Repairs taking place as part of an integrity management plan.

Sending pipelines to rehab: a strategy for success

by Adrian Horsley, Principal Engineer and Will Sharman, Principal Engineer, Rosen Group, Newcastle upon Tyne, UK

As assets age, operators are tasked with planning maintenance, often having decide between performing rehabilitation activities or replacing deteriorating assets. This paper discusses the benefits of careful and rigorous planning when it comes to developing strategic rehabilitation options for external anomalies.

Global oil and gas reserves stand at 25 to 50 years at current production rates; however, much of the onshore transmission infrastructure is more than 50 years old. As assets age and deteriorate, pipeline operators face increasingly difficult decisions when it comes to deciding whether to replace or rehabilitate.

Using the US as an example, at least 55 per cent of the one million kilometres of onshore gas transmission pipeline infrastructure was installed before 1970 and at least 71 per cent was installed before 1980.[1] The cost of complete replacement of this infrastructure, assuming a rebuild cost of US$2 million/km[1], would be around US$2 trillion.

Adding these costs to the associated disruption in supply means that there is a clear incentive to extend the operational life of the pipeline through alternative lower cost means, such as sectional replacement or rehabilitation.

Planned rehabilitation is often in direct conflict with the need to address immediate integrity threats – for example, where a pipeline may currently be de-rated until a number of critical defects are repaired. This prioritisation often limits the ability to develop a rehabilitation strategy as shown in Table 1.

The focus of this article is the planned strategic rehabilitation – i.e. non-emergency structural repair, coating replacement or full sectional replacement – with an emphasis on the rehabilitation of external anomalies. The same process can be applied to the rehabilitation of internal degradation, although it should be recognised that implementation of a robust corrosion management plan is nearly always the most cost-effective method of managing internal anomalies.

ASSESSING THE NEED TO REHABILITATE

Rehabilitation cannot simply be viewed as a time dependent requirement. The proven in-service performance of many coating systems, coupled with the effectiveness of cathodic protection (CP) systems, means that many pipelines have been operated for decades with minimal intervention.

Operating the pipeline within a robust integrity management framework will maximise the ability to firstly identify and then quantify the severity of anomalies. Of course, appraisal of the current and future integrity status of the pipeline is usually the primary driver.

Apparent high corrosion growth rates along the length a pipeline from progressive inspection activities can lead to a perceived need to rehabilitate when projecting these into the future. Identification of the root cause of degradation is critical to understanding the realisation of future corrosion growth and the need to rehabilitate.

The real world complication is that multiple unrelated degradation mechanisms can combine over time to require a coordinated involvement across a range of integrity disciplines, such as corrosion, geotechnics, materials, defect assessment and stress analysis.

General CP under-protection, for example, may be straightforward to mitigate and monitor through adjustment of rectifiers, regular CP surveys and continued repeat inline inspection (ILI). However, other mechanisms, such as CP shielding due to coating disbondment, are not solely influenced by the CP system and normally require detailed assessment to identify the root cause of the coating degradation and an associated strategy to mitigate the threat. It is also important to recognise that other strategic business considerations must also feed into the rehabilitation decision making process. This includes:

- End of life definition – a clear definition of the required future duty of the pipeline will not only drive the need to rehabilitate, but also shape key factors of the rehabilitation plan itself.
- Future operating profile – an understanding of the future throughput required from the pipeline will shape rehabilitation requirements.
- Budget – generally available OPEX budgets govern the rehabilitation strategy to be adopted.

An ageing, deteriorating pipeline.

Immediate or critical defect	Response will be immediate and opportunities to optimise strategy is limited by to critical timeline
Short-term features for repair	Opportunities for efficiencies can be developed but the focus is still on performing digs and repairs, better grouping and planning increase efficiency
Long-term features for repair	Largest opportunity to address the root cause and extend time until investigation is required or apply a mitigation removing the growth mechanism

TABLE 1: Emergency repair vs planned rehabilitation.

RISK

OPTION	REHABILITATION PHILOSOPHY
Do nothing (reactive)	Manual spot driven structural repair of critical anomalies driven by inspection data
Reactive with increased inspection frequency	Manual spot driven structural repair of critical anomalies driven by inspection data
Short-term planned	Manual spot driven structural repair of critical anomalies combined with pre-emptive spot recoating of less critical anomalies
Long-term planned	Structural repair and pre-emptive coating rehabilitation across longer sections of the pipeline
Sectional replacement	Financial case for a specific section of pipeline to be replaced
Full replacement of the pipeline	N/A

COST

TABLE 2: Rehabilitation strategy options.

