## 9.5.4 Diesel Generator Fuel Oil Storage and Transfer System

The diesel generator fuel oil storage and transfer system (DGFOSTS) provides for the required storage capacity and transfer of fuel oil to each diesel engine as required for seven days of operation. The system is comprised of a storage tank, electrically driven transfer pumps, day tank, fuel delivery pump, injection pump, piping, filters, and monitoring systems. Each emergency diesel generator (EDG) has a separate, independent fuel oil storage and transfer system, as shown in Figure 9.5.4-1—Emergency Diesel Generator Fuel Oil Storage and Transfer System.

### 9.5.4.1 Design Basis

The DGFOSTS is safety related and is required to function following a loss of offsite power (LOOP) to achieve and maintain the plant in a safe shutdown condition.

- The DGFOSTS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC 2).
- Each DGFOSTS remains functional after a safe shutdown earthquake (SSE) and each performs its intended functions following a postulated hazard, such as internal missiles or pipe break (GDC 4).
- The DGFOSTS is designated as safety related and is not shared by the individual diesel generators (GDC 5).
- Safety functions can be performed, assuming a single active component failure coincident with the LOOP, due to the 4 by 100 percent design structure of the diesel generator system (GDC 17).
- The active components of the DGFOSTS can be tested during plant operation. Provisions are made to allow inservice inspection of components at appropriate times specified in the ASME BPV Code, Section XI (Reference 1) (GDC 45 and 46) (See Section 3.2).
- The DGFOSTS is designed and fabricated to codes consistent with the quality group classification assigned by RG 1.26 and the seismic category assigned by RG 1.29. The power supply and control functions are in accordance with RG 1.32.
- Following a LOOP, the system provides onsite storage and delivery of fuel oil for at least seven days of diesel generator operation at the continuous rating. Additionally, following a LOOP, the system is designed to supply fuel oil at all times under the most severe environmental conditions probable at the plant site. The design of the DGFOSTS complies with RG 1.137.
- The DGFOSTS has the capability to replenish fuel oil from an external source following a design basis event (DBE) without interrupting diesel operation.

The DGFOSTS has no power generation design basis.

### 9.5.4.2 System Description

#### 9.5.4.2.1 General Description

The DGFOSTS is located in the Class I Emergency Power Generation Building (EPGB) and is comprised of a storage tank, electrically driven transfer pumps, day tank, fuel delivery pump, injection pump, piping, filters, and monitoring systems. Each EDG has a separate, independent fuel oil storage and transfer system.

The DGFOSTS is shown schematically in Figure 9.5.4-1. The DGFOSTS for each diesel generator has an above ground storage tank with transfer pumps, day tank, strainers and filters, piping, valves, instruments, and controls.

The fuel oil storage tanks for EDG 1 and 2 have a cross tie between them which consist of a removable spool piece and locked closed isolation valves. EDG 3 and 4 have the same arrangement for their fuel oil storage tanks. This allows for a 3.5 day fuel oil storage inventory in each fuel oil storage tank (plus 10 percent for surveillance testing) and still maintains a seven day fuel supply to the minimum required number of EDGs.

The oil fill connection to the storage tank is located above grade and includes a locked closed valve. A hose connection, normally isolated by a locked closed valve, is connected to the fuel oil storage tank low point drain. The hose connection is located adjacent to the fill connection to provide a connection of filtering equipment for maintaining fuel quality and for pump out of the tank for maintenance and inspection activities. The transfer pumps take suction from the fuel oil storage through duplex fuel oil strainers, and the fuel oil discharge from the transfer pumps is piped through duplex fuel oil filters to the top of the day tank at its fill connection.

