CONTENTS

1. GENERAL

These instructions are intended to provide advice and directives for the project design and detailed design of external fuel storage facilities for Demag Delaval Industrial Turbomachinery AB (DDIT) turbines.

The instructions given below must not be regarded as being comprehensive. The instructions give general guidelines of how the fuel system should be constructed. Every plant must be designed in accordance with the laws and ordinances in force in the country in which the plant is installed, taking into account the product to be stored.

Permits and/or notifications to the specified extent are necessary for the storage, handling and transport of flammable goods. A classification plan shall be established for each project.

2. INTRODUCTION

The fuel used in the gas turbine must be of specified quality to ensure high performance, high reliability and long useful life of the gas turbine. Fuel from a refinery is usually of very high quality, but contamination and degradation may take place during transport and storage of the fuel.

A contaminated fuel may cause corrosion and damage to the turbine and other components of the system. Correct storage and handling of the fuel and an appropriate fuel treatment system will ensure that fuel of high quality will be supplied to the turbine.

3. STORAGE OF FUELS

The tank employed for a specific fuel must conform to

- the legal requirements in force in the relevant country
- the characteristics of the fuel (flash point, volatility, low-temperature properties, etc.)
- the climatic conditions at the site

The fuel supplier, the manufacturer of tanks and DDIT can recommend a suitable tank for the storage of a particular fuel.

Note!
Fuel must not be pumped into a tank at the same time it is being pumped out.

For applications with continuous operation on liquid fuel must therefore at least two tanks be installed. Each tank is used separately and alternately. This means that one tank is filled and settled, allowing water and particles to sink to the bottom of the tank, while the other tank is in use.

The tank sizes must be determined on the basis of the calculated fuel consumption rate, filling time and settling time.

A common target for the settling time is approximately 3 hours/meter tank height.

On condition that floating suction is installed, the following settling times acquired by experience can be used:

- Aviation gasoline 1 hour
- Aviation kerosene 5 hours
- Diesel fuel (medium) 8 hours

Note!
A special drain pipe must be fitted to the lowest point of the tank. The tank bottom must slope to assist the drainage of water.

All components, such as pumps, filters, etc., must be selected to suit the fuel stored.

3.1. STORAGE OF DISTILLATES

Tanks with a fixed roof can be used for storing distillates with low vapour pressure. Tanks with a floating inner roof are recommended for storing highly volatile fuels (with high vapour pressure).

Note!
The tanks must be equipped with a floating suction in order to minimize the risk of dirt and water being admitted into the gas turbine.

A distillate fuel must always be stored at a temperature of minimum 10°C above the cloud point. The lowest recommended storage temperature is though +5°C in order to avoid freezing of any water at the bottom of the tank or in valves. The fuel supplier should be consulted for advice on a suitable storage temperature.

Note!
Coalescer filters and/or separators must be installed in the external fuel system. Solid particles and water must be removed from the fuel. See chapter 6.

3.2. STORAGE OF RESIDUAL FUELS

Tanks with fixed roof, fixed suction pipe and fuel heating unit are used for storing residual fuels.

