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INTEGRITY MANAGEMENT: PRACTICAL EXAMPLES FROM AROUND THE WORLD, APPLIED TO PIPELINES & BEYOND.

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ABSTRACT

Pipeline integrity managers have long considered the application of a dynamic process - serving to ensure improved security, safety and risk-control within Oil & Gas pipelines - a best-practice technique.

In some cases, regulators attempt to implant such a dynamic process into the day-to-day rhythm of pipeline operators by calling for deliverables and reports that can best be produced as a by-product of such an Integrity Management Cycle.

In this paper, we examine how an Integrity Management Cycle is defined and applied by various operators around the world – including some who face regulation and others that do not. Particular attention will be made to compare these operators with Pemex and their subsidiaries. This exercise will illustrate those aspects common to all best practice operators, regardless of the regulatory environment within which they operate

Provided that they align with the principles of continuous improvement, there is sound business logic to justify operations along the lines of an Integrity Management Cycle. In developing this paper from a Plenary Session paper at the 2007 Pemexpoducto, we highlight the traits that are necessary to ensure that great businesses benefit from such process cycles.

The consideration that the Integrity Management Cycle is a business process is further underlined by a case study detailed within this paper. This illustrates how a consistent business process was extended beyond pipelines and shaped to apply to pipeline operators' facilities - ensuring that the entire transport system was covered by such a best-practice business operating technique.

INTRODUCTION

This paper is written to promote a structured approach to asset management, applied to ensure Pipeline Integrity. The structured approach, driven by Goals and directed toward continuous improvement, is considered to distinguish world-leading businesses from world-class businesses – both in pipeline operations and other fields of industry.

This paper is divided into five main parts. In Part 1, the Integrity Management Cycle is defined, including an examination of the need to provide direction for such a Cycle with Goals and Objectives.

In Part 2, two specific examples are described that illustrate how Operators, in different regions and with different drivers, configure the Integrity Management Cycle. These configurations are made to ensure that the application of the Cycle is appropriate for each Operators need.

In Part 3, any common traits that have been noted within wider examinations are highlighted to illustrate the way in which great businesses can benefit from such integrity management cycles

Part 4 demonstrates the consistent nature of the Pipeline Integrity Management Cycle with continuous improvement processes developed for non-Pipeline assets – in this case, above ground installations and ancillaries to pipelines within a Hydrocarbon Transport System.

Finally, this paper closes with conclusions identified within Part 5.

PART 1: DEFINING AN INTEGRITY MANAGEMENT CYCLE

1.1 SETTING BUSINESS DIRECTION

Throughout all industries, traits of successful businesses are founded in the continuous measurement of performance against recognised goals. Goals define the performance by which successful businesses are measured. Prior to the implementation of plans & strategies, the communication of goals identifies the end-game. In this way, a business' leadership team can manage the expectations of their stakeholders and influencers. Consistent performance measurement is required through change; effective & relevant performance metrics make this possible - goals must be S.M.A.R.T. in that they should be Specific, Measurable, Actionable, Relevant & Timely. Such goals empower the whole business team to pull in the same direction - each individual knowing and understanding both the goal itself and their role in enabling its achievement.

1.1.1 CONSIDERING BUSINESS-WIDE GOALS

The goals set by a business must satisfy the desires and wishes of it's stakeholders; in the private sector these are the business's equity holders; in the public sector, these are the electorate and their nominated representatives. An example of public-sector stakeholder led goals is seen in Mexico. Within 5 days of coming to power, in December 2006, President Felipe Calderon issued a budget that was forecast to balance in 2007; he also committed to maintain this balance for the following five years of his office. With national growth expected to slow to an average of 3.6% over this period, and a government expenditure growth of over 9.4%, balancing the budget was highly dependant upon revenues from the state owned oil company Petroleos Mexicanos (PEMEX). The spending plan was based on an oil price of $42.5 per barrel; the productivity goals placed upon PEMEX were therefore both public and tangible.

Whereas stakeholders determine goals; influencers (for example: customers, business resources and regulators) set the boundaries within which such goals can be met. Determining how to meet the goals set by the stakeholders within the parameters set by other influencers, requires business strategy.

In considering the goals placed upon them, in the example above, PEMEX would have examined those factors that influence and govern the way they set about meeting production goals – product reserves, product demand and the means to extract and transport product from one location to the other. In the event, 2007 average prices of $64.20 per barrel counted to offset shortfalls on these production goals, and the administration elected to take hedge cover was taken on sub-$70 per barrel exports from 2008 onwards. However, continued economic and production slowdowns has maintained pressure to achieve and surpass these Goals.

1.1.2 DEFINING STRATEGIC OBJECTIVES

The needs & wants of a customer base (and their market influencers) shape ways that goals can be met. In addition, business managers must balance & prioritise the resources with which they can satisfy such needs & wants. Within the oil industry, this is illustrated in the Venezuelan heavy oil reserves & Albertan oil sands reserves. Extraction is only viable with oil prices above a certain threshold. It is therefore difficult for business managers to set long-term tangible profit goals. Instead, a goal of profit maximization within varied market conditions is set, along with a commitment to find ways to maintain a favourable threshold. At the highest level, oil-exporting nations can be said to exert some influence over the price of oil by controlling supply. At a more direct level, these producers can effectively reduce the threshold at which extraction is viable by seeking and applying new technology that has an incremental impact upon extraction efficiency.

1.1.3 PROVIDING INTEGRITY MANAGEMENT DIRECTION FROM BUSINESS GOALS & STRATEGIC OBJECTIVES

Strategic objectives shape a pipeline's functional specification. Pipeline managers must align specific integrity management goals with these strategies. Commonality can be found across some integrity management-goals. This list below, for example, is common to both an offshore oil pipeline operator in South East Asia and an onshore gas pipeline operator in North Africa:

"We manage the integrity & reliability of our pipelines in such a manner so as to:

- ✓ Maintain a productivity that maximises contribution to our stakeholders.
- ✓ Ensure supply uptimes that satisfy the demands of our customer base.
- ✓ Minimise the environmental, health & safety impact of our operation.
- ✓ Demonstrate compliance with all appropriate regulations.
- ✓ Adopt procedural best practice that exceeds the statutory requirement.
- ✓ Prove "good value", in a tangible and consistent manner, to all influencers.
- ✓ Promote the reputation of our business on the world stage, should international expansion be sought"

Quantitative considerations also shape pipeline integrity goals, - these include commercial contracts, operating programs and transmission programs to which the pipeline operator's business is committed. Integrity management goals often also include consideration of hot topics that face pipeline managers. A Latin American operator, for example, wants to identify pipeline segments that are particularly vulnerable to intentional third-party damage; a North African operator, on the other hand, wishes to characterise the cause and effect of black powder in pipelines. These considerations may have been highlighted by the rhythm of a previous iteration of the integrity management cycle.

With all considerations duly made, pipeline managers can compile a set of integrity management goals with which to direct the subsequent integrity management cycle. Provided that they are S.M.A.R.T., these goals align the pipeline operating team, manage stakeholder & influencer expectations and provide a performance measurement scale.

1.2 CONSIDERING INTEGRITY MANAGEMENT AS A CONTINUOUS IMPROVEMENT PROCESS

The approach outlined within this paper considers that the integrity management cycle, which lies at the heart of any structured approach to pipeline integrity, is a continuous improvement process consistent with the Deming Cycle. This is a model for continuous improvement of quality. It consists of a logical sequence of four repetitive steps for continuous improvement and learning: Plan, Do, Check and Act. The steps can be summarised simply:

Plan ahead for change, analyse and predict results.

