MANUAL

DRAIN SYSTEMS FOR OFFSHORE INSTALLATIONS

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DESIGN AND ENGINEERING PRACTICE

PREFACE

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The Hague, The Netherlands,

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The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for the design of drain systems for offshore oil and gas production facilities. Though primarily intended for use during the design of new fixed platform facilities, the guidelines should also be followed for floating facilities, including FPSOs (Floating Production, Storage and Off-loading), and as far as is practical for the modification of existing facilities.

Drain systems on offshore facilities are an integral part of the platform's safety and operability aspects. Serious incidents have been caused by failings in drain systems design which therefore requires careful consideration. Drainage streams are produced from many sources in a facility and the guidance contained in this DEP covers the safe collection and disposal of streams from the following:

- process equipment and maintenance drains;
- rain, deluge and wash-down water from deck drains in process and utility areas;
- instrument drains.

This DEP does not cover the drainage of domestic waste water and sewage streams from accommodation and control room areas, or drainage from drilling units. These systems require special consideration and shall not be integrated with or connected to the facility's plant drain systems.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors nominated by them (i.e. the distribution code is "C" as described in DEP 00.00.05.05-Gen.)

This DEP is intended for use in offshore oil and gas production facilities but may also be applied to onshore facilities located in bodies of water, i.e. in lakes and swamps.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project, or operation or maintenance of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 ABBREVIATIONS

CD	Closed Drain system
HVAC	Heating, Ventilation and Air Conditioning

OHD	Open Hazardous area Drains
ONHD	Open Non-Hazardous area Drains

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (5).

2. DRAIN SYSTEMS PHILOSOPHY

2.1 PURPOSE AND FUNCTION OF PLATFORM DRAIN SYSTEMS

The purpose of the drain systems considered in this DEP is to collect and convey platform drainage streams to an appropriate disposal system in such a way as to protect personnel, plant and equipment, and to avoid environmental pollution. Note that the release of pollutants to the sea and hence the design features required of offshore drain systems are generally subject to the MARPOL convention, to which most countries are now signatories.

Drain systems provide the means of safely removing residual process and wash-down fluids from vessels, pipes, flooring and instruments, resulting either from operational activities or from preparation prior to carrying out maintenance work. The fluids are collected and transported to a recovery system or are disposed of in a safe and environmentally acceptable fashion. A fundamental safety consideration is that a drain system must not provide a route for migration of flammable liquids or vapours from one hazardous area to another, or to non-hazardous areas. Other factors affecting the safety and environmental acceptability of drain systems include:

- interconnections between drain systems;
- effect of blockages;
- accidental or deliberate misuse;
- preventing the spread of fires or flammable fluids;
- pollution of the sea;
- release of toxic materials to the atmosphere;
- incorrect material specifications;
- inability to be cleaned and maintained.

Drain streams shall therefore be segregated into specific systems, each designed for a particular type of stream, with no interconnection between the different systems. Existing drain systems should be modified to remove all interconnections. However, where this proves impractical, reduction to a single interconnection employing a dip-pipe seal in a drain caisson may be considered. In such cases, the dip-pipe shall be corrosion-resistant and the caisson vent be large enough to prevent the liquid seal being broken in the event of gas blow-by to the drain from the largest connected pressurised source. The system should be regularly tested to ensure the seal is maintained.

2.2 DRAIN SYSTEM CLASSIFICATION

The types of drain system found on typical offshore installations can be classified as follows:

2.2.1 Open non-hazardous area drain system

This system provides drainage from those areas of the facility which have been designated non-hazardous. These generally include storage vessel areas for utility materials such as diesel fuel and lubricating oils.

This type of drain system handles fluids collected from floors, drip pans and tundishes or funnels in non-hazardous areas and operates at atmospheric pressure. Open non-hazardous area drains shall be completely segregated from all other open or closed drain systems to eliminate the possibility of hydrocarbon vapour transmission through the drains from other areas to the non-hazardous area.

2.2.2 Open hazardous area drain system

This system provides drainage from those areas which are designated hazardous. These generally include all process areas and other locations in the facility where hydrocarbons are present in significant quantities.

Open hazardous drain systems handle fluids collected from plated decks, drip pans and tundishes or funnels in hazardous areas. Open drain systems shall only be used for draining residual hydrocarbon liquids from vessels and equipment when those vessels or equipment have been subjected to a maintenance preparation procedure (see 3.4.1).

2.2.3 Closed maintenance drain system

Process vessels may contain hydrocarbon fluids which, even after depressuring to atmospheric pressure, would release significant volumes of hazardous vapour if they were discharged via an open drain system. In these cases, a hard-piped connection to a collection header, routed to a dedicated drains vessel, shall be provided for the safe removal of generated vapour. This system is referred to as a closed drain and handles hazardous fluids from process vessels, keeping them away from atmospheric contact.

For new facilities, drain systems of this type should be avoided, if possible, since they require strict and verifiable adherence to rigorous operating procedures to avoid the occurrence of hazardous events. However, they should be used where the process involves toxic fluids such as those containing hydrogen sulphide.

Closed drain systems shall only be used for draining hydrocarbon liquids from process vessels when the vessels have been depressurised to atmospheric pressure under a maintenance preparation procedure (see 3.4.1).

2.2.4 Process drain system

This system is for the disposal of liquids discharged from equipment operating at high pressure, for example liquid streams from compressor scrubber (knockout) vessels. However, routine disposal of such liquids to a process drain system should be avoided wherever possible and compressor scrubber liquids should preferably be routed to a lower pressure part of the process.

2.2.5 Instrument drain system

Because process facilities have many widely dispersed instruments, it is generally not practical to provide a comprehensive open or closed drain system for instrument drainage. In most cases, particularly where the process does not involve toxic gases (e.g. H_2S), local venting and draining of an instrument is generally the most practical method in both open and closed platform modules. The drained liquids may be collected in a suitable container for disposal into an open hazardous area drain or may be piped to that drain, provided that the operator can observe the draining liquid when operating the instrument's drain valve.

