CHAPTER 2 CONTENTS

2 – PRELIMINARY DESIGN

Overview

Designing a generator set installation requires consideration of equipment and installation requirements. These vary depending on the reasons for having the generator set and its intended use. Reviewing and understanding these reasons is an appropriate starting point for the system design and equipment choices.

Power Requirements

General Requirements

The need for on–site generation of emergency and standby electricity is usually driven by mandatory installations to meet building code requirements, and/or risk of economic loss due to loss of electric power.

Mandatory installations for emergency and standby power follow, from building code requirements referenced by the regulations of federal, state, local, or any other governmental authority. These installations are justified on the basis of safety to human life, where loss of the normal power supply would introduce life safety or health hazards. Voluntary installations of standby power for economic reasons are typically justified by a mitigation of the risk of loss of services, data, or other valuable assets. Mandatory and voluntary installations of on–site generation may be justified on the basis of favorable load curtailment rates offered by the electric utility. The same on–site generation system may be used for both of these general needs, provided that life safety needs have priority, e.g. generator capacity and load transfer arrangements.

Specific Requirements

A wide range of specific requirements will result in the need for on–site electric generation systems. Some common needs are outlined below.

Lighting: Egress lighting for evacuation, illuminated exit signs, security lighting, warning lights, operating room lighting, elevator car lighting, generator room lighting, etc.

Control Power: Control power for boilers, air compressors, and other equipment with critical functions.

Transportation: Elevators for fire department use.

Mechanical Systems: Smoke control and pressurization fans, waste water treatment, etc.

Heating: Critical process heat.

Refrigeration: Blood banks, food storage, etc.

Production: Critical process power for laboratories, pharmaceutical production processes, etc.

Space Conditioning: Cooling for computer equipment rooms, cooling and heating for vulnerable people, ventilation of hazardous atmospheres, ventilation of pollutants or biological contamination, etc.

Fire Protection: Fire pumps, jockey pumps, alarm and annunciation.

Data Processing: UPS systems and cooling to prevent data loss, memory loss, program corruption.

Life Support: Hospitals, nursing homes, and other health care facilities.

Communications Systems: 911 service, police and fire stations, hi–rise building public address systems, etc.

Signal Systems: Railroad, ship, and air traffic control.

System Types and Ratings

On–site power generation systems can be classified by type and generating equipment rating. The generating equipment is rated using standby, prime, and continuous ratings. The ratings definitions are important to understand when applying the equipment. Please refer to the ratings guidelines that follow. The type of on–site generation system and the appropriate rating to use is based on the application. See **Table 2–1** and descriptions of the following.

Emergency Systems

Emergency systems are generally installed as required for public safety and mandated by law. They are typically intended to provide power and lighting for short periods of time for three purposes: to permit safe evacuation of buildings, for life support and critical equipment for vulnerable people, or for critical communications systems and facilities used for public safety. Code requirements typically specify the minimum load equipment to be served.

Legally–Required Standby

Legally–required standby systems are generally installed as mandated by legal requirements for public safety. These systems are typically intended to provide power and lighting for short periods of time where necessary to prevent hazards or to facilitate fire–fighting operations. Code requirements typically specify the minimum load equipment to be served.

Optional Standby

Optional Standby systems are generally installed where safety is not at stake, but loss of power could cause an economic loss of business or revenue, interrupt a critical process, or cause an inconvenience or discomfort. These systems are typically installed in data centers, farms, commercial and industrial buildings, and residences. The owner of the system is permitted to select the loads connected to the system.

In addition to providing a standby source of power in case of loss of a normal power supply, on–site generation systems are also used for the following purposes.

Prime Power

Prime power installations use on–site generation in lieu of a utility electricity supply, typically where utility power is not available. A simple prime power system uses at least two generator sets and a transfer switch to transfer supply to the loads between them. One or the other of the generator sets runs continuously with a variable load, and the second generator set serves as backup in case of a failure, and to allow downtime for required maintenance. A changeover clock within the transfer switch alternates the lead generator set on a predetermined interval.

Peak Shaving

Peak shaving installations use on–site generation to reduce or flatten peak electricity use for the purpose of saving money on energy demand charges. Peak shaving systems require a controller that starts and runs the on–site generator at the appropriate times to flatten the user's peak demands. Generation installed for standby purposes may also be used for peak shaving.

Rate Curtailment

Rate curtailment installations use on–site generation in accordance with electric energy rate agreements with the serving electric utility. In exchange for favorable energy rates the user agrees to run the generators and assume a specified amount of load (kW) at times determined by the utility, typically not to exceed a specified number of hours per year. Generation installed for standby purposes may also be used for rate curtailment.

Continuous Base Load

Continuous base load installations use on–site generation to supply a constant power (kW) typically through interconnection equipment into a utility grid. These installations are usually owned by electric utilities or under their control.

Co–Generation

Often, continuous base load generation is used in Co–Gen application. Simply put, Co–Gen is utilizing both the direct electricity generation and waste exhaust heat to substitute for utility supplied energy. The waste heat is captured and either used directly or converted to electricity.

