SPECIFICATION: **Corrstop Dual Laminate Equipment**

Corrstop®
Dual Laminate Equipment

CUSTOMER / PROJECT: _____

REQUIREMENTS

1.0 GENERAL

Dual laminate equipment shall be manufactured by Composites USA, Inc., incorporating only first class, virgin raw materials, sound engineering design and state of the art manufacturing techniques as outlined below.

2.0 SCOPE

This specification is to give information on dual laminate equipment to fabricate a corrosion resistant thermoplastic liner with a reinforced thermoset resin plastic (RTRP) structured overlay.

The overall fabrication is to meet th project requirements as specified and the minimum requirements of ASME RTP-1e-1999 and BS-4994 as applicable.

This specification utilizes the recommended practices, procedures and testing of materials and fabrication, as outlined in ASME RTP-1e-1999, ASTM C-582, C-1147, D-570, D-635, D-638, D-648, D-696, D-756, D-790, D-792, D-903, D-1042, D-1238, DIN 53455, DIN 53479, and DIN 53735.

This specification shall provide information on materials, fabrication practices and welder and fabricator qualifications and testing for dual laminate equipment.

3.0 MATERIALS

Materials used shall adhere to the ASTM and DIN standards for material testing by the manufacturers, as listed in Section 1.3 of this specification. Only virgin, first class materials are to be used in fabrication. All materials are to meet the manufacturer specifications. Certifications to that effect are to be kept on file at Composites USA, Inc., the equipment manufacturer.

3.1 PVC / CPVC for lining

3.1.1 The PVC / CPVC shall be no less than 0.125" (3mm) thick or more than 0.250" (6mm) thick unless specified. Delamination due to the differences in the coefficient of thermal expansion between the liner and the RTRP structural overwrap is possible and must be accounted for in the design.

3.1.2 Only chemical grade, rigid unplasticized (per ASTM D-1784), press laminated PVC / CPVC sheet not exceed the sheet thickness.

3.1.3 The welding rod and the sheet shall be of the same material. The welding rod diameter shall not exceed the sheet thickness.

3.1.4 For a bonded liner the bonding resin is to be Derakane 8084, BASF Palat al A-410, Owens-Corning E-105, Crystic 392 or an approved equal. The bonding resin is to be applied as per the manufacturer recommendations.

3.2 Polypropylene / Polyethylene for lining

3.2.1 The polypropylene / polyethylene shall be no less than 0.090" (2.5mm) thick or more than 0.187" (5mm) thick, unless specified. Delamination due to the differences in the coefficient of thermal expansion between the liner and the RTRP structural overwrap is possible and must be accounted for in the design. The sheet shall have a thermoformable fabric or glass knit backing. The manufacturer shall be Compression Polymer, Simona or Westlake Plastics, unless otherwise specified.

3.2.2 Only chemical grade polypropylene / polyethylene (homopolymer), stress relieved fabric or glass backed sheet is to be used, unless otherwise noted on the equipment specification.

3.2.3 The melt flow index of the sheet, rod and cap strip must be closely matched. The welding rod diameter shall not exceed the sheet thickness. The cap strip will be 0.060" (1.5mm) thick fabric or glass backed material x 5/8" (19mm) wide.

3.3 Fluoropolymers for lining

3.3.1 Fluoropolymers shall be no less than 0.060" (1.5mm) thick or no more than 0.090" (2.5mm) thick, unless specified. Delamination due to the differences in the coefficient of thermal expansion between the liner and the RTRP structural overwrap is possible and must be accounted for in the design. The fluoropolymer sheet shall have a thermoformable fabric or glass knit backing. The manufacturer shall be Compression Polymer, DuPont, Simona, Symalit or Westlake Plastics, unless otherwise specified.

3.3.2 The welding rod and the sheet shall be of the same material. The welding rod diameter shall not exceed the sheet thickness. The cap strip will be 0.060" (1.5mm) thick fabric or glass backed material x 5/8" (19mm) wide. The melt flow index of the sheet, rod and cap strip must be closely matched.