Due attention shall be paid to the possible influence that an instrument drain may have on the hazardous classification of an area. Instrument drains which by their nature, location or frequency of use would affect the hazardous area classification should be avoided if possible; alternatively, such liquids can be hard-piped to a closed drain system.

2.2.6 Helideck drain system

Rainwater from a helideck should be collected and discharged overboard via a drain system equipped with a fire-trap. The design should take into account the drainage of spilt aviation fuel with the purpose of removing any spillage quickly from the vicinity of the aircraft.

2.2.7 Firewater and deluge drain systems

Where deluge systems or firewater monitors are installed for fire control, a direct overflow of firewater into the sea may be required to prevent excessive deck loading caused by back-up of water. Deluge water within modules shall be collected in open drain gullies and discharged directly overboard via downcomers, which may serve several drain outlets. Manifolding of the drains shall be such that upstream hazardous and non-hazardous area segregation is maintained and the drain discharge shall be to a safe location. Seal legs will be required where the deluge drains originate in pressurised modules.

2.2.8 Living quarters drain system

A separate sewage/domestic water drain system is required to collect and dispose of waste water from accommodation and offices. Treatment should be in accordance with local regulations and to the MARPOL standards. Living quarters drain systems shall not be interconnected with any other drain system.

NOTE: Living quarters drains are not considered further in this DEP.

2.2.9 Laboratory drain system

Laboratory drains are used for the disposal of hydrocarbon samples, chemicals and solvents. The normal disposal route would be to an open hazardous area drain via a water sealed drain pipe into an OHD gully outside the laboratory wall. Since the laboratory is itself a non-hazardous area, the drain shall not be hard-piped to the OHD to avoid the possibility of back-flow of flammable vapours.

Only hydrocarbon and water samples may be disposed of into the laboratory drain system. All other fluids shall be collected in drums for removal from the platform. If the only convenient drain is an open non-hazardous drain, then all fluids including hydrocarbons shall be collected in drums for off-platform disposal.

NOTE: Laboratory drains are not considered further in this DEP.

2.2.10 Drilling module drain system

A mud drainage system is provided to collect and handle drilling mud/chemicals spillage from the rig floor and mud treatment areas. Because of the possibility of blockages, this system shall be totally segregated from other facility drain systems. The diameter of mud drainage lines shall not be less than DN 200; they shall be free of sharp bends and shall be equipped with adequate rodding facilities for clearing blockages.

NOTE: Drilling module drains are not considered further in this DEP.

3. DRAIN SYSTEMS DESIGN GUIDELINES

3.1 SOURCES AND DESTINATION OF DRAIN SYSTEM FLUIDS

(Table 1) lists the most commonly encountered drain fluid sources, their expected contents, the type of drain system to which fluids would normally be routed and the probable classification of the area in which the source is located. The type of drain system that each source ties into shall be given careful consideration to avoid the introduction of additional hazards.

Table 1 Sources and destination of drain fluids

Drain fluid source	Expected Contents	Suitable Destination	Probable area classification
1. Drains on process equipment and lines containing hydrocarbons	Oil, condensate, some gas, produced water, sand, wash water	OHD (CD if toxic fluids)	Hazardous
2. Process drains from pressure vessels	Oil, condensate, some gas, produced water	LP process vessel or dedicated collection (flash) vessel	Hazardous
3. Drip-pans under process equipment	Oil, wash water	OHD	Hazardous
4. Drains from aviation fuel storage drip-pans/bunds	Aviation fuel, water	ONHD (OHD if located in hazardous area)	Non-hazardous
5. Drains/overflows on diesel fuel tanks/systems	Diesel fuel, wash water	ONHD or OHD (Note 1)	Non-hazardous or hazardous
6. Drains on compressor seal oil tanks	Oil/condensate, some gas	OHD (CD if toxic gas)	Hazardous
7. Drains on turbine and compressor lube oil tanks	Lubricating oil	ONHD or OHD (Note 1)	Non-hazardous or hazardous
8. Drip-pans under chemical storage tanks/vessels	Spilled chemicals, wash water, rain	ONHD or OHD (Note 1)	Non-hazardous or hazardous

9. Drains on equipment not in hazardous service	Water (potable, treated, sea)	ONHD or OHD (Note 1)	Non-hazardous or hazardous
10. Hazardous modules floor drains	Spilled oil, wash water, rain water	OHD	Hazardous
11. Non-hazardous modules floor drains	Spilled lube oil, wash water, rain water	ONHD	Non-hazardous
12. Deluge drains	Firewater	Overboard	Non-hazardous or hazardous
13. Roof & outside deck drains (oil-free areas)	Rain water	Overboard	Non-hazardous
14. Helideck drains	Rain water, spilled fuel	Overboard (via fire trap)	Non-hazardous
15. Instrument drains (if not collected locally)	Oil, water, chemicals	ONHD or OHD (Note 1)	Non-hazardous or hazardous
16. Sample point drains (if not collected locally)	Oil, water, chemicals	OHND or OHD (CD if toxic fluids) (Note 1)	Non-hazardous or hazardous
17. Laboratory drains	Oil, water, chemicals	ONHD, OHD, collection drums (Note 2)	Non-hazardous or hazardous
18. Accommodation/ sewage drains	} Not detailed in this document		
19. Drilling rig mud drains	} Shall be kept separate from other facility drain systems.		

NOTES:

1. The destination of the drained fluids depends on whether the system being drained is located in a non-hazardous or hazardous area.

2. See (2.2.9).

3.2 OPEN NON-HAZARDOUS AREA DRAIN SYSTEM

Drainage from non-hazardous areas shall be completely segregated from any other drainage system in order to eliminate the risk of hydrocarbon vapour transmission to safe areas. Discharge to the system shall be by open gullies for the floor drains and a tundish type system for equipment drains. (Figure 1) shows a typical gully seal design.

