IMPLEMENTATION OF AN INTEGRATED RISK BASED INSPECTION (RBI) SYSTEM IN AN ONSHORE INSTALLATION

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Abstract:
Risk Based approaches for managing inspection and maintenance have emerged during the last decade as useful tools for optimising spending on asset integrity while managing safety and business risk. The more advanced quantitative methods allow prediction of the effect of inspection on the installation risk profile and assist in the development of optimised inspection programs. These methods have now started becoming mature thanks to the development of integrated software solutions, which exchange information with the plant databases, manage the execution of the inspection and maintenance programs and maintain evergreen asset and inspection data.

This paper presents the implementation of such an integrated RBI and Inspection system to an onshore installation in the Middle East. Field NDT inspections are conducted on selected equipment based on detailed RBI analysis and past inspection history. Asset data, inspection history and documents are centrally kept in a computerised system. This has the ability to store and view different types of documents and drawings. The system allows inspection and maintenance work orders to be created and monitored and it is able to communicate with other enterprise systems. A knowledge database is available for asset integrity activities. Data exchange is also facilitated with MS Excel importing/ exporting functionality.

1. Introduction

Effective Asset Integrity Management involves a risk based strategy for maintenance and inspection planning (i.e. condition-based). These strategies are associated with company and plant objectives with respect to plant availability and safety. Risk based methods such as Risk Based Inspection (RBI), Safety Integrity Level (SIL) Assessment and Reliability Centred Maintenance (RCM) can be used to rank system and equipment criticality and to develop strategies for maintenance and inspection to manage the risks. Strategies are implemented through detailed planning, organizing ('grouping' and 'job packing') and scheduling. Figure 1shows the overall process of Risk Based Maintenance (RBM) for a typical process installation, as implemented by DNV.

The working process is essentially divided into two main parts i.e. screening and detailed analysis. The objective of the screening process is to identify low risk systems and focus the attention towards the high risk systems, which are the main contributors to the operational risk i.e. safety, environmental and business risk.

Subsequent to the screening process, high risk tags are subjected to detailed analysis using RBI, RCM and SIL for management of safety-critical equipment so that inspection and maintenance strategies can be developed and implemented in the plant CMMS.

- RBI addresses the failure mode "fail to contain". It basically captures all process and associated utility systems.
- SIL is used for the evaluation of the instrumented protective functions such as ESD, fire and gas detection, blowdown.
- RCM covers all equipment and all other failure modes. It captures all the systems including process & utilities, electrical, safety.

Low risk system tags are not omitted, but appropriate strategies are identified and developed specifically for these tags. The items that need additional 'consequence mitigation study' are also identified in the process.

This paper concentrates on RBI and on the Inspection process in general, including inspection planning, execution, history recording/retrieval, and ever-greening.

