MANUAL

DESIGN OF SEA WATER SYSTEMS AND UTILITY HEAT TRANSFER SYSTEMS FOR OFFSHORE INSTALLATIONS

DEP 37.05.10.10-Gen.

November 1994

DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

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1. INTRODUCTION

1.1 SCOPE

This new DEP provides requirements and guidelines for the design of sea water systems and closed circuit heat transfer systems on offshore oil and gas production installations. Functional requirements are provided for the various components included in such systems, e.g. caissons, pumps, piping and valves, heat exchangers and instrumentation. The detailed technical specifications for the various components are covered by other DEPs.

Fire water systems and water injection facilities are excluded from the scope of this DEP.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, 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 and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F" as described in DEP 00.00.05.05-Gen.)

This DEP is intended for use by all those involved in the design or modification of sea water systems or closed circuit heat transfer systems on offshore oil and gas production facilities.

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 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

1.3.1 General 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 of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by 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.

1.3.2 Specific definitions

Caisson Open-ended pipe section extending from the platform to below sea level and used for drawing water or for disposing of used water.

Cooling medium Fluid for the removal of heat from process and utility equipment.

Heating medium Fluid used to input heat to process and utility equipment.

1.4 ABBREVIATIONS

DN	Diameter nominal
EHRU	Exhaust heat recovery unit
HT	Heat transfer

HVAC	Heating ventilation and air conditioning
NPSH	Net positive suction head
TEG	Tri-ethylene glycol

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 (7).

2. OVERALL GOALS AND SPECIFIC OBJECTIVES

2.1 INTRODUCTION

On offshore platforms, sea water is supplied to many users. Some users consume water, e.g. the pressurised firewater ring main, wash down facilities, water maker units, water injection facilities, drilling mud makers and potable water making units. Other users do not consume water, such as process heat exchangers and equipment coolers, which return the water to the sea with no change except in temperature; these users are sometimes called "once-through users". Closed-circuit heat transfer systems are used for heating and cooling duties in process and utilities equipment.

It is essential at the initial design stage to determine whether the user is hazardous or not. A hazardous user is one where, if the equipment should fail, the sea water or the medium of the closed circuit heat transfer system can be contaminated with a flammable or toxic substance and potentially affect other users. Hazardous users typically include process heat exchangers, such as crude oil coolers, gas coolers, etc.

2.2 OVERALL GOALS

The goal of a sea water lift and distribution system is to provide a safe, stable, and reliable supply of sea water, at the required pressure and flow, to all on board users.

The goal of a heat transfer system, either a direct sea water cooling system or a closed circuit heating or cooling medium system, is to provide a safe, stable, and reliable supply of heat transfer medium at the required temperature, pressure and flow, to all relevant on board heating or cooling loads.

The system should ensure that the fluid, be it sea water or heat transfer medium, is of sufficient quality so as not to cause blocking, fouling, contamination or undue corrosion of user equipment and the system itself. The system should be designed to provide ease of operation and maintenance, and have a design life which meets the needs of the facility, taking account of lifecycle economics.

2.3 SPECIFIC OBJECTIVES

The following is a list of specific objectives for the design of sea water lift and distribution systems and heat transfer systems:

- designs should take into account the demands of present and planned future users;
- all necessary considerations and good engineering practice should be used to ensure that the system can be operated safely without hazard to any personnel, plant and equipment on the installation;
- when designing new systems, hazardous users should be segregated from non-hazardous users;
- in existing systems where hazardous and non-hazardous users are supplied from a common header, the best practicable means should be used to ensure that hazardous substance or hydrocarbon migration from one area to another is not possible;
- designs should comply with the environmental constraints of the locality;
- suitable materials and corrosion protection should be used in all aspects of the design in order to attain the expected design life of the system;
- systems should be designed to allow for ease of operation and maintenance;
- adequate provision should be made in the design of system vessels and pipework to allow for fluid expansion during heating;
- vessels and heat exchangers shall be protected with over-pressure protection devices;
- means should be provided to detect hydrocarbon leaks in heat exchangers.

3. SEGREGATION OF USERS

3.1 INTRODUCTION

In sea water and closed-circuit heat transfer systems, certain modes of equipment failure may result in the ingress of a hazardous substance into the system, followed by migration to and release into an unprotected non-hazardous area on the installation. The consequences of this may be subsequent ignition, explosion, poisoning or asphyxiation. Ingress of such substances, including hydrocarbons and hydrogen sulphide, will normally be caused by failure of the barrier between the hazardous process stream and the utility stream.

Hazardous and non-hazardous users shall be segregated to prevent the possibility of hazardous substance migration into non-hazardous areas/users.

3.2 NEW INSTALLATIONS

The means of achieving segregation for new installations shall be as follows:

- Complete segregation of hazardous users from non-hazardous users; a separate utility system serves each of the two user categories, see Figure 1.
- An intrinsically safe system as shown in Figure 2. A single sea water lift system supplies non-hazardous users and cools a closed circuit heat transfer system serving hazardous users.

3.3 EXISTING INSTALLATIONS

On existing installations, when hazardous users and non-hazardous users are supplied from a common header, the following methods, in order of preference, shall be employed to prevent the possibility of such migration:

- the installation of a dedicated system for non-hazardous users;
- the insertion of break tanks in the appropriate lines as shown in Figure 3. The water flow should enter the tank above the water level. The tank shall be continuously vented, the vent being of sufficient capacity to handle the maximum rate of gas produced in case of a leak or failure of the hazardous users (e.g. failure of one tube in shell and tube heat exchangers). If toxic gas (e.g. containing hydrogen sulphide) may be present, venting should be through the installation relief system. If a high concentration of toxic gas may be present, an in-depth analysis should be carried out to ensure that it is not possible for toxic gas to migrate to the safe users through the break tank. There shall be suitable protection to maintain the integrity of the liquid seal.
- the installation of detection systems and automatically actuated valves to prevent migration from hazardous to non-hazardous users. For large leaks in gas coolers, this is achieved by isolating offending coolers on the detection of high pressure in the cooling medium return line; smaller leaks are identified using a displacement chamber located at a high point in the system. Detection systems should not be used for crude oil coolers, because suitable oil-in-water detectors are not yet available.

The implementation of the last two solutions above shall be validated by a detailed reliability analysis to show that the selected system provides a sufficient level of confidence that the hazardous users are properly segregated from the non-hazardous users. The rigour of the analysis is particularly important if an instrumented system is being considered since there are potential reliability problems. All such systems shall be independent of the normal process control system to avoid common mode failure.

