Using a Health, Consequence, and Confidence Scale to Prioritize and Budget

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Based on projections from the US Energy Information Agency, coal burning plants will continue to be a major contributor to the US power generation mix for the foreseeable future. Since environmental regulations make it difficult to build new plants, existing plants will need to operate for a significant number of years into the future to meet energy demands. To meet this need, it becomes ever more important to determine the health of individual components to help budget and plan for their continued operation.

The boiler has historically been the leading cause of forced outages, so it is a top priority to track the condition of its parts and prioritize analysis and inspections to determine when those parts may need replacement or repair. Structural Integrity has developed a semi-quantitative approach to benchmark the overall health of such components. The resulting health index is used to prioritize replacements, repairs, and further study through inspections and analyses. The end result is then applied to determine capital budgets for equipment replacements and O&M costs for repairs or further study to improve the accuracy of the assessment.

Our approach was recently applied to an aging plant in North America where it was desired to develop long term budgets for both capital and O&M costs. To achieve that, an overall assessment of the health of individual components needed to be performed while prioritizing what areas would need the most attention or at least need attention the soonest. While we can't provide specific details of that assessment, the examples are representative of the study performed.

Our process begins with the collection of available information for the boiler, which would typically include:

- Component drawings
- Design data
- Details of any design changes, repairs, or replacements
- Historical and current operating data for each component
- Fuel analysis
- Water chemistry control program and recent analysis results
- Inspection reports
- Metallurgical reports – both routine tube samples and failure investigations

An important part of the information review is a site visit to collect documents, perform a brief walkdown of the unit, and most importantly, we interview site personnel to collect information regarding plant issues and history.

We review the information for each individual component, and we summarize the findings in a consistent, easy-to-read format using Component Assessment Snapshots, an example of which is shown in Figure 1. The key information in the snapshot is:

- Component identification and summary of service history and replacements.
- List of potential damage mechanisms for the component type, along with an indication of whether there is evidence that each damage mechanism has been active, and to what extent.
- Details of component geometry including tube/header dimensions and materials.
- Sketch of drawing of component indicating locations of significant NDE test results, failures, etc.
- Description of any life estimation calculations performed for the component. The nature of life estimation performed depends on the type of component, the identified operative damage or failure mechanism, and the available information. For example, for the final superheater and reheater sections, a tubing life estimate is made considering the effects of steam temperature, pressure, and flow, an estimated or assumed heat flux, internal steam oxide formation, external wall loss due to erosion or fireside corrosion, and creep of the tubing material. The specificity of the calculation depends strongly on the amount and nature of input data, e.g., penthouse tubing oxide thickness data indicating temperature variations across the boiler, fireside corrosion rate information from wall thickness measurements or tube sample examination results, etc.
- A descriptive summary of issues discovered during the information review and life assessment calculations, including a description of any key data missing and needed to draw substantive conclusions.
- Numerical ratings of overall component condition (asset health index), consequence of component failure, and confidence level of the performed assessment. These ratings are qualitative, based on engineering judgment and our past experience with similar components. The asset health ranking ranges from 0 (needs immediate or very-near-term replacement) to 10 (component in like-new condition with no issues); the failure consequence ranking ranges from 1 (personnel safety risk) to 5 (little consequence – unit can continue to operate); and the confidence level rating ranges from 0 (low confidence in results, with very little data available) to 5 (high confidence in results).
- A list of recommended actions either needed to improve the confidence of the assessment, to continue monitoring the damage development, or to repair or replace possibly damaged components.
- A summary list of documents reviewed relative to the specific component.

