SUBSEA PRODUCTION CONTROL SYSTEMS EQUIPMENT LIST.

A GUIDE FOR ENGINEERS MONITORING SUBSEA PRODUCTION CONTROL SYSTEMS IN THE OIL & GAS INDUSTRY.

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Subsea Production Control Systems

Subsea Production Control Systems control the flow of crude oil and natural gas (collectively known as hydrocarbons) from wells located below the surface of the seabed. The wells are accessed by drilling into the seabed and the SPCS provides a way to manage the flow of the hydrocarbons from the such that they can be transferred safely to the surface to be processed. An SPCS consists of supply and control equipment located on the surface (topside) and equipment on the seabed (subsea) that acts upon the commands of the topside systems.

Offshore Installations and Vessels

Drill Rig – a mobile platform that is used to drill into the surface of the seabed in order to access crude oil and natural gas wells. They are normally either fully floating vessels (known as drill ships), semi-submersible platforms that are anchored to the seabed (known as semi-subs) or they have legs that extend down from a floating platform and locate onto the seabed (known as jack-ups). These platforms can also be used to conduct work over existing wells.

> **Workover Control System (WOCS)** – a means of controlling the well control equipment, such as Christmas Trees (XMT) and Subsea Safety Valves (SSSV). WOCS are similar in function to and share components with Subsea Production Control Systems (SPCS) but they are normally limited to the ability to control single wells, rather than entire systems. WOCS are normally located on drill rigs to support drilling of new wells or work-over of existing wells.

Production Platform – an offshore installation that extracts crude oil and natural gas (hydrocarbons) from subsea wells and processes it for transportation via pipelines to onshore facilities. Processed gas is often used to power equipment on the platform rather than being transported onshore.

Floating, Production, Storage & Offloading (FPSO) – an offshore installation that extracts crude oil and natural gas from subsea wells, processes and stores it for future transportation via tankers to onshore facilities. Processed gas is often used to power equipment on the platform rather than being transported onshore.
Dive Support Vessel (DSV) – a floating vessel/ship that is an operational base for commercial diving projects. Often used during subsea intervention campaigns, including diagnosing faults on subsea electrical distribution infrastructure.

Construction Support Vessel (CSV) – a floating vessel used during construction and maintenance of offshore installations.

Topside Equipment

Integrated Control and Safety System (ICSS) – combines the various functions normally carried out by process control (e.g. DCS) and safety systems (e.g. SIS) into one integrated control system.

Distributed Control System (DCS) – a type of automation and process control system in which autonomous controllers are distributed throughout the system, with no single central supervisory control over all systems.
Safety Instrumented System (SIS) – a type of automation and control system focused on safety, typically monitoring/detecting and responding to threats from fire and gas and over-pressures in offshore hydrocarbon production process systems.

Master Control Station (MCS) – provides the control function of a Subsea Production Control System (SPCS). Typically sends and receives signals and data from the main components within the system such as the Electrical Power Unit (EPU), Hydraulic Power Unit (HPU) and Subsea Control Modules (SCM), interfaces with

other offshore systems (e.g. DCS, ICSS) and provides a means for human interface with the system. The MCS is made up of various individual replaceable items, normally housed in a cabinet within a temperature and humidity controlled room. The following items are typical components of an MCS:

Industrial Personal Computer (IPC) – similar to a desktop computer but designed to run continuously with minimum downtime. IPCs are manufactured using high quality components and normally include features such as increased cooling capability and more stable power supplies than standard PCs.

Programmable Logic Controller (PLC) – a type of computer that is designed specifically for the control of industrial automated processes. A PLC continuously monitors inputs and outputs and acts upon them according to a pre-programmed code.

Human-Machine Interface (HMI) – an interface that allows a human to control a machine, system, or device. In the MCS, this HMI is normally a keyboard, video display (monitor) and mouse or trackpad/ball.

Keyboard, Video & Mouse switch (KVM) – a device that allows control of multiple computers from one or more HMIs.

Modem - a device that converts signals produced by one type of device to a form compatible with another and that is used especially to transmit and receive information between computers via electrical cabling.

Router - a device that mediates the transmission routes of data packets over an electronic communications network. Also often referred to as a switch, in regards to an MCS

Electrical Power Unit (EPU) – the source of distributed subsea electrical power in a SPCS. The EPU receives a mains electrical supply from the offshore installation's generators, filter and regulate/amplify the input into a signal of suitable voltage, current and frequency and then distribute and monitor the converted electrical power to the relevant subsea wells via the power distribution infrastructure. The EPU is made up of various individual components, normally housed in a cabinet within a temperature and humidity controlled room.

Input Module – receives, filters and regulates the electrical input from the installation's mains electrical supply ensuring a clean signal is distributed within the EPU.

Output Power Module / Subsea Output Module (SOM) / Subsea Controller (SSC) – the output power module regulates or amplifies an electrical signal to the correct voltage, current and frequency required for the subsea control modules (SCM) to operate. Distributes and monitors the output. Provides safety functionality via over/under voltage and over current protection circuitry that can isolate the output to prevent harm to personnel or damage to equipment.

