4th Middle East NDT Conference and Exhibition, Kingdom of Bahrain, Dec 2007
For all papers of this publication click: www.ndt.net/search/docs.php3?MainSource=57

Best-practice on RBI driven Integrity Assurance of Process Plant Items

A technology process to reliably optimise inspection efforts for pressure equipment assets

Nader Rahim BSc, MBA – Inspection Superintendent, GPIC, Bahrain
Ron Selva BSc, CEng, MIMechE – Principal Engineer, PP SIMTECH, UK

SYNOPSIS

In recent years, the applicable Legislation in a number of countries permits greater flexibility in the setting of inspection strategies (inspection intervals, methods and coverage) for pressure equipment and other static plant items, through the use of RBI (Risk Based Inspection) technology. It is a technology process which, when correctly applied, is used to formally optimise inspection efforts for each static equipment items of plant, whilst minimising equipment failure risks caused by the relevant deterioration mechanisms.

Noting that RBI is still a developing technology, this paper outlines a reliable and proven RBI driven equipment integrity assurance process which is believed to be at the leading edge of best-practice in RBI technology application. The role of NDT in this process cannot be underestimated.

It is currently being successfully implemented at GPIC, a well established operator of Ammonia, Urea and Methanol manufacturing plants. In this context, the paper also describes the challenges faced by GPIC, together with the RBI induced benefits which have been achieved to date, along with potential return on investment which can be attained in the future.

When the described technology is implemented at any plant site, it has been shown to deliver …..

- ❖ Enhanced integrity for each plant item (improved reliability & safety) through better understanding of potential deterioration mechanisms and vulnerable locations.
- ❖ More focused inspection strategies with reliably optimised interval and inspection activities for each equipment item, based on identified ‘active’ and ‘potential’ damage mechanisms.
- ❖ Reduction in number of items inspected during each turnaround, through extended inspection intervals for items which are found to be over inspected, and replacement of intrusive inspections with non-intrusive techniques for items where this is reliably feasible.
- ❖ Reduction in unexpected deteriorations usually found during turnaround inspections which in turn leads to reduction in unplanned repairs, thus avoiding over-run of shutdown period.
- ❖ Formally justified opportunities with recorded evidence to increase plant run-length time between turnarounds and optimise maintenance / inspection turnaround times.

- Better operational and maintenance control strategies to reduce equipment failure risks.
- Improved ‘working together culture’ and ‘asset care’ at plant site and improved self-assurance on reliability and equipment integrity.

In general, the RBI process described in this paper has been successfully applied to oil, gas, chemical, petrochemical and fertilizer manufacturing plants and many of these plant sites have reported attaining benefits beyond their initial expectations in terms of improvement in safety and reliability and the net return on financial investment.

1. TRADITIONAL INSPECTION PRACTICE – BACKGROUND

It is widely accepted that traditional inspection methods employed at prescribed fixed intervals for managing integrity of pressure equipment in service are not necessarily conducive to ensure safety and can contribute to high operational costs. Experience shows that a lack of adequate knowledge of applicable damage mechanisms, their causes and where they occur in each equipment item together with a lack of understanding of their risk profiles have led to:-

- In some cases, failures of plant items with unacceptable consequences, because inspections were not targeted to match all active and potential damage mechanisms applicable to an item.
- In most cases, unduly restrictive plant run-length times and/or costly individual item inspection plans (particularly unnecessarily frequent inspection of many items). It may be worth noting that unnecessarily frequent inspections do not necessarily improve safety.

The traditional inspection process is generally regarded now as reactive rather than proactive.

2. LEGISLATION AND RBI ASSURANCE STRATEGY - BACKGROUND

In many countries, the legislative process is effectively self-regulating with the ‘in-house’ inspection/integrity department at a plant site or an external 3rd Party inspection body defining appropriate levels of inspection. This has resulted in an industry move in recent years towards basing the integrity assurance and inspection of pressure equipment on a technically reviewed risk assessment process, since there are significant safety, reliability and economic gains to be achieved.

As a result of legislative changes, Risk Based Inspection (RBI) strategies and assessment methods have been developed in many forms to maximise benefits.

