FIRE FIGHTING SYSTEMS
FOR OFFSHORE PLATFORMS
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BY

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RESUME.

SUMMARY.
Detection and alarm systems, shutdown systems and fire fighting systems are all important parts of the total active offshore production and drilling platform fire protection system complex. This paper presents a discussion on the use of water and foam water and the use of halons for fire fighting purposes and gives a summary of the main requirements and basic philosophy for the design of offshore fire watersystems and halon systems respectively. Furthermore brief references are made to certain aspects regarding the detection and shut down systems of importance for the reliability of the fire fighting systems.

ZUSAMMENFASSUNG.
Es wird schliesslich auf Verhältnisse, die entscheidende Bedeutung für die Zuverlässigkeit der obengenannte Systeme haben, aufmerksam gemacht.
1. INTRODUCTION.

Although the basic philosophy generally adapted for off-shore fire protection is often the same, there are variations in the different national regulations for fire fighting systems. Specific regulations for the Danish North Sea sector do not exist as yet. Danish regulations are however being prepared and these will probably be in effect in connection with the coming gas field development plan. The Danish demands are expected to be very close to the present Norwegian regulations. There has in fact been a tendency to base requirements for Danish projects on the Norwegian regulations. Where no special references are made, this paper therefore is based on system designs which have been submitted and approved by the Danish Authorities in connection with recent projects.

2. FIRE WATER SYSTEMS.

2.1 Scope.

Fires can be controlled or extinguished by either preventing or controlling the supply of fuel to the fire or by quenching, i.e. preventing oxygen supply to the fire and by cooling (the classic fire triangle: Fuel, oxygen and heat). Water has unequalled cooling properties and on an offshore platform sea water is available in unlimited amounts. It is not surprising, therefore, that means of reliable and adequate application of fire water is required for all parts of an offshore installation and that the fire water system is still considered the basic fire protection system.

The fire water system consists of fire pumps which supply sea water to the platform and a fire water ring main piping system to which the following fire fighting systems and equipment may be connected (figure 1.):

1. Wet pipe sprinkler systems.
2. Fixed water spray deluge systems.
3. Fixed water spray systems for special hazards.
4. Fixed foam-water spray systems.
5. Water monitors.
6. Hose streams.

2.2 Fire Water Pump Systems.

Normally two separate fire pump systems each capable of supplying the nominal water rate are demanded. Each system comprises pumps, discharge pipes, power source, power transmissions and fuel system, etc. U.K. regulations (1) demand that the fire pump systems are located remote from each other. Norwegian regulations (2) specify that the systems are to be separated in such a way that a fire in one area will not put both fire pumps out of action.
Figure 1. General Platform Configuration.
These requirements are however interpreted more broadly and the basic philosophy would more suitably be one that ensured design and location of the systems (including systems for remote control and monitoring) in such a way that no single incident (e.g. fault, fire, explosion, accident, misunderstanding, etc.) will be able to put more than one of the pump systems out of action.

2.3 Fire Water Pumps.

Fire water pumps are generally submerged centrifugal vertical shaft type pumps. The pumps can be of the following types:

1. Vertical long shaft-pumps, driven by an electric motor or diesel engine placed on the deck right above the pump. The shaft and discharge are integral and are normally placed inside a vertical casing (see figure 3).
2. Hydraulically driven pumps. Here the hydraulic motor is submerged with the pumps. The hydraulic unit is either electrically driven or directly driven by a diesel engine.
3. Submerged electrically driven pumps with the motor flanged on the pump (see figure 2).

In the past long shaft pumps have generally been preferred by many operators. However the inspection of these pumps (performed at least once a year) is complicated and time consuming. Pumps with submerged electric motors are therefore coming more and more into use.

Each system normally comprises one 100% pump or two 50% pumps either directly diesel driven or operated from diesel or turbine driven generators. In the case of the direct diesel driven pump the whole system can be designed in accordance with NFPA 20 (3) and equipped with NFPA approved motor controller. In the case of electric driven pumps there are practical problems in meeting NFPA (and other national codes) specifications especially regarding overload protection, allowable voltage drops at start-up etc., due to the very large motors. In the case of the electric pumps it is therefore necessary to design the power supply and overcurrent protection specially for the specific motor installation. Direct starting of the motor is normally preferred and voltage drops of 30% at start-up have been approved in recent installation (as opposed to NFPA demands of a maximum of 10%). Likewise overcurrent protection by setting circuit breakers as for normal motor installations has been accepted.

The prime movers are part of the pump systems and have to be located in A60 enclosures. Power and control cables outside the enclosure which are essential for the performance of the system have to be fire resistant (cables conforming to IEC 331 have been demanded by the Danish Authorities in recent installations).

