General Technical Paper

Platform Life Extension

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Abstract

This paper will detail a structured and holistic methodology to support the extension of the life of an offshore platform beyond that indicated by original design philosophy. The approach identifies the key asset reliability, integrity and process safety issues that need to be addressed in operating an asset beyond its design life. This methodology captures the key issues that arise in operating assets at or beyond design life, including; corrosion, obsolescence of equipment, change in design duties, change in oil or gas properties or production profiles, availability of historic information etc.

This methodology and has been applied to extending the life of the offshore oil and gas platforms in the UK, Danish and Norwegian shelf of the North Sea. In Norway it is a requirement to gain consent from the regulatory body prior to extending the life of a platform or field beyond original design. In the UK, the regulatory body sees such an extension in life as a significant and material change to the "Safety Case". In other parts of the world the shareholders, legislators and other stakeholders require assurance on the reliability and integrity of the asset.

The output from this type of study will identifiy the key Asset Integrity and Vulnerability risks for the platform or field and include a fully costed programme of activities that operators need to carry out to extend and continue to maintain the asset life.

With the volatile oil price and ageing profile of existing offshore platforms, the ability for operators and prospective investors to run assets beyond the original design life, whether for the short, medium or long term and still maintaining high standards of HSE and Integrity Management, is of paramount importance and forms a key part of any strategy to manage current and future business risk.

Issues faced by Offshore Operators

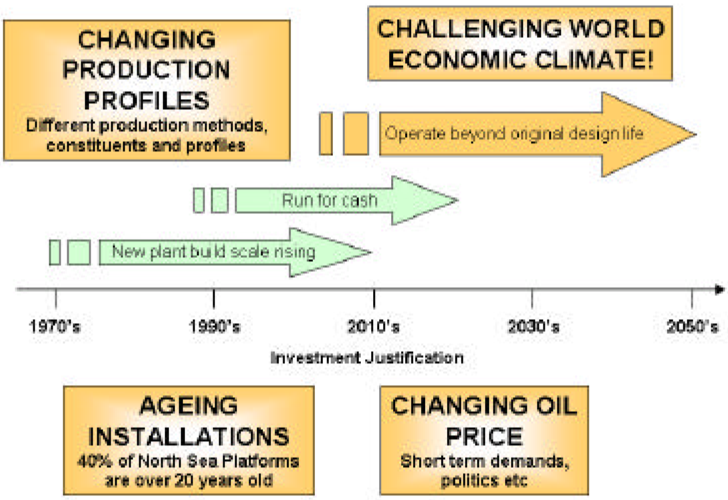


Figure 1 – Issues Faced by Offshore Operators

Availability of capital is not necessarily the main driver when looking at Asset Life Extension. Increasingly, operating companies are “sweating the assets” i.e. operating existing assets beyond their original design life, rather than attempting to build new facilities against a backdrop of increasing competition for scarce EPC resource and long equipment delivery. Figure 1 illustrates some of the challenges faced by stakeholders and decision makers.

To fully understand the issues affecting asset life extension, it is necessary to understand the factors which will have already had an impact and need to be managed in the future. Figure 2 provides a typical view across the whole asset life cycle.

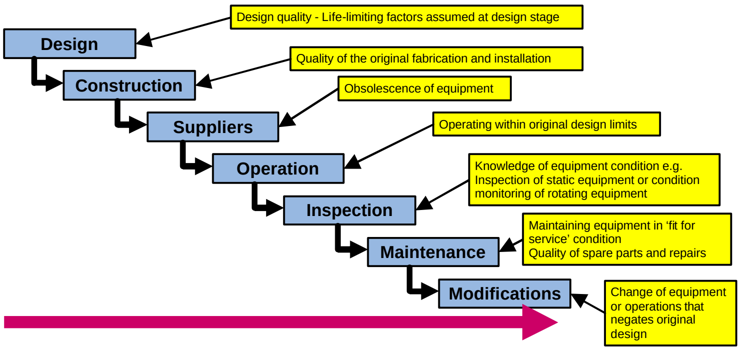


Figure 2 – Asset Life Factors across the Life Cycle

Figure 3 shows a typical process for managing asset life, in this case that given the UK Health and Safety Executive HSG65.