3. SUMMARY OF RBI ASSESSMENT METHODS

RBI assessment methods can be broadly divided into three categories …..

- That which relies primarily on expert judgment, known as 'qualitative'. It is a ‘screening level’ assessment usually used for identifying areas of plant at most risk but considered unsuitable for developing detailed risk based inspection plan on an item basis.
- That which incorporates statistical / probabilistic analysis and engineering calculations known as 'quantitative’. The procedure is complex and time consuming. For these reasons, it is generally regarded as very costly and little practical value to plant inspection engineers who are responsible for managing integrity assurance.
- That which incorporates informed team judgement and some engineering calculations known as 'semi-quantitative’. The ‘semi-quantitative’ approach is now widely regarded as part of the best practice RBI Assurance process [refs. 1- 5]. It is driven by a competent multi-discipline team study approach, similar to a ‘Hazop’ study.

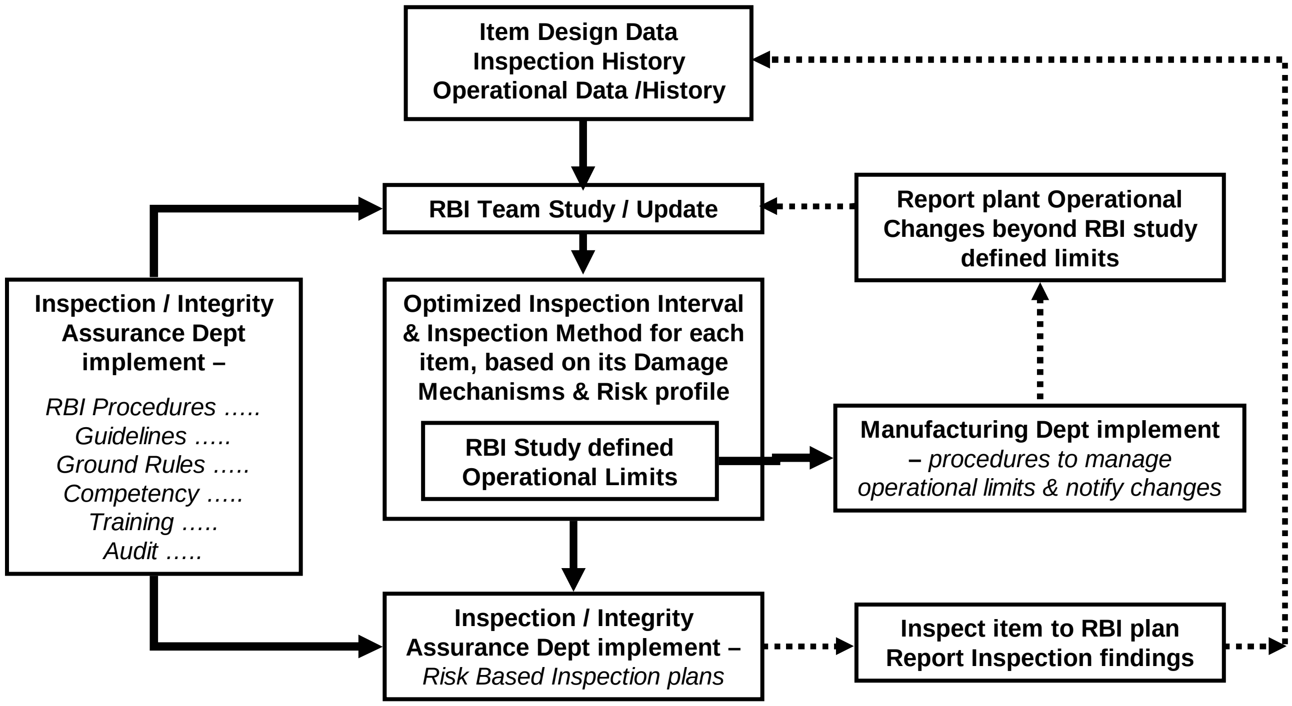
The RBI assurance process described in this paper is based on ‘semi-quantitative’ approach.

