Maximizing Performance of FRP Piping and Equipment

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ABSTRACT

FRP piping, tanks and scrubbers are essential equipment in the bleach plant and other areas of a pulp and paper mill. Chlorine dioxide, bleach, and white liquor are demanding and complex chemistries with highly corrosive characteristics. While Fiberglass Reinforced Plastics (FRP) is an excellent choice as a material of construction for these corrosive services, selecting the right material is only the first step to success and reliable service. A quality project execution plan is required for every project. The author will discuss the critical design considerations for FRP piping and process vessels. Examples of best practices will be provided. To ensure that expectations of performance and reliability are met during operation, a comprehensive maintenance assessment program (MAP) is equally important. Additionally, the paper will present the fundamentals of a quality MAP for FRP equipment, including inspection priorities, equipment aging and service severity. The goal of this paper is to develop a foundation for system and equipment reliability and to predict the end of life of equipment for planning and timely replacement.

INTRODUCTION

FRP has many decades of proven success in the demanding pulp & paper applications, but not without many lessons learned along the way. Like most projects, developing an effective execution plan and then following through with attention to every detail with diligence makes the difference between success and reliability or otherwise problematic performance. Every effective execution plan for FRP equipment has common and proven elements. In this discussion, these common elements will be discussed to establish a project foundation. Once the project is installed and stably operating, in order to maximize equipment service life, it is necessary to develop a strategy to maintain consistent performance and reliability. Without a maintenance assessment program, reliability and performance of FRP equipment is left to chance.

Most operating mills have MAPs that are followed for steel and other metallic equipment, although fewer mills have MAPs for FRP piping and equipment. In some cases this is due to a lack of knowledge of the FRP materials and equipment and how to approach reliability. In other cases, this is due to a lack of subject matter experts and internal resources to develop an FRP special MAP. In this paper, the fundamental elements needed to an effective FRP execution plan will be discussed as well as a risk based plan for managing FRP assets.

FUNDAMENTALS OF THE PROJECT EXECUTION PLAN

The project execution plan for FRP equipment is similar to that of project with metal equipment in principle, although in execution projects can be challenged at many levels. Again, the lack of confident knowledge of FRP and internal resources tends to be the root of the issues that arise during the execution of FRP projects. The basis for the FRP execution plan is as follows:

1. Comprehensive and Prescriptive Project Specifications
2. Qualification of Vendors
3. Technical Support and Detailed Engineering
4. Fabrication and Diligent Quality Control
5. Project Quality Assurance

As noted earlier, there are fundamental elements common to many projects, although the resources and technical expertise to competently and effectively execute these tasks may vary. These elements will be discussed in further detail.

Comprehensive and Prescriptive Specifications

For many years performance-based project specifications were a common approach for the development of many specifications. This approach is more results based and offers flexibility to vendor to develop an appropriate equipment solution, while reducing the demand on the specifier to get in the weeds of additional details in the specification. Although some mill specifications have improved, many FRP specifications are found to be outdated, not including current best industry practices. Today, best practices for specifying FRP piping and equipment is for prescriptive specifications, includes, requirements for materials, engineering, fabrication, tolerances and acceptance criteria, quality control and quality assurance from engineering to installation. Specific expectations need to be defined.

Proven FRP and dual laminate materials are well known and recognized. Technical support from material suppliers is essential to achieve optimal system performance. While there may be good, better, and best options for materials such and resin and glass, approved materials should be clearly defined in the equipment specification. "Or Equal" options should not be recommended. Typically, "Or Equal" options are offered with very little justification, other than a statement of equality. Although the general material category may be the same, the resulting equipment performance of an "Or Equal" option may not meet expectations of service life over time. The best practice for material specification is to explicitly specify all acceptable options with no other equals. This may require input from a Subject Matter Expert (SME), although this approach removed most chances of substandard materials being implemented in the design and fabrication.

Additionally, all engineering requirements, quality control (QC), and testing requirements should be clearly stated. All engineering calculations and design drawings should be checked by an SME to ensure accuracy and compliance of the calculations with applicable Codes and standards. Specifications should define all quality acceptance criteria and tolerances for fabrication. Once in fabrication, inspection by the Mill SME or a Third Party Inspector is always recommended. At least three inspection visits should be planned during fabrication, possibly more if there is a large number of piping or tanks being manufactured, with the final inspection to witness testing and final acceptance.

