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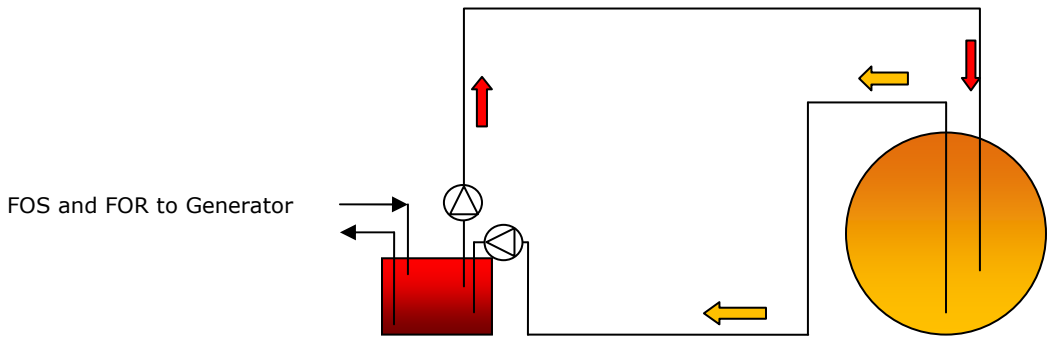
Technical Brief – Fuel system design considerations for critical power generation installations.

As generator fuel systems become larger and more complex, maintaining their reliability presents new challenges that should be carefully studied. Following are recommendations for several design areas that frequently go unnoticed:

Design Issue:
With above-ground fuel storage tanks and above grade day tanks, how is overflow fuel return ensured?

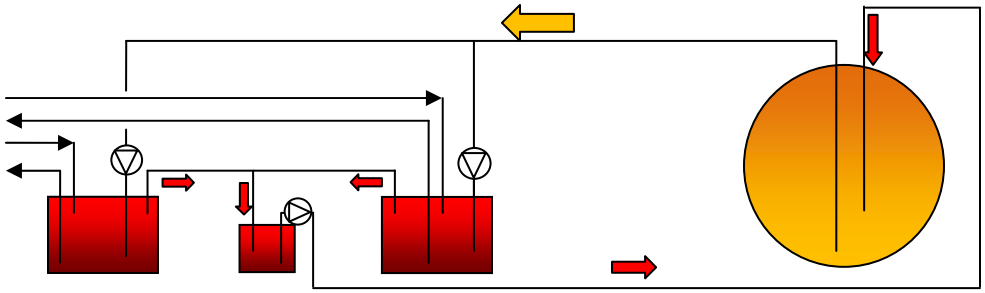
Background:
NFPA 37 (6.5.4, 6.5.4.1, 6.5.4.2) requires that any fuel tank filled by a pump be equipped with an overflow return line. Per NFPA, this overflow return line is to be routed back to the source tank, or to a collection system. When the day tank (freestanding or generator sub-base mounted) is served by an underground storage tank (below grade), the overflow return flow may be able to rely on gravity alone. But, when the source tank is above-ground and portions of the return piping are elevated beyond the height of the day tank, gravity will not be enough for excess fuel to find its way back to the source tank.

Solution #1: If the system involves a single day tank with a single source tank, the simplest solution is to specify that the day tank be equipped with an overflow return pump. Although NFPA does not specifically mention an overflow return pump, it should be clear to the designer that the intent of NFPA is to allow any overflow fuel to return to a source tank or collection system.



Solution #2: If there are multiple day tanks with a single source tank, an easier and less costly solution might be the specification of an "overflow fuel day tank", designed to receive overflow from any of the generator day tanks. This "overflow" day tank would be of relative small size, installed adjacent to the generator day tanks, and would be configured with a fuel return pump activated whenever fuel is present. For increased reliability, the overflow return tank can be specified with a duplex return pump assembly. Note that any overflow return pump must be sized to overcome the maximum (total) fuel flow rate feeding the day tank(s).

