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Brailsford A D & Bullough R. The rate theory of swelling due to void growth in irradiated metals. *J. Nucl. Mater.* 44:121-35, 1972.
[UKAEA, Theoretical Physics, AERE Division, Harwell, Didcot, Berkshire, England]

Rate equations for the spatially averaged interstitial and vacancy concentrations in irradiated materials are derived. The physical roles of the differing possible sink types in the evolving microstructure are elucidated and sink strengths for each of them are evaluated. A general expression for the swelling rate is obtained and this is used to illustrate the influence of the various physical and irradiation parameters. [The *SCI*® indicates that this paper has been cited in over 195 publications since 1972. Based on *SCI* data for 1961-80, it proved to be the most-cited paper ever published in this journal.]

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"Following the discovery of void swelling in reactor irradiated steels, there was intense activity worldwide[1] to understand and hopefully control this unexpected phenomenon. The matter was of some urgency as it was realized that its sensitivity to both neutron fluence and temperature portended the possibility of fuel pin bowing in fast reactors, with concomitant potential mechanical problems during refueling. Additionally, the tolerances which this fuel pin distortion mandated in future fast reactor design were such as to indicate a severe penalty in breeding efficiency.

"It was in this historical context that one of us (A.D.B.) joined the radiation damage group of the theoretical physics division of the Atomic Energy Research Establishment in 1971 as a professorial research fellow. In accord with the division's policy of pursuing fundamental research that is intimately wedded to technology, Brailsford was assigned the task of embarking upon a study of irradiation creep, a phenomenon closely allied to the void swelling problem, upon which research had been in progress for some time under the leadership of the other of us (R.B.).

"As a further part of our duties, we both also served on an Authority-wide working party concerned with modeling overall fuel pin behavior. It was at one meeting of this body that we were first asked to produce a physically based design equation for void swelling which could be used in place of the purely empirical mathematical expressions then being invented to describe an ever-burgeoning mass of experimental data. This will explain why an avowedly crude design equation was highlighted in the abstract of our paper. In the first instance, our work was intended to allay an immediate practical need.

"However, the more durable part of our publication concerns less the design equation itself (which has since been superseded) but, rather, the physics underlying the entire analysis. For we believe it was our perception of the rate theory of point defect processes in materials as a self-consistent effective medium theory that is the most probable reason for our paper being so frequently cited. Indeed, though rate theory had an extensive prior history in this field,[2] our exposition of its fundamental significance, then and in subsequent publications,[3,4] has helped to establish it as a rigorous discipline currently in widespread use by the majority of workers in this field.

"From the scientific point of view, the most exciting aspect of this work, having once understood the significance of rate theory, was the relative ease with which we could: (i) display in analytic fashion the dependence of the swelling rate on different microstructural features of materials (either irradiation—induced or otherwise), and (ii) give a simple demonstration of the shift in the temperature of maximum swelling with a change of irradiation dose rate or cold work.

"From the personal point of view our work also had many rewarding aspects, not the least of which was that it enabled us to bring to bear our somewhat different past experiences upon a shared problem. This led to continued collaboration and a lasting friendship. All in all, the work marks a most pleasurable period in our lives. We are thus delighted to learn that, apparently, it has also been of help to many others."

1. **Pugh S F, Loretto M H & Norris D I R, eds.** *Voids formed by irradiation of reactor materials: proceedings of the British Nuclear Energy Society European conference held at Reading University on 24 and 25 March 1971.* Harwell, England: Atomic Energy Research Establishment, 1972. 365 p.
2. **Damask A C & Dienes G J.** *Point defects in metals.* New York: Gordon and Breach, 1963. p. 77-144.
[Citation Classic. *Current Contents/Physical, Chemical & Earth Sciences* 21(39):20, 28 September 1981.]
3. **Brailsford A D.** Diffusion to a random array of identical spherical sinks. *J. Nucl. Mater.* 60:257-78, 1976.
4. **Brailsford A D & Bullough R.** The theory of sink strengths. *Phil. Trans. Roy. Soc. London A* 302:87-137, 1981.