skoflo	TITLE **Installation, Operation and Maintenance Manual Chemical Injection Metering Valves, Test Flushing Units and Receptacles**	DOC NUMBER **DOC-02666**
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APPROVAL PROCESS				
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REVISION HISTORY			
Effective Date	Rev	Author Initials	Description
18-Mar-2016	A	MGL	Initial Release
02-May-2017	B	AS/SOC	Modified title to include "Receptacle". Document re-structured/ordered significantly; therefore, paragraph numbers are not always referenced. The following information was added: • "Zero-flow differential" to Pumping Zero definition to align with user manual. • Section 8.5 regarding compatibility and corrosion, referenced in 27.3.1 and 27.4.1 • P&ID Figures 1 and 2 • 9.5.4, 9.6.3: clarified pressure sensor outputs • Flow charts for measurement methods in section 11 • Receptacle lifting points • Wet Mate connector installation section • Roark and Young equation reference to 27.4.13 • Resistance check in 27.4.1 • Recommendation for external outlet check valve in 27.4.1 • Maximum Docking Velocity and break-out torque foot note to Table 4. • Clarification on lifting points in 18.6.3 • Additional 50 ft-lb of torque in 18.6.5 • Added caution regarding rotation motion in 18.6.6 • Communication address common cause under "no communication response from CIMV" in 26. • SkoFlo contact information Updated Table 4. • Distinguished "MF" from "HF". • 27.3.4.2: Added details regarding split flange. • Added ground strap notation in Figure 53. Minor updates/clarifications through-out
20-Sep-2017	C	BU	Section updates to include ROV Mate connector: 7.2.2, 8.2, 9.1.3, 9.2.2, 14.1, 14.5, 15.3.2, 18.6.11.1, 19.4.2, 19.5.2, 27.2, 27.3.4.2, 27.4 Figures added to include ROV Mate connector: 13, 15, 17, 19, 22, 23, 31-37, 39, 41, 46-49, 51, 60, 61, 64, 68-70
12-Feb-2018	D	SS	Updated Table 7. Section 8.4.5 "upstream", was "downstream".

08-Sep-2021	E	MH	Restructured section 2.1.2. Removed section 2.1.3. Added SCM to Abbreviation Table in section 4. Edited the definition of Shall in section 5.2. Reworded section 8.1.4 to allow it to apply to all structured products. Removed 10,000 psi designation from Table 1 and Table 2 descriptions. Added disclaimer below Table 1 and Table 2 to indicate the table may not apply for certain products. Reworded section 16.1 to allow it to apply to all structured products. The following information was added to section 17.7: • 17.7.6: Torque the shaft in the CCW direction until breakout is achieved • 17.7.7: Once achieved, reduce the torque to a level sufficient to complete the undocking procedure. • 17.7.8: Continue with CCW rotation until the hard stop is reached. Updated Table 4 to clarify that the dual high flow torque values are only applicable for 10,000 psi products. Added 2271 to 3406 LPH Flow range to Table 7. Added information about cleaning the couplers of debris before storing to section 23.2. Added information about replacing damaged seals on couplers before reinstalment to section 24.2.3. Added information to clear debris accumulation out of the PDFM to the Low Flow CIMV Troubleshooting table in section 25.2.
01-Mar-2022	F	MH	Added note that P3 and P4 are optional in Figure 4 and Figure 5 Updated Figure 10. Updated Figure 11. Fixed broken visual in Figure 28. Corrected referenced to tables and figures in 17.6.11.1, 19.1.2, 26.3.5.3.1 Updated storage temperature to 0°F - 158°F (-18°C - 70°C) in Section 23. Added instructions for tronic split flanges in Section 26.3.5.3
27-Jun-2023	G	CR	Updated Docking Procedure (Section 17 & 18) to state only use enough torque to make the 8 ¾ turns. Perform IR test Prior to installation
20-Oct-2023	H	NL	Removed the 3,000 psi reference with outlet pressure in regards to cavitation (section 25). Updated IR test requirements based off industry standards from API 17F (17.6.3).
12-Dec-2023	J	NL	Updated 22.3.2 to reference 18.7 through 18.9 general, horizontal, and vertical installation, updated 24.4.1 to include 30 year design life. Updated 26.3.2 to reference figure 67. Updated section 9.1 to reference table 1 and 2.

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1. Purpose

1.1 This manual gives an overview of the installation, operation, maintenance and preservation of select SkoFlo subsea products. Procedures described in this manual are intended to be carried out by competent and trained personnel only. The specific products covered are listed below:

1.1.1 Low Flow chemical injection metering valves with positive displacement flow meters

1.1.2 High Flow chemical injection metering valves

1.1.3 Low Flow and High flow test flushing units

1.1.4 Low Flow and High flow receptacles

2. Applicability/Scope

2.1 This document is intended for use for SkoFlo's Structured products. The information herein may be applicable in its entirety to custom projects as well.

2.1.1 Structured Products are defined as follows:

2.1.1.1 Low Flow CIMVs with PDFM

2.1.1.2 High Flow CIMVs

2.1.1.3 Low Flow and High Flow TFUs, with or without pressure sensor

2.1.1.4 Receptacles, Vertical, Horizontal and Extended Horizontal

2.1.2 Structured Products have the following characteristics:

2.1.2.1 Stab Mate connector

2.1.2.2 ROV Mate connector

2.1.2.3 Analog sensors

2.1.2.4 CANbus software version 2.X and higher

2.1.2.4.1 Modbus software information is included in this manual for custom projects utilizing this protocol.

2.1.2.5 LF and MF CIMVs and TFUs utilize a UO-8 hydraulic interface

2.1.2.6 HF CIMVs and TFUs utilize a UO-16 hydraulic interface.

3. Health, Safety, and Environmental Considerations

3.1 Warnings or cautions may be included throughout this instruction. These warnings or cautions do not completely describe hazards or precautionary measures applicable to specific procedures or operating environments they are selected points from the associated Job Hazard Analysis (JHA). During the performance of this procedure personnel may come in contact with material that have potential hazards associated with them and are required to read all applicable Safety Data Sheets (SDS). Personnel are required to use all Personal Protective Equipment (PPE) required by JHA and SDS. For disposition of hazardous waste materials, consult SDSs for each solvent or material. Only trained and qualified personnel shall perform operations required by this procedure.

3.2 Throughout this manual there are steps and procedures which, if not followed, may result in a hazard. The following flags are used to identify the level of potential hazard.

! WARNING

WARNING IS USED TO INDICATE THE PRESENCE OF A HAZARD WHICH CAN CAUSE SEVERE INJURY, DEATH, OR SUBSTANTIAL PROPERTY DAMAGE IF THE WARNING IS IGNORED.

! CAUTION

CAUTION IS USED TO INDICATE THE PRESENCE OF A HAZARD WHICH CAN CAUSE INJURY OR PROPERTY DAMAGE IF THE WARNING IS IGNORED.

! NOTICE

NOTICE IS USED TO NOTIFY PEOPLE OF INSTALLATION, OPERATION, OR MAINTENANCE INFORMATION, WHICH IS IMPORTANT BUT NOT HAZARD RELATED.

3.3 Safety Information

! WARNING

PROPER LIFTING TECHNIQUES SHOULD BE USED. CONSULT SITE RIGGING AND SAFETY PERSONNEL FOR REVIEW AND APPROVAL OF ALL LIFTING PROCEDURES AND SECONDARY LIFTING POINTS.

POTENTIAL PINCH POINTS EXIST – USE CAUTION WHEN HANDLING ALL COMPONENTS TO AVOID INJURY.

WEAR PROPER PERSONAL PROTECTIVE EQUIPMENT (PPE) AS REQUIRED BY SITE SAFETY PERSONNEL WHEN INSTALLING AND TESTING.

MAINTAIN SAFE WORKING DISTANCES AS DETERMINED BY SITE SAFETY PERSONNEL WHEN TESTING.

CONSULT SKOFLO IF ANY PRODUCT CONCERNS ARISE DURING HANDLING.

4. Abbreviations/Acronyms

Abbreviation	Definition
AFM	Automatic Flowmeter Measurement
BOM	Bill of Materials
CCV	Chemical Control Valve
CCW	Counter Clockwise
CIMV	Chemical Injection Metering Valve
CP	Cathodic Protection
CW	Clockwise
dP	Differential Pressure
FTG	Flow Table Generator
G	Gravitational Force Unit
GA	General Arrangement
HF	High Flow
IR	Insulation Resistance
lbf	Pound – Force
LED	Light Emitting Diode
LF	Low Flow
LVDT	Linear Variable Differential Transformer
MEG	Monoethylene Glycol
MF	Medium Flow
P&ID	Pumping & Instrumentation Diagram
PDFM	Positive Displacement Flow Meter
PPE	Personal Protective Equipment
RCU	Remote Control Unit
*RFS	Rated Full Scale
ROV	Remote Operated Vehicle
SCM	Subsea Control Module
SkoFlo	SkoFlo Industries
SIT	Site Integration Test
THI	Transport and Handling Instructions
WI	Wax Inhibitor
XT	Christmas Tree

*Rated Full Scale (RFS): Maximum calibrated flow rate of CIMV core. This is not necessarily maximum CIMV core

5. Definitions

5.1 **Should** – The topic of the statement is a recommendation of SkoFlo.

5.2 **Shall** – The topic of the statement is a requirement that must be followed.

5.3 **Bucket** – ROV mating interface located on SkoFlo docking canisters.

5.4 **Pumping Zero** – Field zero or common mode zeroing of the pressure sensors in the SkoFlo products (reference section 8.4).

5.5 **Core** – Refers to a SkoFlo product that can be housed in the docking canister (reference section 7).

5.6 SkoFlo Product Conventions

SkoFlo Convention	Common Industry Conventions	
CIMV (Chemical Injection Metering Valve)	• CITV (Chemical Injection Throttle Valve) • CCV (Chemical Control Valve) • MCV (MEG Control Valve)	• CIDV (Chemical Injection Dosing Valve) • SIDV (Scale Injection Dosing Valve) • WIDV (Wax Injection Dosing Valve)
Test Flushing Unit (TFU)	• Flusher • Dummy CIMV	• Jumper • Bypass
Receptacle	• Receptacle	

6. References, Industry Standards

6.1 The following documents are referenced throughout this document. Refer to project specific documents when applicable.

6.1.1 General Documents

6.1.1.1 DOC-00067 Pressure Build Up from Mating Hydraulic Couplers

6.1.1.2 DOC-02667 Transport and Handling Procedure, Structured Product, CIMV, Test Flushing Units and Receptacles

6.1.2 Software Specific Documents

6.1.2.1 DOC-00969 Firmware User Manual, Application SIISv2 CIMV (Analog Sensors) v2.X.X (CANopen)

6.1.2.2 DOC-00999 Firmware User Manual, Application Modbus2, CIMV, v2.X.X

6.1.3 Project Specific Documents

6.1.3.1 CIMV Specification Sheet and/or Configuration Sheet:

6.1.3.1.1 The specification and configuration sheets are used to document the project specific requirements.

6.1.3.1.2 Depending on the type of order and project requirements, projects are issued just a specification sheet or may be issued both a configuration sheet and a specification sheet.

6.1.3.1.3 These document(s) should be referenced to determine the types of products purchased and refer to the sections within this manual that are applicable.

6.1.3.2 CIMV GA Drawing

6.1.3.3 Test Flushing Unit Specification Sheet

6.1.3.4 Test Flushing Unit Configuration Sheet

6.1.3.5 Test Flushing Unit GA Drawing

6.1.3.6 Receptacle Specification Sheet

6.1.3.7 Receptacle Configuration Sheet

6.1.3.8 Receptacle GA Drawing

6.1.4 Industry Standards

6.1.4.1 SAE AS4059 - Aerospace Fluid Power – Cleanliness Classification for Hydraulic Fluids

6.1.4.2 API 17H - American Petroleum Institute – Remotely Operated Tools and Interfaces on Subsea Production Systems

7. General Product Information

7.1 SkoFlo has three primary flow controlling devices which are covered by this manual. These devices are as follows:

7.1.1 CIMV Low Flow

7.1.2 CIMV High Flow

7.1.3 TFU

7.2 Each of the above products is considered a “core”. These cores are all delivered in an external package or “docking canister” either designed to utilize a stab mate or ROV mate connection.

7.3 Each core has its own designated set of Hunting hydraulic couplers. This means that each core is a standalone flow loop. A LF core uses Hunting UO-8 couplers, and a HF core uses Hunting UO-16 couplers. A single docking canister can house up to two cores of any combination. The docking canisters are designed with an API 17H bucket (ROV mating interface) and a class 4 docking latch to allow for subsea installation and removal via an ROV. Refer to section 13 for further information. When in operation, the docking canister mates with the fourth primary SkoFlo product:

7.3.1 Receptacle

7.4 A SkoFlo receptacle is required for every docking canister product in operation at any given time (1 to 1 ratio). The receptacle contains the mating Hunting couplers to the cores in the docking canister. These mating couplers are welded to tubing or piping lengths specified by the customer who purchased the unit. Different core configurations in the docking canisters have different coupler configurations or footprints. It is required that the receptacle match the docking canister hydraulic configuration, or the units will not mate. The receptacle is a permanent fixture that is welded in place on the final structure via the customer specified coupler tubing or piping. SkoFlo receptacles can come in either horizontal or vertical configurations depending on the project requirements. Possible configurations are detailed in Receptacle Operation Overview (section 8.3).

7.5 Each SkoFlo product is comprised of various metallic and non-metallic materials. A list of seawater and chemically wetted materials can be found on the product specification sheet. Evaluation of materials for chemical compatibility and corrosion should be taken for both start-up and operation.

7.5.1 Keeping the supply lines to the valve cores clean and confirming chemical compatibility are the most important precautions in the start-up. Often the umbilical lines are flushed with a solvent then followed by the injected fluid. The solvent may cause precipitation when mixed with the calibration fluid (25% ethylene glycol and water) and likewise the injected chemical must be compatible with the solvent to flush the line.

7.5.2 If a fluid is highly conductive, a corrosion cell could exist between compounds. No known problems have been experienced with glycol or methanol. Protecting the inside of the lines with cathodes is not advisable; compatibility tests are recommended if there is any doubt. SkoFlo does not perform chemical compatibility testing.

7.5.3 SkoFlo recommends using a TFU instead of a CIMV during start-up to allow for large displacements of fluid and to minimize potential contamination during commissioning.

8. Product Operation (LF & HF CIMV, Test Flushing Unit, Receptacle)

8.1 CIMV Operation Overview

8.1.1 The SkoFlo subsea CIMV core is a remote adjustable device with feedback abilities. Commands sent to the CIMV result in stem adjustments which change the overall chemical injection flow rate. The CIMV core can adjust by a stem percent request or by a flow rate request. Adjusting by stem percent is primarily used for diagnostic purposes and not production use. Once the core adjusts, it will regulate to the new flow rate within the stated accuracy for the specific CIMV type. Refer to Flow Measurement and Flow Adjustment, LF & HF CIMV (section 10) for in depth information regarding flow adjustment and metering Figure 1 and Figure 2 below provide the P&ID for the low flow and the high flow CIMV.

8.1.2 In addition to flow adjustments accomplished by the operator, the CIMV core flow regulation includes flow adjustments to counter pressure changes on the inlet and outlet of the unit. This is referred to as “pressure independence”. Pressure independence in the SkoFlo products is a completely mechanical process, requiring zero power. The CIMV also has an “as is” failure mode. This means once a flow command has been sent to the CIMV, the power can be cut and the flow will continue to be regulated at the last specified flow rate. Refer to Pressure Independence, LF & HF CIMV (Section 9) for in depth information regarding pressure independence of the SkoFlo CIMV core.

8.1.3 Communication to the CIMV is by means of a two-wire interface. Electrical connection exists in two separate options depending on the configuration being either stab or ROV mate. For stab mate configurations, electrical connection is via a wet mate connector affixed to the docking canister and receptacle junction plate. For ROV mate configurations, electrical connection is via a wet mate connector affixed externally to the docking canister. Refer to Docking Canister Communication and Electrical Interface (section 14) for further information.

8.1.4 Refer to the project specific product specification sheet or the SkoFlo identification tag on the bucket to confirm the pressure rating of the unit.

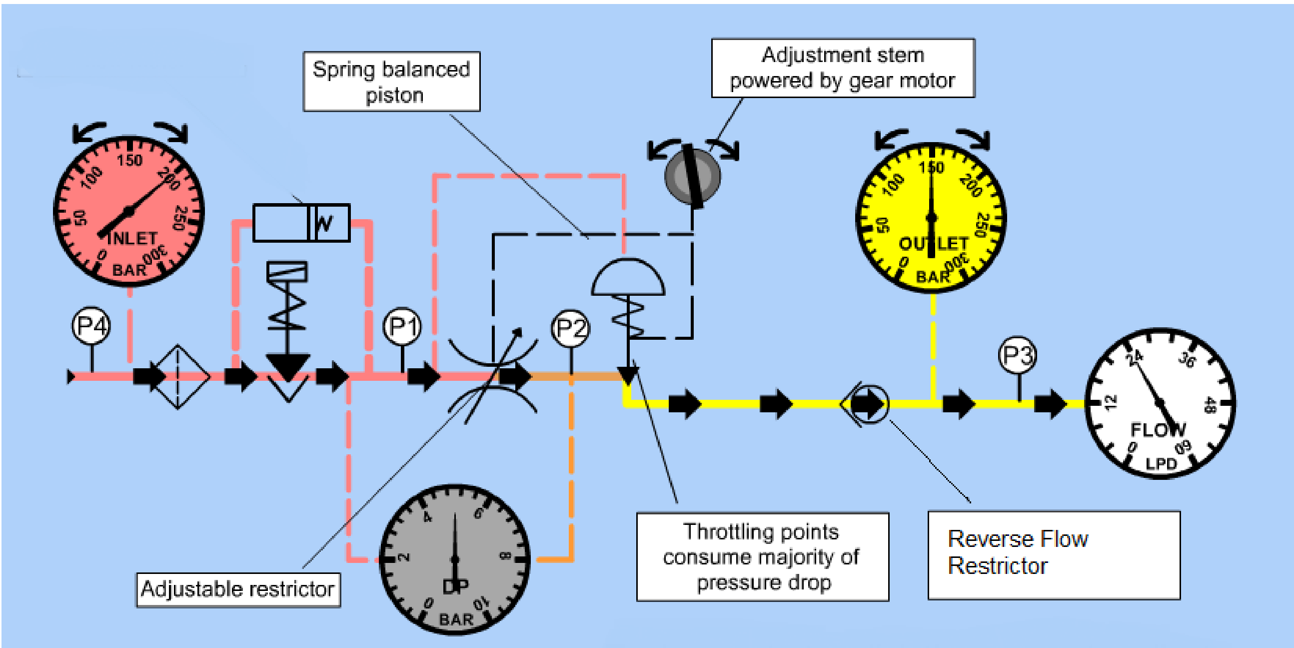


Figure 1: P&ID for Low Flow CIMV

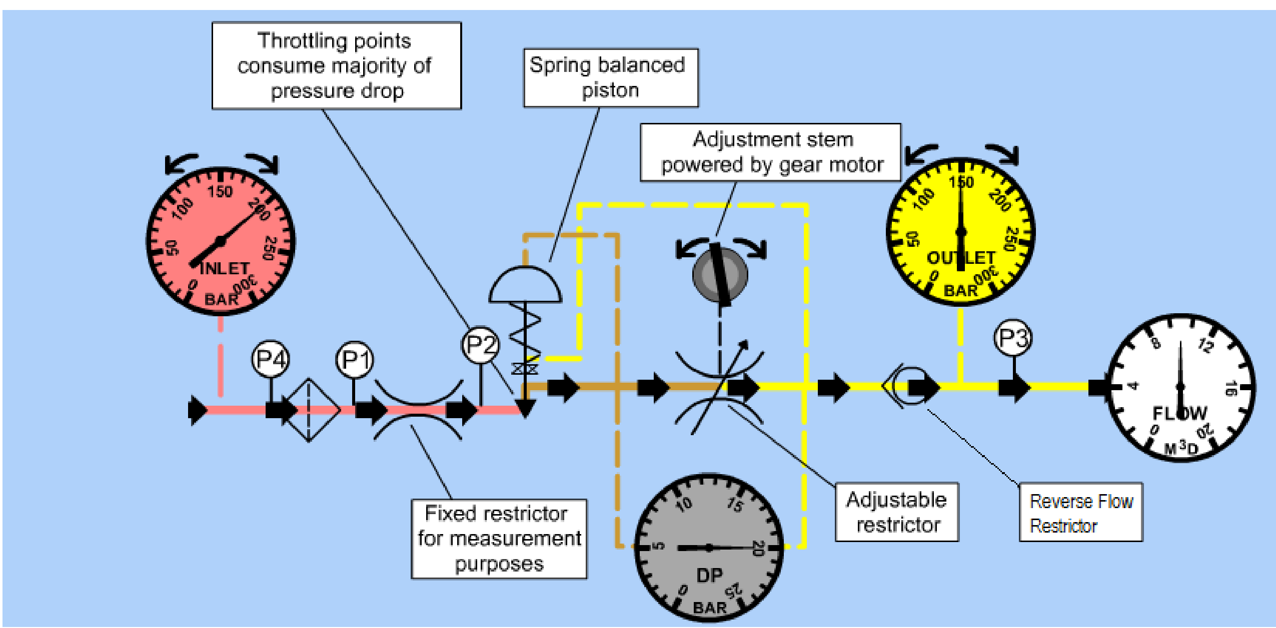


Figure 2: P&ID for High Flow CIMV

8.2 Test Flushing Unit Operation Overview

8.2.1 The SkoFlo test flushing unit (also referred to as jumper or bypass) is designed to be used as a substitute for a SkoFlo CIMV during flushing procedures and/or a long-term replacement for a CIMV in a SkoFlo receptacle. The test flushing unit has a much higher debris tolerance than a CIMV, due to the internal flow path being a relatively large fixed diameter.

8.2.2 The test flushing unit has no rate controller of any kind and has no electrical input. The hydraulic interface of the test flushing unit is designed to be the same as that of the SkoFlo CIMV it is intended to be the substitute for. For stab mate configurations, the test flushing unit comes equipped with a marine growth cap to shield the electrical connector on the receptacle when the test flushing unit is docked. For ROV mate configurations, the test flushing unit is not equipped with a marine growth cap.

8.2.3 The approximate Cv values for the docked (installed in a receptacle) test flushing units can be found in Test Flushing Unit Operation (section 22).

8.3 Receptacle Operation Overview

8.3.1 The receptacle is only applicable to tree or manifold manufacture, not for field operation.

8.3.2 The SkoFlo receptacle is the mating component to the docking canister. It allows for the docking canister to be installed or retrieved from the subsea structure (Christmas tree, manifold, etc.) via an ROV. It is hard mounted to the structure.

8.3.3 Each SkoFlo CIMV or test flushing unit must have a mating SkoFlo receptacle unit when used in the field. These receptacles are designed to match the hydraulic, electrical, and mounting orientation of the CIMV or test flushing unit. Each docking unit shown in section 14 has a mating receptacle.

8.3.4 Refer to Receptacle Installation (section 26) for images of the standard receptacles offered by SkoFlo.

8.3.5 Refer to Receptacle Overview (section 26.3) for further information on hydraulic coupler installation.

8.4 Pumping Zero (Field Zero)

8.4.1 A shut-off valve must be positioned after the outlet of the CIMV core to allow for a common mode zeroing of the orifice pressure sensors (P1 and P2) internal to the SkoFlo CIMV, hereafter referred to as pumping zero. This allows calibration of chemicals subsea for CIMVs configured with a PDFM as well as a method to counter possible sensor drift. Without the pumping zero, larger flow rate inaccuracies will be encountered.

8.4.2 To perform the pumping zero, the downstream shutoff valve must be closed while the topside pumps pressurizing the chemical line stay active.

8.4.3 The operator must monitor the pressure sensor readings coming from the CIMV and wait until the readings have stabilized. The SkoFlo pressure sensors themselves have a one-minute rolling average. The operator's wait time must be at least 1 minute after the actual pressures have stabilized to allow for the sensors to read accurately.

8.4.4 Once pressures have stabilized, the "write pumping zero" command must be sent to the CIMV core. Detailed information regarding specific register addresses can be found in the SkoFlo software user manual.

8.4.5 At any time when the upstream pressure to the CIMV changes more than 1000 psi (70bar) or a different flow table is used, a pumping zero should be performed. The pumping zero value is saved to the onboard memory and is applied to all flow tables.

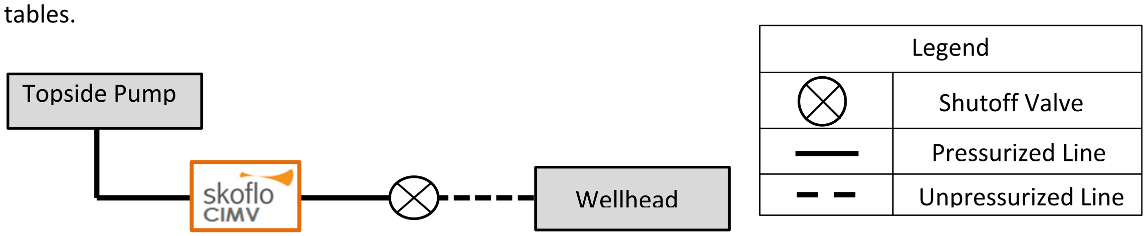


Figure 3: Pumping Zero

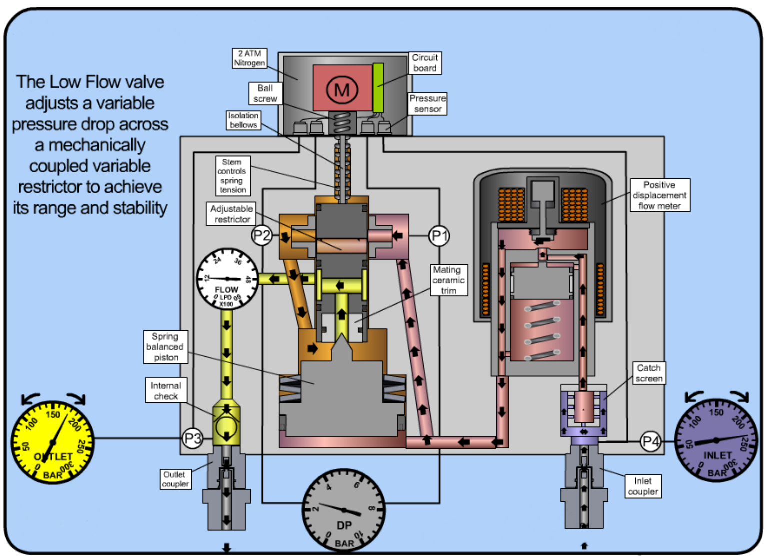
8.5 Low Flow CIMV Operation

8.5.1 Constant flow regulation with changing pressure drops across the LF CIMV is achieved by means of two primary restrictions. The first restriction is an orifice with cascading openings shown as the “Adjustable Restrictor” in Figure 4. This restriction is controlled via the motor driven stem and is responsible for setting the overall flow through the CIMV at the command of the operator.

8.5.2 The second restriction is a ceramic pin that mates up with a ceramic seat. The pin location is controlled via the spring balanced piston and the seat location is controlled by the stem location in the same manner as the orifice. This piston is responsible for maintaining pressure independent flow.

8.5.3 The stem location has a direct impact on the location of the ceramic pin. The pin location is dependent on the pressure above and below the piston. As the stem moves, the gap between the pin and seat changes. This changing gap will allow more-or-less flow to pass through the seat, changing the overall pressure above the piston. As a result, the piston will adjust to a new location. This means that as the stem rises, the piston will rise in response and as the stem lowers, the piston will lower in response.

8.5.4 All four sensors, P1 through P4, are absolute sensors. The dP across the adjustable restrictor, P2, is reported by the CIMV as a differential pressure reading (P1-P2). P4 can be used to monitor the inlet catch screen conditions



P1 – Orifice Inlet Pressure
P2 – Orifice Outlet Pressure
P3 – CIMV Outlet Pressure
P4 – CIMV Inlet Pressure

Note: P1 and P2 sensors are absolute sensors defining the dP flow meter while the P2 reading from the valve only reports the differential pressure (P1-P2). Refer to 8.5.4. P3 and P4 are optional pressure sensors. Refer to the project specific configuration sheet.

Figure 4: Low Flow CIMV Internal

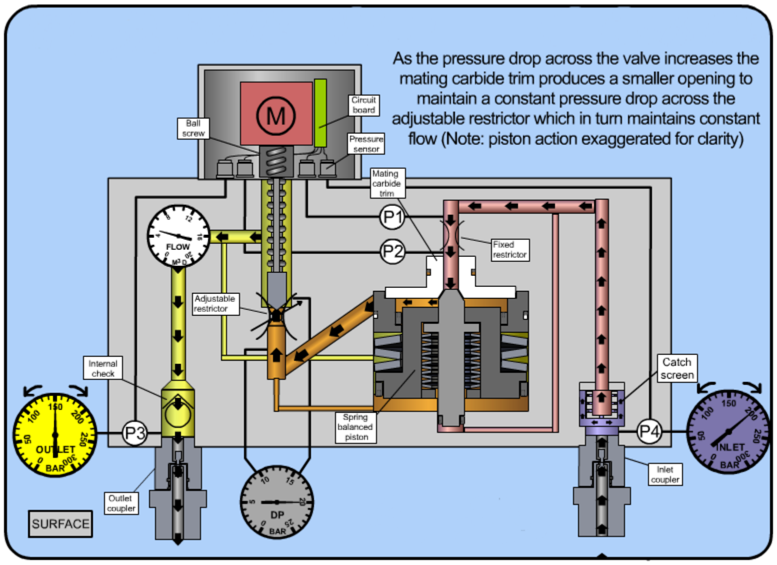
8.6 High Flow CIMV Operation

8.6.1 Constant flow regulation with changing pressure drops across the HF CIMV is achieved by means of two primary restrictions. The first restriction is a carbide mating globe-style seat controlled by the spring balanced piston and carbide pin. The piston maintains a constant pressure drop across the second restriction. The mating globe-style seat dissipates the majority of the pressure drop across the CIMV.