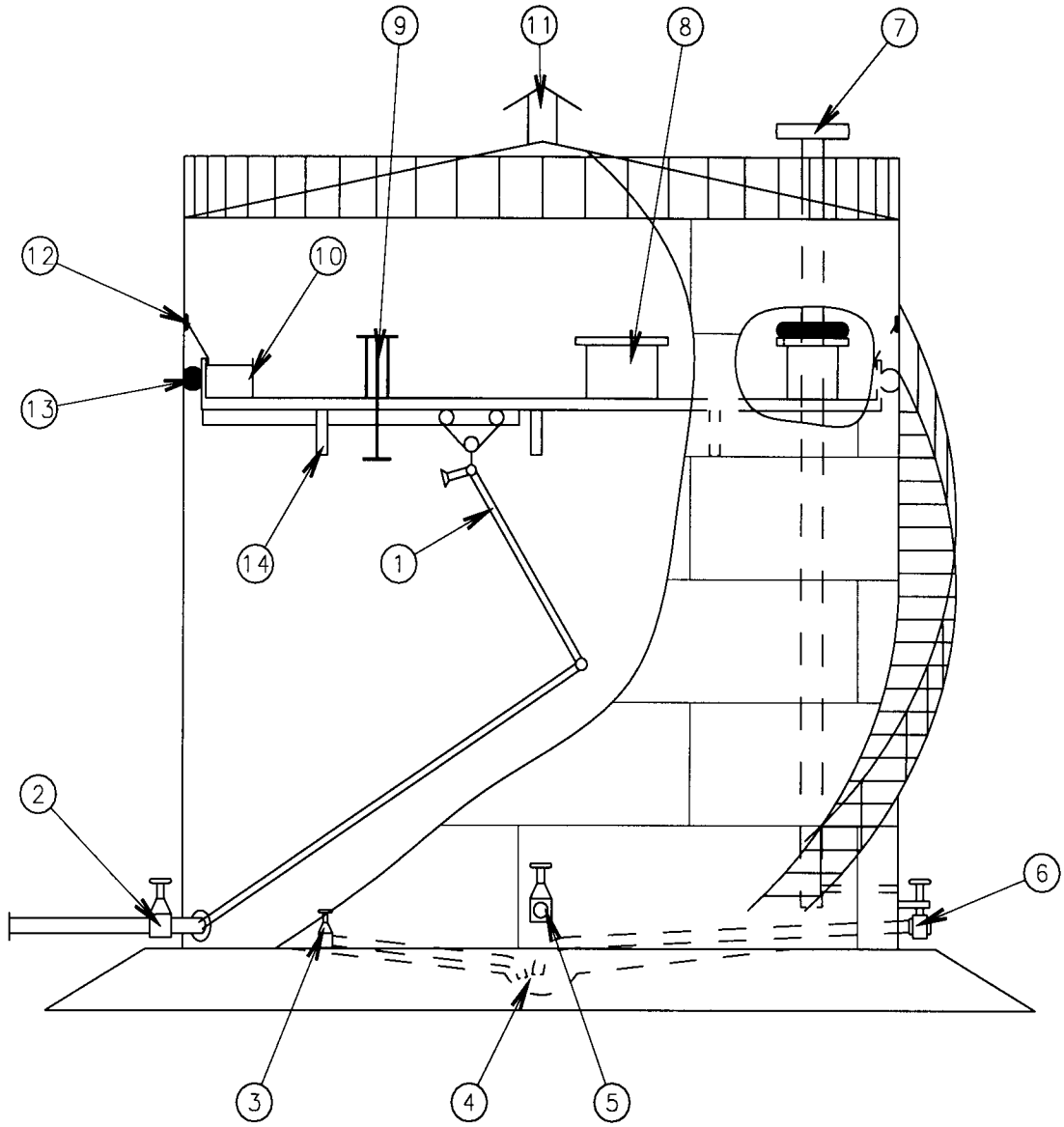
Heavy oils must always be stored at a temperature of minimum 10-15°C above the pour point. The lowest recommended storage temperature is though +5°C in order to avoid freezing of any water at the bottom of the tank or in valves. The fuel supplier should be consulted for advice on a suitable storage temperature.

Note!
Separators and filters must be installed in the external fuel system. Solid particles and water must be removed from the fuel. See chapter 6.

4. TANKS

4.1. COVERED FLOATING ROOF TANK

A tank with a floating inner roof and fixed roof across the tank top, a so called covered floating roof tank, is illustrated in Figure 1. The benefit of this type of tank is that there is practically no space for vaporization above the liquid surface, which reduces the losses during filling and "breathing" and decreases the risk of fire. This tank is therefore suitable for storing volatile fuels. Tanks with a fixed roof connected to a gas recovery system can also be used for storing volatile fuels.

