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THE APPLICATION OF A STRUCTURED INTEGRITY AND RELIABILITY MANAGEMENT PROCESS TO PIPING, VALVES AND ASSOCIATED STRUCTURAL COMPONENTS TO STABILISE SYSTEM INTEGRITY

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ABSTRACT

An essential requirement of many oil & gas pipeline Operators, their customers, employees and the local community is the use of an effective Integrity Management Process. Through integrity planning and the use of predictive and preventative maintenance techniques, this process is used to proactively manage risk, maintain product integrity and optimising system uptime and availability.

By contrast however, many facility and marine terminal operators rely on reactive maintenance in order to minimise maintenance costs. This maintenance philosophy often delivers acceptable operational performance whilst systems are relatively new, but results in rapid deterioration as systems start to degenerate. This deterioration results in increased risk, loss of asset integrity and a reduction in system uptime and availability which affects the operator of the plant, their customers, employees and the local community.

This paper is focused on the application of a structured integrity and reliability management process in order to stabilise the integrity of the piping, valves and associated structural components at a 30 year old marine terminal. The piping systems have been suffering from significant system deterioration, high rates of failure and unplanned shutdowns, resulting in a lack of system availability, often for months at a time.

The review of this structured process will include the applicable codes and standards, the Criticality Analysis methodology used and the 4 stage Direct Assessment process adopted in order to establish the condition and determine the integrity evaluation of the systems. The initial project results and brief case studies will also be presented to demonstrate the benefits of this structured and focused approach.

INTRODUCTION

A number of audits and technical visits have been carried out to the Terminal Maritima Pajaritos over recent years and although significant maintenance and investment has been made to the Terminal, this has mainly been focused on the loading lines, docks and storage systems.

A routine NDT wall thickness calibration measurement programme was carried out in 2002 with the recommendation that significant large diameter piping sections were to be replaced as a result of measurements below retirement thickness.

Based upon the age of the Terminal, the increasing number of leaks and unplanned shutdowns in recent years, concerns were building regarding the integrity of the piping systems and its components. In 2009 and as a result of these safety concerns, PEMEX voluntarily down-rated the MAWP of all systems by 20% and also contracted the Universidad Autonoma de Nuevo Leon and PIMS of London Ltd to carry out an initial project to implement a structured integrity and reliability management process in order to manage risk by stabilizing the integrity of the piping, valves and associated structural components.

The initial focus of the project was to immediately gather all the existing data and system information, review applicable damage mechanisms for each system and carry out visual inspections. From the Visual inspection, 'Fast Track' data gathering actions were determined in order to carry out sample NDT calibration testing in order to ascertain the current condition of each system.

The Integrity evaluation of each system was then conducted and an immediate action plan, risk based inspection plan and a routine maintenance plan was developed for each system.

Also, due to concerns over the threat of imminent failures, an immediate review of current emergency response procedures was undertaken, in order to ensure that the consequences of any imminent failures can be effectively mitigated, wherever possible.

Finally, in order that the process of integrity and reliability of piping, valves and associated structural components, can be understood and sustained in the future, four training courses were developed and delivered to PEMEX personnel so that the principles of Integrity and reliability can be implemented at the TMP on an ongoing basis.

The implementation of this structured approach to manage integrity and reliability, along with a review of some of the preliminary project results is the subject of this paper.

NOMENCLATURE

ENT	Equipo Natural de Trabajo
CA	Criticality Analysis
DA	Direct Assessment
HP	Horse Power
KPI	Key Performance Indicators
NDT	Non Destructive Testing
PADA	Piping and Ancillary Direct Assessment
SCO	Sistema Confiabilidad Operacional
TMP	Terminal Maritima Pajaritos
WT	Wall Thickness

1. BACKGROUND AND HISTORY OF THE TERMINAL MARITIMA PAJARITOS (TMP)

The Terminal Marine Pajaritos (TMP) is located in Coatzacoalcos, Veracruz, 200m from the east bank of the Coatzacoalcos River. It occupies an approximate area of 205 hectares. To the north is the lagoon of Pajaritos on the south the federal highway Coatzacoalcos – Villahermosa and to the east are the industrial and Pajaritos Petrochemical Complexes. Refer to Fig. 1.

