

# 7x24 Exchange

**Generator Sets  
Preliminary Design & Maintenance**



**Rocky  
Mountain**

# INTRODUCTION

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## Preliminary Design

- System Types
- One-Line Designs
- Sizing Generator Sets
- Outdoor Locations
- Indoor Locations
- Diesel Fuel Considerations
- Natural Gas Fuel Considerations
- Engine Exhaust Emissions
- Generator Breaker(s)
- Know Issues for Generator Sets



## System Types

- 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 system and facilities.

## System Types

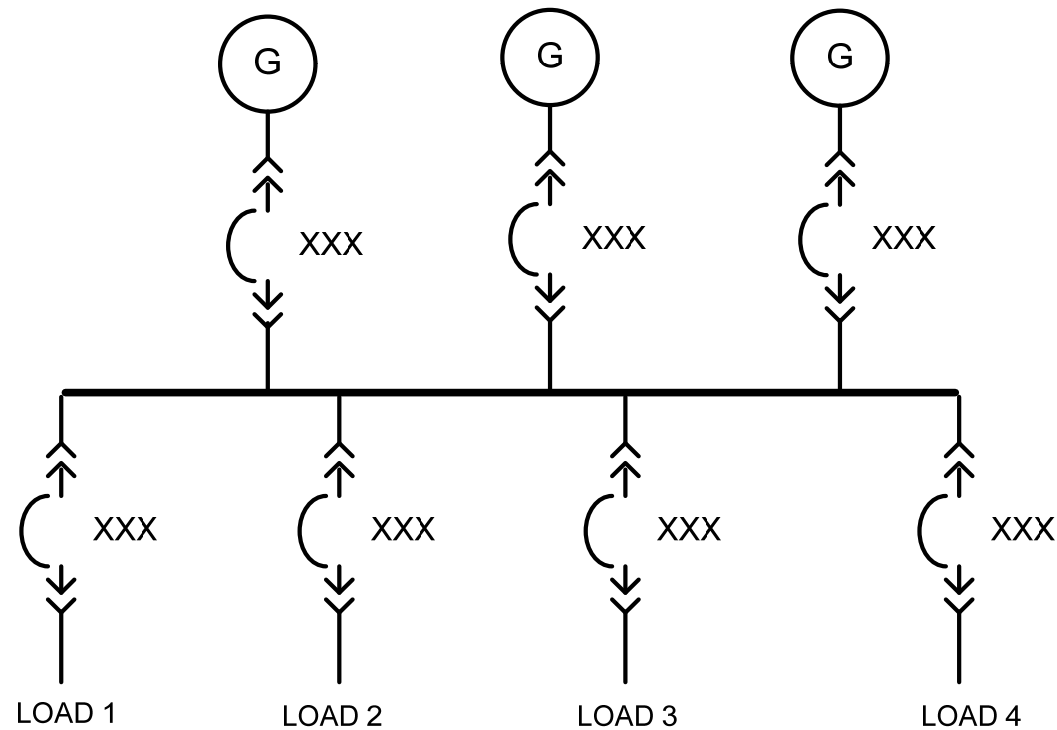
- Legally Required Standby
  - Legally required standby systems are generally installed as mandated by legal requirements for public safety. These systems are typically intended to provide power and lighting for short periods of time where necessary to prevent hazards or to facilitate fire-fighting operations.

## System Types

- 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.

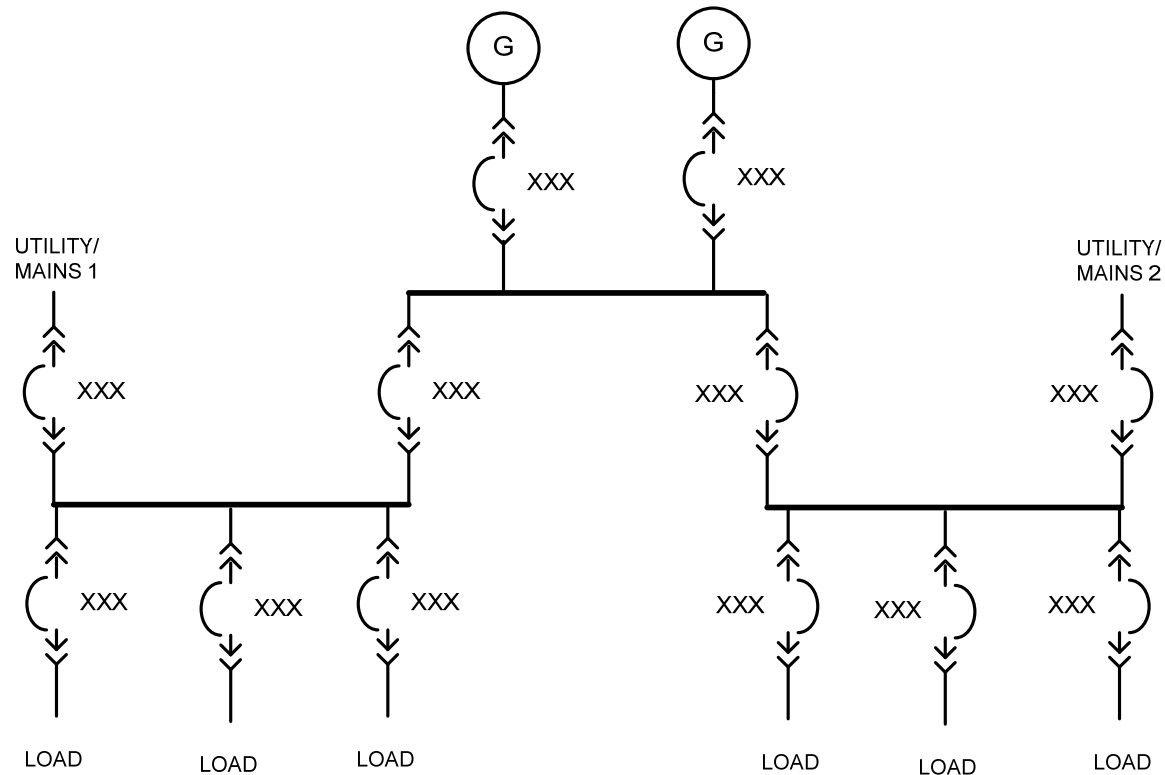
## On-line Designs

- Keep it simple.
- Rely upon proven designs.