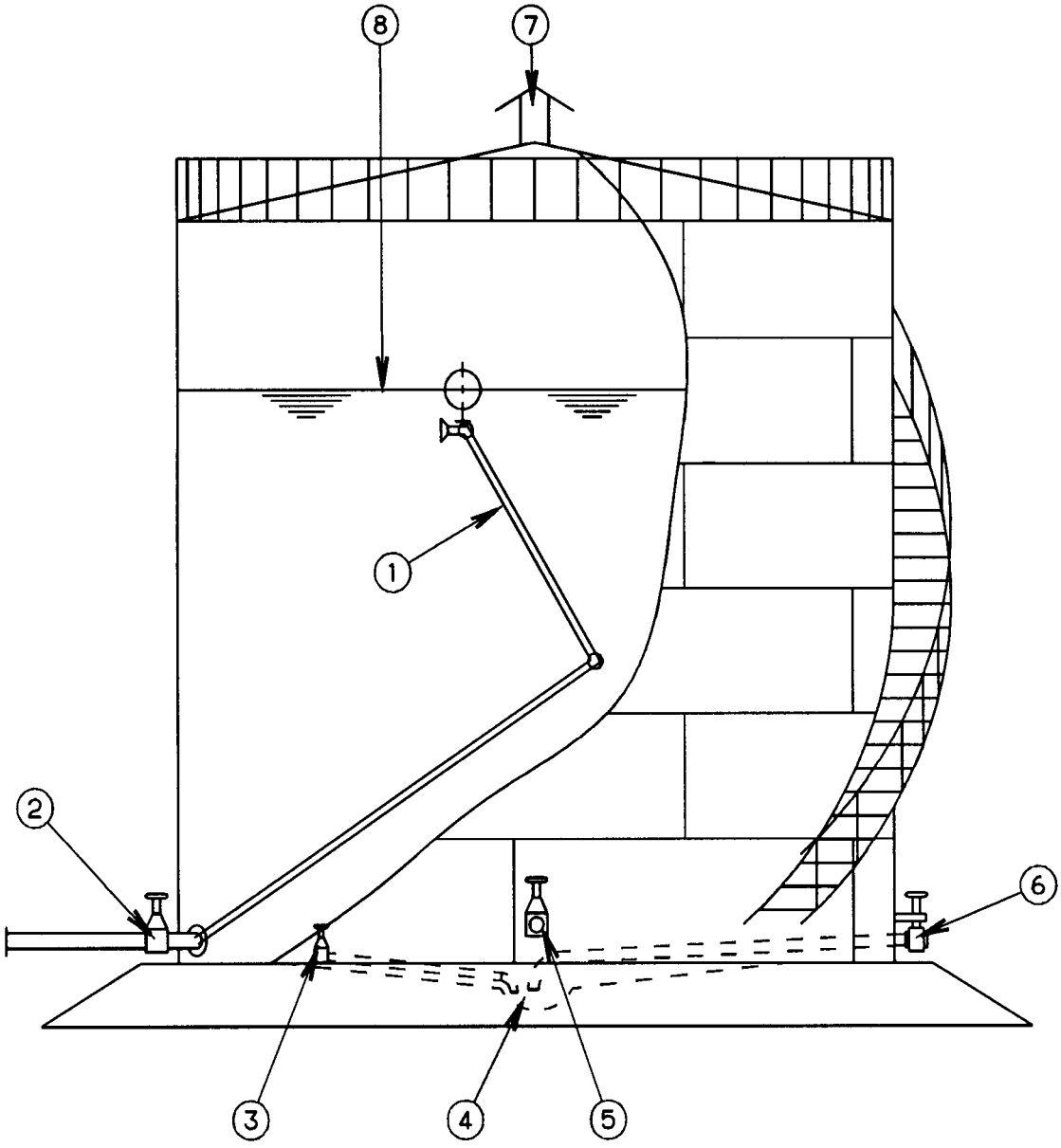


1. Floating suction connection
2. Outlet connection
3. Water drain
4. Centre sump
5. Filler connection
6. Emptying connection
7. Guide tube (Prevents the floating roof from changing position or rotating)
8. Manhole
9. Vent valve (Opens when the floating roof has landed on its supports)
10. Bulkhead
11. Vent
12. Secondary seal
13. Primary seal
14. Supports (Suitable number)

Figure 1 A covered floating roof tank

4.2. TANK WITH FIXED ROOF

A tank with fixed roof is shown in Figure 2. A heating system can be connected to a tank of this type. This tank type is suitable for storing distillate fuels and heavy oils.



1. Floating suction connection
2. Outlet connection
3. Water drain
4. Centre sump
5. Filler connection
6. Emptying connection
7. Vent (possibly pressure/vacuum valve)
8. Liquid level

Figure 2 Tank with fixed roof

5. TANK EQUIPMENT AND DESIGN

5.1. EMBANKMENTS - SAFETY DISTANCES

The necessary safety distances, protective distances and fire breaks between tanks and other buildings as well as embankments around tanks should be provided in accordance with the regulations in force in the relevant country.

5.2. FOUNDATIONS

Tanks installed above ground and in underground caverns must be built on safe foundations and in such a manner that the tank and its accessories will not be exposed to the risk of subsidence. A tank located inside a building shall be mounted on a solid foundation and shall be installed in such a manner that it will not be subjected to dangerous heating.

5.3. MATERIALS

The materials used for the tank should be selected to suit the product to be stored in the tank. Storage tanks are made of steel plate and are all-welded. Moreover, under no circumstances may zinc or zinc treatment be applied to surfaces that will be in contact with the fuel, and the use of copper and copper alloys should also be maintained at an absolute minimum.

Zink is disolved by the fuel, which leads to an increase in the ash content and can possibly cause corrosive deposits in the turbine. Copper from copper alloys can be transferred to the fuel by galvanic action. The presence of copper in the fuel impairs its ability to resist cokeing in the burners and nozzles.

5.4. ROOF

A tank with fixed roof construction and a tank with floating inner roof is shown in Figures 1 and 2. The floating roof must be designed so that it will not sink. This is done by providing the floating roof with a number of liquid-tight bulkheads. The floating roof is provided with a single or double seal at the tank wall. Moreover, the roof must be electrically conductive and must be earthed (grounded).

5.5. TANK BOTTOM

The tank bottom must slope to assist the drainage of water. The slope should be 1:50 and should be towards or away from the centre of the tank. In the former case, a sump is provided in the centre of the tank for collecting and draining the water, whereas in the latter case, the sump is arranged close to the outer shell.

5.6. EQUIPMENT

Storage tanks must be provided with the following equipment:

5.6.1. Filler connection

The size of the filler connection must be such that the velocity of the liquid will be low and will not give rise to unnecessary vortices in the liquid inside the tank. The filler and suction connections should be located on diametrically opposite sides of the tank. Moreover, the filler pipe inside the tank must always be located below the liquid level when filling is started. If the level inside the tank has fallen below the level of the filler connection, filling must be carried out at reduced velocity, i.e. 1 m/s as opposed to the normal value of 3 m/s.