4. RBI DRIVEN INTEGRITY ASSURANCE PROCESS – WHAT IS IT?

Risk based integrity assurance is a proactive process used to understand the equipment risk profile at any particular time during its lifecycle and put in place strategies to manage, and reduce potential risks. Risk Based Inspection (RBI) forms a major part of this assurance process as applied to static equipment items of plant. It is an optimized inspection plan with other mitigating strategies derived from a detailed integrity risk assessment of each equipment item. In a typical chemical plant, the static equipment items referred may include reactors, distillation columns, heat exchangers, various other types of pressure vessels, reformers, boilers, fired heaters, piping, storage tanks, etc.

The assessment is carried out using a competent multi-discipline team study process and particularly focuses attention on all active and potential damage mechanisms, which could affect an item. This is followed by an evaluation of integrity risk profiles for each of the identified damage mechanisms for the item. Optimised inspection plan (inspection interval, method & scope) is then set up, which addresses each of the damage mechanisms applicable to the item, whilst ensuring the effectiveness / capability of the selected NDT methods match the identified damage mechanisms. Through this process the identified risks associated with each item are managed within defined acceptance levels, thus providing integrity assurance & reliability at optimum costs to plant owner.

The dynamics of the whole RBI process is shown in Fig.1. Procedures and responsibilities therefore must be set up to successfully manage the whole process at a plant site.



<u>Fig.1 'Best-practice' on RBI driven Integrity Assurance Model – a dynamic process</u>

4.1 <u>Implementing RBI Assurance process – 'best practice'</u>

Based on the foregoing, the implementation of 'best practice' RBI driven integrity assurance process for pressure equipment assets at a typical chemical plant site therefore requires:-

- An RBI technology process and methodology, which would provide the required self-assurance to plant inspection, mechanical and plant operation chemical engineers at site.
- Inclusion of best practice guidance for RBI technology application. In particular, the methodology must ensure reliable assessment of the risk profile for each of the 'active' and 'potential' damage mechanisms identified for an item. This must also be supported by appropriate 'ground rules' to develop reliably optimised inspection interval for <u>each</u> equipment item (i.e. to ensure equipment item integrity assurance is not compromised).
- An experienced multi-discipline team to carry out the RBI study following the methodology. The team study process for each item needs to be thorough, transparent and auditable.
- Procedures set up for reporting and managing any changes to equipment operational limits identified by the RBI team study. Identify affected items to assess effect of such changes on the inspection plans in place before such changes are implemented. Procedures set up for updating RBI study records & risk based inspection plans.

  Similarly, procedures set up for feed back of inspection results or new information on damage mechanisms / rates to assess effect on RBI plans in place. Procedures set up for updating RBI study records & risk based inspection plans as necessary.
- The software system must have adequate functionality and details to facilitate and support <u>all</u> of the above. The following are minimum …..
  - Needs to support the RBI assurance technology and the multi-discipline team study process
  - For <u>each</u> item, facility for recording team discussions, judgement and decisions

- Needs to be transparent on how the damage mechanisms (DMs) integrity risk profiles for an item are reliably assessed.
- Needs to be transparent on how the optimised inspection inspection interval for an item is reliably derived, based on identified damage mechanisms and the risk profile of each DM.
- All of the above records needs to be fully auditable, including RBI study data used, the initial RBI study and output, team members, subsequent Reviews and Updates.

5. RBI ASSURANCE METHODOLOGY - OUTLINE

This process covers the application of Risk Based Inspection (RBI) strategies to reliably and economically manage equipment integrity at chemical plant sites, which have pro-active commitment for the process from top level management.

The assessment process relies on the availability of historical operating data and previous inspection history and is therefore best suited to plant where this data can be reliably obtained. The technique is still considered of value for application to new plant, in terms of inspecting for the identified damage mechanisms and areas of vulnerability, whilst the inspection intervals developed must take account of greatly reduced availability of actual condition and reliable operational data.

The following section summarises the key elements of an RBI team study. It should be noted that RBI is a methodology to optimise inspection activities based on integrity risk assessment. As such, it is a critical process itself, which must be performed comprehensively and competently. The relevant managers at plant site must therefore be committed to providing the required resources.