Do it, execute the plan by taking measured steps in a controlled environment.

Check the results against the prediction

Act to standardise or improve the process.

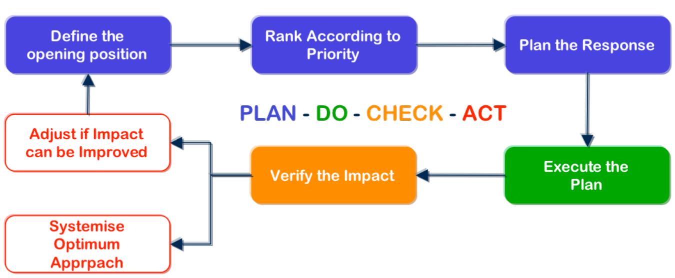

Figure 1: The Plan-Do-Check-Act Cycle

1.3 THE PIPELINE INTEGRITY MANAGEMENT CYCLE

Whilst code based requirements and local regulations may configure a pipeline integrity management cycle differently according to local application, all configurations of the integrity management cycle are broadly consistent with the Plan, Do, Check, Act cycle.

When an operator embarks on the integrity management cycle for the first time, the Plan Step comprises three components:

Planning Preliminaries: Set performance goals; make threat and consequence considerations.

Risk Assessment: Gather and integrate data; complete and validate risk ranking.

Response Planning: Produce the response plan.

With the Plan Step completed, the Do Step involves the Implementation of the response actions required to address concerns identified during that Plan Step.

Once response actions are implemented through the Do Step, the Check Step involves the verification that these response actions had an impact in maintaining the pipeline operation on track toward the achievement of identified integrity and reliability goals. This Step also serves to validate information uncovered during the implementation of response actions – this information serves to refine subsequent iterations of the integrity management cycle; it is particularly useful in ensuring Risk assessments are more robust with each iteration.

The Check Step closes the first iteration of the integrity management cycle. The subsequent Act Step encompasses the Planning Preliminaries sub-category of the Plan Step for the subsequent iteration. It is during this step that Goals are reviewed and consideration is given to the manner in which the integrity management cycle may be maintained – identifying the appropriate balance of internal and external resources required to ensure a sustainable dynamic.

The integrity management cycle can be illustrated thus:

Figure 2: Pipeline Integrity Management Cycle

Each of these Steps and components of the integrity management cycle are described in more detail below.

1.3.1. PLAN STEP

Component a) Planning Preliminaries

The entire Integrity Management Cycle serves to structure the way in which a pipeline manager may meet his identified goals and objectives.

As a preliminary step, pipeline managers must understand the pipeline "unit" by which the asset will be processed through subsequent steps of the Integrity Management Cycle. This exercise is known as segmentation. Segmentation may be made according to location (including locations with common failure consequences), characteristic, data-availability or some combination of this – either way, the pipeline asset must be divided into segments by which common issues can be identified and addressed in an efficient manner. This may result in the need for dynamic segmentation – with different perspectives overlaid to isolate those sections that can be assessed or addressed in a consistent manner.

Pipeline managers have limited resource at their disposal, not all segments can be processed through the Integrity Management Cycle in parallel. The work must therefore be planned with a preliminary consideration as to sequence in which segments will be processed. The fundamental aim is to ensure that all segments will be processed in a timely manner so, whilst the sequence should normally be planned with inherited or perceived consideration of risk or criticality over-riding other considerations, when the total timeframe is acceptable there is also justification to consider the ease at which relevant data may be made available.

By articulating Goals and Objectives, pipeline managers therefore define failure as an event that prevents these Goals and Objectives from being met. This definition extends beyond that which many would consider to be an engineering failure.

On a segment-by-segment basis, Pipeline managers must identify potential causes of failure – threats – in such a manner that their finite resources are focused only upon relevant threats. From a comprehensive list of those threats that may cause failure on any one pipeline, a shortlist of threats relevant to that segment may be drawn. With these shortlists compiled, pipeline managers must consider what information is available to indicate the probability that each threat is present and may result in a failure.

The extent to which Goals and Objectives are missed is described as the degree of consequence. Along with the probability of failure, the consequence of failure is a Risk-assessment factor. With a consideration of all the potential consequences associated with a miss on Goals and Objectives, pipeline managers must identify the information that should be gathered to quantify the degree of Consequence associated with a failure at each pipeline location.

This planning preliminary activity serves two purposes for the Pipeline Manager. First it identifies what information must be sought to create a robust risk assessment; second, it may highlight those threat and consequence combinations that are already apparent and unacceptable. These conspicuous threats and consequences may stimulate some accelerated response measures – "fast-tracked" past the subsequent planning sub-stages to be implemented without further delay.

Planning preliminaries are concluded with the production of a preliminary Integrity Management Plan. This plan identifies pipeline segments and the order of sequence by which they will be processed through the stages of the Integrity Management Cycle. It also contains the data requirement plan, identifying the information that must be gathered, integrated and analysed to create a robust risk assessment. Finally it identifies and justifies fast track response actions that must be taken as an immediate priority.

Component b) Risk Assessment

The risk assessment component of the Plan Step commences with the execution of the data requirement plan. This focuses upon the gathering of available data, integrating data gathered from different sources along a common reference and formatting the data in such a manner that it can easily be processed within a risk assessment exercise.

Pipeline managers should ensure that protocols are in place as a contingency in the event that items identified as required in the data requirement plan do not exist in a reliable form. These protocols should include consideration as to the delays and additional cost associated with actively gathering this missing data (usually involving on-site surveys), engineering assumptions to be made as a temporary supplement for this missing data and "worst-case" scenarios to be input into the subsequent risk assessments. In all cases, the course of action will be documented and it is a best practice that necessary information still missing by the time the risk assessment is completed should be prioritised for collection as a response action.

The protocols are put in place as a best practice provision to ensure that the Integrity Management Cycle is not stalled as a result of missing or incomplete data. As the cycle is a continuous improvement process, it is recognised that the accuracy of results should improve with each subsequent iteration of the cycle. It would be inappropriate to consider an initial risk assessment as an exact science. Instead it must be viewed as a best endeavours structured approach to meeting business goals.

A significant evolution within the field of integrity management that accompanies this structured approach concerns the timing of an integrity evaluation. Much of the field of pipeline integrity developed following the wealth of information that accompanied evaluations such as in-line inspection surveys; risk assessments have often been founded upon the results of an in-line inspection survey. This sequence can be framed in a consistent manner with the Six Sigma DMAIC approach to system-improvement. The approach, divided into the stages of Define, Measure, Analyse, Improve and Control, may be considered to be consistent with the completion of in-line inspection measurements prior to the execution of risk-assessment analysis. Two broad developments within the field of integrity management have resulted in the realignment of tasks in a sequence that places integrity evaluations such as in-line inspection as a response action:

First, pipeline operators who have already inspected their assets using in-line inspection are able to schedule re-inspection intervals as a risk-based activity. This allocates subsequent inspections as an activity whose frequency is determined by a risk assessment.

Second, as wider adoption of the structured approach to integrity management occurs, more pipeline operators with "unpiggable" pipelines are encompassed. These operators require sound business justification before committing to the capital works that make these lines 'piggable'. Such justification can only be made in response to risk, rather than as a means to characterise risk.