4. SEA WATER LIFT AND DISTRIBUTION SYSTEM

4.1 SUPPLY OF SEA WATER TO THE USERS

The capacity of the sea water system, for both present and envisaged future demand, should be determined at an early stage in the design process. The following should be considered in determining sea water demand:

- for some systems, the demand is intermittent;
- if water injection is supplied from the return header, it may not be necessary to include this load in the system capacity calculations;
- capacity should be provided for filter backwashing;
- sea water should be supplied to the coolers at a sufficient rate to prevent precipitation of solids, irrespective of thermal demand.

It is generally advantageous to use warm water returning from process or utility coolers for water injection, because of easier deoxygenation prior to injection. A break tank should be installed between the coolers and the water injection plant, unless systems are in place to detect and vent any entrained gas at the plant. Other consumers may also have a requirement for warm water. It may be necessary to place a lower limit on the temperature of sea water supplied to the crude oil coolers or gas coolers to prevent the formation of wax or gas hydrates which would impair the performance of the exchanger.

The flow to each consumer should either be fixed during commissioning (and checked regularly) or regulated by a temperature controller on the process medium outlet.

The solubility of the various salts contained in sea water reduces at high temperatures. Therefore, the sea water temperature within the system should not exceed a certain value to prevent fouling by salts. This value, which depends on the location (salinity and pH are the main parameters), should be derived using the SCALECHEM program (OLI, New Jersey) or equivalent. Calcium carbonate is normally the first to precipitate, at approximately 85 °C (based on North Sea compositions). It is important to note also that the sea water temperature may need to be limited depending on the type of material used in the sea water system (4.4).

4.2 SYSTEM DESCRIPTION AND COMPONENTS

The system is a piped distribution scheme which is used to lift sea water to deck level, process the sea water to meet the required standards and distribute it to the various users. The pump configuration should take account of the variations in demand, the standard available size of pumps, and starting requirements with respect to power generation. The provision of a sea water pump for essential services (e.g. HVAC, potable water makers) should be considered; the power to the pump should be supplied from an emergency generator.

Where installations have a continuous sea water demand that is critical to oil and gas production, the number of pump sets should provide standby capacity, 2 x 100 percent, 3 x 50 percent, 4 x 33 percent, etc. If the supply of sea water is crucial for the continued operation or installation safety, a system reliability/availability study should be undertaken to determine the optimum configuration (amount of pump sparing, double headers, etc.).

The main components of the sea water system are:

- pump inlet caissons, for drawing sea water from an appropriate depth;
- sea water lift pumps, to provide a stable supply of sea water at the appropriate pressure;
- marine growth inhibition and sea water filtration packages for water quality control;
- sea water supply and return headers;
- an overboard dump caisson providing safe and convenient disposal.

The design pressure of the system components downstream of the pumps should be set at a common value, consistent with the shut-in head of the pumps plus a margin to account for pressure surges. Pressure surges may be critical, particularly during start-up and shut-down, and these should be minimised.

4.3 DESIGN CONSIDERATIONS

4.3.1 Sea water lift caissons

Sea water should be drawn from a depth below the thermocline at which marine life proliferation is substantially less. The proliferation is seasonal (lunar cycles, higher temperatures), and may differ in depth depending on the time of day.

Sea water lift caissons should be located at a sufficient depth below the lowest astronomical tide to ensure that pump inlet conditions remain stable in all sea states. Recirculation of effluent from sea water discharge, drilling cuttings, spent mud or sewage discharge should be prevented. The respective location of the sea water intake and drains or dumps should be determined by tidal currents, winds and the type of platform substructure design. The sea water intake normally should be located above the drilling cuttings chute, and below the sea water discharge.

NOTE: Sea water lift caissons may not be required on installations with concrete substructures, as sea water may be supplied to the lift pumps through an opening in one of the platform legs.

Caissons may be mounted vertically or at an angle provided that pump operation and maintainability are unaffected. Alignment of sea water lift caissons with the leg batter angle on some installations may result in smaller, slimmer jackets and improved accessibility and platform layout. The possibility of increased pump wear and difficulty of handling components should be addressed when installing lift pumps at an angle.

The caisson should be sized to accommodate the largest diameter of pump set plus a radial clearance to allow unrestricted suction flow, account for marine growth, cable space and ease of handling during pump installation/removal. A minimum radial clearance of 50 mm should be provided; for pump sets with a diameter of 500 mm and above, the radial clearance should be increased to 75 mm. Another factor to consider in caisson sizing may be a requirement to maintain a minimum flow velocity around the pump motor casing for cooling purposes.

A mesh should be fitted at the inlet of the caisson to prevent marine life ingress. The caisson shall have a grid or other means of preventing the pump from accidentally falling to the seabed.

4.3.2 Sea water lift pumps and rising main

The sea water lift pumps should be positioned at a suitable depth in order to ensure that the minimum suction head (NPSH) required for the system can be maintained during both start-up and operational modes, consideration having been given to the waves and tidal action.

For installations utilising caisson inlets, sea water lift pumps should be submersible, suspended in the sea water lift caissons, and driven by a submersible electric motor. Line shaft pumps, driven by either a diesel engine or electric motor, should not be used because of the less practical maintenance aspects.

NOTE: Installations with concrete substructures to which sea water is supplied through an opening in one of the concrete legs may be fitted with alternative pump types, such as line shaft driven submersible or horizontally split casing types.

A strainer should be attached to the pump suction inlet, so that it can be cleaned or replaced when the pump is lifted up. The sea water lift pump and its associated rising main should be located such that they can be pulled out by the platform crane and laid down for dismantling.

The rising main should be constructed of sections of rigid pipe. However, when design flowrates are below 400 m^3/h, consideration may be given to a flexible hose type rising main which may offer benefits in terms of cost, weight and maintainability. With such an arrangement, the pump should be firmly secured in position.

The various components of the pumping arrangement are described below:

- To allow operation of the system when one or more pumps are not running, a power actuated discharge isolation valve should be located adjacent to the system header at the top of the rising main from each pump. In addition, a non-return valve should be located upstream of the isolation valve to prevent backflow in the event of a sudden pump trip.

