Technical Documentation

Pump Vaporiser Unit Mk 2 Project Guide, Installation Manual and EOD

PVU

Pump Vaporiser Unit Mk 2 Project Guide, Installation Manual and EOD ..	**PVU**
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PVU

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Everllence
Teglholmsgade 41
DK-2450 Copenhagen SV

Phone +45 3385 1100
Fax +45 3385 1030
www.everllence.com

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Project Guide

Fuel Gas Supply System

Two-stroke Engines

1.1 General

This Project Guide is intended to provide the information necessary for the layout of a Fuel Gas Supply System.

The information is to be considered as preliminary. It is intended for the project stage only and subject to modification in the interest of technical progress. The Project Guide provides the general technical data available at the date of issue.

It should be noted that all figures, values, measurements or information about performance stated in this project guide are for guidance only and should not be used for detailed design purposes or as a substitute for specific drawings and instructions prepared for such purposes.

1.2 Data Updates

Data not finally calculated at the time of issue is marked ‘Available on request’. Such data may be made available at a later date, however, for a specific project the data can be requested. Pages and table entries marked ‘Not applicable’ represent an option, function or selection which is not valid.

The latest, most current version of the individual Project Guide sections are available on the Internet at: www.everllence.com.

1.3 Extent of Delivery

The final and binding design and outlines are to be supplied by Everllence, see Extent of Delivery, Page 116 of this Project Guide.

1.4 Electronic Versions

This Project Guide book and the 'Extent of Delivery' forms are available on the internet at: www.everllence.com where they can be downloaded.

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Edition 5.0

July 2025

1.5 Disclaimer and Additional Details

While remaining the same legal entity, MAN Energy Solutions SE has been renamed to Everllence SE and its products are being rebranded from “MAN” and/or “MAN Energy Solutions” to “Everllence”. As this is an ongoing process, any reference to “MAN” and/or “MAN Energy Solutions” is actually a reference to “Everllence”.

All data provided in this document is non-binding. This data serves informational purposes only and is especially not guaranteed in any way.

Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.

If this document is delivered in another language than English and doubts arise concerning the translation, the English text shall prevail.

Everllence
Teglholmsgade 41
DK-2450 Copenhagen SV
Denmark
Telephone +45 33 85 11 00
Telefax +45 33 85 10 30
info-cph@everllence.com
www.everllence.com

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2 List of Abbreviations

ABS	American Bureau of Shipping
ACH	Anti Condensation Heater
AMS	Alarm and Monitoring System
ASME	American Society of Mechanical Engineers
BOG	Boil Off Gas
DNV	The Norwegian Veritas (Det Norske Veritas)
EI	Electrical Instrumentation
ESD	Emergency Shutdown
FGSS	Fuel gas supply system
GVT	Gas Valve Train
HP	High Pressure
HPSC	Hydraulic Pump Starter Cabinet
JB	Junction Box
JIS	Japanese International Standard
KS	Korean Standard
LEG	Liquefied Ethane Gas
LFF	Second Fuel
LFSS	Second Fuel Supply System
LNG	Liquefied Natural Gas
LP	Low Pressure
LR	Lloyd's Register
ME-ECS	ME-Engine Engine Control System
MEG	Mono Ethylene Glycol
MOP	Main Operating Panel
MPC	Multi Purpose Controller
N_2	Nitrogen
NG	Natural Gas
P & ID	Piping and Instrumentation Diagram
PVU	Pump Vaporiser Unit
SFECC	Second Fuel Control System Cabinet
SGC	Specific Gas Consumption
SMCR	Specified Maximum Continuous Rating
SHPS	Stand-alone Hydraulic Power Supply
SPAF	System Parameter Archive File

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3 Project Guide

3.1 Pump Vaporiser Unit

The Pump Vaporiser Unit (PVU) is a gas supply unit, which increases the gas pressure to the required supply pressure of the ME-GI / ME-GIE engine ranging from 250 bar to 380 bar and heats the second fuel (LFF) to vaporise to the gaseous form at 35 °C to 55 °C. The PVU is designed to supply LNG/ethane to the pressure and temperature required by the Everllence B&W two-stroke ME-GI/GIE engines.

If the PVU used for any other purpose than stated above it is considered as misuse.

The PVU includes pumps (hydraulic actuator and cold-end pump), hydraulic accumulators, vaporiser and a gas strainer. Besides the unit is equipped with control cabinet, main operating panel and a control system with safety functions. The PVU is designed with a high-pressure reciprocating pump, consisting of three cylinders actuated by linear hydraulic pistons. The gas is in liquid form from the gas storage tank, through the cold end of the pump until it reaches the vaporiser. The PVU evaporates the liquid gas in the vaporiser and thus heats up the gas from approximately -160°C to 50°C for methane and from -90°C to 50°C for ethane. The vaporiser is a printed circuit heat exchanger.

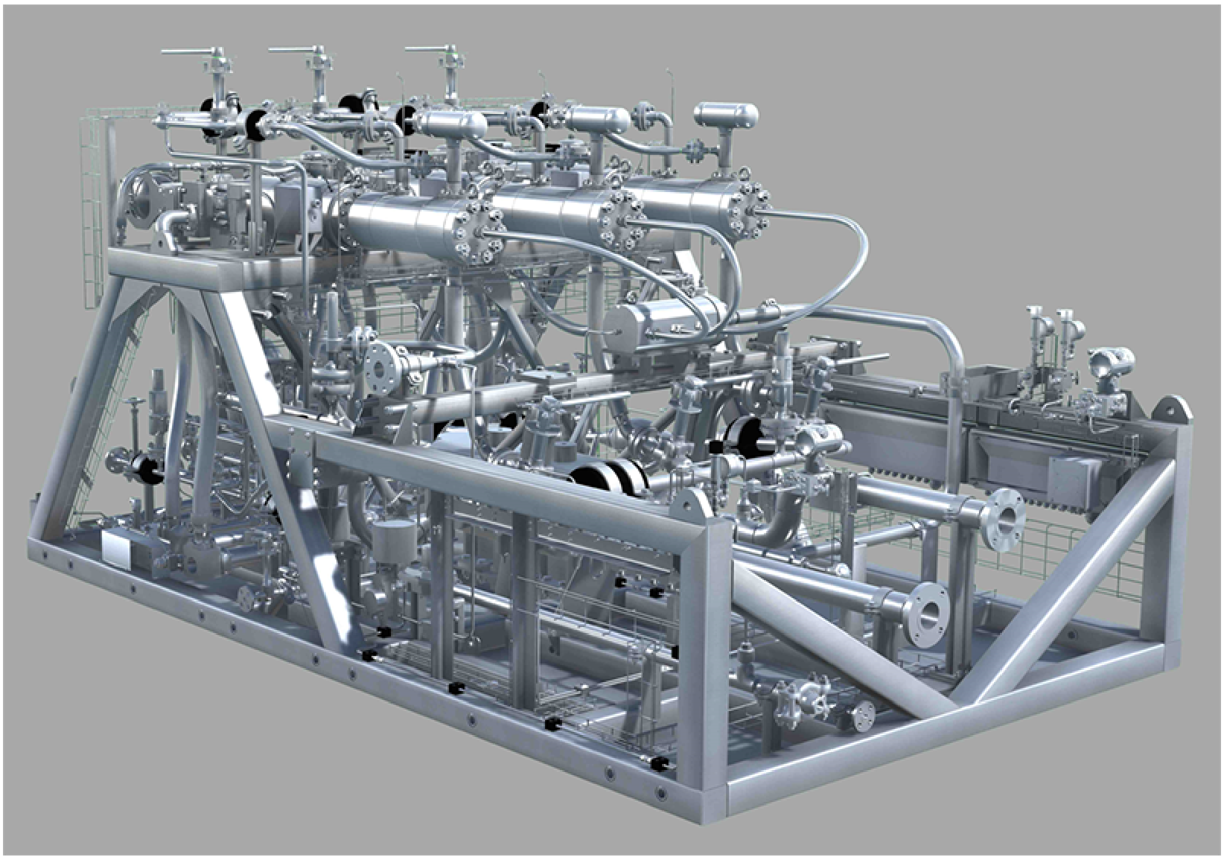

Figure 1: Pump Vaporiser Unit

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3.1.1 Ambient Conditions

Description	Details
Ambient air temperature	-20 to +50 °C
Relative humidity at summer	90%
Atmosphere	Marine

Table 1: Ambient conditions for PVU

3.1.2 Prerequisites

The shipyard or LFSS integrator must prepare and consider some prerequisites before the PVU is installed. Shipyard and LFSS integrator should have familiarized themselves with Everllence Specification of Second Fuel (FGSS).

- Filling up system with hydraulic oil and Nitrogen
- 10 µm cryogenic full flow filter downstream the LP supply pump, including display indication, alarm and nitrogen purge connection to vent. The filter capacity is suggested to be factor 2.5 – 2.7 of maximum gas flow to ensure sufficient time between cleaning depending on LNG cleanness
- Foundation including bolts and epoxy resin for PVU skid
- Foundation including bolts for SHPS
- Glycol plant including foundation and 250 µm GWS filter installed as close to PVU as possible
- Control cables to PVU junction boxes
- Control cables SHPS junction boxes
- Power cabling to control unit
- Cabling heat tracing for cold end
- Power cabling and starter cabinets to SHPS hydraulic pumps
- Hydraulic piping/hoses from SHPS to PVU
- Piping connection to PVU interfaces: Nitrogen, air supply, vent, supply, discharge
- Heat tracing for hydraulic piping from SHPS to PVU if needed
- Heat tracing for LFF piping to engine if needed
- LFSS manufacturer or yard must ensure that the total pressure loss has been calculated ensuring that correct supply pressure at the engine inlet is achieved
- Cable glands for junctions boxes are standard, in case integrator choose cables not fit for mounted cable glands these may need to be changed accordingly
- Single line diagram for PVU network installation incl. indication of cable routing lengths to be informed to Everllence

NOTICE Install PVU in a Fuel Preparation room EX zone1 which is mandatory in order to fulfill IGF/IGC code. .

3.1.3 Types

- PVU3000
- PVU4000E
- PVU5000
- PVU8000

PVU is applicable for two types of fuels, Methane and Ethane, PVU with ethane is denoted using E.

3.1.4 Heating and Insulation

Heating and insulation is to be applied to the upstream GVT fuel gas piping. This prevents expansion temperatures from reaching critical limits and furthermore help guarantee the required fuel gas temperature at main engine inlet.

Heating and insulation is to be designed to maintain fuel gas temperature requirements considering minimum ambient temperatures; defined on project basis, classification society requirements or Everllence recommended value of -25°C. The design must fulfil the worst condition of the following two scenarios at minimum ambient temperatures:

- Gas mode start: GVT slow-filling procedure; LFSS vaporiser heat is to be considered
- Gas mode stand-by: 30 minutes stand-by period; fuel to be ready for next start-up

3.1.5 Principle

The PVU receives subcooled second fuel (LFF) supplied by a cryogenic centrifugal pump and it is pressurised by a high pressure reciprocating pump, consisting of three cylinders actuated by linear hydraulic pistons. The pressurised second fuel flows through a compact printed circuit heat exchanger, where it is heated by a warm glycol water. Fine particles, present in the gas, are caught by a 10 ym low pressure filter installed in the shipyard's FGSS pipeline before the PVU. Additionally a safety filter with larger mesh size is installed in the inlet pipeline on the PVU itself, as an extra precaution from bigger particles from pipelines, fine filter damages etc and the gas is thereafter directed towards the PVU pumps, heat exchanger, gas valve train (GVT) and the engine. The gas pressure delivered to the engine is controlled by hydraulic flow control of the pump. The separate control of the three pump heads provides redundancy in case one unit is deactivated.

The standard operation of a PVU is three pump operation, as this gives the highest volumetric efficiency of the pump and the most steady operational performance. In addition to this there is an alternative option , that is two pump operation which is also possible in the redundancy mode in case maintenance is required to one of the cold ends until it can be changed with a new cold end or an overhauled one. In addition to this there is an alternative option, that is two pump operation which is also second fuel possible in the redundancy mode if required due to failure of one pump until the three pump operation again is re-established.

Everllence recommends standard three pump operation and using two pump operation as redundancy mode only.

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The PVU control system design is based on knowledge of the ME-GI engine design and control system. Further, the GVT downstream of the PVU control system, ensures integrated control with the ME-GI engine.

3.1.6 Pump Vaporiser Unit Description

3.1.6.1 Low Flashpoint Fuel Pumps (LFF)

The PVU is designed with three high-pressure reciprocating pumps, consisting of three cylinders actuated by linear hydraulic pistons. Second Fuel pump is divided into two sections hydraulic actuator and cryogenic pump. The hydraulic actuator and cryogenic pump are constructed as to form a single unit.

Hydraulic actuator (A) structured as an linear piston system. The unit has an interface (B) for the installation of the cryogenic pump (C), as well as control valve for hydraulic (D).

The cryogenic pump (C) works as an linear piston pump, that pumps liquefied gas by moving a piston back and forward in a pump house. The cryogenic pump (C) is driven back and forward by a hydraulic piston (A), which is activated by a hydraulic control valve (D).

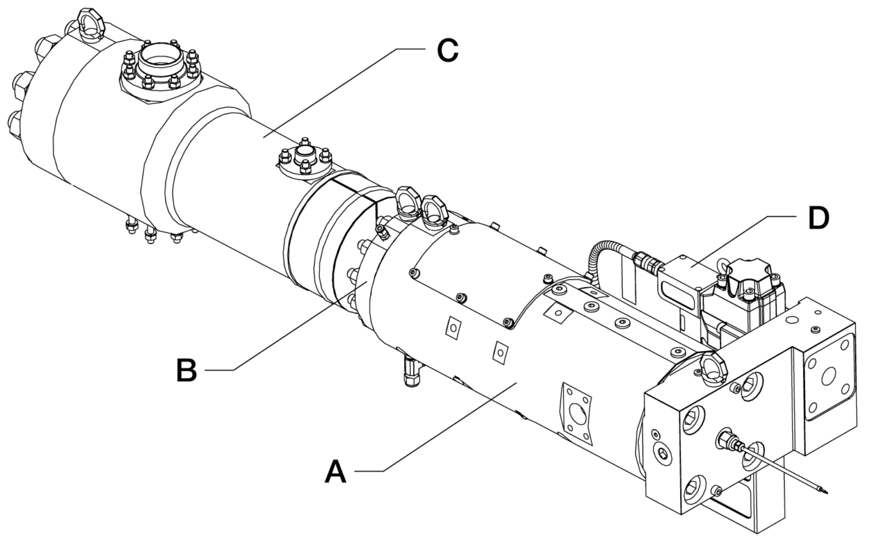

Figure 2: LFF Pump

Piston Pump Design for Cold End

Recirculation

The pumps are cooled down before start up and continuously cooled by flow going through the pump and into the recirculation lines.

NOTICE It is critical for the operation of the pump that it is sufficiently cooled to ensure liquid phase being present in all operation conditions.

In case of vapor forming inside the pump at critical points, cavitation may occur and reduce the lifetime of parts.

The pump is connected to the recirculation line at two points (B) + (C). The

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largest recirculation line (B) is situated on top of the inlet to prevent stagnant flow at the suction valve. The smallest recirculation line (C) is situated close to the packing gland.

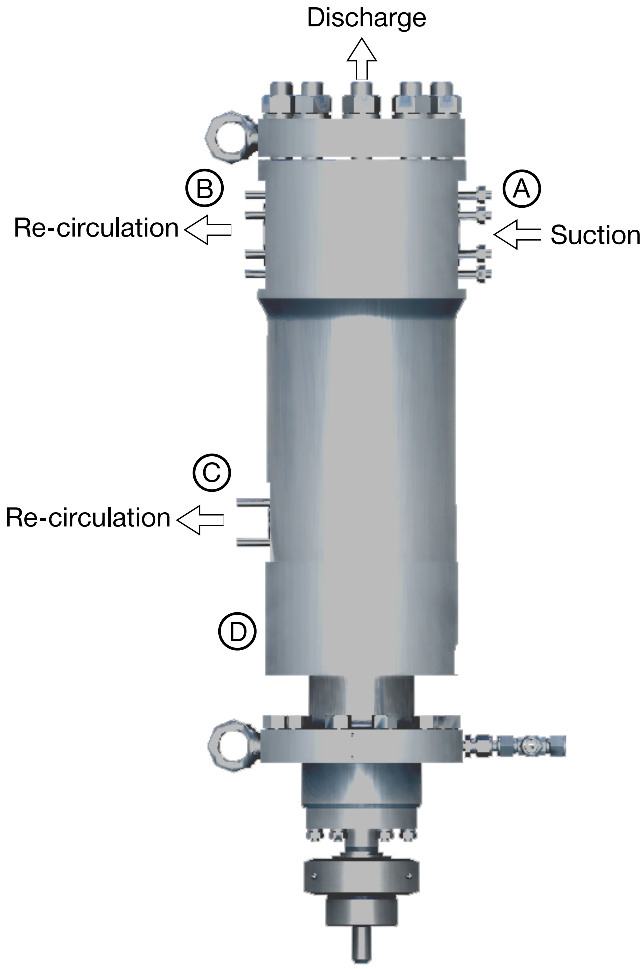

Figure 3: Piston pump design for cold end

Packing gland

The seals are continuously heated by a heat tracing element (D) mounted on top of the housing exterior. The heating ensures that the seals remain flexible during cold operation.

The packing gland consists of various elements that will minimize the leak of the pump media. The elements closest to the piston are surrounded by liquid phase media, but the elements in the middle of the packing gland are surrounded by gaseous phase of the media as a consequence of low flow, frictional heating and external heating.

A small amount of the media passes through the sealing elements and are purged away from the sealing elements by a continuous flow of nitrogen.

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3.1.6.2 Heat Exchanger

The PVU consists of a compact, plate-type heat exchanger. The fluid flow channels are chemically milled into the thickness of the plates, which are then stacked between end plates and diffusion bonded together to form solid metal blocks containing fluid flow passages.

The function of the heat exchanger is to convert second fuel from liquid state to gaseous state. Both the fluids i.e glycol water and second fuel are stable, non-reactive, and compatible with the materials of construction. Also there are no removable or adjustable components.

3.1.6.3 Accumulators

The PVU consists of two types of accumulators first being the bladder accumulator and other is the membrane accumulator, both having same function which enables a liquid under pressure to be accumulated, stored and recovered at any time.

Operation of the gas loaded bladder accumulator is based on the considerable difference in compressibility between a gas and a liquid, enabling a large quantity of energy to be stored in an extremely compact form. The bladder accumulators used for PVU consist of a fluid section and a gas section with the bladder acting as the gas-proof screen. The connection of the fluid around the bladder to the hydraulic circuit results on the bladder accumulator drawing in the fluid.

This happens when the pressure increases, leading to the compression of the gas. When the pressure drops, the compressed gas expands and forces the stored fluid into the circuit. The movement of the bladder stops when system and nitrogen gas pressures are balanced. When a downstream action such as actuator movement creates system demand, hydraulic system pressure falls and the accumulator releases the stored, pressurised fluid to the circuit. When movement stops, the charging cycle begins again.

In the membrane accumulator a membrane is used as partition between the fluid side and the gas side of the accumulator. It is made of two strong steel halves that are welded together. The U-formed membrane separates the nitrogen gas from the hydraulic fluid. When pre-filled, a robust steel knob seals off the hole at the fluid side and this prevents the membrane from being pushed out of the accumulator. The membrane accumulators are maintenance free (except from refilling with N_2 on regular basis) and cannot be repaired, since they have been specially designed for high production, low cost applications, for which it is more practical and convenient to replace rather than repair the equipment.

3.1.6.4 Standalone Hydraulic Power System (SHPS)

A hydraulic power system is a set of interconnected pipes carrying pressurised oil used to transmit mechanical power from a pump to hydraulic pistons. The hydraulic actuator consists of:

a. HP (High Pressure) hydraulic oil chamber, where pressure reaches 300 bar during the pumping stroke, and is then released to tank during return of the piston.

b. LP (Low Pressure) hydraulic oil chamber, where a constant 40-45 bar pressure contributes to return the piston.

The second fuel pumps pressurise and deliver gas by means of piston pumps. At all times one pump is pumping, other pump piston is reverting, i.e.

filling the pump, and the third pump is on stand-by. The piston pumps are driven by hydraulic pressure through SHPS.

The discharge pressure of the PVU pumps is determined by the hydraulic pressure and the area ratio between the hydraulic driven piston and the second fuel pumping piston.

While the pressure and flow is controlled by the hydraulic pressure and flow, the sequencing of the second fuel pumps is controlled by the hydraulic on/off valves at the hydraulic actuator cylinders. One cylinder is activated at a time, and when the pumping cylinder is near to end, it is deactivated and the next pump cylinder is activated.

3.1.6.5 Gas Valve Train (GVT)

The Gas Valve Train (GVT) is used as interface between PVU and engine. GVT has a high-pressure double block and bleed system designed for directing flow of second fuel for two stroke ME-GI / ME-GIE. The GVT is normally a engine builder delivery product.

The GVT is a single component designed for controlling and directing the flow of second fuel delivered from the FGSS to the engine or to the exhaust. The GVT has an integrated slow pressure build-up function which allows the system to be pressure controlled before operation. All the functions in GVT are controlled through ME-GI / ME-GIE control system and FGSS.

GVT is a part of the following functionalities:

1. Supply gas to the two stroke ME-GI / ME-GIE engine.
2. Slow pressure build up and supply for engine.
3. Stop the gas supply to engine and send gas from the pipe systems and GVT to the vent header in case of normal or emergency shutdown.
4. Purging of the pipe system between GVT and ME-GI / ME-GIE.
5. Purging of the pipe system between GVT and FGSS.

3.1.6.6 Glycol Water System (GWS)

The GWS is a part of Fuel Gas Supply System (FGSS). This system is composed of main components such as GW circulation pump, expansion tank, storage tank, steam supply control valve, drain pot & condensate control valve.

Whole glycol water is circulated by circulation pump with constant speed motor. The discharged GW is divided into each glycol water consumer with prefixed flow rate at the downstream of glycol water heater.

The cold glycol is collected in the expansion tank and sucked into the circulation pump. The pumped glycol is heated by GW steam heater through heat exchange with steam. Then the warm glycol water is supplied to the system.

Condensate water is controlled through level control valve. Drain pot with level sensor is installed at the condensate outlet of GW heater. As per the measured level, the level control valve is modulated.

Both engine cooling water and steam heating or a combination can be used. Can be delivered by Everllence or third party. Everllence makes the specification requirements for the GWS plant.

3.1.6.7 Control System (CS)

A PVU control system is a unit that controls a series of actuators on a PVU system to ensure optimal performance. The PVU - CS consists of a number of computer-based multi purpose controllers, operating panels and related equipment located in the fuel preparation room.

The MOP (Main Operating Panel) is the Human Machine Interface (HMI) through which the PVU control system is operated. The PVU is a separate, stand-alone unit independent and removed from the control system for the engine.

The PVU-CS is able to receive certain data from the ME-CS making it fast during load changes etc. The PVU is able to operate from 0% load to 100% load.

3.1.6.8 Circulation Valve V7050

The purpose of the present description is to clarify the functionality of the circulation line L20 and the Circulation valve V7050. The functionality is the same for both LNG and Ethane.

The circulation line is used to cool down the pump during startup and standby, and to ensure a minimum liquid circulation flow at any PVU load, in order to remove vapor bubbles and avoid cavitation.

The circulation line collects the cold return and the warm return streams from each of the three cold ends. The cold return is coming directly from the suction of the cold end; the warm return is a bypass stream that flows around the cylinder sleeve cooling it down, therefore it is expected to come out of the cold end at a slightly higher temperature. The cold and warm return are mixed, the total flow, controlled by valve V7050, is directed to the tank system. For LNG tanks it can be released to tank top or bottom depending on various consideration including LNG composition and N_2 fraction.

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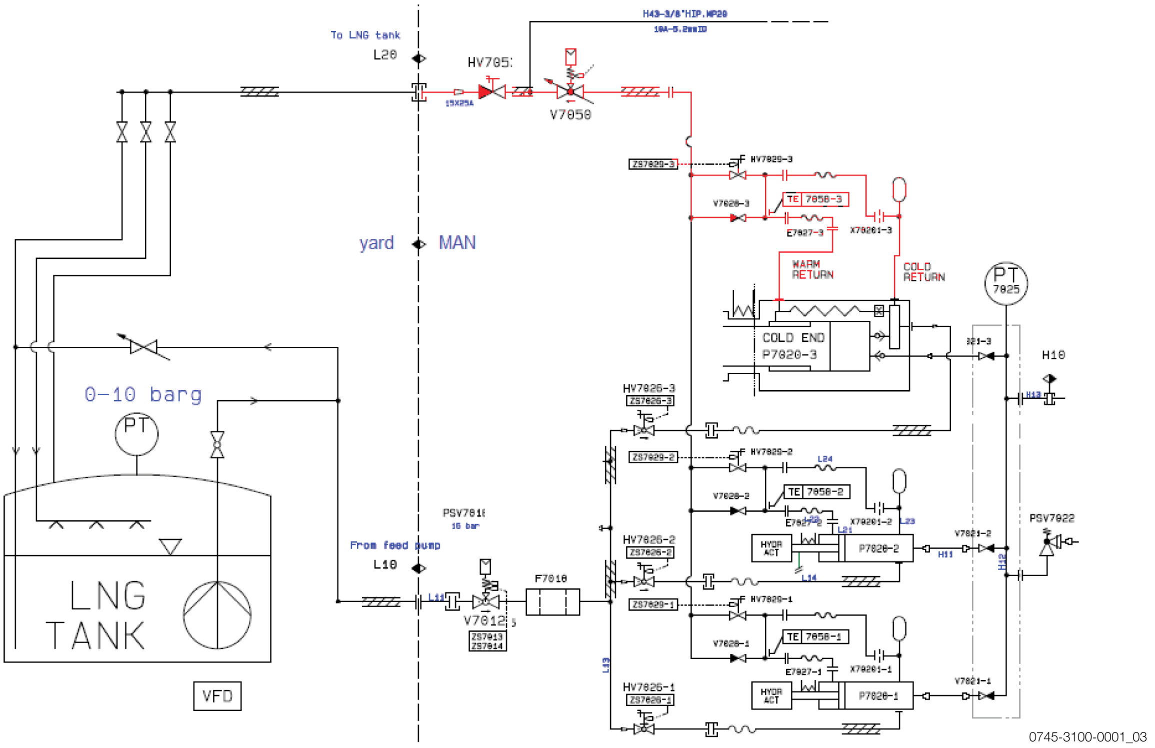

Figure 4: PVU interface connection

Fig. 4, Page 19 shows the pump suction line and circulation line on the PVU. Flange L20 constitutes the interface to the yard system. The characteristics of interface L20 are shown in Table below for LNG and Ethane systems.

Tag	Description	Fluid	T operating [C]	T min/ T max [C]	p operating [barg]	Flow capacity	Flow comment	Flex (*7)	Size	Other
L20	To LNG Tank - Circulation / Tank Return	LNG	-163	-196 / 60	~tank < 14.5	~460 kg/h	approx. LNG and / or HP tank return	*	25A-SCH.40 S	Line to tank to be sized for 800 kg/h @T_{amb}
L20	To Ethane Tank - Circulation / Tank Return	Liquid	-88	-196 / 60	~tank < 14.5	~460 kg/h	approx. LP and / or HP tank return	*	25A-SCH.40 S	Line to tank to be sized for 800 kg/h @T_{amb} *

Table 2: Interface lists for Methane and Ethane

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The flow in the circulation line is controlled by valve V7050, a pneumatic actuated globe type control valve.

The opening degree (i.e. the stem lift) of V7050 depends on operation mode and ME-GI engine load. During ME-GI (or ME-GIE) gas operation, as the Second Fuel load increases, the cold end needs less circulation flow to keep its temperature, therefore the circulation flow can be reduced, thereby minimizing BOG generation in the tank system.