> **! NOTICE**
>
> A MEDIUM FLOW CIMV IS EQUIVALENT IN PERFORMANCE AS A HIGH FLOW CIMV. THE ONLY DIFFERENCE IS THE HYDRAULIC COUPLING SIZE. REFER TO SECTION 2.1.

8.6.2 The second restriction is motor driven, and responds to the commands for flow rate given by the operator. Both the first and second restrictions operate completely independent of each other unlike the low flow CIMV which has the two primary restrictions linked.

8.6.3 All four sensors, P1 through P4, are absolute sensors. The dP across the fixed restrictor, P2, is reported by the CIMV as a differential pressure reading (P1-P2). P4 can be used to monitor the inlet catch screen conditions.



P1 – Orifice Inlet Pressure
P2 – Orifice Outlet Pressure
P3 – CIMV Outlet Pressure
P4 – CIMV Inlet Pressure

Note: P1 and P2 sensors are absolute sensors defining the dP flow meter while the P2 reading from the valve only reports the differential pressure (P1-P2). Refer to 8.6.3. P3 and P4 are optional pressure sensors. Refer to the project specific configuration sheet.

Figure 5: High Flow CIMV Internal

9. Pressure Independence, LF & HF CIMV

9.1 The SkoFlo CIMV is a pressure independent device. This means that pressure changes in either the well head (downstream pressure to the CIMV) or the supply pressure will not affect flow rate significantly of the chemical passing through the CIMV, refer to Table 1 and Table 2 for measurement accuracies. In the SkoFlo product, this is a mechanical process requiring zero power.

9.2 The mechanical pressure independence is achieved by means of a pressure and spring balanced piston. The piston holds the pin that restricts flow through the seat. The piston will position itself to be balanced with the force exerted on it by the fluid passing through the CIMV as well as the force acting on it from a stack of washer springs. Pressure fluctuations cause the overall force acting on the piston to change resulting in an adjustment in the piston position to find the new balanced location.

9.3 If the overall pressure drop across the CIMV increases, the pin closes, restricting the flow path; if the overall pressure drop across the CIMV decreases, the pin retracts, expanding the flow path. These adjustments ensure that the chemical injection flow rate remains constant. The tolerance that is set by SkoFlo for the pressure independence is defined by percent (%) of reading change for each 1,000 psi (69 bar) change in well, or outlet pressure. These position changes maintain a constant pressure drop across the adjustable restrictor. For the CIMV to operate correctly, a minimum pressure drop must be supplied to allow for the pressure balanced piston to achieve a balanced position.

9.3.1 The required minimum pressure drop is located on the project specific product specification sheet for each CIMV part number. In the most simplistic terms, higher viscosity fluids may result in a higher minimum dP requirements to achieve rated full scale. Refer to Minimum Required Pressure Drop (section 12) for further information.

9.4 The pin and seat account for the majority of the pressure drop across the CIMV.

10. Flow Measurement and Flow Adjustment, LF & HF CIMV

10.1 The low flow and high flow CIMVs have multiple options for flow measurement and flow adjustment. Both CIMV types can measure and adjust flow by “flow by differential pressure” (dP) and secondly, “flow by stem”. The low flow CIMV has the additional option of measuring and adjusting flow. This third option is “flow by positive displacement flow meter” (PDFM). Both CIMVs can also be adjusted by stem percent but this feature is used primarily for diagnostic purposes only. This method should not be used to attempt to target a flow rate for operational use.

10.2 Flow by dP

10.2.1 Flow by dP is the primary flow measurement method for all SkoFlo CIMVs. Pressure sensors (P1 and P2) are located on the upstream and downstream side of the metering orifice (refer to Figure 4). During calibration, these pressure sensor values are recorded at each calibration point along with the flow rate for the specific injection fluid. The CIMV stores the difference between the two sensors, or dP. During operation, the CIMV will monitor the dP and continuously report a flow rate based on the differential pressure observed. Requesting a flow rate by dP results in the CIMV moving to a location that provides the correct pressure drop across the orifice for the requested flow rate according to the calibration table.

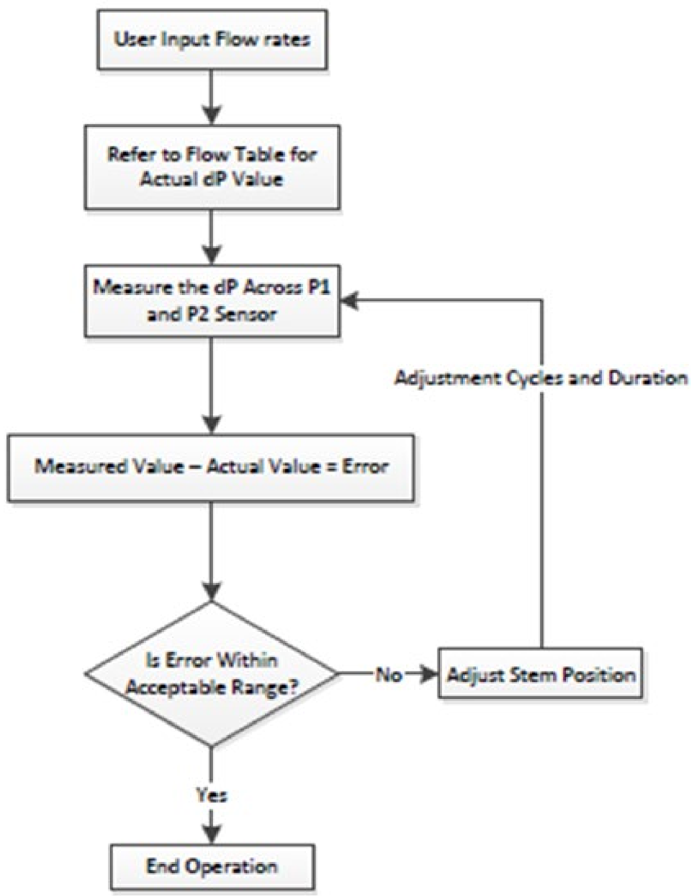


Figure 6: Flow by dP Flow Chart

**The adjustment cycles and duration verifies how many times it adjusts based on user input. E.g. 3 cycles with 2 min wait time in between*

10.3 Flow by Stem

10.3.1 Flow by stem is the backup flow measurement method for both flow by dP and flow by PDFM (when applicable). Flow by stem is based entirely on the correlation between the current stem location and the corresponding flow rate observed during calibration. This means that if the CIMV was commanded to flow 250 GPD by stem, the stem would move to the correct location per the calibration table and then report a 250 GPD flow. This flow rate would be reported regardless of if there was any fluid being supplied to the CIMV at all. For this reason, flow by stem should be used as reference only.

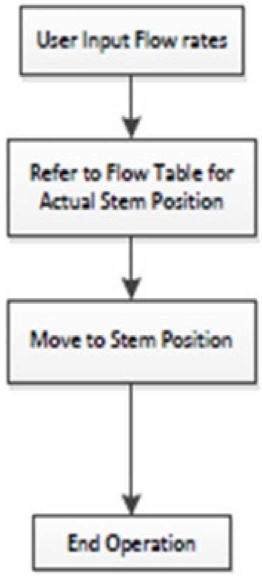


Figure 7: Flow by Stem Flow Chart

10.4 Flow by PDFM (LF CIMV Only)

10.4.1 The PDFM operates similar to a launching style meter proving device and is the most accurate flow measurement device within this SkoFlo low flow CIMV. It creates a flow measurement cycle by diverting flow to move a piston against a return spring whose movement is monitored by a linear variable differential transformer (LVDT). Flow diversion is accomplished by a direct acting solenoid valve closing off a by-pass loop to a flow measurement piston shown in Figure 8. Flow diversion, piston speed measurement, and piston return comprise one PDFM cycle. Flow rate is reported at surface conditions by the CIMV, measuring pressure and flow rate at subsea conditions, then calculating flow that would be measured at surface conditions using the bulk modulus of the fluid.

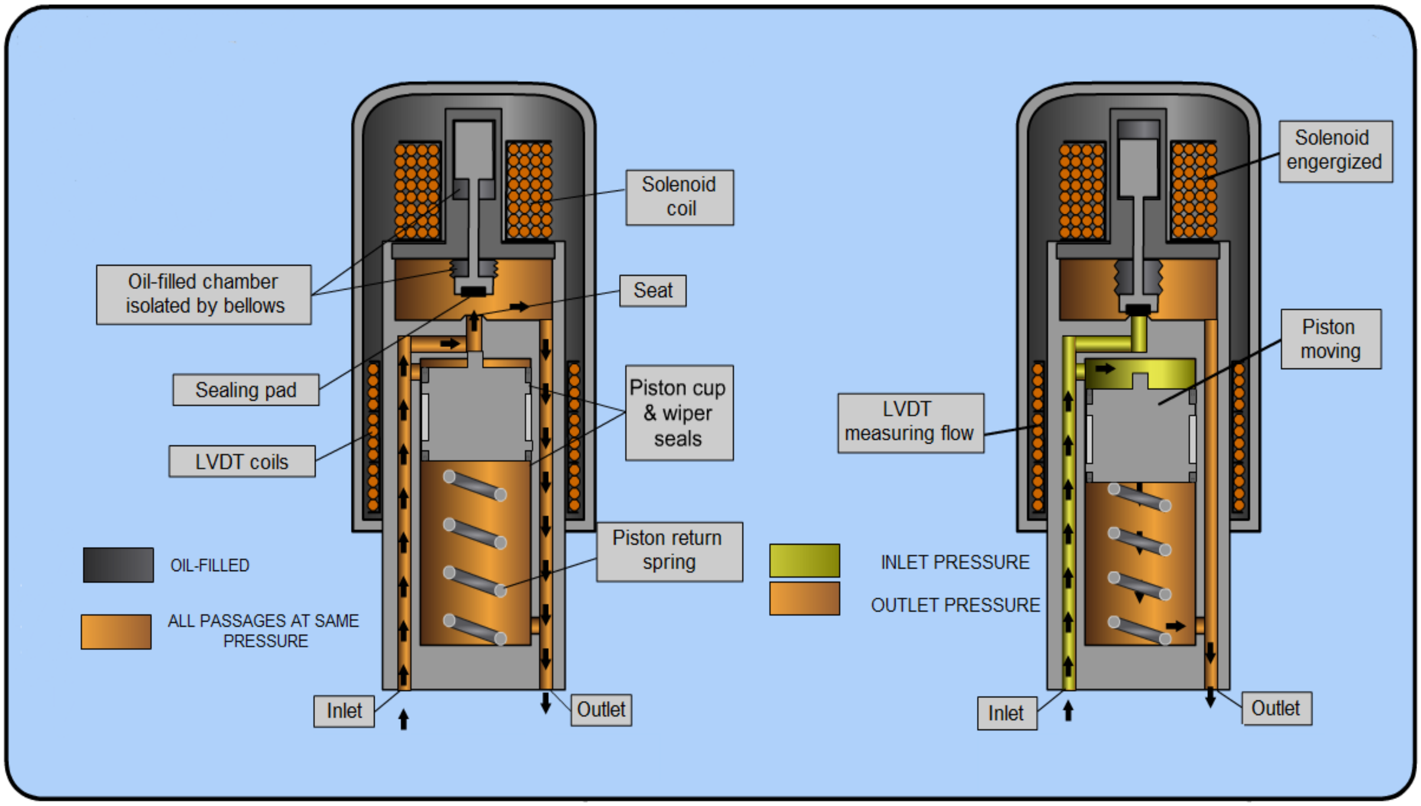


Figure 8: PDFM Internals

10.4.2 The PDFM is dormant during normal CIMV operation, it is not a continuous flow measurement method. During the dormant phase, flow bypasses the piston from the inlet to the outlet of the PDFM. The PDFM only draws power when a flow rate is requested. The PDFM has two standard operation functionality types (see below); any additional functionality can be found in the SkoFlo software manual.

10.4.2.1 **Automatic Flow Measurement (AFM) –** User configurable flow measurement setting for CIMV to automatically measure at a set interval of minutes, minimum is 15 minutes.

10.4.2.2 **Manual Flow Measurement** – Enables users to take a flow rate measurement at any time during operation. This command can be executed while the CIMV is in AFM mode.

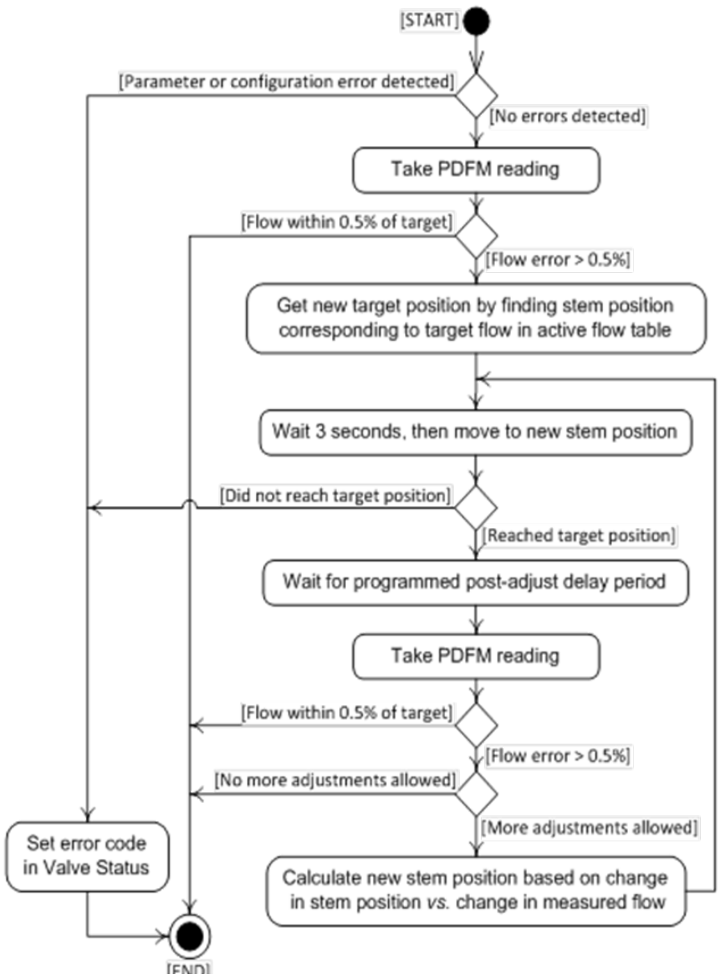


Figure 9: Flow by PDFM Flow Chart

10.4.3 The PDFM also enables users to perform chemical calibration if there is any change of chemical composition or inaccurate flow measurement readings are detected that require re-calibration. Refer to Calibration Matrix Storage and Generation (Section 19) for additional information.

10.4.4 For PDFM measurement accuracy, refer to section 11.

10.5 Stem Percent Adjustment

10.5.1 The stem in the CIMV can be commanded to move to a location by stem percent. This method is used primarily for diagnostic purposes only. It is important to note that the stem percent does not correlate to the full-scale flow range of the CIMV. This is to say that a stem position of 90 percent open does not correspond to 90 percent of the maximum rated flow rate. All adjustments made with the intent of targeting a specific flow should be executed using one of the "Flow by" methods of adjustment and not stem percent.

10.5.2 When making adjustments to or around the maximum or minimum flow rate, the CIMV may intermittently report a flow of 0. This is expected behavior. As the stem adjusts to reach the required location to meet the requested flow rate, it has the potential to move outside of the calibrated range. Outside of the calibrated range, the CIMV does not have any data telling it what the expected flow rate should be which results in a reading of 0. The CIMV will continue to move the stem until it has returned to a calibrated position.

11. CIMV Measurement Accuracy, LF & HF CIMV

11.1 LF CIMVs Only:

11.1.1 Measurement accuracies and pressure independence changes are shown in Table 1.

11.1.2 All stated accuracies for flow by dP and flow by stem are valid for total pressure drops of ≤ 5,000 psi (344.8 bar) across the CIMV. Flow by PDFM accuracy is not by the total pressure drop across the CIMV.

11.1.3 The dP measurement or PDFM is not affected by pressure variance with respect to flow rate measurement accuracy. An example of how to calculate the maximum potential change in flow due to pressure changes is shown below.

11.1.3.1 If a LF CIMV rated to 500 GPD full scale has an outlet pressure change from 5,000 psi to 3,000 psi, the maximum potential change in flow can be calculated as follows:

- Change in outlet pressure = 5,000 psi – 3,000 psi = 2,000 psi
- Determine flow rate pressure independence change per Table 1.
  - If flow rate is 200 GPD, pressure independence = 5% of reading per 1,000 psi change
  - If flow rate is 8 GPD, pressure independence = 25% of reading per 1,000 psi change
- Potential Pressure independence change is calculated as follows:
  - For 200 GPD flow rate: 5% X (2,000 psi/1,000psi) X 200 GPD = 20 GPD
  - For 8 GPD flow rate: 25% X (2,000 psi/1,000psi) X 8 GPD/ = 4 GPD

11.1.4 For a pressure drop change 1,000 psi more than the calibrated amount, the flow rate reading will diminish by approximately number in table for pressure independence. For a pressure drop 1,000 psi less than the calibrated amount the flow rate reading will increase by approximately number in table for pressure independence. Refer to Table 1 and Table 2.

11.1.5 For 1,200 GPD (189 LPH) CIMV configurations, stated accuracies are only applicable when injection fluid is ≤ 50 cP thick. For fluids > 50 cP, refer to project specific configuration and/or specification sheet for details.

Table 1: Measurement Accuracies Low Flow CIMV with PDFM

Flow Range	Flow Rate GPD (LPH)	Measurement Accuracy, Flow by PDFM, %	Measurement Accuracy, Flow by dP, %	Measurement Accuracy, Flow by Stem, %	Pressure Independence
2-500 GPD (0.3-80 LPH)	25 ≤ FR ≤ 500 (3.9 ≤ FR ≤ 80)	3% of reading	5% of reading	10% of reading	5% of reading per 1000 psi (68.9 bar) change
	10 ≤ FR < 25 (1.6 ≤ FR < 3.9)	3% of reading	10% of reading	20% of reading	10% of reading per 1000 psi (68.9 bar) change
	2 ≤ FR < 10 (0.3 ≤ FR < 1.6)	10% of reading	25% of reading	50% of reading	25% of reading per 1000 psi (68.9 bar) change
10-1200 GPD (1.6–189 LPH)	600 ≤ FR ≤ 1200 (94.6 ≤ FR ≤ 189)	3% of reading	5% of reading	10% of reading	5% of reading per 1000 psi (68.9 bar) change
	60 ≤ FR < 600 (9.46 ≤ FR < 94.6)	3% of reading	10% of reading	20% of reading	10% of reading per 1000 psi (68.9 bar) change
	10 ≤ FR < 60 (1.6 ≤ FR < 9.46)	10% of reading	25% of reading	50% of reading	25% of reading per 1000 psi (68.9 bar) change

*Values are for information only. For project specific flowrates and accuracies refer to the applicable specification sheet.

11.2 HF CIMVs only:

11.2.1 Measurement accuracies and pressure independence changes are shown in Table 2.

11.2.2 The dP measurement is not affected by pressure independence with respect to flow rate measurement accuracy.

11.2.3 For a pressure drop change 1,000 psi more than the calibrated amount, the flow rate reading will diminish by approximately number in table for pressure independence. For a pressure drop 1,000 psi less than the calibrated amount the flow rate reading will increase by approximately number in table for pressure independence.

11.2.4 Example of pressure independence calculation, refer to LF CIMV example in Section 11.1.3.1.

Table 2: Measurement Accuracies, High Flow CIMV

Flow Rate	Measurement Accuracy (Flow by dP)	Stem Position Accuracy (Flow by Stem)	Pressure Independence
5 ≤ FR < 10% RFS	±5% RFS	±10% RFS	±25% of reading per 1000 psi (68.9 bar) change
10 ≤ FR < 25% RFS	±5% RFS	±10% RFS	±10% of reading per 1000 psi (68.9 bar) change
25 ≤ FR ≤ 100% RFS	±5% RFS	±10% RFS	±5% of reading per 1000 psi (68.9 bar) change

*Values are for information only. For project specific flowrates and accuracies refer to the applicable specification sheet.

12. Minimum Required Pressure Drop, LF & HF CIMV

12.1 For SkoFlo CIMV cores to provide pressure independent performance, a minimum pressure drop is required across the CIMV to allow the spring-balanced piston to move to a truly balanced location. For more information regarding pressure independence operation refer to Pressure Independence, LF & HF CIMV (Section 9).

12.2 Low flow CIMV cores generally require a smaller pressure drop than the HF CIMV cores. As a general rule, higher viscosities will reduce the rated full scale of the CIMV and increase the minimum required pressure drop. The actual pressure drop values are located on the project specification and/or configuration sheets for each product.

12.3 Figure 10 and Figure 11 depict a simplified graphical representation of minimum pressure drop requirements for LF and HF CIMV cores respectively.

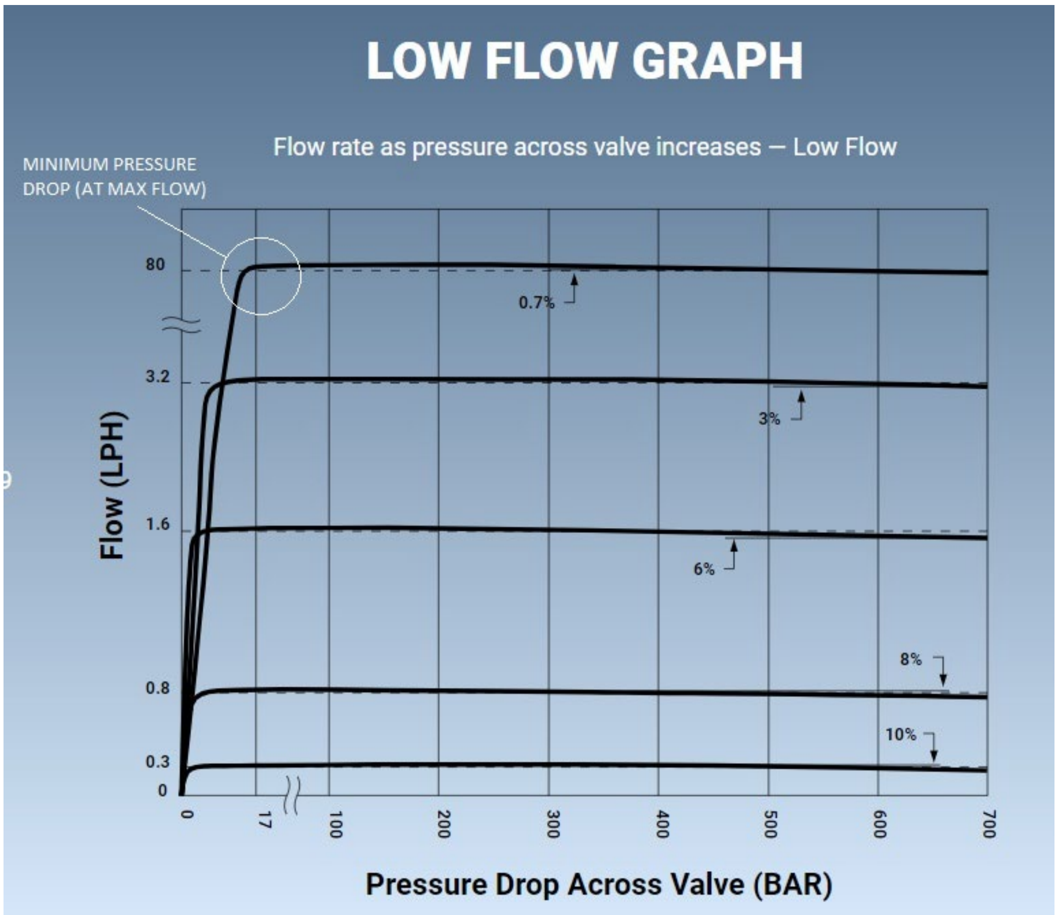


Figure 10: Pressure Independence Curve Low Flow

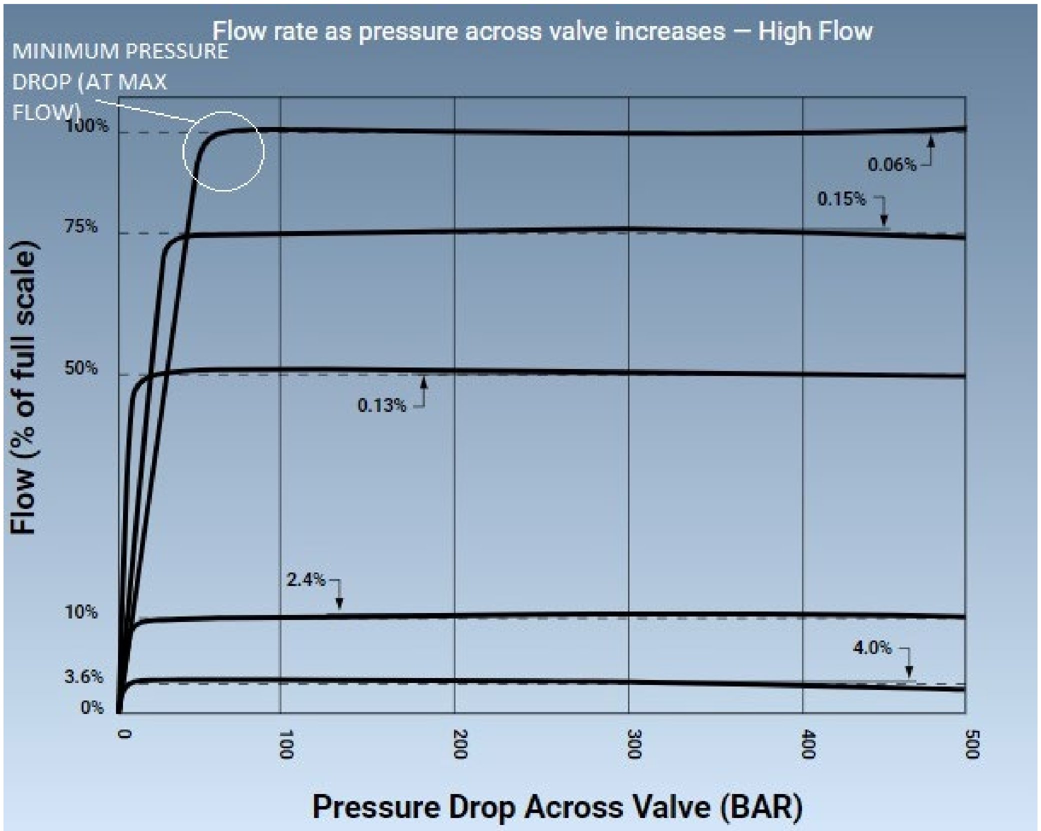


Figure 11: Pressure Independence Curve High Flow

13. CIMV Docking Canister Overview

13.1 The docking canister (or simply canister) is the housing in which all SkoFlo rate control devices are encased. This housing serves to protect the cores as well as to provide a user-friendly interface for the operators. There are two possible canisters: stab mate docking canister and ROV mate docking canister. Both are offered in horizontal and vertical configurations.

13.2 All docking canisters come with an API compliant 17H class 4 bucket and docking latch. This allows for ROV installation and removal of the product.

13.3 Each canister comes with two D-handles for lifting and handling. Both handles are designed to hold the entire weight of the final product individually. Refer to DOC-02667 Transport and Handling Procedure for further lifting information.

13.4 The alignment key on each canister is to ensure that the canister slides into the mating receptacle in the correct orientation for a successful mate.

