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DEVELOPMENT

SEMINAR

SERIES

Generator
Provisioning & Installation

WELCOME TO GPS 160

Generator Provisioning & Installation

ENERGY MANAGEMENT CORPORATION

Motors • Drives • Generators

Engineering Trivia

The volt is a fundamental unit of electrical measurement named after an early physicist.

What was this physicist's name?

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Generator

Provisioning & Installation

Location – Outdoors

- Access and Egress
  - Exit and entrance points to the site
  - Five feet from combustible walls
  - Overhead interference points

- Electrical interconnect
- Fuel source location
- Exhaust discharge location
- Air flow
- Security and flooding
- Sound

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Location – Roof Top

- Structural support
- Vibration isolation
- Crane requirements
- Fuel supply

Location – Indoors

- Air flow
- Exhaust
- Heat
- Fuel
- Fire
- Sound
- Secured area
- Access & egress

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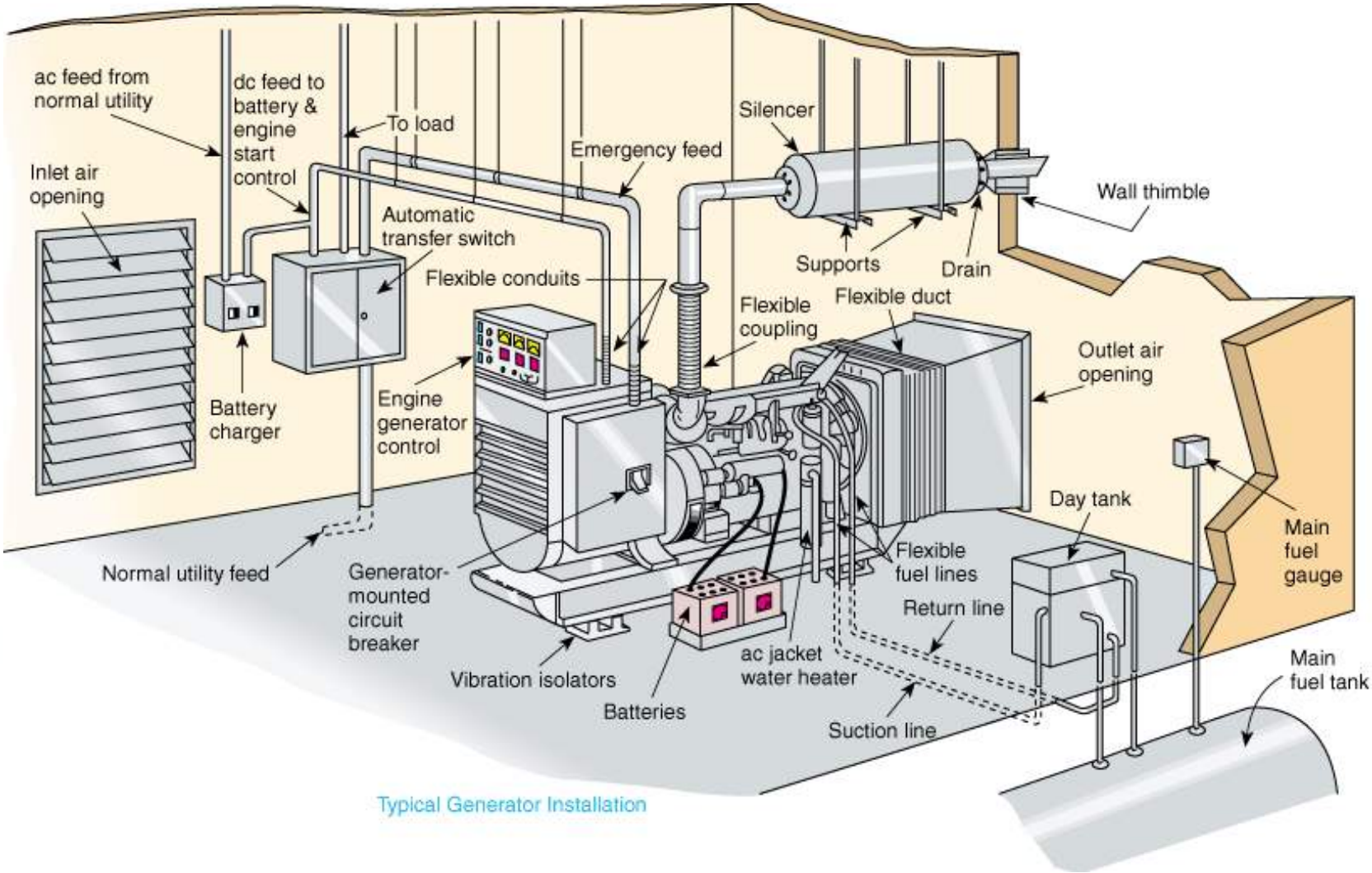
Indoor Location



Typical Generator Installation

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Indoor Location – System Design

- **Separate room (level 1)**
- **Room with two-hour fire rating**
- **Fire protection system**
- **Fire risk evaluation**
- **Battery-powered emergency lighting**
- **Minimum access spacing 36” (NFPA 37)**
  - NEC working space requirements may require 48”

Airflow – Outdoor Locations

- Unrestricted air flow
  - Discharging up versus out
    - Recirculation
    - Prevailing winds
  - Clean, clear area

Airflow – Enclosures

- **Weather**
  - UL2200 tested with unit
  - Materials
    - Steel (typical)
    - Aluminum (optional)
    - Stainless Steel (rare special)

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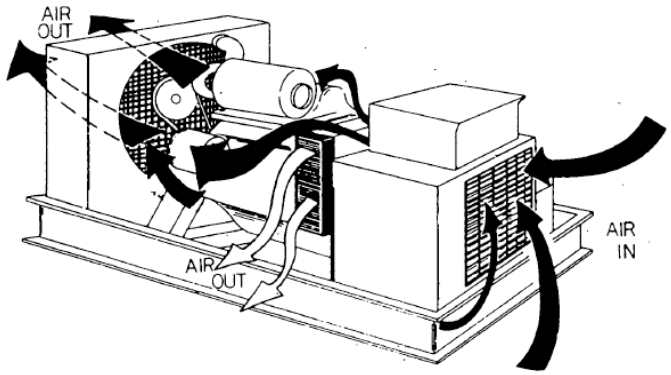
Airflow – Indoor Locations

- Air inlet
  - Opening 1.5 to 2 times radiator area (attached radiator)
  - Size for room temperature rise (remote radiator)
    - CFM ≅ (BTU/Hr rejected) / desired Δ Temp + combustion air