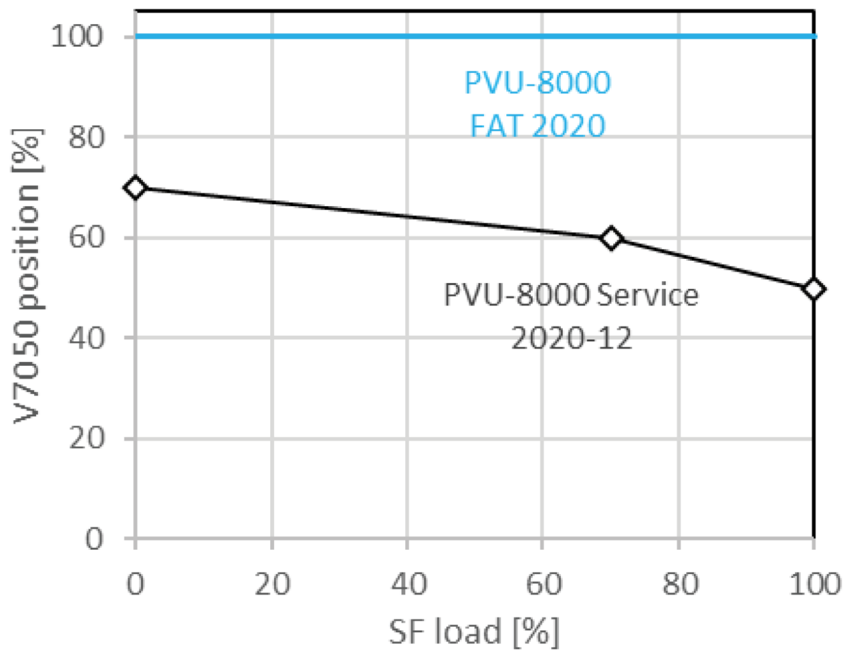

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Figure 5: V7050 Opening degree (lift) as a function of ME load

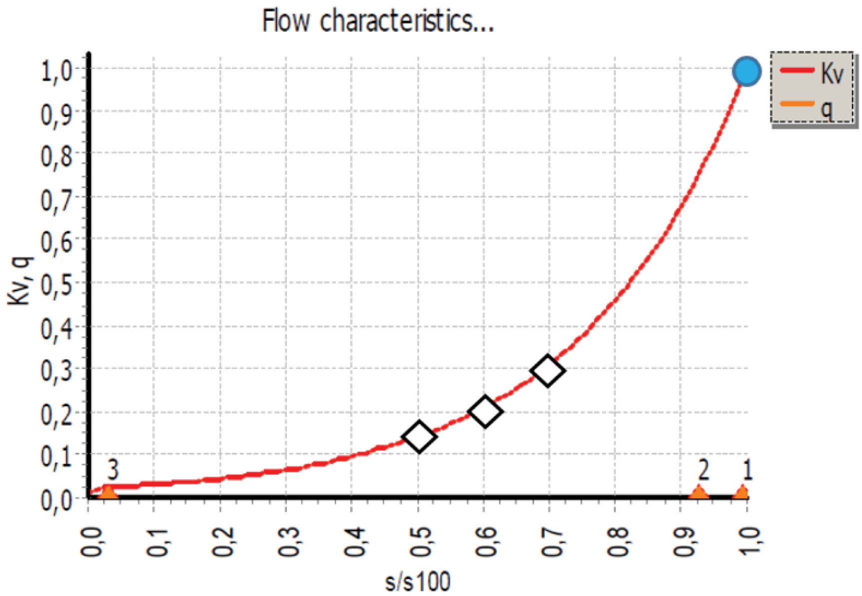

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Figure 6: Valve flow characteristic

The specific values for the V7050 opening degree, depend on the PVU size and operating parameters, and can be adjusted during commissioning and gas trial. Fig. 5, Page 20 constitutes an example of V7050 opening degree for PVU 8000: the figure shows that the valve opening in Stand-By (SF load=0) is 70% of the total lift, at 70% SF load it is 60%, and at SMCR it is 50%. The opening degree is linearly interpolated between these three points. Fig.6, Page 20 shows that the Kv value of the valve at 50% lift is approximately 0.15, indicating that the flow through the valve is estimated to be 15% of the flow in fully open condition.

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V7050 is operating with liquid close to the boiling point. Neglecting the pressure drop in the supply and circulation pipes, the V7050 inlet pressure equals the LP pump supply pressure (PVU suction pressure) and its discharge pressure is the same as the fuel tank pressure. Because of the energy input of the LP pump, and the heat leak across the insulation and within the HP pump, the V7050 inlet temperature will be higher than the tank liquid temperature, therefore flashing will occur either within the valve V7050, in the piping system downstream or in the tank.

Fig. 7, Page 21 shows the valve operation for LNG at different tank pressures, assuming a pump efficiency of 50% and an additional heat input of 3kW into the circulation stream. The lines are made of three segments, showing from left to right: LP pump compression, heat leak at constant pressure, isenthalpic expansion across the valve down to tank pressure.

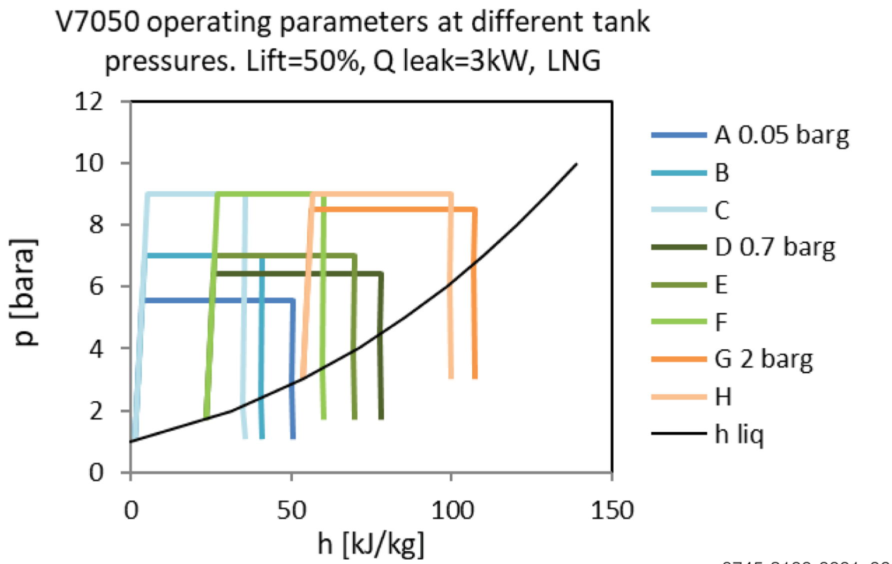

Figure 7: Pressure - enthalpy diagram

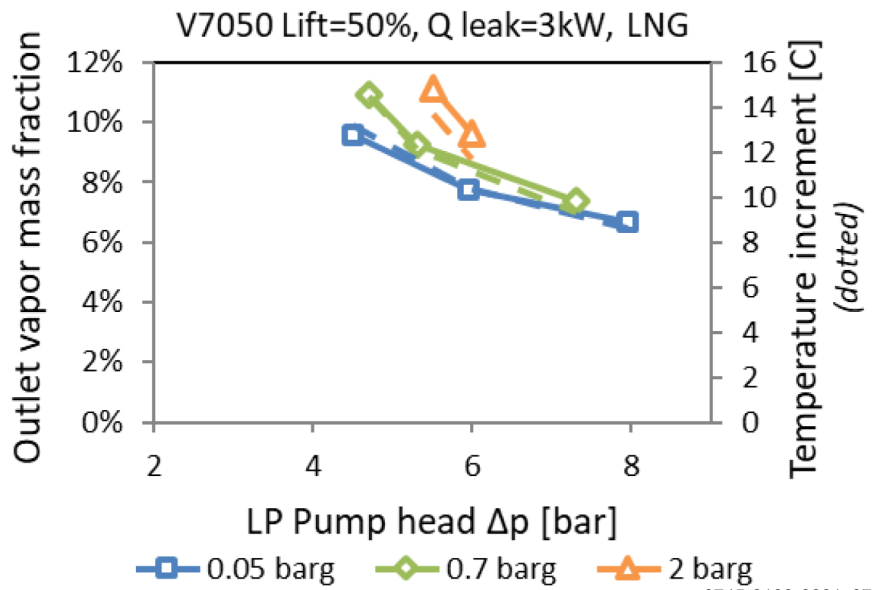

Figure 8: V7050 operating parameters as a function of LP pump head

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It can be seen from Fig. 8, Page 21 and Fig.9, Page 22 that increasing the LP pump head will decrease the temperature increment and the vapor mass fraction in the circulation stream. However higher pressure differential across the valve will increase overall flow, therefore the vapor mass flow will increase, as shown by Fig10, Page 22.

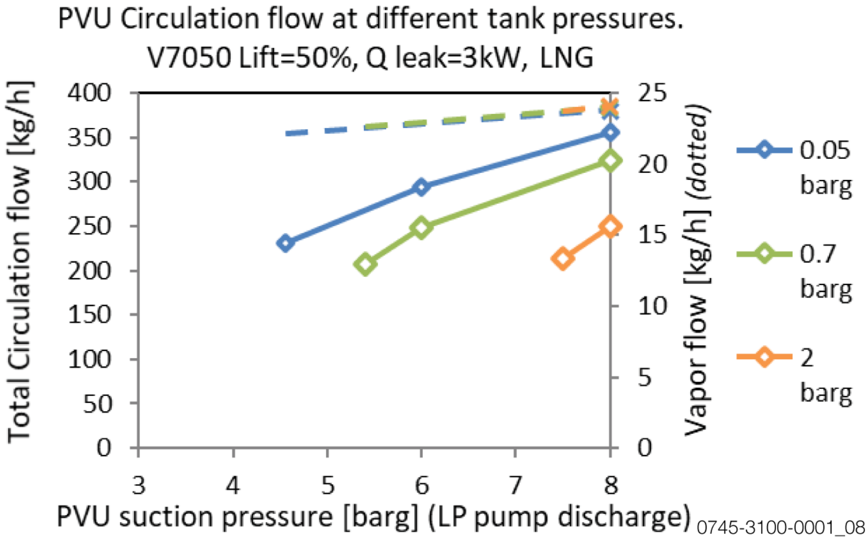

Figure 9: PVU Circulation flow at different tank pressures

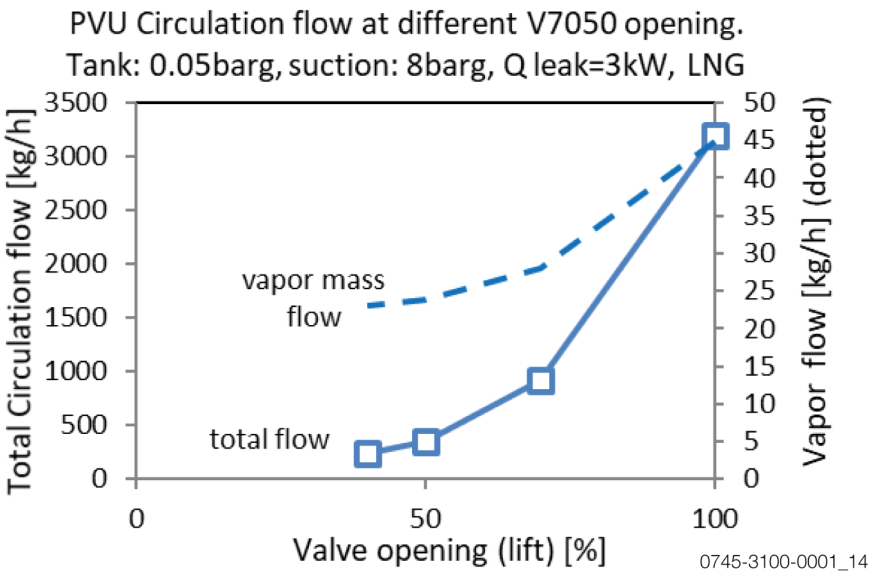

Figure 10: PVU Circulation flow at different V7050 opening

If the V7050 opening degree is increased, the total flows and vapor flows will be higher, as shown in Fig. 11, Page 23, the dependency is non linear, consistently with Fig 7, Page 21. It can be noted that increasing the valve opening will increase the BOG flow, this is because both the heat leak of 3kW and the LP pump energy contribute to the vapor generation, and the latter is proportional to the total circulation flow.

$$\dot{m}_{\mathrm{BOG}} = \dot{m}_{\mathrm{V7050}}\ x_{\mathrm{v}} = \dot{m}_{\mathrm{V7050}} \cdot \frac{h_{\mathrm{flash}} - h_{\mathrm{l,sat}}}{h_{\mathrm{v,sat}} - h_{\mathrm{l,sat}}} = \dot{m}_{\mathrm{V7050}} \cdot \frac{\Delta h_{\mathrm{LPP}} + \Delta h_{\mathrm{Heat\ leak}}}{h_{\mathrm{v,sat}} - h_{\mathrm{l,sat}}} = \frac{\dot{m}_{\mathrm{V7050}} \cdot \Delta h_{\mathrm{LPP}} + \dot{Q}_{\mathrm{leak}}}{h_{\mathrm{v,sat}} - h_{\mathrm{l,sat}}}$$

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The enthalpy increase across the LPP is calculated based on the isentropic Δh assuming a hydraulic efficiency = 50%.

$$\Delta h_{LPP}(\Delta p) = \frac{h(p_2, s_1) - h_{l,sat}(p_1)}{\eta_p}$$

In the below Figures the corresponding values for Ethane, assuming isentropic compression =100%

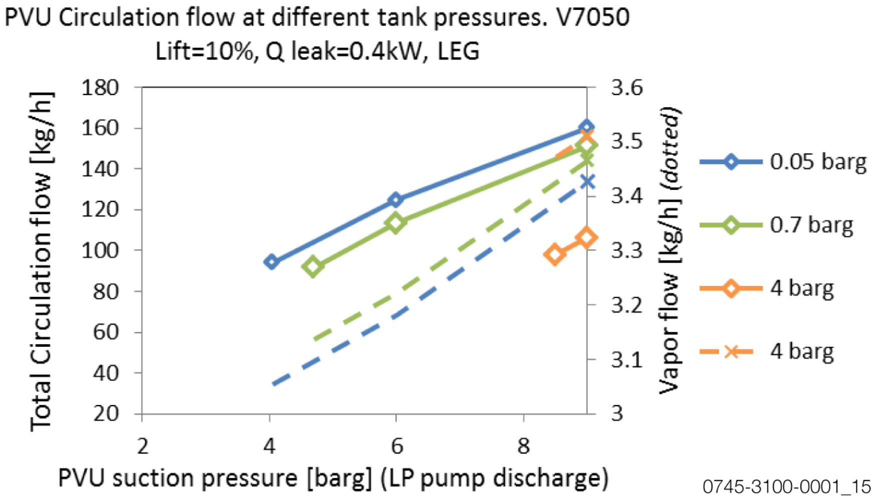

Figure 11: Values for Ethane, assuming isentropic compression =100%

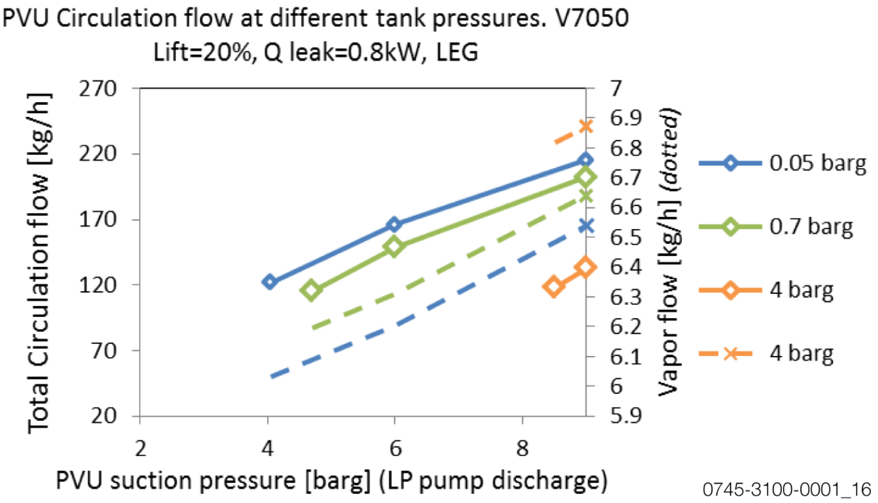

Figure 12: Values for Ethane, assuming isentropic compression =100%

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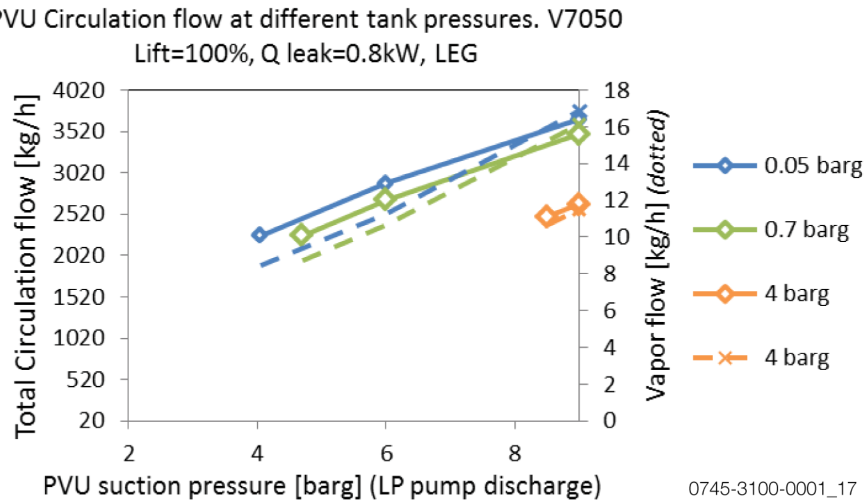

Figure 13: Values for Ethane, assuming isentropic compression =100%

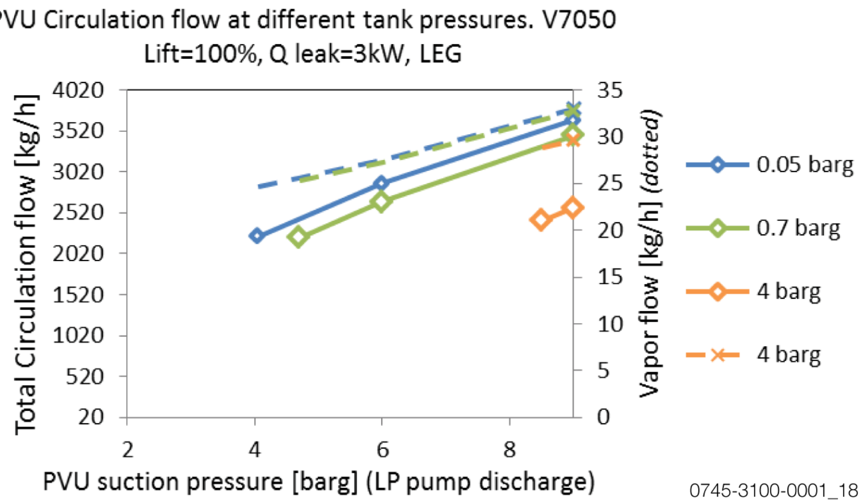

Figure 14: Values for Ethane, assuming isentropic compression =100%

3.1.6.9 Recondenser Connection for PVU3000

It is possible to combine the PVU with a recondenser solution. This will include two extra interfaces on the PVU, which will allow the high pressure cryogenic LNG to be routed from the PVU through a heat exchanger in order to recondense BOG. The interfaces are located between the high pressure pumps and the vaporiser. This option is available on request. Additional yard piping, components and heat exchanger connected with this solution is not part of Everllence scope.

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3.2 Hydraulic Power Supply

This section describes the layout, the components and operating principle of the hydraulic system used in PVU.

The hydraulic medium is used as the main source of system lubricating oil.

3.2.1 Hydraulic System Layout

The hydraulic system on the ME-GI PVU is an electronically controlled system used for actuation of high pressure reciprocating pumps second fuel supply. The engine control system controls and monitors the system.

The hydraulic supply and return line is connected to the lower chamber and allows hydraulic fluid to flow to and from the lower chamber of the actuator.

The hydraulic system is equipped with reciprocating pumps actuated by linear hydraulic pistons, electric motor, oil tank and oil filter.

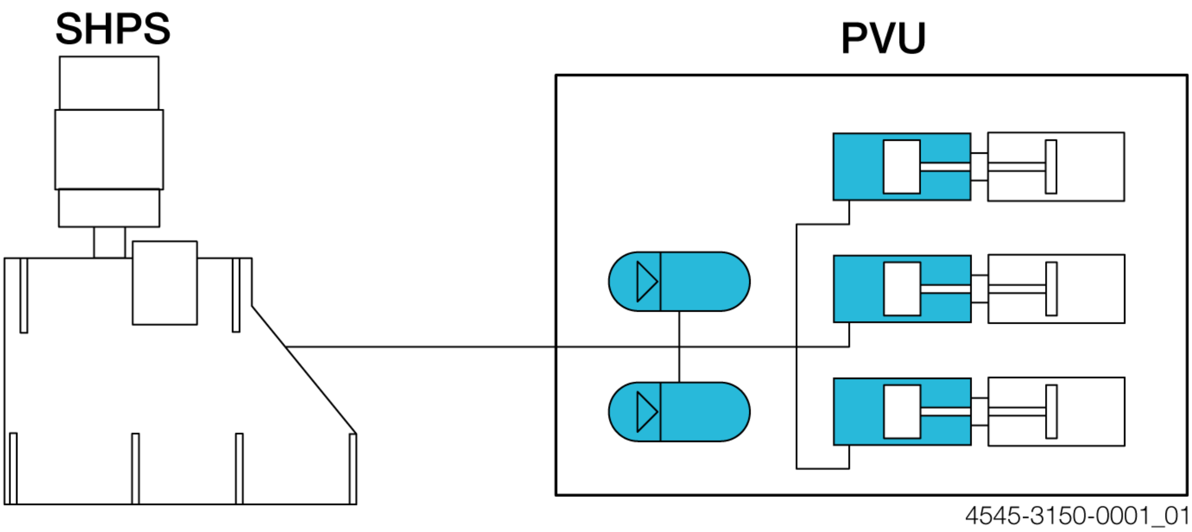

Figure 15: Hydraulic system connection with PVU

3.2.2 Components

The hydraulic power supply system is built on a steel construction with integrated oil tank and a tray to collect potential oil spill during service and maintenance. The unit contains the following:

- Oil tank with equipment such as temperature gauge, level gauge, level transmitters, air breather filter, cleaning covers and drain valves. The oil tank also contains a variety of different hydraulic connections both essential and auxiliary.
- Accumulators
- High pressure pump unit
- Motor
- Filters Oil
- Oil tank
- Electrical junction box

a. Accumulators: Accumulators are attached to the hydraulic actuators. They collect oil from the pumping mechanism and are intended to build and maintain fluid pressure to supplement the motor pumping system.

b. Motor pumps: A hydraulic power unit is equipped with hydraulic axial pumps.

c. Motor: The power source associated with most hydraulic power units is the motor, which is generally selected based on its speed, torque level, and power capacity. A typical three-phase electric motor begins its operating sequence by turning a rotor.

d. Filters: There are two filters on the HP side of SHPS and one filter on return Side.

e. Tank: The tank is a storage unit designed with enough volume for the fluid in the pipes to drain into it. Likewise, actuator fluid may sometimes need draining into the tank.

f. Electrical junction box: Enclosure housing having electrical connections interconnected to the components of PVU. It is a safety barrier for all electrical connections.

3.2.3 Functional Description

A hydraulic power system is a set of interconnected pipes carrying pressurised oil used to transmit mechanical power from a pump to hydraulic pistons. The hydraulic actuator consists of:

a. HP (High Pressure) hydraulic oil chamber, where pressure reaches 300 bar during the pumping stroke, and is then released to tank during return of the piston.

b. LP (Low Pressure) hydraulic oil chamber, where a constant 40-45 bar pressure contributes to return the piston.

The Hydraulic oil, pressurised by a hydraulic pump, forces the membrane/ bladder of the accumulator to compress the nitrogen gas in the air chamber. The compressed nitrogen gas can store the energy just like a spring. When the pump needs the extra flow, the compression energy will release to compensate for the system needs.

The second fuel pumps pressurise and deliver gas by means of piston pumps. At all times one pump is pumping, other pump piston is reverting, i.e. filling the pump, and the third pump is on stand-by. The piston pumps are driven by hydraulic pressure through SHPS.

The discharge pressure of the PVU pumps is determined by the hydraulic pressure and the area ratio between the hydraulic driven piston and the second fuel pumping piston.

While the pressure and flow is controlled by the hydraulic pressure and flow, the sequencing of the second fuel pumps is controlled by the hydraulic on/off valves at the hydraulic actuator cylinders. One cylinder is activated at a time,

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and when the pumping cylinder is near to end, it is deactivated and the next pump cylinder is activated.

3.2.4 Standalone Hydraulic Power System (SHPS)

The SHPS consists of 2 to 3 electrically driven pumps (depending on the size of the PVU) each of which is flow controlled. The color of SHPS is RAL 6019 (light green), same as the color of the main engine.

3.2.4.1 Types

The SHPS (for installation in safe room), is available in Mark 2 variant with the below types.

- SHPS200
- SHPS300
- SHPS500

3.2.4.2 Oil Specification

ISO VG 46 HVLP (Viscosity index 140 or higher) is chosen as standard oil type for PVU – A hydraulic oil with similar specification can be used.

SHPS types	SHPS200	SHPS300	SHPS500
Tank oil capacity	1293 L	1940 L	1840 L
Oil specification	ISO VG 46 HVLP		
Weight dry/without oil	2500 kg	3720 kg	4352 kg
Weight with oil	3600 kg	5370 kg	6041 kg
No. of motor-/pump units	2	3	3
Oil flow/pump	110 L/min	112 L/min	157 L/min
Total oil flow	220 L/min	336 L/min	470 L/min
Max system pressure	300 bar	290 bar	300 bar

Table 3: Oil specification

3.2.4.3 Cooling Water Parameters

Cooling water Temp.:	SHPS MKII					
	200		300		500	
	Flow rate [l/min]	Pressure drop, In-Out [bar]	Flow rate [l/min]	Pressure drop, In-Out [bar]	Flow rate [l/min]	Pressure drop, In-Out [bar]
32 °C	105	0.06	120	0.02	210	0.08
34 °C	130	0.09	128	0.02	260	0.12
36 °C	180	0.16	150	0.03	360	0.22
38 °C	235	0.27	180	0.04	470	0.36

40 °C	240	0.28	250	0.08	480	0.37

Table 4: Cooling Water Parameters SHPS MKII

3.3 Electrical Connections

The PVU is delivered with junction boxes fitted and the internal connections are already made. When installing the PVU on board, the external electrical connections to the control cabinet have to be made.

The electrical connections should be made by an IECEx experienced electrician, see IECEx Components, Page 115. In this document, there is an inspection scheme that should be followed to ensure the most convenient installation. The wiring is subjected to safety standards for design and installation. Allowable wire and cable types and sizes are specified according to the circuit operating voltage and electric current capability, with further restrictions on the environmental conditions, such as ambient temperature range, moisture levels, and exposure to sunlight and chemicals.

Make the electrical connections according to below figure. The installation should be carried out according to the standardisation and Everllence production specification. For updated document please contact Everllence.

