



## Power Generation

# UNDERSTANDING GENERATOR SET RATINGS FOR MAXIMUM PERFORMANCE AND RELIABILITY

Onsite power systems perform at maximum capability only when its generator sets are sized to the appropriate load for an application.

Proper specification of a power system in accordance with a generator set's ratings and the specific application will ensure the required performance over the lifespan of the generator set, providing maximum value to the customer. Ratings such as total power output, running time, load factors and emissions regulations must be defined for every installation. In addition, while all manufacturers comply with most industry basic standards, some rate their generator sets in ways that require careful consideration.

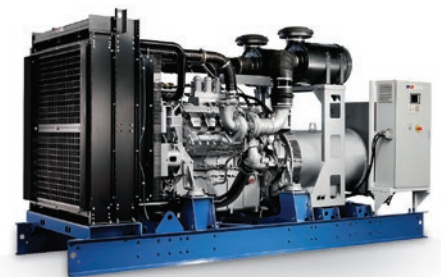
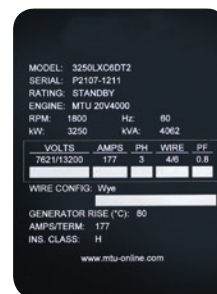
There are four types of ratings that must be considered when specifying a generator set for an application:

- **Industry standard ratings**  
ISO-8528-1:2005 is an industry standard that defines the performance parameters required in various onsite power applications.
- **Manufacturers' ratings**  
Certain manufacturers have ratings that exceed ISO-8528-1:2005 standards or take exception to certain operating parameters.
- **Governmental emissions ratings**  
For example, the U.S. Environmental Protection Agency (EPA) has environmental ratings and regulations for generator sets that vary by drive engine horsepower and application.
- **Custom industry ratings**  
Various organizations and industry segments have created custom ratings to fit particular operational needs.

This array of ratings and standards can complicate the selection of the most appropriate generator set for a given application. This paper will review the various ratings available from manufacturers and provide a guide to specifying the best power system solution.

## Industry standard ratings

ISO-8528-1:2005 defines basic generator set rating categories based on four operational categories: Emergency Standby Power (ESP), Prime Power (PRP), Limited-Time Running Prime (LTP) and Continuous Power (COP). In each category, a generator set's rating is determined by maximum allowable power output in relation to running time and the load profile. Misapplication of the ratings can jeopardize longevity of the generator set, void manufacturers' warranties or in rare instances risk catastrophic failure.



Here is a detailed look at each operational rating category as defined in the standard.

### Emergency Standby Power (ESP)

The emergency standby rating is the most commonly applied rating and represents the maximum amount of power that a generator set is capable of delivering. An ESP generator set is normally used to supply emergency power to a facility in the event of a utility outage until power is restored.

- ISO-8528-1 states that an ESP-rated generator set must provide power for the duration of the outage, with maintenance intervals and procedures being carried out as prescribed by the manufacturers. The ISO standard gives no limit to run time in the event of a utility power outage. Because the ESP rating is the maximum amount of power that the generator set is capable of delivering, no overload capacity is available for the ESP rating. ISO-8528-1 limits the 24-hour average load factor to 70 percent of the nameplate ESP rating. However, an individual engine manufacturer can authorize a higher 24-hour average load factor at its discretion.

For example, all MTU engines in MTU's ESP-rated generator sets are approved for an 85 percent 24-hour average load factor. This higher load factor increases the 24-hour average available generator capacity by 15 percent over the ISO standard. The increased load factor can reduce the size or quantity of generators, which minimizes the total cost of ownership.

### Prime Power (PRP)

Generator sets rated for prime power are designed for supplying electric power in lieu of commercially purchased power from a utility. This type of generator set supplies power for temporary use, as well as applications that are typically remote from a utility grid, such as wilderness outposts, remote mining, quarrying or petroleum exploration operations.

