Integrating Risk Based Inspection into Plant Condition Monitoring Software

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Abstract *- Risk Based Inspection Assessments are often used as a means to prioritize inspections for the next Turnaround (T/A). Inspection history and NDT data from software such as PCMS are needed for the RBI study. Once the RBI study is complete, the results are used to determine the scope of the T/A. Typically upon completion of the T/A, the RBI results tend to just sit in a binder or CD, and are never used again. Thus, the real issue is to find a way to integrate traditional NDT data gathered on daily basis with RBI analytical data gathered on a periodic basis. The introduction of RBI Integrator and RBI Calculator modules to PCMS merges these results into one database and addresses these issues. Within this framework, the paper demonstrates how the NDT and corrosion management data captured on a daily basis are integrated with RBI assessments to help create an "evergreen" inspection process that provides a current view of equipment integrity.*

Keywords: Risk Based Inspection, Corrosion Monitoring, NDT management

1. Introduction

In modern engineering practice, the term "Risk Based Inspection (RBI)" is used by the American Petroleum Institute[1] to denote Risk Assessment focusing on Mechanical Integrity of equipment inthe Petrochemical and Petroleum Industries. Within this framework, Risk Based inspection focuses risk assessment on maintaining integrity by minimizing the risk of loss of containment due to structural/mechanical damage of static equipment such as:

- Pressure Vessels
- Process Piping including safety valves and other piping components
- Atmospheric Storage Tanks
- Pressurized Storage Tanks
- Boilers, Heaters and Furnaces
- Heat Exchangers
- Pump and compressors (mainly casing and mechanical integrity – not functional)

RBI is the use of risk assessment to plan, justify and aid the interpretation of results from inspection, testing and monitoring. It should deliver fully developed inspection and monitoring plans that are consistent with the business objectives and regulatory requirements of the end-user. More specifically the RBI Inspection Plan must use the risk assessment to determine:

- What to Inspect (Scope)
- When to Inspect (Interval)
- How to Inspect (Method)
- Extend of Inspection (Method coverage)

In addition to the definition of Inspection Plan, Risk Management achieved through implementation of Inspection and Maintenance Planning, results in the following benefits:

- Increase Safety, Availability, Reliability
- Reduce number and duration of plant shutdowns
- Reduce scope of routine activities
- Reduce rate and impact of unexpected failures
- Resources prioritized for greatest effect
- Reduce costs

2. Plant Condition Monitoring Software

PCMS is the backbone of an effective RBI since it contains an asset database for all equipment & piping that are inspected and are part of a process safety management program. The intent is to help ensure that an effective asset integrity management (AIM) program is in place. To meet these needs, PCMS utilizes two key modules.

2.1 Corrosion Monitoring Module (Thickness)

The **Thickness** module allows plant personnel to track wall thickness on any piping or equipment. The patented risk technology analyzes reading data to recommend a next inspection date and estimate retirement dates. The thickness data is put through nineteen different tests to determine the next inspection date for each Thickness Monitoring Location (TML). Automatic retiring limit (T-min) calculators are available for use at each TML. The piping T-min calculator is based on ANSI B31.3 or B31.4 standards. ASME Section VIII code is used for pressure vessels, and API 653 standard is used to calculate T-min for storage tanks.

A critical step in monitoring corrosion is the establishment of Circuits. By definition a circuit is a zone of like corrosive behavior. Corrosive behavior is determined by the following four components:

- Process chemistry (service)
- Operating temperature
- Operating pressure
- Metallurgy

Changes in any of these variables may result in a change in the corrosive behavior of the circuit. For each circuit established, PCMS calculates corrosion rates and inspection due dates as illustrated in Figure 1.

2.2 Visual Plus - Inspection Module (Inspect2)

This module provides an organized approach for gathering, reporting, and evaluating inspection data. Inspect2 is an event-based record keeping system. Event based Report Formatting leads to consistent data collection for evaluation purposes. Event based scheduling parameters provide for the scheduling of future inspections. An approval process allows each facility to apply organizational requirements to approving events. Work requests and recommendations can also be tracked.

A key function of Inspect2 is to generate next inspection dates for equipment activities. Figure 2 lists the scheduling activities required for Tower TT100 and their corresponding due dates.

In addition, when performing the above inspection activities PCMS provides a checklist of items to inspect to ensure accurate & consistent inspection reporting. Figure 3 provides a sample inspection checklist when performing an internal inspection on a tower.