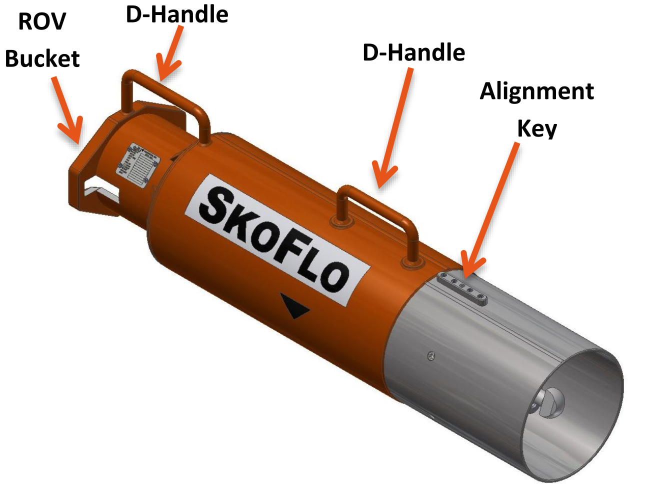


Figure 12: Horizontal Stab Docking Canister External Perspective

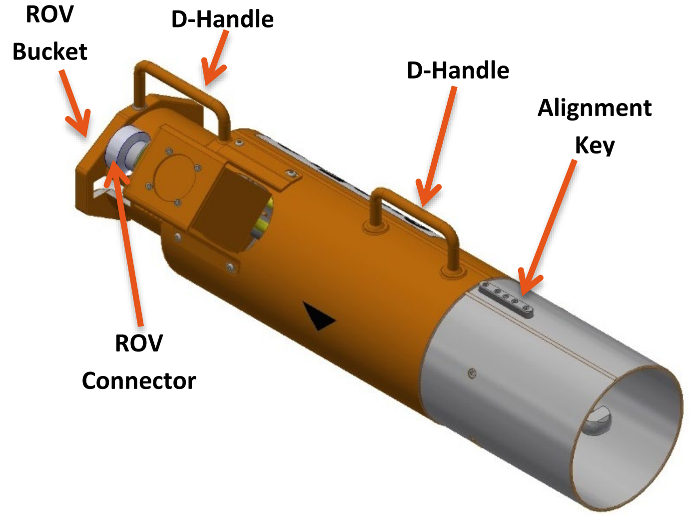


Figure 13: Horizontal ROV Docking Canister External Perspective

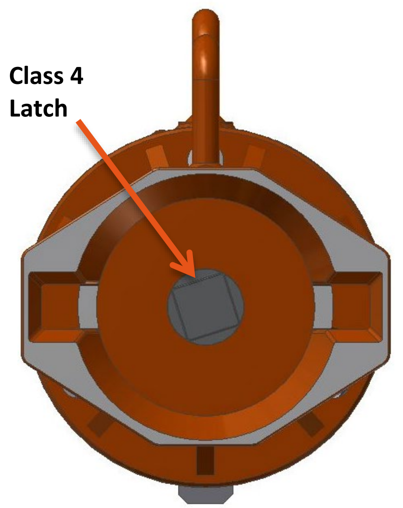


Figure 14: ROV Bucket View, Stab Mate

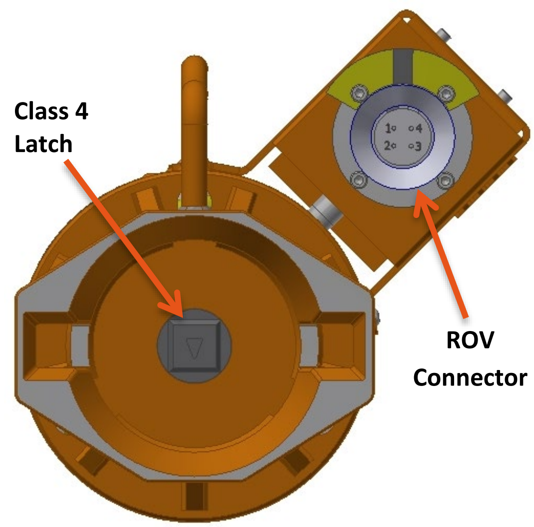


Figure 15: Horizontal ROV Bucket View, ROV Mate

Figure 16: Vertical Stab Mate Docking Canister

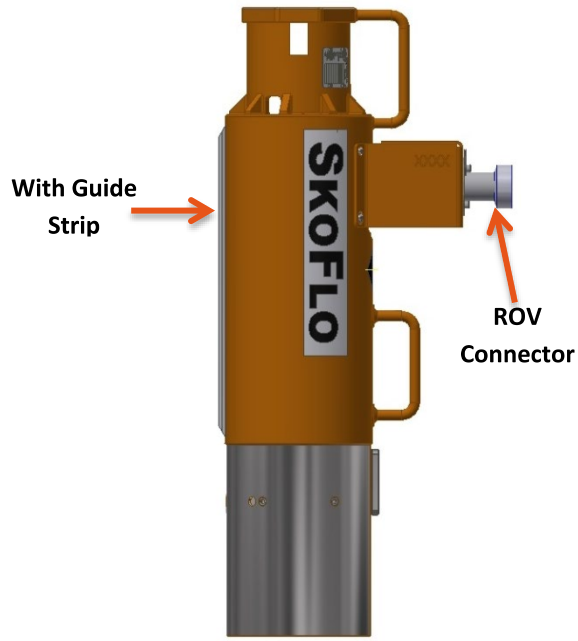


Figure 17: Vertical ROV Mate Docking Canister

Figure 18: Horizontal Stab Mate Docking Canister

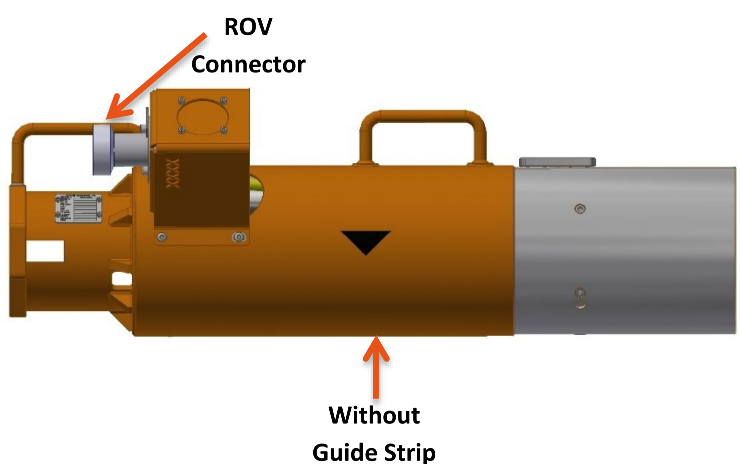


Figure 19: Horizontal ROV Mate Docking Canister

13.5 SkoFlo CIMVs come in two types of installations and two types of configurations: vertical or horizontal and stab or ROV mate respectively. The two physical differences between the two product types is the guide strip and external ROV connector, as shown in Figure 16 through Figure 19. Vertical docking canisters come with a guide strip and horizontal docking canisters come without a guide strip. The purpose of the guide strip is to assist with the installation into the receptacle by minimizing the chance of damaging coating during the vertical installation process. Docking canisters with guide strips will not fit into horizontal receptacles.

! NOTICE

IT IS IMPORTANT TO IDENTIFY THE CIMV INSTALLATION TYPE TO ENSURE THE CORRECT EQUIPMENT IS USED FOR INSTALLATION.

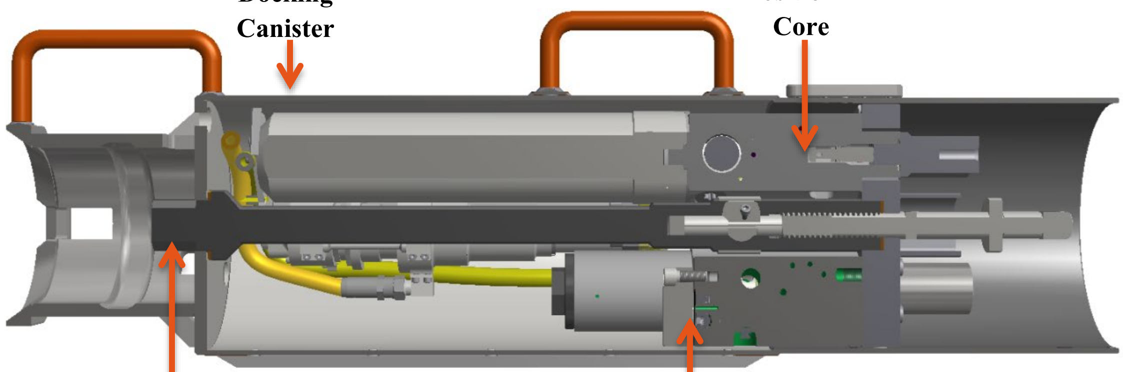


Figure 20: CIMV Overview Inside Docking Canister

13.5.1 The CIMV docking canister can contain one or two cores (as shown in Figure 20). These cores can be any combination of LF CIMV, HF CIMV or test flushing units.

13.5.2 The CIMV docking canister is made of stainless steel and is connected to the subsea CP system by means of conductivity between receptacle junction plate and CIMV latch. All cores are designed with a minimum debris tolerance defined by SAE AS4059 Class 12B-F.

14. Docking Canister Communication and Electrical Interface

! WARNING

REFER TO THE PROJECT SPECIFIC GA DRAWING AND COMMUNICATION SECTION OF THE PRODUCT SPECIFICATION SHEET FOR COMMUNICATION AND ELECTRICAL INTERFACE DETAILS.

14.1 The CIMV core is a remotely adjustable device with feedback abilities. Communication is made by means of a two-wire interface.

14.2 SkoFlo supports SIISV2 CANopen and Modbus communication protocol.

14.3 SkoFlo offers stab and ROV mate electrical configurations for structured product.

14.3.1 Stab mate electrical connections are affixed to the receptacle junction plate. When the docking canister is placed into the receptacle, the class 4 latch draws the canister into the receptacle. This action mates the stab electrical connection. Refer to Figure 21.

14.3.2 ROV mate electrical connections are affixed externally to the docking canister. The horizontal ROV connection is placed at a 45-degree offset (Figure 22) and the vertical ROV connection is placed with no offset (Figure 23). Similar to stab mate, when the ROV docking canister is placed into the receptacle, the class 4 latch draws the canister into the receptacle.

14.3.3 Stab mate electrical connections cannot be used in a dual HF CIMV or a dual HF test flusher with sensor(s) configuration as there is no room left on the junction plate to add the connector. ROV mate electrical connection can accommodate all HF/LF CIMV and test flusher configurations.

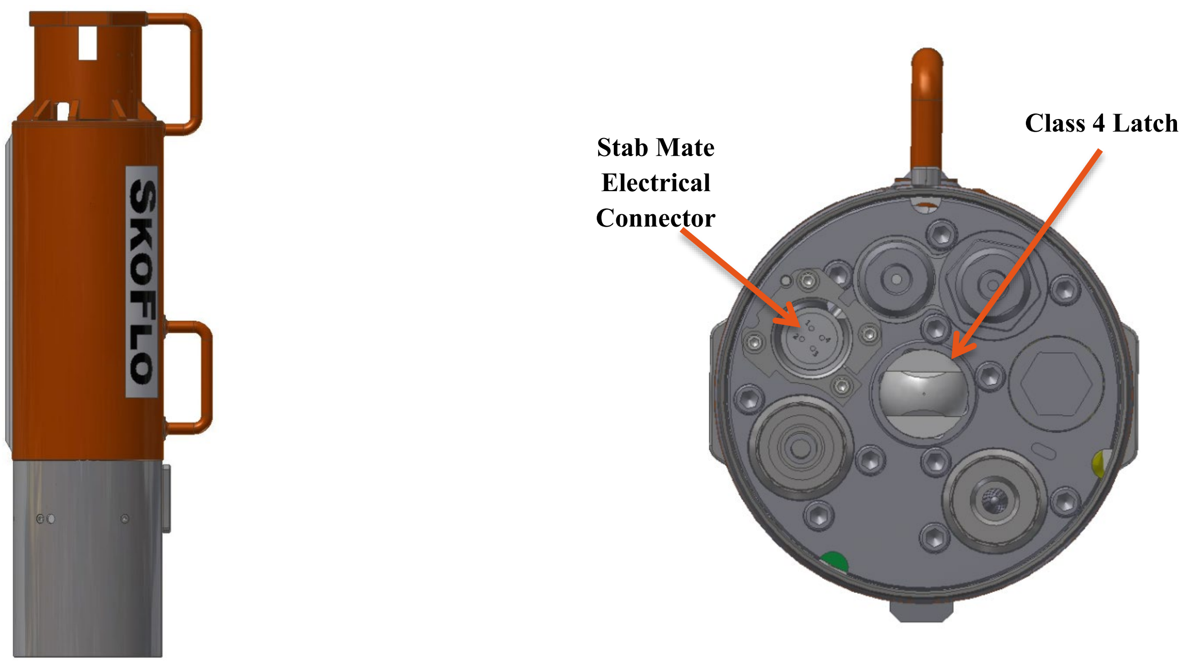


Figure 21: Stab Mate CIMV

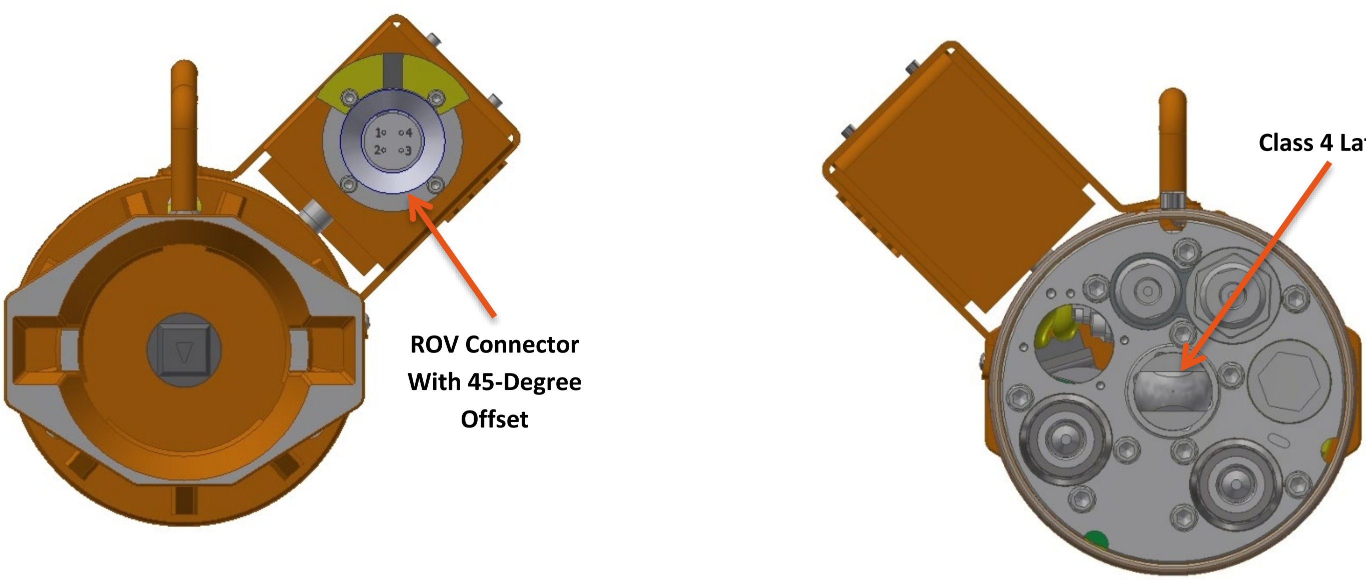


Figure 22: Horizontal ROV Mate CIMV

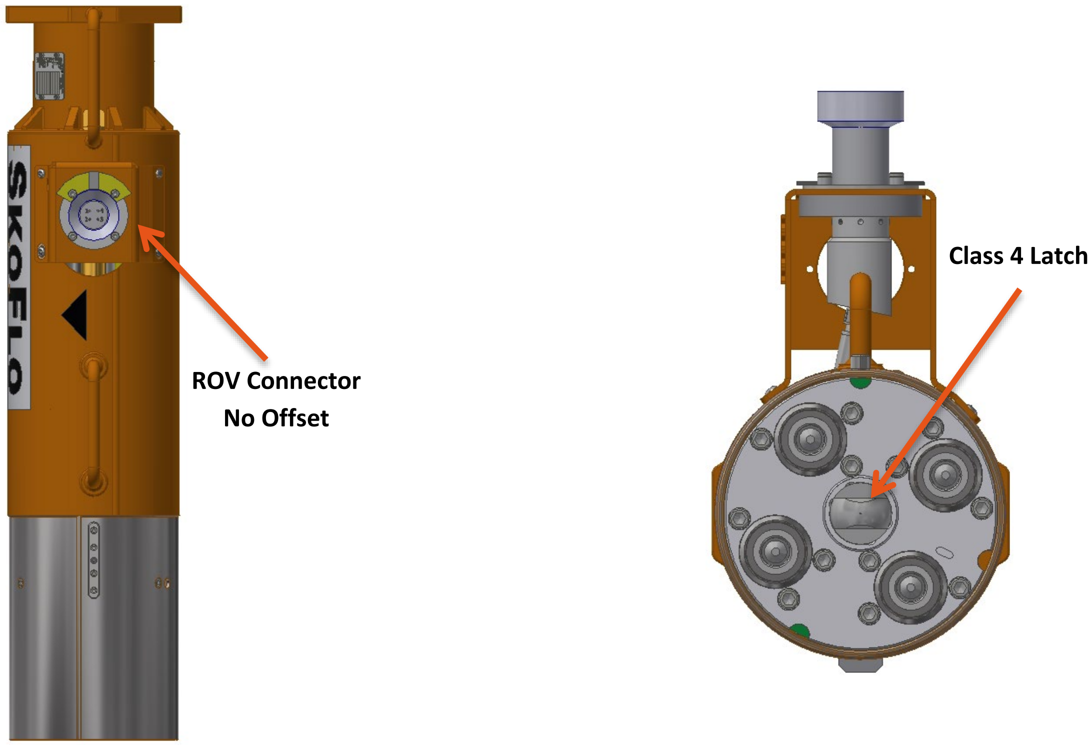


Figure 23: Vertical ROV Mate CIMV

14.4 For dual core CIMV configurations, the electrical wiring is shared between two cores as shown in Figure 24.

14.5 Test flushing units that do not have components that require power come equipped with a marine growth cover. This is a plastic cover that caps and protects the electrical connector on the receptacle when the TFU is docked.

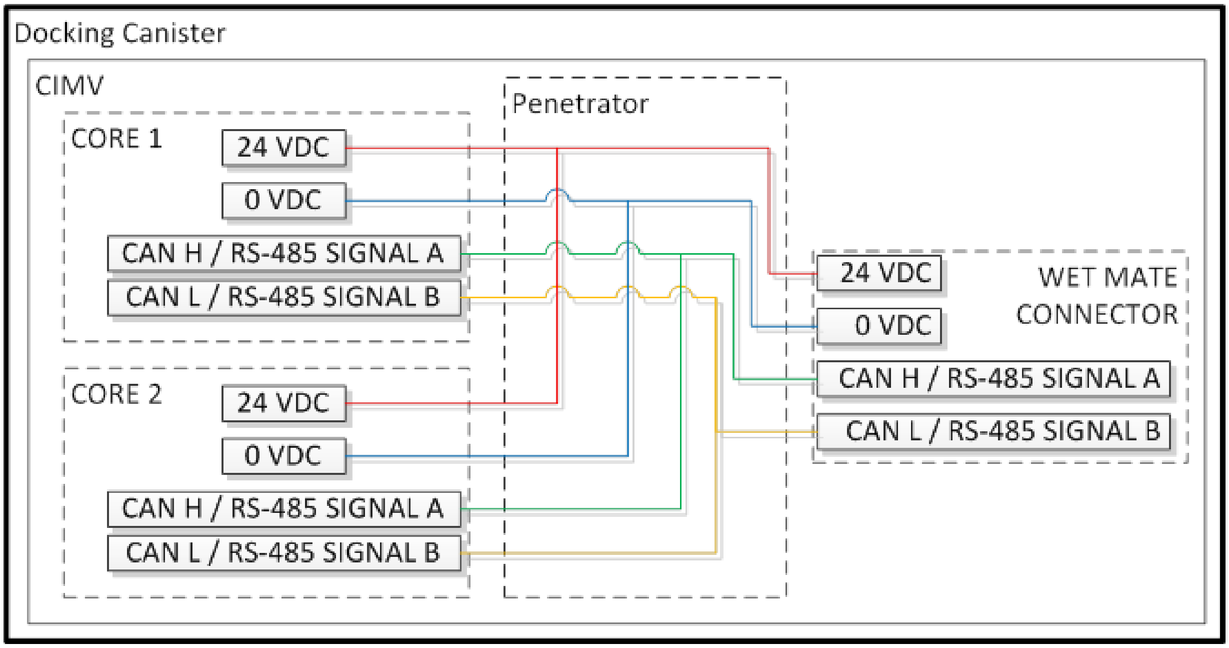


Figure 24: Typical CANBus or ModBus Dual Core Electrical Connector

15. Docking Canister Hydraulic Interface

! WARNING

FIGURES IN THIS SECTION ARE FOR ILLUSTRATION PURPOSES ONLY. REFER TO THE PRODUCT SPECIFIC GA DRAWING FOR THE CORRECT POSITION OF THE HYDRAULIC COUPLERS.

15.1 Each core in a docking canister is accessed through an individual set or pair of Hunting hydraulic connectors. For dual core units, there are two sets of inlet/outlet hydraulic couplers (4 couplers total), while single core units have one set of inlet/outlet hydraulic couplers (2 total), as shown in the figures in this section.

15.2 The couplers are fixed to their respective core which in turn is fastened to the junction plate. When the docking canister is placed into the receptacle, the class 4 latch draws the canister into the receptacle. This action mates the stab hydraulic connections between the core and the receptacle.

15.3 The docking latch is the centroid of the configuration, and the cores are positioned around the latch facing inward.

15.4 Flow passes through a LF CIMV core and a HF CIMV core in opposite directions. This means that the inlet and outlet are switched between these two CIMV types.