Hot liquids that would cause a temperature higher than 45 °C in the drain system shall be cooled first or discharged into a dedicated cooling vessel before being introduced into the drains system.

In order to prevent possible vapour communication between areas through the open drains system, all closed modules shall have liquid seal traps in the drain connections. Account must be taken of possible pressure differences between modules resulting from the operation of HVAC systems. The preferred seal type is an inverted cap design that can be easily inspected (see Figure 1). The liquid seals in the traps may evaporate, especially in closed modules containing equipment operating at relatively warm temperatures, and so must be checked regularly. Alternatively, provision of a constant trickle flow of service water through the gullies to maintain seal levels avoids the need for frequent checks. Open modules do not require seal traps.

The drains stream should normally be discharged into a dedicated non-hazardous caisson, separate from the one installed on the OHD system (or the one for the accommodation drainage system). Alternatively, a collection tank, also separated from the OHD system, may be considered. The relative merits of the two alternatives, together with guidance regarding sizing aspects, are described in (4.4).

The hydrocarbons settling out in the tank or caisson must eventually be pumped back to the process. They shall be routed to a suitable location, such as (in order of preference) an OHD gully in an open area, the OHD caisson or the produced water treatment system. The design of the disposal route shall ensure that no backflow is possible (see also 4.7).

3.3 OPEN HAZARDOUS AREA DRAIN SYSTEM

Drainage from hazardous areas shall be routed to a hydrocarbon recovery system to remove and recycle the contained oil before allowing the water component to be discharged overboard. Discharge to that system shall be by open gullies for the floor drains and a tundish or funnel system for equipment maintenance drains. As in the open non-hazardous area drain system, liquid seal traps shall be provided in the open hazardous drain system to prevent the transmission of hydrocarbon vapours between modules/areas. The contents of a hydrocarbon-containing vessel shall only be discharged via an open system after the vessel has undergone a maintenance preparation procedure (see 3.4.1).

Plated deck areas under equipment or flanged piping shall be equipped with a localised bunded area to prevent spillage of hydrocarbons direct into the sea. However, care must be taken to keep the bunded area size to a practical minimum to reduce the load on the drain system during operation of the deluge system and periods of heavy rain. Rainwater which cannot be contaminated by hydrocarbons, e.g. from open roof areas, should be routed directly overboard and not directed to the OHD system.

The open hazardous area drain stream shall be collected and routed to either a dedicated OHD caisson or to an OHD collection tank. Section (3.2) applies.

On some older facilities incapable of being modified to ensure complete segregation of drains systems, the OHD and Closed Drain may share a common caisson or collection tank. This shall only be allowed when the two systems are separated by a liquid seal of at least 3 m and the capacity of the caisson/tank vent has been demonstrated to be capable of preventing breakage of the seal in the event of gas breakthrough from the largest single item connected to the Closed Drain. The dip-pipe shall be made of corrosion resistant material (e.g. Monel) and shall be inspected regularly to confirm its integrity. In the case of collection tanks, side and bottom entry connections shall be used in place of dip-pipes.

NOTE: A Closed Drains drum shall be included upstream of the caisson or tank to ensure proper degassing of drained liquids.

The destination of the hydrocarbons from the OHD caisson or tank is less critical than with the ONHD because the latter involves a connection between hazardous and non-hazardous areas. Suitable disposal points include the Closed Drains drum, produced water system or a low pressure part of the process, e.g. the flare knock-out drum. Reliable backflow protection is required see (4.7).

3.4 CLOSED (MAINTENANCE) DRAIN SYSTEM

There are two options available for handling drained fluids from process vessels undergoing maintenance. The fluids may be routed to either the OHD or a closed drain (CD) system.

The former may be more suited to a simple satellite platform with an open module design and the latter for larger complex platforms with closed module design. See (Table 2) for the advantages/disadvantages of each system. However, the currently recommended approach is to design the OHD system for maintenance drainage and not install a closed drain system, thereby eliminating the inherent potential hazards associated with misuse of CD systems. For facilities handling sour (H_2S containing) production, it is normal practice to install a CD system unless the concentration of toxic components in atmospheric vapour releases is very low and can be confidently expected to remain so throughout the production lifetime.

Table 2 Open hazardous drain versus closed (maintenance) drain

Open Drain	**Advantages**
	1. Problems during drainage operation easily recognised (e.g. line blockages, inadequate preparation to remove vessel pressure or toxic gases). 2. Integrated with deck gully drainage lines.
	Disadvantages
	1. Full depressuring requires atmospheric vent system. 2. Effective flushing/purging required if toxic gases present (high concentrations may preclude this option). 3. Liquid back-up through lower module seal-pots undetected if blockages occur or inadequately sized lines are used unless separate drain headers used.
Closed Drain	**Advantages**
	1. Atmospheric system not required. 2. Suitable when toxic gases present. 3. Eliminates risk of liquid back-up into lower modules. 4. Tolerant of upsets.
	Disadvantages
	1. Problems during drainage operation not easily recognised. 2. Separate collection system from deck gully drains. 3. Can be misused by operator (vessels drained under full process pressure).

Discharge to the closed drains shall be by hard-piped connections that shall be positively isolated from the process during normal operation. The drain points should be fitted with double block valves with an intervening spade or spectacle blind rated for the upstream connection pressure. This ensures isolation from both the vessel and drain system when removing the spade or swinging the spectacle blind. An alternative isolation system for sight-glass drainage is a double-block-and-bleed arrangement. The main drainage header should be fabricated from 150# rated piping class and terminate at a closed drains drum. The branch connections from the vessels to the main header or up to the first pipe diameter increase shall be rated for the same pressure as the vessel itself. This is because it is in the smaller branch pipes that hydrates are likely to form, should the vessel be inadvertently drained under pressure. Branches shall be connected to the top of the main header(s). There shall be no block valves in the drain system except for those at the individual drainage points. The need for hydrotesting the CD system means that a flange must be installed at the specification break in the piping so that the two pipe classes can be isolated from one another.