Additionally, the **RBI technology used** to carry out the RBI team study **must be able to reliably assess equipment item risk profile** based on identified damage mechanisms. This is essential to the whole process **because the evaluation of optimised inspection interval for an item mainly depends on its risk profile**. Satisfying these requirements would help provide the required self-assurance to plant inspection, mechanical and operations chemical engineers.

It is also important that throughout the organisation RBI is not perceived as a one-off exercise to modify inspection periods and inspection scope but as a comprehensive risk based integrity assurance process for the lifetime of a plant. This involves responsibilities for plant operations chemical engineers to manage identified RBI dependent operational parameters within the agreed band. The initial RBI study and developed RBI plans also require reviews and updates accordingly, due to feedback of inspection results or due to operational changes. Procedures must be put in place to accommodate these tasks.

5.1 Best -Practice Aspects of RBI driven Integrity Assurance Process

The following points list the various mandatory elements, in order to provide an overview to what are considered the best-practice aspects within a reliable RBI Assurance process:-

❖ The RBI study must be carried out by a competent multi-discipline team the members of which each have suitable qualifications and experience. Normally team membership would be covered by five core team members:
  - RBI team study Facilitator
  - Plant Inspection Engineer
  - Plant Mechanical (or Maintenance) Engineer
  - Plant Operations & Process Engineer
  - Metallurgist (or Corrosion) Engineer

For audit reasons, team member names should be recorded in the study for each item.

- ❖ Training must be given to all personnel involved in the implementation of the RBI process.
- ❖ The RBI methodology used must be thorough, clearly defined and transparent. The application of the methodology and resulting documentation must be recorded in such a way that the study process, key discussions and decisions made are fully auditable and future reviews / updates are carried out easily and efficiently with minimum resource commitment.
- ❖ The RBI study data for each item (including design conditions, operating loads / fluid streams data and historical changes, inspection history) must be accurate.
- ❖ The methodology and the team study process must be thorough enough to provide high confidence in determining all ‘active’ & ‘potential’ damage mechanisms applicable to an item.
- ❖ The failure mode for each of the identified damage mechanisms should be determined in order to evaluate realistic consequence of failure.
- ❖ The consequence and in particular the probability of failure for each of the identified damage mechanisms applicable to an item must be reliably assessed by the team. From the assessment of the risk profile, the optimised inspection interval for the item must also be reliably evaluated against an acceptable risk profile for each of the damage mechanisms.
- ❖ The operational limits of key process parameters and maintenance issues (e.g. external paint coatings, fire-cladding & insulation) must be defined and the implementation audited.
- ❖ The study must consider confidence levels the team has in the assessment, which may be reduced, for e.g. owing to limited availability of data. The output must be adjusted accordingly.
- ❖ The process must include for the development of an inspection plan derived from the RBI assessment with consideration and specification of reliable NDT methods linked to the damage mechanisms. This inspection plan must consider the capabilities and effectiveness of NDT and the need for speculative and sample inspections to ensure that any unexpected deterioration is covered, particularly for high consequence items.
- ❖ The process must manage the transfer from current inspection plan to RBI driven inspection plan with consideration of the requirements of governing local legislations.
- ❖ The whole RBI process must be internally audited within the QA system.
- ❖ The site Inspection Dept shall retain full responsibility for RBI implementation.
- ❖ Specific ground rules to suit site must be identified and implemented in the RBI team study process to ensure consistent application and to avoid misuse of RBI technology.
- ❖ Procedure must be put in place at plant site to ensure that the RBI study output is embedded into the site practices and procedures including the management of future reviews & updates.
- ❖ A supporting software system should be installed at plant site to facilitate and reflect the RBI technology assurance and implementation process described above.

Based on experience, the foregoing process has been proven to provide improved reliability, safety and a reliably optimised inspection interval and inspection requirements for each item of plant.

5.2 The role of NDT in RBI driven Integrity Assurance Process

When the RBI technology process is used to justify extended inspection intervals, in particular for high consequence items, or extended plant run-length times between turnarounds, the role of NDT and the accuracy required of the inspection results in this process cannot be underestimated.

