**Newton's First Law of Motion states that a body at rest will remain at rest... and a body in motion... will remain in motion... unless acted upon by an outside force.**

**The mission of a daytank is simple. Have a viable supply of fuel ready for the generator when it needs it.**

**To accomplish this mission, we designed a system that embraces this first law and adheres to the following:**

- **Recognize and remove as many potential failure points as possible.**
- **Minimize steps in process to accomplish the mission.**
- **Minimize the change of state in devices.**
- **Minimize the footprint to the greatest extent possible.**
- **Give the client what they need, avoid excess.**
- **Remember the mission!**

**When the generator starts our system starts and runs concurrent with the generator.**

**One change in state is required for our system to accomplish its mission.**

**Standard design requires a continuous change in state throughout the run cycle of the generator. This introduces opportunity for failure as opposed to designing it out of the system.**

**As failures have occurred or been recognized as possibilities, the tendency has been to add more components to compensate for this potential. This is not the answer.**

## Steady State Fuel Supply System

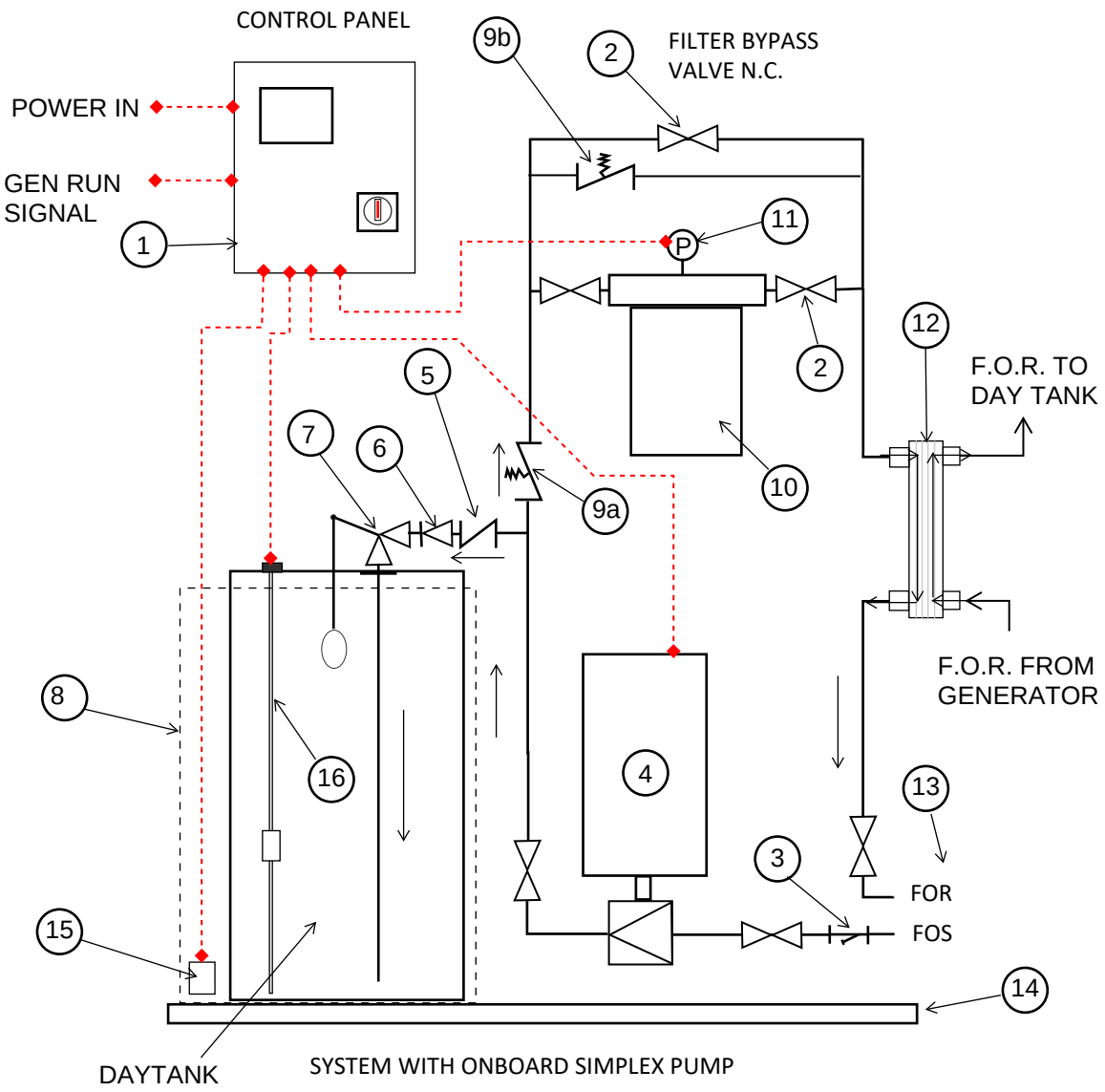
Steady State Fuel System (SSFS) is designed to replace the role of a traditional day tank which provides a fuel supply to a diesel-powered emergency generator (generator). The steady state fuel system will only be used in generator fuel supply systems that include a bulk or "main" storage tank.