The wide ranging nature of these factors dictates the need for an integrity management framework that includes:

- Clear Policies & Objectives
- Appropriate Organisational Structure & Clear Responsibilities
- Effective Planning, Procedures & Implementation
- Measurement (KPIs)
- Review & Audit

The management framework is essentially a structure for managing risk and should address the key areas of Competent People, Reliable or Predicable Assets and Effective Systems.

Managing risk is not only about equipment condition. Equipment could have been originally specified, designed and constructed to the best possible standards, but if it has not been maintained, inspected, modified and operated in an appropriate manner in line with standards and best practice, its effective operating life will have been reduced. Further, if in the future, an inappropriate Asset Management strategy is not followed, the future operating life and budgetary requirements are almost impossible to predict.

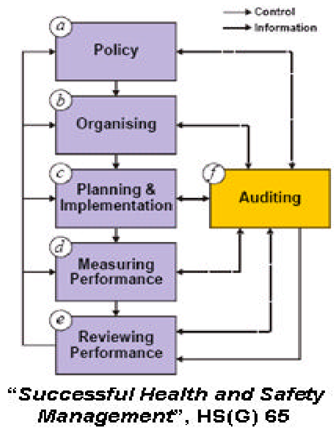


Figure 3 – Asset Life Management Framework (HSE 1997)

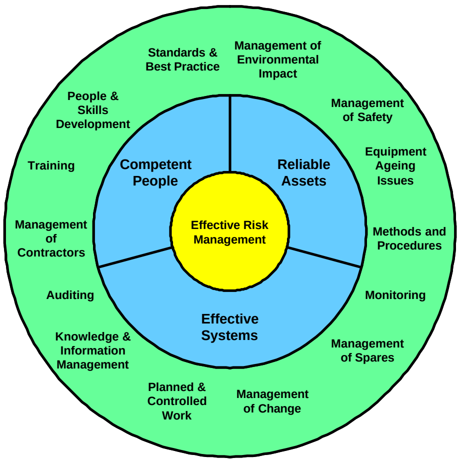


Figure 4 – The Key Elements of Effective Risk Management

Effective risk management is a wide ranging and holistic activity, as can be seen from Figure 4, which shows only a typical list of the activities and processes required to support Competent People, Reliable Assets and Effective Systems. Hence, any study or review to look at asset life extension must be comprehensive and not simply equipment focussed.

The long term viability of the field, whether for oil or gas or both, is the key life extension consideration. Once this viability is established, then the capability of the installation, in terms of fabric and equipment, to continue to operate for the remaining period of viability for the field is an obvious next step.

This is usually covered by detailed review of the sub-sea elements such as the well heads, jackets, main platform structures and sub-sea piping. Failure or significant degradation of the structures or the sub-sea elements renders the installation unusable and inoperable. Once these have been addressed, the top-sides equipment must also be able to deliver expectations in terms of asset life, often against changing future demands and operating regimes.

In this area, asset life is not simply the integrity of the top-side equipment items; such degradation of pipework or vessels, obsolete equipment or unreliable machines, but also needs to include the capability and competencies of the operations, maintenance and engineering organisations to allow the life to be extended and cope with changing circumstances. In addition, equipment must also be capable of dealing with changing production demands such as changes in well pressure as well as new deterioration mechanisms or potential failure modes that arise from these changes, such as running compressors at low rates or the impact of new corrosion mechanisms driven by new or increasing contaminants such as hydrogen sulphide, carbon dioxide or mercury.

To illustrate this, the following list is a compilation of the typical issues relating to the top-sides identified during recently undertaken asset life extension studies for offshore installations.

- Removal of redundant equipment to simplify the systems and reduce structural loadings or create space for new equipment
- Replacement of obsolete equipment, often a number of times during the life cycle
- Reducing equipment reliability, particularly machines and rotating equipment
- Need to replace people skills with automation as skilled people become harder to recruit and retain
- Management of newly emerging corrosion/deterioration mechanisms not always considered at the design stage that relate to new production regimes, increased understanding of deterioration, such as corrosion under insulation or long cycle time based, such as creep.
- Lack of defined operating envelope for some equipment, giving the risk of operations outside the original specifications
- Turn down capacity of key equipment as process requirements change
- Integrity of minor structures (handrails, walkways, ladders)
- Maintenance of competencies against ageing workforce and retention of corporate knowledge
- Electrical power limitations, often as a result of increased demand or equipment reliability/availability.
- Compliance with current and future environmental legislation
- Active and passive fire Protection due to ageing or as an opportunity to adopt best practice
- Upgarding Safety and Escape equipment as standards improve
- Availability, ownership and access to key condition and inspection information, both historic and current, particularly where 3rd parties are involved
- etc.