Qualification of Vendors

There are many vendors in the FRP industry. Some are skilled and experienced in manufacturing FRP piping while others specialize in the fabrication of FRP tanks and vessels. There are only a few manufacturers that excel at fabrication of piping and tanks. Further, like many businesses, FRP manufacturers are not stagnant. At any time, there are manufacturers that are improving while other may be working through challenges, such as quality issues or overcoming the loss of key personnel. For this reason, it is a good practice to review and audit FRP vendors to understand their status at any point and time. This is particularly beneficial when preparing for a large capital project.

Technical Support and Detailed Engineering

While many FRP manufacturers have notable fabrication expertise, it is equally important to understand their level of technical expertise and engineering capability. It is helpful to ask for example case histories for similar projects. Additionally, many FRP vendors may have a sole engineer to perform piping and tank design calculations. Correspondingly, it is important to have all design calculations reviewed by an engineer, having experience in the design of FRP equipment. This is part of the quality assurance program, which should be ongoing throughout the project. Design calculations should be compliant with the project specifications and the current version of appliable standards, ASME NM.2 for FRP piping, ASME RTP-1 for storage tanks and process vessels, below 15 PSIG, and ASME Boiler and Pressure Vessel Code Section X for FRP pressure vessels about 15 PSIG.

Fabrication and Diligent Quality Control

As risk management during projects and later in operation continues to be a priority, many plants and mills are beginning to require certified FRP equipment, i.e. stamped tanks and vessels, built and stamped by ASME certified manufacturers. This approach reasonably guarantees that purchased equipment has been designed with certified material properties and with the process documented from engineering to fabrication in accordance to ASME standards. Additionally, certified equipment is confirmed to follow the design approach and to the defined quality acceptance criteria defined by the applicable standard. Alternately, some vendors may offer phrases like, "Built to" or "Designed to" the standard. It should be understood that in execution these offerings are not equal to a certified vessel or tank. Certified manufacturers must certify bonders and laminators that are performing the work. This is similar to certified welders for steel equipment.

Project Quality Assurance

While project Quality Assurance (QA) starts with updated specifications and approving vendors for bid, it does not end there. Technical bid review and engineering compliance are essential elements of QA as well. An FRP Inspection and Test Plan (ITP) with critical hold points for monitoring and testing is an important component of QA. This includes a shop inspection program through the fabrication process as well as field inspection during installation. Field inspection is particularly important in the case of a new FRP piping installation.

THE FRP MAINTENANCE ASSESSMENT PROGRAM

A Maintenance Assessment Program is crucial to ensure safe operation of process equipment. MAPs provide current condition assessments of equipment to maintain equipment reliability in operation and to minimize opportunities for personnel safety hazards, such as leaks and chemical releases. Most mills and operating plants have established MAP for traditional operating equipment, such as rotating and static equipment of metal construction. In many cases, when it comes to FRP piping and equipment, there is an uncertainty of how to approach a MAP for FRP equipment, so a MAP may remain unaddressed.

MAPs are necessary for all equipment so that mill or plant operations can make informed decisions on maintenance, necessary repairs and/or replacement equipment at the end of its reliable service life. Leaks and failure can create unsafe working conditions for personnel. Similarly, unplanned down time and loss production are not tolerated by mill management. Without a reliable condition assessment of equipment, damage and deterioration of a service may go unnoticed or at least may be uncertain.

An FRP MAP should be a risk-based condition assessment plan to identify risk to personnel safety and operation of a plant. The purpose of the MAP is to provide clear assessments of operating equipment so the plant can make timely decisions to manage the operating risks and eliminate unnecessary hazards to personnel and interruptions to production. For FRP piping and equipment, such as tanks, stacks, vessels, internal inspections are necessary to obtain a complete picture of the equipment's condition. This may be by confined space entry or by remote access such as with a boroscope inspection.

A common form for a MAP may be part of a larger equipment database or as simple as a spreadsheet. Basic information of a MAP for FRP equipment are listed below.

Equipment Description
1. Equipment Number
2. Description
3. Chemical Contents
4. Manufacturer
5. Dimensions
6. Installation Date

Materials of Construction
1. FRP Corrosion Barrier Resin
2. Lining Material (if Dual Laminate)
3. Corrosion Barrier Thickness
4. Structural Resin (if different)
5. Laminate Construction (Filament Wound or Hand Lay-up)

Chemistry of the contents and concentrations is an important parameter to track. Fluctuations in concentrations and other trace elements can accelerate corrosion and deterioration. Additionally, fluctuations or cycling of operating conditions can create system instability introducing accelerated fatigue and other concerns. Defined and tracking operating conditions should also be part of the MAP for FRP equipment as well. It is important to maintain awareness of operating limits. Listed below are operating conditions to be considered for an FRP MAP.

