OFFSHORE NORGE

075 – Offshore Norge recommended guidelines for water-based firefighting systems

Original version

FOREWORD

These guidelines are recommended by the Offshore Norge network for technical safety, the HSE Managers Forum and the Operations Committee. They have also been approved by the director general.

The responsible manager in Offshore Norge is the manager for HSE, who can be contacted via the association's main switchboard at +47 51 84 65 00.

These guidelines have been developed with broad participation by interested parties in Norway's petroleum industry and are owned by Offshore Norge on behalf of the industry. Their administration is assigned to Offshore Norge.

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CONTENTS

1 INTRODUCTION

1.1 Purpose

The purpose this document is to develop recommendations for the design, testing, maintenance and inspection of water-based firefighting systems, with associated performance requirements, based on experience from the industry.

The document covers relevant issues and solutions related to corrosion and marine fouling and to foreign objects in the firewater piping systems which could reduce coverage of firewater by the clogging of nozzles. This could reduce reliability below the level considered acceptable for the firewater system.

1.2 Definitions and abbreviations

Cu-Ni - copper-nickel
GRP - glass reinforced plastic
NCS - Norwegian continental shelf
NiAl – nickel aluminium
ROV - remotely operated vehicle

1.3 References

See chapter 4 on standards and regulations.

2 CHANGES MADE

2.1 Summary

Changes made in this revision of the 075 guidelines are based largely on new knowledge and operational experience from various operator companies.
No changes have been identified which will have consequences in cost terms by comparison with the previous revision of the relevant guidelines.
The document has now been edited in accordance with the Offshore Norge format for guidelines. The following changes have been made.

Chapter 1 Introduction
Simplified text structure, eliminated sections 1.1, 1.2 and 1.3.

Chapter 2 (now 3) Relevant issues
Simplified text structure in former sections 2.1, 2.2 and 2.4.
Deleted duplicated text in former section 2.3.

Chapter 3 (now 4) Standards and regulations
Updated the chapter with regard to current applicable regulations and standards.

Chapter 4 (now 5) Design, operation, maintenance and modifications
Simplified the text structure throughout the chapter.
Deleted the content in the former section 4.3 because of duplication.
Content in the new section 5.3 and former section 4.6 (now 5.6) has been restructured and recommendations related to marine fouling and the depth of the firewater intake included/deleted. Duplicated text has also been deleted.

Chapter 5 (now 6) Inspection and testing
Simplified the text structure and deleted duplicate text throughout the chapter.
Recommendations in section 5.2 (now 6.2) on internal/external inspection of the firewater intake and ring main have been strengthened.

Recommendations in section 5.3 (now 6.3) on conduct of and intervals for fire pump testing have been sharpened on the basis of practice in the industry.
Requirement added to test the inner core seat of self-regulating elastomer valves.
Amended the recommendations for the conduct of full-scale testing of deluge systems. Adjusted acceptance criteria for the percentage of clogged nozzles.
Increased test intervals for deluge systems based on test history and the dimensioning firewater scenario.
Former section 5.4 has been deleted and parts of the text moved to new section 6.3.

Chapter 6 References
This chapter has been deleted, with references to requirements and standards moved to chapter 4.

3 RELEVANT ISSUES

A brief description of the challenges is discussed below.

3.1 Corrosion

Corrosion occurs most frequently as a general corrosive attack over the whole surface. Carbon steel with or without a damaged surface coating is particularly vulnerable to this type of corrosion. Internal corrosion of carbon steel piping can lead to corrosion products which may be torn loose with activation of the firewater system, and may in turn clog nozzles and constrict piping. Experience indicates that corrosion products will be 10 times thicker than the loss of wall thickness.

Pitting corrosion is restricted to small areas. For one reason or another, these areas have become anodic in relation to the rest of the metallic surface. Stainless steel grades such as austenitic (316, for example) and super austenitic (6Mo) steels and duplex types could experience this kind of corrosion. A similar mechanism has also been observed with carbon steel.