	Generator Set Rating		
	Standby	**Prime**	**Continuous**
System Type	Emergency	Prime Power	Base Load
	Legally–required Standby	Peak Shaving	Co–Gen
	Optional Standby	Rate Curtailment	

Table 2–1. Rating and System Types

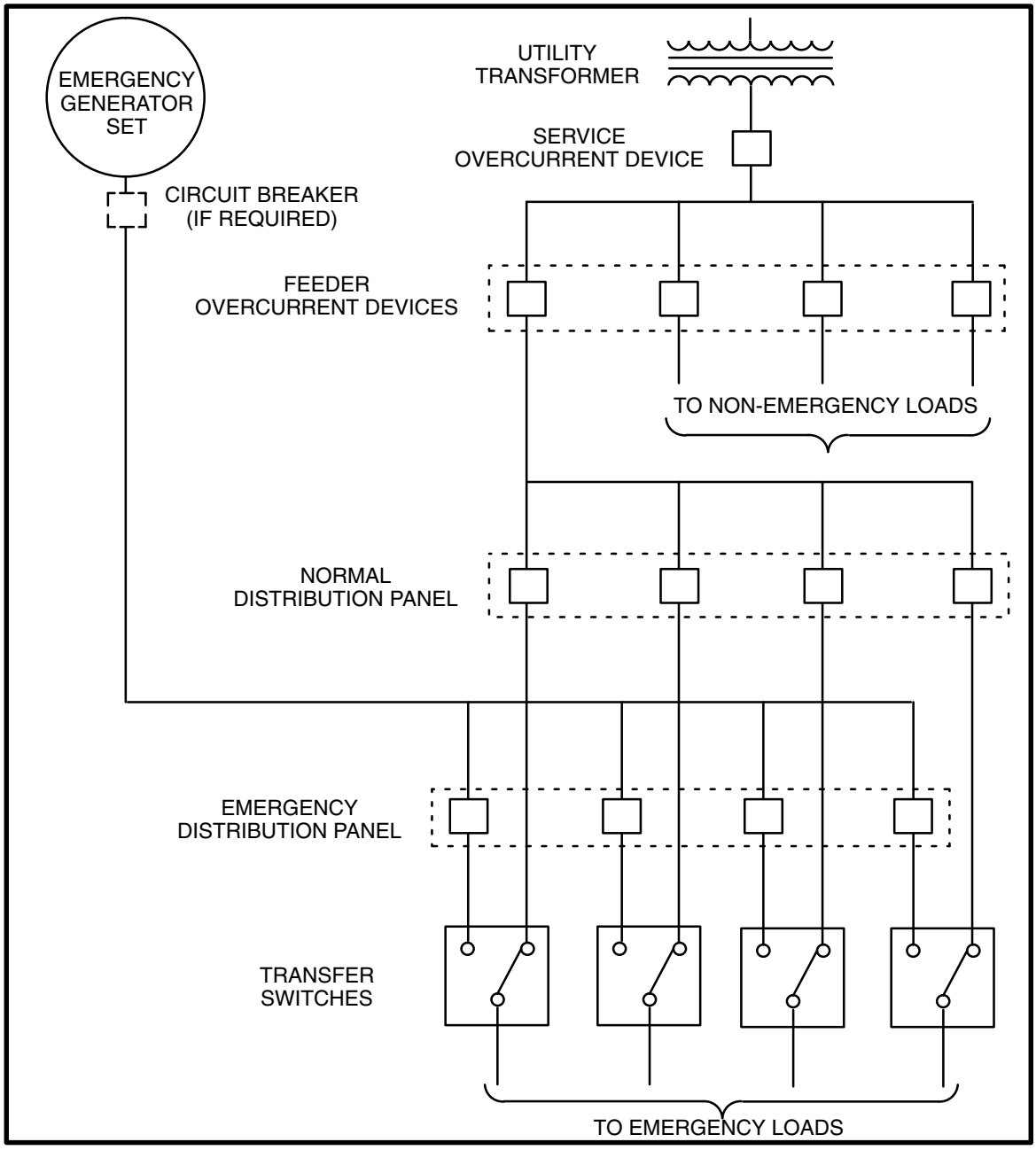


Figure 2–1. Typical One-Line Diagram of an Electrical Distribution System

The One–Line Diagram

A one–line electrical system diagram is an important element for understanding the system and connection arrangement. It can be especially critical for communicating that information during planning, installation, startup and/or servicing the system. These diagrams depict the major components such as generator(s), power transfer equipment, protective relaying, overcurrent protection and the overall connection scheme. A one–line diagram should be developed as early as possible during the project planning to aid the system design. **Figure 2–1** is a typical one–line diagram of a basic generation system.

Guidelines for Generator Set Power Ratings

Power ratings for generator sets are published by the manufacturers[31]. These ratings describe maximum allowable loading conditions on a generator set. The generator set will provide acceptable performance and life (time between overhauls) when applied according to the published ratings. It is also important to operate generator sets at a sufficient minimum load to achieve normal temperatures and properly burn fuel. Cummins Power Generation recommends that a generator set be operated at a minimum of 30% of its nameplate rating.

The following explanations describe the ratings types used by Cummins Power Generation. The associated **Figures, 2–2 thru 2–5,** depict the load levels (P_1, P_2, P_3, etc.) and time at that load level (T_1, T_2, T_3, etc.) allowed under the various ratings.

Standby Power Rating

The standby power rating is applicable to emergency power applications where power is supplied for the duration of normal power interruption. No sustained overload capability is available for this rating (Equivalent to Fuel Stop Power in accordance with ISO3046, AS2789, DIN6271 and BS5514 as well as emergency stand by power (ESP) per ISO 8528). This rating is applicable to installations served by a reliable normal utility source. This rating is only applicable to variable loads with an average power output of 70 percent of the standby rating over 24 hours of operation for a maximum of 200 hours of operation per year. In installations where operation will likely exceed these limits, the prime power rating should be applied. The standby rating is only applicable to emergency and standby applications where the generator set serves as the back up to the normal utility source. No sustained utility parallel operation is permitted with this rating. For applications requiring sustained utility parallel operation, the prime power or base load rating must be utilized.