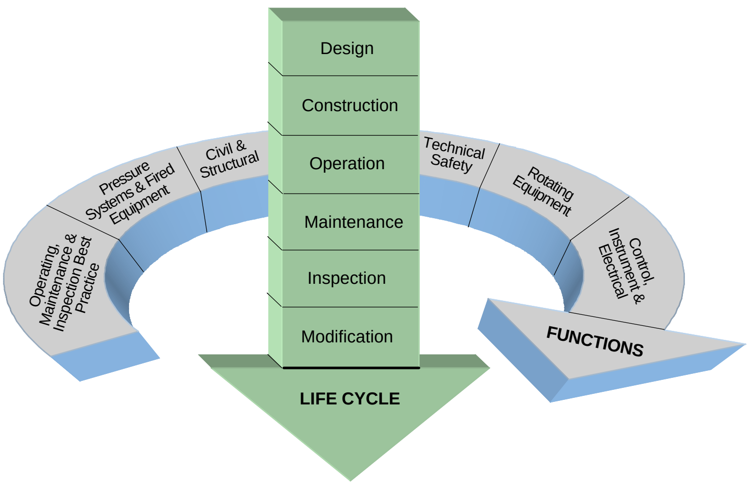


Figure 5 – Asset Life Key Factors

Top-sides asset life extension studies therefore require a holistic approach covering a wide range of topics and expertise, as illustrated in Figure 5. The key, as will be described later in the paper is to apply the expertise in the most efficient manner, delivering results in an acceptable time to a level of accuracy compatible with the capability of the operator to predict the future.

Overall, Asset Life Extension is effectively developing a strategy to manage future risk of which equipment integrity is only one factor. Figure 6 shows the wide range of potential topics involved in a truly holistic approach.

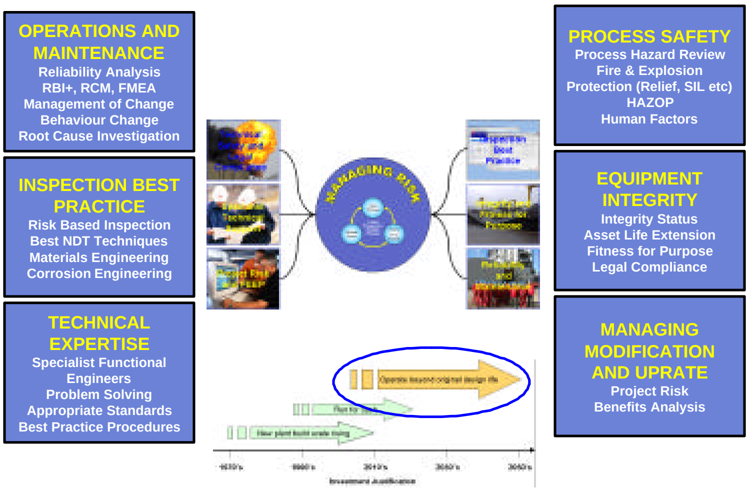


Figure 6 – Managing Asset Life Extension Risk

Basics of an Asset Life Extension Assessment Methodology

An Asset Life Extension Methodology needs to address two areas:

- The effectiveness of Risk Management, as shown in Figure 4.
- The integrity of the equipment

There are many options for assessing Risk Management capability in terms of the people, practices, procedures and systems aspects of the current regime. Methodologies, often called Health Checks, in this area are usually in the form of a gap analysis, using a combination of quantified measures, such as benchmarking or best practice KPIs in combination with the semi-quantification of qualified assessments, using word models to assess areas such as the quality of the inspection process, availability of expert technical support or the levels of people competency. A typical gap analysis could look something like that shown in Figure 7.