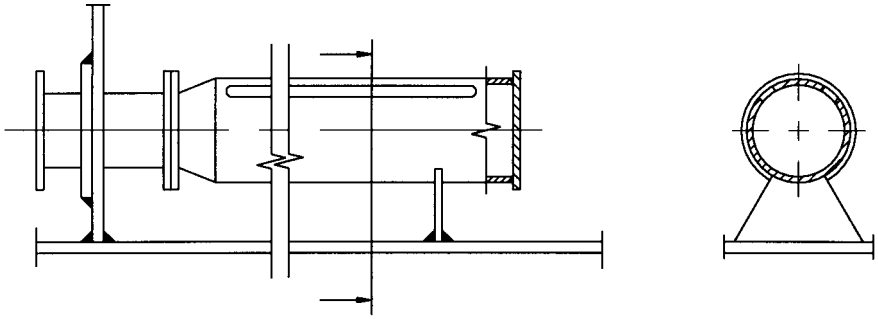


Figure 3 Filler connection

5.6.2. Suction pipe
A floating suction nozzle must always be employed in tanks for lighter fuels as shown in Figures 1 and 2. The suction opening must not suck fuel from a level lower than 400 mm above the tank bottom.

Fixed suction pipes can be employed in tanks used for storing heavy fuels, where separators are used in accordance with 6.2. A fixed suction pipe is shown in Figure 4. The suction must be placed at least 400 mm above bottom.

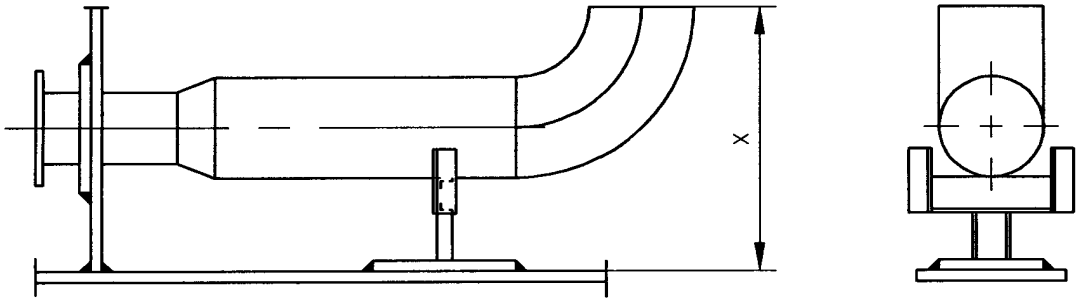


Figure 4 Fixed suction connection

5.6.3. Emptying and drainage
Water must be drained from the tank at regular intervals. A drainage pipe for this purpose should be provided at the lowest point of the tank as shown in Figure 5. A bottom suction pipe is necessary for emptying the tank. In the same way as a water drain pipe, the bottom suction pipe should be located at the lowest point of the tank. The bodies of the valves used here shall be made of steel casting or an equivalent material.

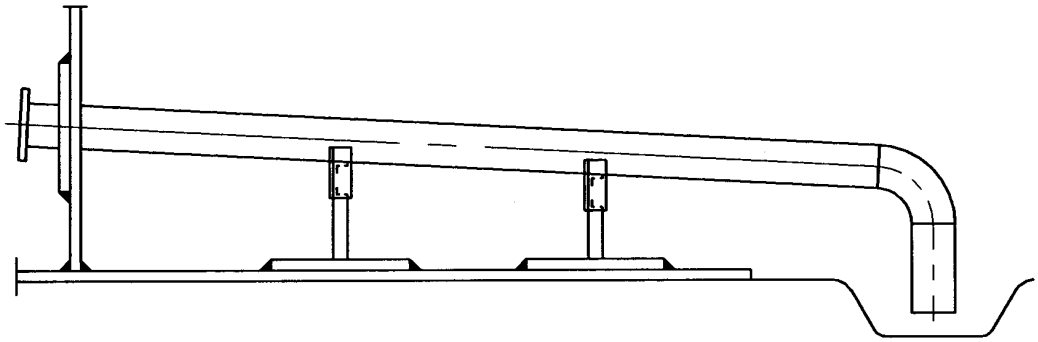


Figure 5 Water drain pipe

5.6.4. Valves
Shut-off valves must be provided in all pipes connected to the tank below its maximum liquid level. The valves should be fitted directly to the pipe branch on the tank or as close as possible to it. The body of a valve next to the shell or bottom of the tank shall be made of steel casting or an equivalent material.

5.6.5. Ventilation
A tank must have a vent arrangement designed so that no inadmissible pressure or vacuum will occur inside the tank. The vent arrangement shall discharge at a suitable point outdoors. If the vapours discharged could easily be ignited, the vent arrangement shall be provided with a flame trap.

