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FEATURING:

WHAT ARE THE KEY INGREDIENTS OF A SUCCESSFUL FFS TEAM?

BY GUY ST-ARNEAULT, SR. MECHANICAL INTEGRITY GROUP ENGINEER, GCM CONSULTANTS

CONTRIBUTING AUTHOR: HUGO JULIEN, MECHANICAL INTEGRITY GROUP MANAGER, GCM CONSULTANTS

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By: Guy St-Arneault, Sr. Mechanical Integrity Group Engineer, GCM Consultants

Contributing Author: Hugo Julien, Mechanical Integrity Group Manager, GCM Consultants

INTRODUCTION

Let us consider the following situation. You are in the middle of a planned shutdown and everything is going well so far. But after a scheduled inspection, an inspector comes to see you with some bad news. Inspection of equipment X has revealed a localized area that is extremely corroded. In fact, measurements show metal loss well over the corrosion allowance specified in the equipment data sheet. You need to know quickly and with relative certainty whether the equipment can be put back into operation at the end of the shutdown or if it needs to be repaired, or worse yet, replaced. Unfortunately, you do not have the resources on site to answer this question and must hire an outside firm. Since important decisions will be based on the results of the fitness-for-service (FFS) determination, you need to be sure that you have a strong FFS team.

But what are the key ingredients of a good FFS team? This article provides some guidelines to help you answer this question.

KEY INGREDIENTS

Since API standard 579-1/ASME FFS-1 represents what can be qualified as state-of-the-art for a FFS assessment, a good portion of the answer comes directly from this standard itself.

A quick overview of API 579-1/ASME FFS-1 will provide a list of essential ingredients of a solid FFS team.

1. Knowing who needs to be involved in the FFS assessment and understanding the responsibilities of each participant.

This point may seem obvious and simple, but it is very important. Knowing who should be involved in a FFS assessment will definitely set the foundation for a good FFS team. FFS assessments are usually multidisciplinary, and involve engineers from various fields such as materials, design, fabrication, inspection, and operations. Each professional involved in the FFS assessment has their role and certain responsibilities. Paragraph 1.4 of API 579-1/ASME FFS-1 lists the required participants in a FFS, along with their responsibilities as follows[1]:

Owner/user:

- Overall responsibility for Fitness-For-Service assessment
- Ensures that the results of the assessment are documented and filed with the equipment records

Inspector:

- Works in conjunction with the NDE engineer
- Responsible to the owner/user for determining that the requirements for inspection and testing are met
- Provides all necessary inspection data required for a fitness-For-Service assessment
- Controls the overall accuracy of the flaw detection and sizing activities
- May also be responsible for the Fitness-For-Service Level 1 assessment (for screening purposes)

Engineer:

- Responsible for most types of Fitness-For-Service assessments
- Reviews the analysis when a Level 1 Assessment is performed by an inspector or other non-degreed specialist

In the context of API 579-1/ASME FFS-1, the term Engineer applies to a combination of the following disciplines.

Materials or Metallurgical Engineering:

- Identify the material damage mechanisms
- Establish the corrosion/erosion rates
- Determine material properties including parameters and crack-like flaw growth parameters
- Develop suitable remediation methods and monitoring programs.

Mechanical or Structural Engineering:

- Calculate the minimum required thickness and/or MAWP (MFH) of the equipment/component
- Perform required thermal and stress analyses
- Provide experience and knowledge in design of and practices relating to pressure containing equipment codes and standards.

Inspection Engineering:

- Establish an inspection plan in order to detect, characterise and size flaws or damage
- Select the examination procedures in conjunction with available NDE expertise

Fracture Mechanics Engineering:

- Responsible for the assessment of crack-like flaws using the principles of fracture mechanics
- Non-Destructive Examination (NDE) Engineering:
- Select and develop the methods to detect, characterize, and size flaws or quantity the amount of damage
- Analyse and interpret the inspection data

Process Engineering:

- Document past and future operating conditions, including normal and upset conditions
- Identify the contained fluid and its contaminant levels

Plant Engineer:

- In the context of API 579-1/ASME FFS-1, the term Plant Engineer applies to an engineer with knowledge of the equipment/component containing the flaw or damage.
- May perform both a level 1 and level 2 assessments.

Looking at the responsibilities described above, it becomes obvious that a FFS assessment cannot always be performed by one individual. FFS assessments require a group of specialists and owner/users should take great care in selecting this group of engineers. Since these engineers are responsible for most types of FFS assessments, every individual in this group must have sound theoretical knowledge mixed with solid practical experience in their respective discipline. Given that the success of the FFS assessment is strongly related to the group of engineers performing it, the rest of this article will focus on the skills of the team members.