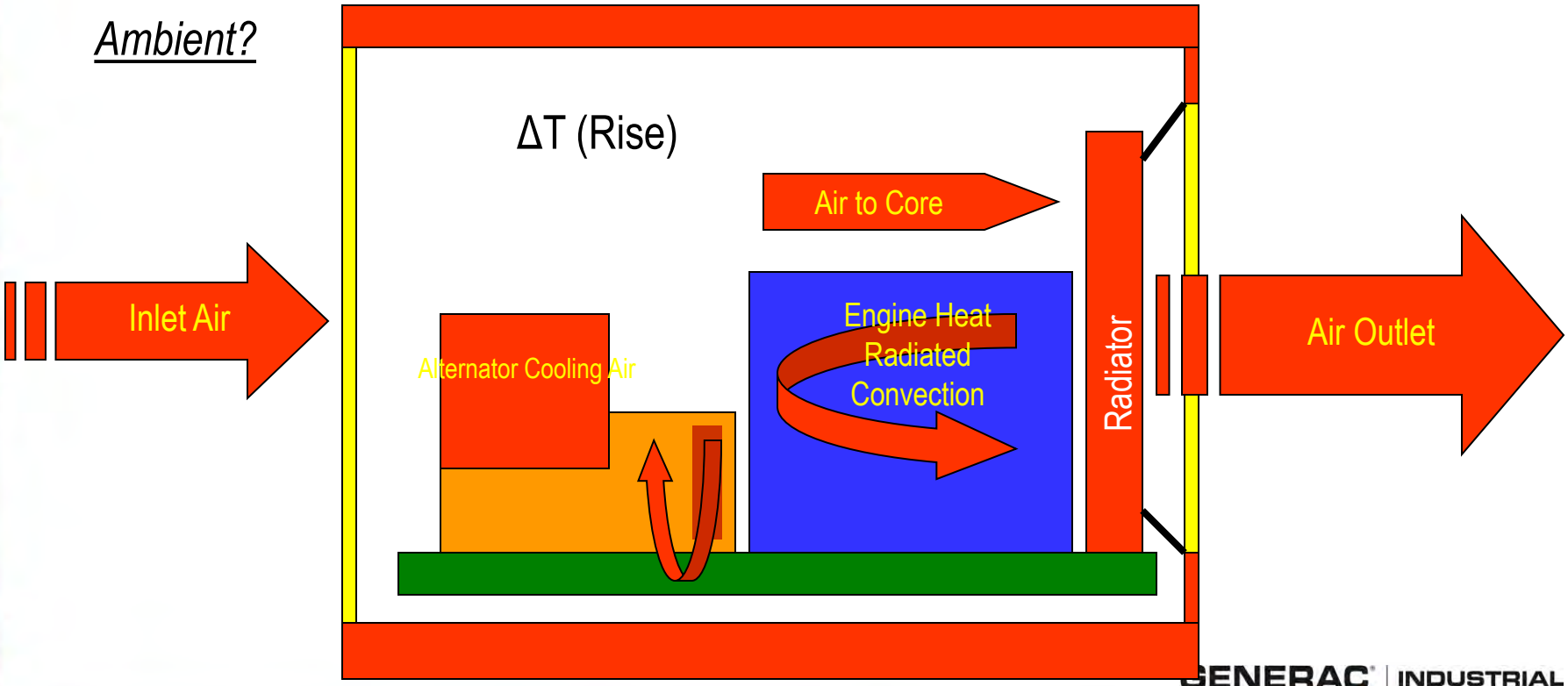
- Air outlet
  - Match radiator flange or larger
    - Compensate for louver or screens
    - Minimal duct work (straight & short)
    - Watch for recirculation



Airflow – Indoor Locations

What is ambient temperature?

Is it measured inside or outside the room?



Exhaust – System Design

- **Flex connection**
- **Condensate traps**
- **Thermal expansion**
- **Exhaust blankets**
- **Thimble**
- **Acceptable back pressure**
- **Silencer**
  - Industrial, Critical, Hospital, etc.
  - Key is to specify desired sound level for the system

Exhaust – Discharge

- Exhaust direction
- Air handler intake

Exhaust stacks when necessary

Exhaust – Location in Enclosures

- **On top**
  - Aesthetics & rust from muffler
- **In discharge hoods**
  - Limited to 400 kW
- **Inside enclosure**
  - Must be thermally wrapped

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Cooling System – Block Heaters

- **Block heater (100ºF min)**
  - Convection & circulating types used
  - Wattage based on engine size
  - Required on diesels

- **Spark-ignited engines**
  - Crank speed determines start-ability
    - Battery heater
    - Synthetic oil
  - Block heater may not be the best choice for small (< 100 kW) spark-ignited engines
    - Operation cost
    - Maintenance cost

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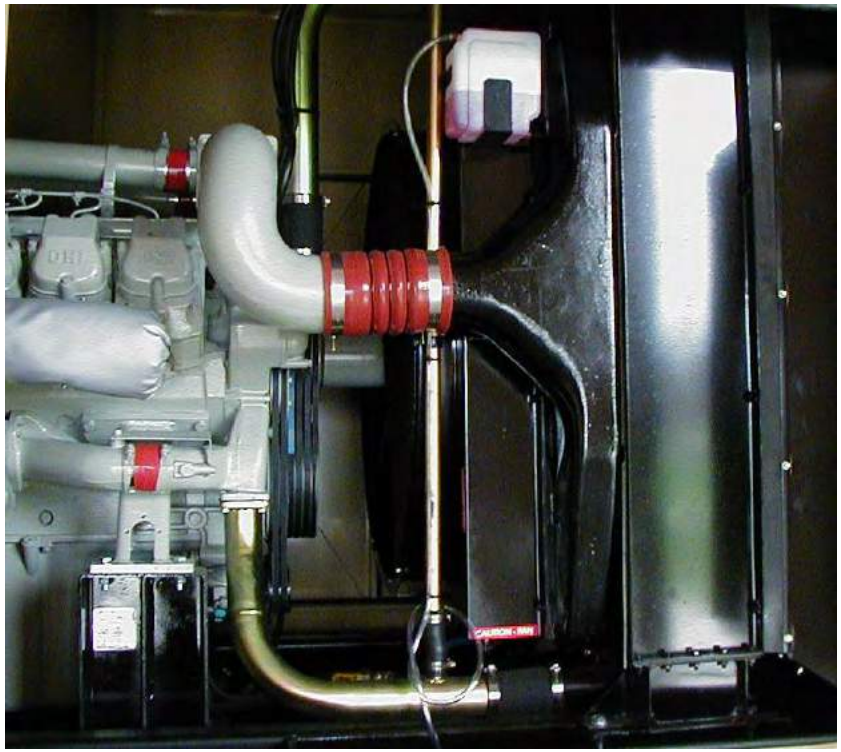
Cooling System – Radiators