Crevice corrosion is restricted to cracks in the surface or to the gap/crevice between two connecting surfaces – at flanges, for example. The mechanism is roughly similar to the one which produces pitting. Material within crevices and cracks can easily become anodic in relation to the surface. Crevice corrosion can also be regarded as being caused by differences in concentration. Steel types subject to pitting may also experience crevice corrosion.

Galvanic corrosion can arise if metals with differing electrode potentials are in contact in a wet environment. Corrosion will always affect the metal with the lowest potential. As a rule of thumb, a potential difference of >0.2V could give rise to galvanic corrosion.

Erosion corrosion can take the form of pure corrosion caused by turbulence, or can occur as a combined effect of corrosion and mechanical deterioration. Turbulent liquid flows, cavitation and particles in the liquid are all factors which may cause erosion corrosion. Carbon steel and copper-nickel alloys are materials which could be particularly vulnerable to this process.

Intercrystaline corrosion can arise if the material is worn and cracks along grain boundaries. The most frequent cause is that secondary phases with a higher potential than the base material have been precipitated at the grain boundaries. Stainless steel grades may also suffer this form of corrosion.

Bacterial or microbiological corrosion arises from the action of substances produced by microorganisms within the piping system.

3.2 Marine fouling

Systems in contact with seawater can be subject to marine fouling caused, for example, by seaweed or mussels.

3.3 Foreign objects

Foreign objects in firewater piping systems, such as welding sponges , welding rods, transport plugs and forgotten blind spades, which block flow in the firewater system, have been found by experience to pose problems during construction, modifications and hook-ups.

4 STANDARDS AND REGULATIONS

A number of statutory regulations and standards govern the design and testing of firewater systems. References are provided below to relevant standards and regulations relating to the design, maintenance and testing of deluge systems.

Statutory regulations for the Norwegian petroleum activity
Relevant provisions are sections 36 and 37 of the facilities regulations on firewater supply and fixed firefighting systems respectively, as well as sections 45 and 47 of the activities regulations on maintenance and the maintenance programme respectively.

Norsok, S-001, technical safety, provides specific requirements for firefighting systems.

ISO 13702, petroleum and natural gas industries – control and mitigation of fires and explosion on offshore production installations requirements and guidelines 1999, specifies requirements for function-testing of deluge systems at a minimum of six-monthly intervals, and a minimum of one full-scale test per year.

Design codes for firefighting installations are mainly provided by the following standards.

NFPA 13, Standard for the installation of sprinkler systems
NFPA 14, Installations of standpipe and hose systems
NFPA 15, Water spray fixed sprinkler and foam-water spray systems
NFPA 16, Deluge foam-water sprinkler and foam-water spray systems
NFPA 20, Standard for the installation of centrifugal fire pumps.

Norsok's materials standards also regulate the choice of materials for piping systems. These are covered primarily by the following standards.

M-001, Material selection
M-630, Material data sheets for piping

5 DESIGN, OPERATION, MAINTENANCE AND MODIFICATIONS

5.1 General

Recommendations made in the document are based on experience from various operations organisations on the NCS.

5.2 Choice of materials

5.2.1 Recommended materials

Titanium
Titanium has very good corrosion resistance. High ductility means it is suitable for cold-bending. This reduces the number of welds and thereby secures uniform material quality. A low elasticity modulus provides flexible piping systems, but also poses a risk of vibration problems and associated fatigue.

As a material, titanium can be recommended for ring mains, including sectioning valves and flanges, distribution systems, deluge systems and valves, and nozzles.

Super duplex (25Cr)
Super duplex (25Cr) steel offers high strength and very good resistance to most forms of corrosion. It has proved to have good resistance to crevice corrosion in seawater at temperatures below 25°C.

This type of steel can be recommended in ring mains, including sectioning valves and flanges, distribution systems, and deluge systems and valves, as long as the temperature in the facilities does not exceed 20°C.

