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Contents

1.0 Introduction

This Installation and Operation Manual applies to all variants of the Nautilus plug and receptacle connectors, and the Nautilus penetrator connectors. Each connector's outline and interface details can be provided on a separate drawing.

Figure 1: Examples of Remote Operated Vehicle (ROV), Stab Plate, and Penetrator Nautilus Configurations

NOTE: This is a generic manual covering all Nautilus connectors. Any project specific instructions, such as field-installable terminations, will be dealt with in a separate document.

NOTE: For Nautilus High Power Connectors, please refer to **DN 63860**.

CAUTION! This procedure may contain products that are Electrostatic Discharge Sensitive (ESDS). Electrostatic discharge (ESD) can change the electrical characteristics of a semiconductor device, degrading or destroying it. Always follow all instructions that pertain to ESD requirements for the safety of the assembly. Refer to the industry standard **ANSI/ESD-S20.20** or equivalent.

CAUTION! For plastic fastening components, use threadlock products that are safe for plastic. Threadlock and primer products that are specified for metallic components can cause stress cracking if used on or near amorphous plastics; Ultem, acrylic, polycarbonate, and PVC.

NOTE: Surface finishes and appearance of the Nautilus connector may differ from the images within this document.

2.0 Installation

In general, Nautilus connectors are simple and straightforward to install, usually without the need for special tools. However, the following sections should be read to prevent damage to connectors.

NOTE: Where cable termination work and mounting are carried out by those other than Teledyne Oil & Gas, the responsibility for that work lies with the customer or his subcontractor, and the following information is provided for guidance only.

2.1 Solder cups

Both plug and socket are provided with gold plated solder cups for wire termination. Standard solder cups can accommodate wire sizes up to 12 AWG (4.0 mm^2) and up to 10 AWG (6 mm^2) using solder cup adaptors. Termination should be performed per an industry recognized soldering standard such as IPC/J-STD-001 or IPC-WHMA-A-620.

Nautilus Solder Cup/Pot Capacity						
Maximum Conductors	1	1	1	2	2	2
(AWG) Wire Gauge	12	14	16	18	20	22
Equivalent Metric Wire Gauge (mm^2)	4.0	2.5	1.5	1	0.75	0.5
(AWG) Cross Section (mm^2)	3.31	2.08	1.31	0.823	0.518	0.326

2.2 Boot Seals

If rubber "mechanical" boot seals are employed, then both wire jacket and boot seal nipple should be cleaned with a warm, 50% distilled water/alcohol solution (verify wire jacket is compatible with alcohol), dried, and then lightly lubricated with dielectric silicone lubricant (e.g., Dow Corning, DC-4). Take care to verify the wire is cut cleanly and that no sharp edges or stray wires are sticking out that may damage the boot seals during installation. It is recommended that the integrity of seals be verified using standard Insulation Resistance practices.

NOTE: If other cleaning agents or solvents are to be used, contact Teledyne Oil & Gas for confirmation of their compatibility with the plastic and rubber parts of the connector.

2.3 **O-rings**

Both the plug and receptacle are supplied with all O-rings required for sealing the connector onto its mounting. Normally, these are Nitrile O-rings and their compatibility with the contained fluid (if any) should be confirmed. The O-rings are supplied in a clean separate bag. Prior to fitment, verify that the O-ring grooves and O-rings in the connector are clean. Lightly lubricate the O-rings with silicone lubricant and install in grooves.

2.4 **General Notes of Caution**

Do **not,** under any circumstances, insert anything into the Nautilus receptacle except the Nautilus plug. Insertion of foreign objects such as electrical test probes will most likely damage the seals or break the stoppers. Similarly, probing the pins in the Nautilus plug could result in cracking of the pin insulation.

These Nautilus connectors are designed to withstand differential pressure across them only when the pressure is applied from the connector face normally exposed to the sea. Application of differential pressure in excess of 150 psi from the solder cups side of Nautilus connectors will result in irreparable damage to the connector. For purposes of designing pressure balanced oil-filled systems (PBOF), pressure on the solder cups side of these connectors should not exceed the ambient exterior pressure applied to the connector's open face by more than 150 psi.

