

An Engineering Guide to Modern Fuel Systems

This publication is intended as a resource for designers, installers, and system operators. In this document we highlight the typical indoor components and operational requirements of modern diesel fuel or fuel oil systems.

A Guide to Modern Fuel Systems

Table of Contents

Introduction.....	2
Heated returns from generators.....	3
Generator pump sizing and selection.....	5
Boiler system pump sizing and selection.....	6
Pump Types.....	8
Building fuel piping and fittings.....	12
Day tank sizing and selection.....	13
Care and storage of diesel fuel.....	17
Controls, monitoring and communications.....	20
Engineering data, generator equipment sizing.....	22
Engineering data, boiler equipment sizing.....	23
Engineering data, routine maintenance.....	24

Introduction

The focus of this guide is diesel fuel systems for emergency generators and other applications that require long term storage of diesel fuel (or fuel oil). We will discuss the portion of the fuel system that is found in the building. Storage tanks and buried piping will not be addressed.

Description of a modern diesel fuel system as a standby energy source.

The modern diesel fuel or fuel oil systems are used differently than systems designed a decade or more ago. In early fuel oil system designs, boilers were the primary user of the fuel. The fuel oil was a primary energy source used consistently throughout the year. With the advent of natural gas, the liquid fuels were replaced throughout most of the country as a primary energy source and relegated to stand-by status.

Natural gas systems in their early life were unreliable and insufficient for use throughout the entire year. The operators of large natural gas equipment would be required, usually during cold weather, to shift from burning natural gas to burning fuel oil. Systems designed during that time were sized with the intent that the fuel would be turned over several times throughout the year.

Today, the natural gas infrastructure is very reliable, if boilers do have a back up fuel oil system, they may operate on oil for brief periods each year, never consuming much fuel. On emergency generator systems, the fuel usage is typically no different. In both of these cases, the stored fuel may sit in the storage tanks for years at a time and will require special treatment to insure reliable operation when needed.

In this guide we specifically address several issues unique to diesel fuel systems supporting emergency generators. Many of the same issues will apply to boilers where very small amounts of oil are burned each year.

Diesel Fuel Properties

Besides providing chemical energy for the boiler or generator to convert, diesel fuel serves as a lubricant for the pumps and lubrication/cooling for the injectors of engine generators. When not maintained the fuel will degrade rapidly beyond the point of usability, especially for generator systems. The degradation process is accelerated by; moisture, heat, oxygen, and biological growth. Diesel fuel or #2 fuel oil is hydrophilic, it will attract moisture. Some of the moisture will settle out of the fuel to become free water. Removing the moisture and free water is key to maintaining the fuel.

Heated returns from generators

The diesel engines that powers modern generators are built with an integral onboard fuel pump. This pump will draw fuel from the day tank or fuel supply header and deliver it to the fuel injectors at the correct pressure. This pump moves more fuel than the generator will consume at any given load. The unused fuel is circulated through several components as a means of cooling them under varying loads. By design this unused fuel absorbs heat and, in most cases, this heated fuel is returned to the day tank

The temperature differential between the generator pump inlet and return to day tank may be less than 15°F. Though the initial rise in day tank temperatures is modest, the effects are cumulative and under certain load conditions the day tank temperature may approach critical levels. One consequence of the fuel heating up is that at a certain point the generator output will decline. A good rule of thumb is a 1% decrease in output per 10°F rise in fuel temperature above 100°F. Another consideration is that most generators now employ high fuel temperature cutouts, these switches typically activate, shutting down the generator at a fuel inlet temperature of around 150°- 160° F.

Since diesel fuel can have a flashpoint near 140°F, it is advisable to never let the fuel get this warm. Besides producing potentially explosive vapors, its stability can be so damaged the diesel fuel loses most of its lubricating properties. The fuel management and monitoring systems should maintain the fuel temperature below 130°F. Here are a few options available to designers to control diesel fuel temperatures in the system:

Option A – On board fuel cooler

Most large generator manufacturers provide an option to add a fuel cooler. This may be a section in the engines radiator or a separate on-board fuel cooler with its own fan. This is usually preferable when available.

Option B – Day tank fuel replacement

Specify a day tank temperature control option. This type of system is fairly simple, monitor the tank temperature, when it reaches a predetermined point, pump most of the fuel back to the storage tank and refill with relatively cool fuel from the storage tank. One advantage of this approach is that every time you replenish the tank, the pumping and control system is checked for proper operation.

Option C – External fuel cooler

External fuel coolers are typically used in situations where the cooler was not included in the initial design. These systems offer a cost effective retrofit provided there is enough physical space in the equipment room or adjacent outdoor area to accommodate the extra equipment. One limitation that must be accounted for with these arrangements is the ability of the generator's fuel pump to return the fuel. Any head pressure caused by piping layout or pressure drop through the cooler must be within the tolerances specified by the engine manufacturer.

Option D – Piped return to storage tank

An option that can work only under a few specific circumstances is returning the heated fuel back to the storage tank instead of the day tank. This arrangement requires the pump set to be sized to accommodate the added flow of fuel, including the fuel not being consumed by the engine. It would also require a much larger day tank to accommodate the same run time requirements.

Generator Pump Sizing

Pump sizing is typically straightforward. Calculate the total generator load, convert KWH to GPH fuel consumption then multiply by 4 to determine pump size. The factor of 4 is typical with the goal to provide a 15 minute fill cycle at full load for the pumps. This factor can be altered, especially in multi day tank applications as long as the designer is accounting for all of the variables.

The following table was developed to assist in sizing the transfer pumps for a generator fuel system. This table is not designed to replace proper engineering calculations in final system design. The fuel consumption is based on the rule of thumb that it takes about 7 gallons of #2 diesel fuel per hour to generate 100KW electrical power in a single generator.