2. Qualifications

It is important that owner/users take the time to evaluate whether all of the engineers on the team have the appropriate qualifications to perform an effective FFS assessment. Paragraph 1.5.1 of API 579-1/ASME FFS-1 states that the education level and/or experience of all participants shall be related to the complexity of the assessment[1]. The standard also specifies, in paragraph 1.5.4, that the engineers shall be competent to perform the level of assessment required and meet all required qualifications to perform engineering work within the applicable jurisdiction[1]. To ensure that all engineers have the required qualifications and that they will fulfill their specific responsibilities, the owner/user hiring an external firm for a FFS assessment should ask for the professional resumes (curriculum vitae) of the engineers who will be performing the assessment.

In addition to the degree of education and number of years of experience, experience with API 579-1/ASME FFS-1 philosophy, assessment procedure, and limitations, the following expertise should also be considered by the owner/user when selecting the engineers assigned to a FFS team:

Materials/Metallurgical Engineering Expertise:

- Material behavior in relation to specific environments, temperatures and conditions
- Corrosion phenomena
- Welding techniques (certifications: API 577, AWS, CWB, etc.)
- Damage mechanisms (certifications: API 571, NACE, etc.)
- Construction codes and standards present editions and older editions
- Up-to-date with the new developments in their discipline (continuous training)

Mechanical/Structural Engineering Expertise:

- Construction codes and standards (such as ASME Section VIII div 1 and 2, ASME B31.3, etc.) present edition and older editions.
- Stress Analysis such as Finite Element Analysis to accurately estimate the stress of the equipment/ components.
- Dynamic effect on equipment (pressure/temperature variations, wind, vibrations, earthquake, etc.)
- Probability and statistics techniques
- Up-to-date with new development in their discipline (ASME Committee follow-up, continuous training).

Inspection Engineering Expertise:

- Data requirements for FFS assessment
- In-Service Inspection/Monitoring (certifications: API 510, API 570, API 653, etc.)

Fracture Mechanics Engineering Expertise:

- Crack propagation
- Mechanical failure mechanisms
- Investigation
- Fracture and crack growth analyses (ECA)
- Finite Element (FE) based fracture analyses
- Fracture and fatigue testing

Non-Destructive Examination (NDE) Engineering Expertise:

- NDE techniques
- Identification of the most suitable inspection method and technology related to specific flaw types combined with accessibility to the damaged area (certifications: SNT-TC-1A, ONCG, etc.).

3. Engineers performing FFS should understand the origin of the API 579-1/ASME FFS-1 standard.

It may seem obvious, but this foundational knowledge should not be overlooked or taken for granted. Construction codes for pressurized equipment, such as the ones developed by ASME and API, provide rules for the design, fabrication, inspection, and testing of new equipment. These codes do not provide rules to evaluate equipment that degrades during operation[2,3]. Post-construction Codes/standards API 510, API 570, API 653 and NB-23 address this point. API 579-1/ASME FFS-1 was developed to supplement and augment the requirements of the above-mentioned post-construction Codes/Standards[1]. FFS uses quantitative engineering methods to evaluate the integrity or remaining life of an in-service piece of equipment or component containing a flaw or damage[1,4]. API 579-1/ASME FFS-1 provides guidelines for performing FFS assessments and these guidelines can be used to make run-repair-replace decisions to help determine if the equipment containing flaws can continue to operate safely for an established period of time[1].

4. Engineers performing the FFS assessment should know the different levels of the assessment and understand when and how to apply them.

As per API 579-1/ASME FFS-1 there are three different levels of assessments[1].

- Level 1 is intended to provide conservative screening with minimal data and can be performed either by an inspector or an engineer.
- A Level 2 assessment is intended to provide a more detailed evaluation with more precise results than Level 1. Typically, Level 2 should be performed by plant engineers or engineering specialists who are experienced and knowledgeable about FFS.
- Level 3 provides the most detailed evaluation. A detailed inspection and detailed equipment information are required for this level. Level 3 assessments should be performed by engineering specialists experienced and knowledgeable about FFS.