Insulation Monitoring Device (IMD) / Line Insulation Monitor (LIM) - An insulation monitoring device monitors the ungrounded system between an active phase conductor and earth. It is intended to give an alert (light and sound) or disconnect the power supply when the resistance between the two conductors drops below a set value.

V-LIM - The principle of insulation monitoring is to apply a voltage between the copper conductors in a cable and earth and measure the resulting current that flows. Using any Insulation Monitoring Device (IMD) to monitor IR degradation in a cable which is submerged in seawater will cause damage to the copper conductors at the point where the conductor insulation is damaged. The V-LIM has been designed to substantially reduce the copper loss when compared with competing devices on the market.
V-LIFE - V-LIFE is a preventative and active 'healing' solution for low insulation resistance caused by water ingress. The V-LIFE effect is achieved by the application of a low voltage passivation signal to the

faulty line which through an electro-kinetic and electrochemical process generates and sustains a solid precipitate at, and only at, the location or locations in the subsea circuit where seawater has ingressed. The precipitate produced is electrically insulating and its propagation at the source of the fault results in an increase in the Insulation Resistance of the circuit often by more than 100x.

PLC – as per MCS PLC. Provides control and monitoring functions within the EPU and interfaces with the MCS.

Hydraulic Power Unit (HPU) - provides a pressurised supply of hydraulic control fluid to power hydraulically actuated subsea valves. The HPU is generally housed in a large external container on an offshore installation and is part of the control and feedback loop mastered by the MCS. Typical components found within an HPU include:

Reservoir(s) – storage tanks containing hydraulic control fluid. The control fluid can be mineral oil based or water based. The control fluid often contains additives such as corrosion inhibitor, anti-freeze and anti-foaming agents.

Pump(s) – electrically driven pumps that pressurized the control fluid within the system. Normally also contain a recirculation pump that is used to circulate fluid through an off-line filtration system prior to it being pressurised in the main system. There will generally be separate pumps for low pressure (LP – up to 207bar/3000psi) and high pressure (HP - 345bar/5000psi and over) requirements, although some systems may also have medium pressure (MP – between 207bar and 345 bar) supplies.

PLC – as per MCS PLC. Provides control and monitoring functions within the HPU and interfaces with the MCS.

Accumulator(s) – a bladder housed within a metal container that acts as a pressure storage device. The accumulator stores control fluid under pressure and automatically discharges it when there is a high demand on the system.

Control Valve(s) / Regulator(s) – manually or electrically operated valve, used to regulate the flow of control fluid in the hydraulic system by varying the size of the flow passage within the valve.

Pressure Relief Valve(s) (PRV) - a type of safety valve used to control or limit the pressure in the hydraulic system.
Gauge(s) – a visual indicator of the pressure at particular point within the hydraulic system.

Filter(s) & Strainer(s) – filter unwanted particles and contaminants from the control fluid prior to the fluid being distributed subsea.

Control Panel – human interface to manually control the HPU. Typically contains power on/off switches, pump selection switches and remote gauges.

Topside Umbilical Termination Unit (TUTU) – the connection point at which the subsea control umbilical interfaces the topside infrastructure. A structure or frame typically made up of chemical/hydraulic and electrical connections, with associated isolation valves, pressure gauges and electrical junction boxes.

Subsea Equipment

Control Umbilical – provides a means of connecting topside and subsea equipment. Chemical, hydraulic and electrical supplies are transferred via the umbilical to enable the remote control of the subsea equipment from topisde.

Hydraulic/chemical cores – hoses, tubes and flexible pipework that transfers pressurised supplies from the HPU and chemical injection system to the subsea manifolds, christmas trees and associated equipment.

Electrical distribution cores - transfers electrical power supplies from the EPU and control signal/ communications from the MCS to the subsea manifolds, christmas trees and associated equipment.

Subsea Umbilical Termination Unit (SUTU) / Umbilical Termination Assembly (UTA) / Subsea Umbilical Termination Assembly (SUTA) – similar to the TUTU but located at the opposite end of the umbilical, terminating subsea and interfacing with the subsea equipment.

Subsea Template – a large structure into which multiple sub-items such as manifolds and christmas trees are located.

Manifold – diverts/routes the flow of hydrocarbons from multiple sources (christmas trees) into a smaller quantity of flowlines, in order to simplify the transfer of hydrocarbons from subsea to topside. Manifolds often contain other subsea equipment and carry out additional functions to simplify packaging, such as distribution of control system supplies. Typical equipment found on or within w manifold include:

Pipeline End Termination (PLET) – the connection at which a pipeline, or flowline, terminates subsea and interfaces with control and distribution equipment, such as the manifold.

Manifold Control Module (MCM) – similar in design and function to the SCM found on XMT.

Multiphase Meter (MPM) / Multiphase Flow Meter (MPFM) – a device used to measure the flow of hydrocarbons contained within other fluids. Oil and gas are extracted from the wells along with water, sand and various production chemicals. The MPFM measures the hydrocarbon content within the production fluid.

Flying Leads / Jumpers - Flying Leads, also known as Jumpers, are part of the subsea distribution infrastructure that connect the various subsea equipment.