Generator KWH each	GPH fully loaded each generator	Transfer pump flow for 1 generator	Transfer pump flow for 2 generators
100	7.0	28 gph	56 gph
125	8.8	35 gph	70 gph
150	10.5	42 gph	84 gph
175	12.3	49 gph	98 gph
200	14.0	56 gph	112 gph
250	17.5	70 gph	140 gph
300	21.0	84 gph	168 gph
350	24.5	98 gph	196 gph
400	28.0	112 gph	224 gph
450	31.5	126 gph	252 gph
500	35.0	140 gph	280 gph
600	42.0	168 gph	336 gph
700	49.0	196 gph	392 gph
800	56.0	224 gph	448 gph
900	63.0	252 gph	504 gph
1000	70.0	280 gph	560 gph
1250	87.5	350 gph	700 gph
1500	105.0	420 gph	840 gph
1750	122.5	490 gph	980 gph
2000	140.0	560 gph	1120 gph
2250	157.5	630 gph	1260 gph
2500	175.0	700 gph	1400 gph
3000	210.0	840 gph	1680 gph
3500	245.0	980 gph	1960 gph
4000	280.0	1120 gph	2240 gph

Boiler Systems Pump Selection

Typical modern boilers will fire natural gas as the primary fuel, with a percentage of these using #2 fuel oil as a backup fuel. A system designer should be aware of a couple of key points when involved with boiler fuel oil systems. 1) Most boilers firing fuel oil will have their own fuel oil pump. 2) This pump can typically handle a low suction pressure of 15”Hg without difficulty but a high suction pressure of over 3 psig can cause the failure of the pumps seals. This high pressure can be caused by a fuel transfer pump or the static head caused by an elevated (relative to boiler pump) supply system.

Low Suction Pressure Limit – 15”Hg High Suction Pressure Limit – 3 psig

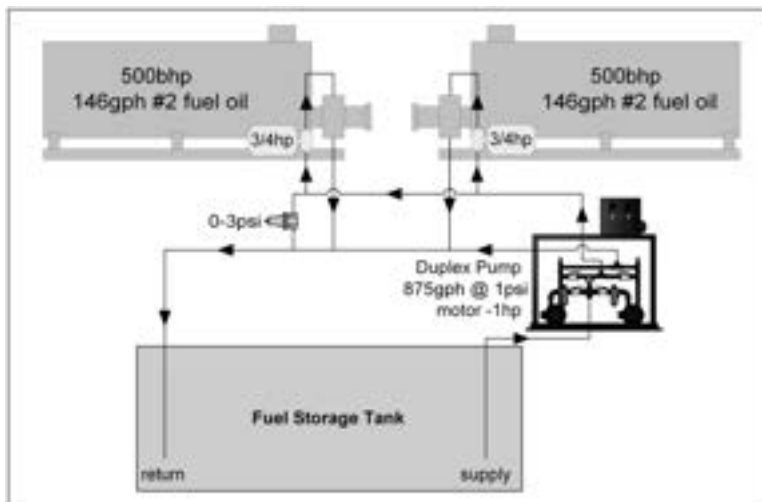
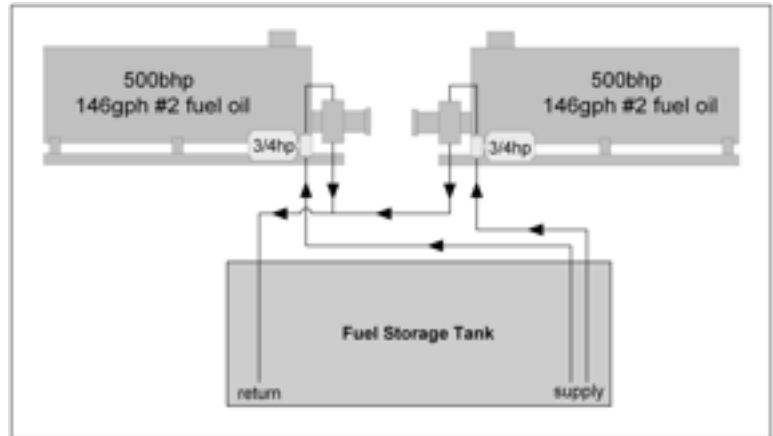
Simplifying the fuel system , reducing capital and operational costs is simple, the fuel systems for modern boilers have evolved in a way that more than 80% of new boilers that burn fuel oil are provided with their own on-board fuel oil pumps. If the onboard pumps have the ability to pump directly from the single storage tank this may be a very practical and efficient arrangement. In most systems this is not typical and a transfer pump is needed to pump oil out of the storage tank(s) and deliver to the boiler mounted pumps at a very low pressure. This transfer pump must be over sized by a factor of 1.5-2 to accommodate the extra flow required by the onboard pumps. Always check the flow of the fuel pump supplied by the manufacturer. On some boilers there can be a 5 to 10 times factor for the pump size compared with the burn rate. A simple solution is to do away with the boiler’s onboard pumps and increase the supply pressure from the transfer pumps.

This arrangement will eliminate the cost and electrical load of the boiler mounted pumps, reduce the electrical load of the transfer pump as well as reduce the required pipe sizing. The only cost adder may be a pressure regulator on the fuel supply pipe to each boiler. This cost is usually offset by the elimination of the burner pump and removes the single point of failure that the burner mounted pump introduces. This table was developed to assist in sizing the transfer pumps for a boiler fuel oil system. This table is not designed to replace proper engineering calculations in final system design. The fuel consumption is based on a typical firetube boiler firing 140,000btu/g #2 fuel oil.

Boiler HP	#2 Fuel Usage	Transfer Pump Flow
100	30.0 gph	60.0 gph
125	37.5 gph	75.0 gph
150	45.0 gph	90.0 gph
200	60.0 gph	120.0 gph
250	75.0 gph	150.0 gph
300	90.0 gph	180.0 gph
400	120.0 gph	240.0 gph
500	150.0 gph	300.0 gph
600	180.0 gph	360.0 gph
700	210.0 gph	420.0 gph
800	240.0 gph	480.0 gph
900	270.0 gph	540.0 gph
1000	300.0 gph	600.0 gph

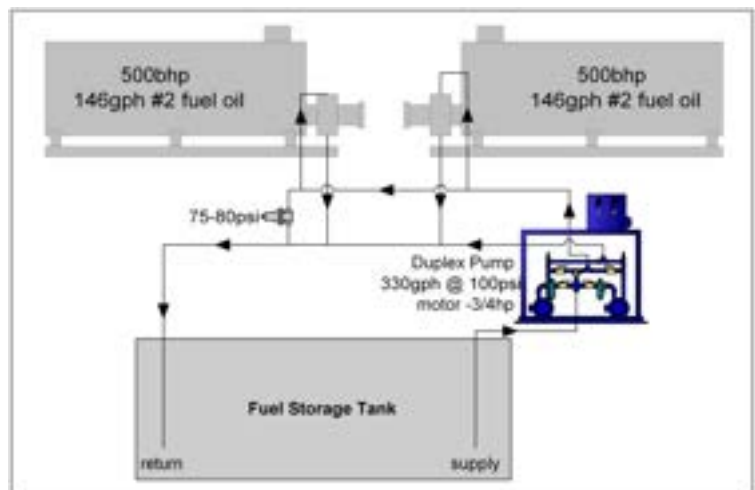
Boiler Systems Pump Selection

This arrangement will work fine, in most cases, as long as the pump suction does not exceed 15”Hg. This arrangement is not recommended for multiple storage tanks.