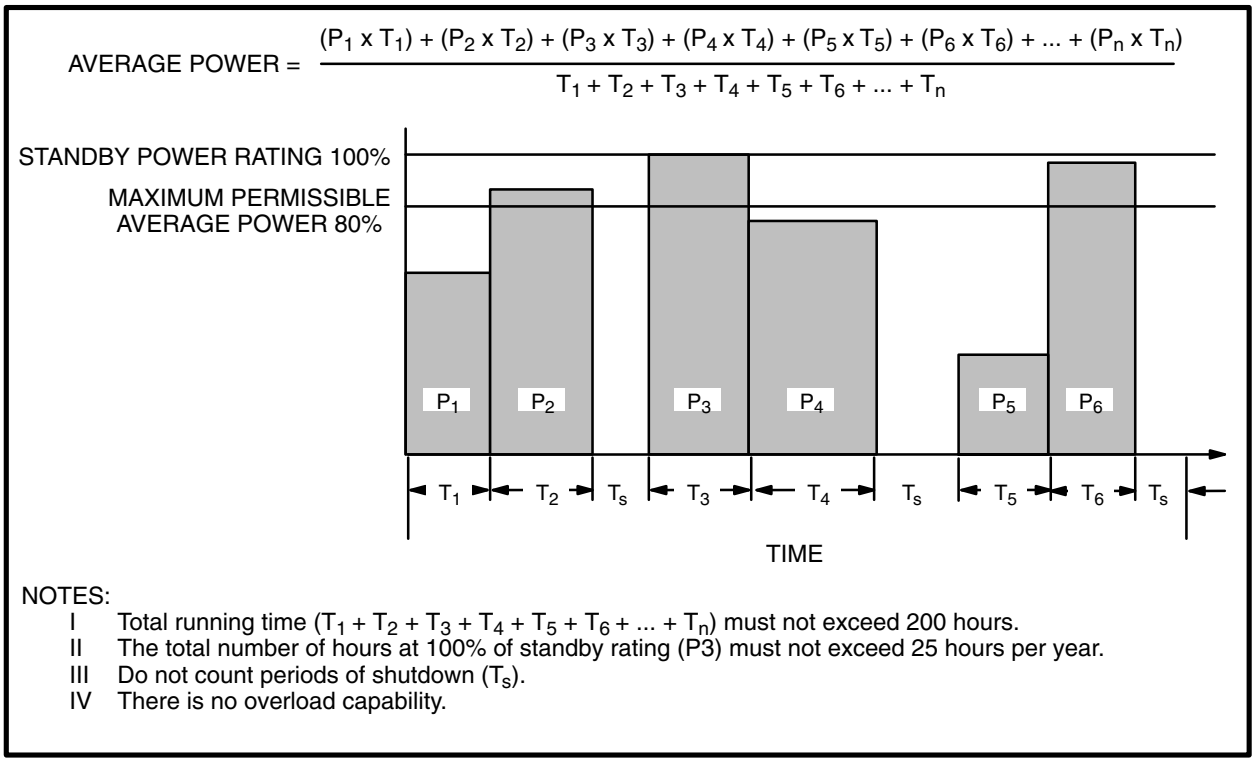
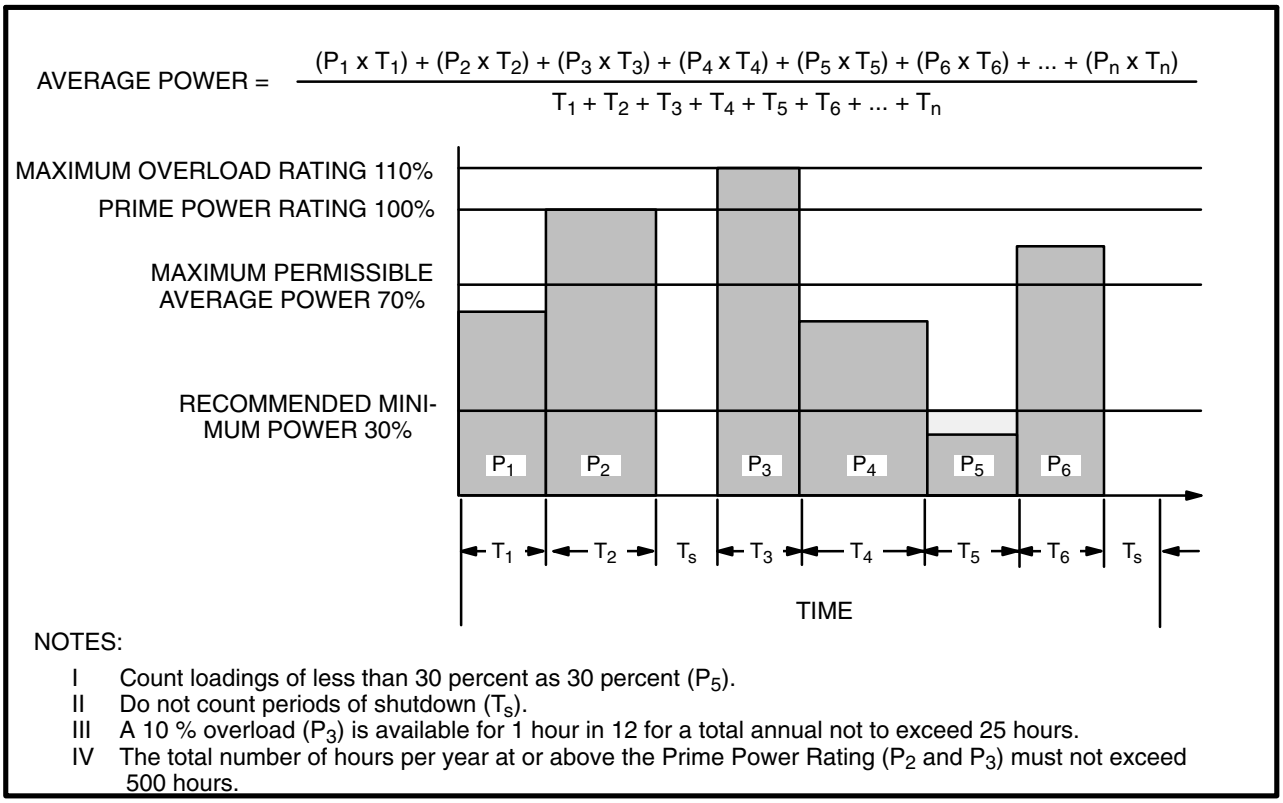


Figure 2–2. Standby Power Rating.

