An overview of marine & utility system for offshore platform

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Abstract: Main marine & utility (M & U) systems are essential to the routine operation of offshore units, and are extremely important as they are the system that will ensure the basic safety of offshore platforms. This paper gave a general explanation and guideline of the marine & utility systems in offshore projects including their interface with topside, M & U engineering, equipment sizing operation and control.

Key words: marine & utility systems; offshore platform

1 Introduction

The marine & utility (M & U) systems of an offshore project can be divided into the following categories: marine system, utility system, topside utility system, cargo handling and gas blanketing system, and active firefighting system. Normally the cargo handling, gas blanking & inert gas system are parts of M & U systems in oil floating production storage, offloading projects, and depending on the project conditions and scope of work, active firefighting system (fire main, overall firefighting system and local firefighting) is also considered in M & U systems. A brief explanation of each system is provided to be understood easily.

2 Marine system

The marine system is related to the seawater systems and found in the machinery space like ballast and bilge systems.

2.1 Ballast system

The ballast system keeps the offshore unit in a stable condition and at a suitable draught, heel and trim in all relevant states of operation. The segregated ballast system is designed in floating production storage and offloading (FPSO) to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) regulations. It has ballasting/deballasting and transfer functions from one tank to any other ballast tanks. Ballast filling is via ballast main pipes which run to the ballast tanks. Recently most projects have received ballast seawater from topside seawater lift pumps or topside utility pumps using gravity filling.

In previous FPSO projects, the ballast pumps were located in pump room, but recently projects have installed the hydraulic operated, submersible centrifugal type pumps in the central wing ballast tanks. In semi-submersible type projects, ballast pumps had functions of ballasting/deballasting and located at the machinery space in pontoon areas. However in the recent projects, the ballasting is operated by topside seawater lift pumps and electric motor driven, centrifugal type, deballasting pumps have function of transfer and deballasting to overboard above the deepest waterline. To size ballast pumps, cargo loading/offloading capacity is to be considered in ship shape projects and restoring units from damage conditions in semi-submersible projects.

2.2 Bilge system

The bilge system enables water and oily water to be removed from machinery spaces, pump rooms, void spaces and other compartments. There are two suction lines for emptying each bilge well. The first line is connected to the bilge through bilge main pumps (or daily bilge pumps) which have 5~10 m³/h capacity. The second line is the direct bilge suction (or emergency bilge suction) and must be connected...
directly to emergency bilge pumps suction. This is used in emergency and at least two direct bilge suction (or emergency bilge suction) must be provided at machinery space in each pontoon area in semi-submersible project and pump room and aft & forward machinery spaces in FPSO project. It is a classification requirement that the bilge system has an emergency connection that is connected to the largest seawater pump. This is provided so that the maximum possible pump capacity can be used in case of flooding of the pump room or machinery space. The bilge water separator is capable of producing an effluent containing no more than 15 ppm (1 ppm=10⁻⁶) of oil in compliance with MARPOL and classification requirements.

3 Utility systems

The utility systems are mainly support systems of equipment operation and living quarter area like seawater/freshwater cooling, diesel oil, fresh water generation, potable water, hypochlorite, utility & instrument air, sewage treatment and heli fuel system.

3.1 Seawater/freshwater cooling system

The seawater service system provides seawater to the central freshwater coolers, fresh water makers, inert gas generator in FPSO, deck water seal in FPSO, firewater pumps, hypochlorite generators, sewage treatment and hydraulic power unit (HPU) coolers. Seawater is used to cool down the condenser for the refrigeration unit which cools the closed freshwater cooling circuit. In previous projects, seawater pumps took suction from sea chests and fed seawater to cooling water plate type coolers. Recently seawater lift pumps and utility pumps are installed in caissons mounted outside of the hull and terminating topside supply seawater to hull distribution (ballast, freshwater generation, sewage treatment and so on). When main seawater lift pumps are not available, seawater utility pumps supply seawater to hull distribution, during tow to site offshore installation and start-up. All seawater overboard pipes are connected above the deepest waterline. In addition, seawater lift pump caissons often terminate in a seawater suction hose in order to bring up water from depths with low temperatures and oxygen levels.

The central fresh water cooling system is a closed loop circulating system. The system uses a refrigeration system with seawater and the evaporator cooling the fresh water. By this way it can provide fresh water at a temperature lower than cooling the condenser the seawater temperature. Central cooling fresh water system is predominantly used by heating, ventilation & air conditioning (HVAC) systems. Diesel driven emergency generators and instrument air compressors normally have their own fan cooling water to air exchanger since they must run in emergencies. Diesel driven fire main pumps usually use a slip stream of firewater for all cooling. Large kilowatt HPUs may have a fresh water cooling system that cools against the seawater system. Fresh water is used here to limit contamination of the hydraulic fluid and damage of hydraulic parts if there is a leak from the cooling system to hydraulic fluid.