- Following pump start-up, air from the rising main should be vented before the discharge isolation valve (at the top of the rising main) is opened. Any air trapped within the system will expand upon pump shut-down, and this may create severe pressure surges. An air vent line should be located at a high point of the rising main, adjacent to and upstream from the non-return valve. The vent line should be fitted with a float type air valve to prevent sea water leakage after all air has been expelled, and with a restriction orifice downstream of the air valve, to control the rate of rise of the water column. The vent line should be ascending up to the restriction orifice. The sizing of the restriction orifice should be such that air in the rising main is evacuated in approximately 30 seconds. The opening of the discharge valve should be controlled by a timer linked to the pump starter. The length of time the pump is running dead-headed against the discharge isolation valve should be kept as short as possible.
- Reverse rotation arising from the draining of the rising main should be prevented. The pump set may otherwise be damaged if it is attempted to start it immediately after a trip. The pump should be fitted with a latch or brake to prevent reverse rotation upon draining of the rising main. Alternatively, the pump set should be equipped with a non-return valve (in which case the topside non-return valve located upstream of the discharge isolation valve may be omitted). The non-return valve should have a hole to allow controlled draining of the rising main, without allowing reverse rotation of the pump.
- Under conditions of reduced sea water demand on a normally manned installation, the sea water lift pumps should be protected from dead heading by pressure regulation at the system return header. A split range controller should maintain constant header pressure by actuating the overboard dump line control valve and the sea water supply header control valve. Any reduction in demand by consumers will be compensated for by increasing the overboard dump, maintaining the pumps at the required operating point. On normally unmanned installations minimum flow protection should be provided by an overboard sea water discharge line fitted with a restriction orifice direct from the sea water supply header.
- The pump electric cable terminal box should be located close to the top of each pump caisson to facilitate disconnecting and cable storage.

4.3.3 Anti-fouling system

An anti-fouling system is necessary to inhibit marine growth and fouling within the sea water system, except in systems where copper-nickel piping material is used (the release of slight quantities of copper ions from this material inhibits settlement of marine organisms).

Fouling should be controlled by the continuous injection of sodium hypochlorite. The injection of copper ions may also be considered. When the installation requires water injection for reservoir pressure maintenance, sodium hypochlorite injection is preferred.

The following applies specifically to sodium hypochlorite systems:

- Sodium hypochlorite is poisonous. Designs shall ensure the safety of persons involved in handling sodium hypochlorite and operating of the system.
- The injection concentration depends on the concentration of organic material, and should be set such that the residual chlorine concentration at the discharge is in the order of 0.2 mg/l (to be monitored by regular sampling). In addition, regular batching at higher concentrations (e.g. once a month) should be considered.
- The injection of sodium hypochlorite into sea water is normally under gravity at the pump inlet. The injection should be controlled by a shut-off valve interlocked with the pump motor to prevent injection when the pump is not running (however, controlled dosing into the caisson should be undertaken during prolonged pump shut-down). Too high concentrations may cause severe corrosion and harm the environment. It is also possible to inject at other locations, but this normally requires pumped distribution, and flow to individual dosing points should be metered locally by a needle valve and rotameter.

- Dosing line sizing should ensure sodium hypochlorite flow velocities greater than 0.5 m/s to minimise deposition of suspended solids. Needle valves, rotameters and shut down valves should be mounted in a short section of line running vertically upwards to avoid deposition of solids when there is no flow.
- A spare 100% sodium hypochlorite generator should be provided, including the distribution pumps when applicable.
- Sodium hypochlorite generators produce hydrogen as a by-product and should be provided with suitable alarms to announce malfunction. Sodium hypochlorite holding tanks should be provided with twin 100 percent ventilation fans for hydrogen dilution below the explosive limit.

4.3.4 Filtration

Sea water filtration quality shall be determined from a review of the sea water quality in relation to the user requirements. As a general rule, sea water should be filtered to 1000 µm particle size. Further filtration should be based on the need of the individual users. Filters should be designed for continuous operation throughout any marine life bloom period.

Filters should be of the backwashable type unless the quantity of sea water demand is small, in which case cartridge filters may be more appropriate. The sea water lift pump capacity shall allow for the expected filter backwash flowrate as indicated by the filter supplier. Automatic backwashing of the filters should be provided upon a time or differential pressure programme.

Filters should be fitted with a differential pressure gauge measuring the pressure drop across the inlet and outlet headers. This should be arranged to alarm before the maximum unit differential pressure to signal that backwashing is to be initiated. A closed manual bypass line should be provided at the filters to allow unfiltered sea water to be supplied in case of emergency.

4.3.5 Pipework system design

Pipework and valving should be designed in accordance with DEP 31.38.01.11-Gen. and DEP 31.38.01.15-Gen. Since pressures encountered in sea water systems are generally low, piping classes ANS 150 will normally apply.

The fluid velocity in pipework should in general be limited to 15 m/s. This does not apply to copper-nickel alloys, for which the velocity should not exceed 3.5 m/s for sizes above DN 100, 2 m/s for sizes between DN 50 and DN 100, and 1 m/s for sizes below DN 50.

Pipework should be kept as simple as possible, avoiding any unnecessary use of complex arrangements, dead ends, reducers and enlargers. Sufficient extra tie-in points should be provided to allow easy modification and connection of extra branches for future planned utilities.

Balancing and regulating valves should be provided on branches supplying the various users to correctly balance the flow to an individual user or group of users.

Check valves should be of a non-slam type to minimise potentially damaging pressure surges.

Isolation valves and spectacle blinds should be provided to isolate any individual piece of equipment without interrupting the service or production.

4.3.6 Overboard discharge caisson

The overboard discharge caisson should be positioned to ensure the safe disposal of used sea water whilst preventing recirculation of warm water back into the inlet caisson.

To help prevent cavitation at the overboard dump control valve and to avoid the loss of system contents on pump shutdown, the dump line should enter the caisson above the elevation of the supply and return headers and major items of equipment.

The caisson should be vented. If toxic gas may be present, the caisson should be vented to the installation relief system.

The caisson diameter should be large enough to prevent gas entrainment. Sizing should be based on Froude number scaling, using a Froude number of 0.3 for caisson sizes below DN 300, 0.5 from DN 300 to DN 600, and 0.7 above DN 600.

The Froude number is defined as:

$$Fr = \frac{v_L}{\left(g(\rho_L - \frac{\rho_g}{\rho_L}) D \right)^{1/2}}$$

v_L	=	liquid velocity in the caisson
g	=	acceleration due to gravity
ρ_L	=	liquid density (sea water)
ρ_g	=	gas density (air)
D	=	caisson internal diameter

4.4 MATERIALS

Sea water, because of dissolved oxygen, salts and marine organisms, is a highly corrosive liquid. Susceptibility to corrosion shall be minimised through the use of corrosion resistant materials or the application of protective internal coatings. Corrosion inhibition, combined with an internal corrosion allowance, is not acceptable.

The choice of material should be based on life cycle economics, taking into consideration the type of service (water temperature, level of chlorination), the cost of material (noting that higher allowable water velocities imply smaller line sizes), the physical location and extent of pipework on the installation and, for refurbishment work, the existing platform piping classes.

