

DIESEL FUEL OIL SYSTEMS

Presented by:

Mark Drow

David Eoff

**PREFERRED UTILITIES
MANUFACTURING CORP.**

AGENDA

- About the Speakers
- Aboveground & Underground Systems
- Fuel Load Calculations
- Fuel Oil System Overview & Components
- Eliminating Problems/Common Errors
- Proper Pipe Sizing
- DEMO: Pipe Sizing Program for Windows

Please ask questions at any time.....

MARK DROW

*Preferred Utilities Distributor,
Fuel Oil Handling*

mdrow@voyager.net

7347-260-2776 cell

DAVID EOFF

National Sales Manager

DEoff@Preferred-Mfg.com

203.788.4471 cell/direct



PREFERRED UTILITIES MFG. CORP.

ABOUT PREFERRED UTILITIES

- Operating since 1920
- Headquarters in Danbury, Connecticut
- Factory in Danbury, Connecticut
- Experts in Mission Critical Facilities
- UL- and FM-listed products
- UL508 control panel shop
- Four major divisions:
 - *Preferred Utilities: Fuel Oil Handling*
 - *Preferred Instruments: Boiler Controls*
 - *W.N. Best: Combustion Systems*
 - *Preferred Engineering: Nuclear Outage Support*

ABOVEGROUND VS. UNDERGROUND

ABOVEGROUND

- Simple
- Inexpensive
- Fast construction
- Easy to inspect and maintain
- Easier to expand
- Less regulations/code issues
- Limited capacity (48K gal)
- Exposed (unsightly; not secure)
- Potential thermal issues

UNDERGROUND

- Complex
- Expensive
- Slow/disruptive construction
- Difficult to inspect and maintain
- Harder to expand
- More regulations
- Virtually unlimited capacity
- Buried/hidden
- Tank and piping stay cooler

ABOVEGROUND OVERVIEW

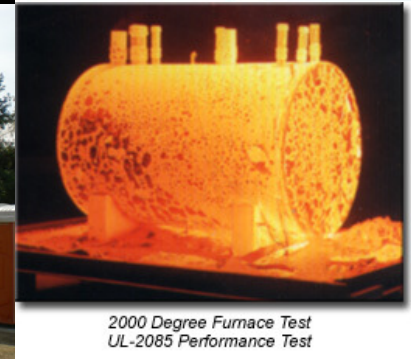
- UL142 or UL2085 tanks?
- UL142 is double-walled, sometimes open secondary [rupture basin] tank
- UL2085 is double-walled, closed top, fire-rated (“vaulted”)
- Aboveground Storage Tanks (AST’s) are generally UL2085, for safety, insurance, and capacity reasons
- Day tanks are generally UL142, because they’re smaller, and often indoors



UL142



UL2085



UNDERGROUND OVERVIEW

- Underground Storage Tanks (UST's) are double-wall, either *fiberglass* or *composite* (steel primary; fiberglass secondary)
- Pressure systems: California requires continuous monitoring system for tank and underground piping.
- California also requires double-wall sumps with interstitial monitoring (polyglycol is common).



HYPOTHETICAL PROJECT EXAMPLE

We will go through a typical medium-sized project example...

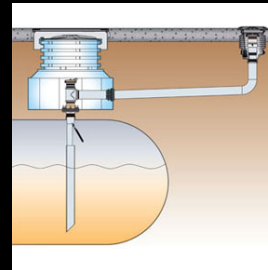
- Data Center.
- Brand new project - owner only knows size and quantity of generators, and runtime.
- We need to make recommendations for the fuel oil handling system, then design it.

