Ronald Tuls, Bron Hekkema, and Sebastian Ruik Beyhaut, The ROSEN Group, describe how a prioritisation plan can be created for out of service inspections at tank terminals using a risk based inspection methodology.

Considering the high economical risk of having an asset out of service, there is a need for optimal availability of tanks operating at an acceptable risk. Consequently, risk based inspection (RBI) has been adopted worldwide as a complementary tool to time based activities, not only for minimising asset integrity risk, but also economic risk.

Through a case study example, it is possible to show the steps needed to establish a master reference plan (MRP) containing a ranking of out of service inspections, using a prioritisation module on tanks at various terminals. This exercise is based on implementing an RBI methodology, where priorities for 21 tanks at seven different terminals are given, considering operations, safety and economical information.

**Risk based inspection**

RBI, as a risk based approach, concentrates specifically on the equipment and associated deterioration mechanisms representing the most risk to the asset. In focusing on risks and their mitigation, RBI provides a better linkage between the mechanisms that lead to equipment failure and the inspection approaches that will effectively reduce the associated risks. The main targets are to avoid catastrophic failures and unplanned shut downs; minimise and structure a service maintenance and inspections; and lastly, optimise planned shut downs.

RBI requires data gathering from many sources, specialised analysis, and risk management decision making. In most cases, one individual does not have the background or skills to single handedly conduct the entire study. Usually, a team of people with the requisite skills and background is needed to conduct an effective RBI assessment. A typical tank RBI team consists of:

- Team leader.
- Qualified tank inspector.
- Material and corrosion engineer.
- Tank design engineer.
- Operations and maintenance staff.
- Process specialist.
- Quality, environmental and safety personnel.
- Facilitator.

RBI needs to be an integral part of the quality system of a company. Management must be committed to the
RBI methodology and the tasks and responsibilities must be made clear. RBI is a process; therefore it can only be implemented by the end user. The tank owner is responsible and needs to decide on the used methodology, assumptions and consequences. Each tank owner will have a different RBI process implementation, although the methodology used may be the same.

The final deliverable of an RBI methodology is an inspection plan for the tank and its subcomponents. The inspection plan details the activities related to the current operation from a safety/health/environment perspective and/or from an economic standpoint. For risks considered unacceptable, the plan contains the mitigation actions that are recommended to reduce the risk to an acceptable level. The plan describes the type, scope and timing of inspections/examinations recommended.

**Case study: OCP Ecuador**

At the beginning of 2011, OCP approached Rosen with a request to implement an RBI methodology for their tank terminal. The aim was to have a structured tank inspection plan to optimise asset availability, and reduce both asset integrity risk and asset economical risk. This project implemented the tools and provided the services required for OCP, using a RBI approach to establish an out of service inspection plan.

A stepped approach was used to gather all required elements (Figure 1), which would allow an adequate prioritisation plan to be drawn up for 21 tanks.

**Figure 1.** Project workflow.

**Figure 2.** Corrosion degradation and rejection criteria within ROAIMS.

**Data gathering**

Many storage tanks/spheres had been designed and built by national or international tank contractors. There is often minimal knowledge available to the asset owner to determine whether a new tank is designed in accordance with common codes, equipped with the correct accessories, or built for a particular operational window (the strength of the tank). A full data gathering was carried out, using local interviews to perform a gap analysis for all missing technical data. The data gathering results were then integrated into the RBI process.

**External in service inspections**

The on-stream inspection was carried out in accordance with the API 653 requirements and led by a certified API 653 inspector. As part of the external on stream inspections, the inspection scope was defined as:

- Full detailed visual inspection of the tank, conforming to API 653 on stream inspection requirements.
- Tank shell thickness measurements by means of ultrasonic equipped crawler.
- Thickness measurements of the roof at various locations.
- For floating roof tanks:
  - Checking sleeves of the roof supports for corrosion.
  - Checking seals for degradation, failures and miss operations.
- Ultrasonic thickness measurement on shell and roof nozzles.
- Tank differential settlement.
- Plumpness/planar tilt.

**Initial data integration**

For the 21 identified tank data sources, data was integrated within ROAIMS for tanks. For these identified tanks, a number of activities were undertaken:

- Data hierarchy (structure).
- Tank creation.
- Integration of operation, mechanical and historical tank information.
- Document upload into a centralised document repository.
- Inspection information upload into a centralised tank database.
- Data quality check.