It is intended that the CD system shall be used only to empty residual liquids from equipment prior to maintenance. No process shall be drained via the CD system unless that process has been fully depressurised.

The closed drains drum shall be designed with sufficient volume to receive the drained fluids and to permit vapour disengagement (see 4.4). Safety margins shall be applied to cover additional volumes which may be drained and adequate vessel level instrumentation shall be provided, including a high level alarm, to prevent overfilling. An overflow to the OHD caisson shall be provided. The drum shall have a minimum design pressure of 350 kPa, thus eliminating the risk of rupture in the event of a deflagration, and should be freely connected to an atmospheric vent system. The vent shall be sized to discharge the greatest vapour flow that could enter the drum if the CD system is operated (improperly) under pressure or is inadequately degassed.

The contents of the vessel should be pumped out under level control to a suitable low pressure location in the process to minimise the potential for backflow.

3.4.1 Drainage of process equipment for maintenance

Depending on the type of drain system installed, the measures to be taken in preparation for draining fluids from equipment before carrying out maintenance work are as follows.

(A) to Open Hazardous Drain system

The equipment shall first be emptied as far as possible through the normal process route and then depressurised to atmospheric pressure to ensure that there is minimum residual vapour present and that any remaining hydrocarbon liquids are fully degassed.

If maintenance is to be carried out on one of multiple process trains, then an atmospheric vent is required in the facility. In such cases, depressuring through a process flare or vent may not be adequate since, with other trains continuing in operation, there will be a residual pressure in the flare or vent system of possibly several hundred millibars. However, if the complete facility has been shut down for maintenance, then depressuring through the normal process flare or vent is acceptable since there will be minimal back-pressure on the system.

Once the equipment has been fully depressurised, it should then be flushed with water through the normal process route and/or purged with inert gas to remove any remaining hydrocarbons as far as possible. Only then should the residual fluids be drained into the OHD.

(B) to Closed Drain system

Liquid levels in the equipment to be maintained shall be lowered to the minimum practical level using the normal process connections and it is essential that the equipment is fully depressurised before draining via the CD system. Depressuring may lead to cooling of the vessel contents which should then be allowed to regain ambient temperature before being admitted to the drainage system. Only after this procedure has been completed shall the spades or spectacle blinds be opened to allow the residual liquids to pass into the closed drain system.

3.5 PROCESS DRAIN SYSTEM

The drainage systems described in this DEP are provided principally as a process equipment maintenance facility and are not designed to dispose of process fluids to overcome operational difficulties. On the other hand, the “process drains” (or operational disposal) system provides for the onstream removal of fluids from process equipment, such as the fuel gas and compressor knock-out drums. Hence it should be considered as part of the normal process equipment and it is not part of the drainage systems addressed in this DEP. No direct connection between the two shall be made.

When installed, the process drain system should discharge preferably to a dedicated sump or collection vessel with no interconnection to other drain systems. However, in many facilities the flare KO drum also serves as the process drain collection vessel. Depending on the pressure levels in the process, an intermediate flash vessel may be required upstream of the collection vessel. Collected liquids are normally pumped back to an appropriate point in the process, and so a connection to pressurised process equipment is required. Accordingly, the drain system piping shall be designed to a sufficient pressure rating to withstand the effects of possible blockages in the system and consideration shall be given to potential backflow events. Recovered hydrocarbons should be transferred back to the process by means of a positive displacement pump equipped with a non-return valve. The pressure rating of all piping upstream of the collection vessel shall be sufficient for the highest pressure connected to it so that it can withstand the effects of blockages in the system. The design pressure of the collection vessel should be at least 350 kPa and the venting capacity from the vessel shall be sufficient to prevent overpressurisation in the worst foreseeable case of gas blow-by from connected upstream equipment.

3.6 INSTRUMENT DRAIN SYSTEM

Instruments in non-volatile, non-sour service shall be drained into a container or to the OHD via tundishes or funnels. The instrument drain piping should be arranged so that the draining liquid is visible to the operator when the instrument is being drained.

For volatile or sour service, it may be acceptable to employ an open system as described above if the volumes of drained liquid, and hence evolved gas, are very small. Appropriate operating procedures and/or personal protective equipment may be required in such cases. Larger volumes of drained fluids such as from sight-glasses and instrument bridles should be hard-piped to closed drain and vent systems. Each facility should be assessed on a case-by-case basis.

3.7 HELIDECK DRAIN SYSTEM

A helideck shall have its perimeter contained within a curb and rainwater shall be collected in gullies and drained overboard. The helideck drains shall be fitted with fire traps so that burning fuel cannot pass directly overboard. Aircraft fuel storage tanks shall be surrounded by a bund to prevent the spread of any fuel spillage. The bund shall be drained via the OHD.

3.8 FIRE WATER AND DELUGE DRAIN SYSTEM

The quantities of water used in fire-fighting are usually much greater than other drainage quantities. It would generally be uneconomic to design a water clean-up facility so as to allow the passage of these quantities and it is therefore normal practice to provide a separate additional route for fire water drainage. Inadequate fire water drainage could cause a fire to spread within the facility and may overload the support structure of an offshore platform. The fire water drain system is therefore designed to minimise fire spread while also preventing the OHD from being overloaded.

Where deluge systems or fixed monitors are installed for fire control, a direct overflow into the sea shall be provided. Deluge water within any module shall be collected in open drain gullies and discharged directly overboard via downcomers which are sized to serve several drain outlets. Any manifolding shall maintain area segregations and discharges shall be to a safe location. In pressurised areas, seal legs will be required.

The take-off point for deluge water from the drain gully shall be above that for the normal open drain so that the deluge water effectively overflows.