FUEL LOAD CALCS: START HERE

- Start your design by doing fuel load calcs
- Begin with desired runtime [72 hrs]
- What's burning fuel? [4 x 2mW generators]
- Use rule of thumb: 7gph per 100kW
- $20 \times 7 = 140\text{gph}$; $140 \times 4 = 560\text{gph}$
- $560 \times 72\text{hrs} = 40,320 \text{ gallons}$
- *Question: Considering some capacity in day tanks for the generators, what size main storage tank do we need?*

TRICK QUESTION

- We need 40,320 gallons of *useable* fuel
- We need to account for *ullage* and *drop tube gap*
- Add 10% for ullage (adjust as necessary per region, etc.)
- Add 10% for drop tube gap (adjust)
- Add 5% for gen testing/exercising fuel
- $40,320 \times 125\% = 50,400$ gallons
- We'll round that to 50,000 gallons
- Some additional capacity from day tanks can be included, depending upon their size
- For our example, we will say that our (4) generators have 2,500-gallon base tanks, totaling 10,000 gallons, so we are back to 40,000 gallons needed in [nominal] bulk storage



OTHER FUEL LOAD CONSIDERATIONS

- Redundancy? If this is a 2N site (only 2 gens are needed for full load), you'll have to use (2) separate fuel tanks, 20,000-gallons each, redundant controls, redundant piping, etc.
- Site access: Can a 40,000-gallon tank be trucked in? Can a large crane get in there?
- One large tank can be more economical
- Two smaller tanks can be safer/increase uptime, in case of a problem



DAY TANKS

- Open rupture basin, or double-wall.
- Size as large as possible...2-4 hours runtime, or larger, is ideal.
- Larger day tanks give you more fuel local to the generator.
- The larger the day tank, the cooler the fuel (we will come back to this later).
- PUMC day tanks can be custom-built...tall, thin, L-shaped, round, etc., to best fit the room.
- Return pumps are always a good idea, to prevent overflow, reduce fuel heat, and circulate fuel so that it will get polished.
- *Be sure to specify the number and sizes of bungs in packaged day tanks, or generator base tanks [a.k.a. "belly tanks"], before they are ordered.*



DAY TANK SIZE

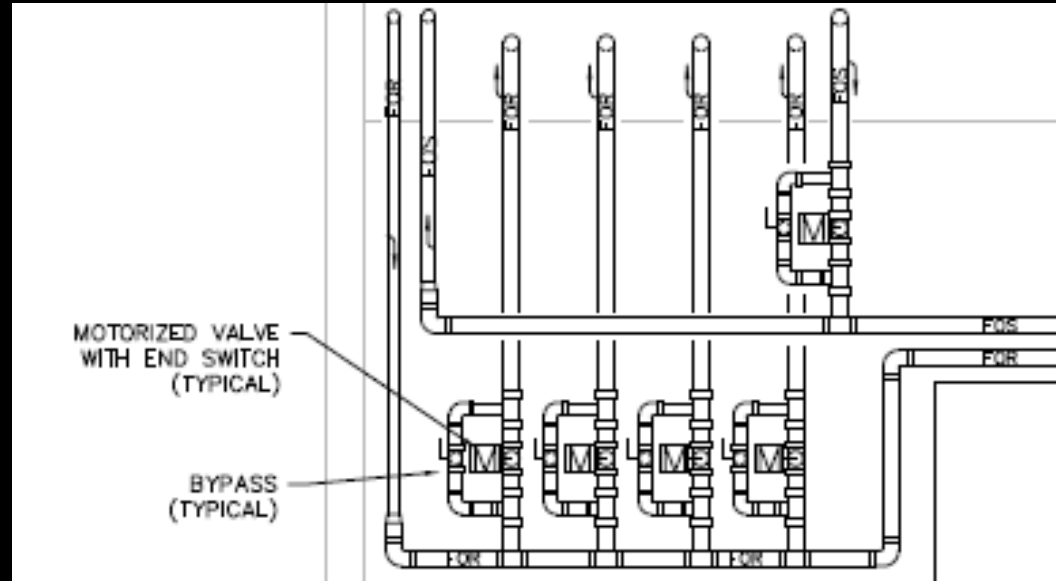
The bigger, the better...but how big can you go...?