Great care should be taken not to drop these connectors. Their solder cups are vulnerable to mechanical damage prior to termination.

Connectors should not be handled by their pigtails. This may cause damage to the solder joints resulting in electrical failure.

Live Connection and Disconnection - These connectors are **NOT** designed to be connected or disconnected while power is applied to the electrical circuits. **Severe** damage (including connector failure) can occur if this is done. In the event that live connection may occur or has occurred, please contact Teledyne Oil & Gas for further guidance.

Energized Plug Pins – Power should **NOT** be applied to the electrical plug pins while unmated. This will result in a shock hazard that could lead to personal injury.

Subsea Storage of Unmated Connector - The electrical plug connector should not be left unmated subsea for a cumulative period of greater than two weeks due to corrosion and marine growth. Electrical plug connectors should never be left unmated with power applied to exposed pins. Electrical plug connectors left unmated for more than 2 weeks should be cleaned and inspected. Upon re-deployment it may remain for another 2-week period. Plug connectors should never be left unmated subsea if there is a possibility that the circuits may become energized, this will most certainly result in damage. In the event unmated connectors are to be stored subsea, contact Teledyne Oil & Gas, Inc. for the appropriate protective covers.

Cathodic Protection of Connectors – Teledyne Oil & Gas generally manufactures its connectors from titanium which does not require cathodic protection. However, Teledyne Oil & Gas does manufacture connectors from various other materials including Stainless Steels. These other materials do require cathodic protection in the subsea environment to prevent corrosion. It is the customer's responsibility to provide cathodic protection to the connectors as required by the materials. The GA drawing will indicate the size and depth needed for the earth screw. It is the customer's responsibility to locate, prepare and install the earth screw.

Galvanic Isolation – Teledyne Oil & Gas manufactures its connectors from various materials. Most notably, the ROV connectors are manufactured from titanium. Teledyne Oil & Gas can provide isolation adapters for all of its connectors should the mounting structure be made from a dissimilar material. Please contact Teledyne Oil & Gas for connector materials and isolation adapters to prevent galvanic corrosion.

Storage of Assemblies – Nautilus assemblies were designed for subsea use and when storing connectors it is optimal to store them in an environment similar to subsea conditions. Maximum life will be obtained from Nautilus if it is stored in a cold, dark location. Exposure to UV sources should be limited as much as possible. Exposure to chemicals (including Ozone) must be limited. It is strongly recommended that chemical exposure is not allowed during storage (Including Ozone). If there is concern that Nautilus connectors may be exposed to chemicals during storage, contact Teledyne Oil & Gas for additional guidance. Additionally, if the assemblies remain unused after 2 years of storage, it is strongly recommended that they be returned to Teledyne Oil & Gas for evaluation. If in doubt, contact Teledyne Oil & Gas for further information and guidance.

Chemical Exposure – Do not expose Nautilus to chemicals including the following: (beyond trace concentrations) Hydrocarbons, Xylene, Brayco SV/A, Carnation Mineral Oil, Hydrolubric 120-B, or Midel 7131. Exposure to these chemicals has a detrimental effect on the insulating materials and can damage the product. Limited exposure (time) and low concentrations can be tolerated in some instances. If a connector has been exposed to any of these chemicals, or requires exposure to these chemicals please contact Teledyne Oil & Gas for guidance.

Plastic Protective Caps – Plastic protective caps are available for all connectors to provide mechanical, and sometimes electrical, protection of the connectors. These plastic caps were designed for subsea operation and should be stored in a similar manner to the Nautilus product (as described above). Plastic caps require being fully mated to their respective connector to function correctly. Should a cap not be fully mated, damage to the connector, as well as damage to the plastic cap could occur. Teledyne Oil & Gas has seen instances where, when plastic protective caps are not fully mated, the latch fingers, which retain the cap, can change shape and permanently damage the connector. This can be avoided by verifying the Protective Cap is fully mated (subsea or during storage). Plastic protective caps do not require any materials to aid in their functionality. **DO NOT** fill the protective caps with any type of viscous fluid in an attempt to further protect the connectors. Teledyne Oil & Gas has seen instances where this type of process has caused damaged to the Nautilus connectors.