- **Engine-mounted**
  - Most common and reliable
  - Usually designed for 50° C
- **City-water cooling**
  - Limited acceptance
- **Remote radiator**
  - Heat exchangers
  - Circulating pumps
  - Electric-driven fans
  - Complexity and reliability concerns



Cooling System – Remote-Radiator Considerations

- **Basic design considerations**
  - Engine constraints
    - Pressure and flow restriction on engine water pump
    - Pressure constraints on engine seals
  - Piping layout
    - Isolation valves (monitoring)
    - Burping the system
    - Air entrainment
  - Powering fans and circulation pumps
    - Powered by generator (emergency distribution panel)
    - Breakers (monitoring)
    - Direct connection (no motor starters)

Cooling System – Remote-Radiator Considerations

- **Other design considerations**
  - Charge Air Cooling (CAC)
    - Air-to-air
    - Separate water jacket
    - Temperature requirements
    - EPA emission characteristics
  - Other cooling
    - Fuel coolers
    - Oil coolers

Sound – Levels

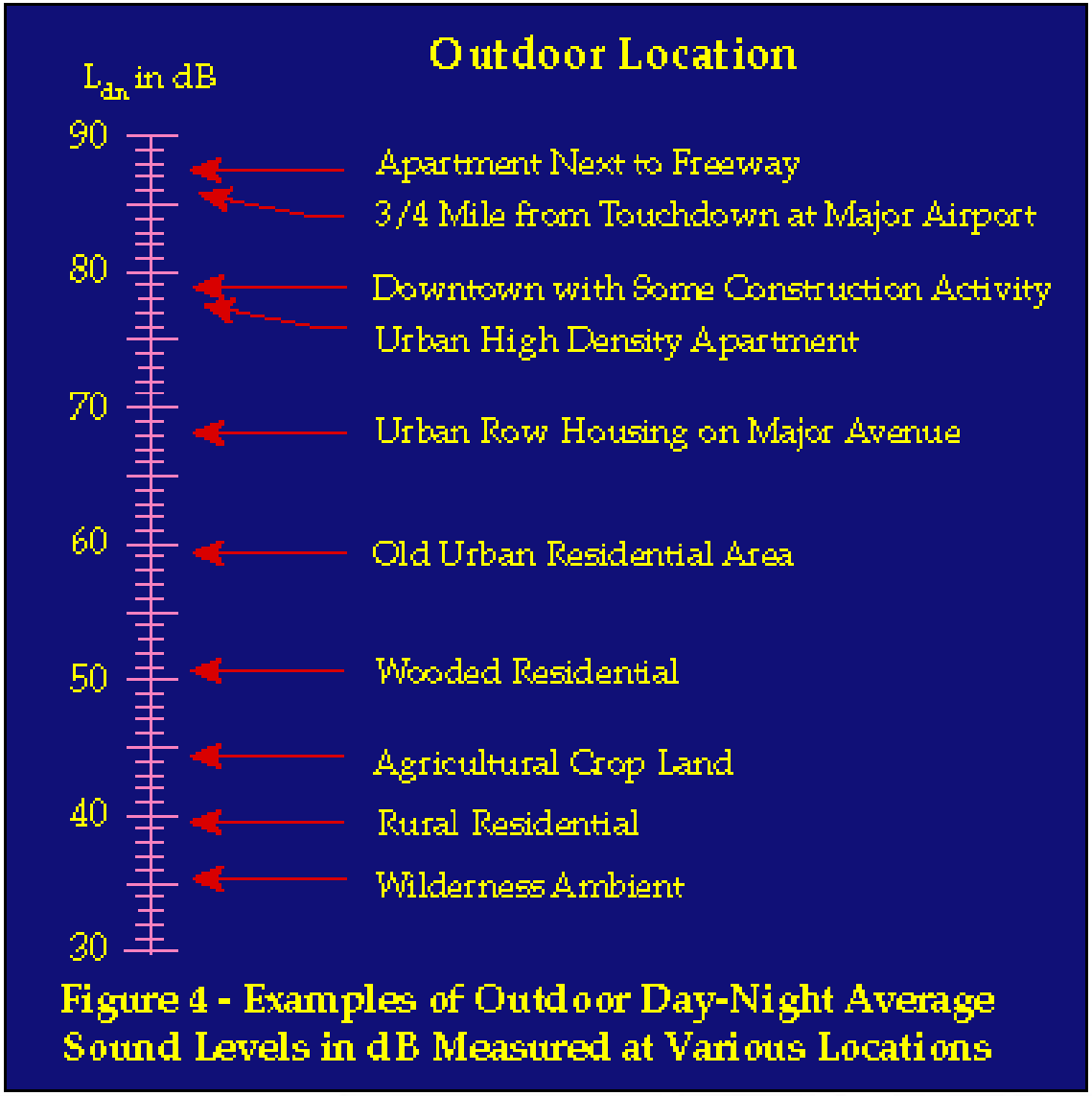


Figure 4 - Examples of Outdoor Day-Night Average Sound Levels in dB Measured at Various Locations

Sound – Enclosures

- **Sound Attenuated**
  - Weather housing (-5 dBa)
  - Standard sound housing (-15 dBa)
  - Level 2 sound housing (-20 dBa)
  - Custom enclosure designs (-25 dBa)

- **Custom enclosures**
  - Expensive and not factory supported (testing)

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Sound – Design Concepts

- **Enclosure options**
  - Become costly at low dBa levels
- **Distance**
  - Double distance is a 6 dBa reduction
- **Walls**
  - Direct sound up
  - Provides other benefits
    - Enhanced security
    - Added wind protection

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Mounting – Concrete Slab

- Concrete slab
  - Required to secure and support
  - Extend beyond profile of generator (18” minimum)
  - Designed to support wet weight
  - Wire or re-bar reinforced as required
  - Double check stub-up location

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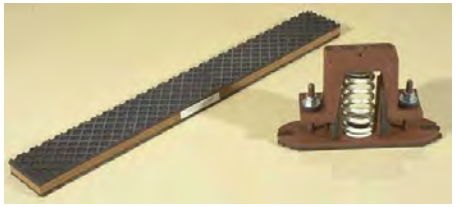
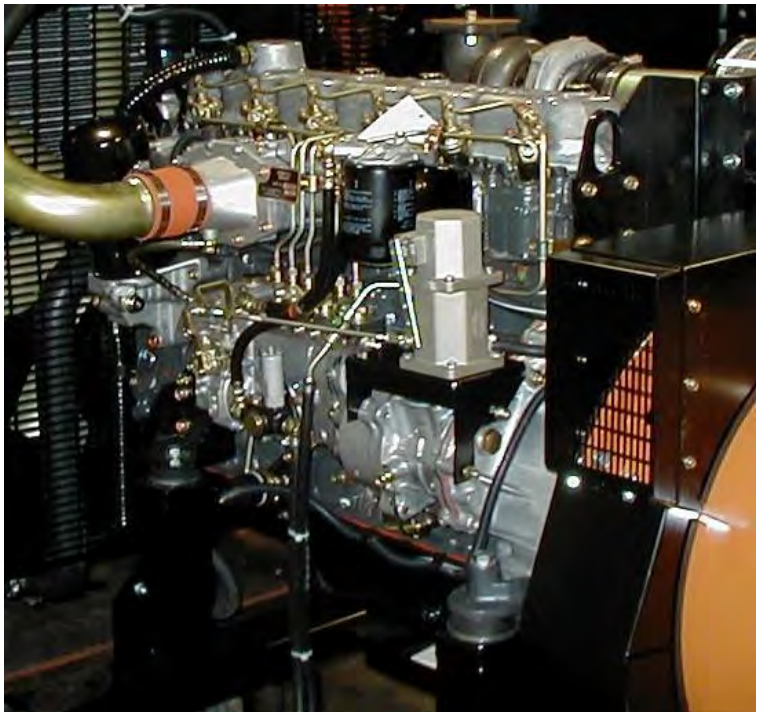
Mounting – Isolators