Cu-Ni alloys (Cu-Ni 90:10)
Cu-Ni alloys provide good resistance to most types of corrosion, and to most forms of marine fouling owing to their copper content. However, these alloys have weaknesses in terms of mechanical strength which can be related to pressure surge and erosion problems. They can also suffer from crevice corrosion under stagnant conditions.

Vulcanised heat-resistant piping systems in rubber
The piping system is flexible and can be bent around corners and possible obstacles. Metal components in titanium are used as inserts for joints, branches, reductions, end pieces and nozzle connections. Fire-insulation of joints should be considered.

Such systems are suitable for small ring mains as well as for distribution systems downstream the deluge/sprinkler valve.

GRP piping
Relatively good experience has been registered with such piping in large dimensions. However, the pipes are vulnerable to dynamic loads – pressure surge could cause joints to fail, for example. Consequently, extra attention should be given to vendors' recommendations with respect to installation.

Design, installation and qualification of installations require special expertise and careful follow-up. If these requirements are met, the material can be used in ring mains/distribution systems and for the largest distribution pipes in a deluge system

5.2.2 Materials not recommended

Carbon steel piping with or without galvanisation
Carbon steel piping with or without galvanisation is not recommended, since rusting and corrosion products can reduce functionality over time by clogging pipes and nozzles. Experience shows that maintaining the necessary performance is very resource-intensive. Fully galvanised carbon steel piping should be usable for minor modifications/replacements in existing installations which already incorporate galvanised spray networks and if the remaining lifetime of the facility is short.

Austenitic steel grades, such as 6Mo or 316
Experience shows that austenitic steel suffers major problems with crevice corrosion and pitting, even at relatively low temperatures. Many of the crevice corrosion problems arise from using the wrong seals and inadequate flange tensioning. Corrosion damage has occurred after a relatively short period in use.

Austenitic steel, at a minimum 6Mo, should be used only for minor modifications in existing facilities which are already constructed in an austenitic steel grade. Alternatively, materials with a higher potential can be utilised.

NiAl bronze and copper alloys in pump house and impellers
Experience shows that impellers fabricated in NiAl bronze and copper alloys have a short life span because of erosion/cavitation/corrosion problems. Using other materials for these components is therefore recommended.

Graphite seals in the firewater system
Glass fibre- or aramid-reinforced rubber seals or the like should be used in preference to graphite seals, which can give rise to crevice corrosion. That applies to all material grades.

5.3 Design and modifications

Depth of the water intake
An adequate depth of the water intake should be assured when designing new facilities. Generally speaking, the intake should be deeper than 20 metres (60 metres recommended). The optimum depth must be determined on the basis of field-specific conditions and assessments. If the depth of the intakes for firewater, seawater and ballast varies on an installation, water which ensures pressurisation and replacement the firewater system (ring main) should come from the deepest intake.
Securing an adequate depth can be difficult on certain installation solutions, such as floating platforms and production ships.

Chlorine injection
Chlorine should be injected in the intake section to prevent marine fouling. However, ensuring that the chlorine concentration does not become too high is important, since this could increase corrosion. Chlorination must be planned and implemented on a seasonal basis. Chlorine injection is recommended as a minimum in the summer season or on the basis of field-specific experience.

Intake strainer
The intake strainer should be coated with an anti-fouling substance if it is not protected by chlorine injection.

Flushing points in the ring main
The installation of flushing points with blind flange or valve on the firewater ring main is recommended. This provides opportunities for flushing in several directions, so that possible shell residues and other foreign objects are removed from the deluge systems.

Strainer
The installation of a strainer upstream from the deluge valve, which can be cleaned during operation, is recommended. The type and design should accord with NFPA 15.

Deluge nozzles
MV nozzles have a large nozzle opening and consequently need no filter.

HV nozzles may require filters. Should that be the case, the filter design must be assessed since this could increase the risk that nozzles will become clogged when the system is activated. Their small nozzle opening makes HV nozzles more vulnerable to clogging.