Handling of ROV Connectors – Teledyne Oil & Gas ROV connectors employ metallic latch fingers to perform the mating/de-mating function for the connectors. These metallic fingers are actuated by a slide shell which slides over the outside of the connector and provides a mounting point for the orange ROV handle. This slide shell may be activated by other methods, including (but not limited to) dropping the connector and impacting the front of the connector. This will force the connector slide to the actuated position fully engaging the latch fingers. In this instance it is possible to damage these latch fingers with excessive loading, or impact energy. To prevent damage, take great care not to over actuate the slide shell/latch fingers during surface handling.

3.0 Operation

Nautilus Connectors require no special instructions regarding their operation. The following lists the capabilities of the Nautilus Connector. These should not be exceeded.

NOTE: Nautilus Connectors are intended for general subsea use. They are wet-mateable at the surface and at depth.

NOTE: The following table refers to the Nautilus Connectors' qualified capabilities and not to the Factory Acceptance Tests actually carried out on the delivered connectors. Refer to the test procedure for details of the delivered connectors tested parameters.

3.1 Standard Nautilus Specification

Parameters		Ratings [D]		
Maximum Operational Depth Pressure Balanced		6400 m (10,000 psi)		
Maximum Operational Differential Pressure, bar (psi) [A]			**Receptacle**	**Plug**
		4 - Way	427 (6200)	438 (6350)
		7 - Way	259 (3750)	338 (4900)
		12 - Way	224 (3250)	303 (4400)
Operational Temperature [B]	Seawater	-5°C to +40°C	(23°F to 104°F)	
	Air	-10°C to +50°C	(14°F to 122°F)	
Storage Temperature [B]		-30°C to +60°C	(-22°F to 140°F)	
Subsea Mate/De-mate Cycles [C]		1000 total cycles maximum after Factory Acceptance Testing, 200 cycles maximum in turbid seawater		
Design Life		30 Years		
Maximum Operational Current per Circuit		30 Amps		
Maximum In-Rush Current		100 amps for 0.5 seconds		
Maximum Operational Voltage		1.0 kVAC Phase-to-Ground		
		1.73 kVAC Phase-to-Phase		
		3.3 kVDC		
Insulation Resistance		≥ 10 GΩ @ 1 KVDC		
Typical Contact Resistance		≈ 10 mΩ per contact		
Mated Connector Continuity Resistance		≤ 0.2 Ω per contact		

[A] = Pressure ratings to allow 30-year life with 99% reliability for standard Nautilus connector bases, project specific ratings may vary

[B] = Maximum allowable product temperature including ambient, solar, and internal contributions

[c] = Mate/De-mate of connectors performed only when power is disconnected and all residual charge is drained

[D] = Ratings compliant to Statoil TR1233, TR2390 and Total GE EP SPS 021

3.2 ROV Mate Nautilus Connectors

ROV connectors should be mated and de-mated using only the attached handle. The mate is a simple push to connect and de-mate is a simple pull to disconnect, both via the handle. Any attempt to disconnect by pulling on other parts of the connector (including the hose or cable termination) will likely result in permanent damage to the connector. Section 3.3 lists the capabilities of the ROV Mate Nautilus Connector. These should not be exceeded.

The ROV Connector may be provided with a protective cap. This cap is removed and re-applied by pulling the handle towards the operator as seen in Figure 2.

Figure 2: ROV Protective Cap

Nautilus ROV connector latch fingers should not be left for an extended period of time in the open position, as seen in figure 3. This can cause damage to the latch finger mechanism.