With the available data gathered, integrated and formatted it can be processed into a ranked risk assessment. This is essential to support pipeline managers decisions to prioritise limited resources among their assets; prioritising those segments where risk must be controlled with selected and scheduled response actions.

A risk assessment is simply a manner to characterise risk by factoring consistently defined probabilities of failure with consistently defined consequences of failure. When pipeline managers have limited data at their disposal, it is therefore quite acceptable to assemble subject matter experts and exploit their broad experience and depth of knowledge to arrive at an "engineering logic" conclusion regarding probability of failure, consequence of failure and ranked risk.

If historical pipeline failure data is available, it is possible to reinforce the engineering logic approach with an extrapolated relative risk model. When a pipeline manager considers that the criticality of the lines justifies a more detailed risk assessment, scenario-based models can be constructed by examining detailed consequences and factoring-in failure probabilities using event, decision & failure tree processes. For full probabilistic models, pipeline managers must utilise specialist risk assessment software and expertise to support them.

These four approaches to risk assessment are recognised as appropriate according to individual circumstance. Some countries choose to regulate that such tasks are completed over a predetermined frequency – for example, within Mexico a new regulation is to be introduced that requires, among other things, that a risk assessment be conducted on pipelines by any such approved approach on an annual basis.

As risk assessments are central to shaping integrity management decisions; results must always be validated. Selected multidisciplinary validation teams must be deployed to perform data & result reviews on representative sample sets. These teams should also cross check sample segments to ensure consistency with established engineering practice, regardless of the risk assessment technique originally used.

The risk assessment component of the Plan Step is concluded when a Validated Risk Ranking is produced. This enables a prioritised view of all pipeline segments according to risk and allows for the identification of the constituent threats and consequences that drive that overall risk ranking. It is important to understand the constituent drivers of risk to determine whether the priority should focus upon addressing threat probability, failure consequence or both factors. In the case of the new Mexican regulation, mentioned above, there is a provision relating to this aspect, which states that pipeline segments with a high-risk ranking driven by consequence should be tagged for preventative response, for example.

Component c) Response Planning

The value of the risk assessment outputs is realised when they support pipeline managers decisions to control risk by selecting & scheduling appropriate response actions. Response planning actions encompass all aspects of response technique, scheduled to safeguard the pipeline system against obstructions to the pipeline managers goals and objectives. The actions selected within a response plan can be considered to fall within four main categories:

First, predictive response actions may be identified and scheduled. Risk assessment activity will identify where certain conditions are conducive to the occurrence of certain threats. This will justify a set of response actions that must be taken to identify, locate and characterise these threats before they cause failure. Predictive response actions include (but are not limited to) the range of survey & in-line inspection techniques available to pipeline managers. These actions are often considered in isolation to other actions but, as we have highlighted above, there is increasing and robust evidence within the industry that these actions be considered as responses to be selected and scheduled after the completion of a risk assessment.

Second, corrective response actions may be scheduled. These actions are measures that must be taken to address threats that are already present before they cause failure. Corrective response actions, such as pipeline or coating repairs, are often mistakenly referred to as "preventative" actions. Though it can be considered that the actions prevent failure, they only do so by correcting a threat that has already become apparent, rather than removing the chance for that threat to occur. Corrective responses often fall into two main categories – immediate actions that must be taken to remedy a defect that is considered critical and scheduled actions that are set out to be taken prior to the next interim predictive response. Truly preventative actions constitute the third category of response covered by a plan. These encompass methods by which pipeline managers can control the conditions that may give rise to a threat, or even remove a potential consequence. While a common example of preventative response is that of cathodic protection, a more comprehensive illustration of a preventative response may be associated with the LPG pipeline and the school. The proximity of the pipeline to the school resulted in an unacceptable consequence associated with engineering failure of that pipeline. It was not considered that the probability of pipeline failure could be suitably contained; the response plans therefore focused on ways to eliminate consequence, decreasing the proximity of the pipeline to the school. In this illustration, the most cost-effective way to decrease this proximity was not by re routing the pipeline itself but by relocating the school.

Finally, there is a "last line of defence" regarding response - reactive actions taken to respond to a failure. In completing a Response Integrity Management Plan, pipeline managers must make due consideration to the manner in which they can respond to a failure and successfully limit consequence. World-class companies are often judged by the way they deal with adversity. Within Latin America and North Africa, two pipeline operators stand out with regard to the manner in which they have been able to build response teams that can quickly and efficiently restore product flow and recommission pipelines following intentional third party pipeline strikes.

In selecting and scheduling any of these response actions, pipeline managers need to consider the cost/benefit associated with that action. Firstly, a cost/benefit approach must be taken to determine what actions are the most economic way to address unacceptable and imminent risk concerns. This might include the selection of the most appropriate repair technique with which to correct a critical pipeline defect. Secondly, such an approach may be used to justify the early adoption of certain measures that economically address risk considerations that may become critical over an operators term of tenure over a pipeline. Ironically therefore, from a business perspective, the more conservative options may be extended beyond that which is required by Risk-based considerations. For example, should a pipeline be planned to be operational for twenty-five year life, then corrective actions such as coating repairs completed in year six may be considered to be more economically viable than continued Integrity Evaluation and pipeline repair in year twelve. It is for these reasons that response planning beyond that prescribed in codes is often best considered on a cost/benefit basis.

The conclusion of the response component and the Plan Step itself is marked by the production of a Response Integrity Management Plan. This plan drives the next step of the Integrity Management process by identifying, justifying and scheduling the mix of internal actions to be performed by the pipeline management team together with those tasks that must be performed by third parties and specialist contractors.

1.3.2 DO STEP

The Do Step marks the first point at which an action is taken that impacts upon pipeline managers' integrity goals and objectives. It comprises the implementation of those actions identified and scheduled in the Response Integrity Management Plan together with the fast tracked completion of critical actions identified and scheduled within the Preliminary Integrity Management Plan.

In illustrating the direction intended for actions scheduled in a response plan, it is worth considering them within the context of a "response matrix". Actions are taken to respond to the threats that may obstruct the achievement of Goals and Objectives. The manner in which they response is by either predicting presence, location and patterns, correcting located threats before they cause failure, preventing the threat from occurring or removing the consequence, provisions to react to a failure should it occur in order to limit consequence.

Though each individual response action, listed in the matrix labelled as Figure 3 overleaf, is not exhaustive it is a good illustration of an appropriate action for each scenario.

1.3.3. CHECK STEP

The Check Step closes this iteration of the integrity management cycle. This involves the verification that implemented response actions had an impact in maintaining the pipeline operation on track toward the identified integrity and reliability goals. As with the planning preliminary component of goal setting, this is an essential step that must fully reconcile the integrity management cycle with the objective set out by both business and pipeline managers.

A simple code-based example can be used to test the effectiveness of each iteration. Within the American Petroleum Institute's Approved National Standard 1160 (Managing System Integrity for Hazardous Liquid Pipelines), the following two questions are used as a basis of Program Evaluation:

Did you do what you said you were going to do?

This prompts a review of the actions set out within the Preliminary and Response Integrity Management Plans. It serves to highlight those actions that must be carried-forward into the subsequent iteration of the integrity Management cycle.

Was what you said you were going to do effective in addressing the issues of Integrity in your Pipeline system?