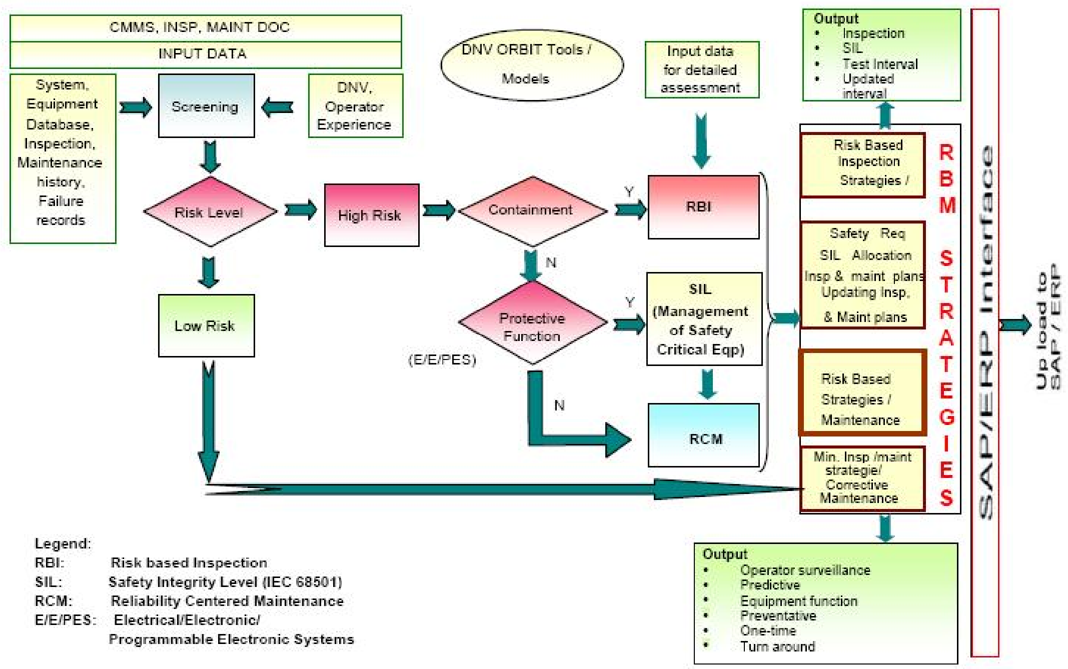


Figure 1: Risk Based Maintenance

2. Risk Based Inspection

2.1 RBI Methodology

In 1994 the American Petroleum Institute (API) decided to develop a Risk Based Inspection (RBI) methodology. The sponsor group of companies under API awarded the development contract to DNV. The methodology developed under API was published in 2000 as API 581 [1]. A more generic recommended practice was published 2 years later under API RP 580 [2]. The ongoing development is sponsored by 22 companies, represented on a special sub-committee on RBI, under the API Committee on Refinery Equipment.

As the API methodology was primarily geared to the needs of the refineries, DNV decided to further develop the quantitative RBI software and produced a new package "ORBIT Onshore". This has a robust architecture and a user-friendly efficient user interface. It also includes a fast interpolation approach for consequence analysis, based on the industry standard PHAST consequence analysis model. ORBIT Onshore can model any fluid if physical property data are available and it has a database of 1500 chemicals and about 1700 materials of construction (ASME). The software is currently available in English, French and Chinese.

Risk in RBI is defined as the product of the likelihood and consequence of failure. In mathematical terms, the risk for a scenario s is:

$$Risk_s = F_s * C_s$$

where, s = scenario number
F_s = failure frequency (per year) for scenario s
C_s = consequence (area in m^2 or cost) for scenario s

The failure frequency is estimated as function of time for the various active damage mechanisms, including external damage, general or localised thinning, SCC, HTHA, Brittle Fracture, Fatigue, liner failure etc.

The consequence analysis in ORBIT Onshore is based on an event tree approach. The main consequences are:

- Heat radiation & explosion effects on people and on equipment
- Toxic effects on people
- Business Interruption
- Asset repairs for non-ignited releases

Setting maximum acceptable risk targets is the standard method for defining inspection dates in the future. ORBIT proposes an inspection date, which avoids that the targets would be exceeded. ORBIT also proposes an inspection effectiveness.

2.2 Inspection Management

RBI provides a rational method for creating inspection guidelines (including inspection dates and effectiveness). On the other hand the inspection process involves a substantial volume of data and there is a need for a tool to facilitate the detailed implementation of the inspection plan, including resources allocation, scheduling, history data recording and follow-up.

ORBIT+IDS is such a software tool. Figure 2 shows an outline of the functionality of ORBIT+IDS, which is also used for document management and asset tracking.