31 Ratings for generator sets from Cummins Power Generation are published in the Power Suite software package.

Prime Power Rating (PRP)

The prime power rating is applicable when supplying electric power in lieu of commercially purchased power. The number of allowable operating hours per year is unlimited for variable load applications but is limited for constant load applications as described below under Limited Running Time Prime Power. In variable load applications the average power output should not exceed 70 percent of the Prime Power Rating over 24 hours of operation (Equivalent to Prime Power in accordance with ISO8528). A 10 percent overload capability is available for a period of 1 hour within a 12–hour period of operation, but not to exceed 25 hours per year.(Over Load Power in accordance with ISO3046, AS2789, DIN6271 and BS5514.)



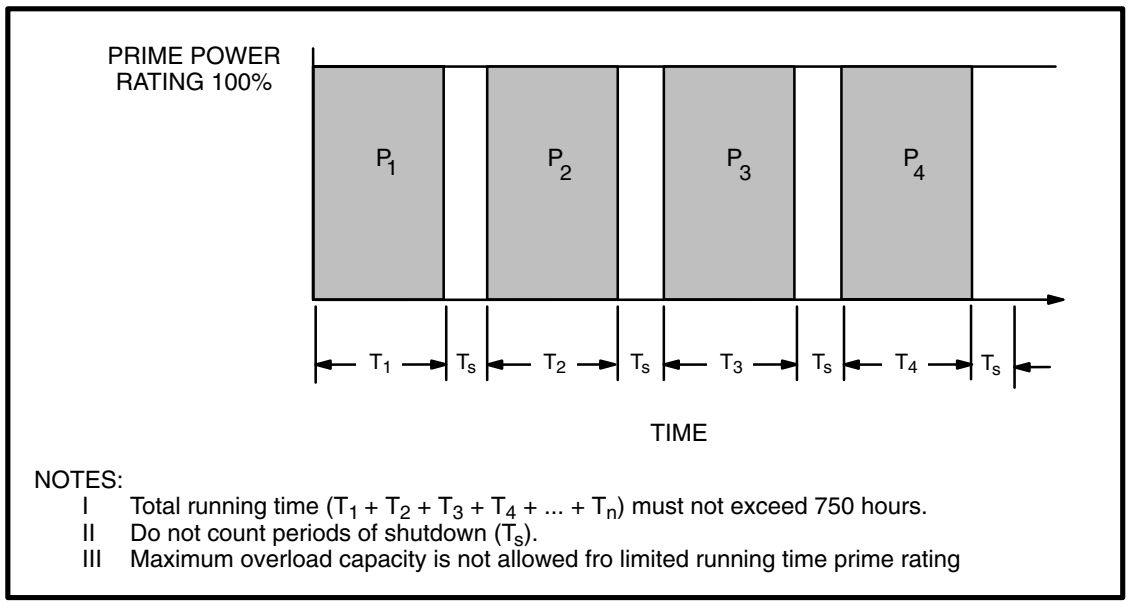
NOTES:

I Count loadings of less than 30 percent as 30 percent (P_5).
II Do not count periods of shutdown (T_s).
III A 10 % overload (P_3) is available for 1 hour in 12 for a total annual not to exceed 25 hours.
IV The total number of hours per year at or above the Prime Power Rating (P_2 and P_3) must not exceed 500 hours.

Figure 2–3. Prime Power Rating (PRP)

Limited Running Time Prime Power (LTP)

Prime power is available for a limited number of annual operating hours in constant load applications such as interruptible, load curtailment, peak shaving and other applications that normally involve utility parallel operation. Generator sets may operate in parallel with the utility source up to 500 hours per year at power levels not to exceed the Prime Power Rating. It should be noted that engine life will be reduced by constant high load operation. Any application requiring more than 500 hours of operation per year at the Prime Power Rating should use the Base Load Power Rating.