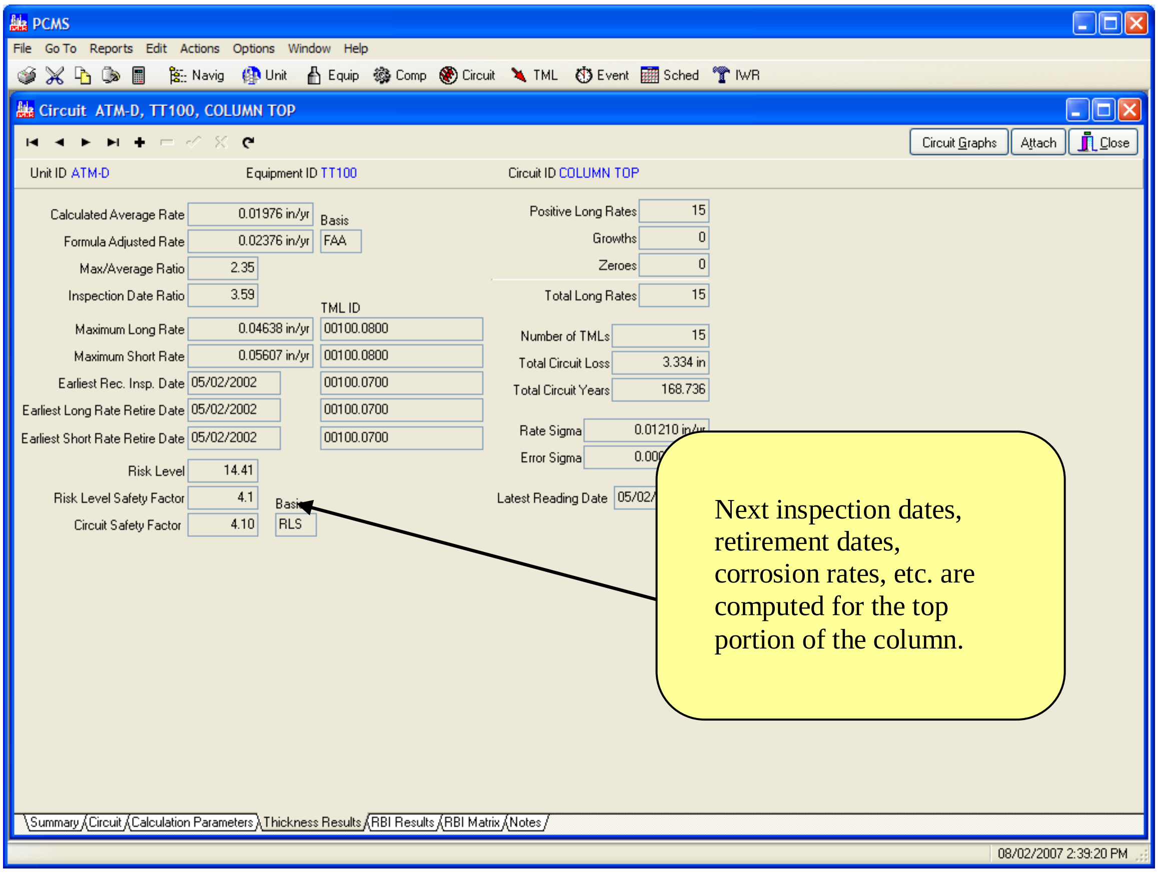


Figure 1: Calculated Values for Circuit Corrosion

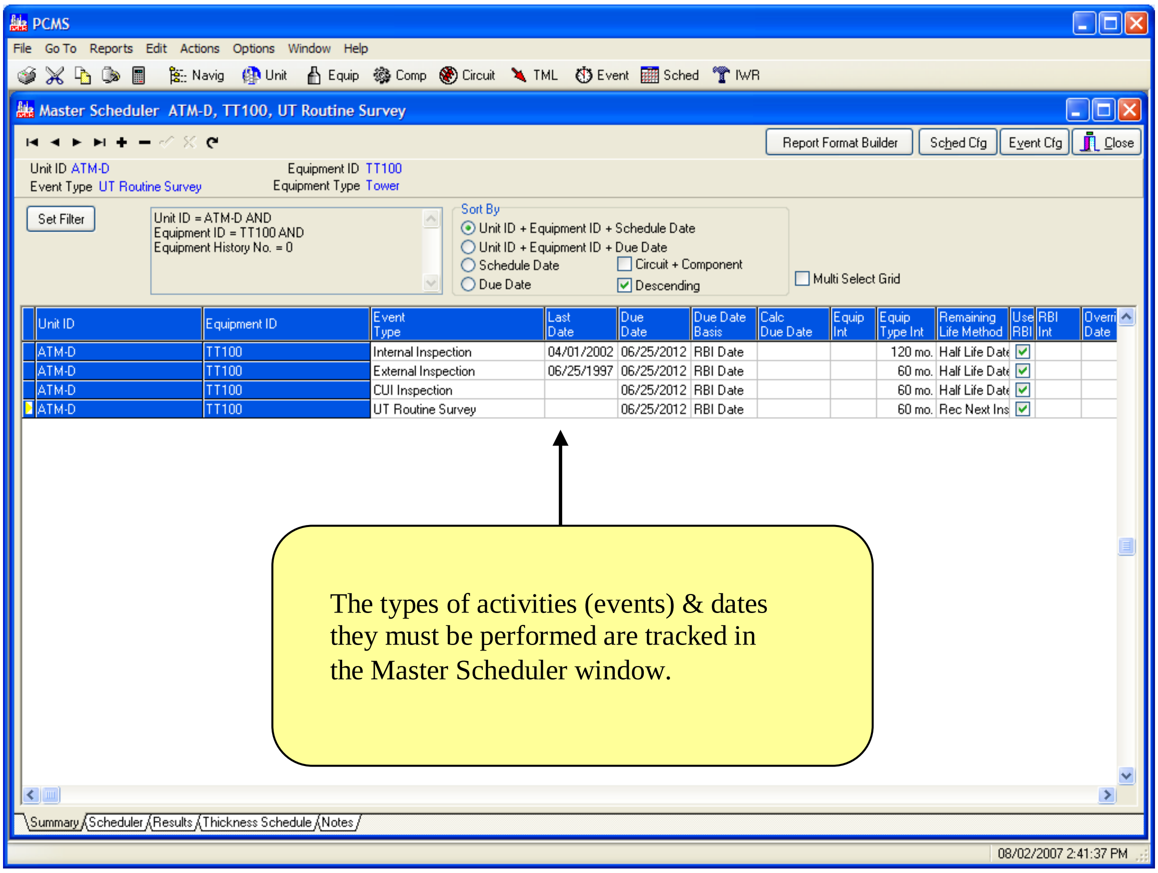


Figure 2: List of Inspection Activities and Due Dates

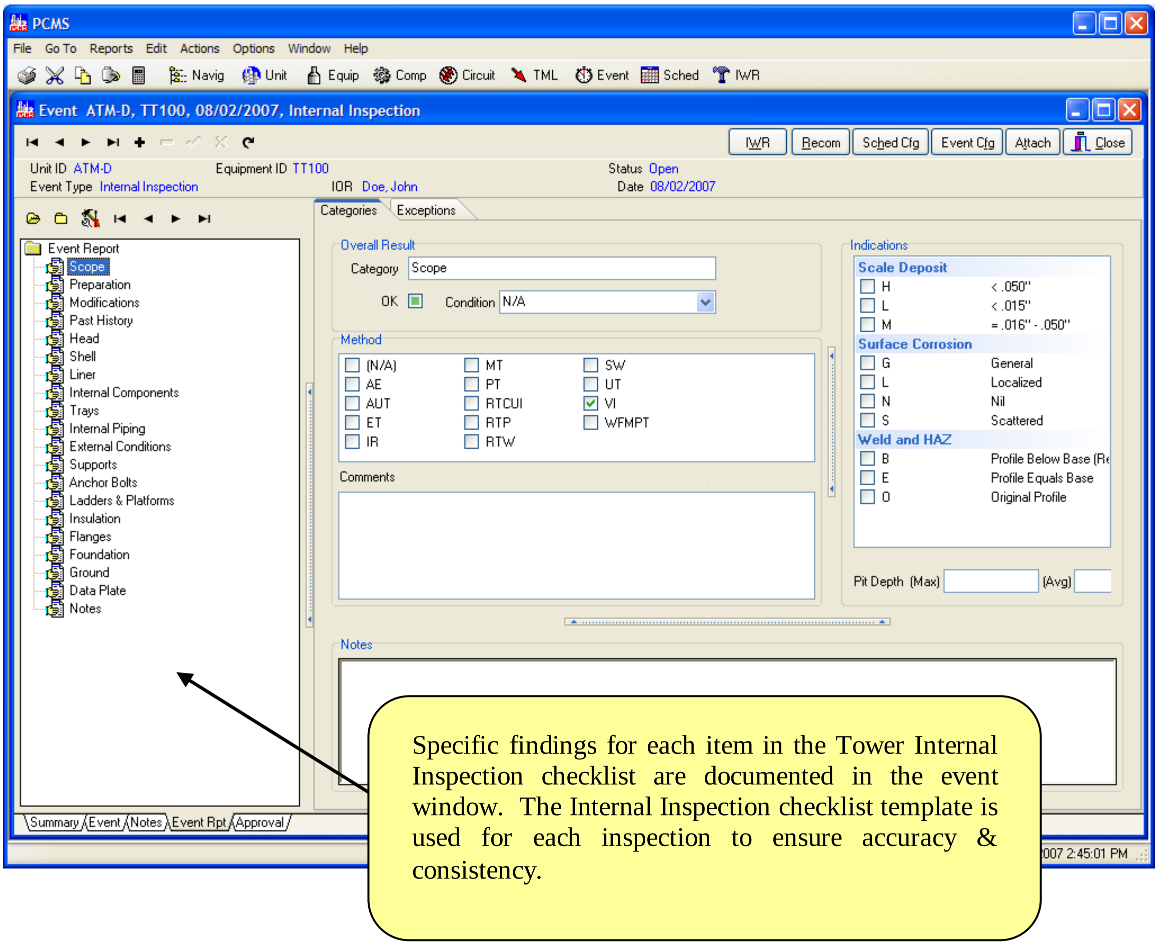


Figure 3: Tower Internal Inspection Checklist

3. RBI Calculator Module

Risk assessment involves two main factors:

- Likelihood of Event Occurrence (usually negative event)
- Consequences associated with the Event

The equation describing risk calculation can be expressed as:

$$\text{Risk} = \text{Likelihood X Consequence}$$

It is evident from risk definition that Likelihood of Event and Consequence of event are equally important and that risk cannot be assessed by ignoring one of the factors. Risk management aims to define the factors affecting risk, calculating risk, evaluate risk as acceptable or not acceptable (or as Low-Medium-High) and schedule proper actions for risk reduction.

Within this framework, for each circuit in PCMS, the RBI Calculator computes the following:

- Probable damage mechanisms
- Consequence of failure
- Risk Rank based on probability & consequence of failure
- Date the circuit will exceed a risk threshold without inspection
- Recommended inspection technique for each damage mechanism

Figures 4 and 5 show the results of RBI calculations for each circuit. Overall results as well as specific damage mechanisms are displayed.

