Your Questions Answered (26)
Fuel System Control and Monitoring

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10.01 What are the control requirements for duplex pump systems?

Duplex pumps operate so that failure of one pump is monitored and activates the second pump. A secondary aspect of the controls is to alternate operation to test performance and equalize wear on pump units.

The controller monitors the following aspect of the pumps: (a) position of pump selector switch for Not-in-Auto, (b) current sensor for pump On / Off condition, (c) pump motor starter overload condition, (d) pump flow or pressure, (e) pump inlet vacuum and outlet pressure, (f) pump set leak sensor, (g) pump run hours.

Pump controllers can be set for any of the following common operating modes:

1. Lead / Lag (Primary / Secondary): The lead (primary) pump is selected by the user and the lag (secondary pump operates when a failure of the primary pump is detected.
2. Alternating: Operates per Lead / Lag (Primary / Secondary) except that the operating pump and lead / lag status alternate on consecutive starts. A variation is to alternate the pumps based on the operating time (hour meter) of the lead pump.
3. Twin: Both pumps start when there is a fuel requirement.

10.02 What are the control requirements for tank fill systems?

Tank fill controllers provide information on tank levels, monitor high level alarm conditions, and operate actuated valves in tank fill piping that are used for multi-tank selection and high level shutoff. Valve positions are monitored using limit switch inputs to the controller.

Simple controllers will monitor high level switches in the tanks typically 85% high warning, 90% high alarm, and 95% critical high alarm. Level transmitters can also be integrated to provide a gallons or % fill display at the fill station.

Inlet pipe actuated valves are controlled for 2 functions: (a) shutoff on high level, and (b) open valve to allow filling of a single tank on a multi-tank system and confirm closed state of other tank valves.

A typical control sequence would be:

- Less than 85% fill level: allow selection of tank for filling and opening of inlet actuated valve.
- 85% fill level: activate audible and visual alarm
- 90% fill level: activate audible and visual alarm and close inlet valve. Allow short cycle opening of valve upon alarm reset.
- 95% fill level: activate audible and visual alarm and close and disable inlet valve.

10.03 What are the control requirements for day tanks?

The primary function of day tank controls is to operate inlet valves and transfer pumps to refill the day tank as the generator consumes fuel

Typical day tank level switch activations and associated actions are:

- 90% High Level: Activate audible / visual alarm, redundant valve close and pump stop signal, and optional start of high level overflow return pump
- 85% Fill Stop Level: Close inlet valve and stop signal to pumps
- 75% Fill Start Level: Open inlet valve and send signal to pumps for start
- 50% Low Level: Activate audible / visual alarm, redundant open inlet valve and signal to pump start, activate secondary valve and secondary pump
- 15% Critical Low Level: Activate audible / visual alarm, signal to generator controls for optional generator shutdown

Leak Sensor: Activate audible / visual alarm, disable valve open and pump start signals

Other day tank control functions are: (a) monitor controller for Not-in-Auto status, (b) monitor optional level transmitter and display tank volume in gallons, inches and % fill, Monitor optional temperature transmitter and display tank temperature, (d) operate high level overflow pump for temperature control functions, (e) provide system status information to BMS systems.

10.04 What are the control requirements for multi-tank selection?

Large fuel systems use multiple tanks for several reasons: (a) to provide redundancy against a single tank failure, (b) to provide total fuel volumes in excess of maximum commercially available tank sizes, (c) to provide total required fuel volumes where space limitations set the single tank maximum volume, or (d) to provide total required fuel volumes where regulatory limitations set the single tank maximum volume.

Tank selection controls are required for several purposes: (a) to fill multiple tanks safely from a common fill station, (b) to allow supply of generator fuel from one tank, and safely return fuel to that same tank, and (c) to allow filtration of one tank with return of fuel to that same tank

Tank Fill Control:

The fill station controller monitor high level sensors in the tank at 85%, 90% and 95% fill. Inlet pipe actuated valves are controlled for 2 functions: (a) shutoff on high level, and (b) open valve to allow filling of a single tank on a multi-tank system and confirm closed state of other tank valves. Inlet valve positions are monitored by limit switch inputs to the controller.

Generator Fuel Supply:

Facility operators want to manually select the lead supply tank in the system to manage fuel levels and even the operating time for equipment. One tank may be operated until its level is reduced to allow for receipt of a full truckload of fuel to maximize purchasing efficiency.

The control system will automatically switch to a tank for fuel supply if (a) the primary supply tank is in low level, or (b) the primary tank dedicated pumps or valves are in a fail condition.