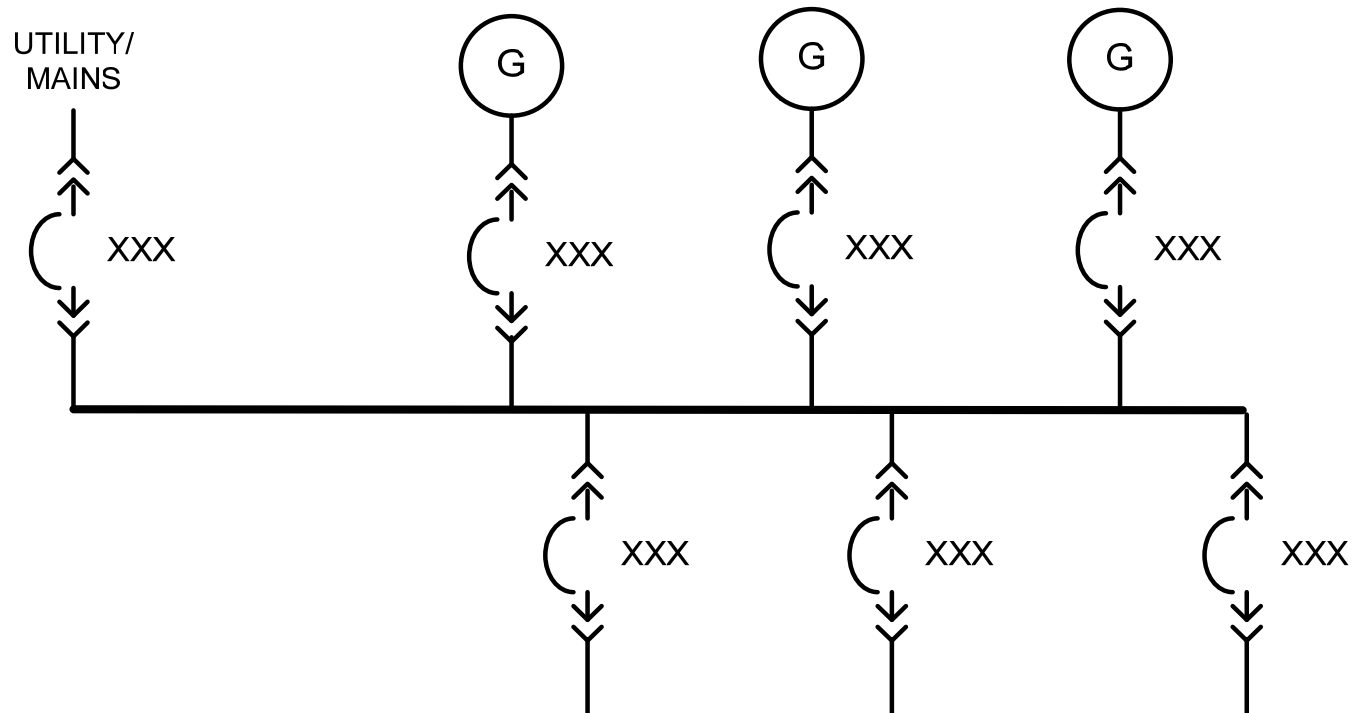
# On-line Designs

- Keep it simple.
- Rely upon proven designs.



# On-line Designs

- One-line designs to avoid.



## Sizing Generator Sets

- Let one or two suppliers assist with the sizing of the genset(s).
- Non-linear loads.
- Starting a load is different than running a load.
- Step start loads for a smaller generator set.
  - Specify the load transfer/start-up scheme.
- Altitude and temperature considerations.
- Look at the available real estate.
- When do multiple generators make sense.

## Outdoor Locations

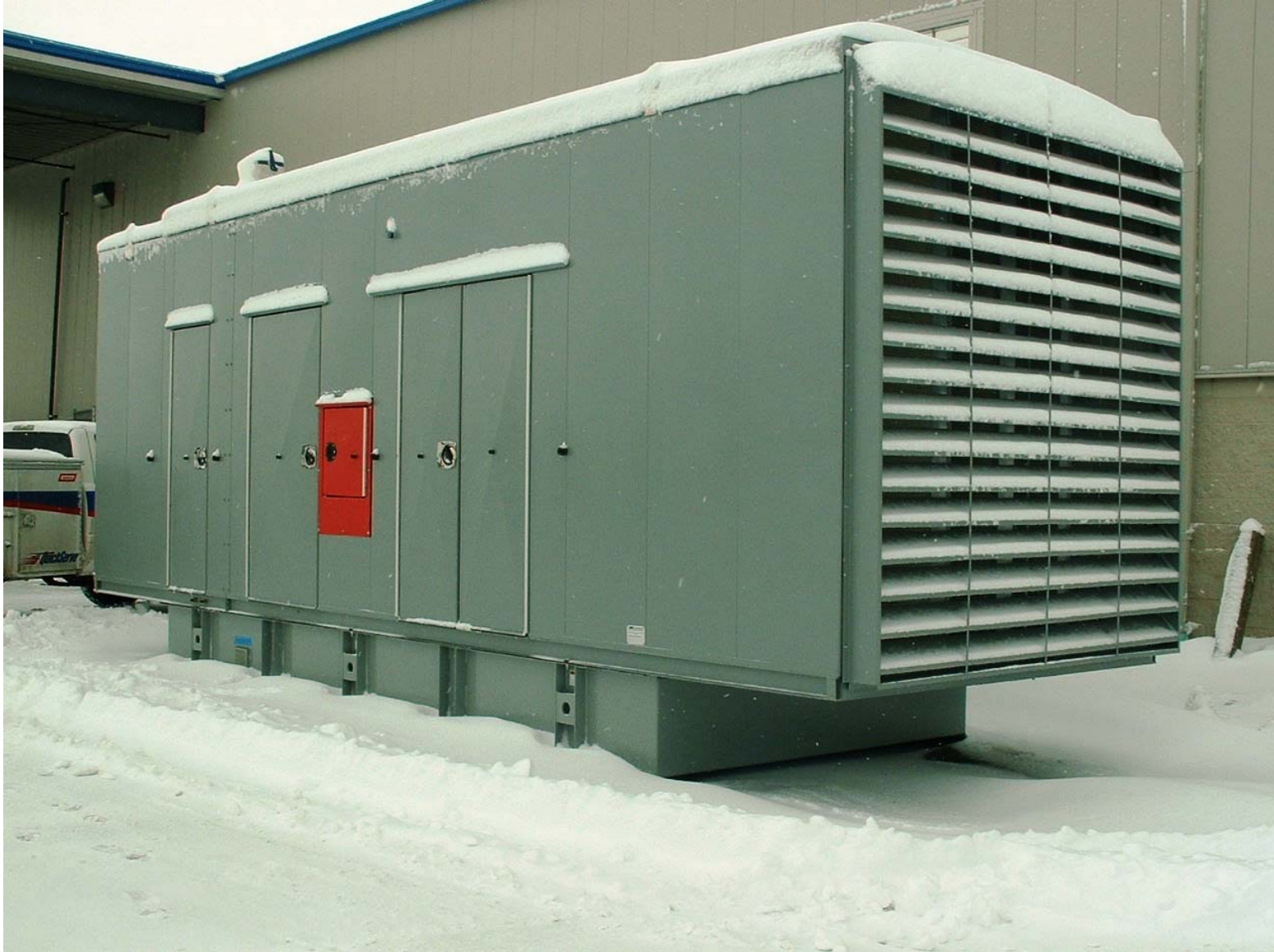
- Location, Location, Location.
- Airborne noise.
  - Sound attenuated enclosures, screen walls or sound barriers.
- Weather-protective enclosures.
  - These are not weather-tight or weather-proof. Rain and snow will enter and possibly accumulate on the floor or tank top.
  - Lighting protection maybe considered for active strike areas.