- ISO-8528-1 states that a PRP-rated generator set must provide power for an unlimited number of hours per year under the agreed operating conditions with the maintenance intervals and procedures being carried out as prescribed by the manufacturers.
- Because the PRP rating is less than the ESP rating, overload capacity is typically available for the PRP rating. This is commonly used for electrical regulation purposes, but not dictated by the ISO standard.
- ISO-8528-1 limits the 24-hour average load factor to 70 percent of the nameplate PRP rating. Similar to the ESP rating, an individual engine manufacturer can authorize a higher 24-hour average load factor at its discretion.

### Limited-Time Running Prime (LTP)

Generator sets rated for limited-time running prime are typically designed for supplying electric power to utility as part of a financial arrangement. LTP applications include load management, peak shaving, interruptible rate, load curtailment and cogeneration.

- ISO-8528-1 states that a LTP-rated generator set must provide power for up to 500 hours per year with the maintenance intervals and procedures being carried out as prescribed by the manufacturers.
- The LTP rating dictates no requirement for overload capacity.
- ISO-8528-1 allows the 24-hour average load factor to be up to the full LTP rating.

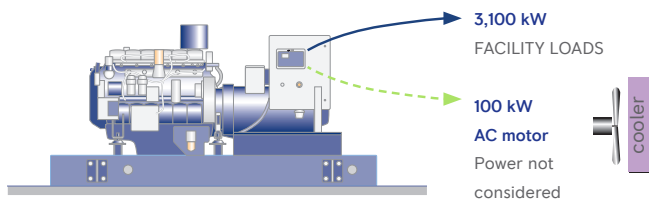
### Continuous Power (COP)

The continuous power rating is used for applications without a source for utility power, relying upon the generator set to supply a constant load for an unlimited number of hours annually. These applications, such as remote power stations, typically use multiple generator sets to achieve a constant load, which is also known in the industry as a "baseload power station." The base load is the minimum amount of power that a utility must make available to meet its customers' demands for power.

- ISO-8528-1 states that a COP-rated generator set must provide power for an unlimited number of hours per year under the agreed operating conditions with the maintenance intervals and procedures being carried out as prescribed by the manufacturers.
- No overload is dictated by the ISO standard.
- Similar to the LTP rating, ISO-8528-1 allows the 24-hour average load factor to be up to the full COP rating, or 100%, unless otherwise agreed by the manufacturer.



## Gross power output

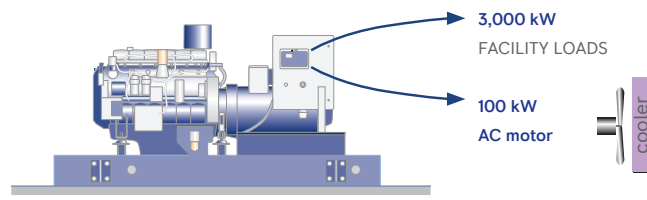


Generator set Scope of Supply

Example 1. Generator set with electronically driven cooling fan

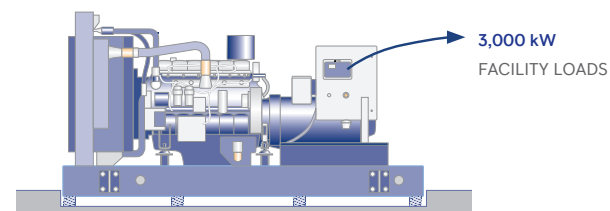
When comparing various generator sets, it is important to evaluate them based on net power output.

## Net power output



Generator set Scope of Supply

Example 1. Generator set with electronically driven cooling fan



Generator set Scope of Supply

Example 2. Generator set with mechanically driven cooling fan

## Manufacturers' ratings

Some manufacturers deviate from the ISO 8525-1 ratings in order to best fit their customer requirements, performance capabilities or maintenance schedules. Four of the most common confusion points are net power versus gross power output, overload capability, load factor and maximum run time allowed.

### Gross Power Output versus Net Power Output

Most generator manufacturers offer remote-cooled generator set versions designed to allow a third party to supply the cooling package. This gives the system designer more flexibility as it allows for the cooling package to be mounted remotely in a different location than the generator set, which can be beneficial for some installations. Since a third party provides the cooling package, the cooling fan power draw is often not considered as part of the complete system's power output.

