STANDARD PRACTICES FOR THE FABRICATION OF

DUAL LAMINATE

THERMOPLASTIC LINED REINFORCED

THERMOSETTING PLASTIC VESSELS

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Issued by B. Pascali

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I General

1. Scope

A. This specification covers suggested practices and techniques suitable for the fabrication of dual laminate structures for chemical resistant and high purity water or chemical service.

B. **Fisher|Moore** provides such information for the purpose of establishing guidelines based upon our knowledge, experience and trade practices. Applicability of dual laminate structures must be based upon sound and proven practices. These practices are agreeable to specific guidelines of the thermoplastic or fluoropolymer resin manufacturer's guides and technical specifications.

C. Reference to specific publications of National Bureau of Standards, ASTM, British Standards Institution, SPI MTI-QAR, and ASME RTP-1 shall mean the latest edition, including addenda, supplements, and revisions. Technical handbooks and trade information supplied by the thermoplastic sheet manufacturers shall be most recent.

2. Quotations

A. In order to adequately prepare quotations for dual laminate structures it is essential to have a complete listing of all materials potentially to be stored or that will come in contact with the process side. This should include relative concentrations, temperature of use, and trace amounts.

B. Mechanical parameters are necessary for the adequate design of the vessel. Such information must include agitation, specific gravity, live loads, personal access, also seismic, snow loads or wind loads.

3. Design

A. Flanges are flat full face with bolt pattern in accordance with ANSI-B 16.5. In some cases Van Stone type such as +GF+ Plastic Systems adapters and backing rings may be used. All pipe nozzles shall be the same material as the tank lining.

B. Flange faces shall be thermoformed to eliminate welds at the intersection of the flange plane and the pipe that becomes the nozzle throat. Welds will be made in the nozzle throat from either interior or exterior surfaces, as required.

C. Nozzles where practicable due to geometry of tank size shall be attached according to BSI 4994:1987 figures 19e and 19f. Where loading may require gussets, figure 21 of BSI 4994:1987 shall apply. Plate gussets are avoided.

D. Tanks must be adequately supported and restrained. Section 3.10.2 of BSI 4994:1987 shall apply as well as UBC 2001.

E. Bolt patterns shall straddle centerlines with respect to major axis of tank. The customer shall specify the type of bolt material, or otherwise plated mild steel will be standard.

F. Special consideration must be given to horizontal vessels. See section 3.10.3.1 BSI 4994:1987

G. All loading design of vessels will not take into account any contribution of thermoplastic liner material. Calculations for vertical flat bottom tanks all are in accordance with ASTM D 3299-95 or ASME RTP-1.

H. Rectangular tanks are a special case requiring adequate reinforcement in the rib design and adequate knuckle radii of all corners, 1-1/2” minimum. Thermal cycling may dictate greater than 1-1/2" radii.

4. Drawings

A. **Fisher|Moore** is limited to producing shop drawings based upon customer's detailed drawings, and will submit such for approval by customer.

B. Drawings will represent all agreements as to location, size, number, and orientation of tank appurtenances. Any changes of customer or shop drawings are noted in a revised drawing.

C. Customer's drawing must indicate type of material to be stored and concentration as well as temperature extremes and any other important engineering considerations.

D. **Fisher|Moore** shop drawings will indicate type and thickness of thermoplastic liner necessary. Where a thickness is not given it will be understood that for DI water storage 90 mil sheet is standard, 0.120" is standard for polypropylene, and 90 mil is standard for ethylene-chlorotrifluoroethylene (ECTFE) sheet and ethylene-tetrafluoroethylene (ETFE). PVC non-fabric backed sheet varies in thickness. 2.3mm is standard for FEP and PFA fabric backed sheet.

II Thermoplastic Liner

1. Material Selection

A. PVDF fabric-backed material shall be synthetic knit sheet such as produced by Symalit, or Westlake Plastics. Copolymer flexible resins are used exclusively such as Kynar 2800 or Kynar 2850.

B. ETFE and ECTFE sheet is polyester backed as produced by Westlake Plastics or Symalit.

C. Polypropylene sheet shall be synthetic backed material such as produced by Compression Polymers or Westlake Plastics.

D. FEP and PFA Teflon sheets are supplied by +GF+ Plastics Systems.

2. Properties

A. Mechanical calculations are based solely upon RTP over wrap. Thermoplastic liner shall be utilized for chemical resistance only.

B. Minimum interlaminar shear stress values obtained shall be within factory acceptable standards.

C. All samples of fabric backed material will be tested by means of a 90° peel test by **Fisher|Moore** Quality Control. In addition samples may be tested according to ASTM D1781 and have a minimum peel of 50 inch pounds per inch for synthetic fabric backed materials. Non-fabric backed PVC materials shall attain a minimum of 25 inch pounds per inch as well as glass backed Teflon materials.

D. Random samples will be tested to determine tensile elongation values and perform according to manufacturer's minimum requirements.

3. Construction and Methodology

A. General construction procedure will require material to be handled such that scratches and contamination is minimized. Fluoropolymer materials must remain protected by polyethylene film wherever possible, as supplied by the extruder of the sheet.

B. All vessel heads will be attached to tank wall with a minimum knuckle radius of 50 mm or 1-1/2 inches for tanks greater in

diameter than 48". Design consideration should be given to knuckle joint areas to minimize discontinuity stresses. BSI 4994:1987 may be consulted for design considerations. Top flanged lids and flat top tanks require a knuckle radius in all situations greater than 48" in vessel diameter.

C. Top heads requiring drainage or requested by customer will be 10° toriconical tops with required knuckle radii and sufficient reinforcement.