Dump line downstream from the deluge valve
Installing a dump line downstream from the deluge valve is recommended to prevent firewater (seawater) entering the deluge system (dry section) when function-testing the deluge valve. Contact with seawater must be minimised for piping constructed in carbon steel with or without galvanisation. In addition, process equipment must be protected as far as possible from exposure to seawater.

Flushing points downstream from the deluge valve
Installing flushing points downstream from the deluge valve is recommended in order to be able to flush away rust particles or foreign bodies clogging the pipes, particularly at low points and bends.

Drainage holes in the deluge spray network
Drainage holes can be drilled at low points in the deluge system to drain water from such dead legs in order to prevent corrosion. This is most relevant for piping systems constructed in carbon steel with or without galvanisation, but is also generally important for all types of deluge systems to prevent ice plugs forming in the system. Material and hydraulic conditions must be taken into account when determining the diameter of the drainage holes. These should be in the order of 5-8mm.

The preferred alternative to drilling holes is to install nozzles at the low point corresponding to the smallest nozzle type for the system in question. Changing to nozzles with a larger opening is recommended if problems are encountered with deposition or corrosion products. Water consumption for drainage holes/nozzles must be included in the hydraulic calculations.

Installation of anodes on risers
Installing anodes on risers is recommended to prevent galvanic corrosion of risers and pumps.
Should inspections reveal that corrosion of the caisson is a problem, consideration should be given to increasing the anode area (spreading the corrosion) by removing possible internal paint in the caisson, and to reducing the cathode – in other words, the pump including the riser – by painting it. The paint should be an anti-fouling type.

Internal anodes upstream from the deluge valve
Installing internal anodes upstream from the deluge valve (wet section) is recommended to prevent galvanic corrosion of the deluge valve if the material in adjacent systems is a different type, with a potential difference of >0.2V.

Piping design with minimum pressure drop in pipe bends
Efforts should be made to achieve a design consisting of pipe bends which will prevent rust particles, foreign objects or shell residues becoming stuck and clogging/reducing the water flow in the deluge system. This measure is particularly important for deluge systems constructed in carbon steel and for dimensions below two inches. It can be achieved, for example, by installing 45-degree bends (with a spool between them) or bends with a radius of 3-5 times the diameter (by cold or induction bending, for example).

Firewater/seawater intake and drainage system
To reduce opportunities for nutrients in drain water providing nourishment for marine organisms, an adequate distance between the firewater/seawater intake and the drainage system to the sea should be ensured.

Slope to low points and nozzles
Designing the deluge system with adequate slopes to low points and nozzles is recommended to prevent water remaining in the system after drainage.

5.4 Commissioning

During construction and hook-up, it is important to focus attention on work procedures in order to prevent foreign objects entering the system.

Checks should be carried out during commissioning to locate possible forgotten blind spades, block valves in the wrong position, forgotten purge gas plugs, insulation materials and seals, and so forth.

Flushing the whole system is recommended as part of the commissioning process.

5.5 Repair methods

Socket/sealing couplings, welded splices (doubling plates) or laminating with GRP, for example, can be used as a solution until a pipe length which has begun leaking as a result of corrosion has been replaced.

Apart from splicing, these methods must normally be regarded as temporary solutions and plans must be made for permanent replacement of the pipe sections.

5.6 Operation and maintenance, plus drainage, cleaning and preservation

Follow-up of chlorination equipment in firewater systems

Chlorine in the form of sodium hypochlorite (NaOCl) is a frequently used and effective biocide for inhibition, and is highly effective against bacteria and other micro-organisms.

The maintenance programme must include a programme for periodic sampling of firewater. Water samples can reveal marine fouling, foreign objects and corrosion, will be guiding for the use of hypochlorite injection equipment, and will identify any need to change the quantity of hypochlorite injected. Note that there are marine organisms which do not need light to grow. When the facility is new, water samples should be taken monthly. The sampling interval can be changed on the basis of documented history, but should not exceed six months.