The elevated position of the day tank, with respect to the diesel engine, enables fuel oil to be supplied to the engine-driven fuel oil pump by gravity flow. In the event of a loss of adequate fuel oil pressure from the diesel engine-driven fuel oil pump, a fuel oil auxiliary pump taking suction from the supply line from the day tank will supply the necessary fuel oil pressure to the diesel engine fuel injectors. Duplex oil strainers are installed in series into the fuel oil lines from the day tank to the fuel pumps, and duplex filters are installed between the fuel pumps and the engine. Duplex strainers and filters can be cleaned without interrupting fuel oil flow. The excess fuel from the engine is returned to the day tank through an orificed recirculation line.

Precautions have been taken in the design of the fuel oil system in locating the fuel oil day tank and connecting fuel oil piping with regard to possible exposure to ignition sources such as open flames and hot surfaces. The fuel oil day tank is located with the fuel oil storage tank in a separate room located at a building level above the diesel room. There is no elevated fuel oil piping adjacent to the engine. The fuel oil piping

between the day tank and the engine drops down from the tank and runs below the elevation of the engine until it reaches the engine. The transfer pumps and auxiliary pump are located in the engine room. There are no open flames in the diesel generator room. The engine exhaust system is insulated to shield potential fuel spray from hot exhaust system components.

#### 9.5.4.2.2 Component Description

The major components of the DGFOSTS are described in the following paragraphs. The safety classification and seismic design classification for these components, along with their design and fabrication code, are provided in Section 3.2.

The DGFOSTS is designed and constructed in accordance with quality group C and Seismic Category I.

##### Main Fuel Oil Storage Tank

One vertical cylindrical fuel oil storage tank is provided for each EDG. The tanks are located adjacent to their respective divisions in separate rooms located at each end of the EPGBs. This separation provides a missile barrier, serves as a spill reservoir, and provides a three hour firewall between the fuel oil tanks and the diesel engine room. The capacity of each tank is based on the fuel consumption by one diesel engine for operation at the continuous rating for seven days, plus an additional ten percent for surveillance testing. The tank is vented, via a flame arrester, to the atmosphere outside the EPGB at a location above the tank connections.

The tank has a manway that allows access for cleaning bottom sediment and inspecting the tank lining. The tank bottom is constructed so that a low point sump exists for collection and drainage of any water or sediment that may be present. Additionally, the system incorporates the pumps, the pump discharge piping, and conduits.

Fill lines and transfer pump suction lines are located above the sump to preclude disturbance of sediment or water which might lead to the introduction of contaminants into the fuel oil system. The fuel oil storage tanks are equipped with sample lines, level transmitters, manual level gauges and drain lines for sampling the fuel oil, draining the tanks, and monitoring tank levels.

The exterior surfaces of the tanks are painted for corrosion protection. The interior surfaces of the tanks are coated with a corrosion resistant material.

##### Fuel Oil Unloading Station

The fuel oil unloading station enables the transfer of fuel oil from a bulk fuel oil carrier to the storage tank. Fuel is transferred from the bulk carrier by a truck mounted pump to the storage tank. The design provides sufficient features and administrative control

on the storage tank outside fill, vent, and pump-out lines to protect against damage from vehicles, tornado, missiles, floods, extreme cold, and accidental contamination.

The fill piping contains an inline filter to preclude sediment particles from being introduced into the storage tank during fuel unloading. Each of the four fuel oil storage tanks is equipped with a pump-out line. The configuration is in conjunction with the fill line to provide connection of a temporary filtration unit for periodic recirculation and filtration of the fuel inventory when the sampling and testing program shows a need to reduce entrained particulate matter. The fill and pump-out lines are equipped with locking caps. State and local codes and regulations (e.g., NFPA 30 and 40 CFR Part 112), apply for fuel unloading stations.

### Fuel Oil Transfer Pump

Two 100 percent transfer pumps are provided for each EDG. Each pump motor is powered from the same Class IE bus associated with its EDG. The capacity of each transfer pump is approximately twice the consumption rate of the EDG at its continuous rating. The pumps are protected by a common duplex suction strainer and individual pressure relief valves. The pumps discharge to a common duplex filter prior to fuel oil entering the fuel day tank. One pump is designated as the primary pump and the second pump is designated as the standby pump, the latter serving in the event of a failure of the primary pump.

