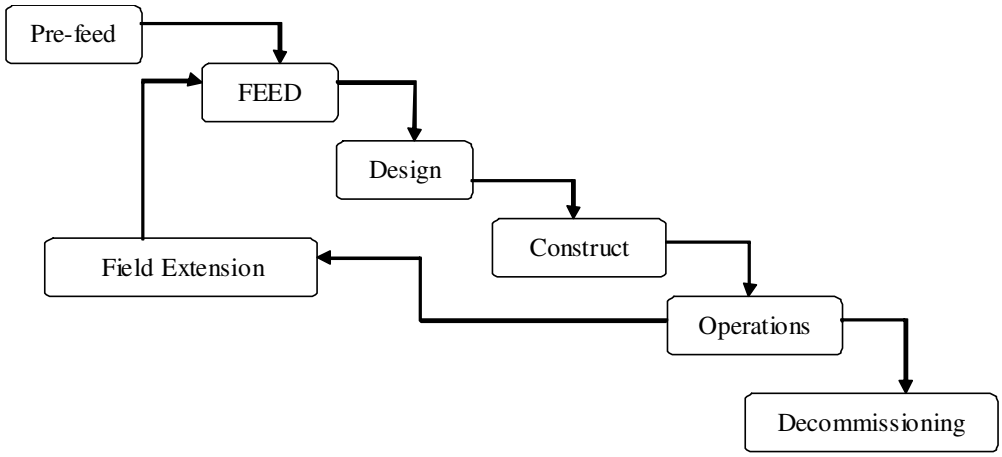
Intertek, Next Generation Oil and Gas

Life Cycle Integrity Management

During the lifecycle of an oil and gas asset, activities are carried out that ensure the integrity of the asset to be maintained from first operation through to decommissioning. This article describes the key integrity processes that are required during each of the stage of the asset lifecycle.

The lifecycle stages of a project comprise of:

- Pre-FEED
- FEED
- Design
- Construction & Commissioning
- Operations
- Decommissioning



Factors that contribute to integrity of the facility during each of the phases are discussed below.

Pre-FEED & FEED

Pre FEED and FEED are the stages of a project that enable scope to be defined in more detail and risks minimized thereby reducing the overall project costs. Pre-FEED refers to the concept stage of the project where the integrity objectives are to determine the overall feasibility of a project and define a cost effective solution for delivery. At this early stage only general proposals for integrity control are normally addressed, for example, what generic options should be considered that are likely to be cost effective.

At the pre-FEED stage it is typical to carry out a high level assessment of corrosion conditions to determine whether carbon steel (with or without chemical treatment) is a suitable material or whether high capital cost corrosion resistant materials will be required. This stage involves assessment of fluid from early explorations and high level life cycle costs. These are combined with an assessment of the uncertainty in the data available and the acceptable level of risk for the asset to select the main materials of construction (typically pipelines and high cost facilities)

During the FEED stage itself, consideration must also be given to material procurement, fabrication, legislation, and tax issues. At this stage a detailed full life cost analysis is normally carried out. Integrity related issues covered here include material section, chemical treatment facilities, monitoring & inspection requirements etc.

Design

Design stage is normally divided into 2 steps, design and detailed design. The first higher level stage enables approvals to be obtained without going into too much detail and therefore minimizes the amount of rework required. This phase involves the following assessments

- Confirmation of materials selection using design codes, standards and procedures for construction, fabrication and assembly
- Assessment of proposed corrosion control options.
- Detailed Engineering Design comprises of detailed specification and drafting procedure to deliver the finalized design specifications.

The materials selection decisions are refined during the Design stage to enable a more detailed material selection to be carried out including coating and insulation requirements. During this stage the process simulation and the design of the process facility are developed and, therefore, factors such as gas sweetening and gas dehydration which influence the corrosivity of a fluid and thus the materials choice are discussed. A more detailed understanding of fluid properties is required and this sometimes requires testing to confirm CO_2, H_2S, water composition, chlorides, etc.