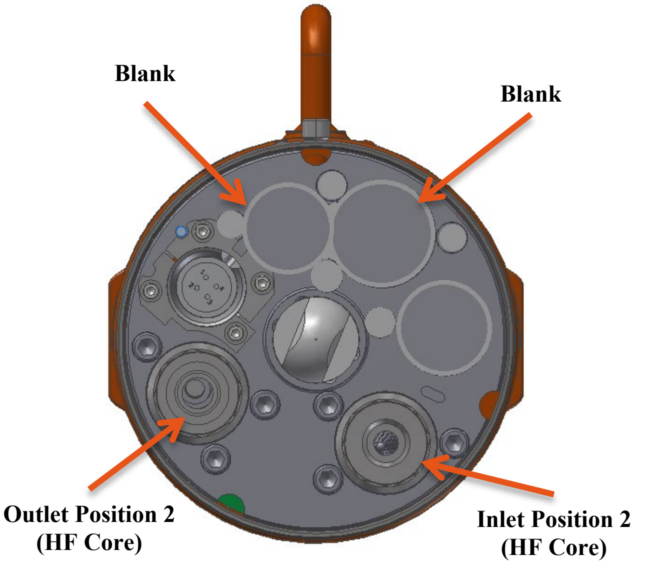


Figure 25: Single Core HF Junction Plate Stab

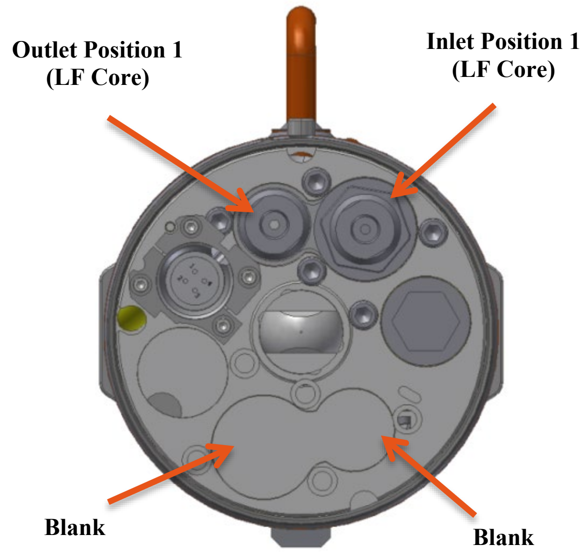


Figure 26: Single Core LF Junction Plate Stab

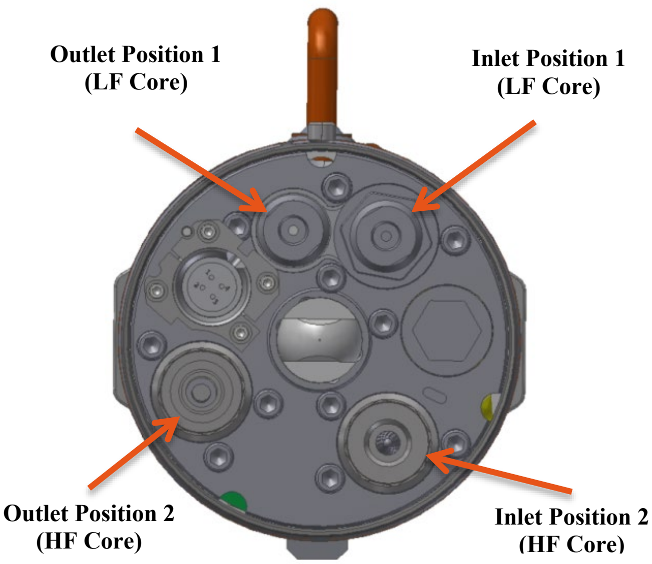


Figure 27: Dual Core LF/HF Junction Plate Stab

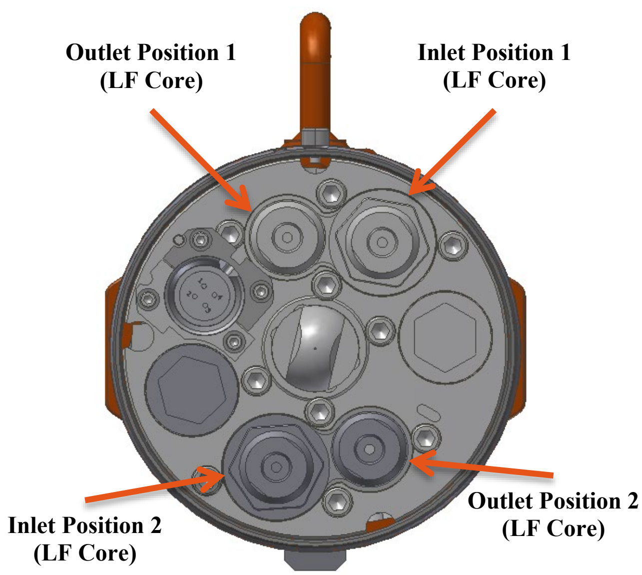


Figure 28: Dual Core LF/LF Junction Plate Stab

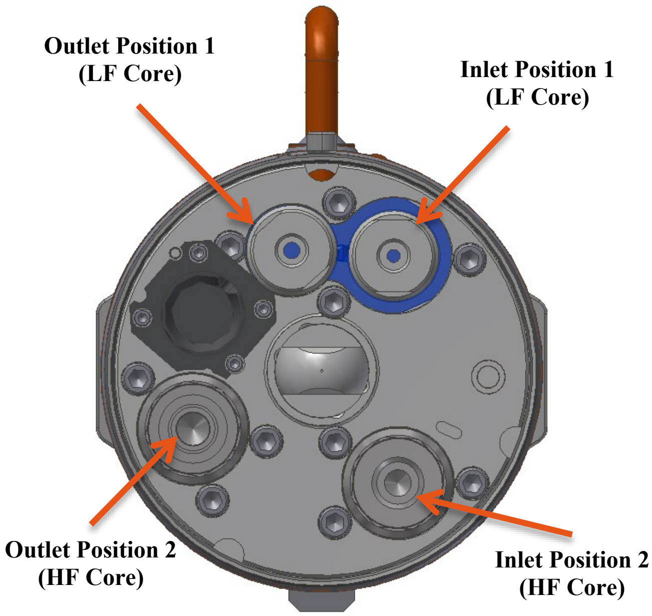


Figure 29: Dual Core LF/HF TFU Junction Plate Stab

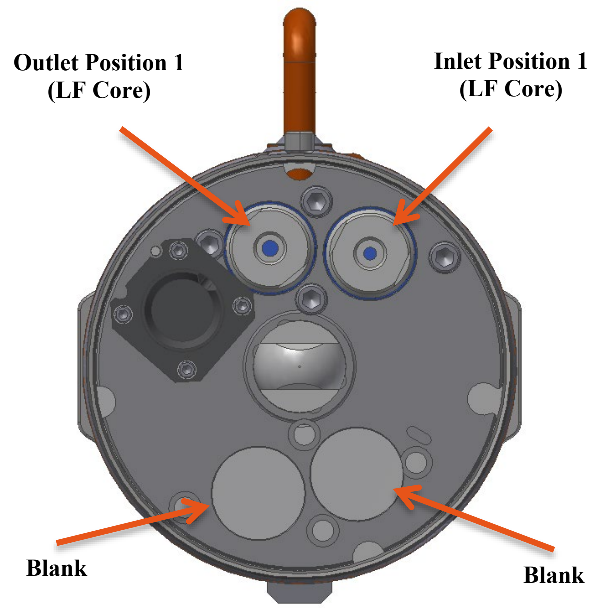


Figure 30: Single Core LF TFU Junction Plate Stab

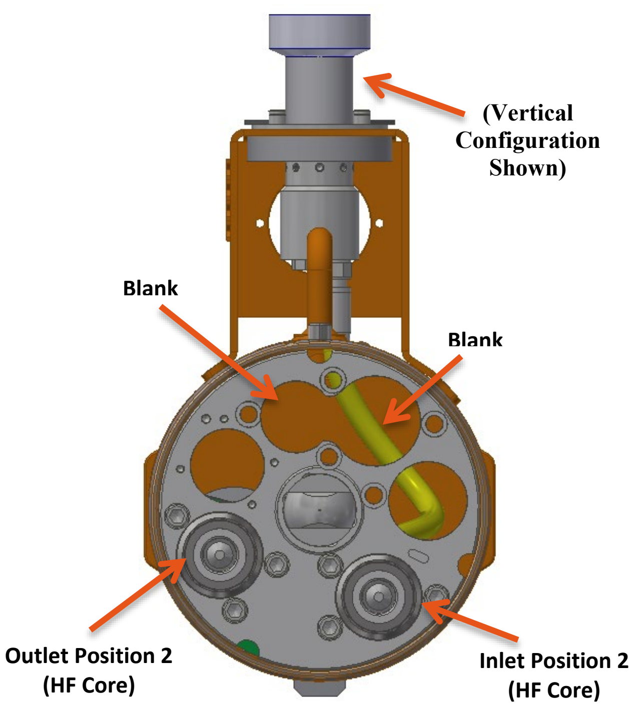


Figure 31: Single Core HF Junction Plate ROV

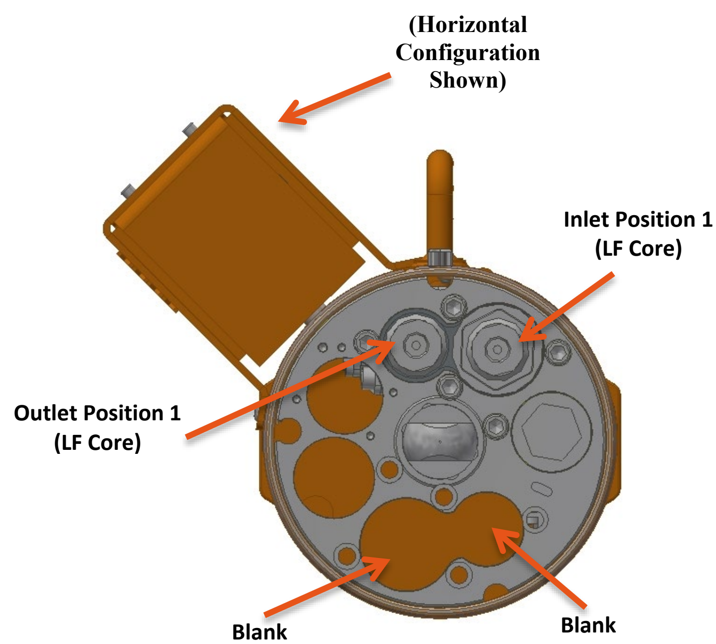


Figure 32: Single Core LF Junction Plate ROV

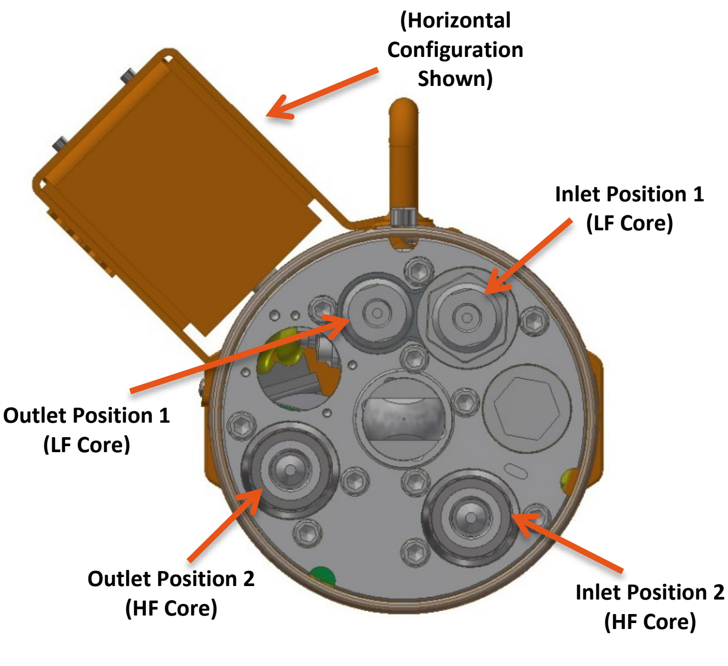


Figure 33: Dual Core LF/HF Junction Plate ROV

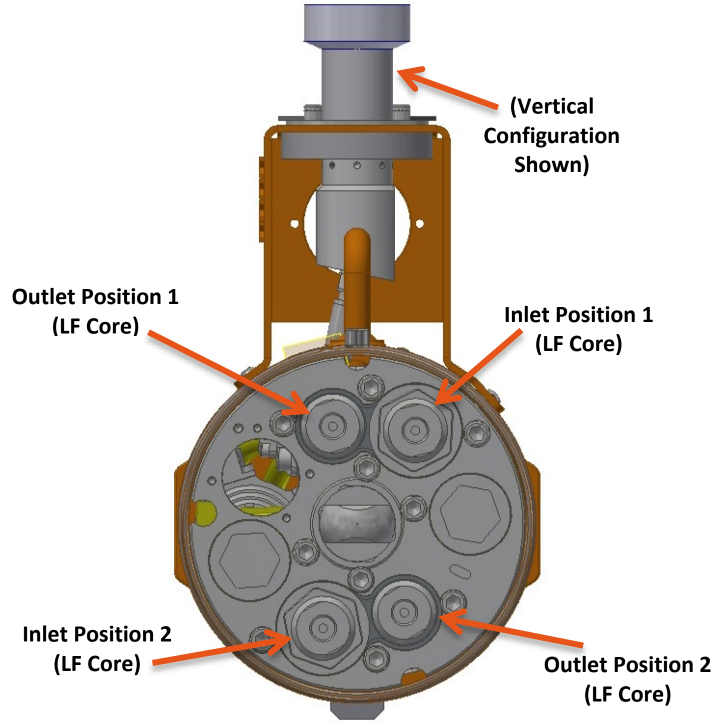


Figure 34: Dual Core LF/LF Junction Plate ROV

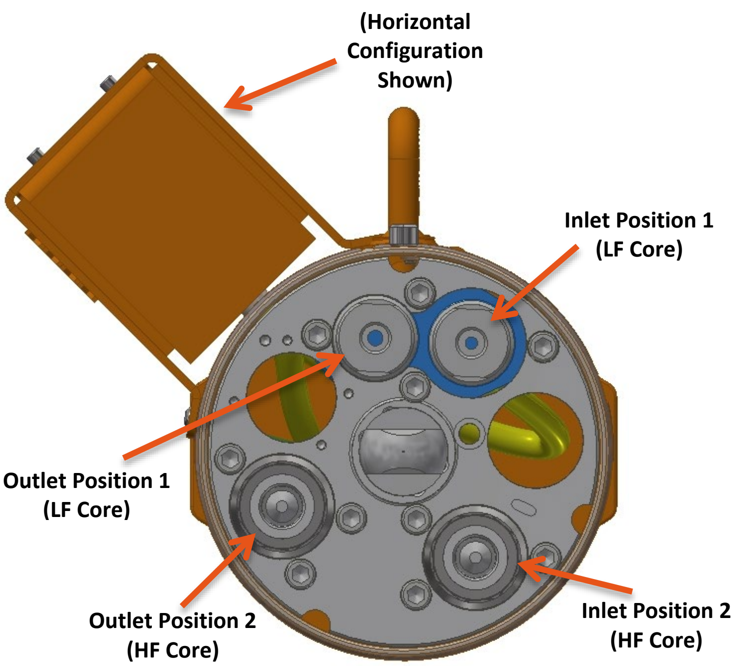


Figure 35: Dual Core LF/HF TFU Junction Plate ROV

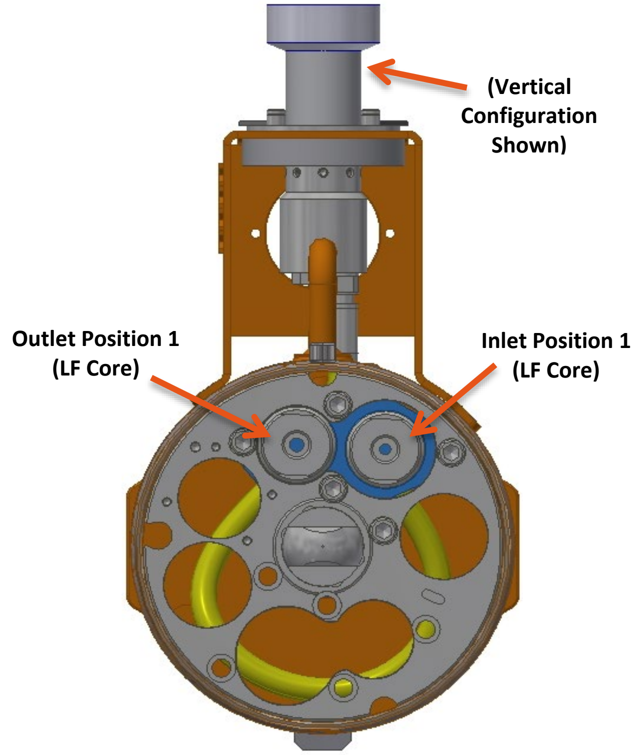


Figure 36: Single Core LF TFU Junction Plate ROV

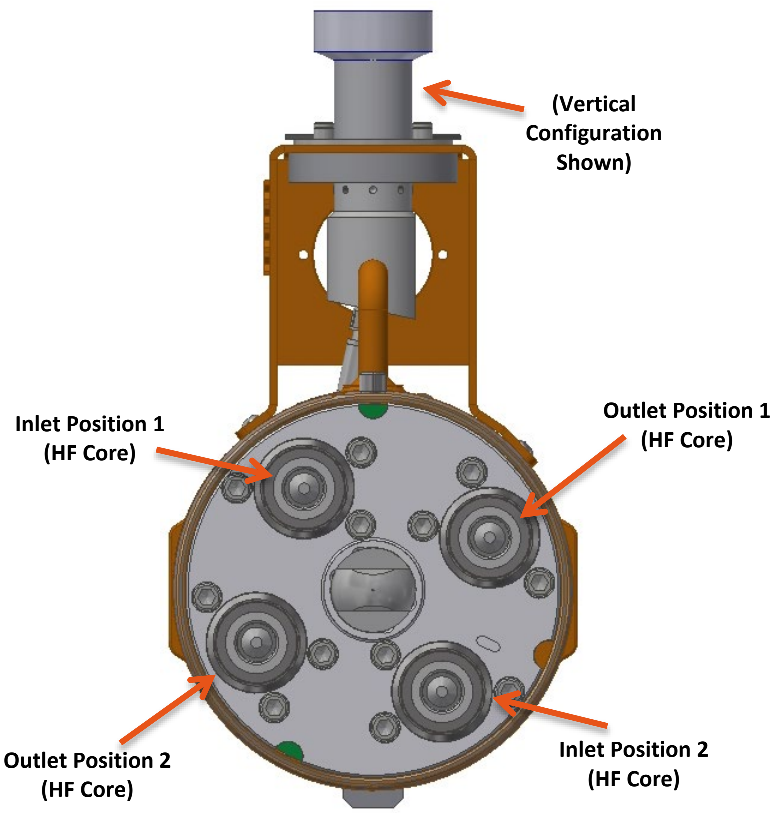


Figure 37: Dual Core HF Junction Plate ROV

16. CIMV Pressure Ratings

> **! WARNING**
>
> REFER TO THE GENERAL SECTION OF THE PRODUCT SPECIFICATION SHEET FOR DESIGN PRESSURE DETAILS.

16.1 SkoFlo CIMVs are designed to operate with a specific internal pressure. Refer to the product specification sheet to find the design pressure of the product before performing any operations.

16.2 The operating flow rate for the CIMV is dependent on specific project requirements. Refer to the product specification sheet or consult with SkoFlo engineering before operating the product.

16.3 Fluid Cavitation

16.3.1 Fluid cavitation occurs when the pressure of the injection fluid passing through the CIMV drops below the vapor pressure of the given fluid. This can be caused by a combination of CIMV inlet and outlet pressures, injection fluid viscosity, and injection fluid velocity. When the SkoFlo CIMV enters the cavitation region, energy released from vapor compression at the pin/seat interface may cause premature wear of throttling components.

> **! WARNING**
>
> IT IS RECOMMEND THAT THE BACKPRESSURE SUPPLIED TO CIMV EXCEED CIMV DIFFERENTIAL PRESSURE TO AVOID CAVITATION.

16.3.2 To avoid cavitation in the SkoFlo CIMV, it is imperative that CIMV backpressure (outlet pressure) exceeds the pressure drop across the CIMV. If the inlet pressure is X and the backpressure pressure is Y, then the pressure drop (X-Y) should be no greater than Y.

16.3.3 For further example, a CIMV with an inlet pressure of 10,000 psi (689 bar) and a back pressure of 6,000 psi (414 bar) results in a pressure drop of 4,000 psi (276 bar). In this case, the pressure drop does not exceed the backpressure so there is no risk of cavitation. The same CIMV running with a 4,000 psi (276 bar) backpressure is subject to cavitation, as the pressure drop would now be 6,000 psi (414 bar) which exceeds the 4,000 psi (276 bar) backpressure. The negative effects of cavitation can be amplified with higher flow rates and reduced fluid viscosities

17. Docking and Undocking (Docking Canister)

17.1 This section details the procedure required to dock and undock a SkoFlo docking canister into a SkoFlo receptacle. The same procedure is used operating on surface or subsea.

17.2 Section 18 goes into further detail regarding setup that is required for subsea installation.

17.3 Required Tools and Parts

17.3.1 The tools in Table 3 are required for the installation. These tools are not part of SkoFlo’s scope of delivery.

Table 3: Required Tools and Components

(Not Provided by SkoFlo)

Tools and parts	Quantity
Torque wrench(es) with torque meter and end effector to Class 4 nut in ROV bucket. *(Refer to Table 4 for required torque values)*	1
End Effector / Torque Reactor A device that interfaces with an API 17H bucket and counters torque that is applied to the bucket docking latch. *(Must be used when applying more than 100 ft-lb torque)*	1
Lifting strap *(Refer to SkoFlo product drawing for unit weight)*	1
Hoist *(Refer to SkoFlo product drawing for unit weight)*	1
Megger Capable of testing IR at 50VDC at 5 GOhms	1
Test harness for wet mate connector	1

17.4 Torque Tool Settings

! CAUTION

TO AVOID LATCH AND SHAFT DAMAGE DO NOT OVER-TORQUE. ONLY APPLY TORQUE REQUIRED TO MAKE 8 ¾ TURNS.

! WARNING

REFER TO GA DRAWING TO DETERMINE IF DOCKING CANISTER UNIT HAS UO-8 OR UO-16 COUPLERS.

! NOTICE

IF APPLYING A TORQUE GREATER THAN 100 FT-LB END EFFECTOR IS REQUIRED TO BE DOCKING INTO THE BUCKET TO PREVENT SIDE LOADING ON COUPLERS.
IF DOCKING UNIT RETURNED FROM FIELD AN END EFFECTOR WILL LIKELY BE REQUIRED.

17.5 Use Table 4 to locate the correct torque setting for the torque tool.

Table 4: [1]Torque Settings

Operation		Single UO-08 Coupler Dual UO-08 Coupler Dual UO-08/UO-16 Coupler Single UO-16 Coupler	Dual UO-16 Coupler (10,000 psi option only)
Docking Canister Without Engagement into Receptacle	Torque	< 10 ft-lb (13.6 N-m)	< 10 ft-lb (13.6 N-m)
	Turns	9 1/4 ± 1/4	9 1/4 ± 1/4
Docking Canister into Receptacle (unpressurized receptacle)	Torque	< 80 ft-lb (108.5 N-m)	< 80 ft-lb (108.5 N-m)
	Turns	8 3/4 ± 1/4	8 3/4 ± 1/4
Docking Canister into Receptacle (max pressurized receptacle)	Torque	400 to 500 ft-lb (542 to 678 N-m)	800 to 1100 ft-lb (1085 to 1491 ± 13.6 N-m)
	Turns	8 3/4 ± 1/4	8 3/4 ± 1/4
Maximum Torque Allowable		600 ft-lb (746 N-m)	1100 ft-lb (1491 N-m)
Maximum Docking Velocity		0.82 ft/s (0.25 m/s)	0.82 ft/s (0.25 m/s)

[1]*Break-out torque may be higher during first quarter turn. Maximum torque applied should not exceed that specified in 18.6.3 to avoid damage*

17.6 CIMV Docking Canister Installation

! WARNING

ENSURE THE LIFTING STRAP IS SUITABLE FOR THE CIMV WEIGHT AS LISTED ON THE GENERAL ARRANGEMENT DRAWING AND/OR THE NAME PLATE ON THE PRODUCT. IF THE WEIGHT CANNOT BE DETERMINED, CONTACT SKOFLO.

! CAUTION

DAMAGE MAY OCCUR TO EQUIPMENT IF THE CIMV IS INSTALLED OR REMOVED WITH POWER TURNED ON TO ELECTRICAL CONNECTOR.

! NOTICE

IDENTIFY THE INSTALLATION ORIENTATION OF THE CIMV BEFORE LIFTING TO AVOID EQUIPMENT DAMAGE. REFER TO PRODUCT SPECIFICATION SHEET AND GA/BOM DRAWING FOR DETAILS. ENSURE COUPLER SHIPPING COVERS ARE REMOVED PRIOR TO DOCKING CIMV.

17.6.1 Confirm there is no power on the CIMV receptacle. If the power is on, turn off before proceeding.

17.6.2 Inspect inside the CIMV receptacle to ensure there is no obvious damage or obstructions. Confirm that any protective covers on the electrical and hydraulic couplers have been properly removed.

17.6.3 Using a megger set to 50 VDC, perform an insulation resistance test using the test harness with all 4 pins joined together to the case. After 60 seconds, insulation resistance should measure 1 GOhms or greater.

17.6.4 Identify the lifting point for the applicable installation configuration per Figure 38 or Figure 40 and strap the D-handle on the docking canister with lifting strap. Use hoist to lift strapped docking canister.

17.6.4.1 Refer to Figure 38 for horizontal installations. Use the valve handle located in the middle of the canister to attach ROV buoyancy device if needed.

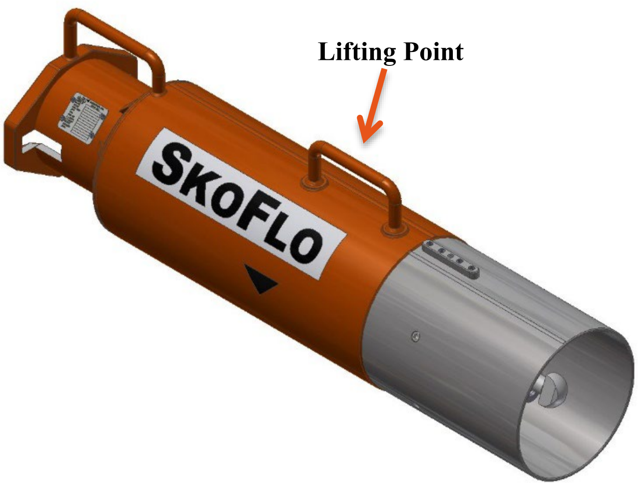


Figure 38: Horizontal Lifting Point Stab

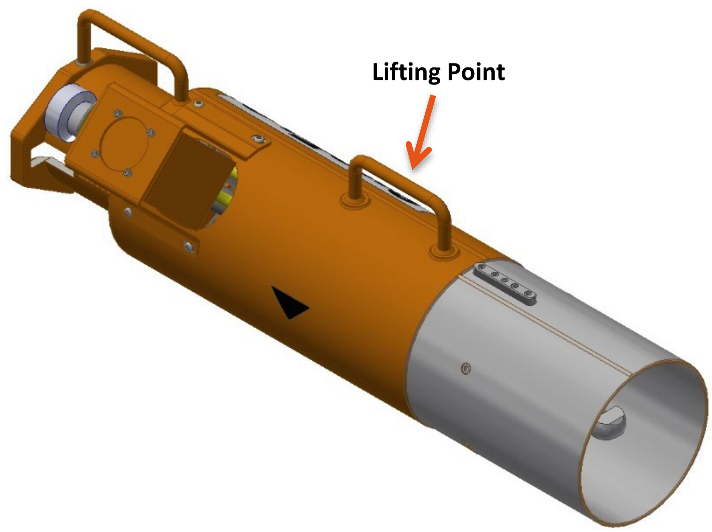


Figure 39: Horizontal Lifting Point ROV

Figure 40: Vertical Lifting Point Stab

Figure 41: Vertical Lifting Point ROV

17.6.5 Position docking canister in front of receptacle with non-coated canister end pointed towards receptacle. Ensure that the CIMV key is aligned with the receptacle keyway. Refer to Figure 45.

17.6.6 Ensure that the docking canister latch has been turned fully CCW to hard stop and an additional approximate 50 ft-lb (67.8 N-m) torque applied.

! CAUTION

LATCH MUST BE TORQUED FULLY CCW BEFORE INSTALLING TO PROTECT THE WET MATE AND HYDRAULIC CONNECTORS MATING TOO RAPIDLY.

17.6.7 The latch is designed so that the spud will go through the receptacle J-plate when it is in the fully CCW position for docking. There is a stop built into the shaft that prevents critical engagement of the couplers and wet mate connectors during initial docking. The subsequent torquing of the latch makes the final connections between the couplers and connectors.

! CAUTION

ALL ROTATIONAL MOTION OF THE LATCH DURING INSTALLATION MUST BE IN THE SAME DIRECTION TO THE RECOMMENDED NUMBER OF TURNS. APPLY ONLY THE TORQUE REQUIRED TO ACHIVE THE REQUIRED NUMBER OF TURNS. PLEASE TAKE SPECIAL ATTENTION THAT THE TORQUE TOOL IS NOT MOVED IN THE CCW DIRECTION AT ANY POINT DURING THE INSTALLATION PROCESS. IF THIS IS DONE, THE CIMV MUST BE TURNED FULLY CCW TO THE INITIAL POSITION, BEFORE STARTING COUNTING TURNS IN CW DIRECTION AGAIN.

17.6.8 Insert the docking canister into the receptacle. Slide the canister into the receptacle by pushing on the front of the docking canister (bucket) until a hard stop is reached. Adjustments to the lifted height of the docking canister may be required to slide docking canister fully into receptacle.

! NOTICE

WHEN CIMV IS FULLY DOCKED, THE GUIDE KEY WILL HAVE A GAP FROM THE BOTTOM OF THE KEYWAY. THE GAP IS TYPICALLY AROUND 0.75” (19 MM). IN ADDITION, IF CIMV HAS DOCKING ARROWS, THE ARROWS SHOULD BE ALIGNED, REFER TO FIGURE 45.

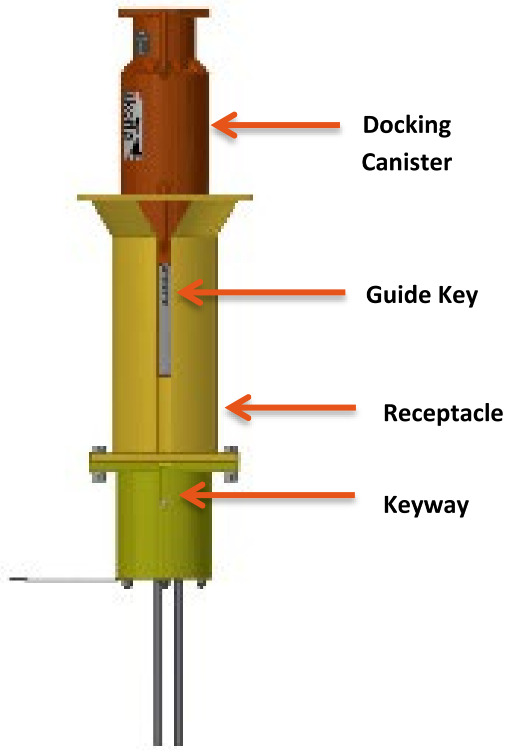


Figure 42: Vertical Unit Docking

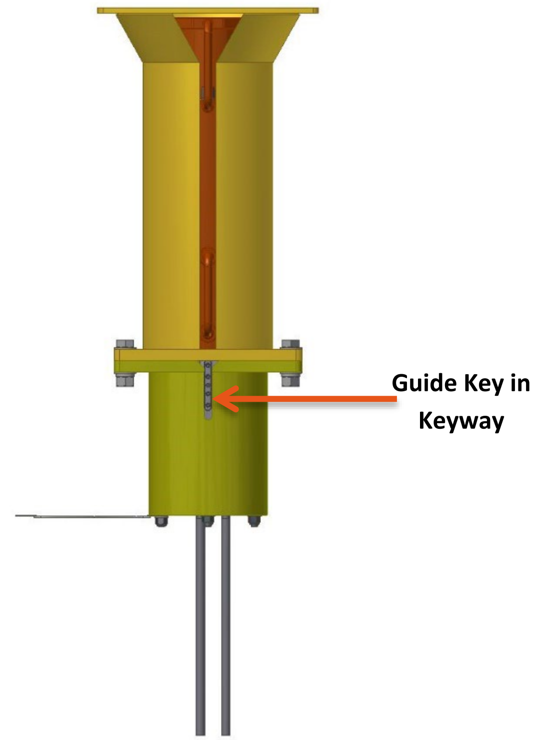


Figure 43: Vertical Unit Docked

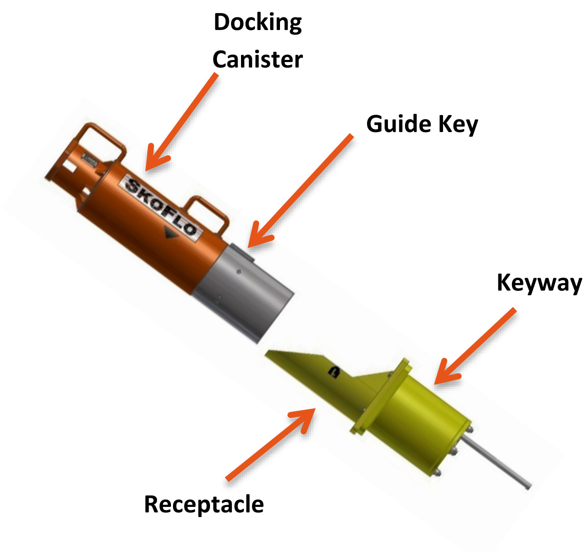


Figure 44: Horizontal Unit Docking

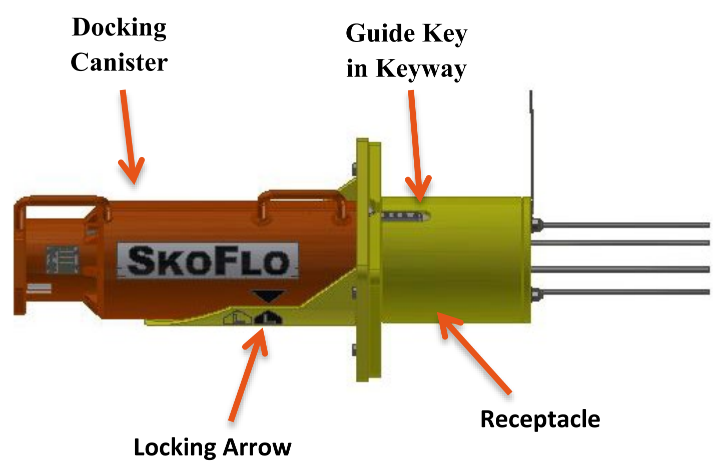


Figure 45: Horizontal Unit Docked

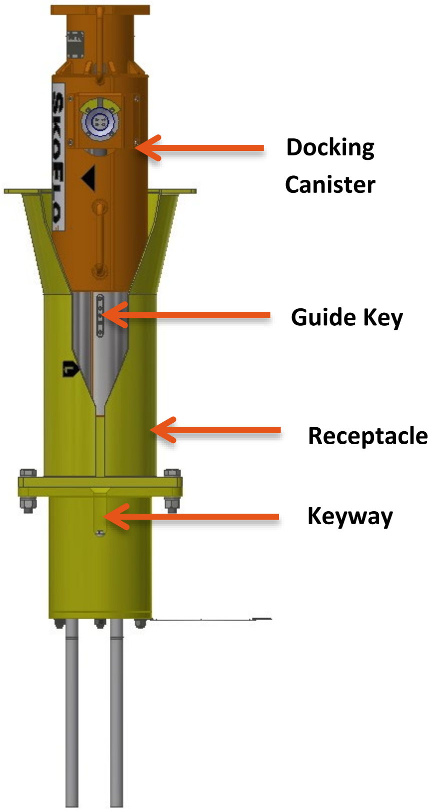


Figure 46: Vertical ROV Unit Docking

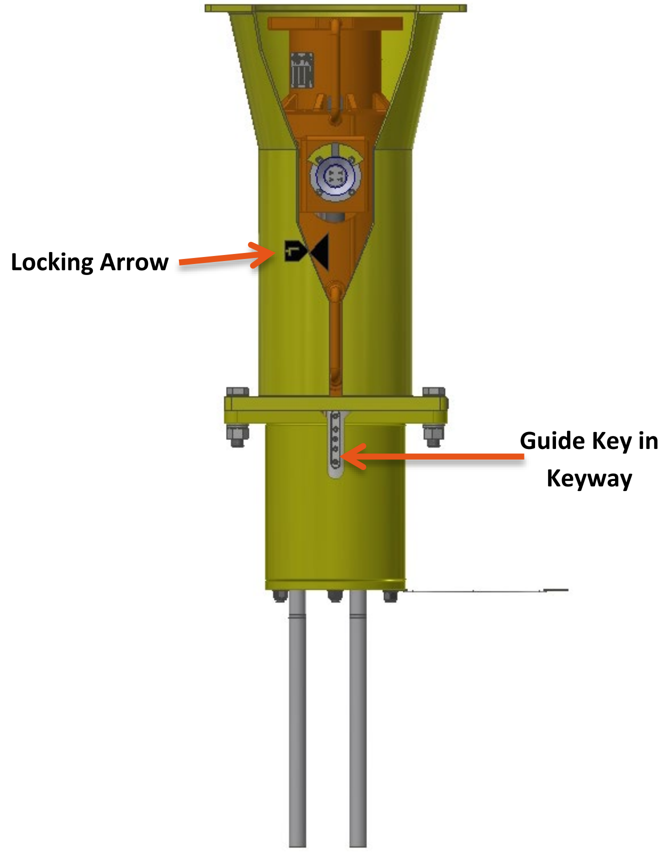


Figure 47: Vertical ROV Unit Docked

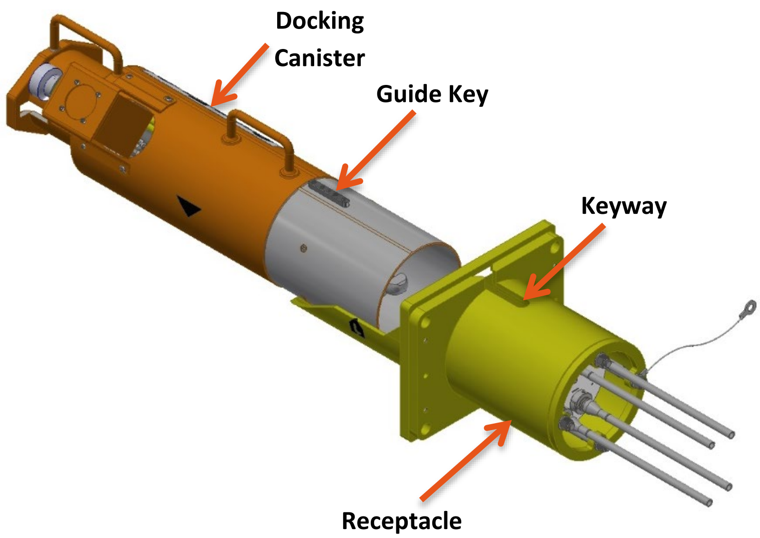


Figure 48: Horizontal ROV Unit Docking

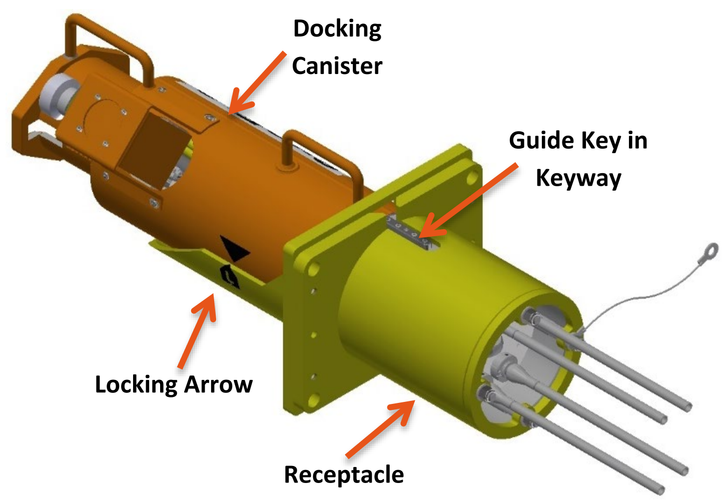


Figure 49: Horizontal ROV Unit Docked

17.6.9 Install the end effector into the docking canister bucket.

17.6.10 Install a 0-2000 ft-lb (class 4) adapter onto the torque tool so that the torque tool can engage on the docking canister torque latch (1.50-inch square).

17.6.11 Place the class 4 torque tool into the docking canister bucket shown in Figure 14. The torque tool should be appropriately sized to meet requirements of Table 4: [1]Torque Settings.