Typical materials which may be considered for use include super duplex, high molybdenum stainless steels, copper-nickel alloys, titanium alloys, and glass fibre reinforced thermosetting plastic (GRP). Most of these materials have temperature limitations, and advice from a materials/corrosion specialist should be sought.

The following types of gaskets should be used in sea water systems (in order of preference):

- compressed asbestos fibre (CAF), regulations permitting;
- mineral filled gaskets, see report MF 94-0960;
- GRE laminated gaskets;
- spiral wound gaskets with graphite filler with an inner ring more cathodic than the adjacent piping.

Plain graphite gaskets shall not be used with corrosion resistant alloys.

Care shall be taken to ensure that the pipework materials are matched throughout, to prevent galvanic corrosion. Where the coupling of dissimilar materials cannot be avoided, a sacrificial spool should be used to segregate the materials.

EP 89-0198 provides guidelines on the use of corrosion resistant alloys for sea water service. Glass fibre reinforced plastic pipes and fittings should be in accordance with DEP 31.40.10.31-Gen.

5. CLOSED CIRCUIT HEAT TRANSFER SYSTEMS

5.1 SYSTEM DESCRIPTION AND COMPONENTS

A closed circuit heat transfer system provides a stable supply of heat transfer medium at the required temperature and flowrate to process, utility and equipment heat exchangers. The heat transfer medium is drawn by circulation pumps from a header vessel and distributed to the heat exchangers. The medium is then passed through the system heat exchanger where heat is either removed or added depending on whether the system is a cooling or heating utility. The medium then returns to the header vessel for recirculation.

The main components in a closed circuit heat transfer system are:

- the heat transfer medium itself, e.g. a water/glycol mixture, thermal oil or diesel fuel;
- the heat transfer medium cooler or heater, depending on whether the system is cooling or heating;
- end user heat exchangers, e.g. process gas coolers, crude heaters;
- pipework and control systems for distribution of the heat transfer medium to individual end users;
- circulation pumps;
- the header expansion vessel, to provide a means of storing the medium while maintaining a stable supply to the circulation pumps.

A supply/mixing tank may be included for the preparation of batches of medium, such as water/glycol mixtures.

In a closed circuit heating system, a trim cooler may need to be included when the flow to heat loads is less than the minimum necessary for the safe operation of the medium heater.

5.2 DESIGN CONSIDERATIONS

5.2.1 Heat transfer media

Potable water, with the addition of ethylene glycol as an antifreeze in cold climates (typically 30 percent concentration by weight), is normally used as coolant. The addition of chemicals may be required in the mixture for scaling and corrosion control. On installations where glycol is in use for other systems, e.g. TEG for gas dehydration service, the same type of glycol should be used to avoid possible mistakes when replenishing.

Ethylene glycols are hazardous chemicals. Appropriate precautions shall be incorporated into designs to ensure the safety of personnel involved in handling and operations.

Heating fluids may consist either of thermal heat transfer oils, diesel fuel, or potable water with ethylene glycol where antifreeze properties are necessary (TEG is preferred because of better stability at higher temperatures).

The selection of the fluid is primarily based on costs and the ability to accommodate the required process temperatures. Other factors, such as the sharing of equipment with other utilities, may be important. In situations where process temperatures above 150 °C are required, the use of glycol is inadvisable as it could lead to glycol degradation, although it is possible to heat TEG to higher temperatures in oxygen free environments without degradation. Degradation of glycol can lead to fouling and corrosion problems within the system. Thermal oil should be used where elevated temperatures are required.

5.2.2 Filling and make-up

If no mixing tank is provided, filling and make-up is achieved by injecting batches of heat transfer fluid directly into the header/expansion vessel. If the vessel is pressurised, a portable positive displacement pump should be provided. Where water is required as part of the medium, it should be injected into the vessel from the pressurised potable water system (if available), with appropriate means to avoid cross-contamination.

If a mixing tank is used, connections should be provided to the glycol and water storage systems. A filling/mixing pump arrangement should be provided which can operate in two modes:

i) mixing by recirculation of fluid through the tank;

ii) transfer of the fluid into the system.

Initial filling of the system should be done in batches, with proportioning of the mix controlled by sightglass and checked by sampling.

The same mixing tank may serve several services, such as cooling and heating systems. A common mixing tank can only be used if the systems use the same liquids. Temporary spools or hoses shall be used for connecting to the respective systems, being disconnected upon completion of replenishing.

The mixing tank should be vented and provided with overflow, drain, manway, level gauge, and sampling connections.

Where appropriate, connections for injecting scale inhibitor, corrosion inhibitor or oxygen scavenger into glycol/water systems should be provided.

5.2.3 System drainage

Valved drain connections should be installed at the various low points and on associated vessels and equipment. Due to the relatively low concentrations of glycol (typically 30 percent by weight) and the degradability of glycol, water/glycol mixtures may be routed to overboard discharge via the open drain system. However, it should be noted that some corrosion inhibitors which may be used in these mixtures may be toxic, preventing discharge into the environment. For equipment containing thermal oil, a means should be provided to collect and drain oil leakage back into a collection drum.

5.2.4 Header vessel

The header vessel should be placed in the ring main to allow through flow of the heat transfer fluid. The pipework returning the fluid from heat exchangers and the bypass line should both enter the vessel above the liquid level. This ensures that the exchangers remain full of liquid, improves degassing of the medium, permits direct glycol/water mixing in the system, and allows fast detection of separated hydrocarbon gas. The vessel should be located at a high point in the system to allow easy priming and provide sufficient NPSH for the circulation pumps.

A gas blanket (nitrogen or fuel gas) should be used to maintain pressure within the header vessel in order to prevent air contamination of the medium, prevent vaporisation of the medium anywhere in the system and maintain the NPSH requirements of the circulation pump. The vessel ullage should be sufficient to accommodate twice the expected expansion of the total medium volume in the system during the transition from minimum to maximum system temperature.

High and low pressures in the header vessel should be detected by an alarm. Facilities should be provided for topping up with blanket gas and for relieving excess pressure.

A safety relief valve shall be fitted to the header vessel, having sufficient capacity to relieve the largest rate of gas produced in case of a leak or failure of any single hazardous user. If toxic gas may be present, venting should be through the installation relief system.

Refer to DEP 20.05.50.10-Gen. for the specific design aspects of header vessels.

5.2.5 Heat transfer fluid circulation pumps

Pumps for this service should be electric motor driven centrifugal pumps in accordance with DEP 31.29.02.30-Gen. The pump should be designed to operate within the expected heat transfer fluid temperature range.

A standby pump should be provided, taking account of individual project requirements and economics to determine the optimum arrangement, e.g. 2 x 100 percent, 3 x 50 percent etc.