## Outdoor Locations

- Ventilation.
  - Horizontal or vertical discharge air flows.
  - Maintain free and clear areas for air intake.
- Exhaust.
  - Use prevailing winds or cooling air discharge to move smoke away from occupied space.
  - Avoid terminating exhaust near building air intake systems.
  - Avoid using mechanical rain caps where maintenance access is a problem.

## Outdoor Locations

- Starting and load accepting loads.
  - The engine needs to be kept warm for rapid starting and acceleration to rated speed.
  - Block (water jacket) heaters, lube oil heaters, battery heaters, fuel heaters and/or space heaters may be required.
  - Minimize heat loss from the outdoor enclosure with insulated walls, motorized or gravity dampers on the inlet and outlet openings.



## Outdoor Locations

- Fuel systems.
  - Base fuel tanks. Stand alone design or used as a day tank.
  - Day tanks within or adjacent to the enclosure.
  - Day tank systems may need return flow pumps.
- Accessory Power Supply.
  - Each accessory may be powered by a dedicated circuit.
  - One feeder to each enclosure for all accessories.

## Outdoor Locations

- Roof top installations.
  - Require additional structural design considerations.
  - Vibration isolation from the structure is vital.
  - Fuel delivery and storage can be an issue.
  - Containment of leaking fluids.

## Indoor Locations

- Dedicated generator room.
  - Large air flows, fuel storage, noise levels, vibration to structure.
  - Freezing temperatures while running.
  - Fire rating or containment requirements
- Working space.
  - Code clearances and approach isles to electrical equipment.
  - Isles and openings large enough to remove generator sets.

## Indoor Locations

- Ventilation.
  - Design intake and discharge openings to minimize total static restriction. Must be under the manufacturer's maximum allowable restriction.
  - The air flow design must sweep air over the generator end, over the engine and then into the radiator for discharge. Lack of air movement near the generator end will cause the alternator to overheat.

## Indoor Locations

- Ventilation.
  - In cold weather areas, a modulated short circuiting damper can be installed to help maintain the room temperatures while allowing the cooling fan to move its designed air flow.