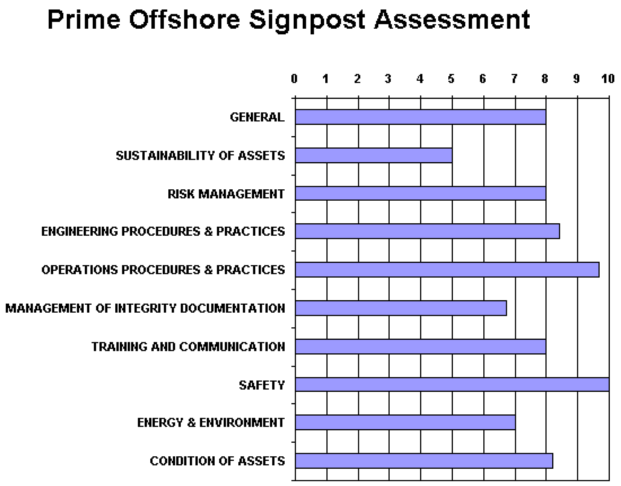


Figure 7 – Health Check Gap Analysis

Studying the asset life limitations for equipment requires an understanding of the likely deterioration modes and assessment of the capabilities of the equipment to resist the deterioration, largely based on the Life Cycle factors shown in Figure 2 and the capability of the organisation to manage the risk.

A typical list of the deterioration modes relevant to offshore installations is:

- Corrosion, particularly those arising from changing operations and production profile
- Fatigue, particularly where corrosion and material loss results in stress increases
- Creep
- Structural and Fabric Integrity
- Wear Out
- Obsolescence
- Thermal induced deterioration
- Overstress as loadings change over time
- Blockage and Choking resulting in dead legs for corrosion and overstress
- Explosion which is an extreme view but often relates to inadequate management of risk from equipment in potentially explosive atmospheres

The basic process for assessing the equipment integrity is shown in Figure 8.

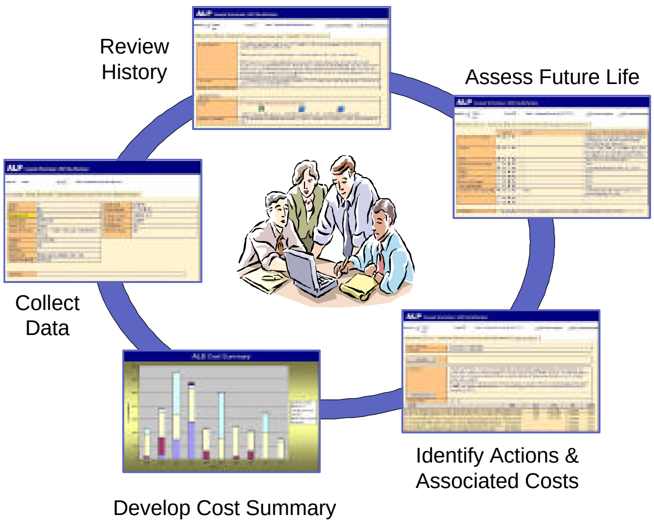
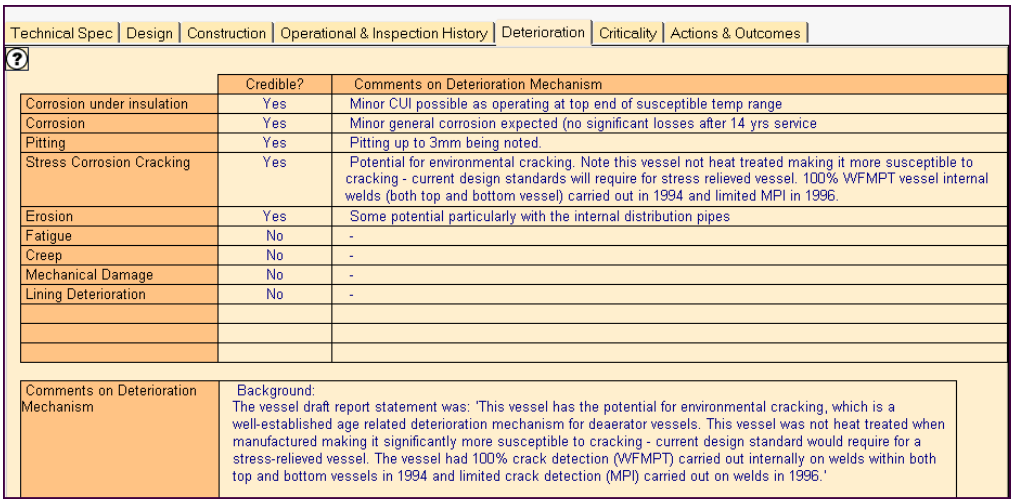


Figure 8 – Equipment Asset Life Assessment

Figure 9 illustrates an assessment of asset life of an item of equipment, in this case a deaerator vessel.