### Fuel Oil Transfer Pump Duplex Suction Strainers

The function of the strainer is to remove any entrained contaminants to protect the pump. There is a single set of duplex strainers in the supply line to the transfer pumps. Each element is sized for operation of both transfer pumps simultaneously. The fuel oil duplex strainers are designed for servicing on line.

The fuel oil strainers have remote and local instrumentation for monitoring strainer differential pressure. An alarm will alert the operator if a degraded condition exists and selection of the alternate strainer is required.

### Transfer Pump Discharge Check Valves

Each transfer pump is equipped with a discharge check valve. The check valve prevents backflow during single pump operation. The valves are capable of being tested while in service.

### Transfer Pump Discharge Relief Valves

Each transfer pump is equipped with a discharge pressure relief valve to protect the pump and pipe from overpressure. The valves relieve to the storage tank.

### Fuel Oil Transfer Pump Discharge Filters

The function of the transfer pump discharge fuel filter is to provide a large volume primary filter to remove any entrained contaminates. The primary fuel oil filters are a duplex type with two 100 percent filters that can be maintained on line.

The fuel oil filter has local differential pressure indication to allow monitoring of filter condition. A differential pressure alarm will alert the operator of a degraded condition.

### Fuel Oil Day Tank

A cylindrical day tank is provided for each EDG. Each day tank is installed in a separate room with the fuel oil storage tank in the EPGB of the EDG it serves, with its physical location above the diesel engine. The tank elevation makes sure there is adequate net positive suction head on the engine-driven fuel oil pump at all times. Each day tank has a capacity equal to approximately two hours of operation of the diesel engine at its continuous rating. The tanks are vented, via a flame arrester, to the outside of the EPGB. The overflow and drain connections on the day tanks are piped to the main fuel oil storage tanks. A sampling connection is provided to the bottom of each tank for periodic sampling of the fuel oil for quality and for drawing off any accumulated condensation and sediment.

The exterior surfaces of the tanks are painted for corrosion protection. The interiors of the day tanks are coated with a corrosion resistant material.

Instrumentation is provided, as described in Section 9.5.4.6. The level settings make sure that there is at least a one hour supply of fuel oil, plus a 10 percent margin in each day tank for the diesel engine (based on the fuel consumption rate at 100 percent of the engine continuous rating). When the setpoint level is reached, fuel oil is automatically added to the day tank by the transfer pump from the main storage tank.

### Engine Fuel Oil Pump Suction Strainers

The suction strainer located between the day tank and the engine-driven and auxiliary fuel pumps functions to remove any entrained contaminants to protect the pumps. The fuel strainer is a duplex type with two 100 percent filters that can be maintained on line.

The fuel oil strainer has local differential pressure indication to allow monitoring of strainer condition. A differential pressure alarm will alert the operator of a degraded strainer condition.

### Engine-Driven Fuel Oil Pump

The fuel oil pump is an engine-driven positive displacement pump. The pump takes suction off the day tank and circulates fuel oil through the engine injection header. Maximum pump discharge pressure is controlled by a relief valve at the pump discharge that relieves to the day tank through the fuel return line. The discharge of the pump can be aligned to the full bypass line that is equipped with flow and differential pressure indication for inservice testing.

### Engine-Driven Fuel Pump Discharge Check Valve

The engine-driven fuel pump is equipped with a discharge check valve. The check valve prevents backflow during auxiliary fuel pump operation. The valve is equipped with isolation valves and pressure taps for inservice testing.

### Auxiliary Fuel Oil Pump

The auxiliary fuel oil pump is a positive displacement pump that is capable of delivering full flow and pressure for diesel engine operation at 110 percent power. The pump is safety related and is supplied by Class 1E power. The function of the auxiliary fuel oil pump is to supply fuel oil flow to the diesel engine during startup and in the event of a failure of the engine-driven fuel oil pump.