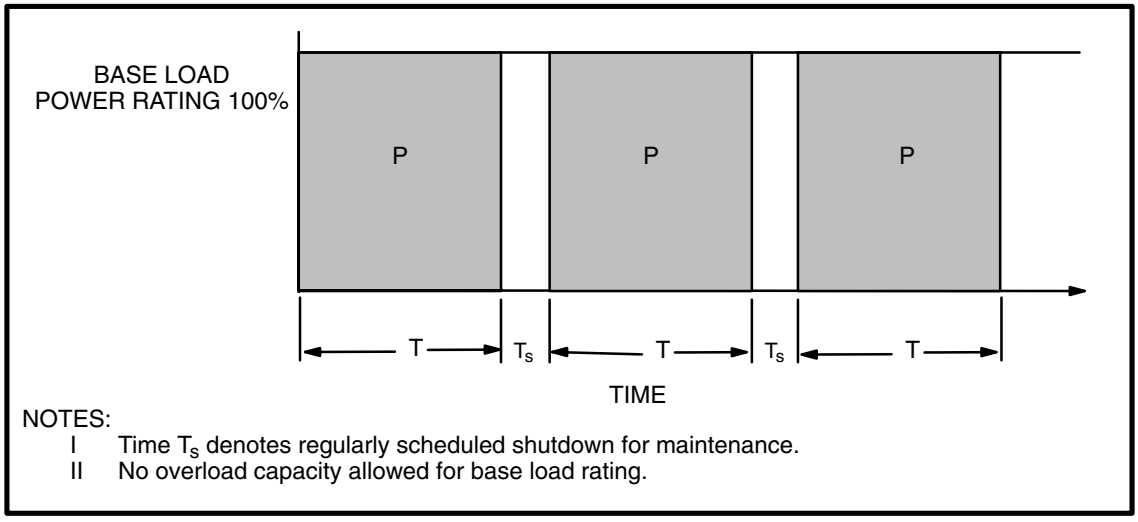


NOTES:
- I Total running time ($T_1 + T_2 + T_3 + T_4 + ... + T_n$) must not exceed 750 hours.
- II Do not count periods of shutdown (T_s).
- III Maximum overload capacity is not allowed fro limited running time prime rating

Figure 2–4. Limited Running Time Prime Power (LTP)

Continuous Power Rating (COP)

The base load power rating is applicable for supplying power continuously to a load up to 100 percent of the base rating for unlimited hours. No sustained overload capability is available at this rating (Equivalent to Continuous Power in accordance with ISO8528, ISO3046, AS2789, DIN6271 and BS5514). This rating is applicable for utility base load operation. In these applications, generator sets are operated in parallel with a utility source and run under constant loads for extended periods of time.



NOTES:
- I Time T_s denotes regularly scheduled shutdown for maintenance.
- II No overload capacity allowed for base load rating.

Figure 2–5. Continuous Power Rating (COP)

Sizing

It is important to assemble a reasonably accurate load schedule as soon as possible for budgeting project costs. If all the load equipment information is not available early in the project, estimates and assumptions will have to be made for the first sizing calculations These calculations should be iterated as more accurate information becomes available. Large motor loads, uninterruptible power supplies (UPS), variable frequency drives (VFD), fire pumps, and medical diagnostic imaging equipment have considerable effect on generator set sizing and should be looked at closely. Tight specifications on transient performance, voltage and frequency dip and recovery times, during motor starting and block load acceptance also have considerable effect on sizing. See section 3*, Electrical Load Impact on Generator Sizing* in this manual regarding sizing calculation and the kinds of information needed for different types of load equipment.

For preliminary estimation purposes some conservative rules of thumb may be used:

- Motors – ½ HP per kW.
- UPS – 40% oversize for 1∅ and 6 pulse, or 15% oversize for 6 pulse with input filters and 12 pulse UPS.
- VFD – 100% oversize unless pulse–width–modulated, then 40% oversize.

When loading the generator set, division of the loads into discrete steps or blocks of load may have a favorable effect on the size of generator set required. Use of multiple transfer switches or some other means (time delay relays, PLC, etc.) would be necessary to allow the generator set voltage and frequency to stabilize between steps.

Depending on the total load (generally above 500 kW), it may be advantageous to parallel generator sets. Although technically feasible, it is usually not economically feasible to parallel generator sets when the total load is 300 kW or less.

Location Considerations

One of the first design decisions will be to determine whether the location of the generator set will be inside a building or outside in a shelter or housing. The overall cost and ease of installation of the power system depend upon the layout and physical location of all elements of the system — generator set, fuel tanks, ventilation ducts and louvers, accessories, etc. For both indoor and outdoor locations, consider these issues:

- Generator set mounting
- Location of distribution switchboard and transfer switches
- Branch circuits for coolant heaters, battery charger, etc.
- Security from flooding, fire, icing, and vandalism
- Containment of accidentally spilled or leaked fuel and coolant
- Possible simultaneous damage to normal and emergency services
- Service access for general maintenance and inspections.
- Access and working space for major work such as overhauls or component removal/ replacement.
- Access for load bank testing when required for maintenance, proper excersize, or code.

Outdoor Location Considerations

- Airborne noise and treatment. Sound barriers may be required. In addition, increased distance between the generator set and the noise sensitive area will decrease the perceived noise. Acoustic housings are often available and may be required to meet customer expectations or local noise ordinances.
- Weather protective housing may be required, as their name suggests, for protection from weather but also may provide a certain level of security as well as aesthetic containment of the generator set.
- Starting and accepting load, and doing so within specific time constraints, in cold ambient temperatures may be an issue. Emergency systems as defined by codes require the ambient temperature around the genset to be maintained at minimum levels. Examples are NFPA110 which requires the minimum ambient temperature around the generator set to be 40° F (4° C), and CSA 282 which requires this minimum temperature to be 10° C (50° F). Maintaining these minimum tempeature requirements in a “skin–tight” or other similar housing may be difficult or impossible. An insulated and perhaps heated housing may be required. A housing that is designed strictly for acoustic treatment will contain insulation material but may not provide sufficient heat containment. Single unit “drop over” housings or walk in enclosures are usually available with insulation, motorized or gravity louvers, and heaters if necessary.
- Several auxiliary heating devices may be required for starting or improved load acceptance, even if the application is not an emergency system. Heaters for coolant, batteries, even oil may be necessary. Refer to the section in this manual titled Standby Heating Devices for Generator Sets under section 4, *Equipment Selection* for more detailed information.
- Fuel conditioning and heating. At cold ambient temperatures diesel fuel will become cloudy, clog filters and pumps, or not flow sufficiently. Blended fuels are often used to address this issue however, fuel heating may be required for reliable operation.
- The salt air in coastal regions may cause corrosion issues on outdoor–installed steel genset enclosures, skid bases, and fuel tanks. The use of an optional aluminum genset enclosure and skirt, whenever offered by CPG, is considered to be proper installation practice due to the additionial corrosion resistance and is thus required for outdoor applications in coastal regions, defined as locations 60 miles and closer to bodies of saltwater.
- Service access for major repairs, component replacement (such as radiator or alternator), or overhaul, should be considered in the design of housings and placement of generator sets near other equipment or structures. If major work is required due to high hours of operation or major component damage/failure, access allowances will be critical. These allowances include access covers, removable housing walls, adequate spaces to nearby structures, and access of required support equipment.
- Security fences and sight barriers
- Property line distances
- Engine exhaust must be directed away from vents and building openings.
- Grounding – Electrodes or grounding rings may be required for separately–derived system and/or equipment grounding.
- Lightning protection