17.6.12 Torque the docking canister latch in the CW direction.

17.6.12.1 For horizontal stab and ROV installations, ensure that the total number of turns are in compliance with Table 4 and that the locking indicator arrows are aligned. Refer to Figure 49, Figure 50, and Figure 51.

17.6.12.2 For extended horizontal stab and vertical stab installations, there are no locking indicator arrows on these configurations. Therefore, ensure that the total number of turns are in compliance with Table 4.

17.6.12.3 If the number of latch turns is not in compliance, contact SkoFlo engineering. Use only the torque required to achieve the number of turns required. Over torquing the latch may result in a high torque to undock.

17.6.13 For horizontal installation only, ensure the lock indicator (if applicable) is aligned after complete docking as shown in Figure 50.

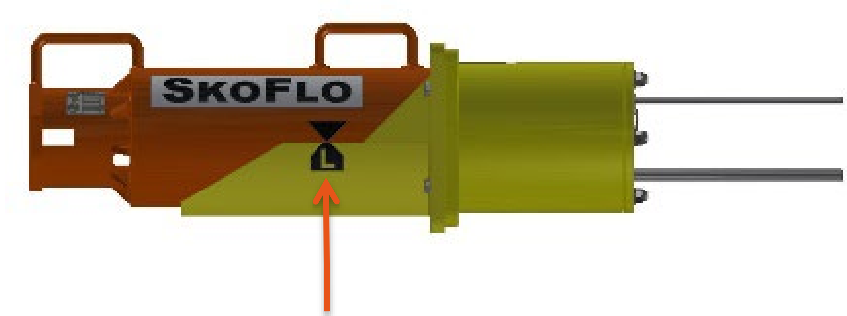


Figure 50: Locking Indicator for Horizontal CIMV Stab Installation

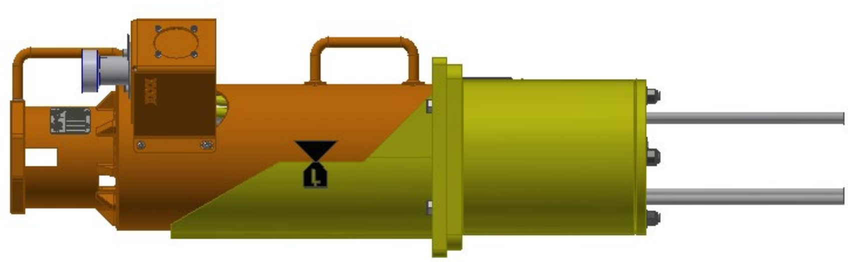


Figure 51: Locking Indicator for Horizontal CIMV ROV Installation

17.7 CIMV Docking Canister Removal

! WARNING

ENSURE THE LIFTING STRAP IS SUITABLE FOR THE CIMV WEIGHT AS LISTED ON THE GENERAL ARRANGEMENT DRAWING AND/OR THE NAME PLATE ON THE PRODUCT. IF THE WEIGHT CANNOT BE DETERMINED, CONTACT SKOFLO.

! NOTICE

IDENTIFY THE INSTALLATION ORIENTATION OF THE CIMV BEFORE LIFTING TO AVOID EQUIPMENT DAMAGE. REFER TO PRODUCT SPECIFICATION SHEET AND GA/BOM DRAWING FOR DETAILS.

! CAUTION

DAMAGE MAY OCCUR TO EQUIPMENT IF THE CIMV IS INSTALLED OR REMOVED WITH POWER TURNED ON TO ELECTRICAL CONNECTOR.

17.7.1 Confirm power is turned off to the docking canister (if applicable) prior to removal.

17.7.2 Identify the lifting point shown in Figure 38 and Figure 39 and strap the D-Handle with lifting strap.

17.7.3 Install a 0-2000 ft-lb (class-4) end effector onto the torque tool so that the torque tool can engage on the docking canister torque latch (1.50-inch square).

17.7.4 Set max torque for torque tool with the torque calibration tool shown in Table 4.

17.7.5 Place the Class 4 torque tool into the docking canister ROV bucket shown in Figure 14.

17.7.6 Torque the shaft in the CCW direction until breakout is achieved.

17.7.7 Once achieved, reduce the torque to a level sufficient to complete the undocking procedure.

17.7.8 Continue with the CCW rotation until the hard stop is reached.

17.7.9 Remove torque tool from bucket.

17.7.10 Using the lifting strap and hoist, slide the docking canister out of the receptacle.

17.7.11 The docking canister can be placed to rest in either the vertical or horizontal position shown in Figure 52.

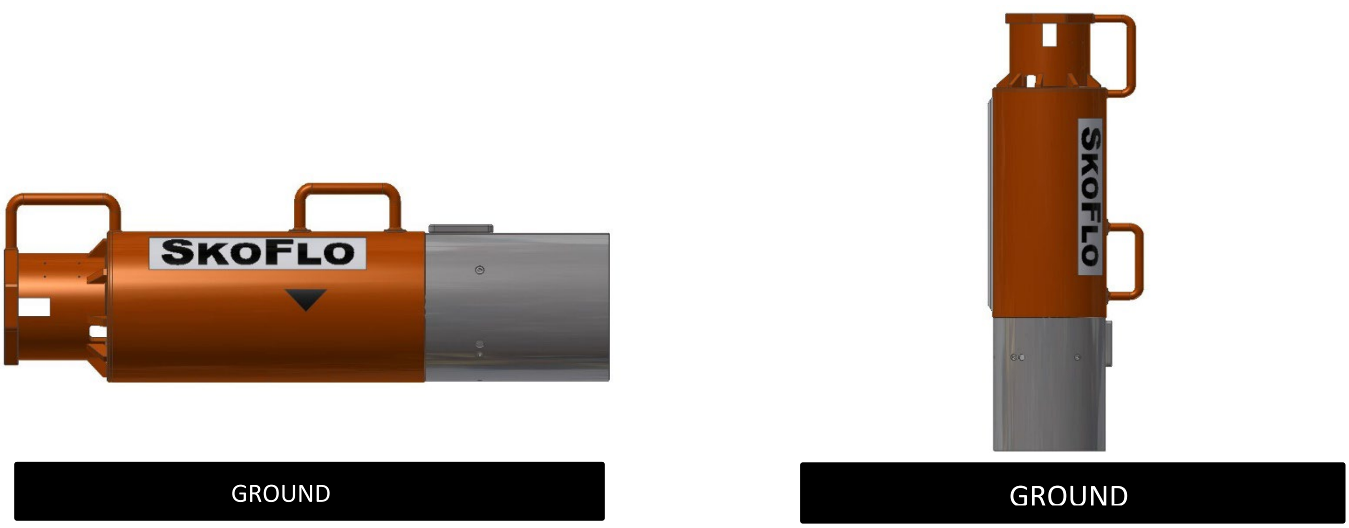


Figure 52: Ground Position

18. Subsea Installation and Retrieval (Docking Canister)

18.1 Required Tools and Parts

18.1.1 This section is an addendum to section 17.

! NOTICE

THE LISTED TOOLS AND PARTS ARE SUGGESTED FOR INSTALLATION. THESE ITEMS ARE NOT PART OF SKOFLO'S SCOPE TO PROVIDE.

18.1.2 The tools listed in Table 5 are suggested for installing a CIMV or Test Flushing Unit subsea.

Table 5: Suggested Tools for Subsea Installation

(Not Provided by SkoFlo)

Tools and Parts	Quantity
Torque Tool API 17H Class 4	1
Remote Control Unit (RCU) (This tool is optional dependent on ROV design. If the RCU unit is embedded into ROV, this tool will not be required. Consult respective ROV providers on this.)	1
Calibration Test Jig	1
ROV Water Jet	1
Installation/Retrievable Basket (Optional)	1
Wireline/Buoyancy/Lifting Mechanism (For vertical installation only)	1

18.2 Pre-Deployment ROV Recommendations

18.2.1 It is recommended by SkoFlo that any ROV installing or retrieving a docking canister unit should have the following capabilities:

- Manipulator Arm Claw – with full 360 degrees of rotation.
- Water Jet Fitted.

18.2.2 ROV Torque Tool settings shall be in accordance with Table 4. Only use the torque required to achieve the desired number of turns. Over torque may result in higher-than-normal undocking torque.

18.3 CIMV or Test Flushing Unit Subsea Retrieval General Steps

18.3.1 Identify the orientation type (horizontal or vertical) of the receptacle installed to the subsea system.

! NOTICE

IDENTIFY THE ORIENTATION OF THE INSTALLED DOCKING CANISTER UNIT BEFORE DEPLOYING THE ROV SUBSEA. TO ENSURE THE CORRECT ORIENTATION, REFER TO GENERAL SECTION OF THE PRODUCT SPECIFICATION SHEET OR PRODUCT GENERAL ARRANGEMENT DRAWING.

18.3.2 Install the RCU onto the ROV, if applicable.

18.3.3 Calibrate the torque tool per Table 4 with the calibration test jig.

18.3.4 Install the torque tool and water jet onto the ROV and test in accordance with the installation contractor’s procedures.

18.3.5 Ensure electrical power to the docking canister unit is off (only applicable to units that require power).

! CAUTION

DAMAGE MAY OCCUR TO EQUIPMENT IF A CIMV CORE IS INSTALLED OR REMOVED WITH POWER ON.

18.3.6 Perform normal ROV pre-dive checks in accordance with installation contractor’s procedures.

18.3.7 Launch the ROV to the work location.

18.3.8 Perform a pre-operational survey of the work site.

! NOTICE

DURING ALL SUBSEQUENT OPERATIONS ENSURE THE WORK AREA AND EQUIPMENT IS CLEAN. MAKE USE OF THE WATER JET AND/OR THE SUCTION CAPABILITY OF THE DREDGING PUMP IF NECESSARY.

18.3.9 If applicable, deploy the installation/retrievable basket on a suitable location.

18.3.10 Navigate the ROV to the position of the docking canister unit on the structure.

Proceed to section 18.4 for vertical retrieval and section 18.5 for horizontal retrieval.

18.4 Vertical Retrieval

! NOTICE

COMPLETE STEPS FROM SECTIONS 18.1 THRU 18.3 PRIOR TO STARTING THIS SECTION.

! NOTICE

THIS SECTION ONLY APPLIES FOR VERTICAL RETRIEVAL. SECTION 18.5 REFERS TO HORIZONTAL RETRIEVAL.

18.4.1 Clean any marine growth or objects that might obstruct the operation with a water jet.

18.4.2 If the docking canister has an ROV mate connector, disconnect the connector per the ROV electrical connector supplier’s instruction.

! CAUTION

DAMAGE MAY OCCUR TO ROV ELECTRICAL CONNECTOR IF NOT DISCONNECTED PROPERLY PRIOR TO UNDOCKING CANISTER.

18.4.3 Align the torque tool with the docking canister’s ROV bucket shown in Figure 14 and carefully place the torque tool into the docking canister’s ROV bucket.

18.4.4 Run the torque tool shown in Table 5.

18.4.5 Remove the torque tool away from the docking canister's ROV bucket.

18.4.6 Hook the D-Handle on the docking canister lifting point shown in Figure 39 using the wireline or buoyancy with the ROV assistance.

18.4.7 Retrieve the docking canister back to the surface either by ROV or place the retrieved unit into the installation/retrieval basket to be retrieved by wireline.

! CAUTION

DO NOT LEAVE RECEPTACLE OPEN OVER 2 DAYS IN SUBSEA CONDITIONS WITHOUT INSTALLING ANOTHER CIMV, TEST FLUSHING UNIT, OR MARINE GROWTH COVER PLATE.

18.5 Horizontal Retrieval

! NOTICE

THIS SECTION ONLY APPLIES FOR HORIZONTAL RETRIEVAL. SECTION 18.4 REFERS TO VERTICAL RETRIEVAL.

18.5.1 Clean any marine growth or objects that might obstruct the operation with water jet.

18.5.2 If the docking canister has an ROV mate connector, disconnect the connector per the ROV electrical connector supplier's instruction.

! CAUTION

DAMAGE MAY OCCUR TO ROV ELECTRICAL CONNECTOR IF NOT DISCONNECTED PROPERLY PRIOR TO UNDOCKING CANISTER.

18.5.3 Align the torque tool with the docking canister's ROV bucket shown in Figure 14 and carefully place the torque tool into the unit's ROV bucket.

18.5.4 Run the torque tool shown in Table 5.

18.5.5 Remove the torque tool away from the docking canister's ROV bucket.

18.5.6 Pull the canister out from its receptacle using the ROV's manipulator and grab the D-Handle of the docking canister.

18.5.7 Retrieve the canister back to the surface either by ROV or place the retrieved unit into the installation/retrieval basket to be retrieved by wireline.

! CAUTION

DO NOT LEAVE RECEPTACLE OPEN OVER 2 DAYS IN SUBSEA CONDITIONS WITHOUT INSTALLING ANOTHER CIMV, TEST FLUSHING UNIT, OR MARINE GROWTH COVER PLATE. PREFERABLY PLANNING SHOULD BE TO INSTALL A NEW PART RIGHT AFTER RETRIEVAL.

18.6 Retrieval if latch is stuck or inoperable:

18.6.1 If the latch becomes stuck or inoperable, it is still possible to remove the fully-docked CIMV from the receptacle. The CIMV will require service at SkoFlo after this process for repair.

18.6.2 Insert ROV mounted torque tool into CIMV canister torque bucket and lock into position. Pull out lightly to ensure torque tool is fully locked to CIMV canister.

18.6.3 Rotate the torque tool until the latch spud breaks off and releases the CIMV from the receptacle. The latch spud will fail and fall away from the back of the receptacle at approximately 2000 ft-lb (2712 N-m). Junction plates will yield slightly from over-torquing, but a new CIMV may be installed due to the stroke length of the latch design.

18.6.4 Lift outward on the CIMV to remove from the receptacle.

18.7 Docking Canister Subsea Installation General Steps

18.7.1 Identify the orientation type of the installed docking canister in subsea.

! NOTICE
IDENTIFY THE ORIENTATION OF THE INSTALLED DOCKING CANISTER BEFORE DEPLOYING THE ROV SUBSEA. REFER TO GENERAL SECTION OF THE PRODUCT SPECIFICATION SHEET.

18.7.2 Verify the docking canister latch is in the fully open position by torquing it CCW as per Table 4.

18.7.3 Remove the electrical and hydraulic protection cover from the docking canister. Ensure the hydraulic couplers are not damaged or contain any plugs or debris before subsea installation.

! NOTICE
ENSURE COUPLER SHIPPING COVERS ARE REMOVED PRIOR TO DOCKING THE DOCKING CANISTER.

18.7.4 Install the RCU onto the ROV (if applicable).

18.7.5 Calibrate the torque tool with calibration test jig.

18.7.6 Install the torque tool and water jet onto the ROV and test in accordance with installation contractor's procedures.

18.7.7 For horizontal installation, place the docking canister into the installation/retrieval basket.

18.7.8 For vertical installation, attach the docking canister to the wireline.

! NOTICE
POSITION THE DOCKING CANISTER IN A WAY THAT IS EASY FOR THE ROV TO GRAB.

18.7.9 Ensure that the electrical power to the receptacle installed subsea on the structure is off.

! CAUTION
DAMAGE MAY OCCUR TO EQUIPMENT IF THE CIMV IS INSTALLED OR REMOVED WITH POWER ON.

18.7.10 Perform normal ROV pre-dive checks in accordance with installation contractor's procedures.

18.7.11 Launch the ROV to the work location.

18.7.12 Perform a pre-operational survey of the work site.

! NOTICE
DURING ALL SUBSEQUENT OPERATIONS ENSURE THE WORK AREA AND EQUIPMENT IS CLEAN. MAKE USE OF THE WATER JET AND/OR THE SUCTION CAPABILITY OF THE DREDGING PUMP IF NECESSARY.

18.7.13 Navigate the ROV at the installation area.

18.8 Vertical Installation

> **! NOTICE**
> THIS SECTION ONLY APPLIES FOR VERTICAL INSTALLATION. REFER TO SECTION 18.9 FOR HORIZONTAL INSTALLATION PROCEDURE.

18.8.1 Using the water jet, clean any marine growth or objects that might obstruct the operation in the receptacle.

18.8.2 Using the wireline, carefully deploy the docking canister into its receptacle guide cone. Ensure the D-Handle of the docking canister is aligning with the receptacle key slot shown in Figure 42 and Figure 43.

18.8.3 Using the ROV, unlock the latch lifting tool and remove the latch lifting tool away from the ROV bucket.

18.8.4 Align the torque tool with the docking canister's ROV bucket shown in Figure 14 and carefully place the torque tool into the docking canister's ROV bucket.

18.8.5 Run the torque tool shown in Table 5. Verification of a fully installed docking canister shall be determined by counting the number of turns of the torque latch.

18.8.6 Remove the torque tool away from the docking canister's ROV bucket.

18.9 Horizontal Installation

> **! NOTICE**
> THIS SECTION ONLY APPLIES FOR HORIZONTAL INSTALLATION. REFER TO SECTION 18.8 FOR VERTICAL INSTALLATION PROCEDURE.

18.9.1 Deploy the installation/retrieval basket on a suitable area.

18.9.2 Using the ROV manipulator, grab the D-Handle of the docking canister shown on Figure 38 from the installation/retrieval basket.

18.9.3 Carefully insert the docking canister into the receptacle. Ensure the D-Handle of the docking canister is aligning with the receptacle key slot shown in Figure 44 and Figure 45.

18.9.4 Align the torque tool with the docking canister's ROV bucket shown in Figure 14 and carefully place the torque tool into the CIMV's ROV bucket.

18.9.5 Run the torque tool as per Table 4. Verification of a fully installed docking canister shall be by counting the number of turns.

18.9.6 Remove the torque tool away from the docking canister's ROV bucket.

18.9.7 Ensure the locking indicator is aligned shown in Figure 50. This step is only applicable if the receptacle has a horizontal guide ledge (not applicable to the horizontal extended guide ledge).

18.10 Seawater Ingress

18.10.1 Based on Pitting Resistance Equivalence Numbers (PREN) of the materials that would be exposed to seawater, an estimate of 10% seawater could be in the chemical injection lines for continuous use with no damage to the SkoFlo products (LF and HF CIMV).

18.10.2 It is important to make sure that an excess of seawater does not enter the chemical injection lines while installing or removing a docking canister product.

19. Calibration Matrix Storage and Generation

19.1 Chemical Flow Table General Information

19.1.1 The SkoFlo Sub Sea CIMV has the capability of holding up to 4 flow calibration tables (matrices) in its onboard controller memory. When populated, these tables may represent different chemicals. Only one table may be active at a time. Switching between tables is done through the control system topside. Table 1 is reserved for the initial SkoFlo flow calibration (generally FAT glycol/water) and should not be altered. This table is used in the generation of new tables.

19.1.2 The active calibration table must match injected fluid properties and approximate absolute and differential pressure conditions in order for stem and differential pressure flow readings to be accurate. Refer to section 11 and 19.2 for details.

19.2 Chemical Flow Table Stored Information

19.2.1 Flow tables contain flow points from CIMV calibrations. Each calibration table contains stem position, differential sensor reading, and either externally measured flow rate (high flow CIMVs) or internally measured flow rate (low flow CIMVs via PDFM) for each point. Calibration of the base table (Table 1) is performed at constant inlet and outlet pressures with a 3,000 psi (207 bar) pressure drop across the CIMV. SkoFlo test chemical is pumped through the CIMV at 24 different stem positions. At each point, the previously mentioned parameters are recorded resulting in a complete flow table.

19.2.2 For HF CIMVs, Table 2 through Table 4 must be generated by SkoFlo to meet the needs of the end user. There is no option for users to create calibration tables in the field. These tables can be generated by SkoFlo and downloaded to the CIMV while the unit is installed subsea. SkoFlo will need the specific gravity for the new fluid(s) to be injected.

19.2.3 For LF CIMVs with the PDFM, the CIMV is shipped out with only Table 1 populated. It is up to the operator to generate the required tables for field use. These tables are to be generated using the PDFM auto-calibration feature once the CIMV has been commissioned.

19.3 LF CIMV Flow Table Field Generation (Auto-calibration)

19.3.1 The auto-calibration feature is only available on LF CIMV cores with the PDFM. The calibration is intended to be executed once the CIMV has been deployed subsea and once the actual chemical injection fluid can be passed through the CIMV core. Until this calibration is complete, the CIMV may not meet the stated measurement accuracies in Section 11.

19.3.1.1 The CIMV can still regulate flow using the factory calibration Table 1 without performing the auto-calibration. Flow by dP, flow by stem and/or flow by PDFM can be used to adjust flow rates. Measurement accuracies for flow by dP and flow by stem will be based on 25% MEG; flow by PDFM measurement accuracies shall comply with Table 1.

19.3.2 Auto-calibration must be completed when a new chemical is introduced to the CIMV.

19.3.3 Auto-calibration should be completed for the following situations:

- Inlet pressure to the CIMV shifts to a new pressure that is more than 1,000 psi (68.9 bar) from the calibrated inlet pressure.
- Outlet pressure of the CIMV shifts to a new pressure that is more than 2,000 psi (137.9 bar) from the calibrated outlet pressure.

19.3.3.1 Failure to perform auto-calibrations at these times can result in degraded flow measurement accuracy.

19.3.4 The software manual (DOC-00969 for analog SIISv2 and DOC-00999 for analog Modbus) contains detailed instructions on how to perform an auto-calibration in the field using the PDFM once the input parameters are determined. The following are the required input parameters:

- Maximum and minimum flow
- Fluid specific gravity
- Fluid bulk modulus
- Target table
- Number of samples to average with PDFM
- Post move delay
- Post sample delay

! NOTICE

AT ANY TIME DURING THIS CALIBRATION PROCESS THE OPERATOR MAY ABORT THE PROCESS BY SENDING A STOP COMMAND TO THE CIMV.

19.3.5 Maximum and minimum flow:

19.3.5.1 This section of the Operation and Maintenance manual uses the following terms:

- Desired Operating Flow: The minimum and maximum flow rate at which the CIMV is going to be used in service.
- Required Calibration Flow: The minimum and maximum flow range that must be achieved during calibration to allow for the successful use of the CIMV at the desired operating flow while in service.

19.3.5.2 In order for the CIMV to auto-calibrate, the required calibration flow range must be specified. This flow range must be 5% or 0.5 GPD (whichever is greater) wider than the desired operating flow range to allow for over and undershoot.

19.3.5.2.1 For example, if the minimum required calibration flow range is 2 GPD, 5% of 2 GPD is 0.1 GPD. 0.5 GPD is greater than 0.1 GPD, therefore, 0.5 GPD is subtracted from 2 GPD resulting in a minimum required calibration flow range of 1.5 GPD.

19.3.5.2.2 For example, if the maximum required calibration flow range is 500 GPD, 5% of 500 GPD is 25 GPD. 25 GPD is greater than 0.5 GPD, therefore, 25 GPD is added to 500 GPD resulting in a maximum required calibration flow range of 525 GPD.

Low Viscosity Injection Fluid Example (3 cP)			
Minimum desired calibration flow, GPD (LPH)	Minimum desired operating flow, GPD (LPH)	Maximum desired operating flow, GPD (LPH)	Maximum desired calibration flow, GPD (LPH)
1.5 (0.24)	2.0 (0.31)	500 (78.9)	525 (82.8)

High Viscosity Injection Fluid Example (100 cP)			
Minimum desired calibration flow	Minimum desired operating flow	Maximum desired operating flow	Maximum desired calibration flow
1.5 (0.24)	2.0 (0.31)	315 (49.7)	331 (52.2)

19.3.5.3 Additional consideration must be taken to account for fluid viscosity. Thicker fluids will reduce the maximum desired operating flow / rated full scale flow. SkoFlo utilizes conservative equations to determine viscosity impact on maximum desired operating flow. Minimum flow rates are not affected by the fluid viscosity. Project specific values generated with the SkoFlo equations can be found on the product specific configuration sheet. These values are calculated based off of the thickest fluid viscosity information provided to SkoFlo by the customer / buyer.

19.3.5.3.1 For example, a fluid viscosity of 3 cP will deliver a maximum operating flow range of 500 GPD whereas a fluid viscosity of 100 cP will deliver a maximum operating flow range of 315 GPD.

19.3.5.3.2 The equations used to determine maximum achievable flow for a given fluid viscosity are listed below for both a 500 GPD maximum flow CIMV and a 1200 GPD maximum flow CIMV respectively:

$$\text{M}aximum\ Achievable\ Flow\ (500\ GPD\ CIMV) = -1.853 * viscosity\ (cP) + 501.17$$

$$\text{M}aximum\ Achievable\ Flow\ (1200\ GPD\ CIMV) = -4.73 * viscosity\ (cP) + 1234$$

19.3.5.4 When performing an auto-calibration, the maximum desired operating flow range is either based on the project specific configuration sheet or determined when the CIMV is installed subsea. To determine the maximum desired operating flow range subsea, drive the CIMV to 90% stem position (not flow by stem) and take a flow by PDFM reading. This PDFM reading is the highest available value that can be used for the maximum required operating flow. The top side or system pump must be capable of maintaining the highest flow rate such that pumping pressure is not the limiting factor.

! NOTICE

IT IS NECESSARY TO DETERMINE THE MAXIMUM REQUIRED CALIBRATION FLOW RATE BEFORE AN AUTO-CALIBRATION IS PERFORMED. IF THE MAXIMUM REQUIRED CALIBRATION FLOW RATE ENTERED IS GREATER THAN WHAT THE CIMV CAN ACTUALLY ACHIEVE, THE AUTO-CALIBRATION WILL FAIL AND THE PROCESS WILL BE ABORTED.

19.3.6 Fluid specific gravity:

19.3.6.1 This value is used to calculate a flow from differential pressure across the metering orifice in the CIMV. If the incorrect value is used, flow by dP will lose accuracy.

19.3.7 Fluid bulk modulus:

19.3.7.1 The bulk modulus of the injection fluid is used to compensate for compression of the fluid in the PDFM. Incorrect values here will result in error of the PDFM readings as the PDFM measures volumetric flow rates.

19.3.7.2 The operator can reference the bulk modulus and specific gravity of the chemical used during operation. The default calibration SkoFlo uses for bulk modulus is 470,000 psi for a 25% MEG / 75% water solution, and 280,000 psi for ethanol. The maximum likely reading error when calibration is done incorrectly will be about 1% of reading.

19.3.7.3 If the operator wants to have the subsea "uncompensated" value both for PDFM and DP reading, the bulk modulus needs to be set to a high value since the formula for calculating compensated flow rate is the following: Compensated = uncompensated*(1+supply pressure (P1)/bulk modulus. Note that the compensated value is dependent on a good P1 reading, whereas the uncompensated value is not.

19.3.8 Target Table:

19.3.8.1 The population of this field tells the CIMV which internal lookup table the operator wants the calibration data to be stored in. The possible input values here are 1 thru 4 however it is very important not to target Table 1 for rewrite. This is the SkoFlo factory table and is required to perform auto-calibrations for Tables 2 thru 4.

19.3.9 Number of samples to average with PDFM:

19.3.9.1 During auto-calibration, the PDFM takes flow readings to populate the flow lookup table. Because of the criticality of the PDFM measurement, it is possible to tell the CIMV to take multiple PDFM readings for each calibration point and to average them. The number of flow samples taken is left to the discretion of the operator; however, SkoFlo recommends that 2 readings are taken at a minimum.

19.3.10 Post move delay:

19.3.10.1 This input is the number of minutes the CIMV will wait before taking and recording a flow reading after stem movement. The pressure sensors in the CIMV operate on a 1-minute rolling average. Allowing the CIMV to "rest" for at least 1 minute prior to recording the dP value is advisable to allow for the pressure sensors to settle out. Standard practice for SkoFlo is to use a 2-minute delay here.

19.3.10.2 Using a 2-minute post move delay on a calibration ranging from 520 GPD for maximum desired calibration flow and 1.5 GPD for minimum required calibration flow (full flow range of the CIMV), approximately 5 U.S. gallons of chemical will be required.

19.3.11 Post sample delay:

19.3.11.1 The post sample delay is the number of seconds that the CIMV waits until moving to make the next flow measurement. Units are stored as seconds. The higher the value, the longer the auto-calibration will take. The factory recommendation is to set this value to 4.

19.3.11.2 There are 24 flow measurements made during the auto-calibration. An increase of this value from 4 to 6 seconds would result in a nominal increase in auto-calibration time of 48 seconds. This additional time does not take into account actual measurement time which can vary by flow and pressure conditions.

19.3.12 Once the operator initiates the start command for auto-calibration, the CIMV will go to the highest flow in the selected flow range and begin taking flow measurements. It will automatically move through the flow range taking intermittent flow measurements and storing them to the controller.

19.3.13 While the auto-calibration is being performed, the CIMV will not be able to receive commands. Interruption of the process will result in the need to restart the auto-calibration.

19.3.14 When the flow measurements are complete, the CIMV will prompt the operator to perform a zero-flow differential pressure calibration operation, refer to the user manual for more details. When the CIMV receives the zero-flow differential pressure value, the calibration is complete, and the operator can resume normal operation.

20. Condition and Performance Monitoring

20.1 This section explains the basic warnings that are built into every CIMV. It is recommended by SkoFlo to allow for monitoring of these warnings as they can notify operators in advance if the CIMV requires routine maintenance or if service is required.

Table 6: CIMV Warnings

CIMV Software Object	Description	Causes	Solution
Zero-Flow Recalibration Warning	Indicates that the supply pressure (P1) differs by more than 1000 psi (68.9 bar) from the supply pressure recorded during the last pumping zero. For CANbus software version 2.6 and higher, the pressure limit is user adjustable, but defaults to 1,000 psi (70 bar)	Change in supply pressure; temperature or chemical flow regulation.	For LF CIMV: Step 1) Perform pumping zero. (Refer to Section 8.4) Step 2) Perform auto-calibration at new inlet pressure.
			For HF CIMV: Step 1) Perform pumping zero. (Refer to section 8.4) Step 2) Adjust supply pressure to within 1000 psi (68.9 bar) of the calibration supply pressure.
LF core filter P1-P3 Difference Warning (Refer to 21.3 for filter size)	Indicates the differential pressure between orifice inlet pressure (P1) and CIMV outlet pressure (P3) is less than 250 psi (17 bar). For CANbus software version 2.6 and higher, the warning limit is user adjustable, but defaults to 250 psi (17 bar)	Inlet pressure to CIMV is too low.	Increase inlet pressure to CIMV.
		Catch screen is clogged.	Check pressure drop across P4 – P1. If pressure is greater than 500 psi (34 bar) consult SkoFlo engineering.
		Pumping zero is being performed.	There is no issue. The warning will go away once the pumping zero is complete and downstream flow is no longer blocked.
Flow Table Generator (FTG) Supply Pressure Shift Warning (Refer to section 19 for auto-calibration information)	Supply pressure (P1) varies more than ±500 psi (34.5 bar) over the course of the auto-calibration.	Supply pressure changed more than ±500 psi (34.5 bar).	Abort or pause the current auto-calibration and wait for the supply pressure to stabilize. Once stabile, start a new auto-calibration.