The principal objective of the TMP is the receipt, storage, reformulation, distribution and transport of hydrocarbons and petrochemical products. It receives products from the Minatitlán refinery through 10" and 12" by 27.5 Km Polyductos pipelines in addition to a 14" by 33Km Combustoleo pipeline. Petrochemical products are also received from the Cangrejera petrochemical complex for loading onto bulk tankers for export or to the Marine Terminals of Lerma and Tuxpan. Alternatively products can be routed through TMP piping systems for storage and subsequent distribution. Products can be imported from the Marine Terminal Madero and if required can also be sent to the Minatitlán refinery through the Poliductos pipelines.

To carry out this function TMP consists of the following infrastructure:

- 58 tanks with total capacity of 7,960,000 Bbls
- 6 pump houses with 101 pumps equivalent to 47,425 HP
- Building areas 59,650 m2
- 27 piping circuits equivalent to 193,775 m
- 12 electrical substations
- 8 wharves with 14 docking positions
- 17 metering skids
- 9.5 Km intercomplex piping racks

The Terminal Marítima Pajaritos is considered an installation of strategic importance within the PEMEX infrastructure. After construction the terminal benefitted from many successful and highly reliable years of operation. However in recent years the TMP has suffered from increasingly high failure rates and unplanned system shutdowns. Through the use of an experience operational maintenance team and temporary repair clamps etc., systems were generally brought back into operation quickly and efficiently. However, although this reactive maintenance philosophy has been very successful for the TMP in sustaining up-time, after 30 years of operations, in an aggressive environmental climate, the piping, valves and associated structural components have deteriorated significantly. This has resulted in increasing concern over system integrity, reliability and safety in recent years.

In addition to the safety and environmental concerns of crude oil and refined product leaks, these failures have also resulted in some systems being shut down for significant periods for repairs to be carried out. The consequence of these shut downs has been that alternative arrangements need to be made to transport products to the terminal by road tanker rather than through the TMP piping systems. This results in supply uncertainty, logistics complexity and significant cost.

In order to stabilise the integrity and reliability of the TMP systems and to implement a future-proof and sustainable integrity process, as part of this project PEMEX wanted to establish a Centro de Administracion de Integridad (CAI) at the Terminal. This CAI is now located in a dedicated office including meeting room facilities and is used as the base for all the personnel involved in the integrity and reliability management of the Terminal. It also provides a central library of all system data, information and records to be stored in one place which allows easy access to the most up to date information and to the appropriate integrity experts in order to enable fast and efficient integrity and reliability decision making to be made.

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2. THE INTEGRITY AND RELIABILITY MANAGEMENT PROCESS CYCLE

The implementation of the structured integrity and reliability management process cycle provides the overall strategy and implementation plan for the management and optimisation of integrity and reliability of the installation and is governed by the over-arching strategic framework of Sistema de Confiabilidad Operacional (SCO). Refer to Fig. 2.

This structured process was used to ensure that the project was carried out on the 20 highest priority piping systems of the 27 systems at the TMP. The project was carried out in a systematic manner, that information was integrated between each step of the process and that the project was also aligned with the TMP business goals and objectives.

The works were governed by the appropriate PEMEX and international API and ASME codes and standards applicable to process piping and terminal operations, such as ASME B31.3, API PUB353 and ASME PCC-2.

The following describes the structured integrity and reliability management process.

A. Foundation Step: Goals and Objectives

This step of the Process Cycle was carried out at the beginning of the project, with one of the initial activities being to form the Equipo Natural de Trabajo (ENT). This team consisted of personnel responsible for carrying out the project, in addition to representatives from each discipline such as safety, maintenance and operations at the TMP. This team was a valuable source of information and historical reference and for the project. Fast and effective access to local knowledge of the systems, procedures and failure history was considered to be particularly important, due to current concerns over system condition and the risk of imminent failure.

The integrated integrity and reliability management process cycle was initiated by the ENT with an initial review of the scope of work, project plan and historical performance and issues associated with the systems. This was then used as an input to the development and agreement of project goals and objectives which were aligned and consistent with the overall TMP business goals and strategy.

