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Understanding ISO 8528 Generator Set Ratings

July 18th, 2017 11:00 PDT / 13:00 CDT
(1PDH issued by Cummins)



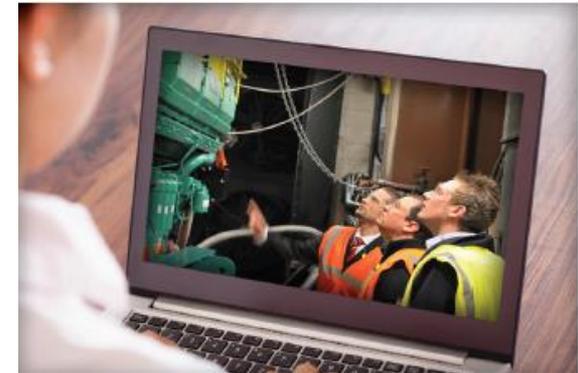
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Sales Application Engineering Leader – North America
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Cummins facilitator:



Tom Bakritzes,
Global Sales Training Manager
Cummins

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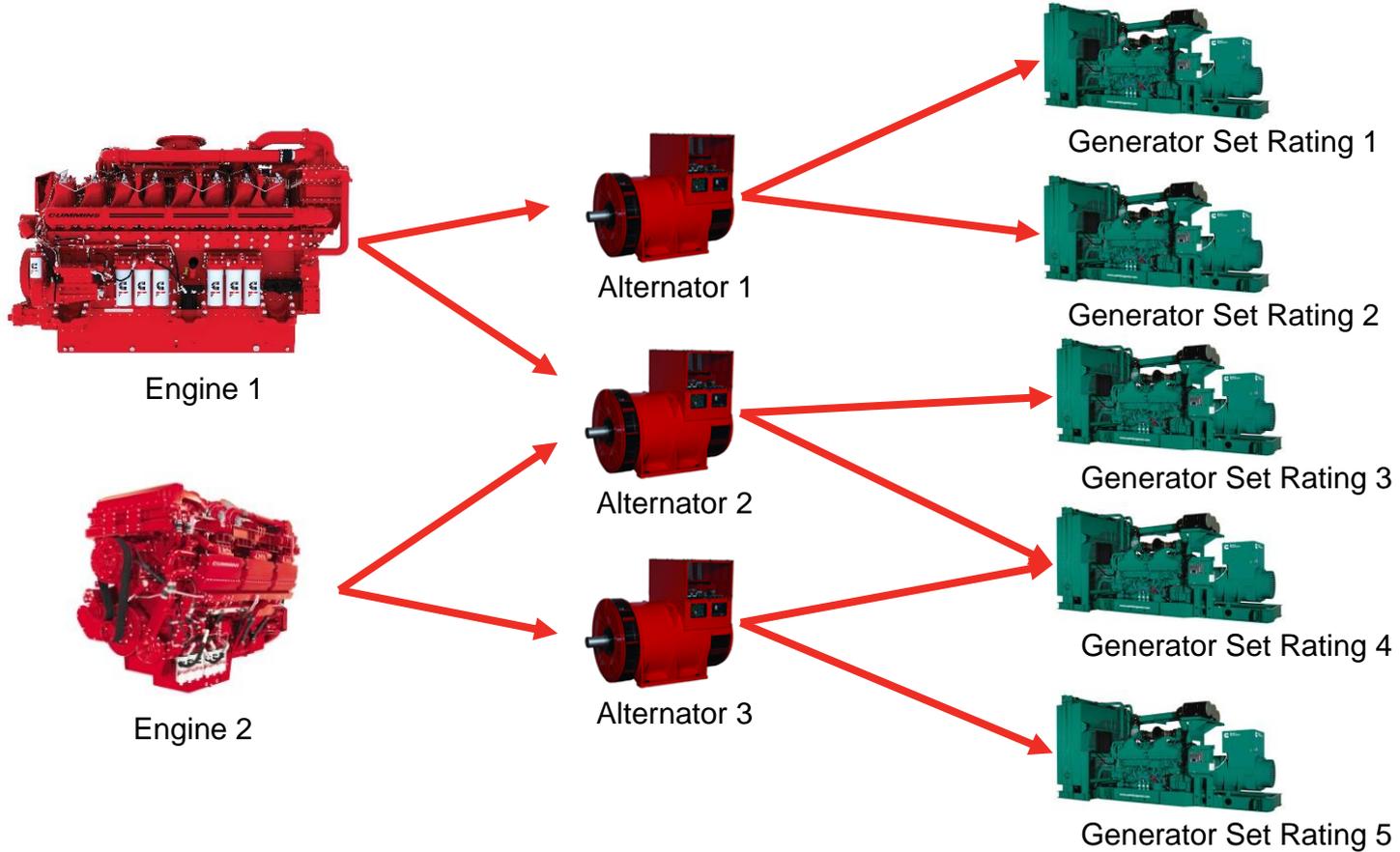
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Course Objectives

Participants will be able to:

- Describe generator set ratings definitions per the ISO 8528-1.
- Identify appropriate usage of industry-adopted ratings.
- Recognize alternator thermal ratings and appropriate selection considerations.