When the suction pressure is too much for the boiler mounted pumps or when multiple storage tanks are required this has been the traditional arrangement.

By eliminating the boiler mounted pumps the overall electrical load and equipment cost can be reduced.



Pump Types

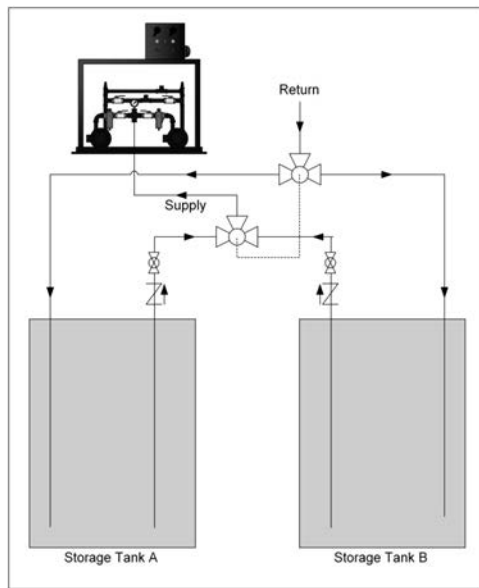
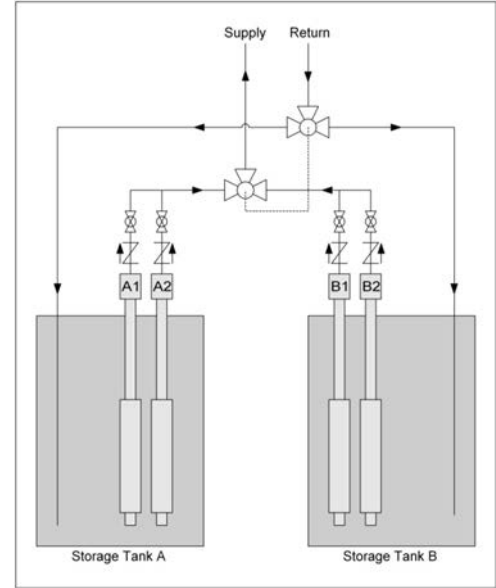
Suction pumps or pressure (submersible) pumps? Choosing between a submersible pump and a suction type pump set is fairly easy. A suction type pump set is almost always the best choice when accounting for ease of operation and maintenance. The primary point when considering locating a suction pump set is the location relative to the vertical distance between the bottom of the storage tank to the actual pump suction. If this lift (plus the pressure drop through piping, valves and fittings) exceeds the 15”Hg capacity of a suction pump then the design engineer has no other option than to specify a submersible pump. Other key points of consideration in the installation of a suction pump are the availability of space and facility lay-out.

After the designer has determined the required pumping capacity the next choice to make is the pump type. The design engineer has the choice of two different general types of pumps to transfer fuel from the storage tank to the day tanks or piping systems. The two types are; 1) suction systems, built with positive displacement pump sets, or 2) pressure pump systems which are submersible pumps installed in the diesel fuel storage tanks.

If the system is going to have any underground piping note that the EPA has requirements for leak testing of buried piping. Pressurized piping systems have a much more stringent requirement for testing than suction type systems. In fact, if the suction type system piping; 1) is installed with enough slope back to the storage tank to complete drainage after the pump shuts off, and 2) the only check valve installed is installed close to the pump, then no leak detection system is required for the piping. All other systems are required to employ monitoring systems and line tightness testing on a periodic basis.

The following drawings show the suction and pressure pump sets in multiple tank applications with full redundancy. In order to have redundant pumping ability with each storage tank a pressure pump system requires 2 pumps in each storage tank. Notice in both drawings that the supply and returns are piped into a common tank selection valve.

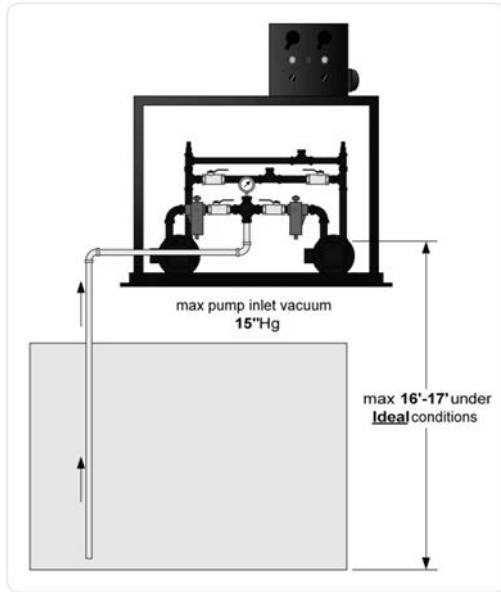
Pressure Pumps are completely submerged in the fuel with the pump inlet at a minimum of 6" from the bottom of the tank. Full redundancy requires the use of 2 pumps in each tank. Typically, each pump will require a separate piping sump when the tanks are buried. This is to allow clearance to install and remove the pump.



Suction Type Pump sets may be constructed using multiple pump arrangements. The typical pump set is a duplex type which should be specified to mean two pumps, each sized to meet the entire system flow requirements with the other being fully redundant.

Suction Pump Construction. Pump seals should be mechanical, self adjusting seals that permit no leakage under normal conditions. Packing type pump seals are normally not permitted for use with flammable liquids. The following features are typically standard for diesel fuel applications:

- Cast or forged steel construction, bronze or other soft metals not allowed.
- Suction strainer with mesh basket
- Flow proving switch
- Black steel piping, threaded 1"NPT or smaller, welded 1.25"NPT and larger.
- Pumps mounted on base that serves as a leak reservoir.



The 15”Hg limit is a hard limit. If flow calculations (including line and fitting losses) approach 15”hg, the designer should consider making changes to the system such as relocating the pump set to improve suction pressure.

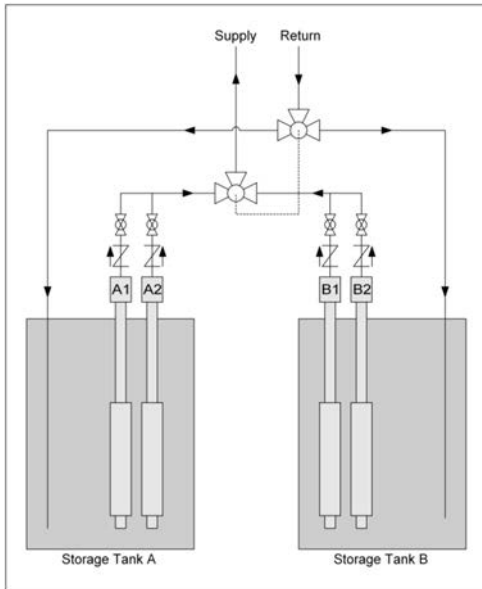
Tank Selection method is a crucial aspect of design that can mitigate the risk of spilling fuel due to one of the most common causes of spills in modern installations, valve misalignment.

