

**QUALITY ASSURANCE AND  
MANUFACTURING PROCEDURES FOR  
FLUOROPOLYMER SHEET LINED  
METAL VESSELS**

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## I Purpose

This standard sets forth the minimum requirements for the quality assurance and manufacturing procedures for fluoropolymer lined steel structures completed at **Fisher|Moore**. This program reviews the fabrication of fluoroplastic lined and electrostatically powder coated steel vessels for applications into the nuclear, chemical processing, electronics and semiconductor industries.

## II Requirements

### 1. Organization

**Fisher|Moore** is organized in a manner that allows the quality assurance inspector to report directly to the company president. This organizational structure allows for the inspection of all fluoropolymer lined and coated metal projects throughout the manufacturing process, and for any necessary corrective action to be consistently adopted and documented.

### 2. Quality Assurance Program (QAP)

- A. A QAP has been established at **Fisher|Moore** in accordance to applicable ASME NQA - 1A requirements. This program provides for the systematic inspection of fluoropolymer lined products throughout the manufacturing process for the explicit purpose of reducing and eliminating defects in materials and workmanship. **Fisher|Moore** management shall regularly review this quality assurance program and ensure that it remains adequate and correctly applied.
- B. The purpose of quality control is to insure adherence to industry standards and practices as well as customer specifications. It is critical the fabricated items conform to the customer's approved design and intended usage in a safe manner over an expected life span.
- C. Inspection documentation will be filed in each job file. Inspection documents will be kept in permanent file for a

minimum of 5 years, or as specified in contract documents. Only approved documents will be used for entering data accumulated during making the inspections.

- D. When nonconformities or imperfections are discovered, a Correction Report will be issued by the Quality Control Manager. The Correction Report will be forwarded to the General Foreman and or his assistants, in his absence to initiate corrective action.

### 3. Design Control

- A. The design of fluoropolymer lined steel shall be defined, controlled, and verified. Liner design for steel vessels shall be in accordance to the steel fabricator, **Fisher|Moore**, and end user recommendations.

Important areas of design include metal fabrication, liner and adhesive selection, and fabrication methods.

- B. Liner material selection shall be made in accordance with resin manufacturers' recommendations, **Fisher|Moore** experience, and end user preference. Liner selections shall consist of various fluoropolymer fabric backed materials including ETFE Tefzel, PVDF (2800 and 2850 copolymer), FEP, and PFA. Additionally, polypropylene and PVC may be considered for the lining of metal structures.

The adhesive system used by **Fisher|Moore** for all fluoropolymer lined steel applications consists of an elastomer modified thermosetting epoxy.

### 4. Procurement Document Control

It is necessary to qualify; monitor and test materials supplied by subcontractors and to monitor subcontracted services and purchased materials. All incoming material and subcontractor work shall be independently verified for quality prior to acceptance and use at

**Fisher|Moore.** Such qualifications of materials may include tensile testing, climbing drum peel, and photo microscopy.

5. Calculations and Drawings

- A. When required a licensed and registered engineer shall perform all calculations. The engineer will base the vessel design upon the latest applicable standards, such as NACE Standard RPO178-95, ASME NQA-1, BSI 4994, API, ASTM D413, D638, D1781, NACE 1, and UBC 1999.
- B. When required, all shop drawings shall be done at **Fisher|Moore** according to the ANSI Y14.5 standard. An approved shop drawing must be received by **Fisher|Moore** prior to beginning any work.

6. Document Control

Document control for the QAP shall be maintained by the Quality Control Manager in a file separate from the current work in progress file. A duplicate copy shall also be stored with the applicable job file.

7. Control of Purchased Items and Services

- A. Critical purchased items and services for lined steel vessels include steel vessel fabrication, sandblasting, adhesive testing, and fluoropolymer liner material integrity.
- B. Steel fabricators and subcontractors must meet the minimum requirements of manufacturing and preparation as outlined in the **Fisher|Moore** document. Any deviations in quality shall be noted and the part returned to the subcontractor for modification and rework. Only those steel fabricators familiar with the requirements of plastic sheet lining are acceptable.
- C. All lot numbers of incoming adhesive are noted. The gelation time of each adhesive lot shall be tested during application. The adhesive will be stored in the manufacturer's recommended environment. Application of the adhesive shall be in accordance to the manufacturer's instructions. All

personnel attaching the liners shall periodically submit lined adhesive samples to maintain competent workmanship and lining practices. The use of each adhesive lot shall be noted and tracked with the vessel in which it is used. This record will be used for any future references to the structure's interior and adhesive.