**Software implementation**

Based on the outcome of the initial work session, an implementation workflow was defined, which considered corporate IT guidelines, software setup, hardware and network connections, as well as any connections to third party instances (for example: rights management). Specialists then implemented the system on a server with the appropriate hardware and according software specification (provided by OCP Ecuador).

OCP Ecuador was handed over a comprehensive software suite, including all functionalities, server installation, data and the required capabilities to operate and update its RBI plan for the overall storage tank environment.

**Calculation and master reference plan**

Risk based decision making processes have become increasingly important as tools for managing a company's
activities, processes, products and services. RBI is one such tool used to determine the preventive inspection task requirements to achieve optimal tank availability with efficient maintenance efforts. While not intended as a rigorous method to determine design criteria, tank RBI brings a consistent methodology of risk assessment to maintenance, inspection and safeguarding of an asset. All RBI calculations were described in an RBI report, using the ROAIMS software for tanks.

The data required for establishing the next inspection dates (i.e. shut downs) was based on literature study, existing inspection history and experiences, as well as the RBI methodology. The corrosion rates, as found within the literature and suggested within the software, were compared with contractor and owner experiences, specifically to

Figure 3. Risk based inspection into master reference plan within ROAIMS.

Figure 4. OCP marine terminal, Ecuador.

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Training workshop, roles and responsibilities

RBI programs and integrity assessments of tank storage systems heavily depend on the accuracy and reliability of various input parameters to produce optimum results. OCP’s integrity team was trained to manage asset related data by means of a non-redundant and selectively accessible central database, thus supporting the integrity management methodology.

OCP integrity engineers needed to update their background or skills according to the latest best practices and regulations in order to conduct the entire RBI assessment in an effective manner. As such, tailored training was organised at early stages of the project.

All team members (tank inspectors, tank maintenance staff, operations staff, material/corrosion engineers, reliability engineers, etc.) received training on RBI methodology and on the program(s) being used. This training was primarily geared towards facilitating understanding and effective application of RBI. Moreover, the training helped them to further understand the technical integrity issues of tanks in general and the consequences of failure.

The way forward

Once the first tank goes out of service and possible corrosion is found in the tank bottom, any RBIs previously undertaken should be reassessed as more data on corrosion rates is gathered. The corrosion rate used for the remaining life assessment of the bottom of the tank should be a realistic value, not a worst case estimation, as used during the first RBI calculations. A conservative approach means that the assessment team considers using a higher corrosion rate than the actual expected rate. However, the initial conservatism is corrected during reassessment. Furthermore, to determine the corrosion rate for RBI assessments, a corrosion handbook for tank bottoms is started, and added to the corrosion books for shell and roof that are already available.

During the out of service inspection (bottom inspection) period, OCP had the opportunity to cross check the amount of corrective actions based on repair advice. This repair advice included suggestions as to how much effort should be expended on repairs, while reviewing the changes in risk associated with the next inspection interval of the tank. Into the future, the RBIs should be recalculated frequently using the latest information on corrosion rates.

OCP has already implemented an RBI methodology for tanks, which can be expanded into use with other assets, as the foundations for such methodology are already built up. An integrity approach for other assets (such as piping) has many steps in order to achieve its full purpose and objective. An initial element of implementing such a protocol is to identify the more significant threats/risks to the identified asset integrity as part of the initial screening level risk assessment. This will identify the most likely failure mechanisms that could lead to a loss of integrity. Further, the severity of a given failure is outlined so resources can be focused on the important areas. A suitable inspection plan will be the result of this risk analysis.

Conclusion

Establishing a prioritisation plan for a tank terminal is a time consuming activity. However, by using engineering experience, training, relevant code information and software solutions, operators can make more accurate decisions within short time windows, optimising tank availability.

Inspection costs can be more effectively managed through the utilisation of RBI. Resources can be applied or shifted to those areas identified as at higher risk or targeted based on the selected strategy. A major benefit is the development of a proactive tank maintenance prioritisation plan, which systematically reduces the likelihood of failures by making better use of the inspection resources and improving the reliability of the facility. Part of this planning process is the determination of what to inspect, how to inspect (technique), and the extent of inspection (coverage), thus helping to optimise the total cost of ownership.

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