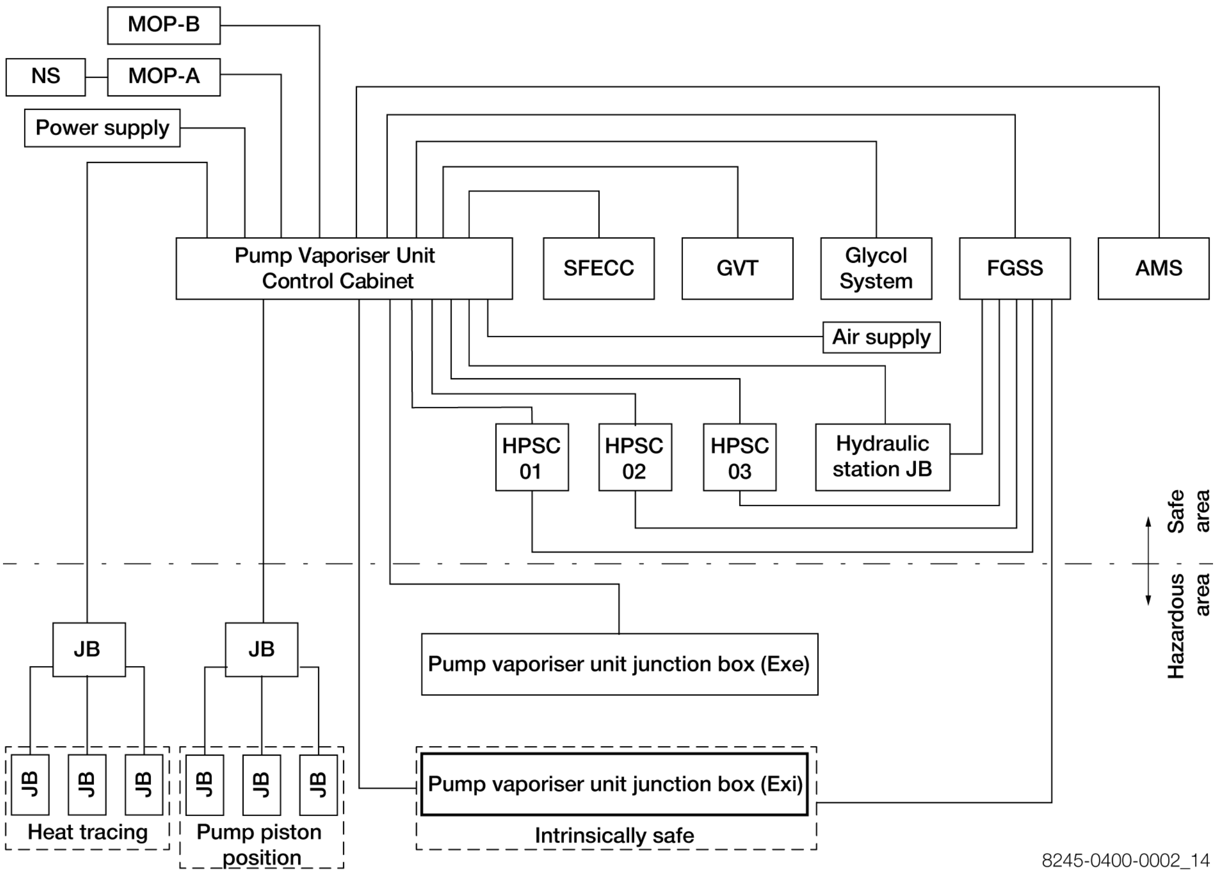

Figure 16: Electrical cabling connections

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3.4 List of Capacities

3.4.1 Capacities and Power Consumptions

3.4.1.1 Methane

PVU main data	Unit	3000	5000	8000
Nominal volume flow	L/min	100	178	256
Nominal mass flow (*1)	kg/h	2669	4806	6903
Max SMCR (*2)	MW	17.5	29.6	44.9
Glycol Water flow	kg/h	65376	115000	161460
Glycol Water nominal heating duty	kW	600	980	1700
Air consumption	L/min	390 l/min actual		
Nitrogen consumption	kg/h	2-2.5 kg/h		
PVU skid dimensions L x W x H	mm	3700 x 2240 x 2011		3900 x 2240 x 2011
PVU skid Weight	kg	4500	4900	5500

Table 5: Methane capacities and power consumption

(*1) Nominal mass flow calculated at reference LNG density: 450kg/m^3
(*2) Max SMCR based on LHV=48.7MJ/kg; SGC=140g/kWh

3.4.1.2 Ethane

PVU main data	Unit	4000E
Nominal volume flow	L/min	102
Nominal mass flow (*1)	kg/h	2989
Max SMCR (*2)	MW	19.0
Glycol Water flow	kg/h	63143
Glycol Water nominal heating duty	kW	370
Air consumption	L/min	390 l/min actual
Nitrogen consumption	kg/h	2-2.5 kg/h

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PVU skid dimensions L x W x H	mm	3700 x 2240 x 2011
PVU skid Weight	kg	4500

Table 6: Ethane capacities and power consumption

(*1) Nominal mass flow calculated at reference pressure: Ethane, 4 bara

(*2) Max SMCR based on LHV=47.5MJ/kg; SGC=152g/kWh

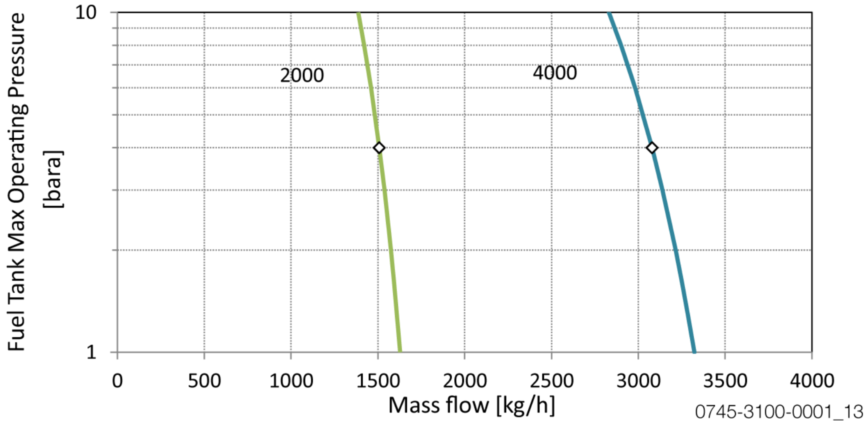

Figure 17: Ethane capacities and power consumption

3.4.2 Calculation of Capacities

3.4.2.1 PVU8000

Pump capacity	Unit	PVU8000	
		2 Pumps	3 Pumps
Piston Diameter (Cold end) diameter	mm	80	80
Actual stroke	mm	97	97
Displacement	dm^3	0.49	0.49
Volumetric efficiency	-	0.88	0.92
Pump frequency	Hz	9.2	9.5
Density of saturated Liquid	kg/m^3	450	450
PVU capacity - Vol. flow	l/min	237	256
PVU capacity - Mass flow	kg/h	6395	6903

Table 7: Calculation of capacities

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3.4.2.2 PVU5000

Pump capacity	Unit	PVU5000	
		2 Pumps	3 Pumps
Piston Diameter (Cold end) diameter	mm	80	80
Actual stroke	mm	97	97
Displacement	dm^3	0.49	0.49
Volumetric effi-ciency	-	0.92	0.92
Pump frequency	Hz	6.6	6.6
Density of saturated Liquid	kg/m^3	450	450
PVU capacity - Vol. flow	l/min	178	178
PVU capacity - Mass flow	kg/h	4806	4806

Table 8: Calculation of capacities

3.4.2.3 PVU3000

Pump capacity	Unit	PVU3000	
		2 Pumps	3 Pumps
Piston Diameter (Cold end) diameter	mm	50	50
Actual stroke	mm	96	96
Displacement	dm^3	0.19	0.19
Volumetric effi-ciency	-	0.88	0.92
Pump frequency	Hz	9.2	9.5
Density of saturated Liquid	kg/m^3	450	450
PVU capacity - Vol. flow	l/min	92	99
PVU capacity - Mass flow	kg/h	2472	2669

Table 9: Calculation of capacities

3.4.2.4 PVU4000E

Pump capacity	Unit	PVU4000E	
		2 Pumps	3 Pumps
Piston Diameter (Cold end) diameter	mm	50	50
Actual stroke	mm	96	96
Displacement	dm^3	0.19	0.19
Volumetric effi-ciency	-	0.88	0.92
Pump frequency	Hz	9.2	9.5
Density of saturated Liquid	kg/m^3	504	504
PVU capacity - Vol. flow	l/min	92	99
PVU capacity - Mass flow	kg/h	2769	2989

Table 10: Calculation of capacities

3.4.3 Pressures and Flow Velocities

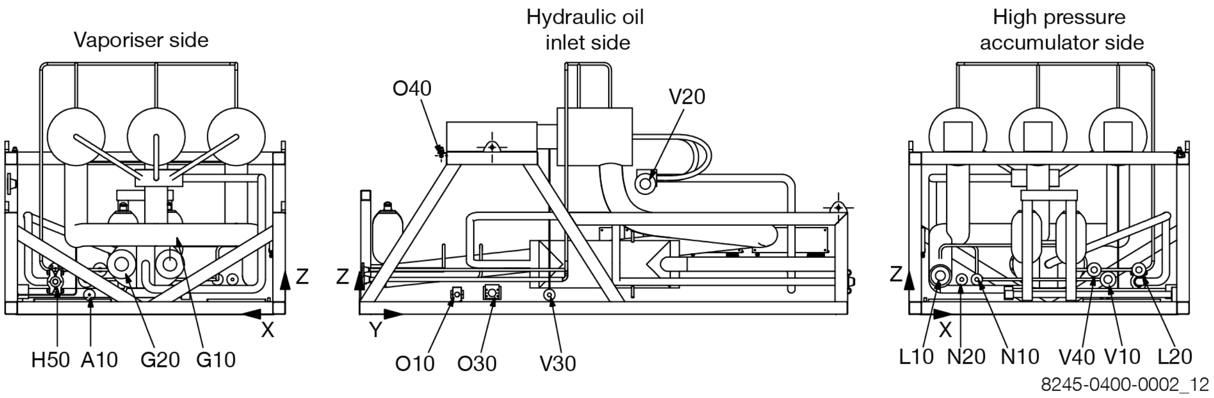

Figure 18: Flange dimensions and measurements

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3.4.3.1 Methane Interfaces

PVU8000

Interface	Description	Fluid	T operating C	T Design min/ max [C] (*10)	p Operating [barg]	p Design [barg]	p Test [barg]	Flow Capacity	Flow comment
A10	From Pneumatic Air System - Instrument Air	Air	Ambient	-25 /60	7-10	10	-	390 l/min	actual:@p supply (*9)
G10	From Glycol System - Glycol Inlet	MEG Water 50%	55	-25 /80	3-6	10	15	193752 kg/h	Max flow for pipe sizing (*13)
G20	To Glycol System - Glycol Return	MEG Water 50%	55	-25 /80	3-6	10	15	193752 kg/h	Max flow for pipe sizing (*6)
H50	To GVT - Gas Outlet	NG	55	-196 /80	250-326	350	525	7629 kg/h	Max flow for pipe sizing
L10	From Feed Pump - LNG Inlet	LNG	-163	-196 /60	6-8 <12	16	24	8685 kg/h, 429 l/min	Pressure > 6 bar above saturation (*2). Yard to size line. Filtration (*11)
L20	To LNG Tank - LNG Circulation / Tank Return	LNG	-163	-196 /60	~ tank <12	16	24	~460 kg/h	approx. LNG and/or HP tank return
N10	From Nitrogen Purge System - Maintenance	N_2	Ambient	-196 /60	4-9	16	24	-	~ N2 purge through H30
N20	From Nitrogen System - Pump Seal Gas	N_2	Ambient	-25*/60	4-9	10	24	~2-2.5 kg/h	seal gas consumption
O10	From Hyd Supply - HP Oil Inlet	Hyd oil	45	-25 /60	250-300	315	473	470 l/min	-
O30	To Hyd Supply Tank - Oil Return	Hyd oil	45	-25 /60	<10	30	-	470 l/min	-
O40	To Hyd Supply Tank - Oil Drain	Hyd oil	45	-25 /60	<10	30	-	<15 l/min	actuator pilot + leakage

Interface	Description	Fluid	T operating C	T Design min/ max [C] (*10)	p Operating [barg]	p Design [barg]	p Test [barg]	Flow Capacity	Flow comment
V10	To LP vent - LP PSV	LNG	Amb./ -163	-196 /60	<0.5*	16	24	see relief load list	PSV capacity (*3) (*4)
V20	To HP Vent	LNG	Amb./ -50	-196 /80	< 4 built-up	40	-	see relief load list	PSV capacity (*3) (*4)
V30	To LP Vent - Pump Seal Gas	N_2 / LNG	Ambient	-196 /60	<0.5*	<10	-	~2-2.5 kg/h	seal gas consumption
V40	To LP vent - LP bleed	LNG	Ambient	-196 /60	<0.5*	<10	-	-	bleed (*3)

* Preliminary value
*1 Operating temperatures: Liquid N2 FAT test: -196C; LNG operation: -163C; Minimum allowable ambient temperature in the pump room: -25C
*2 Working pressure on the suction line should be at least 6 bar above the saturation pressure at the pump inlet. Yard should take into account pressure drop and heat leak in the transfer piping. Long pipe dead ends and vapor pockets should be avoided as far as possible in the suction piping, in order to minimize the risk of vapor transport to the suction.
*3 One or more temperature sensors should be installed at a convenient location in the LP vent system (eg. common Knock-Out drum), in order to detect liquid in the vent system Liquid detection in the vent system is part of the yard scope of supply*10 Design temperature range for PVU process piping, materials and components. Yard connecting piping shall follow yard specifications.
*4 The vent line downstream the vent connections should be sized in diameter and length in order to keep the backpressure during vent discharge below the specified value If the vents are collected in a common volume or silencer the entire line should be calculated and sized in order to prevent backpressure at each of the vent connections of the PVU For sizing purpose, the maximum (peak) flow of the Safety Valves (PSV) connected to each vent is provided (calculated at operating temperature and set pressure)
*6 The line from the Glycol outlet connection (G20) to the Glycol tank (vented to atmosphere) should never be closed during operation and during emergency shutdown All valves in this line should be Normally Open (NO)
*7 Flexible element recommended, for isolation of vibration, static and dynamic forces from piping to PVU and vice versa. Eg.: Flexible metal hose, Flexible hydraulic hose, Bellow
*8 Standard material is stainless steel AISI 316/316L dual-certified
*9 Pneumatic air quality according to ISO 8573-1:2010 [7:2:3] Particles: Class 7, size ≤ 40 μm, concentration ≤ 10 mg/m3; Humidity: Class 2, dew point ≤ -40 °C or dew point < minimum ambient temperature; Oil: Class 3, Concentration of total oil (aerosol, liquid and vapour) ≤ 1 mg/m^3
*10 Design temperature range for PVU process piping, materials and components. Yard connecting piping shall follow yard specifications.
*11 Required 10μm filter on yard liquid supply line. Vapor pockets in the filter should be minimized. The unit should be installed as far as possible from the PVU inlet to limit risk of vapor carryover to the pump suction.
*13 Required 250μm filter on GW supply line to PVU. The filter can be placed in the proximity of interface G10 or in the GW system.

Table 11: Specification (PVU8000)

PVU5000

Interface	Description	Fluid	T operating C	T Design min/ max [C] (*10)	p Operating [barg]	p Design [barg]	p Test [barg]	Flow Capacity	Flow comment
A10	From Pneumatic Air System - Instrument Air	Air	Ambient	-25 /60	7-10	10	-	390 l/min	actual:@p supply (*9)
G10	From Glycol System - Glycol Inlet	MEG Water 50%	55	-25 /80	3-6	10	15	138000 kg/h	Max flow for pipe sizing (*13)
G20	To Glycol System - Glycol Return	MEG Water 50%	55	-25 /80	3-6	10	15	138000 kg/h	Max flow for pipe sizing (*6)
H50	To GVT - Gas Outlet	NG	55	-196/80	250-326	350	525	4667kg/h	Max flow for pipe sizing
L10	From Feed Pump - LNG Inlet	LNG	-163	-196/80	6-8 <12	16	24	5049 kg/h, 317 l/min	Pressure > 6 bar above saturation (*2). Yard to size line. Filtration (*11)
L20	To LNG Tank - LNG Circulation / Tank Return	LNG	-163	-196/80	~ tank <12	16	24	~460 kg/h	approx. LNG and/or HP tank return
N10	From Nitrogen Purge System - Maintenance	N_2	Ambient	-196/80	4-9	16	24	-	~ N^2 purge through H30
N20	From Nitrogen System - Pump Seal Gas	N_2	Ambient	-25*/60	4-9	10	24	~2-2.5 kg/h	seal gas consumption

Interface	Description	Fluid	T operating C	T Design min/ max [C] (*10)	p Operating [barg]	p Design [barg]	p Test [barg]	Flow Capacity	Flow comment
O10	From Hyd Supply - HP Oil Inlet	Hyd oil	45	-25 /60	250-300	315	473	315 l/min	-
O30	To Hyd Supply Tank - Oil Return	Hyd oil	45	-25 /60	<10	30	-	315 l/min	-
O40	To Hyd Supply Tank - Oil Drain	Hyd oil	45	-25 /60	<10	30	-	<15 l/min	actuator pilot + leakage
V10	To LP vent - LP PSV	LNG	Amb./ -163	-196 /60	<0.5*	16	24	see relief load list	PSV capacity (*3) (*4)
V20	To HP Vent	LNG	Amb./ -50	-196 /80	< 4 built-up	40	-	see relief load list	PSV capacity (*4)
V30	To LP Vent - Pump Seal Gas	N_2 / LNG	Ambient	-196 /60	<0.5*	<10	-	~2-2.5 kg/h	seal gas consumption
V40	To LP vent - LP bleed	LNG	Ambient	-196 /60	<0.5*	<10	-	-	bleed (*3)

* Preliminary value
*1 Operating temperatures: Liquid N2 FAT test: -196C; LNG operation: -163C; Minimum allowable ambient temperature in the pump room: -25C
*2 Working pressure on the suction line should be at least 6 bar above the saturation pressure at the pump inlet. Yard should take into account pressure drop and heat leak in the transfer piping. Long pipe dead ends and vapor pockets should be avoided as far as possible in the suction piping, in order to minimize the risk of vapor transport to the suction.
*3 One or more temperature sensors should be installed at a convenient location in the LP vent system (eg. common Knock-Out drum), in order to detect liquid in the vent system Liquid detection in the vent system is part of the yard scope of supply
*4 The vent line downstream the vent connections should be sized in diameter and lenght in order to keep the backpressure during vent discharge below the specified value If the vents are collected in a common volume or silencer the entire line should be calculated and sized in order to prevent backpressure at each of the vent connections of the PVU For sizing purpose, the maximum (peak) flow of the Safety Valves (PSV) connected to each vent is provided (calculated at operating temperature and set pressure)
*6 The line from the Glycol outlet connection (G20) to the Glycol tank (vented to atmosphere) should never be closed during operation and during emergency shutdown All valves in this line should be Normally Open (NO)
*7 Flexible element recommended, for isolation of vibration, static and dynamic forces from piping to PVU and viceversa. Eg.: Flexible metal hose, Flexible hydraulic hose, Bellow

*8 Standard material is stainless steel AISI 316/316L dual-certified *9 Pneumatic air quality according to ISO 8573-1:2010 [7:2:3] Particles: Class 7, size ≤ 40 μm, concentration ≤ 10 mg/m3; Humidity: Class 2, dew point ≤ -40 °C or dew point < minimum ambient temperature; Oil: Class 3, Concentration of total oil (aerosol, liquid and vapour) ≤ 1 mg/m^3 *10 Design temperature range for PVU process piping, materials and components. Yard connecting piping shall follow yard specifications. *11 Required 10μm filter on yard liquid supply line. Vapor pockets in the filter should be minimized. The unit should be installed as far as possible from the PVU inlet to limit risk of vapor carryover to the pump suction. *13 Required 250μm filter on GW supply line to PVU. The filter can be placed in the proximity of interface G10 or in the GW system

Table 12: Specification (PVU5000)

PVU3000

Interface	Description	Fluid	T operating C	T Design min/ max [C] (*10)	p Operating [barg]	p Design [barg]	p Test [barg]	Flow Capacity	Flow comment
A10	From Pneumatic Air System - Instrument Air	Air	Ambient	-25 /60	7-10	10	-	390 l/min	actual:@p supply (*9)
G10	From Glycol System - Glycol Inlet	MEG Water 50%	55	-25 /80	3-6	10	15	78451 kg/h	Max flow for pipe sizing (*13)
G20	To Glycol System - Glycol Return	MEG Water 50%	55	-25 /80	3-6	10	15	78451 kg/h	Max flow for pipe sizing (*6)
H50	To GVT - Gas Outlet	NG	55	-196/80	250-326	350	525	2823 kg/h	Max flow for pipe sizing
L10	From Feed Pump - LNG Inlet	LNG	-163	-196/80	6-8 <12	16	24	3130 kg/h, 228 l/min	Pressure > 6 bar above saturation (*2). Yard to size line. Filtration (*11)
L20	To LNG Tank - LNG Circulation / Tank Return	LNG	-163	-196/80	~ tank <12	16	24	~460 kg/h	approx. LNG and/or HP tank return
N10	From Nitrogen Purge System - Maintenance	N_2	Ambient	-196/80	4-9	16	24	-	~ N^2 purge through H30
N20	From Nitrogen System - Pump Seal Gas	N_2	Ambient	-25*/60	4-9	10	24	~2-2.5 kg/h	seal gas consumption

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Interface	Description	Fluid	T operating C	T Design min/ max [C] (*10)	p Operating [barg]	p Design [barg]	p Test [barg]	Flow Capacity	Flow comment
O10	From Hyd Supply - HP Oil Inlet	Hyd oil	45	-25 /60	250-300	315	473	201 l/min	-
O30	To Hyd Supply Tank - Oil Return	Hyd oil	45	-25 /60	<10	30	-	201 l/min	-
O40	To Hyd Supply Tank - Oil Drain	Hyd oil	45	-25 /60	<10	30	-	<15 l/min	actuator pilot + leakage
V10	To LP vent - LP PSV	LNG	Amb./ -163	-196 /60	<0.5*	16	24	see relief load list	PSV capacity (*3) (*4)
V20	To HP Vent	LNG	Amb./ -50	-196 /80	< 4 built-up	40	-	see relief load list	PSV capacity (*4)
V30	To LP Vent - Pump Seal Gas	N_2 / LNG	Ambient	-196 /60	<0.5*	<10	-	~2-2.5 kg/h	seal gas consumption
V40	To LP vent - LP bleed	LNG	Ambient	-196 /60	<0.5*	<10	-	-	bleed (*3)

* Preliminary value
*1 Operating temperatures: Liquid N_2 FAT test: -196C; LNG operation: -163C; Minimum allowable ambient temperature in the pump room: -25C
*2 Working pressure on the suction line should be at least 6 bar above the saturation pressure at the pump inlet. Yard should take into account pressure drop and heat leak in the transfer piping. Long pipe dead ends and vapor pockets should be avoided as far as possible in the suction piping, in order to minimize the risk of vapor transport to the suction.
*3 One or more temperature sensors should be installed at a convenient location in the LP vent system (eg. common Knock-Out drum), in order to detect liquid in the vent system Liquid detection in the vent system is part of the yard scope of supply
*4 The vent line downstream the vent connections should be sized in diameter and lenght in order to keep the backpressure during vent discharge below the specified value If the vents are collected in a common volume or silencer the entire line should be calculated and sized in order to prevent backpressure at each of the vent connections of the PVU For sizing purpose, the maximum (peak) flow of the Safety Valves (PSV) connected to each vent is provided (calculated at operating temperature and set pressure)
*6 The line from the Glycol outlet connection (G20) to the Glycol tank (vented to atmosphere) should never be closed during operation and during emergency shutdown All valves in this line should be Normally Open (NO)

*7 Flexible element recommended, for isolation of vibration, static and dynamic forces from piping to PVU and viceversa. Eg.: Flexible metal hose, Flexible hydraulic hose, Bellow *8 Standard material is stainless steel AISI 316/316L dual-certified *9 Pneumatic air quality according to ISO 8573-1:2010 [7:2:3] Particles: Class 7, size ≤ 40 µm, concentration ≤ 10 mg/m3; Humidity: Class 2, dew point ≤ -40 °C or dew point < minimum ambient temperature; Oil: Class 3, Concentration of total oil (aerosol, liquid and vapour) ≤ 1 mg/m^3 *10 Design temperature range for PVU process piping, materials and components. Yard connecting piping shall follow yard specifications. *11 Required 10µm filter on yard liquid supply line. Vapor pockets in the filter should be minimized. The unit should be installed as far as possible from the PVU inlet to limit risk of vapor carryover to the pump suction. *13 Required 250µm filter on GW supply line to PVU. The filter can be placed in the proximity of interface G10 or in the GW system

Table 13: Specification (PVU3000)

3.4.3.2 Ethane Interfaces

PVU4000E

Interface	Description	Fluid	T operating C	T Design min/ max [C] (*10)	p Operating [barg]	p Design [barg]	p Test [barg]	Flow Capacity	Flow comment
A10	From Pneumatic Air System - Instrument Air	Air	Ambient	-25 /60	7-10	10	-	390 l/min	actual:@p supply (*9)
G10	From Glycol System - Glycol Inlet	MEG Water 50%	55	-25 /80	3-6	10	15	76032 kg/h	Max flow for pipe sizing (*13)
G20	To Glycol System - Glycol Return	MEG Water 50%	55	-25 /80	<10	10	15	76032 kg/h	Max flow for pipe sizing (*6)
H50	To GVT - Gas Outlet	Ethane	55	-196/80	380-400	420*	630	3705 kg/h	Max flow for pipe sizing
L10	From Feed Pump - Liquid Ethane Inlet	Liquid Ethane	-137/-89 (*1)	-196/60	<14.5	16	24	127 l/min	Pressure > 5 bar above saturation (*2). Yard to size line. Filtration (*11)
L20	To Ethane Tank - Circulation / Tank Return	Liquid Ethane	-137/-89 (*1)	-196/60	~ tank <14.5	16	24	~460 kg/h	approx. LNG and/or HP tank return
N10	From Nitrogen Purge System - Maintenance	N_2	Ambient	-196/60	4-9	16	24	-	~ N^2 purge through H30
N20	From Nitrogen System - Pump Seal Gas	N_2	Ambient	-25*/60	4-9	10	24	~2-2.5 kg/h	seal gas consumption

Interface	Description	Fluid	T operating C	T Design min/ max [C] (*10)	p Operating [barg]	p Design [barg]	p Test [barg]	Flow Capacity	Flow comment
O10	From Hyd Supply - HP Oil Inlet	Hyd oil	45	-25 /60	250-300	315	473	258 l/min	-
O30	To Hyd Supply Tank - Oil Return	Hyd oil	45	-25 /60	<10	30	-	258 l/min	-
O40	To Hyd Supply Tank - Oil Drain	Hyd oil	45	-25 /60	<10	30	-	<15 l/min	actuator pilot + leakage
V10	To LP vent - LP PSV	Liquid Ethane	Amb./ -89	-196 /60	<0.5*	16	24	see relief load list	PSV capacity (*3) (*4)
V20	To HP Vent - HP PSV	Liquid Ethane	Amb./ -50*	-196 /80	< 4 built-up	40	-	see relief load list	PSV capacity + blowdown (*4)
V30	To LP Vent - Pump Seal Gas	N_2 / Ethane	Ambient	-196 /60	<0.5*	<10	-	~2-2.5 kg/h	seal gas consumption
V40	To LP vent - Liquid bleed	LNG	Ambient	-196 /60	<0.5*	<10	-	-	bleed (*3)

* Preliminary value
*1 Operating temperatures: Liquid N_2 FAT test: -196C; Ethane operation: -89C; Minimum allowable ambient temperature in the pump room: -25C
*2 Working pressure on the suction line should be at least 5 bar above the saturation pressure at the pump inlet. Yard should take into account pressure drop and heat leak in the transfer piping. Long pipe dead ends and vapor pockets should be avoided as far as possible in the suction piping, in order to minimize the risk of vapor transport to the suction.
*3 One or more temperature sensors should be installed at a convenient location in the LP vent system (eg. common Knock-Out drum), in order to detect liquid in the vent system Liquid detection in the vent system is part of the yard scope of supply
*4 The vent line downstream the vent connections should be sized in diameter and lenght in order to keep the backpressure during vent discharge below the specified value If the vents are collected in a common volume or silencer the entire line should be calculated and sized in order to prevent backpressure at each of the vent connections of the PVU For sizing purpose, the maximum (peak) flow of the Safety Valves (PSV) connected to each vent is provided (calculated at operating temperature and set pressure)
*6 The line from the Glycol outlet connection (G20) to the Glycol tank (vented to atmosphere) should never be closed during operation and during emergency shutdown All valves in this line should be Normally Open (NO)

*7 Flexible element recommended, for isolation of vibration, static and dynamic forces from piping to PVU and viceversa. Eg.: Flexible metal hose, Flexible hydraulic hose, Bellow *8 Standard material is stainless steel AISI 316/316L dual-certified *9 Pneumatic air quality according to ISO 8573-1:2010 [7:2:3] Particles: Class 7, size ≤ 40 µm, concentration ≤ 10 mg/m3; Humidity: Class 2, dew point ≤ -40 °C or dew point < minimum ambient temperature; Oil: Class 3, Concentration of total oil (aerosol, liquid and vapour) ≤ 1 mg/m^3 *10 Design temperature range for PVU process piping, materials and components. Yard connecting piping shall follow yard specifications. *11 Required 10µm filter on yard liquid supply line. Vapor pockets in the filter should be minimized. The unit should be installed as far as possible from the PVU inlet to limit risk of vapor carryover to the pump suction. *13 Required 250µm filter on GW supply line to PVU. The filter can be placed in the proximity of interface G10 or in the GW system

Table 14: Specification (PVU4000E)

3.4.3.3 Relief Load Specifications

PVU8000

Item	Type	Interface	Sizing Case	Orifice Size (mm)	S/P (barg)	Back Pressure (interface)	Discharge to	Fluid : LNG		Required Capacity (kg/hr)	Rated Capacity (kg/hr)	Notes
								Phase	Temp ° (C)			
PSV7016	Pressure safety valve	V10	Blocked outlet	17.5	16	< 1 barg	LP Vent	Liquid (Flash)	-163	-	16000 - 18000	*2
PSV7018	Pressure safety valve	V10	Thermal expansion	9	16	< 1 barg	LP Vent	Liquid (Flash)	-163	*3	3800	*2
PSV7054	Pressure safety valve	V10	V7060 relief, blocked outlet	13	16	< 1 barg	LP Vent	Liquid (Flash)	-163	600	1200 (vap) 9000 (liq)	*1,*2 Rated capacity for vapor (V7060 blocked outlet) and liquid (general scenario)
PSV7055	Pressure safety valve	V10	Thermal expansion	9	16	< 1 barg	LP Vent	Liquid (Flash)	-163	*3	3800	*2
PSV7022	Pressure safety valve	V20	Blocked outlet	8	345	4 barg	HP Vent	Vapor	55	6903	9400 - 12000	Acceptable 4barg caused by PSV7022 discharge.

V7033	Blowdown valve	H30	Automatic blowdown	5.16 Cv = 0.45		4 barg	HP Vent	Vapor	55	-	1900 - 3200	

Notes:
General : Total backpressure may not exceed 10% of the set pressure of PSV.
*1 Flow rates calculated with 1 bar at the PVU interface, this will reduce with the increasing backpressure in the vent system, which depends on the piping configuration & super imposed backpressure.
*2 Liquid fluid flashing in the two phase region, mass flow might be lower than the rated capacity.
*3 Valve sized as thermal relief valve.

