# GENERAL SPECIFICATION

## SAFETY

### GS EP SAF 321

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<tr>
<th>Rev.</th>
<th>Date</th>
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<tr>
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1. Scope

1.1 Purpose of the specification

The purpose of this specification is to define the safety requirements for the design, installation and testing of fire water pumps and fire water mains. It shall be read in conjunction with other Company specifications in particular mechanical, providing more detailed requirements on the subject of fire water pumps.

1.2 Applicability

This specification is applicable for all onshore and offshore facilities where an all encompassing fire water system shall be installed. It is not applicable to the other sites, where Company has decided to install limited fire-fighting water systems. For such cases, specific requirements shall be given by Company.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

<table>
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**Standards**

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<tr>
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### Regulations

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### Total General Specifications

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3. Terms and definitions

There are three types of statements in this General Specification: "shall", "should" and "may". They shall be understood as follows:

**Shall**
Is to be understood as mandatory. Any deviation from a “shall” statement requires a derogation approved by the Company.

**Should**
Is to be understood as strongly recommended to comply with the requirements of the specification. Alternatives shall provide a similar level of protection and this shall be documented.

**May**
Is used where alternatives are equally acceptable.

4. Fire water requirement and supply

4.1 Water supply

4.1.1 Onshore facilities

4.1.1.1 Water source
Onshore, the water source may consist of river, lake or pond, sea (for coastal installations), underground water reservoir, public water main.

The adequacy and dependability of the water source shall be checked to ensure the overall reliability of the fire water system. The water source shall be adequate in quality and quantity all along the year.

The fire water pumps may either be fed directly by the water source or take suction from an artificial water storage replenished by the water source. The water source shall not be used to feed directly the fire water pumps if the source does not meet the same reliability as the fire water pumps (this may be for example the case for underground water reservoir because of risk of well plugging). In such a case, an artificial water storage shall be installed. This storage may be the open type (basin) or closed type (tank).

4.1.1.2 Water storage replenishment system
This system shall be sized adequately to allow the replenishment of the water storage in a time sufficiently short to limit disruption after usage of the fire water for fire-fighting. As a general rule the fire water storage shall be filled up in less than 24 hours, unless otherwise specified by Company.

The replenishment system shall include easy-to-clean suction strainer facilities. Provisions for possible injection of chemicals against algae growth and/or corrosion inhibition in the replenishment and storage system shall be made.
4.1.1.3 Fire water capacity
Where an artificial storage is used, its size shall not take into account the make up from the replenishment system. The overall fire water storage shall provide the maximum flow required throughout a minimum period of:

- **6 hours** for fire zones including more than 50 m³ of liquid hydrocarbons (including liquid hydrocarbons storage and inventories) (*)
- **3 hours** for fire zones including less than 50 m³ of liquid hydrocarbons or for non-hydrocarbon facilities (including liquid hydrocarbon storage and all liquid hydrocarbon inventory inside the vessels) (*)

(*) Liquid inventory shall be calculated at NLL (Normal Operating Liquid Level) for each vessel/equipment.

It may be necessary in some instances to provide additional means or increase capacity or seawater back-up.

4.1.1.4 Fire water pump feeding facilities
Water source or storage shall be located as near as possible to the fire water pumps. If a storage tank is used, it shall be located where risks due to fire, explosion, or impact are at minimum.

Artificial storage shall be provided with a level indicator and the maximum filling level shall be fitted with an overflow. Adequate fencing and basic life saving equipment (buoys, etc.) shall be provided for open type storage (e.g. ponds).

Fire water pump suction shall be direct, siphoning is not acceptable.

4.1.2 Offshore facilities
Fire water pumps shall be generally of submerged vertical type installed in a pump caisson composed of a steel pipe securely attached to the platform for protection against wave action and mechanical damage:

- For fixed offshore platform, pumps shall be either of vertical suspended type with right angle gearbox, if required, or submerged type (electric or hydraulic driven);
- For FPSO, pumps shall be of submerged type (electric or hydraulic driven)

Where practicable, the pump caisson shall be located where it can be protected by the platform framing to minimise the risk of mechanical damage by boats. The pumps shall be located away from lay down areas and, more generally, shall be protected against the fall of heavy loads. The upper extremity of the pump caisson shall be located above the air gap.

The package design shall be of single lift type i.e. all package components shall form a completely and self-contained skid mounted package ready for bolting down on the foundations and hook-up.

4.2 Maximum fire water flow rate requirement
Fire water flow rate shall match the fire water demand in accordance with requirements developed in GS EP SAF 322.
The fire water pumps shall be sized to provide water to the most demanding fire zone (both for cooling, e.g. deluge and for fire-fighting, e.g. foam generation), plus 120 m³/h for one monitor plus an extra capacity of 60 m³/h for fire hoses.

