

Rogers H C. The tensile fracture of ductile metals.
Trans. Met. Soc. AIME 218:498-506, 1960.
[General Electric Research Laboratory, Schenectady, NY]

Ductile fracture was found to initiate by void nucleation at inclusions or coarse particles. Because of enhanced triaxial tension at the center of the neck, voids grow most rapidly there leading to central crack formation. Lateral crack growth is terminated by cup-cone or double-cup fracture. [The SC][®] indicates that this paper has been cited in over 100 publications since 1961.]

Harry C. Rogers
Department of Materials Engineering
Drexel University
Philadelphia, PA 19104

June 24, 1983

"During the two decades following World War II, the General Electric Research Laboratory was an exciting place to work for a young materials scientist. J.H. Hollomon had assembled a group of the foremost materials scientists to work on all aspects of the behavior of materials. Fully employing the charter of this great laboratory, Hollomon allowed these investigators great freedom to direct their work as they saw fit to maximize creativity and the chance for significant discoveries. Only when the management felt that progress had ceased or that an investigation had become mired in relatively unimportant detail were suggestions made that perhaps new approaches or potentially more fruitful areas for study should be sought. I was a 'victim' of this system.

"Around 1957, after I had spent a number of years deeply involved with the problem of hydrogen embrittlement, my immediate manager decided that, although scientifically interesting, hydrogen embrittlement of metals was a rather narrow subject which would not have broad implications. Somewhat miffed because I felt otherwise, I asked him to suggest a broader failure problem. He suggested that little was known about

ductile fracture and it obviously had wide implications for a variety of failure conditions. This investigation and paper were the result of following up on this suggestion.

"Undoubtedly, the reason for the many citations of this paper is that it was probably the first experimental study in this area to describe reasonably well all the major features of the ductile rupture process as we know them today. Since its publication, there have been hundreds of studies of void-nucleated fracture, both experimental and analytical. Scientists such as A. Argon, M. Ashby, D. Broek, J. Low, F. McClintock, J. Rice, G. Smith, and many others have examined the metallurgy and mechanics of the ductile rupture process in great detail. My own research in this area was set back by a two-year hiatus involving research administration. Following this I returned to active research, investigating the roles of material and processing variables in the development of damage and fracture during metal working operations.

"In the initial study of ductile rupture, I recognized that two different roles are played by particles or inclusions in the ductile fracture process depending on their size. Large inclusions or particles nucleate voids at relatively low tensile strains and grow as deformation increases. In some metals they actually grow to coalescence, producing a 'spongy' fracture surface. In others, fracture occurs when the large voids connected by planar arrays of very fine voids generated by myriads of extremely small or 'invisible' particles as a result of the intervoid shear strain concentration. Such arrays I described as 'void sheets,' a term that is still used today.

"Today more than ever I appreciate the opportunity I was given to tackle a poorly understood problem with little preconception of either the approach or probable outcome. The number of citations of the published results helps support the contention that this approach does have validity at least on occasion. For more recent publications in this field see Broek¹ and Rosenfield.²

1. Broek D. The role of inclusions in ductile fracture and fracture toughness. *Eng. Fracture Mech.* 5:55-66, 1973.
2. Rosenfield A R. Criteria for ductile fracture of two-phase alloys. *Met. Rev.* 13:29-40, 1968.