Indoor Location Considerations

- Dedicated generator room – For emergency power systems, certain codes may require that the generator room be dedicated for that purpose only. Also consider the effect that large ventilating airflow would have on other equipment in the same room, such as building heating equipment.
- Fire rating of room construction – Codes typically specify a 1 or 2–hour minimum fire resistance rating. Consult local authorities for applicable requirements.
- Working space – Working space around electrical equipment is usually specified by code. In practice, there should be at least three feet (1 M) of clearance around each generator set. The alternator should be replaceable without removing the entire set or any accessories. Also, access for major work (such as overhaul or component replacement such as a radiator) should be allowed for in the installation design.
- Type of cooling system – A factory–mounted radiator is recommended, however, the radiator fan can create a significant negative pressure in the room. Access doors should therefore swing into the room – or be louvered — so that they can be opened when the set is running. See Generator Cooling in the *Mechanical Design* section for additional cooling options.
- Ventilation involves large volumes of air. An optimum room design draws intake air directly from outdoors and discharges the air directly outdoors through the opposite wall. Room ventilation fans will be required for optional generator set cooling configurations that involve heat exchanger or remote radiators.
- Engine exhaust – The engine exhaust outlet should be as high as practical on the prevailing down–wind side of the building and directed away from building intake vents and openings.
- Fuel storage and piping – Local codes may specify fuel storage methods inside buildings and restrict fuel storage amounts. Early consultation with the local Cummins Power Generation dealer or the local fire marshal is recommended. Access will be required for refilling storage tanks. See Fuel Selection below.
- It is recommended that provisions be included in the electrical distribution system for connection of a temporary genset load bank.
- Location within a building must allow for access both for initial product delivery and installation, and later for servicing and maintenance. The logical preferred location for a generator set in a building based on this is on the ground floor, near a parking lot or access driveway, or in an open parking ramp. Understanding that this is the premium building space, if forced to an alternative location, keep in mind that heavy equipment may be needed for placement or major service of the unit. Also, deliveries of fuel, coolant, oil, etc. are needed at various intervals. A fuel system will most likely be designed with supply tanks, pumps, lines, day tanks, etc. but lubricating oil and coolant changes can be difficult if the materials have to be hand carried in barrels or buckets.
- Rooftop installations, while common, require further planning and structural design consideration. Vibration and fuel storage/delivery may be problematic with rooftop installations.
- Indoor locations generally require a dedicated room with fire resistive construction. Providing the required airflow to an interior room may be difficult. Fire dampers in ductwork to interior rooms are generally not permitted. Ideally the room will have two exterior walls opposite each other so that intake air flows over the generator set and is discharged out the opposite wall on the radiator end of the unit.

Fuel Selection Considerations

The selection of natural gas, diesel, or LPG fuel will affect generator set availability and sizing. Consider the following:

Diesel Fuel

- Diesel fuel is recommended for emergency and standby applications. ASTM D975 No. 2–D Grade diesel fuel is recommended for good starting performance and maximum engine life. Consult the engine manufacturer distributor regarding the use of alternative grades of diesel fuel for various engines.
- On–site fuel storage must be provided, however the tank should not be too large. Diesel fuel lasts up to two years in storage, so the supply tank should be sized to allow for fuel turnover based on scheduled exercise and testing in that time period. A microbicide may need to be added if fuel turnover is low, or if high–moisture conditions promote the growth of fuel microbes. Microbes in the fuel can clog fuel filters and disable or damage the engine.
- Cold climates — Premium No. 1–D Grade fuel should be used when ambient temperatures are below freezing. Fuel heating may be required to prevent fuel filters from clogging when temperatures fall below the cloud point of the fuel — approximately 20° F (–6° C) for No. 2–D and –15° F (–26° C) for No. 1–D.
- Emissions requirements may be applicable. See Environmental Considerations.

Biodiesel Fuel

- Biodiesel fuels are derived from a broad variety of renewable sources such as vegetable oils, animal fats, and cooking oils. Collectively, these fuels are known as Fatty Acid Methyl Esters (FAME). When used in diesel engines, typically smoke, power, and fuel economy are all reduced. While smoke is reduced, the effect on other emissions varies, with some pollutants being reduced while others are increased. Biodiesel fuel is a substitute fuel, meaning the performance and emissions of the engine cannot be warranted when operated on this fuel[32].
- A blend of up to 5% volume concentration biodiesel fuel with quality diesel fuel should not cause serious problems. Above 5% concentration serious operational problems should be expected. Cummins neither approves nor disapproves of the use of biodiesel blends. Consult Cummins for additional information.

Natural Gas

- No on–site fuel storage is required for most sites.
- Natural gas may be an economical fuel choice where available, at required flow rates and pressure.
- An on–site backup LPG fuel supply may be required for emergency power supply systems.
- Field natural gas can be used with certain generator sets. However, fuel analysis and consultation with the engine manufacturer are required to determine potential power derating and whether fuel composition will lead to engine damage due to poor combustion, detonation, or corrosion.
- Detonation and engine damage may result when some utilities occasionally add butane to maintain line pressure. Natural gas engines require clean, dry, pipeline–quality gas to generate rated power and ensure optimal engine life.
- Frequency stability of spark–ignited engine generator sets may not be as good as diesel engine generator sets. Good frequency stability is important when supplying UPS loads.

