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**POLYMER COATED TUBING FOR USE IN SYSTEMS WHERE PROTECTION FROM
SOURCES OF EXTERNAL CORROSION IS EMPHASIZED**

Attached you will find a sample specification. It is intended for the application of polymer coated tubing for use in systems where protection from sources of external corrosion is emphasized and freezing ambient conditions are not a requirement. This specification is submitted for your consideration. You may copy, amend and modify this document as needed.

These specifications incorporate the advantages of the O'Brien TAW05589 polymer coating system and tube preparation in order to maximize resistance to sources of external corrosion. The effectiveness of this combination of material, tube preparation, extrusion process and end sealing system has been verified using ASTM G85 standard practice and witnessed by a Level III NACE Coatings Inspector from DNV / Columbus OH.

POLYMER COATED TUBING FOR USE IN SYSTEMS WHERE PROTECTION FROM SOURCES OF EXTERNAL CORROSION IS EMPHASIZED

1. SCOPE

This specification is to be used for control, process and utility piping less than 1" or 25mm in diameter when the effects of external corrosion are severe enough to warrant the use of higher grade corrosion resistant alloys than required by the process conditions.

2. GENERAL REQUIREMENTS

- 2.1. All tubing and fittings shall be protected from sources of external corrosion.
- 2.2. Supplier shall provide a comprehensive system of protection including but not limited to: polymer coated tubing, sealing boots, fitting seals, material handling equipment for large spools, tube straightening equipment, support and fastening clips, design and plan review and on-site training of installers worldwide.

3. TUBING SELECTION

- 3.1. The use of long continuous coiled tubing is preferred. Stick tubing may be substituted only when specifically identified and approved.
- 3.2. Coiled tubing shall be supplied in the longest continuous lengths available for a stated OD, wall and metallurgy.
- 3.3. When required and approved stick tubing shall be supplied in random lengths of 20' +0", -18".
- 3.4. Tube size, wall thickness, construction and material shall be specified and be compatible with the process conditions. Except as specifically defined for compatibility with process chemistry all tubing covered by this specification will be dual certified 316/316L seamless SS with diameter and wall thickness per the requirements specification.
- 3.5. All 316/316L (UNS S31600/S31603) tubing shall comply with the following:
 - 3.5.1. ASTM A213 *Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes*. Nominal wall thickness tubing will be supplied.
 - 3.5.2. ASTM 269 *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*
 - 3.5.3. ASTM 632 *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service*
 - 3.5.4. ASTM A1016 / A1016M *Standard Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes*
 - 3.5.5. NACE MR0175 *Standard Material Requirements for Metals for Sulfide Stress Cracking and Stress Corrosion Cracking Resistance in Sour Oilfield Environments*
 - 3.5.6. NACE MR0103 *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

SAMPLE SPECIFICATION Cont'd

4. TUBE COATING MATERIAL

- 4.1. All tubing shall be protected with TAW05589 a non-halogenated flame retardant polyether based thermoplastic polyurethane polymer formulated for UV, ozone, abrasion and tear resistance as well as tear propagation, hydrolytic stability and fungus resistance as supplied by O'Brien Corporation. Properties of polymer coating shall be as listed in Table 1.

Properties	Test Method	Typical Value		
		English	SI	
Physical				
Hardness	Shore A	ASTM D-2240	75A	75A
Mechanical				
Tensile Strength	Psi/MPa	ASTM D-412	6000 psi	41 MPa
Elongation at Break	%	ASTM D-412	685%	685%
Tear Strength	lb/in N/mm	ASTM D624 Die	325 lb/in	57 N/mm
Taber Abrasion Resistance / mg loss	1000 gr/H-18	ASTM D-1044	20 mg	20 mg

Table 1

- 4.2. Standard color shall be black. Optional colors may be substituted as needed for visual identification. Identification colors shall be chosen from: white, grey, blue, yellow, red, orange, purple or green.

5. Application of Protective Polymer

5.1. Tubing Surface Preparation

- 5.1.1. The exterior of all tubing shall be prepared per the requirements of TAW05589 to remove all trace chlorides and hydrocarbons.
- 5.1.2. The exterior of all tubing will be clean, dry and free from dirt, grease or other foreign contaminants.
- 5.1.3. All tubing will be visually inspected for any mechanical damage including but not limited to ovality, abrasion or kinking. If any of these conditions are detected the tube shall be rejected.
- 5.1.4. As an option the interior of all tubing shall be cleaned to meet the cleanliness requirements specified in NAS 1638 Class 6 / ISO 4406 Range 17/15/12.
- 5.1.5. When optional cleaning is specified tubing shall be packaged with both ends accessible.