When a deluge system is activated, pool fires would form if the drains were under-sized, which would increase the chance of a fire spreading. To prevent excessive back-up of water in the modules, the deluge drain lines shall be sized for the full deluge system discharge capacity in each area plus an additional 50% to allow for extra fire-fighting equipment. Some of the deluge water in hazardous areas will travel via the normal OHD system and if a drains collection tank is employed, this should be considered when sizing the overflow line.

Schematics of typical drain systems arrangements, without and with closed drains, are shown in (Figure 2) and (Figure 3) respectively.

4. GENERAL DESIGN CONSIDERATIONS

4.1 SIZING DRAIN SYSTEMS

The flowrate of fluids to a facility's drain systems will vary widely and will be intermittent. The design rate for sizing the system components will be specific to each case and some of the main factors to be taken into account are:

- rainwater falling on open deck areas to be discharged through drain gullies;
- washdown water from hand-held hoses to be discharged through drain gullies;
- deluge water from fixed fire monitors, deluge systems and portable fire-fighting equipment to be collected in drain gullies and discharged overboard;
- draining the contents of process vessels for maintenance. The capacity of the drain system should allow this to be carried out within a reasonable time;
- the presence of solids, e.g. dirt and rust particles, debris.

4.2 DRAIN SYSTEM LEVELS

If two pieces of equipment on different levels are being drained at the same time through an open drain system, there is the possibility of fluid flowing into the lower level vessel or overflowing from tundishes into the lower area if a restriction is present upstream of the receiving system. Separate drain headers from each level to the receiving systems shall be used to overcome this potential problem.

4.3 DRAIN SYSTEM GRADIENTS

For normal drains service, a slope of 1 : 100 is sufficient to prevent hold-up of liquids or solids in the drains. Where unusually large amounts of solids (e.g. from sand drains) are expected, a slope of 1 : 75 should be used. For floating production systems such as FPSOs, specific attention should be paid to drain system gradients to ensure the drains function correctly over the normal operating range of vessel movement.

4.4 SELECTION AND SIZING OF CAISSONS AND DRAIN VESSELS

The sizing criteria for caissons, collection tanks and closed drain drums shall be consistent with the intended operations and maintenance procedures. The overall volume of each of the chosen collection systems shall be sufficient to contain:

- the largest volume of oily water that is expected from the draining/maintenance operations;
- the volume of hydrocarbons that may result from a spill or equipment failure; or
- the largest volume of water expected from the open drain during heavy rain or use of a deluge system.

It is clear from this that sizing design will be an iterative procedure with both maintenance and safety aspects interacting with process requirements.

It is not possible to predict droplet size distribution in drain systems because of the many different hydrocarbons and hydrocarbon sources that are present. Therefore the settling time criterion as used in other oil-water gravity separation equipment cannot be used for sizing. The volume of hydrocarbons expected in caissons from open drains (where not used for maintenance drainage) is negligible compared to that resulting from spillage or maintenance draining. Therefore, if the caisson is sized according to the total volume criterion, settling times for these open drain systems will be adequate. When a large amount of hydrocarbons has entered the system and is likely to underflow the caisson, operational procedures should ensure that it will be pumped out on manual control immediately.

Drainage from an open non-hazardous drain system should normally be discharged into a dedicated non-hazardous caisson, separate from the one installed on the OHD system or the one for the accommodation drainage system. Alternatively, separate ONHD and OHD collection tanks may be considered. The advantages and disadvantages of caissons and vessels are described in (Table 3) below. If caissons are the selected choice, an indication of the position of the oil-water interface within the caisson should be provided to ensure that hydrocarbons do not underflow into the sea.

The hydrocarbons settling out in the tank or caisson must eventually be pumped back to the process. They shall be routed to a suitable location, preferably an OHD gully in an open area.

Normally it will be impractical to size a collection tank or vessel to give sufficient residence time for separation to the required oil-in-water (OIW) disposal quality, although this may be considered. If efficient separation is provided, the water can be disposed of overboard and the oil pumped back to the process. Otherwise the tank contents may be pumped on level control to the produced water system or possibly discharged with the export oil. The outlet from the tank to the return pump shall be located below the pump's stop/start float switch to prevent sand build-up interfering with the stop/start control.

When the water from the drainage system is eventually disposed of into the sea, adequate separation from any seawater lift facilities shall be maintained to prevent the possibility of hydrocarbons being lifted with the seawater.

Table 3 Caissons versus collection vessels

Caissons (vertical)	**Advantages**
	1. Easy to achieve low point drainage and large holding volumes for hydrocarbon fluids. 2. Less affected by solid materials in drained fluids. 3. Little or no water recycled back to the process system. 4. Tolerant of upset conditions.
	Disadvantages
	1. Access for inspection and return pump maintenance needs careful consideration during facility design. 2. Likely to be more expensive than collection vessels and to entail higher maintenance costs. 3. Difficult to confirm that there is no underflow of hydrocarbons and hence there is a greater environmental risk. 4. Wave motion causes fluctuations in internal pressure and levels. 5. Level control instrumentation not easily accessible and failure may lead to hydrocarbon underflow.
Collection vessels	**Advantages**
(horizontal)	1. Likely to be less costly than caissons. 2. Easy access and maintainability. 3. Possible to measure discharge water quality/flow.
	Disadvantages
	1. Must be installed at a low point in the facility requiring special provisions in the structural framework. 2. Susceptible to accumulation of solids in both the vessels and back in the process system. 3. Limited capacity for hydrocarbon holding volumes.

4.5 PIPING DESIGN

Drain piping should be sized (running full) for the maximum expected flow, including 70% of the firewater deluge system or the maximum expected flow during heavy rain, whichever is the higher. Fluid velocities in drainage piping should be limited to a maximum of 0.8 m/s.

If operated at atmospheric pressure, the design pressure of the piping shall be 1000 kPa based on the requirement to allow the connection and use of fire hoses for flushing and cleaning. The design pressure of collection vessels shall be 350 kPa minimum.

No block valves shall be included in drain system piping except for isolation valves (and spades/spectacle blinds) at vessel connections into a closed drain system.