- D. All lot numbers of incoming fluoropolymer sheet shall be noted. All sheet material shall be visually inspected and may include photo microscopy to insure it is free from defects, voids, and surface irregularities.

The sheet thickness shall be measured and a peel test (ASTM D 1781) is conducted to determine the strength of the fabric backing. Results from all these tests shall be compiled and stored for reference. The use of each material lot in the structure's interior shall also be noted.

#### 8. Identification and Control of Items

Control and documentation of adhesive materials and fluoropolymer sheets shall be instituted to insure that only correct material shall be applied to the surfaces of equipment to be lined.

#### 9. Control of Processes

- A. All processes involved in sheet linings shall be routinely examined and evaluated to insure a continuous level of quality. These processes include adhesive preparation and application, vacuum bagging, and welding.
- B. Fluoropolymer lined adhesive test samples shall be routinely submitted for testing and evaluation. Testing shall include visual inspection, thickness measurements, and peel tests. The adhesive strength as evaluated by the peel test shall be used to determine both the strength of the adhesive and the effectiveness of the vacuum bagging process. Peel strengths of 75 pounds per square inch is a minimum standard for synthetic fabric backed fluoroplastic sheet as tested by ASTM

D-1781. 50 inch pounds per inch is a minimum for glass-backed materials. It should be noted peel strengths can vary by wide margins among the various sheet manufacturers. (Most glass-backed materials cannot meet this minimum standard and are not recommended unless no synthetic alternative exists.)

- C. Welding of the fluoropolymer sheet shall be conducted in accordance to manufacturer's recommendations. Weld samples will be routinely cut into a dog-bone pattern and tensile tested to determine the overall weld factor. Strengths of single rod welds and cap stripping welds shall not be less than 90% of virgin sheet. The strength of double rod welds shall not be less than 85% of the unwelded sheet. All welders performing work on the fluoropolymer liner must have completed the Moore Plastic Welding Course and have a minimum of three years experience in welding plastic sheets adhered to steel substrates and retested annually.

10. Inspection

- A. Regular inspections will occur throughout the entire fabrication process of fluoropolymer lined steel vessels.
- B. Steel Welding and Fabrication
  - 1. Where possible the steel structure to be lined should be fabricated by a shop familiar with techniques of lining, such as rubber lining or plastic sheets to insure the completed vessel is suitable for lining. The steel fabricator should be thoroughly familiar with NACE RPO178-95.
  - 2. Welds need to be neat and smooth and must be ground flush on all interior surfaces to be lined. (See Figure 1 p. 3 NACE RPO178-95.)
  - 3. Weld splatter must be removed from any welded areas. (See Figure 3 p.4 NACE RPO178-95.)

4. It is preferred that corners of rectangular structures be bent to minimize the number of seams and joints and should be free of welds.
5. Flat surfaces should be even and planer. Care should be taken to prevent warpage during fabrication.
6. Minimum radius at corners is 1/8" for PVDF copolymers, ECTFE, PFA and FEP to reduce stress in sheet; See NACE RPO178-95 Section 4:1 p.2.
7. Threaded nozzles or appurtenances are not allowed. All connections are flanged. If threaded connections are required consultation with Fisher Company engineering is necessary. See NACE RPO178-95 Figure 4, p.4.

All flanges of each pipe size, appurtenances must be identical and uniform in internal and external diameter, (plus or minus 1/16").

#### C. Surface Preparation

1. The steel surface to be lined must be thoroughly cleaned and free from oil, scale, rust or contaminants.
2. Surfaces are to be sandblasted to an NACE #1 finish or white metal profile. Chemical etchants can be used in restricted environments where particulate matter from blasting would be unacceptable. Blast profile to NACE #1 standards will be verified by the optical comparator method. Silica sand is the preferred blast media.
3. Carbon steel tanks need to be lined reasonably soon after blasting to prevent oxidation.

D. Plastic Liner Qualifications

1. The plastic liner selected to apply the fluoropolymer sheet should be able to demonstrate his experience and ability with other jobs of similar nature.
2. Liner must be authorized by the fluoropolymer sheet manufacturer to use the particular sheet selected, such as Atofina for the Kynar® PVDF (2800, 2850) liner, DuPont for ETFE, and +GF+ Symalit™ for ETFE, FEP and PFA.
3. Liner's shop will be open to inspection only when allowed by contractual agreement during the lining process for compliance to recognized standards and accepted procedures.
4. Welders joining the sheet together must have been trained by the sheet manufacturer with the specific sheet to be used and successfully completed a manufacturer's sheet lining course.
5. Samples of weld must be submitted for evaluation and destructive testing to insure weld factors of at least 90% of the tensile strength of the base sheet.