Without the cooling fan power draw, the generator set's power rating is derived from the gross power output since some of the published power output will have to be used by the generator set to sustain its own operation. If the cooling package's fan power draw is subtracted from the generator set's output, this rating is considered the net power output. This can be thought of in terms of a salary, where gross pay is the amount prior to tax withholdings, and net pay is the "take-home" amount after taxes. When comparing genset ratings, it is important to evaluate them based on the complete system power output.

### Overload Capability

Historically, the PRP generator set output was less than the ESP rating, and this would allow an overload capability to be utilized. For PRP-rated units, this is commonly advertised as the 10% overload capability for some amount of time. For MTU powered generator sets, the 10% overload is available for one hour out of every 12 hours, up to 87 hours per year. Other generator set manufacturers state that this one-hour overload can only be used up to 25 hours per year.

### Load Factor

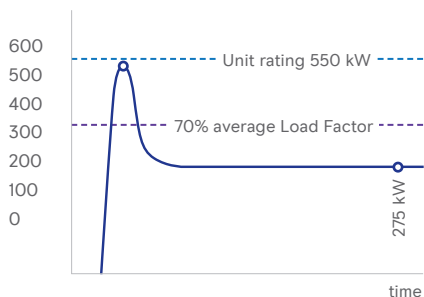
Load factor is commonly misunderstood in the industry, since generator sets are commonly known as their maximum application (nameplate) rating. As generator set technology progressed, the equipment was required to run harder than in the past. Generator manufacturers used the average load factor as described by ISO-8528 as a key assumption to establish their maintenance schedules.

When comparing products with different published load factors, it's important to consider some of the advantages of a generator set with a higher published load factor. In the past, a simple, single-step, generator set loading method was often used. It typically had the highest power requirement for the generator set, and consequently the generator set size was dictated by this rating. This is known as your "starting power requirement." In these system designs, the average power requirement of the generator set after the initial loading (called the "running power requirement") was typically 40-60% of the nameplate rating which follows the 70% guideline from ISO-8528.

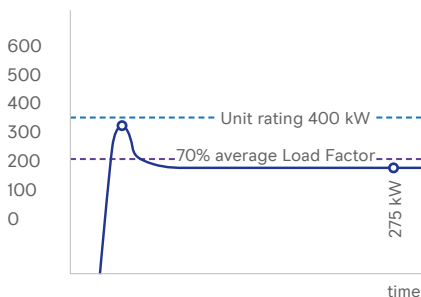
In comparison, today's more complex, multiple step, soft-loading methods are often preferred by electrical engineers. These methods effectively reduce the starting power requirement, which often reduces the maximum power output required of the generator set and results in a better system cost since a smaller generator set can be utilized. By using the smaller generator set in the same system, the same running power requirement exists and is now a higher percentage of the nameplate rating, often resulting in a 75-85% load factor. In conclusion, a higher average load factor allows electrical engineers to take advantage of today's more advanced loading methods. This results in smaller generator sets, which run at a higher average load factor, with a lower total cost of ownership.

## Load Factor Advantage example

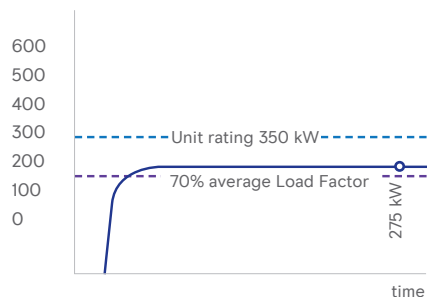
Scenario 1. 550 kW generator set, 50% Load Factor, 25 HP motors (6) started across the line with 150 kW resistive loads, all in one step.



Scenario 2. 400 kW generator set, 69% Load Factor, 25 HP motors (6) and 150 kW resistive loads started in separate steps.