- NFPA 37 6.3.2.2 states that maximum aggregate day tank capacity attached to one generator is 660 gallons. Of course, usually that means one 660-gallon day tank.
- NFPA 37 6.3.2.2 also states that, if a single tank exceeds 660 gallons, it must be in its own dedicated room.
- NFPA 37 6.3.2.3 states that, if aggregate day tank capacity exceeds 1,320 gallons, those day tanks must be in a dedicated room.
- Local codes also determine day tank size. Example: Los Angeles allows only 60-gallon day tanks, regardless of generator size.
- Ideally, size day tanks for 2-4 hours of generator runtime at 100% load. More is better.
- Day tank size will affect performance of day tank controls.

MULTIPLE DAY TANKS

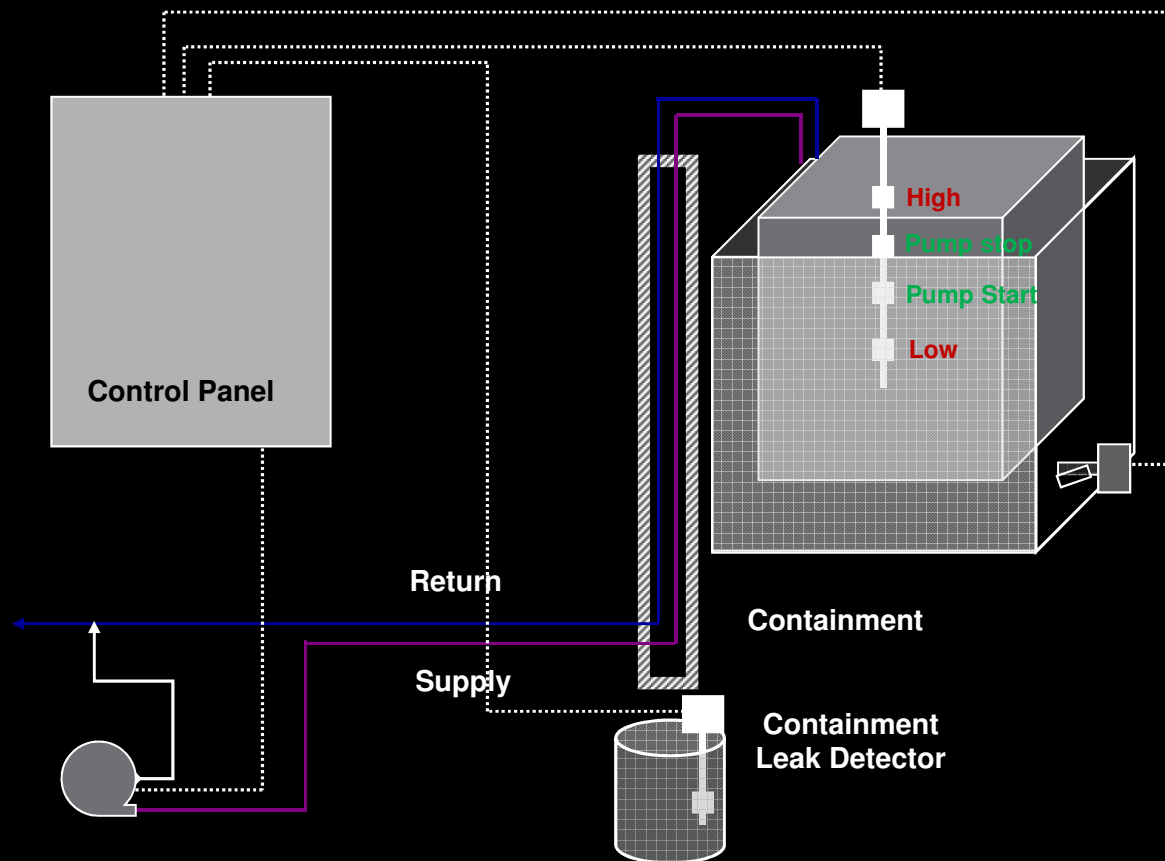
- If a pump set is supplying more than one day tank, a flow control manifold (fill valve) will be required on each day tank.
- If any tank calls for oil, the pumps are energized and the flow control manifold for that tank is opened.
- Fill valves usually have a manual bypass.
- Sometimes fill valves are motorized ball valves with open/close limit switches.