5.6.6. Inspection covers
A tank shall be provided with manholes, inspection covers and other equipment necessary for inspection, maintenance and periodic service.

5.6.7. Liquid level gauge
The tank should be equipped with a device that enables the liquid level in the tank to be reliably determined.

5.6.8. Railings and ladder
Railings around the roof of the tank and external steps or a ladder with suitable guards should be installed.

5.6.9. Earthing of the tank
There is serious risk of static electrical charges occurring in the handling of petroleum products. The tank must therefore be earthed (grounded).

5.6.10. Fire fighting equipment

Fire protection in accordance with the laws and regulations issued by the state and local authorities must always be provided for a tank.

5.6.11. Expansion pipe

An expansion pipe or safety valve discharging into the tank shall be provided for parts of the fuel system in which the fuel may conceivably be enclosed during a standstill and be unable to expand. This applies particularly to above-ground pipes which may be exposed to radiant heat. An expansion pipe or safety valve shall be installed independent of how far apart the valves are (i.e. independent of how long the pipe is where the fuel can be trapped).

5.7. SURFACE TREATMENT - INSULATION

Storage tanks shall be painted inside according to local legistlation in the country. An alternative to painting can be a corrosion addition of 1mm. Painting/corrosion addition is primarily to protect the tank from corrosion damage but also to prevent corrosion from contaminating the fuel.

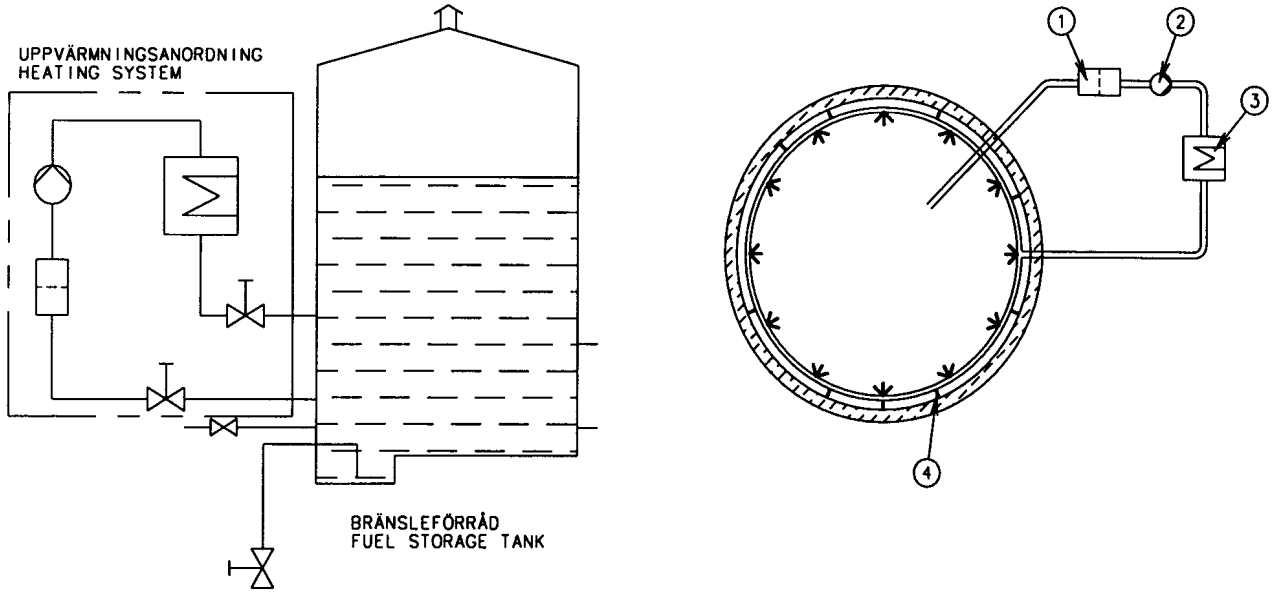
The shell and roof shall be sandblasted and painted on the outside. If volatile fuels are stored, the outer wall and roof should be painted in a colour that has a heat radiation coefficient of at least 70 %.

Tanks in which fuel is preheated shall be insulated to reduce the heating costs. To minimize fuel losses due to vaporization, it may also be justifiable to insulate tanks used for storing volatile fuels. Mineral wool is usually employed for insulating tanks. Aluminium sheet is used for cladding. Note that the insulation should not extend all the way to the ground.

5.8. HEATING

Fuel must be heated if the ambient temperature is below the fuel handling temperature or if the pumpability is not acceptable.

The most suitable method for heating the fuel is by circulating it through a heater unit located outside the tank and consisting of a filter, circulation pump and heat exchanger. The circulation circuit should be arranged so that the return fuel will always be discharged below the liquid surface. The arrangement is illustrated in Figure 6.