NDT plan - Need to match the Damage Mechanism (DM)

- Define purpose of NDT – [to detect DM or to assess DM rates or both]
- Define how to inspect, which components of the item, what methods and what coverage.
- Optimise balance between risk, effectiveness & cost. Depends on consequence & complexity.
- Invasive or Non-Invasive inspection?
  - Consider feasibility and benefits.
  - Need a structured decision process.
- Capability & Effectiveness of the technique and Reliability of results is key.
- More responsibility is placed on the NDT Engineers
  - Expected to be more proactive
  - Qualification and experience relevant to DMs
  - Accuracy of results – need to check calibration and question the findings at the time of inspection. If in doubt ASK. (*It is too late when the plant is back on- line)*
  - Better reporting of results to help update RBI study output and future inspection plans.
  - Need clearly defined procedures to narrow reliability gap between NDT engineers' performance to improve confidence in results and repeatability.
- Non-invasive Inspection [NII]
  - Decide in accordance with recommended practice
  - NII methods targeted and tailored – need data on degradation types / locations

6. FINANCIAL ANALYSIS OF POTENTIAL BENEFITS TO PLANT OWNER

To analyse whether RBI implementation is successful at a plant site, the plant site needs to define the short, medium and long term RBI objectives. Common objectives usually considered are:

- Improvement to equipment integrity assurance [enhanced reliability and safety] through better understanding of equipment vulnerabilities and resulting inspection strategies.
- Improvement to equipment availability & reliability and reduction in unexpected failures.
- Increased plant run-length time between turnarounds and reliably optimised (or extended) inspection interval and inspection activities for each equipment item.
- Replacement of intrusive inspections with non-intrusive techniques for relevant items and reduction in scheduled turnaround inspection scope for items which are over inspected.

Key Performance Indicators [KPI] should be defined within the RBI Assurance process for each of the selected objectives to monitor progress and the implementation must be managed as a project.

7. IMPLEMENTING RBI TECHNOLOGY AT GPIC – A SUCCESS STORY

The venture into new technology or improvement to any system has to be part of the corporate objectives of the organization for it to succeed and flourish. The decision for GPIC to implement RBI technology is part of the overall vision of the company to adopt state of the art, proven technology to enhance its asset reliability and safety. The main pillars that the company vision and mission are built on, formulated the main criteria for selecting, planning, and implementing the right RBI technology process in GPIC. The overall plan for the RBI technology process selection and implementation is shown in fig.2.

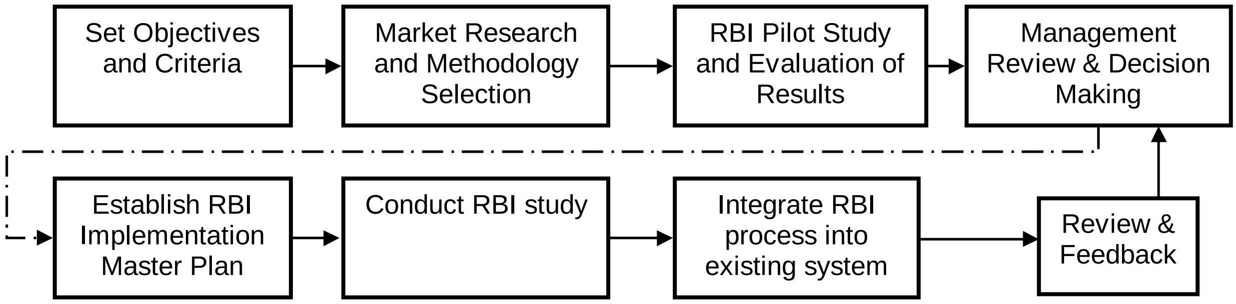


Fig.2. RBI Implementation plan of GPIC

The main objective of GPIC's venture into the adoption of RBI technology was to enhance and reliably optimise the overall inspection activities at site whilst improving each equipment item reliability and safety in a structured, scientific, and transparent way to meet the internal and external stakeholder requirements and expectations. In order to select the appropriate methodology from the many that were in the market, a number of criteria were set to evaluate the different options. The main criteria can be classified into Reliability & Robustness of the RBI technology process, Methodology for successful implementation, the Structure, thoroughness & Transparency of the RBI team study process, Simplicity of use, Flexibility, and Technical support.