Once the project goals and objectives were established, a review session was held in order to discuss and agree the Key Performance Indicators (KPIs), important to PEMEX and applicable to the project. This included a discussion regarding operation priorities, historical performance, failures and the fact that PEMEX had voluntarily down-rated all the piping systems by 20% from MAOP, as a safety precaution. On this basis, Key Performance Indicators for the project were then finalised in order to monitor progress throughout the project towards achievement of the goals and objectives. Refer to Table 1 below

KPI	Equation	Goal
Availability	Hour available * 100/ Hours of the time span	100%
Failure Frequency	# of Failures/month	0
Safe Operating Pressure	Safe Operating Pressure/ Desired MAOP	0,8

Table 1 – Key Performance Indicators

In addition to establishing project meeting, reporting and communication protocol, the key PEMEX and international codes and standards to be adopted for the project were reviewed and agreed. This formed the basis of one of the foundation aspects of the project which was to gather and review the applicable NORMAS, internal PEMEX standards, along with all the applicable international codes and standards that apply to the integrity management of the Terminal piping systems and associated components. This analysis and the library of the codes and standards would then be held in the CAI and used as a future reference source for the future integrity and reliability management of the terminal.

The key Codes and Standards utilised are as follows:-

ASME B31.3	Design and Installation of Process Piping
API PUB353	Integrity Management of Terminal and Tanks Farms
API 570	Piping Inspection Code
API 571	Damage Mechanisms affecting Fixed Equipment
API 579	Fitness for Service
API 580	Risk Based Inspection
ASME PCC-2	Repair of Pressure Equipment and Piping
DNV RP G103	Non-Intrusive Inspection

B. Foundation Step: Segmentation

The systems to be analysed as part of the integrated integrity and reliability management cycle needed to be defined in terms of individual segments to be analysed. These segments are to be small enough to provide analysis results that can be used to develop focused and appropriate Fast Track actions and maintenance plans. However, the segments must not be too small as to require unnecessarily complex data gathering, processing and engineering to be of impractical use when developing and optimising the resulting actions and plans.

The TMP piping systems are segmented operationally into three segments. 1. Supply piping system to storage tanks, 2. Storage Tanks to pump suction, 3. Pump discharge to Wharfs. However, segmenting all the systems using this reference would result in very large and complex segments to analyse, as the systems do not physically run in parallel on the plant. An alternative segmentation methodology that was also considered was based on product type, as this could potentially group systems by susceptibility to similar damage mechanisms. For example, in this case it would have identified those systems considered to be susceptible to internal corrosion, by differentiating Crude oil systems from the remaining refined products systems.

However, on review, the conclusion was to segment based on one circuit for each product stream, forming the entire supply, suction and discharge piping system to the wharfs.

C. Foundation Step: Prioritisation and Criticality Analysis

During the initial stage of the project, this prioritisation process step was specifically required in order to define those systems to be included in the project scope of work. Thereafter, it was used to ensure that effort was focused on ensuring that systems with highest perceived risk or strategic importance were analysed and their integrity assessed first.

For the prioritisation, it was essential that the multi-disciplined Equipo Natural de Trabajo (ENT) team was utilised in order to evaluate the strategic importance and perceived risk of each system and to assist in generating the relative ranking of the 27 TMP piping systems. This notional prioritisation was based on the consensus of the ENT and using qualitative criteria such as systems with known operational problems, failures or with potentially high failure consequence. However, as this project was only to include 20 of the 27 TMP piping systems, all of the systems were prioritised and the 20 systems with highest perceived priority defined and included in the scope of work.

This ranked prioritisation was then used to define the allocation of effort and resources in order to focus the data gathering and engineering effort to those systems which would provide the most benefit from the application of the reliability methodologies. Rather than simply processing those systems with the greatest initial availability of data.

Once the 20 systems included in the work scope were defined, the data gathering process was initiated. Data for the systems was downloaded from SAP; however, only basic system attribute data was stored. Therefore despite the fact that all available system information was collected, very little design, construction, operational and maintenance data actually existed. However, comprehensive NDT wall thickness calibration data was available across the TMP from a project undertaken in 2002.