- **External Isolators**
  - Pad or Spring
  - Most generators ≥ 500 kW use spring isolators
  - Most generators ≤ 400 kW internally isolated
  - Avoid spring on ≤ 400 kW (typically not required)





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Diesel Fuel – Engine Options

- **Typical Options**
  - Secondary filter/water separator
  - Secondary filter with heater
  - Fuel data from engine ECM (EPA tier 3 engines)

- **Non typical options**
  - Duplex secondary filters
  - Mechanical fuel pressure gauges

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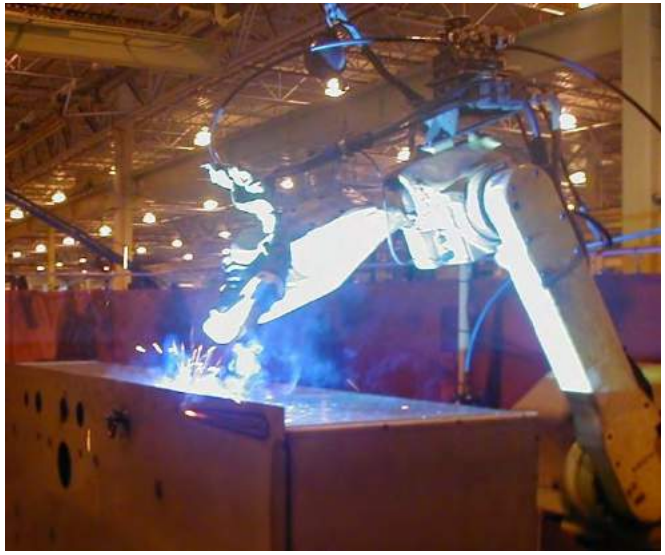
Diesel Fuel – Tanks

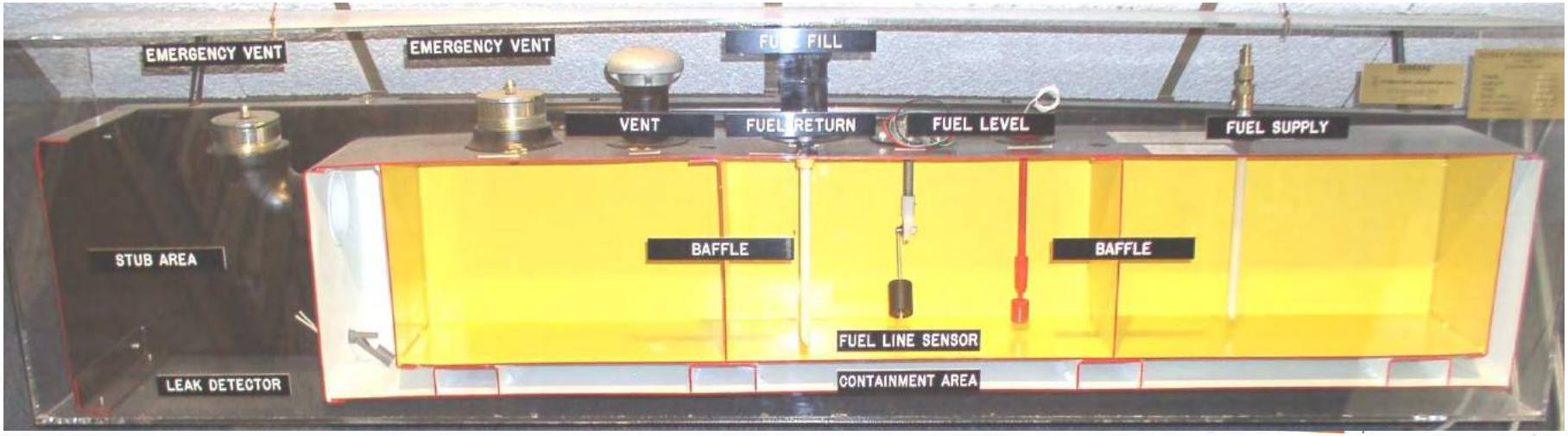
- **Typical tanks**
  - Secondary containment sub-base tanks (8-hour, 12-hour, 24-hour)
  - Main Storage tanks (24 hours and up)
  - Day Tank (2-hour, 4-hour)

- **Special requirement tanks**
  - Sub-base day tank (8 hours with transfer pumps)
  - UL2085 fire rated (code-required in select markets)

Diesel Fuel – Standard Tanks

- Sub-base configuration (very common)
- Secondary containment (double wall)
- Various heights and capacities
- UL 142 listed
- Stub-up at rear of the tank
- Various connections





Diesel Fuel – Special Tanks

- **Local code special requirements**
  - Fill–spill box
  - High level contact
  - Remote fill-alarm panel
  - Special fill connection
  - Auto fill shutoff
  - Normal vent elevation
  - Tank elevation

Diesel Fuel – System Design

- Is the system fail-safe?
  - Return lines or pumps (day tanks)
  - Isolation valves and solenoids
  - Piping is protected
  - Safe filling system
  - Vents installed
- Is the fuel source reliable?
  - Other users
  - Fuel maintenance program

Diesel Fuel – System Design

- **Day tank with main storage tank**
  - Main tank lower elevation
    - Day-tank pump
    - Gravity return
    - Engine return to main tank
  - Main tank higher elevation
    - Isolation solenoid (bypass capability, NFPA110 5.6.3.2.1)
    - Return pump (sized larger than inlet flow)
    - Fuel cooler may be needed

Gaseous Fuel Systems

- Natural Gas
- LP Vapor
- LP Liquid
- Dual Fuel (LP or Natural Gas)
- Bi-Fuel™ (Diesel and Natural Gas)