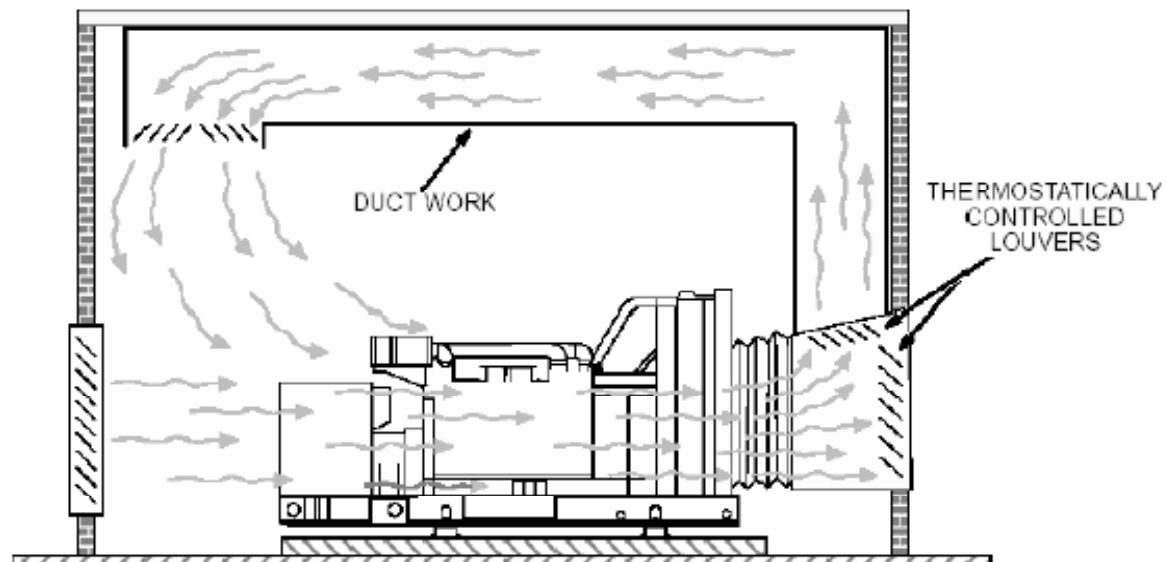


Figure 6-57. Room Recirculation System

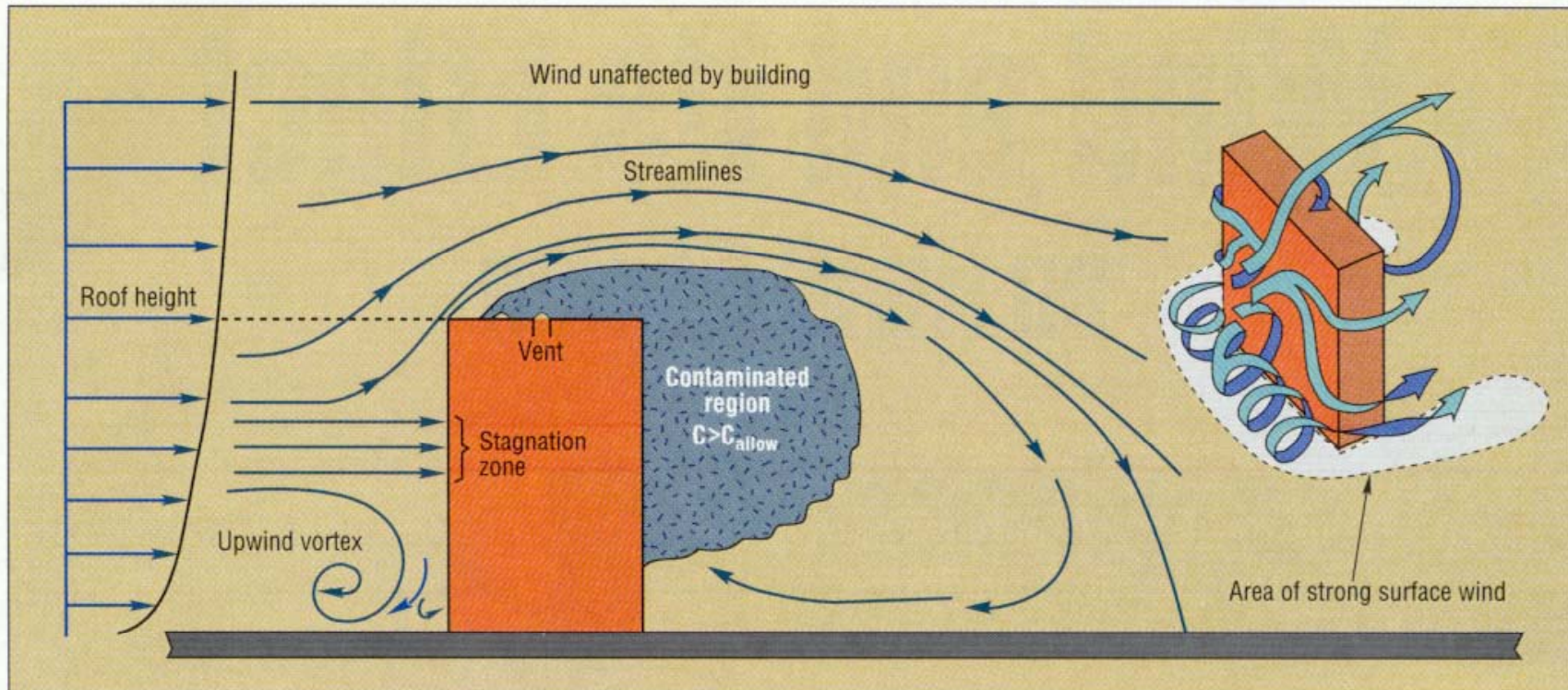
## Indoor Locations

- Exhaust.
  - Long exhaust pipe runs create problems that must be overcome.
    - Consult with equipment manufacturer to verify the minimum pipe size given the installation and exhaust pipe routing.
    - Install thermal expansion joints as needed.
  - Insulate the bulk of the exhaust system to minimize heat radiated into the generator space or adjacent space.

## Indoor Locations

- Exhaust.
  - Use prevailing winds or cooling air discharge to move smoke away from occupied space.
  - Avoid terminating exhaust near building air intake systems.
  - Define who provides the roof or wall penetration thimbles.

# Wind Effects on Exhaust



1 Wind striking the face of a building separates from the surface of the roof at the sharp edge of the roof. This separation generates a recirculating wind flow that extends for some distance onto the roof. The dimensions of the recirculation region are determined from the width and height of the upwind face of the building. (Source: ASHRAE *Handbook of Fundamentals*, Chapter 14, 1993)

## Indoor Locations

- Starting and load accepting loads.
  - The engine needs to be kept warm for rapid starting and acceleration to rated speed.
  - Block (water jacket) heaters, battery heaters and/or space heaters may be required.
  - Minimize heat loss from the generator room with insulated walls, motorized or gravity dampers on the inlet and outlet openings.

## Indoor Locations

- Fuel systems.
  - Main fuel storage is typically several hundred feet away.
  - Day tanks adjacent to the generator.
  - Base fuel tanks. Stand alone design or used as a day tank.
  - Day tank systems may need return flow pumps.
  - Specially designed fuel transfer manifolds.

A few words about practicality...



