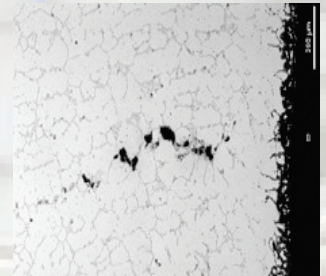


REMAINING LIFE ASSESSMENT FOR STEAM METHANE REFORMERS (SMR)

Objectives:

- Integrate inspection information into a remaining life model.
 - Use of remaining life model should reflect the physics of creep and the specific loading, temperature, and time exposure for a reformer tube under various designs and operating history.
- Provide Remaining Life calculations based on experience and expert judgment for:
 - Fitness For Service (FFS) decisions
 - Replacement strategy (Long range forecasting)
 - Purchasing and support of overall tube life management
- Fully integrated into the MP Tube Life software



Typical Creep Micrograph

MP/USTT/SES Proprietary Creep Model Basis

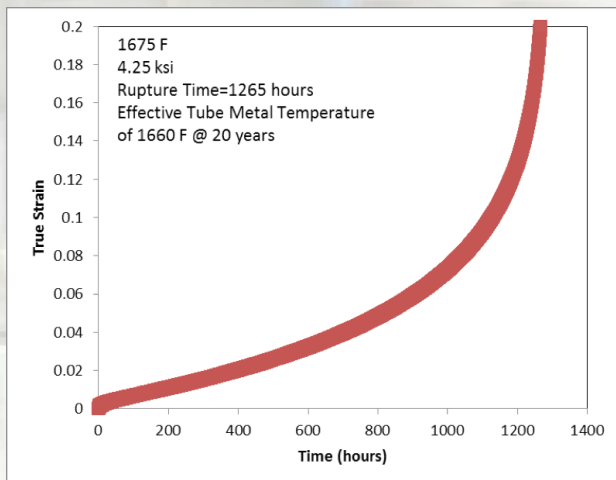
- Developed from accelerated creep rupture tests from as-cast and service aged materials.
- Magnetische Prüfanlagen (MP) / US Thermal Technology (USTT) / Stress Engineering Services (SES) proprietary creep model analyzes data that capture complex behavior trends of reformer metallurgies under stress, temperature, and time.
 - Accounts for damage caused by aging or thermal softening and damage caused by strain softening and cavitation damage.
 - Model constants were developed from accelerated creep rupture tests and further refined from NDE (OD/ID % strain and eddy current) experience and destructive metallurgical evaluations.
- Model output includes estimates for an equivalent metal temperature to cause strain at a given time (or age of the tube). The equivalent temperature approach allows for estimating future damage based upon damage accumulated in the past.
- Provides a basis for sensitivity analysis and what-if scenarios (e.g. predictions of accelerated damage associated with a short term transient).
- Considers creep ductility trends with stress, temperature, and time.
- Provides an enhanced framework for replacement and life extension strategies for reformer tubes.
- MP/USTT/SES can also provide creep testing and remaining life confirmation through creep testing of samples taken from in-service aged tubes.

MP/USTT/SES prefers to carry out Remaining Life Assessments without the removal of sample tubes from the furnace so that the life of each tube can be analyzed individually as opposed to relating the damage of sample tubes to the entire population of the reformer. However, with proper sample selection based on the Remaining Life Assessment data the destructive data can be very informative.

REMAINING LIFE ASSESSMENT FOR STEAM METHANE REFORMERS (SMR)

Summary:

- Utilization of MP/USTT/SES modeling is being fully implemented into the MP/USTT Tube Life Software.
- Better remaining life assessments utilizing actual MP/USTT obtained inspection data can be generated as part of the inspection process.
- New MP/USTT/SES modeling provides a more accurate and improved assurance of remaining life predictions.
- Modeling is a key tool to inform highly experienced and expert MP/USTT/SES personnel as they make life predictions and future inspection planning recommendations to clients.
- Allows for better planning for tube replacement and tube purchasing.



MP/USTT/SES Model Captures Ageing Effects and Reasonably Predicts Short Term Creep Tests

Typical Results Based on Remaining Life Assessment Model

Sequence	# of Tubes	Failure Group
1	000	1 to 2 years
2	011	2 to 4 years
3	058	4 to 6 years
4	058	6 to 8 years
5	177	8 to 11 years
6	244	11 to 16 years
7	316	16 years
Total	864	