Generator Ratings



Generator Set Data Sheet

Model: C3500 D6e
Frequency: 60 Hz
Fuel type: Diesel
kW rating: 3500 standby
 3000 prime
 2750 continuous
Emissions level: EPA NSPS Stationary Emergency Tier 2

Model: C3500 D6e
Frequency: 60 Hz
Fuel type: Diesel
kW rating: 3500 standby
 3000 prime
 2750 continuous

Fuel consumption	Standby				Prime				Continuous			
	kW (kVA)				kW (kVA)				kW (kVA)			
Ratings	3500 (4375)				3000 (3750)				2750 (3438)			
Ratings without fan ¹	3806 (4608)				3107 (3884)				2857 (3572)			
Load	1/4	1/2	3/4	Full	1/4	1/2	3/4	Full	1/4	1/2	3/4	Full
US gph	77	130	183	236	68	114	159	204	65	106	147	189
L/hr	291	492	693	893	257	431	602	772	246	401	556	715

¹Ratings for reference with the optional remote radiator cooling configuration. See note 1 under "Alternator data" section.

Engine	Standby rating	Prime rating	Continuous rating
Engine model	QSK95-G9		
Configuration	Cast iron, Vee, 16 cylinder		
Aspiration	Turbocharged and Aftercooled		
Gross engine power output, kWm (bhp)	3768 (5051)	3215 (4309)	2956 (3962)
BMEP at set rated load, kPa (psi)	2634 (382)	2248 (326)	2088 (300)
Bore, mm (in)	190.0 (7.48)		
Stroke, mm (in)	210.1 (8.27)		
Rated speed, rpm	1800		
Piston speed, m/s (ft/min)	12.8 (2480)		
Compression ratio	15.5:1		
Lube oil capacity, L (qt)	647 (684)		
Overspeed limit, rpm	2070		
Regenerative power, kW	321		

Fuel flow	
Maximum fuel flow, L/hr (US gph)	1801.1 (423)
Maximum fuel inlet restriction with clean filter, kPa (inHg)	13.5 (4)
Maximum fuel return line restriction, kPa (inHg)	34 (10)
Maximum fuel inlet temperature, °C (°F)	71.1 (160)
Maximum fuel outlet temperature, °C (°F)	92.2 (198)

Air			
Combustion air, m ³ /min (scfm)	281 (9930)	270 (9550)	265 (9370)
Maximum air cleaner restriction with clean filter, mmH ₂ O (inH ₂ O)	457 (18)		
Alternator cooling air, m ³ /min (scfm)	255 (9005)		

Exhaust			
Exhaust flow at set rated load, m ³ /min (cfm)	709 (25040)	641 (22640)	609 (21520)
Exhaust temperature at set rated load, °C (°F)	490 (914)	441 (825)	417 (783)
Maximum back pressure, kPa (inH ₂ O)	7 (28)		

Industry Standard for Generator Set Ratings

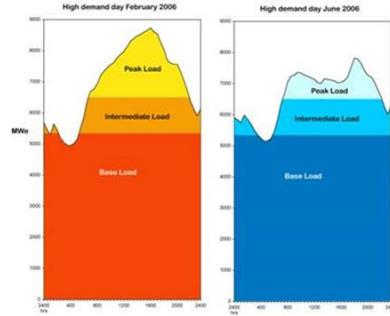
- ISO 8528: Standard for reciprocating internal combustion engine driven alternating current generator sets.
- Defines application, ratings and performance of generator sets.
- Sect. 13 defines these ratings:
 - Emergency Standby Power (ESP)
 - Limited Time Prime Power (LTP)
 - Prime Rated Power (PRP)
 - Continuous Operating Power (COP)
- Any manufacturer can go above and beyond the ISO ratings definitions.
 - Data Center Continuous (DCC)



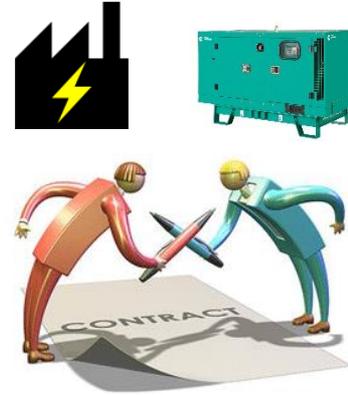
Factors Affecting Choice of Generator Set Rating



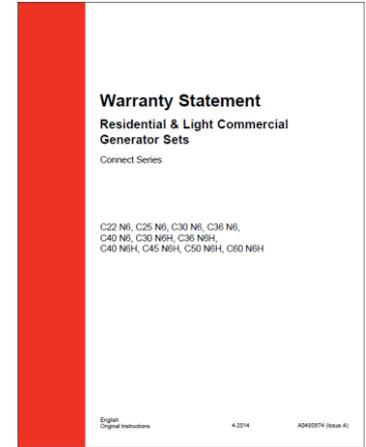
Annual
Generator Set
Run Time



Applied Load
(Variable or
Constant)