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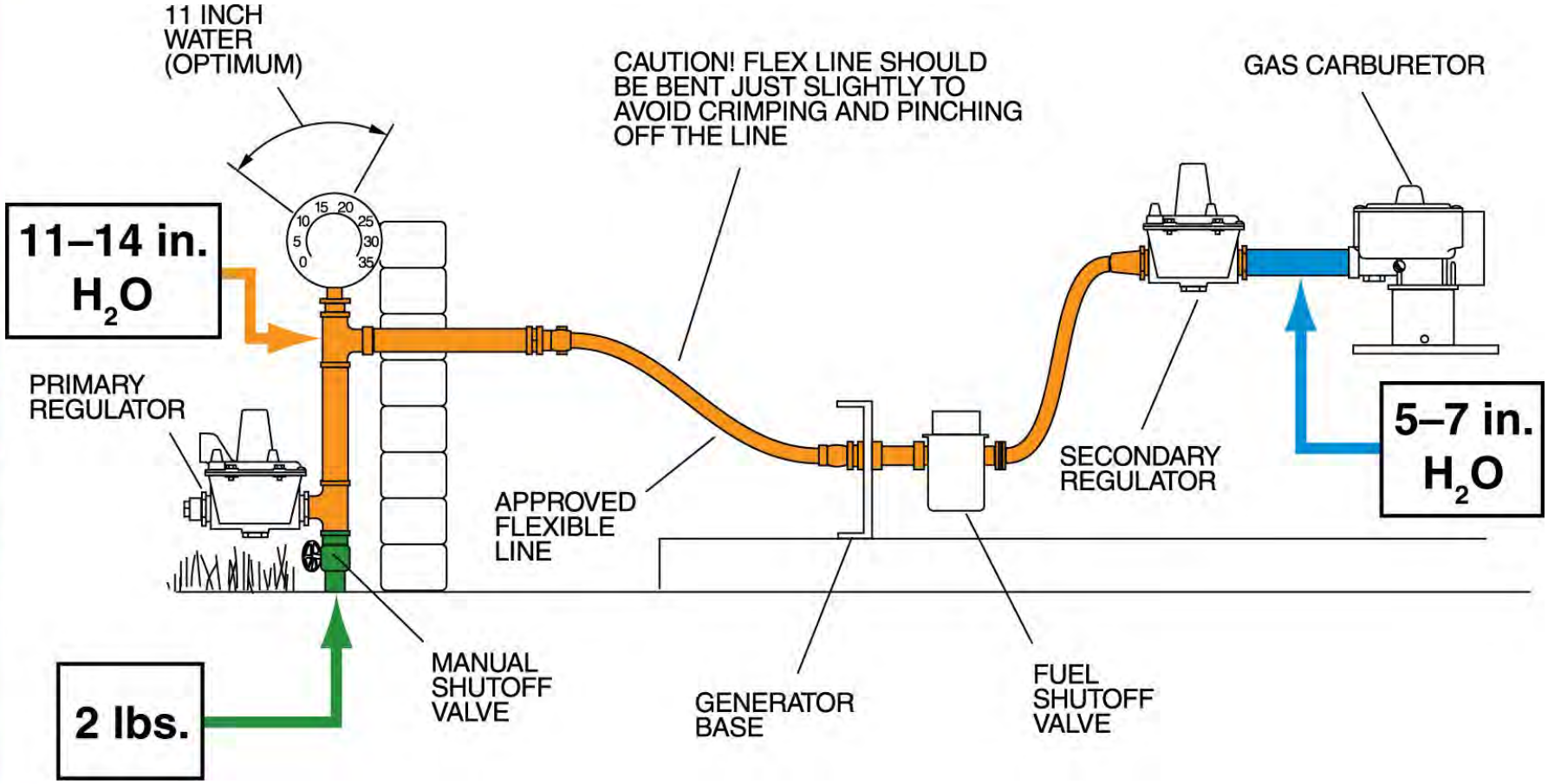
Fuel Systems – Natural Gas



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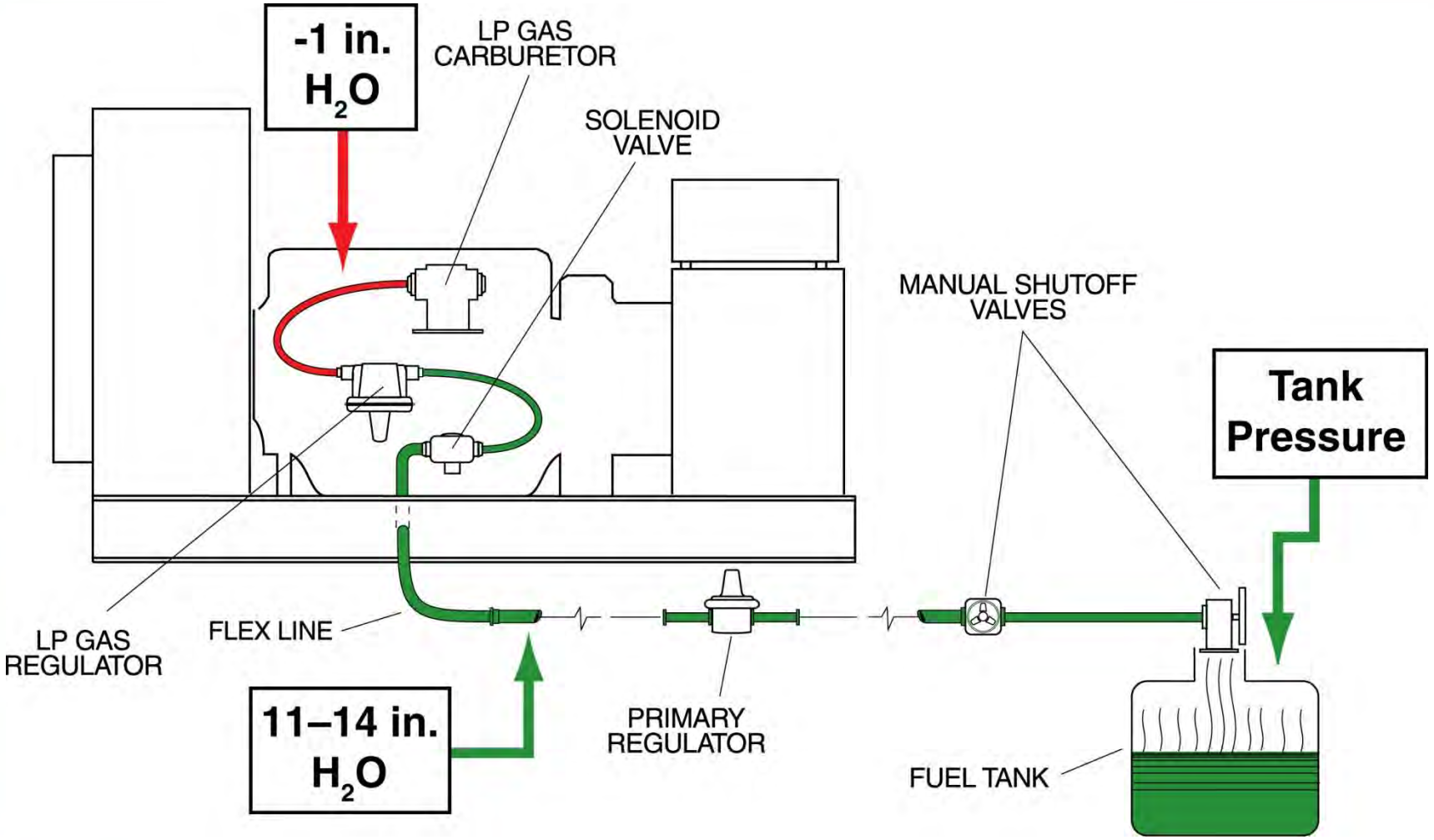
Gaseous Fuel Systems