During engine startup the pump operates until the fuel oil header is supplied by the engine-driven pump at a pressure level high enough for engine start and continued operation. During engine operation the pump starts automatically if engine fuel oil header pressure decreases to a level that affects diesel operability.

The auxiliary fuel oil pump is capable of manual start-stop from the main control room (MCR). The discharge of the pump can be aligned to the full bypass line that is equipped with flow and differential pressure indication for inservice testing and transferring of the day tank fuel to the storage tank for inspection or maintenance of the day tank.

During engine operation an alarm will alert the operator if the pump is activated by low fuel oil pressure.

### Auxiliary Fuel Pump Discharge Check Valve

The auxiliary fuel pump is equipped with a discharge check valve. The check valve prevents backflow during normal operation of the engine-driven fuel pump. Inservice testing can be performed on the discharge check valve.

### Fuel Oil Filters

The function of the filters is to remove any entrained contaminants to protect the engine fuel injectors. The fuel oil filters are a duplex type with two 100 percent filters that can be replaced on line. The fuel oil filter has local differential pressure indication to allow monitoring of filter condition. A differential pressure alarm will alert the operator of a degraded filter condition.

### Fuel Shutoff Valves

The fuel shutoff valve is a normally open solenoid valve in the supply line to each of the fuel supply pumps. The valve is operated by the engine control system in the event of an emergency engine shutdown. There also are manual valves at the engine skid that can be closed to shut off the fuel supply in the event of a control system failure.

### Piping and Valves

Safety-related piping for the DGFOSTS is safety class, Seismic Category I and is made of carbon steel. The exterior surfaces of the piping are painted for corrosion protection.

In addition to the transfer line, fill line, and vent line, the storage tank and the day tank are interconnected via the day tank overflow lines. If the storage tank vent becomes totally restricted, venting can occur through the day tank vent line. The vent sizes are based on filling operations and not engine operations. The operating vent requirements are significantly less than those required for filling. Sizing of the vent lines meet the requirements of NFPA 30, Section 4.2.5.1.2 (see Section 3.2).

There are provisions in the design to prevent entrance of water into the storage tank during adverse environmental conditions, including maximum probable flood conditions. These include a vent line with a flame arrestor, which is goose-necked downward, and the fill connections that are capped and penetrate the building wall at a point well above flood level. The maximum probable flood level does not exceed the elevation of the vent and fill connections and they are not subject to flood conditions. Neither connection will allow the entrance of water into the system during adverse environmental conditions.

### Flame Arrestors

Flame arrestors are applied to the storage and day tanks to prevent foreign material from entering the tanks through the vent system during standby and operating modes. Flame arrestors are designed to operate to the same design requirements as the rest of the DGFOSTS system. Flame arrestors are not required for Class 2 liquids by NFPA 30 but are required by RG 1.137.

### 9.5.4.3 System Operation

#### 9.5.4.3.1 Normal Operation

Each EDG has its own independent fuel oil pumping train from the fuel oil storage tank to the day tank. Level transmitters installed on the day tanks initiate the signals to start the transfer pumps on low level and stop the pumps on high level. If the EDGs are running, the transfer pumps will cycle on and off based on the day tank level. One transfer pump will be in auto with the other in standby. The pump set on auto starts on low day tank level and stops on high level. If the auto pump fails to maintain day tank level, the standby pump will start on low-low day tank level and will stop on high level.

Fuel oil is supplied by gravity to the diesel engine-driven fuel oil pumps.

The storage tanks are replenished by delivery trucks through the oil fill connections located above grade. The minimum fuel quality defined in RG 1.137 and incorporated into the fuel testing program must be met prior to adding new fuel to the storage tanks to minimize the possibility of degrading the overall quality of the stored fuel.