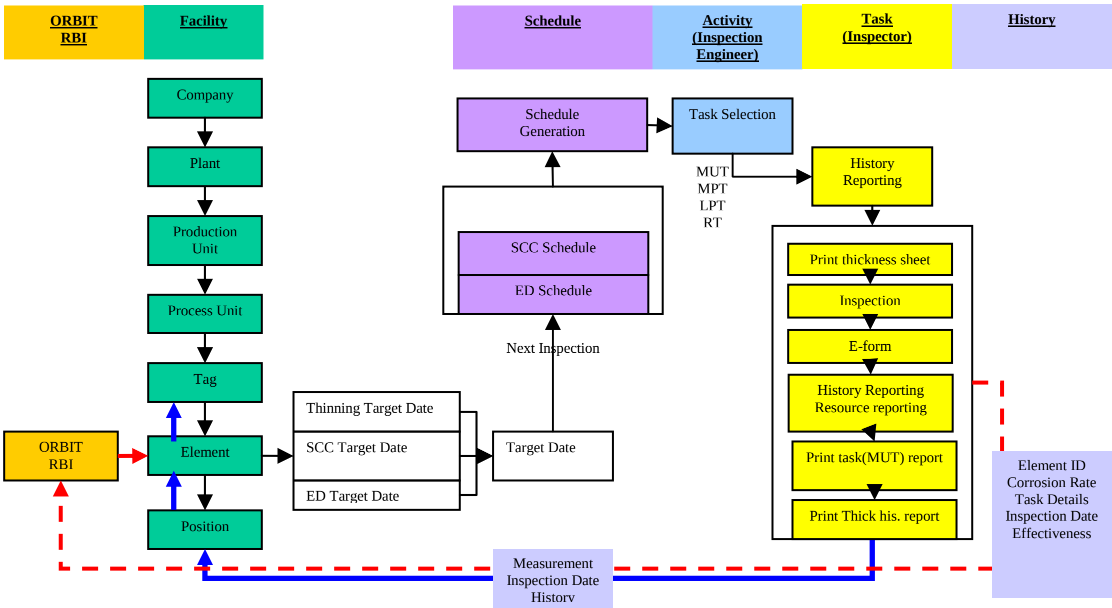


Figure 2: Inspection Management with ORBIT+IDS

3. Onshore Case Study

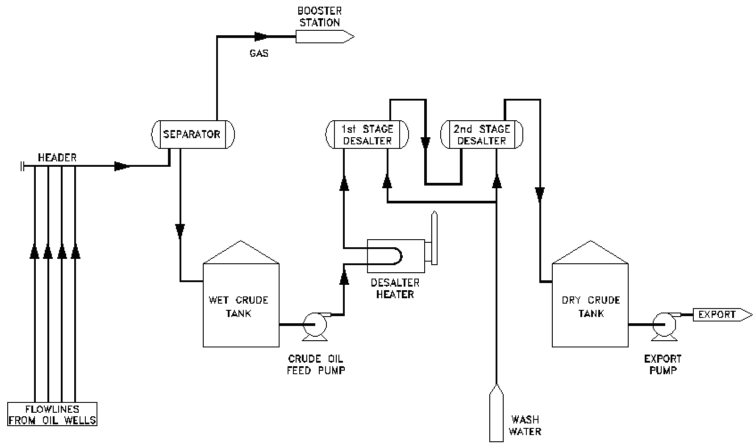
This is a case study of implementation of an RBI system (ORBIT Onshore) and an inspection software (ORBIT+IDS) on onshore installations of the Kuwait Oil Company (KOC).

3.1 Installations

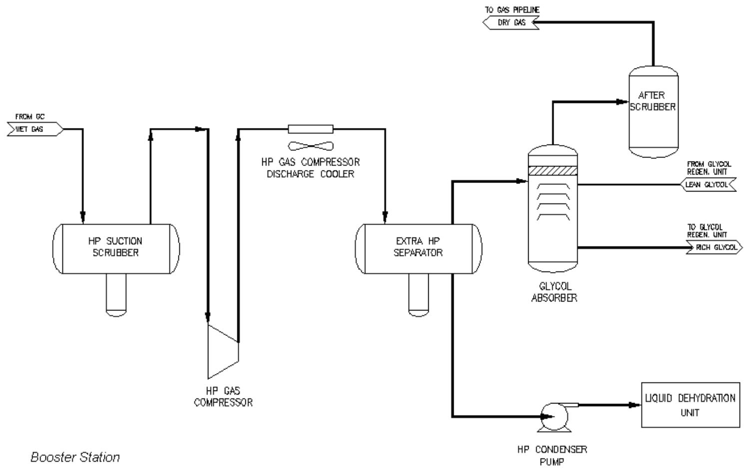
The KOC facilities in the scope of RBI work include 21 Gathering Centres and 3 Booster Stations. Figure 3 shows typical process flow diagrams of these installations.

a) Gathering Station
Oil from oil wells gathers through the header into gas-liquid separator. The gas is sent to the Booster Station, while the oil goes through 3 separation trains, before it is exported as stabilised crude.

b)Booster Station
Feed gases from the Gathering Centres go to the Booster Station for compression, dehydration and transmission by pipeline. This includes the following units:
1. Compression Train
2. Gas and liquid dehydration, mainly to provide protection against pipeline corrosion.
3. Gas Stream. Wet gas goes to the dehydration scrubber and then exported as dry gas.