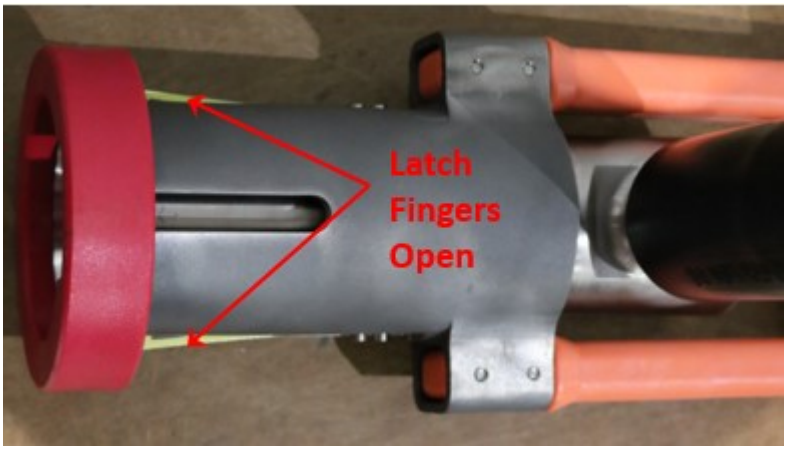

Figure 3: Latch Fingers in Open Position

In order to close the latch fingers without mating the connector, firmly grasp the connector at the base of the bend restrictor and push the handle toward the connector as shown in figure 4.

Figure 4: Closing Latch Fingers without Mating the Connector

3.3 ROV Mate Nautilus Specification

Parameters	Ratings[A]
Maximum Mate/De-mate Force	< 500N (112 lb_f)
Minimum De-mate Force (min. force needed to de-mate)	98N (22 lb_f)
Connector Mated Breakaway Force (applied via hose or termination shell)	> 1330 N (300 lb_f)
Maximum Allowable Axial Force During Mating (depending on connector configuration)	2000 N (450 lb_f)
[A] = Ratings compliant to Statoil TR 1233 and Total GE EP SPS 021	

3.4 Funnel Guide and Base Bushing

Pin Configuration	Base Bushing Color
4 Way	Red
7 Way	Green
12 Way	Black or White

CAUTION! Shipping/Dust Caps/Covers must be removed prior to hydrostatic testing or subsea deployment. Failure to do so may damage the connectors.

3.5 ROV Mating Indication

ROV connectors are equipped with latch fingers to verify proper engagement of the connector halves. The sides of the latch fingers have high visibility paint applied to either side to provide a visual indication of a successful mating. Refer to Figures 5 and 6 for image of the latch fingers. When mating the ROV connector pair, ensure that the latch fingers are in the closed position, indicating a successful mate.

Figure 5: ROV Latch Fingers in the Closed Position

Figure 6: ROV Latch Fingers in the Open Position

3.6 Maintenance

Nautilus connectors require no periodic maintenance and are maintenance-free for their intended life subsea. If damage occurs to the connector, then the entire connector must be returned to Teledyne Oil & Gas for repair or replacement.

General Connector Cleaning

If necessary, Nautilus connectors can be cleaned following the instructions below:

NOTE: Do not disassemble connectors. General cleaning is intended for light to moderately soiled connectors. If a connector exhibits reduced performance and extreme soiling is suspected, return the connector to Teledyne Oil & Gas for repair or replacement.

3.6.1 Nautilus plugs: Plugs can be cleaned with a warm 50% distilled water/alcohol solution. This includes the pins, shell, and most boot seals. Some rubber compounds display reduced electrical performance after exposure of alcohol; please contact Teledyne Oil & Gas prior to cleaning boot seals to verify materials. If the boot seals are cleaned with alcohol and insulation resistance is lost, the boots must be replaced to recover the insulation value. An alternate cleaning solution of Alconox may be used and will not affect the performance of the boot seals. Rinse the connector thoroughly with the solution followed by a clean water rinse. If performance does not improve, clean again using a soft, natural bristle brush.

NOTE: Use caution when cleaning pins, side loading will result in cracked pins.

3.6.2 Nautilus receptacles: Receptacles can be cleaned by rinsing with clean water. Do not clean receptacles with alcohol, the Alconox solution cleaner may be used on receptacles.

NOTE: Never insert anything into the receptacle since this may introduce contamination into the connector or cause internal damage.