SSFS maintains a constant supply of fuel to a generator when used in conjunction with main fuel storage that requires a fuel supply pump to move the fuel from the main tank to the daytank as fuel from the daytank is consumed by the generator.

This system maintains this fuel supply without the need for the industry standard electrical infrastructure. Traditional daytank systems rely on the generators fuel consumption to draw down the liquid level in the day tank, as fuel level lowers an electrical switch is actuated and then communicated to a control panel which then energizes a relay which will operate a fuel oil supply inlet valve (typically solenoid or motor operated ball valve) and send a signal for a fill pump to start. As the level fills another switch is actuated and the process is reversed. If the switches fail, backup switches are often deployed.

The steady state fuel system differentiates itself from a traditional day tank in several ways:

- SSFS maintains fuel level in the daytank without the need for electrically actuated valves (solenoid or motorized ball valve) or an electrically actuated level switch.
- SSFS minimizes the start/stop cycles of fuel supply pumps & associated electrical valves which creates unwanted wear and tear on equipment.
- SSFS does not rely on a level switch to create a fill cycle on the daytank.
- SSFS operates under the principal that once an emergency generator starts the fuel supply system should start and run concurrently with the generator thereby minimizing the potential for equipment failure that typically occurs during a change in state (start/stop).
- SSFS supplies fuel to the daytank via a mechanical float valve. The float valve only opens to top off the daytank as fuel is consumed from the generator. When the float valve closes the fuel is bypassed back to the main storage tank.
- SSFS uses the bypassed fuel to filter fuel from the main tank and exchange heat with fuel returning from the generator, keeping the fuel supply to the generator within an appropriate temperature range.
- SSFS minimizes fuel system complexity, and installation/maintenance costs.
- SSFS serves two traditional fuel system functions (fuel supply and filtration) with one system. This limits the required infrastructure, maintenance and energy consumption required as well as the complexity associated with multiple systems.




1. SYSTEM CONTROL PANEL
2. ISOLATION VALVE TYPICAL, NORMALLY OPEN UNLESS MARKED AS CLOSED (N.C.)
3. Y-STRAINER
4. PUMP AND MOTOR ASSEMBLY
5. CHECK VALVE FOR FLOW CONTROL
6. FLOW RESTRICTOR
7. FLOAT CONTROL VALVE
8. 11 GALLON TANK WITH RUPTURE BASIN
9. SPRING LOADED CHECK VALVE FOR BYPASS
10. FUEL FILTER
11. DIFFERENTIAL PRESSURE SENSOR
12. HEAT EXCHANGER
13. FUEL OIL SUPPLY AND RETURN FROM AND TO MAIN STORAGE TANK
14. DRIP BASIN
15. LEAK SWITCH
16. 4-20 mA LEVEL PROBE