The 20 systems were then subjected to a Criticality Analysis. This is a ranked assessment of the critical nature or risk of a system and is defined as the frequency with which a failure happens multiplied by the magnitude of the consequence. However, as this analysis requires a significant amount of information and historical data, this had to be compiled and the Criticality Analysis completed on the basis of interviews with the key maintenance and operational staff at the TMP. Also, an important input for the CA was the failure and repair history for the TMP however this information had not been gathered or collated previously. Therefore, it was necessary to compile the failure history from reviewing the entries in all the operational daily logbooks for the last 5years, in order to build up leak history. We also had to determine, with members of the ENT, the location and corresponding piping system associated with each leak, along with information relating to repair time and cost etc.

Once all the failure and repair history and other system data was collected, the Criticality Analysis was 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 system were then ranked and also plotted on a Criticality Matrix to prioritise the systems and allocated a high, medium or low Criticality Range.

The results of the Criticality Analysis were then used to re-prioritise the 20 piping systems and to re-programme the integrity and reliability activities. The results of the Criticality Analysis are included in Fig 3.

D. Integrity Assessment Process

Following the system priority established as a result of the Criticality Analysis, the integrity assessments were conducted. These integrity assessments were carried out by utilizing the experience and recent developments in the field of Direct Assessment. For this application a new Direct Assessment methodology was developed for the evaluation of the piping systems, mechanical joints, valves and the structural piping supports, integral to the system. This Direct Assessment application is termed Piping and Ancillaries Direct Assessment (PADA)

The PADA methodology utilises established DA principles in order to assess integrity and is a compilation of four methodologies, each one intended for the assessment of a specific component of the piping system: the piping itself, the valves, the mechanical joints and the supports.

The four stage PADA process is described as follows:-

Pre-Assessment - Gather and Assess Data

For piping, the main objective of this stage is to identify the susceptible damage mechanisms that affect the piping in a particular system. This identification was done comparing system data and information against API 571 in order to assess the susceptibility of the systems to each of the damage mechanisms.

As result of this analysis, external corrosion (in contact areas with supports) was identified as the main threat to the integrity of piping in the TMP, along with other possible active damage mechanisms being identified for each system such as Corrosion Under Insulation, microbiological induced corrosion and erosion, amongst others.

Having identified the mechanisms, the systems were segmented into susceptibility circuits and a review of the previous NDT records from 2002 was undertaken. Visual inspection activities were then planned with a view to identifying metal loss areas affected by external corrosion. For damage mechanisms imperceptible through an external visual inspection, the objective was to identify the most appropriate locations and NDT testing methodology to be adopted to identify these damage mechanisms during the subsequent detailed inspection.

For valves, this stage was focused on identifying susceptibility to external leaks (through the stem, fittings and flanges etc) and internal seat passing failure modes. In order to achieve this, a model was developed in order to correlate the service and other operational conditions with such susceptibility.

For structural supports, a model was developed in order to judge the susceptibility to failure due to overload or because of reduction in the load carrying capability through deterioration of the concrete of the support or corrosion of the internal steel reinforcement structure.

During this stage all the existing system data was gathered and loaded into a database used to store and maintain all the information on each system.

Indirect Inspection – Visual Inspection

On the basis of the Pre-assessment, the Visual Inspection process was carried out on a system by system basis. This was used to identify and verify the presence, location and impact of the susceptible damage mechanisms. The locations for verification of the previous 2002 NDT results were also identified in addition to determining the condition of the piping system, including the review of all existing pipe repairs. The visual inspection of valves and supports were used in order to identify active external valve leaks in addition to any damaged or missing pipe supports.

The results of the Visual Inspections for each system were used to specify the ‘Fast Track’ actions required, such as NDT data gathering actions and in very severe cases, repairs considered to require urgent and immediate action.

Direct Inspection – Examination and Testing

Based on the results of the Visual Inspection of each system, field operations teams were mobilised to carry out the specified 'Fast Track' actions. These actions included activities such as UT wall thickness measurements, Guided Wave inspections in addition to NDT of welds and dents for the identification of cracks. On completion of these activities, the results were compiled, to be used in the determination of the impact of each damage mechanism, the remaining wall thickness, defect assessment and fitness for purpose assessment of each system.

For valves, in-service corrective maintenance actions (greasing, bolt tightening etc.) were developed in this stage in order to establish whether or not the leaks could be eliminated in-situ. Any valves with significant leaks that could not be corrected are scheduled for refurbishment or replacement.