For FPSO a fire management strategy may be put in place: this strategy is to divide the process fire zone into a number of deluge zones. In the event of a fire, deluge shall be initiated in the deluge zone where fire was detected, plus adjacent deluge zones. Process areas remote from the fire would not be deluged. This option shall be justifiable provided it can be demonstrated that a fire cannot extend beyond the deluge zone. In that strategy the largest fire water demand of the deluge zones/areas, plus spare for any future equipment or system alteration, shall determine the dimensioning of the fire water pumps. Appendix 3 shall be carefully followed to determine the fire water management strategy on the FPSO and the sub-deluge zones assessment.

4.3 Fire main pressure requirements

4.3.1 Fire water pressure maintenance

The fire water main shall be permanently pressurised. In case it is not pressurised by means of a jockey pump, connection to a cooling water supply system or static head from a water storage tank may be envisaged but shall be subject to Company's approval. In any case the fire water network shall be pressurised at 7 barg at the highest point of the fire water network.

The jockey pump shall have a minimum capacity of 30 m³/hr for offshore installations and 60 m³/hr for onshore installations and shall be capable for making up the allowable fire water system leakage. A jockey pump shall always be spared.

Permanent connections between fire water and service water system are allowed only if they do not put the proper operation of the fire water network at risk. However they are not recommended.

4.3.2 Operating pressure

The fire water system components (flanges, fittings, line pipe, etc.) shall withstand the maximum pressure allowed by ASME B 16.5 for flange class 150#.

The fire water pumps and the fire water main shall be designed to supply the adequate flow rates at the most remote location(s). Under flowing conditions, fire water shall be available at 8 barg at the hydraulically most remote monitors, deluge valve or hydrant and at the pressure recommended by the nozzle Manufacturer for the deluge or spray systems. These requirements shall apply even if one supply branch of the fire water mains is blocked (see chapter 6 (Fire water mains)).

4.4 Fire water treatment

4.4.1 Chemical injection

For all facilities using seawater or brackish water produced from underground reservoirs, a suitable chemical injection system shall be provided to prevent formation and growth of marine organisms. Where possible, preference shall be given to a manual system for batch treatment.

Advice shall be sought from Company specialist for the chemical injection requirements. The determination of the type of chemical, the injection rate and the design of the injection system shall also be approved by Company specialist.
4.4.2 Filtering system

No filtering system shall be installed downstream of the fire water pump station but replenishment water shall be filtered upstream the storage tank. Jockey pumps shall always discharge through a filter.

Filters for fire water service (both replenishment and jockey pump) shall be 100 µ and shall be fitted with a by-pass and all other suitable appliances.

5. Fire water pumps

5.1 Pumping capacity and distribution

The number of pumps shall be adequate to provide at least 100% of the maximum fire water requirement, assuming one fire pump accidentally fails when called to operate. In other words, if n is the number of pumps necessary to produce the required flow rate, a minimum of n + 1 pumps shall be installed.

Installation of pumps of individual capacity exceeding 1200 m³/h shall require agreement by Company. For installation of pumps of such high capacity, it shall be demonstrated and checked that the integrity of the fire water distribution system cannot be impaired by the surge effect during transient flow regimes, that there is no specific drivers limitation and that there is no other drawbacks such as reliability of demand.

For FPSO, individual capacity of fire water pumps shall not exceed 2500 m³/hr.

The configuration of the pump station shall be:

- Either 3 x 50%, each pump having a minimum capacity of 50% of the maximum fire water requirement
- Or 2 x 100%, each pump shall have a minimum capacity of 100% of the maximum fire water requirement.

The selection between 3 x 50% and 2 x 100% shall be driven by cost optimisation and material availability. The arrangement 4 x 33% or, say, 4 x 40%, is not recommended, unless it is unavoidable for technical reasons; for instance installation of an additional fire water pump to cover additional needs required by the extension of an existing facility.

For FPSO, the firewater system shall be supplied by 4 sets of fire water pump sets (refer to GS EP SAF 380- chapter 7.9.3). In this case each fire water pump shall have a minimum rating of 35% of fire water demand.

Alternate operating procedures, such as use of temporary external fire-fighting means (e.g. offshore: fire-fighting boat) may be adopted by the Company to cover such situations where one pump is under long maintenance period. If not permanently available, provision of space and tie-in facilities for installation of a temporary diesel driven pump shall be provided.

In the case of a 3-pump arrangement it shall be checked if 3 x 67% configuration is achievable at no additional (or marginally higher) cost. If feasible this alternative shall be preferred because, assuming the network operating pressure is 1 bar lower than nominal (i.e. 7 barg instead of 8 barg), only one pump can supply 90% of the total fire water demand.

