

DISCUSSION

A. T. Donaldson¹ (written discussion)—(1) In your photographs of samples of tubing, those with low frequency and incidence of nodular corrosion showed nodules aligned in strings along tube axial direction. Can you comment why this occurs?

(2) In your plots of weight gain versus tube wall thickness at constant tube diameter weight gain reduced as wall thickness reduced. Is this simply a dependence on degree of cold work?

C. T. Wang et al. (authors' closure)—(1) No particular cause was found for the formation of nodule strings in the present work. On other occasions we have found that galling or lubrication breakdown during extrusion has led to formation of linear patterns of nodules.

(2) The samples are in the fully annealed condition, so the reduction in weight gain is not affected by degree of residual cold work. Rather, it is affected by a combination of factors, including accumulated reduction in area in the previous three passes, Q -factors of reduction process, and texture of the tube, although the last correlation is not well established.

B. F. Kammenzind² (written discussion)—The values that you presented as the matrix content of the solute elements (Fe, Cr, and Ni) are much larger than the terminal solubility values for these elements in available binary phase diagrams. Could you have included precipitates in your analysis area? The increased variability that you observed in your measurements with increasing annealing temperature may be merely a result of increased precipitate spacing.

C. T. Wang et al. (authors' closure)—A preliminary TEM work on the Zircaloy-2 tubing samples showed that the mean spacing for precipitates ranges from 0.141 to 0.941 μm , while the excitation zone of electron beam is on the order of 1 μm . It is conceivable that the analysis is influenced by the fluorescence of the precipitates. However, the comparison of concentrations between samples is still valid, as stated in the section on Results of Examination and Analyses—Solute Concentrations. The most important point is that this relatively inexpensive microprobe method can produce results which correlate with nodular corrosion resistance measured in high temperature autoclave tests. More expensive and time consuming techniques, such as TEM analysis and atom probe analysis, are probably more definitive than this microprobe technique in terms of precipitate compositions, but these techniques may not correlate as well to the nodular corrosion behavior. The correlation of precipitate size and distribution to the matrix analysis is under investigation using SEM and TEM techniques and will be reported upon separately.

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