D. The knuckle radii are formed by a continuous thermoforming process to reduce welds and surface irregularities.

E. Welding equipment must be able to maintain temperature requirements of sheet manufacturer and should be checked periodically with a pyrometer. Inert nitrogen gas is recommended for all fluoroplastic materials and mandatory for ETFE, ECTFE, FEP and PFA.

F. Fabricating sequence is at the discretion of **Fisher|Moore** best judgment and current recommended factory directions. Sequence generally is as follows:

a. Prepare mold or tooling.
b. Apply earthing strip, if non metallic tooling.
c. Cut material and fit to mold for correct dimensions.
d. Prepare sheet by removing fabric backing and bevel edges for welding.
e. Edges prepared for welding must be free of fiber contamination.
f. Weld material with a suitable size rod or cap strip.
g. Spark test welds not exceeding 5 kV/mm or 15 kV maximum.
h. A resin coat to thoroughly wet out fabric backing insuring an air free shear area is necessary. For PVC materials a suitable primer coat is applied to insure bonding.

i. Apply conductive graphite veil or paste to welded joints.
j. The calculated reinforcement is filament wound or sprayed up depending upon customer's requirement. Unless otherwise requested a combination of both including unidirectional roving is normally done following ASTM D 3299-95, ASTM D 4097-95 or ASME RTP-1. For design purposes a maximum hoop tensile modulus of 1.5 million has been verified by independent testing. Testing reports are available upon request.
k. Install appurtenances and other required structures, including heads or tank bottoms etc.
l. Spark test and visually inspect all welds. Any defective weld joint is ground out and replaced.
m. Hydro test vessel at customer's request insuring adequate support during test of tank bottom or walls. It is recommended hydro testing be done at the customer's site following installation.
n. Repeat spark testing procedure.

4. Quality Assurance and Testing

A. All incoming materials are inspected and checked to determine compliance to manufacturer's minimum published guidelines. Following appropriate testing and inspections materials are released for fabrication.

B. Hold points critical for conformance to customer's specifications and **Fisher|Moore**'s design are established by means of the Shop Traveler form.

C. Material certifications for the liner and over wrap including lot numbers, date of manufacture, type and material are kept in permanent files including results of all testing for a minimum of 5 years.

III Fiberglass Reinforced Plastic Over wrap

1. Material for Outer Laminate

A. Materials for outer laminate are selected for the physical properties including resilience unless otherwise requested due to concerns for external corrosion resistance.

B. Vessels for outside service must be protected with an ultraviolet absorbing gel coat. This protective layer will be gray in color unless otherwise specified.

2. Design Criteria for Composite Over Wrap

A. Strength of outer wall will be determined by ASME RTP-1, ASTM D-3299-95 for filament wound vessels and ASTM D-4097-95 for contact molded tanks. Where UBC seismic calculations are required, **Fisher|Moore** will submit required PE stamped calculations.

B. Suitable walls will be determined for rectangular tanks using NBS PS 15-69. Allowable deflection is less than 1/2% of the span, unless customer specifies otherwise.

C. Special cases of varying tank geometry must be considered individually with adequate design calculations within allowable strain limitations such as described in ASME RTP-1 and other applicable standards.

D. Ribs for minimizing deflection are of composite construction. Encapsulated steel is unsatisfactory due to permeation and potential corrosive failure.

3. Quality Assurance

A. Standard practices of the industry will be followed utilizing Barcol hardness tests and acetone sensitivity tests for insuring adequate cure of the fiberglass resins.

B. Prior to coating vessel with the pigmented ultraviolet absorbing exterior coat the vessel may be, at customer's desire, visually inspected at **Fisher|Moore**'s production site.

C. After installation at customer's plant site the vessel will be thoroughly inspected by a **Fisher|Moore** technician. Such testing will include a spark test of a minimum of 5 kV per millimeter of fluoropolymer liner, and a visual inspection.

IV Vessel Handling and Inspection

1. Packaging, Handling, and Shipping

A. The utmost care must be given to fiberglass and dual laminate vessels to prevent damage. Following the procedures outlined will be helpful in minimizing freight damage.

B. Upon arrival at destination, customer shall be responsible to inspect for damage in transit. If damage has occurred, it should be noted on delivery receipt prior to signing acceptance. This is in accordance with paragraph 14.4 of ASTM D3299-95 and ASTM D4097-95.

C. Handling Precautions

a. Operators of hoist equipment should follow proper rigging procedure at all times.
b. Always lift; never roll or slide a vessel.
c. Never drop or allow a hard impact.
d. Never let tools strike or drop on either the inside or outside of the tank.

e. Ladders used inside the tank should be wood or have rubber protectors.
f. Workmen entering tank should wear soft-soled shoes.
g. Never lift vessel by using any fitting other that specific lifting lugs.
h. Never use chains or cables around vessels.

2. Inspection and Cleaning

A. Tanks intended for high purity service will be cleaned as far as is practical at **Fisher|Moore**. This cleaning can include a vacuum cleaning of all particulate matter, an isopropyl alcohol wipe down with a non-particulating fabric, or a DI rinse and drying with non particulating wipes.

B. All flanged openings and nozzles will be covered to keep out contaminants during transport.

C. Tanks and vessels are, unless otherwise specified, shipped F.O.B. **Fisher|Moore**, North Salt Lake, Utah.

E. References

1. NBS PS 15-69 Contact Molded Tank Product Standard
2. ASME RTP-1
3. ANSI B 16.5 - B 16.21
4. BSI 4494:87
5. ASTM D3299-95
6. ASTM D4097-95
7. Engineering Handbook, George Fischer +GF+
8. Le Polyfluorure De Vinylidene Solvay, Solvay & Cie
9. UBC 2001

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