## Indoor Locations

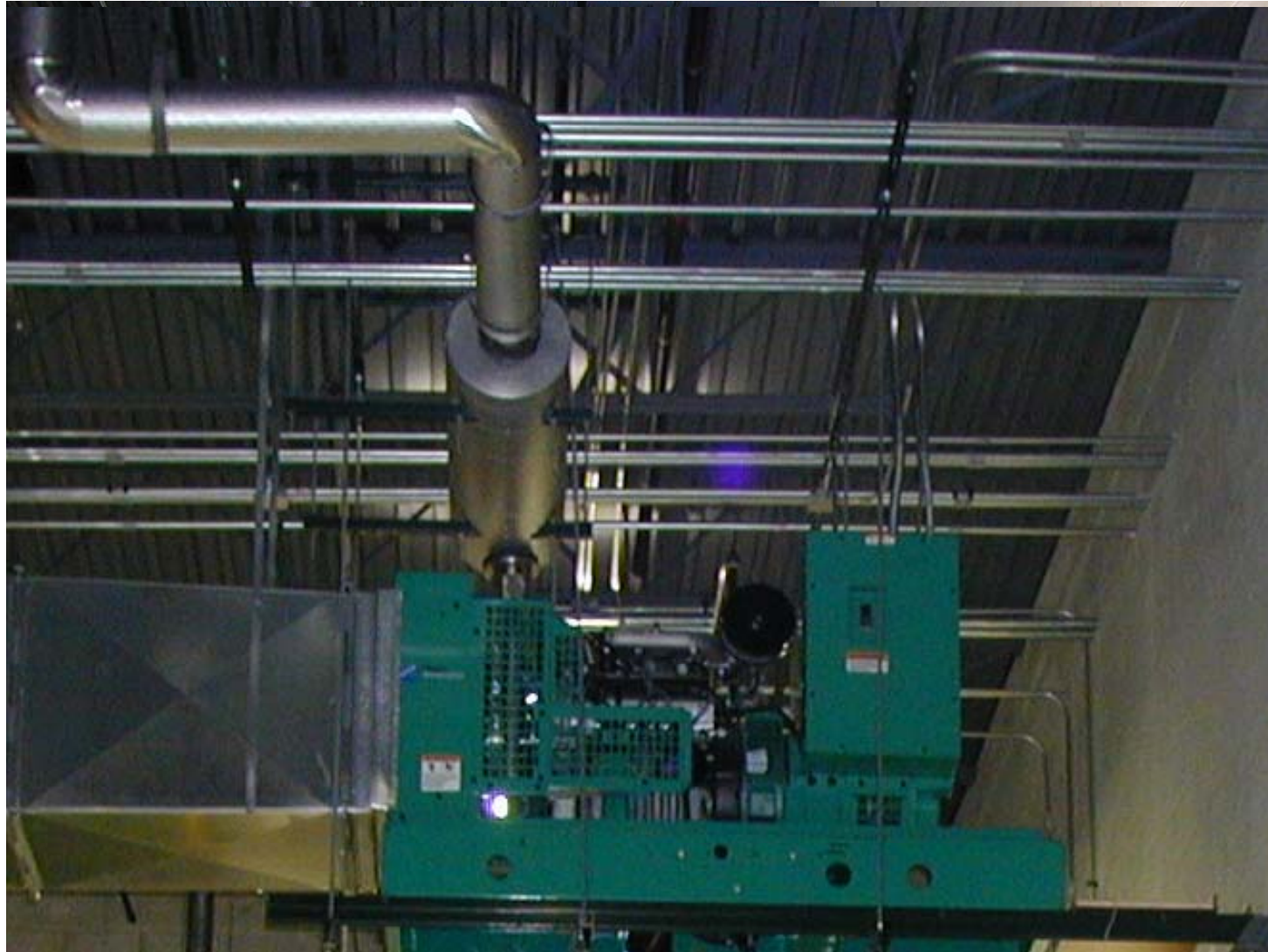
- Accessory Power Supply.
  - Each accessory may be powered by a dedicated circuit from load center adjacent to the generator set.
  - Some accessories are shipped loose for mounting by the installing contractor. Including control panels.



## Indoor Locations

- Above grade or penthouse installations.
  - Require additional structural and seismic restraint design considerations.
  - Vibration isolation from the structure is vital.
  - Try and avoid occupied space around the generator set.

And the problem here is...?



## Diesel Fuel Considerations

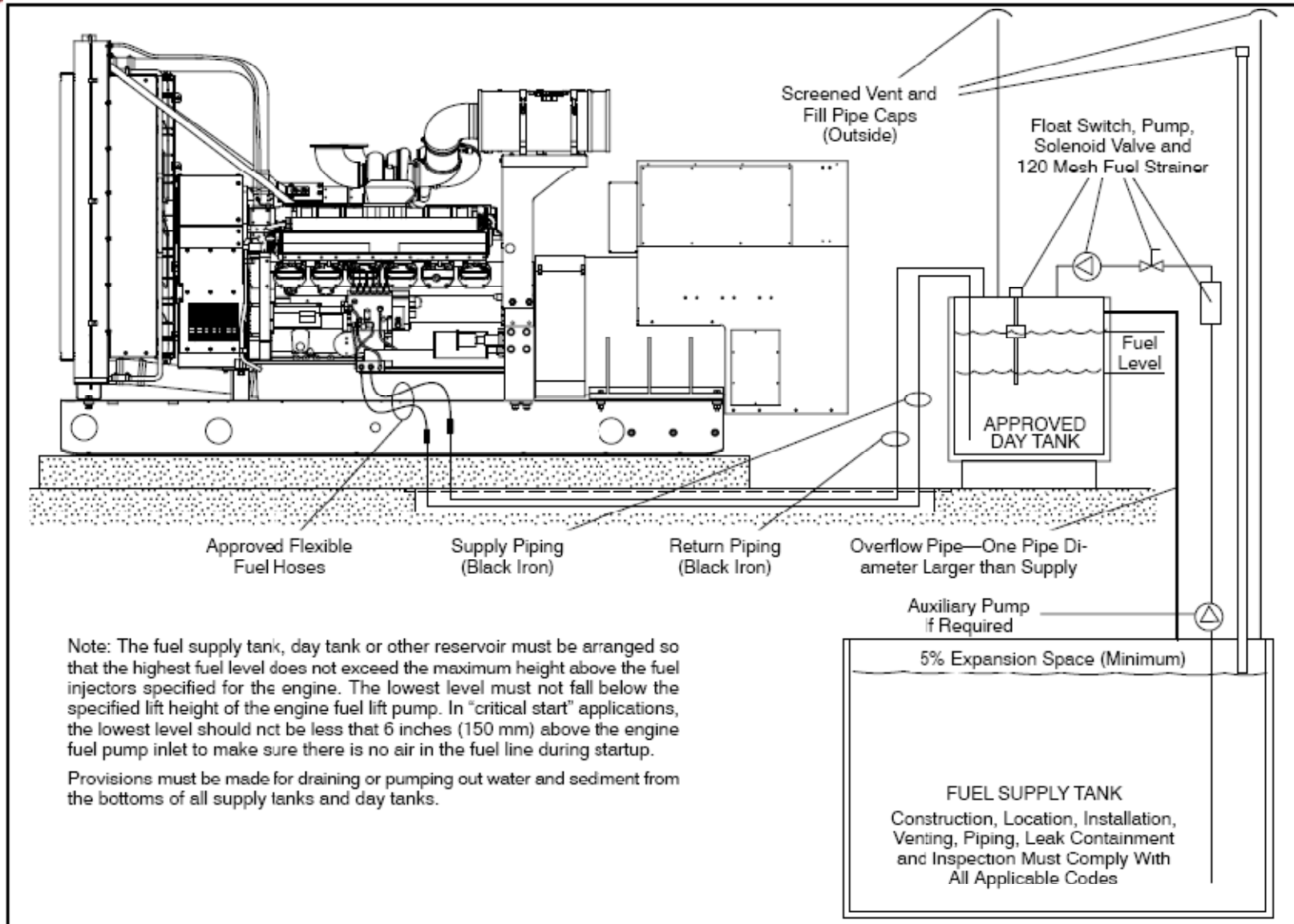
- On site fuel storage. Maybe legally required by code.
- Typical storage tanks come in a UL-142 or UL-2085 classification.
- Fuel maybe stored in multiple tanks, in several areas.
- Try to push fuel between tanks. Suction systems have multiple limitations.
- Fuel transfer systems from bulk storage tanks should be provided by the tank vendor and include redundant pumps and associated pump controls.

