ETD

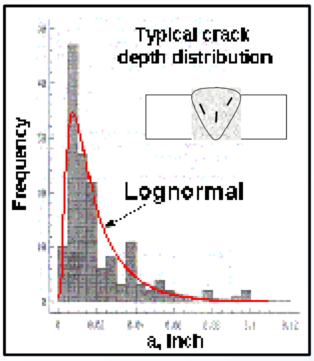
European Technology Development Ltd

Linking Technology with Success

ETD Probabilistic Life Assessment

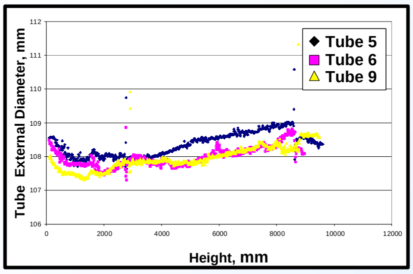
Why Probabilistic Life Assessment

In the increasingly cost-competitive market, accurate and timely information on equipment condition is vital for input to repair/replacement strategies and associated costs. This is resulting in an increased need for more reliable and realistic life prediction methods, particularly for aged equipment/plant.



Existing remaining life evaluation techniques and defect assessment procedures are deterministic in that they require specific data input. In most practical situations, the key inputs to a deterministic life assessment are not single valued but distributed:

- through spatial changes (e.g. thickness, temperature, stress, etc.) or temporal variability (e.g. operating conditions, ageing, etc.)
- through the imprecision of measurements and scatter in the data (e.g. inspection, on-line monitoring data, materials data, etc.)



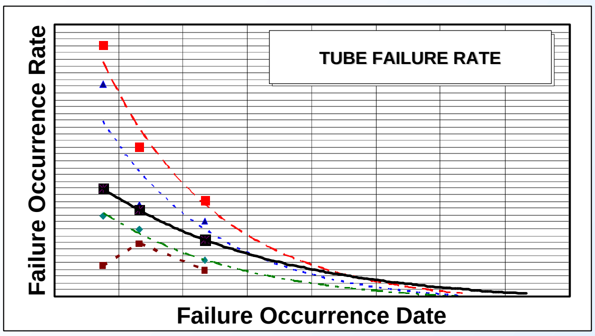
To take into account these uncertainties/variations, quite often the assessment is based on the "worst-case scenario" and conservative values/bounds for the inputs are used in the analysis. However, this generally provides an overly conservative and unrealistic result.

One way to provide a more realistic estimate of the component remaining life is to use a Probabilistic Approach that enables statistical quantification of the variation in the key inputs in terms of a nominal value and the scatter or drift around this value.

ETD Approach to Probabilistic Assessment

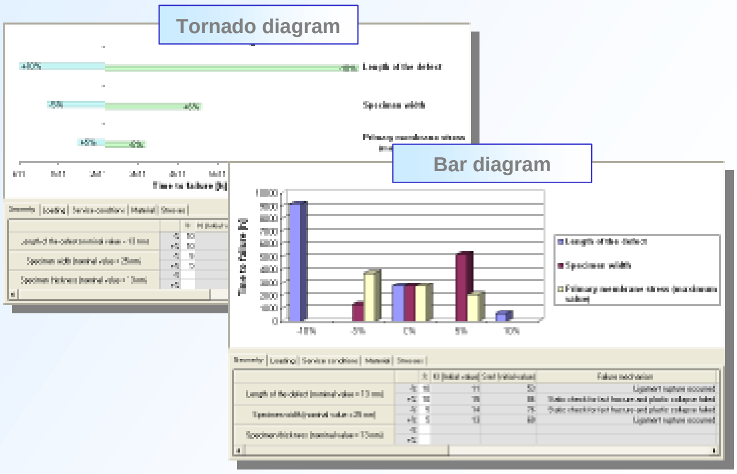
ETD offers a range of tools, skills and techniques for probabilistic assessment and analysis of component integrity and remaining life. Depending on the problem analysed and the data available, ETD provides one of following two routes for assessing the component future damage accumulation and/or failure:

- **Historical Failure Data:** Only applicable when significant historical data (inspection, operation, etc.) are available, preferably specific to the damage mechanism(s) investigated. This approach is simple to apply, but is hard to use in differentiating and evaluating the effects of each of the involved mechanisms on the predicted failure.