Fuel oil may be added to the tank of an operating diesel without interrupting diesel operation for as long as may be required under all environmental conditions specified in the plant technical requirements. Fuel oil fill has no time constraints, but fuel oil temperature must be maintained above the cloud point of the fuel during transfer to the site and transfer into the storage tank. Fuel in the system including the storage and day tank and associated piping must remain above the cloud point of the stored fuel at all times. This is accomplished by making sure that all portions of the system are located in heated space within the EPGB, with the exception of the fill and pump-out station.

In the unlikely event that one of the oil storage tanks must be replenished without interruption of the associated EDG, the tank fill design provides reasonable assurance that sediment will not be stirred up during replenishment. The fuel system design also includes inline filters that help prevent particulates in the fuel from reaching the injection nozzles.

Normal operation of the system is required any time the EDGs are running. During normal diesel engine operation, fuel oil flows by gravity from the day tank to the suction of the engine-driven fuel delivery pump and the auxiliary fuel pump. The fuel oil is discharged through duplex filters to the fuel injectors and into the engine cylinders. When the engine receives a start signal, either automatic or manual, the electric motor-driven auxiliary fuel oil pump is automatically started to provide the engine with an adequate fuel supply for engine operation. The auxiliary fuel oil pump is de-energized once the engine-driven fuel pump pressure is established. Fuel oil is

transferred from the storage tank to the day tank based on its level to maintain a level in the day tank capable of meeting engine fuel demands.

With the plant operating under normal conditions, the EDGs are maintained in standby. The fuel oil system required storage volume is maintained ready to support EDG operation.

The fuel oil system supports testing of the EDGs on a periodic schedule defined by the plant Technical Specifications. The engine is manually started from the MCR and increased to rated speed in two steps with engine parameters monitored at the local EDG control panel and MCR. The engine accelerates to idle speed (≈ 60 percent of rated speed) and is maintained there for a short period to make sure of proper engine temperature, then engine rpm is increased to rated speed.

The fuel oil system also supports testing to simulate a LOOP. This test is an auto-actuation whereby the diesel starts, accelerates to rated speed, and is under the control of the plant protection system for automatic load sequencing. This test is normally run during plant outage.

Additionally, the EDGs are tested by starting them on a safety injection signal. The diesels will fast start and reach rated frequency and voltage, but will not auto connect to the bus and take the load. This test is normally run during plant outage.

#### 9.5.4.3.2 Abnormal Operation

In the event of low discharge pressure on the primary fuel oil transfer pump, the second fuel oil transfer pump will start to automatically maintain the required fuel level in the day tank.

In the event of low discharge pressure on the engine-driven fuel pump, the auxiliary fuel oil pump will automatically start to maintain the required fuel pressure to the engine.

In the event that the fuel filters become fouled during engine operation, they are designed to be replaced on line without affecting engine operation.

On a LOOP, a time-delayed startup signal is transmitted from the plant protection system to the EDGs. The auxiliary fuel oil pump auto starts to begin flow from the day tank to the engine until fuel is supplied via the engine-driven pump.

### 9.5.4.4 Safety Evaluation

With the exception of the fill and vent connections, the DGFOSTS is located inside the EPGB.

- The EPGB is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of this building. The buildings for the storage tanks are missile protected. The building design forms watertight barriers to prevent water entry into the tank rooms from ground water and flooding.

- The safety-related portions of the DGFOSTS are designed to remain functional after an SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. There are no high energy lines in the EPGB. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to verify that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

- To establish that shared systems and components important to safety are capable of performing required safety functions, the DGFOSTS system for each EDG is independent of any other diesel engine system with the exception of cross ties between DGFOSTS storage tanks 1 and 2 and storage tanks 3 and 4. These cross ties each have a removable spool piece and locked closed isolation valves to prevent sharing.

- The four-division design of the DGFOSTS provides complete redundancy; therefore, no single failure will compromise the EDG safety functions. Vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8. This meets the recommendation of NUREG/CR-0660 (Reference 2).

- The DGFOSTS is initially tested with the program given in Chapter 14. Periodic inservice functional testing is done in accordance with Section 9.5.4.5.