ELECTRICAL CONNECTION

FLUID CONNECTION

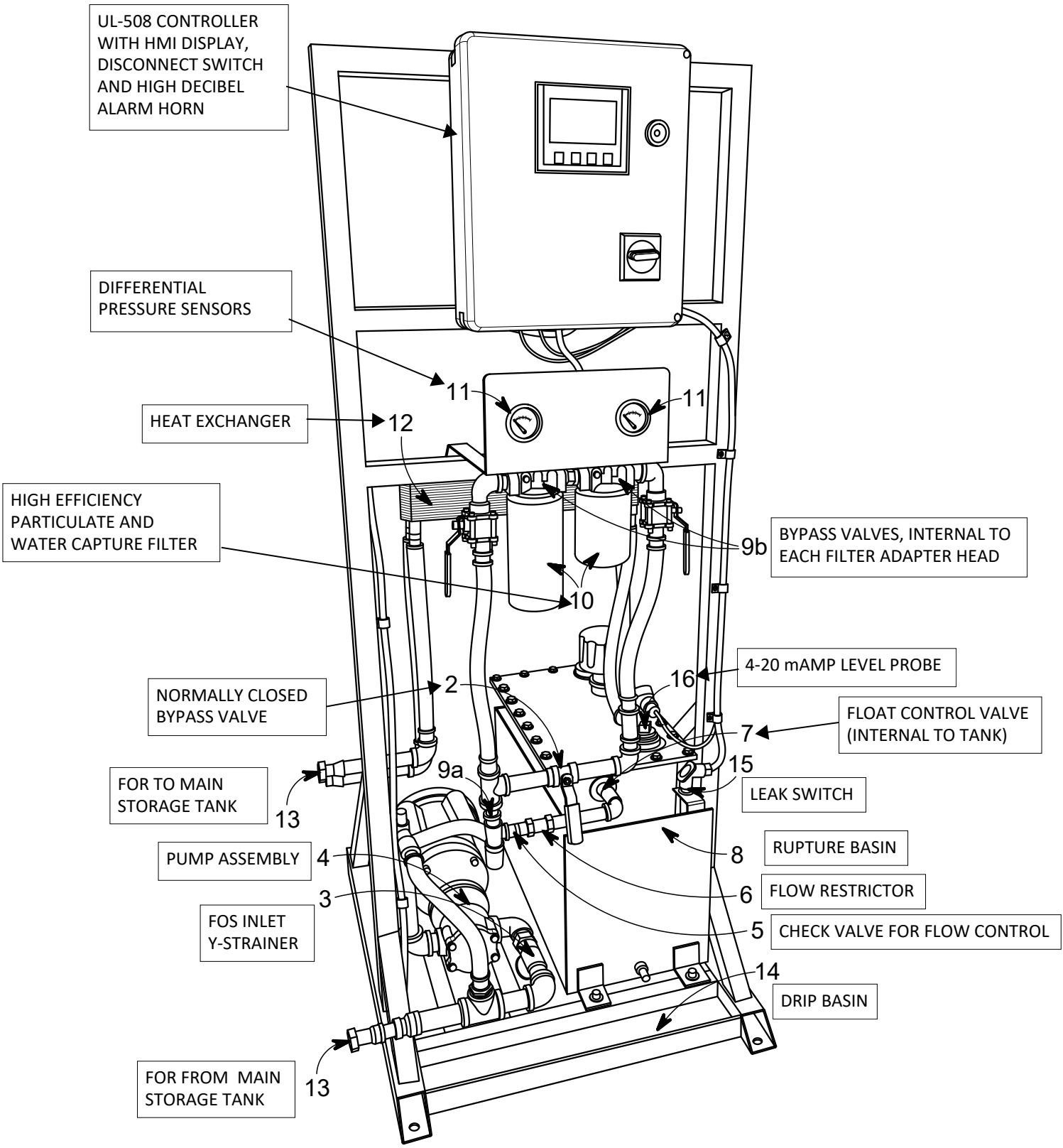
**FIGURE 1**

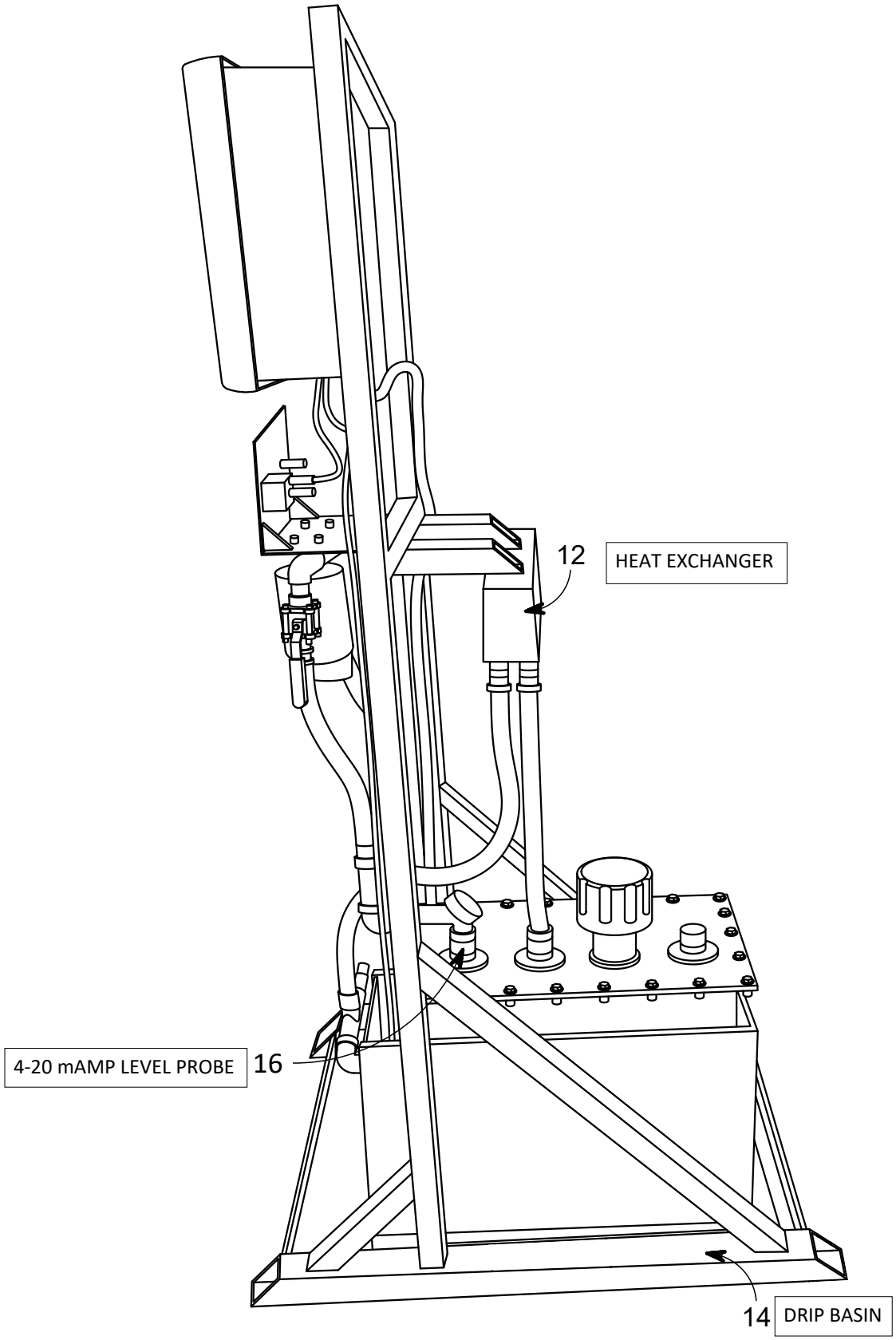
**FIGURE1 - Standard system with simplex fuel supply pump**