3.4 **Laminate:** The laminate shall consist of 4 distinct parts interior (corrosion barrier) Sections 3.0 - 3.3.2, a bonding layer, Section 3.4.3, a structural layer and an exterior layer.

3.4.1 **Resin:** The thermoset resin will be a specified or dictated by application, environment or the particular equipment specification.

3.4.2 **Reinforcement:** The reinforcing material shall be a commercial grade of glass fiber having a coupling agent, which will provide a suitable bond between the glass reinforcement and the resin and in accordance with ASTM C-582.

Typical Liner Material Properties

Mechanical Properties	ASTM	Unit	PVC	CPVC	PP	PVDF	PVDF AS	ECTFE	ETFE	FEP	PFA	RTRP Typical
Specific Gravity[1]	D792	See Note 2	1.32	1.55	.91	1.76	1.78	1.69	1.70	2.15	2.15	1.12
Tensile Strength[1]	D638	psi (SI)	6300 (45)	8000 (55)	5000 (33)	7111 (50)	4900 (32)	6400 (45)	6250 (44)	3400 (25)	3840 (27)	18000
Tensile Modulus[1]	D638	psi (SI)	360000 (2500)	360000 (2500)	170700 (1200)	341400 (2400)	250000 (1750)	241800 (1700)	156500 (1100)	60500 (425)	39800 (280)	1550000
Flexural Modulus[1]	D790	psi (SI)	415000 (2860)	415000 (2860)	200000 (1460)	320000 (2250)	241800 (1700)	241800 (1700)	184900 (1300)	98900 (660)	98900 (660)	1150000
Flexural Strength[1]	D790	psi (SI)	15100 (104)	15100 (104)	6685 (47)	10525 (74)	6381 (44)	6258 (44)	5500 (39)	2560 (18)	2560 (18)	23000
Hardness	D2240	Shore D	80	80	73	77	77	75	67	56	60	
Elongation at Break[1]		%	20-30	20-30	20-300	20-80	15	200	200	299	300	
Thermal Properties												
Max Service Temp.		°F °C	140 60	190 90	200 94	300 149	250 120	300 149	300 149	400 205	500 260	300
Linear Thermal Exp. Coef.[3]	D696	°F	35	35	85	70	80	40	75	50	70	18
Heat Melt Point		°F	220	230	330	342	315	465	515	525	590	N/A
Distortion Temp.	D648 @ 264 psi		135	180	107	235	150	170	270	118	118	200-280
Fire Class	UL 94		V-O	V-O	HB/V-2	V-O	V-O	V-O	V-O	V-O	V-O	

Note 1: Tests were run at ambient temperatures, and the manufacturers supplied the results.
Note 2: PSI = Pounds per square inch, SI = N/mm^2: Newton per square millimeter.
Note 3: Thermal expansion 10^{-6} in/(in x °F change)

3.4.3 **Bonding Laminate:** The bonding laminate with a conductive element for spark testing will consist of one of the following:

A. 1-2 layers of conductive veil, followed by 2-layers of 1-1/2 oz. chopped strand mat, utilizing the same resin of construction.

B. The entire thermoplastic liner is wet out with a graphic-loaded resin (the conductive resin shall be checked for a sufficient conductivity per RTP-1e-1999, Section M14B-644.2). Followed by 2- layers of 1-1/2 oz. chopped strand mat, utilizing the same conductive resin mixture. The layers of mat shall be rolled to remove any entrapped air and allowed to exotherm.

C. Weld seams may also be provided with a permanent grounding strip of conductive resin putty (33-40% by weight of carbon/graphite), followed by 2-layers of 1-1/2 oz. chopped strand mat, utilizing the same conductive resin mixture. The layers of mat shall be rolled to remove any entrapped air and allowed to exothem.

These conductive options allow for the ability to inspect the liner after the equipment is completed, as well as to check on the integrity of the liner after it has been in service by utilization of a spark test.

The bonding laminate is considered as a part of the structural wall for overall thickness, because the thermoplastic liner is the corrosion barrier of the equipment.