After many presentations by RBI service providers and feedback from end users, the project was awarded to PP SIMTECH to provide the RBI technology process and support for implementation. Importantly, this RBI methodology included a proven technology breakthrough, which provides a process to easily and reliably assess the risk profile for each of the identified damage mechanisms applicable to an item. This in turn ensures that the resulting inspection interval is reliably optimized, thus providing the required confidence and self assurance to plant site staff responsible for equipment integrity and reliability assurance.

It was concluded that an open and transparent RBI study conducted in-house with the available experience and facilitated by PP SIMTECH would be more beneficial for the company for both short and long term. In order to ensure that the selected methodology would deliver the expected benefits and to get a feel for requirements of such methodology, a pilot study was initially carried out on a specific unit of the plant, before embarking on RBI full implementation.

The RBI pilot study was designed to include various types of equipment in the plant, to identify any shortcomings of the selected RBI methodology, to assess duration of the study and resource commitment and quality of the final outputs. Table –1 summarizes the outcome of the pilot study.

Table –1: RBI Pilot Study Summary

Equipment Type	**No. of Items**	**No. of Identified Damage Mechanisms**	**No. of Days (time taken for RBI team study)**
Heat exchangers	31	137	15. 5
Tanks	3	18	1. 5
vessels	17	66	8. 5
Columns	2	10	1. 5
Total	53	285	27. 0

The points below outline the findings of the RBI pilot study:-

- 21 items required ultrasonic thickness scanning at specific locations
- The study uncovered many potential damage mechanisms in areas where they had not previously been considered active. These damage mechanisms include various types of corrosion, fretting damage, caustic & chloride stress corrosion cracking and fatigue.
- Inspection intervals of 44 items could be safely and reliably extended.
- Non intrusive on-line NDT inspection techniques were included for some equipment items at an intermediate inspection period to cater for any uncertainty and improve confidence.

During the management review of the pilot study outcome, it was very clear that the selected RBI methodology fully satisfied the set objectives and criteria. Furthermore it was able to provide many other tangible benefits to the company, such as capturing process modifications, enhancing wider experience of the RBI study team members through knowledge sharing, and training of graduate engineers in plant operational influence on equipment integrity, failure analysis and troubleshooting.

After approving the methodology & allocating the necessary resources for full implementation of this RBI technology process at site, a master plan was established highlighting the number of items to be assessed every year, bearing in mind the other commitments of the RBI team members from the site. Table –2 highlights the master plan of the RBI study for full implementation.

Table – 2: Overall Project plan for RBI full Implementation

Items Planned/year for RBI Team Study

Facility	**2005**	*** Actual 2006**	**2007**	**2008**	**2009**	**2010**	**Total Planned**	**Completed**
Methanol	**152**						152	**100%**
Ammonia	**20**	**44**	10	27	25	0	126	**49%**
Urea	**0**	**12**	10	28	20	35	105	**11%**
Utilities	**0**	**0**	10	30	29	15	84	0%
Offsite	**0**	**0**	0	15	0	22	37	0%
Overall	**172**	**56**	**30**	**100**	**74**	**72**	**504**	**45%**

***** Actual completed up to December 2006

The **above plan is very flexible** with respect to core team availability & actual plant requirements.

7.1 <u>The key stages of the RBI team study process at GPIC for each item included</u> …..

In order to assist the facilitation of the RBI team study process, future reviews of the studies carried out and help to ensure transparency, auditability and consistency, the supporting software system rbiAsyst™ is being used. Additionally, for this purpose, full advantage is taken of the facilities provided in rbiAsyst™ to record data used, key discussions, judgments & decisions made.

As a background note, after reviewing many of the RBI softwares available in the market place against the best practices in developing RBI technology, the software system rbiAsyst™ was originally developed jointly by PP SIMTECH & BP Chemicals in 2002 to successfully support the implementation of best-practice technology process as described in Sections 4 and 5.