- Regulatory and time constraints – depending on the installation location, differing levels of regulatory oversight is provided; these bodies can serve improvement and prohibition notices that can result in an operator being given a time constraint within which to repair or rehabilitate the pipeline.

HIGH LEVEL REHABILITATION OPTIONS

Where high corrosion growth rates are identified across large sections of a pipeline, a significantly high number of features may be predicted to require remediation over a specified period, typically five years. This may present an operator with a number of high level rehabilitation options with an associated risk versus cost trade-off, as illustrated in Table 2.

To illustrate the practical implications these options, consider a pipeline with 30 repairs predicted in 2018 and a predicted repair that is increasing by 30 per cent annually, as seen in Figure 1. The operator may have a finite capacity to continue to perform repairs, influenced by logistics, personnel and annual budgets. If this annual repair capacity was 100 repairs, then this strategy would become unmanageable by 2023.

A repeat inspection before the annual number of repairs exceeds the operator's capacity may reset some of the uncertainty associated with extrapolating corrosion growth rates over long intervals. As discussed earlier, corrosion growth rate calculations are often uncertain because of short inspection intervals and the assumption that corrosion is a linear process.

To illustrate the point, Figure 2 assumes that no further rehabilitation was carried out, i.e. localised structural repairs only, and the global corrosion threat to sub-critical anomalies has therefore not been mitigated. In this case, the inspection interval has remained static at four years before the annual repair capacity of the operator is approached.

Figure 3 illustrates the potential influence of combining further rehabilitation with necessary localised structural repairs on the pipeline, i.e. mitigating the root cause of the external corrosion for many sub critical anomalies. Following the next ILI, the number of predicted repairs over a period of five or more years may be expected to increase at a lower rate, as many

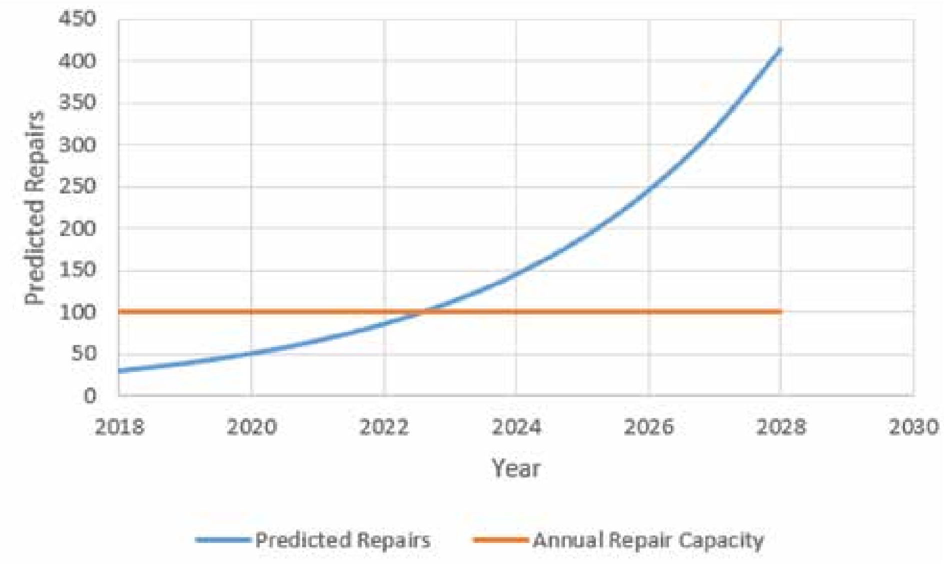

FIGURE 1: Increasing annual repair plan.