When a tank with submersible pumps is selected, its pumps are activated when the day tanks require fuel. When suction pumps are used, the controller opens an actuated valve in the suction pipe, and confirms that the valves in the other tank suction piping is closed.

A critical aspect of the control is that the tank selected for fuel supply is required to receive any return flow or overflow fuel. This occurs by opening the return flow pipe actuated valve (or directing a return flow 3-way valve) for the selected tank and confirming the closed position of the return flow valve at other tanks.

Filtration Functions:

Filtration functions are the same as the characteristics of selecting a tank for generator fuel supply. An important difference is the risk associated with failure to properly control return flow valve positions. Since filter transfer pumps operate for relatively long durations – and typically automatically, a small transfer rate between tanks can proceed un-noticed until a tank overfill condition occurs.

For this reason it is critical that tank high level sensors are monitored and disable the filtration system on a high level condition.

Note that actuated ball valves are recommended for tank selection systems for generator fuel supply and filtration systems. Actuated butterfly valves or ball valves are used for tank fill systems. Solenoid valves are not recommended because of their tendency to leak fuel through the valve when the seat is damaged, deteriorates with age, or sealing is compromised by particulates.

10.05 What are the control requirements for filtration / polishing systems?

Control panels include monitoring functions for the filter and pump operation, and the operator interface for selecting operating modes and timer cycles.

Filtration / Polishing units are designed to accommodate a variety of operating modes:

(a) continuous operation
(b) manual operation start with auto stop based on programmable cycle time
(c) automatic repeating operation based on a programmable ON and OFF cycle time.
(d) automatic repeating operation based on day-time start and ON cycle time
(e) manual operation start with auto stop based on programmable filtered volume
(f) automatic repeating operation based on day-time start and programmable filtered volume.

Controllers also monitor the operating performance of the systems including (a) pump current sensors, (b) pump overload status, (c) filter assembly leak detection, (d) filter water accumulation, (e) filter differential pressure.

10.06 What are typical points monitored by the fuel system controls?

Fuel system controllers monitor a wide range of operating characteristics and provide this information to building management systems. Here are some of the typical points monitored:

Bulk Tanks: Volume (Gallons), Temperature compensated volume, ullage – empty space in tank, temperature, tank leak status, sump leak status, pipe leak status.

Fuel Pumps: On / Off status, Manual- Off-Auto status, motor starter overload status, pump current sensor, duplex pump assembly leak detection, pump hours, pump flow rate, pump fail, lead – lag status

Day Tanks: High level. low level, critical low level , leak, fill active

Tank Selection: Tank Active, fuel supply valve position, fuel return valve position, high tank level, low tank level.

Filtration: Active status, filter assembly leak, pump fail, water alarm, differential pressure alarm, pump hours, filter gallons.

10.07 How are tank monitors such as Veeder Root integrated into fuel system controls?
Tank monitors are integrated into fuel system controls by 2 methods: (a) output relays for tank conditions, and (b) through a serial interface – ASCII via RS-232 or Ethernet.

Typical output relay functions are: high level, low level, tank leak, sump leak, pipe leak.

Typical serial information is: tank volume, temperature compensated volume, ullage – space available in tank, and temperature.

10.08 What are the building control interfaces are most common?
Controllers interface with Building Management Systems through a variety of protocols based on the preference of the BMS brand or a facility standard. These protocols include Modbus, BACnet, Metasys N2, and LON.

The major building management systems will integrate using any or all of these protocols. The major systems include: Siemens, Johnson Control, TAC, Honeywell, Automated Logic, and Allerton.

10.09 What is the typical interface with generator controls?
Generator controls may require information from day tank systems, typically: day tank high level, low level, critical low level, and leak. The generator may use the critical low level signal for a shutdown of the generator.

These signals are typically provided as dry contact outputs from the day tank controller.

10.10 What is the typical interface with switchgear controls such as ASCO and Russelectric?
Switchgear controls may also require inputs from the fuel system equipment typically: main tank low level, main tank leak, day tank high level – low level – leak.

These signals are typically provided as dry contact outputs from the day tank controller and tank gauge.

11.01 What are the requirements for mission critical fuel system design?

The requirements of mission critical design is that failure of a single component is monitored by the fuel system, and the system responds with a redundant component to perform the required function. In short, the requirement is 2 of everything with the ability to monitor and switch.

In some instances, designers will use a single fuel supply and fuel return piping system aboveground to generators. The thinking is that welded steel aboveground pipe does not have a relevant failure mechanism. However many designers will provide dual parallel piping paths.