Suction and discharge valves shall be provided and a non-return valve shall be situated in the pump discharge upstream of the discharge isolation valve. A temporary strainer should be provided in the pump suction line.

The pump should be capable of being started and stopped both remotely and locally. If a spare pump is provided, then either pump should be capable of operating as the duty pump. The standby pump should start automatically on low duty pump discharge pressure. Suction and discharge valves need only be manually operated.

Pumps should be provided with a local and remote running light and a remote tripped/available status indication light.

5.2.6 Contamination of heat transfer medium

Specific considerations shall be given to the detection and warning of leakage which may occur within this system. These can be categorised into two specific areas.

- Leakage of sea water into the heat transfer medium:

  Sea water ingress into the closed circuit may lead to serious corrosion if it remains undetected for any length of time. Also, some corrosion inhibitors are affected by a low level of chlorides. Sea water ingress may be prevented by running the heat transfer medium at a pressure above the sea water pressure. A salinity detector, or other suitable monitoring device (routine sampling) should be provided on the fluid outlet line of the heat exchangers interfacing with sea water.

- Leakage of hydrocarbon gases into the heat transfer fluid:

  Gas leakage from pinhole leaks in process heat exchangers should be vented through the header vessel vent (5.2.4). When venting is done through the installation vent stack, back pressure from the relief header causing backflow of hydrocarbon gas into the system should be considered. It should be noted also that CO_2 or H_2S contained in the gas ingress can reduce the fluid pH, which may significantly affect the efficiency of some corrosion inhibitors.

5.2.7 Pipework system design

The requirements of (4.2.5) apply.

5.3 CLOSED CIRCUIT COOLING SYSTEMS - SPECIFIC CONSIDERATIONS

A typical closed circuit cooling medium system is shown in Figure 4. A bypass is incorporated in the system to recycle the cooling medium in excess of user requirements and to maintain a minimum flow through the pump and the cooling medium cooler. The bypass is regulated by a pressure controller.

A temperature controller at the cooling medium exit from the sea water/medium exchanger maintains the medium temperature by regulating the sea water flow from the exchanger. The control system should ensure that a minimum flow is maintained to prevent the sea water from being overheated.

The medium flow to each consumer should either be fixed on commissioning (and checked regularly), or regulated by a temperature controller on the process medium outlet.

The recommended alarms and shutdowns for a closed circuit cooling medium system are given in Table 1.

Table 1 Closed circuit cooling medium system alarms

Location	Instrument	Action
Header vessel	Level indicator	Low/high level alarms in control room Low/low level shutdown of circulation pumps
Header vessel	Pressure indicator controller	High/low pressure alarms in control room
Circulation pump discharge header	Pressure indicator	Low pressure alarm in control room with start of stand-by pump (if fitted)
Cooling medium distribution header or circulation pump discharge	Temperature indicator	High temperature alarm in control room
Header vessel	Hydrocarbon detector	Alarm in control room
Outlet of cooling medium from sea water cooler	High salinity or chloride ions detector	Alarm in control room

5.4 CLOSED CIRCUIT HEATING SYSTEMS - SPECIFIC CONSIDERATIONS

5.4.1 Introduction

The specific aspects of closed circuit heating systems are covered in DEP 20.05.50.10-Gen.

A typical heating medium system layout is shown in Figure 5. As an example, heat is shown to be collected by an exhaust heat recovery unit (EHRU) fitted to a gas turbine exhaust. The flow of exhaust gas to the heat recovery unit is controlled by a bypass damper activated by a temperature controller in the heating medium leaving the EHRU. Any heating medium not required by the process is diverted back to the header vessel via a trim cooler. The trim cooler prevents excessively hot heating medium entering the header vessel.

5.4.2 Thermal (heat transfer) oils

The main consideration for the selection of a thermal oil is to match process temperature requirements with the recommended temperature range of the fluid. Other factors include inventory cost, toxicity, flammability (including auto-ignition of relieved droplets), thermal stability, freezing point, corrosive and fouling characteristics and heat transfer coefficient. Shell Thermia Oil B, or equivalent, is suitable for most applications, but advice from the Principal should be sought for final selection (refer to MF 92-0125).

An oil storage/drainage drum with a transfer pump at a low point in the system should be provided. The drum should be sized to accommodate the oil contained in the largest single component in the circuit.

In cold climates, consideration should be given to winterising thermal oil equipment dead legs where the oil viscosity may become excessive. A bleed through flow arrangement for standby circulation pumps from the operating pump manifold and a heating coil fitted to the storage drum should be considered.

5.4.3 Heat sources

The heat source may be of several types: electric resistance, fired heater, or EHRUs. EHRUs make better use of available energy but they should be selected after due consideration of their limitations (operational flexibility in particular). General type furnaces are covered in DEP 31.24.00.30-Gen.

On installations where power is generated by diesel or gas engines, heat may be recovered from the engine cooling jacket or from the engine exhaust, depending on the required temperature. The maximum heating medium temperature which can be obtained from engine jacket water is around 90 °C.

For gas turbines, EHRUs are normally fitted to each engine exhaust individually to provide operational flexibility and reliability. The size of each unit, e.g. 100 percent, 50 percent etc., should be determined by system availability analysis taking account of changes in heating duty over the installation life, achievable turndown, number of engines in operation and the heat output available. Gas turbine heat recovery systems are covered in DEP 30.75.10.31-Gen.

5.4.4 System shutdown

In systems where heat is recovered from engine exhaust gases, situations can arise where the heating medium flow is shut down and the exhaust gas is switched to fully bypass the EHRU. It is difficult to bypass all the exhaust gas and inevitably some gas will leak into the EHRU. The heating medium can become overheated and be degraded. It is therefore necessary to dump all the heating medium contained in the exchanger during shutdown. Designs should consider the implications of such a shutdown, the dumping procedure and operation of the EHRU without circulation. Alternatively, the flow through the EHRU should be sufficient to prevent medium degradation.

5.4.5 Trim cooler

Where process heating requirements are variable, a large quantity of hot heating medium bypasses the process heaters. A trim cooler is normally used to maintain a consistent return temperature to the header vessel by rejecting the surplus heat to the sea water.

5.4.6 Control and instrumentation

The temperature of the heating medium at the outlet from the heat source should be the basis of control of the system. This temperature should be maintained within the limits of its setpoint by variation of the heat source, through the heat source/heating medium exchanger.

The heating medium flow to each consumer should be either fixed on commissioning or regulated by a temperature controller on the process medium outlet.

The recommended alarms and shutdowns for a closed circuit heating system are given in Table 2.