21. Fluid Cleanliness and Flushing

! WARNING

IT IS NOT RECOMMENDED TO USE THE CIMV TO FLUSH THE CHRISTMAS TREE, MANIFOLD, OR UMBILICAL AS THE MANUFACTURING DEBRIS OR SOLIDIFIED CHEMICAL MIGHT DAMAGE OR CLOG THE CIMV.

21.1 In most cases, line blockages are attributed to the mixing of incompatible chemical and particle accumulations. It is recommended to install filters on the chemical flow lines topside to provide initial warnings if high pressure drops are observed.

High pressure drops across the filter may indicate that fluid mixture has solidified due to the incompatible mixture or simply that the fluid is not clean.

21.2 The SkoFlo CIMV is designed with 4 sensors, P1-P4. The P4 sensor is located between the catch screen and inlet coupler as depicted in Figure 4 and Figure 5. P4 and P1 can be used by the control system to calculate the differential pressure over the catch screen. Monitoring this value is beneficial for all cases where clogging might be a concern, such as in MEG regeneration lines where tar can solidify as a result of asphaltene not being removed from the MEG fluid. The asphaltene can end up getting reinjected into the umbilical flow lines when the MEG fluid is reused, solidifying on the inner diameter of injection lines and last chance catch screens.

21.3 The SkoFlo CIMV has internal screen sizes shown in Table 7. Recommended topside filter sizes are per Table 7.

Table 7: Topside Recommended Filter Sizes

CIMV Model	Flow Range	Screen Hole Size	Recommended Topside Filter Size
LF CIMV with PDFM	0.3 to 80 LPH (2 to 500 GPD)	40 micron	10 to 30 micron
	1.6 to 200 LPH (10 to 1200 GPD)	40 micron	10 to 30 micron
HF CIMV	57 to 1140 LPH (0.25 to 5.0 GPM)	1143 micron	60 to 80 micron
	2271 to 3406 LPH (10 to 15 GPM)	1422 micron	60 to 80 micron
	450 to 9000 LPH (20.0 to 48.5 GPM)	1905 micron	60 to 80 micron

21.4 For flushing the chemical injection system, it is recommended to use a SkoFlo test flushing unit rather than a CIMV in the flow path or to install a bypass loop across the CIMV as shown in Figure 53 below to prevent solidifying chemicals from clogging the CIMV.

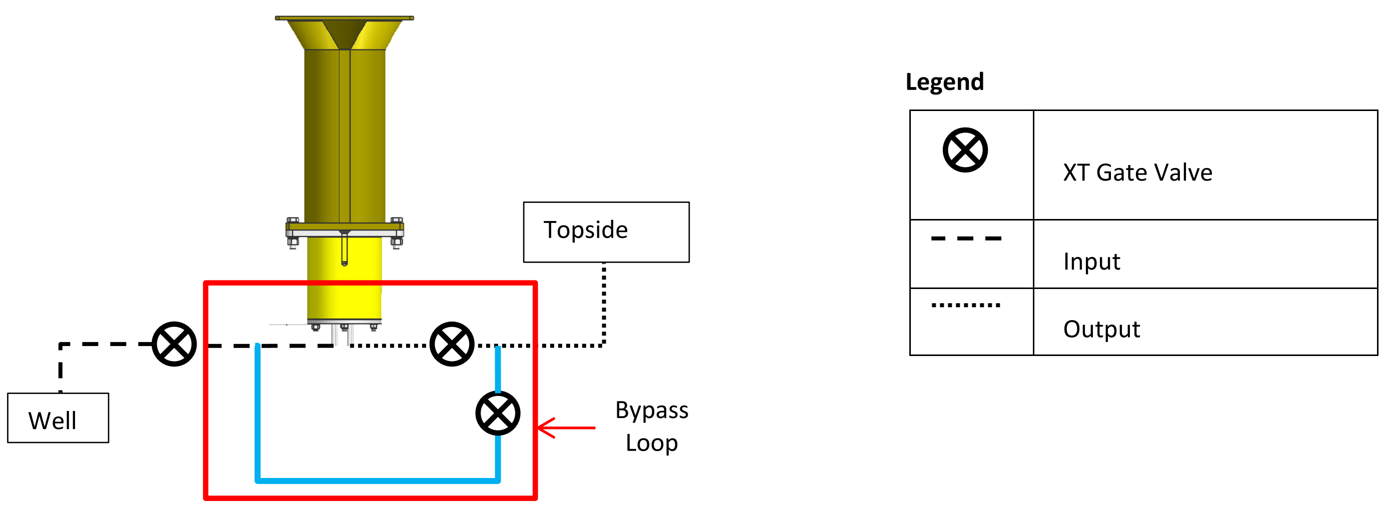


Figure 53: P&ID of a Bypass Loop

22. Test Flushing Unit Operation

> **! NOTICE**
> TEST FLUSHING UNIT MUST BE DOCKED FULLY INTO PLACE. THE SKOFLO SUBSEA TEST FLUSHING UNIT IS A FIXED ORIFICE SIZE WITH NO FLOW ADJUSTMENT OR FEEDBACK ABILITIES.

22.1 The purpose of this section is to describe how to operate the SkoFlo test flushing unit.

22.2 The test flushing unit has the approximate Cv values:

- Low Flow: Cv 1.08
- High Flow: Cv 5.04

22.3 Onshore Flushing

22.3.1 The following steps are the same for test flushing units with and without onboard pressure sensors.

22.3.2 Dock the test flushing unit into the mating SkoFlo receptacle. Follow steps from Sections 18.7 thru 18.9.

22.3.3 With the test flushing unit docking onto the receptacle, apply the flushing fluid to the inlet coupler on the receptacle. The flow exiting the outlet coupler should be diverted to an accumulation tank.

22.3.4 It is recommended to flush for a minimum of 5 minutes. Confirm that the fluid exiting the receptacle meets Class 6B-F.

> **! WARNING**
> DO NOT APPLY PRESSURE EXCEEDING THE DESIGNATED PROOF PRESSURE RATING.

22.4 Subsea Flushing

22.4.1 The following steps are the same for test flushing units with and without onboard pressure sensors.

22.4.2 Ensure that the SkoFlo flushing unit is installed in the receptacle on the flow loop that requires flushing.

22.4.3 Flush the subsea chemical injection pipelines with a flushing chemical that is compatible with the test flushing unit.

> **! WARNING**
> FOR CORROSIVE CHEMICAL FLUID COMPOSITION, CHEMICAL COMPATIBILITY TEST SHALL BE DONE TO ENSURE THE CHEMICAL IS SUITABLE TO BE OPERATED BY TEST FLUSHING UNIT.

22.4.4 SkoFlo has no recommendations for flushing times as this can be a factor of many variables that SkoFlo is not privy to.

22.5 Test Flushing Units with Pressure Sensors

22.5.1 TFUs may be configured with an optional pressure sensor. To determine whether a pressure sensor is installed, refer to the applicable specifications and/or configuration sheet.

22.5.2 TFUs supplied with the optional pressure sensor can be operated in the exact same manner as those without onboard sensors. The TFUs with sensors do not have to be powered up to allow flow through the units. If the operator wishes to monitor the pressure inside the TFU, the units must be supplied power in the same manner as a SkoFlo CIMV.

23. Storage

23.1 All SkoFlo subsea products should be stored in a shelter protected from particulates such as dirt between 0°F and 158°F (–18°C and 70°C). SkoFlo products may be left top side if necessary. Humidity is not an issue with SkoFlo products as they are designed for subsea use. The protective cover supplied with the CIMVs and test flushing units shall remain on the units to protect from damage, corrosion and contamination. This is also true for the protective caps shipped on receptacle couplers. CIMVs and test flushing units may be stored in the horizontal or vertical position; if in the vertical position, the bucket should be oriented at the top end of the unit.

! NOTICE

IT IS RECOMMENDED TO STORE THE ASSEMBLIES IN THE SHIPPING CRATE, IF POSSIBLE.

23.2 It is important to not store the CIMV with production chemicals in the unit. These chemicals can settle possibly resulting in damage to the CIMV. SkoFlo recommends that the CIMV be stored with a mixture of monoethylene glycol in water as the preservation fluid. The couplers should be cleaned of any foreign debris or fluid prior to storage.

24. Maintenance

! WARNING

ANY SERVICE REPAIR SHALL BE PERFORMED BY TRAINED PERSONNEL.

! WARNING

DO NOT HOT PLUG THE ELECTRICAL CONNECTORS TO THE CIMV.

! NOTICE

IF ANY ABNORMALITIES ARE FOUND THROUGHOUT THE MAINTENANCE CHECK, PLEASE REPORT TO THE RESPECTIVE ENGINEERS.

24.1 General:

24.1.1 SkoFlo products are not field-serviceable. The Hunting™ coupler metal seals may be replaced on CIMVs and TFUs but voids any warranty. Replacing the seals requires removal of the hydraulic couplers. A hydrostatic pressure test is required after coupler removal, and this can only be accomplished with a spare receptacle. If the customer wishes to replace the seals in the field, a spare receptacle should be included as a spare part along with the seals. The CIMV can be returned to the factory for seal replacement. For critical service, a spare CIMV should be considered to avoid operation halt.

! CAUTION

IF THE CIMV OR TFU REQUIRES REPAIR, IT MUST BE RETURNED TO SKOFLO.

24.1.2 Anytime a CIMV or TFU is dismantled, even for periodic maintenance, the CIMV or TFU must be re-calibrated (CIMV only) and tested. Therefore, these products should not be repaired on site. All repairs should be returned to SkoFlo for repairs and subsequent recalibration and testing. Contact SkoFlo at service@SkoFlo.com or (425) 485-7816 for pricing and initiation of an RMA.

24.1.3 SkoFlo CIMVs are calibrated and tested at the factory.

24.1.3.1 For Low Flow CIMVs, new flow tables for new chemicals can be generated onsite or subsea, refer to the applicable user manual.

24.1.3.2 For High Flow CIMVs, flow tables for chemicals are generated at the factory. Any changes in fluids require a new flow table to be downloaded. Refer to Section 19.2.2.

! NOTICE

IF THE CIMV IS ONSHORE, OPERATORS MAY PERFORM THE FLOW TABLE DOWNLOAD AS PER SOFTWARE USER GUIDE. FOR SUBSEA, THE OPERATOR SHALL CONSULT SCM PROVIDER.

24.1.3.3 If the CIMV is onshore, operators may perform the flow table download as per software user guide. For subsea, the operator shall consult with the SCM provider.

24.1.4 TFU Maintenance: The TFUs are designed to be maintenance free. If there is any damage found on the assemblies, inform SkoFlo for service/repair before carrying out any work.

24.1.5 Receptacle Maintenance: The receptacles are designed to be maintenance free. If there is any damage found on the assemblies, inform SkoFlo for service/repair before carrying out any work.

24.2 If the CIMV is stored for an extensive length of time, the following inspections and tests may be conducted prior to installation to verify that the unit has not been damaged and is functioning properly.

24.2.1 It is recommended that the CIMV be flushed and cycled several times to condition the seals prior to commissioning or SIT testing.

24.2.2 Contractors can either perform maintenance checks with or without a receptacle.

24.2.3 Visually inspect the CIMV for any damage, contamination, and corrosion, especially on the connector and couplers. If any seals on the couplers are damaged, they must be replaced.

24.2.4 Inspect marking on equipment matches GA drawing; all sub-components are intact.

24.2.5 Verify that electrical continuity between the uncoated CIMV bucket or latch (if CIMV bucket is coated) and the couplers is less than 0.1 ohms.

! NOTICE

THE LISTED TOOLINGS AND PARTS ARE REQUIRED FOR MAINTENANCE CHECKS, NOT PROVIDED BY SKOFLO.

! WARNING

REFER TO IXXAT USB-TO-CAN MANUAL FOR DB9 HEADER CONFIGURATION SETUP (CANBUS).
NO CONFIGURATION MANUAL PROVIDED FOR MODBUS.

! WARNING

REFER TO GA DRAWING FOR ELECTRICAL CONNECTOR PIN-OUTS AND ASSOCIATED SIGNALS.

! NOTICE

NOTE THE BELOW INTERFACE SCREEN SHOTS ARE ONLY AN EXAMPLE AND MAY NOT BE IDENTICAL DUE TO SLIGHT VARIATIONS AND IMPROVEMENTS IN SOFTWARE

24.2.6 Tools required for performing a functional test are listed in Table 8:

Table 8: Function Test Tool Requirements

Tools and parts	Quantity
Multimeter	1
Laptop with SkoFlo's service software ValveCal 2 software installed	1
IXXAT USB-to-CAN or Modbus? (Please refer to Software User guide for the specific supported models)	1
4-pin socket mating electrical test connector with pigtails	1
Power supply	1
Terminal block strip	1
Torque wrench 250 ft-lb (339 Nm)	1
Preservation fluids (optional for flow test)	As Required
Project requirement chemical (optional for flow test)	As Required

24.2.7 If a flow test/mating receptacle cannot be performed, but CIMV can be communicated with:

24.2.7.1 Test-set up:

24.2.7.1.1 Set up CIMV per Figure 54 using the tools listed in Table 8.

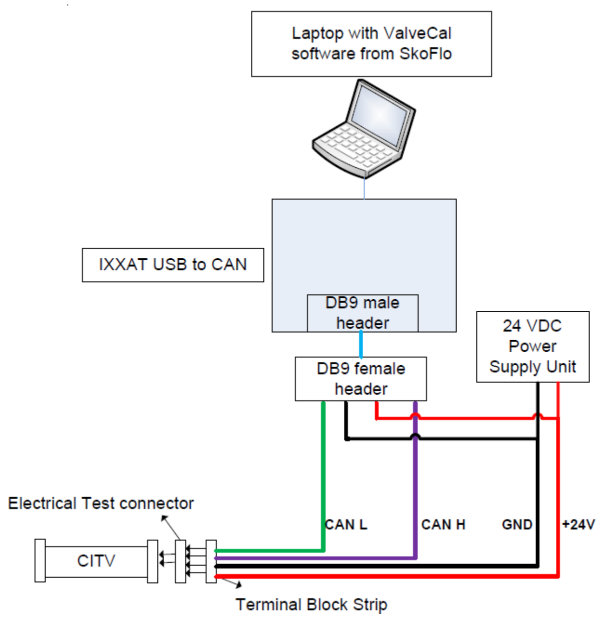


Figure 54: Functional Test Set Up

24.2.7.2 Functional Test:

24.2.7.2.1 For the following operations, refer to the applicable User's Manual (DOC-00969 for SIISv2 analog products and DOC-00999 for Modbus analog products) and Figure 55.

24.2.7.2.2 Command the CIMV to:

1. Set the "Target Position" to be 100%.
2. Click the "Set Position" button
3. Confirm that the "Command Status" states "Completed - no error"
4. Confirm stem position feedback has reached the commanded value (100%).

Note: CIMV stem movement may be heard, but requires the CIMV to be in a quiet environment.

24.2.7.2.3 Repeat step 24.2.7.2.2 except use Target Position of 5%.

24.2.7.2.4 Repeat step 24.2.7.2.2 except use Target Position of 50%.

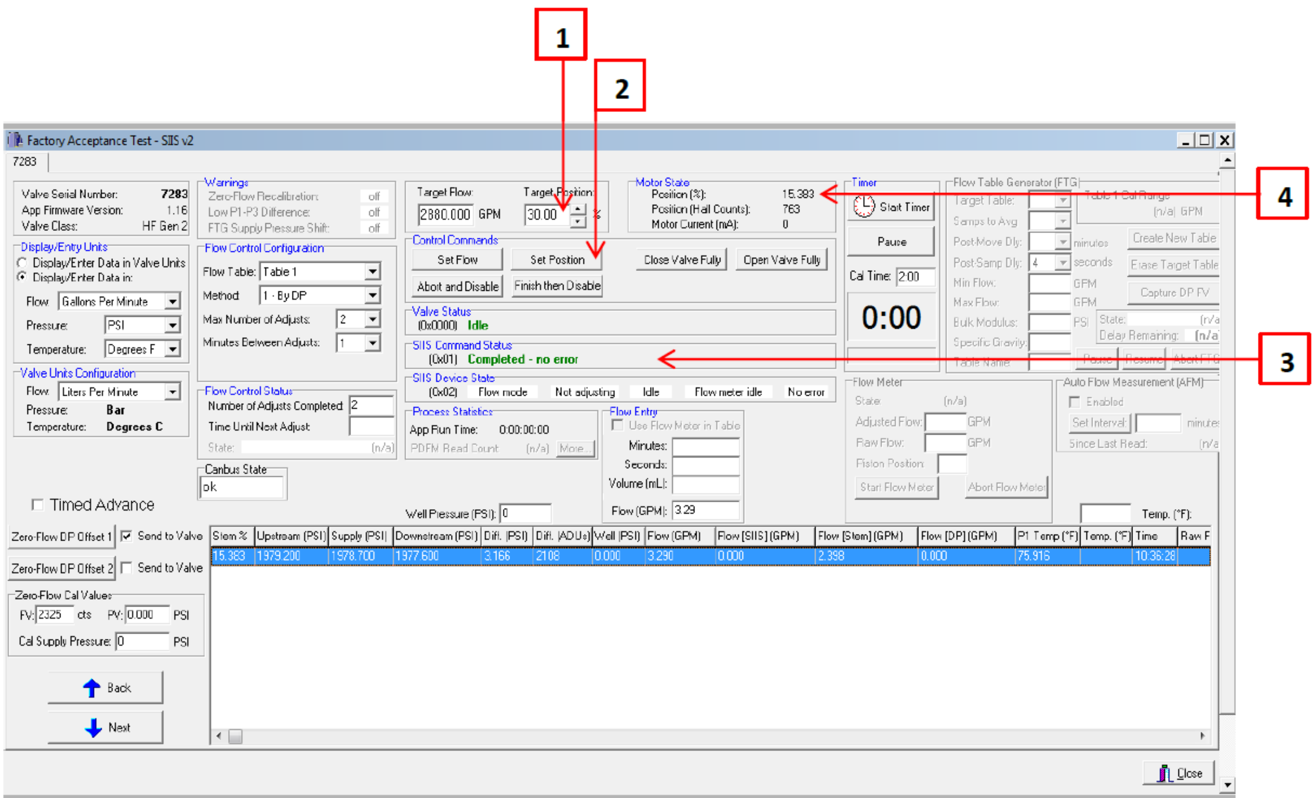


Figure 55: Example of ValveCal Screen

24.2.8 If a flow test with mating receptacle can be performed

24.2.8.1 Refer to User's Manual (DOC-00969 for SIISv2 analog products and DOC-00999 for Modbus analog products) and Figure 56.

24.2.8.1.1 Command the CIMV to:

CIMV Conditioning

1 Set Flow Control Configuration Method to "By Stem"

2 Set the "Target Flow" to maximum rated full scale for the CIMV

3 Click "Set Flow"

4 Ensure the command is completed with no error

24.2.8.1.2 Repeat above steps except set "Target Flow" to 5% of RFS

24.2.8.1.3 Repeat cycling from 100% RFS to 5% RFS a minimum of 5 times

Functional Test

1 Set Flow Control Configuration Method to "By Stem"

2 Set the "Target Flow" to maximum rated full scale for the CIMV

3 Click "Set Flow"

4 Ensure the command is completed with no error

5 Confirm "Flow [Stem]" is within accuracy requirements

6 Confirm "Flow [DP]" is within accuracy requirements

24.2.8.2 Repeat functional test steps using Flow Control Configuration Method set to "By DP" and "Target Flow" to 5% of RFS

24.2.8.3 Repeat above steps using Flow Control Configuration Method set to "By Stem" and "Target Flow" to 50% of RFS.

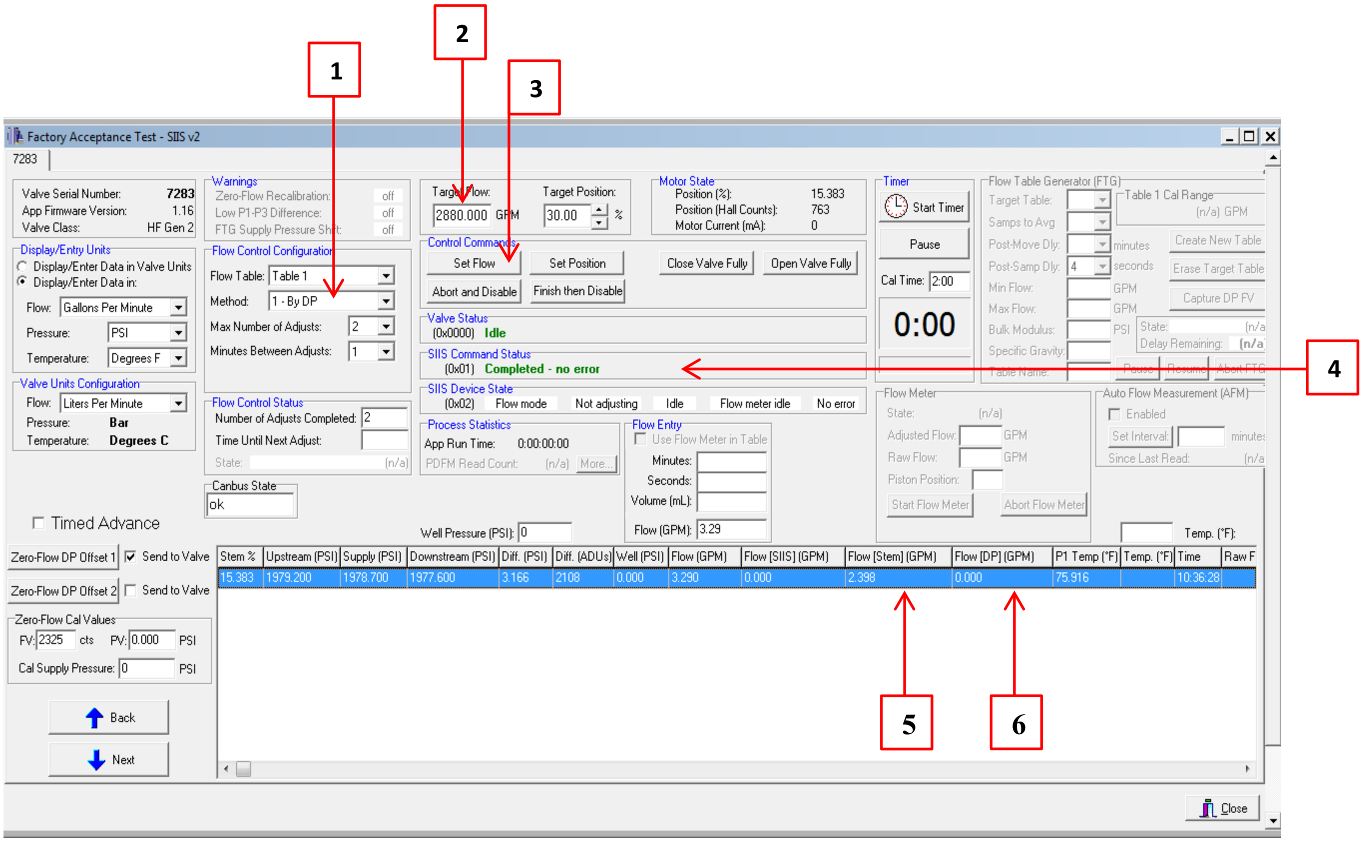


Figure 56: Test Sequence for Flow Rate Adjustment

24.3 Torque Test

! NOTICE

ENSURE COUPLER SHIPPING COVERS ARE REMOVED PRIOR TO DOCKING CIMV

! NOTICE

IF APPLYING A TORQUE GREATER THAN 100 FT-LB AN END EFFECTOR MAY BE REQUIRED

! NOTICE

Table 4 VALUES ARE APPLICABLE FOR BOTH TOPSIDE AND SUBSEA OPERATION.

! CAUTION

TO AVOID LATCH AND SHAFT DAMAGE DO NOT OVER-TORQUE.

! WARNING

DOCKING CIMV WITH SHIPPING COVERS IN PLACE WILL DAMAGE THE CIMV AND NECESSITATE RETURN TO SKOFLO INDUSTRIES FOR REPAIR.

24.3.1 Refer to the applicable general arrangement drawing, specification and/or configuration sheet to determine coupler sizes.

24.3.2 Refer to Table 4 for CIMV/TFU torque and latch turn specifications. The following tests may be performed in either order.

24.3.2.1 Use a 250 ft-lb (340 N-m) torque wrench, torque the latch fully CW and CCW with the CIMV/TFU undocked. Verify latch turns and torque values remain below those specified in Table 4.

24.3.2.2 Dock CIMV/TFU into receptacle, if applicable, using a 250 ft-lb (340 N-m) torque wrench. Verify latch turns and torque values remain below those specified in Table 4.

24.3.3 Inspect hydraulic couplers and electrical connectors for wear or damage.

24.3.4 Re-install protective covers.

24.3.5 Store CIMV in crate per the applicable transport and handling instruction.

! NOTICE

THIS MAINTENANCE CHECK IS NOT MANDATORY.

CIMV Maintenance Check List – WITHOUT Flow Test		
Step	**Activity**	**Check**
1	Check for damage, debris, or corrosion, especially connector and couplers	
2	Inspect marking on equipment per GA and all subcomponents are intact.	
3	Verify resistance between CIMV ROV bucket and Hydraulic Couplers is less than 0.1 ohms using a multimeter.	
4	Verify the resistance between the CIMV latch and Hydraulic Couplers is less than 0.1 ohms using a multimeter.	
5	For functional test without flow through CIMV, setup CIMV per Figure 54.	
6	Turn on power supply and ensure voltage is set to 24 VDC ± 4 VDC.	
7	Power up and run “ValveCal2” software on laptop.	
8	Establish connection to the CIMV. *Refer to the software user guide for establishing connection guidelines.*	
9	On “ValveCal2”, select FAT.	
10	Command the CIMV to 100% target position and verify the software is reporting 100% position. -Refer to Section 24.2.7.2 for functional test without flow	
11	Command the CIMV to 10% target position and verify the software is reporting 5% position[1]. -Refer to section 24.2.7.2.2 for functional test without flow	
12	Command the CIMV to 50% target position and verify the software is reporting 50% position[1]. -Refer to section 24.2.7.2 for functional test without flow	
13	Turn off power supply.	
14	Disconnect the software and remove all wiring, if applicable.	
15	Fully torque the latch CCW per Table 4.	
16	With CIMV undocked, fully torque the latch CW. Count the number of turns, if turns 9 ¼ latch end did not engage. The torque should not exceed 10 ft-lb.	
17	With CIMV undocked, fully torque the latch CCW. Count the number of turns, if turns 9 ¼ latch end did not engage. The torque should not exceed 10 ft-lb.	
18	Inspect the hydraulic couplers and electrical connectors for wear, damage or rust.	
19	After inspection, cover the end of docking canister with protective covers.	
20	Store CIMV in its crate per THI.	
21	Crated CIMV must be stored in conditions stated in Section 23.	

! NOTICE

THIS MAINTENANCE CHECK IS NOT MANDATORY.

! NOTICE

RECEPTACLE MUST BE FULLY ASSEMBLED, REFER TO RECEPTACLE IOM FOR INSTALLATION.

! NOTICE

FLOW TEST CAN BE PERFORMED WITH 25% MEG 75% WATER MIXTURE, OR PROJECT REQUIRED CHEMICALS. CHEMICAL COMPATIBILITY SHALL BE EVALUATED AND CHECKED BEFORE USING OTHER CHEMICALS.

CIMV Maintenance Check List – WITH FLOW TEST		
Step	**Activity**	**Check**
1	Check for damage, debris, or corrosion, especially connector and couplers	
2	Inspect marking on equipment per GA and all subcomponents are intact.	
3	Verify resistance between CIMV ROV bucket and Hydraulic Couplers is less than 0.1 ohms using a multimeter.	
4	Verify the resistance between the CIMV latch and Hydraulic Couplers is less than 0.1 ohms using a multimeter.	
5	For functional test without flow through CIMV, setup CIMV per Section 24.2.7.2	
6	Dock CIMV into receptacle. Refer to Section 17.	
7	Turn on power supply and ensure voltage is set to 24 VDC ± 4 VDC.	
8	Power up and run “ValveCal2” software on laptop.	
9	Establish connection to the CIMV. Refer to the software user guide for establishing connection guidelines.	
10	On “ValveCal2”, select FAT.	
11	Turn on pump[1].	
12	Command the valve to 100% RFS flow rate by stem or by dP. Verify the output reading flow by stem or by dP reading is within adjustment accuracy[1].	
13	Command the valve to 10% RFS flow rate by stem or by dP. Verify the output reading flow by stem or by dP reading is within adjustment accuracy[1].	
14	Command the valve to 50% RFS flow rate by stem or by dP. Verify the output reading flow by stem or by dP reading is within adjustment accuracy[1].	
15	Turn off pump[2].	
16	Replace the chemical fluid with preservation fluid and turn on pump[1, 2].	
17	Flush CIMV for 5 minutes with preservation fluids. Ensure the fluid runs through CIMV by observing output flow rate[1, 2].	
18	Turn off pump[1, 2].	
19	Turn off power supply.	
20	Disconnect the software and remove all wiring, if applicable.	
21	Fully torque the latch CCW per Table 4.	
22	With CIMV undocked, fully torque the latch CW. Count the number of turns, if turns 9 ¼ latch end did not engage. The torque should not exceed 10 ft-lb.	
23	With CIMV undocked, fully torque the latch CCW. Count the number of turns, if turns 9 ¼ latch end did not engage. The torque should not exceed 10 ft-lb.	
24	Inspect the hydraulic couplers and electrical connectors for wear, damage or rust.	
25	After inspection, cover the end of docking canister with protective covers.	
26	Store CIMV in its crate per THI.	
27	Crated CIMV must be stored in conditions stated in Section 23.	

