Outline Syllabus for Tutorial Sessions on T73S04: Creep-Fatigue Crack Initiation Assessment to R5V2/3

Last update: 21/1/15

30	The purpose of R5V2/3: example of hysteresis loops and where the damage occurs; Failure modes addressed as prerequisites; Primary & secondary stress categories & limits; significance of creep; significance of load cycling; cyclically enhanced creep (refer to 27); strict shakedown; global shakedown; How these are demonstrated in R5; The shakedown factor, K_S; Ratcheting; Definition of shakedown reference stress Relates to Mentor Guide questions 1.1, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12, 1.13
31	Materials data required; Ramberg-Osgood: differences between monotonic and cyclic; Conservative estimation of dwell stress; Continuous cycling fatigue data versus endurance with dwells; Creep ductility: dependence on strain rate and triaxiality (and stress?); Spindler fraction; thermal ageing effects; E, ν, α; Elastic follow-up (Z); Definition of creep damage; Reheat cracking in brief: how Z, S and ε_f produce cracking; Relates to Mentor Guide questions 1.2, 1.3, 1.4, 1.5
32	The concept of signed equivalent stress; Definition of equivalent strain range; Qualitative translation of load-time or temperature-time plots into stress-strain hysteresis cycles; Examples of different cycle types; Peak dwell, intermediate dwell; Interaction with smaller cycles; Crude methods for dwell stress estimation Relates to Mentor Guide questions 1.14, 1.15, 1.16, 1.17, 1.18, 1.19
33	Detailed methodology for hysteresis cycle construction (intermediate dwell, parent material); The Neuber construction; Different A and K_S around cycle; Cycle positioning along stress axis; Finding the dwell stress; Is the cycle closed? Definition of total strain range: elastic, plastic, creep, volumetric; Interacting hysteresis cycles; Relates to Mentor Guide questions 1.18, 1.20, 1.21, 1.22, 1.23, 1.24, 1.25, 1.26, 1.27
34	Evaluation of relaxation: integration of forward creep and limitations of Feltham type expressions; Limitation of relaxation to rupture reference stress; Watch out for 'upwards relaxation'!; Defn of creep damage (again); Methods for estimating Z; Plastic Z implicit in Neuber construction; Effective Z for combined pure primary and pure secondary; How sensitive is D_c to Z? Relates to Mentor Guide questions 1.22, 1.28, 1.29, 1.30, 1.31
35	Fatigue strain range with/without creep; Fatigue endurance, S-N curves, correction for size effects (refer to 28); Definition of D_f; Influence of cycling frequency and cycle sequence on fatigue endurance; Transient conditions versus steady cyclic state; R5 combination of creep and fatigue damage (linear) versus other codes (why different?); Sub-surface damage/initiation: the scope & limitations of R5 methodology (unknown stress state development); Beyond R5 (R2): High cycle fatigue, sensitivity to mean stress (Goodman diagram, etc); Relates to Mentor Guide questions 1.32, 1.33, 1.34, 1.35, 1.36, 1.37
36	BE model for austenitic reheat cracking illustrated by S4 welds; Classic creep failure models: cavity nucleation & growth; Rice & Tracy, Hull & Rimmer, etc.; Vacancy diffusion; Pipe diffusion; Where stress state dependence of ductility comes from; Implicit assumption in ductility exhaustion of correlation between deformation (dislocations) and damage (vacancies); Chevalier's correlation of poor creep ductility with low Ni content: is it really due to cavities? Relates to Mentor Guide questions 1.4, 1.51 *PTO...*

37	R5V2/3 methodology for weldments; Definition and usage of FSRF, WSEF and WER; Methodology or for dressed & undressed weldments; Use of WSEF in cycle construction & dwell stress estimation; Factoring by local strength, limitations of R5 for inhomogeneous bodies; What point to assess?; The contribution of monotonic relaxation damage (e.g., residual stresses) Relates to Mentor Guide questions 1.38, 1.39, 1.40, 1.41, 1.42, 1.43, 1.44, 1.45, 1.46
38A	Demonstration of avoidance of ratcheting beyond the R5 global shakedown criterion; Use of cyclic FEA with plastic-creep models (FRSV, ORNL, LeMaitre-Chaboche, etc); Relevance of cyclic constitutive relations; Simple models of the ratchet mechanism; Acceptable ratcheting limits; Difficulty of plastic-creep interaction Procedures beyond global shakedown: acceptable ratcheting limits; Relates to Mentor Guide questions 1.47, 1.48
38B	*New at 2015 - not yet written* The use of probabilistics in R5V2/3 assessments - the procedure of E/REP/BBAB/0028/GEN/13
38C	*New at 2015 - not yet written* Validation; Reporting; Multi-axial rupture; Advice coming from HiTBASS; Alternative damage models; Is creep ductility the wrong way to go? Reheat cracking via stress-rupture equation: an alternative view of why ductility is low; Is all creep strain damaging?; Surprising creep data (faster creep at lower stress; double primary; anomalous temperature reduction results; uncertain hardening laws); Physics based modelling. Relates to Mentor Guide questions 1.49, 1.50, 1.52 and 1.52