The process of establishing the technical specification for the vessel, the original design criteria, construction materials and operational/inspection history is not as time consuming as it might appear and can often be achieved electronically or worst case as a clerical exercise. The deterioration stage is similar to that used for a RBI (Risk Based Inspection) study and is a top down approach rather than a remnant life assessment. The difference between a top down approach and a remnant life assessment will be explained later.

The deterioration review leads to the identification of actions either to manage the risk in terms of best practice actions from the gap analysis, further activities to clarify the risk, such as further inspections, or repair/replacement activities. Each action is allocated a cost and an implementation date, such as that shown in Figure 10, and this allows the production of a budget histogram, such as that shown later in this paper.

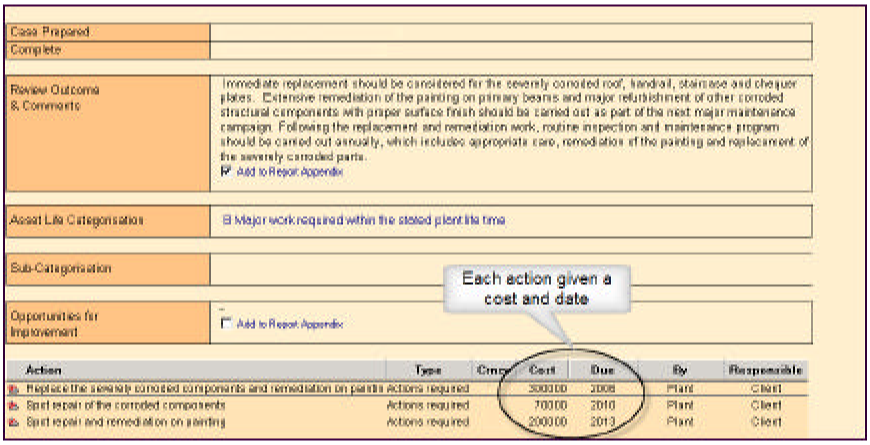


Technical Spec | Design | Construction | Operational & Inspection History | Deterioration | Criticality | Actions & Outcomes

	Credible?	Comments on Deterioration Mechanism
Corrosion under insulation	Yes	Minor CUI possible as operating at top end of susceptible temp range
Corrosion	Yes	Minor general corrosion expected (no significant losses after 14 yrs service
Pitting	Yes	Pitting up to 3mm being noted.
Stress Corrosion Cracking	Yes	Potential for environmental cracking. Note this vessel not heat treated making it more susceptible to cracking - current design standards will require for stress relieved vessel. 100% WFMPT vessel internal welds (both top and bottom vessel) carried out in 1994 and limited MPI in 1996.
Erosion	Yes	Some potential particularly with the internal distribution pipes
Fatigue	No	-
Creep	No	-
Mechanical Damage	No	-
Lining Deterioration	No	-

Comments on Deterioration Mechanism	Background: The vessel draft report statement was: 'This vessel has the potential for environmental cracking, which is a well-established age related deterioration mechanism for deaerator vessels. This vessel was not heat treated when manufactured making it significantly more susceptible to cracking - current design standard would require for a stress-relieved vessel. The vessel had 100% crack detection (WFMPT) carried out internally on welds within both top and bottom vessels in 1994 and limited crack detection (MPI) carried out on welds in 1996.'

Figure 9 – Equipment Asset Life Assessment for a typical vessel



Case Prepared	
Complete	
Review Outcome & Comments	Immediate replacement should be considered for the severely corroded roof, handrail, staircase and chequer plates. Extensive remediation of the painting on primary beams and major refurbishment of other corroded structural components with proper surface finish should be carried out as part of the next major maintenance campaign. Following the replacement and remediation work, routine inspection and maintenance program should be carried out annually, which includes appropriate care, remediation of the painting and replacement of the severely corroded parts. Add to Report Appendix
Asset Life Categorisation	B Major work required within the stated plant life time
Sub-Categorisation	
Opportunities for Improvement	- Add to Report Appendix

Action	Type	Cncy	Cost	Due	By	Responsible
Replace the severely corroded components and remediation on painti	Actions required		300000	2008	Plant	Client
Spot repair of the corroded components	Actions required		70000	2010	Plant	Client
Spot repair and remediation on painting	Actions required		200000	2013	Plant	Client

Figure 10 – Actions and Outcomes for a typical structure

Asset Life, Remnant Life and Top-Down Assessments

The methodology and approach to asset life extension described in this paper is often confused with and not the same as a remnant life assessment.