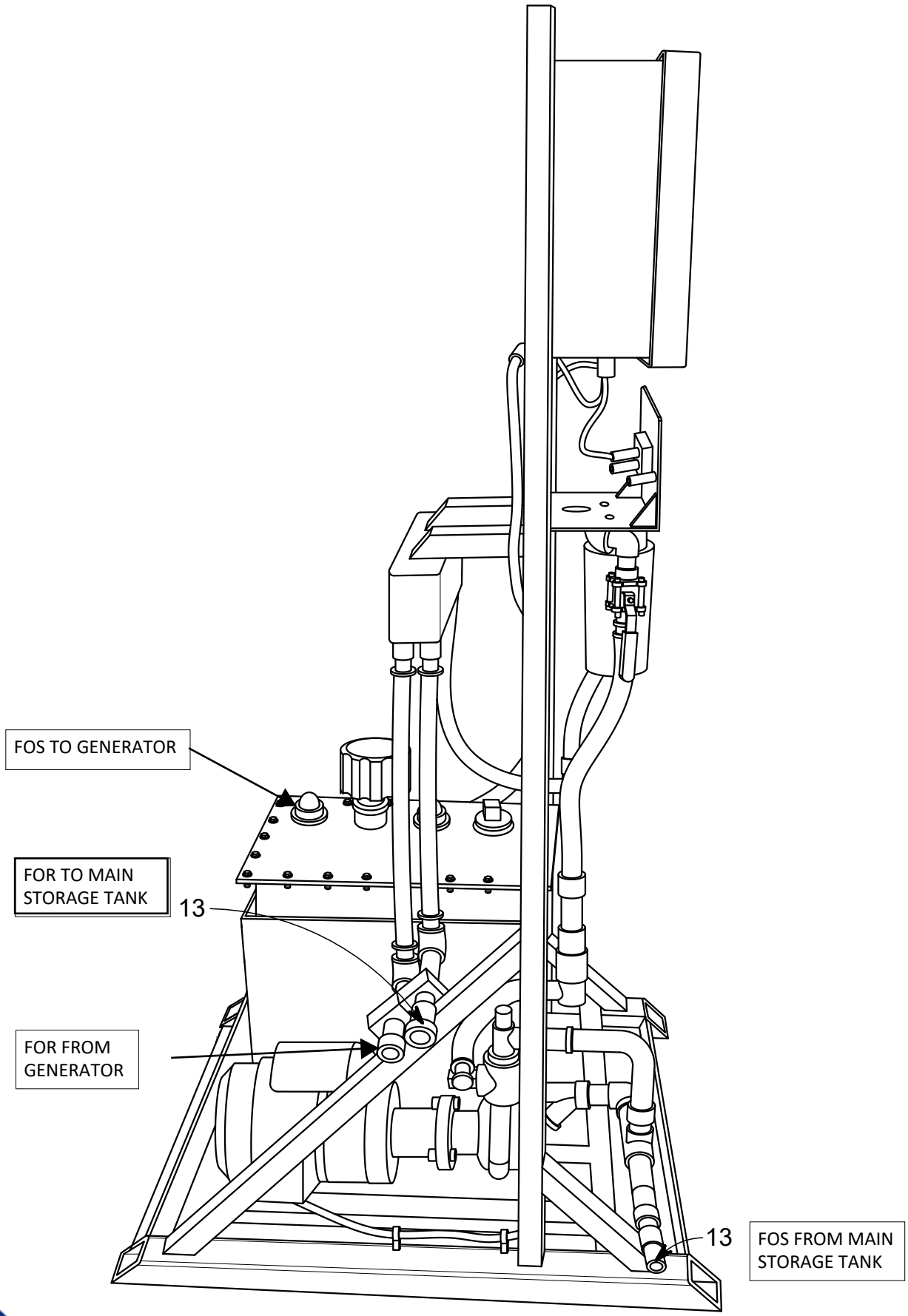
The control panel (1) is a PLC based with a touchscreen interface. The power required is 20 amp, 115/208-230 VAC single phase. Inputs to the panel will be a generator run signal, daytank level (16), leak switch (15) and differential pressure switch (11). The output will be to energize the fuel supply pump (4). Isolation valves (2) are used throughout the system and are considered normally open and only closed for maintenance purposes. If a valve is normally closed during operation, it is marked N.C. on the drawing.