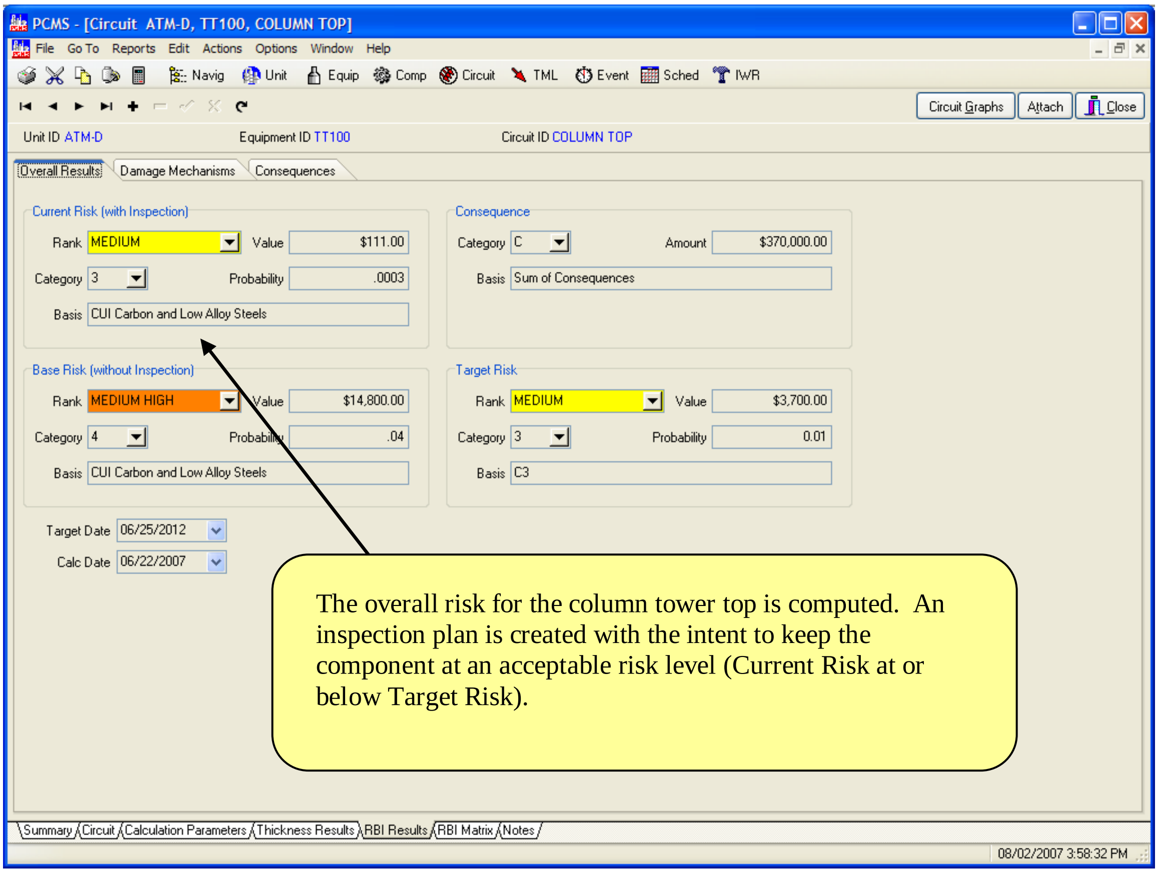


Figure 4: Overall Risk Rank for a given Circuit

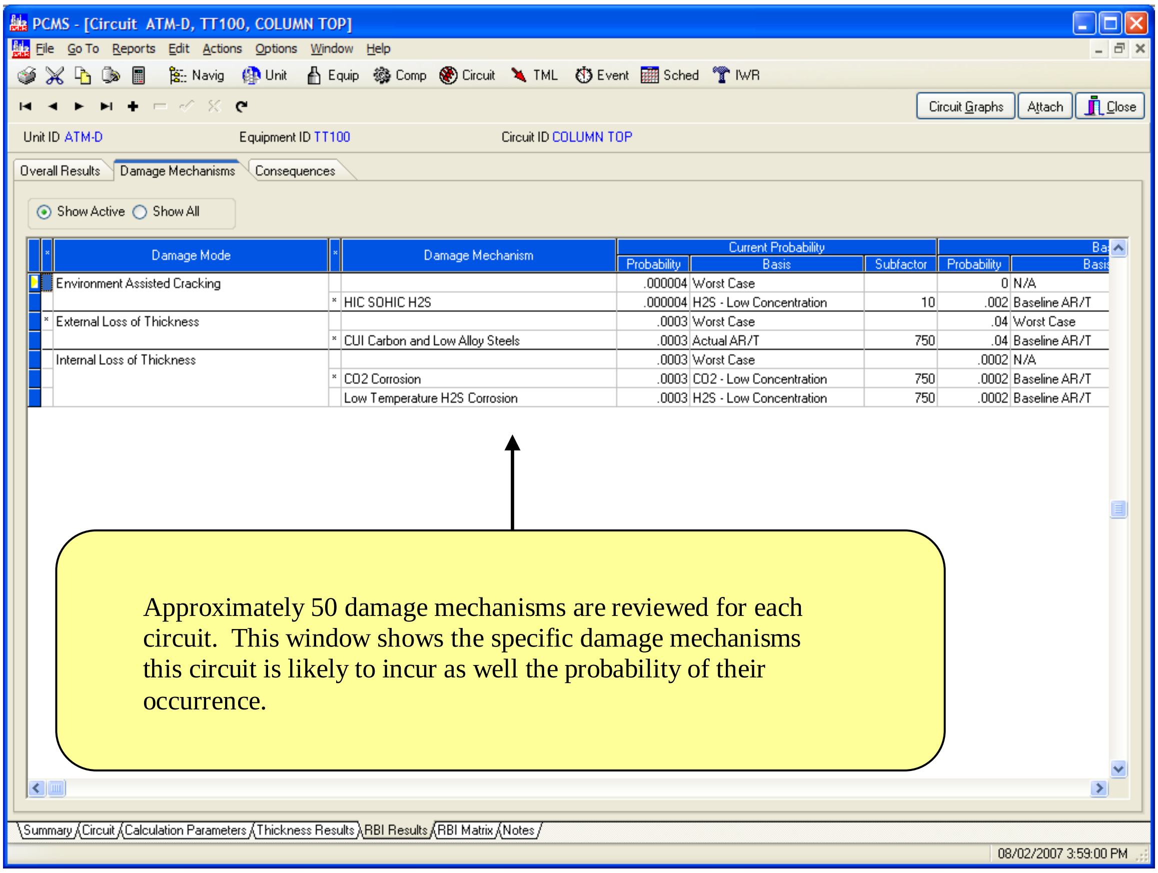


Figure 5: Likely Damage Mechanisms for a given Circuit

4. INTEGRATION

We have seen a sampling of the calculation results generated from traditional and RBI analysis. We will now look at ways that RBI results can be merged into the daily "run and maintain" inspection process conducted at numerous facilities.