Effectively a remnant life assessment is an estimate of the remaining life by calculation or quantification of the effect of the deterioration mechanisms in comparison with the original design. They are governed by specific guidelines and standards, such as API RP 579, for each type of equipment and can be extremely time consuming.

The principal difficulties with remnant life assessments can be summarised below:

- Remnant Life assessments depend on predictable (usually linear) deterioration and consistent operations.
- Hence they are only sensibly accurate over short time periods and usually only add value towards the end of the Asset Life Cycle as shown in Figure 11.
- The accuracy needs to be greater than the shutdown interval.
- They need a lot of fundamental design information to do the calculations for each deterioration mechanism.
- Our experience suggests that it is best to only use them when you have to!

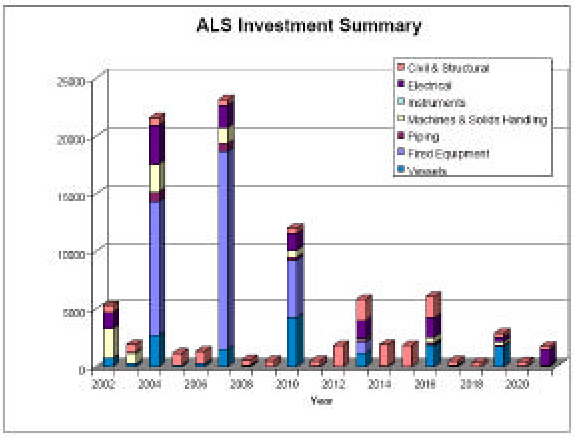


Figure 11 – Asset Life Budget Histogram

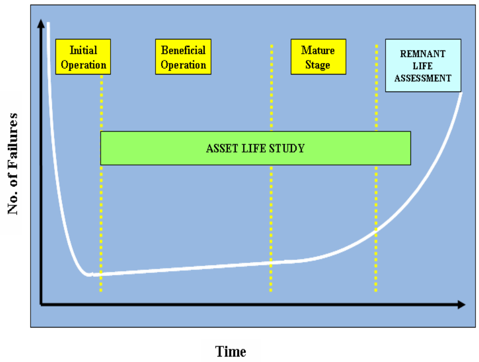


Figure 12 – The Asset Life Cycle

An alternative to the conventional remnant life assessment is the Top-Down approach. Here, starting from the normal design life, taken from design standards or best practice, the impact of deterioration mechanisms is estimated and an assessed life estimated.

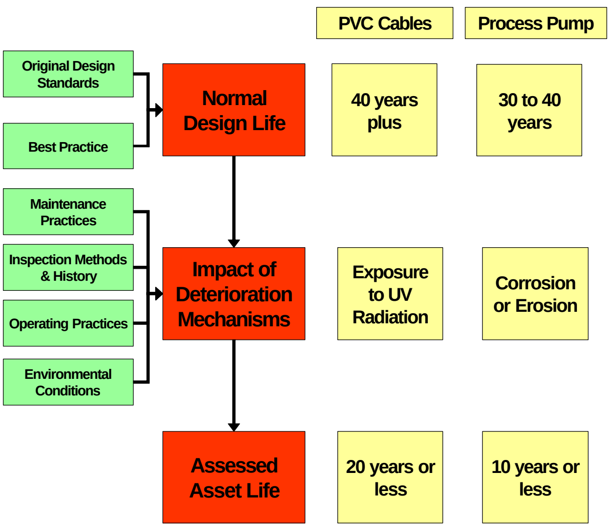


Figure 13 – Top-Down Assessments

This can appear to be a rather crude estimate, but when the limitations and accuracies of conventional remnant life calculations are taken into account, it is certainly comparable and has the considerable advantages of speed and much lower resource usage.

Top-Down approaches can give the impression that they are superficial and do not investigate the issues in sufficient depth. However, when they are done properly, they go onto the same level of necessary detail as other approaches, but only to the level of detail required to justify the required asset life extension. The fundamental objectives of any rigorous top-down approach are to avoid work that does not add value or simply tells the operator what they already knew!

An obvious question relates to what standards to apply when considering the asset life. Over the life of an installation, standards will change. Retrospective application of new standards can result in complex and expensive actions to maintain asset life. A better approach is to understand why the new standards were introduced and review the deterioration or future asset extension requirements in that context.