3.4.4 **Structural Laminate:** The laminate construction shall comply with ASTM C-582. The design and fabrication of the structural laminate is to be in accordance with ASME RTP-1e-1999, ASTM D-3299, D-4097 and BS-4994 as applicable.

3.4.5 **Exterior Laminate:** The exterior laminate and any additives or gel coat shall be as specified and agreed upon between Composites USA and customer.

3.5 **Accessory Items:** Materials of construction for accessory items such as fasteners, gaskets, lugs, braces, brackets, etc. shall be as specified.

4.0 WELDING

4.1 Welder Qualification

All welders must successfully pass the minimum requirements for the weld integrity tests, per RTP-1e-1999, ASTM C-1147 and BS-4994 Section 1.3, as is applicable, on an annual basis. Any welder who has not been actively welding the specific material for a period of 6 months shall requalify to assure the required skill level.

4.2 Welding Procedures

4.2.1 Seam preparation consists of beveling the sheet at 30-35° (60-70° total), with the bevel on the side from which the welding will be done. The bevel should end with 1/32" (0.75mm) of sheet thickness unbeveled. Exceptions are FEP and PFA where the bevel should be 15-20° (30-40° total).

With fabric or glass backed sheet, the sheet backing must be cleared from the weld area, so that none of the fibers will contaminate the weld. This must be kept to a minimum; unless a fabric or glass backed cap strip is to be used. When using a backed cap strip, the backing can be removed 1/2 the width of the cap strip on each side of the weld. The seam to be welded will have a 1/32" (0.75mm) gap left between the two parts to assure a good penetration root weld.

4.2.2 Dual laminates should always be welded from the outside, if the sheet is 0.090" (2.5mm) or less and if the diameter does not allow for access. The welds shall be placed on flats and away from corners, whenever possible as shown as preferred fabrication in BS-4994 Section 18.4.1. This places the seams outside of the high stress areas, and allows for better welds. Corners and connections where 90° turns are common shall be thermoformed, thus eliminating the requirement for welding in the corners where possible.

4.2.3 When doing fabrication involving thermoforming and hot gas welding it is necessary to perform the tasks at the proper temperature to assure quality fabrication. The welder shall be checked and set to the proper welding temperature before welding every day. Table 1 gives a basic outline on temperatures to use for the different processes to be carried out, as well as the requirements for the type of gas to be used when welding.

4.2.4 An in house welder certification and evaluation program shall be maintained. This is to assure proficiency of technicians and the quality of the equipment produced. The performance of weld tests and evaluations in house shall be made with the use of precision testing equipment and conform to RTP-1e-1999.

4.2.5 Prior to welding the prepared weld seam and welding rod shall be wiped with alcohol to remove any surface contaminates. After completion of the welding all the seams will be spark tested. If a cap stip is to be used the root weld shall be ground or scrapped flat and spark tested prior to cap strip being applied. The cap-striped seam shall be spark tested prior to the application of the bonding laminate. (See Test Procedures 6.1- 6.1.3)

Table 1

		PVC	CPVC	PP	PVDF	PVDF AS	ECTFE	ETFE	FEP	PFA
Welding Temp*	°F	475	520	555	600	585	615	650	725	761
	°C	245	270	290	315	310	325	342	405	405
Forming Temp	°F	200	250	300	335	325	350	365	550	575
	°C	95	120	150	175	162	178	185	287	302
Inert Gas		No	No	Yes	No	No	Yes	Yes	No	No

* Temperature measured 3/16" (5mm) in front of welder nozzle.

4.3 Nozzles and Manways

4.3.1 Fabrication of nozzles using sheet material is to be in accordance with Sections 3.1 through 3.2.5.

4.3.2 Flange face liner shall be of one piece, full face or stub end with a backup ring, construction for nozzles up to and including 30" diameter, 150# ASA B16.5 dimensions. The flange or stub end face being thermoformed so that the connection weld to the nozzle neck takes place in the neck, as shown in Figure 1.

4.3.3 The preferred method of connecting the nozzle to tank or vessel wall is by thermoforming in such a way that the weld takes place in the nozzle neck, as shown in Figure 1. This method normally takes place after the structural wrap of the vessel body or head has been finished.