NOTE: Never inject connectors with any type of fluid or attempt to clean connectors with any fluid not stated above. For specific questions, contact Teledyne Oil & Gas.

Removal of Marine Growth and Calcareous Deposits

To remove calcite growth from the Nautilus connectors, a solution of 50% by volume of Citric Acid and water is recommended. All Seawater exposed elastomeric materials in the connectors have been fully tested against Citric Acid and are compatible for duration of 1 hour. After soaking, rinse with fresh water to remove traces of the Citric Acid solution.

CAUTION! A low-pressure water jet is acceptable, but the jet MUST not be directed onto the white stoppers at the front of the receptacle or into the radial vent holes as this will result in water being forced through the primary seals which could render the connector inoperable and/or unable to mate.

4.0 ROV Mating Guidelines

4.1 ROV Stabilization

4.1.1 There are two fundamental ways to control the ROV prior to mating the Teledyne Oil & Gas, Inc. connectors. The ROV can either grab on to the subsea structure with one of the manipulator arms while mating, or not grab on at all and 'free-fly' mate the connectors together.

4.1.2 Although Teledyne Oil & Gas, Inc. does not promote one method above another, great care must be taken if the ROV is supported by grabbing onto the structure with one manipulator arm. This fixed point can act as a pivot point, causing excessive off-axis loading on the connectors leading to severe connector damage.

4.2 ROV Mating Guidelines – Horizontal Connection

4.2.1 Use the ROV manipulator jaw to grasp the flying lead handle squarely. Adjust the arm so that the connector is held as close to horizontal as possible. The alignment keyway in the ROV connector should be aligned with the key on the bulkhead.

4.2.2 Position the manipulator jaw and the connector such that the camera is in line with the centerline of the axis of the connector.

NOTE: Positioning the camera off axis to the ROV connector increases the potential for damage due to misalignment.

4.2.3 Once the conical lead-in on the ROV flying connector has engaged the outer bushing on the bulkhead connector and proper alignment is confirmed, mate the connectors by applying linear motion and along the axis of the connectors.

NOTE: If the ROV connector is not aligned with the bulkhead connector, attempt again to re-align the connectors before mating. If the stab is mated with very slight misalignment (+/- 5° tilt), the connector handle is compliant enough to allow the connectors to mate without damage. However, excessive angular misalignment (greater than +/- 5°) can cause severe damage to the connectors.

4.2.4 Positive thrust should be maintained until the locking arms (latch fingers) on the ROV flying connector are witnessed as flush with respect to the side of the ROV connector shell.

4.2.5 Inspect latch fingers per Figures 3 & 4. Ensure that latch fingers are flush with respect to ROV connector shell.

4.3 **ROV Mating Guidelines – Vertical Connection**

4.3.1 Use ROV manipulator jaw to grasp the plastic handle on the ROV flying connector.

4.3.2 Position the manipulator jaw and connector such that the camera is in line with the centerline axis of the connector.

NOTE: Positioning the camera off axis to the ROV connector increases the potential for damage due to misalignment.

4.3.3 Use the ROV manipulator jaw to gently set the ROV flying connector onto the bulkhead connector so that the acceptance cone in the ROV flying connector guides down onto the bulkhead connector bushing.

NOTE: If the ROV connector is not aligned with the bulkhead connector, attempt again to realign the connectors before mating. If the stab is made with very slight misalignment (+/- 5° tilt), the connector handle is compliant enough to allow the connectors to mate without damage. However, excessive angular misalignment (greater than +/- 5°) can cause severe damage to the connectors.

4.3.4 Release the manipulator jaw from the connector handle.

4.3.5 Turn the manipulator jaw on its side and gently press down on the top of the handle until the locking arms (latch fingers) on the ROV connector are witnessed as flush with respect to the side of the ROV connector shell.

4.3.6 Inspect latch fingers per Figures 3 & 4. Ensure that latch fingers are flush with respect to ROV connector shell.

4.4 **ROV De-mating Guidelines – Horizontal Disconnection**

4.4.1 Position the manipulator jaw and connector such that the camera is in line with the centerline axis of the connector.