Manual – Individual supply and return valves aligned by operator. This arrangement does not meet the requirement by NFPA 30 that prohibits a shut-off valve in the return back to the tank. With this arrangements the danger of a misalignment are high, resulting in release of fuel into the environment.

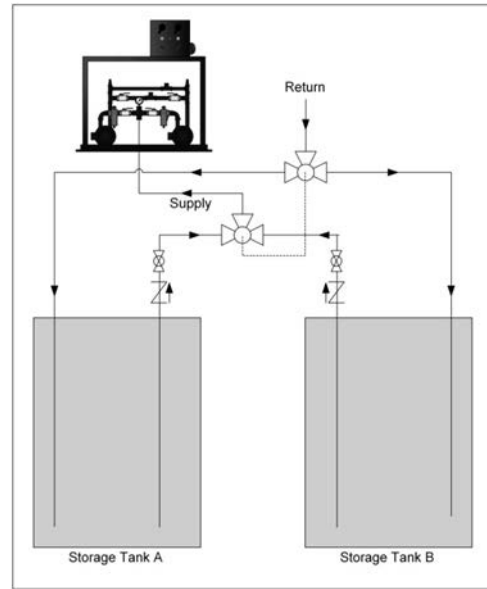
Manual Safe – The use of a multiport, tank selector valve is a safe way of designing the fuel tank selection for two storage tank applications. These valves are typically plug valves built with 6 ports that force the operator to choose one tank or the other. When properly piped it will not allow misalignment of the supply and return since the selection ports are either on a common shaft or cast into a common plug. Other “manual safe” arrangements would incorporate position switches installed on all manual supply and return valves, preventing the pumps from starting if; a) one return valve is not proven full open and all others proven closed, b) the corresponding supply valve is not proven opened and all others proven closed.

Semi Automatic – Semi Automatic selection is accomplished by operator selection through an electronic control system. The operator chooses which tank to place in service through the controller. The controller then aligns the return and supply valves. Systems with only two storage tanks should use a motorized, multiport tank selection valve. Larger systems would use motorized valves, rated for use with oil, with position indicator switches to prove correct alignment before the pumps are permitted to start.

Automatic – In full automatic systems the storage tanks are monitored by the controller and selection is based on the logic in the processor. The valving would be the same as the semi automatic selection.



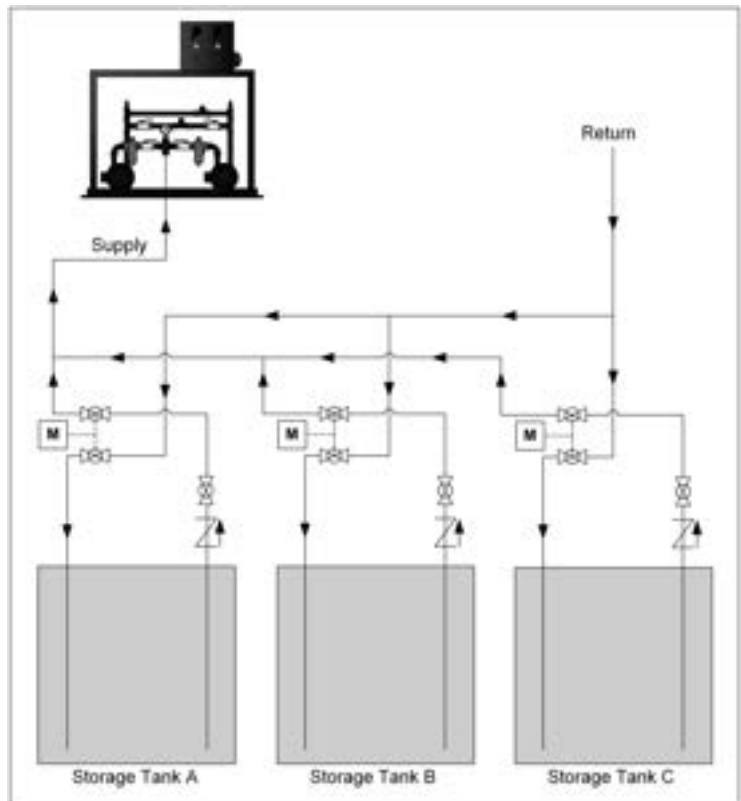
Pressure (submersible) Pumps



Suction Pumps

Systems that have more than two storage tanks involved presents some unique design challenges. Any multi-storage tank system should meet the following conditions:

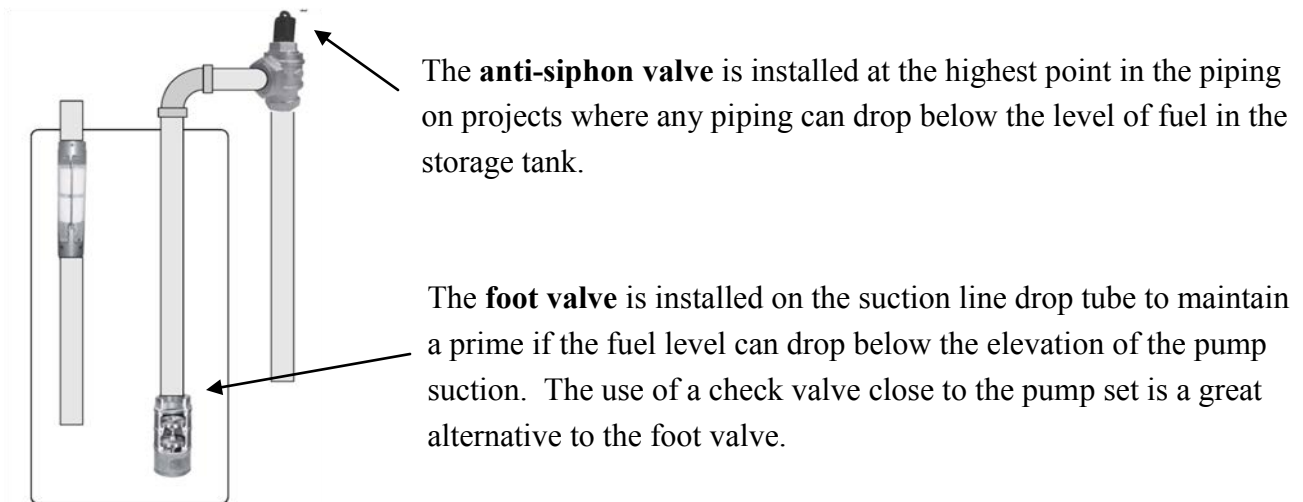
- Mechanically or electrically link the supply and return valves for each tank to prevent misalignment.
- Equip the valve assemblies with position proving switches and tie into pump controller to keep pump offline until only one tank valve assembly is open.
- Provide for manual operation of automated systems in emergencies.