Sidenote: A similar strategy may be used when returning fuel from day tanks to multiple bulk storage tanks...



CONTROL STRATEGY OVERVIEW

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DAY TANK CONTROLS

- Liquid level switches are most common, and have 4 or 5 positions [e.g., “Lo-Lo, Pump-On, Pump-Off, Hi-Hi].....
- Level switches can be interlocked directly with another component. For example, return pump can be interlocked with the Hi-Hi float. Or, a generator shutdown signal with a Critical-Low float.
- Ultrasonic level devices are handy for shallow base tanks.
- RTD probes can be used to control fuel temp (covered later).
- Rupture Basin Switch (RBS) leak detector.....



LEAK DETECTION

LEAK DETECTION

- Required in tank interstitial spaces.
- Recommended in pump set leak basins.
- Required in containment piping.
- A good idea anywhere oil is likely to leak and accumulate.

Note: NFPA code is mute on how many leak detectors are required in containment piping.



PUMPS

Gear Pumps

- High head; lower volume
- Necessary for high-rise jobs, remote fills
- Require suction line
- Must achieve/maintain prime; install priming-T
- Can be used on some [small/shallow] UST projects, and can eliminate need for continuous monitoring

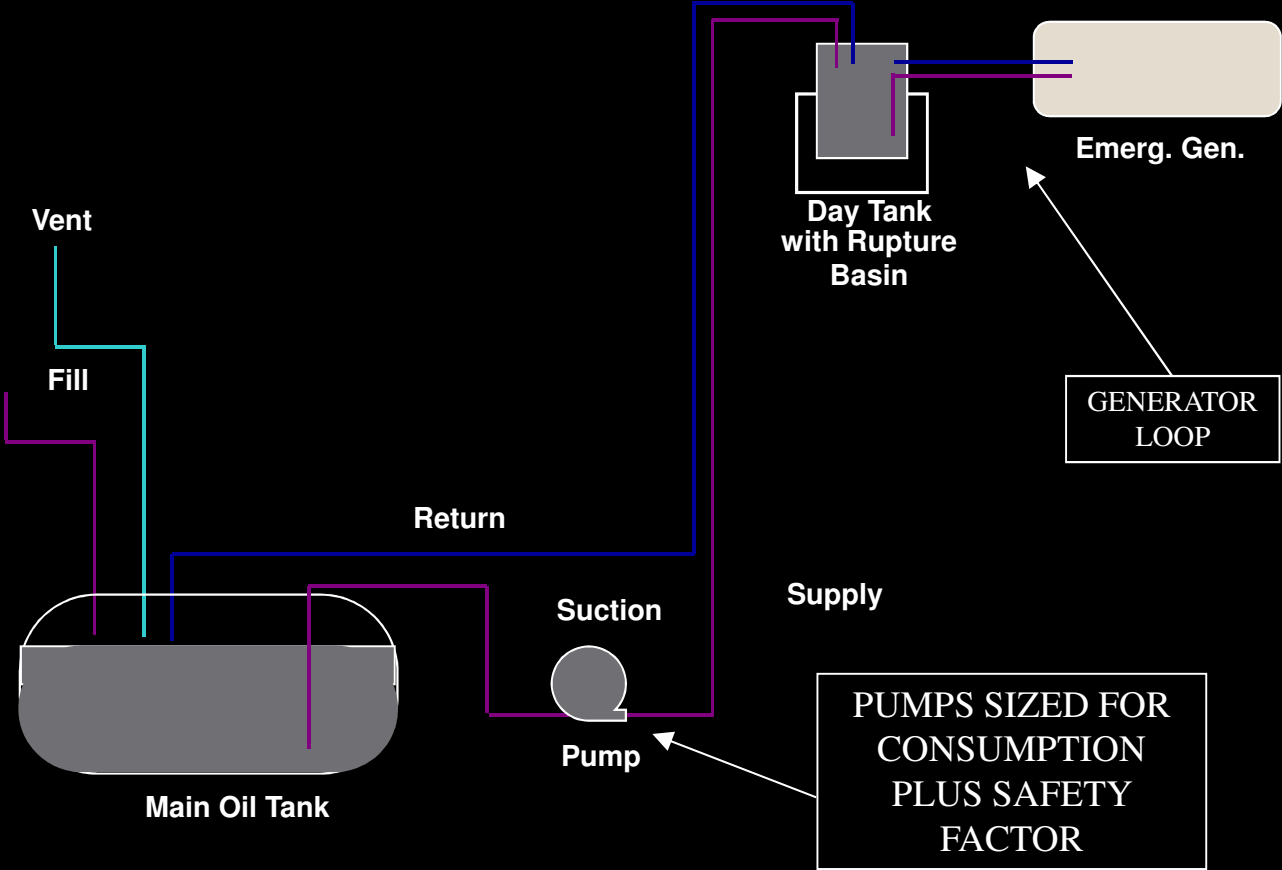
Submersible Pumps

- Low head; high volume
- Good up to about 5 floors, maximum
- No suction line
- No priming necessary; submerged impeller

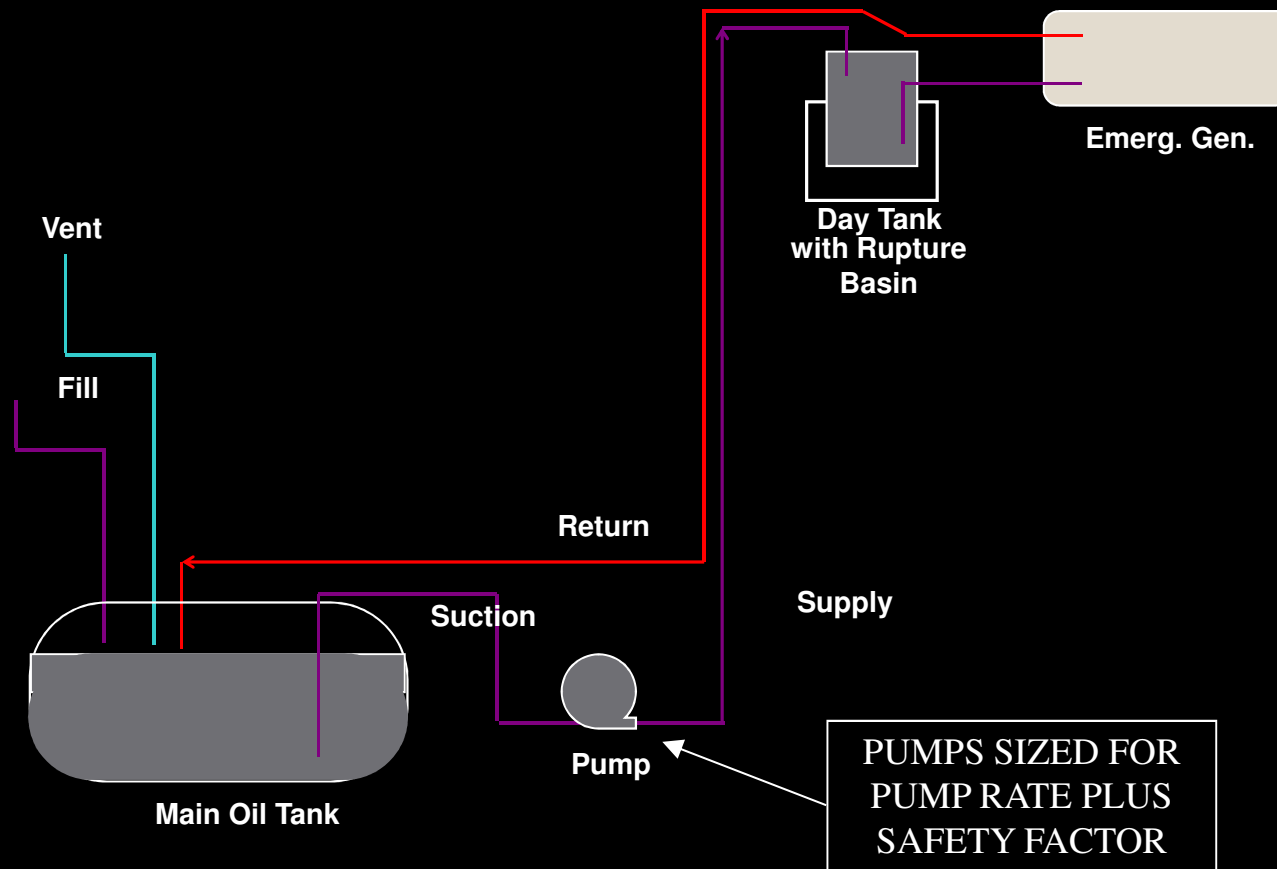
***Pump Sizing Rule of Thumb:
4:1 ratio, or pumps running 25% of the time***