This prompts a comparison of the status of the pipeline system at the end of the cycle compared to that at the beginning. It requires the use of the goals and objectives as a consistent metric and should include a consideration of the incremental position against that metric compared to that if no actions had been taken over the period of the cycle.

in-house, provision should be made to ensure that the pipeline management team is developed and strengthened as required to ensure that they are increasingly able to manage subsequent iterations of the integrity management cycle with decreasing levels of external support.

Response Integrity Management Plan Pipeline Risk&Response Matrix		Predictive Response *To confirm Threat likelihood, location and pattern*	Corrective Response *To address a detected Threat before it causes Failure*	Preventative Response *To remove a Threat or mitigate a Consequence*	Reactive Response *To contain Consequence once a Failure has occurred*
Evolutionary Threat	Internal Corrosion	Sampling, MFL ILI +Int.Eval	Lining, Replace	Chemical Cleaning	Strike/Leak Detection
	External Corrosion	ECDA, MFL ILI +Int.Eval	Repair, Replace	Cathodic Protection	
	EAC	HT, CD ILI, Screen +Int.Eval	Repair, Replace	Environment Change	Supervisory Control
Binary Threat	Fabrication Defect	UT ILI +Int.Eval QA	Replace	Specification, QA	
	Construction Defect	Geo & MFL/TFI ILI +Int.Eval	Replace, Stabilise		Emergency Response
	Faulty Accessory	UT/NDT Surveys +Int.Eval	Replace	Preventative Maint.	
Event-led Threat	Mech. Damage (intent)	Susceptibility Screen	Intruder Detection	RoW Management	Strategic Reserve
	Incorrect Operation	QA Auditing	Corrective actions	Procedural Compliance	
	Climatic Force	Susceptibility Study	Replace, Stabilise	Re-routing	Root-cause Analysis

Figure 3: Response Matrix

As with all structured approaches, the Check Step has value when it is used to either validate the continuation of a consistent approach determine how the subsequent iterations of the integrity management cycle should be adjusted to improve incremental impact of each action. Any such adjustment is made during the subsequent Act Step of the cycle.

1.3.4 ACT STEP

The Act Step is a substitute for the Planning Preliminaries sub-category of the Plan Step beyond the first iteration of the cycle. It aims to streamline this step, now that the preliminaries have been performed, also to strengthen and improve the foundation by which the rest of the subsequent iteration is launched.

The performance goals and objectives are reviewed during this step. The aim of the review is to establish whether the goal remains valid, is suitable for an improved metric or target point or should be replaced with another goal that is more relevant to the next iteration of the integrity management cycle. The segmentation exercise is also checked to ensure that it is valid for the next iterations and perceived threats and consequences are adjusted as appropriate.

There are three fundamental provisions that must be made during this step. Firstly, a mechanism must be put in place to ensure that additional data gathered during response implementation in the previous iteration is brought forward to ensure that the next risk assessment is more reliably fed. Secondly, outstanding tasks that carry over from the last iteration of the integrity management cycle must be programmed for completion during this iteration. Thirdly, on the basis that a business wishes to retain the integrity function

An updated Integrity Management Plan marks the conclusion of the Act Step itself. This plan drives the next iteration of the integrity management cycle and sets out those outstanding tasks that must be completed therein. As an indication that the pipeline manager is developing greater levels of control over the pipeline asset, it would be anticipated that fast-track response actions diminish during each iteration.

Along with a reduction in the number of fast-track actions, the evolutionary nature of the integrity management cycle will be underlined by a pipeline manager's decreasing reliance on external parties and consultants during the Plan Step. When properly achieved, this reduction can be interpreted as an improvement in the skill set and self-reliance of the pipeline manager's team. This goal of sustainable improvement reinforces the notion that the integrity management cycle is a true continuous improvement process.

PART 2
EXAMPLES OF INTEGRITY MANAGEMENT CYCLE CONFIGURATION AND APPLICATION.

Two Operators are cited as examples in this Section – "Operator R" is an onshore Gas Exploration and Production company in East Europe; "Operator N" is a Refined Products Distribution company in North Africa. Both companies operate between 1500km and 2000km of Pipelines; neither company considers Pipeline Operation to form their core Business.

In line with best-practice asset-management strategy, both operators wanted to strike the right balance between Preventive and Reactive Maintenance. Examples of this balance are illustrated below, with Group A pursuing a less conservative approach and a reliance on reactive maintenance, Group B pursuing a more conservative approach to avoid failures at all costs and Group C pursuing the approach that involves lowest Total Cost:

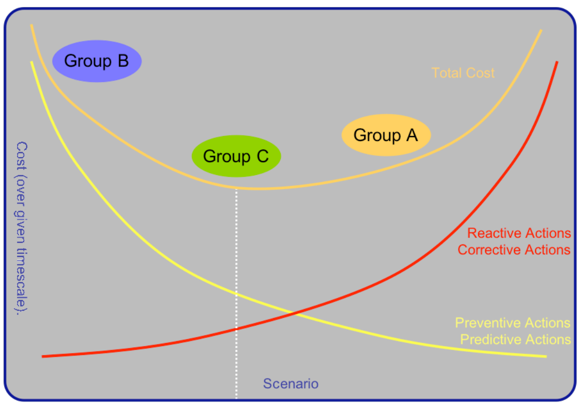

Figure 4: Reactive, Preventive & Total Cost Curves

Both Operator N and Operator R appreciated the need to determine the condition of their pipeline asset before they could be sure of maintaining a relationship between preventive and reactive actions that would hold Total Costs somewhere close to the orange curve above. In other words, both operators realised that they needed to fully understand where targeted pro-active actions would have a direct and corresponding impact in reducing consequential reactive costs.

Both operators released Requests for Quotations into the pipeline inspection marketplace, inviting inspection vendors to survey their entire assets and provide sufficient information for each operator to decide where and when to direct their preventive maintenance regimes.

Operator N did not proceed with the inspection contract because none of the vendors could assure Operator N that the surveys would focus only upon the pertinent Integrity threats and correctly support decisions regarding preventive maintenance regimes, despite quotations that exceeded Operator N's total external expenditure budget.

Instead of proceeding with the inspections, Operator N instead called upon Consultants to structure their approach to pipeline integrity. This approach was built around an Integrity Management Cycle and was driven by Operator N's desire to perform in the following areas:

- Cost-effectiveness: ***improvements*** demonstrated by a ***reduction*** in the total cost/volume ratio, expressed annually or on a per kilometre basis.
- Product-quality: ***better*** product consistency supplied to Operator N's consumers, proven with a ***reduction*** in the number of out-of-specification incidents.
- Environmental-impact: ***reductions*** in the impact of Operator N's operations, proven by lower pipeline ***failure rates*** & consequential costs.
- Health-impact: ***maintenance*** of Operator N's strong safety record demonstrated with ***consistent*** statistics over time.
- Security-of-Supply: a ***more secure*** network, with less external threat to supply security, demonstrated by ***less*** incidents and an overall ***lower*** risk ranking.
- Pipeline-capacity: ***increased*** capacity, proven by a ***better*** ratio between the time it takes to replenish reserves and the rate at which these reserves deplete.
- Life-extension: ***maximised*** viable pipeline life, reflected in a ***high*** net asset value.
- Staff-capability: ***improved*** skills & training levels, with Operator N staff ***less*** reliant on contractors to manage the rotation of the Integrity Management Cycle.