Fire pump buildings have to be monitored by fire/gas detection systems. In case of a gas alarm inside the generator room, in the pressurization ducts or in the combustion air ducts, the start-up of the system will be inhibited. It stands to reason
Figure 2. Submerged Electrically Driven Pump. (1) Discharge Flange (2) Pump: 560 m³/h at 10.6 bar. (3) Suction Strainer. (4) Pump Motor: 320 HP.

that gas detectors with inhibiting control should be designed with redundancy. A two-out-of-three voting system is considered as the minimum protection. Fail-safe control action circuits should be avoided.

Furthermore, fire/gas detection systems and appropriate control action systems with control over a pump system should be considered as part of the pump system as regards the general philosophy with respect of full separation of the systems.

2.4 Nominal Fire Pump System Capacity.

Each pump system must be designed with sufficient capacity for simultaneous water supply for the following:

1. The combination of fixed spray systems that are likely to be activated by the same fire, i.e., systems covering adjacent areas, giving the largest water consumption.
2. All hose streams and monitors that may be in use in connection with the fire.
3. Helideck foam monitor and/or portable foam units.

The pump head at the nominal water rate must be sufficient to ensure adequate water pressure in the upper parts of the system (typically five to six bar at the helideck). As it appears the pumps will in many cases only be capable of supplying a few systems out of many simultaneously. If more spray systems are activated than has been allowed for in the pump dimensioning, the effect of all the operated systems is likely to be impaired. It is therefore essential that any possibility of unintentional or faulty activations of deluge valves be eliminated. This must be taken into consideration in the design of remote control stations for the deluge systems. One might say that the activation of too many systems at one time can have just as serious a result as activation of one system too little.

2.5 Fire Water Main.

The fire water pumps feed into the fire water main, which is designed as a ring system allowing all connected fire fighting systems to be supplied from two directions. The ring main is always water filled and pressurized to avoid delay in the water supply. The pressure is normally maintained by smaller make-up pumps. In the North Sea (and other locations where freezing conditions occur), reliable frost alarms have to be installed in the piping so that proper action can be taken to prevent freezing of the pipes.

2.6 Pump Start.

The fire pumps and associated generators, prime motors, etc., generally start automatically on pressure drop in the fire water main. The start of prime movers is normally controlled by approved fire pump controller, e.g. NFPA 20 motorcontroller (3).
Figure 4. Diesel Driven Pump Generator Unit. Caterpillar 750 Kw for direct Start of two 235 Kw Electric Driven Fire Pumps. Overall length: 3.86 m. Overall width: 1.70 m. Overall height: 1.90 m. Weight: 7065 KG.

2.7 Fixed Water Spray Systems.

Purpose of Systems.

Fixed water spray deluge systems are required (1) on well-head areas, production areas and other areas where hydrocarbons are handled or stored. Systems are used for the following purposes:

1. Fire extinguishing.
2. Control of burning.
3. Exposure protection.
4. Fire and explosion prevention.

Class A fires (fires in flammable solids) are readily extinguished by water spray. Some extinguishing effect can be obtained for Class B fires (flammable liquids) by cooling off liquid surface below flash point and in some cases by an emulsification effect or by smothering effected by steam. It is a well known fact however, that extinguishment cannot always be achieved by water alone and supplementary quenching by applying foam or dry chemical powder is often necessary. In the case of Class B fires, control of burning achieved by the cooling effect of water is of greater significance. In some cases a controlled burning is preferable to extinguishment as this avoids accumulation of dangerous amounts of flammable gases or liquids. Exposure protection of critical surfaces by water spray to prevent a fire from spreading and to reduce damage to structures and equipment is likewise an important feature of the spray system.

System Design.

Fixed spray deluge systems consists of an open pipe system fitted with open spray nozzles, these are arranged and spaced so that the specified water coverages on the wetted surfaces are obtained.

In principal there are two main types of fixed spray nozzles:

1. Medium velocity nozzles: The nozzles provide a spray giving water droplets of 1 to 2 mm size. The minimum operating pressure 1.5 bar.
2. High velocity nozzles: These provide a spray with droplets size of 1.5 to 2.5 mm. The minimum operating pressure is 3 bar.

Nozzles are available in a great variety of orifice sizes and discharge angles. Medium velocity nozzles are used for general purpose systems. High velocity nozzles are more suitable where a long range spray is required or where wind conditions would interfere with a medium velocity spray pattern.

The minimum water coverages demanded are as follows: (2) and (4)

Wellhead areas: 20 L/min/m²
Processing areas: 10 L/min/m²
Surfaces of vessels: 10 L/min/m²
Horizontal main structural steel members: 5 L/min/m²
Vertical main structural steel members: 10 L/min/m² (wetted surface)

Figure 7. Large Water Monitor for Fire Boat, Well Head Protection. Ginge A/S, Type KERR 4705. Capacity: 2700 m³/h.
For control of burning the minimum requirements are 20 L/min/m² on spills and 20 L/min/m² of projected surface area for pump glands and similar critical parts.