3.2 Diesel oil system

The diesel fuel oil system covers fuel storage and transfer, fuel purification and distribution of diesel fuel to the consumers, the topsides dual-fuel fired turbines, topside cranes, engine generators and various minor users such as lifeboats, rescue boat, etc. The diesel fuel storage and transfer system is designed for the filling of diesel oil storage tanks from bunker stations, offloading of diesel fuel from storage tanks to ship/barge and purifying the diesel fuel received from the bunker stations and in the system. Many diesel users are only operated in emergency situations and it is very important that the diesel users are able to run smoothly on the platform diesel fuel usually for 8 h in emergency situations. Diesel fuel purification needs one or more tanks to receive oil, pumps, purifiers, and tanks to receive the purified diesel fuel.

One very good system required by American Bureau of Shipping (ABS) for self-propelled drilling units would fill service/settling tanks from the bunker stations or diesel oil storage tanks. There would be two diesel fuel storage tanks and two diesel fuel transfer pumps, taking suction from the diesel oil storage tanks and supplying diesel oil to the bunker stations as well as the service/settling tanks. The diesel oil purification package automatically processes unclean diesel fuel from the settling tanks and returns purified diesel fuel to the service tanks.

Fully automatic, self-cleaning, clarifying type diesel oil purifiers are the best practice. Diesel oil purifiers normally work in parallel way. The treated diesel oil is transferred to the day tanks of diesel generators, topside gas turbine generators, hull consumers, inert gas generators day tanks in FPSO, fire water pump tanks and life boats & rescue boats. All pumps and equipment have 100% redundancy and diesel oil purifiers have N+1 redundancy.
3.3 Fresh water generation system

The fresh water generation system on offshore platforms is supplied with seawater and generates fresh water through the fresh water generator. There are two major components to the system, the seawater ejector (or transfer) pumps and the fresh water generator units. Fresh water generators are of two types. The first one is the distillation of seawater via vapor vacuum compression (VVC) for fresh water production. The second is reverse osmosis (RO) type. Most platforms use hypochlorite to control marine growth in the seawater system and it is recommended to install charcoal filters to remove the hypochlorite upstream of RO membranes since hypochlorite concentrations above 0.5 ppm can damage the RO membranes. The fresh water generator size is based on 200–400 L/d per person.

3.4 Potable water system

The potable water system comprises potable water storage and transfer, potable water purification and distribution to consumers, topsides and hull utilities, topsides eyewash and safety showers, and hot and cold water for personnel usage. The potable water storage and transfer system is designed for the filling of bunker tanks, i.e., fresh water tanks, from bunker stations and filling of fresh water tanks from fresh water generators. Water transferred from ship or barge is metered and chlorinated into the fresh water tanks. Water from the fresh water generators is also chlorinated per regulation as it leaves the generators. The fresh water is also re-mineralized, via rehardening filters in order to increase the pH and make it be potable water. Water that is stored in fresh water tanks can be re-circulated to the tanks and re-chlorinated to maintain sanitary requirements as needed. Further treatment of potable water is accomplished through micronic filtration and ultraviolet (UV) sterilization. The potable water service system supplies potable water to all the offshore platforms consumers. The system is normally divided into utility usage and personnel usage. All water that is allocated for personnel usage is protected from utility users by a backflow preventer. The potable water for personnel usage is further subdivided into a hot water component and a cold water component.

3.5 Hypochlorite generation system

The purpose of hypochlorite system is to keep the offshore platforms seawater inlets and accompanying piping free of marine organisms and organic growth. Hypochlorite inhibits the growth of bio-foul ing organisms and prevents them from attaching to the interior surfaces of seawater cooling system piping and components. The hypochlorite system is designed to chemically treat seawater by supplying sodium hypochlorite to achieve a concentration of 3 ppm in the incoming seawater. Dilute hypochlorite solution (0.1 %) is generated on the offshore platforms from seawater via an electrolytic cell generator. A small tank serves to separate the co-generated hydrogen gas from the hypochlorite solution and provide buffer capacity. The hypochlorite solution is distributed by gravity to the suction of seawater lift pumps, seawater utility pumps, jockey pumps and ballast pumps. The system is designed based on the residual free chlorine (1~1.5 ppm for continuous operation), continuous dosing (3 ppm) and shock dosing (5 ppm).