- **Gas pressure is critical**
  - Consult manufacturer data sheets
    - 5” to 14” H_2O typical for units less than 60 kW
    - 11” to 14” H_2O typical for units 60 to 300 kW
    - 2 psi typical for units larger than 300 kW
  - Verify gas service capacity
  - Adequate piping size is critical

Fuel Systems – LP Vapor



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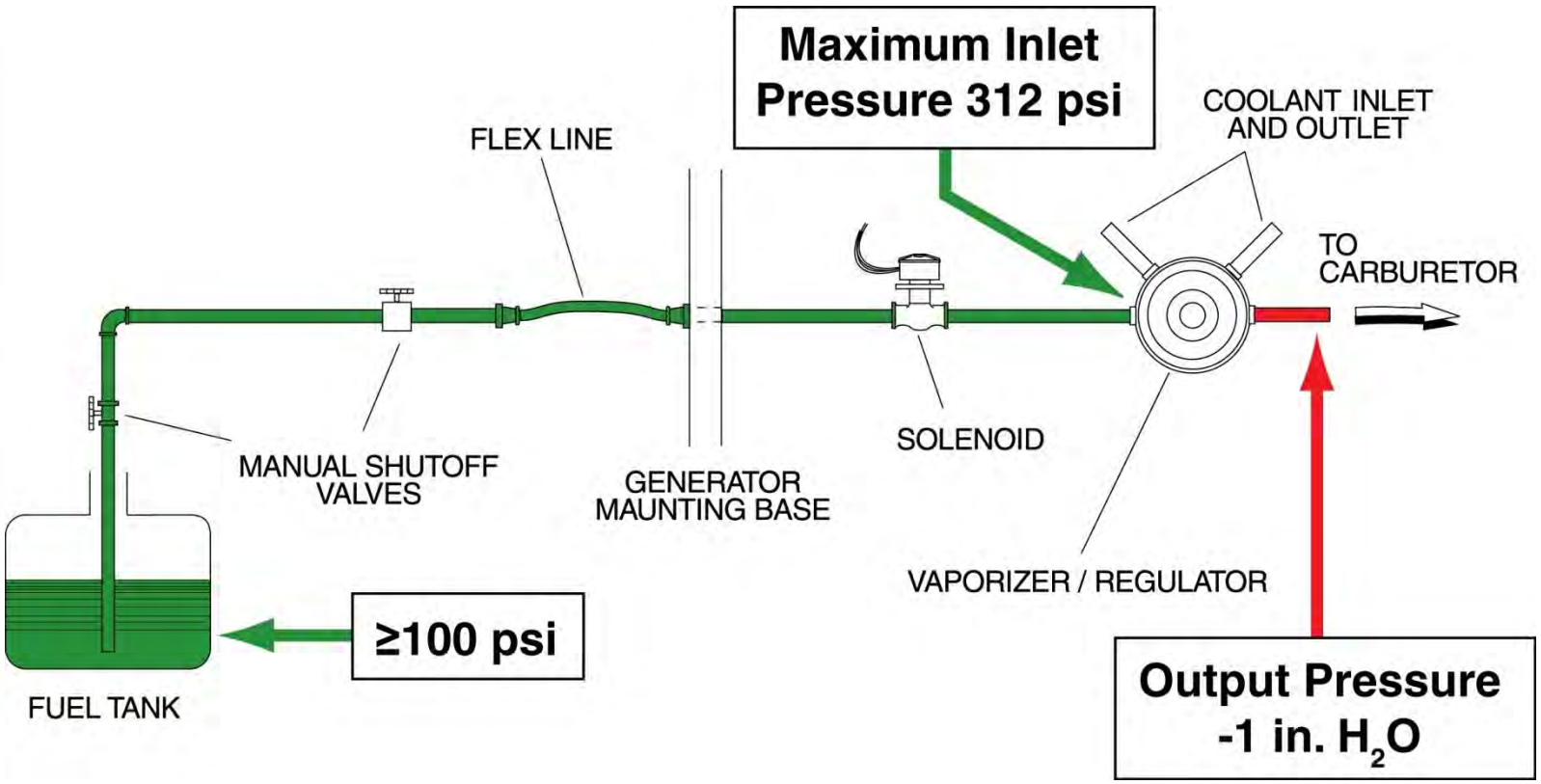
Fuel Systems – LP Liquid



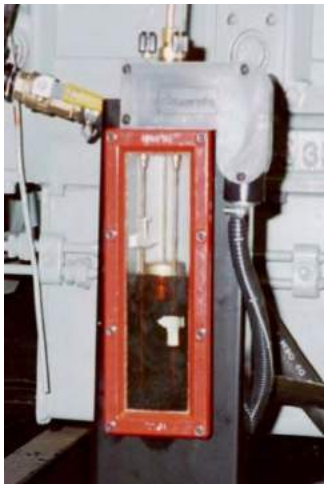
Gaseous Fuel Systems

- **Adequate service or tank size**
  - Consider other gas loads
  - Consider ambient temperatures
- **Adequate pipe sizing**
- **Primary pressure regulator at unit**
- **Isolation valves (secured)**
- **Flexible fuel lines (approved)**

Oil Lubrication System

- **Typical Options**
  - Oil heaters
  - Oil make-up systems (consult manufacturer recommendations on tier 3 engines)
  - Oil temperature indication and alarms (may be standard on tier 3 engines)

- **Non-typical requirements**
  - Pre-lube systems
  - Oil-level indication and alarms



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Starting System – Battery

- **Lead acid (generally maintainable)**
  - Cost effective and excellent cranking amps
  - Highly reliable when on maintenance cycle
  - Familiar to end-users
    - Fast replacements
    - Jumping and boost charging
- **NiCad**
  - Expensive (initial cost & disposal)
  - More sensitive charging requirements
  - Poor end-user awareness
- **Typical options**
  - Oversized batteries
  - Dry batteries (storage applications)