As a general rule, fire water pumping capacity shall be achieved with dedicated fire pumps. However the use of cooling water pumps for fire water service may be envisaged if they have adequate characteristics (flow and pressure) and if it is demonstrated that they shall ensure a
reliable fire water supply in all circumstances, even in case of loss of all utilities. The decision to proceed along these lines shall be subject to a special study and specific approval by Company.

5.2 Pump characteristics

5.2.1 Pump type selection

NFPA 20 shall be used to determine the type of pumps according to their application and the required characteristics. Self priming pumps are not acceptable for fixed fire water pumps.

5.2.2 Pump characteristic curves

As per NFPA 20.

All fire pumps shall be suitable for operation in parallel even if normal operation does not require all fire pumps running in parallel.

5.2.3 Pumps accessories

Each pump discharge line shall be fitted with a non return valve, pressure gauge and isolation valve. Refer to Appendix 1.

5.2.3.1 Test line

Periodic testing of fire pump performances is of the utmost importance. Therefore a test line equipped with a flow rate measuring device shall be provided to enable individual testing of each fire water pump. The test line and associated instruments shall be functionally and physically independent of air relief devices and mini-flow protection but can be shared with the surge protection system (see section 5.2.3.4).

Testing facilities shall be designed to enable testing of the pump at 150% of the rated pump capacity. Special care shall be taken to ensure proper supporting of test line and appurtenances.

The supporting system shall be able to provide stability and integrity of the whole testing arrangement.

5.2.3.2 Air relief facility

Submersible fire water pumps installed in a pump caisson shall be fitted with an Air Relief Valve (ARV) tied onto the discharge of vertical pump, immediately upstream of the check valve and the minimum flow connection.

The ARV shall be suitably sized to dispose of the large flow of air expelled out of the lift column when the pump is started.

5.2.3.3 Minimum flow protection

Each pump shall be equipped with minimum flow system to prevent the pump from overheating when operating with no or low water demand. The minimum flow system shall always be kept separate and independent from the other circulation systems such as pump testing and surge/pressure control for instance.

The mini-flow line shall be located just downstream of the pump discharge. The minimum flow protection device shall be an Automatic Minimum Flow Valve (“Schroedahl”, “Schroeder” type or equivalent). In case of diesel engine-driven pumps, the engine cooling water, taken from the fire water pump discharge, may be used as mini-flow providing it ensures an adequate minimum flow rate.
The minimum flow system shall be designed with adequate dynamic actions to avoid sudden change in flow rate generating hammer effect which would possibly damage the fire water mains. In all circumstances the minimum flow shall be fully open upon fire water pump start up.

5.2.3.4 Surge/pressure control valve

The problem of surge is especially critical offshore and/or when GRE piping is used. A surge analysis study shall be conducted wherever this problem is likely to happen.

A possible solution consists in the implementation of a circulation control valve. In such a case, the surge/pressure control system, if any, shall be carefully studied in order to ensure that the overall reliability of the fire water system is not jeopardized. In particular the risk of circulation control valve failing to close (thus reducing the water supply) shall be assessed and adequately addressed at design stage. The circulation valve shall always be of the "fail close" type. Pressure control valves mounted in line with the main fire water stream are prohibited for surge/pressure control purposes.

It is acceptable to have a common circulation system fulfilling both requirements for pump testing and surge/pressure control (see section 5.2.3.1), providing the overall reliability of the fire water system is maintained.

GRP pipework shall not be used for dry network (but only Cu-Ni and/or stainless steel for offshore; for onshore facilities galvanised carbon steel or special alloys may be used). In case GRP pipework is used for wet network, following requirements shall be met:

The calculations performed during design by Projects shall be adequate to identify surge, vacuum and water hammer effects from both the start up of the pumps and the sudden closing/opening of valves (manual or automatic) in the network and that the pipe support is designed accordingly. This shall include ramp-up sequences and temporary fluctuations. Proper data shall be input in the stress model (weight of equipment, reaction force of PSV, vibration of equipment, real dynamic curve of the pumps, etc.). This study shall include a careful review of GRE piping stress model and in particular where heavy loads require adequate supports.

5.2.3.5 Overpressure protection

If necessary, a pressure relief valve shall be installed downstream of the fire water pump to preclude over pressurisation of the fire water systems. This requirement is especially applicable to diesel engine-driven fire water pumps which operate at over-speed in case of governor failure. The relief valve shall guarantee the network integrity during the re-start and the operation of the pumps.

5.2.4 Material

Fire water pumps and all accessories exposed to seawater or brackish water shall be built with materials resistant to the expected corrosive conditions.