Table 15: PVU8000 relief load

PVU5000

Item	Type	Interface	Sizing Case	Orifice Size (mm)	S/P (barg)	Back Pressure (interface)	Discharge to	Fluid : LNG		Required Capacity (kg/hr)	Rated Capacity (kg/hr)
								Phase	Temp °(C)		
PSV7016	Pressure safety valve	V10	Blocked outlet	17.5	16	< 1 barg	LP Vent	Liquid (Flash)	-163	-	16000 - 18000
PSV7018	Pressure safety valve	V10	Thermal expansion	9	16	< 1 barg	LP Vent	Liquid (Flash)	-163	*3	3800
PSV7054	Pressure safety valve	V10	V7060 relief, blocked outlet	13	16	< 1 barg	LP Vent	Liquid (Flash)	-163	600	1200 (vap) 9000 (liq)
PSV7055	Pressure safety valve	V10	Thermal expansion	9	16	< 1 barg	LP Vent	Liquid (Flash)	-163	*3	3800
PSV7022	Pressure safety valve	V20	Blocked outlet	8	345	4 barg	HP Vent	Vapor	55	6903	9400-12000
V7033	Blowdown valve	H30	Automatic blowdown	5.16 Cv = 0.45		4 barg	HP Vent	Vapor	55	-	1900 - 3200

Notes:
General : Total backpressure may not exceed 10% of the set pressure of PSV.
*1 Flow rates calculated with 1 bar at the PVU interface, this will reduce with the increasing backpressure in the vent system, which depends on the piping configuration & super imposed backpressure.
*2 Liquid fluid flashing in the two phase region, mass flow might be lower than the rated capacity.
*3 Valve sized as thermal relief valve.

Table 16: PVU5000 relief load

PVU3000

Item	Type	Interface	Sizing Case	Orifice Size (mm)	S/P (barg)	Back Pressure (interface)	Discharge to	Fluid : LNG		Required Capacity (kg/hr)	Rated Capacity (kg/hr)
								Phase	Temp °(C)		
PSV7016	Pressure safety valve	V10	Blocked outlet	17.5	16	< 1 barg	LP Vent	Liquid (Flash)	-163	-	16000 - 18000
PSV7018	Pressure safety valve	V10	Thermal expansion	9	16	< 1 barg	LP Vent	Liquid (Flash)	-163	*3	3800
PSV7054	Pressure safety valve	V10	V7060 relief, blocked outlet	13	16	< 1 barg	LP Vent	Liquid (Flash)	-163	600	1200 (vap) 9000 (liq)
PSV7055	Pressure safety valve	V10	Thermal expansion	9	16	< 1 barg	LP Vent	Liquid (Flash)	-163	*3	3800
PSV7022	Pressure safety valve	V20	Blocked outlet	6	345	4 barg	HP Vent	Vapor	55	2776	5458
V7033	Blowdown valve	V10	Automatic blowdown	5.16 Cv = 0.45		4 barg	HP Vent	Vapor	55	-	1900 - 3200

Notes:
General : Total backpressure may not exceed 10% of the set pressure of PSV.
*1 Flow rates calculated with 1 bar at the PVU interface, this will reduce with the increasing backpressure in the vent system, which depends on the piping configuration & super imposed backpressure.
*2 Liquid fluid flashing in the two phase region, mass flow might be lower than the rated capacity.
*3 Valve sized as thermal relief valve.

Table 17: PVU3000 relief load

PVU4000E

Item	Type	Interface	Sizing Case	Orifice Size (mm)	S/P (barg)	Back Pressure (interface)	Discharge to	Fluid : LNG		Required Capacity (kg/hr)	Rated Capacity (kg/hr)
								Phase	Temp °(C)		
PSV7016	Pressure safety valve	V10	Blocked outlet	17.5	16	< 1 barg	LP Vent	Liquid (Flash)	-163	-	16000 - 18000
PSV7018	Pressure safety valve	V10	Thermal expansion	9	16	< 1 barg	LP Vent	Liquid (Flash)	-163	*3	3800
PSV7054	Pressure safety valve	V10	V7060 relief, blocked outlet	13	16	< 1 barg	LP Vent	Liquid (Flash)	-163	600	1200 (vap) 9000 (liq)
PSV7055	Pressure safety valve	V10	Thermal expansion	9	16	< 1 barg	LP Vent	Liquid (Flash)	-163	*3	3800
PSV7022	Pressure safety valve	V20	Blocked outlet	6	420	4 barg	HP Vent	Vapor	55	5000	5458
V7033	Blowdown valve	V20	Automatic blowdown	5.16 Cv = 0.45		4 barg	HP Vent	Vapor	55	-	1900 - 3200

Notes:
General : Total backpressure may not exceed 10% of the set pressure of PSV.
*1 Flow rates calculated with 1 bar at the PVU interface, this will reduce with the increasing backpressure in the vent system, which depends on the piping configuration & super imposed backpressure.
*2 Liquid fluid flashing in the two phase region, mass flow might be lower than the rated capacity.
*3 Valve sized as thermal relief valve.

Table 18: PVU4000E relief load

3.4.4 Auxiliary System Capacities

3.4.4.1 Standalone Hydraulic Power Supply System

SHPS Data	Designation	SHPS200	SHPS300	SHPS500
SHPS Hyd pressure (nominal)	bar	300	300	300
SHPS Hyd flow (with margin)	L/min	260	443	470
SHPS Pump capacity installed	L/min	220	336	470
SHPS Power installed	kW	128	192	297
Number of Hyd. Pumps	-	2	3	3
SHPS skid dimen-sions	mm	1850 x 2157 x 2324	1850 x 2907 x 2324	1850 x 2907 x 2324
SHPS skid Weight (with oil)	kg	3600	5370	6041

Table 19: Capacities for Standalone Hydraulic Power Supply System

3.4.4.2 Glycol Water System

Description	**Marine Glycol Water System**
Fluid	MEG Glycol / Water mixture 50% weight
Outlet Temperature (˚C)	55 ± 2 C SP. (Set Point). Avoid Temperature fluctuations
Inlet Temperature(˚C)	Approx 45-55 ˚C return from PVU, depending on load
Pressure drop in PVU [bar]	Maximum 3 bar
Flow	Avoid flow fluctuation, choose constant flow, or slow control based on engine load.
Heating medium	1. Saturated steam 2. Engine Jacket water 3. Other
Piping standard	1. ASME 2. JIS 3. KS
Material	Not specified, according to yard specifications and corrosion class
Power supply	440 V / 60 Hz / 3 Ph
Special requirements	Marine class For Example : 1. ABS 2. DNV 3. LR

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Description	Marine Glycol Water System
Ambient conditions	Ambient Temperature between -25/+45 , moist air with salt content, corrosion potential
IECEx certificate	Glycol water system to be installed in safe area Only for inside glycol water expansion tank and vent outlet consider Ex Zone 1 Methane and T_{amb} -25/+50 ˚C (T1),

Table 20: Capacities for Glycol water system

PVU Load*1	PVU3000	PVU4000E	PVU5000	PVU8000
%	GW Kg/hr			
100	65376	63143	115000	161460
75	53672	53672	97750	128520
50	47357	47257	86250	113400
25	41043	41043	74750	98280
*1) The required GW flow can be calculated by interpolating the above values, using the SMCR mass flow for the PVU model in question, refer table 22-25				

Table 21: Glycol Water flow rate

3.4.5 Capacity at Specific Loads

3.4.5.1 PVU8000

PVU capacity at specific loads							Estimated SHPS500
	2 Pumps Operation			3 Pumps Operation			
PVU Load	Pump Freq	Vol.flow	Mass flow	Pump Freq	Vol.flow	Mass flow	Elec. Power*2
%	[Hz]	[l/min]	[kg/h]	[Hz]	[l/min]	[kg/h]	[kW]
25	2.4	64	1726	2.4	64	1726	66
50	4.8	128	3452	4.8	128	3452	127
75	7.1	192	5178	7.1	192	5178	174
97	9.2	237	6395	9.2	248	6685	232
100				9.5	256	6903	239
*2) The power is estimated with a tolerance 11%, taking into account the minimum size of SHPS for the specific PVU size. The electrical connections must be installed according to the motor maker specifications.							

Table 22: PVU8000 Capacity at Specific Loads

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3.4.5.2 PVU5000

PVU Capacity at Specific Loads				Estimated SHPS300
	2 or 3 Pumps Operation			
PVU Load	Pump Freq	Vol Flow	Mass Flow	El. Power*2
%	[Hz]	[l / min]	[kg / h]	[kW]
25	1.65	45	1202	48
50	3.31	89	2403	84
75	4.96	134	3605	115
100	6.61	178	4806	154
*2) The power is estimated with a tolerance 11%, taking into account the minimum size of SHPS for the specific PVU size. The electrical connections must be installed according to the motor maker specifications.				

Table 23: PVU5000 Capacity at Specific Loads

3.4.5.3 PVU3000

PVU capacity at specific loads							Estimated SHPS200
	2 Pumps Operation			3 Pumps Operation			
PVU Load	Pump Freq	Vol.flow	Mass flow	Pump Freq	Vol.flow	Mass flow	Elec. Power*2
%	[Hz]	[l/min]	[kg/h]	[Hz]	[l/min]	[kg/h]	[KW]
25	2.4	25	667	2.4	25	667	31
50	4.8	49	1334	4.8	49	1334	49
75	7.1	74	2002	7.1	74	2002	73
97	9.2	92	2472	9.2	96	2589	89
100				9.5	99	2669	92
*2) The power is estimated with a tolerance of 11%, taking into account the minimum size of SHPS for the specific PVU size. The electrical connections must be installed according to the motor maker specifications.							

Table 24: PVU3000 Capacity at Specific Loads

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3.4.5.4 PVU4000E

PVU capacity at specific loads							Estimated SHPS200
	2 Pumps Operation			3 Pumps Operation			
PVU Load	Pump Freq	Vol.flow	Mass flow	Pump Freq	Vol.flow	Mass flow	Elec. Power*2
%	[Hz]	[l/min]	[kg/h]	[Hz]	[l/min]	[kg/h]	[KW]
25	2.4	25	747	2.4	25	747	35
50	4.8	49	1495	4.8	49	1495	55
75	7.1	74	2242	7.1	74	2242	82
97	9.2	92	2769	9.2	96	2898	101
100				9.5	99	2989	105

*2) The power is estimated with a tolerance 11%, taking into account the minimum size of SHPS for the specific PVU size. The electrical connections must be installed according to the motor maker specifications.

Table 25: Capacity loads for PVU4000E

3.4.6 PVU control system electrical consumers

Consumer	Power (W) @24VDC	Power (W) @230VAC	AMP @230VDC	The experience figures (W)	Heat dissipation PVU cabinet
PVUCU-1	230		1.5	50	12
PVUCU-2	230		1.5	50	12
PVUCU-3	230		1.5	50	12
PVUCU-4	0			0	0
Heat Tracing Pump 1		1200	10	500	0
Heat Tracing Pump 2		1200	10	500	0
Heat Tracing Pump 3		1200	10	500	0
EC-MOP-A	25		0.1	25	0
EC-MOP-B	25		0.1	25	0
Power Supply					40
DC/DC					24
			19002	A	
			4370.5	W	
			4.4	kW->kVA	

Table 26: PVU control system electrical consumers

NOTICE These are only guiding values in a high load condition for more details contact Everllence.

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3.5 Fuel Supply System

The ME-GI engine requires fuel gas at a load-dependent pressure and a temperature. This requirement is met by PVU .

The PVU is the unit of the fuel gas supply system consisting of:

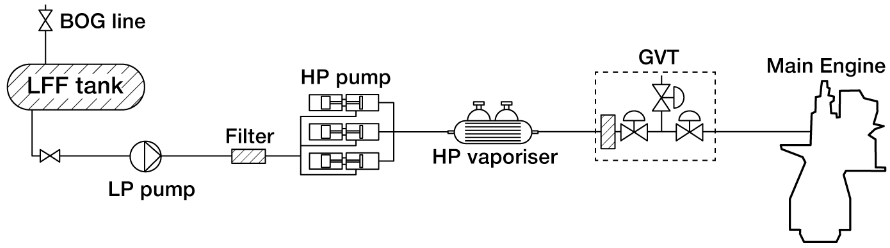
- Stand-alone hydraulic power supply system carrying pressurised oil used to transmit mechanical power from a pump to hydraulic pistons
- Gas valve train (GVT) for control of the fuel gas flow to the engine
- Glycol water system

Normally, the individual shipyard/contractor carries out the detailed design of the gas supply system (LFSS and auxiliary systems). Therefore, the gas supply system is not subject to the type approval of the PVU.

Apart from these systems, the PVU auxiliaries will comprise some new units, the most important ones being:

- As the supply of gas is liquid natural gas (LNG) it requires a Cryogenic HP Pump and vaporiser solution
- The ME-GI / GIE Engine Control System (ME-ECS)
- Leakage detection system to incorporate leakage detection.
- Inert gas system, which enables purging of the fuel gas supply system
- Heat traced and insulated gas supply pipes

Fuel gas is also referred to as second fuel (LFF).



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3.5.1 Guiding Fuel Gas Specification

3.5.1.1 Methane

Liquefied Natural Gas (LNG, Methane) is natural gas fuel that has been changed into a liquid state by cooling it to -162°C though a refrigeration process at a liquefaction plant. LNG is naturally clear, non-toxic and odorless. More importantly impurities such as water (H_2O), ammonia (NH_3) and carbon dioxide (CO_2) are removed to the extent possible. Higher hydrocarbons are also removed.

As there can be significant variation in gas and liquid fuels, it is important to understand the overall fuel composition and properties, to properly assess impacts to performance and operability. This assessment should include fuel properties, as well as determining if the fuel contains any contaminants.

Parameters	LNG
Boiling Point °C	-162°C

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Specific Gravity kg/m^3	0.555
Density kg/m^3	194 kg/m^3 (300 bar)
Lower Calorific Value (LCV) MJ/kg	50.00

Table 27: Properties of Methane

3.5.1.2 Ethane

Ethane for ME-GIE engines is a hydrocarbon gas mixture consisting of primarily ethane with minor amounts of other hydrocarbons. The values mentioned below guiding fuel gas specification refer to the hydrocarbon mixture as delivered to the ship. Liquid or solid contaminants such as metal shavings, welding debris, insulation (i.e. perlite), sand, wood, cloth and oil must be removed from the ethane.

Parameters	Ethane
Boiling Point °C	-88°C
Specific Gravity kg/m^3	1.05
Density kg/m^3	440 (380 bar)
Lower Calorific Value (LCV) MJ/kg	47.79

Table 28: Properties of Ethane

3.5.2 Boil-Off Gas Influence

LNG in the ships' tanks will change composition and properties over time. This is due to the unavoidable heat-influx from the surroundings, which will cause vaporisation of lighter compounds, like nitrogen (N_2) and methane. This process is called ageing and the gas produced is referred to as boil-off gas (BOG). BOG contains a higher amount of nitrogen compared to the LNG bunkered.

The remaining LNG will have an increased percentage of higher hydrocarbons. The composition of the LNG bunkered will, hence, not necessarily be the same as the composition of the 300 bar fuel gas delivered to the engine.

The nitrogen (N_2) content delivered to the engine may vary, which is acceptable, to a level of 15% (mol). If the nitrogen content delivered to the engine exceeds 15% (mol), it can be handled by either decreasing the engine load or by increasing the pilot injection of liquid fuel such as diesel or fuel oil.

Please contact your Everllence two-stroke representative for more information.

3.5.3 Fuel Gas Bunkering

Liquid or solid contaminants must be removed from the gas. It is generally considered as good engineering and operating practice to have LNG cargo strainers in the loading and discharge lines in order to minimise particulate contamination of the LNG and subsequent tanks and equipment.

It is recommended that the filter is controlled by a surveyor after the bunkering to establish the contamination degree. It is important to note that the quality and impurity degree can vary among the suppliers due to production and handling differences and the type of bunkering/transfer process (for example: terminal tank to vessel, truck to vessel, vessel to vessel, portable tank transfer).

Everllence strongly recommends installing filters in the bunkering line and/or in the fuel gas supply system

3.5.4 Gas Valve Train (GVT)

The GVT basically is a double block and bleed system which will separate the FGSS from the ME-GI during shutdown. Furthermore it contains nitrogen purging and testing functionalities. As an option, and subject to class approval, the GVT can also function as the Master Gas Valve.

The GVT is controlled by the Engine Control System. As the GVT represents the ME-GI interface to the external systems, it can only be delivered by suppliers which have been approved as GVT suppliers by Everllence.

3.6 Control System

The PVU control system is designed based on knowledge of the ME-GI engine and the PVU mechanics. This ensures dedicated control integration between the systems, and high gas supply control accuracy and condition monitoring features. The engine gas pressure and flow demands are quickly transferred to the PVU, resulting in a stable gas pressure control, in which it secures efficient ramp up and ramp down in all operating conditions. Further, the GVT downstream of the PVU is controlled by the ME-GI engine control system, ensuring integrated control with the ME-GI engine. The PVU control system is based on the same hardware platform as the ME engine control system, which means that no extra spare parts are required.

Everllence strives to use the same components on the PVU as use on the ME-GI/GIE engines in order to minimize the amount of spareparts onboard. As an example the controllers (MPC’s) are identical and interchangeable with the once used on the main engine.

3.6.1 Control Cabinet and Main Operating Panel (MOP)

⚠ WARNING Control cabinet and MOP are only for installation in safe zone and NOT in Ex zone.

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The MOP (Main Operating Panel) is the Human Machine Interface (HMI) through which the PVU control system is operated. The PVU is a separate, stand-alone unit independent and removed from the control system for the engine. The MOP as such comprises a PC, with the PVU system software installed, a 15" touch screen and a keyboard with integrated mouse.

The MOP unit is basically an integrated marine approved and certified PC with touchscreen. The touch screen needs bare skin contact in order to function. An actual installation comprises a MOP unit, and EMS which is custom made hardware for Everllence and is standard.

The MOP(s) must be installed in the engine control room or similar control station. The maximum length of the cable between the control cabinet and MOP is 230 m, and taking internal cabling in the PVU control cabinet into consideration the total cable length from the PVU control cabinet to the PVU MOP must be less than 225 m. If two MOPs are applied, the 225 m length is the sum of the cable between the MOPs and the cable between the MOP and the PVU control cabinet.

The maximum cable length from PVU skid to PVU control cabinet is 80 m (limited by IEC Ex requirements).

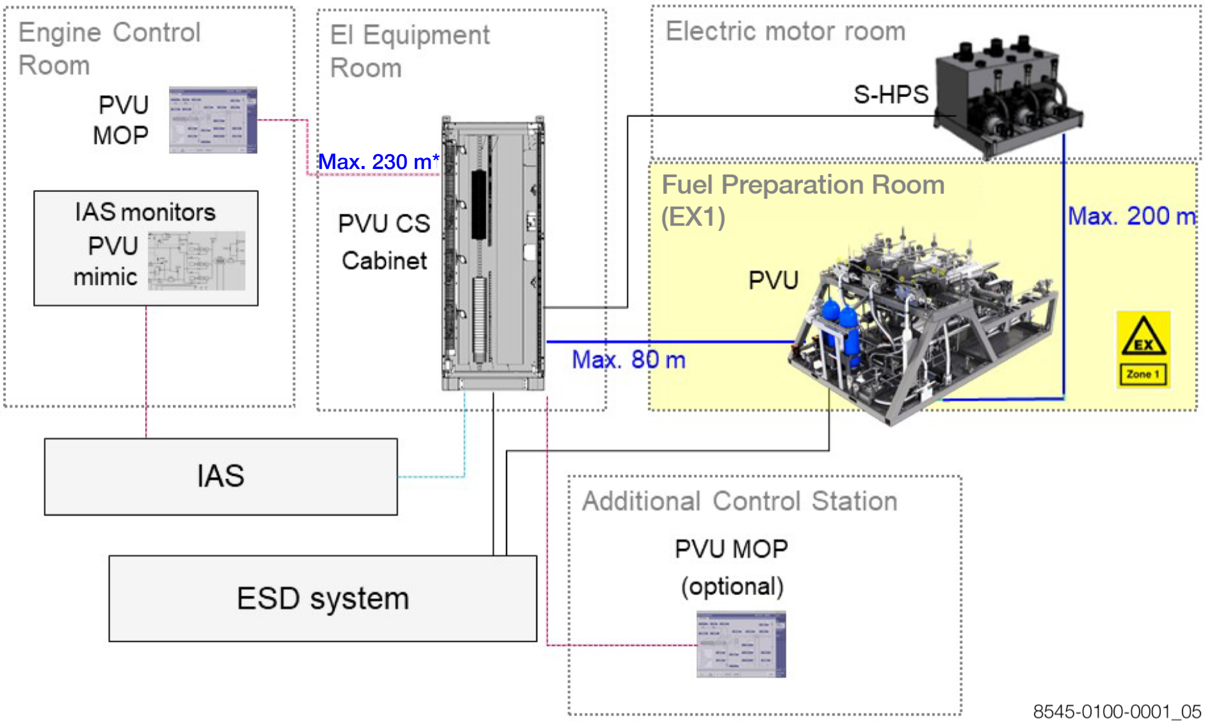

Figure 19: PVU with Control system

NOTICE (*): Single line diagram for PVU network installation incl. indication of cable routing lengths to be informed to Everllence.
If this total cable length is more than 100 meter, contact Everllence for further information.

NOTICE Special cable types (80 m cable) : Refer to cable specifications for details and makers.

NOTICE Air Lock : As an additional safety feature, a hard power cut-off can be made in the PVU control cabinet by a relay in the Fuel Gas Supply Safety system.

This feature is intended for situations where the safe area containing the SHPS unit is compromised, i.e. if the air lock between the safe area and the Ex area is breached, and will cut-off all power from the PVU control to subsystems. The power cut-off is activated by opening a normally closed relay contact.

3.6.1.1 Built in Dimensions for Control Cabinet

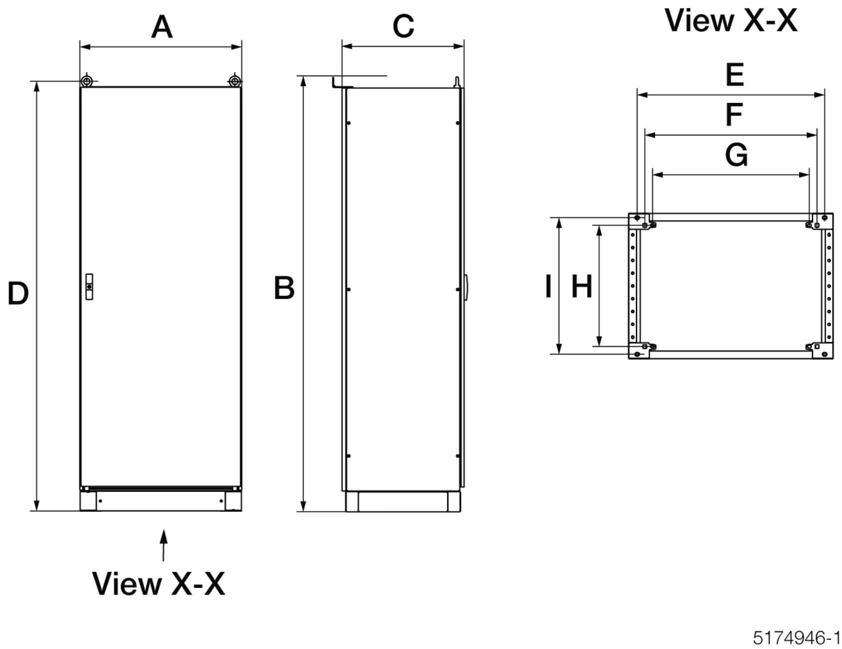

Figure 20: Built in dimensions for control cabinet

A	B	C	D	E	F	G	H	I
735	2131	605	2100	735	675	615	475	535

Table 29: Built in dimensions for control cabinet

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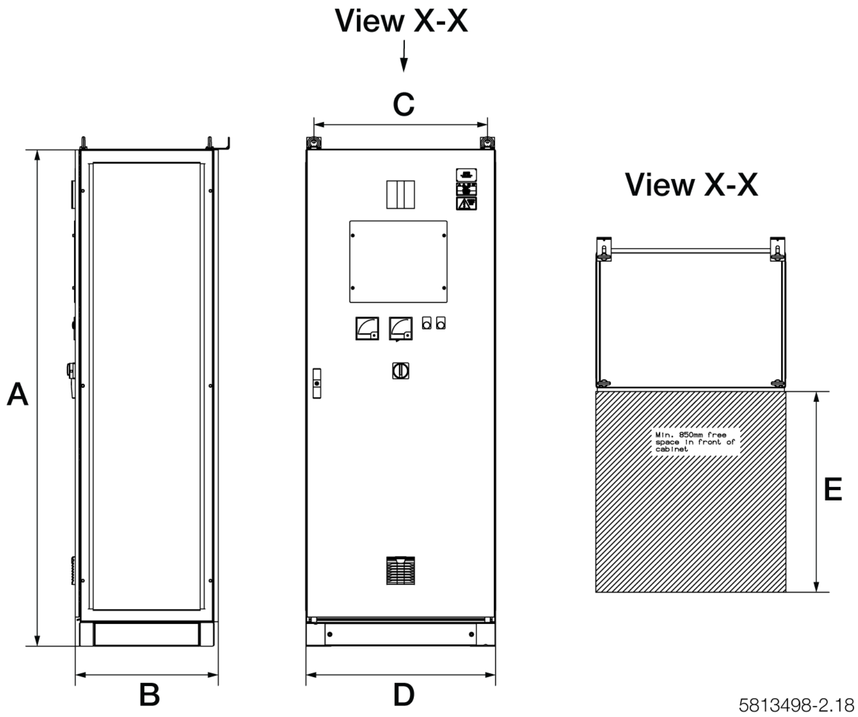

Figure 21: Built in dimensions for control cabinet

A	B	C	D	E
2100	605	735	802.75	850

Table 30: Built in dimensions for control cabinet

3.6.1.2 Built in Dimensions for MOP

NOTICE It is recommended to install the PVU MOP in close vicinity of MOP B (ECS) and the MOP of the FGSS. Thereby, all data relating to dual fuel operation will be easy accessible and enabling quick overview on status and quick assessment of effect from changes in parameters when tuning.

If the Control cabinet is installed far away from the control room and thereby MOP 1 ,another option is to install a second MOP in the PVU cabinet already prepared for it for easy commissioning and daily operational checks.

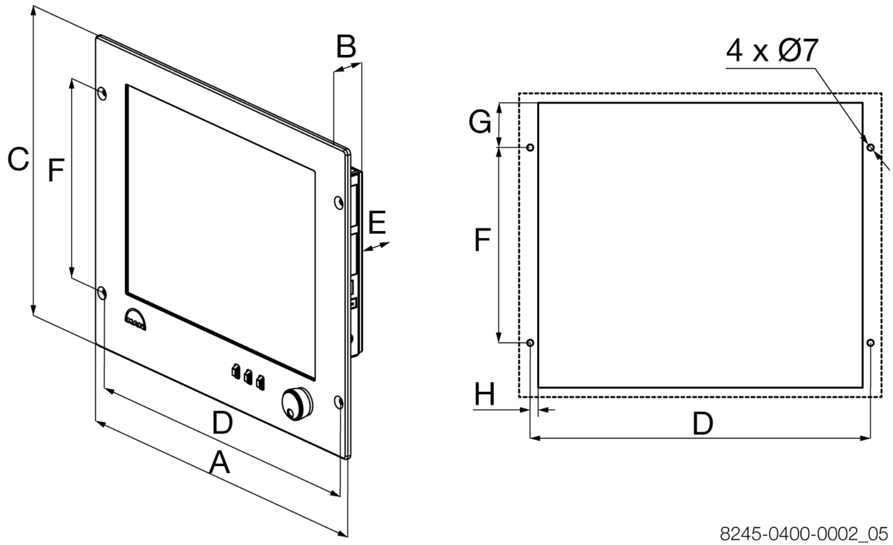

Figure 22: MOP dimensions

Dimensions (mm)							
A	B	C	D	E	F	G	H
412	68	345	387	40	222	51	9

Table 31: Built in dimensions for MOP

3.6.1.3 Keyboard and Trackball Mouse for MOP

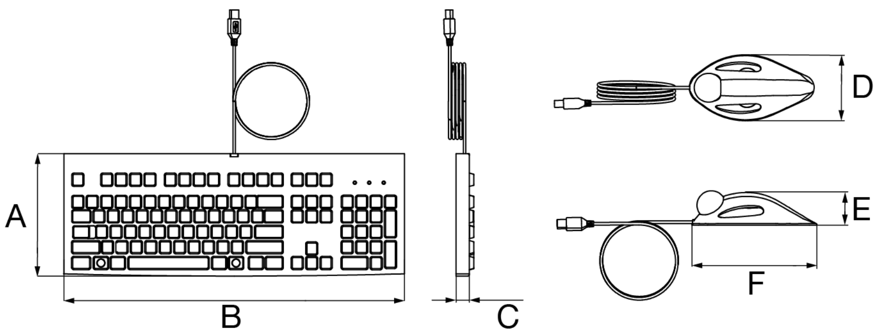

Figure 23: Keyboard and Trackball Mouse for MOP

Dimensions (mm)					
A	B	C	D	E	F
165	460	18	43	165	87

Table 32: Keyboard and Trackball Mouse for MOP

Check out the control net specification in *references, electrical EN700AF.0 control net cables.*

NOTICE Note that when the control cabinet has to be connected to the junction boxes on the PVU, this has to be done by an ATEX certified electrician.

