



Standard Test Method for Measurement of Creep Crack Growth Times in Metals¹

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1. Scope

1.1 This test method covers the determination of creep crack initiation (CCI) and creep crack growth (CCG) in metals at elevated temperatures using pre-cracked specimens subjected to static or quasi-static loading conditions. The solutions presented in this test method are validated for base material (i.e. homogenous properties) and mixed base/weld material with inhomogeneous microstructures and creep properties. The CCI time, $t_{0.2}$, which is the time required to reach an initial crack extension of $\delta a_i = 0.2$ mm to occur from the onset of first applied force, and CCG rate, $\dot{a}$ or da/dt are expressed in terms of the magnitude of creep crack growth correlated by fracture mechanics parameters, C^* or K , with C^* defined as the steady state determination of the crack tip stresses derived in principal from $C^*(t)$ and C_t (1-17).² The crack growth derived in this manner is identified as a material property which can be used in modeling and life assessment methods (17-28).

1.1.1 The choice of the crack growth correlating parameter C^* , $C^*(t)$, C_t , or K depends on the material creep properties, geometry and size of the specimen. Two types of material behavior are generally observed during creep crack growth tests; creep-ductile (1-17) and creep-brittle (29-44). In creep ductile materials, where creep strains dominate and creep crack growth is accompanied by substantial time-dependent creep strains at the crack tip, the crack growth rate is correlated by the steady state definitions of C_t or $C^*(t)$, defined as C^* (see 1.1.4). In creep-brittle materials, creep crack growth occurs at low creep ductility. Consequently, the time-dependent creep strains are comparable to or dominated by accompanying elastic strains local to the crack tip. Under such steady state creep-brittle conditions, C_t or K could be chosen as the correlating parameter (8-14).

1.1.2 In any one test, two regions of crack growth behavior may be present (12, 13). The initial transient region where elastic strains dominate and creep damage develops and in the steady state region where crack grows proportionally to time.

Steady-state creep crack growth rate behavior is covered by this standard. In addition specific recommendations are made in 11.7 as to how the transient region should be treated in terms of an initial crack growth period. During steady state, a unique correlation exists between da/dt and the appropriate crack growth rate relating parameter.

1.1.3 In creep ductile materials, extensive creep occurs when the entire un-cracked ligament undergoes creep deformation. Such conditions are distinct from the conditions of small-scale creep and transition creep (1-10). In the case of extensive creep, the region dominated by creep deformation is significant in size in comparison to both the crack length and the uncracked ligament sizes. In small-scale-creep only a small region of the un-cracked ligament local to the crack tip experiences creep deformation.

1.1.4 The creep crack growth rate in the extensive creep region is correlated by the $C^*(t)$ -integral. The C_t parameter correlates the creep crack growth rate in the small-scale creep and the transition creep regions and reduces, by definition, to $C^*(t)$ in the extensive creep region (5). Hence in this document the definition C^* is used as the relevant parameter in the steady state extensive creep regime whereas $C^*(t)$ and/or C_t are the parameters which describe the instantaneous stress state from the small scale creep, transient and the steady state regimes in creep. The recommended functions to derive C^* for the different geometries shown in Annex A1 is described in Annex A2.

1.1.5 An engineering definition of an initial crack extension size δa_i is used in order to quantify the initial period of crack development. This distance is given as 0.2 mm. It has been shown (41-44) that this initial period which exists at the start of the test could be a substantial period of the test time. During this early period the crack tip undergoes damage development as well as redistribution of stresses prior reaching steady state. Recommendation is made to correlate this initial crack growth period defined as $t_{0.2}$ at $\delta a_i = 0.2$ mm with the steady state C^* when the crack tip is under extensive creep and with K for creep brittle conditions. The values for C^* and K should be calculated at the final specified crack size defined as $a_o + \delta a_i$ where a_o is initial size of the starter crack.

1.1.6 The recommended specimens for CCI and CCG testing is the standard compact tension specimen C(T) (see Fig. A1.1) which is pin-loaded in tension under constant loading conditions. The clevis setup is shown in Fig. A1.2 (see 7.2.1 for

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² The boldface numbers in parentheses refer to the list of references at the end of this standard.