



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

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1. Scope

1.1 This test method covers the determination of creep crack growth rates in metals at elevated temperature using compact type, $C(T)$, (see Fig. 1) specimens subjected to static or quasi-static loading conditions. The time rate of crack growth, $\dot{a}$ (t) or da/dt is expressed in terms of the magnitude of crack growth rate relating parameters, $C^*(t)$, C_t or K .

1.1.1 The choice of the crack growth rate relating parameter, $C^*(t)$, C_t , or K depends on the material behavior. Two types of material behavior are generally observed during creep crack growth tests; creep-ductile and creep-brittle. In creep ductile materials, creep crack growth is accompanied by substantial time-dependent creep strains at the crack tip and the crack growth rate is correlated by $C^*(t)$ and/or C_t (1-4).² 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, K is chosen as the correlating parameter (5).

1.1.2 In creep ductile materials, extensive creep occurs when the entire uncracked ligament undergoes creep deformation. Such conditions are distinct from the conditions of small-scale creep and transition creep (4, 6). In the case of extensive creep, the region dominated by creep deformation is significant in size in comparison to the crack size and to the uncracked ligament size. In small-scale-creep only a small region of the uncracked ligament near the crack tip experiences creep deformation. 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 (4).

1.1.3 Only steady-state creep crack growth rate behavior is covered by this method. During steady state, a unique correlation exists between $\dot{a}$ and the appropriate crack growth rate relating parameter. Transient crack growth conditions occur in the early stages of crack growth tests for the whole range of

creep brittle/ductile behavior which is excluded by this method.

1.1.4 The state-of-stress at the crack tip may have an influence on the creep crack growth behavior and can cause crack-front tunneling in plane-sided specimens. Specimen size and geometry also will affect the state-of-stress at the crack tip and are important factors in determining crack growth rate.

1.1.5 The recommended specimen is the standard compact tension specimen $C(T)$ with $B/W = 0.5$ and pin loaded in tension under constant loading conditions, Fig. 1. The specimen configuration has fixed planar dimensional proportionality with an initial normalized crack size, a_o/W , of 0.45 to 0.55. Side-grooved specimens are recommended to promote uniform crack extension across the thickness of the specimen (7).

1.1.6 Residual stresses can influence the measurement of crack growth properties (8). The effect can be significant when test coupons are taken from material that characteristically embodies residual stress fields; for example weldments, and/or thick cast, forged, extruded, products and product shapes where full stress relief is impractical. Specimens taken from such products that contain residual stresses will likewise themselves contain residual stresses. Extraction of specimens in itself partially relieves and redistributes the residual stress pattern, however, the remaining magnitude can still cause significant effects in the ensuing test. Residual stress is superimposed on applied stress and results in crack-tip stress intensity that is different from that based solely on externally applied forces or displacements. Distortion during specimen machining often indicates the presence of residual stresses. No allowance is included in this standard for dealing with residual stresses.

1.1.7 Specimen configurations other than the $C(T)$ specimen tested under constant load may involve validity requirements different from those presently specified in this test method. Nevertheless, use of geometries other than $C(T)$ are permitted by this method provided data are compared to data obtained from $C(T)$ specimens. Other specimens used in creep crack growth testing include the Single Edge Notch Bend (SENB) specimen, Single Edge Notch Tension (SENT) specimen, Middle Cracked Tension $M(T)$ specimen.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.3 *This standard does not purport to address all of the*

¹ This test method is under the jurisdiction of ASTM Committee E08 on Fracture Fatigue and is the direct responsibility of Subcommittee E08.06 on Crack Growth Behavior.

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