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See sections Electrical Connections and Intrinsically Safe Connections, Page 114.

3.7 Vibration

3.7.1 Vibration Limits

The vibration limits apply in on-board condition by comparing measured vibration levels with our vibration limits. Thus vibration limits apply for the combined vibration due to self- and externally-excited vibration sources.The vibration limits are to be satisfied in order to ensure:

- Satisfactory vibration performance of the combined PVU and hull structure vibration system.
- Protection against fatigue failure of PVU’s welded support structure.
- Protection against vibration damage of both electrical and mechanical components mounted internally on the PVU caused by excessive vibration.

Vibration limits are as follows

- 25 mm/s overall rms. vibration, frequency range 4-200 Hz
- Maximum single vibration component: 25 mm/s, 0-peak in frequency range 4- 200 Hz.
- Vibration limits apply for measurements taken on the PVU frame only: ST1, ST3, Ra1 and Ra3.

3.7.2 Measuring Positions

- Ra1: Aft most corner of PVU frame closest to Pump1 (P1)
- Ra3: Aft most corner of PVU frame closest to Pump3 (P3)
- ST1: Fore most corner of PVU Top Plate closest to Pump 1 (P1)
- ST3: Fore most corner of PVU Top Plate closest to Pump 3 (P3)

3.7.2.1 Measuring Positions

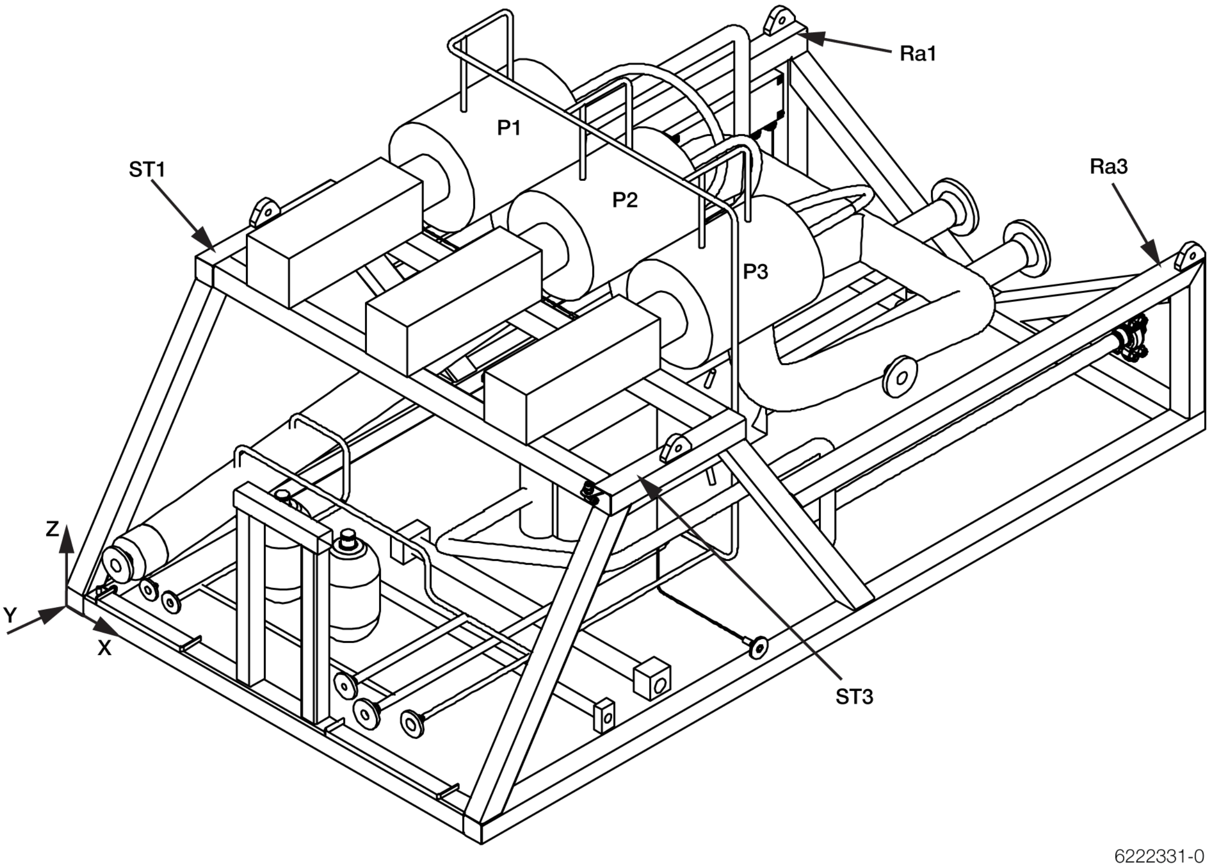

Figure 24: Measuring positions

3.7.3 Recommended Lowest Natural Frequency of the PVU/ Hull Structure

It is recommended that the combined vibration system of the PVU unit and the local vessel structure (PVU foundation structure), is verified during vessels design stage.

FEM calculations can be used in the verification process by using the PVU mass and geometry properties listed below. It is recommended that the lowest natural frequency of the combined PVU/hull vibration system is above 35 Hz (installed stiffness).

3.7.4 Excitation Forces and Moments

If a simplified FEM model of the PVU model has been made to calculate the natural frequency of the PVU/Hull structure, based on the data shown in the mass elastic data for the PVU at the centre of gravity, it is also possible to calculate forced response of the system.

The inertia forces and moments generated by oscillating masses in the PVU pumps are shown in below table. The forces in the table work in the X direction, and the moment work around the Z direction.

3.7.4.1 Excitation Forces and Moments from Oscillating Masses on PVU5000/8000

		Three pumps working		Two pumps working			One pump working[3]	
Harmonic	Frequency (Hz)	Force (N)	Moment (Nm)	Force (N)	Moment[1] (Nm)	Moment[2] (Nm)	Force (N)	Moment (Nm)
1	3.9	-	655	-	280	380	590	-
2	7.8	-	600	1080	-	-	540	-
3	11.7	825	-		245	180	275	-
4	15.6	-	205	370	-	-	185	-
5	19.5	-	485	-	100	280	440	-
6	23.4	365	-	245	-	-	125	-
7	27.3	-	145	-	220	85	135	-
8	31.2	-	405	725	-	-	365	-
9	35.1	565	-	-	120	120	190	-
10	39.0	-	60	105	-	-	55	-
11	42.9	-	340	-	165	200	310	-
12	46.8	830	-	555	-	-	280	-
13	50.7	-	270	-	245	155	245	-
14	54.6	-	100	175	-	-	90	-
15	58.5	1355	-	-	160	290	455	-
16	62.4	-	150	265	-	-	135	-
17	66.3	-	530	-	245	305	480	-
18	70.1	870	-	580	-	-	290	-
19	74.0	-	580	-	230	335	525	-
20	77.9	-	560	1015	-	-	505	-
21	81.8	230	-	-	150	50	75	-

		Three pumps working		Two pumps working			One pump working[3]	
Harmonic	Frequency (Hz)	Force (N)	Moment (Nm)	Force (N)	Moment[1] (Nm)	Moment[2] (Nm)	Force (N)	Moment (Nm)
22	85.7	-	375	675	-	-	340	-
23	89.6	-	215	-	230	335	195	-
24	93.5	1360	-	910	-	-	455	-
25	97.4	-	210	-	145	120	190	-
26	101.3	-	545	980	-		490	-
27	105.2	1185	-	-	115	255	395	-
28	109.1	-	365	660	-	-	330	-
29	113.0	-	380	-	180	200	345	-
30	116.9	845	-	565	-	-	285	-

1 two neighbor pumps (#1+#2 or #2+#3
2 two non-neighbor pumps (#1+#3
3 This column only for information - this is not a running mode supported by the PVU's control system

Table 33: Excitation forces and moments from oscillating masses on the PVU5000/8000

3.7.4.2 Excitation Forces and Moments from Oscillating Masses on PVU3000/4000E

		Three pumps working		Two pumps working			One pump working[3]	
Harmonic	Frequency (Hz)	Force (N)	Moment (Nm)	Force (N)	Moment[1] (Nm)	Moment[2] (Nm)	Force (N)	Moment (Nm)
1	4.2	-	480	-	280	555	435	-
2	8.4	-	475	855	-	-	430	-
3	12.6	1135	-		245	485	380	-
4	16.8	-	155	275	-	-	140	-
5	21	-	170	-	100	200	155	-
6	25.2	415	-	280	-	-	140	-
7	29.4	-	380	-	220	435	340	-
8	33.6	-	175	315	-	-	160	-
9	37.8	545	-	-	120	235	185	-
10	41.9	-	235	420	-	-	210	-
11	46.1	-	285	-	165	330	260	-
12	50.3	300	-	200	-	-	100	-
13	54.5	-	425	-	245	490	380	-
14	58.7	-	285	510	-	-	255	-
15	62.9	745	-	-	160	320	250	-
16	67.1	-	240	435	-	-	220	-
17	71.3	-	425	-	245	490	385	-
18	75.5	225	-	150	-	-	75	-
19	79.7	-	400	-	230	460	360	-
20	83.9	-	285	510	-	-	255	-
21	88.1	700	-	-	150	300	235	-

		Three pumps working		Two pumps working			One pump working[3]	
Harmonic	Frequency (Hz)	Force (N)	Moment (Nm)	Force (N)	Moment[1] (Nm)	Moment[2] (Nm)	Force (N)	Moment (Nm)
22	92.3	-	310	555	-	-	280	-
23	96.5	-	400	-	230	460	360	-
24	100.7	625	-	420	-	-	210	-
25	104.9	-	250	-	145	285	225	-
26	109.1	-	410	740	-		370	-
27	113.3	530	-	-	115	230	180	-
28	117.4	-	290	520	-	-	260	-
29	121.6	-	310	-	180	355	280	-
30	125.8	760	-	505	-	-	255	-

1 two neighbour pumps (#1+#2 or #2+#3
2 two non-neighbour pumps (#1+#3
3 This column only for information - this is not a running mode supported by the PVU's control system

Table 34: Excitation forces and moments from oscillating masses on the PVU3000/4000E

3.8 Spares and Tools

3.8.1 PVU List of Spares

Everllence recommends to use spare parts that are recommended by the following Classification Society only: ABS, DNV*

In order to stay compliant and safe, PVU needs to be operational at all times. The service kit is highly recommended for the same purpose on board vessels with two-stroke ME-GI engines with PVU.

Everllence strives to use the same components on the PVU as use on the MEGI/GI as e.g. Multipurpose Computers (MPC) are identical for PVU and main engine.

*) The final scope of spare parts is to be agreed between the owner/operator and Everllence builder/yard.

Fuel Processing Inlet, plate 4072-3100

1 set Seal kits and Gaskets
1 piece Feedback sensor, Inductive sensor, Resistance temp. sensor, Pressure transmitter

Fuel Venting, plate 4072-3150

1 set Seal ring
1 piece Feedback sensor and Temperature sensor

Cryogenic Pump - Repair Kit, plate 4072-3500

1 piece Packing kit

Cryogenic Pump, plate 4072-3501

1 piece Pump complete

Fuel Processing Discharge, plate 4072-3550

1 set Gaskets and Sealing rings

Fuel Processing Low Pressure Venting, plate 4072-3650

1 set Gaskets and Sealing rings

Fuel Processing Outlet, plate 4072-3800

1 set Gaskets and Sealing rings
1 piece Difference transmitter, difference pressure switch, resistance temperature sensor

Fuel Processing Circulation, plate 4072-3850

1 set Seal kits and Gaskets
1 set Hoses with flanges
1 set I/P converter, Temperature sensors

Cryogenic Filter, plate 4072-3900

1 set Repair kit

Oil Drain, plate 4572-3040

1 piece Level Switch

Hydraulic Low Pressure Pipe, plate 4572-3250

1 set O-rings and Gaskets

Hydraulic High Pressure Pipe, plate 4572-3255

1 set O-rings and Gaskets

Hydraulic Pump Actuator, plate 4572-3500

1 piece Repair kit
1 piece Temperature sensor
1 set Pressure transmitters

Heat Exchanger, plate 5272-3100

1 set Sealing rings and packing rings
1 piece Resistance temperature sensor, Difference pressure switch and pressure transmitter

Pneumatic Components, plate 7072-3010

1 set Pressure transmitter, Solenoid valve

3.8.2 SHPS List of Spares

3.8.2.1 Hydraulic High Pressure Supply System, plate 4572-3900

1 set Vent caps
1 piece Resistance temperature sensor
1 piece Level switch
1 set Oil filters
1 set Elastic spiders
1 piece Difference pressure switch
1 piece Pressure transmitter
1 set Hydraulic hoses

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3.8.3 PVU Tools

3.8.3.1 Cryogenic Pump Tools

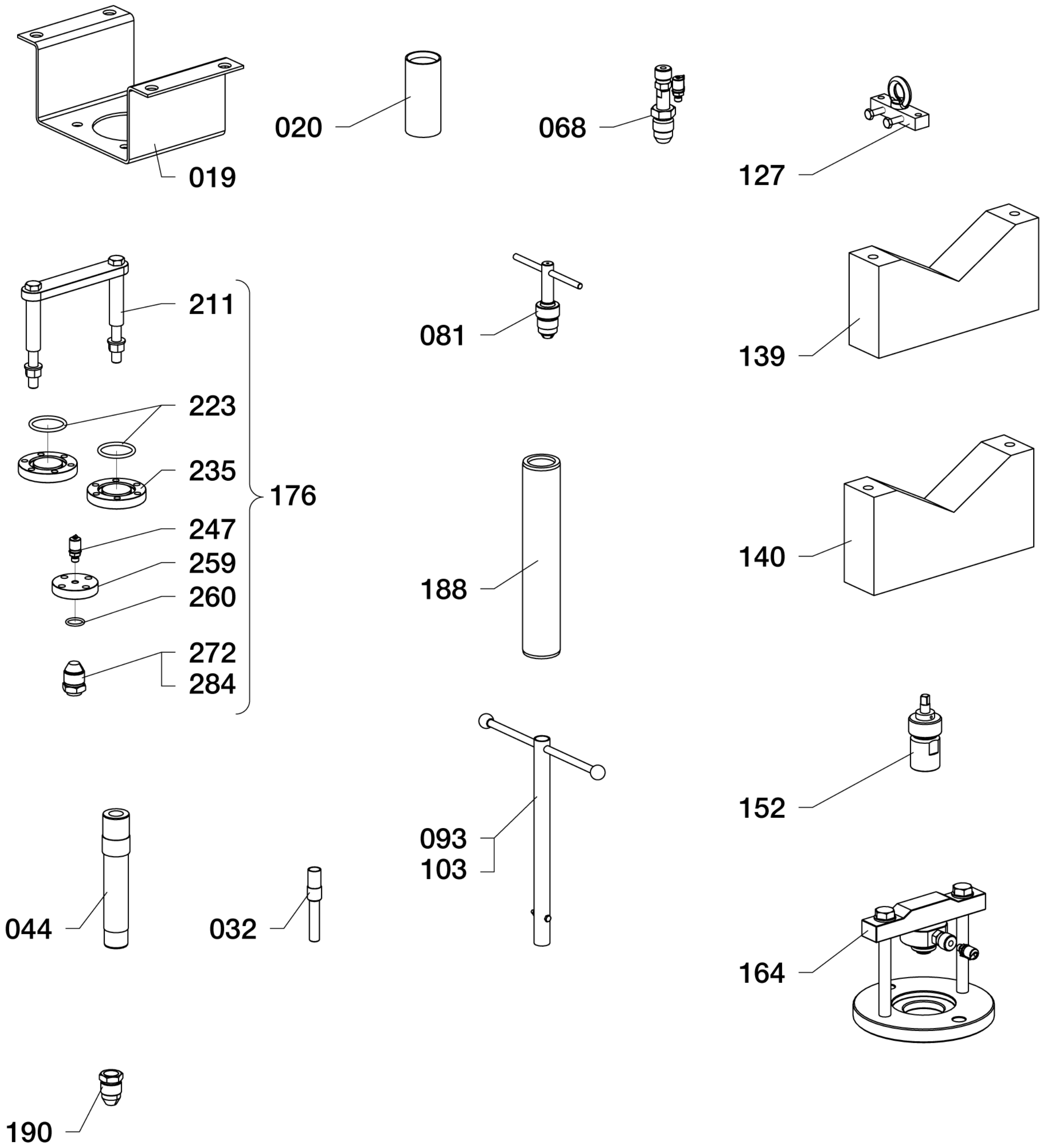

Figure 25: Cryogenic Pump Tools

Basic tools included in PVU deliveries		Optional tools			
127	Lifting bracket for discharge flange	019	Service bracket for cryogenic pump, vertical	020	Guide for cryogenic pump piston ring
139	Service bracket for cryogenic pump, horizontal, large diameter	032	Guide for stuffing box sleeve	044	Guide for valve head sleeve
140	Service bracket for cryogenic pump, horizontal, small diameter	068	Leak testing tool for discharge	081	Grinding mandrel for pipe seat
		093	Handle for extractor tool	103	Cylinder valve head extractor tool
		152	Grinding tool for high pressure pipe	164	Leak testing tool for discharge poppet
		176	Leak testing tool for packing gland	188	Pushing tool for pump packing gland
		190	Plug for leakage search	211	Clamp
		223	Sealing ring	235	Flange
		247	Quick coupling, minimess	259	Flange
		260	Sealing ring	272	Nut
		284	Plug		

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3.8.3.2 Hydraulic Actuator Tools

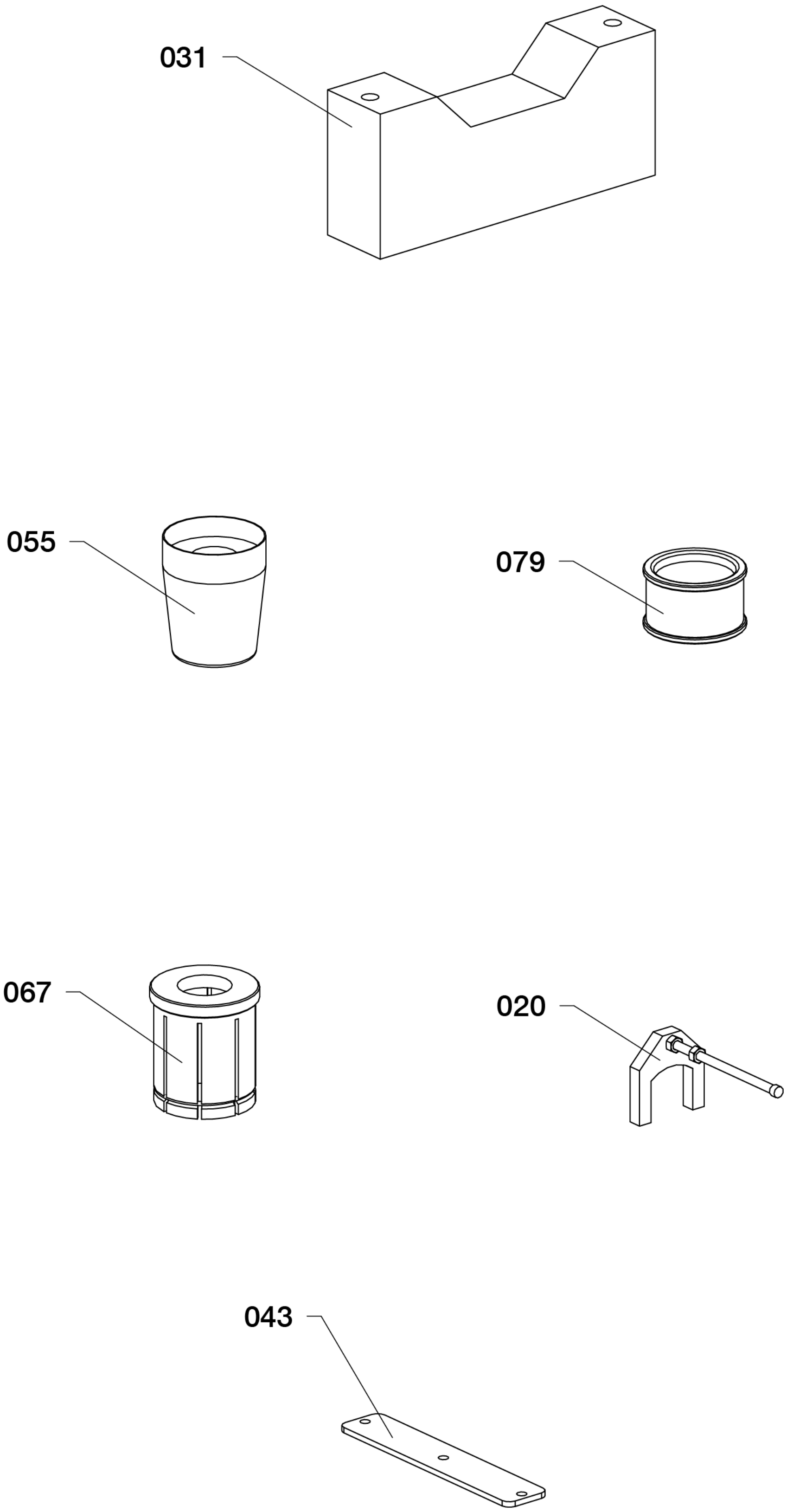


Figure 26: Hydraulic Actuator Tools

Basic tools included in PVU deliveries		Optional tools			
020	Jacking tool	031	Service bracket for hydraulic actuator	055	Cone for hydraulic actuator, piston sealing ring
043	Service bracket for hydraulic actuator	067	Pushing tool for hydraulic actuator, piston sealing ring	079	Compression tool for hydraulic actuator, piston sealing ring

4 Installation Manual

4.1 Safety Precautions

4.1.1 Safety Notes

⚠ DANGER This warning is used when an operation, procedure, or use may cause personal injury or loss of life.

⚠ WARNING This warning is used when an operation, procedure, or use may cause a latently dangerous state of personal injury or loss of life.

⚠ CAUTION This warning is used when an operation, procedure, or use may cause damage to or destruction of equipment and injury.

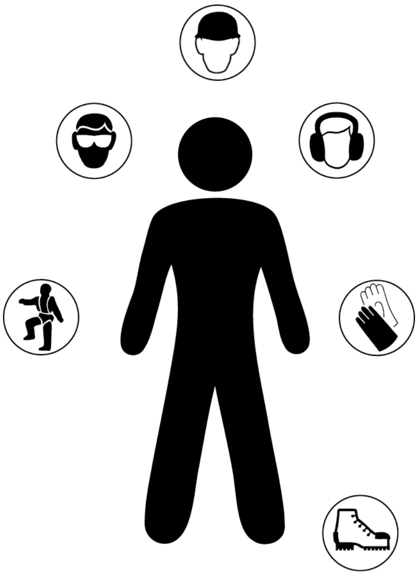
NOTICE This warning is used when an operation, procedure, or use may cause damage to or destruction of equipment.

4.1.2 Requirement for Fuel Preparation room and Personal Protective Equipment

NOTICE Install PVU in a Fuel Preparation room EX zone1 which is mandatory in order to fulfill IGF/IGC code.

Location of the PVU is in a fuel preparation room on the upper deck and this fuel preparation room shall have some features as mentioned below:

- EX Zone 1
- Effective ventilation with alarm in case of stop
- Fixed HC sensor with alarm in case of gas release
- Sign on the access door: No entrance for unauthorized personnel / Wear gas detector / oxygen tester with alarm



Minimum personal safety equipment requirements:

1. Safety shoes
2. Hearing protection, *see caution.*
3. Boiler suit or other similar protective wear

⚠ CAUTION PVU running

In case of abnormal condition during PVU running, loud noise peak can occur.

Both earplugs and earmuffs must be used, in combination.

4.1.3 Special Dangers

NOTICE A number of situations may lead to risk of serious injury to the body or loss of life. The following recommendations must always be observed:

Keep clear of the space below a crane with load.

Before opening of cocks, always observe which way liquids, gases or flames will move, and keep clear.

Dismantling of parts may cause the release of springs.

Removal of plugs may cause the release of pressurized fluids or gases.

Always carry a calibrated gas detector while working on the PVU.

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Ensure power supply for PVU is turned off and breaker is tagged while performing any maintenance on the PVU, non compliance to this warning may be fatal.

4.1.4 Fire

Do not weld or use naked lights in the PVU work area until it has been ascertained that no explosive gases, vapour or liquids are present.

Attention is furthermore drawn to the danger of fire when using paint and solvents with a low flash point. Porous insulating material, soaked with oil from leakages, is flammable and should be renewed.

4.1.5 Order/Tidiness

Hand tools should be securely fastened and placed on easily accessible tool panels. Special tools should be securely fastened close to the area of use in the PVU room.

Do not leave major objects unfastened, and keep floor clear at all times.

4.1.6 Spares

PVU spare parts should be kept well secured and accessible by crane.

All spares should be protected against corrosion and mechanical damage. The stock should be checked at intervals and replenished in good time.

4.1.7 Lighting

Ample working light should be permanently installed at appropriate places and portable working light should be obtainable everywhere. Only use light approved for the correct Ex zone and gas free the area before working

4.1.8 Hazardous Materials

When working with hazardous materials, extra care should always be given to safety and the steps below must always be followed.

All risks must be identified in a risk assessment. Safety measures must be implemented in relation to the activity and in consideration of the safety data sheets before work begins.

- Always follow the manufacturer's specific instructions, i.e. the material safety data sheet (MSDS)
- Use protective gloves, goggles, breathing mask, and any other recommended protective gear stated in the material safety data sheet
- Read the material safety data sheet regarding first aid measures in the event of skin contact
- When handling harmful materials it is important to ensure proper ventilation and shielding if needed

- In the event of leaks or spillage, spread binding agents immediately. Dispose of the binding agents according to the material safety data sheet

4.1.9 Guidelines for All Lifting Tools

Lifting tools and load handling equipment

The use of lifting tools and load handling equipment may only be carried out by trained operating personnel.

- Depending on the load and situation, suitable lifting tools and load handling equipment and attachments should be selected.
- Before using cranes, check the functionality, i.e. slow and fast movement/lifting and end stop functionality. In case of double jib cranes also check that the two cranes lift at the same speed.
- Before each use, lifting tools and load handling equipment must be checked for damage.
- Do not use lifting tools and load handling equipment that are not clearly identified, that are damaged, that are not marked with the Work Load Limit (WLL).
- All operations such as striking, lifting, moving, landing and separating of lifting tools and load handling equipment must be carefully considered and carried out with due care.
- Before lifting a load, the weight and center of gravity must be uniquely determined.
- Always use all intended and available lifting points when lifting loads.
- For loads without existing anchor points, the anchor points must be determined.
- Secure loads against slipping by fixing with suitable means.
- To avoid damaging load handling equipment use edge protectors for sharp edges.

Pay attention to reducing the maximum load capacity

0° – 30° = 50 % load per sling leg	30° – 60° = 75 % load per sling leg	90° – 120° = 100 % load per sling leg	above 120° prohibited

Reduction of the load capacity by the sling angle

At the synthetic web slings pay attention to the maximum load!

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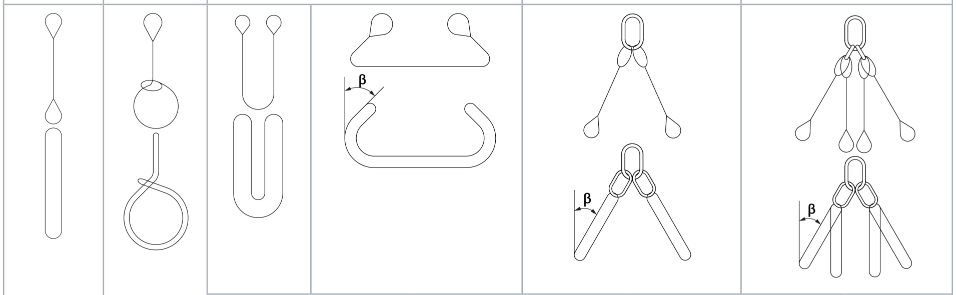
WLL of sewn webbing component	Colour of sewn webbing component	Working load limits (WLL) in tonnes								
		Straight lift	Choked lift	Basket hitch			Two leg sling		Three and four leg slings	
										
				Parallel	β = 0 - 45°	β = 45 - 60°	β = 0 - 45°	β = 45 - 60°	β = 0 - 45°	β = 45 - 60°
		M = 1,0	M = 0,8	M = 2,0	M = 1,4	M = 1,0	M = 1,4	M = 1,0	M = 2,1	M = 1,5
1,0	Violet	1,0	0,8	2,0	1,4	1,0	1,4	1,0	2,1	1,5
2,0	Green	2,0	1,6	4,0	2,8	2,0	2,8	2,0	4,2	3,0
3,0	Yellow	3,0	2,4	6,0	4,2	3,0	4,2	3,0	6,3	4,5
4,0	Grey	4,0	3,2	8,0	5,6	4,0	5,6	4,0	8,4	6,0
5,0	Red	5,0	4,0	10,0	7,0	5,0	7,0	5,0	10,5	7,5
6,0	Brown	6,0	4,8	12,0	8,4	6,0	8,4	6,0	12,6	9,0
8,0	Blue	8,0	6,4	16,0	11,2	8,0	11,2	8,0	16,8	12,0
10,0	Orange	10,0	8,0	20,0	14,0	10,0	14,0	10,0	21,0	15,0
Over 10.0	Orange									
M = Mode factor for symmetrical loading. Handling tolerance for slings or parts of slings indicated as vertical = 6°										

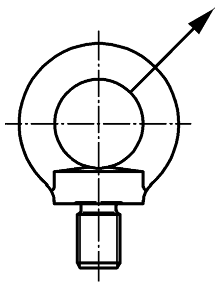
Shackles

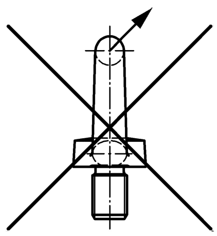
Screw pins to be tightened to full contact.