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COMPONENT	ASSET HEALTH INDEX 0 = very poor 10 = like new	FAILURE CONSEQUENCE RATING 1 = severe 5 = minor	CONFIDENCE IN ASSESSMENT 0 = poor 5 = very high
Boiler feedwater piping	3	3	3
Furnace waterwalls	7	2	2
Superheater assemblies	5	4	4
Superheater outlet header	7	3	2

Table 1. Example Component Rating Summary

BOILER CONDITION ASSESSMENT

COMPONENT	RECOMMENDATIONS	
	Action item	Priority
Boiler feedwater piping	■ Perform FAC assessment.	*High*
Furnace waterwalls	■ Perform a tube wall thickness survey in areas prone to fireside corrosion to establish current condition. ■ Metallurgical evaluation of tube samples taken from panels removed during next outage.	*High* *Medium*
Superheater assemblies	■ Measure oxide thickness in penthouse for outlet terminal tubes. ■ Remove furnace tube samples for analysis. ■ Inspect for oxide scale accumulations in outlet pendant loops. ■ Inspect a sampling of DMWs, take tube sample.	*High* *High* *Medium* *Medium*
Superheater outlet header	■ Re-inspect outlet header girth welds using advanced ultrasonic techniques next or following major outage.	*Medium*

Table 2. Example Component Recommendation Summary

Once the individual Condition Assessment Snapshots have been completed, we compile the information contained in them into a summary, typically at the beginning of an overall unit report containing a collection of snapshots. The key elements of the summary are tables listing the component rating results, the predicted remaining lives (where available), and prioritized, recommended inspection actions judged necessary to either confirm current condition or obtain data/information needed to improve the confidence of remaining life predictions. Tables 1 and 2 are example component rating results and recommendation summary.

This approach to a boiler condition assessment program establishes a succinct picture of the overall health of the boiler, what components and locations represent the highest risk for forced outages, and what near-term inspections would be most effective to increase the assessment confidence.

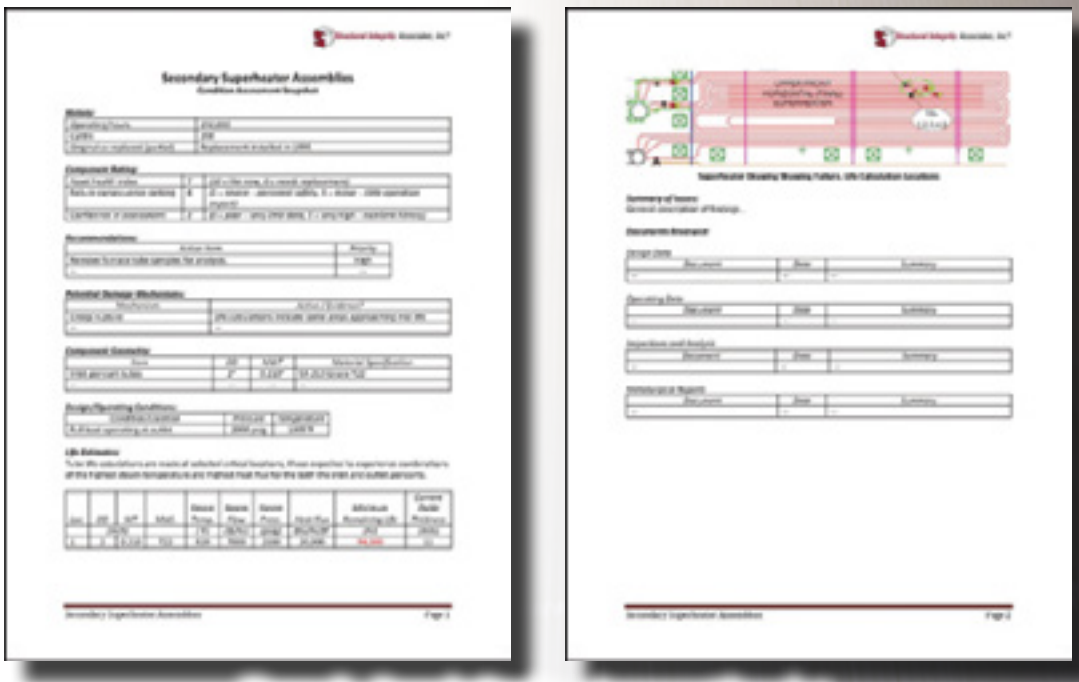

Figure 1. Example Condition Assessment Snapshot.