Building Fuel Piping and Fittings

Foot Valves are designed to maintain a prime in suction pump systems where the pumps are installed at a higher elevation than the fuel level in the storage tanks. Foot valves and anti siphon valves have significant pressure drops.

Anti - Siphon Valves will, when properly sized and installed, prevent the free flow of oil from the storage tanks through a break in the fuel piping. Anti-siphon devices are required by NFPA when the fuel piping, at any point, drops below the level of fuel in the storage tanks.



Fire Safe Valves are typically required when fuel piping enters the building or passes through a fire rated wall. These valves will normally utilize a fusible link or disk with a spring powered shut-off element. It is recommended that in mission critical and critical care facilities these valves are monitored by the control system. This is accomplished with the aid of electric position switches integrated into the shut off valves. For “fail safe” operation these switches, should be opened when the valve is closed.



A modern firesafe shut-off valve

Modern fire safe valves have all of these necessary components integrated into the valve, simplifying installation and operation. Early versions of these valves were simply spring loaded, lever operated, gate valves. The levers were held in the open position by a cable fastened to a wall or fixture through a fusible link. When the heat melts the link, the spring will slam the valve shut. The position switches for these valves are installed on a bracket affixed to or near the valve. The lever would “chop” through the switch actuator, closing the contact.

Day tanks

Day tanks are required in most generator applications. Day tanks are only used in boiler systems to solve specific job site conditions. The following tanks are readily available throughout the marketplace:

Independent Day Tanks are day tanks manufactured and installed separately from the generator. This type of design offers more flexibility in design and sizes than the generator mounted belly tanks.

Single wall day tanks with tub type rupture basins have been standard in the industry for decades. The rupture basin is usually sized for 160% of the capacity of the day tank.



Double wall day tanks are completely contained. This allows total containment of system fluid, under pressure in the event of a primary vessel failure.

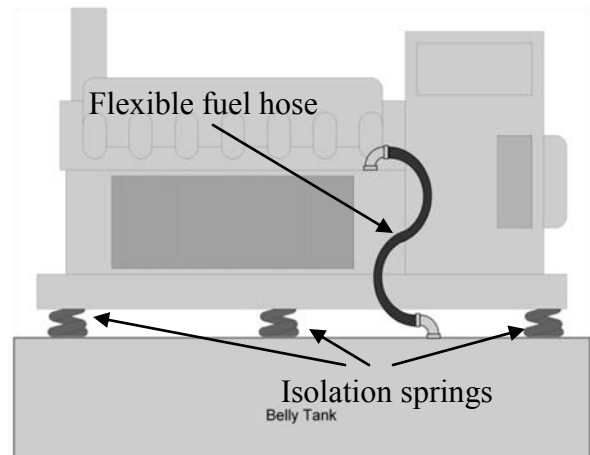
Single wall day tanks are available with or without a rupture basin. Most jurisdictions do not allow the installation of this type of tank except in very specific circumstances.

Generator Base (belly) Tanks

The generator and engine will sit right on top of the belly tank. Because of the tremendous amount of vibration created by the engine, care must be taken to ensure that belly tank is isolated, as much as possible from the genset. This is done by placing springs between the genset and the base tank and using flexible hose connections to feed fuel to the engine. Even with this isolation the belly tank may still be subjected significant vibrations.

The belly tank is built as a structural component to not only withstand the vibration but also the entire weight of the engine generator. The instrumentation installed in the base tank should be hardened against high vibration and inspected regularly for proper operation and structural integrity. The generator belly tanks must meet the same requirements as independent day tanks, be UL 142 listed and provide containment.

Not only does the generator have to be isolated from the belly tank, the associated instrumentation should be hardened against vibration.



Day Tank Instrumentation usually consists of a visual tank gauge or level indicator, a multi-point float type level switch, and float type leak detector switches. Level transmitters are normally not used for these applications.



A 3-point float switch similar to what is used for monitoring and controlling day tank levels.

A visual tank level indicator is an option that is usually requested on day tanks.

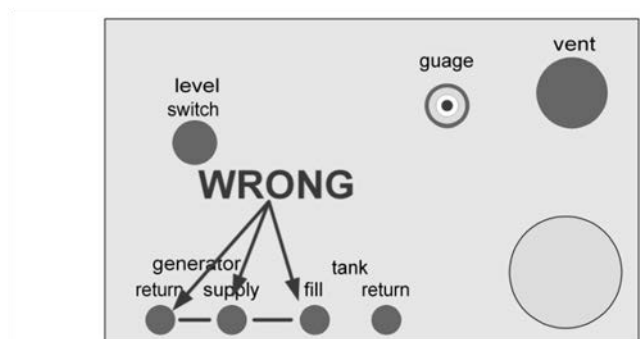
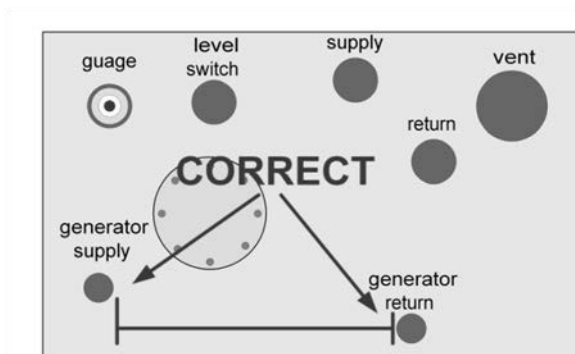


Day Tank Sizing and Selection

When sizing a day tank one must consider several factors. The first consideration is the amount of generator run time desired from each day tank. The generator is going to consume around 7 gph per 100KWH. So for 3 hour run time the calculation is $KWH \times .07 = GPH \times 3\text{hours} = \text{day tank size}$. This number is often arbitrary and should not necessarily define the project scope. Other less subjective considerations are actual space requirements and code issues that may limit the amount of flammable liquid allowed to be stored in the building. In some jurisdictions the amount of flammable liquid permitted to be stored in the space is severely limited and will restrict the size and number of the day tanks.

