1170	38.6	38.0	217.5	G	134.5	[illegible]	[illegible]
	875	875	43.0	40.0	217.0	G	180.0	125	[illegible]
40	3540	3555	46.0	46.5	290.0	G	59.2	[illegible]	[illegible]
	1770	1770	51.0	50.0	290.0	G	118.5	[illegible]	[illegible]
	1170	1180	51.0	50.0	290.0	G	179.5	[illegible]	[illegible]
	875	865	57.5	55.0	290.0	G	239.5	125	[illegible]
50	3555	3555	59.5	61.5	362.0	G	73.8	[illegible]	[illegible]
	1770	1770	61.0	60.6	362.0	G	147.8	[illegible]	[illegible]
	1170	1180	64.0	61.0	362.0	G	223.0	[illegible]	[illegible]
	875	865	73.0	67.0	362.0	G	299.0	125	[illegible]
60	3555	3555	69.6	72.5	435.0	G	88.5	150	[illegible]
	1770	1775	75.5	73.5	435.0	G	177.0	[illegible]	[illegible]
	1175	1185	80.6	73.6	435.0	G	267.0	[illegible]	[illegible]
	875	865	87.0	77.5	435.0	G	356.0	125	[illegible]
75	3555	3560	86.5	86.0	542.0	G	110.5	[illegible]	[illegible]
	1775	1720	91.0	91.0	542.0	G	221.0	[illegible]	[illegible]
	1175	1185	96.0	90.0	542.0	G	333.0	[illegible]	[illegible]
	880	885	97.0	95.0	542.0	G	446.0	125	[illegible]
100	3520	3550	113.0	116.0	725.0	G	147.0	[illegible]	[illegible]
	1775	1780	119.0	120.0	725.0	G	296.0	[illegible]	[illegible]
	1180	1180	122.0	119.0	725.0	G	444.0	[illegible]	[illegible]
	885	885	123.0	129.0	725.0	G	593.0	[illegible]	[illegible]
125	3560	3565	147.0	142.0	907.0	G	184.0	[illegible]	[illegible]
	1780	1775	151.0	149.0	907.0	G	369.0	[illegible]	[illegible]
	1175	1185	154.0	146.0	907.0	G	556.0	[illegible]	[illegible]
	885	890	158.0	160.0	907.0	G	741.0	[illegible]	[illegible]
150	3560	3565	171.0	166.0	1085.0	G	221.0	[illegible]	[illegible]
	1775	1775	173.0	174.0	1085.0	G	443.0	[illegible]	[illegible]
	1175	1185	175.0	177.0	1085.0	G	665.0	[illegible]	[illegible]
	885	885	182.0	204.0	1085.0	G	888.0	[illegible]	[illegible]
200	3560	3565	230.0	226.0	1450.0	G	294.0	[illegible]	[illegible]
	1775	1775	234.0	227.0	1450.0	G	591.0	[illegible]	[illegible]
	1175	1185	241.0	240.0	1450.0	G	890.0	[illegible]	[illegible]
250	3560	3565	290.0	275.0	1815.0	G	368.0	[illegible]	[illegible]
	1775	1775	280.0	280.0	1815.0	G	738.0	[illegible]	[illegible]
	1180	⑥	294.0	⑥	1815.0	G	1111.0	[illegible]	[illegible]
300	3560	3565	333.0	336.0	2170.0	G	442.0	[illegible]	[illegible]
	1775	1775	337.0	343.0	2170.0	G	887.0	[illegible]	[illegible]
350	3560	3570	384.0	382.0	2530.0	G	516.0	[illegible]	[illegible]
	1780	⑥	404.0	⑥	2530.0	G	[illegible]	[illegible]	[illegible]
400	3565	⑥	452.0	⑥	2900.0	...	591.0	...	...
	1780	⑥	470.0	⑥	2900.0	...	1181.0	...	...

Typical speed-torque curves for polyphase motors, Types K and KG.



Typical speed-torque curve for single-phase motors.

Type KC, Single-phase, 60 Hz (Dripproof)

½	3530	1637	24.0	H	.75	3.5	3.8	
	1730	1637	22.0	J	1.52	3.5	3.5	
	1140	1637	20.0	K	2.30	5.3	4.2	
	865	1637	20.0	K	3.00	5.1	7.7	
¾	3570	1637	30.0	L	1.13	3.1	3.5	
	1735	1637	30.0	L	2.27	7.4	3.3	
	1135	1637	30.5	L	3.47	8.0	6.9	
	865	1647	30.0	L	4.50	8.0	11.0	
1	3570	1637	35.0	K	1.49	3.0	5.6	
	1735	1637	35.0	K	3.04	9.0	6.0	
	1135	1637	35.0	K	4.55	9.5	9.7	
	865	2137	35.0	K	6.07	9.5	14.6	
1½	3500	1637	37.0	J	2.23	4.5	4.6	
	1715	1637	36.0	J	4.29	12.5	10.1	
	1150	1647	30.0	J	6.83	13.0	13.0	
	865	2137	30.0	J	9.14	14.0	20.0	

2	3495	1637	46.0	J	3.00	3.5	5.5	
	1745	1637	46.0	J	6.00	16.0	12.0	
	1145	2137	46.0	J	9.00	18.0	14.0	
	865	2137	60.0	H	12.1	19.0	17.0	
3	3510	1637	90.0	H	4.50	7.5	8.0	
	1730	1637	90.0	H	9.10	22.0	10.0	
	1125	2137	90.0	H	13.00	22.0	20.0	
5	3560	1647	130.0	G	7.20	11.0	11.5	
	1730	1647	130.0	G	15.0	30.0	26.0	
	1740	2137	130.0	G	15.0	30.0	26.0	
	1140	2137	130.0	G	22.7	40.0	40.0	
7½	3530	2137	200.0	G	11.2	10.0	20.0	
	1790	2137	200.0	G	22.2	40.0	40.0	
10	3530	2137	200.0	G	14.9	20.0	27.0	
	3530	2137	200.0	G	14.9	20.0	27.0	
	1790	2137	260.0	G	29.0	32.0	40.0	

NOTES: FL Breakdown

① Average expected values.
② For 115-volt connection, multiply 230-volt currents by 2.0
③ Indicates starting line kva.
④ Furnished for 200 volts only
⑤ Applies to dripproof only.
⑥ Totally enclosed, nonventilated.
⑦ Refer to factory for TEFC motor values.
⑧ Applies to TEFC only.
⑨ Non NEMA values.

POOR ORIGINAL

Data subject to change without notice