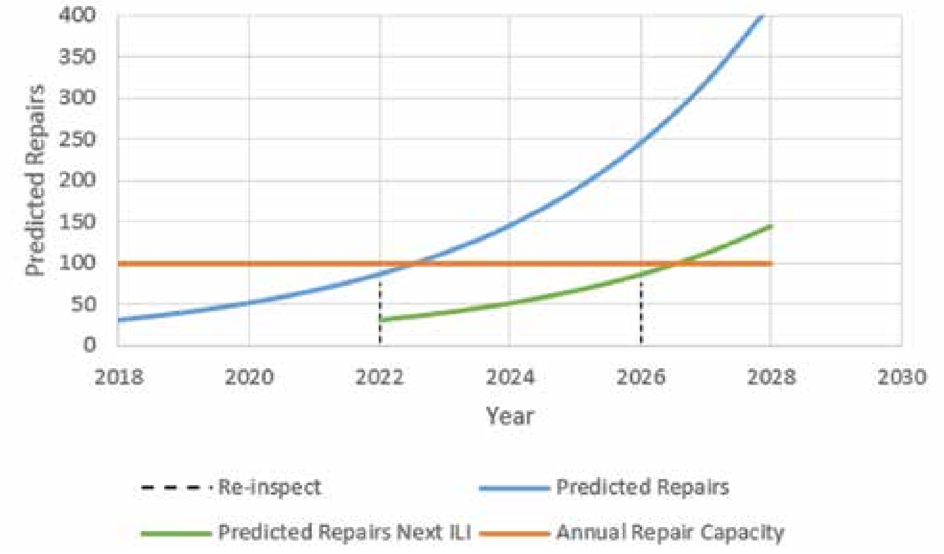

FIGURE 2: Increasing annual repair plan offset by repeat ILI.

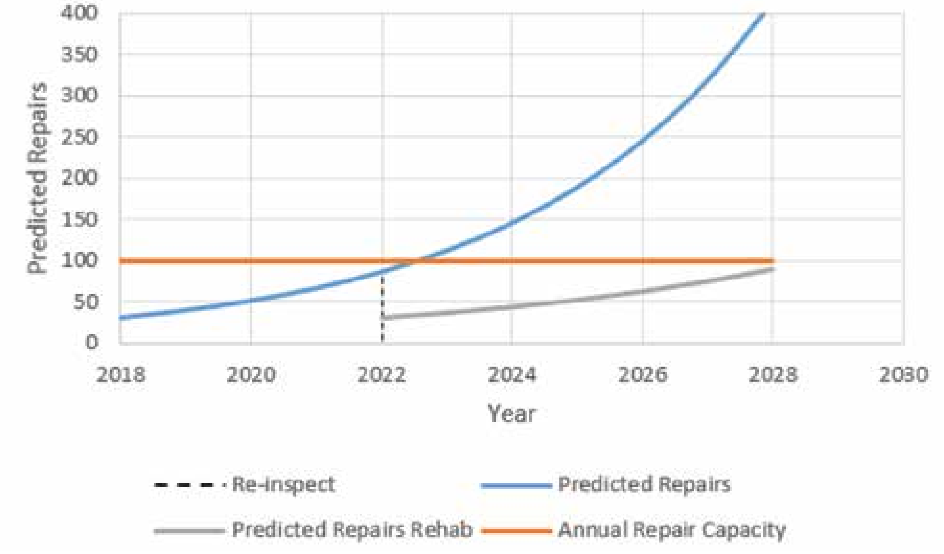

FIGURE 3: Increasing annual repair plan with rehabilitation.

sub critical anomalies are recoated and corrosion growth halted. Consequently, annual repair plans may remain manageable for longer periods of time and inspection intervals may be increased.

REHABILITATION STRATEGIES

The detailed development of an optimal rehabilitation strategy for a pipelines must consider many interconnected, competing drivers from both a technical and business standpoint. A controlled assessment cycle ensures that various rehabilitation options can be generated and compared on a 'like-for-like' basis in terms of technical performance, cost and time.

For each repair plan, a list of required excavations can be produced, each with an associated optimum rehabilitation method and cost. The cost of the excavation will be a function of the techno-economic inputs identified in the development of the strategy, typically:

- Excavation presents a significant proportion of the overall rehabilitation costs for any rehabilitation strategy, especially in difficult areas such as rocky, sloping or waterlogged terrain.
- The most cost-effective rehabilitation method is primarily driven by the excavation length and the number of excavations – shorter excavations are likely to be cost-effective manually.
- As well as being driven by excavation length, multiple recoating or structural repair solutions may be valid across a pipeline depending on the geotechnical considerations, such as soil type, groundwater and climate.

MONITORING AND REVISITING THE CYCLE

Implementation of a rehabilitation plan should be considered to be a live process. Constant feedback of up-to-date inspection and cost data into the plan during implementation is essential where longer term strategies are being considered. In particular, the comparison of measured corrosion growth against theoretical predictions can drive a change in strategy, which has the potential to significantly reduce overall costs. Over time, the effects of planned rehabilitation can also allow the re-allocation of manpower from emergency repairs to planned rehabilitation and further improve the effectiveness of the strategy.

CONCLUSION

Justification and implementation of a cost-effective rehabilitation plan is a complex process requiring multiple operational, engineering and risk considerations to be integrated with commercial drivers specific to the pipeline. Applying a consistent and rigorous methodology to the process provides the ability to compare options on a like-for-like basis and provide insight to the optimal solution.

REFERENCES

1. Smith, E., 'Oil Pipelines Lead the way in Strong 2014', Oil and Gas Journal, Volume 113, Issue 9, July 2015.