[1] Perform only if flow test is required. Refer to Section 24.2.8 for test sequence.

[2] Not required if preservation fluids are used.

24.4 Periodic Subsea Maintenance - CIMV

24.4.1 SkoFlo CIMVs are rated for 30-year service (may vary depending on project specific requirements). SkoFlo recommends flushing CIMVs with preservation fluid approximately every two years before commissioning to ensure functionality is fully intact. If subsea storage is required, fully dock the CIMV into a receptacle to activate CP with the tree.

! NOTICE

LISTED TOOLING AND PARTS ARE REQUIRED FOR MAINTENANCE CHECKS. NOT PROVIDED BY SKOFLO.

! WARNING

CIMV SHALL BE CONNECTED TO THE TREE'S CP SYSTEM OR DUMMY RECEPTACLE DURING STORAGE. MAXIMUM ALLOWABLE DURATION OF STORAGE WITHOUT CP IS 2 DAYS.

24.4.2 Maintenance check subsea with flow test discretion.

! NOTICE

THIS SECTION IS A GUIDELINE IF THE OPERATOR WANTS TO TEST A VALVE IN OPERATION. TEST TO BE RUN AT OPERATOR DISCRETION.

! NOTICE

IF SUBSEA PRODUCTION SYSTEM (SPS) PROVIDER SOFTWARE IS USED, CONSULT WITH RESPECTIVE TECHNICIANS FOR GUIDELINES.

! NOTICE

THIS MAINTENANCE CHECK IS MEANT FOR CIMV'S ALREADY INSTALLED SUBSEA.

! WARNING

CHEMICAL COMPATIBILITY SHALL BE DONE AND CHECKED BEFORE USING CIMV, EXCEPT FOR MEG WATER MIXTURE.

CIMV Maintenance Check List – SUBSEA, WITH FLOW TEST		
Steps	**Activity**	**Check**
1	If available, use ROV to check CIMV for damage, debris, or corrosion.	
2	Power subsea tree and establish connection to the CIMV.	
3	Turn on the pump and inject chemical fluids to the CIMV.	
4	Command valve to 10% RFS flow rate by dP. Verify output dP reading is within adjustment accuracy, refer to Section 11.	
5	Command valve to 50% RFS flow rate by dP. Verify output dP reading is within adjustment accuracy, refer to Section 11.	
6	Command valve to 100% RFS flow rate by dP. Verify output dP reading is within adjustment accuracy, refer to Section 11.	

24.4.3 Maintenance check without flow test:

CIMV Maintenance Check List – SUBSEA, NO FLOW TEST		
Steps	**Activity**	**Check**
1	If available, use ROV to check CIMV for damage, debris, or corrosion.	
2	Power subsea tree and establish connection to the CIMV.	
3	Turn on the pump and inject chemical fluids to the CIMV.	
4	Command CIMV to fully open and verify the output position is reporting 100% opening[3].	
5	Command CIMV to fully close and verify the output position is reporting 0% opening[3].	
6	Command CIMV to 50% open and verify the output position is reporting 50% opening[3].	

[3]Performing fully open and close allows the CIMV stem to re-adjust 0-100% opening scale.

24.5 TFU Maintenance

24.5.1 Periodic maintenance for in-house storage:

! NOTICE

LISTED TOOLING AND PARTS REQUIRED FOR MAINTENANCE CHECKS ARE SHOWN IN TABLE 9. NOT PROVIDED BY SKOFLO.

Table 9: Required and Equipment

Multimeter	1
Torque Wrench 250 ft-lb (339 Nm)	1

TFU Maintenance Check List – IN-HOUSE STORAGE		
Step	**Activity**	**Check**
1	Check for damage, debris, or corrosion.	
2	Inspect marking on equipment per GA and all subcomponents are intact.	
3	Verify resistance between flusher ROV bucket and Hydraulic Couplers is less than 0.1 ohms using a multi-meter.	
4	Verify the resistance between the flusher latch and Hydraulic Couplers is less than 0.1 ohms using a multi-meter.	
5	Fully torque the latch CCW per Table 4.	
6	Fully torque the latch CW. Count the number of turns, if turns 9 ¼ latch end did not engage.	
7	Fully torque the latch CCW. Count the number of turns, if turns 9 ¼ latch end did not engage.	
8	Inspect the Flusher's hydraulic couplers for wear, damage or rust.	
9	After inspection, cover end of docking canister with protective covers.	
10	Store CIMV in its crate per THI.	
11	Crated CIMV must be stored in conditions stated in Section 23.	

24.5.2 Maintenance checks are not possible for subsea flushers.

24.6 Receptacle Maintenance

24.6.1 Periodic Maintenance for in-house storage:

RECEPTACLE Maintenance Check List – IN-HOUSE STORAGE		
Steps	**Activity**	**Check**
1	Check for any damage, debris, or corrosion.	
2	Inspect marking on equipment per GA and all subcomponents are intact.	
3	Perform resistance check per receptacle IOM. *Resistance check for wet mate connector can be excluded if wet mate connector does not come as part of the assembly.*	
4	Inspect the receptacle's hydraulic couplers for wear, damage or rust.	
5	Store receptacles in crate per THI.	
6	Crated CIMV must be stored in conditions stated in Section 23.	

24.6.2 Periodic maintenance is not required for subsea receptacles.

25. FREQUENTLY ASKED QUESTIONS AND TROUBLESHOOTING

25.1 All CIMVs

ALL CIMVs	
Question	**Answer**
CIMV shutoff ability	SkoFlo CIMVs are not shut off devices.
Protection against reverse flow	Seal damage may occur if the pressure drop across the CIMV in reverse flow exceeds 2,000 psi (138 bar). The CIMV is also vulnerable to debris in reverse flow scenarios as there is no filtration system on the outlet of the product. It is recommended to have an external check valve installed downstream of the SkoFlo CIMV to mitigate these risks. The SkoFlo CIMV does have an onboard check valve located at the outlet. The purpose of the onboard check valve is surge protection and it is not designed to completely stop production fluid from entering the CIMV; it is not an isolation device.
Minimum differential pressure to operate	See CIMV specification sheet to determine required minimum pressure drop. The flow regulation component of the CIMV is controlled by a spring, which counter acts a fluid driven piston. Full stated minimum pressure differential is needed to fully exercise this spring and give the stated adjustable range. Lower available pressure drops will result in decreased maximum flow rate. During operation, if the minimum dP across the CIMV is not maintained, the CIMV's full scale flow rate capabilities will be limited and there will be a loss of pressure independence.
Fluid Cavitation and Excessive Pressure Drops	Fluid cavitation occurs when CIMV pressures, fluid viscosity, and velocity cause a drop below the injection fluid’s vapor pressure. When the SkoFlo CIMV enters its cavitation region, energy release from vapor compression at the pin/seat interface may cause premature wear of compression-point components. Low Flow: For flows above 100 US gallons per day (15.8 LPH), pressure drops across the CIMV should not exceed the outlet pressure for extended periods to avoid cavitation. As a general rule, the outlet pressure must be greater than or equal to the pressure drop to avoid cavitation. For applications where the continuous differential pressure may exceed the outlet pressure during the life of the field, contact SkoFlo. A second stage can be incorporated to allow a higher continuous differential pressure if additional allowance of pressure drop due to viscosity cannot be granted. High Flow: For high flow applications the maximum drop can exceed the outlet pressure by no more than 1500 psi ($Maximum\ dP = Outlet\ Pressure + 1500\ psi$).
Power Switching	Once docked, the power may be cycled on or off as needed. The operator may want to shut off the power to the CIMV for extended periods to conserve power and power up the CIMV when a reading is needed or an adjustment may be required. SkoFlo CIMVs do not require electrical power to maintain a set flow rate under fluctuating pressures.
Chemical filming	Based on SkoFlo historical performance, chemical filming has not occurred before for CIMV design. Chemical filming is dependent on chemical composition selection by the user. It is recommended to perform a chemical filming test to verify if the chemical composition selected by user will cause chemical filming.

25.2 Low Flow CIMVs

Low Flow CIMV Troubleshooting		
Symptom	**Common Cause**	**Remedy**
No flow or reduced flow from flow by dP measurement method without stem adjustments	Flow rate is out of the calibrated range of the CIMV	Ensure that total pressure drop across the CIMV is between the minimum required pressure drop stated on the product specification sheet and ½ of the rated working pressure of the CIMV. Request a flow rate via one of the flow by flow rate methods available on the product. Do not adjust by stem percent.
	Inlet pressure is equal to outlet pressure	Confirm downstream shutoff valve is open. Increase inlet pressure to CIMV.
	Upstream catch screen plugged	Look to see if pressure sensor 4 (P4) is greater than 30 psi (2 bar) over pressure sensor 1 (P1). If true, service upstream catch screen; contact SkoFlo for replacement.
	Debris or contamination settling in the gate at extremely low flow rates	Drive the CIMV to 100% RFS flow rate by Flow by Stem. Allow CIMV to flush for 10 minutes minimum. Drive CIMV to desired flow rate utilizing any flow rate set method to determine if problem is resolved or improved. If improved but not resolved, repeat process to flush out remaining contaminants.
	***Note**: If the upstream filter is clogged, increasing the pumping pressure while opening the stem will show an increase in the difference between flow by stem position and flow by dP*	
No communication response from CIMV	CIMV canister not fully docked	Remove CIMV canister and re-dock per SkoFlo procedure.
Overcurrent trip	Stem stuck	Return to SkoFlo for service
Leak detection in electronics can	Leak in canister or faulty sensor	Return to SkoFlo for service
Flow by Stem and Flow by dP out of agreement beyond 15% of reading	Wrong flow table selected	Select proper flow table
	dP pressure sensors	Perform pumping zero
Flow by PDFM and Flow by dP out of agreement beyond 15% of reading	Wrong flow table selected	Select proper flow table
	dP pressure sensor drift	Perform pumping zero
	Debris accumulation in throttling pin and seat	Drive the CIMV fully open and allow CIMV to flush for 10 minutes minimum. Then return the CIMV to desired set point.
	Fluid changed in injection line	Perform auto-calibration

25.3 High Flow CIMVs

High Flow CIMV Troubleshooting		
Symptom	**Common Cause**	**Remedy**
No flow or reduced flow from flow by dP measurement method without stem adjustments	Flow rate is out of the calibrated range of the CIMV	Ensure that total pressure drop across the CIMV is between the minimum required pressure drop stated on the product specification sheet and ½ of the rated working pressure of the CIMV. Request a flow rate via one of the flow by flow rate methods available on the product. Do not adjust by stem percent.
	Inlet pressure is equal to outlet pressure	Confirm downstream shutoff valve is open. Increase inlet pressure to CIMV.
	Upstream catch screen plugged	Look to see if pressure sensor 4 (P4) is greater than 30 psi (2 bar) over pressure sensor 1 (P1). If true, service upstream catch screen; contact SkoFlo for replacement.
	Note: *If the upstream filter is clogged, increasing the pumping pressure while opening the stem will show an increase in the difference between flow by stem position and flow by dP*	
No communication response from CIMV	CIMV canister not fully docked	Remove CIMV canister and re-dock per SkoFlo procedure.
Overcurrent trip	Stem stuck	Return to SkoFlo for service
Leak detection in electronics can	Leak in canister or faulty sensor	Return to SkoFlo for service
Flow by Stem and Flow by dP out of agreement beyond 15% RFS	Wrong flow table selected	Select proper flow table
	dP pressure sensors	Perform pumping zero

26. Receptacle Installation

26.1 Each SkoFlo CIMV or test flushing unit must have a mating SkoFlo receptacle unit. These receptacles are designed to match the hydraulic, electrical, and mounting orientation of the CIMV or test flushing unit. Each unit shown in Section 14 has a mating receptacle. The receptacle unit is intended to be permanently attached to the final subsea structure. The information within this section pertains to receptacle configuration and installation only and not for field operation.

26.2 The images below are models of mating receptacles for stab and ROV mate configured docking units.

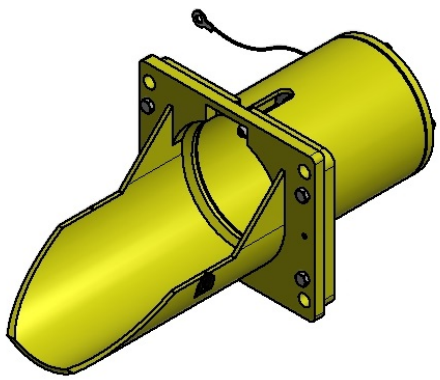


Figure 57: Stab and ROV Mate Horizontal Receptacle with Guide Ledge

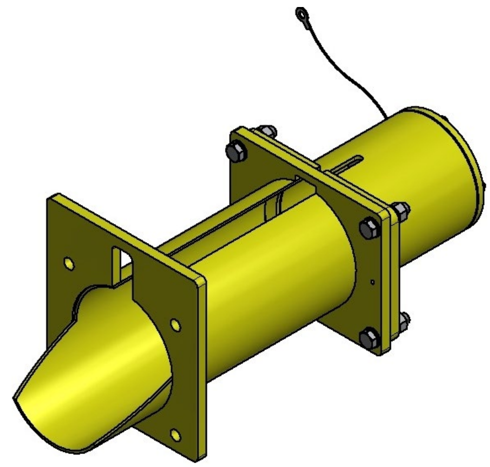


Figure 58: Stab Mate Horizontal with Extended Guide Ledge Receptacle

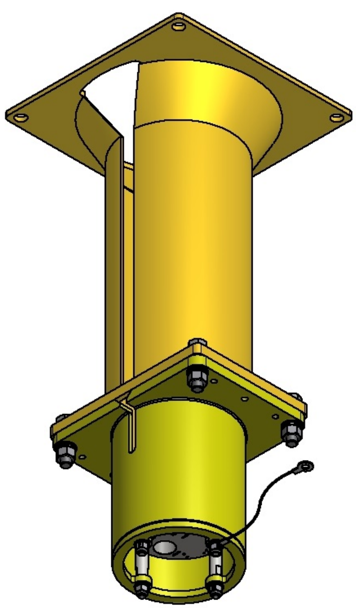


Figure 59: Stab Mate Vertical Receptacle with Guide Cone

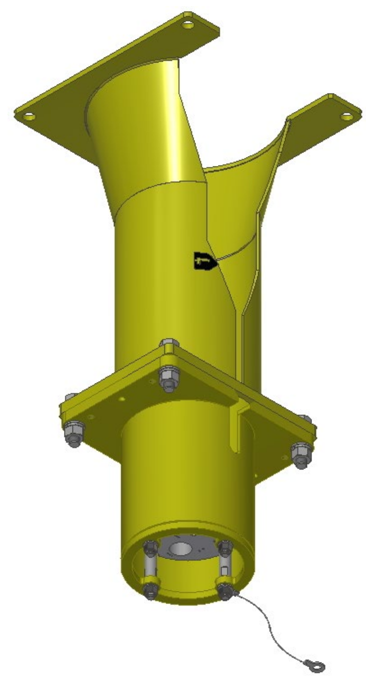


Figure 60: ROV Mate Vertical Receptacle with Guide Cone

26.3 Receptacle Overview

26.3.1 The receptacle unit is intended to be permanently attached to the final subsea structure. Each receptacle has lifting points as shown in Figure 61. Lifting points are designed to hold the entire weight of the receptacle. Refer to DOC-02667 Transport and Handling Procedure for further lifting information.

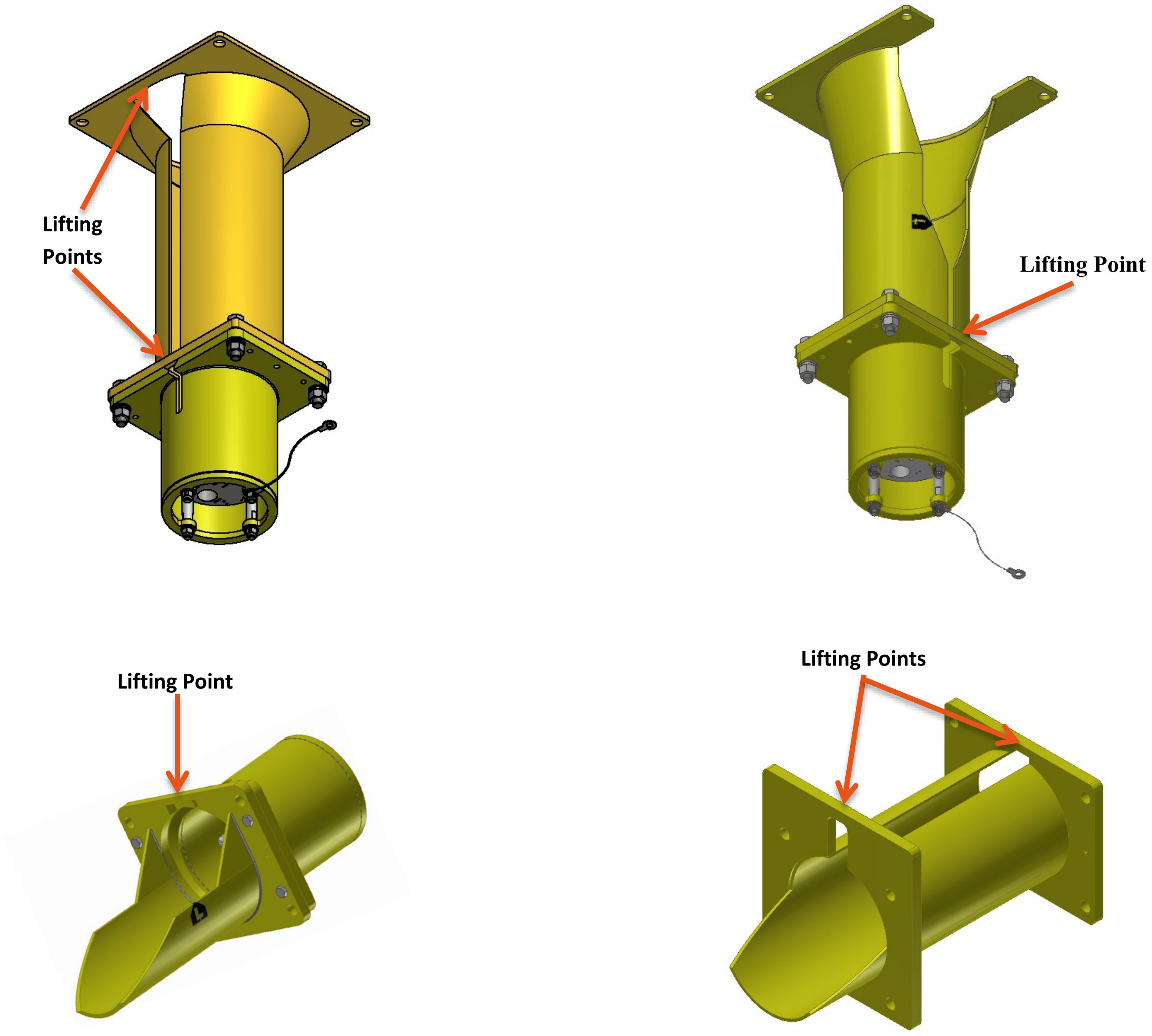


Figure 61: Receptacle Lifting Points

26.3.2 Depending on configuration requirements, the same receptacle part number may be used for both a single core and dual core CIMV. When a single core CIMV/TFU is used with a dual core configured receptacle, extra through holes in the J-plate are to be expected. Refer to Figure 67 for a pictorial example.

! NOTICE

PERFORM THESE STEPS ONLY IF UNABLE TO ASSEMBLE THE HYDRAULIC AND WET MATE CONNECTOR THROUGH THE RECEPTACLE GUIDE CONE.

26.3.3 For the installation instructions within this section, the terms extended guide ledge, guide ledge and guide cone are considered equivalent.

26.3.4 If disassembly is required:

26.3.4.1 Separate the guide cone from the receptacle as follows. The J-plate should NOT be removed from the receptacle.

! WARNING

THE J-PLATE SHOULD NOT BE REMOVED FROM THE RECEPTACLE.

26.3.4.2 For the vertical receptacle installation, carefully place the receptacle into the orientation shown in Figure 62 with the receptacle's housing facing upward. The stab and ROV vertical receptacle both have the same hardware and disassembly procedure.

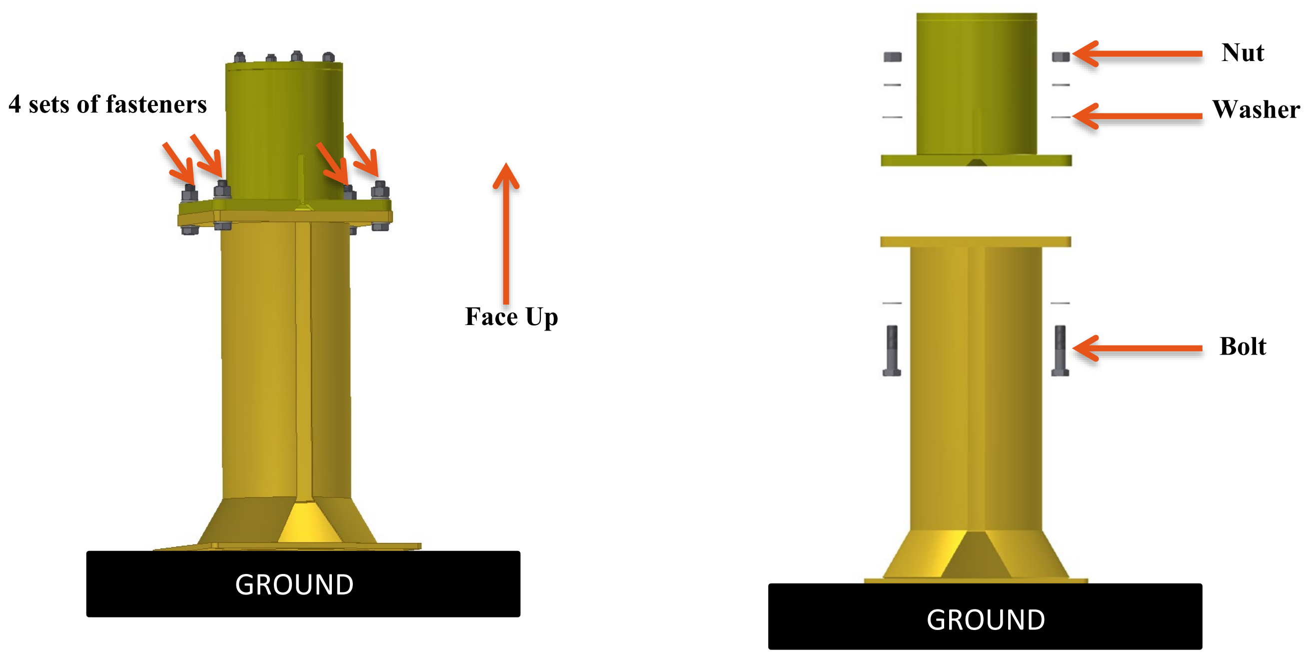


Figure 62: Vertical Receptacle Disassembly

26.3.4.3 For horizontal and extended horizontal receptacles, rest assemblies on the ground in the horizontal orientation.

26.3.4.4 Remove the four bolts, nuts and washers on the four corners of the flanges using a 15/16" socket wrench and remove the guide cone. Set aside for re-use.

26.3.5 Wet Mate Stab Connector Installation

26.3.5.1 Refer to GA drawing and identify the location to place the wet mate connector shown in Figure 21.

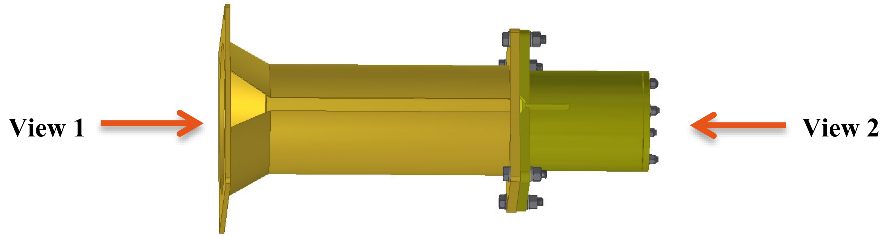
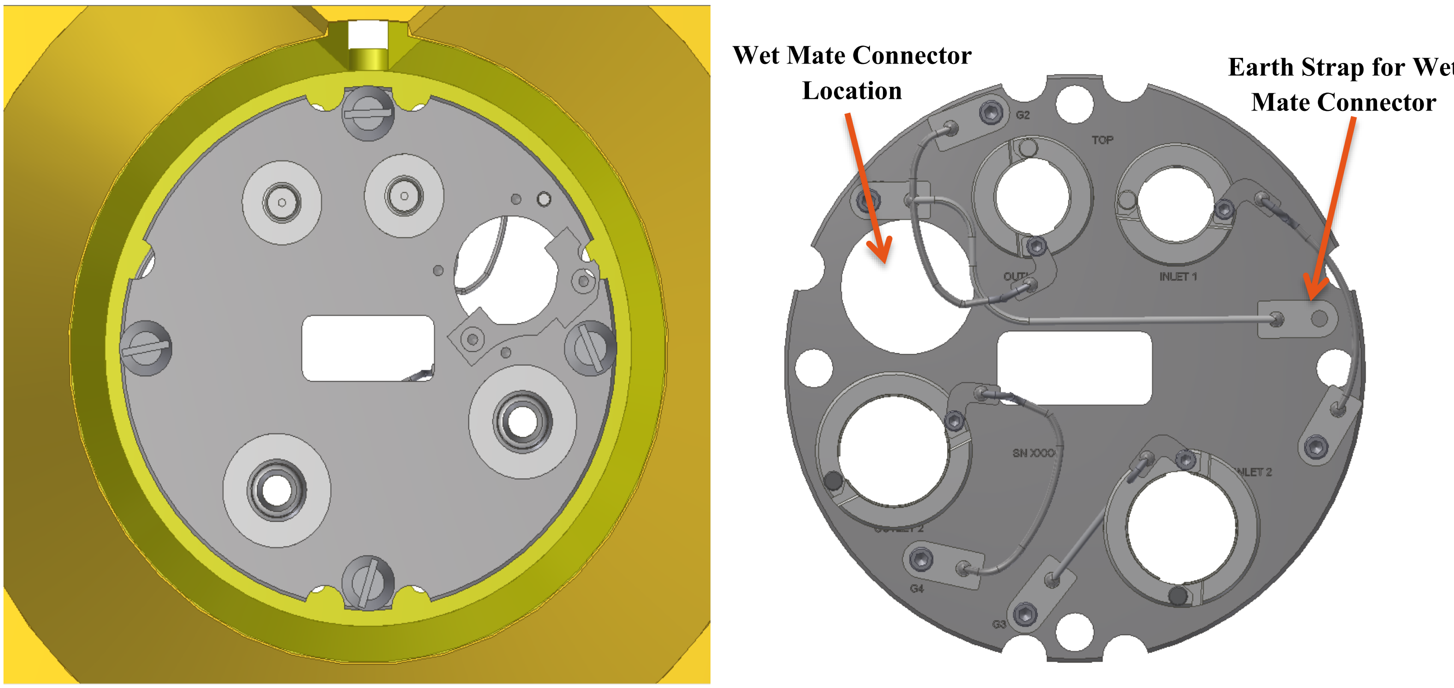


Figure 63: Stab Overview



Stab Receptacle Junction Plate (View 1) Stab Receptacle Junction Plate (View 2)

Figure 64: Junction Plate – Wet Stab Mate Connector Location

(Location may vary depending on arrangement)

! WARNING

FOR ALL HF CIMV AND/OR HF TFU W/SENSOR WITH STAB MATE CONNECTOR, SKOFLO PROVIDES A SPLIT FLANGE TO BE USED DURING CONNECTOR INSTALLATION. FAILURE TO USE THIS SPLIT FLANGE MAY RESULT IN DAMAGE.

26.3.5.2 SkoFlo provides a split flange wet mate connector for any configurations that contain a HF CIMV or HF TFU with sensor. This manufacturer supplied split flange must be used to avoid any interferences.

26.3.5.3 Install the wet mate connector (customer supplied) to the junction plate in the receptacle with split flange clamp.

26.3.5.3.1 The manufacturer's supplied connector should include two halves of a split flanged clamp with fasteners. If a SkoFlo split flange mount is provided with the receptacle, use the modified flange and customer supplied split flange mount as shown in Figure 65.

26.3.5.3.2 For tronic connectors install the SkoFlo supplied split flange and customer supplied split flange mount. Use the dowel pins and grub screw from the customer supplied split flange to attach the SkoFlo split flange as shown in Figure 66.

26.3.5.3.3 A dowel pin is provided on the junction plate to orient the customer supplied flange mount as shown in Figure 67.

26.3.5.4 Secure the wet mate connector to the junction plate with the M6-1 x 15 socket head cap screws. Ensure that the connector ground strap is attached to one of the fasteners for the wet mate connector and the opposite end is attached to the junction plate. Torque the fasteners to 5 to 7 ft-lb (6.78 to 9.49 Nm) to secure split flange to junction plate.