3.6 Utility & instrument air system

There are normally two compressed air systems on offshore platform, the utility and instrument air systems. Normally, air compressors compress air up to 10 bar (1 bar=100 kPa) and the air is sent to a utility air receivers. Utility air is sent to utility air users and instrument air dryers. The instrument air dryers normally dry air and then flow to instrument air receiver. Instrument air pressure may be reduced to 7 bar before being sent to instrument air distribution depending on pressure rating of the instrument air users.

Instrument air should be dried at a minimum to a pressure dew point 10 °C colder than the lowest expected ambient temperature and never warmer than 4 °C. Historically, dryers used heat to drive the moisture out of the desiccant and regenerate it. Nowadays, most dryers are heatless and use a side-stream of dried air at low pressure to regenerate the desiccant. Most instrument air dryers on the market can dry air to ~40 °C dew point. Equipment location varies with project and many times the main air production is located on topsides. Then, hull air compressors and dryer packages are installed in the hull machinery space to supply service and instrument air to hull users independently from topside system. Utility air (or service air) supplies intermittent hull utility air users. Air or water cooled oil-free screw/reciprocating type compressors deliver air to air dryer package, from where it flows to the utility air receivers and instrument air receivers. Topside supply line connects upstream hull utility & instrument air receivers. During normal operation, utility air is supplied from top-
side to hull users (utility stations, ballast pump educators and air driven equipment).

Instrument air (or control air) receivers will be installed in hullside to distribute compressed instrument air to hull consumers (pneumatic operation valves, fire dampers and nitrogen generators). Instrument air is taken from downstream of hull air compressors and dryer packages. Dried air is stored in the hull instrument air receivers. Instrument air from topside connects upstream instrument air receivers. Under low pressure, topside & hull utility air service header will be isolated and instrument air to the hull will be closed. Some projects have installed main utility & instrument air compressors and dry packages on the hullside and stored hull & topside air receivers and delivered air to each hull & topside distribution header.

3.7 Sewage treatment system

The sewage system can be divided into grey water and black water system. The grey water is drainage water of shower, wash basins and sinks in the living quarter as well as from galley and laundries. Grey water from the hospital area is connected to the grey water system with the sewage treatment units. The purpose of black water system is to take care of sewage from toilets in the living quarters by a vacuum system and send it to sewage treatment units. Showers, wash basins and toilets in the hospital area are connected to separate header routed to the main header at the vacuum unit. For units in most locations, the sewage treatment package must be approved or certified by the government controlling the water in which the unit is located.

3.8 Helifuel system

The helifuel system performs the storage of helifuel onboard the offshore projects and supply of helifuel to helicopters. The helifuel package has mainly two different packages. One is helifuel storage and pump package; the other is helifuel dispensing package. The storage and pumping package is located on the laydown area, within crane coverage and close to living quarter. It includes replaceable tote tanks and helifuel transfer pumps. The helifuel dispensing unit is used for filling helifuel into the helicopters. The package is comprised of 1 helifuel filter, 1 flow meter with flow totalizer fuel monitor panel, hose reel and dispensing nozzles. Since the helideck and fuel dispensing package is normally located on the living quarter roof for crew change reasons, safety systems like electrical bonding (no sparks), spill containment (combing) and fire suppression (foam) are of vital importance.

4 Topside utility systems

Topside utility systems are mainly topside supporting. The nitrogen system or parts of topside system are located in hullside such as produced water and methanol system in FPSO.

4.1 Nitrogen system

The nitrogen system supplies nitrogen for various intermittent and continuous users. The system comprises nitrogen package and nitrogen receiver. Nitrogen of 97 % purity is generated in a membrane separation process using dry instrument air at pressures between 8 bar and 11 bar as feed. The main users of nitrogen are HP & LP flare stack purging and compressors seal gas in topside. In normal projects, hull receives pressurize nitrogen from topside to supply to hull users (methanol tanks gas blanketing and so on). However, some projects have installed nitrogen generator packages and receiver in hullside and delivered nitrogen to each hull & topside distribution header.

4.2 Produced water system

Produced water system is designed to reduce oil in water content of produced water coming from the topsides 1st & 2nd stage separator, de-oiling hydrocyclones and produced water cooler to an environmentally acceptable level so that treated water is suitable for overboard discharge. The produced water fills from topside. Produced water will be directed to two hull produced water tanks for settling/separation before discharge of the water overboard at the maximum oil in water 15 ppm. Each produced water tank shall be fitted with electric motor driven or hydraulic operation deep-well, centrifugal type produced water transfer pumps. The clean water from the bottom of the tanks will be transferred by produced water transfer pumps and routed to a dedicated overboard discharge via an oil discharge monitoring equipment (ODME). Off spec produced water is routed to the dirty slop tank or topside hydrocyclones unit to remove any residual oil from water.