Day tank construction should be such to permit access to all ports and minimize the chance of leakage into the environment. All tappings (except drain) should be on the top of the tank. All fuel flowing into the tank should enter the tank through drop tubes, these fittings should be located as far away from the generator supply fittings as possible (see illustration) to limit the possibility of foaming into generator supply line.

Multiple pieces of equipment may draw from a common day tank provided that meets with equipment manufacturer's recommendations. In these applications each equipment supply pump must have its own suction line with drop tube, multiple pumps cannot share a suction line without inviting suction problems. The equipment may share a common return provided it's properly sized and meets with the manufacturer's approval.



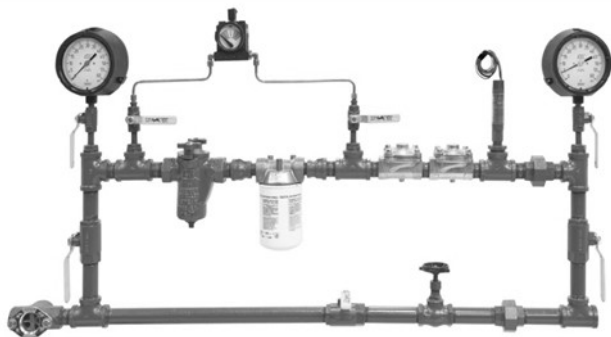
Day Tank Return Pumps

Return pumps serve a few different purposes, the first is to provide a means to lower the level of the day tank during start-up and periodic testing. The second reason one would install a day tank with return pumps would be to provide for fresh fuel with relatively cool fuel from the storage tank. The third and final primary purpose of including a return pump is to empty the day tank in the emergency. The return pump should be sized to empty the day tank faster than the tank will fill under normal operation.



This is a fully contained, double wall day tank with a single return pump and motor control panel installed on the day tank.

Day Tank Fill Manifolds Accurate control of fuel flow into the day tanks will allow the system designer to optimize pump and piping size. This is especially true when the day tank is provided with a return pump.



A proper fill control manifold should be comprised of the following:

- bypass valves
- 2 automated valves
- strainer to protect valves
- Flow limiting orifice

Care of Diesel Fuel

Designers of modern diesel fuel systems must take into account that the fuel is going to be sitting in the storage tanks for a long period of time. This is because the primary use of this fuel is as a standby energy source for emergency power. As diesel fuel sits it will break down.

The University of Idaho conducted a study to determine the life expectancy of stored diesel fuel. The study shows that untreated diesel fuel quality, under normal conditions, can degrade more than 26% in a single month, the degradation is quantified through a series of ASTM defined tests . The degradation process will be accelerated by the following factors:

- Water
- Temperature extremes
- Oxygen
- Biologicals

Water is the enemy of diesel fuel, it is left over from the refining process and delivered to the storage tanks. New water enters, as vapor, through the atmospheric tank vents and condenses on the walls of the storage tank, collecting at the bottom of the storage tank, water is even generated in the storage tank. A biological growth that occurs in the tank at the fuel/water line will produce water as waste.

At the fuel/water line in a storage tank one could find more than two dozen different species of microbial life feeding on the fuel, producing more water and growing to form a filter clogging mat. This contamination will take your generator or boiler down cold.

Filtration Systems

Filtration is the foundation of a fuel maintenance program. This is where water and particulate contamination is removed from the storage tank. The process utilizes multiple stages of filtration for particle removal, a coalescing stage for water removal, a pump to circulate the fuel, and tank selection valves.



Filtrations sets regardless of physical layout should have a minimum of these components.

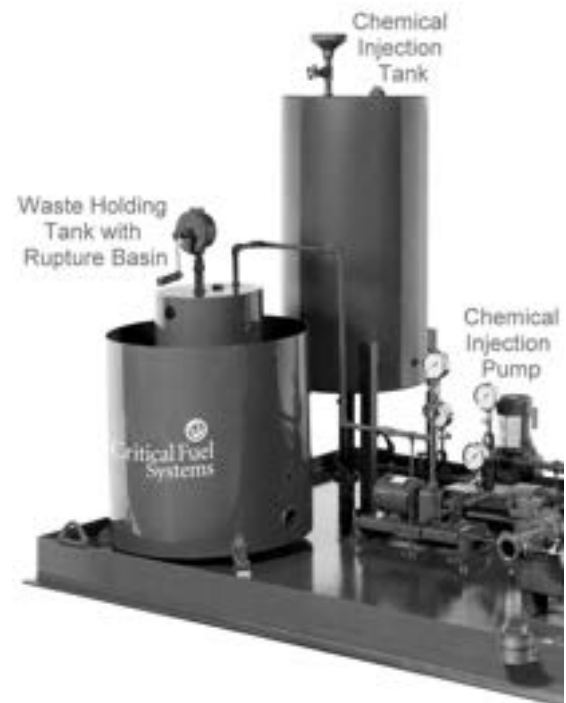
- Strainer
- Circulation Pump
- Water Separator
- Final Filtration

Waste Holding and Chemical Injection

The purpose of the filtration module is to remove water and waste. Without this module operators may be required to empty the small reservoir several times during the filtration run cycle. By choosing the waste holding option you can reduce these nuisance maintenance issues.

The chemical injection module provides a way to automate the treatment of your fuel oil. The system can automatically inject biocides, cetane boosters and stabilizers into the fuel to dramatically extend its shelf life and improve the reliability of your generator or boiler system.

10,000 gallons of clean diesel fuel can contain up to 5 gallons of water, dirty fuel or fuel tanks can have much more. The small reservoirs on the bottom of the water separators may hold less than a cup. A waste holding tank and automated purge option can be invaluable in system operation and reliability.



Filtration System Options

Manufacturers should offer options such as tank selection manifolds to make the installation and operation of these systems easier. Options such as fine polishing filters or centrifugal separators can be added to meet more stringent job site conditions.

Control Options

You may have several options for controlling the maintenance and filtration system. The options include; a dedicated controller, typically based on a microprocessor with a touch screen operator interface. Another option is to integrate the filtration control into the total fuel system management controller. A rarely used or recommended option is a simple manual set up.