When integrating traditional NDT and RBI results, we must focus on several key areas for an effective inspection management program. In particular, we are looking to perform the following:

1. Circuit Analysis – Set a relative risk ranking of circuits and equipment so that inspection activities can be prioritized.
2. Inspection Planning – Establish due dates for inspection activities to ensure compliance and acceptable risk levels.
3. Inspection Tracking – Perform economical yet effective inspection techniques & document them in a consistent manner.

4.1 Circuit Analysis

The PCMS RBI module projects corrosion rates based upon an analysis of material, temperatures, process service and tables from API 581. If insufficient thickness readings exist to establish an actual corrosion rate, PCMS uses the projected RBI rate to calculate next inspection dates. Once enough baseline data is captured for actual corrosion rates, PCMS uses the actual rates for computing next inspection dates. At this point, the RBI rates are used as a reference and can be used as a measuring gage when reviewing actual corrosion rates.

When evaluating circuits and setting inspection priorities, the circuit class is often used. For example, Class 1 Piping circuits should have UT and Visual inspections every five years. The introduction of RBI Risk Ranking can also be used in setting inspection priority. The circuit is placed in a 5 X 5 matrix to indicate its relative risk ranking as compared to other circuits. Inspection can help reduce the probability of failure whereas engineering changes are usually required to reduce consequences of failure. When reviewing circuit inspection dates and performing turnaround planning it is helpful to note the overall risk of each circuit.

Figure 6 shows the distribution of circuits by risk in 5 X 5 risk matrix. The distribution is user-configurable and analysis can be performed by numerous parameters such as process unit or equipment type. For example, we can see the distribution of piping circuits for a particular process unit.

Figure 7 shows a list of circuits sorted by risk (highest risk circuits at the top). The circuit class is also shown to help establish inspection priority.