5.3 Drivers

5.3.1 General

The fire water pump drivers shall be either diesel engines, or electric motors (see restrictions developed in section 5.3.2), or else electric motors fed by a dedicated diesel generator. Fire water pumps driven by the emergency generator and/or through the emergency switchboard are not acceptable.
Diesel generator driven fire water pumps shall be of the self contained type and a totally independent, permanent and direct electric circuit shall link the generator to the pump electric motor with no intermediate switch gear. Advice shall be sought from Company specialist for the specific requirements.

### 5.3.2 Driver selection

Practically, when combined to the pump station configuration, the requirements listed hereafter lead to the following driver characteristics:

#### Table 1 - Driver selection

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<thead>
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<th>No external power supply</th>
<th>Diesel engine or diesel generator</th>
<th>Electric motor (main power supply)</th>
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<tr>
<td>2 x 100%</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>3 x 50%</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>3 x 67% ((^1) ((^2) ((^4))</td>
<td>2</td>
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</tr>
<tr>
<td>4 x 40% ((^2) ((^4))</td>
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<td>3 x 50% ((^3))</td>
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<td>3 x 67% ((^1) ((^2) ((^4))</td>
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</tr>
<tr>
<td>4 x 40% ((^2) ((^3))</td>
<td>2</td>
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\(^1\): One electric motor acceptable assuming additional flow requirement are matched with only one diesel driven pump running. See section 5.1.

\(^2\): One electric motor acceptable assuming additional flow requirement are matched with only two diesel driven pumps running. See section 5.1.

\(^3\): All fire water pumps can be diesel or diesel generator driven.

\(^4\): 67% x 150% NFPA 20 pump curve is equivalent to 100% of nominal flow rate for one pump.

Driver type(s) selection shall adhere to the fundamental principle that at least 100% of the maximum fire water requirement shall be ensured by pumps that shall remain powered in case of total power failure (normal + essential power). This can be achieved either by diesel engines (or diesel driven generators) or by electric motors when electricity is supplied by an external reliable grid and assuming that normal power is not lost after an emergency shut down on fire detection.

Additionally the driver selection shall be such that, for any fire considered in the SAFETY CONCEPT and leading to an ESD-1 situation, the power supply required to ensure 100% pumping capacity shall be provided nevertheless.

### 5.3.3 Diesel engine

Diesel engines shall be designed, installed and tested in compliance with Company mechanical specification GS EP MEC 022. Vertical axis diesel engines are not allowed.
Especially diesel engines shall be provided with two distinct starting systems completely independent of the plant support facilities:

1. one main starting system (electric or air starting)
2. one back-up hydraulic starting system.

Moreover drip pan underneath the diesel engine shall be provided to protect any accessories from oil spillage.

5.4 Pump arrangement

5.4.1 Weather protection
Where necessary, the fire pumps stations (including pumping unit, accessories, control panel, etc.) shall be sheltered for weather protection.

5.4.2 Protection against fire or explosion
The fire water pump stations shall be protected to minimize the possibility of damage in the event of a fire occurring in other parts of the installation. The minimum distances defined in specifications GS EP SAF 021 and GS EP SAF 253 shall be applied, or the fire water pump station shall be protected by H120 fire resistant walls or enclosure. The enclosure, when required, shall comply with GS EP MEC 022 requirements to meet the noise and the installation area classification requirements.

Offshore, when the risk of fire or explosion damage cannot be completely eliminated, the fire pumps shall be located in two different parts of the installation, in order to minimize the possibility of a single fire or explosion damaging all pumps. Diesel-driven fire pumps shall be located at least 5 m away from any other fire pump unit, or separated from other pumping unit by H0 type wall or equivalent.

5.4.3 Protection against ignition of flammable gas cloud
Diesel driven fire water pumps shall be installed preferably outside hazardous areas (1). If this is not feasible the pumps shall be installed within hazardous areas but inside a gas tight pressurised enclosure taking air from a non hazardous area.

For offshore and coastal environment, the enclosures shall be made of painted carbon steel to prevent them from corrosion.

Doors shall be fitted with anti-panic handles on the inside.

The enclosure air ventilation system shall be designed to comply with following requirements:

- Limit the enclosure internal temperature to a temperature compatible with electronic devices within the enclosure,
- Limit outlet air temperature to the rated site temperature plus 15°C at the rated engine power.
- Control hazardous zones
- Promote the dilution of flammable gas, vapour and mist leaks.

Enclosure ventilation shall be insured by a main ventilation system backed up by a standby ventilation system.
Main and standby ventilation (back-up) shall be sized to provide adequate ventilation as a minimum, typically a uniform ventilation rate of at least 12 volumetric air changes per hour with no stagnant areas.

The air inlet ventilation duct shall be equipped with cleanable, barrier type filters.

