# Syllabus for Tutorial Sessions on Creep-Fatigue Crack Growth (R5V4/5 & R5V7, Mentor Guide T73S03)

Last update: 5/6/11

| Session number | Subjects Covered |
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| 39 | Distinction between redistribution & relaxation (recap); Definition of C(t) and C*: units; Relation between C* & J, and between C(t) and J for short times; Qualitative variation of C(t) against t: primary & secondary loads; Crack tip fields for stationary crack in creeping material (no plasticity); Hence reasonableness of C(t) control of creep crack growth; Qualitative observations for moving crack tip, Hu-Riedel (HR) fields; |
| 40A | Mechanisms which could initiate cracks: original sin, reheat cracking, Type IV cracking, fatigue, thermal fatigue, creep-fatigue, corrosion, etc.; R5V4/5 demonstration of insignificant creep or cyclic effects; The end point of a ccg assessment (fracture, collapse, rupture); Define inputs required for an R5V4/5 assessment (plant data, loads, materials data - recap): when can continuous cycling fatigue data be used?; Environmental effects (oxidation-creep-fatigue?); Recap: shakedown, and how cyclic effects would influence a subsequent R5V4/5 assessment; |
| 40B | Methods of incubation assessment (HTFAD, CTOD, sigma-d). Sigma-d method in detail. |
| 41 | Obtaining CCG data; Basic experimental arrangement & instrumentation; LLD rate, DCPD, ACPD; Growth calibration; Code size requirements; Empirical formulae for C*; Can C(t) be measured?; Typical da/dt v C* plots; Tails: why they occur & comparison with trend line; Is $da/dt = A.C(t)^q$ justified? Real data: puzzle over 316H HAZ; Typical range of experimental C* cf assessments of plant (extrapolation).; Estimate of *A* in terms of ductility and *q* in terms of *n*; |
| 42 | Fatigue crack growth; Paris Law versus small crack law; Definition of $\Delta K_{eff}$ and physical meaning; fcg within cyclic plastic zone; When are plasticity corrections to $\Delta K_{eff}$ required: $\Delta J$; fcg threshold $\Delta K_{eff}$ and its physical origin (recap); Effect of dwells on apparent fcg rate: is it really creep?; C* reference stress formula; C(t) estimation formula for primary loading alone; Redistribution time; Effect of plasticity on the latter; Derivation of $da/dt = A.C(t)^q$ from continuum damage mechanics; Sensitivity to constraint (factor of 50?); Derivation of relation of *q* to *n*, and *A* to $\varepsilon_f$; Inconsistency of reheat crack initiation assumptions & ccg rates |
| 43 | C(t) estimation formulae for primary+secondary loads; R5V7 type approach: outline of how derived: $(K_{TOT}/K_P)^2$ factor; Effect on redistribution time; Limitations of R5V7 method (ignores relaxation); R5V4/5-RAA/DWD C(t) estimation; Concept of total, or pseudo, reference stress: is it well defined?; Elements of RAA/DWD procedure; Significance of out-of-plane secondary stresses; Competing effects of relaxation and crack growth on pseudo-reference stress; Prescription for service initiated cracks: reset the 'time' datum: what 'initial' quantities in C(t)/C* mean; Illustrate by example,(i)the C(t) spike,(ii)the importance of plasticity in ameliorating the latter; |
| 44A | Procedural issues: Validity of da/dt-C* correlation; Definition of dimensionless crack velocity; Assessment of creep crack growth if C* correlation is invalid; Provision for enhanced crack growth rates prior to steady cyclic conditions; Simplified assessment of enhanced creep crack growth during redistribution when t > $t_{red}$; Two methods for combining fatigue and creep crack growth; How creep crack growth is taken into account for cracks within the cyclic plastic zone; Combinations of materials data bounds: creep strain rate and creep crack growth law parameters, for (a)ferritic materials, (b)austenitic materials; Effects of prior creep damage on fatigue and creep crack growth rates; Procedure for assessing defects which have initiated in-service. |

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| 44B | Integrability of $da/dt = A.C(t)^q$; Derivation of K-based formula for crack growth when $t << t_{red}$; Paradox of apparent temperature independence: process zone and real temperature dependence (RAA report); The “Safe Lives” methodology – IMAN#5. *(This session does not align with any T73S03 Knowledge & Skills requirements – though Safe Lives assessments are, in practice, the most common application of R5V4/5 methodology).* |
| 45 | Ferritic weldment zones & relevance in cfcg; Significance of residual stresses: criteria in, (a)R5V4/5 App.4 and (b)R5 V7; Features of cfcg specific to a TJ or graded TJ; Procedures for ligament rupture assessment, (a)for steady creep, (b)when cyclic loading is significant and/or under combined secondary and primary loading, (c)for TJs; Recommended materials data bound combinations for ferritic & austenitic; Illustration by example of, (a)range of results, (b)difference of time or strain hardening assumptions in predicting the effect on da/dt of change in temperature or stress; |