A sample of pipe supports in a variety of conditions, were identified to be subjected to both Destructive (hammer test, compression test) and Non Destructive Testing (potential measurement, chloride concentration, etc.). Based on these results and the condition of the supports, repairs or replacements were recommended and scheduled.

Post Assessment - Integrity Evaluation

Based on the results of the Pre-Assessment, Indirect Inspection and Direct Inspection, the integrity evaluation of the piping was developed using API 579 procedures in order to calculate the actual safe operating pressure of defects and remaining life of anomalies. Due to a lack of previous wall thickness data it was not possible to calculate reliable corrosion growth rates for systems therefore a MAWP was recommended for each system based on scenario modelling.

Repair recommendations were made for each defect, on the basis of ASME PCC 2 guidelines and a review of suitability of all existing repairs was carried out against the above mentioned standard.

In order to prevent future system deterioration, mitigation actions were recommended based on an RCA analysis; those recommendations were divided in three groups:

a) Immediate mitigation actions: intended to re-establish the integrity of the system.

b) Medium and long term RBI: risk analysis using API RBI procedures were developed in order to determine the future integrity assessment dates based on risk mitigation. Also, specialized inspections were scheduled based on the RBI results.

c) Routine I&M plan: based on confirmed active damage mechanisms and for those not yet active but likely to be encountered, maintenance actions were selected to preserve the integrity of the systems, while inspection activities were chosen on the basis on their suitability for detecting, measuring and monitoring the discontinuities resulting from those mechanisms

E. Maintenance Planning Integration

On completion of the Medium and Long Term Inspection Plan Based on Risk and the Routine Maintenance Plans for each system, these will be consolidated and form the maintenance plan for each system. Driven by the philosophy of the CAI, this scope is to be combined with the requirements to maintain the long term management of integrity and reliability of the TMP and is to be developed into a PEMEX Technical Basis to be issued for public tender.

F. Execution of Fast Track Actions

These activities form the implementation of the 'Fast Track' actions identified for each system as a result of the implementation of the Integrity and Reliability Management Process Cycle. The execution of the 'Fast Track' actions are implemented in order to reduce risk and to mitigate against immediate threats to the integrity of the system. This stabilises the integrity and reliability of each of the systems in order to avoid leaks and to allow the system operational capability to be restored to full MAWP.

G. Performance Review

The Performance Review is carried out at the end of the project and includes a review of the executed 'Fast Track' remedial actions and the integrity and reliability progress and results achieved as a result of executing the actions. This improvement in operational, integrity and reliability performance of each system can be monitored and measured by reviewing the Key Performance Indicators results and comparing to the KPI baseline established at the beginning of the project.

A validation is also carried out during this stage to ensure that the database of information has been fully updated in order to maintain accuracy and to ensure all the system information is held centrally in the CAI.

Finally, the overall project performance is then compared to the project goals & objectives with the specific purpose of identifying future improvement and optimisation areas. The output of this Performance Review stage then provides the inputs required in order to initiate the next annual iteration of the Integrity and reliability management process cycle with the Goals and objectives stage in order to continue to manage and optimise the integrity and reliability of the TMP.

3. INITIAL RESULTS

In order to show the benefits of the application of this methodology below are the initial results from three case studies:

Case Study 1: Turbosina system

Existing condition before the project:

PEMEX were planning to rebuild the system (6950m of piping between 8" and 24") in accordance with the recommendations of the 2002 NDT study, based on the retirement thicknesses established in PEMEX standard AVIII-4. The system's design pressure is 10,5Kg/cm2 (150 psi) which was voluntarily down-rated to 9 Kg/cm2 (130 psi) in early 2009. However, due to safety concerns over leaks, PEMEX had shut down the Turbosina system completely.

The consequence of this shutdown other than the obvious operational inconvenience was the significant cost and logistics of transporting Turbosina from Salina Cruz and other producing plants by road tanker.

Therefore, as a result of the safety concerns of this system, an immediate Pre-assessment, Visual Inspection and Detailed Inspections were carried out and the result used to evaluate the system integrity. Immediate corrective actions were then established to enable the system to be brought back on line as fast as possible.