E. Adhesive

1. Care must be taken to select an appropriate adhesive for attaching the sheet liner to the steel substrate. Temperature and thermal stresses need to be evaluated to insure the adhesive has a proper peel and shear strength. Tanks for elevated temperature service should utilize a high temperature adhesive.
2. After full cure adhesion of sheet to substrate should reach a minimum of 75 pounds per inch of climbing drum peel strength as measured by ASTM D-1781, and in all cases more than 50 psi as an average.

#### F. Lining Procedures

1. The steps for lining a steel structure should follow the recommendations of the liner/fabricator.
2. After preparation and cleaning of all steel substrate surfaces the fluoropolymer sheet and steel substrate are covered with a film of adhesive to insure a 100% bonded liner. Any discernible entrapped air bubbles are removed.
3. All corners of structures should be thermoformed rather than seamed and welded. Welds in the liner in corners result in unnecessary levels of stress and should be avoided.
4. The sheet can be held in position and the entrapped air removed by means of a vacuum bagging technique. The vacuum pump should be operating at minimum efficiency of 20 to 22" of Hg during the bagging procedure to insure adequate pressure and freedom from air entrapment under the fluoropolymer sheet lining.
5. In order to achieve a good fit all sections of sheet liner to be used must be trimmed and formed as required prior to the vacuum bagging procedure.

#### G. Welding of Liner

1. Only those persons trained and experienced in welding fluoroplastic lining materials are allowed to weld the sheet. Welders should have a minimum of three years experience in welding liners on metal substrates.
2. Welding equipment should be of the type to accurately control temperatures of welding gasses as recommended by sheet manufacturer.

3. Preferred welding gas for all liners is nitrogen. If hot air is used it must be filtered and dry.
4. After cleaning the seams from excess adhesive a root weld is placed between the sheets to be welded. Gaps or bridges with voids are not acceptable where one weld may cross over another.
5. In order to achieve maximum integrity, a 1 mm thick cap strip can be welded over the root weld to seal the weld. The root weld(s) must pass a complete and thorough spark test before the cap strip is applied.

#### H. Quality Assurance and Testing

1. After the welding is completed a spark test is required in the presence of the owner or customer or his representative. All welded joints should be free of holidays or pinholes. No spark can jump between the liner and steel substrate.
2. Voltage is between 12 and 15 kV for the spark tester for 90 mills to 3 mm thick sheet material.
3. At the option of the customer the tank may be filled with water for 24 hours and then examined and re-spark tested for leaks or any disbonding.
4. Thermally cycling the bonded liner with high temperature water and steam followed by quenching the exterior with cold water may be used in lieu of a hydrotest. The vessel would be spark tested after the thermal cycling.

#### 11. Test Control

- A. Testing is done by **Fisher|Moore** technicians at the company lab in Centerville, Utah.
- B. When required, outside testing labs may be subcontracted to analyze or verify test results.

12. Control of Measuring and Test Equipment

All test and measuring equipment shall be routinely inspected so that a consistent level of quality control can be maintained by **Fisher|Moore**. Any deviations noted or corrective action required shall be monitored and documented so that the appropriate changes will occur.

13. Handling, Storage, and Shipping

All applicable materials shall be handled, stored, and shipped in the prescribed and recommended manner. Any significant deviations from normally recommended practices shall be noted and documented.

14. Inspection, Test, and Operating Status

Upon agreement between **Fisher|Moore** and the customer arrangements can be made to make a final inspection in the field prior to startup to insure no damage has occurred in transit or upon installation.

15. Control of Non Conforming Items

Any purchased or manufactured item exhibiting unacceptable quality shall be returned or reworked by the applicable organization for the necessary improvement. All items rejected will be documented so that the corrective action can be tracked and noted.

16. Corrective Action

Any existing conditions that may impede quality fabrication and workmanship standards shall be determined and identified. These conditions shall be documented so that the necessary corrective action can be instituted by either the Quality Assurance Inspector, **Fisher|Moore** management. Any required follow-up action shall also be noted and documented.

17. Quality Assurance Records

Quality assurance documents and records shall be prepared and maintained by **Fisher|Moore** for every fluoropolymer lined steel project. These records shall be kept and stored in a neat and legible format with the applicable project for a period of not less than 5 years.

**End of Document**