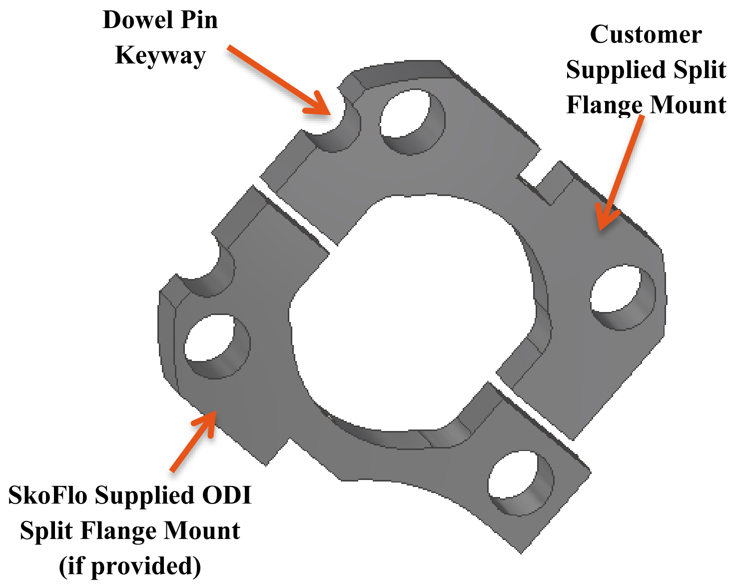


Figure 65: ODI Split Flange

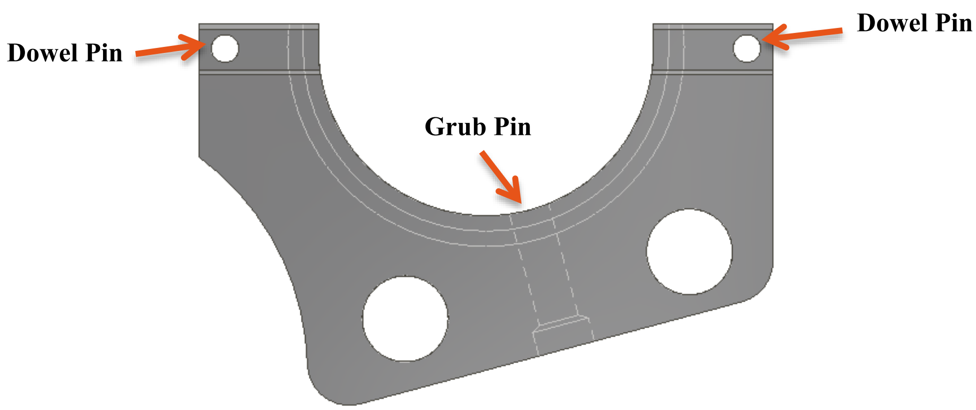


Figure 66: SkoFlo Supplied Tronic Split Flange

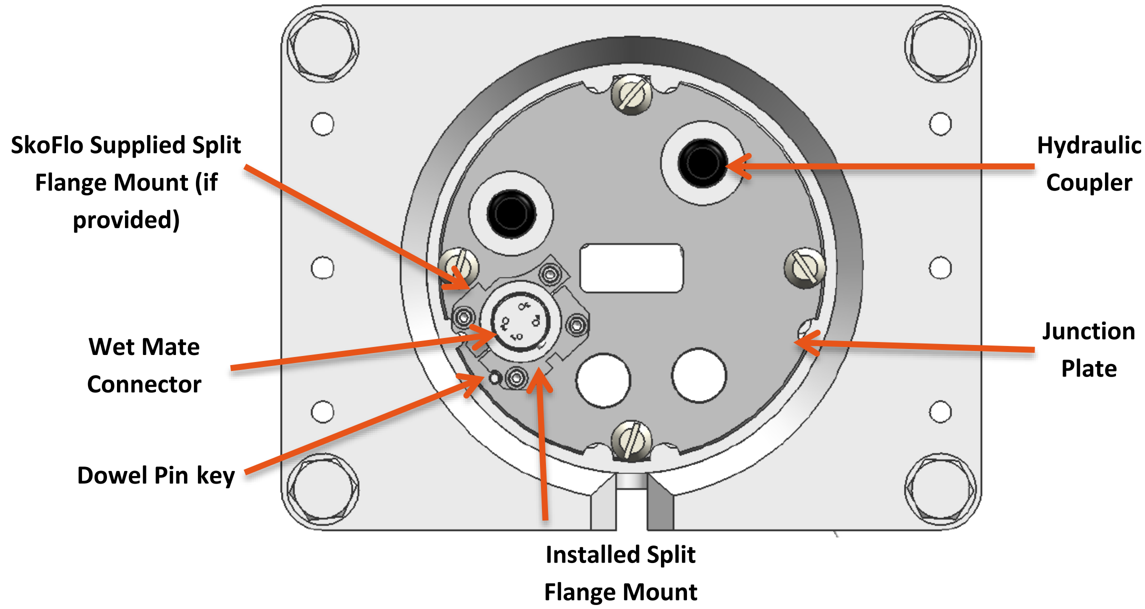


Figure 67: Wet Stab Mate Connector Installation

Shown with dual core junction plate, only one set of hydraulic couplers installed

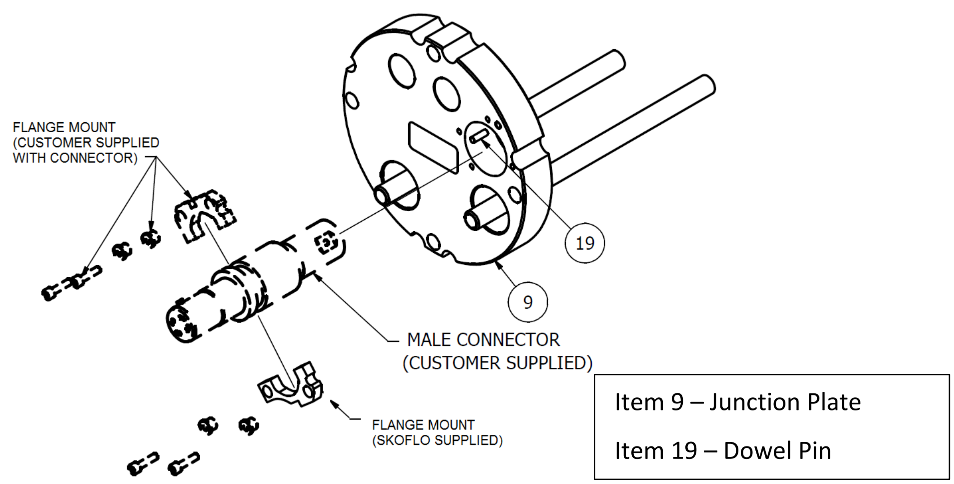


Figure 68: Split Flange Clamp Installation

26.3.5.5 Keep end of electrical connector covered while working on mounting structure to avoid contamination from debris.

26.3.6 Re-assemble guide cone onto the receptacle, aligning the guide key slots between the guide cone and receptacle.

26.3.7 Re-install the fasteners, bolt head is on the guide cone side with flat washer; receptacle side has flat washer, lock washer and nut. Apply anti-seize compound onto threads such as Dynatex 49560 or equivalent.

26.3.8 Torque bolts to a nominal 250 ft-lb.

26.3.9 Verify the resistance between the 18” ground strap and the stand-offs or nuts is less than 0.1 ohms. Attach the 18” ground strap to the tree/cathodic protection. If the 18” ground strap is not used, then use alternate methods to verify that the J-plate is properly grounded to the cathodic protection with less than 0.1 ohms resistance.

26.4 ROV Mate Connector Installation

26.4.1 Refer to GA drawing and identify the location to place the ROV wet mate connector shown in Figure 71.

26.4.2 The Male ROV connector is customer supplied.

26.4.3 Grounding is achieved through the external bracket grounded via the docking canister in all ROV configurations.

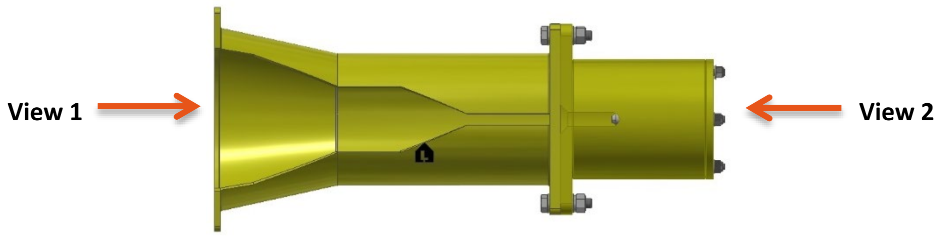
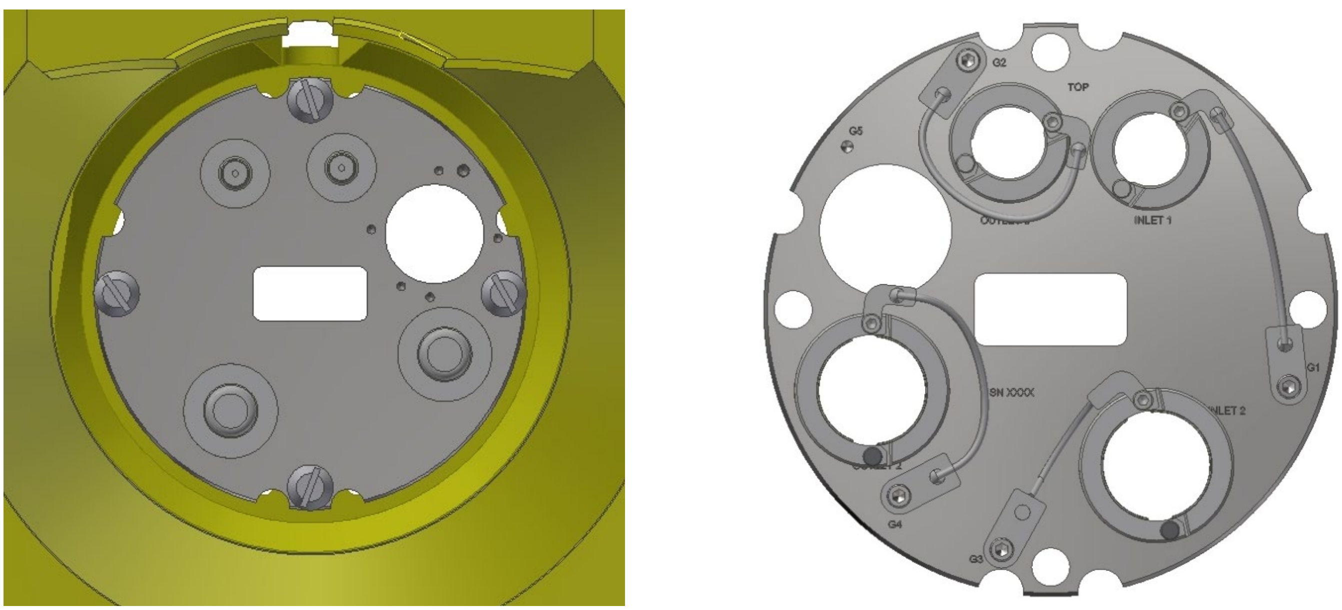


Figure 69: ROV Overview



Stab Receptacle Junction Plate (View 1)

Stab Receptacle Junction Plate (View 2)

Figure 70: ROV Junction Plate

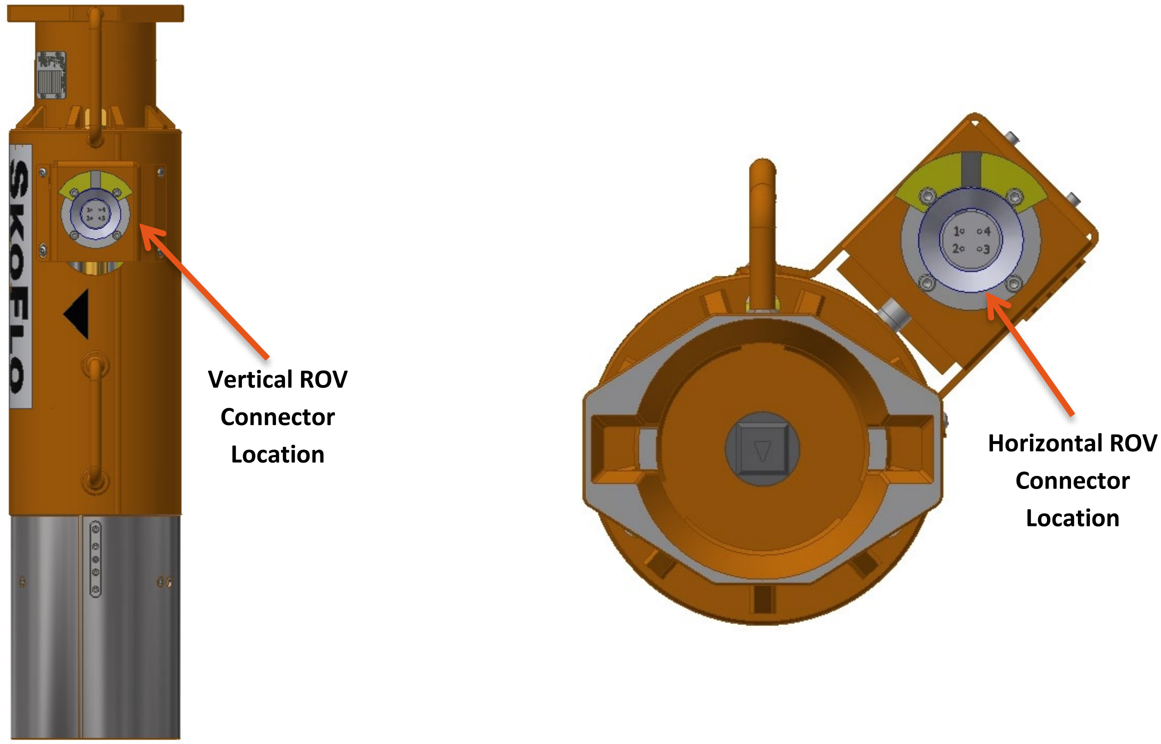


Figure 71: ROV Mate Connector Location

26.5 Hydraulic Coupler Installation:

> **! CAUTION**
> IT IS IMPORTANT TO CLEAN THE HYDRAULIC CONNECTIONS THOROUGHLY BEFORE ASSEMBLY TO PREVENT DEBRIS FROM ENTERING THE TUBING THAT MIGHT CLOG THE CIMV.

26.5.1 The coupler weldment assemblies are to be welded to the final subsea structure after the receptacle itself is bolted in place.

26.5.2 Keep inlet and outlet hydraulic coupler connections clean – debris entering the inlet tube can clog the SkoFlo CIMV. These inlet and outlet couplers are connected to the junction plate.

26.5.3 Couplers are clean when shipped. If re-cleaning is necessary, the couplers should be flushed clean using a cleaning agent. Example cleaning agents include water or a Castrol Transaqua line product. Discharge fluid must meet SAE AS 4059 Class 12B-F cleanliness.

26.5.4 Couplers are shipped loose (not attached to the receptacle) and must be installed into the receptacle onsite. Refer to Receptacle Installation (Section 26).

26.5.5 The following components are required for coupler installation: junction plate, hydraulic coupler, C-clamp and two C-clamp SHCS. See Figure 72. Figure shown represents UO-8 couplers.

26.5.6 The following tools are required for coupler installation:

- 50 in-lb or 100 in-lb torque wrench with Allen wrench attachment suitable for a M5 SHCS.

! CAUTION

JUNCTION PLATE IS NOT TO BE REMOVED FROM THE RECEPTACLE DURING COUPLER INSTALLATION. THE FOLLOWING IMAGES HAVE THE JUNCTION PLATE REMOVED TO ADD VISIBILITY TO THE PROCEDURE

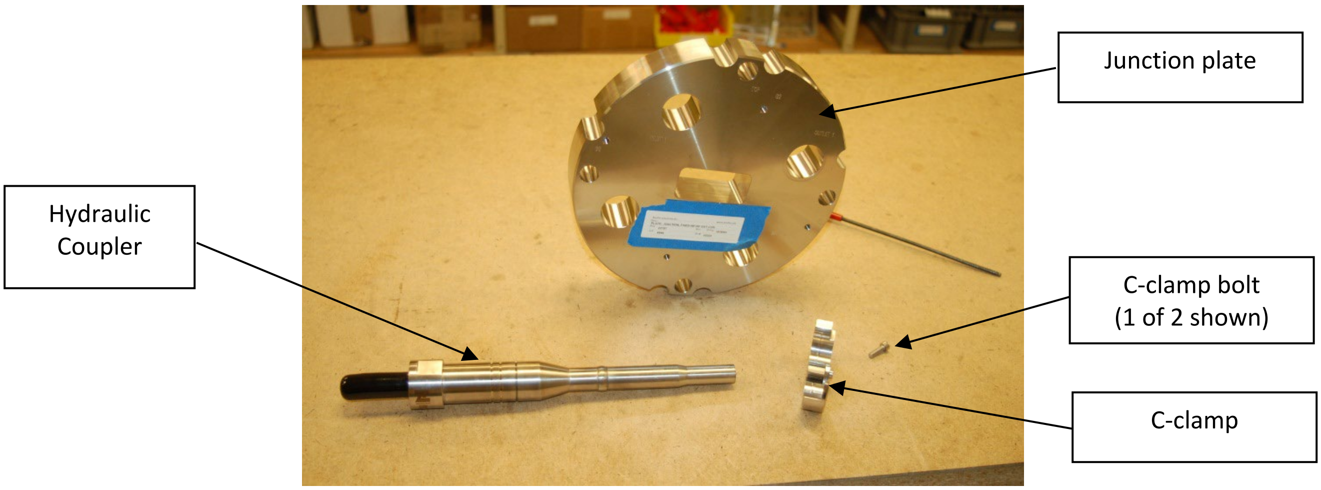


Figure 72: Coupler Assembly Step 1

26.5.7 Insert the coupler through the CIMV side of the junction plate. See Figure 73.

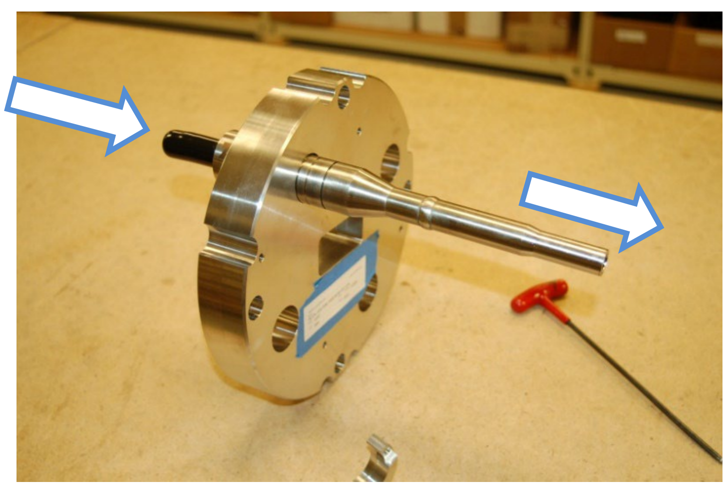


Figure 73: Coupler Assembly Step 2

26.5.8 Position C-clamp over the end of the coupler such that the groove and ridges match to hold the coupler in place. Refer to Figure 74.

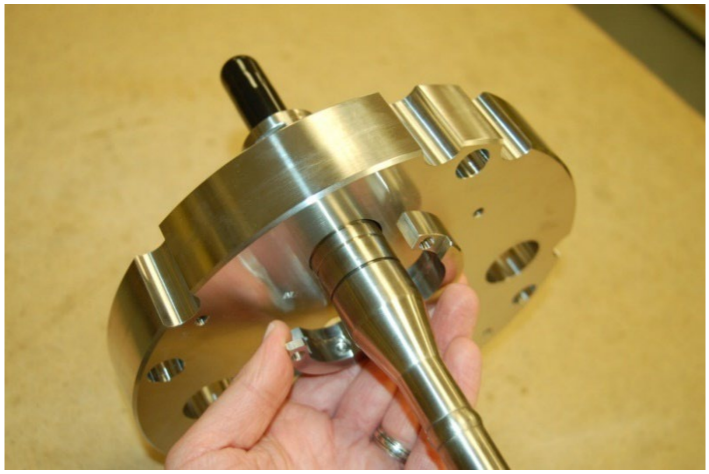


Figure 74: Coupler Assembly Step 3

26.5.9 Install the SHCS onto the C-clamps to hold them together. The threaded pin is used to prevent clamp rotation. Torque SHCS to 40 in-lb (4.5 N m). Refer to Figure 75.

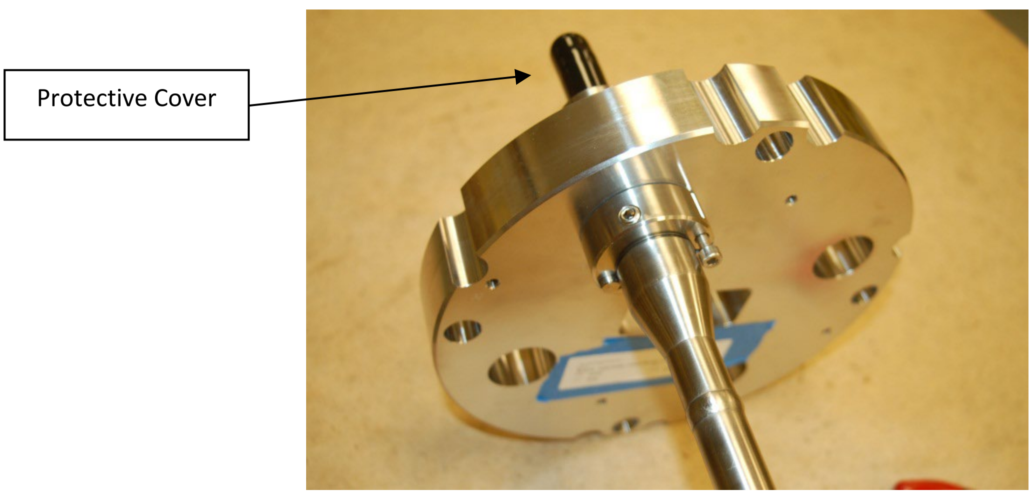


Figure 75: Coupler Assembly Step 4

! NOTICE
REMOVE PROTECTIVE COVER(S) FROM HUNTING COUPLERS BEFORE DOCKING CIMV

26.5.10 Install ground straps as shown in Figure 76 (dual core LF CIMV/LF CIMV shown). A ground strap is provided for each coupler weldment, connector (if applicable) and receptacle.

26.5.10.1 Single Core products would have 4 total ground straps: 2 coupler weldments, 1 connector (if applicable) and 1 receptacle.

26.5.10.2 Dual Core products would have 6 total ground straps: 4 coupler Weldment, 1 connector (if applicable) and 1 receptacle.

26.5.11 Confirm wet mate connector is also grounded with strap supplied by SkoFlo.

26.5.12 Ground straps must remain clear of rectangular hole and gap between junction plate and receptacle housing. Coupler movement must not be restricted by the ground straps.

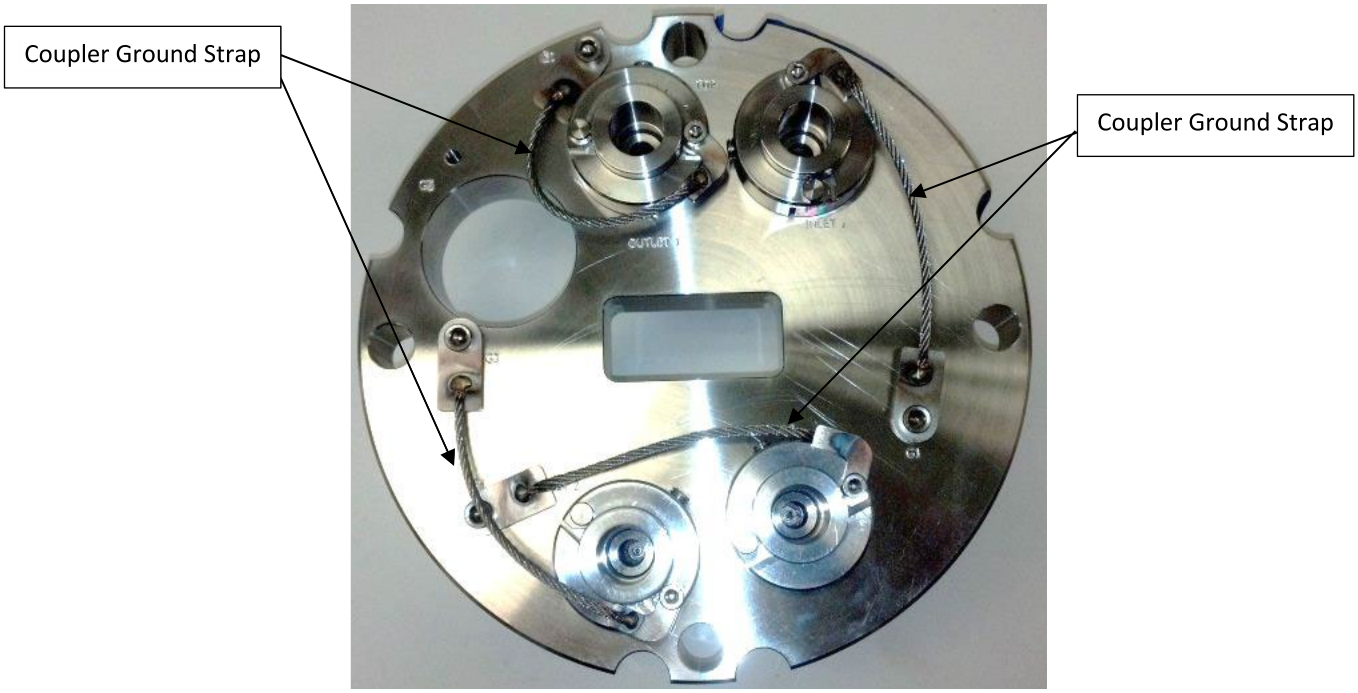


Figure 76: Ground Strap Installation

Coupler weldment ground straps shown

Connector and receptacle ground straps not shown

26.5.13 Receptacle couplers must be allowed to float in position a maximum distance of 0.05" to ensure proper sealing. Rigid supports must be installed far enough away from the mating end of the coupler weldment to allow for this movement with the application of a maximum force of 75lbf (333.6 N). When calculating this distance, it is advised to take into account the following:

- Tubing/piping material
- The required 0.05" of float to mate the receptacle coupler with the docking unit coupler
- Maximum force to float the tubing/pipe and not gall the mating coupler (estimated at 75lbf)
- The distance the tubing/pipe must be flexed to align it with the tree / manifold to weld (this will add additional stress to the system)
- Tree / manifold pressurized conditions as this will affect the rigidity of the tubing/pipe material
- Refer to Roark and Young equations for cantilever beam (tubing) deflection

26.5.14 Dock a SkoFlo test flushing unit in the receptacle to keep the male Hunting couplers perpendicular to fixed junction plate when welding the tubing to Hunting coupler pigtail ends

! CAUTION

FOR WELDING RECEPTACLE COUPLERS TO A STRUCTURE IT IS NOT ADVISABLE TO USE A SKOFLO CIMV AS DAMAGE COULD OCCUR TO THE CIRCUIT BOARD.

26.5.15 Weld the structure tubing to Hunting™ connectors tubing.

26.5.16 Do not distort SkoFlo receptacle flange during installation. Receptacle keyway should be 0.730/0.780 inches (18.5/19.8 mm) wide after installation is complete.

! NOTICE

KEY ON THE SKOFLO CIMV MUST BE ABLE TO PASS THROUGH THE PANEL ON THE RECEPTACLE

26.5.17 If receptacle ground strap position needs to be changed, grip 1-inch (25.4 mm) diameter standoff rod with a tool that will not scratch or cause damage to the standoff rod when removing lock nuts. The protective Xylan coating should be removed under the washer in the new ground strap location to ensure electrical continuity. The exposed metal is carbon steel; any exposed carbon steel at the conclusion of the ground strap move should be covered appropriately to ensure that corrosion is not an issue at these locations.

! WARNING

DO NOT LOOSEN MORE THAN ONE STAND NUT AT A TIME OR REMOVE FIXED JUNCTION PLATE FROM RECEPTACLE WELDMENT; ALIGNMENT BETWEEN FIXED JUNCTION PLATE AND RECEPTACLE WILL BE DISTURBED

26.5.18 Perform a resistance check to ensure receptacle is properly grounded. Using a multi-meter, perform a resistance check between the components defined in Table 10.

Table 10: Resistance Check Points

Parts	Acceptance criteria
Between earth strap and four bolts shown in Figure 77	< 0.10 Ω
Between earth strap and junction plate	< 0.10 Ω
Between earth strap and hydraulic coupler	< 0.10 Ω
Between earth strap and wet mate connector	< 0.10 Ω

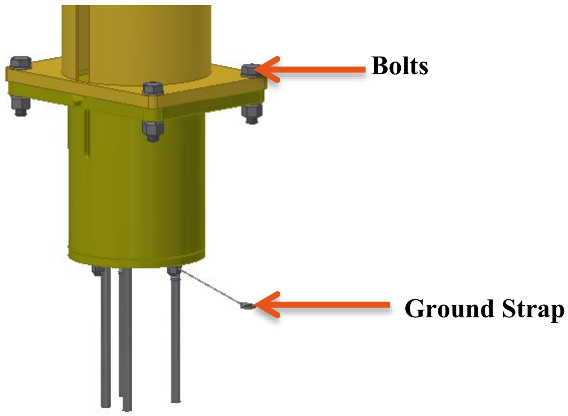


Figure 77: Resistance Check Points

26.5.19 Flush receptacles with a SkoFlo test flushing unit. This should be done before receptacle is deployed and/or chemicals are changed.

26.5.20 Install a remote-controlled shutoff valve as close to the outlet of the SkoFlo receptacle as possible while still allowing sufficient volume for worst case pressurized docking of a CIMV (refer to warning below). This shutoff valve will be used to field-zero differential sensors on the CIMV. The pressure build-up in the receptacle and tree tubing/piping during docking is caused by seawater getting trapped in the Hunting couplers prior to being fully docked. From the point that the seawater is trapped to the point of a fully docked CIMV or test flushing unit, the volume of the system (encompassing the volume from the outlet of the CIMV internal check valve to the shutoff valve) is decreased. This results in the pressurization of the water in the system. Further information regarding this possible issue can be made available upon request.

! WARNING

PROVIDE SUFFICIENT VOLUME BETWEEN CIMV AND NEAREST SHUTOFF VALVE TO ENSURE DOCKING FLUID DISPLACED DOES NOT EXCEED CIMV INTERNAL PRESSURE RATING OR THAT OF THE RECEPTACLE / CHRISTMAS TREE TUBING. REFER TO SKOFLO DOC-00067 FOR EXAMPLE CALCULATIONS

26.5.21 Some form of backflow prevention should be employed external to the check valve supplied in the SkoFlo product. If a reverse flow situation occurs causing over 2000 psi (138bar) differential across the CIMV, seal damage may occur. The SkoFlo check valve is intended to stifle or stop reverse flow to protect the seals from the reverse pressure drop. The check valve may not prevent all fluid from passing through the CIMV in reverse flow. Depending on seal condition, fluid cleanliness and pressures, the check valve can be leak tight. An external outlet check valve is recommended to be installed within 20 feet after the CIMV outlet to prevent production fluid from reaching the CIMV as well as prevent pressure surges driven by environmental conditions such as initial pressure conditions, fluid velocity and check valve closing conditions.