Main findings

From the inspections it was evident that external corrosion was the main threat to the integrity of the system, which had caused a severe corrosion problem at areas of contact with supports.

Also, three indications were identified which were judged as presenting an imminent failure risk, a localized corrosion defect, a highly corroded blind flange in the suction line and a partial line cut on the pump discharge line.

Nine previous repairs were identified in this system, six of which were installed contacting with pipe supports. Repair suitability was judged against ASME PCC-2 guidelines, resulting in the fact that two of them need further action in order to fulfil the requirements of the standard.

Achievements

After two weeks inspecting, analyzing and correcting imminent failure conditions, the system was returned into service at a de-rated pressure of 7 Kg/cm2 (100 psi). Immediate repairs were carried out using reinforcing composite material and the replacement of pipe sections was not considered necessary.

After finishing the whole PADA process seven additional non-metallic repairs were recommended and replacement of the non-metallic reinforcing plate at contacts areas with fully welded metallic patches was proposed in order to re-establish the MAWP to its original value. All these repairs can be implemented without the system being shutdown.

Also, system recoating and the installation of cathodic protection at road crossings along with an inspection and maintenance routine plan were recommended in order to ensure a remaining service life of at least ten years.

The focused action plan developed as a result of this project resulted in a potential cost saving of at least two orders of magnitude compared with the pipe replacement action plan based upon the 2002 retirement thickness recommendations.

Study Case 2: Combustoleo System

Existing condition before the project:

The normal operating pressure of the Combustoleo system was down-rated from 10,5 Kg/cm2 (150 psi) to 7 Kg/cm2 (100 psi) in March 2009. This decision was taken based on safety concerns due to failures in other systems.

Based on the recommendations of the 2002 NDT study, PEMEX planned to change approximately 500m of 6" pipe in this system.

Main findings

After carrying out the PADA process, Corrosion Under Insulation was found to be the main threat to the integrity of the system. Two non-repaired leaks were identified as a result of the visual inspection process, however no other imminent failure conditions were discovered.

Seven previous repairs were identified in this system, all of them non-commercial temporary repair clamps, installed on the pipe body. Permanent repair methods were recommended based on ASME PCC-2 guidelines for replacing the temporary clamps.

Achievements

As result of PADA implementation, sixteen new non-metallic repairs were recommended to be installed in order to up-rate the system back to the previous operating condition. All the repairs can be done without requiring the system to be shutdown.

System recoating and insulation replacement along an inspection and routine maintenance plan were recommended in order to ensure a remaining service life of at least ten years.

The action plan developed as a result of this focused project would provide a cost saving of at least one order of magnitude compared with the action plan based upon the 2002 retirement thickness recommendations.

Study Case 3: Succion de Crudo System

Existing condition before the project:

As with the other systems, the MAWP of this system was down-rated from 10,5 Kg/cm2 (150 psi) to 5 Kg/cm2 (70 psi) in March, this year. This decision was taken based on safety concerns and leaks suffered in this system.

Based on recommendations of the 2002 study, PEMEX planned to change 1500m of 36' pipe in this system.

Main findings

The main threats to the integrity of this system were found to be internal and external corrosion also a large number of gouges were identified in the circuit, which required further investigation.

The visual inspection identified one crude oil leak, however no other imminent failure conditions were discovered.

Eighty four previous repairs were identified in this system, forty three of which will require replacement based on ASME PCC-2 guidelines.

Achievements

As result of PADA process implementation a pressure test of the system was recommended. System recoating and chemical treatment of the fluid and maintenance routine plan were also recommended in order to ensure a remaining service life of at least ten years.

The action plan developed as a result of the focused project is extensive but considered to be more cost effective than the action plan based on the 2002 retirement thickness recommendations. However, the plan based on PADA methodology would not require extensive system shutdown and would also prevent future deterioration of the system, which was not contemplated in 2002 recommendations.

Finally, for all the systems corrective and preventative actions were recommended in order to ensure the integrity and functionality of valves, mechanical joints and supports in addition to an inspection plan intended to identify and monitor for conditions that could lead to the future deterioration or failure of these assets.

4. CONCLUSIONS

The use of an integrity and reliability management process is essential to maintain system condition, to avoid system deterioration and the increased risk of failure and unplanned system shutdown.