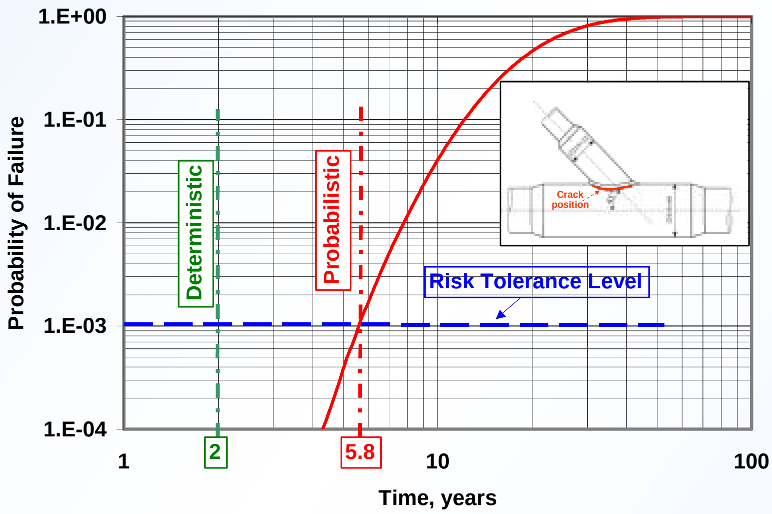


***Example of Boiler Tube Failure Data*:** Use of existing data to predict future failures and their rate

- **Predictive Life Model:** Fully validated model for the relevant damaging mechanisms under consideration e.g. creep, fatigue, corrosion, etc. The advantages of this approach include sensitivity analysis and mechanism discrimination. It is generally limited to time dependent failure and hence does not cover random failures.



Example of Sensitivity Analysis: Used to identify the impact of scatter in the inputs on time to failure



Example of Predictive Model for Creep Crack Growth: Use of the probabilistic methodology applied to defect assessment can reduce significantly the conservatism that one has to assume in the deterministic approach due to the uncertainties in the input and scatter in the material properties.

ETD Probabilistic Assessment Tools

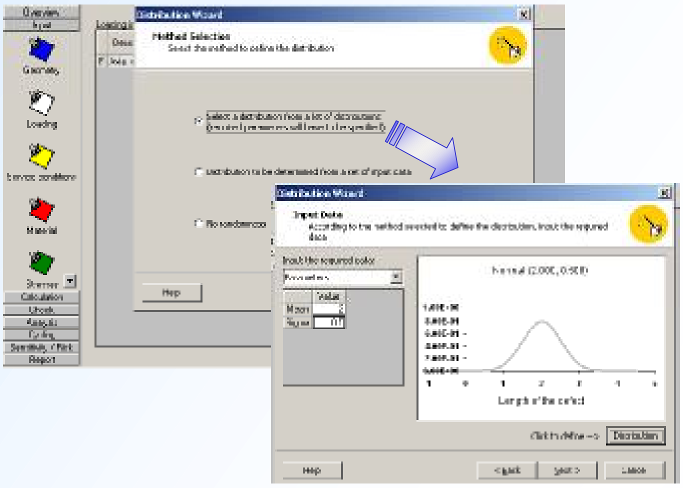
ETD has developed a range of effective and robust in-house tools that incorporate own practical field experience together with the widely accepted codes:

- Remaining life techniques (API530, API579, TRD508, EN12952, R5) for assessing defect free components. Applications include thin and thick wall pressure equipment operating under creep and/or fatigue conditions, which may experience corrosion/erosion degradation mechanisms such as ***boiler tubes***, ***heater tubes***, etc.
- Defect assessment procedures (BS7910, BS5500, R6, R5, RCCMR A16) for evaluating the crack stability and growth in cracked structures. Applications include high and low temperature equipment containing initial postulated/detected cracks including parts with cracked welds and/or repair welds.