Eye screw / Eye nut

Tighten to full contact without any gap. Be aware of loading direction.

Lateral loading is prohibited in all cases!





Prohibited lateral load

Load capacity depending on the load direction

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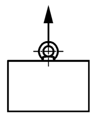
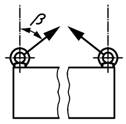
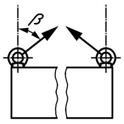
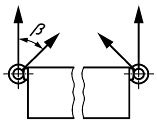
Installation position to thread axis:	vertical			horizontal
Direction of loading:	axial	obliquely		laterally
				
Opening angle:	0°	β ≤ 45°	β > 45°– 60°	β ≤ 45°
Load capacity in %:	100 %	75 %	50 %	

Hooks

Only hooks with safety latches are allowed for lifting.

Chain tackles

Be aware of lifting angle.

4.1.10 Working Air

Use of working air requires safety goggles and gloves.

Avoid blowing pressurised air directly at any part of the body, especially exposed skin, eyes and ears.

4.1.11 Sealing Materials

Use gloves made of neoprene or PVC when removing O-rings and other rubber/plastic-based sealing materials which have been subjected to abnormally high temperatures.

4.1.12 Splash Guard

It is required that the hydraulic oil lines and flanged connections are screened or are suitably protected to avoid oil onto hot surfaces, air intakes, electrical installations or other sources of ignition.
Splash guard removed in connection with maintenance or repair work must be reinstalled again when the work has been carried out.

4.1.13 Hot / Cold Surfaces

⚠ WARNING Be alert at areas around the relief valves to prevent the risk of getting cold burn caused by the emitted gas if the relief valves open.

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Beware of hot or cold surfaces and always use appropriate gloves.
Note that PVU components and/or piping systems containing gases or volatile liquids may be very hot/cold due to expansion of gases or vaporisation of liquids.

4.1.14 Alarms

It is important that all alarms lead to prompt investigation and remedy of the error. No alarm is insignificant. The most serious alarms are equipped with slow-down and/or shut-down functions. It is therefore important that all engine and PVU operation personnel are well-trained in the use and importance of the alarm system.

4.1.15 Subsuppliers and External Equipment

Check the special instructions concerning subsupplier delivery and external equipment for specific warnings.

4.2 Space Requirement

4.2.1 Methane

The PVU methane product range cover different types, *see below table*.
The capacities cover engine outputs up to 49.6 MW.

Type of PVU	LNG (kg/h)	Engine power (MW)	Length x Width x Height (mm)	Weight (kg)
PVU3000	1401 - 2800	9.1 - 18.4	(3700 x 2240 x 2011)	4500
PVU5000	2801 - 4700	18.5 - 30.3	(3700 x 2240 x 2011)	4900
PVU8000	6801 - 7600	44.1 - 49.6	(3900 x 2240 x 2011)	5500

Table 35: Methane product range

4.2.2 Ethane

The capacities cover engine outputs up to 21.6 MW.

Type of PVU	Ethane (kg/h)	Engine power (MW)	Length x Width x Height (mm)	Weight (kg)
PVU4000E	1701 - 3500	10.7 - 21.6	(3700 x 2240 x 2011)	4500

Table 36: Ethane product range

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4.2.3 Pump Vaporiser Unit (PVU)

There are two frame sizes, one for PVU3000, PVU4000E, PVU5000 and one for PVU8000. It is possible to transport both frame sizes in a 20-feet container.

Before installing the PVU, it is important to ensure that there is enough workspace around the PVU frame to carry out overhaul and maintenance on the unit. Furthermore, there must be access to either a crane or a lift eye above the unit.

⚠ WARNING Always use lifting gear with sufficient Working Load Limit (WLL).

Lift capacity for maintenance:	500 kg to 1000 kg (depending on size of PVU)
Lifting height above the PVU:	Minimum 800 mm
Minimum space required:	
L x W x H (PVU8000):	5500 mm x 4540 mm x 2765 mm

Table 37: PVU space requirements

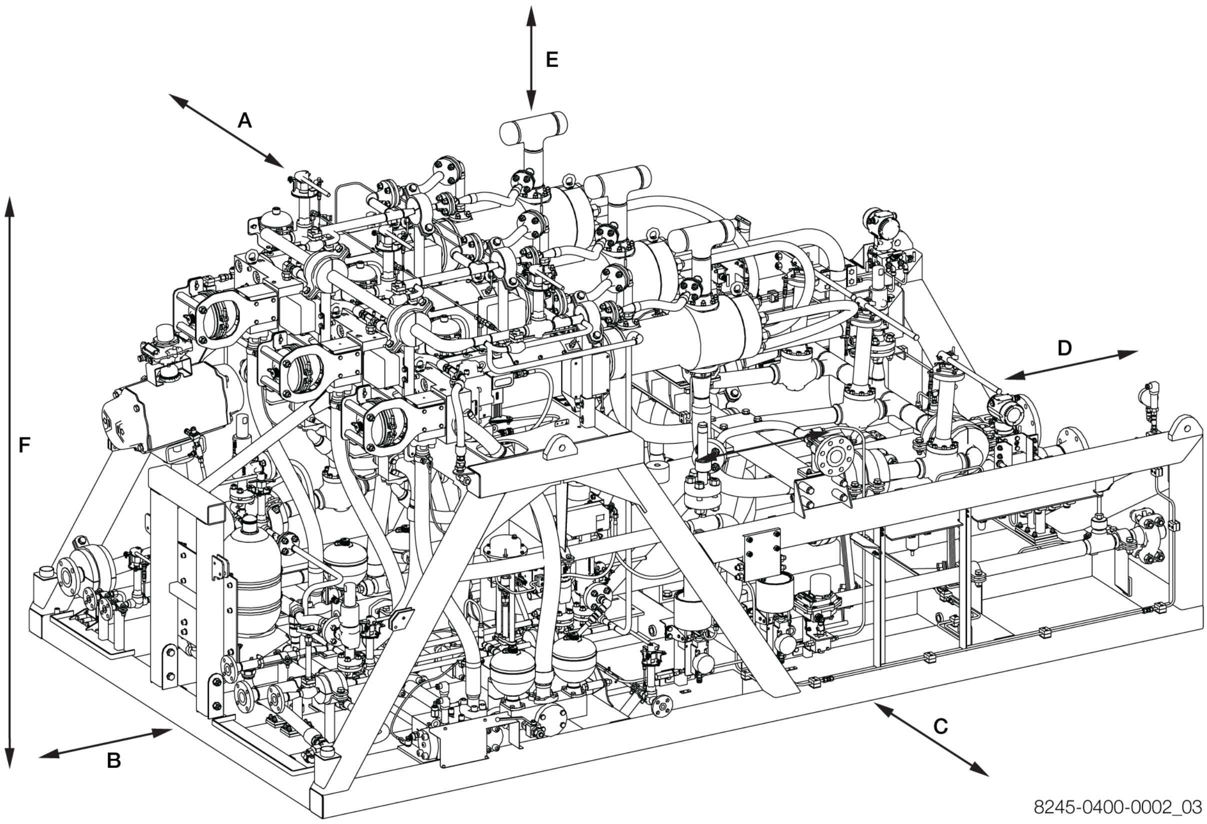

Figure 27: Space requirement around the PVU frame for maintenance and overhaul

Dimensions (mm)					
A	B	C	D	E	F
1500	800	800	800	800	2015

Table 38: PVU space requirement

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NOTICE *Minimum space requirement for the overhauling side should be 1500 mm.

In addition to the space requirement for the maintenance of PVU provision for lifting and handling of 1 (out of 3) gas pumps shall be made in order to ensure safe overhaul and maintenance of the gas pumps. It is highly recommended that such maintenance are carried out in a dedicated area outside the fuel gas preparation room i.e. in non-hazardous zone.

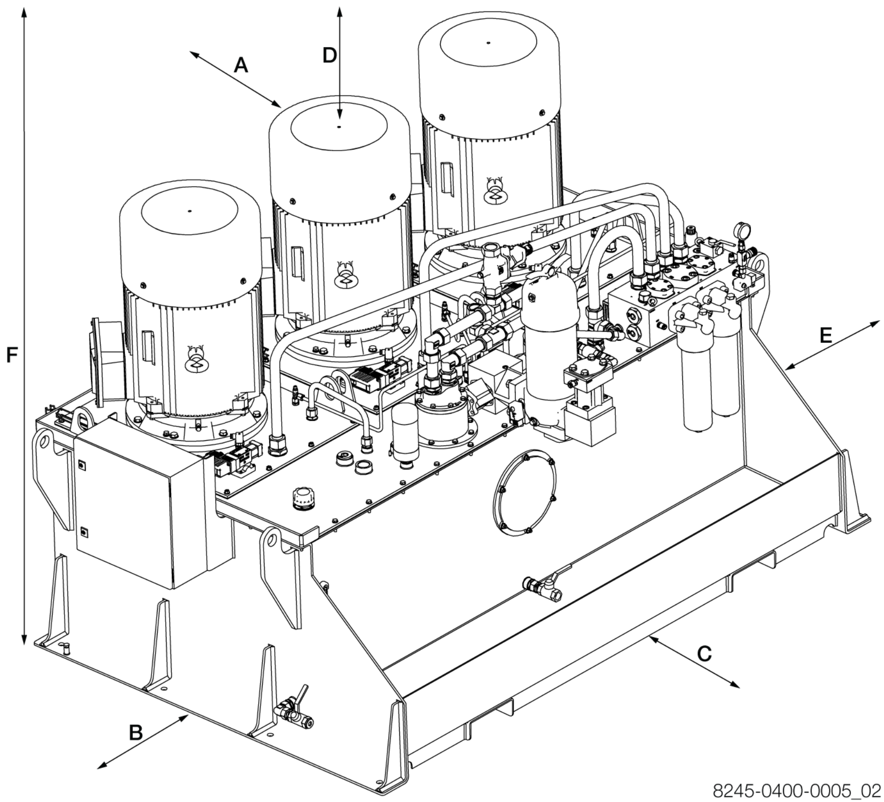
Therefore, the routing and safe procedures in transporting to such dedicated works space needs to be considered early in the phase of creating the layout of FGSS and other machinery space.

Everllence have designed a structure to support the gas pump when working on the pump itself.

4.2.4 Standalone Hydraulic Power Supply (SHPS) Mk 2

NOTICE If auxiliary systems are located at a different deck than the PVU, special considerations shall be made with regards to maintenance and draining procedures.

NOTICE It is recommended to install SHPS in non-hazardous area.



Dimensions (mm)					
A	B	C	D	E	F
500	500	500	1000	500	1848

Table 39: SHPS Mk 2 space requirement

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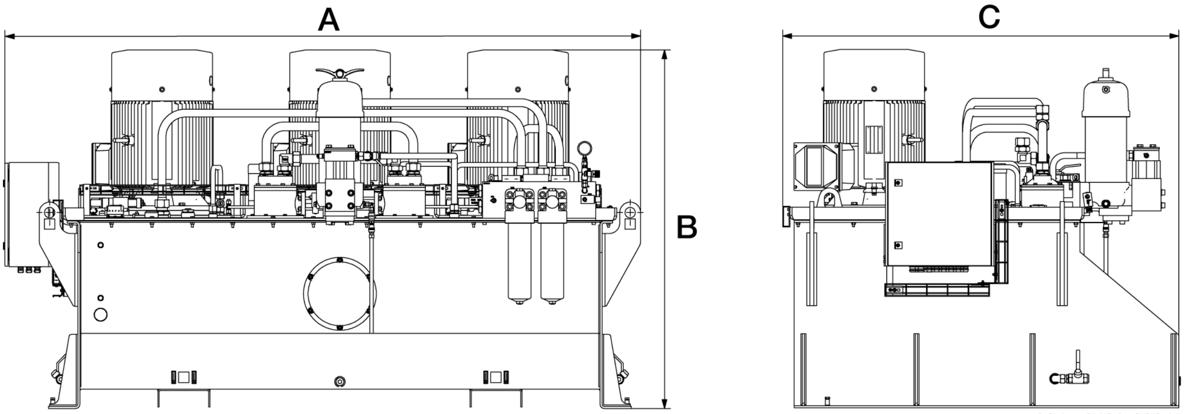

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SHPS type	A (mm)	B (mm)	C (mm)	Dry weights (kg)
SHPS200	2305	1721	1904	2500
SHPS300	3062	1722	1891	3720
SHPS500	3062	1848	1904	4352

Table 40: Dimensions for SHPS

4.2.4.1 Layout Dimensions

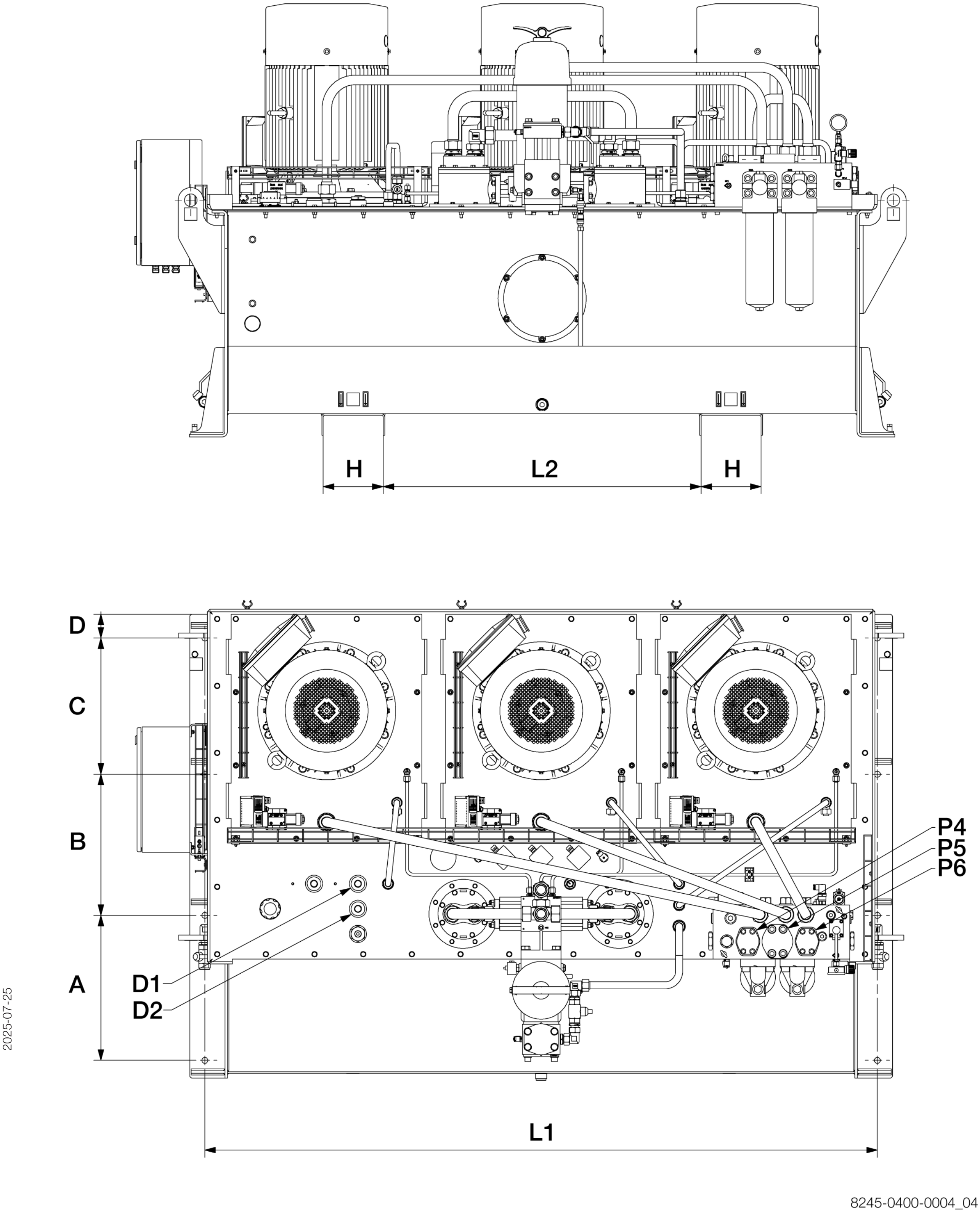

Figure 28: Dimensions for SHPS

Position	Dimensions (mm)
A	587
B	563
C	543
D	95
H	238

Table 41: Dimensions for SHPS

SHPS type	L1 (mm)	L2 (mm)
SHPS200	1930	512
SHPS300	2680	1262
SHPS500	2680	1262

Table 42: Dimensions for SHPS

Connections	SHPS200	SHPS300	SHPS500
Pressure outlet, P4	SAE 1 - 1/2 '' 6000 PSI	SAE 1 - 1/2 '' 6000 PSI	SAE 1 - 1/2 '' 6000 PSI
Pressure outlet, P5	SAE 2'' 6000 PSI	SAE 2'' 6000 PSI	SAE 2'' 6000 PSI
Pressure outlet, P6	SAE 1 - 1/2 '' 6000 PSI	SAE 1 - 1/2 '' 6000 PSI	SAE 1 - 1/2 '' 6000 PSI
Recommended P-pipe	Ø 56 x 8.5 mm	Ø 56 x 8.5 mm	Ø 56 x 8.5 mm
Tank return, T	SAE 3'' 3000 PSI	SAE 3'' 3000 PSI	SAE 3'' 3000 PSI
Recommended T-pipe	Ø 73 x 3 mm	Ø 73 x 3 mm	Ø 73 x 3 mm
Oil drain from PVU, D1	G1 - 1/2''	G1 - 1/2''	G1 - 1/2''
Oil drain from PVU, D2	G1 - 1/2''	G1 - 1/2''	G1 - 1/2''
Recommended D-pipe	Inner dia. Ø 25mm	Inner dia. Ø 25mm	Inner dia. Ø 25mm
Vent	G1 - 1/2''	G1 - 1/2''	G1 - 1/2''
Cooling water			
Water In	G1 - 1/2''	G1 - 1/2''	G1 - 1/2''
Water Out	G1 - 1/2''	G1 - 1/2''	G1 - 1/2''

Table 43: Connections and hose sizes

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4.2.4.2 Parameters for SHPS

Order information	SHPS200	SHPS300	SHPS500
Hydraulic Specifications			
Tank oil capacity	1293 L	1940 L	1840 L
Oil specification	ISO VG 46 HVLP		
Weight dry/without oil	2500 kg	3720 kg	4352 kg
Weight with oil	3600 kg	5370 kg	6041 kg
No. of motor-/pump units	2	3	3
Oil flow/pump	110 L/min	112 L/min	157 L/min
Total oil Flow	220 L/min	336 L/min	470 L/min
Max. System pressure	300 bar	290 bar	300 bar
Electrical Specifications			
Shaft power/E-motor @ 60 Hz	64 kW	64 kW	99 kW
Total shaft power	128 kW	192 kW	297 kW
Full load current/motor @ 440 VAC	100 A	100 A	158 A
Full load current/motor @ 690 VAC	70 A	70 A	108 A
Total full load current @ 440 VAC	200 A	300 A	474 A
Total full load current @ 690 VAC	140 A	210 A	324 A
Cooling			
Min. water flow inlet	180 L/min	150 L/min	360 L/min
Max. water inlet temperat-ure	36°C	36°C	36°C
Cooling capacity [kW]	45 kW	70 kW	90 kW

Table 44: Parameters for SHPS Mk. 2

NOTICE For dimensioning, the load current/motor at actual voltage shall be used.

NOTICE For more information on inlet cooling water flow and temperature, refer Cooling water paramenters, Page 27.

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4.2.4.3 Connections

A flexible hose assembly is a short length of metallic or non-metallic hose normally with prefabricated end fittings ready for installation. Flexible hose assemblies are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions. Flexible hoses are to be installed in clearly visible and readily accessible locations.

At the place of location, the routing of tubes and hoses must be routed in protective guides, and service access and safety must be taken into account. It is not allowed to step on or be located nearby hydraulic high pressure hoses.

NOTICE Hydraulic tube work requires cleanliness and professional knowledge hence it should only be performed by skilled technical personnel.

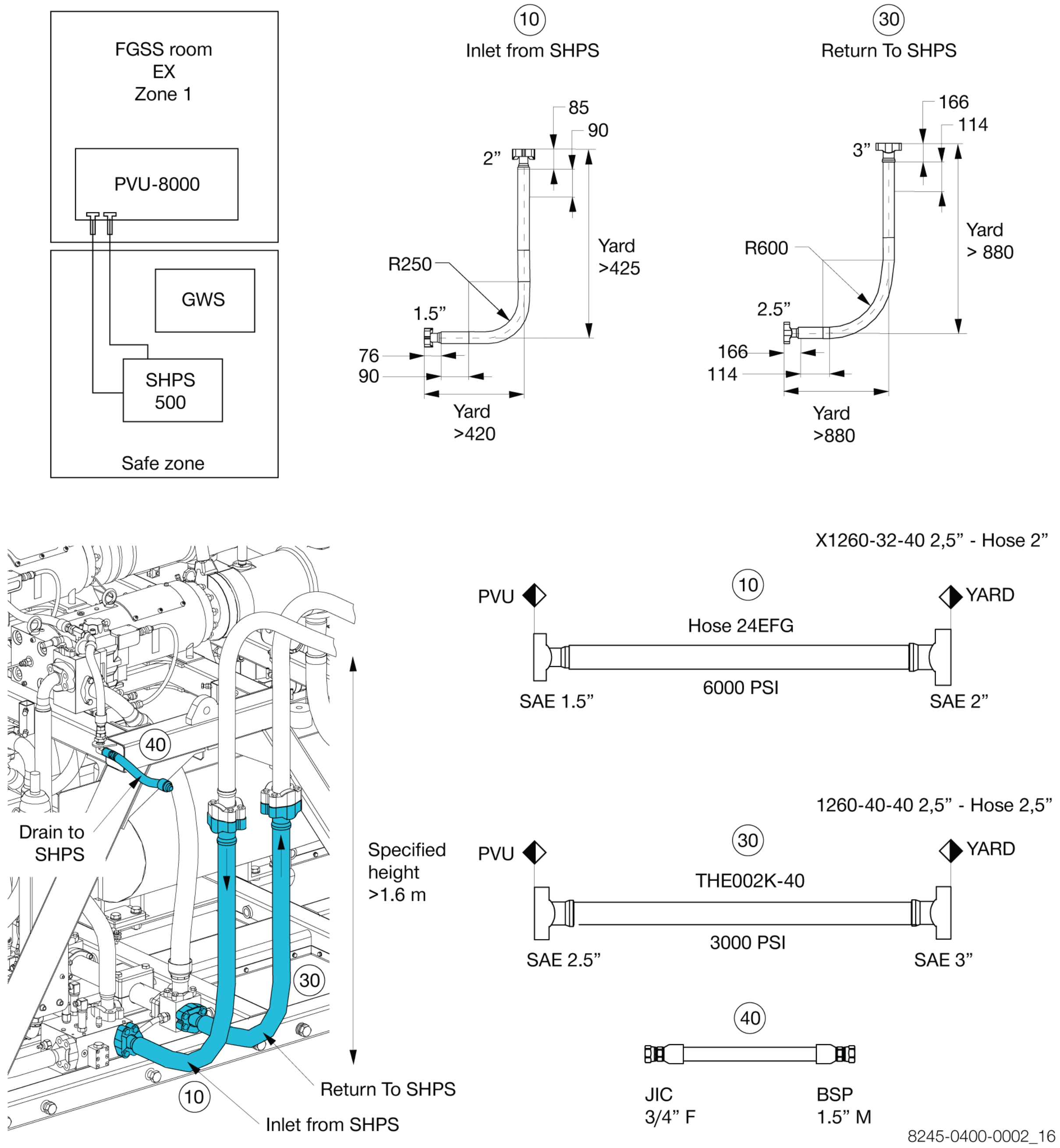

Figure 29: Example - Hose connections from PVU to SHPS

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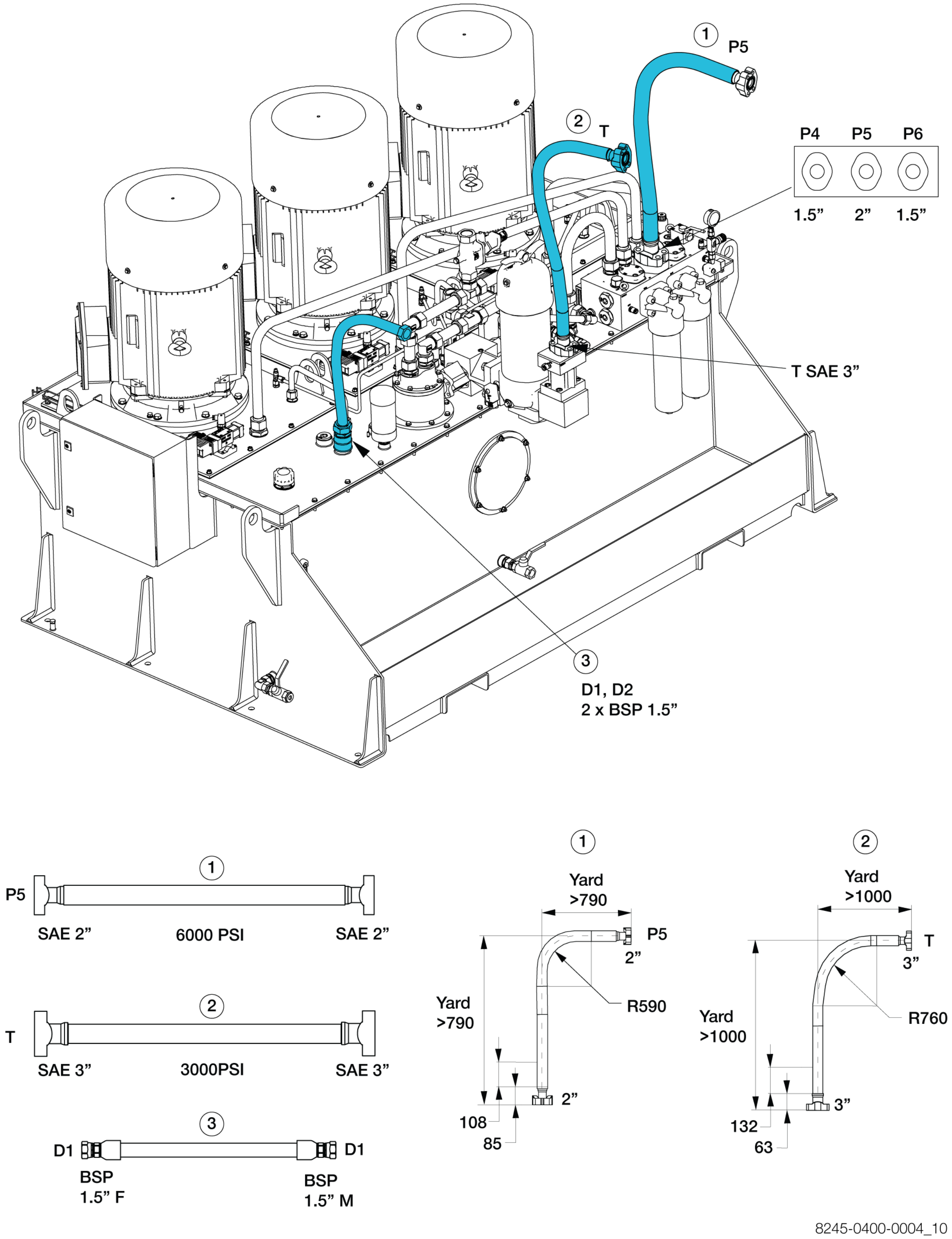

Figure 30: Example - Hose connections from SHPS to PVU

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	HP	Tank	Drain
Maker	GS Hydro	GS Hydro	-
Hose type	TFDR015 - 32	THE002K - 48	-
Minimum Bend Radius	590 mm	760 mm	-
Connection	2 '' SAE 6000 PSI	3 '' SAE 3000 PSI	D1 BSP 1.5''
Type	1310/1300 H	1260 - 48 - 48 Carbon Steel	-
Split		S003 - 48 Split Carbon Steel	

Table 45: SHPS Flex hose

4.2.4.4 SHPS Orientation

Following is the recommendation of SHPS position on the ship.