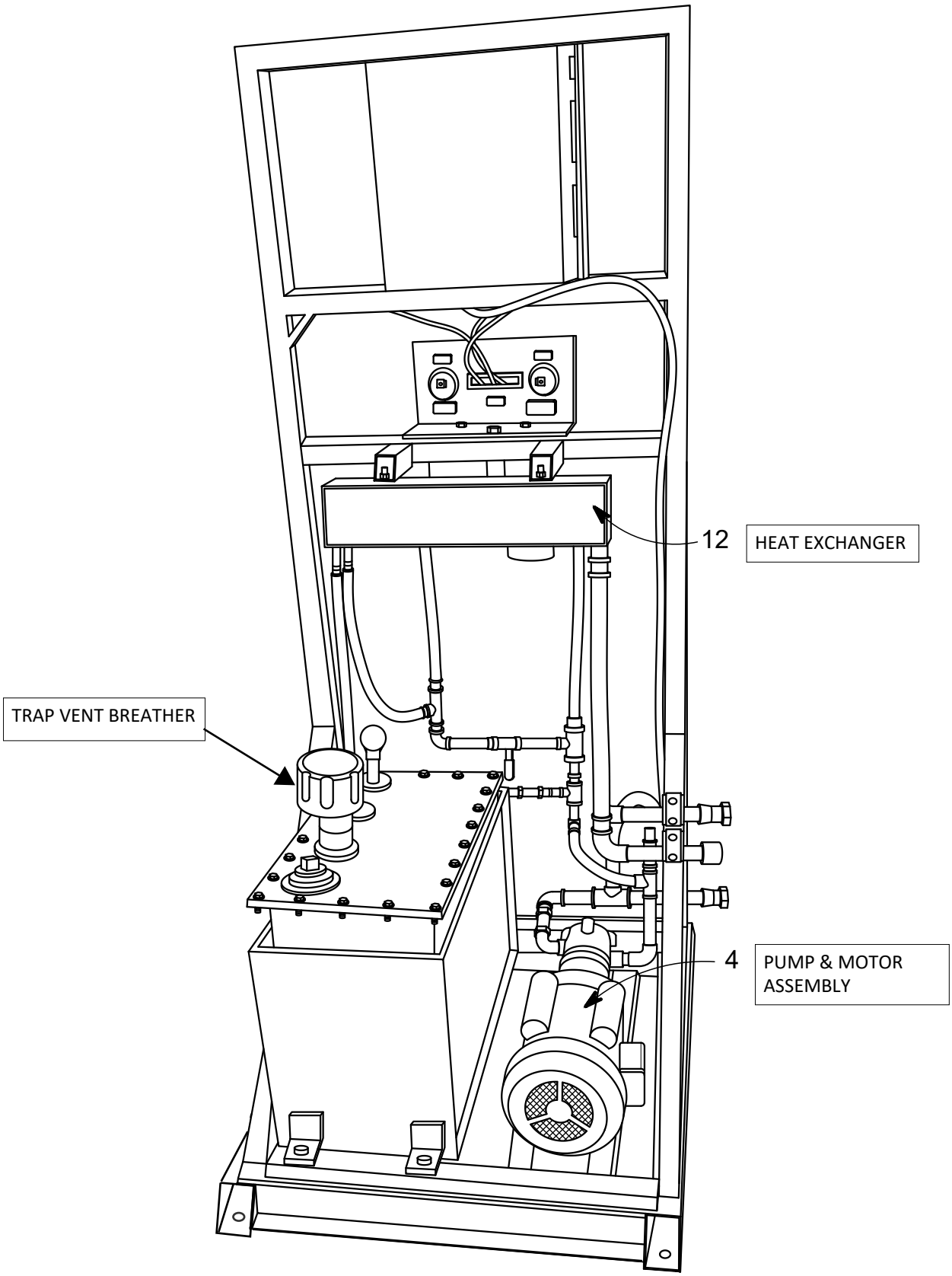
**SEQUENCE OF OPERATION FIGURE 1:**

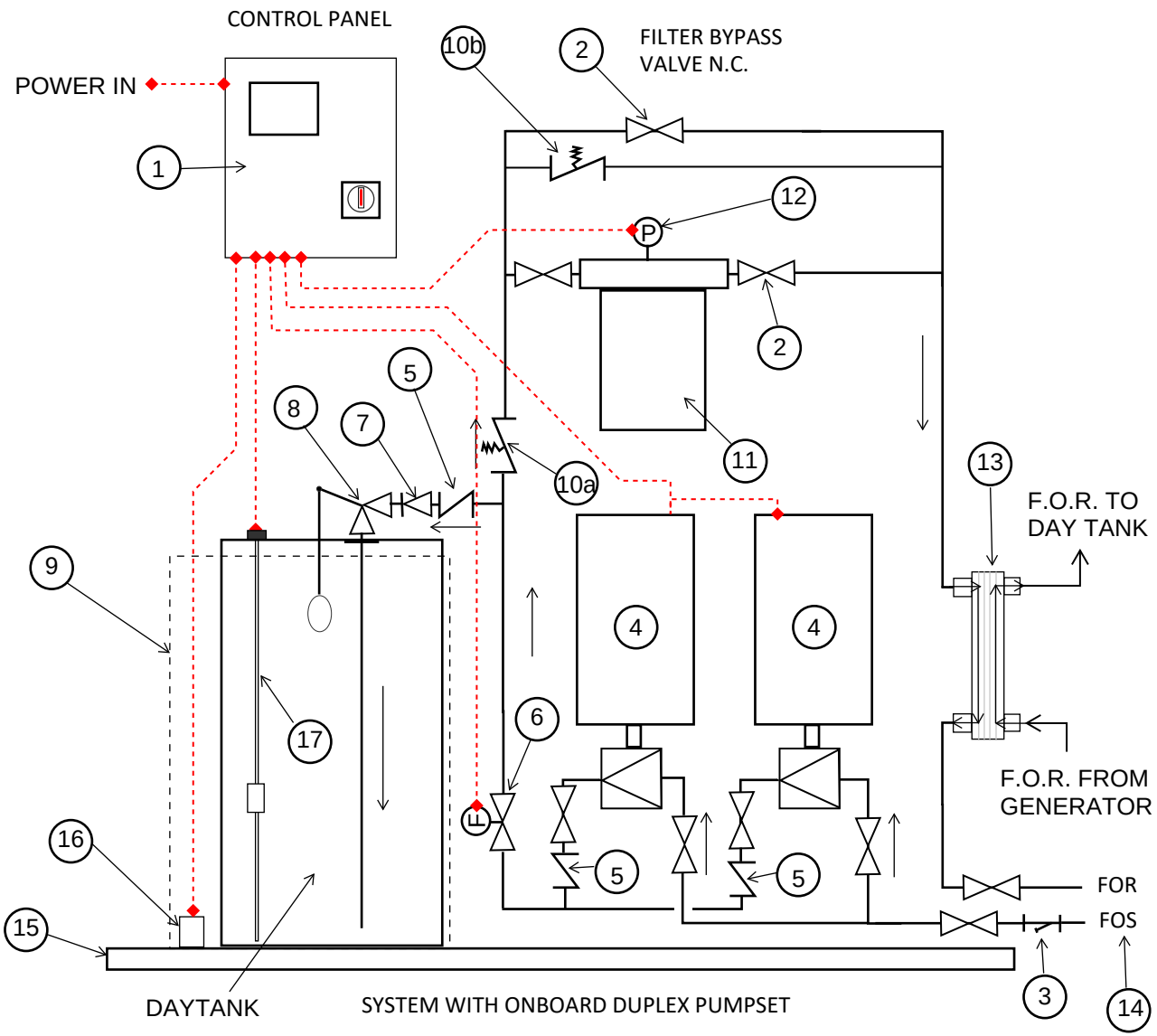
1. As Emergency Generator comes online a run signal will be received from the generator controls. This input will create a start signal for the fuel supply pump and the pump will start.
2. Fuel supply pump will draw fuel from the main storage tank and pressurize the inlet piping to the daytank. Fuel entering the system will be strained when passing through the fuel inlet strainer (3).
3. Passing through the inlet isolation valve (2) the fuel will then enter the inlet side of the positive displacement pump (4). Fuel will become pressurized and exit the discharge side of the pump through the discharge isolation valve (2).
4. The fuel will then enter a manifold and flow in one of two possible directions. One flow path will be to fill the daytank if the float control valve (7) is open. Float control valve opens as the tank empties and closes as the tank fills, keeping the daytank filled with a ready fuel supply for the generator. Fuel entering the daytank via this manifold will first pass through a one-way flow control check valve (5) then through a flow restrictor (6) and finally the float control valve (7) before entering the daytank.
5. Once the daytank has been filled and the float control valve is in the closed position the fuel will be forced to overcome approximately 10 psi of backpressure generated by the spring-loaded check valve (9a) and pass through the filter manifold (10).
6. When passing through the manifold, fuel will be filtered for free water and particulate matter. As the filters clog differential pressure will be created across this manifold.
7. If 20 pounds per square inch (psi) is reached on the differential pressure sensor (11) an alarm will occur notifying the operator that a filter change is required.
8. If the pressure through the manifold approaches 25 psi the spring-loaded bypass check valve (9b) will open allowing fuel to continue to flow through the system.
9. As fuel continues to flow back to the main storage tank it will pass through a heat exchanger (12). In the heat exchanger, heated fuel returning from the generator will be cooled by the relatively cooler fuel from the main storage tank, minimizing temperature gain in the daytank.
10. If the daytank developed a leak or an overflow occurred, the containment basin (8) will contain the fuel, and the leak sensor (15) will trip sending a signal to the control panel.
11. Drip basin (14) is designed to catch any drips from filter changes etc.
12. The system is designed to run continuously while the generator is running.
13. The system can also run as needed to filter fuel from the main tank on a predetermined schedule regardless of the status of the generator.