1 Filter
2. Pump
3. Heat exchanger
4. Brackets securing the return pipe 300 mm above the bottom

Figure 6 Schematic picture of a heating system for liquid fuel

However, the fuel in the tank can also be heated by means of coils located below the lowest liquid level in the tank. The coils should be placed loosely on supports secured to the bottom of the tank. The design of the supports should be as shown in Figure 4. Consideration should be given to ease of access for cleaning the tank.

6. FUEL TREATMENT

Even though the fuel has been correctly stored and transported, it may contain solid impurities and water in such quantities that the turbine could sustain damage. Solid particles and water can be removed from the fuel by filtration and/or separation. Coalescer filters and/or separators should always be installed in the external fuel system.

6.1. DISTILLATE TREATMENT

For clean distillate fuels a coalescer filter shall be installed in the external fuel system. The coalescer filter should be located immediately adjacent to the internal fuel unit as shown in Figure 7. The coalescer filter should have a filter beta ratio finer than 10 μm β=75.

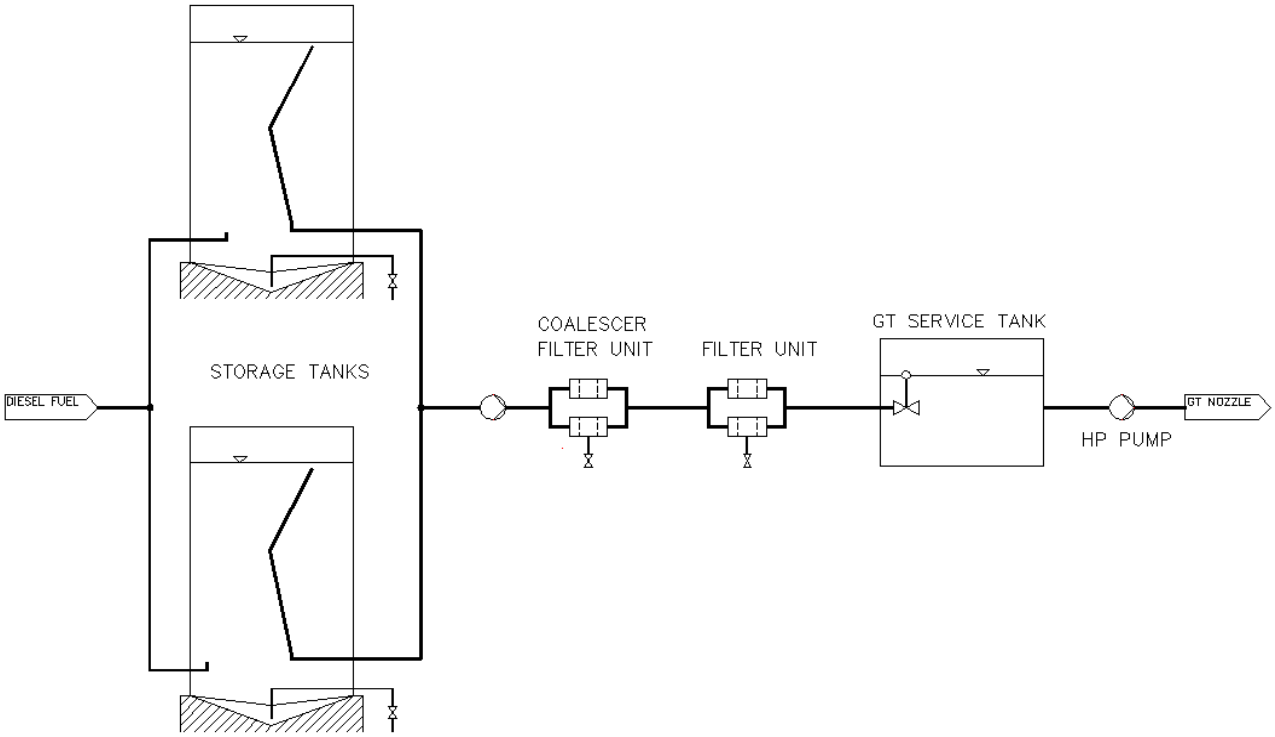


Figure 7 Fuel system for treatment of clean distillate fuel

Note!
Double coalescer filters are recommended to enable change-over and cleaning of the filters during operation and thereby secure continuous operation of the turbine.

The fuel flowing through the filter must be at the correct temperature and flow velocity.

If the distillate fuel is heavily contaminated a separator unit shall be installed after the storage tanks. The separator unit removes water and solid particles. The fuel is piped from the separator to a day tank. A coalescer filter shall be installed immediately adjacent to the internal fuel unit in accordance with Figure 8. The coalescer filter should have a filter beta ratio finer than 10 μm β=75.

