

A re-assessment of elastic follow-up in high temperature piping

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Submitted to the 13th International Conference on *Pressure Vessel Technology* (ICPVT13)

20-23 May, 2012, London, UK

The problem of elastic follow-up in high temperature piping has a long (and interesting) history. Until a paper by Robinson¹ in 1955 it was assumed that since the piping was ‘deformation-controlled’, the strain would remain broadly constant with the stress relaxing from the initial elastic stress. Robinson demonstrated that this was not the case since some simple piping configurations could have large inelastic strain concentration at some locations due to elastic behaviour of other locations (which he termed ‘follow-up elasticity’), which led to a slower stress relaxation. From this observation, many attempts were made to try to characterise the amount of extent of elastic follow-up in a simple way. A review of the various attempts was given by the author² in 1987: it was noted that a common design approach could be developed based on isochronous stress-strain trajectories for the high strain locations. It was found that these trajectories were approximately linear and relatively insensitive to the creep model and, as such, formed a good basis for a simple design approach which avoided inelastic analysis. Most studies of elastic follow-up have been based on relatively simple creep models, specifically the power law. However it has recently been shown by the author³ that if a stress range dependent constitutive model (that is, the form of the constitutive model, even for secondary creep, changes as the stress increases from low through moderate to high stress) is used, then stress-strain trajectory is no longer insensitive to the creep model and current design approaches could be highly conservative. The aim of this paper is to examine the consequences for this observation in high temperature piping, specifically providing a re-assessment of some of the examples given by Nakamura & Boyle⁴ and to compare to current design practice.

¹ Robinson, E.L., 1955, “Steam piping design to minimize creep concentration”, *Trans. ASME*, **77**, pp. 1147-1162.

² Boyle, J.T., and Nakamura, K., 1987, “The assessment of elastic follow-up in high temperature piping systems – overall survey and theoretical results” *Int. J. Pres. Vess. & Piping*, **29**, pp. 167-194.

³ Boyle, J.T., 2011, “Stress relaxation and elastic follow-up using a stress range dependent constitutive model” *Proc. IMechE, Part C: J. Mechanical Engineering Science* (In press)

⁴ Nakamura, K. and Boyle, J.T., 1987, “The assessment of elastic follow-up in high temperature piping systems – some example problems” *Int. J. Pres. Vess. & Piping*, **29**, pp. 249-273.