Case Study – Asset Life Extension for a North Sea Installation

An operator in the northern sector of the North Sea required an external risk based assessment of the expenditure required to provide continued operation of the installation until the end of the licence. At the time of the study, the platform and field had been in operation for about 25 years and a further 30 years. The main decision faced by the operator was to refurbish or replace and the primary objective of the study was to provide the essential inputs into their OPEX and CAPEX budgets to support the decision making process. A secondary objective was to assess the current vulnerability to identify any major issues not currently understood and covered by the budgets. Here vulnerability is defined as a measure of how well risk is being managed.

The scope of the study covered the topside equipment, including:

- Vessels/Storage Tanks/Sea sumps
- Piping, including risers from splash zone
- Valves, include wellhead valves/Christmas trees
- Machines and Rotating Equipment
- Structure including cranes, well supports and life boat davits/supports
- Control/instrumentation
- Electrical and Power Distribution
- HVAC

The scope excluded subsea assets such as pipelines and jackets, well and well operations, the drilling rig and helicopter/marine support. These areas had been covered previously by the operator either intranall or via other 3rd party studies.

The study revealed no significant obstacles to the required life extension and showed many areas of good practice:

- Knowledgeable & committed workforce, on-shore & off-shore
- Key asset integrity issues largely covered by existing plans
- Standards of asset care generally good
- Management systems in place for effective asset care
- Evidence of high standards e.g. electrical cabling & cable racks, Pressure vessel inspection and housekeeping

Some of the key issues that required specific action are summarised as follows:

- **Corrosion Protection**
  - Assets showed evidence of a historically reactive approach to “Fabric Maintenance”
  - Observed levels of corrosion should not prevent life extension
  - Without a proactive & planned programme of fabric maintenance, it is unlikely that the asset life targets would be met
- **Piping**
  - Only 20-50% of piping systems were inspected using a thorough scheme of examination and concerns arose relative to inspection of small bore systems and branches. Remediation or replacement was assessed as high cost.
  - Registration required of all systems required to support risk based asset strategy

  - Utility piping CS corrosion allowance consumed e.g. Fire Water piping system
  - Some areas of hydrocarbon piping subject to Micro Biological Induced Corrosion (MIC) and will require replacement in Super Duplex
- **Vessels**
  - Reduced life of internal protective coatings due to inappropriate application methods, driven by shutdown duration rather than technical merit.
  - Fatigue life calculations required to determine remaining life of a pressure swing absorber on the instrument air system.
  - Future corrosion and deterioration management strategy required to manage increasing levels of H_2S and Sulphate Reducing Bacteria as feedstocks change.
- **Electrical**
  - The original Low Voltage Switchgear was obsolete and spare parts were difficult to obtain, requiring an action to replace original equipment with new switchboards
  - Most cables and cable support systems were in very good order but attention required to steelwork attachments
  - Power limitations and supply reliability related to generation equipment unreliability rather than capacity limitations.
- **Structural**
  - Process required for inspection, repair and replacement of weather and fire doors
- **Rotating Equipment**
  - Structural vibrations associated with replacement diesel generators was a major contributor to unreliability
  - HVAC Refrigeration – R22 conversion was required by 2010
  - Fire Water Pump long term unreliability is a significant threat and requires an investigation followed by equipment replacement
  - Export Compressor turn-down and low suction capability was inadequate against the predicted production profile
  - Gas turbine CO and NOX emissions were likely to be beyond future consent levels

The above issues were translated into a range of actions and recommendations, which were in turn allocated costs and timings. Timings were related not only to priorities but also to opportunities to perform the work, such as shutdowns or resource availabilities. The resulting cost histogram is shown in Figure 14.