The structured integrity and reliability process including the PADA methodology adopted for this project was used to baseline and stabilise the integrity and reliability of the piping, valves and structural supports at the TMP.

The use of this structured process was applied very quickly and cost effectively to bring the Turbosina system back on-line and was also used for the Combustoleo and Succion de Crudo systems to identify immediate corrective actions based upon a fitness for purpose analysis and the requirement to up-rate the systems back to MAOP.

In addition to assuring the immediate integrity, the use of the PADA methodology also provides a medium and long term inspection plan based on risk, in addition to a routine maintenance and inspection plan to preserve and manage the future integrity and reliability of the system.

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Figure 1- Terminal Maritima Pajaritos

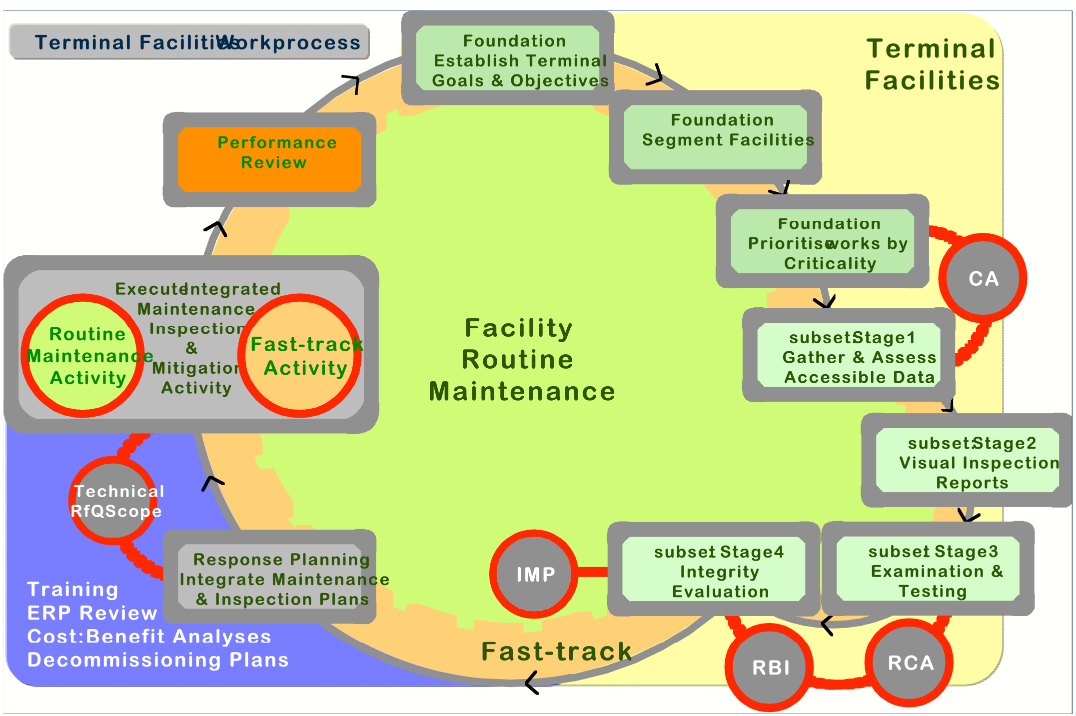

Figure 2 – Integrity and Reliability Management Process Cycle

FRECUENCIA DE FALLAS					
4					SUCCIÓN DE CRUDO
3			RECIBO DE CRUDO MAYA GASÓLEO RECIBO DE CRUDO OLMECA TAME ALQUILADO	TURBOSINA INTERCONEXIÓN DE GASOLINAS NOVA, AMORFA Y PREMIUM GASOLINA NAFTA DE IMPORTACIÓN	COMBUSTÓLEO LASTRE A MUELLES 3, 4, 5 Y 6
2			DESCARGA CRUDO A MUELLES 3 Y 4 RECIBO DE CRUDO REX TOLUENO PEMEX DIESEL DIESEL PRIMERIO	DESCARGA CRUDO A MUELLE 7 DESCARGA CRUDO A MUELLE 6 BENCENO	
1				PEMEX MAGNA PARAXILENO	
	3	6	9	12	15
	CONSECUENCIAS				

Figure 3 – Criticality Matrix of the Circuits