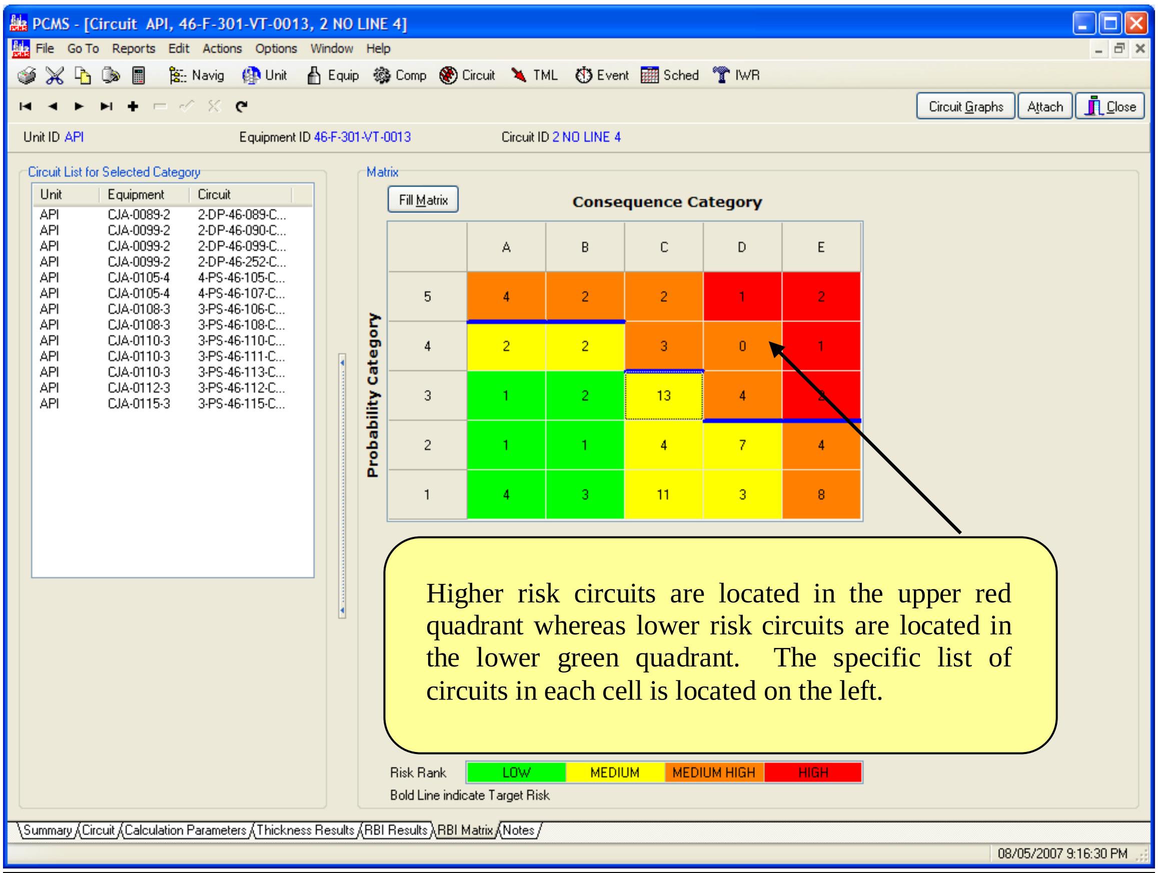


Figure 6: The Distribution of Circuit Risk Ranking in a 5 X 5 Matrix

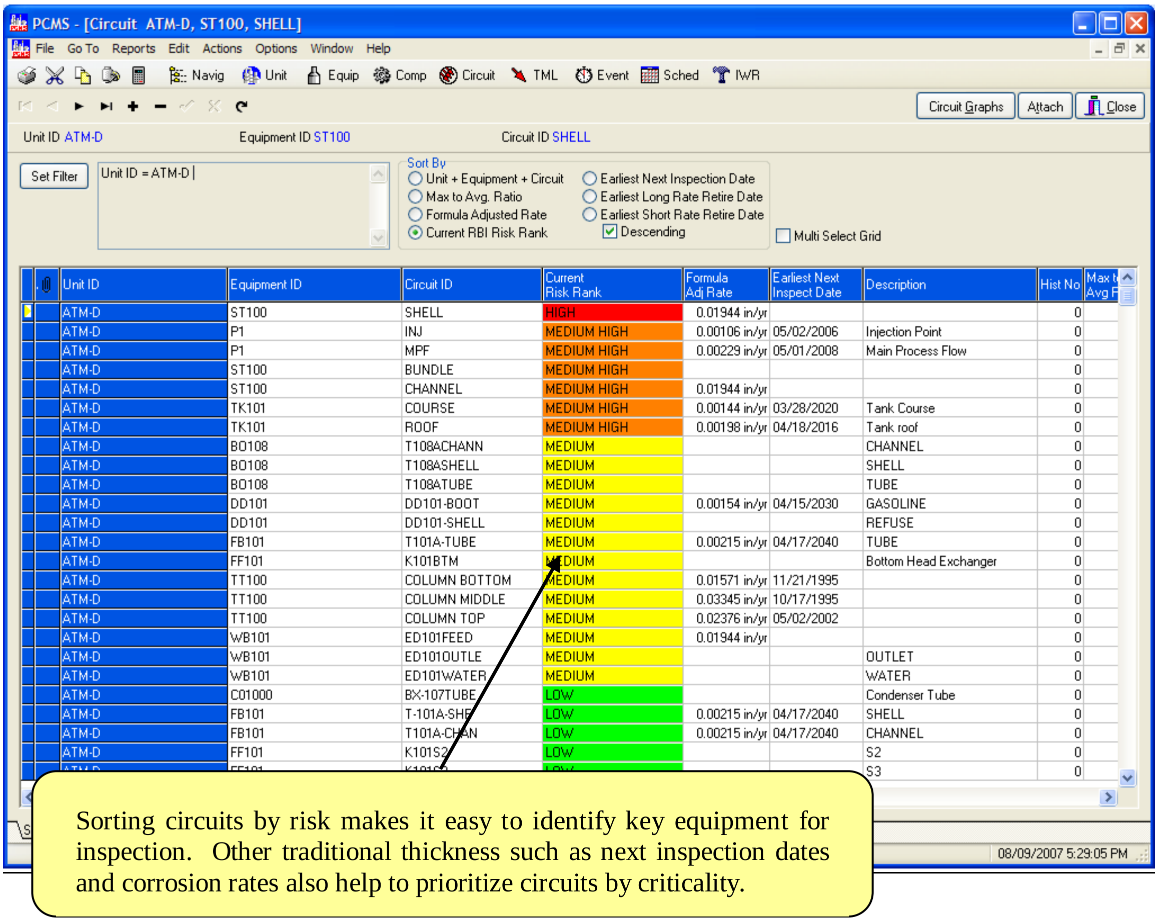


Figure 7: Identification of Highest Risk Circuits

4.2 Inspection Planning

The first step in inspection planning is to identify the activities (or events) that must be completed to ensure regulatory compliance. Each activity has an associated due date based upon governing codes. Fixed interval and half-life calculations have been traditionally covered by PCMS. RBI introduces a new date known as the target date. This is the date the equipment will exceed an acceptable level of risk – if no inspection is performed. When reviewing a T/A list, the inspection may be deferred or a less intrusive method may be used depending on the target date.

Figure 8 shows a tower on a 10 year internal inspection interval. However, the equipment will not exceed an acceptable risk level until two years later. The inspection may be performed at the 10 year interval or could possibly be deferred an additional two years.