Corrosion monitoring and mitigation requirements are specified at this stage as these will need to be designed into the facility. This can include the use of online and off-line instrumentation. In-line monitoring systems (such as corrosion coupons and corrosion probes) will require access fittings to be located at “appropriate” positions in pipelines and piping, as will injection systems for chemical treatment packages. For any type of pipelines the requirement to run cleaning pipeline tools will require launching facilities at “appropriate” locations throughout the system. Understating the predicted degradation mechanisms and the likely future operating scenarios is required in order to define these “appropriate” locations.

During the detailed design phase, these monitoring and injection requirements are finalized and detailed requirements specified; e.g. which instrumentation is required and the exact location and orientation of the instrumentation. This enables issues to be identified as early as possible and minimizes the opportunity for good intentions to go wrong.

Qualification testing or certification of materials is carried out to ensure the materials that are purchased are in line with expectations (e.g. for sour service all materials are suitable in accordance with NACE and ISO standards). The operational requirements for chemical injection pumps are defined (unfortunately, all too often, pumps are purchased that cannot meet the required chemical injection rate to protect the carbon steel pipeline from internal corrosion). Fatigue and vibration issues are considered during the design phase and the geometry of piping etc designed so as to minimize vibration issues.

Detailed legislation and expediting requirement should all be considered. While these may seem like indirect issues, in some regions it is more straightforward to import during the construction phase. Therefore all corrosion monitoring equipment and consumables should be included in this package, rather than leaving to the commissioning/operations phase and having additional paperwork and duty requirements.

One concern during the design phase is ensuring that good current field practice is transferred into new projects, not only by use of standards and codes but also incorporating practical field experience to ensure cost effective Operation and Maintenance (O&M) . This is not always achieved if members of the design team have limited on-site experience or there is poor communication between teams such as the proponent O&M team, the design team and corrosion specialists

Construction & Commissioning

This is the project phase where the systems are set up that will enable ongoing monitoring on integrity. During the construction phase, modules are often constructed in different location and brought together during the final stages, alignment of these modules and a 3-dimension map of the facility can be obtained by laser scanning of key components and facilities. This 3-dimension map can be used during operational phase and an intelligent information system developed by adding key data to the system

Inspection of components during the construction phase is vital, this ensures that relevant standards are met and that at the components are fit for purpose. In addition to the construction inspection activities it is also common for wall thickness checks (using non-destructive inspection systems, such a ultrasonic wall thickness systems) to be carried out to provide baseline data for ongoing operations.

During this phase the Integrity Management Systems themselves are normally set up. This should comprise a suit of documentation that enables a structured framework for integrity management to be delivered and should cover integrity policy, strategy, codes of practice procedures, specifications and guidelines; all of which are all required for a successful structured framework. Some of they typical documentation required includes:

- Integrity management Policy & strategy
- Sand management strategy,
- Corrosion management manual
- Hydrotest & preservation procedures
- Chemical management strategy
- Risk Based inspection strategy
- Corrosion Monitoring manual
- Inspection procedures

Risk Assessments and the generation of Risk Based Inspection plans require process flow diagrams (PFDs), piping and instrumentation diagrams (P&IDs), material selection diagrams (MSDs), pipework isometric drawings, vessel data sheets and process and operations manuals to be available. Development of the integrity management system during the construction and commissioning phase enables the systems to be implemented from day 1 of operations. This ensures that all operational data is collected and fed back into the system.

Corrosion and materials consulting engineers typically act in an advisory capacity during the Construction and Commissioning phase to assist in the following activities

- Define requirements for integrity management systems
- Reassess design decisions related to integrity monitoring and mitigation
- Advise on materials approvals, quality control and quality assurance checks

During commissioning it is important that the detailed hydrotest and preservation procedures are followed, the chemical injection packages are commissioned and the dose rates and logistics associated with chemical supply are confirmed. Vibration screening should be also carried out during commissioning of susceptible components.