Sizing and Selection of a Fuel Maintenance System

Sizing the fuel maintenance has been a point question on most projects. The following is intended to providing some guidelines in what's needed. The points requiring consideration are:

- Tank cycle time/filtration flow rate
- Particulate filtration effectiveness
- Additive storage

Tank Cycle Times/Filtration Flow Rates

Tank size	Hours per Filtration Cycle					
	4	8	10	12	18	24
5,000	1,250	625	500	417	278	208
10,000	2,500	1,250	1,000	833	556	417
15,000	3,750	1,875	1,500	1,250	833	625
20,000	5,000	2,500	2,000	1,667	1,111	833
25,000	6,250	3,125	2,500	2,083	1,389	1,042
30,000	7,500	3,750	3,000	2,500	1,667	1,250
40,000	10,000	5,000	4,000	3,333	2,222	1,667
50,000	12,500	6,250	5,000	4,167	2,778	2,083
Gallons per Hour Filtration Flow Rate						

Additive Storage Estimates

Tank size	Biocide	Stabilizers	Total
5,000	1.0	2.5	3.5
10,000	2.0	5.0	7.0
15,000	3.0	7.5	10.5
20,000	4.0	10.0	14.0
25,000	5.0	12.5	17.5
30,000	6.0	15.0	21.0
40,000	8.0	20.0	28.0
50,000	10.0	25.0	35.0
This is not a dosage chart! It is intended only to assist designers in determine sizing of additive storage tank!			

Tank should be treated upon receipt of new fuel load and when tests determine the necessity.

Controls, Monitoring and Communications

Fuel system controls and monitoring systems can be broken down into two separate systems. The first is the tank gauging system. The other is the fuel system controller. A key to successful plant operation is to ensure these systems are able to integrate together and communicate with the building management system.

EPA Certified (Compliant) Tank Gauging and Leak Detection Systems are a necessity when a release of fuel into the environment must be detected immediately, the cost of these compliant systems are comparable to non-compliant systems. The purpose of these systems is to provide accurate inventory control and monitor the tank and piping systems for leakage. With the compliant systems a certified third party will not only review the hardware, they review the internal logic as well to ensure that the system meets the stringent operational requirements set forth by the Environmental Protection Agency for leak detection. In non-compliant systems the hardware and panel construction is usually listed with a listing organization, indication that the assembly is electrically sound but no third party review is ever made of the actual operation or logic functions.

These are the basic components found on compliant tank gauging and leak detection systems:

- Console
- Level Probes
- Leak detector Sensors

Leak Detection

These are dedicated monitoring systems purpose built for tank level monitoring and leak detection. The EPA maintains a list of compliant systems on their website here is the link; http://www.epa.gov/swerust1/pubs/atg_0900.pdf . Several options are available as to the type of leak detector and when to apply which type. The EPA does a good job of explaining these options in their 35 page document, “Straight Talk on Tanks” found at; http://www.epa.gov/oust/pubs/STOT05_Rev4-6-09.pdf .



“Make sure the vendor of the leak detection method you use has provided you with evidence that your leak detection meets regulatory requirements for performance.” EPA’s Straight Talk on Tanks publication.

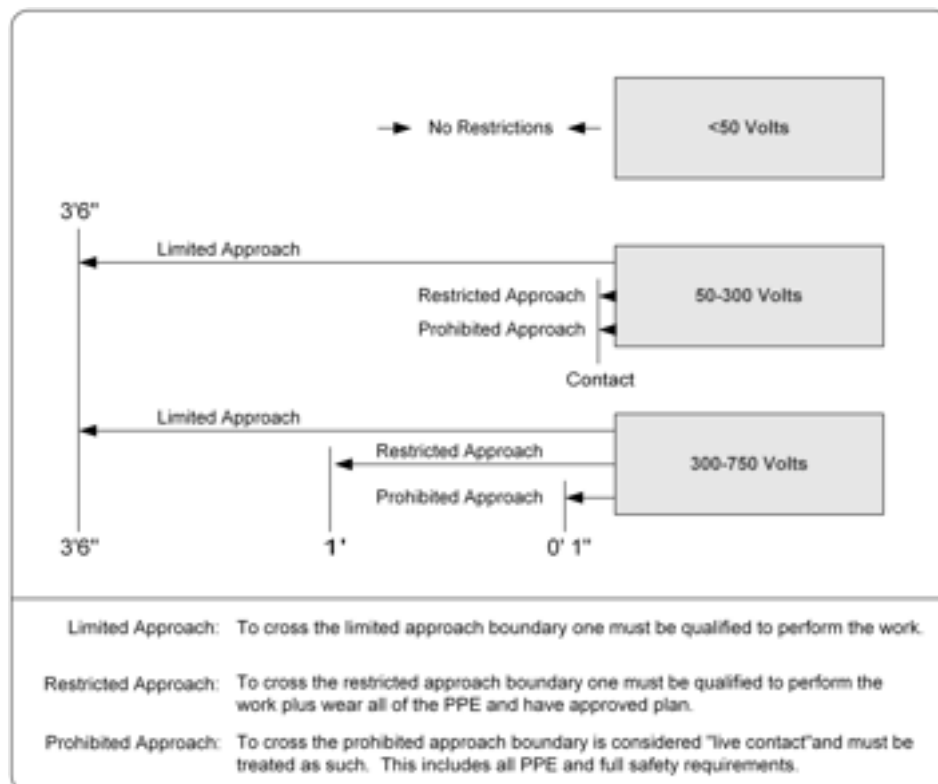
Fuel System Controls

The Control systems come in a variety of forms and functions, due to the wide variety of fuel systems designs there is simply no single best system design. The broader points that warrant attention in specifying these systems are, using nonproprietary components that are widely available. Since these systems are mostly used in emergency situations they don't get much wear so the useful life of the hardware may be decades. So it is important that the supplier have both a long history and will be around to support the equipment.

Communications are another important feature when considering control hardware. Often, when a system specification is being written and the project is being bid, the building management system vendor has not been chosen, so the communication protocol required is unknown. The fuel system control manufacturer should be required to provide flexibility in the choice of communication protocols without an impact in design or cost.