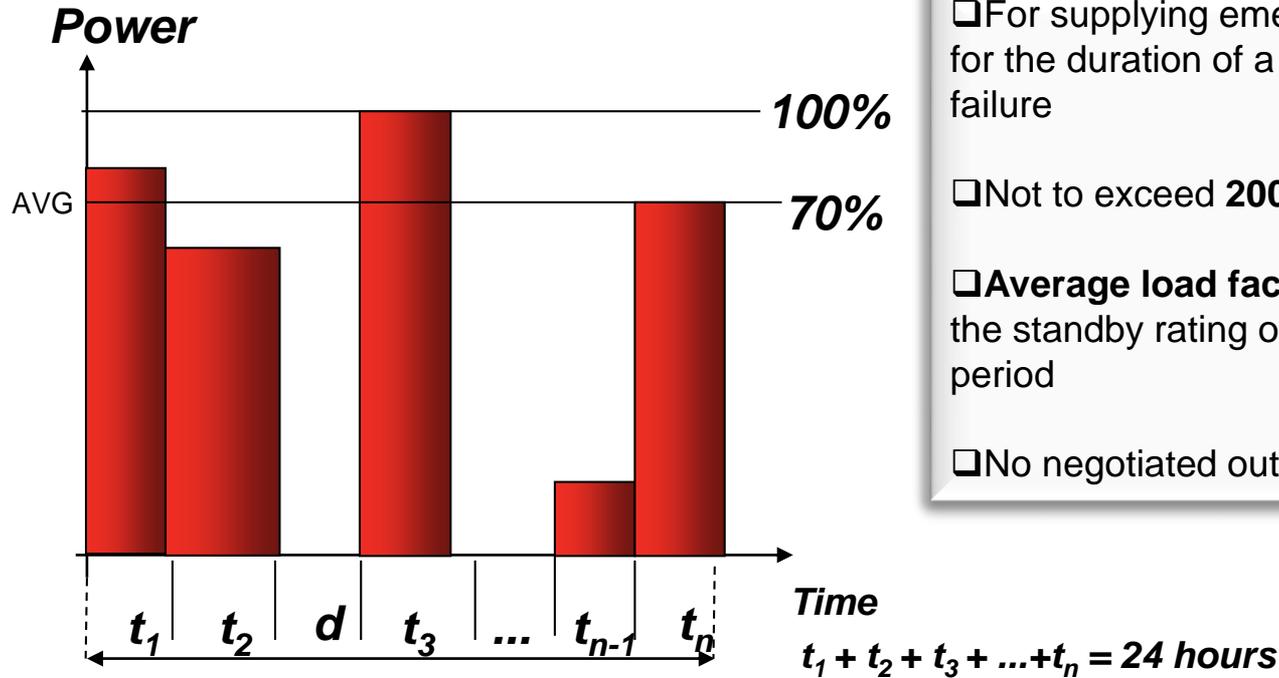


Negotiated
Contracts (Rate
Curtailment
Programs)



Warranty

Emergency Standby Power (ESP)



- For supplying emergency power for the duration of a utility power failure
- Not to exceed **200 hrs/yr**
- Average load factor of 70%** of the standby rating over 24 hour period
- No negotiated outage operations

$$P_{pa} = \frac{P_1 t_1 + P_2 t_2 + P_3 t_3 + \dots + P_n t_n}{t_1 + t_2 + t_3 + \dots + t_n} = \frac{\sum_{i=1}^n P_i t_i}{\sum_{i=1}^n t_i}$$

Example ESP Applications

- Emergency (such as backup to Life Safety, legally required or critical loads)
- Optional Standby (not required by the Authority Having Jurisdiction, but desired to minimize economic losses or equipment damages at a site due to utility power interruptions)



Application:

2 x Cummins DQGAA (1250 kWe)
1 x Cummins DQGAB (1500 kWe)

Location:

Intermountain Healthcare Facility in
Salt Lake City, UT



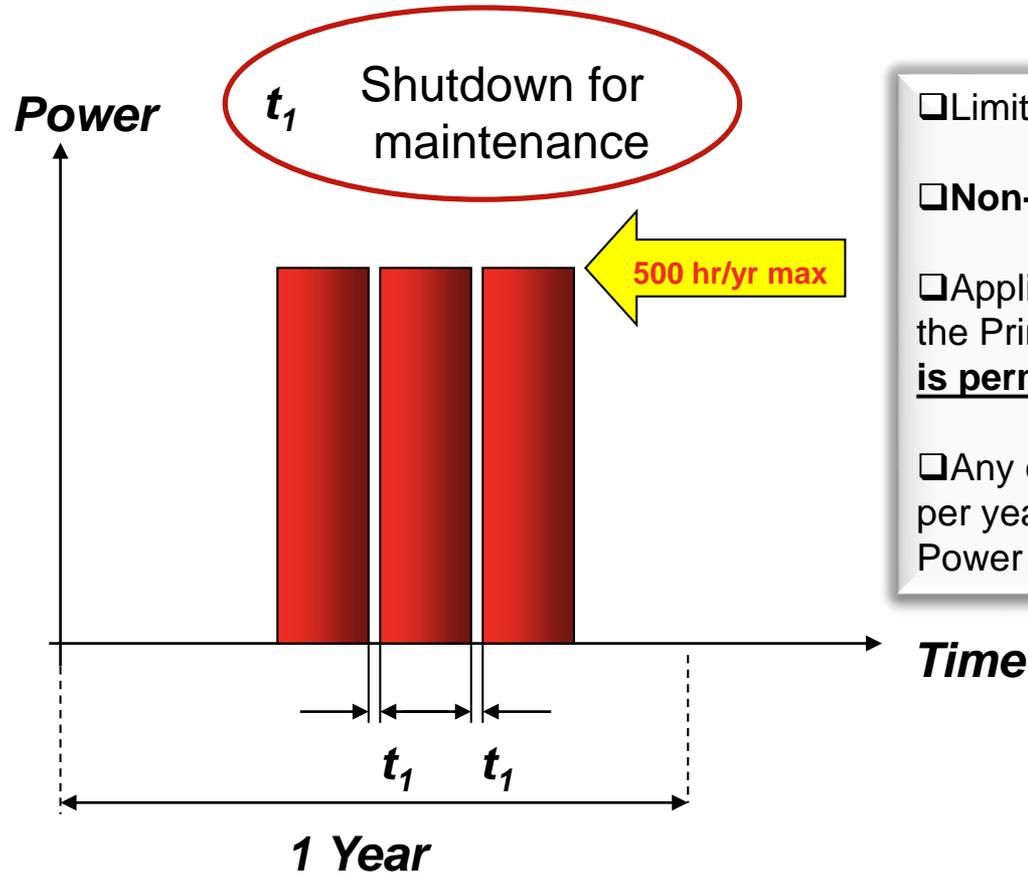
Application:

Fully Integrated standby power system
containing 7 Cummins C2000D6 (2000
kWe) generator sets individually
controlled and paralleled with PCC3201

Location:

Samsung SDS Institute in Suwon,
South Korea

Limited Time Prime Power (LTP)



Limited number of hours **500 hr/year**

Non-Variable Load

Applications not to exceed **100%** of the Prime Power rating (**no Overload is permitted**)

Any operation exceeding 500 hours per year should use the Continuous Power Rating

Examples of LTP Applications

- Base Loading
- Rate Curtailment

Application:

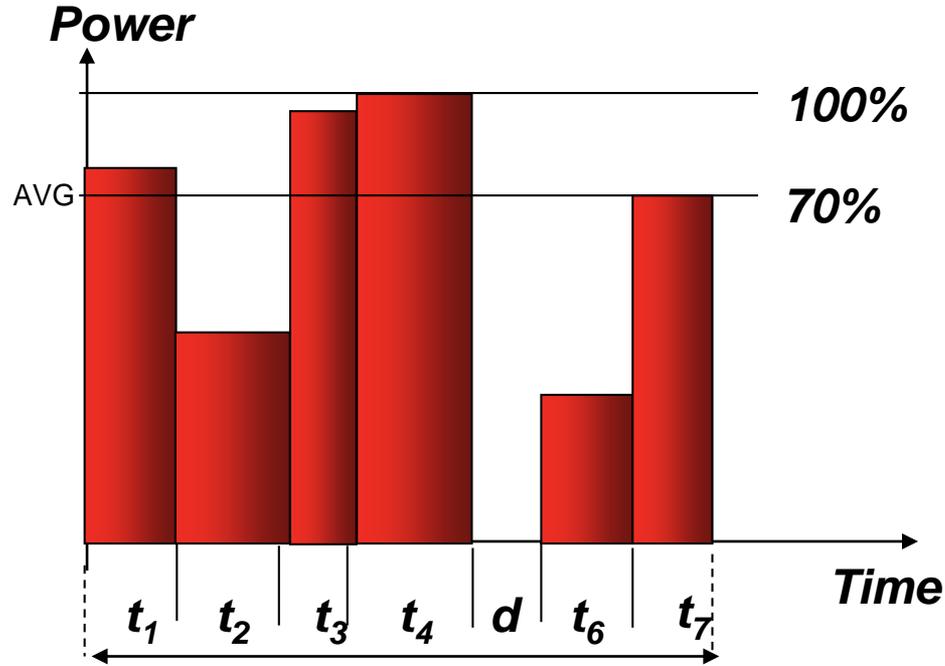
9 x Cummins C2000 D6
(2000 kWe ISO LTP)

Location:

Santo Domingo, Dominican Republic



Prime Rated Power (PRP)



24 Hours/365 days a year

Unlimited number of hours per year (**8760 hr/yr less service**)

Variable load

Not to exceed **70% average** of the **Prime rating** during any operating **period of 24 hours**

$$P_{pa} = \frac{P_1 t_1 + P_2 t_2 + P_3 t_3 + \dots + P_n t_n}{t_1 + t_2 + t_3 + \dots + t_n} = \frac{\sum_{i=1}^n P_i t_i}{\sum_{i=1}^n t_i}$$

Examples of PRP Applications

- Applications that use on-site generation in lieu of a utility electricity supply, typically where utility power is not available.
- Peak shaving and rate curtailment.

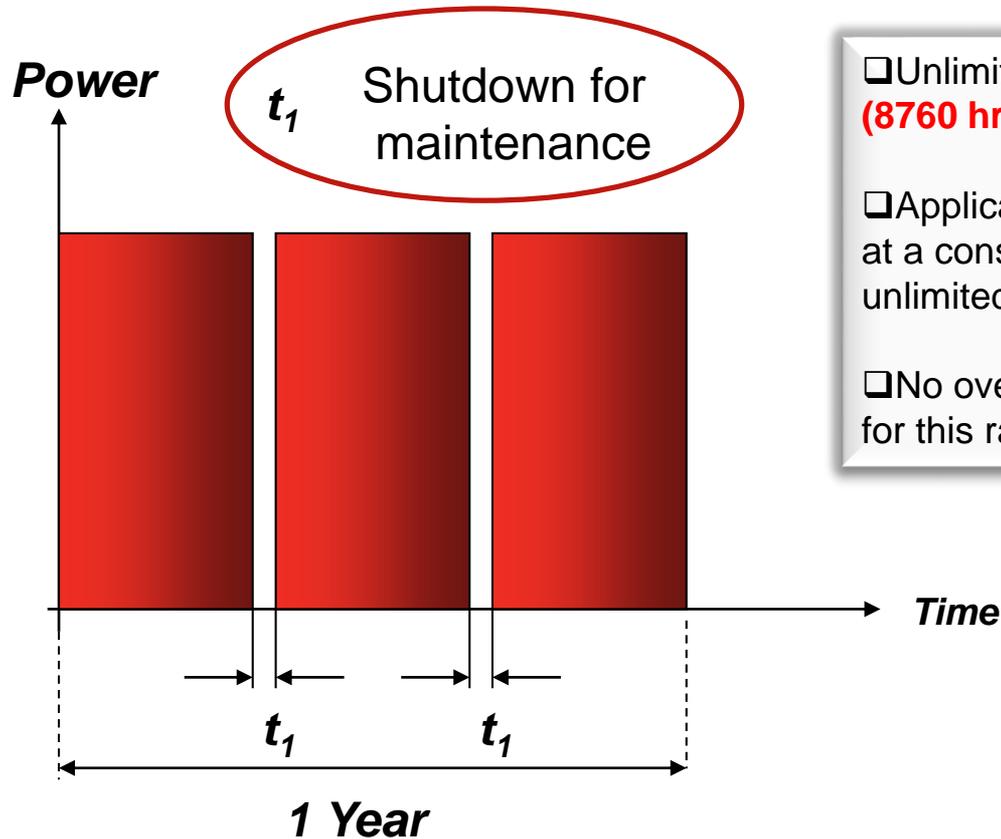
Application:

500kVA generator powers the dockside rubber tyred gantry cranes.

Cranes lift capacity is 88 tons and can move at 440 feet per minute.



Continuous Operating Power (COP)



- Unlimited number of hours per year (**8760 hr/yr less service**)
- Applicable for supplying utility power at a constant **100% load** for an unlimited number of hours per year.
- No overload capability is available for this rating.

Examples of COP Applications

- The COP Rating Genset is generally used when paralleled to the utility
- Base Loading
- Combined Heat and Power (CHP)



The Cummins Power Generation lean-burn generator set produces up to 1.75 MW of electricity and 4,000 pounds of steam per hour in a CHP application.



The lean-burn engine's radiator and critical exhaust silencer are roof mounted.



Industry-Adopted Ratings

Uptime Institute Compliance

- The tier rating system is the industry standard for benchmarking data center reliability.
- Four tiers, each building on requirement to the one below (ex. Tier II requires all of Tier I capability, plus the added requirements).
- Power Generation and distribution is one of 16 subsystems evaluated.
- No fractional tier ratings.
- Tiers do not specify certain equipment, but rather a level of redundancy and security to maximize run time.
- To be an enterprise class data center, UPS and generator sets are required equipment.
- Significant costs associated with higher tier rating.



Generator Sets for Tier III or Tier IV Systems

- “Disruptions to the utility power are not considered a failure but an **operational condition** for which the site must be prepared”
- “A Tier III or Tier IV engine-generator system, along with its power paths and other supporting elements shall meet ... performance confirmation tests while they are **carrying the site on engine-generator power**”
- “Engine-generators for Tier III and Tier IV sites **shall not have a limitation on consecutive hours of operation** when loaded to ‘N’ demand”

Data Center Continuous Ratings

- Data Center Continuous (DCC) Ratings meet the Uptime Institute Tier III and Tier IV requirements
- Data Center Continuous (DCC) Rating is defined as:

The maximum power which the generator is capable of delivering continuously to a constant or varying electrical load for unlimited hours in a data center application.

“... where a reliable utility power is available...”

For more details, watch out for upcoming **PowerHours**, *Generator Ratings for Data Centers* and *Generator Set Features for Data Centers!*