Operations

Implementation of the integrity management strategy involves the correct execution of the mitigation, monitoring and inspection activities that ensure the facility remains fit for purpose. Examples of these activities are corrosion rate monitoring, process monitoring and inspection, data collection, analysis, reporting and corrective action.

The requirements for implementation are:

- The strategy should translated into practical instructions, for example, planned maintenance routines, operating instructions and work packs. There should also be a means for implementation of the strategy.
- Written procedures, work instructions and guides to performing the implementation tasks should be provided. Responsibility for implementation should be identified.
- Adequate manpower, material and equipment resources need to be allocated to undertake the plan. Permanent physical facilities should to be installed.
- The locations for monitoring and inspection activities should be defined.
- Procedures and instructions should include criteria of non-conformance.
- A damage reporting process should be continuously in place to capture information regarding failures that occur unconnected to the planned activity.
- A procedure should be in place to allow for opportunity based inspection, separate to the plans, of items that are not normally accessible for operational reasons.

Regular proactive and reactive monitoring should be undertaken to measure the degree to which the policy objectives of integrity management plan are being achieved. There are two measurements of success;

- Meeting the performance limits for the effectiveness of the corrosion barriers, i.e. the fitness for purpose of the facility and
- Meeting the targets in terms of the effectiveness of identifying the barriers and organizing, planning and implementation, i.e. the success of the management system itself.

A number of format and data management options are available for this monitoring activity; the critical factor is that the information is distributed at the appropriate level. Senior management must be made aware of significant integrity threats and also need to be able to confirm that planned actions are being carried out, but will not have time to

review too much technical detail. Ensuring clear lines of reporting and effective communications should be defined in the Integrity management strategy documentation.

Periodic Audits of an integrity management system should be carried out to determine whether the integrity management system effectively conforms to the requirements. They are an essential check on the performance of the system and are normally carried out by an independent party. Audits cover the following aspects:

- Implementation of procedures and processes
- Competency
- Checks in place
- Compliance

In addition to identifying non-compliance with systems and procedures, audits can be used to identify gaps in the system and enables improvements to be made. This review and improve cycle ensure best practice is maintained

Decommissioning

Decommissioning covers repair, replacement and abandonment and offers the opportunity to re-use / scrap existing assets. During this process a team will be formed to manage this activity, and offers the potential for any lessons learned during the decommissioning process to be fed back into new projects and existing operations. These include evaluation of:

- Materials selection
- Effectiveness of inhibitors and their delivery systems
- Evidence of unexpected deterioration (sites, components and modes)
- Evidence of over-design or excessive allowances
- Coating performances
- Integrity of repairs (e.g. pipe clamps)
- Comparison of inspection/NDT results against actual condition (e.g. CUI)
- Effectiveness of corrosion monitoring techniques (including probes and coupons if used).

Financial savings can be made by re-use of assets that are fit for purpose, and recycling of materials. This requires the integrity to be confirmed based on current degradation and future / new operating condition. Detailed inspection (NDT and visual) of components allow these decisions to be made.

Often decommissioned plant is left in situ and isolated from operational assets, as with operational plant, this mothballed plant has the continuing need for maintenance, inspection and surveillance if it is to retain integrity for re-use. It should be noted that a typical timescale from design/construct to final decommissioning could be well beyond a ‘workforce generation’. Thus, reliance cannot be placed on retained staff knowledge. Consequently, the maintenance of adequate records from as-built status to cessation of operational duties is essential if re-certification for re-use is contemplated.

Summary

Managing the integrity of an oil and gas facility requires a multi-disciplinary approach; it needs to consider the fundamental performance of materials in the oilfield environment in addition to the economics of the oil industry and local operations and the acceptable

level of risk. This requires an understanding of operational and maintenance issues in addition to the management regime and technical understanding. No one system is appropriate for all assets, but a vast number of tools are available that require a coordinated approach for successful implementation.

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