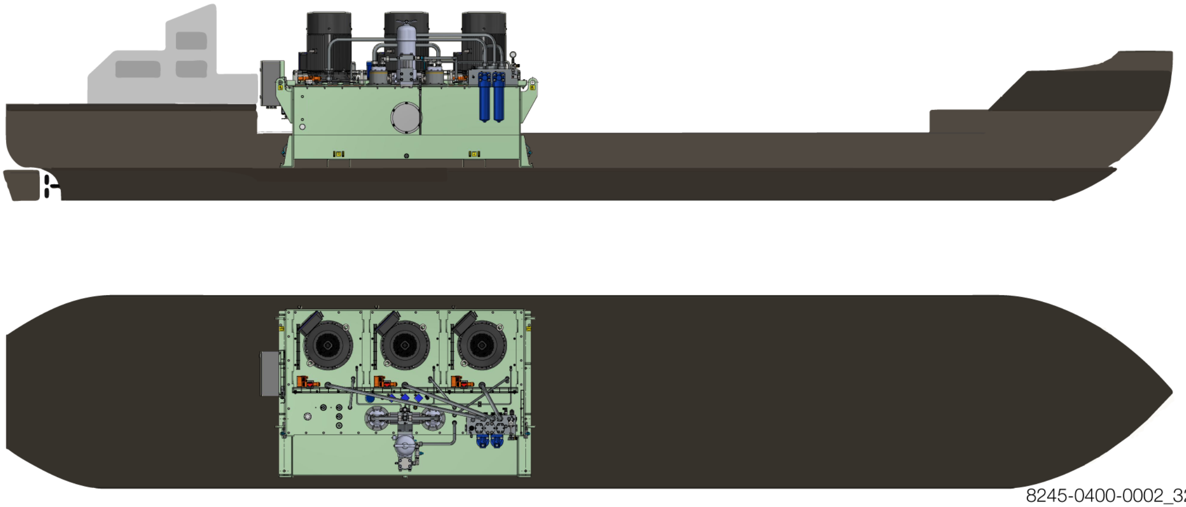

Figure 31: Example of orientation of the SHPS in relation to the longitudinal direction of the ship.

4.3 Outline and Pipe Connections

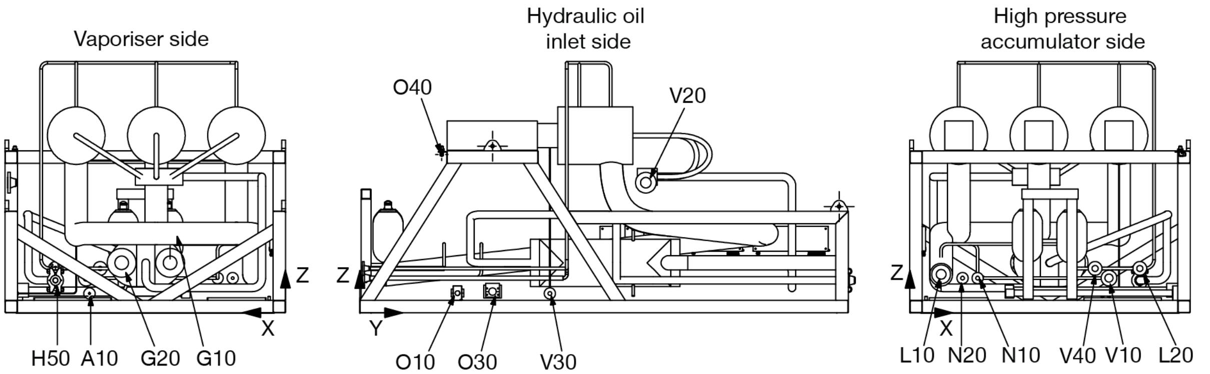

Figure 32: Flange dimensions and measurements

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4.3.1 Flange dimensions and measurements - PVU8000

Reference	Description	Fluid	Flange type	Flange size	PVU8000			Allowable Nozzle Loads		Material
					X	Y	Z	Fx/Fy/Fz	Mx/My/Mz	
A10	From pneumatic air system - Instrument air	Air	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40	1565	3880	155	45 N	-	AISI 316/316L
G10	From Glycol system - Glycol inlet	MEG Water 50%	ANSI B16.5 Class 150 Flange	DN100-SCH.10	921	3880	400	475 N	355 Nm	AISI 316/316L
G20	From Glycol system - Glycol return	MEG Water 50%	ANSI B16.5 Class 150 RF Welding Neck Flange	DN100-SCH.10	1308	3880	400	475 N	355 Nm	AISI 316/316L
H50	To GVT - Gas outlet coordinate indicates yard weld point	NG	Grayloc Flange	DN50-SCH.XXS	1837	3956	260	1050 N	135 Nm	AISI 316/316L
L10	From feed pump - LNG inlet	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN50-SCH.40	251	20	308	205 N *	75 Nm	AISI 316/316L
L20	To LNG tank - LNG return	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN25-SCH.40	1837	20	355	90 N	-	AISI 316/316L
N10	From Nitrogen purge system - maintenance	N_2	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40	542	20	278	45 N	-	AISI 316/316L
N20	From Nitrogen system - Pump seal gas	N_2	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40	422	20	278	45 N	-	AISI 316/316L

Reference	Description	Fluid	Flange type	Flange size	PVU8000			Allowable Nozzle Loads		Material
					X	Y	Z	Fx/Fy/Fz	Mx/My/Mz	
O10	From Hyd Station HP Oil inlet	Oil SAE30/ Hyd	Flange SAE J518 (ISO6162-2)	DN40-CODE62 (1-1/2'' - 6000 PSI)	2140	780	158	Flexible connection		Coated Carbon Steel
O30	To Hyd Station tank - Oil return	Oil SAE30/ Hyd	Flange SAE J518 (ISO6162-1)	DN65-CODE61(1-1/2'' - 3000 PSI)	2140	1060	170	Flexible connection		Coated Carbon Steel
O40	To Hyd Station tank - Oil drain	Oil SAE30/ Hyd	JIC Male Fitting (SAE J514) (ISO 8434-1)	3/4''	2205	655	1267	Flexible connection		Coated Carbon Steel
V10	To LP vent - LP PSV	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN40-SCH.40	1591	20	278	155 N	35 Nm	AISI 316/316L
V20	To HP vent - HP PSV + Blowdown	LNG	ANSI B16.5 Class 300 RF Welding Neck Flange	DN50-SCH.40	2220	2284	1041	270 N	80 N	AISI 316/316L
V30	To LP vent - Pump seal gas	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40	2220	1518	155	45 N	-	AISI 316/316L
V40	To LP vent - LP bleed	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN25-SCH.40	1480	20	355	90 N	-	AISI 316/316L
Earthing	Earthing connection to hull	-	Screw Connection	M12	130	50	130	-	-	AISI 316/316L
TE sensor pocket for driptray	Ø 8 mm L=160 mm (in-cluding thread)	-	Screw Connection	1/4 '' NPT	600	2460	10	-	-	AISI 316/316L

Table 46: Flange dimensions and measurements - PVU8000

4.3.2 Flange dimensions and measurements - PVU5000

Reference	Description	Fluid	Flange type	Flange size	PVU5000			Allowable Nozzle Loads		Material
					X	Y	Z	Fx/Fy/Fz	Mx/My/Mz	
A10	From pneumatic air system - Instrument air	Air	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40	1565	3680	155	45 N	-	AISI 316/316L
G10	From Glycol system - Glycol inlet	MEG Water 50%	ANSI B16.5 Class 150 Flange	DN100-SCH.10	921	3680	400	365 N	230 Nm	AISI 316/316L
G20	From Glycol system - Glycol return	MEG Water 50%	ANSI B16.5 Class 150 RF Welding Neck Flange	DN100-SCH.10	1308	3680	400	365 N	230 Nm	AISI 316/316L
H50	To GVT - Gas outlet coordinate indicates yard weld point	NG	Grayloc Flange	DN50-SCH.XXS	1837	3756	260	828 N	71 Nm	AISI 316/316L
L10	From feed pump - LNG inlet	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN50-SCH.40	251	20	308	159 N *	37 Nm	AISI 316/316L
L20	To LNG tank - LNG return	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN25-SCH.40	1837	20	355	90 N	-	AISI 316/316L
N10	From Nitrogen purge system - maintenance	N_2	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40	542	20	278	45 N	-	AISI 316/316L
N20	From Nitrogen system - Pump seal gas	N_2	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40	422	20	278	45 N	-	AISI 316/316L

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Reference	Description	Fluid	Flange type	Flange size	PVU5000			Allowable Nozzle Loads		Material
					X	Y	Z	Fx/Fy/Fz	Mx/My/Mz	
O10	From Hyd Station HP Oil inlet	Oil SAE30/ Hyd	Flange SAE J518 (ISO6162-1)	DN40- CODE62 (1-1/2'' - 6000 PSI)	2140	780	158	Flexible connection		Coated Carbon Steel
O30	To Hyd Station tank - Oil return	Oil SAE30/ Hyd	Flange SAE J518 (ISO6162-1)	DN65- CODE61(1-1 /2'' - 3000 PSI)	2140	1060	170	Flexible connection		Coated Carbon Steel
O40	To Hyd Station tank - Oil drain	Oil SAE30/ Hyd	JIC Male Fitting (SAE J514) (ISO 8434-1)	3/4''	2205	655	1267	Flexible connection		Coated Carbon Steel
V10	To LP vent - LP PSV	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN40- SCH.40	1591	20	278	159 N	37 Nm	AISI 316/316L
V20	To HP vent - HP PSV + Blowdown	LNG	ANSI B16.5 Class 300 RF Welding Neck Flange	DN50- SCH.40	2220	2284	1041	273 N	80 N	AISI 316/316L
V30	To LP vent - Pump seal gas	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15- SCH.40	2220	1518	155	45 N	-	AISI 316/316L
V40	To LP vent - LP bleed	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN25- SCH.40	1480	20	355	90 N	0.5 Nm	AISI 316/316L
Earthing	Earthing connection to hull	-	Screw Connection	M12	130	50	130	-	-	AISI 316/316L
TE sensor pocket for driptray	Ø 8 mm L=160 mm (in- cluding thread)	-	Screw Connection	1/4 '' NPT	600	2460	10	-	-	AISI 316/316L

Table 47: Flange dimensions and measurements - PVU5000

4.3.3 Flange dimensions and measurements - PVU3000

Reference	Description	Fluid	Flange type	Flange size	PVU3000			Allowable Nozzle Loads		Material
					X	Y	Z	Fx/Fy/Fz	Mx/My/Mz	Description
A10	From pneumatic air system - Instrument air	Air	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40S	1565	3680	155	45 N	-	AISI 316/316L
G10	From Glycol system - Glycol inlet	MEG Water 50%	ANSI B16.5 Class 150 Flange	DN80-SCH.10S	946	3680	630	365 N	230 Nm	AISI 316/316L
G20	To Glycol system - Glycol return	MEG Water 50%	ANSI B16.5 Class 150 RF Welding Neck Flange	DN80-SCH.10S	1293	3680	401	365 N	230 Nm	AISI 316/316L
H10	To Recondenser	LNG	Grayloc Flange	DN40-SCH.XXS	261	3462	260	828 N **	71 Nm	AISI 316/316L
H20	From Recondenser	LNG	Grayloc Flange	DN40-SCH.XXS	461	3462	260	828 N **	71 Nm	AISI 316/316L
H50	To GVT - Gas outlet coordinate indicates yard weld point	NG	Grayloc Flange	DN40-SCH.XXS	1837	3747	260	828 N	71 Nm	AISI 316/316L
L10	From feed pump - LNG inlet	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN40-SCH.40S	251	20	308	159 N *	37 Nm	AISI 316/316L
L20	To LNG tank - LNG return	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN25-SCH.40S	1837	20	355	90 N	-	AISI 316/316L
N10	From Nitrogen purge system - maintenance	N_2	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40S	542	20	278	45 N	-	AISI 316/316L

Reference	Description	Fluid	Flange type	Flange size	PVU3000			Allowable Nozzle Loads		Material
					X	Y	Z	Fx/Fy/Fz	Mx/My/Mz	
N20	From Nitrogen system - Pump seal gas	N_2	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40S	422	20	278	45 N	-	AISI 316/316L
O10	From Hyd Station HP Oil inlet	Oil SAE30/ Hyd	Flange SAE J518 (ISO6162-1)	DN40-CODE62 (1-1/2'' - 6000 PSI)	2140	780	158	Flexible Connection		Coated Carbon Steel
O30	To Hyd Station tank - Oil return	Oil SAE30/ Hyd	Flange SAE J518 (ISO6162-1)	DN65-CODE61 (1-1/2'' - 6000 PSI)	2140	1060	170	Flexible Connection		Coated Carbon Steel
O40	To Hyd Station tank - Oil drain	Oil SAE30/ Hyd	JIC Male Fitting (SAE J514) (ISO 8434-1)	3/4''	2205	655	1267	Flexible Connection		Coated Carbon Steel
V10	To LP vent - LP PSV	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN40-SCH.40S	1591	20	278	159 N	37 Nm	AISI 316/316L
V20	To HP vent - HP PSV	LNG	ANSI B16.5 Class 300 RF Welding Neck Flange	DN50-SCH.40S	2220	2284	1041	273 N	80 N	AISI 316/316L
V30	To LP vent - Pump seal gas	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40S	2220	1518	155	45 N	-	AISI 316/316L
V40	To LP vent - LP bleed	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN25-SCH.40S	1480	20	355	90 N	0.5 Nm	AISI 316/316L
Earthing	Earthing connection to hull	-	Screw Connection	M12	130	50	130	-	-	AISI 316/316L

Reference	Description	Fluid	Flange type	Flange size	PVU3000			Allowable Nozzle Loads		Material
					X	Y	Z	Fx/Fy/Fz	Mx/My/Mz	
TE sensor pocket for driptray	Ø 8 mm L=160 mm (including thread)	-	Screw Connection	1/4 '' NPT	600	2460	10	-	-	AISI 316/316L

Table 48: Flange dimensions and measurements - PVU3000

4.3.4 Flange dimensions and measurements - PVU4000E

Reference	Description	Fluid	Flange type	Flange size	PVU4000E			Allowable Nozzle Loads		Material
					X	Y	Z	Fx/Fy/Fz	Mx/My/Mz	
A10	From pneumatic air system - Instrument air	Air	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40S	1565	3680	155	45 N	-	AISI 316/316L
G10	From Glycol system - Glycol inlet	MEG Water 50%	ANSI B16.5 Class 150 RF Welding Neck Flange	DN80-SCH.10S	946	3680	630	365 N	230 Nm	AISI 316/316L
G20	From Glycol system - Glycol return	MEG Water 50%	ANSI B16.5 Class 150 RF Welding Neck Flange	DN80-SCH.10S	1293	3680	401	365 N	230 Nm	AISI 316/316L
H50	To GVT - Gas outlet coordinate indicates yard weld point	NG	Grayloc Flange	DN40-SCH.XXS	1837	3747	260	828 N	71 Nm	AISI 316/316L
L10	From feed pump - LNG inlet	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN40-SCH.40S	251	20	308	159 N *	37 Nm	AISI 316/316L
L20	To LNG tank - LNG return	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN25-SCH.40S	1837	20	355	90 N	-	AISI 316/316L
N10	From Nitrogen purge system - maintenance	N_2	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40S	542	20	278	45 N	-	AISI 316/316L
N20	From Nitrogen system - Pump seal gas	N_2	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40S	422	20	278	45 N	-	AISI 316/316L

Reference	Description	Fluid	Flange type	Flange size	PVU4000E			Allowable Nozzle Loads		Material
					X	Y	Z	Fx/Fy/Fz	Mx/My/Mz	
O10	From Hyd Station HP Oil inlet	Oil SAE30/ Hyd	Flange SAE J518 (ISO6162-1)	DN40-CODE62 (1-1/2'' - 6000 PSI)	2140	780	158	Flexible connection		Coated Carbon Steel
O30	To Hyd Station tank - Oil return	Oil SAE30/ Hyd	Flange SAE J518 (ISO6162-1)	DN65-CODE61(1-1/2'' - 3000 PSI)	2140	1060	170	Flexible connection		Coated Carbon Steel
O40	To Hyd Station tank - Oil drain	Oil SAE30/ Hyd	JIC Male Fitting (SAE J514) (ISO 8434-1)	3/4''	2205	655	1267	Flexible connection		Coated Carbon Steel
V10	To LP vent - LP PSV	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN40-SCH.40S	1591	20	278	155 N	37 Nm	AISI 316/316L
V20	To HP vent - HP PSV + Blowdown	LNG	ANSI B16.5 Class 300 RF Welding Neck Flange	DN50-SCH.40S	2220	2284	1041	270 N	80 N	AISI 316/316L
V30	To LP vent - Pump seal gas	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN15-SCH.40S	2220	1518	155	45 N	-	AISI 316/316L
V40	To LP vent - LP bleed	LNG	ANSI B16.5 Class 150 RF Welding Neck Flange	DN25-SCH.40S	1480	20	355	90 N	0.5 Nm	AISI 316/316L
Earthing	Earthing connection to hull	-	Screw Connection	M12	130	50	130	-	-	AISI 316/316L
TE sensor pocket for driptray	Ø 8 mm L=160 mm (in-cluding thread)	-	Screw Connection	1/4 '' NPT	600	2460	10	-	-	AISI 316/316L

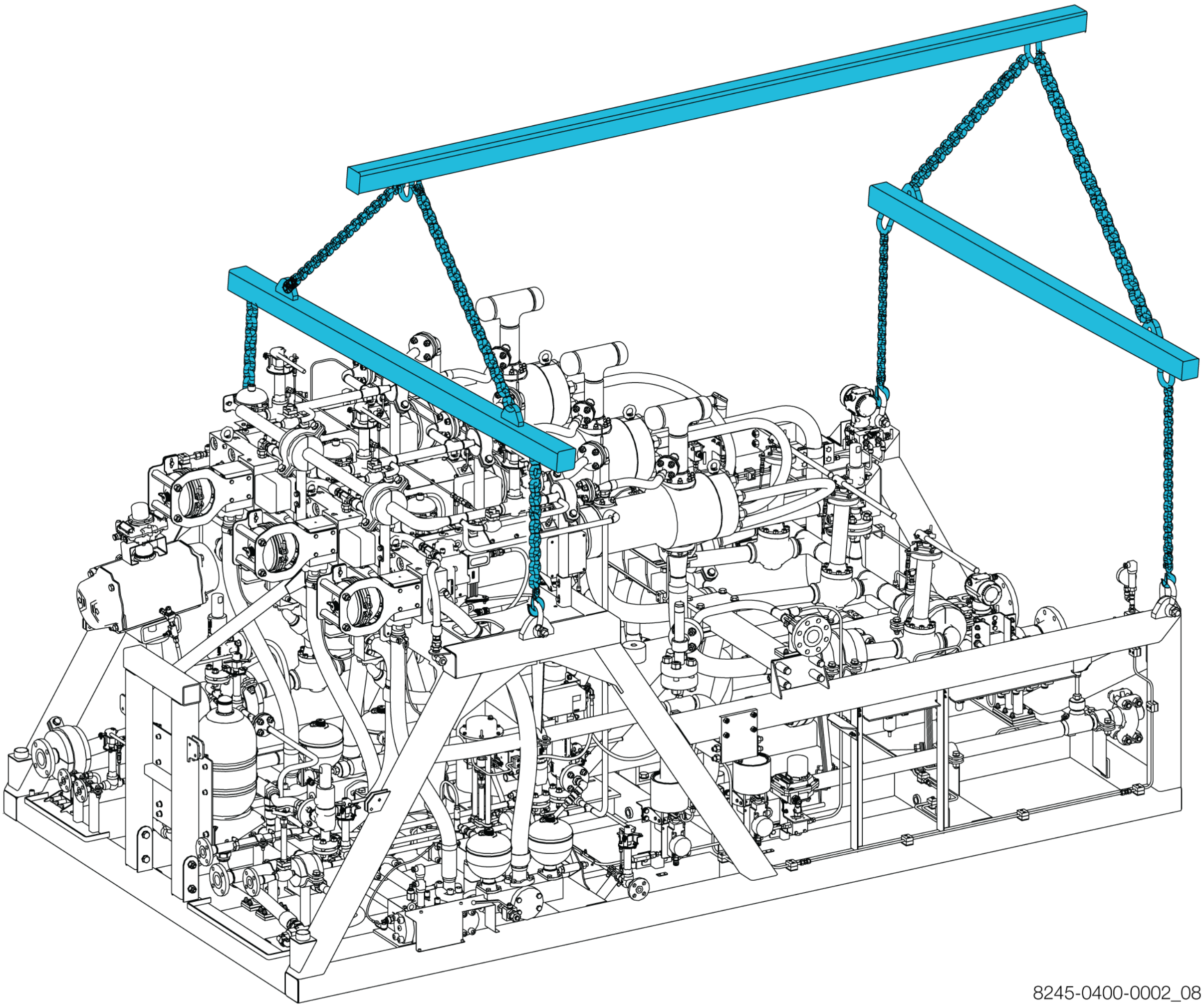
Table 49: Flange dimensions and measurements - PVU4000E

4.4 Lifting on Board (PVU)

⚠ WARNING Always use lifting gear with sufficient Working Load Limit (WLL).

NOTICE The tool for lifting the PVU shown in the graphics is only for reference.

The PVU must be moved from the storage location and placed alongside the vessel by a forklift. Afterwards, it must be lifted on board by crane using the four lifting eyes and placed on the PVU foundation on the deck for mounting.



8245-0400-0002_08

Figure 33: Lifting on board, proposal for lifting

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⚠ WARNING Use similar lifting tool to avoid risk of bending of the PVU frame.

4.4.1 Lifting Co-ordinates

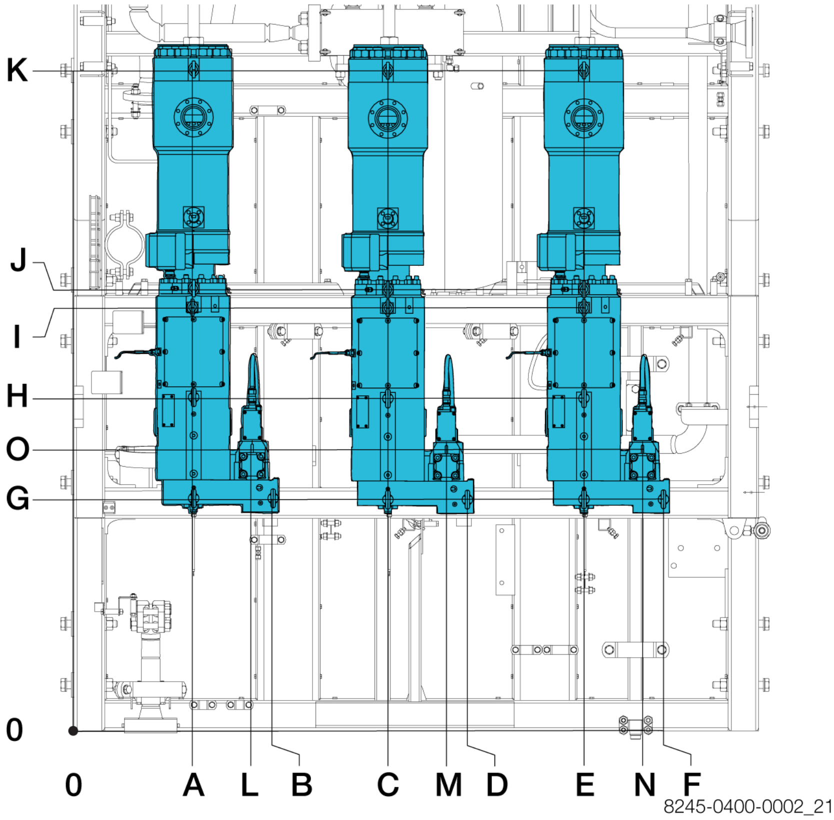

Figure 34: Lifting co-ordinates

Position	Dimensions (mm)
A	391
B	651
C	1031
D	1291
E	1671
F	1931
G	760.5
H	1091.5
I	1390
J	1447.5
K	2164
L	583
M	1223
N	1863
O	923

Table 50: Dimensions for lifting co-ordinates

4.4.2 Lifting Arrangement for High Pressure Pump Complete

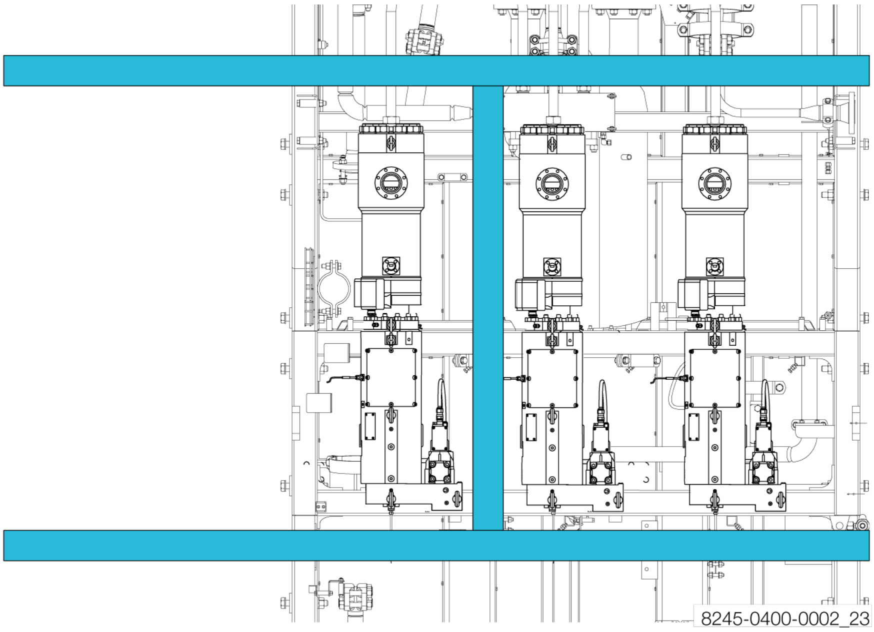

Figure 35: Lifting crane trolley for high pressure pump

A crane hoist is used for lifting of the high pressure pump complete or the cold ends alone or other individual parts on the PVU. A crane hoist can move the pump vertically and horizontally as well. It has two chain loops – hand chain and lifting chain. Hand chain sits on a wheel located in the lifting mechanism, it needs to be pulled by hand in order to lift a load. The wheel inside the lifting mechanism has got special pockets that allow the hand chain to move the wheel.

Figure 36: Example for lifting of HP pump

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4.4.3 Lifting of SHPS

⚠ WARNING Always use lifting gear with sufficient Working Load Limit (WLL).

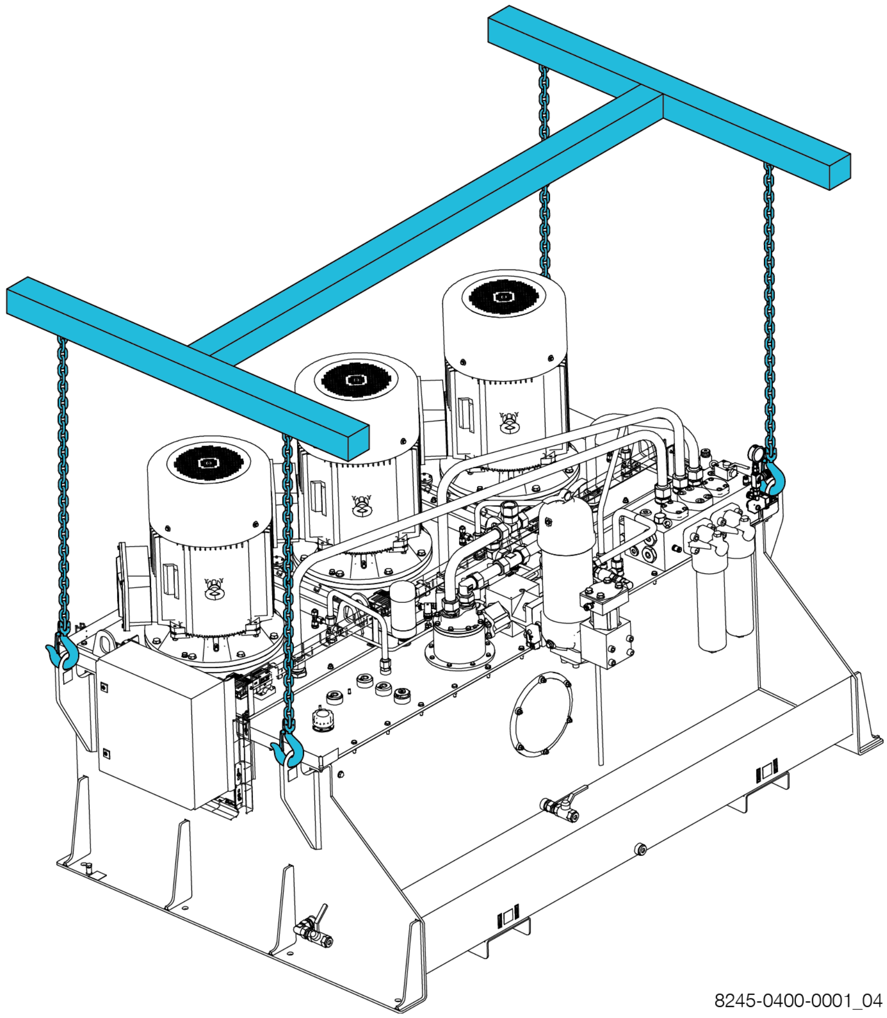

Figure 37: Lfting of SHPS

NOTICE Lift the unit only when empty.