Specification sheet

Diesel generator set QSK95 series engine

2750 kW - 3350 kW 60 Hz
Data Center Continuous
EPA Tier 2 emissions regulated

Description

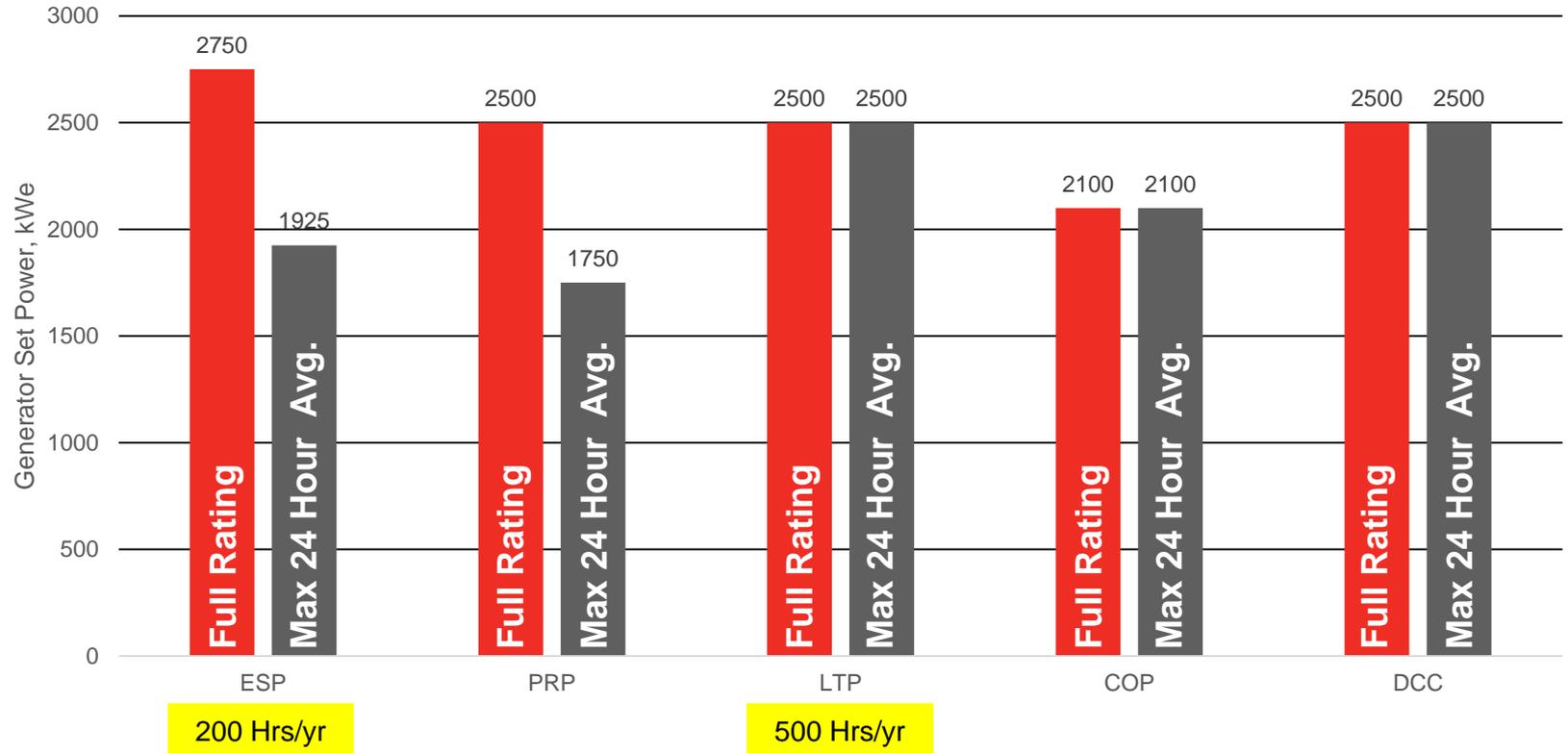
Cummins Power Generation commercial generator sets are fully integrated power generation systems providing optimum performance, reliability and versatility for Data Center applications.

Features

Data Center Continuous (DCC) - Applicable for supplying power continuously to a constant or varying electrical load for unlimited hours in a data center application.

Uptime Compliant - Meets the requirement of a Tier III and IV data center site by being rated to run for unlimited hours of operation when loaded to 'N' demand for the engine generator set.

Rating Example – Generator Set Model DQLF



Generator Set Rating Example

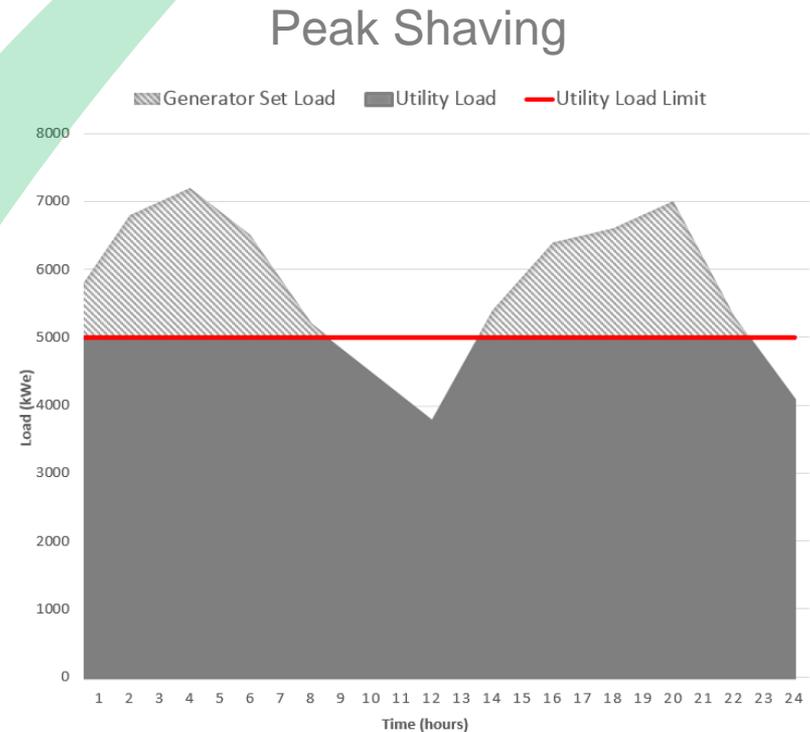
- Emergency Standby Power rating **2750 kW**
 - Max avg. load in 24h period (70%): **1925 kW**
 - 200h/year
- Prime Rated Power rating **2500 kW**
 - Max avg. load in 24h period (70%): **1750 kW**
- Limited Time Prime Power rating **2500 kW**
 - Max avg. load in 24h period (100%): **2500 kW**
 - 500h/year with non-variable load
- Continuous Operating Power **2100 kW**
 - Max avg. load in 24h period (100%): **2100 kW**
- Data Center Continuous rating **2500 kW**
 - Max avg. load in 24h period (100%): **2500 kW**
 - Unlimited hours in Data Center Application



Concept Check

Based on the application shown, which ISO 8528-1 generator set rating should be selected?

- a) Emergency Standby Power
- b) Prime Rated Power
- c) Limited Time Prime Power
- d) Continuous Operating Power



Generator Set Ratings Watch-Outs

- Parasitic losses

- Not all generator set manufacturers publish ratings that include all parasitic losses such as cooling systems.