These are net rates. The average rate per square metre of protected area will, due to overshooting, hydraulic balance, etc., be anything from 10% to 25% larger.

The Christmas trees on the wellheads present special hazards. In the case of a blow-out or leakage on a tree, the down hole valve is the only mean of shutting off the flow. If this valve fails large amounts of water may be required for fire and explosion prevention, or if a fire has already started for control of burning and exposure protection. In theory this can be provided by use of monitors manually operated from high points above the wellhead or by remote hydraulically operated monitors placed on the wellhead. In practice however, it is difficult to place monitors so that all points can be covered and the reaction of personnel in a blow-out situation is often unpredictable. It is therefore more sensible to provide a high rate fixed spray system with fixed high velocity nozzles positioned for concentrated coverage of the Christmas trees.

Strategically positioned monitors providing supplementary coverage with large streams of water should, of course, still be included.

In case of a major blow-out the stationary systems normally provide a certain amount of exposure protection. Extinguishment or control of the fire will in many cases be dependant on bringing up fire fighting vessels with very large water monitors (figure 7).

**Activation of Fixed Spray Systems.**

Deluge valves are normally tripped by pneumatic detection, either of the frangible bulb type or of the metallic tube type monitoring the area covered by the respective spray system in question. Furthermore, break-glass boxes for manual release should be placed at strategic positions in the area.

On wellhead areas and certain process areas, U.V. detection for rapid activation of the spray systems is now being demanded in most installations.

Faulty activation of a spray system is a serious matter resulting in time lost in correcting and flushing of the system. It is therefore essential that at least two U.V. detectors are installed over a potential hazard, and that simultaneous alarms only trip the deluge system. It is however even more important than the U.V. detectors are so located and screened that all possibility of faulty activation by fires or other causes outside the area covered by the spray system are eliminated.

**2.8 Sprinkler Systems.**

Wet pipe sprinkler systems are usually required for protection of accommodation areas, work shops and the like outside the
process areas. A prescribed water coverage of 6 L/min/m² is generally acceptable (2).

2.9 Monitor/Hose Stream Application.

All platforms must be supplied with monitors or hosestations spaced in such a way that the entire installation can be reached by hose streams from at least two directions. Hose streams and monitors provide means for manual local applications of larger water streams supplementing the fixed spray systems for control of burning and for exposure protection of structural elements not covered by fixed spray.

Water filled hose reel stations are also required in all the process areas and furthermore in accommodation enclosures. The hose reels are likewise to be spaced so that any point can be reached from at least two directions.

Hose reels provide means of fast manual extinguishment of smaller fires, typically Class A fires and for means of supplementary exposure protection as mentioned for the monitor/fire hose coverage.

2.10 Foam Systems.

Foam has a quenching effect on Class B fires and therefore facilitates the extinguishing of such fires. Low expansion fixed spray water-foam systems and (2) foam monitors are used for special applications supplementing the fixed spray system or as a system integrated in the fixed spray system for injection of foam agent.

Portable medium foam units (7) for manual use are usually provided throughout the installation and are mandatory on helideck platforms in the Danish North Sea (5).

Low expansion foam monitors for helideck protection are demanded in the U.K. and Norwegian sectors and are expected to be mandatory in the future in the Danish Sector (figure 8).

It should however be borne in mind that foam application will be of limited duration and that many fires e.g. fires involving low flush point gasses or fires in connection with leaks from pressure vessels, Christmas trees etc. are not readily extinguished by foam. So in many cases the ultimate safety often falls back to the reliability and capability of the water spray and the monitor and hose stream systems to provide control of burning and exposure protection.

3. DRY CHEMICAL UNITS.

A brief mentioning of dry chemical application is included. Dry chemical units in the form of fixed pipe systems or more commonly portable hose reel units for manual application, should be installed to supplement foam units and are in any case man-
Dry chemical application for Class B fires is for many hazards more compatible with water streams or spray than foam application and is therefore often suitable for dual medium application in conjunction with water for fast extinguishment of oil fires.

4. HALON EXTINGUISHING SYSTEMS.

4.1 Halon 1301.

Halon 1301, Bromotrifluoromethane, CB\(_x\) F\(_3\), is believed to be the least toxic of the halon agents and is therefore the most widely used halon on offshore installations. Extinguishment is obtained by an anticatalyst action on the burning process by the agent. The agent is stored under pressure and evaporates immediately upon release to an odourless and colourless gas. In the usual concentration Halon 1301 is slightly toxic. The products of decomposition produced be exposure to flames or heated surfaces above 480°C are however toxic even in small concentrations and cause irritation. Halon systems provide efficient fire protection in total flooding systems where an electrically non-conductive and non-corrosive medium is desirable or where the clean-up of other media would be a problem.