Scenario 3. 350 kW generator set, 79% Load Factor, 25 HP motors (6) soft-started with 150 kW resistive loads in same step.



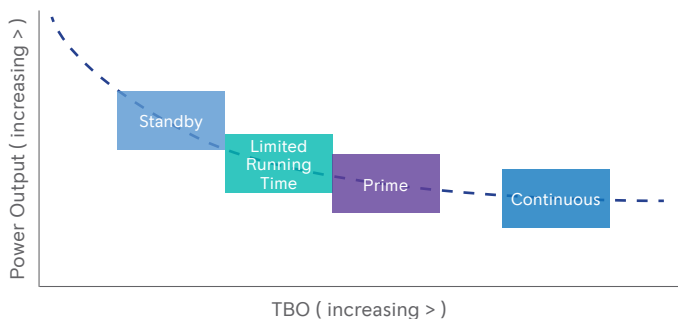
### Maximum Run Time

Although the ISO-8528 standard provides a guideline for the ESP maximum run time per year under test conditions, it does not state any run time limits in the event of a utility outage. As this is rather ambiguous, most generator set manufacturers have declared their own expected maximum annual run time, based on typical experience from the field. MTU-powered generator sets have a 500-hour annual recommendation, while many manufacturers have a 50-200 hour limit.

This can be another source of confusion, as some customers are concerned with exceeding the limit in the event of a utility outage. In this case, some manufacturers' may have an alarm or forced shut down, but a MTU-powered generator set will continue to produce power without issue. The only repercussion of this action will be executing the standard maintenance program quicker due to increased usage.

There is an inverse relationship between type of application and the estimated time before overhaul (TBO) of a generator set. In general, ESP-rated equipment have a higher power output than the same equipment with a PRP or COP rating, and because of this the ESP-rated equipment also has the shortest TBO. This generally applies to an ESP application as they are typically used less than 500 hours per year.

### Typical engine Time Between Overhaul curve



In contrast, generator sets used in PRP or COP applications have a more conservative output rating compared to the ESP rating, which allows for an extended TBO. With the typical usage of a PRP- or COP-rated generator set running many more hours in a year than ESP, the higher TBO is a significant benefit to the users of these applications by extending their maintenance schedules and decreasing product lifecycle costs.

Some generator set manufacturers will share their time before overhaul information, where others will not and rather rely on regularly scheduled inspection of the equipment's condition. However, if the TBO is not known when comparing ratings from different manufacturers, it's an incomplete comparison. One could end up purchasing a generator set with an increased load factor to compete with another manufacturer's rating, without ever knowing the consequence of a decreased TBO which results in a higher cost of ownership over the lifespan of the product. MTU-powered generator sets publish the TBO in the maintenance manual for every rating.

### Governmental emissions ratings

The Environmental Protection Agency (EPA) emissions rating is an important rating that impacts diesel generator sets used in the USA. The EPA began to enforce limits on off-road engines use in generator sets in 2006 and began phasing in regulations by tier levels and engine type. It's useful to be aware of the differences between stationary emergency, stationary non-emergency, and mobile generator set engines.

#### Emergency Engines

An emergency engine can be used without time limit, during an emergency power outage only, with a few exceptions.

- 100 hours of operation are allowed for non-emergency use via maintenance and testing.

Emergency-classified diesel engines must only meet Tier 2, 3, and 4-interim (4i) standards, depending on the maximum power of the engine. There is no federal regulation in place currently that requires a more stringent requirement in the future, so at this time the requirement is indefinite.

### Non-emergency Engines

A non-emergency engine is any engine that doesn't meet the emergency engine category. Examples include a generator set used before a storm hits while utility is available, or a genset located in a remote location where no utility power is available.