The piping shall be self-draining with horizontal sections sloped downwards towards collection vessels with a slope of not less than 1 : 100.

4.6 SAND AND SOLIDS

The presence of sands/solids may cause problems during drainage operations. If solids are expected, piping of 4" diameter or greater shall be used. Sand/solids will tend to collect in seal traps and may block or restrict flow in the pipework. The seal traps will require regular inspection (and they should be easy to clean). Sufficient piping clean-out provisions should be installed if sand/solids are expected. Ideally, there should be a rodding point at each position where sand or solids may accumulate. These should be line size, should be accessible for easy use and should be installed to facilitate clean-out in the normal direction of flow. Clean-out provisions for under-deck drain lines shall be brought to an above-deck position with 45-degree bends to allow access without the use of scaffolding. Seawater hose connections may be fitted at the rodding points.

The number of bends and flanges should be minimised as these are more prone to blockage with solids. Where much sand is expected, bends of only 45 degrees should be used.

Sand/solids may cause further problems if a collection tank is used instead of a caisson due to the potential build-up of material in the tank and the blockage of pump filters and suction lines. Entry into the pump suction line shall be above the base of the tank to allow for the presence of some solids in the collection vessel. After an equipment maintenance programme the collection tank should be inspected and cleaned.

4.7 BACKFLOW PROTECTION

Hydrocarbon fluids separated in caissons, drums or tanks will eventually be pumped back to a convenient point in the process for recovery. A link is therefore required between the live process and the drains, but this has the drawback that vapours can flow back from the process to the drains. In order to minimise this possibility, the pumps shall discharge to the lowest practical pressure level in the process thus reducing the backflow potential. A reliable non-return system shall be employed which, in addition to a non-return valve, shall consist of another system to positively prevent backflow such as an actuated valve tied into the pump start/stop logic. A positive-displacement pump will also help to prevent backflow.

4.8 LIQUID SEALS AND DIP PIPES

Drain lines from open drains shall enter drains collection vessels via a liquid seal, typically a U-bend, to prevent possible backflow of vapour. The liquid seal requires regular checking to ensure its integrity and accessibility aspects shall therefore be considered during detailed piping design.

Dip pipes shall be provided if a caisson is used for the CD or OHD systems even though it might appear that they are not strictly required where non-hazardous and hazardous area drainage systems, including collection caissons, are totally segregated from one another. However, they are useful in minimising vapour release into the modules in the event of backflow or other system upset conditions by creating an extra water seal between the process and the drainage systems. Where hydrocarbons from an ONHD caisson are routed to an OHD caisson, the dip pipe from the ONHD caisson shall extend at least one metre further below sea level than that from the OHD, which itself shall extend 3 metres below lowest astronomical tide (LAT). If an OHD system is routed to the same caisson as a closed maintenance drain, then the OHD dip pipe shall extend 10 metres below LAT.

In order to avoid corrosion, drain piping within caissons shall be made of Monel or glass-fibre reinforced plastic (GRE/GRP).

4.9 FLOOR DRAINS

Where the risk of hydrocarbon spillage can reasonably be expected to be negligible, grating should be used instead of solid plate wherever possible. Rain and deluge water will then be discharged directly overboard, thereby reducing the volumes of uncontaminated water which would otherwise be collected through the drains system.

Plate decks and floors shall be adequately sloped to promote flow to drainage system gullies, thus minimising the formation of liquid pools and limiting the spread of spills. On larger complexes with segregated hazardous areas, the open drains from each area shall be routed to separate drain headers, segregated from each other by liquid seals.

4.10 DRIP PANS

Drip pans shall be installed under equipment, such as wellheads and pig traps, where spillage of hydrocarbons direct to the sea is possible. However, since drip pans are likely to form a hazardous zone, they should preferably be avoided as far as possible by designing out potential sources of leaks. Where this is not completely achievable, drip pans are acceptable provided that their sizes are limited, they are designed to be self-draining to avoid standing pools of liquid hydrocarbons and provision has been made for convenient clean-out. Drip pans should be installed only under those parts of equipment that may potentially leak and not under complete equipment skids since this could lead to excessive loading on the drain system during periods of heavy rain.

4.11 TUNDISHES AND FUNNELS

All tundishes/funnels shall be fitted with covers when not in use to prevent debris entering the pipework which could lead to blockage or flow restriction. These covers will also help to restrict the backflow of vapours. The use of valves in pipework below the tundishes to restrict backflow is not recommended due to operability and cost disadvantages.

The height of all funnels should be kept as low as possible and they should be installed at an approximately equal elevation to minimise the possibility of liquid backflow. The end of a drain line shall terminate inside a funnel, not above it, to avoid splashing and spread of the drained fluid. Funnels beneath sampling points shall have a side-entry slot to allow insertion of sample bottles.

Funnels should preferably be routed to a floor drain gully upstream of a liquid seal. Where they are piped to a drain header, the connection should be via a liquid seal and be flanged. This allows the funnel connection to be blinded off for pressure testing the drain piping and also provides a flushing connection for clean-out.

4.12 VENTS

The atmospheric vents associated with the drainage systems, e.g. from the collection vessels or the drains caissons, shall not be interconnected with each other and should preferably be dedicated vents. They shall be designed and positioned so that ignition by static electricity (or other ignition source) is precluded. The top of the vent pipe shall be sharp-edged to prevent brush discharges. Consideration should be given to placing the vent within the protective "umbrella" of the facility's lightning conductor system or inside the Faraday cage formed by part of a structure, such as the flare boom. When sizing the vents, abnormal vapour flow rates shall be taken into account, such as those resulting from an incompletely depressurised vessel.

The vents shall be sited away from HVAC inlets and shall not be fitted with flame arrestors.

4.13 DISPOSAL TO SEA

When water from the drainage system is eventually disposed of into the sea, adequate separation from the seawater lift facilities shall be maintained to prevent the possibility of hydrocarbons being lifted with the seawater. The respective locations of seawater intakes and drains caissons should be determined with account being taken of tidal currents, winds and the type of platform substructure design.