Fresh air intakes to the enclosure shall be located in a safe area, at least 2 meters away from a hazardous area, and should be up the prevailing wind from the rest of the installation. Enclosure ventilation air exhaust shall be located 5 meters at least from any machinery combustion air exhaust.

Diesel engine shall be equipped with:

- a combustion air shut-off valve with limit switch and manual reset that shall be triggered in case of engine overspeed
- a spark arrester with an ash removal trap.

Diesel driven fire pump installed inside the restricted area shall be provided with gas detection immediately outside the air intake duct and inside the pump enclosure or shelter, if any. In case of gas detection near the pump or total black shutdown (ESD-0), automatic start-up shall be inhibited but, if the pump has already started up, the pump shall not be stopped.

The inhibit to start signal consecutive to gas detection or ESD-0 shall be of the **non fail safe** type (i.e. energise to shutdown) in order to ensure that a non genuine gas alarm (e.g. instrument cables damaged by fire) cannot prevent the pump to start when required. The line integrity shall be electrically monitored.

(1): The wording "hazardous area" as meant in IP 15 or API RP 505.

**5.4.4 Protection against impact**

All precautions shall be taken to protect the fire water pumps and their associated ancillary equipment against dropped objects, traffic impacts, supply boats bumping into the jacket legs or boat landing, etc. This requirement shall preferably be achieved by adequate position, but, if necessary, physical barriers shall be installed.

**5.5 Fire protection**

A fire water pump station shall be self protected by fire detection and active fire protection systems (refer to GS EP SAF 322 and GS EP SAF 331). The active protection shall be fixed CO₂ extinguishing system when total flooding of the enclosure is possible, or a manually operated dry chemical fire extinguisher.

All diesel engine enclosures shall be protected by a fire protection system based on:

- a high pressure water mist extinguishing system (preferred) as per NFPA 750 and Company requirements (GS EP SAF 332).
- a carbon dioxide extinguishing system as per NFPA 12, and Company requirements. GS EP SAF 331 and GS EP SAF 332.
5.6 Operation

5.6.1 Operating modes

Four modes of operation shall be made available by mean of a mode selector switch: Automatic, Manual, Test, Off.

5.6.2 Start up sequence

The start up sequence shall be designed to achieve two objectives: (i) start the pumps up as fast as possible and (ii) avoid that two pumps start simultaneously. The sequence described below is a typical for a 3 x 50% arrangement with diesel driven fire water pumps and is active only if there is no gas detection in the pump air duct vicinity or in the pump shelter.

The start up order is routed to the pump selected to start first (pump no. 1). The control system shall activate the main starter through a 1.5 minute "attempt to start" cycle including three attempts (15 seconds of cranking followed by 15 seconds of cool down, although these values may vary with the equipment installed). As soon as this cycle is completed or as soon as pump no. 1 is running, whichever comes first, the signal initiating the start up cycle on the main starter shall be sent to pump no. 2, unless the fire water main ring pressure has gone up back to normal in the meantime. The start up signal shall be sent to pump no. 3 (often referred to as "stand by pump") if, after suitable delay, either pump no. 1 or pump no. 2 has failed to start. Pump no. 3 shall also undergo a 1.5 minute attempt to start cycle, using its main starter. This signal is cancelled, if the pressure in the fire water ring main is back to normal before the cycle commences.

When all the pumps have been through their first start up cycle and if the fire water pressure in the ring main is still below the set point, then the whole sequence is repeated all over again for those pumps which are not already running.

If the fire water demand increases after the pumping station has been started and has reached a first steady state running status, e.g. another deluge valve opens or monitors are activated to provide additional fire-fighting capability, and if this demand cannot be met with the pumps in operation, then the whole starting sequence shall be repeated from the very beginning except that pump(s) already running shall be skipped. See logic diagram attached in Appendix 1.

After each pump have been cranked up 6 times, the automatic start up system shall be deactivated and further attempts to start shall be made manually from the pump local control panel. The use of the back-up starter (hydraulic) shall be manual and local only. The case of remote and/or unmanned control room shall be carefully considered. The possibility to reinitiate the start up sequence from the central control room can be envisaged, providing the adequate alarms and status information are also available in the central control room.

Upon disappearance of the starting signal, the pump(s) shall continue to run whatever the pressure might be in the fire water mains. The only mean for the operator to shutdown the fire pumps shall be by pressing the local stop pushbutton. The fire pumps shall automatically shutdown only in case of driver over-speed. Fire or gas detection at the fire pump shall not stop the pump.

5.6.3 Status and alarms indications

Unit Control Panel of the fire water pumps shall be provided with the following status, alarms, shutdown, as a minimum:
• Status
  - Diesel engine available
  - Diesel engine on demand
  - Diesel engine running
  - Diesel engine failed to start
  - Diesel engine start inhibited
  - Diesel engine air flaps status, fully open and fully close.