Defining chlorination equipment as safety-critical should be considered in order to ensure systematic follow-up. Residues of chlorine and possibly copper are measured in test/dump lines, for example, or at hose points. Some seawater/firewater systems are designed in such a way that free chlorine can be measured in the dump line without being present in the system. In such case, sampling points should also be established elsewhere to provide assurance that free chlorine is present in the firewater system.

Minimum levels of chlorine and copper in firewater
Recommended levels of copper and chlorine for minimising problems with marine fouling in piping systems should be a minimum of 50µg/l and 5µg/l for free chlorine and copper respectively (correspond to 0.050ppm of free chlorine and 0.005ppm of copper). Where only chlorination is used, the concentration of free chlorine should be at least 0.2mg/l (>0.2ppm).

Continuous chlorine dosing
Continuous dosing using hypochlorite or possibly copper combined with hypochlorite should be used to prevent formation of biofilm in firewater/seawater systems.

Regular activation of hydrants and hose reels
Regular activation of hydrants/hose reels is recommended to protect functionality by ensuring that piping is supplied with chlorinated water. The frequency of such activation should be based on experience with the individual installation.

Caustic and acid washing
Washing the firewater system with a combination of a caustic solution followed by acid should dissolve organic material through the caustic treatment and inorganic materials such as shells and various deposits with the acid.
Frequency/need must be assessed on the basis of the facility's condition.

High-pressure flushing of the ring main
High-pressure flushing is a widely used method which effectively cleans the ring main, including branches to deluge valves, hydrants and hose reels. The method is labour-intensive, and should be combined with video inspection to verify/map the condition of the pipes after cleaning.
Frequency/need must be assessed on the basis of the facility's condition.

Full flushing of the ring main without chemicals
Implementing this method is recommended in particular for ring mains constructed in carbon steel with or without galvanisation in order not only to remove corrosion products or keep these under control, but also generally in newer piping systems to remove fouling. The simplest method is to run all the firewater pumps and dump directly to the sea via a dedicated dump line on the ring main or by sectioning parts of the ring main to ensure a higher flow speed. Material quality, rust in the piping and findings from a full flush will determine intervals for each facility. This method should be combined with video inspection to verify/establish the condition of the pipes after the flushing operations.
Frequency/need must be assessed on the basis of the facility's condition.

Drainage of the deluge system after full-scale testing
The distribution system should be drained completely through the deluge valves and/or drainage holes/nozzles at low points in the deluge system in order to prevent corrosion from seawater left standing in the pipes. This is also important to prevent ice plugs/salt deposition which can later come loose and clog nozzles in the deluge system. This routine should be included in the established test procedures for the facility.

High-pressure flushing of the spray network in the deluge system
Implementing the method is recommended for spray networks constructed in carbon steel with or without galvanisation in order to remove corrosion products (rust) in the deluge system (spray network) should internal rusting in the pipes be very extensive. Rust particles could reduce or block the water flow and clog nozzles. The method should be combined with video inspection to verify/establish the condition of the pipes after cleaning.
Frequency/need must be assessed on the basis of the facility's condition.

Freshwater flushing after full-scale testing
The method should be implemented for all piping systems not constructed in seawater-resistant materials. Including corrosion inhibitor in freshwater flushing is recommended.

6 INSPECTION AND TESTING

6.1 General

It is important to emphasise that the following recommendations on testing and inspection must be regarded as a supplement to company-specific preventive maintenance programmes.

6.2 Inspection

ROV inspection of intake section/caisson with opportunities for flushing

Making provision for ROV inspection/flushing of the intake section/caisson is recommended.

Inspections should basically be conducted annually. Should the condition of the intake strainer/caisson be satisfactory after three consecutive inspections, this interval can be increased.

Video inspection of the caisson
Internal video inspection of the caisson should be considered. This activity should form part of the routine/operational condition which involves pulling of risers/pumps.

Checking and inspecting the ring main
The ring main, including flanges and supports, should be checked and inspected. Paying particular attention to insulated parts of the facility is recommended.

Inspection intervals should fall within one-three years, depending on material grade.

Checking of sectioning valves
Sectioning valves in the ring main should be checked regularly, and secured in the correct position.