Where drains collection vessels are used instead of caissons, sampling points with convenient access shall be provided so that the quality of the water discharged from the drains vessels can be monitored. The quantities of drains water are generally small in comparison with produced water and do not normally justify installation of on-line, continuous metering or quality measurement. However, regulators adopt different practices throughout the world and the local requirements for measuring oil in water concentrations and/or metering should be met.

5. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.

INTERNATIONAL STANDARDS

Pollution from Ships (MARPOL 1973) and Protocol of 1978 relating thereto

Issued by:
International Maritime Organisation
4, Albert Embankment
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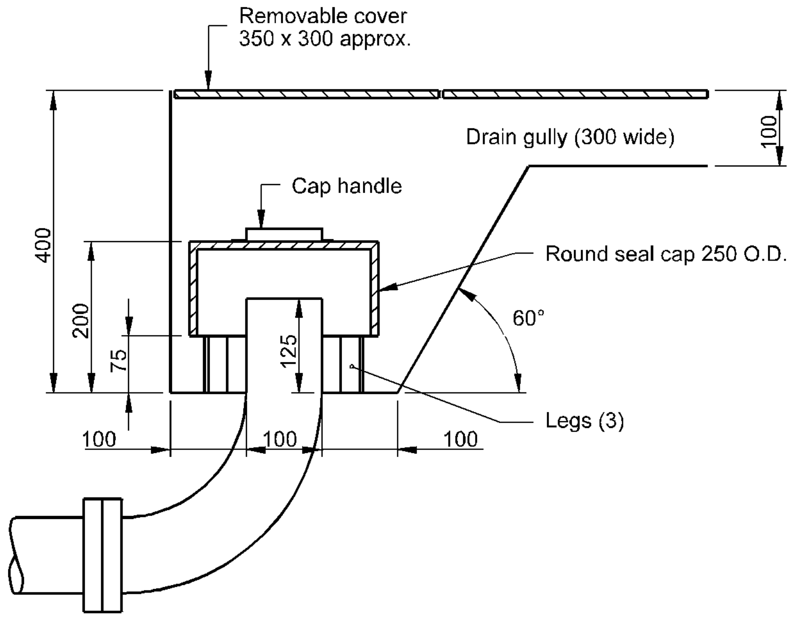
UK

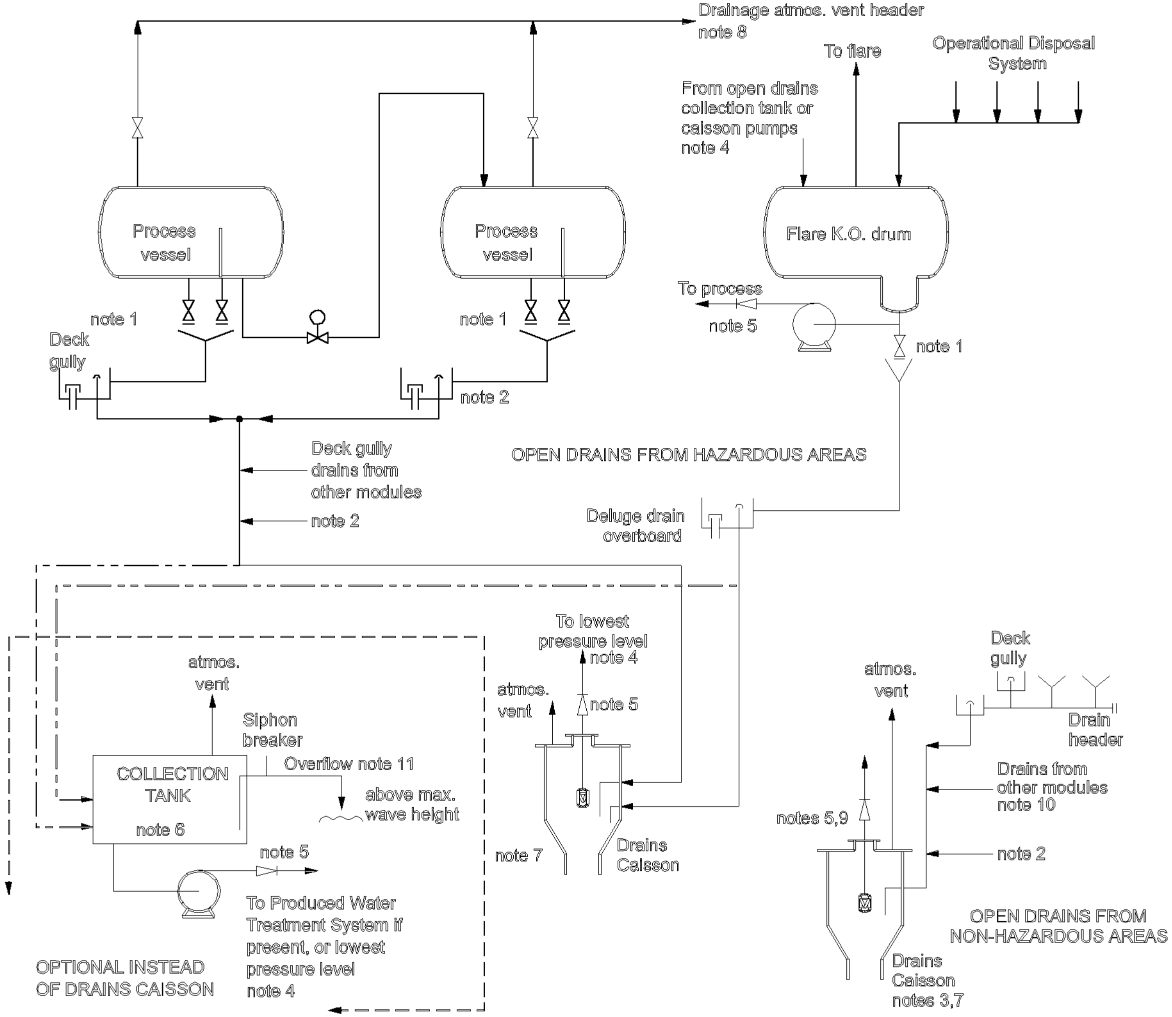
APPENDIX 1 FIGURES

Figure 1 Typical seal-trap arrangement



Notes:
1. All dimensions in mm.
2. Deluge drain can be included in trap box.