Underground piping systems, we believe should always have redundant parallel paths. The reason is that underground piping is continually subject to ground and surface loads, and that secondary containment test failure, whether real or a false positive, can trigger a shutdown of the piping system as a regulatory requirement.

11.02 Why are typical problems for fuel systems?

There are many problems with fuel systems that are based on the initial design of the system. Once a well designed system is commissioned, with any installation errors corrected, they operate as highly reliable systems.

Some of the typical post-commissioning problems for fuel systems are:

(a) pump or valve activation failure from loose wiring
(b) loss of prime in suction pump piping system
(c) leak in piping systems, sometimes due to overstress from thermal expansion (d) solenoid valve leakage from seating surface debris or deterioration.
(e) failure of elements in relays or point sensing elements
(f) solenoid valve electrical failure
(g) submersible pump capacitor failure
(h) failures from line leak detection systems

11.03 What is fuel system commissioning?

Fuel system commissioning is a method of proving fuel system performance and accuracy, particularly in the event of failure of system components. The interaction of the fuel system with other building systems, such as building management systems is also demonstrated.

The first step in the process is development of a commissioning script document. This is a step by step procedure for testing that can range up to several hundred steps. The document is typically prepared in draft by the fuel system specialist, with review and approval by the design engineer and commissioning agent.

The commissioning procedure is typically performed by the fuel system supplier and installer, and observed by the commissioning agent and / or facility personnel.

11.04 What inspections and tests are required to assure ongoing reliability? Fuel system inspections and tests can be summarized as follows:

- daily inspection of the fuel system for leaks and observation of the control and monitorinsystem for alarm conditions.
- Monthly or annual testing of secondary containment leak detection systems as required for state and local regulatory compliance
- Annual, or more frequent testing, in accordance with the original commissioning script.

It is recommended that the systems be designed to facility ongoing testing. These details include:

- pressure and vacuum gauges on piping system
- day tank return flow pumps to lower tank levels and test refill
- position indicators for actuated valves
- quick disconnect wiring connectors for valves and sensors

In some instances, an automatic commissioning function is designed into the fuel system controllers.

12.01 How is a Simplex day tank integrated into a fuel system?

The Simplex day tank controller is based on a printed circuit board with fixed inputs and outputs. Integration for pump run signals and day tank alarm conditions are through output relays. Where signals for day tank alarms are required by multiple systems, then supplementary multi-pile relays may need to be added by the installer.

12.02 How is a Pryco day tank integrated into a fuel system?

The Pryco day tank controller is based on wired relay logic with fixed inputs and outputs. Integration for pump run signals and day tank alarm conditions are through output relays. Where signals for day tank alarms are required by multiple systems, then supplementary multi-pile relays may need to be added by the installer.

12.03 How is a Tramont day tank integrated into a fuel system?

The Tramont day tank controller is based on a printed circuit board with fixed inputs and outputs. Integration for pump run signals and day tank alarm conditions are through output relays. Where signals for day tank alarms are required by multiple systems, then supplementary multi-pile relays may need to be added by the installer.

12.04 How is a Veeder Root tank monitor integrated into a fuel system?

Tank monitors are integrated into fuel system controls by 2 methods: (a) output relays for tank conditions, and (b) through a serial interface – ASCII via RS-232 or Ethernet.

Typical output relay functions are: high level, low level, tank leak, sump leak, pipe leak.

Typical serial information is: tank volume, temperature compensated volume, ullage – space available in tank, and temperature.

12.05 How is a Red Jacket pump controller integrated into a fuel system?

The basic Red Jacket pump controller allows for a 120 VAC input signal (which they call a hook signal) to activate the submersible pump. The Earthsafe duplex pump controller activates the controllers by providing this signal.

The basic Red Jacket controller provide motor protection, but lacks the following features that are often required of mission critical systems:

- local power disconnect switch
- manual mode switch in addition to its passive auto mode • current sensor or other feedback demonstrating pump function.

12.06 How is a FE Petro pump controller integrated into a fuel system?

The basic FE Petro pump controller allows for a 120 VAC input signal (which they call a hook signal) to activate the submersible pump. The Earthsafe duplex pump controller activates the controllers by providing this signal.

The basic FE Petro controller provide motor protection, but lacks the following features that are often required of mission critical systems:

- local power disconnect switch
- manual mode switch in addition to its passive auto mode
- current sensor or other feedback demonstrating pump function

The base controller also has a function for extended run shutoff after a 60 minute operating time. For mission critical applications, this function should be de-selected by the dip switch settings within the controller.

