Structural Integrity Associates, Inc.®

The Probabilistic Gas Touched Length Analysis (PGTLA)

The Probabilistic Gas Touched Length Analysis is a powerful asset management tool designed to predict the likelihood of tube failures due to exhaustion of creep strength at any location in a superheater (SH) or reheater (RH). Historically, a deterministic approach has been applied to quantify remaining tube life, but this approach has proven to be incapable of addressing the inherent variability of key influences on tube life, with the result that predictions developed using the deterministic approach either are forced to be excessively conservative to avoid unanticipated failures or carry so broad a potential error band that from a practical standpoint they are of limited value for effective asset management.

The PGTLA was developed to:

1. Address creep failure probability anywhere in a SH or RH section,
2. Account for variability in geometry, material properties, and operating influences (i.e., temperature, pressure, etc.)
3. Provide the information necessary to establish priorities for future inspections, repairs, and/or replacements.

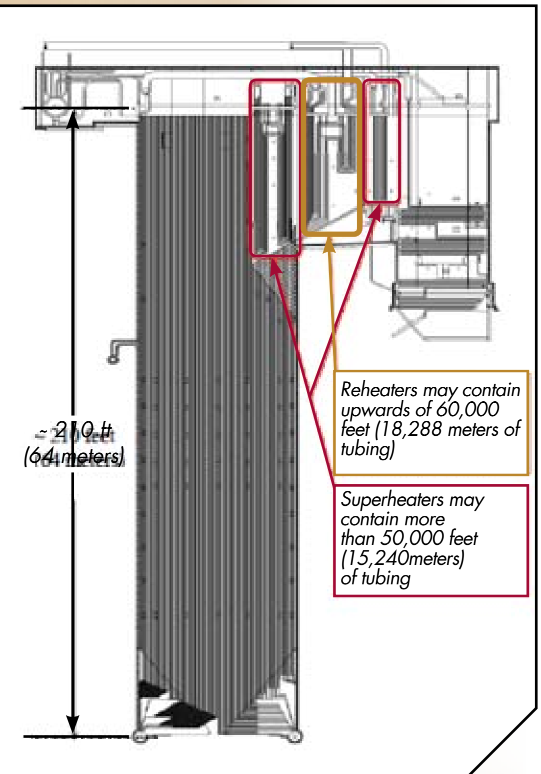
Effectively managing the life of so critical an asset as a SH or RH section is a formidable challenge when it is considered that each section contains tens of thousands of feet of tubing with the conditions of operation varying continuously along the length of each one of those tubes. The PGTLA was specifically developed to meet that challenge.

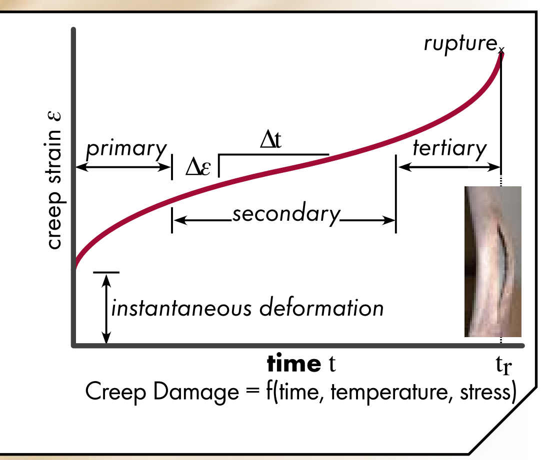
What is Creep?

Creep is a process of time dependent damage accumulation that is an inevitable part of the operation of tubing in the highest temperature regions of utility-type boilers. Creep dictates that the life of any SH or RH tube will be limited, although when the sections are designed in accordance with ASME's allowable stresses a lengthy period of satisfactory service can be expected. How long that period will be, however, can vary substantially from unit to unit and from tube to tube depending on actual operating conditions. The challenge of managing these critical assets is to identify where along the length of a given tube the combination of temperature and stress (with secondary factors such as wastage and internal oxide growth acting to influence stress and temperature) will produce the earliest failures.

What is a Gas Touched Length Analysis (GTLA)?

A Gas Touched Length Analysis (GTLA) is a design stratagem used by the boiler manufacturers to predict steam and metal temperatures along the length of a tube exposed to the flue gas. The curves produced serve as the basis – together with the ASME Boiler & Pressure Vessel Code - for selecting both the tube material and tube dimensions for all high temperature boiler sections.