Table 2 Closed circuit heating medium system alarms

Location	Instrument	Action
Header/Expansion Vessel	Level indicator	Low/high level alarms in control room Low/low level shutdown of circulation pumps
Header/Expansion Vessel	Pressure indicator controller	High/low pressure alarms in control room
Circulation pump discharge header	Pressure indicator	Low pressure alarm in control room with start of stand-by pump (if fitted)
Header/Expansion Vessel	Hydrocarbon detector	Alarm in control room
Outlet of heating medium from sea water trim cooler	High salinity detector or sampling routine	Alarm in control room
Heating medium return header or circulation pump discharge	Temperature indicator controller	High temperature alarm in control room
Heating medium distribution header	Pressure indicator controller	High/low pressure alarms in control room
Heat source heating medium outlet	Temperature indicator controller	High temperature alarm in control room High high temperature shut-down or bypass of heat source

6. SPECIAL CONSIDERATIONS FOR HEAT EXCHANGERS

Shell and tube heat exchangers should be in accordance with DEP 31.21.01.30-Gen. More compact printed circuit heat exchangers may be considered instead of shell and tube exchangers (advice should be obtained from the Principal).

In shell and tube heat exchangers, the process fluid is often on the tube side, since it is generally corrosive and at a high pressure. A number of hazardous events arise from tube failure in high pressure shell and tube gas heat exchangers. The sudden failure of a single tube will expose the shell side to a rapid rise in pressure.

If the design pressure of the shell is less than two thirds of the design pressure of the tubes, the shell shall be protected against overpressure, in accordance with DEP 31.21.01.30-Gen. The pressure relief device should be a bursting disc. Relief valves are not recommended since they do not react quickly enough to the rapid pressure rise caused by a tube failure.

Because the pressure increase will also affect the piping and equipment connected to the heat exchanger, the protection of the heat exchanger cannot be considered in isolation. The bursting disc should fail at not more than 1.5 times the design pressure of the piping and equipment connected to the heat exchanger.

All external surfaces of heat exchangers and associated piping operating at temperatures in excess of 70 °C shall be provided with personnel protection. This should be by application of shielding to all parts which are accessible during normal operation. The insulation of hot surfaces for the purpose of personnel protection is not recommended in view of the potential corrosion under the insulation. Shielding shall include parts accessible by temporary maintenance platforms or scaffolding if it is intented to provide access while the equipment is hot. Warning signs and barriers shall be provided to prevent access to any hot equipment which is not provided with such personnel protection.

7. 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.
Design guide for high temperature heat-transfer fluid systems	DEP 20.05.50.10-Gen.
Gas turbine heat recovery steam generators	DEP 30.75.10.31-Gen.
Shell-and-tube heat exchangers (Amendments/Supplements to TEMA standards)	DEP 31.21.01.30-Gen.
General type furnaces (incl. waste heat boilers)	DEP 31.24.00.30-Gen.
Centrifugal pumps (Amendments/Supplements to API 610)	DEP 31.29.02.30-Gen.
Piping - General requirements	DEP 31.38.01.11-Gen.
EP piping classes	DEP 31.38.01.15-Gen.
Glass fibre reinforced plastic pipes and fittings (Amendments/Supplements to API Spec 15HR)	DEP 31.40.10.31-Gen.
Stainless steels for sea water handling systems	EP 89-0198
Heat transfer fluid selection for high temperature HTF systems	MF 92-0125
Performance requirements and acceptable products for asbestos and asbestos substitutes for jointing, packing and sealing materials	MF 90-0960