5.2. The polymer coating shall be continuously extruded with no gaps or voids allowed.

- 5.2.1. During extrusion the following variables will be controlled per the requirements of TAW05589 to produce a uniform melt and blending of colorants and polymers: pellet temperature and dew point, screw temperature in a minimum of four zones, die temperature, cross head temperature, screw rpm and pull speed.

- 5.2.2. Applied jacket thickness shall be a nominal 0.050" (1.27mm).

6. Construction, Identification and Packaging

- 6.1. The exterior marking shall indicate the tube OD, wall thickness, metallurgy, and the manufacturer's part number and identifying batch number. Marking shall repeat and extend along the entire length of the tube.
- 6.2. Maximum allowable process temperature for polymer coated tubing shall be 250°F (120°C). The exterior of coated tubing shall be continuously marked with the following: CAUTION – MAY BE HOT.
- 6.3. Multiple Polymer Coated Tubing

SAMPLE SPECIFICATION Cont'd

6.3.1.1. Individual polymer coated tubes meeting all the requirements above may be combined to create two, three and four tube flat bundles.

6.3.1.2. All bundles greater than a single tube shall be of parallel (not cabled) construction to reduce work hardening and provide a minimum bend radius with no tube kinking. Cabled tubing inside the bundle is not acceptable.

6.3.2. In addition to the marking requirements of 6.1 polymer coated tubes inside an outer jacket shall have a unique repeating identification number printed the entire length of the tube.

6.3.3. Individually polymer coated tubes shall be bound together using silicone coated fiberglass and Mylar to bind tubes together and hold them in relative positions inside the bundle.

6.3.4. Bundles of three & four polymer coated tubes will include a marine grade aluminum stabilizer plate under the Mylar binding to keep the parallel configuration.

6.4. The manufacturer's part number and identifying batch number shall be continuously printed along the entire length of product.

6.5. Single and Multiple polymer coated tube bundle coils shall be provided on spools.

6.6. Leading and trailing ends of coiled tubing shall be sealed to prevent ingress of contaminants.

7. Bend Radius

7.1. Single polymer coated tubing shall be limited to the following minimum bend radius unless specifically defined elsewhere:

Tube Diameter	Minimum Bend Radius
1/4"	15/16"
3/8"	1-1/2"
1/2"	3"

7.2. Tube bundles shall have the following minimum bend radius:

7.2.1. Tube bundles with two or more 3/4" diameter tubes and with a small dimension of greater than 45mm shall have a 300mm minimum bend radius.

7.2.2. All other tube bundles shall have a 200mm minimum bend radius.

8. FASTENERS AND INSTALLATION TOOLS

8.1. Fasteners shall be 300 series stainless steel and maintain multiple tubes perpendicular from the mounting rail. Fasteners shall be sized for the appropriate diameter and quantity of tubes in the bundle.

8.2. Manufacturer shall provide approved payout equipment providing for the safe and efficient installation of long continuous coiled tubing.

8.3. Manufacturer shall provide approved installation, handling and straightening equipment and methods suitable to the product(s) supplied.

8.3.1. Combination spool stand and bundle straightener with loading ramp and spool brake. Stand shall accommodate up to 60" diameter spools weighing up to 590 Kg.

8.3.2. Spool handling equipment shall be fitted with safety restraints to limit uncontrolled uncoiling of coiled tubing.

8.3.3. Straightener for 1/8"/3mm through 1/2"/12mm bare and polymer coated tubing. Straightener shall be equipped for hand held use and mounting on the combination spool stand.

8.3.4. Straightener for 1/2"/12mm through 1"/25mm bare and polymer coated tubing. Straightener shall be equipped for mounting on the combination spool stand.

SAMPLE SPECIFICATION Cont'd

8.3.5. Tube straighteners shall be split to allow side loading of tubing.

9. CONNECTIONS AND SEALING

- 9.1. All coatings shall be removed for connection to compression or other style fittings.
- 9.2. Bare tubing and the initial compression nut of fittings shall be covered with adhesive lined polyolefin heat shrink sleeves. Black silicone self-fusing tape may be used in conjunction with heat shrink sleeves on "T" and elbow connections or other areas where heat shrink sleeves are not applicable.
- 9.3. A minimum of four layers of black silicone self-fusing tape properly applied may be used in lieu of heat shrink sleeves.
- 9.4. Self-fusing silicone tape and / or adhesive lined polyolefin heat shrink sleeves shall extend a nominal distance of 1" (25mm) over the extruded jacket on each side of fittings.
 - 9.4.1. Self-fusing silicone tape shall meet MIL I 46852C.
 - 9.4.2. Adhesive lined polyolefin heat shrink shall meet MIL I 81765/1, SAE AS81765.
- 9.5. Where multiple individual polymer coated tubes exit the overall bundle, the outer jacket of the bundle shall be sealed to the individual tubes by use of:
 - 9.5.1. Two, three and four leg adhesive lined polyolefin heat shrink boots.
- 9.6. Black RTV silicone adhesive liberally applied between each tube and an adhesive lined polyolefin heat shrink sleeve over the outer jacket.