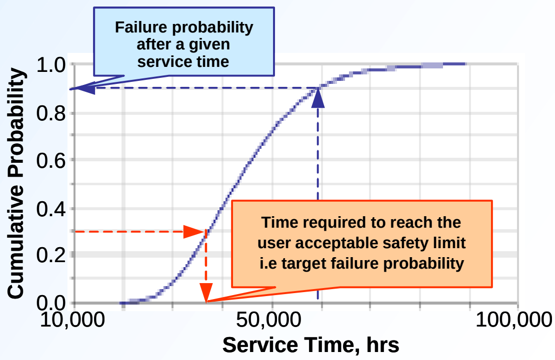
These special purpose tools offer both deterministic and probabilistic life assessment. The key issue in a probabilistic analysis is the characterisation of the statistical distribution of the inputs selected as random variables. This is overcome within ETD tools by offering the user flexible input data options, i.e. the user may provide:

- either the parameters characterising the input statistical distribution, or,
- a set of data (inspection, on-line monitoring data, etc.) which are processed automatically by the software to identify the distribution that best fits these data and to determine its parameters.

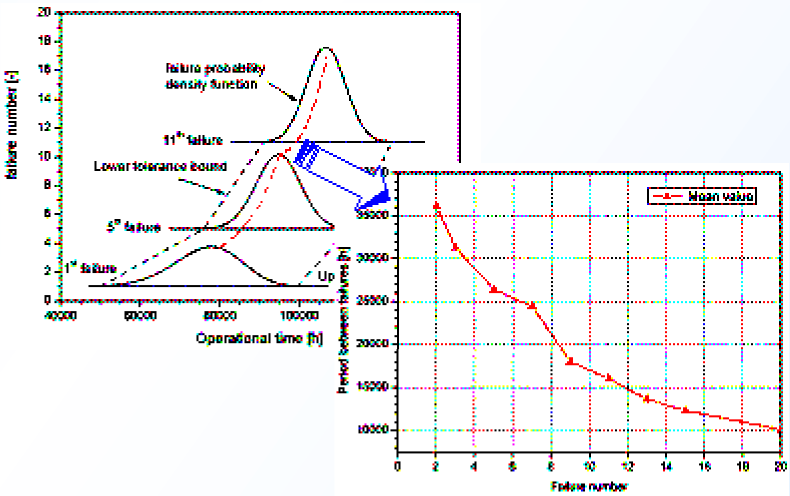
ETD probabilistic tools generate various statistical functions such as failure rate, mean time between failures, cumulative probability of failure, etc.



Example of the statistical distribution definition



Typical Cumulative Probability of Failure and how it can be used



Estimation of the time between tube failures

These ***outputs*** can be combined with:

- Maintenance and repair data to generate availability functions.
- Consequence data to quantify the risk of failure or to identify the time to reach an unacceptable failure rate/probability of failure.
- Financial data to enable economic decision-making.

Benefits

ETD Probabilistic tools aim at assisting the user to improve the overall management of the equipment under investigation. They offer a range of advantages including but not limited to:

1. The possibility of accommodating all uncertainty in material data, including material variability.
2. Option to account for variability in the operating conditions, allowing effects on reliability to be quantified.
3. A direct link of the probabilistic output with classical risk/reliability analysis including task prioritisation and cost prediction.
4. The prediction of future degradation as well as end of life, thus allowing periodic refinement through direct on-line data monitoring, NDE and/or condition assessment.

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