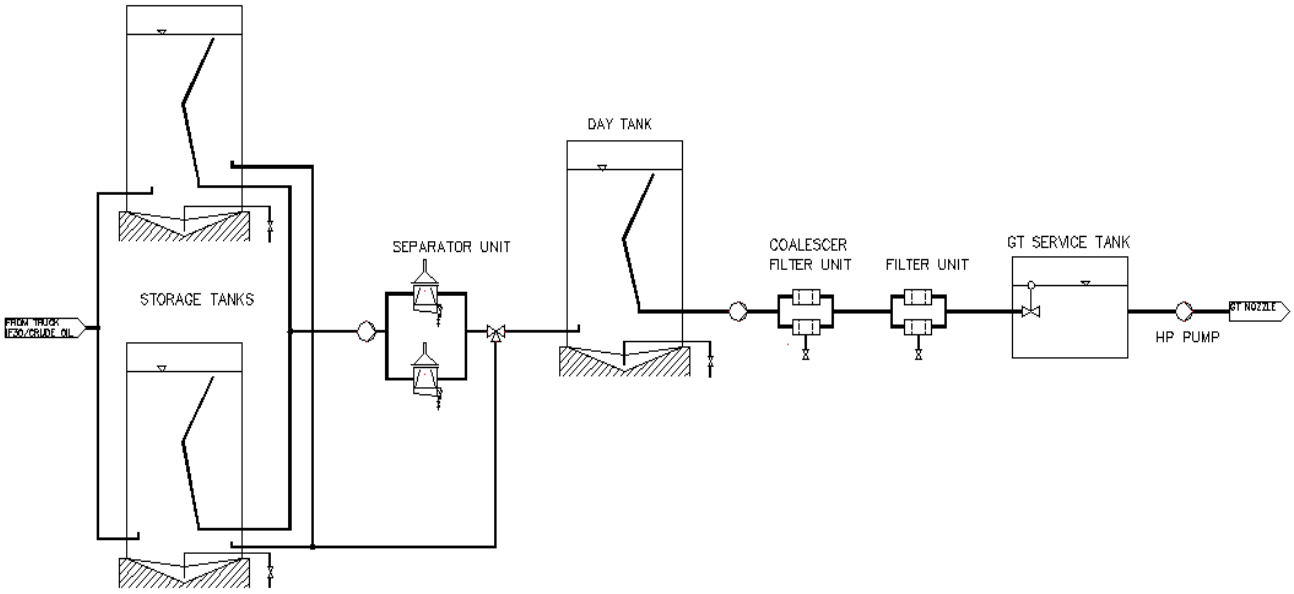


Figure 8 Fuel system for treatment of contaminated distillate fuel

Note!
Double separators and coalescer filters are recommended to enable maintenance during operation and thereby secure continuous operation of the turbine.

6.2. CRUDE OIL AND HEAVY FUEL TREATMENT

An external fuel system for crude and heavy oil treatment is shown in Figure 9.

The fuel is piped from the storage tank to a separator unit and further to a day tank.

The fuel quality and its degree of contamination should be taken into account when selecting the separation equipment (water washing, one or two stage separation, dosage equipment etc).

A deep filter shall be installed in immediate connection to the internal fuel unit to remove alphaltenes and suchlike components. The filter should have a beta ratio finer than 10µm β=75, but the fuel quality must be taken into consideration.

If diesel shall be used as a back-up fuel a storage tank tank for this can be installed in accordance with Figure 9. A coalescer filter shall be installed in immediate connection to the internal fuel system. The filter should have a beta ratio finer than 10µm β=75.

Correct fuel temperature and flow velocity should be maintained throughout the treatment process