TYPICAL PIPING ARRANGEMENT



ALTERNATE PIPING ARRANGEMENT



VALVES – MOST COMMON

- Foot Valves.....



- Overfill Prevention Valves.....

- Anti-Syphon Valves.....



- Solenoid Valves.....



- Ball Valves.....



- Check Valves.....



- Fire Safety Valves.....



VALVES – OTHERS

- Backpressure Regulating Valves.....



- Vacuum Breakers.....



- Pressure Relief Valves.....



- Pressure Reducing Valves.....



PLC CONTROLS

- Standard relay-based systems will generally shut down systems when a leak is detected.
- PLC-based systems can be programmed to run or not run based on multiple factors/variables.
- Example: If there is a leak detected in Tank Sump 1, and there is a call for fuel...issue an alarm, and do NOT run pumps. HOWEVER, if there is ALSO a generator-run signal...issue an alarm, and run the pumps.
- Complex sequences can also be programmed, and re-programmed.



ELIMINATE PROBLEMS BEFORE THEY HAPPEN

- Generator Flow versus Consumption
- Hot Regions
- Cold Regions
- Fuel Filtration

GEN FLOW VS. CONSUMPTION

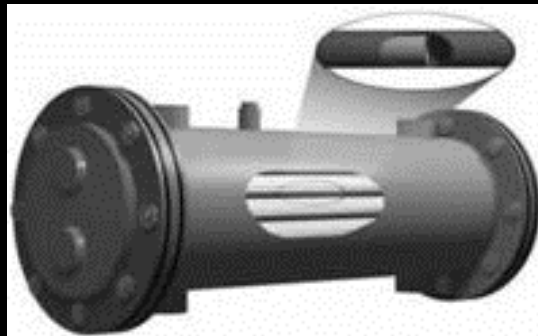
- Generators use a certain amount of fuel for internal cooling (of the fuel rails).
- Most of the fuel that the generators draw from the day tanks is not burned, but rather returned to the day tanks.
- A 2,000kW generator may consume (burn) about 140gph, but may flow 400gph.
- *Be sure to size piping between main storage tanks and day tanks to accommodate generator consumption.*
- *Be sure to size piping between day tank and generator to accommodate generator total flow (larger).*
- *If fuel is returned directly from gens to the main storage tanks (not day tanks), YOU MUST RE-SIZE ALL SUPPLY PIPING AND PUMPS TO MEET FLOW VOLUME.*

HOT AREAS

- As we know, when generators return fuel, in the absence of a fuel oil cooler, it will be returned hot.
- High ambient temperatures, combined with generator internal cooling, as well as generator fan/radiator cooling within the generator enclosure, can cause the day tank fuel temperature to increase.
- Recirculated fuel in the day tank could reach a temperature that may cause an automatic **generator shutdown**.
- *Use of Resistance Temperature Detector (RTD) probes in the day tanks can detect hot fuel, and activate/alternate supply and return pumps to “bounce” the fuel levels within the day tanks until enough cooler fuel from the main tanks has been exchanged to cool down the day tank fuel.*
- *Specifying double-contained pipe, and painting it a light/reflective color, can also assist in keeping fuel cool in hot outdoor areas.*