⚠ CAUTION Inappropriate alignment can cause mechanical stress to the unit. This could lead to leakage from hydraulic tank. Alignment of the unit must only be performed under surveillance of skilled technical personnel.

4.5 Identification Plate

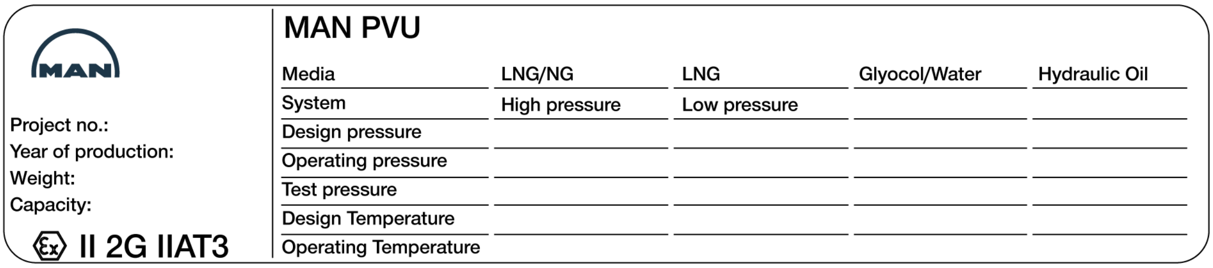

Figure 38: Example of PVU identification plate

4.5.1 PVU8000

Media	LNG/NG	LNG	Glycol/Water	Hydraulic oil
System	High pressure	Low pressure		
Design pressure	350 bar (g)	16 bar (g)	10 bar (g)	315 bar (g)
Operating pressure	200-326 bar (g)	7-10 bar (g)	3-5 bar (g)	250 - 300 bar (g)
Test pressure	525 bar (g)	24 bar (g)	15 bar (g)	473 bar (g)
Design temperature	-196 °C / +80 °C	-196 °C / +80 °C	-25 °C / +80 °C	-25 °C / +60 °C
Operating Temperature	-163 °C / +55 °C	-163 °C	55 °C	45 °C

Table 51: Parameters for PVU8000

4.5.2 PVU4000E

Media	Liquid Ethane/ Ethane	Liquid Ethane	Glycol/Water	Hydraulic oil
System	High pressure	Low pressure		
Design pressure	420 bar (g)	16 bar (g)	10 bar (g)	315 bar (g)
Operating pressure	380-400 bar (g)	7-10 bar (g)	3-5 bar (g)	250 - 300 bar (g)
Test pressure	630 bar (g)	24 bar (g)	15 bar (g)	473 bar (g)
Design temperature	-196 °C / +80 °C	-196 °C / +80 °C	-25 °C / +80 °C	-25 °C / +60 °C
Operating Temperature	-137 °C / +55 °C	-137 °C / +88 °C	55 °C	45 °C

Table 52: Parameters for PVU4000E

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4.6 Layout

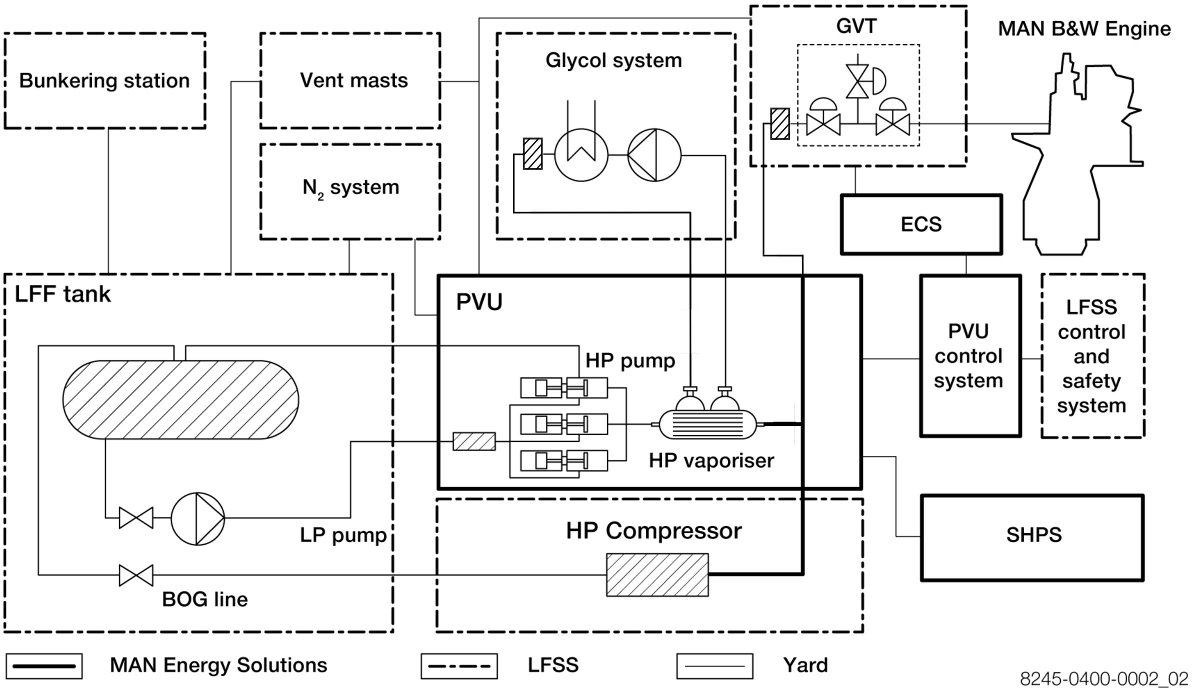
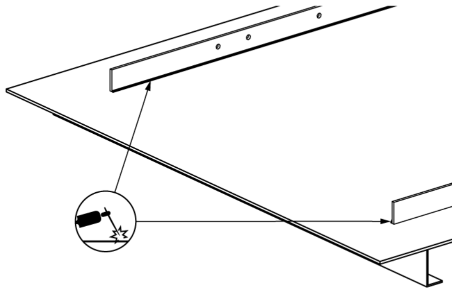


Figure 39: PVU layout

4.7 Installation Procedure

NOTICE The installation procedure is independent of the size of PVU. As per the PVU variant, the distances between bolts used in installation may vary.

1. Weld the two brackets to the foundation as indicated on the illustration. The flat bars should be welded to the deck with minimum 10 mm and maximum 20 mm wider apart than the width of the PVU frame in order to ease installation. The gap will be compensated with epoxy resin when PVU is in place.



2. Lift and place the PVU between the two brackets for permanent installation, using lifting eyes, tackle and crane.
3. Lower and hold the PVU at X = 10 mm above the foundation between the brackets.

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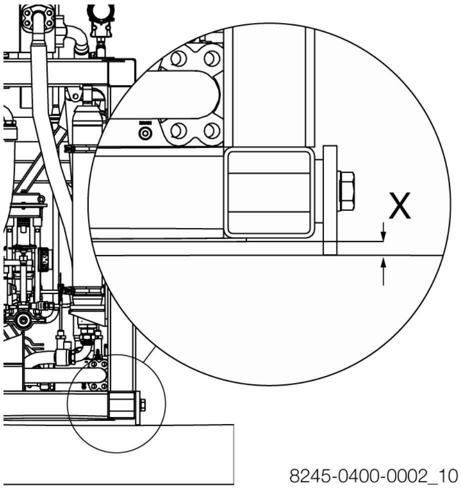
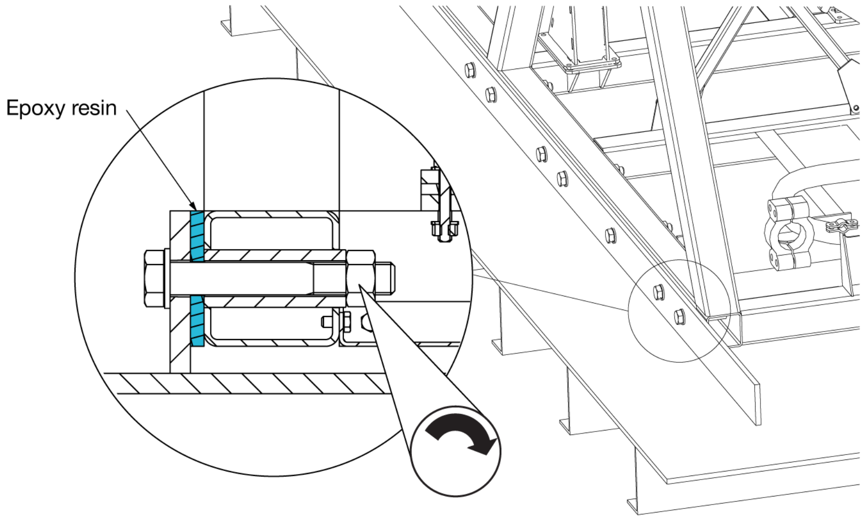


8245-0400-0002_10

4. Mount the bolts and pour the epoxy resin in between the side plate and the frame, on both sides of the PVU.
5. After the epoxy resin is hardened, apply thread seal on the bolt threads. Mount and tighten the nuts with a tightening torque of 460Nm.



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NOTICE Epoxy resin is placed in between the PVU frame and the bracket for insulation purpose, to compensate pre-stress from imperfections.

4.8 Storage Conditions

4.8.1 Cryogenic Pump

If the cryogenic pump is not installed immediately, it should be stored in a dry place, protected from dust, impurities and spattering of oil. An extended period of storage should never take place in a place which is subject to vibrations (e.g. any area close to a compressor should be avoided). The protection made of the polyethylene protective sheeting should be kept in place for as long as possible, e.g. up to the time of commissioning of the equipment.

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4.8.1.1 Long time storage with SEI4C packing

If the packing is not opened or damaged, you can let the cold-ends as it is :

- Every years, you will have to open the crate and the bag, purge with Nitrogen, place a new desiccant and remove the former one, vacuum and re-seal the bag, re-close the crate. The packing has to be SEI4C.
- Every 5 years, you will have to open the cold-end and inspect the soft seals and use the kit Quick-fix if necessary.

For long time storage onboard offshore :

- Every years, you will have to open the crate and the bag, purge with Nitrogen, place a new desiccant and remove the former one, vacuum and re-seal the bag, re-close the crate. The packing has to be SEI4C
- Every 3 years, you will have to open the cold-end and inspect the soft seals and use the kit Quick-fix if necessary.

In both long time storage, if crate have external damages, it is necessary to repack SEI4C + issue a cold-end inspection and use the kit quick-fix of soft gaskets if necessary.

4.8.1.2 Storage Preservation Conditions

Duration after delivery	Outdoor	Under shelter	Inside warehouse	Unpack and install on site not running)
0 to 3 months	▪ Packages as received (unopened) ▪ Storage area not subject to vibration or shocks	▪ Packages as received (unopened) ▪ Storage area not subject to vibration or shocks	▪ If packages have been opened for Customs check or other reasons, advice the vendor ▪ Storage area not subject to vibration or shocks	▪ Storage area not subject to vibration or shocks ▪ Start ACH
3 to 9 months	▪ Storage forbidden (see guaranty section)	▪ Packages as received (unopened) ▪ Storage area not subject to vibration or shocks	▪ Same as above	▪ Same as above
9 months to 1 year	▪ Storage forbidden (see guaranty section)	▪ Storage forbidden (see guaranty section)	▪ Same as above ▪ If storage extends beyond 9 months, carry out a purging of the atmosphere inside the protective plastic using warm (+10°C) Nitrogen gas (or dry air) at 1 Nm3/h and 0.05 bar for 6 hours, and then reseal the packaging.	▪ Same as above ▪ Purge inside of pump with dry air or Nitrogen.
1 and 5 years	▪ Storage forbidden (see guaranty section)	▪ Storage forbidden (see guaranty section)	▪ Same as above ▪ Every year, carry out a purging of the atmosphere inside the protective plastic using warm (+10°C) Nitrogen gas (or dry air) at 1 Nm3/h and 0.05 bar for 6 hours, and then reseal the packaging and replace the silica gel.	▪ Same as above
5 years after delivery	▪ Storage forbidden (see guaranty section)	▪ Storage forbidden (see guaranty section)	▪ Proceed with the pump soft seals replacements such as (cupper seals, hat seal, lip seals, o-rings, guiding sleeve)	▪ Proceed with the pump soft seals replacements such as (cupper seals, hat seal, lip seals, o-rings, guiding sleeve)

Table 53: Storage Preservation Conditions for Cryogenic Pumps

4.9 Cleanliness

The PVU and SHPS comes pressure tested, cleaned and dried from supplier, whereas any opening up of the system should be done with great care to avoid entry of debris into the system.

The PVU work area should always be kept clean and tidy.

Oily rags must never be left around the PVU work area as they are highly flammable and slippery.

Remove any oil spill immediately.

If there is a risk of grit or sand blowing into the PVU work area, stop the ventilation and close the ventilating ducts, skylights.

Welding or other work that causes spreading of grit and/or swarf must not be carried out near the PVU unless the system is fully purged and isolated.

The exterior of the PVU should be kept clean, and the paintwork maintained, so that leakages can be easily detected.

4.9.1 Pump Vaporiser Unit

The procedure for checking the pressure is described in the transportation documentation. Inlet and outlet pipes have flanges with a minimess coupling to apply, control and drain the pressure.

It is recommended to keep the transportation flanges mounted as long as possible and only drain the nitrogen pressure just before connecting the PVU to the vessel's piping system. If it is necessary to alter the PVU piping when connecting it to the vessel's piping, make sure that openings are covered with masking tape in order to keep grinding and welding debris out of the system.

NOTICE Ensure that the LFF inlet and outlet pipes are clean and free from foreign particles.

The responsibility of the cleanliness of the pipe connections lies with the shipyard.

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4.9.2 Standalone Hydraulic Power Supply

NOTICE Ensure that the pipe connections between SHPS and PVU are clean at the time of installation.

The responsibility of the cleanliness of the pipe connections lies with the shipyard.

The hydraulic unit must be installed in a clean environment free from dust. It must be taken into consideration that the installation location must be able to handle possibly oil spillage. The hydraulic unit has built-in spill tray, which can contain a significant amount of oil from the tank.

Both the PVU and SHPS shall be considered arriving clean and free from debris, whereas all external piping connecting PVU and SHPS shall be cleaned before connecting. Hydraulic oil pipes, shall be flushed, bypassing the PVU and SHPS (scope of shipyard), to a minimum cleanliness value according to ISO 4406 18/16/13 after flushing the system. Wherein 18 specifies the number of particles larger than 4 μm (c), 16 specifies the number of particles larger than 6 μm (c), 13 specifies the number of particles larger than 14 μm (c) related to 1 ml respectively 100 ml of the inspected fluid. The result of the flushing is to be verified by particle counting. An online laser fluid sensor can be used for particle counting. The online laser particle counter will save time at the flushing. Correct oil cleanliness level can be verified during the flushing process and it can be ended at the moment when correct cleanliness level is obtained. For detailed flushing procedure, refer document 0744901-3.

4.10 Filtration

In order to protect the gas supply system and engine against particles and contaminants, the Second Fuel supply system supplier must ensure that the below filter requirement is met.

Designation	Value
Maximum particle size [μm][1]	10

The cleaning and maintenance procedures should be considered for any filter position with respect to heating, purging, depressurization, personal safety during opening, recommissioning after cleaning and cool-down amongst others. Filters should be fitted with differential pressure transmitters for monitoring and alarm. In case particles or ice might be present in general and otherwise in accordance with the requirements of operation set by the ship owner, parallel or duplex filters could be considered

*1 ME-GI Fuel supply - LF fuel system

For detailed information refer the Design Documentation for Yards.

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4.11 Center of Gravity

4.11.1 PVU8000

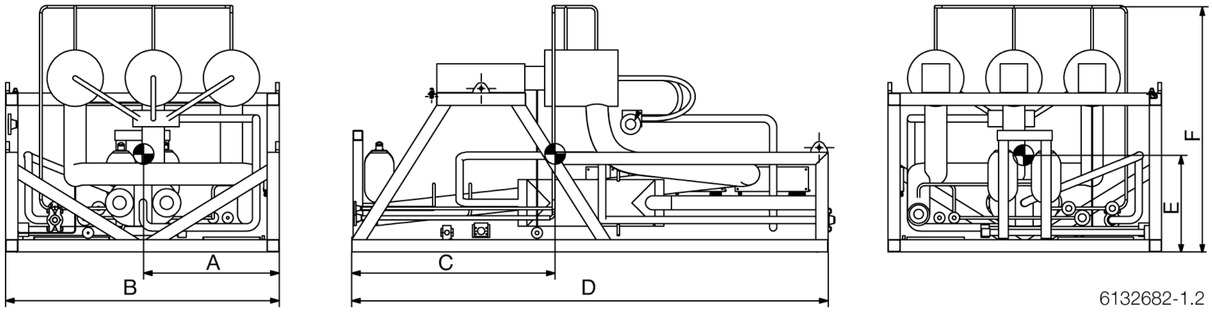

Figure 40: Center of Gravity PVU8000

A	B	C	D	E	F
1110	2240	1665	3900	800	2011

Table 54: Center of Gravity PVU8000

Mass Elastic Data at the Centre of Gravity

Mass moment of Inertia [kg m^2]		
I_x	I_y	I_z
5850	3350	6100

Table 55: Mass moment of Inertia

4.11.2 PVU5000

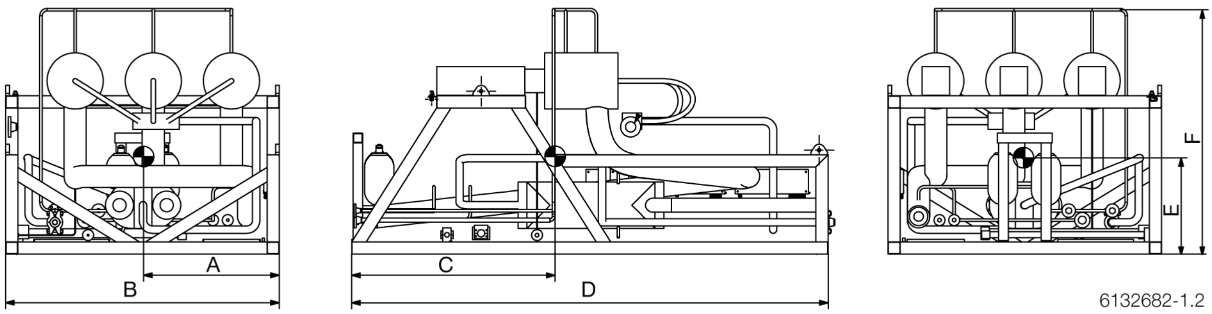

Figure 41: Center of Gravity PVU5000

A	B	C	D	E	F
1110	2240	1540	3700	830	2011

Table 56: Center of Gravity PVU5000

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Mass Elastic Data at the Centre of Gravity

Mass moment of Inertia [kg m²]		
I_x	I_y	I_z
4825	3200	5100

Table 57: Mass moment of Inertia

4.11.3 PVU3000

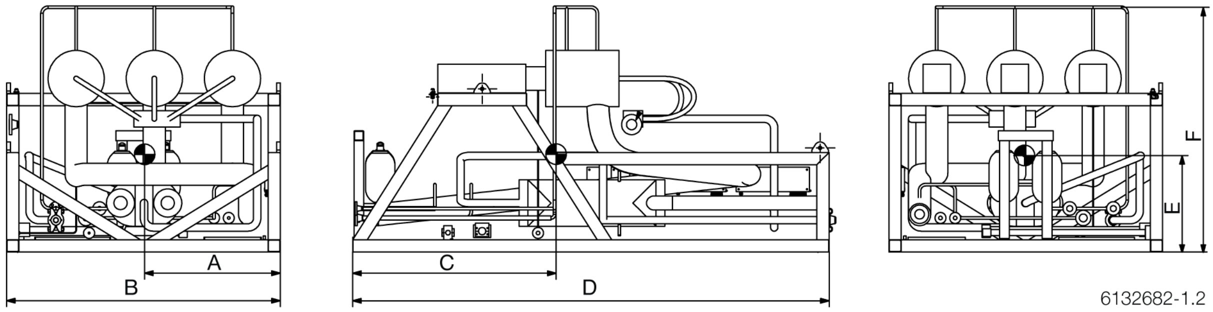

Figure 42: Center of Gravity PVU3000

A	B	C	D	E	F
1110	2240	1540	3700	800	2011

Table 58: Center of Gravity PVU3000

Mass Elastic Data at the Centre of Gravity

Mass moment of Inertia [kg m²]		
I_x	I_y	I_z
4400	2900	4600

Table 59: Mass moment of Inertia

4.11.4 PVU4000E

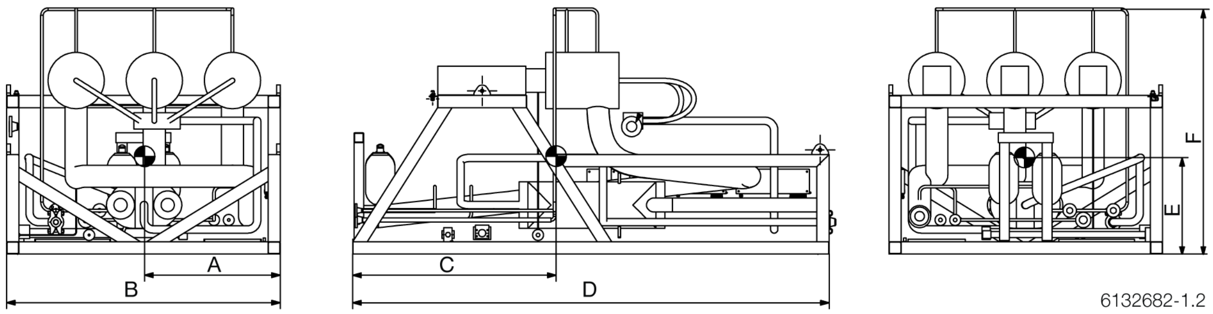

Figure 43: Center of Gravity PVU4000E

A	B	C	D	E	F
1110	2240	1540	3700	800	2011

Table 60: Center of Gravity PVU4000E

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Mass Elastic Data at the Centre of Gravity

Mass moment of Inertia [kg m²]		
I_x	I_y	I_z
4400	2900	4600

Table 61: Mass moment of Inertia

4.12 Foundation for PVU

The foundation for the PVU consisting of two longitudinal flat bars welded upright to the deck. It is important that the flat bars are crossing deck stiffeners and that the flat bar is continued to take support from next reinforcement outside the PVU frame.

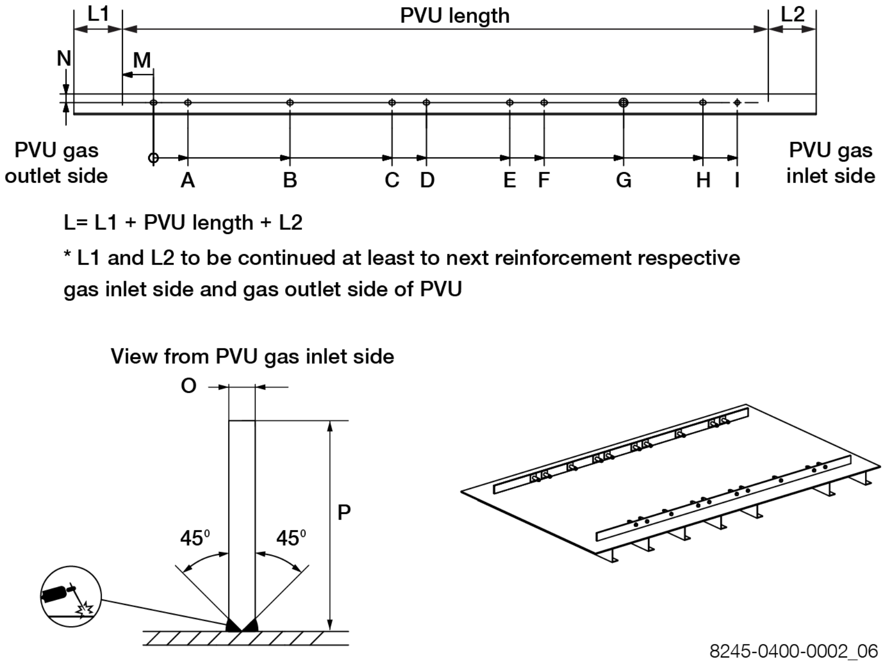


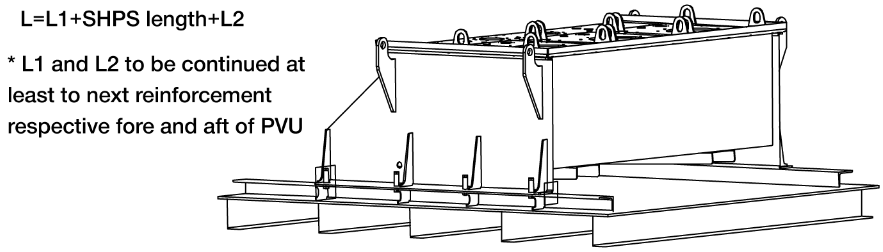
Figure 44: Foundation for PVU, example PVU8000

Dimensions											
PVU Size	A (Oval)	B (Oval)	C (Oval)	D (Oval)	E (Oval)	F (Oval)	G (Oval)	H (Oval)	I (Circular)	M (Oval)	PVU Length
8000	200	887	1589.5	1789.5	2275	2475	2937.5	3400	3600	150	3900
5000	200	795	1389.5	1589.5	2075	2275	2737.5	3200	3400	150	3700
3000	200	795	1389.5	1589.5	2075	2275	2737.5	3200	3400	150	3700
4000E	200	795	1389.5	1589.5	2075	2275	2737.5	3200	3400	150	3700

Table 62: Dimensions for PVU foundation

4.13 Foundation for SHPS

Everllence recommends a foundation for the SHPS consisting of two longitudinal angle bars welded upright to the deck. It is important that the angle bars are crossing deck stiffeners and that the angle bar is continued to take support from next deck stiffener outside the SHPS frame.



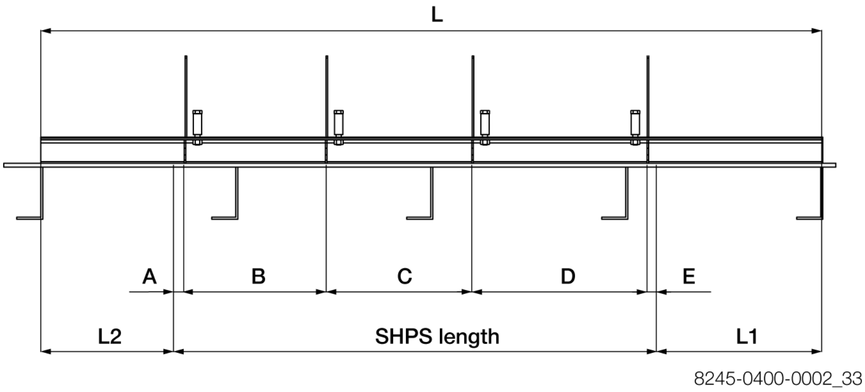


Figure 45: Foundation for SHPS

Dimensions (mm)					
SHPS type	A	B	C	D	E
200	40	543	563	674	30
300	49	543	563	674	21
500	54	543	563	674	16

Table 63: Dimensions for SHPS foundation

4.14 Electrical Connections

4.14.1 Intrinsically Safe Connections

The junction boxes are fitted in a hazardous area (Ex) Zone 1. Refer to the instructions regarding electrical work in a hazardous area (Ex) zone production specification 0743606-1. For updated document please contact Everllence PrimeServ.

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4.14.2 IECEx Components

Qualifications

The inspection and maintenance of IECEx installations shall be carried out only by experienced personnel, whose training has included instruction on the various types of protection and installation practices, the requirements of standard IEC 60079-17 and the relevant classification/national regulations/company rules applicable to the installation.

Maintenance

To ensure that the IECEx installations are maintained in a satisfactory condition for continued use within a hazardous area, either

- regular periodic inspections, or
- continuous supervision by skilled personnel, and, where necessary, maintenance shall be carried out.

An inspection plan must be created for the installation. The inspection plan must include the maintenance requirements for the individual components.

The grade of inspection may be visual or detailed. Visual inspections can be performed with the equipment energised. Detailed inspections will generally require the equipment to be isolated.

Replacement parts shall be in accordance with the applicable documentation supplied by the manufacturer. Alterations to equipment shall not be carried out without appropriate authorisation where they adversely affect the safety of the equipment as stated in the applicable documentation.

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5 Extent of Delivery

Required info data is minimum to be informed enabling Everllence to specify layout of PVU and SHPS type. All remaining data is required before final layout and final quotation can be given.

Kindly fill the EOD form and send it back to respective contact person and pvusales@everllence.com.

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