The key stages of our RBI team study included the following …..

1. Familiarization with item purpose, design, construction, materials & environment.

2. Detailed review of item inspection history & any repairs, modification and cause.
3. Detailed review of actual operational loads/duty and operational process fluids data and historical changes and excursions.
4. Focused discussion on the item by review against a standard list of questions in the RBI software rbiAsyst™.
5. Identification of all damage mechanisms (active & potential) based on stages 1 to 4, their causes & affected locations and other potential locations for damage occurring.
6. Team confidence assessment with respect to the item.
7. Reliable assessment of integrity risk profiles for each of the identified damage mechanisms leading to evaluation of latest inspection date for each damage mechanism applicable to item.
8. Development of risk based inspection plan for the item based on results of stages 5 to 7. It comprises reliably optimised inspection interval, inspection type, inspection method and inspection coverage for the Major and any Intermediate [usually non-intrusive] examinations. Specification of appropriate NDT as applicable to match the identified damage mechanisms for the item. The chosen NDT method(s) must have the required effectiveness and capability.
9. Checks to ensure the agreed RBI Ground Rules are adhered to when finalising inspection intervals for each item.
10. Identification of any critical operational boundaries, maintenance & NDT issues which may have a direct influence on the identified damage mechanisms applicable to the item and reliability of the inspection results. These are key parameters which if not adhered to can adversely affect the risk based inspection plans and the inspection results.

The team study for full RBI implementation at site started early in 2005. The relevant team members ensured that the required inspection and operational data was accurate and was populated in the RBI software rbiAsyst™ in advance of RBI team study meetings. The study was facilitated by PP SIMTECH and the complete team study is recorded in this software system for each item.

On average, approximately 2 - 3 items are completed per working day depending on the complexity of the item and the availability of the required data.

The initial periods of the study faced many challenges which were addressed during and after each set of study period. Corrective actions and management controls were implemented to ensure full commitment and smooth execution of the project. Below are some of the main challenges:-

- Availability of appropriate team members
- Quality of available historic (operational and inspection) data of plant
- Repetitive training of members to the RBI team

The benefit of the RBI study in terms of existing systems improvement was realised by GPIC from the pilot study phase and these are currently being addressed.

Any recommendations and actions resulting from RBI team study meetings including details of the team member assigned to follow-up the action and the closeout response are recorded in rbiAsyst™. This and other facilities catered for in rbiAsyst™ ensure transparency, auditability and reliable implementation of the RBI technology process. The existing inspection reporting system is utilized to report the follow-up work carried out as a result of these actions and recommendations.

A management review meeting is held to discuss the outcome of the study on a monthly basis and to improve on the overall process in terms of achieving the set objectives. One of the most significant outcomes of these review meetings was to adopt this RBI methodology to assess the integrity of piping systems and enhance the existing piping inspection program.

7.2 Benefits to GPIC …..

The main strategy adopted by GPIC to implement the RBI technology process is outlined in the foregoing sections. To date many benefits have been gained. These benefits, some of which are interlinked, can be broadly classified into the following four sections:

1) Enhancing plant equipment integrity & reliability through …..

- **a.** Identification of several new potential damage mechanisms ranging from various corrosion mechanisms, fretting, metal dusting, various H_2 & H_2S induced mechanisms, creep, stress relaxation cracking to various types of fatigue damage and many stress corrosion cracking damage mechanisms.
- **b.** Identification of vulnerable locations for these damage mechanisms and specification of inspection methods to reliably assess condition of each equipment item.
- **c.** Establishing a reliable and optimised inspection plan for each item. The optimised inspection interval, inspection method and scope of inspection are matched to identified damage mechanisms and vulnerable locations, whilst ensuring the risk profile for the item is acceptable within the optimised inspection interval set by the RBI team.

2) **Resource optimization**

   a. As anticipated, for almost 80% of the items studied, the previous internal inspection interval can be safely and reliably extended to at least double the existing frequency. This has a direct benefit on resource allocation requirements for routine and turnaround inspection activities. Additionally plant turnaround time can be improved.