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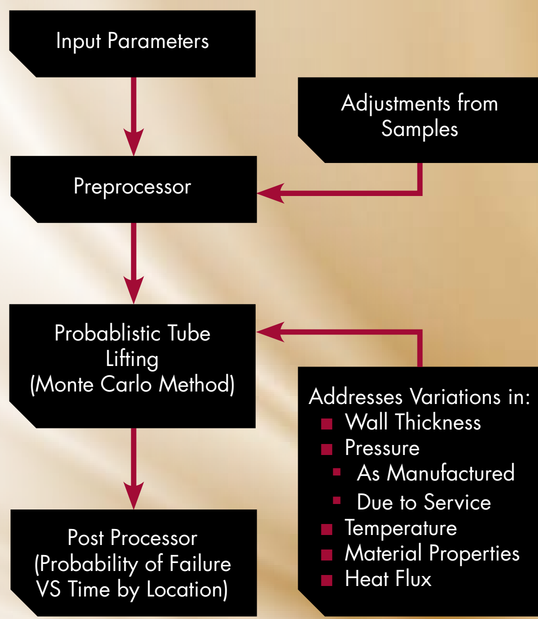
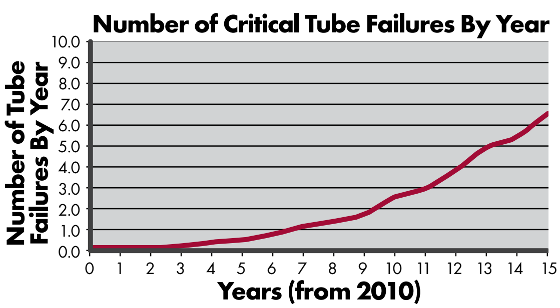
What is PGTLA?

The PGTLA is a dynamic life assessment tool that, like its static GTLA forebear, permits the determination of steam and metal temperatures at specific locations of interest along a circuit. However, the PGTLA then takes this basic information and monitors the change in temperature and stress at these locations over time – changes which occur due to such influences as internal scale growth and wall loss - and calculates the incremental increase in creep damage and the corresponding reduction in life. For the purposes of the program, the calculations extend from the time of the initial operation of the tubing in question to a point 15 years into the future.

As already discussed, for many of the critical influences on tube life, such as temperature, stress, material properties, etc. specific values over the life of the asset cannot practically be obtained. This is why a probabilistic treatment of the available data is essential. Using available operating and inspection data, as well as published material properties, statistical distributions can be developed to account for variability. To accomplish this, a Monte Carlo-Type Simulation Method is used to assess the impact of variations in the key influences within defined ranges. The end result is a series of iterative calculations in which a unique level of accumulated creep damage is obtained for each set of assumed values, and then a statistical portrait of the damage is created, based on the damage distribution over the total number of iterations performed.

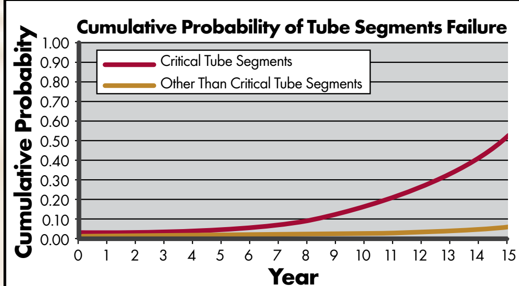
Parameter	Single Value	Variable
Operating Hours	X	
Stress		X
Wall Thickness		X
Diameter		X
Pressure		X
Temperature		X
Material Properties		X
Heat Flux		X





Cumulative Probability of Failure

Year	Critical Tube Segments	Other Than Critical Tube Segments	Number of Critical Tube Failures By Year
0	0.011	0.003	0.2
1	0.013	0.003	0.2
2	0.016	0.004	0.2
3	0.020	0.005	0.3
4	0.026	0.005	0.4
5	0.034	0.006	0.6
6	0.045	0.007	0.8
7	0.062	0.008	1.2
8	0.082	0.010	1.4
9	0.107	0.011	1.7
10	0.144	0.013	2.6
11	0.187	0.017	3.0
12	0.242	0.021	3.9
13	0.313	0.026	5.0
14	0.391	0.033	5.5
15	0.485	0.045	6.6



Number of Years Probability Threshold is Evaluated For	Probability Threshold for Critical Tubes	Number of Critical Tube Segments	Number of Other Than Critical Tube Segments
15	0.001	70	1460
Assembly	Circuit	Segments	Max. Probability
11	9	Y	0.168
21	2	Y	0.045
10	2	Y	0.041
23	10	X	0.019
14	10	X	0.019

After the simulations are complete, the user queries the results by applying a Probability Threshold over a selected period of years into the future. The resulting output defines the number of Critical Tubes (those which meet the Probability Threshold within the timeframe) and of Non Critical Tubes (the rest of the population). These are portrayed graphically showing the Cumulative Probability of Failure versus time into the future. In addition a rank ordering of the tubes can be developed based on the Maximum Probability within the defined timeframe. This facilitates targeted inspections or sampling prior to the occurrence of a tube failure.

The final output from the model is the Number of Tube Failures by year over a period 15 years into the future. The graphical presentation along with the maximum probability information allows the user to optimize the timing for partial or complete replacement strategies.

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