## Diesel Fuel Considerations

- NFPA 30 requires the following above ground storage tank accessories:
  - A normal atmospheric vent for all enclosed compartments.
  - An emergency relief vent for all enclosed compartments.
  - Fill piping that enters the top of the tank must terminate within 6" of the bottom of the tank.
  - Spill containment means installed around the fill port.
  - A high level alarm to notify operator to stop filling the tank.

## Diesel Fuel Considerations

- NFPA 30 requires the following above ground storage tank accessories :
  - An overfill prevention device to stop the delivery of fuel at 95% capacity.
  - All piping connections to the tank are made above the maximum fuel level for secondary containment tanks.
  - Anti-siphon device installed on piping where a siphon may occur.
  - Collision barriers shall be provided.
  - Leak detection means installed in secondary containment compartments.



## Natural Gas Fuel Considerations

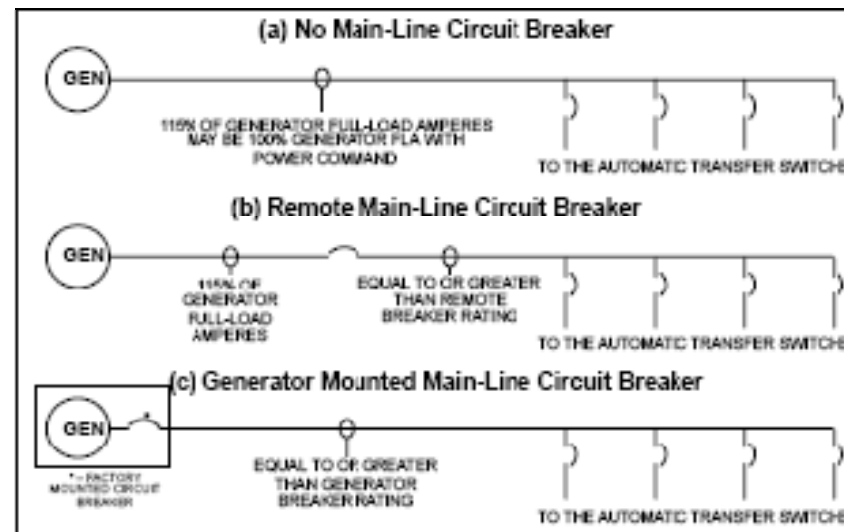
- An economical fuel choice where NG is available at the proper pressure and volume to operate the generator set.
- Typically there is no on site fuel storage.
- An on site backup LPG fuel supply may be required for emergency power systems.
- NG engines typically respond to load changes slower than diesel engines. Larger voltage dips and longer recovery times.
- NG engines are greatly affected by altitude.

## Engines Exhaust Emissions

- Both diesel and spark-ignited engines need to meet the current EPA standards when installed in the United States.
- Most manufacturers have certified engines in their products. Check.
- Emissions considerations should be addressed on used gensets moving in to the USA from other countries.
- Get ready for 2011. The next Tier levels go into effect. The result will be increased initial costs, increased maintenance costs and space requirements. Most manufacturers will use “After Treatment” solutions to meet the Tier IV levels for diesels.

# Generator Breaker

- At the generator or somewhere else.
  - Protecting the generator set.
  - Disconnect means.
  - Emergency circuit separation requirements.
  - Selective coordination requirements.



## Known Issues for Generator Sets

- Leading power factors in facilities.
  - Harmonic filters create leading power factors
  - Gensets see the leading power factor as reverse kVAR.
  - Alternators have a limit on the reverse kVAR they can tolerate.