10. SYSTEM TESTING, CERTIFICATION and THIRD PARTY VALIDATION

- 10.1. The corrosion control system of TAW05589 polymer coated tubing, fasteners, and sealing connectors shall be tested according to ASTM G85 Standard Practice for Modified Salt Spray (Fog) Testing Annex 3 Acidified Synthetic Sea Water and per repetitive six hour spray-dry-high humidity cycle defined by Appendix X2. Minimum duration shall be 1000 hours exposure. Representative samples of each component shall be inspected by an accredited third party. No form of corrosion may be present on any protected surface.
- 10.2. The corrosion control system of TAW05589 polymer coated tubing, fasteners, and sealing connectors shall be covered by a current Certificate of Design Assessment issued by ABS (American Bureau of Shipping.)
- 10.3. The corrosion control system of polymer coated tubing and sealing connectors shall pass a High Pressure Water Ingress test.
 - 10.3.1. Preparation of test specimens:
 - 10.3.1.1. A section of litmus paper shall be wrapped around the tube adjacent to each face of the fitting.
 - 10.3.1.2. Fittings are protected following the standard installation instructions for heat shrink sleeves and application of self-fusing silicone tape.
 - 10.3.2. High pressure spray equipment capable of a 2700 psig (186 bar) water spray of 1 gal/min (4 l/min) delivered through a standard 15° fan tip from a distance of 4 – 6" (100 – 150 mm) shall be used. Water shall be directed over the entire surface of test specimen for no less than 3 minutes.
 - 10.3.3. Immediately following the conclusion of the test the exterior surface will be dried using compressed air. The protective seal shall be removed and the litmus paper inspected for indications of water ingress. No penetration is allowed.
 - 10.3.4. A minimum sample size of three is required for each tube size and fitting type to be protected.

SAMPLE SPECIFICATION Cont'd

- 10.4. The corrosion control system of polymer coated tubing, fasteners, and sealing connectors shall pass a weld splatter test:
- 10.4.1. Preparation of test specimens: 24" long sections of each configuration of polymer coated and multiple polymer coated tubing shall be mounted according to published installation instructions and at the minimum adjacent spacing possible. No less than four sections of each type shall be used. Bare 1/2" diameter 316L stainless steel tubes will be positioned between each set of four test specimens or on each side of a single set.
- 10.4.2. A 1/8" thick carbon steel plate of 30" long is suspended 30" above the test specimens. Using a gouging rod with an electric arc of 225A the carbon plate is cut and the weld splatter and slag is allowed to drop onto the test specimens. The arc cut will be perpendicular to the test specimens and extend for the full 30".
- 10.4.3. At the conclusion of the test the bare 316L tubing will be inspected for adhered weld splatter. There must be a minimum ten instances of weld splatter adhered to the bare tube for the test to be considered valid.
- 10.4.4. If the test is determined to be valid the test specimens of polymer coated and multiple polymer coated tubing are inspected for pits and deformities in the jacket caused by the weld splatter. No weld splatter shall penetrate the polymer coating.

11. ENGINEERING AND DATA REQUIREMENTS

The Seller shall furnish the following data with his quotation.

- 11.1. Model number and complete descriptive literature for all material quoted.
- 11.2. A list of items individually priced for heating bundles, seals, tape, jacket patches, boots, equipment tags and nameplates and any other accessories bidder feels may be needed.
- 11.3. Installation, Operation, and Maintenance Instructions shall cover all the equipment supplied.
- 11.4. Manufacturer shall provide a per diem rate for installation planning. This shall include planning of suggested routing and material take off estimates.
- 11.5. Manufacturer shall provide a per diem rate for installation consulting and/or installer training. The methods and procedures used and presented shall be consistent with a 20-year life cycle objective.
- 11.6. MTRs for all tubing shall be traceable through the manufacturers batch number printed on the outer polymer coating or the heat number on the bare tubing.

12. ADDITIONAL REQUIREMENTS

- 12.1. At buyer's discretion line specific tagging for each identifiable component shall be provided on the product and documentation.
- 12.2. Preparation for Shipment shall be in accordance with Seller's standards. All packing and packaging material must comply with IPPC ISPM 15 Guidelines and Regulations of Wood Packing Material in International Trade.
- 12.3. Seller shall be solely responsible for adequacy of the preparation for shipment to ensure that the material reaches its destination in ex-works condition.
- 12.4. Coiled tubing in bare, polymer coated single tubes or bundle forms shall be packaged on wood spools having a minimum product diameter of 30" (760 mm).
- 12.5. Stick tubing shall be packaged in crates or heavy PVC tubes.