Operator N's Integrity Rhythm was therefore structured with a progressive approach, with an emphasis on preliminary, risk assessment and response planning functions in order that subsequent inspections were focused upon the areas and specific threats where they would have the most impact and value. The progressive approach involved the completion of:

- A set of SMART metrics that can be used to measure Operator N's pipeline performance.
- An outline audit that determines how Operator N is performing against these metrics and against recognised international benchmarks, today.
- A set of Goals & Objectives that give direction for Operator N's pipeline performance, over an agreed timescale, as will be verified by these SMART metrics and industry benchmarks.
- A comprehensive and segmented Threat Analysis that determines failure modes, which may obstruct Goals & Objectives, together with a set of Classed Consequence Locations.
- A Data Requirement Plan, produced to identify the information that should be gathered to support an initial risk-assessment.
- A set of Aligned & Formatted Data, suitable for the risk-assessment, compiled from contributions from the following parties:

- All available data, which is internal to Operator N, provided by Operator N.
- All available data, which is external to Operator N, provided by Consultant.
- Provisions and assumptions, that substitute unavailable data, will be suggested by Consultant and agreed by Operator N.

- An initial, validated Risk-assessment that ranks all pipeline segments according to risk-severity and identifies constituent probability and consequence of failure.
- A Response Integrity Management Plan that identifies justifies & schedules the actions that must be taken to manage risk and set Operator N in the right direction to meet their Goals & Objectives.
- A set of Verification Criteria for each response, to check the incremental impact that each action has upon the achievement of Operator N's Goals & Objectives.
- A Change-management Plan that identifies the way in which Operator N can develop the operating rhythm to maximise Pipeline Integrity, with optimum acceptance and adoption levels from within the organisation.

The structured approach defined for Operator N can therefore be illustrated as follows:

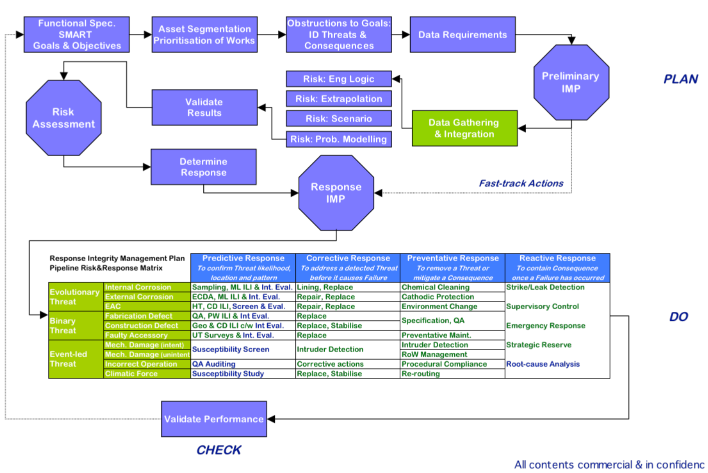

Figure 5: Illustration of Operator N Integrity Management Cycle

In addition to the business-driven desire operate in line with best-practice asset-management strategy; in Eastern Europe Operator R anticipated prescriptive regulations that would direct them to complete blanket-coverage Integrity Evaluations over a two-year period. The Request for Quotation that Operator R released received no response from inspection vendors – not only because of an inability to demonstrate that the inspection results would forge a relationship between preventive and reactive actions, but also because none of the asset was "piggable" - suitable for in-line inspection - without significant and costly engineering works across the 1,600km asset.

Operator R therefore worked with Consultants and Engineering teams to devise a structured approach that would provide compliant Integrity Evaluations for their entire asset and enable them to fully understand where targeted pro-active actions would have a direct and corresponding impact in reducing consequential reactive costs. This structured approach was therefore devised to help Operator R take control of the asset.

The primary stage in this approach involved screening the entire asset to determine criticality levels across all 708 segments within the 1,600km system. Though location played a part in consequence considerations, this was not as detailed as class location allocations because of the relatively low levels of resolution available at the outset. In this instance, security of supply was a prevalent factor in screening the system – this was dominating Operator R's agenda due to potential ongoing interruptions to the piped gas supply that the country imports from Russia, via the Ukraine.

With the entire network screened according to criticality, including a high-level consideration of consequence, the structured approach would then enable progressive integrity evaluations to be performed, focusing upon the most critical segments first.

The approach includes that application of direct assessment as an integrity evaluation method. This utilizes a progressive, structured process to integrate knowledge of the physical characteristics and operating history of the pipeline segment with the results of inspection, examination, and evaluation, in order to determine the integrity of that segment.

The direct assessment is configured across four steps and is deployed to determine the presence of internal corrosion, external corrosion and other integrity threats encountered during the works. In performing the first step, historical knowledge of the pipeline including facilities information and operating history is integrated with the results on line walking and pipeline location exercises. This information is aligned and held in a geospatially-referenced database to support the successive steps in the process.

When considering external corrosion, preliminary conclusions are drawn as to the locations of prior and active external corrosion. The appropriate indirect inspection methods are then selected. When considering internal corrosion – remembering that these are dry gas gathering lines– facility descriptions and related historical data on operations and inspections are examined, including events and repairs. If it is conceivable that water or other electrolyte has entered the pipeline section, software-based calculations will be made to determine the likely locations of accumulation and impact.

In the second step, surveys are performed at the locations selected during the pre-evaluation stage, using the methods selected in that stage, also. All relevant survey information is aligned on a common linear reference to ensure that interacting properties and features are identified. Additionally, algorithms are developed to support the determination of corrosion severity in these segments and to support the selection of regions in subsequent segments.

The third step of the progressive, structured approach is performed with direct and local examinations upon pipeline locations selected upon the completion of the indirect inspections. By aligning and overlaying survey findings, on a common linear reference as mentioned above, environmental and pipeline specific relationships can be determined.

Validation check on the overall process is consistent with that identified within Annex B1.4 of the ASME American National Standard B31.8S "Managing System Integrity of Gas Pipelines".

For each segment evaluated, the fourth step generates an Integrity Evaluation Report, specifying how and when risk can be mitigated by responding to the integrity assessments and other relevant data encountered up to this point. The responses are categorized as immediate, scheduled, or monitored. The mitigation elements in each Report consist of two parts – Repair & Prevention.

Though much of the activities undertaken can be seen to conform with the rhythms of NACE RP0502-2002 "Pipeline External Corrosion Direct Assessment Methodology" and NACE SP0206-2006 "Internal Corrosion Direct Assessment Methodology for Pipelines Carrying Normally Dry Natural Gas", which themselves conform with a Plan-Do-Check-Act cycle, it is worth understanding that these cycles are segment-specific whereas the Integrity Management Cycle defined for Operator R is system-wide.

The four steps of direct assessment within Operator R's rhythm form a sub-process within the overall integrity management process. The sequence of these sub-processes are determined by the system screening stage; the performance of these sub processes serve to build a system-wide risk assessment; the outputs of these sub-processes are aggregated into a system-wide response stage integrity plan. Response execution and impact validation follows this plan.

The benefit of this approach is that the more comprehensive (and costly) stage 2 and 3 direct assessment actions performed on critical segments enable operator R to apply these actions more conservatively on less critical segments, but still retain suitable confidence in the Integrity Evaluation results due to the wealth of data collated and aligned during the earlier stages.