5. Engineers performing a FFS assessment must do so by following a proven approach.

FFS should not be performed haphazardly. It should be performed following a well-known and approved methodology. Since API 579-1/ASME FFS-1 represents what can be qualified as state-of-the art for FFS, the procedure should be based on this standard. The procedure proposed by API 579-1/ASME FFS-1, in paragraph 2.1.3, is well understood and accepted by the industry, and is applicable to all flaw types. The general procedure described in API 579-1/ASME FFS-1 is the following[1]:

- Step 1 – Flaw and Damage Mechanism Identification
- Step 2 – Applicability and Limitations of the FFS Assessment Procedures
- Step 3 – Data Requirements
- Step 4 – Assessment Techniques and Acceptance Criteria
- Step 5 – Remaining Life Evaluation
- Step 6 – Remediation
- Step 7 – In-Service Monitoring
- Step 8 – Documentation

6. Understanding of API 579-1/ASME FFS-1 philosophy, assessment procedures, applicability and limitations.

All engineers involved in a FFS assessment should know the applicability and limitations of the FFS procedure described by the API 579-1/ASME FFS-1 standard. The applicability and limitations of a given procedure are relative to the level of assessment[1]. Experience with API 579-1/ASME FFS-1 provides the engineer with a better understanding of the philosophy behind the standard, and the differences between the three levels of assessment. Advanced comprehension of the philosophy behind the API 579-1/ASME FFS-1 will help the engineer, in each discipline, to make the right decision/assumption during the assessment. A better understanding of the FFS and the three different levels of assessment will help the engineer determine the required assessment (i.e., which part to use) and the required level. Knowing which level of assessment to perform can save significant time and money.

7. Knowledgeable in Data Requirements

Since the results of a FFS assessment depend on the data available to perform it, all engineers involved must be able to determine what the required data for a specific assessment are and challenge the data received from the owner/user. The extent of data required depends on the damage mechanism and assessment level[1]. By knowing the data requirements, the engineer should be able to define the required data and measurements for the FFS assessment. The engineer should also be able to provide the list of