Published Rating: 3350 kWe

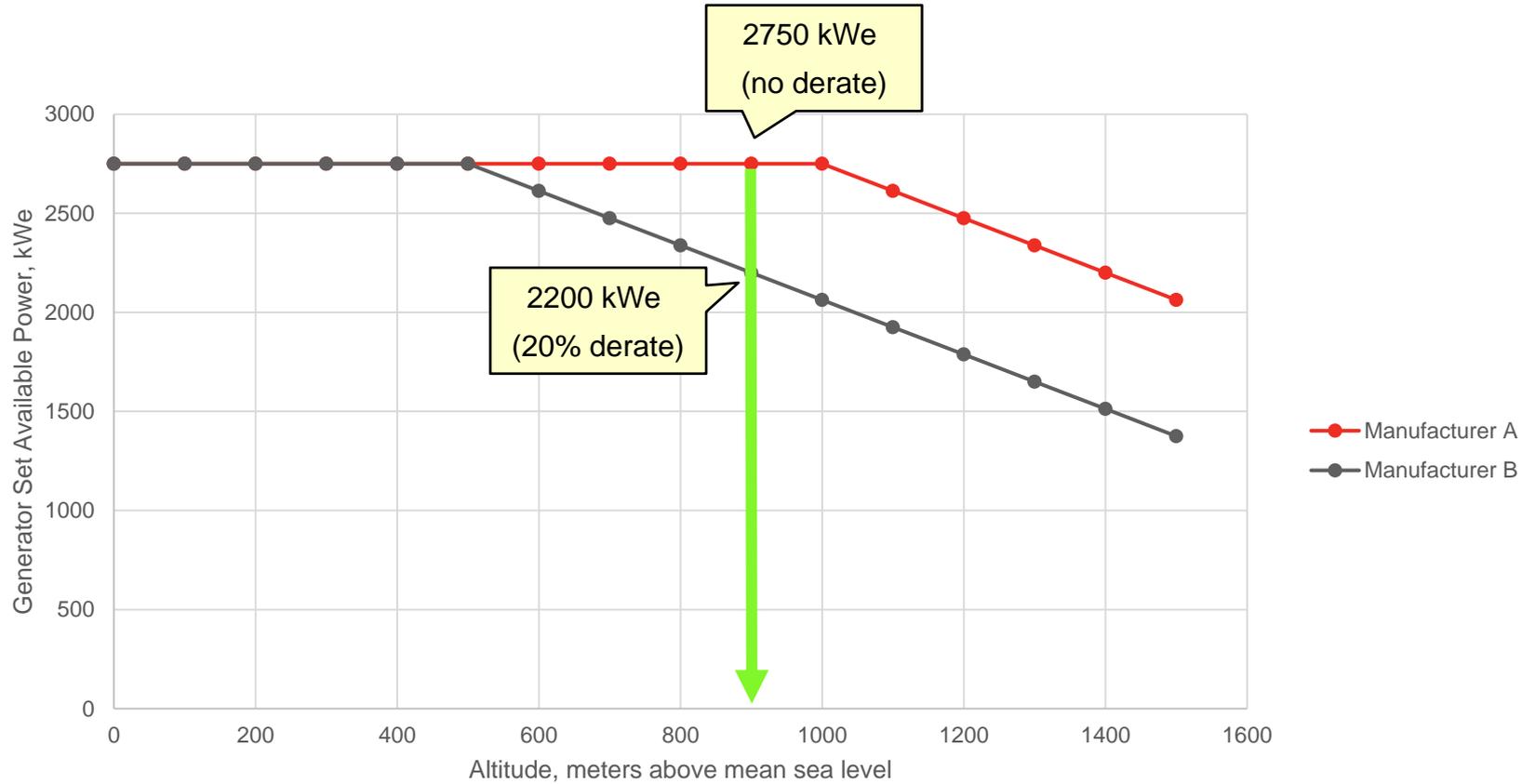
Parasitic Losses: 100 kWe  Cooling Fans

Actual Available Customer Load: 3250 kWe

- Site impact on ratings

- Altitude and ambient conditions may impact available customer load.
- Generator set manufacturers adopt a wide variety of “standard” conditions.

Altitude Impact





EPA Usage Categories

EPA Product Use Definitions

- EPA definitions are NOT the same as ISO8528-1
- EPA definitions are determined by actual product use and engine horsepower:

Stationary (40 CFR Part 60)

- Stationary Emergency
- Stationary Non-Emergency

Nonroad CI (40 CFR Part 89)

- No emergency provision in non-road rules

Nonroad SI (40 CFR Part 1048)

- No emergency provision in non-road rules

- Emissions are most stringent for non-road and stationary non-emergency, compared to stationary emergency
- Codes and details found on EPA website
 - <http://www.epa.gov/ttn/atw/icengines>

Concept Check

You are the owner of a new facility that requires generator sets for the sole purpose of providing emergency backup power for the utility. The annual utility outage expected is around 20 hrs/year with a variable load profile.

Which ISO 8528-1 Generator Set rating/EPA Exhaust Emissions designation should you select?