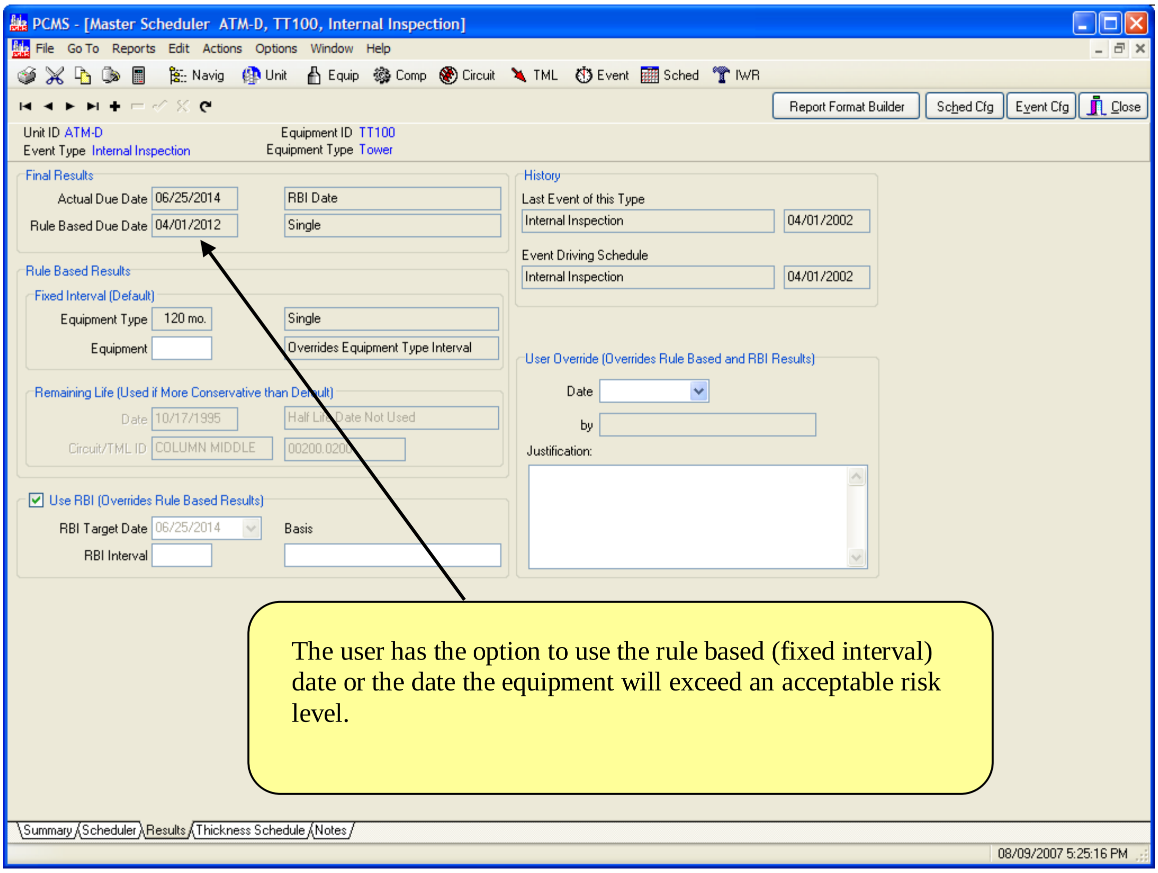


Figure 8: RBI Target Date Can Override Traditional Interval Date

4.3 Inspection Tracking

Once the T/A list has been generated, the actual inspection techniques and scope for each activity must be generated. Checklists are used to ensure consistent and effective inspection techniques are used. A portion of the checklist is built to ensure all equipment components are properly inspected. In addition, an RBI section is added to the checklist to ensure all susceptible damage mechanisms are looked for.

Another critical aspect of RBI analysis is documenting the effectiveness of inspection. The probability of failure can be reduced by the use of proper inspection techniques. When documenting the inspection results, the effectiveness is captured and used to re-calculate the probability.

Figure 9 displays a form used to document inspection results using a checklist.