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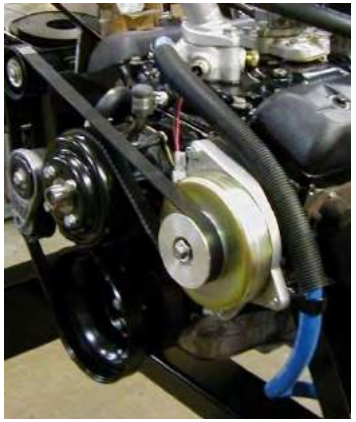
Starting System – Charging

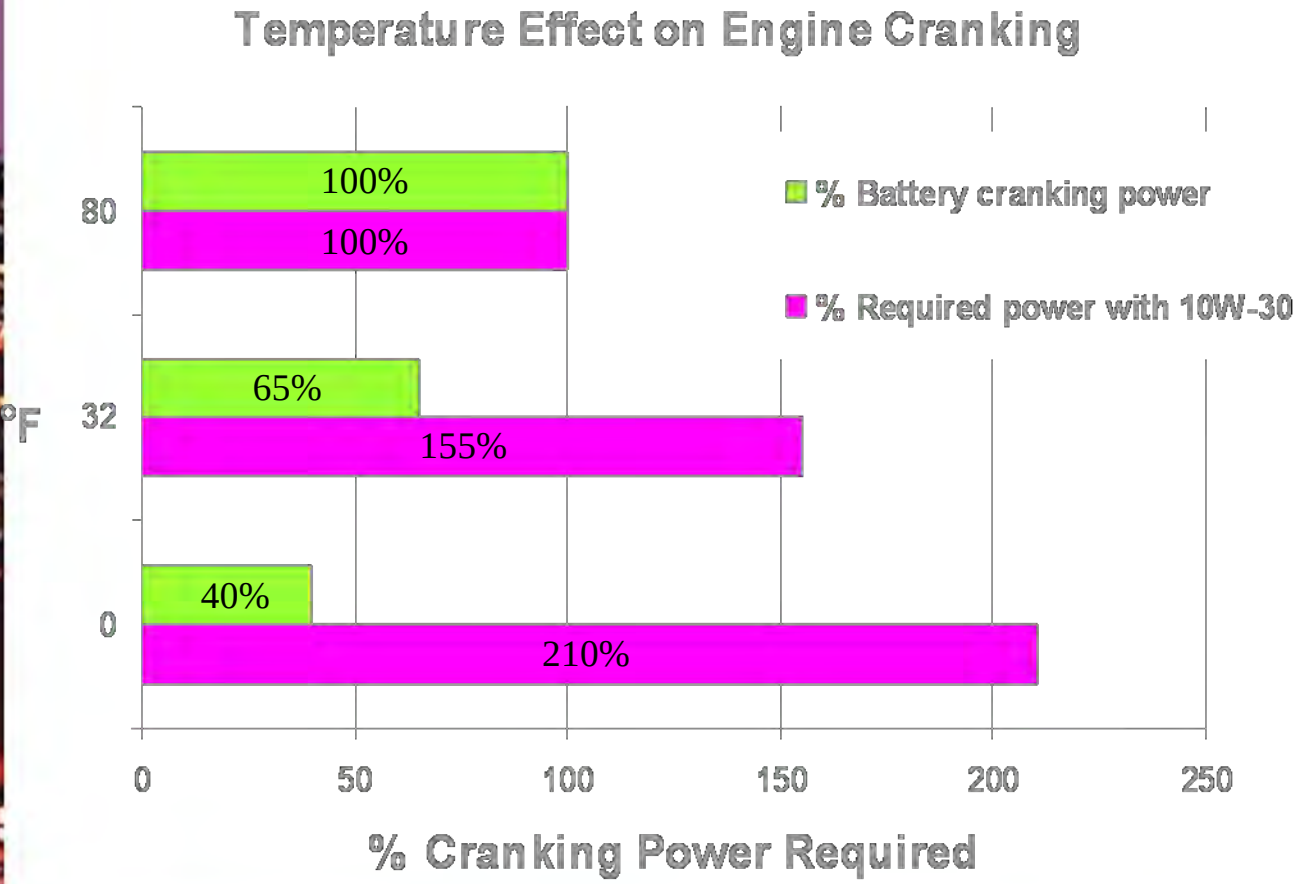
- **Float-equalized charger**
  - Maintains battery charge
  - Equalizes cells for maximum cranking amps
  - Usually 10 amps

- **Engine-charging alternator**
  - Fast battery recovery after cranking
  - Adds reliability to system (failed charger)



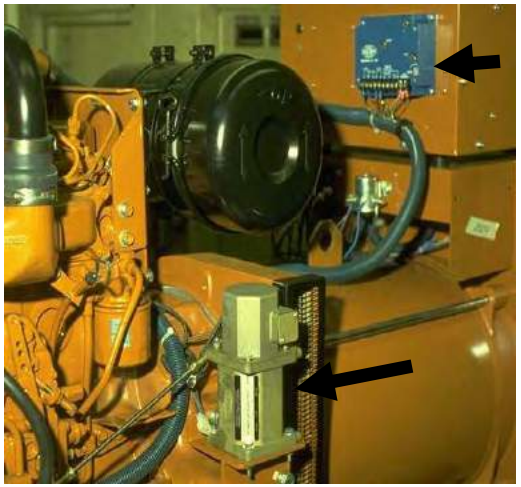
Starting System – Battery Heater

- Battery blanket option



Speed Control – Governor System

- **Electronic (industry norm)**
  - Isochronous (maintains 60 hertz operation)
  - Typically integrated into generator or engine controller
  - Older designs may use an external controller
  - +/- 0.25% frequency regulation



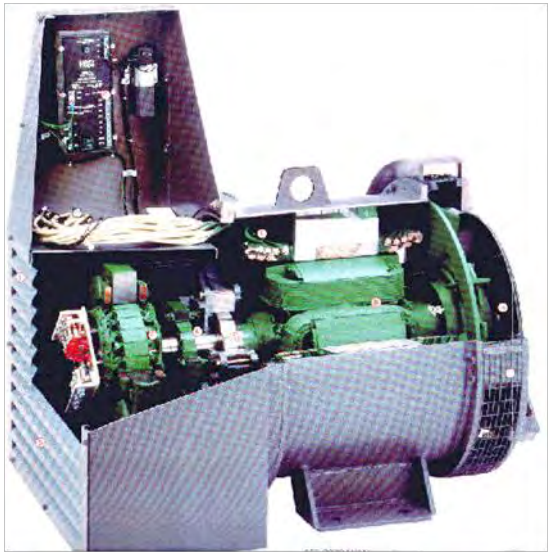
- **Mechanical**
  - Droop (speed decreases when load increases)
  - Historically common in small diesels
  - +/- 5% frequency regulation