Operating Conditions
1. Operating Pressure
2. Vacuum conditions
3. Operating Temperature
4. Maximum Upset Temperature
5. Maximum Upset Pressure

These elements are the foundations of a Maintenance Assessment Database. With this foundation, it is important to develop a time history for condition assessment of each piece of equipment. The wear in FRP materials in chemical service cannot always be measured in loss material to the one-thousandth of an inch. The accuracy of ultrasonic testing and material condition of FRP materials is not that exact in measurement, approximately +/- 10% thickness at best. Many chlorine and chlorine dioxide services in pulp & paper mills are even more complicated as chlorine slowly attacked the resin in in FRP corrosion barrier, forming a residue, commonly called chlorine butter, which does not show an evident loss in material thickness or degree of deterioration.

Limited information can be obtained from an external only inspection. Most real deterioration is only visible from the inside of the vessel or pipe. Best practice for most FRP equipment and piping in aggressive corrosion services is to conduct internal condition assessment inspections every two years. Inspection reports should include a comprehensive condition assessment with recommendations for repairs, monitoring, or other actions by operations. Over time these reports will provide operations and reliability managers with a number of data points to build a tend, providing a sense of the equipment condition, concerns if any, and a relative prediction of equipment reliability and remaining service life.

Not every observation leads to a repair. Some may identify areas for monitoring or additional inspection points. Notations for monitoring ensure continued touch points of necessary equipment assessment. In the MAP, all observations of condition assessments should be documented. Additionally, next steps and planning should be noted including:

- Next Boroscope for all FRP piping in 2024 outage
- Where a tank was found to be a end of life, a note might say, Plan to reline bleach vessel in 2025.
- Reline bottom 6 feet of vessel in 2024.
- Prepare budget for ClO2 scrubber replacement by End-of-Year in 2023.
- Next FRP tank and duct inspection to be scheduled for 2024.

BENEFITS OF A MAINTENANCE ASSESSMENT PROGRAM

There are a number of demanding chemical services in pulp & paper processing, which present risks or challenges to safety and operations. Maintaining security of all systems and reliability of their operations is critical. Current equipment condition assessments in all services are essential to meeting these objectives. A Maintenance Assessment Program allows operations and mill management to manage risks in the mill. Accidents and unplanned down time events are not tolerated or acceptable to mill management. When operations and management are informed, sound decisions can be made regarding the status of equipment. MAPs afford operations time for advanced planning, which minimizes loss time and production as well. No one like surprises.

For FRP equipment, risk-based assessments are made based on the following criteria.

- Aging of the Equipment
- Understood Severity of the Chemical Exposure based on the Service Specific Data

- Expected Service Life for the Service
- Operating Conditions for the Service
- Stability of the Operating Service
- Documented Inspection Findings and Observed Trends

COMMENTARY AND SUMMARY

A Project Execution Plan sets the foundation for reliable service of FRP equipment and piping. To fully realize optimal expectations for FRP system performance, a comprehensive approach is necessary. Without attention to details through the Project Execution Plan, the likelihood of reliable service is reduced or at least left to chance. A total quality program including updating equipment specifications with current standards, to quality control in design, to quality assurance in fabrication and installation are essential for best results and meeting all expectations.

A Maintenance Assessment Program will flag changes to operational controls that may eventually impact performance. FRP piping expands and contracts about 2.5-3 times that of carbon steel, so piping can move and shift through operation, especially if temperature or pressure excursions are experienced. Piping and pipe support site audits help to evaluate the on-going performance of piping, to provide a current status of piping reliability and concerns. Additionally, for FRP piping sampling can afford destructive testing, which can provide high quality analytical data on piping condition. This is particularly effective for piping that handles highly corrosive media. A small pipe spool can be removed from the system and replaced with a new identical spool. Then destructive testing can be performed on the removed pipe spool to obtain an in-depth analytical condition assessment of the piping. Obtaining clear and accurate assessment of FRP piping can be difficult. Sampling is an effective approach to achieve accurate data on FRP piping condition.

A well-executed Maintenance Assessment Program provides quality documentation and tracking of the service condition of FRP equipment and piping so that operators can make informed decisions on FRP assets. MAPs reduce risk and liability to the mill. Plant safety is improved with more confident equipment assessments and more predictable system performance. Improved reliability and consistent operations helps to extend the service life of equipment and maximize mill performance.

REFERENCES