cracking when the atmosphere contained a certain amount of moisture along with iodine, and interpreted this to be the effect of hydrogen dissolved in the Zircaloy. Videm & Lunde[8] have indicated that moisture was not effective in causing cracking, but failed to provide any quantitative consideration of their finding. Since moisture similarly oxidized Zircaloy, it may be expected to produce an effect similar to oxygen gas in respect of iodine SCC.

5. Cracking and Fracture Observation

Cracking in cold-worked and 480°C annealed tube specimens took the forms shown in **Photos. 1(a)** and (**b**). While most of the failed tubes had cracked at only one position, some others were broken at two points. The wider gap seen in the cold-worked specimen evidences residual stress.

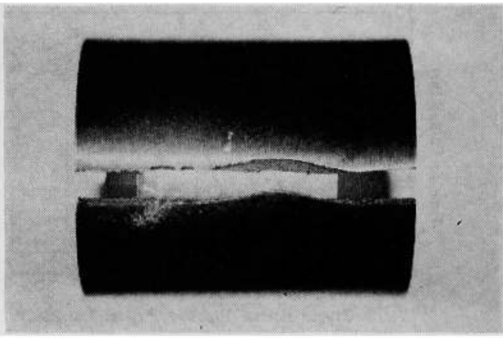

Photo. 1(a) Cracking in cold-worked tube

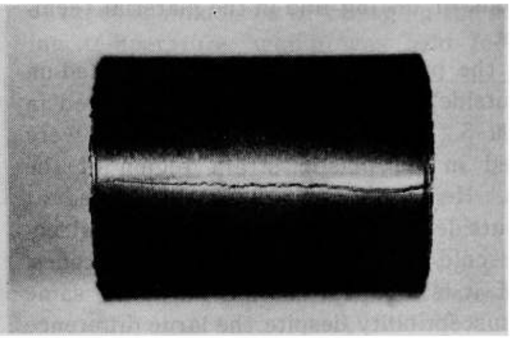

Photo. 1(b) Cracking in annealed (480°C, 2 hr) tube

As seen in **Photo. 2**, the cracks that did not completely traverse the specimen thickness had generally initiated on the outer surface, which was directly exposed to iodine corrosion. This behavior, however, does not agree with the report by Garlick & Wolfenden [2], who observed cracks initiating mainly from the inner surface.

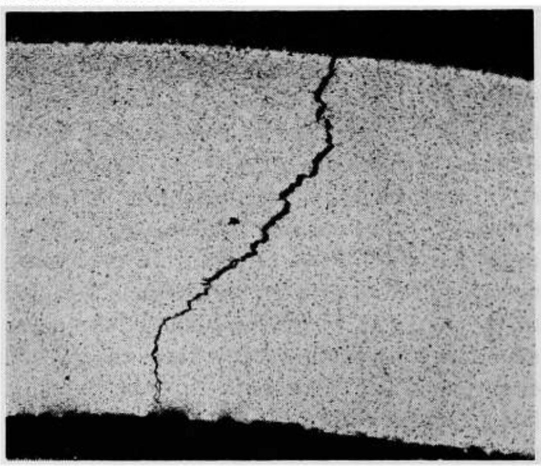

Photo. 2 Face view of unpenetrated crack on specimen

Scanning electron micrographs of the fracture surfaces of cold-worked tube are shown in **Photos. 3(a)** and (**b**), which represent experimental conditions of $P_{O_2} \simeq 0$ and $P_{O_2} \simeq 4$ torr, respectively. Transgranular cleavage facets of flat form, of area approximately equal to the cross section of one grain, are observed in Photo. 3(a), which also reveals typical simple river patterns. No evidence is seen of the dimpled structures, which are known to be associated with micro-void coalescence in ductile failure. The relatively oxygen-rich atmosphere represented in Photo. 3(b) is seen to have generated numerous cracks on the oxide film, while on the other hand, the fracture surface oxidation has prevented occurrence of the cleavage facets that characterized Photo. 3(a).

IV. Conclusion

(1) The unit of critical iodine concentration is more appropriately expressed in concentration per unit free volume than per unit surface area of the material. The critical concentrations required to cause the cracking are 0.15 mg/cm³ at 300°C and 1.1 mg/cm³ at 350°C.

(2) Cracking was observed to occur only