4.3.4 The minimum size for nozzles fabricated and installed per 3.3.2 & .3 is 2". Nozzles smaller than 2" or threaded connections will require welding on the inside and outside without a cap strip, per BS-4994, as shown in Figure 2. The use of a fabric or glass backed cap strip to the coupling, above the weld bead, is to allow for the RTRP laminate to bond to the fitting.

4.3.5 Nozzles or manways, which for some reason cannot be connected to the vessel body or head as outlined in Section 4.3.3 will be installed in accordance with BS-4994 Section 3, Figures 20 e and 20 f.

5.0 RTRP FABRICATION QUALIFICATIONS

Fabricators shall meet the minimum requirements for lay up and secondary bonding physical properties as outlined in ASME RTP-1e-1999 and BS-4994 as are applicable.

6.0 TOLERANCES

The tolerances governing the liner, the structural and the overall for the equipment shall be governed by ASME RTP-1e-1999 and BS-4994 standards as are applicable.

7.0 TESTING

The Composites USA Vessel Inspection Report shall be used for documenting final product quality. The report meets the requirements of ASME RTP-1e-1999 and BS-4994.

7.1 Spark Testing

7.1.1 Spark testing with a hand held high-voltage, high frequency probe. The voltage shall be set at least to 5kv per mm of liner thickness. The spark tester is to be calibrated by arch length with the Peak Voltage Calibrator prior to each test and periodically through out the test.

7.1.2 If a cap strip is used the root weld is to be ground or scraped to near flush and spark tested prior to the cap strip application.

7.1.3 If a weld fails to pass the spark test it must be repaired. The repair procedure consists of the following: Grind out the pinhole and a minimum of 1" on either side of the failed area. Re-weld, and then re-test the affected area at 90% of the previous voltage. Install the cap strip, if applicable. A final spark test shall be performed after the hydrostatic test has been completed at 90% of the original voltage used to prevent damage to the liner.

7.1.4 Test certificates shall be issued upon the satisfactory completion of the required tests, per ASME RTP-1e-1999 and BS-4994, Section 32.

Visual inspections are to be carried out in accordance with ASME RTP-1e-1999 Table M14D-1 and BS-4994 as is applicable. Visual examination shall be required prior to the bonding laminate being applied. After the bonding laminate has been applied and again prior to the application of any gel coat, after the structural laminate is finished. The Visual inspection of the liner is required. Special attention must be focused on the weld seams and the thermoformed parts, for charring or cold welds and for thinning or stretching during the thermoforming.

7.3 Dimensional Checks

Dimensions shall comply with the requirements set out by ASME RTP-1e-1999 and BS-4994 as is applicable. Dimensional checks of the liner prior to overlay must take into account the skrinkage of the RTRP and this must be designed into the fabrication of the liner.

7.4 Hydrostatic Testing

7.4.1 When required, shop hydrostatic testing of dual laminate equipment will be completed as noted in the Composites USA, Inc. proposal and as agreed with by the customer. For RTP-1e-1999 the hydrostatic testing will be performed in accordance with section 6-950.

7.4.2 A final spark test shall be performed after the hydrostatic test has been completed per Section 6.1.3 of this specification.