13.01 What is typically monitored in fuel tank and piping systems?

The monitoring of fuel tanks and piping is determined by US EPA requirements, State, and Local regulations. The points of monitoring typically include the following:

- tank gallons, tank temperature compensated gallons, ullage (empty space in the tank), fuel inches, water inches, water gallons, tank temperature.
- tank interstitial leak detection, or hydrostatic monitoring for wet interstitial systems, or vaccum monitoring for vacuum systems
- tank sump liquids, and double wall tank vacuum, or hydrostatic
- double wall piping interstitial dry, hydrostatic, or vacuum

13.02 What are the leading tank monitor brands?

Veeder Root Tank Monitors are used in a reported 80% of all tank installation. This is worldwide brand that is extremely well supported by local technicians.

Secondary brands include: Pneumercator, Omntec, OPW (former Petrovend) and Incon / EBW (Franlkin Electric)

13.03 What is line leak detection for piping?

Many State and local regulations require a line leak detector for pressurized underground piping. Line leak detectors for underground piping are used to detect a loss of integrity in the piping with a consequential shut down of the pump. There are 2 types of line leak detectors – mechanical and electrical.

Mechanical line leak detectors install on the submersible pump body. The pump must start against a closed valve to allow pressure to build in the line sufficiently to allow the line leak detector to open and flow. If pressure does not build in the line properly, then the mechanical line leak detector trips and restricts the pump flow.

Electronic line leak detectors operate in conjunction with a tank monitor such as a Veeder Root panel. After each pump run cycle, the panel turns on the pump automatically and measures the pressure in the line using a pressure transducer. The panel displays a pass / fail test result and may be required to be configured to disable th submersible pump.

Line leak detectors are designed to work reliably with motor fuel dispensing operations where dispensers include solenoid valves to work in conjunction with the submersible pumps. In emergency generator applications, especially mission critical applications, the devices can be problematic where test failures can shutdown the fuel supply system. Control systems need to include appropriate valve / pump timing controls to allow successful tests, and also detect failure and switch to a secondary pumps.

13.04 What is vacuum monitoring for tanks, sumps, and piping?

The State of California requires continuous active monitoring of underground fuel systems including tanks, sumps, and piping. The concern was that dry interstitial spaces at atmospheric pressure could fail without recognition, and that a leak could escape from the containment prior to flowing to a sensor and being detected.

The regulation allowed pressure, vacuum, and hydrostatic methods of monitoring fuel containment secondary spaces. The hydrostatic method had been used for many years successfully in underground fiberglass tanks. The same method was extended to fiberglass sumps and double wall fiberglass piping. Pressure based systems have not been widely adopted.

The vacuum system has been widely adopted in California for a several reasons:

- The leading tank monitor developed systems to generate and monitor vacuum systems
- The vacuum generating device is the submersible fuel pump already present in most UST systems
- The vacuum method works for either fiberglass of flexible plastic piping system
- The vacuum method works for steel or fiberglass tanks and sumps

The vacuum monitoring system works essentially as follows:

- The Veeder Root monitor activates the submersible pump which is detailed to draw a vacuum on the interstitial spaces of tanks, sumps, and piping
- A Veeder Root vacuum sensor measures the vacuum and the vacuum decay rate.
- The control monitor determines if the vacuum decay rate is within the test pass parameters or not
- The tank monitor indicates a pass or fail result for the test.

13.05 How does a Veeder Root communicate with BMS equipment?

- Tank monitors are integrated into fuel system controls by 2 methods: (a) output relays for tank conditions, and (b) through a serial interface – ASCII via RS-232 or Ethernet.
- Typical output relay functions are: high level, low level, tank leak, sump leak, pipe leak.
- Typical serial information is: tank volume, temperature compensated volume, ullage – space available in tank, and temperature.

13.06 What is intrinsically safe wiring?

Intrinsically safe wiring is a method of operating instruments, sensors, and devices in the hazardous electrical areas around flammable and combustible liquids and gases. Essentially, the electronics within the control panel limit the amount of energy through the wiring to the sensor or device, such that the energy is insufficient to create an electrical spark that could ignite the flammable liquids or gases.

Intrinsically safe installations are an alternative to explosion proof conduit and wiring systems, which are typically designed to contain the energy of an explosion caused by an electrical spark

Most standard tank gauges are used primarily in gasoline tank installations at retail service stations. For this reason, their instruments and sensors are designed as intrinsically safe devices.

In planning fuel system controls, and important consideration is that intrinsically safe conduit systems must be separated from other wiring.