FIGURES

FIGURE 1 SEA WATER SYSTEM WHERE HAZARDOUS USERS AND NON-HAZARDOUS USERS ARE ENTIRELY SEGREGATED

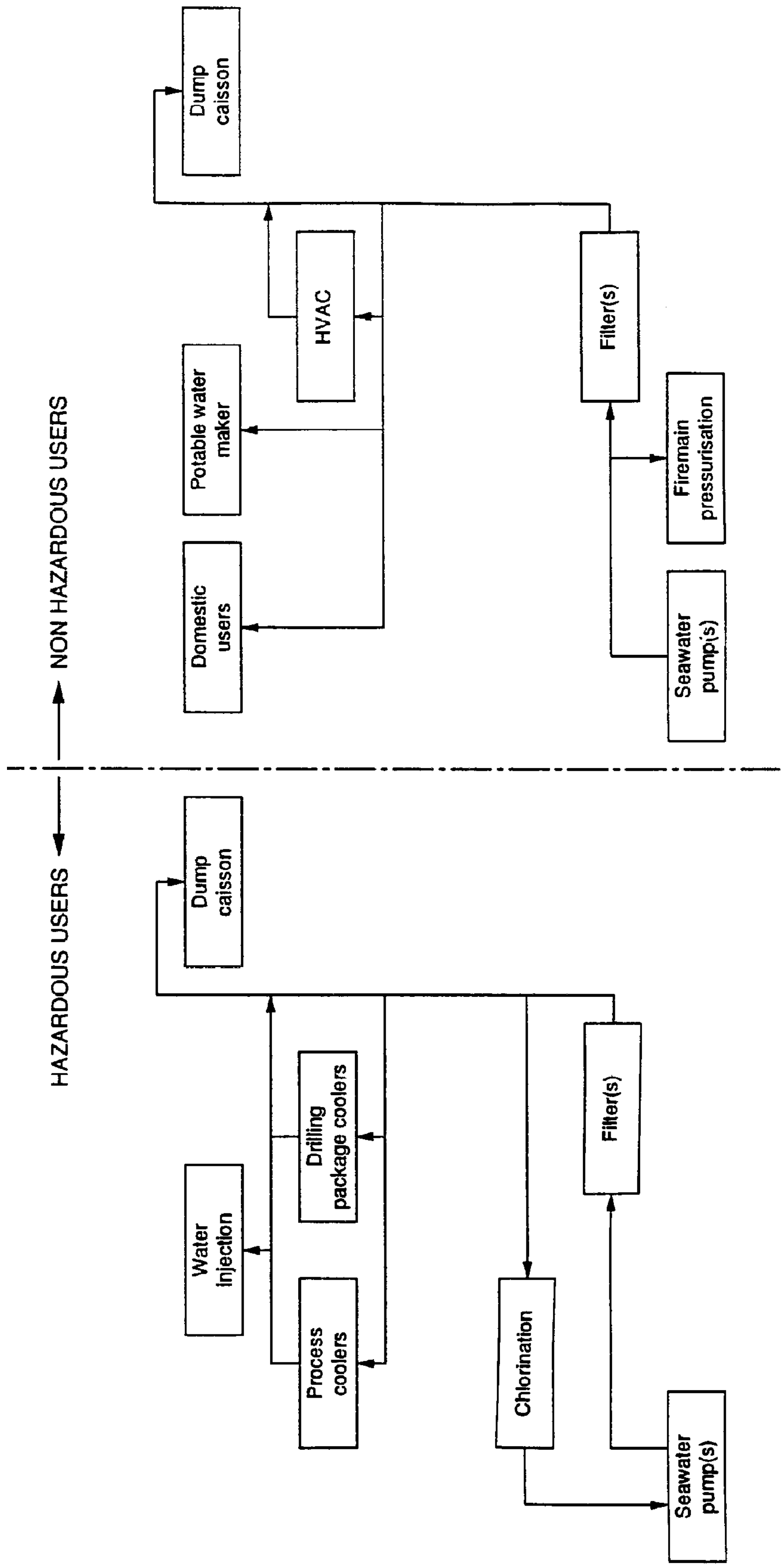

FIGURE 2 SEA WATER SYSTEM WHERE HAZARDOUS USERS AND NON-HAZARDOUS USERS ARE SEGREGATED USING A CLOSED CIRCUIT HEAT TRANSFER SYSTEM