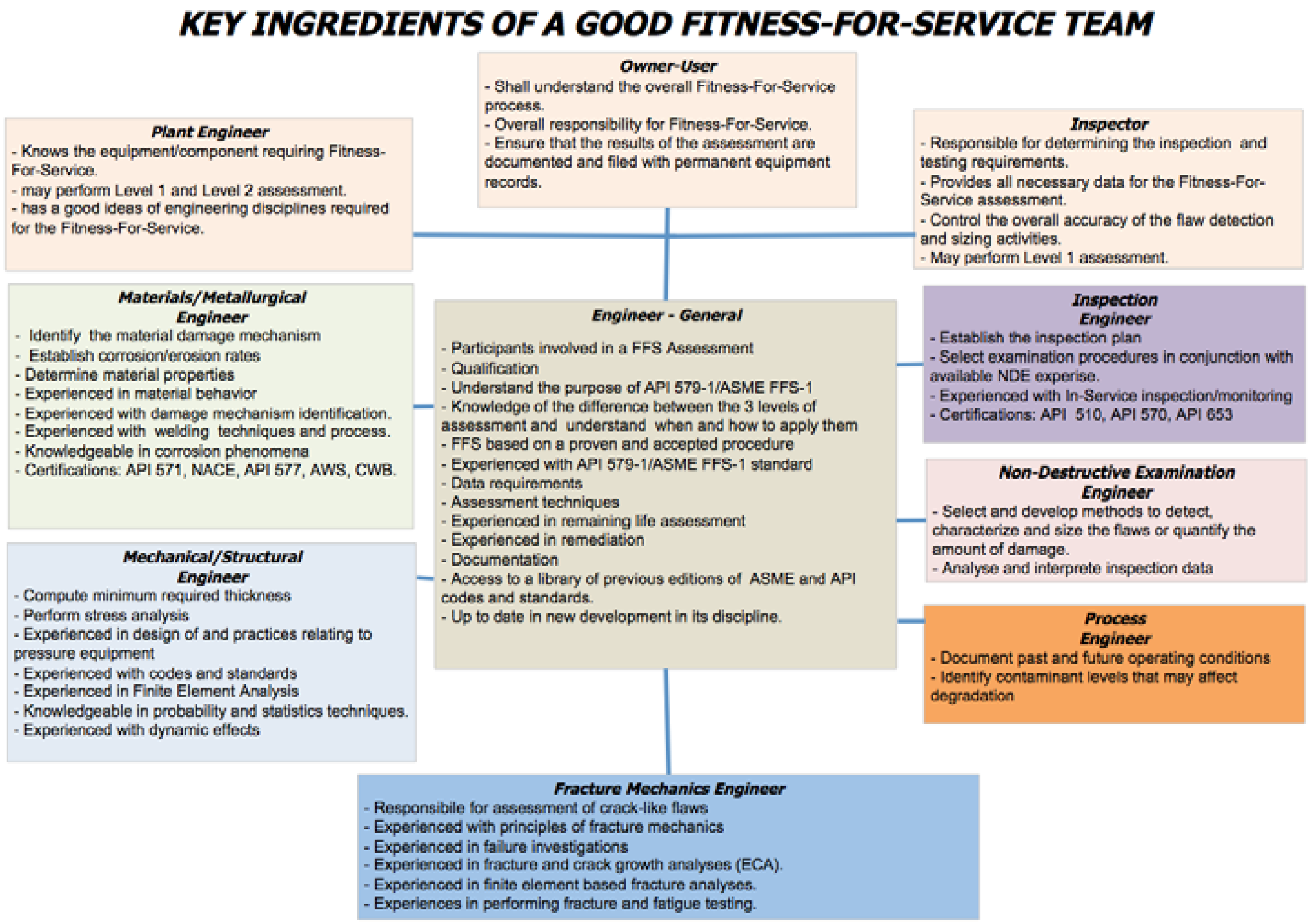

Figure 1. Summary of these key ingredients in a one page diagram.

original equipment design data required, and if some of this information is not available, should also identify what needs to be done to provide the missing information (physical measurements, tests, field inspection).

8. Determine Assessment Techniques and Acceptance Criteria

By knowing the difference between the 3 levels of assessment (previously discussed), the engineers should be capable of determining the assessment technique to be used. As per API 579-1/ASME FFS-1, each level provides a balance between conservatism, the amount of information required, the required skills, and the complexity[1]. The engineer should have an in-depth understanding of the acceptance criteria (allowable stress, remaining strength factor, failure assessment diagram) utilized in the methodologies presented in the API 579-1/ASME FFS-1 standard.

9. Experience in Remaining Life Assessment

If the assessment demonstrates that the damaged equipment/component is acceptable for the current application and conditions, engineers should then determine the remaining life for the equipment/component. In API 579-1/ASME FFS-1, the remaining life is used to establish an appropriate inspection interval, an in-service monitoring plan, or the need for remediation[1].

The engineers performing remaining life estimation should be experienced with the guidelines provided in API 579-1/ASME FFS-1.

10. Experience in Remediation

In some circumstances, remediation may be necessary. When this occurs, and keeping in mind that each situation is unique and requires a special attention, engineers involved in the FFS assessment should be experienced with remediation in order to propose a practical solution. Engineers should also have knowledge and experience with other codes and standards such as API 510, API 570, API 653 and ANSI/NB-23.

11. Experience with In-Service Monitoring

When future conditions, such as the corrosion rate, cannot be properly estimated or when the remaining life is short, in-service monitoring may be required. In such cases, the inspection engineer should provide an in-service monitoring plan. This in-service monitoring plan should be in accordance with API 579-1/ASME FFS-1.

12. Knowledgeable in the Documentation to be Recorded

The engineers performing the FFS assessment should sufficiently document the assessment so the analysis can repeated in the future. All calculations and documentation should be kept with the inspection records.

CONCLUSION

When faced with selecting a Fitness-For-Service team, owner/users should base their choice on the important parameters found in API 579-1/ASME FFS-1. A quick overview of API 579-1/ASME FFS-1 allows one to compile a list of the essential ingredients for a solid FFS team. Once again these key ingredients include:

1. Knowing who should be involved in a FFS assessment and their responsibilities;
2. Having the required qualifications;
3. Knowing the origin of the API 579-1/ASME FFS-1 standard;
4. Knowing the different levels of assessment;
5. Working with a proven procedure;
6. Knowing API 579-1/ASME FFS-1 philosophy, assessment procedures applicability and limitations;
7. Knowing Data Requirements;
8. Determining Assessment Techniques and Acceptance Criteria;
9. Being Experienced in Remaining Life Assessment;
10. Being Experienced in Remediation;
11. Being Experienced with In-Service Monitoring; and
12. Being Knowledgeable in the Documentation to be Recorded.

REFERENCES

1. API 579-1/ASME FFS-1 Fitness-For-Service, Second Edition, para 1.4.
2. ASME B31.3 Process Piping, 2012 Edition.
3. ASME Boiler & Pressure Vessel Code, Section VIII division 1, 2012 Edition.
4. Fitness-For-Service and Integrity of Piping, Vessels and tanks, George Antaki.

Guy St-Arneault is a member of the Mechanical Integrity Group at GCM Consultants, based out of Quebec, Canada. Mr. St-Arneault graduated (1992) from l'École Polytechnique de Montréal with a degree in Mechanical Engineering, with specialization in design. He is a member of the following Canadian Order of Engineers: Quebec (OIQ), Ontario (PEO) and British Columbia (APEGBC). Over his career, Mr. St-Arneault has gained substantial experience in the design and analysis of pressure equipment and piping, and also has significant experience in coordinating fabrication and quality control.

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