The overall Integrity Management Cycle, in this case, can be illustrated as follows:

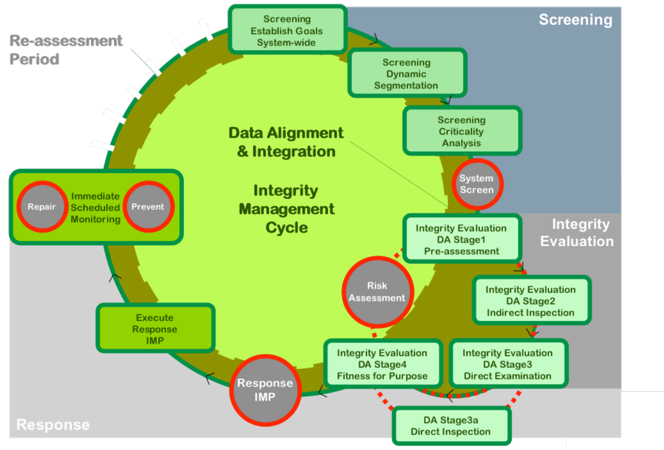

Figure 6: Illustration of Operator R Integrity Management Cycle

By structuring the approach to asset management in this manner, Operator R was able to configure a rhythm that would both comply with anticipated Regulation and forge a relationship between Preventive and Reactive actions that would maintain total costs somewhere close to the minimum possible combination.

Interesting consistencies can be found between these two examples and the approaches taken within the Subsidiaries of PEMEX. PEMEX is shortly facing a new Mexican Regulation PROY-NOM-027-SESH-2009 (NOM), which focuses upon the management of integrity in hydrocarbon gathering and transmission pipelines. This NOM can be considered as comparable with both ASME American National Standard B31.8S "Managing System Integrity of Gas Pipelines" and API American National Standard 1160 "Managing System Integrity for Hazardous Liquid Pipelines". It can be summarized in the illustration below:

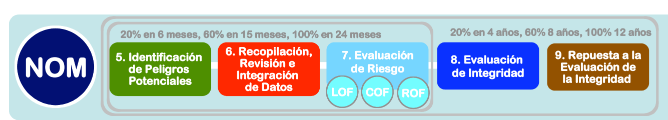

Figure 7: Summary of the NOM

Within PEMEX, a system-wide approach has been planned that will allow compliance with the NOM, but may still allow configuration to suit the needs of each Subsidiary. This approach is called the "Plan de Administración de Integridad de Ductos" (PAID) and can be seen to align with the Plan-Do-Check-Act approach to continuous improvement. For example, within the Refining subsidiary of Pemex a strategy has been proposed that concerns the transmission product pipeline network; this strategy can be illustrated as follows:

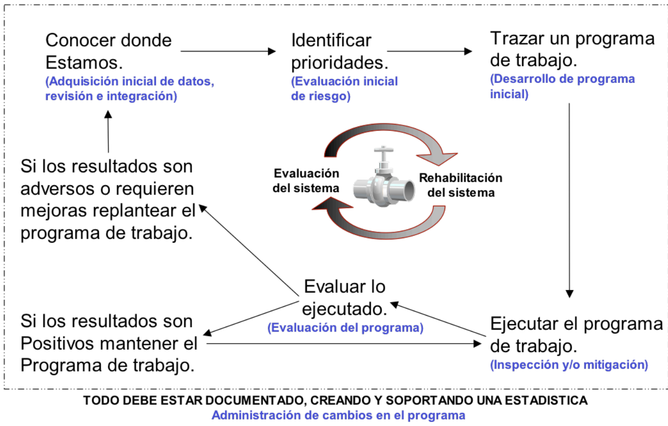

Figure 8: PEMEX Refinacion Pipeline Strategy

Broad comparisons can be drawn between this approach and that adopted by Operator N. Within PEMEX exploration and production (PEP), the transmission pipelines are already being managed in a manner setout by PAID, which can be illustrated as follows:

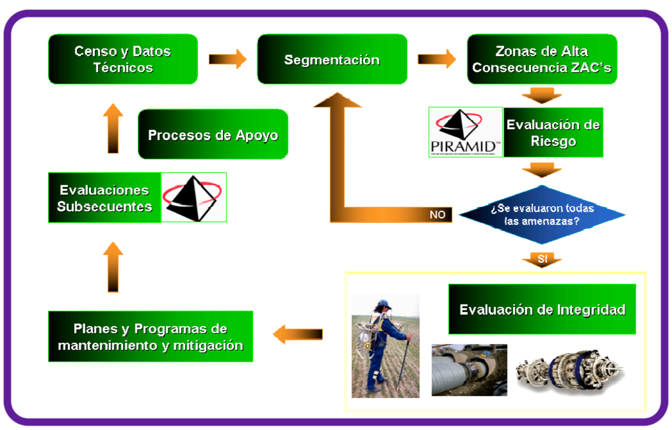

Figure 9: PAID

The gathering system operators within PEP are required to apply PAID, to comply with the new NOM, across a large and complex network of small gathering pipelines – an asset that does not yet benefit from consistent levels of historical condition and integrity data. It can be seen, therefore, that the configuration of an Integrity Management Cycle might be set out in a manner similar to that developed for Operator R – respecting PAID, together with the NOM and the recommendations associated with Global Best Practice (including the use of Key Performance Indicators – KPI's). Such an Integrity Management Cycle can be represented as follows:

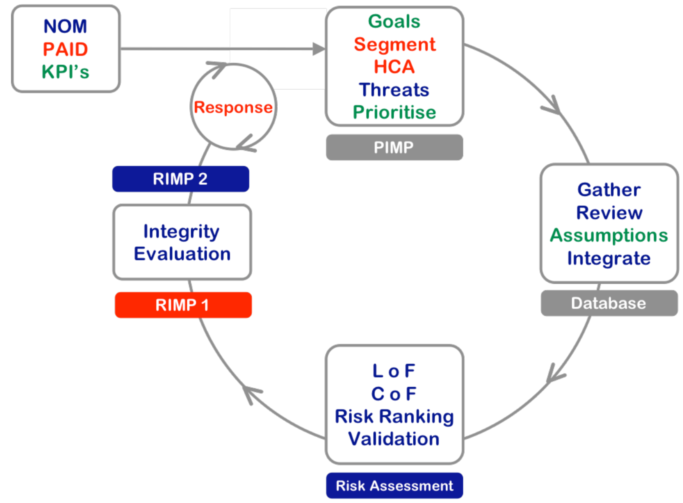

Figure 10: Potential Integrity Management Cycle to suit PEP Gathering Lines

PART 3

HIGHLIGHTING THE TRAITS THAT ARE NECESSARY TO ENSURE THAT GREAT BUSINESSES BENEFIT FROM SUCH INTEGRITY MANAGEMENT CYCLES.

There are proven benefits to the alignment of a pipeline operator's rhythm with the flow of an integrity management cycle; additional key traits that govern the effectiveness of the approach.

Businesses must be structured to facilitate the flow of an integrity management cycle. The dynamic way in which departments are organised, how they communicate and how they flow work interactively between teams all impact the harmony and effectiveness of the integrity management cycle.

Within these structures, leaders make a difference – they require sufficient domain knowledge and objectivity to organise and allocate resources in an appropriate manner. Additionally, they must be able to track, review and adjust performance. Their leadership traits must be coupled with an ability to encourage imaginative and creative response. This coupling can be found within every organisation that is considered to be successful.

Skill-set optimisation is common to all successful businesses. Gap analysis of workforce skills and those required to sustain the integrity management cycle must be integral to all threat and consequence considerations. Businesses that find effective and sustainable methods to close these gaps have a greater propensity to thrive. Seeking ways to secure acceptance and familiarity with new techniques resulted in a "learning-by-doing" approach as a central cornerstone of operating reliability methods amongst pipeline operators.