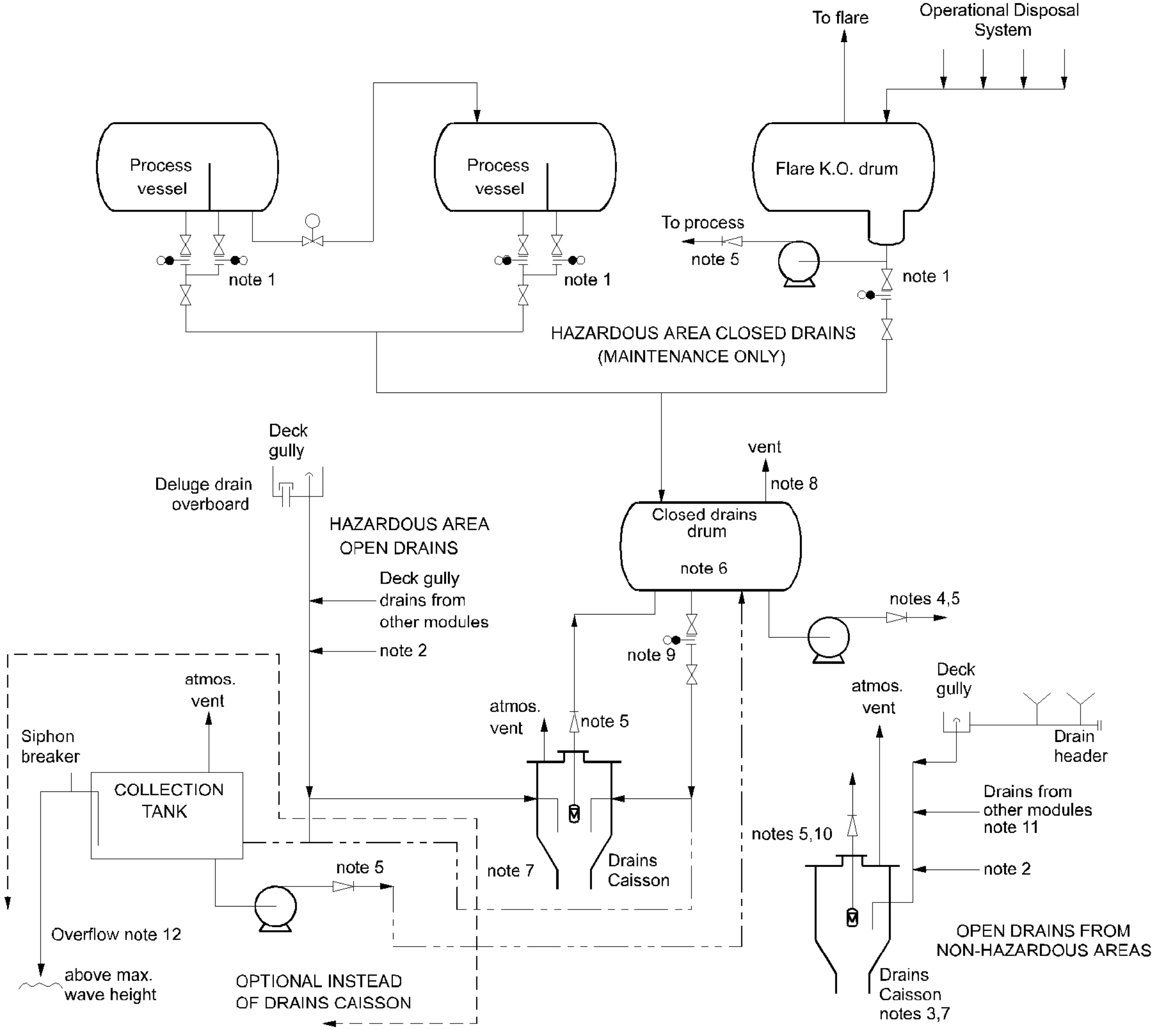
Figure 2 Schematic – drainage system without closed drains



NOTES

1. For maintenance use only. Equipment shall undergo maintenance preparation procedure (water flushing, isolated, depressured to atmosphere) before use.
2. For closed module designs only. Each module should be separately sealed.
3. A collection tank is a suitable alternative.
4. A flare knock-out drum is the most likely choice.
5. A reliable backflow protection system shall be employed.
6. A collection tank should be placed at a suitable low point (slung beneath the cellar deck)
7. An indication of the oil-water interface is required to prevent oil flowing out of the bottom of the caisson.
8. An atmospheric vent is required in order to ensure complete depressurisation prior to the use of the open drains system.
9. For routing see section (3.2)
10. Each level shall have a separate drain header to the caisson.
11. Overflow in case of pump/level control failure.

Figure 3 Schematic – drainage system with closed drains



NOTES

1. Equipment shall be isolated and depressured before draining. Spades shall normally be closed.
2. For closed module designs only. Each module should be separately sealed.
3. A collection tank is a suitable alternative.
4. The stream should go to the produced water treatment system, if present.
5. A reliable backflow protection system shall be employed.
6. A closed drains drum should be placed at a suitable low point.
7. An indication of the oil-water interface is required to prevent oil flowing out of the bottom of the caisson.
8. The vent should be connected to the lowest pressure vent header.
9. This connection shall be for the maintenance of the closed drain drum only. Spade shall normally be closed.
10. For routing see section (3.2)
11. Each level shall have a separate drain header to the caisson.
12. Overflow in case of pump/level control failure.