

# This Week's Citation Classic

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Coffin L F, Jr. A study of the effects of cyclic thermal stresses on a ductile metal. *Trans. ASME* 76:931-50, 1954.  
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The results of a study of cyclic strain and fatigue failure arising from cyclic thermal stresses are reported. Among the findings, fatigue crack initiation is shown to be determined by the cyclic plastic strain range of the alloy and upon the alloy's tensile ductility. [The SCJ<sup>®</sup> indicates that this paper has been cited over 115 times since 1961.]

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"At the time this paper was written I was a research associate at the Knolls Atomic Power Laboratory (KAPL), then part of General Electric's Research Laboratory. I went there in 1949, having previously been at Massachusetts Institute of Technology for ten years, teaching, doing war research, and completing my ScD. KAPL and its people were dedicated to the concept of building the first peacetime nuclear reactor, a sodium cooled intermediate neutron spectrum breeder, a very ambitious project as it now seems. There were, of course, many problems, but the resources in equipment and technical support were plentiful, and there was great enthusiasm in tackling these problems. One which interested me and which led to the paper cited here was how to account for the damage to structural components from repeated application of thermal transients due to sudden changes in the liquid sodium coolant temperature. Although fatigue was certainly involved, there was no information as to how this particular problem could be handled with the teachings of the time. The unique feature from a fatigue viewpoint was that the cyclic

stresses were produced by severe cyclic elastic plus plastic strains of thermal origin, a quite different situation from the then current view. Although at the time fatigue was not a major interest of mine, I set about to devise, construct, and experiment with a simple apparatus that heated and cooled a tubular test specimen while the ends of the tube were constrained from deformation. The results proved to be quite different than what was expected and led to some new insights about mechanical behavior of metals, especially from the viewpoint of cyclic strain.

"My feeling after reviewing the paper prior to writing this commentary is that there were several conclusions derived from the work having significance today. However, I am sure that its frequent citation is because of an experimentally derived relationship between cyclic plastic strain and cycles to failure. Originally called Coffin's law, with the discovery that a similar relationship was independently proposed by S.S. Manson,<sup>1</sup> the name was changed to the Coffin-Manson equation and rapidly gained credibility as a fatigue failure criterion. This early work was almost immediately applied to the formulation of fatigue design rules for life prediction of nuclear reactor structural materials and subsequently to a wide variety of components including gas and steam turbines.<sup>2</sup> Aside from its design application, the Coffin-Manson equation is often used in interpreting strain controlled fatigue results performed for basic compositional and microstructural interests, for materials performance at elevated temperatures, loading forms and environments, for life prediction, and material data compilation.

"Although I have published about 120 papers, this one was, I feel sure, my best. I was quite proud of it at the time and still am today. My interest in fatigue was kindled by this work, and has continued over the past 28 years. The work represented by this paper was, I believe, a significant contributing factor in my selection for awards from various engineering societies in recent years."

1. Manson S S. *Behavior of materials under conditions of thermal stress*. Cleveland, OH: National Advisory Committee for Aeronautics, 1953. NACA-TN-2933.
2. Spers D A & Mowbray D F, eds. *Thermal fatigue of materials and components*. Philadelphia: American Society of Testing and Materials, 1976. ASTM STP 612. 262 p.