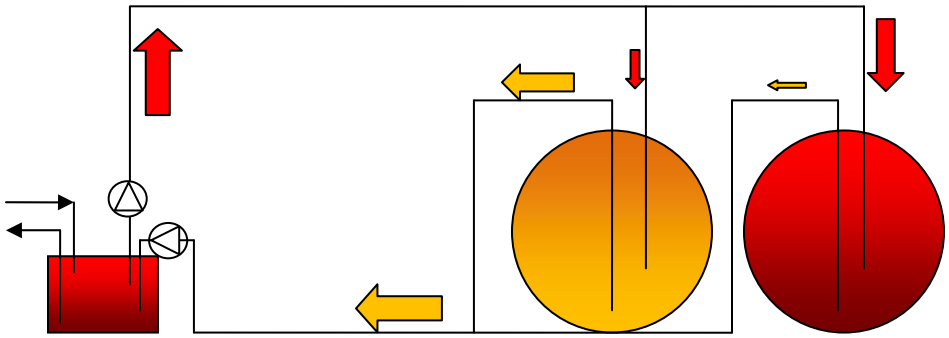
FOS and FOR to Generators



Design Issue:
Multiple day tanks are filled from multiple source tanks. How does one control which source tank receives potential overflow fuel returning from the day tanks?

Background:
This installation requires careful attention to ensure that any potential fuel overflow be returned back to the proper "source tank". For example, consider that day tank #1 requires fuel and its day tank-mounted fill pump begins to draw fuel from the common fuel supply manifold. Without any fuel flow controls, greater fuel flow may come from the nearest source tank, or that tank which provides the lowest resistance to fuel flow (see sketch below). Let's now imagine that day tank #1 goes into an overflow condition and begins returning fuel via the common fuel return manifold (which is connected to all source tanks). Will the return fuel be guaranteed to flow into AST#1, or could it flow into AST#2? What if AST#2 is nearly full?

FOS and FOR to Generator



Solution #1:
When the source tanks are not adjacent to each other, a "tank selection panel" might be required. This panel would select and control which fuel tank is used for fuel supply and also for any potential fuel return. The tank selection is accomplished via electrically-operated valves installed in each of the tank's supply and return connections. Although NFPA states that any return line "shall be free of valves or traps", there are also references in NFPA that require that fuel piping include necessary valves for proper fuel flow control during normal operation and emergency operation. It might be argued that the latter justifies the use of electrically-operated valves on return lines to control fuel flow and prevent tank overflow. If valves are used, they should be equipped with position indicators (limit switches) to positively identify whether they have acted as directed (when signaled to travel to the "open" position, a limit switch confirms travel to the open position, and viceversa). Any system control panel used in this application should incorporate these feedback signals into a failsafe logic scheme (failure of any valve to actuate as directed should immediately signal the condition and trigger backup procedures).

Solution #2:
When the source tanks are adjacent to each other, a simpler solution might be to

connect the fuel supply lines into a common manifold at the main tanks to create a siphoning effect between tanks. When a remote pump draws fuel through the common manifold, the siphon effect will equalize the fuel level between the tanks.

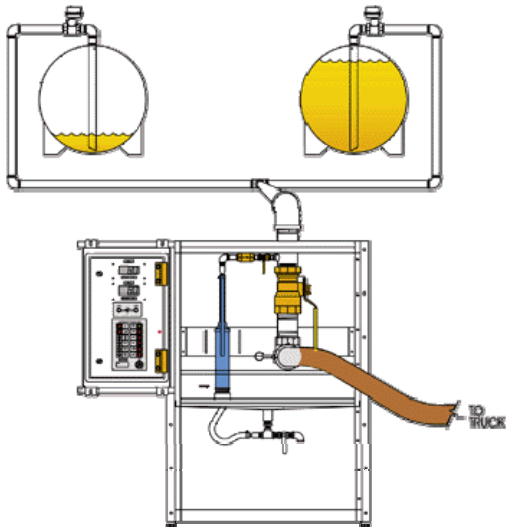
Design Issue:
Generator fuel tank filling requirements. Where are filling operations allowed?