32 Cummins Power Generation assumes no warranty responsibility for repairs or increased costs of operation with biodiesel fuel.

- Cold climates — In ambient temperatures below 20° F (–7° C) spark–ignited engines generally start easier and accept load sooner than diesel engines.

NOTE: Cummins Power Generation does not recommend piping high–pressure natural gas (5 psig [34 kPa] or more) into buildings.

LPG (Liquefied Petroleum Gas)

- The local availability of LPG should be investigated and confirmed prior to selecting an LPG–powered generator set.
- On–site fuel storage must be provided. LPG can be stored indefinitely.
- Frequency stability of spark–ignited engine generator sets may not be as good as diesel engine generator sets. This is an important consideration when supplying UPS loads.
- Cold climates — Either the LPG storage tank must be sized to provide the required rate of vaporization at the lowest ambient temperature expected, or liquid withdrawal with a vaporizing heater must be provided.

NOTE: Cummins Power Generation does not recommend piping high–pressure LPG (20 psig [138 kPa] or more), liquid or vapor, into buildings.

Gasoline

Gasoline is not a suitable fuel for stationary standby generator sets due to volatility and shelf life of gasoline fuel.

Substitute Fuels

In general, diesel engines may be run on substitute **fuels with acceptable lubricity** during periods when the supply of No. 2–D diesel fuel is temporarily limited. Use of substitute fuels may affect warranty coverage, engine performance, and emissions. The following substitute fuels are generally within prescribed limits:

- 1–D and 3–D diesel fuel
- Grade No. 2 fuel oil (heating fuel)
- Grade Jet A and Jet A–1 aviation turbine fuel (commercial jet fuel)
- Grade No. 1 GT and No. 2 GT non–aviation gas turbine fuel
- Grade No. 1–K and No. 2–K kerosene

Environmental Considerations

The following is a brief approach to evaluating environmental issues related to noise, exhaust emissions, and fuel storage. Refer to the *Mechanical Design* chapter for more complete information.

Noise and Noise Treatment

Noise treatment, if required, needs to be considered early in the preliminary design. Generally, noise treatment methods will add a considerable cost and increase the physical area required for the installation. A generator set is a complex noise source that includes the cooling fan noise, the engine noise, and the exhaust noise. Effective noise treatment has to address all of these sources of noise. For the most part, the recommended noise treatment methods modify or redirect the path for the noise from the generator set source to people hearing it. Simply using a critical grade muffler may or may not do anything to reduce the noise level at a specific location. Because noise is directional, careful consideration needs to be given to the location, orientation, and distance of the generator set with respect to property lines or places where the noise may be objectionable.

NOISE ZONES	PEAK DAYTIME dB(A)	PEAK NIGHTTIME dB(A)	CONTINUOUS DAYTIME dB(A)	CONTINUOUS NIGHTTIME dB(A)
Urban—Residential	62	52	57	47
Suburban—Residential	57	47	52	42
Very Quiet Suburban or Rural Residential	52	42	47	37
Urban—Nearby Industry	67	57	62	52
Heavy Industry	72	62	67	57

Table 2–2. Representative Outside Noise Levels

Noise Levels and Regulations

In North America, state and local codes establish maximum noise levels for given areas. Most community noise regulations specify the maximum allowable noise level at the property line. **Table 2–2** shows some representative outdoor noise level regulations. Compliance with noise regulations requires an understanding of the ambient noise level and the resultant noise level with the generator set running at full load in that ambient.

Noise regulations also exist to protect worker's hearing. Persons working in generator rooms should always wear ear protection while a generator set is running.

Engine Exhaust Emissions Regulations

Generator sets, regardless of application, may be subject to engine exhaust emissions regulations on a local or national level or both. Compliance with emissions regulations usually requires special permits. Certain localities may have specific designations requiring gaseous–fueled engines and/or exhaust after–treatment strategies for diesels. Check with the local air quality agency early in the design phase of any project for permitting requirements.

Table 2–3 includes typical diesel exhaust emissions for 40–2000 kW generator sets with untreated exhausts which can be used for estimating purposes. Consult the engine manufacturer for detailed information on specific products.

In North America, mobile generator sets (that are moved more than once a year) are subject to EPA Certification which essentially limits NO_x Federal emissions to 6.9 g/bhp • hr. See a Cummins Power Generation distributor for available models.

Fuel Storage Regulations

Fuel supply tank design and installation in many areas is controlled by regulations that are generally written for two separate purposes: environmental protection and fire protection. Because the regulations, their enforcement and exemptions from regulation vary by location, it is necessary to research and understand local requirements.

In North America, environmental protection regulations generally exist at both federal and state levels. Different sets of regulations apply to underground vs. aboveground fuel storage tanks. These regulations cover design and construction standards, registration, tank testing, and leak detection. They also cover closure requirements, preparation of spill prevention plans, provisions for financial responsibility, and trust fund coverage. As a general statement subject to local verification, exemptions from regulation are granted for underground and above–ground diesel storage tanks serving on–site emergency generator sets where 1) the capacity of the facility storage tanks is 1,320 gallons (500 L) or less, 2) no single tank has a capacity in excess of 660 gallons (250 L), and 3) the fuel is consumed at the facility (not dispensed).