The agent provides extinguishment of following types of fires:

1. Fires involving flammable gasses and flammable liquids.
2. Surface fires in flammable solids.
3. Certain deep seated fires on flammable solids.

Gas fires and fires involving flammable gasses are extinguished instantaneously by the agent. Surface fires in solids are likewise extinguished quickly. Flames are put out instantaneously and embers are usually completely extinguished within minutes (e.g., ten minutes), after application of the agent. Deep seated fires are slowed down by the presence of halon, but total extinguishment of deep seated fires cannot always be achieved.

4.2 Application.

Because of these properties halon 1301 is suitable for and normally demanded in the following locations: (1)

1. Control rooms.
2. Engine and generator rooms.
3. Switchboard rooms.
5. Gas turbine hoods

and any other enclosure where application of water is undesirable and where other total flooding agent (e.g., CO\(_2\)) would make occupancy impossible. The agent is likewise suitable for application in enclosures where the inerting of gas for explosion prevention is wanted.
Figure 8. Foam Monitor for Helideck Protection. Ginge A/S, 4" Monitor. Capacity 120 m³/h.

Figure 9. Typical Halon Battery Arrangement.
4.3 System Design.

Systems are normally designed for release of 5% halon by volume in the protected enclosure. This concentration will have no effect on personnel for brief exposures (one minute) but is sufficient to put out all surface fires in solids and flammable liquids that are normally encountered. If inerting effect for gasses or extinguishment of fires involving flammable liquids is contemplated, consideration must be given to specific flammable gasses and liquids that may occur in each case.

Some typical design concentrations of Halon by percentage volume are given below (8):

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Extinguishment</th>
<th>Inerting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>5.0</td>
<td>7.6</td>
</tr>
<tr>
<td>Benzene</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Ethanol</td>
<td>5.0</td>
<td>11.1</td>
</tr>
<tr>
<td>Ethylene</td>
<td>8.2</td>
<td>13.2</td>
</tr>
<tr>
<td>Methane</td>
<td>5.0</td>
<td>7.7</td>
</tr>
<tr>
<td>n-Heptane</td>
<td>5.0</td>
<td>6.9</td>
</tr>
<tr>
<td>Propane</td>
<td>5.2</td>
<td>6.7</td>
</tr>
</tbody>
</table>

The values include appropriate safety factor.

Due allowance must be made for possible leakage from the enclosure in determining the correct volume of agent to be released. If initial concentrations above 7% are necessary, areas which are normally occupied should be evacuated immediately upon discharge of the agent. Concentrations above 10% should not be used in occupied areas. Volumes of 10% to 15% may be used in normally unoccupied areas provided evacuation of personnel can be achieved within thirty seconds after release. Systems are normally specified in accordance with NFPA 12A.

In large systems the Halon containers are placed in a central battery and the Halon distributed by pipes to the discharge nozzles. The central battery should contain at least one permanently connected reserve bank allowing for a full second release (figure 9).

In enclosures where Halon is released on gas alarm for inerting purposes (e.g. enclosures where vital electronic control equipment is required to operate after gas has been detected) consideration must be given to the length of time hazardous conditions may occur, with possible provision for automatic and continuous (twenty-four hours) supply of make-up Halon into the enclosure to compensate for leakage.

4.4 Activation of Halon Systems.

Systems are designed so that the full concentration in the room is achieved within ten seconds after activation. (8)
It is vital that fires are detected as quickly as possible so that the initiation of Halon release takes place before burning becomes deep seated and before large surfaces are heated to a degree where Halon is decomposed.

In areas which are continuously manned, manual release of the system should be considered with detectors giving alarms only. This makes possible the extinguishment of minor fires by hand extinguishers and eliminates the risk of spurious Halon release. In engine rooms automatic release should be accomplished by fixed temperature thermal detectors, gas detection and possible U.V. detection. Rate-of-rise thermal detectors and smoke detectors should give alarm only.

Accidental Halon release is an unpleasant experience for the personnel and costly. Automatic release should therefore always be designed with voting systems, e.g., a minimum of two-out-of-three for gas detectors and a minimum of two smoke zones (if smoke detectors are to be used).
REFERENCES.

(1) U.K. regulation for offshore installations, (Fire fighting equipment).

(2) The Norwegian Petroleum Directorate's regulation for offshore installations.

(3) NFPA 20, Centrifugal Fire Pumps.


(5) Danish Civil Aviation Authority's regulations regarding helidecks.

(6) NFPA 16, Foam-water Sprinkler and Spray Systems.

(7) NFPA 11, Foam extinguishing Systems.

(8) NFPA 12A, Halon 1301 Systems.

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