NFPA 70e 2009– Electrical safety in the workplace

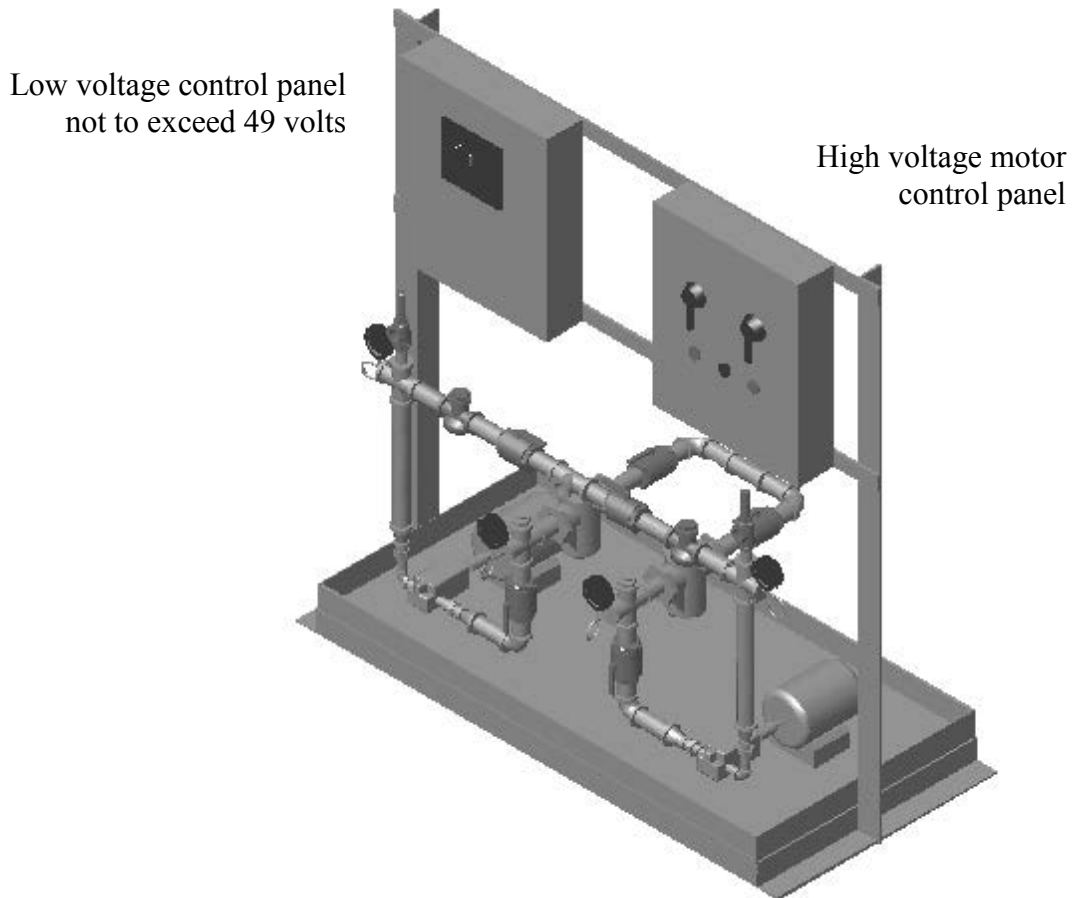
This standard is not intended to regulate the design of equipment but to provide workplace standards to increase safety for those that work around and/or with electrical equipment. By paying attention to standards such as these equipment manufacturers have the opportunity to design products that are safer to operate and maintain, reducing the administrative costs and efforts for the end users.



Safe Design

Industrial equipment controls should be designed with the knowledge that the panel is going to be opened for various evolutions, some of which require that panel to be live at the time. Start up technicians and maintenance personnel often have to access the panel while it's energized to check various circuits, limits and switches for proper voltage and continuity. This can be done safely and legally if the design is correct. Most systems are going to be comprised of high and low voltages.

The solution is to specify that the controller and all associated circuits be low voltage, not to exceed 49 volts, and built into their own UL508 listed industrial control panel. The high voltage motor starters, transformers and disconnects be contained in a separate UL508 listed industrial control panel.



Engineering Data—Generator Equipment Sizing

Generator Fuel Transfer Pump Selection Table

Generator KWH each	GPH fully loaded each generator	Transfer pump flow for 1 generator	Transfer pump flow for 2 generators
100	7.0	28 gph	56 gph
125	8.8	35 gph	70 gph
150	10.5	42 gph	84 gph
175	12.3	49 gph	98 gph
200	14.0	56 gph	112 gph
250	17.5	70 gph	140 gph
300	21.0	84 gph	168 gph
350	24.5	98 gph	196 gph
400	28.0	112 gph	224 gph
450	31.5	126 gph	252 gph
500	35.0	140 gph	280 gph
600	42.0	168 gph	336 gph
700	49.0	196 gph	392 gph
800	56.0	224 gph	448 gph
900	63.0	252 gph	504 gph
1000	70.0	280 gph	560 gph
1250	87.5	350 gph	700 gph
1500	105.0	420 gph	840 gph
1750	122.5	490 gph	980 gph
2000	140.0	560 gph	1120 gph
2250	157.5	630 gph	1260 gph
2500	175.0	700 gph	1400 gph
3000	210.0	840 gph	1680 gph
3500	245.0	980 gph	1960 gph
4000	280.0	1120 gph	2240 gph

**Generator fuel transfer pump is based on:
 .07 gallons diesel fuel consumed per KWH generated
 or
 7gph per 100KWH generated**

Rule of thumb—the transfer rate should be sized at a factor of 4 to provide an acceptable transfer rate

Engineering Data—Boiler Equipment Sizing

Boiler Fuel Pump Selection Table

Boiler HP	#2 Fuel Usage	Transfer Pump Flow
100	30.0 gph	60.0 gph
125	37.5 gph	75.0 gph
150	45.0 gph	90.0 gph
200	60.0 gph	120.0 gph
250	75.0 gph	150.0 gph
300	90.0 gph	180.0 gph
400	120.0 gph	240.0 gph
500	150.0 gph	300.0 gph
600	180.0 gph	360.0 gph
700	210.0 gph	420.0 gph
800	240.0 gph	480.0 gph
900	270.0 gph	540.0 gph
1000	300.0 gph	600.0 gph

**Boiler fuel transfer pump is based on:
 .3 gallons of #2 fuel consumed per boiler horsepower (BHP)
 or
 30gph per 100BHP**

Rule of thumb—the transfer rate should be sized at a factor of 1.5 –2.0 to provide an acceptable transfer rate

Engineering Data—Routine Maintenance

Diesel fuel system routine maintenance.

This maintenance guide takes into consideration the recommendations of NFPA 110 and industry experience. It is not intended to replace manufacturers maintenance requirements or recommendations but to provide design engineers, operations personnel and installing contractors an idea of the regular maintenance typically required by these mission critical and critical care facilities. Refer to manufacturers operation manuals for specific information on performing routine maintenance.

Weekly

- Check Day tank level
- Check Storage tank(s) level
- Check Storage tanks for water
- Test..... Day tank level switches
- Test System pump operation
- Test..... Fill manifolds

Monthly

- Inspect/replace Hoses and flexible connectors
- Test..... Control, pump, and monitoring systems

Quarterly

- Inspect/clean Transfer pump strainers
- Inspect/clean Fill manifolds, strainers, and filters

Semi Annually

- Inspect/clean Day tank vents and vent caps
- Inspect/clean Storage tank vents and vent caps
- Test/treat Storage tank diesel fuel
- Test..... All system leak detectors

Annually

- Inspect/test Entire piping system



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