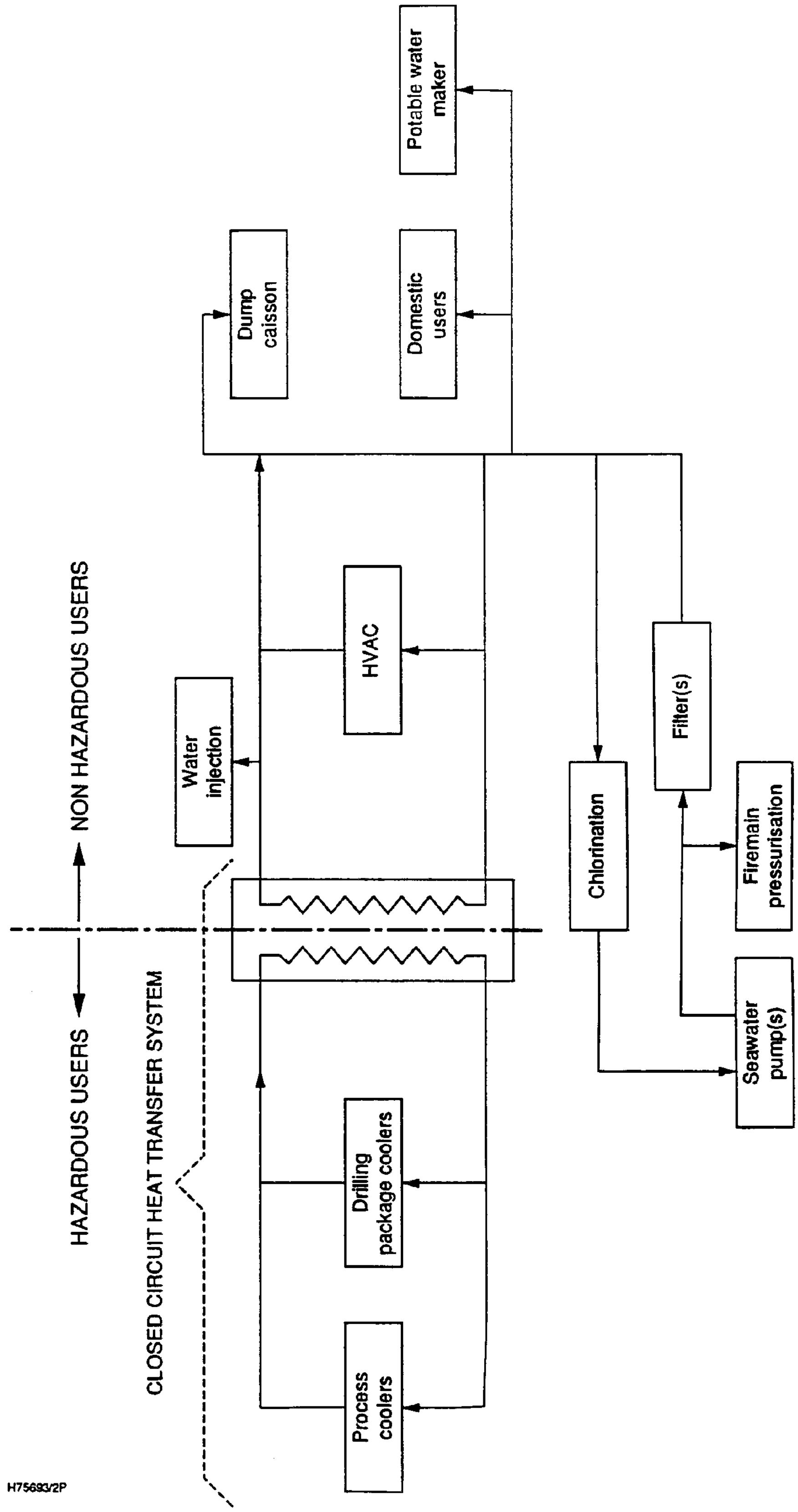

FIGURE 3 SEA WATER SYSTEM WHERE HAZARDOUS USERS AND NON-HAZARDOUS USERS ARE SEGREGATED USING A BREAK TANK

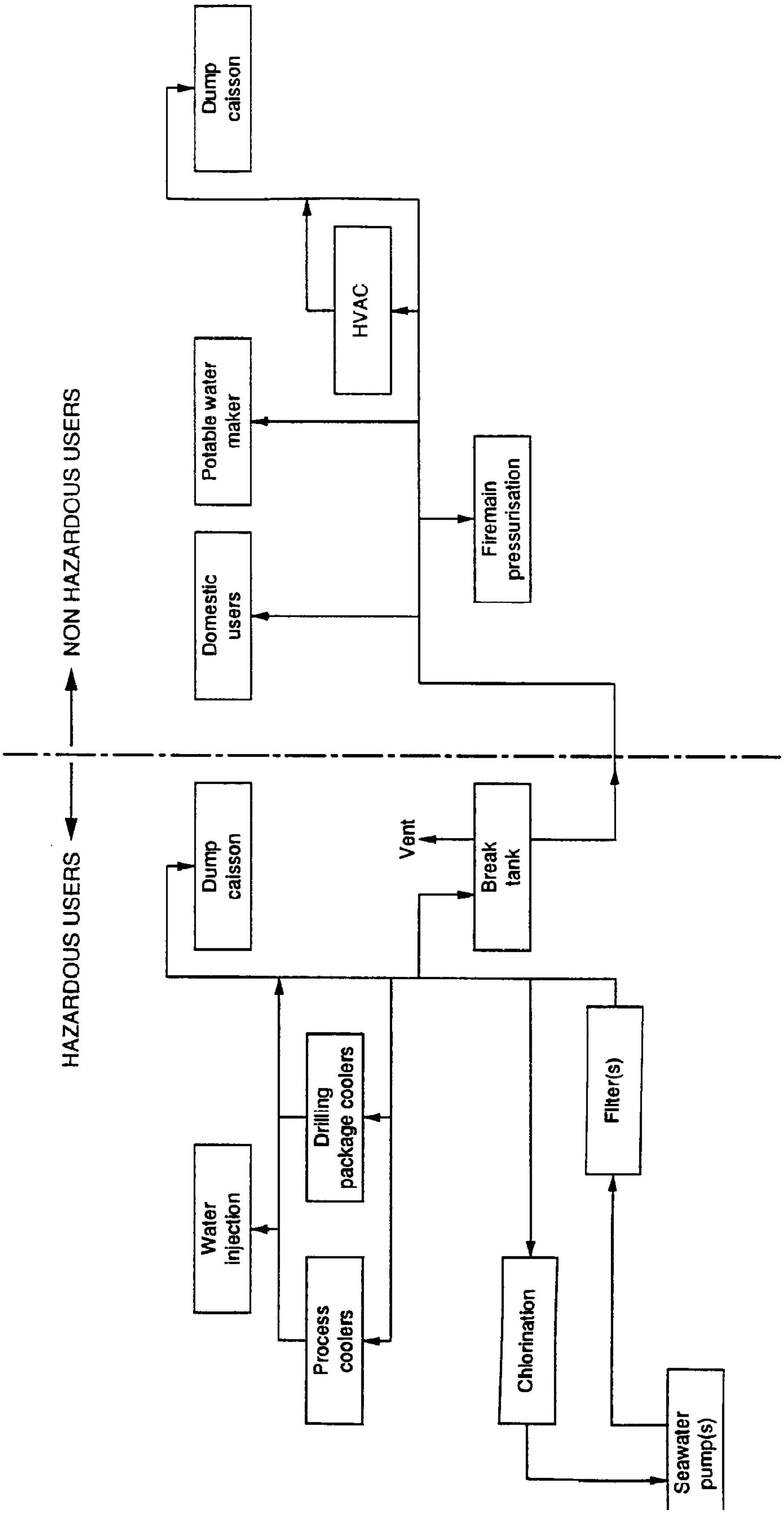

FIGURE 4 DIAGRAM OF A TYPICAL CLOSED CIRCUIT COOLING MEDIUM SYSTEM

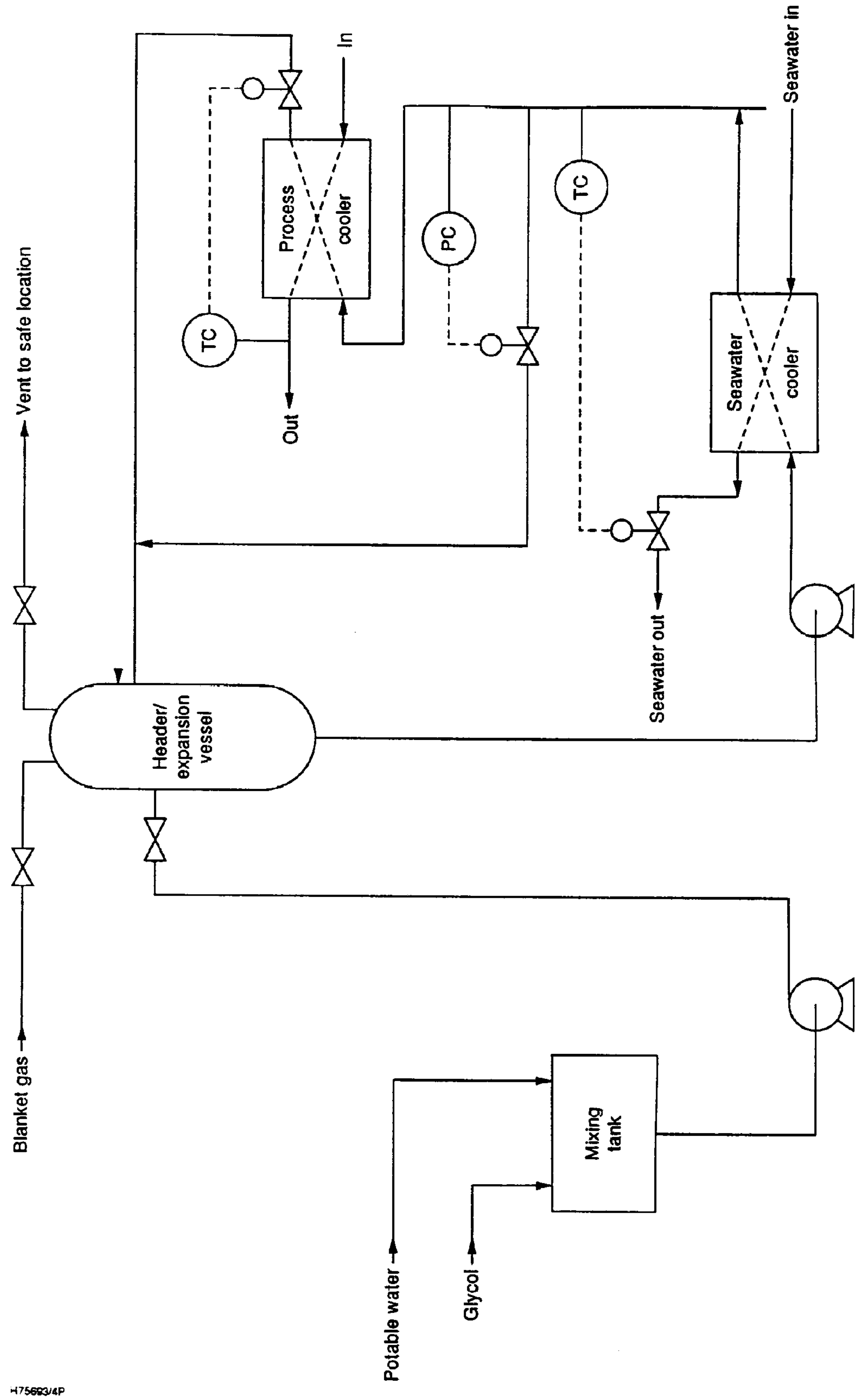

FIGURE 5　DIAGRAM OF A TYPICAL CLOSED CIRCUIT HEATING MEDIUM SYSTEM