COLD AREAS

- In colder climates, cold fuel can create problems with proper filtration, pumping, or even combustion.
- Diesel #2 has a cloud point of about 32 degrees F.
- Gel point of diesel #2 is about 15 degrees F.
- *Use of in-tank heaters is a good idea in cold areas.*
- *Heat-trace can be used around the piping to keep fuel warm.*
- *Circulating fuel throughout the piping loop with a pump/heater combination system on a schedule, or thermostat, is also very effective, and guarantees that your system is functioning.*



FUEL FILTRATION

- Fuel filtration units, or “polishers” are critical pieces of the system.
- Typically installed in their own piping loops.
- Fully programmable, with dedicated PLCs.
- Multi-stage particulate filtration, and water-separation.
- Bacteria and fungus can live in the water, and feed on the fuel. They can clog the system and cause problems.
- *All fuel is taken from the BOTTOM of fuel tanks, because of the drop tubes. Since fuel is lighter than water, water gathers at the bottom of the fuel tanks, where the drop tubes are trying to draw fuel from. Generators don't run on water!*



PIPE SIZING

- Size the pipe diameter assuming that ALL day tanks are making calls for fuel simultaneously, so ALL supply valves will be open.
- Fuel flow must *exceed* consumption rating of ALL generators combined.
- Size the pipe so that velocity will not exceed 7 feet per second. Diesel fuel can foam, which can cause floats and other devices to deliver erroneous information.
- Different piping materials, valves, and fittings will all create friction and affect fuel velocity, and therefore, pipe sizing.
- Size return piping at least as large or larger than supply.
- **Rule of thumb for return piping: “One Size Up”**

SUCTION PIPING

- When using gear pumps, suction lift should be limited to 15" Hg vacuum or less.
- Typical piping [friction] loss is 5" Hg.
- This leaves 10" Hg for static lift, or 12' of oil.
- Thus, the pump should not be located more than 12' above the bottom of the tank.
- *Use PUMC Pipe Sizing program for Windows to determine pump inlet suction.*

VENT PIPING

- Vent requirements vary by project location.
- UL2085 AST's in California, when *outdoors*, require an operating vent with a piping termination 12 feet above relative grade, a primary emergency vent, and a secondary emergency vent, which can be vented at the top of the tank (no piping required).
- UL2085 AST's in California, when *indoors*, require three vents: *Operating, Emergency (primary tank), and Emergency (secondary tank)*.
- In some other locations, such as Washington State, the operating vent piping to the outdoors is required, but the emergency vents can be vented into the room.
- UST's in California require one vent per tank, terminating 12 feet above grade.
- DAY TANKS: California generally requires three vents: *Operating, Emergency (primary tank), and Emergency (secondary tank)*.
- PUMC day tanks generally only require two vents, operating and emergency (primary), because most have open rupture basins.
- Remember: Vent pipe diameter must be carefully calculated, and tall vertical risers must account for pressure variations. Ensure proper clearance from doors and windows, even if they're non-opening windows. Same rules apply for loading docks.

REMOTE FILL PORTS

- In-ground fill ports can be sumps, totally self-contained with spill bucket, hose fitting, and overfill alarm horn/light.
- In-ground fill ports can also consist of just a spill container and fitting, with an overfill alarm mounted somewhere nearby, aboveground.
- Aboveground fill ports can be free-standing, or flush or surface-mounted on a wall. These fill ports will require a delivery truck with a pump, so will also require the proper type of OPV.
- Remote fill ports are common on larger outdoor UL2085 storage tanks, especially cylindrical tanks.
- “Boosted” fill ports are common in high-rise buildings, and usually incorporate a centrifugal, spur-gear, or screw pump, to provide enough pressure to reach upper floors.



PUMC PIPE SIZING PROGRAM

- Can be uploaded to your network server.
- Can be installed by all staff (no licensing).

THANK YOU!

Thank you for attending.

Please call or e-mail us anytime with questions.

We are here to support you with design-assist,
spec-assist, problem-solving, etc.