4.3 Methanol system

The methanol storage tanks and system provide the methanol to the offshore platforms and subsea in order to prevent hydrate formation. The methanol is bunked on the offshore platforms and is stored in the methanol tanks. Each methanol tank is fitted with two methanol transfer pumps. These pumps allow the
5 Cargo handling and gas blanketing system

5.1 Cargo handling system

In FPSO, cargo handling system receives stabilized crude oil cargo from the topsides processing plant. The crude oil fills hull cargo tanks up to the maximum designed rate on a continuous basis, and simultaneously but intermittently, offload (export) the stored crude oil through a metering system and an oil offloading line (OOL) system from FPSO to the single point mooring (SPM) buoy or a tandem offloading system to an export tanker. The conventional cargo pumps in FPSO were located in a pump room, but nowadays hydraulic operated, submersible centrifugal type pumps are installed on main deck. The cargo handling system has 4 separate headers on FPSO; loading header to load crude oil from topside to cargo tanks or slop tanks; offloading header to transfer crude to the metering skid and offloading unit; transfer header to transfer crude from one tank to another or to lift crude oil to topside; crude oil washing header for crude oil and water washing.

5.2 Gas blanketing system

Gas blanketing system allow blanketing of cargo tanks and slop tanks maintaining blanket gas in order to prevent flammable atmosphere in accordance with International Maritime Organization (IMO) requirements. Gas blanket is supplied by the flare and hydrocarbon (HC) blanket recovery package provided by topside. The HC blanket gas header is connected to flare and HC blanket recovery package. And it is also connected to the inert gas supply system in case of shutdown of HC blanket system. The system capacity is not less than 1.25 times the maximum offloading rate as per safety of life at sea (SOLAS) regulations. Each cargo tank and slop tank have individual pressure/vacuum (P/V) relief valve sized taking into consideration all the operation conditions of protected tanks. Header liquid filled P/V breaker is over-pressure protection of the tanks after P/V valves and connected to the gas blanket system. HC blanket gas vent is installed to prevent back flow of HC blanket gas and has small flow and large flow high velocity exhausts valves.

5.3 Inert gas system (IGS)

The IGS is installed to provide inert gas to all cargo oil tanks, produced water tanks, if needed, and slop tanks. The IGS shall be capable of supplying 125 % of the maximum cargo offloading rate. Packaged inert gas generators are capable of being fired by either fuel gas from process fuel gas system or diesel oil (or marine gas oil). The cargo tank venting system shall be designed for both cargo loading case and cargo transfer case. The purge main shall be connected to a vent riser terminating with a flame screen. Independent high velocity P/V valves shall be mounted on each cargo tank and slop tank. The outlet from the P/V valves shall be joined to a common blow-off header and riser to be located. If gas blanket system is installed on projects, IGS is the backup system during normal loading/offloading operations.

6 Active firefighting system

Depending on the project conditions, active firefighting system (fire main, overall firefighting system, local firefighting and heli deck foam system) is also considered part of the M & U systems.

6.1 Fire main system

The purpose of the firewater main system is to provide firewater to various users throughout the hull and topsides areas of the offshore platforms. These users include all fire hose reels/cabinets, deluge systems (hull and topsides), foam systems (hull and topsides) and the accommodations/deck house.

The firewater main system consists of 1 ring main route in the hullside and 4 risers from firewater pumps that are located in the hull machinery spaces. The firewater main ring provides all firewater in the hull and topsides areas. Normally risers from the main ring supply topsides with firewater. Pressure is maintained in the main ring from jockey pumps (or charging pumps) located in the machinery space or pump rooms in the hullside. The jockey pumps (2 × 100 %) are operated on a “duty” and “standby” basis with the duty pump running continuously and discharging overboard. Main fire pumps (200 %) are designed in accordance with National Fire Protection Association (NFPA) recommendations. Fire pumps will start automatically in sequence based on preset main fire ring pressure; the jockey pump works first,
which is followed by the main pumps, if the jockey pumps cannot meet the demand.

6.2 Overall firefighting system

There are several fire suppression systems: Novec 1230, CO₂, low expansion foam and high expansion foam fire extinguishing systems in the offshore unit to active fire protection (AFP). Novec 1230 fire extinguishing system is designed as a total flooding system for machinery space and pump room. It has an environmentally friendly and immeasurable environmental impact and safe for use in the areas where humans are working. Similar systems are Inergen and FM200.