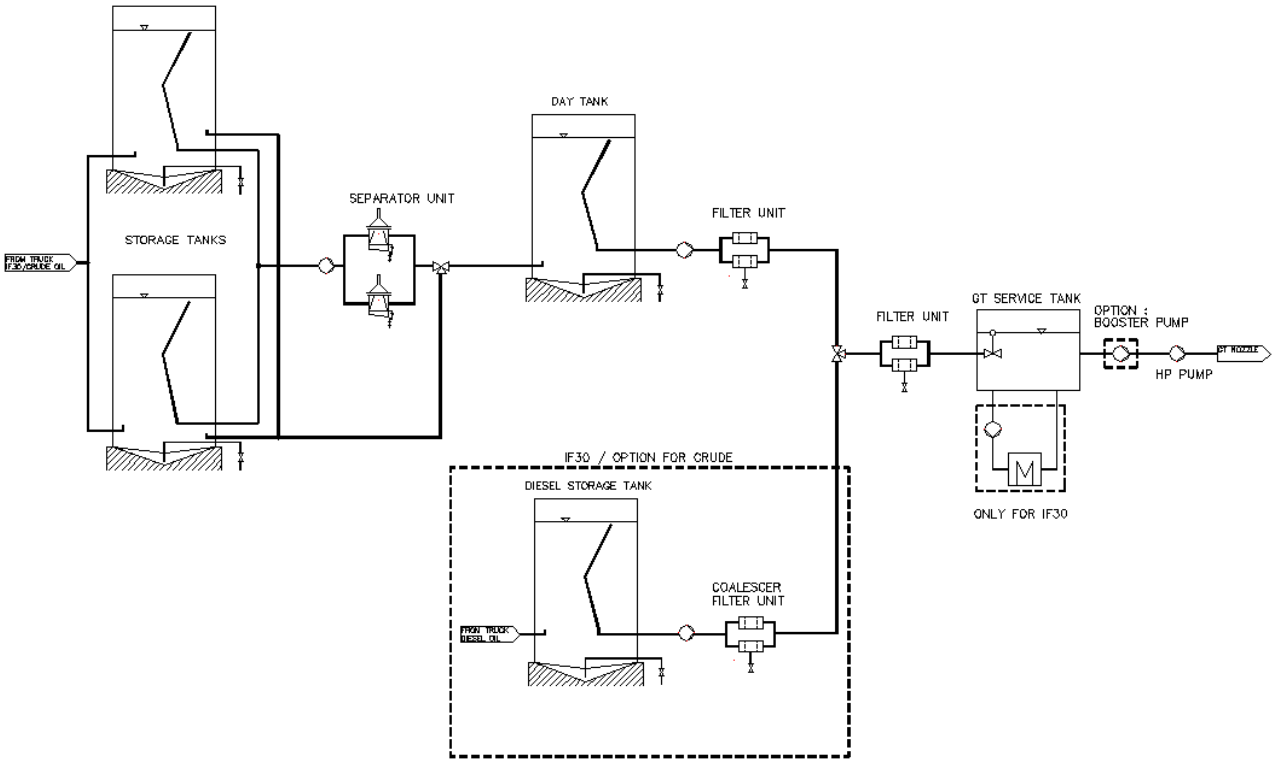


Figure 9 Fuel system for treatment of crude oil and heavy fuel

Note!
Two separator units should be installed in parallel to ensure continuous operation. The capacity of the separator units should be adjusted to the required consumption of the fuel.

The size of the day tank should be adjusted to the required consumption of the fuel.

Double filters shall be installed to ensure continuous operation.

Advice on appropriate systems can be obtained from the fuel supplier, the separator manufacturer, the filter supplier and DDIT.

7. MAINTENANCE INSTRUCTIONS

7.1. NEW TANKS

The legally stipulated design examinations and manufacturing inspections shall be carried out.

All pipes shall be thoroughly cleaned before the system is taken into operation. If possible, welds that will be in contact with the fuel shall be ground, and then pickled and sandblasted.

The system shall be flushed with a fuel of the type for which the plant is intended. Flushing shall be carried out at the highest possible fuel velocity, and the system filters shall be cleaned at regular intervals to remove impurities. Care should also be taken to ensure that no impurities are recirculated back to the tank. If the system is to be entirely clean, the flushing time is seldom shorter than 24 hours. A temporary return pipe must be arranged for such flushing.

If the fuel is contaminated during flushing, it must be changed, and the system must be flushed again with clean fuel.

7.2. FILLING OF TANK

Note!
Fuel must not be pumped into a tank at the same time that it is being pumped out.

When the tank is being filled, the fuel must flow through a filter with a mesh which is determined by the fuel type and the requirements made for that particular plant. Measures should also be taken to prevent overfilling.

The tanker vehicle must be earthed (grounded) to the plant to prevent static electrical charges and sparking. The discharge hose must have an electrically conductive connection between the end couplings.

The liquid velocity in the filler pipe should not exceed 3 m/s. If the liquid level in the tank is below the filler connection, filling must be carried out at reduced velocity, i.e. a maximum of 1 m/s.

At low ambient temperatures, any condensate at the bottom of the tank may freeze if the fuel flowing into the tank is at low temperature and no fuel heating facilities are provided.

Note!
The fuel must be left for settling (at least 24 hours) and the tank must be drained before the fuel is used.

7.3. MAINTENANCE

1. **Water should be drained from the tank at regular intervals**. This should be done through the special drain valve fitted to the lowest point of the tank. A quantity corresponding to at least the volume of the pipe should be drained in order to ensure that any water that has been collected at the bottom of the tank will be discharged through the drain pipe. (Note that oil will first be discharged through the drain pipe and will then be followed by water. This is because the drain pipe is at a higher level than the bottom of the tank). Water should be drained at intervals determined by experience. However, the tank should be drained of water about 24 hours after filling. This time should be somewhat longer for heavier fuels.

2. Draining, cleaning and changing of filters should be done at regular intervals.

3. The separator unit, if any, should be regularly inspected and cleaned.

4. Representative samples of the fuel should be taken regularly, in accordance with K-8436-2.

5. The tank, pipework and equipment shall be regularly inspected in order to ensure that the tank performs satisfactorily in accordance with the requirements in force in the relevant country.

6. The tank should regularly be cleaned. Approved sludge extraction contractors should be retained for removing sludge. However, care should be taken during this work, since there is a serious risk of bacterial contamination.