7.4.3 Test certificates will be issued upon the satisfactory completion of the required tests, per BS-4994, Section 32.

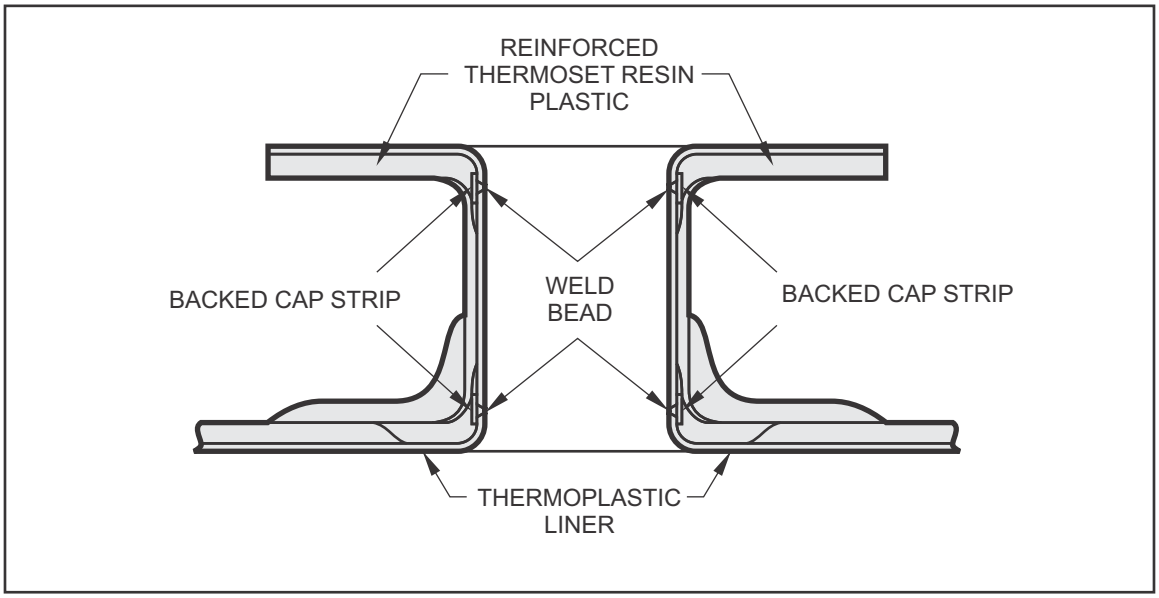

FIGURE 1: Preferred Dual Laminate nozzle detail.

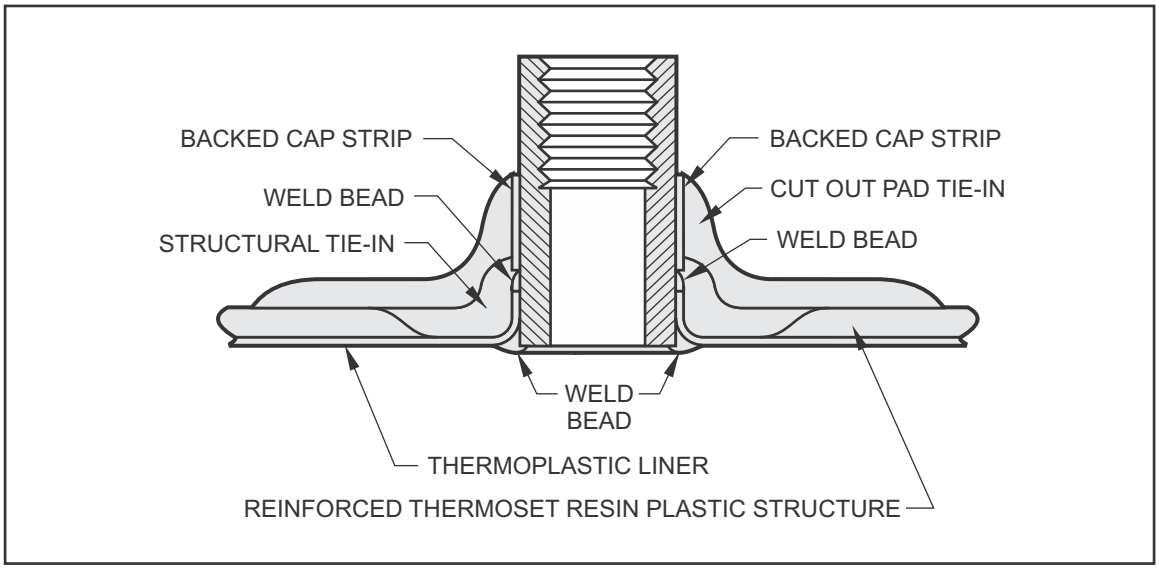

FIGURE 2: Less than 2" Ø nozzles and half couplings (as shown) detail.