• Alarms
  - Low cooling water level
  - Low fuel level
  - Low oil pressure (diesel engine and right gear box)
  - High oil temperature (diesel engine and right gear box)
  - High cooling water temperature
  - Diesel engine high exhaust temperature
  - Starting systems (low pressure, low voltage)
  - Weekly start due.

• Shutdown
  - Diesel engine over-speed.

5.6.4 Jockey pump
Where two jockey pumps are provided, the spare jockey pump shall be started automatically in case of shutdown of the first jockey pump.

Jockey pump pressure control shall be ensured by a PCV discharging overboard (offshore) or recycling back to the fire water storage tank (onshore). Restricted orifices, highly sensitive to erosion, shall be avoided.

6. Fire water mains

6.1 Design
Fire water mains are used to transport water from the fire water pumps to the users (hydrants, monitors, deluge valves, sprinkler control valves, etc.). The fire water mains shall always be strictly independent of the other water networks (process water, drinking water, cooling water, etc.) and shall only be used for fire-fighting purposes, although connection with cooling water for instance are tolerated for pressurisation.

Fire water mains shall be filled (wet system) from the fire pumps up to the users (deluge valves, monitor block valve, etc.).

6.1.1 Fire water distribution
Fire water mains shall be designed to supply fire water to all facilities within the installation likely to be exposed to a fire as per SAFETY CONCEPT requirements.
The mains shall be arranged in the form of a ring around fire zones so that each ring and any area within a fire zone where can be supplied with water coming from two opposite directions. This rule accepts however a few exceptions and single fire water lines supplying fire-fighting systems are acceptable for a jetty, a fire-fighting training ground, helidecks, warehouses, etc. and other low-risk, non-hydrocarbon processing, equipment (assessment shall be made on a case per case basis). Single lines are also acceptable for interconnections between fire zones or even between fire pumps and fire zones when the installation of two lines in parallel do not increase significantly the availability of the system. This can be the case when the risk to which the interconnecting line is exposed is low (e.g. onshore buried line suitable protected against corrosion) or when the two lines cannot be laid far apart enough to avoid simultaneous exposure to a possible risk (e.g. interconnection between two offshore platforms by a single bridge).

6.1.2 Isolation valves

Fire water mains (ring and branches) shall be equipped with isolation valves, so that any section of the grid can be taken out of service and the grid can still supply water through adjacent sections to protect the installations. The isolation valves shall be of a gate or butterfly type approved by Company.

A 4-way junction shall always be fitted with three valves, while a 3-way junction (a Tee) shall be equipped with two valves.

![Isolation valves on fire water mains branches](image)

Figure 1 - Isolation valves on fire water mains branches

In the limit of what is achievable and to limit risk of non availability, connections to fire water consumers shall be grouped together on the main on the shortest possible length comprised between two block valves. However this is not always practical and this does not constitute a mandatory requirement.

![Connections to fire water consumers](image)

Figure 2 - Connections to fire water consumers

Isolation valves shall be located with particular care so that (i) they shall remain accessible during an emergency and (ii), in case of a buried fire water network, their layout shall not confuse the operator. They shall always be located close to accesses (and/or roads for onshore installations).
Underground valves shall be provided with above surface position indicator, and the piping arrangement around the valves shall be shown on a local panel, or painted on the ground. Adequate illumination shall be provided.

6.1.3 Piping design
The pipe sizes in the fire water mains network shall be calculated based on design flow rate to give the required pressure at the fire-fighting equipment even when one of the supply branches of the loop is blocked. The maximum allowable velocity in the fire water mains shall be 3 m/s during normal operation, and 4 m/s with one of the supply branches isolated. The piping shall be capable to withstand the maximum pressure with the fire water pumps in operation with no take-off flow, plus the overpressure which could be developed due to surge (hammer effect) at pump start-up or when the take-off flow is stopped. A dynamic study shall be carried out, and the need for surge protection shall be assessed (see section 5.2.3).