Regular video inspection of the deluge system (dry section)
Video inspection of the deluge system (dry section) can be performed in special cases (in the transformer room, for example) as an alternative to full-scale testing for establishing the internal condition of the piping system.

6.3 Testing

Function and capacity testing of pumps
An established maintenance and inspection programme for the pumps is important.

Function (start) and capacity testing of the system should be conducted regularly. Intervals must be based on experience with the reliability of the pump system.

Where the capacity test is concerned, flow quantity and activation pressure must be checked against established pump curves.
Acceptance criteria must be established for degradation of the pump curve.

Corrective measures must be implemented if the results are not acceptable.

A capacity test should be conducted annually. Where function testing is concerned, the interval should accord with recommendations in ISO 13702 ref annex C5.

Function testing of sectioning valves in the ring main
The sectioning valves in the ring main should be function-tested (open/close function). As a general rule, the test should be conducted annually.

Testing deluge valves
Deluge valves should be function-tested regularly for the open/close function by running water to the dump line. The recommended test interval will accord with ISO 13702 – annex C5. Checking/cleaning the inner core seat of elastomer valves is recommended to remove possible salt deposition/particles.

Full-scale test of the deluge system
A full-scale test of the deluge system should be conducted. During such testing, the system must provide the full flow rate to the nozzles while the spray pattern for each nozzle is verified.
Two flow meters should be used for full-scale testing. Pressure should be read from at least two deluge nozzles, where one should be in the most unfavourable position hydraulically. To eliminate possible venturi effects, installing a temporary valve is recommended to permit pressure readings from "open and closed" nozzles.

Pressure and water quantity readings (test nozzles and downstream from the deluge valve) must accord with the hydraulic calculations. Nonconformities could indicate fully or partly clogged nozzles or impurities in the piping. Corrective measures should be implemented in the event of clogged nozzles. The limit values presented below are based on safety assessments and established practice in the industry. The following actions are proposed on the basis of the various scenarios per deluge system (defined as the dry section of the piping system connected to a deluge nozzle).

< 3% clogged nozzles:
Clean the clogged nozzles, assess the cause and conduct a new test.

3%-10% clogged nozzles or a maximum of three in each branch/loop:
Clean clogged nozzles, assess the cause and conduct a new test. Corrective measures must be taken. Test intervals must be assessed.

> 10% clogged nozzles:
Clean clogged nozzles. Adopt corrective measures, which will comprise cleaning/upgrading/replacement. Compensating measures or stopping production in the relevant module until the position has been rectified should be assessed.

Intervals for full-scale testing of facilities in seawater-resistant materials
Two independent successful tests should be conducted for a system (at 12-monthly intervals). Given a satisfactory test history, where hydraulic calculations coincide with test data, verifications and visual inspections, the test interval can be increased to a maximum of six years. The reference module must be tested annually.

Where large facilities are concerned, splitting the deluge installations into groups is recommended so that each group is tested annually and all the systems thereby have a test cycle of six years. A reference module will not be required with such an implementation.

Intervals for full-scale testing of facilities not in seawater-resistant materials
When the facility is new, the test interval should be 12 months. Changing these intervals can be assessed on the basis of test history. Methods must be implemented for drainage, inspection and possible protection between each test. Freshwater flushing after activation can be used as a protection method.

Testing the dimensioning firewater scenario
In addition to regular full-scale testing of each deluge system, one (1) test must be conducted with the dimensioning firewater scenario as part of the commissioning process and in connection with major conversions/installation of new systems. These tests must confirm that the systems are also correctly dimensioned when they are activated together with other systems and that the firewater supply has sufficient capacity. Providing the hydraulic calculations are kept up to date, and the deluge systems and fire pumps maintain a satisfactory level of performance, the scenario tests do not need to be repeated.

Testing firewater monitors and hose points
Testing the firewater monitors and hose points/hydrants at least once a year is recommended. The interval must be assessed on the basis of technical condition and test history.

Note: Special requirements apply for helidecks.