Background:
This item prompts many questions. Here are some pertinent items:

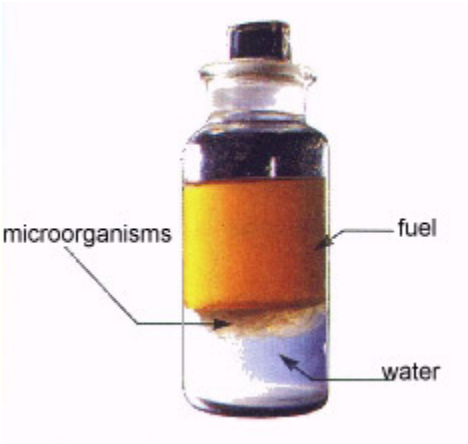
- NFPA 30 (21.7 & 21.7.1.6 through 21.7.1.6.2) requires that fuel tanks greater than 1320 gallons and that reach a height greater than 12 feet (including vent piping, fill piping, etc.), be equipped with means for controlling the filling operations.
- NFPA 37 (6.6.2) requires that engine-mounted Class II fuel tanks be filled by closed piping systems. Generator subbase diesel tanks ("belly tanks") appear to fall under this requirement.
- NFPA 37 (6.6.3.1) requires that a tank's fill pipe terminate outside the building at least 24" from any building opening.

Local jurisdictions' interpretations on these requirements vary, but most seem to rule that any filling must be performed outside of building structures. With this in mind, what is a safe method for filling of a tank, when the tank is not within sight of fuel delivery personnel?

Solution:
Automatic fuel fill stations are available to provide a single connection point for single or multi-tank filling. These systems also provide the operator with audible and visual indications when the tanks reach a "full level" condition. The key component of these systems is their ability to stop fuel fill operations automatically, upon sensing that the destination tank is nearing a full level. The typical automatic fuel fill station will also include spill containment and means to indicate a tank leak. Fuel fill stations are also available with built-in fuel transfer pumps to allow fuel offloading from trucks not equipped with on-board pumps, or those equipped with on-board pumps without sufficient capacity to reach the fuel tank (typically used with tanks installed above grade, parking garages, rooftops, etc.).



Design Issue:
How long can diesel fuel be stored? How does water get into diesel fuel and how do I prevent the problems that it can cause?



Background:
If you keep it clean, cool and dry, diesel fuel can be stored 6 months to 1 year without...(read more). Water gets into diesel fuel storage in several ways – by condensation of...(read more).

Solution:
With an understanding of the root causes for fuel contamination and degradation, you can design a system that allows for proper fuel storage. There are four main steps that summarize a well-planned design and maintenance program:

1. **Specify equipment to automatically remove water and sediment from the stored fuel**: Removing water and sediment regularly can be accomplished by filtering of the stored fuel through a series of water separators and media filters. Portable equipment can be contracted. However, for facilities with large fuel depots, we recommend stand-alone, permanently-installed automated filtration systems. When installing a permanent system, NFPA and UL standards should be followed. Fuel Technologies International's diesel fuel maintenance equipment is FM APPROVED and NFPA compliant (read more).

2. **Suggest to your client (and/or facility manager) that fuel quality tests be conducted annually**: two fuel samples should be drawn annually. One from the very bottom of the fuel tank, for visual inspection for free water and debris. The second sample from the supply line to the prime mover and sent to an accredited laboratory for testing for existing particulate and stability using ASTM Approved Test Methods.

3. **Suggest implementation of a microbial contamination elimination program (if contamination is ever present)**: A biocide (Kathon 1.5P is recommended) should be introduced to the fuel per the manufacturer's recommendation to control microbial growth within the diesel fuel storage tank. Kathon 1.5P is an EPA-registered biocide in all 50 States. More details here: http://www.fueltechnologiesinternational.com/kathon-fp15.html.

4. **Suggest treatment of the stored fuel for stability (if prolonged storage is anticipated)**: LTSA-35A is recommended as a chemical additive (treatment) that promotes diesel fuel stability. It is self-dispersing and does

not require costly injection systems for introduction to the stored fuel. More details here: http://www.fueltechnologiesinternational.com/ltsa-35a.html.

These guidelines and schematics are general in nature. For specific applications, please contact our office to review any options or accessories that might be needed to ensure a reliable and safe design for your fuel system. Additional resources related to generator fuel systems are available at http://www.hurtado.cc/resources.htm.