6.2 Material
The following table gives the acceptable materials for fire water piping:

<table>
<thead>
<tr>
<th></th>
<th>Sweet water</th>
<th>Seawater</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Underground wet pipe</strong></td>
<td>Carbon steel (1) or Glass fibre reinforced epoxy (2) (3) (4)</td>
<td>Carbon steel with cement lining or Glass fibre reinforced epoxy (2) (3) (4) or Stainless steel</td>
</tr>
<tr>
<td><strong>Aboveground wet pipe</strong></td>
<td>Carbon steel or Glass reinforced epoxy (2) (3) (4)</td>
<td>Copper-nickel pipe (2) or Glass fibre reinforced epoxy (2) (3) (4)</td>
</tr>
</tbody>
</table>

(1): Buried steel pipe shall be suitably coated and wrapped for corrosion protection.
(2): Cu-Ni alloy or GRE can be used if, when empty or full of stagnant water, they shall be able to withstand a fire for 5 (five) minutes before the fire water commences flowing inside the pipe. Once the water flow has started the whole system (pipes, flanges, joints, etc.) shall remain fully operational for 2 (two) hours. Fire proofing protection shall be provided, if necessary, to fulfill these requirements. Refer to GS EP PVV 148 for fire tests on GRP and Cu-Ni
(3): The Supplier shall provide a test performed by an approved laboratory and proving that the pipe resistance is sufficient to match the criteria mentioned above. GRE installation onsite shall be supervised by the representative of an approved Supplier.
(4): Special care shall be dedicated to the selection and protection of joints. The necessity to protect these joints by an adequate coating, even though the pipe itself does not require it, shall be carefully assessed for each specific application.

Other, generally modern technology, materials may be used (e.g. ALUMER™, aluminized carbon steel pipe, manufactured by SANYO Co. or ELASTOPIPE™ manufactured by TRELLEBORG). In these circumstances the guidance and approval of Company specialist shall be sought and obtained.

The pipes, fittings, valves and accessories shall be in compliance with the piping material classes (refer to GS EP PVV 112).
6.3 Arrangement

6.3.1 General
The aboveground piping shall be properly supported and routed, under or behind main structural members where possible, for protection from explosion or fire.

6.3.2 Onshore facilities
Fire water main piping shall be, where practical, separated from hydrocarbon piping.

Fire water ring main shall normally be laid underground (except downstream of the deluge valves) in order to improve the safety of the system and provide protection against freezing in areas where temperatures may fall below 0°C. The required depth of the ring main depends on prevailing local conditions but shall be at least 0.8 m below the ground level. In areas where freezing might occur, the ring main shall be below the frost-line; above-ground parts of the fire water ring main, if any, shall be equipped with adequate drainage facilities.

Piping should run along side roads at some distance from hydrocarbon piping and 2 m away from the edge of the road or 1 m from the sidewalk if any. Specific precautions shall be taken in areas accessible to traffic and at road crossings.

If the material used may be subject to corrosion, the fire water pipes shall be laid at a sufficient distance from electric cable banks to prevent any electro-chemical corrosion, induced current, etc. Cathodic protection shall be provided when necessary.

6.3.3 Offshore facilities
Particular attention shall be paid to the arrangement of the fire water mains. All the fire water piping shall be, as far as practical, routed to ensure protection against impacts, fire and explosion. The fire water mains should be preferably laid under the deck they are supplying, deck penetration being provided individually at each fire-fighting device.

Routing in the wellhead area shall be designed so that main beams may provide protection against the impact of any drilling or workover objects.

6.3.4 Flushing
The fire water mains shall be provided with full bore valved flushing connections so that all sections and dead end can be properly cleaned up. Flushing flow rate shall be in compliance with NFPA 20.

7. Inspection and testing

7.1 Pump unit inspection and testing
The fire water pump units shall be inspected and tested in compliance with NFPA 20 and relevant Company specifications, in particular GS EP MEC 022.

7.1.1 Shop inspection and tests
As per relevant Company specification GS EP MEC 022.
7.1.2 Preliminary acceptance tests

The conformity of the installation with the design requirements shall be checked during the phase of commissioning and the audits. A second test shall be carried out on the jobsite or at integration yard, in operating conditions, with the pumps connected to the distribution network. Each pump shall be tested at 150% rated capacity. Each diesel engine shall be tested at a 10% over-speed for 2 hours.

7.2 Fire water mains


7.3 Dynamic tests

When necessary and/or advisable, flow rates shall be checked using non intrusive Doppler radar.

8. Documentation

8.1 Documents provided by Company

Documents that shall be provided by Company shall be the SAFETY CONCEPT, STATEMENT OF REQUIREMENTS and, when relevant, the OPERATING PHILOSOPHY.

8.2 Documents that shall be provided at design stage

Documents that shall be provided by Engineering at basic design and detailed engineering stage shall be in compliance with Company specifications. As a minimum, they shall include:

<table>
<thead>
<tr>
<th>Table 3 - Documents that shall be provided at design stage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Engineering stage</strong></td>
</tr>
<tr>
<td>• Job specifications</td>
</tr>
<tr>
<td>• P&amp;IDs</td>
</tr>
<tr>
<td>• Fire-fighting equipment layout</td>
</tr>
<tr>
<td>• Fire water demand calculation note</td>
</tr>
<tr>
<td>• Hydraulic study (steady state and transient)</td>
</tr>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

8.3 Documents that shall be provided by Supplier

These documents shall be in compliance with relevant Company specifications and with the following:

8.3.1 Documents that shall be supplied after the purchase order

• Preliminary drawings
• Preliminary dimension and weight for the equipment
• Preliminary calculation notes
• Preliminary list of spare parts
• List of exceptions to specifications.