- Section 6.6 provides the ASME BPV Code, Section XI requirements that are appropriate for the DGFOSTS.

- Section 3.2 delineates the quality group classification, seismic category, and design and fabrication codes applicable to the safety-related portion of this system. The power supplies and control functions necessary for safe function of the DGFOSTS are Class IE, as described in Chapters 7 and 8.

- The capacity of each emergency fuel oil storage tank is sufficient for seven days of operation of one EDG at its continuous rating. Within this period, additional fuel can be delivered to the plant site by truck. Fuel consumption is calculated in accordance with the method outlined in ANSI/ANS-59.51 (Reference 3).

- Maintenance of the stored fuel oil temperature is achieved by enclosing the equipment in heated buildings. The fuel oil program makes sure that the temperature of the replenishment fuel oil is maintained at an adequate temperature above the cloud point prior to transfer into the storage tanks.

### 9.5.4.5 Inspection and Testing Requirements

Preoperational testing is described in Section 14.2, test #104,105, and 106.

The DGFOSTS is tested periodically along with the complete EDG system. This test demonstrates the performance, structural, and leak tight integrity of each system component.

Equipment and components are readily available for inspection and maintenance. Provisions are made to pressure test portions of the system. The fuel oil transfer system can be tested independently of each EDG by draining the day tanks (manually to the storage tanks) to the levels that automatically start the pumps. The pump flow rate is verified by monitoring the day tank level indicators. Level annunciators in the storage tanks are used to verify the leak tightness of the tanks.

The fuel oil in the storage tank and day tanks is periodically sampled to verify quality as defined in the EDG fuel sampling and testing program. Degenerated fuel oil can be pumped out of the storage tanks by truck connections provided at the fuel oil transfer station. Accumulated moisture and sediment is removed periodically, via the sump drain, to minimize degradation of the fuel oil.

The storage and day tanks are provided with access and provision to make sure condensation can be drained, samples can be taken and tanks can be cleaned as defined in the EDG fuel sampling and testing program.

### 9.5.4.6 Instrumentation Requirements

Each diesel engine is provided with sufficient instrumentation to monitor the operation of the fuel oil system. The alarms are separately annunciated on the local EDG control panel, which also signals a general diesel trouble alarm in the MCR. The fuel oil system is provided with the indicators and alarms as shown in Table 9.5.4-21—DGFOSTS Indicators and Alarms.

Instrumentation and controls for the DGFOSTS are designed to provide the following safety control functions:

- Auxiliary fuel pump – The auxiliary fuel oil pump is an electric motor-driven pump that is actuated during engine starts and on low oil pressure from the discharge of the engine-driven pump during engine operation.
- Transfer pumps – The fuel oil transfer pumps maintain a high level in the day tank.

The DGFOSTS instrumentation and controls are designed to provide the following non-safety control functions:

- Monitoring of fuel oil levels – The fuel oil levels in both tanks are continuously monitored. Low level alarms are provided to alert the operator in the MCR. Particularly, the alarm labeled as fuel inventory below the required seven day quantity warns the operator to refill the storage tank. The actuators used to perform this function are as follows:

- Storage tank level indication.
- Day tank level indication.

Fuel oil shutoff valves – The fuel oil shutoff valves are energized during emergency and overspeed trips to shut off the fuel supply to the engine and auxiliary fuel pumps. The actuator used to perform this function is as follows:

- Engine fuel oil pump-supply shutoff valve

**Table 9.5.4-1—DGFOSTS Indicators and Alarms**

| Component | Indication / Alarm |
|---|---|
| Main Storage Tanks | Low level and high level annunciators |
| | Technical Specification low-low level alarm |
| | Level indication |
| | Tank gauge glass |
| Fuel Oil Day Tank | High level alarm |
| | Low level alarm |
| | Low-low level alarm |
| | Level indication |
| Fuel Oil Strainers and Filters | High differential pressure alarm |
| | Differential pressure indication |
| | Outlet pressure indication |
| | Low fuel oil pressure alarm |