Electrical Flying Lead (EFL) / Electrical Jumper – lengths of electrical cable, sometime housed within an oil filled hose, terminated with special connectors that enable transmission of electrical power and communication signals between subsea equipment. The connectors are either conductive and provide a direct link via a dry connection, or they are inductive that transfer the electrical power/signals indirectly.

Hydraulic Flying Lead (HFL) / Hydraulic Jumper – lengths of hydraulic hose terminated with connectors that enable the transfer of pressurised hydraulic and chemical supplies between subsea equipment.

Bundle – multiple individual HFLs and/or EFLs bundled together into one recoverable item.

Stab plate –multiple conectors on E/HFLs can be mounted onto a stabplate that then becomes a single connection point onto a structure, XMT, SCM etc. A stabplate is driven into it's location, normally utilising a male spigot and female receptacle, and secured in place.

Christmas Tree (XMT) – controls and monitors the production of hydrocarbons from, and injection

of fluids into, a subsea well via a series of valves and associated pipework. There are different types of subsea XMT, including:

Horizontal Christmas Tree (HXT) – the valves within the tree are mounted on the horizontal plane.

Vertical Christmas Tree (VXT) – the valves within the tree are mounted on the vertical plane.
Production Christmas Tree (PXT) – used for the production of hydrocarbons from subsea wells.

Water Injection Christmas Tree (WIXT) – used to inject water into subsea wells to maintain pressure in the well, which aids the recovery of hydrocarbons.

High Pressure, High Temperature (HPHT) – designed and manufactured to withstand hydrocarbons flowing at higher pressures and temeperatures than standard subsea XMTs.

Downhole Pressure & Temperature (DHPT) – a sensor that is installed 'downhole' to monitor the pressure and temperature of the production hydrocarbons prior to them reaching the XMT. The sensor is remotely connected to an interface card which is located on the XMT, normally within the SEM/SCM but they can also be housed in separate units called Downhole Interface Units.

Downhole Interface Unit (DIU) – an independent recoverable unit that houses a DHPT interface card.
Choke Valve / Production Choke Valve (PCV) / Injection Choke Valve (ICV) – these valves operate like taps, varying the flow of fluids or gas in and out of the XMT. Choke valves are mastered by the SCM.

Production Master Valve (PMV) – the primary barrier valve that opens or closes upon command to allow or prevent the flow of fluids within the production flow loop.

Production Wing Valve (PWV) - a secondary barrier valve that opens or closes upon command to allow or revent the flow of fluids within the production flow loop.

Annulus Master Valve (AMV) - the primary barrier valve that opens or closes upon command to allow or prevent the flow of fluids within the annulus flow loop.

Annulus wing Valve (AWV) - a secondary barrier valve that opens or closes upon command to allow or prevent the flow of fluids within the annulus flow loop.

Cross Over Valve (XOV) – a valve that controls the flow of fluids between the production and annulus flow loops.

Chemical Injection Valve (CIV) – a barrier valve that opens or closes upon command to allow or prevent the flow of chemicals being injected into the production or injection flow loops.

Chemical Injection Throttle Valve (CITV) / Chemical Injection Metering Valve (CIMV) – a valve that acts like a self-regulating tap to manage the flow of chemicals being injected into the production or injection flow loops.

Acoustic Sand Detector (ASD) / Subsea Particle Monitor (SPM) – a device that monitors the production fluid to detect the presence of sand within the fluid.

Pressure & Temperature Transducer (PTT) – a device to monitor the pressure and temeperature of production or injection fluids.

Subsea Control Module (SCM) – installed on XMTs, the SCM provides the control and monitoring functions

for equipment installed on the XMT, manifold (if MCM) and downhole. The SCM is a retrievable unit, meaning it can be recovered to the surface and replaced without major construction work. Typical control and monitoring functions provided by the SCM include: communication with topside equipment; actuation and position monitoring of tree/manifold/downhole valves; monitoring of tree/manifold/downhole pressures, temperatures and flow rates; monitoring of sensors such as sand detectors. Components that make up the SCM include the following items:

Subsea Electronic Module (SEM) – the SEM is the brain of the SCM. Installed internally within the SCM, the SEM is essentially a subsea computer, converting various forms of electrical communication signals into instructions that, in turn, open and close subsea valves, gather data from sensors

Directional Control Valve (DCV) - allows the flow of hydraulic control fluid into different paths depending on the path requested by the operator. DCVs usually consist of a spool inside a cylinder which is mechanically or electrically actuated.

Manifold – Low Pressure (LP) & High Pressure (HP) hydraulic systems, pipework, filters, mounting for DCVs.
Top Cover – the main cover over the internal components of the SCM. Once the top cover is installed, the module is filled with dielectric fluid to prevent electrical arcing.
Pressure Transducer (PX) – a device to measure pressure within the hydraulic control lines.

Bladder Accumulator – same as HPU accumulator.
Pressure Compensation Bladder – a device to equalise the pressure within the SCM, compensating for the change in pressures at increased water depths.

Subsea Safety Valve (SSSV) / Surface Controlled Subsea Safety Valve (SCSSV) – the primary safety barrier to control the flow of fluids in and out of the well.

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