CRITERIA POLLUTANTS	GRAMS / BHP □ HR
HC (Total Unburned Hydrocarbons)	0.1–0.7
NO_x (Oxides of Nitrogen as NO_2)	6.0–13.0
CO (Carbon Monoxide)	0.5–2.0
PM (Particulate Matter)	0.25–0.5
SO_2 (Sulfur Dioxide)	0.5–0.7

Table 2–3. Typical Diesel Exhaust Emissions

Even when an installation is exempt from regulation it must be recognized that cleanup expenses may be very high for even small amounts of fuel spill resulting from leaks, overfilling, etc. The trend in diesel fuel storage for on–site generator sets both indoors and outdoors, has been towards third party certified above ground dual–wall sub–base tanks with leak detection and overfill protection. See Section 6, *Mechanical Design*, for more information on fuel system design.

Fire Protection

In North America, fire protection regulations typically adopt or reference one or more of the National Fire Protection Association (NFPA) standards. These standards cover such requirements for indoor fuel storage capacity, fuel piping systems, the design and construction of fuel tanks, fuel tank locations, diking, and/or safe drainage provisions. Refer to NFPA Standard No. 37, Installation of Stationary Engines. Local fire authorities may have more restrictive requirements or interpretations of requirements than those in the national standards.

The design, selection and installation of fire protection systems is beyond the scope of this manual due to of the wide range of factors to consider, such as building occupancy, codes, and the efficacy of various fire protection systems. Consider the following, however:

- The fire protection system must comply with the requirements of the authority having jurisdiction, such as the building inspector, fire marshal or insurance carrier.

- Gensets that are used for emergency and standby power should be protected from fire by location or by the use of fire–resistant construction in the genset room. In some locations, generator room construction for installations that are considered to be necessary for life safety must have a two–hour fire resistance rating[33],[34]. Some locations will also require feeder fire protection. Consider use of automatic fire doors or dampers for the genset room.

The genset room must be ventilated adequately to prevent buildup of engine exhaust gases or flammable fuel supply gas.

- The generator room should not be used for storage purposes.
- Generator rooms should not be classified as hazardous locations (as defined by the NEC) solely by reason of the engine fuel.
- The authority having jurisdiction will usually classify the genset as a low heat appliance when use is only for brief, infrequent periods, even though exhaust gas temperature may exceed 1000° F (538° C). Where exhaust gas temperature may exceed 1000° F (538° C), some diesels and most gas engines may be classified as high heat appliances and may require exhaust systems rated for 1400° F (760° C) operation. Consult the engine manufacturer for information on exhaust temperatures.
- The authority having jurisdiction may specify the quantity, type, and sizes of approved portable fire extinguishers required for the generator room.
- A manual emergency stop station outside the generator room or remote from a genset in an outside enclosure would facilitate shutting down the genset in the event of a fire or other type of emergency.
- Typical liquid fuel systems are limited to 660 gallons (2498 liters) inside of a building. However, the authority having jurisdiction may enforce much more stringent restrictions on the amount of fuel that can be stored inside a building. Also, exceptions may be made to allow use of larger amounts of fuel in a genset room, especially if the genset room has properly designed fire protection systems.
- Fuel tanks located inside buildings and above the lowest story or basement should be diked in accordance with NFPA standards and environmental regulations.
- The genset should be exercised periodically as recommended under at least 30 percent load until it reaches stable operating temperatures. It should also be run under nearly full load at least once a year to prevent fuel from accumulating in the exhaust system.

33 **CODE NOTE:** In the US, NFPA110 requires that gensets used in Level 1 emergency systems be installed in a room with a 2–hour fire resistance rating. Other emergency systems are required to have 1–hour fire resistance ratings.

34 **CODE NOTE:** In Canada, CSA282–2000 requires that a room with 1–hour fire resistance rating protect emergency power systems that are installed in buildings.

PRELIMINARY DESIGN CHECKLIST

System Type

- ☐ Emergency
- ☐ Legally–Required Standby
- ☐ Optional Standby
- ☐ Optional Standby
- ☐ Prime Power
- ☐ Peak Shaving
- ☐ Load Curtailment
- ☐ Base Load

Generator Set Rating

- ☐ Standby Rating
- ☐ Prime Rating
- ☐ Continuous Rating

Generator Set Size

- ☐ Single Unit ___ kW ___ kVA ___ PF
- ☐ Parallel Units ___# ___ kW ___kVA ___PF

Generator Set Voltage and Frequency

___ Voltage ___ HZ

- ☐ Single–phase
- ☐ Three–phase

Location

- ☐ Indoor
- ☐ Ground Level
- ☐ Upper Level
- ☐ Below Ground
- ☐ Outdoor
- ☐ Ground Level
- ☐ Rooftop

Direct Access for Instal/Service
Yes ___ No ___

Fuel

- ☐ Diesel
- ☐ Natural Gas
- ☐ LPG

Fuel Supply – Diesel

- ☐ Day Tank
- ☐ Sub–Base Tank
- ☐ Outdoor Tank

Fuel Supply – LP

- ☐ Vapor Withdrawal
- ☐ Liquid Withdrawal

Housing

- ☐ Weather Protective
- ☐ Acoustic
- ☐ Walk–In Enclosure
- ☐ Drop Over
- ☐ Coastal Region

Accessories

- ☐ Paralleling Switchgear
- ☐ Automatic Transfer Switch
- ☐ Battery Chargers
- ☐ Network Interface
- ☐ Remote Alarms/Monitoring
- ☐ Circuit Breakers(s)
- ☐ Paralleling Control Modules
- ☐ Muffler
- ☐ Vibration Isolators

Special Alternator Requirements

- ☐ Reduced Temperature Rating, 105C 80C
- ☐ RTDs or Thermistors

Cooling System

- ☐ Unit Mounted Radiator
- ☐ Remote Radiator