UL-508 CONTROLLER WITH HMI DISPLAY, DISCONNECT SWITCH AND HIGH DECIBEL ALARM HORN
DIFFERENTIAL PRESSURE SENSORS
HEAT EXCHANGER
HIGH EFFICIENCY PARTICULATE AND WATER CAPTURE FILTER
NORMALLY CLOSED BYPASS VALVE
FOR TO MAIN STORAGE TANK
PUMP ASSEMBLY
FOS INLET Y-STRAINER
FOR FROM MAIN STORAGE TANK
BYPASS VALVES, INTERNAL TO EACH FILTER ADAPTER HEAD
4-20 mAMP LEVEL PROBE
FLOAT CONTROL VALVE (INTERNAL TO TANK)
LEAK SWITCH
RUPTURE BASIN
FLOW RESTRICTOR
CHECK VALVE FOR FLOW CONTROL
DRIP BASIN
11
11
12
10
9b
2
16
7
9a
15
13
8
4
6
3
5
14
13


12
HEAT EXCHANGER
4-20 mAMP LEVEL PROBE
16
14
DRIP BASIN


FOS TO GENERATOR
FOR TO MAIN STORAGE TANK
13
FOR FROM GENERATOR
13
FOS FROM MAIN STORAGE TANK


12
HEAT EXCHANGER
TRAP VENT BREATHER
4
PUMP & MOTOR ASSEMBLY




1. SYSTEM CONTROL PANEL
2. ISOLATION VALVE TYPICAL, NORMALLY OPEN UNLESS MARKED AS CLOSED (N.C.)
3. Y-STRAINER
4. PUMP AND MOTOR ASSEMBLY
5. CHECK VALVE FOR FLOW CONTROL
6. FLOW INDICATION SWITCH
7. FLOW RESTRICTOR
8. FLOAT CONTROL VALVE
9. 11 GALLON TANK WITH RUPTUR BASIN
10. SPRING LOADED CHECK VALVE FOR BYPASS
11. FUEL FILTER
12. DIFFERENTIAL PRESSURE SENSOR
13. HEAT EXCHANGER
14. FUEL OIL SUPPLY AND RETURN FROM AND TO MAIN STORAGE TANK
15. DRIP BASIN
16. LEAK SWITCH
17. 4-20 mA LEVEL PROBE

ELECTRICAL CONNECTION

FLUID CONNECTION

**FIGURE 2**

**FIGURE 2- System with duplex supply pumps**

The operation of the duplex pump package is the same as the simplex pump package with the following distinctions.

- Pumps alternate in lead/lag fashion on run signals with only one pump running at any point in time.
- The flow switch (6) provides verification to the control panel that the requested pump is running, and flow has been achieved.
- Flow control check valves (5) are placed on pump discharge lines to prevent backflow and a potential for short cycling the fuel.
- When the run signal is received from generator the lead pump will start and flow should be confirmed via flow indication switch (6) after a 5 second interval.
- If the flow is not confirmed the control panel will generate a pump failure alarm and start lag pump.

**SEQUENCE OF OPERATION FIGURE 2:**

The control panel (1) is a PLC based with a touchscreen interface. The power required is 20 amp, 115/208-230 VAC single phase. Inputs to the panel will be a generator run signal, daytank level (16), leak switch (15) and differential pressure switch (11). The output will be to energize the fuel supply pumps (4). Isolation valves (2) are used throughout the system and are considered normally open and only closed for maintenance purposes. If a valve is normally closed during operation, it is marked N.C. on the drawing.

SEQUENCE OF OPERATIONS:

1. As Emergency Generator comes online a run signal will be received from the generator controls. This input will create a start signal for the lead fuel supply pump and the pump will start.
2. Flow is confirmed via the flow indication switch (6).
3. If flow is not confirmed withing 5 seconds the lead pump is considered failed, lead pump run signal will be turned off and alarm is generated at control panel (1).
4. Lag pump will start and if flow is not confirmed within 5 seconds flow failure alarm will be generated but lag pump run signal will remain energized.
5. Fuel supply pump will draw fuel from the main storage tank and pressurize the inlet piping to the daytank. Fuel entering the system will be strained when passing through the fuel inlet strainer (3).
6. Passing through the inlet isolation valve (2) the fuel will then enter the inlet side of the positive displacement pump (4). Fuel will become pressurized and exit the discharge side of the pump through the discharge isolation valve (2).
7. The fuel will then enter a manifold and flow in one of two possible directions. One flow path will be to fill the daytank if the float control valve (8) is open. Float control valve opens as the tank empties and closes as the tank fills, keeping the daytank filled with a ready fuel supply for the generator. Fuel entering the daytank via this manifold will first pass through a one-way flow control check valve (5) then through a flow restrictor (7) and finally the float control valve (8) before entering the daytank.