Other traits centre upon motivation and utilisation of the workforce. In Egypt one of the leading pipeline companies has developed a centre of excellence to develop team skills that can be contracted to neighbouring pipeline operators; practical skills such as cleaning, inspection and repairs. Among other benefits, this initiative has allowed viable workforce retention a level desired by their stakeholder, the government.

In examining Integrity Management from a business perspective, businesses with an open communication flow - from high-level goals, through to business strategy and onto integrity goals and objectives - are differentiated. The integrity management cycle brings best value when it is considered as an extension of a goal driven functional specification. This portrays the cycle as a means of ensuring pipeline health required and set out by the business & pipeline managers – implying that such health results in regulatory compliance as a by product of an iteration.

With effective goals and strategies in place, pipeline managers require well-defined processes to break down seemingly formidable tasks into a series of manageable steps. The processes sit as macro-processes above the integrity management cycle and micro processes within it. Well-managed processes also serve to provide support for decisions that result in the implementation of tasks and the appropriate choice of tools and technology.

Processes ensure that individual actions and tactics collectively result in the execution of strategy that in turn serves to meet the goals of the business. Any business process needs to be reviewed frequently to ensure that it is still the appropriate vehicle for delivering goals in a changing business environment. They should be organic in that they are capable of being adapted to suit changing needs. The integrity management cycle is just one such process.

Finally, world-class businesses anticipate change and resistance to change. Continuous improvement cycles, by definition, involve change. The effectiveness of the cycle is governed by the degree to which such changes are facilitated throughout the cycle and beyond. A trait common to those companies who see most benefit from this structured approach to integrity management is that they accompany the approach with change management programmes. This advantage is underlined by change management considerations that are formally included within operating reliability systems aimed at improving pipeline & facility integrity & reliability on a company wide basis.

PART 4

CASE-STUDY, ILLUSTRATING HOW A CONSISTENT BUSINESS PROCESS WAS EXTENDED BEYOND PIPELINES AND SHAPED TO APPLY TO A PIPELINE OPERATORS' FACILITIES.

PEMEX implemented PAID, their structured approach toward pipeline integrity management, business-wide, in 2007. A PAID Process & Code of Practice, involving a consistent Integrity Management Cycle, was developed and refined in application. Within the context of a wider approach to ensuring reliability throughout their operations (PEMEX is a wellhead to consumer Oil & Gas company) PAID sits as one element within a component to ensure the "reliability of installations and pipelines". PEMEX sought to complete the other element with a comparable approach for installations – this was named PAICI – an acronym (in Spanish) for the Installation Integrity & Reliability Management Plan.

In developing the PAICI Process, applicable codes, standards and regulations were considered alongside existing PEMEX Maintenance Processes. Due to the strategic PAICI & PAID symmetry, when approaching operating reliability, a review of the existing PAID Process & Code of Practice was conducted to determine alignment & consistency wherever possible.

4.1 DESCRIPTION OF THE PAICI PROCESS

The PAICI Process was designed as an integrated, annual process that incorporates a continuous improvement cycle operating harmoniously with routine facility maintenance each year shown in figure 11 below:

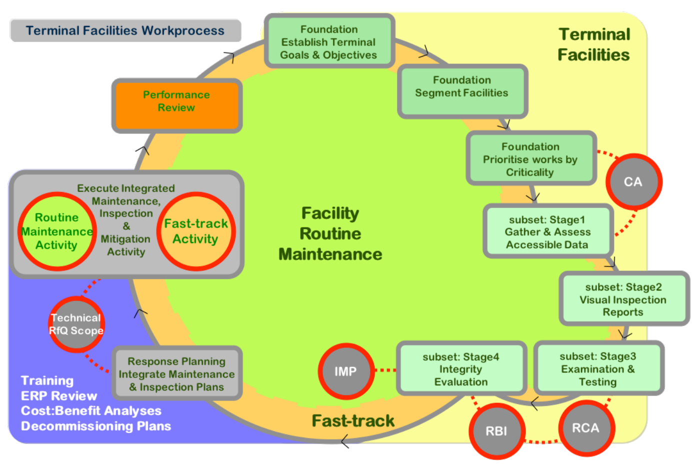

Figure 11: PAICI Process Illustration

The equipment, systems and installations are processed through the PAICI Engineering, Planning and Programming Process shown around the outside of the cycle, on an annual basis. This cycle can be seen to be comparable to that of the pipeline Integrity Management cycle. The cycle includes installation specific activities such as the application of the reliability methodologies, the development and optimisation of the resulting Maintenance Execution Plan, together with a performance review of activities and results for the current year before developing and issuing the annual Plan for implementation the following year.

4.2 PAICI ENGINEERING, PLANNING AND PROGRAMMING CYCLE

The following is a general description of the activities included in each step of the PAICI Engineering, Planning and Programming Process:

4.2.1 PLAN STEP

Cycle component A: Establish Goals & Objectives

This step of the cycle is carried out towards the end of each year and is initiated with a Goals & Objectives Workshop session, in order to establish the business Goals & Objectives for the following year. During the Goals and Objective Workshop session, the performance results from the previous cycle, along with the improvement and optimisation areas identified, are also reviewed and assessed along with the associated resourcing, funding, budgeting or timing constraints. Goals and objectives specifically related to the implementation of PAICI and the integrity and reliability performance of the installations are then established. Key Performance Indicators are used in order to monitor progress towards achievement of the Goals and Objectives.

Finally, the improvement and optimisation areas identified are evaluated against any established Goals and Objectives and incorporated into the final version of the Plan to be executed in the following year. This component is comparable to the Goal Setting and Planning elements that are performed within a Pipeline Integrity Management Cycle.

Cycle component B: Segment Facilities

As with Pipelines, the segmentation process is used to define the minimum unit of analysis to be used for the efficient application of reliability methodologies that will subsequently applied upon each installation. The segments must be small enough to provide analysis results that can be used to develop focused and appropriate maintenance plans, but not too small as to require the data gathering, processing and engineering to be unnecessarily complex to be of practical use when developing and optimising the resulting maintenance plans.

Once the segments are defined for each of the installations and for each of the reliability methodologies, the existing installation attribute data can be reviewed, validated and the data requirements for each of the segments defined. This component is comparable to the segmentation and data requirement plan elements that are performed within a Pipeline Integrity Management Cycle.

Cycle component C: Prioritise Works by Criticality

With regard to installations, concerning the initial stages of implementation of the reliability methodologies, this prioritisation process step is specifically required in order to ensure that effort is focused on ensuring the equipment and systems with highest perceived risk or at installations of more strategic importance are processed first. For this prioritisation step, a multi-disciplined team is established to evaluate the perceived relative strategic importance of the installations and the relative ranking of systems and equipment by perceived risk. This assessment of perceived risk, is based on the qualitative consensus of the team and using notional criteria such as equipment with known operational problems, failure history and prioritisation of the equipment which could most benefit from the application of the reliability methodologies for maintenance to be optimised. This prioritisation is to be used as a guide for the allocation of resources to focus data gathering and engineering effort on processing those areas where maintenance activities can most benefit from the application of the reliability methodologies rather than simply based on the equipment or systems with the greatest availability of data.