Alternator Accessories

- **Strip heaters**
  - Extends life by minimizing moisture

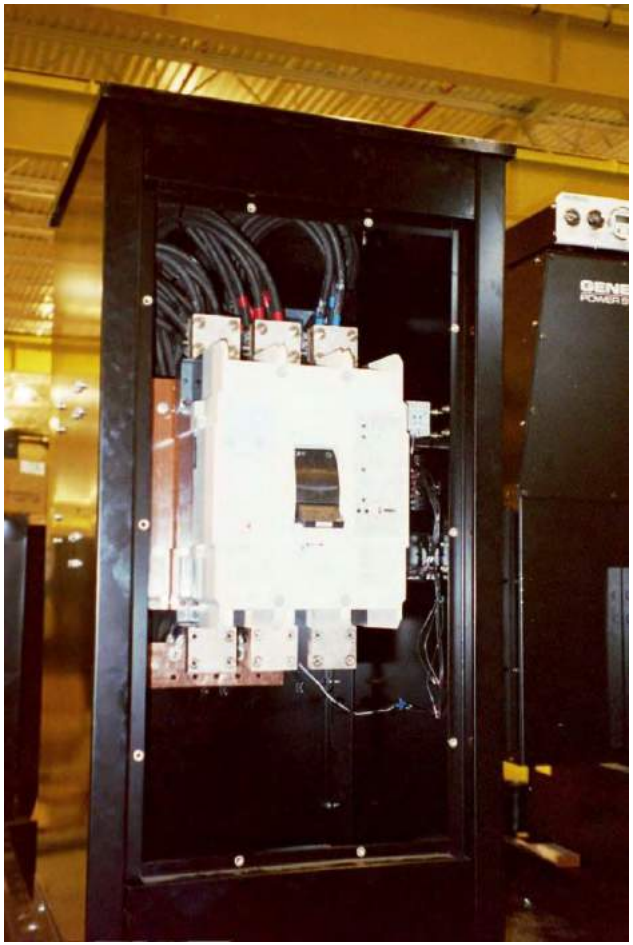
- **Tropical coating**
  - Epoxy “green” over-coating
  - Additional moisture barrier

- **PMG (permanent magnetic generator)**
  - Standard in larger kW units
  - Supports breaker coordination



Circuit Breakers

- **Standard**
  - Thermal magnetic
  - Single breaker
- **Options**
  - Multiple breakers
  - Shunt trip
  - Auxiliary contacts
  - Electronic trip
  - Ground fault



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Coordination

- Has the genset arrival at the site been scheduled?
- Does the transport company have a contact?
- Has rigging been arranged?
- Identify location of loose parts
- Larger units require exhaust mounting

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Checking for Shipping Damage

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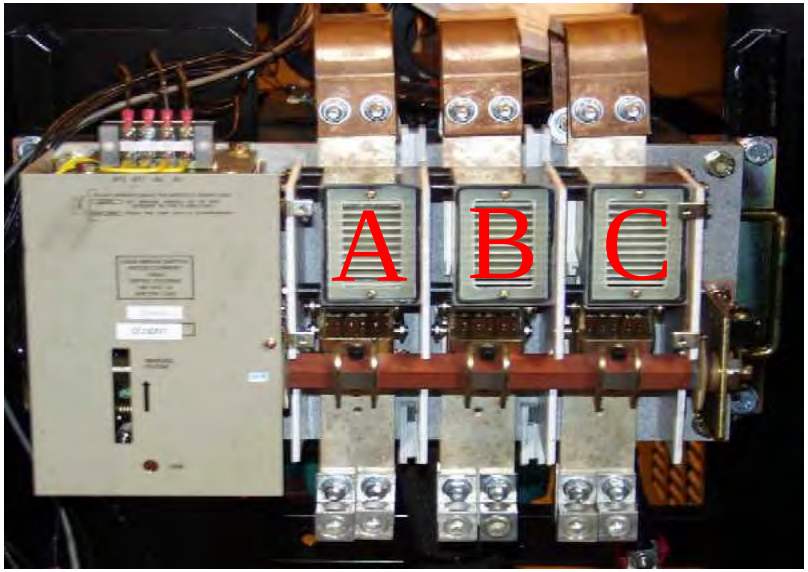
Installation Safety

- **Keep system disabled prior to startup**
  - Batteries disconnected
  - Generator in OFF position
  - Breaker open
  - ATS in manual

Power Wiring – Phase Rotation

- **Phase rotation**
  - Confirm generator and facility rotation at ATS (startup check)
  - Connections should include enough cable to change rotation



Power Wiring – Terminations

- **Conduits**
  - Cluster conduits under breaker
  - Keep ABC and N conductors grouped together
  - Plan for regrouping phases in conduit layout

- **Terminations**
  - Cable termination determined by ATS and breaker lugs
  - 75-degree cable requirements (don't use 90-degree cable)
  - Support lugs when tightening (broken ATS and breakers)

Note: Alternator leads are 150-degree wire

Power Wiring – Load Bank Provisions

- **Is load bank testing required (ref NFPA 110)?**
- **Periodic load bank testing is recommended**
- **Wiring provisions???**

Power Wiring – Grounding and Bonding

- Neutral should be bonded for grounded systems
- Three-pole ATS, the neutral is bonded at the service
- Four-pole ATS, the neutral is bonded at the generator
- Generator requires a grounding conductor
- Grounding electrode (rod) does not replace grounding conductor

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Auxiliary Power Wiring

- **Battery charger and block heater**
  - 120/240 VAC
  - May want on separate circuits
    - Spark-ignited generators in summer ($ savings)
    - Block heater failures – maintain battery charger

Auxiliary Power Wiring

- **Other 120/240 accessories to be powered (options)**
  - Battery blanket heaters
  - Alternator strip heater
  - Motor-operated louvers
  - Load centers
  - Convenience outlets
  - Typically OEM wired

Controllers

- Usually standard component with options
  - Digital controller meeting NFPA 110, level 1
  - Governor and regulator integration
  - Paralleling capability

Control Accessories

- Annunciator
- Alarm horns
- Communication capability (modem, Ethernet, etc.)
- Additional I/O capability
- Custom logic/functionality

Control Wiring

- **General**
  - Control wiring in separate conduit
  - Pull spare control wires
  - Wiring requirements vary with control type
  - Consult wiring diagrams and owner manuals

- **Typical control wiring**
  - 2-wire start (2 wires, ATS to generator)
  - ATS position indication (3 wires, ATS to generator)
  - Communications (2 wire shielded, various)
  - Remote annunciator (4 wire shielded from generator)

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Generator Provisioning & Installation

Questions?