- Non-Emergency Diesel Engines must meet Tier 4 emission standards
- Any engine that exceeds the operating limitations placed on emergency engines can be used to supply power as part of a financial arrangement; including revenue-generating utility programs.
- Any mobile genset must meet non-emergency requirements

### Mobile Engines

Nonstationary or mobile generator sets fall into the same requirements of the non-emergency engines. There is one exception to this rule—the Transition Program for Equipment Manufacturers (TPEM). The TPEM allows for mobile generator set manufacturers to use the previously accepted mobile genset engine tier requirement for new equipment, in a limited quantity for a limited time period. This is often also referred to as the “mobile flexibility” provision, which MTU uses.

Lastly, while these requirements refer to national EPA standards, be aware that local jurisdictions — identified by EPA as nonattainment areas — may impose stricter emissions regulations on all types of generating systems.

## Custom industry ratings

### Continuous Standby

A mission-critical organization called The Uptime Institute has set design standards for data centers to ensure data safety. As generator sets are often a critical piece of the data center's design, the organization has developed regulations that apply to generator sets. One of these regulations defines acceptable generator set ratings for different levels or tiers (not to be confused with exhaust emission tiers) for data centers. One of the most often misunderstood attributes is the “Manufacturer's Runtime Limitation.”

The Uptime Institute states that generator sets for tier 3 or 4 data centers shall not have a limitation on the consecutive hours of operation when loaded to “N” demand, and generator sets that do have a limit on consecutive hours of operation are only suitable for tier 1 or 2 data centers. From this statement, data center designers frequently believe they must request a PRP- or COP-rated generator

set to adhere to the “no runtime limitation” section. Since so many manufacturers have different ratings, The Uptime Institute often requires letters from the manufacturer that prove the supplied unit meets the uptime requirements. When a special letter is needed, please work with your MTU representative. MTU has a wide range of generator sets that meet The Uptime Institute's requirements.

### Conclusion

Generator set ratings can be broken down into Industry Standard ratings, Governmental Emissions ratings and Custom Industry ratings. The proper understanding of the standards will ensure the best rating selection for the purpose the generator set serves, which is the basic foundation to customer satisfaction.

## Emergency diesel engines

kW <sub>(HP)</sub>	2009	2010	2011	2012	2013	2014
kW(HP)<8(11)	Tier 1	Tier 1	Tier 1	Tier 1	Tier 1	Tier 1
8(11)≤kW(HP)<19(25)	Tier 1	Tier 1	Tier 1	Tier 1	Tier 1	Tier 1
19(25)≤kW(HP)<37(50)	Tier 1	Tier 1	Tier 1	Tier 1	Tier 1	Tier 1
37(50)≤kW(HP)<56(75)	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2
56(75)≤kW(HP)<75(100)	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2
75(100)≤kW(HP)<130(175)	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2
130(175)≤kW(HP)<225(300)	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2
225(300)≤kW(HP)<450(600)	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2
450(600)≤kW(HP)≤560(750)	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2
560(750)<kW(HP)≤2238(3000)	Tier 3	Tier 3	Tier 3	Tier 3	Tier 3	Tier 3
2238(3000)<kW(HP)	Tier 4	Tier 4	Tier 4	Tier 4	Tier 4	Tier 4

■ Tier 1   
 ■ Tier 2   
 ■ Tier 3   
 ■ Tier 4

- Used only in emergency situations when normal power source is interrupted
- Exceptions are up to 100 hours annually of maintenance and testing

Uptime Institute Tier Level	Tier 1	Tier 2	Tier 3	Tier 4
Acceptable MTU rating	ESP-rated generator set taking into consideration site conditions.		ESP rated generator set taking into consideration site conditions and load profile.	
Method for approval	No approval necessary.		Contact your MTU representative for a letter to comply with Uptime's requirements.	

Rolls-Royce provides world-class power solutions and complete lifecycle support under our product and solution brand MTU. Through digitalization and electrification, we strive to develop drive and power generation solutions that are even cleaner and smarter and thus provide answers to the challenges posed by the rapidly growing societal demands for energy and mobility. We deliver and service comprehensive, powerful and reliable systems, based on both gas and diesel engines, as well as electrified hybrid systems. These clean and technologically advanced solutions serve our customers in the marine and infrastructure sectors worldwide.