8. Once the daytank has been filled and the float control valve is in the closed position the fuel will be forced to overcome approximately 10 psi of backpressure generated by the spring-loaded check valve (10a) and pass through the filter manifold (11).
9. When passing through the manifold, fuel will be filtered for free water and particulate matter. As the filters clog differential pressure will be created across this manifold.
10. If 20 pounds per square inch (psi) is reached on the differential pressure sensor (12) an alarm will occur notifying the operator that a filter change is required.
11. If the pressure through the manifold approaches 25 psi the spring-loaded bypass check valve (10b) will open allowing fuel to continue to flow through the system.
12. As fuel continues to flow back to the main storage tank it will pass through a heat exchanger (13). In the heat exchanger, heated fuel returning from the generator will be cooled by the relatively cooler fuel from the main storage tank, minimizing temperature gain in the daytank.
13. If the daytank developed a leak or an overflow occurred, the containment basin (9) will contain the fuel, and the leak sensor (16) will trip sending a signal to the control panel.
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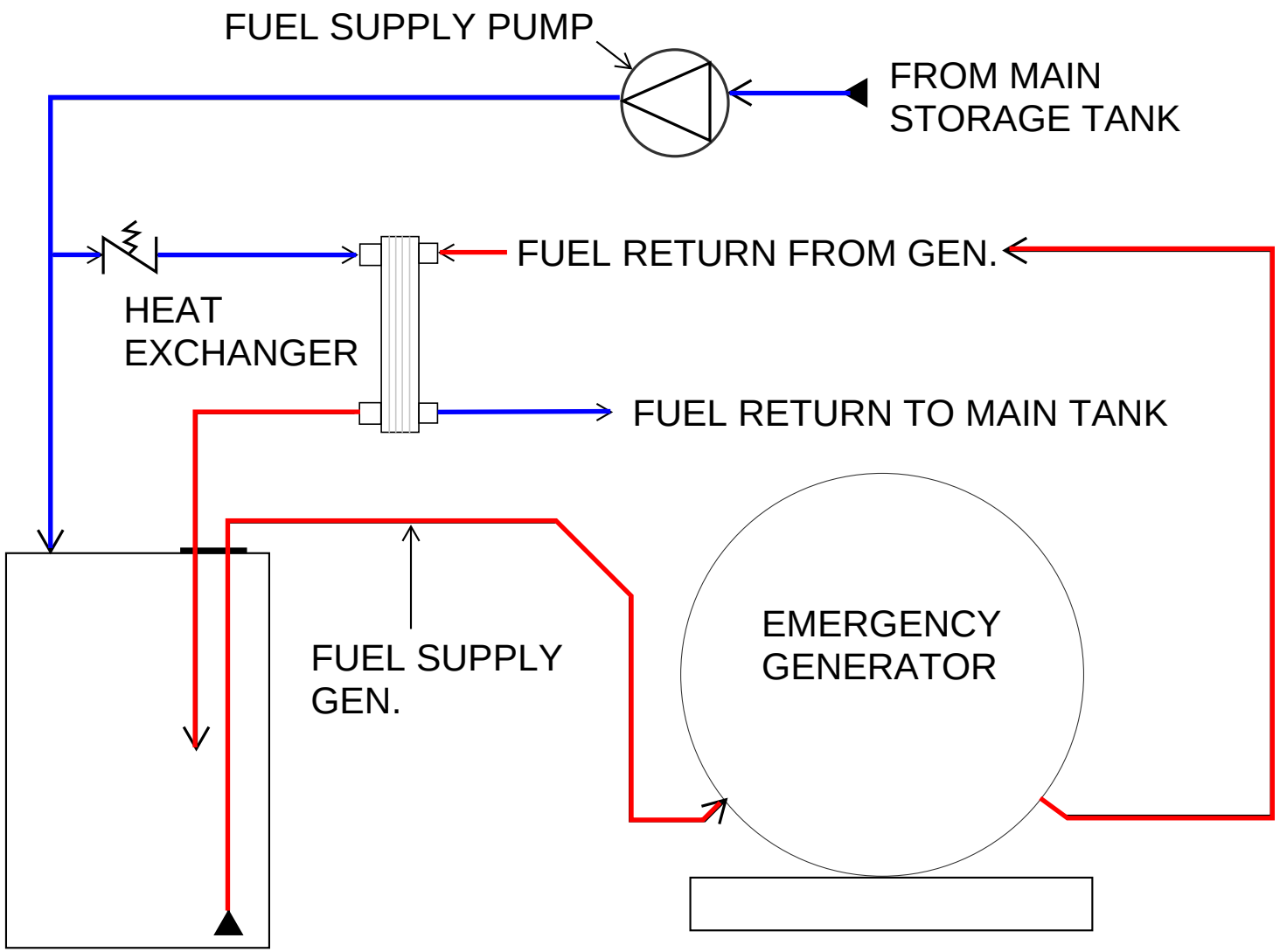


**FIGURE 3**

Simple diagram of fuel flow path through the system. Some items are removed for clarity.