8.3.2 Documents that shall be supplied for shop acceptance

• Final dimensional drawings approved by ENGINEERING
• Detailed test reports with actual characteristics curves, efficiency and NPSH
• Material certificates
• Final list of spare parts
• For electric motors: tests reports
• For diesel engines: complete set of test reports with data on performances, useful power, speed and fuel consumption.

Where fire-fighting systems require certification, application files shall be submitted to the competent certifying authorities for agreement.

8.3.3 Documents that shall be supplied upon provisional acceptance

• Detailed acceptance test reports, with actual characteristic curves.
Bibliography

ISO 13702  Control and mitigation of fires and explosion on offshore production installations – Requirements and guidelines

NFPA 24  Standards for the Installation of Private Fire Service Mains and their Appurtenances
Appendix 1  Typical fire water schematics

Figure 3 - Typical fire water schematics and logic diagram

Note 1: Logics show only sequence for pump selector set on 1/2/3 position & PSLL loop for pump #1.

Note 2: Inhibit to start on gas detection shown as if all pumps were diesel or non certified motor driven.

Note 3: Test valve to open upon SU if necessary according surge study.

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Appendix 2  Typical sketch of fire water ring main

Block valves arrangement is only typical.
Rule = when they are n lines, (n-1) block valves shall be installed (refer to section 6.1.2)

Figure 4 - Typical sketch of fire water ring main
Appendix 3  Definition of Sub Deluge Zones on FPSO

The purpose of this Appendix is to define the sub division of fire zones into sub deluge zones with the objective of limiting the maximum firewater demand on FPSOs.

1) The following definitions of Fire Zone / Sub Deluge Zone and Module are used:

- **Module** – An individual sub structure / plant unit. Each module shall be supplied with its own deluge via a dedicated FW deluge valve.
- **Sub Deluge Zone** – A group of Modules (selected according to the location of the fire scenario) that shall be deluged simultaneously in the event of a specified fire scenario.
- **Fire Zone** – All modules / sub deluge zones forming the boundary of the Fire Zone. Within a Fire Zone an event (refer to GS EP SAF 253) in any module shall not escalate beyond the Fire Zone boundary by virtue of the separation / segregation provided.

2) The conventional approach within Company referential is to split oil and gas facilities into separate fire zones, with provision for adequate separation / segregation, to prevent escalation. In such cases ESDV isolation is provided at the boundary of each Fire Zone and it is assumed that the Firewater deluge system can supply the total fire zone FW requirement in each case, see Figure 6.
3) The above conventional design approach is generally not suitable for large FPSO firewater system design due to the very large flow rates of water required. Therefore - in order to limit the maximum firewater demand - the FPSO Process Fire Zone may be split into a number of sub deluge zones. In this case, depending on the location of the fire, the **minimum** number of modules requiring deluge, within the sub deluge zone, shall be as follows:

   a) The module on fire
   
   b) Modules bordering the module on fire

This arrangement is represented in Figure 7 below, note that the sub deluge zone is represented by all green shaded modules.

![Figure 7 - Sub Deluge Concept](image)

4) It shall be demonstrated that the consequences of any single module design basis fire - (refer to **GS EP SAF 253**) - does not extend beyond the limit of the applied deluge. This demonstration is required to be performed on a module by module basis, see Figure 8.

![Figure 8 - Consequences of fire in Module](image)

5) Where a process line has potential to the feed the module on fire – originating from outside of the sub deluge area – then ESDV isolation shall be fitted at the module boundary of such lines in addition to the existing equipment SDV. Note this only applies to liquid HC lines as it is assumed that gas process lines shall be automatically depressurized via the EDP system. Process lines crossing modules within the sub deluge zones shall require SDV isolation only, in this case SDVs shall have the same valve body as ESDVs and specified as being spring return, fail closed, fire-safe valves, thus with actuator specification as for ESDVs.
This arrangement is represented in Figure 9.

**Figure 9 - Isolation of Sub Fire / Deluge Zones with ESDV / SDV**

6) A Fire Risk Assessment shall be carried out for each module, within the Fire Zone, to demonstrate that the risk of escalation beyond the adjacent module boundary is acceptable.

Note that for the case where additional ESDV is identified as a requirement, based on 5) above, but the Fire Risk Assessment demonstrates that the liquid HC line is of sufficiently low hazard to not significantly impact escalation - then it may be justifiable to provide SDV isolation (only).