- a) Emergency Standby Power/Stationary Non-Emergency
- b) Prime Rated Power/Stationary Non-Emergency
- c) Emergency Standby Power/Stationary Emergency
- d) Continuous Operating Power/Stationary Non-Emergency

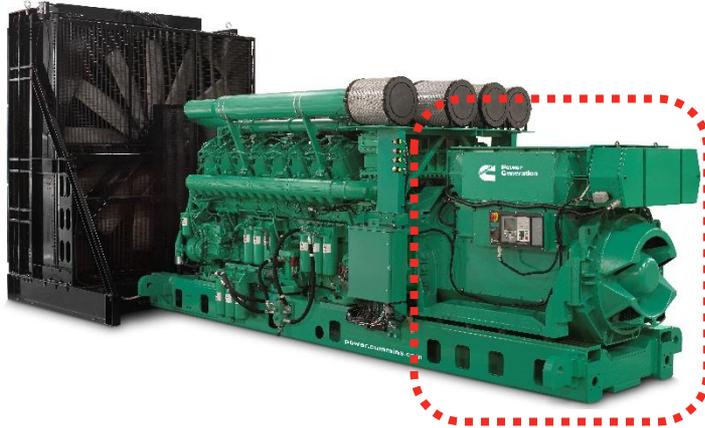


Alternator Ratings

Generator Set Alternator Options and Ratings – Key Points

- Several generator set models may be based on the same engine platform.
- In turn, each generator set is typically offered with multiple ratings options as discussed previously.
- Each generator set rating may be offered with multiple alternator options with varying voltage options.

Generator Set Alternator Options and Ratings – Example

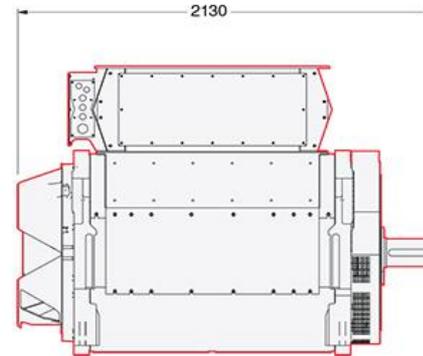


60Hz Diesel Model: C3500 D6e

Standby: 3500 kW_e

Prime: 3000 kW_e

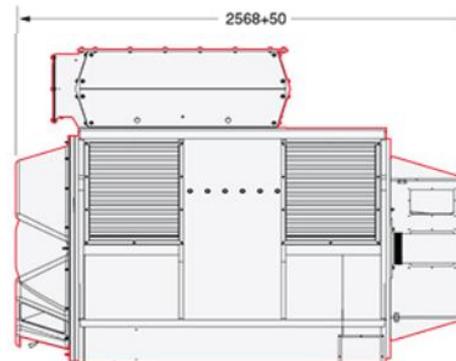
Continuous: 2750 kW_e



STAMFORD P80-HV

HVSI804W - 3032 kW

HVSI804X - 3436 kW



AvK DIG-HV

DIG142c - 3398 kW

DIG142d - 3644 kW

DIG142f - 4299 kW

Generator Set Alternator Ratings Definitions

- Insulation Class

- Maximum operation temperature allowed by the insulation material in the winding
 - Class F (155°C) and Class H (180°C)
- Defined by international standard (NEMA, UL, IEC)

- Temperature Rise Class/Ratings

- Temperature rise allowed over an ambient temperature
- Depends on the application
 - Standby or Continuous

Temp. Rise Class	Allowable Full Load Temp. Rise, °C	Max.Operation Temp. Allowed, °C
B	80	130
F	105	155
H	125	180

Generator Set Alternator Ratings

3 Ø RATINGS (0.8 power factor) (Based on specific temperature rise at 40°C ambient temperature)		60 Hz (winding no)				
		<u>416</u> (12)	<u>440</u> (12)	<u>480</u> (12)	<u>600</u> (07)	<u>380</u> (13)
163°C Rise Ratings	kW	2288	2420	2640	2640	2640
	kVA	2860	3025	3300	3300	3300
150°C Rise Ratings	kW	2224	2352	2560	2560	2560
	kVA	2780	2940	3200	3200	3200
125°C Rise Ratings	kW	2080	2200	2400	2400	2400
	kVA	2600	2750	3000	3000	3000
105°C Rise Ratings	kW	1908	2016	2200	2200	2200
	kVA	2385	2520	2750	2750	2750
80°C Rise Ratings	kW	1664	1760	1920	1920	1920
	kVA	2080	2200	2400	2400	2400

Generator Set Ratings

Generator Set Rating (ISO8528-1)	Emergency Standby Power (ESP)	Limited Time Prime (LTP)	Prime Rated Power (PRP)	Continuous Operating Power (COP)
Load Type	Variable	Constant	Variable	Constant
Annual operating hours	200	500	Unlimited	Unlimited
Average load	70%	100%	70%	100%
Overload	No	No	10% (1 hr/12 hrs, 25 hrs/year)*	No
Max. Alternator Rating (NEMA MG1-32)	Standby	Standby	Continuous	Continuous
Max. Alternator Ratings	Class H Standby 150/40 Standby 163/27 Class F Standby 125/40	Class H Standby 150/40 Standby 163/27 Class F Standby 125/40	Class H 125/40 Class F 105/40 Class B 80/40	Class H 125/40 Class F 105/40 Class B 80/40

*May vary based on generator set manufacturer.

Summary

- Select correct Generator set rating based on intended use, load profile and hours of operation.
- ISO 8528-1 defines industry standard generator set ratings, industry-adopted ratings may go above and beyond ISO 8528-1.
- EPA ratings are not to be confused with ISO8528-1 generator set ratings.
- Thermal ratings are directly correlated to insulation half life and may impact other power system characteristics.

Q&A

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- We will publish consolidated FAQ along with presentation and webinar recording on powersuite.cummins.com

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