NOTE: Positioning the camera off axis to the ROV connector increases the potential for damage due to misalignment.

4.4.2 Stabilize the ROV sub then close the manipulator jaw on the flying connector plastic handle.

4.4.3 Apply linear and steady motion to disconnect the flying lead.

4.4.4 Inspect the connector faces for damage.

4.5 ROV De-mating Guidelines – Vertical Disconnection

4.5.1 Position the manipulator jaw and connector such that the camera is in line with the centerline axis of the connector.

NOTE: Positioning the camera off axis to the ROV connector increases the potential for damage due to misalignment.

4.5.2 Stabilize the ROV sub.

4.5.3 Extend and open the ROV manipulator jaw.

4.5.4 Position the open manipulator jaw squarely under the connector handle.

4.5.5 Raise the manipulator arm vertically to raise the connector slightly off the bulkhead receptacle.

4.5.6 Close the manipulator jaw on the handle to avoid dropping the connector.

4.5.7 Inspect the connector faces for damage.

5.0 Diver Mateable Connector Mating Guidelines

Figure 7: An example of a Diver Mate Connector Pair

5.1 Diver Mate Connector Preparation

5.1.1 Verify both plug and receptacle connectors for damage or build up of debris.

5.1.2 If there is any noticeable quantity of particulate or larger debris, refer to the maintenance section of this document for guidelines.

5.2 Mating Diver Mate Connectors

5.2.1 Position the connectors that are to be mated so that they are both held as close to horizontal as possible. The alignment keyway should be aligned with the mating connector alignment key prior to mating connectors.

5.2.2 Once the key has entered the keyway and proper alignment is confirmed; mate the connectors by applying linear motion along the axis of the connectors until the locking sleeve meets the male thread.

NOTE: A "C" Spanner may be used to rotate the locking sleeve. The maximum torque applied to the locking sleeve must not exceed 20 Nm (15 ft-lbs.).

5.2.3 Rotate the locking sleeve in a clockwise direction until the connector shells meet and the locking sleeve cannot be rotated any further, i.e. it is "Hand Tight."

5.3 **De-Mating Diver Mate Connectors**

5.3.1 Verify the power to the connector has been shut down and a sufficient time has passed for the residual charge to bleed off.

5.3.2 Position the mated connectors so that they are both held as close to horizontal as possible.

NOTE: A "C" Spanner may be used to rotate the locking sleeve during the de-mating sequence, if required.

5.3.3 Rotate the locking sleeve counter-clockwise until the sleeve is free of the threads.

5.3.4 De-mate the connectors.

5.3.5 Inspect the connector faces for damage.

5.3.6 Install protective covers, if available to prevent damage and fouling.

6.0 Use of Gross Alignment Funnel with Enhanced Latching Indicator

Teledyne Oil & Gas has developed a gross alignment funnel and enhanced latching indicator system for use with Nautilus connectors. Use of this equipment is strongly recommended, as the risk of damage to connectors during ROV intervention is greatly reduced.