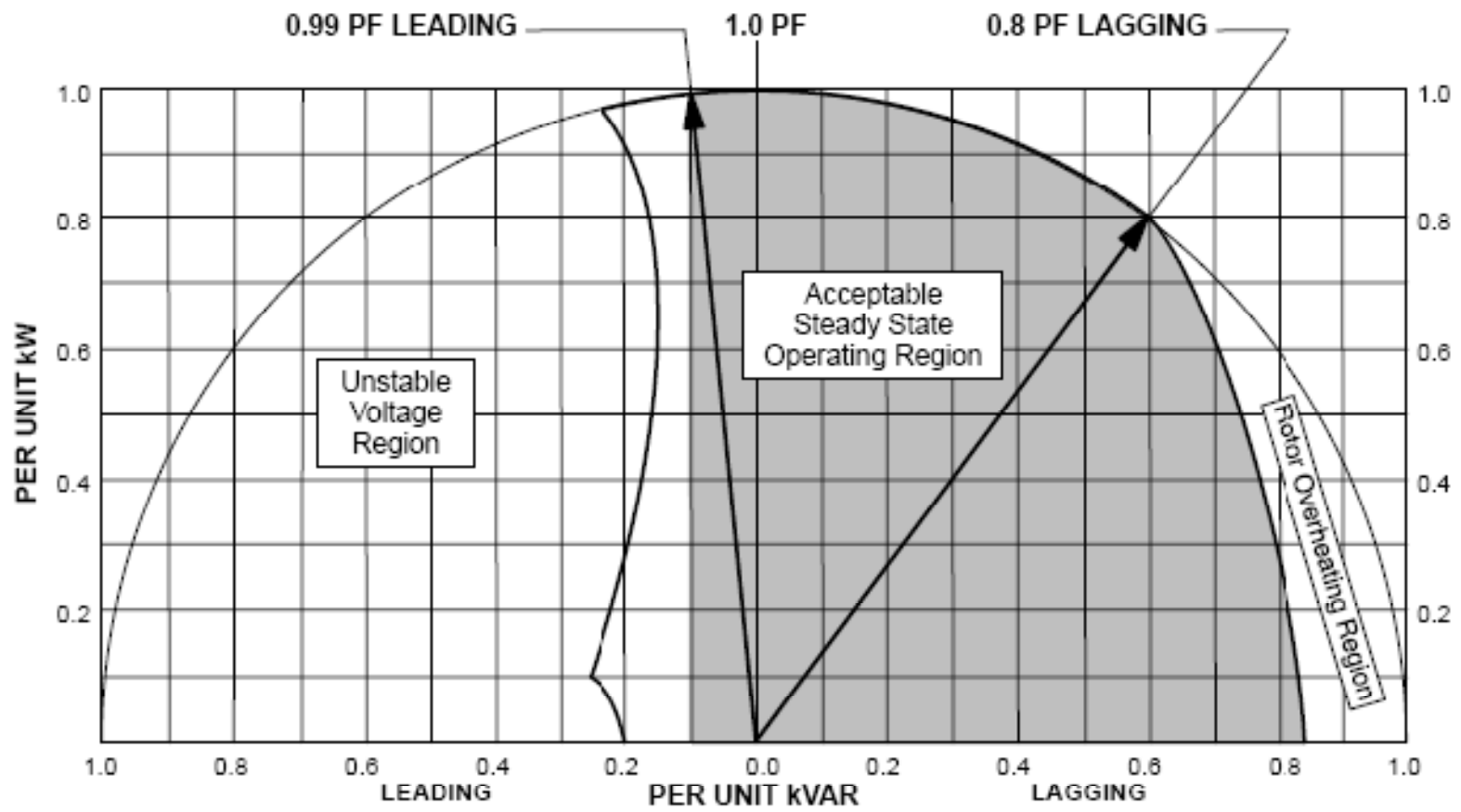


Figure 5-4. Typical Steady State Alternator Reactive Power Capability Curve

## Known Issues for Generator Sets

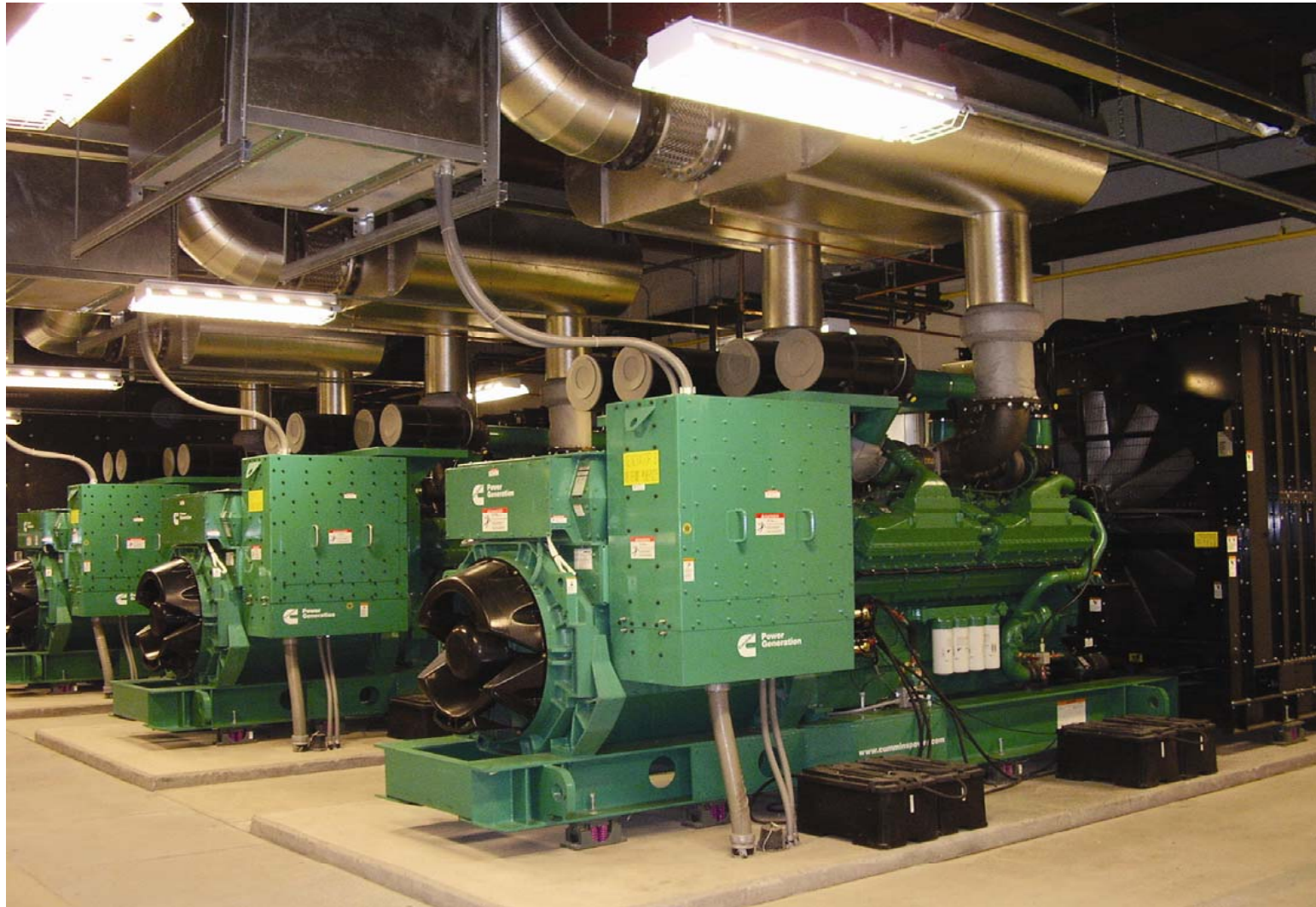
- Cooling air flow.
  - After thought screen walls.
  - Generators in pits, garden level or sub level parking structures.
  - Inadequate air movement in indoor generator rooms.
  - Air intake and discharge restrictions
  - Vegetation debris or landscaping materials being drawn into the generator set radiator.
- Fire sprinkler systems
  - Sprinkler heads installed in close proximity to the exhaust silencer or directly over the engine.