Though some comparisons can be drawn with the planning and fast tracking elements of the Pipeline Integrity Management Process, it is more appropriate to consider this component as being comparable to the engineering logic based approach to risk-assessment. In the case of installations, therefore, it can be said that this approach is proven to be beneficial as a stand-alone step, regardless of the criticality analysis or other reliability methodologies applied later within the cycle.

Cycle component D: Data Gathering

As a preliminary to this step, definition and agreement is made as to the database to be utilised to store, integrate and maintain the data gathered for each installation, in addition to the data format. The data gathering and integration priorities at each installation will have been defined in the earlier steps. The required installation, system and equipment data is gathered, validated and integrated into the database as an ongoing process and any missing information identified. Missing information can be substituted with data from published reference databases, however a protocol is in place that requires a review of the validity and source of any generic data to be used.

Naturally, this step is comparable with the data gathering component of a Pipeline Integrity Management Cycle; it is important to draw a comparison with the provisions that are put in place to ensure the cycle remains dynamic, rather than being stalled by a lack of immediate data upon early iterations of the cycle.

Cycle component E: CA (Criticality Analysis)

The critical nature of an installation is defined in a comparable manner of the risk associated with a pipeline, with the distinction that the frequency with which a failure happens substitutes the probability of failure calculation; this is then multiplied by the magnitude of the consequence. The Criticality Analysis is therefore carried out by determining the failure frequency category of the failure mode with highest impact and the total consequence score obtained. These results for each piece of equipment are then plotted on a Criticality Matrix to determine whether the equipment is deemed to have Criticality Range of high, medium or low.

Whilst broad comparisons can be drawn between the criticality analysis step of PAICI and the completion of risk assessments rankings within a pipeline integrity management cycle, it is clear that with less variables surrounding installations, the responses can be consistently applied to a smaller number of ranked groupings.

Cycle component F: Develop Maintenance Plans

The Maintenance Execution Plan for equipment with low Criticality Range remains traditional - based on the specifications of the manufacturer, recognised maintenance standards and using experience of that specific installation.

The equipment with high or medium Critical Range are subjected to more rigorous analysis and evaluation of reliability through the application of Reliability Centred-maintenance (RCM within an IMP) or Risk-based Inspection (RBI).

In the case of dynamic equipment with medium or high Criticality Range the RCM involves further data gathering and validation. The RCM process requires the development of a process diagram for each piece of equipment and the identification of failure functions and the effects and consequences of each potential failure modes. The maintenance strategy and technical feasibility is then evaluated for each of the failure modes and the maintenance frequency calculated based on cost and resources. The resulting maintenance activities for each piece of equipment are to be optimised and included in the Maintenance Execution Plan for implementation the following year.

In the case of static equipment with medium or high Criticality Range the RBI process also involves further data gathering and validation. The RBI process requires a review of previous inspection and maintenance data in addition to failure and repair history and a review of safety systems in place to detect, isolate or mitigate the effects of a failure. Installation systems and subsystems are identified and equipment groups determined by inventory and by corrosion mechanism for the purposes of the RBI analysis. A Qualitative Risk Assessment (QRA) is then conducted by determining Failure Probability Factors and Consequence Factors in order to determine the Risk Level of each equipment group. On the basis of these results the required inspection plans are developed for each equipment group or system in accordance with API 510, API 570 and API 653. The inspection plans are then optimised, with details included in the annual Plan for implementation the following year.

In the case of equipment or systems with chronic failure history or with high impact failures, irrespective of the Criticality Range, the proposed reliability method to be utilised is that of Root Cause Analysis (RCA). This requires the identification of all potential failure modes and the typical impact, which is plotted on a pareto chart for prioritisation. Root causes along with potential solutions are then determined along with costs, impact and timing and these are evaluated using a cost benefit analysis and prioritised. The resulting maintenance activities identified are to be optimised, with details included in the annual Plan for implementation the following year.

Broadly comparable with the Response Integrity Management Plan that is developed for pipelines, the Maintenance plans are risk-based and include the provision for further fine tuning and prioritisation as a result or subsequent risk discoveries. This underlines the truly dynamic nature of a continuous improvement cycle.

4.2.2 DO STEP

It is important to understand the implementation of the works identified during the Plan Step is undertaken within the "inner cycle" – that of the Maintenance Execution Plan. An important distinction between this approach and that identified within the Pipeline Integrity Management Cycle is that this twin-cycle formation allows for the complete integration of all maintenance activities – not just incremental task of those that are highlighted as a result of the Plan Step.

4.2.3 CHECK STEP

Cycle Step G: Performance Review

This Performance Review stage includes the review of the operational, integrity and reliability performance of each Installation and includes the results of Key Performance Indicators (KPIs).

The Performance Review stage also includes a review of the maintenance actually executed within the "inner cycle" against the plan for the year. A validation is also carried out during this stage to ensure that the records have been updated in order to maintain accuracy and to reflect any installation changes carried out throughout the year.

Finally, the overall performance achieved in the year is then compared to the established Goals & Objectives with the specific purpose of identifying improvement and optimisation areas. The output of the Performance Review stage is then used as the input to the following stage of the process which is initiated with a Goals & Objectives Workshop session. This is used in order to establish the Goals & Objectives for the following year and to finalise and issue the subsequent years plans.

The Check Step is consistent across applications to both Pipelines and Installations – its effectiveness is dependant upon the consistency, strength and characteristics of the initial goals and objectives. When applied to installations, the Check Step incorporates greater focus on updating the records during this step, rather than doing so during the Adjust Step. The reason for this is clear below.

4.2.4 ACT STEP

The most obvious difference in applying an integrity management cycle to installations as opposed to pipelines is the apparent lack of an Act Step within the installation procedure. In fact, the PAICI cycle was developed as an adjustment to the overall maintenance rhythm, this means that the first iteration of the cycle was not a "fresh" activity. This has resulted in the activities prescribed within the Plan Step remaining as valid for subsequent iterations of the cycle a they are for the first. For this reason, it can be seen that the Plan Step incorporates the considerations of the Act Step – with the exception that record updates are required during the Check Step.

PART 5

CONCLUSIONS

In applying a structured approach serving to ensure improved security, safety and risk-control within Oil & Gas pipeline operations, it is worth noting that a continuous improvement process lies at the heart of that approach.

By aligning an integrity management cycle with the principles of continuous improvement, pipeline managers benefit from sound business logic integrated into their operational rhythm. This helps to maintain harmony between pipeline operations and the overall business – whether in the public or private sector.

Regulatory efforts are a potential technique to stimulate best practice in pipeline integrity managers. This is based on the consideration that regulators are attempting to implant an overall dynamic process into the day-to-day rhythm of pipeline operators, but are often only able to do so by calling for deliverables and reports that can best be produced as a by-product of such an integrity management cycle.

Though a continuous improvement process lies at the heart of effective integrity management, the impact of following the process is governed by the way a pipeline operator's business is structured, the priority with which the business seeks to lead and develop its people and the contingency that all planned changes must be sensitively delivered and accompanied by effective change management programmes.

In comparing the integrity management cycle, developed for pipelines, with one configured to suit installations a consistent approach is seen; this underlines the concept that these cycles are based in a continuous improvement cycle.

In contrasting the integrity management cycle, developed for pipelines, with one that was configured to suit installations some interesting differences emerges – rather than pointing towards disparity between the two cycles, these differences may indicate potential for the pipeline integrity management cycle to evolve in a manner that incorporates a more unified approach to operations and maintenance and that is configured with provisions for seamless sustainability in mind.

PART 6

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