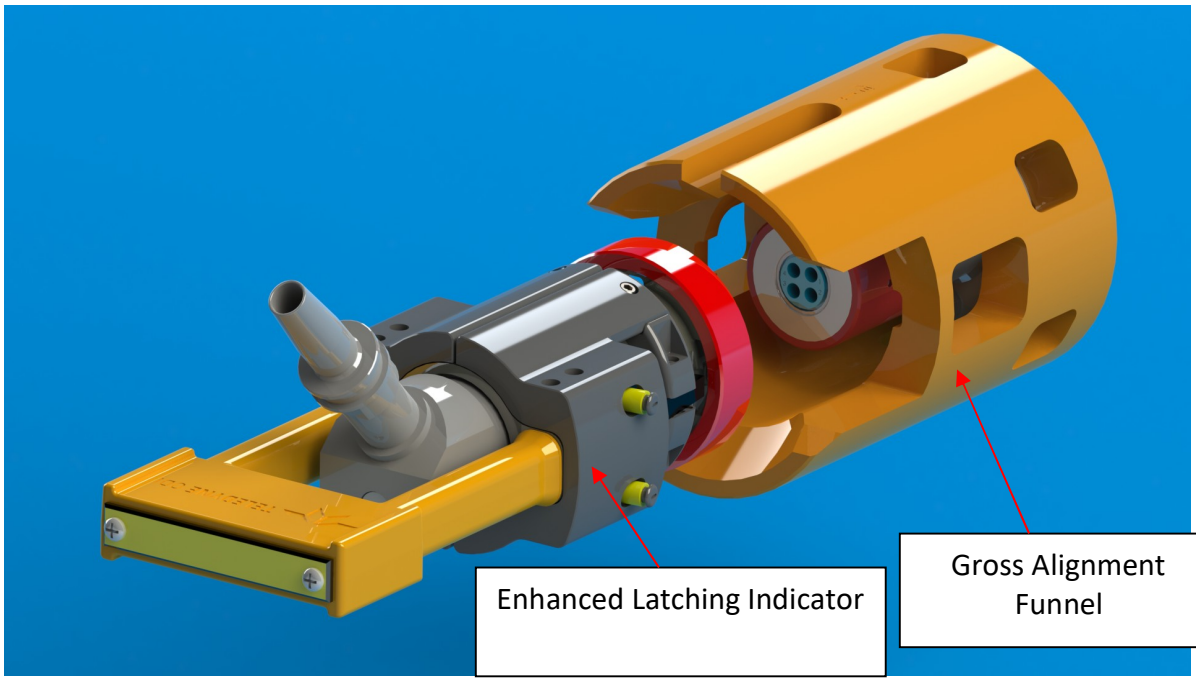

Figure 8: Gross Alignment Funnel and Enhanced Latching Indicator

The use of these components allows a much greater incidence angle during mating approach. The gross alignment funnel has a 60 degree included conical funnel at its mouth, which allows a steeper approach. The piloting dimensions of the latch and funnel together allow a maximum angle of 4 degrees between connectors during engagement.

The enhanced latching indicator can be retrofitted in the field, per Teledyne Oil & Gas assembly procedure **DN 10655**. The gross alignment funnel can be field assembled using Teledyne Oil & Gas assembly procedure **DN 244051**.

The gross alignment funnel must be attached to the bulkhead plug connector during assembly onto the mounting structure. An assembly drawing shall be provided for each unique configuration of the GAF. Torque of mounting bolts is to be 40 in-lbs +/- 4 in-lbs (4.52 N-m +/- 0.45 N-m), unless otherwise specified in a project specific application.

When mating connectors using the GAF/ELI system, the guidelines outlined in section 4.0 should be adhered to, with the following additions:

- For bulkhead connectors having a single alignment key, the GAF contains a slot, which allows for the viewing of the alignment key in the slot when the flying lead is not attached. This feature should be used to identify the correct orientation of the flying connector prior to attempting a mate.

- Although the GAF and ELI system provide guidance of the connector halves together, they do not prevent mating or de-mating connectors at excessive speeds.

- During the mating operation, the yellow enhanced latch indicator buttons should not be visible until the connector is fully mated and latched. Once they are visible, mating is complete.

- Flying connector inspection should include inspection of the enhanced latch indicator arms for any obstructions or damage, which might prevent the functionality of the enhanced latch indicators. Note that impaired functionality of the enhanced latch indicator arms will not affect the ability of the connector set to positively mate and latch.

7.0 Revision History

Revision	CO #	Revised By	Summary of Changes	Release Date
P1	52120	D. Parray	Re-formatted document	05/28/2020
P	52120	D. Parray	Changed the design life from 25-year to 30-year.	09/11/19
N	46327	C. Brink	In section 3.2: added statement that latch fingers should not be left in open position for extended periods of time. In section 3.5: added statement to ensure latch fingers are in closed position when mating the ROV connector pair.	06/29/18
M	39273	T. Sidenstricker	In section 2.4 added: Energized Plug Pins – Power should NOT be applied to the electrical plug pins while unmated. This will result in a shock hazard that could lead to personal injury.	6/7/16