# Top Five Reasons Why Gensets Don't Start

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## Emergency Power Reliability

- Gensets are an integral part of a facilities strategic equipment, but while companies invest hundreds of thousands of dollars in this type of equipment, sometimes the generators don't start when needed.
- What are the leading causes of a "no start" situation and what you can do about them?

## Cause 1 - Lack of Testing

- All causes of gensets not working can be revealed by a good testing program
- The life of the generator will be extended
- Corrosion will be minimized as moisture is chased away
- Engine wear will actually be less as internal parts are lubricated more often

## Cause 1 - Lack of Testing - Solutions

- Experience has taught us that weekly testing is the best practice
- Testing early in the week will provide better opportunity for quick correction
- Testing early in the day allows for correction that day
- Testing with load is better than without
- Testing with actual load transfer is usually a better test than artificial load
- Automatic load testing is easy for most facilities

## Cause 2 - Generator has been neglected

- In many facilities the generator is ignored until a power outage happens
- Generator just doesn't seem as important as other equipment
- It's usual state is "off" which causes inherent neglect
- Sometimes the generator location is out of the way, out of site – out of mind





## Cause 2 - Generator has been neglected - Solutions

- A good maintenance program will help prevent common causes of generators not operating in an emergency
- Maintenance contracts are available from many outside companies if there are no trained on-site personnel
- A Remote Annunciator panel can be installed which will sound an alarm if an abnormal condition occurs to alert building personnel
- More sophisticated monitoring systems can be easily installed providing other types of notification including sending an email when a problem occurs

MAINTENANCE ITEMS	SERVICE TIME				
	See Engine Schdl.	Daily or after 8 Hours	Monthly or after 100 Hours	6 Months or after 250 Hours	1 Year
General set inspection	X <sup>1</sup>	X <sup>2</sup>			
Check engine oil level		X			
Check coolant level		X			
Check coolant heater(s)		X			
Check battery charging system			X		
Check all hardware (fittings, clamps, fasteners, etc.)			X		
Check battery electrolyte level			X		
Check generator air outlet			X		
Check radiator hoses for wear and cracks				X	
Test rupture basin leak detect switch					X <sup>3</sup>
Check drive belt	X <sup>1</sup>				
Check air cleaner (replace as necessary)	X <sup>1</sup>				
Drain fuel filter(s)	X <sup>1</sup>				
Check anti-freeze and DCA concentration	X <sup>1</sup>				
Change engine oil and filter	X <sup>1</sup>				
Change water coolant filter	X <sup>1</sup>				
Clean crankcase breather	X <sup>1</sup>				
Change fuel filter	X <sup>1</sup>				
Clean cooling systems	X <sup>1</sup>				

## Cause 3 - Dead Batteries

- If a generator has been tested, and hasn't been neglected, the most probable cause of it not starting is dead batteries
- Batteries have a limited life expectancy
- Batteries are sensitive to temperature, charge rate, and electrolyte level



## Cause 3 - Dead Batteries - Solutions

- Change batteries out often – yearly is best
- Check electrolyte level and specific gravity often
- Battery charge float level should be correct for the battery and voltage
- Annunciator panel should have low voltage indication
- Generator control should have a “weak battery” alarm
- The battery charger should have an “equalize” setting where the current can be increased for a short time to extend battery life

## Cause 4 - Fuel System

- Next to batteries, fuel contamination or low level is a common problem
- Large fuel systems can contain fuel which is very old
- Fuel systems are subject to contamination by water, corrosion and fungus located at the bottom of the tank where the fuel pickup tube is
- Fuel filters can be overwhelmed within minutes with the amount of contamination in the tank
- Fuel system design can include many components, any of which can cause the entire system to fail
- Fuel level can be ignored until it's too late

## Cause 4 - Fuel System - Solutions

- Keep your fuel clean
  - Send a sample of your fuel out for testing often
  - Install a self-cleaning filters which circulate fuel to local filters
  - Make sure water separators are installed with visible means of detecting contamination
- Inspect/maintain all of the system components including:
  - Filters
  - Hoses and connectors
  - Transfer pumps
- Have in-place emergency procedures for fuel system problems
  - Spare fuel filters
  - Spare pump
  - Hand or electric (DC) fuel transfer pump as backup

## Cause 5 - System Design

- Systems can be designed with inherent features which reduce reliability.
- Limited access for maintenance
- Designed in limitations on testing with load because of the importance of the load

## Cause 5 - System Design - Solutions

- Location of generators should be with Maintenance in mind
- Method of testing should be designed-in
- Closed transition transfer switches to reduce load disturbance when transferring to/from generators
- Load Banks or quick connection boxes should be designed-in to the system

# 7x24 Exchange

## Questions



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