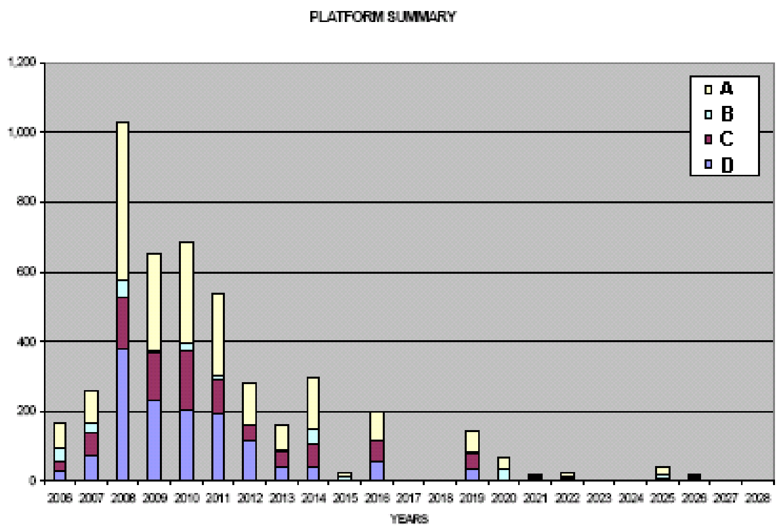


Figure 14 – Case Study Cost Histogram

The profile showed a number of points worthy of note:

A large peak of expenditure was required in the first 5 years or so to replace certain piping systems & control or instrumentation items, but once replaced, these should provide for continued operation with minimal on-going costs.

The profile includes maintenance costs, based on a strategy to ensure that minor issues do not accumulate to create major expenditure but accepting that maintaining old assets, even after major refurbishment, requires a different philosophy to maintaining new assets!

Summary of Benefits and Conclusions

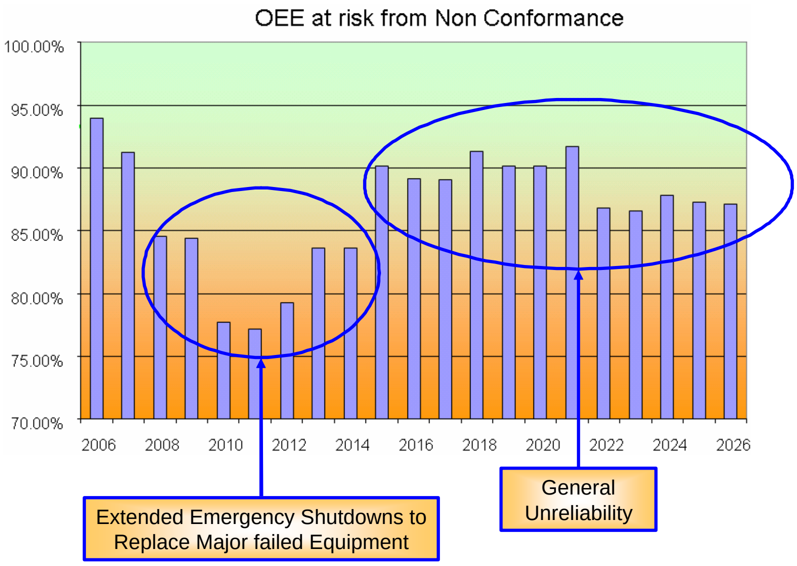


Figure 15 – OEE Benefits form effective Asset Life Planning

Figure 15 shows the impact of poor asset life management on the Overall Equipment Effectiveness of an Asset. Failure to plan for major equipment replacement can easily result in extended shutdowns as inspections reveal unforeseen problems or general reduction in equipment reliability.

Invaribly, a properly conducted asset life extension study will identify at least one 'life threatening' issue not covered by exisiting strategies and plans. Generally more are identified or at least incorporated into universal understanding. Often these issues relate to perceived 'non-core' systems, such as HVAC, potable water or basic utilities. Failure of these systems can have as significant impact as other, more obvious issues presented by front line systems or equipment.

A properly specified and conducted Asset Life Extension Study will identify

- Where & why deterioration is taking place
- What is needed to maintain equipment integrity

It will provide life cycle actions and budgetary plans with investment to prevent failure rather than as a reaction to it

As additional benefits, it will:

- Improvement of operating & maintenance practices
- Demonstration of pro-active management of assets
- Education of Plant personnel from exposure to the study
- Reduced risk of HSE incidents

It allows the development of a strategy to control and manage the risk associated with extending the life of offshore installations based on a systematic process to support the case for life extension of an Offshore Installation that will satisfy stakeholders, shareholders, legislators and employees.

A frequent 'by-product' of this type of study is issues identified with people, practices, procedures and systems, some of which have been described earlier in this paper. A simple focus on purely equipment is unlikely to guarantee ongoing, long term operation. The impact of people competency and supporting current and historical information systems should never be underestimated.

References

Health and Safety Executive (United Kingdom), Successful Health and Safety Management, HSG65, ISBN0717612767, published in 1997.