3) **Strategic planning**

   a. There may be a few items in a plant which can be a barrier to achieve one or more of the set objectives. In this respect, this RBI technology combined with the supporting team study process has been found to be an excellent tool to identify and resolve complex item technical issues (e.g. reactors, reformers, strippers, furnaces, etc.). Accordingly, work has been identified to investigate and resolve any technical barriers in order to help achieve the required benefits for GPIC without compromising reliability or safety. It also provided the core information for a 10 year CAPEX equipment replacement strategy at plant site.

   b. The RBI team study, carried out by a competent multi-discipline team, provided a formal technical justification with recorded evidence for extending statutory examination of 36 items. This was one of the main factors restricting the desired uninterrupted plant run-length time between the turnarounds.

4) **Knowledge sharing & learning**

   a. As part of the RBI technology process, an extensive damage mechanisms document was developed by a team of metallurgists from both PP SIMTECH and their clients including input from GPIC. This document has captured in simple form the distilled information from four international standards and various codes of practice. It is now used at GPIC as a reference for all engineers and in conducting other studies such as HAZOP and Root Cause analysis at site.

   b. On average 2 graduate engineers participate in every RBI study session, thus enabling them to capture a wealth of wider experience of the multi-discipline team & history of the plant.

   c. Fiveway exposure of knowledge and experience sharing is acquired during the RBI team study between mechanical integrity/materials technology support, the inspection & reliability group and the operations & process engineering group.

   d. During the RBI team meetings, full advantage is taken of the facility available in the supporting software rbiAsyst™ to capture valuable knowledge of 'informed resources' at site to benefit corporate memory & facilitate effective transfer of technology to junior engineers.

8. CONCLUSION

The leap from traditional inspection practices to RBI driven equipment integrity assurance process represents a cultural change in terms of improving reliability and plant safety. This paper described the successful implementation at GPIC an RBI technology process, which is believed to be at the leading edge of RBI best-practice. It highlights the benefits which can be gained by properly adopting and integrating it in the overall culture of the Company. The many benefits that can be reliably achieved from adopting such a methodology as highlighted in the paper can range from enhancing the Company's overall strategic planning and achieving the set site objectives to multi-discipline knowledge training of junior engineers at site.

It is clear that there is no short cut to implementing RBI successfully. For any plant site wishing to successfully embark on RBI implementation, the chosen technology and the team study process must be robust and reliable and the process must be managed as a project. The success equally depends on fully understanding the implications of the methodology and the resulting benefits and most importantly recognising the role it will play in achieving the overall company objectives.

9. REFERENCES

1. UK Health & Safety Executive [HSEx] CHID [Control of Hazardous Installation Directorate] Technical Circular to HSEx Inspectors: 'Risk Based Inspection (RBI) – A Risk Based Approach to Planned Plant Inspection', 1999.

2. UK HSEx Research Report - 'Best practice for risk based inspection as a part of plant integrity management', 2001.

3. UK HSEx Gas and Process Safety Technology Division - 'Best practice for the procurement and conduct of Non-Destructive Testing' November 2000'.

4. Selva R A., Verdon-Smith, J., 2000, 'Inspection Strategies based on Mechanical Integrity Risk Assessments', 9th International Conference on Pressure Vessel Technology – Sydney, Australia, 9 - 14 April 2000.

5. Verdon-Smith, J., Riseborough, W J., Selva R A., 1998, 'The risk regulating process for maximising return from chemical plant pressure equipment assets', IMechE international conference 'Assuring It's Safe' – Edinburgh, UK, May 1998.

6. Selva, R A., Amphlett, G., 'High integrity pressure systems in service', IMechE international conference 'Pressure Systems: Operation and Risk management' – London, UK, Oct 1995.

7. API 580 / 581 - Risk Based Inspection / RBI Base Resource Document.

8. PP SIMTECH – 'Best practice on RBI driven Integrity Assurance process as applied to pressure equipment'.

9. PP SIMTECH – 'RBI Assurance System software, rbiAsyst™ '.