

AN INVESTIGATION OF THREE RADIOGRAPHIC ACCESS PORT PLUG GEOMETRIES AND THE SURROUNDING PIPE WALL UNDERGOING CREEP



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FOREWORD

This report evaluates the effects of various plug geometries on stresses that evolve during creep. A quantitative investigation of creep-compliant plugs was conducted. This work identifies the stresses, as a function of plug geometry, in the weld between the plug and the pipe wall.

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EXECUTIVE SUMMARY

When heavy-wall pipe field welds are radiographed, common practice is to route the radiation source through a hole in a pipe near a weld, and locate it on the centerline using a J-shaped tube. The J-shaped tube is then removed and a plug is screwed into the hole. The plug is then welded to the pipe around the plug's circumference. Initially, the stresses are carried by the plug's threads. However, after prolonged service, stresses are increasingly carried by the circumferential plug welds. In addition to thread corrosion, creep stretches the hole in which the plug is located, possibly increasing stress on the circumferential plug weld. Creep failures of radiographic access port plugs have been observed.

The objective addressed in the report is to evaluate the effects of various plug geometries on stresses that evolve during creep. This was done by examining stresses using finite element creep simulation on three different plug geometries. No threads were considered in any of the geometries. The forces due to internal pressure were only resisted by the plug fillet weld. The following geometries were considered.

- 1) A solid plug with no threads.
- 2) A bored out plug (3/8" wall thickness) ceteris paribus. (1/2" bore)
- 3) A bored out plug (1/4" wall thickness) ceteris paribus. (5/8" bore)

The weld geometry considered was a 3/8" circumferential fillet weld between the plug and the pipe.

Three identically-loaded finite-element models were assessed. To assess the plug geometries, maximum and average stress values were compared at five locations in each weld. Principal, Von Mises, hoop and radial stresses were examined (where hoop and radial stress were defined as local to the plug).

Both maximum and average principal stress (largest tensile stress) in the weld increased with plug bore diameter, as did hoop stress values. The analysis results also seemed to show that the use hollowed-out plugs had a detrimental effect on both the maximum and average hoop stress around the plug. Von Mises stress showed no significant dependence or a slight increase with increasing bore diameter. The hollowed-out plugs were slightly more compliant during the initial phases of creep, as shown by more rapid stress change and a quicker time to reach steady-state. However, the relevant stresses, both initially and after creep evolution to steady state, were higher for the hollowed-out plugs.

The comparative behavior of the various plug geometries did not change as the internal pressure was increased, even though the initial stress and creep rates increase. This suggests that hollowed-out plugs offer no significant advantage even at higher internal pressures.

Further examination of a plug design using a 3/8" wall thickness plug (1/2" bore), but with a deeper flat bottom bore hole showed no significant benefit as compared to the original bore geometry. There was no significant stress reduction or improvement in creep compliance, and the resulting stresses initially, and after creep, were still higher than the solid plug geometry.

As failure of the plug weld will be governed predominately by hoop or principal stresses, these results indicate there are no substantial benefits, and possibly detrimental impact, to the use of hollowed-out plugs.