CO₂ fire extinguishing system is a total flooding system using CO₂ gas recovered. The system is proven to be a fast and effective solution on deep seated fires in cargo holds and the system is designed as total flooding system for machinery spaces of category A, engine rooms, pump rooms and cargo holds on board vessels. CO₂ works by displacing oxygen and the CO₂ level must reach 30 % in a given room. CO₂ has a lethal concentration (death in 30 min) of 10 % and many have moved away from its use in occasionally manned areas. Low expansion foam fire fighting system is to protect the cargo areas as per SOLAS Chapter 11-2, Part D, Regulation 61. In FPSO, the topside process modules and supporting structure above the main deck could obstruct the performance of monitors and foam deluge systems used. The foam deluge system will be located on the underside of the topside modules’ supporting structure.

High expansion foam fire fighting system is designed and tested according to International Maritime Organization, Maritime Safety Committee (IMO MSC), Circ. 1165 and Circ.1271. In FPSO, high expansion foam fire extinguishing system uses high expansion foam consisting of a synthetic foam concentrate water and air, which is highly effective for machinery space applications. The system can be installed as total flooding for the entire main machinery space or for individual compartment within that space, pump rooms and other separate machinery spaces. Water mist is produced by running high-pressure pure water through special nozzles. It is very effective at quenching a fire and is being used in some accommodations and equipment rooms.

6.3 Local firefighting system

The system shall be designed and tested according to IMO through SOLAS Chapter II-2, Regulation 7.7 and IMO MSC/Circ. 913. In addition to overall firefighting system, the class requirements for fixed local firefighting system shall be applied using fixed local application water based system for all high risk equipment rooms (such as generator drivers, incinerators, purifiers, inert gas generator, thermal oil heater and boilers, etc.). Above all such equipment, special nozzles shall be fitted. The system shall be fitted with an independent release (both automatic and manual release).

6.4 Helideck foam system

The purpose of the helideck foam system is for firefighting with automatic oscillation foam monitors as well as deluge of helifuel dispenser at helideck and storage tanks/pumps. Each foam monitor is designed for the capacity of 90 ~ 100 m³/h including 3 % foam. All monitors operate simultaneously. The helifuel units (dispenser at helideck and storage tanks/pumps unit) deluge systems are connected to the helideck. The foam unit is located beneath the helideck area.

7 Marine & utility engineering

1) Equipment and pipe sizing. When sizing M & U equipment, one needs to consider client technical engineering standards & practices and rule & regulation requirements for ballast, bilge, sewage treatment, firewater system and so on. Main pipe sizing is to be prepared with considering of hydraulic balance, the maximum allowable working pressure (MAWP) and surge pressure. In addition, temporary equipment is to be prepared for integration, towing offshore, and installation phase.

2) Multi discipline function. M & U system is related to the pipe, machinery, HVAC, safety, instrument & electric discipline and is front runner to lead engineering in offshore projects. It is important to provide engineering data to each discipline and receive vendor information and other documents from other disciplines per project schedule during the engineering stage. In addition, each discipline needs to understand the other discipline requirements.

3) Engineering stages. In front end engineering & design (FEED) and basic engineering stage, M & U needs to prepare the schematic system drawings and is important to set up engineering philosophy which do not influence impact of the other discipline in detail engineering. The vendor data integration and other discipline’s result are to be updated in piping and instrument diagram during detailed engineering. Preliminary commissioning master schedule and procedures are to be prepared during commissioning
stage.

4) Interface with topside. There are several interfaces between hull and topside. A project will not be successful if the hull/topside interfaces are not correct. Marine & utility system is the main discipline to communicate with topside.

5) Safety systems. Instrumentation for safety systems acts as a back-up for the normal platform control systems. Unless there is an emergency situation a safety system will not be required to operate. This means that a safety device could fail with no indication that it will not respond when an emergency occurs. Testing for safety equipment is critical. Many detectors can be bypassed at the central control system and correct operation of the field device can be verified by testing with what the detector is to detect, i.e., pressure, smoke, gas, etc. Other safety devices like shutdown valves cannot be fully closed without stopping the process. There are systems available on the market that allow these valves to be partially closed (or opened for blow-down valves) to verify the shutdown still works with the minimal effect on production. Whenever practical the same safety devices and safety systems should be used for hull and topsides.

8 Conclusions

Main marine & utility systems are supportive and auxiliary to the topside production system in offshore projects. However, it is essential to ensure the basic safety and operation of offshore platforms. Also it is important that various experienced M & U engineers help to set up the engineering procedures and give the engineering guides from project kickoff to completion.

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