Gathering Station



Booster Station

Figure 3: Onshore Installations in Kuwait

3.2 Inspection Project

The KOC RBI and Inspection implementation project included the following phases:

- RBI training.
- Supply and configuration of Inspection software (ORBIT^{+}IDS).
- Transfer of RBI and inspection history data into ORBIT^{+}IDS.
- Field NDT inspections for selected equipment, using MUT, GWUT and AUT on the basis of RBI.
- Fitness for service (FFS) assessment in accordance with API 579 (if required).

The total equipment count for the entire KOC is approximately 5000 equipment and 50,000 piping tags. To ensure the plant asset integrity, KOC has to organise a large database, and prepare inspection plans for an 8 years period. Implementation and monitoring of such massive task is a challenge for the company. ORBIT+ IDS proved to be valuable in translating the RBI inspection guideline into work instruction for the inspectors. The entire concept is for RBI to identify equipment for inspection at an appropriate time, taking into account inspection history. Beyond RBI analysis, all others steps like inspection plan or work instruction, inspection sketches and storage of inspection records are functions provided by ORBIT+ IDS.

3.3 Damage Mechanisms

As part of the total project consideration, the following "inspectable" or potentially active damage mechanisms were identified for evaluation:

- CO_2 Corrosion
- Wet H_2S Cracking
- Microbial Induced Corrosion (MIC)
- Internal Erosion
- Corrosion Under Insulation (CUI)
- External Corrosion - above and below ground
- Fatigue Cracking
- Brittle Failure
- Hydrate formation
- Corrosions applicable to the dehydration system
- Thinning is also split into two categories, i.e. general and localized thinning or pitting.

Wet H_2S SCC and MIC were observed. Some of the units are from the 70s and are unlikely to be constructed of HIC resistant material. We tried to capture all potential damage mechanisms into the RBI software. By modelling those in the RBI software, equipment with different damage mechanisms, material of construction, operating conditions and severity of damage are identified for inspection over a time frame. The inspection recommendations ensure that corrective action is taken, if defect is found. On the other hand, if the suspected damage mechanism is not detected, Orbit Onshore re-analyses the findings and either extends the inspection interval or treats the damage mechanism as unlikely. In this way, the system removes any oversight due to human error in planning.

3.4 Results

3.4.1 Orbit Onshore Output

The Orbit Onshore software provided inspection guidelines for all analysed equipment items in KOC. It essentially identified "which" equipment required inspection, "what" damage mechanisms to inspect for, "when" inspection should be conducted and the level of inspection effectiveness.

However the above inspection guideline is not immediately usable by the inspectors, who also require the following minimum information:

- Inspection method e.g. UT thickness measurement.
- Inspection sketch demarking the location for inspection
- Detailed Inspection record

In the past, inspection records were kept in filing cabinets and retrieval of the drawings was time consuming. It was obvious that inspection planning would be easier if RBI was integrated with an inspection software.

3.4.2 ORBIT+ IDS Solution

To overcome what is mentioned above, $ORBIT^+$IDS is designed to retrieve inspection records, store inspection plan sketches, store inspection records and produce reports. With such a system, inspectors are now able to:

- Identify all inspection to be done at any time frame in advance.
- Identify the appropriate NDT methods.
- Print out inspection plans together with sketches, data form and inspection records if required.
- Update inspection records electronically.

4. Conclusions

The implementation of a RBI system on an onshore facility in the Middle East has been described. Inspection planning is based on the DNV RBI tool ORBIT Onshore. The detailed inspection planning, recording and follow-up is greatly facilitated with an integrated inspection database system ($ORBIT^+$IDS).

5. References

[1] API, Risk Based Inspection Base Resource Document, API Publication 581, May 2000

[2] API, Risk Based Inspection, API Recommended Practice 580, May 2002