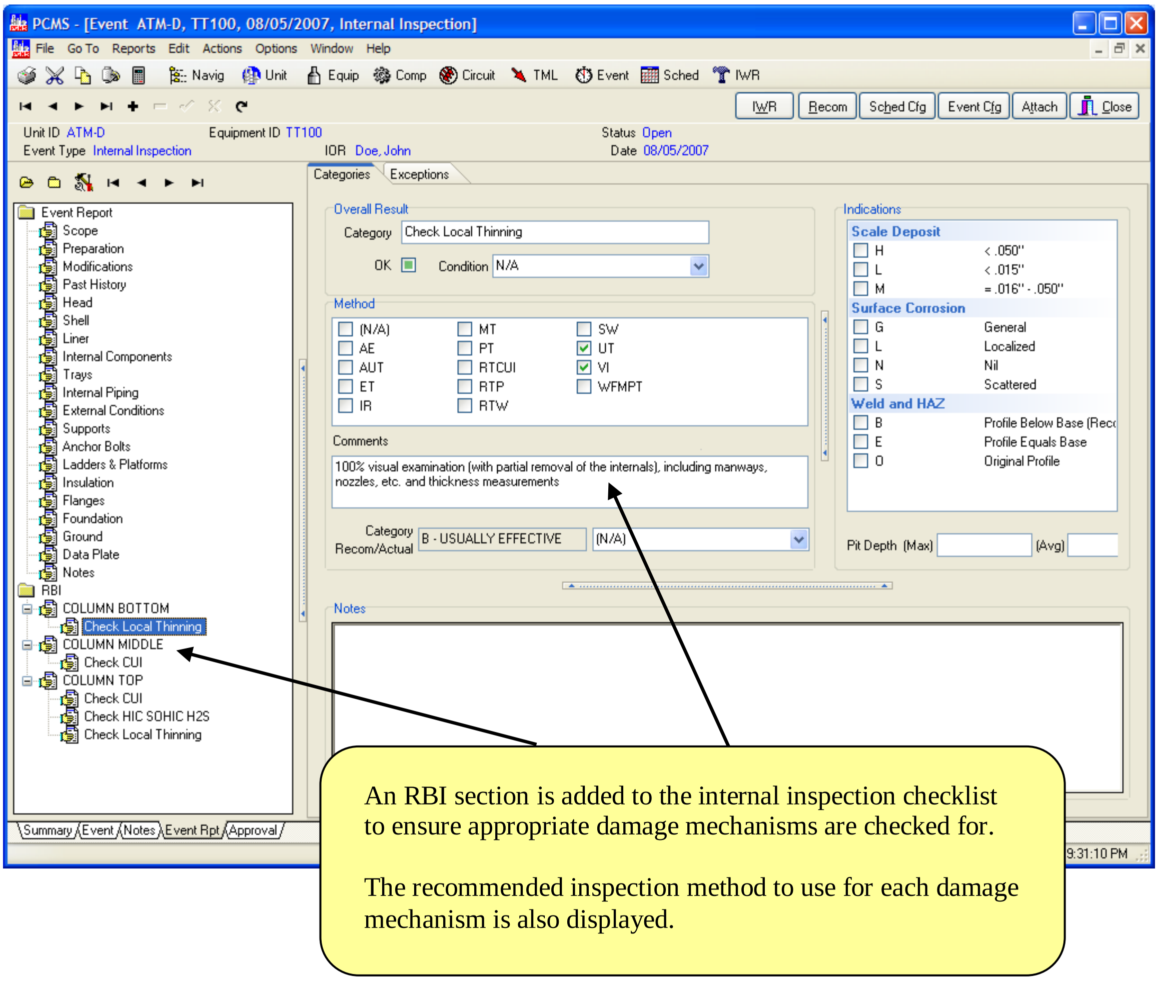


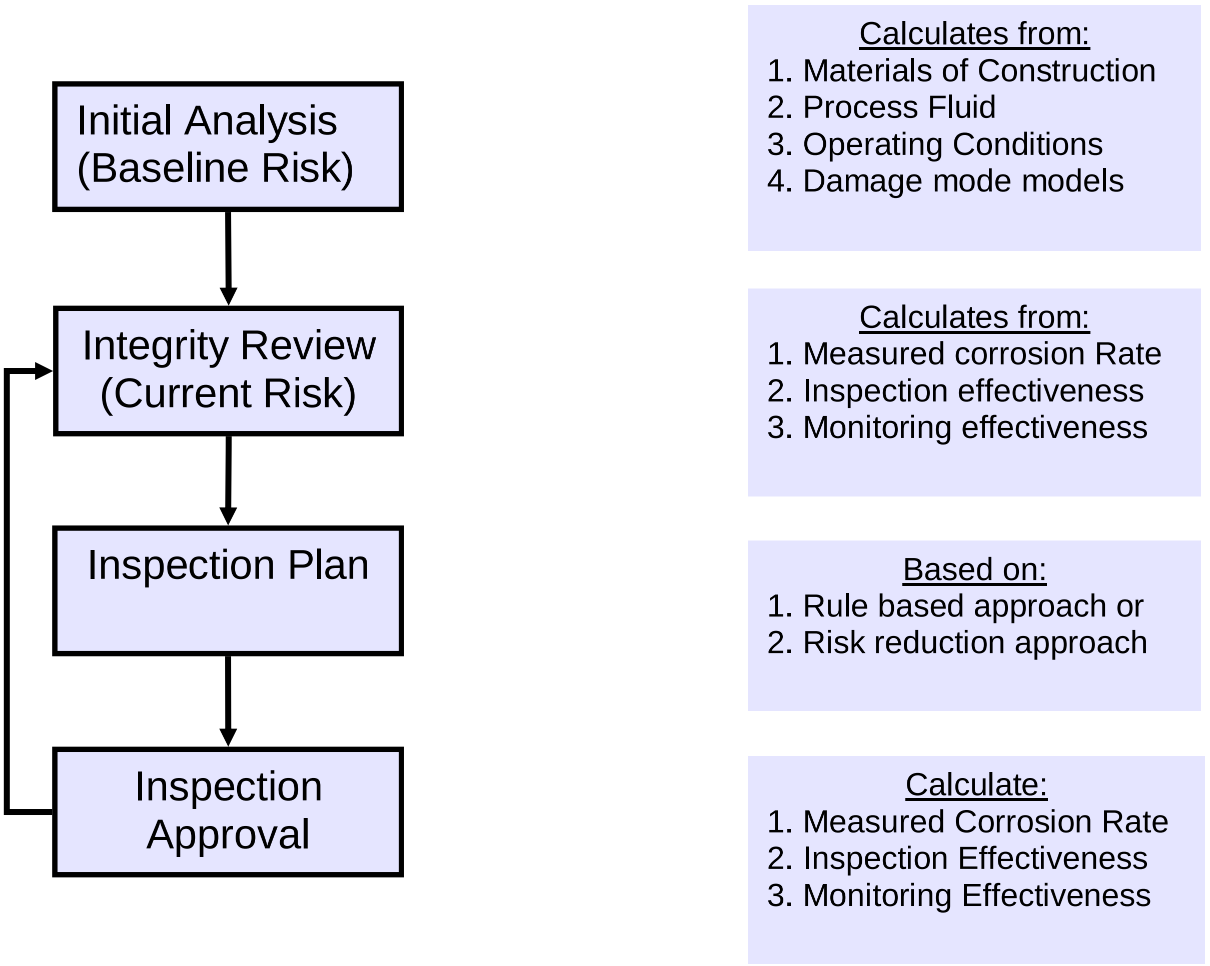
Figure 9: Internal Inspection Checklist with RBI Checking

4. Discussion & Conclusions

By applying RBI strategies it is possible to reduce the level of inspections and to increase intervals between internal inspections resulting in considerable cost savings. In addition to that, RBI implementation results in increased safety and reduces the unexpected shut-downs.

To get the maximum benefits out of an RBI plan, it is necessary to understand and implement new inspection philosophies and continuously update the inspection data base. Within this framework**,** the intent is to integrate RBI into a “Run & Maintain” inspection program.

The previous discussion pinpointed areas where traditional NDT data & RBI results work together to improve analysis and inspection planning. The flowchart below helps illustrate the process required to “evergreen” your asset integrity program using traditional inspection and RBI analysis.



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