

energy was transmitted to the original shroud at these frequencies to cause the observed failures. After the guides were removed, the peak strains at the pump induced frequencies were measured during the demonstration test and were well below the allowable.

## 2.2 DESCRIPTION OF DESIGN MODIFICATION

Two design modifications eliminate potential causes of the failures which were identified by test and by analysis. First, the top three inches of the CEA shroud is removed along with all the CEA guides. This has two effects. It eliminates the potential resonance failure caused by vibration of the CEA guides. It also eliminates the high stress concentration at the top of the tubes and thereby reduces the local stresses induced by global shroud vibration. The function of the CEA guides is provided by a separate tool which is utilized only during refueling operations. It is removed during reactor operation.

The second modification is the addition of snubbers which limit the lateral displacement of the CEA shroud in the global modes of vibration. Snubbers are located on the shroud at the UGS flange elevation and transmit the loading to the UGS flange. This also raises the natural frequencies of the dominant global vibration modes of the shroud relative to the upper guide structure assembly.

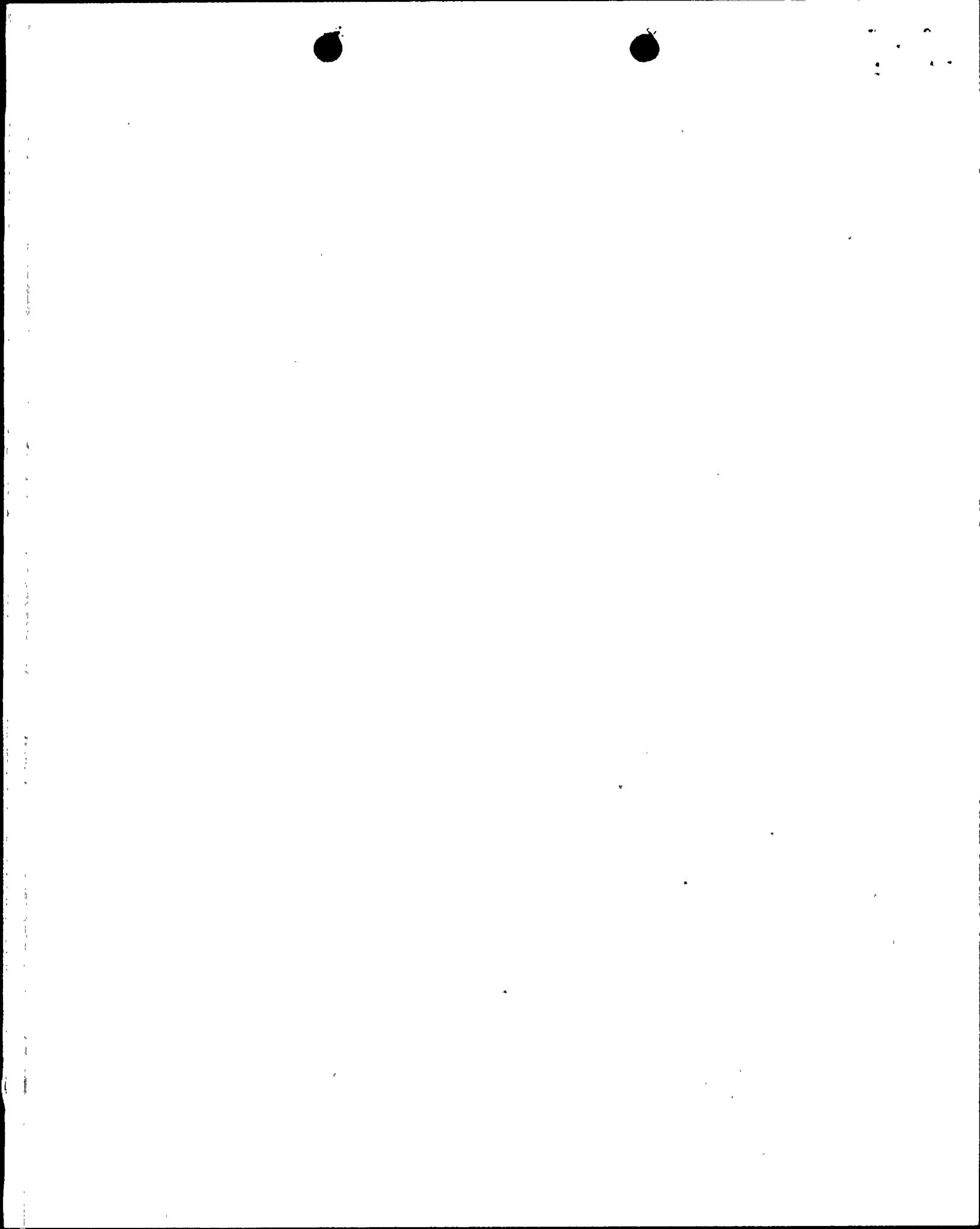
Welds at the web-to-tube junctions near the top and at the tie rod locations on the bottom of the shroud were upgraded to full penetration welds and were fully dye penetrant inspected. Thus, potential crack initiators resulting after cutoff of the shroud are minimized.

The potential for stress corrosion cracking in the crevice between double fillet welds joining webs and tubes of the original Palo Verde 1 shroud is discussed in Section 3.2. The potential for such cracking on the Palo Verde 1 replacement CEA shroud and on the Palo Verde 2 and 3 CEA shrouds was less because relatively few such welds had been made by Shielded Metal Arc Welding (SMAW). ~~Where SMAW had been used, the welds were mechanically removed and replaced, thus eliminating all potential for such crack initiation.~~

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Page 2-5 Last Paragraph

Replace the deleted sentence with the following: "Where SMAW had been used for fillet, double fillet, or partial penetration welds, the welds were mechanically removed and replaced, thus eliminating all potential for such crack initiation. All fillet, double fillet, or partial penetration welds which had been made previously with shielded metal arc (SMA) were mechanically removed and replaced with a full penetration weld or with a weld using a gas metal arc (GMA) or a gas tungsten arc (GTA) process thereby eliminating the probable cause for initiation of such cracks in the failed shroud."



## 5.0 CORRECTIVE ACTIONS

The problem in Section 1.1 was corrected by taking the actions described below.

### 5.1 CEA GUIDE MODIFICATION

A new CEA shroud was procured for Palo Verde 1, identical to the existing CEA shrouds for Palo Verde 2 and 3. The original construction of these shrouds is described here and the modifications made to all three shrouds are described in the following paragraphs.

The shrouds are constructed from 61 tubes 9 in. diameter and 3/16 in. thick and from webs 3/16 in thick on the interior and 1/4 in. thick around the periphery. The tubes are rolled and full penetration seam welded. These characteristics are the same for the three final shrouds and for the failed shroud on Palo Verde 1. However the welding for the failed shroud, as described in Section 3.1.2.1, was somewhat different in that shielded metal arc was utilized in some locations and is considered the source of the TGSCC found in the tube-to-web junctions as discussed in Section 3.2. In the final shrouds, the welds joining the tubes and webs were made by gas metal arc and consist of 1/4 in. fillet welds both sides for 24 in. at top and bottom with either 1/4 in. single fillet welds or 1/8 in. double fillet welds over 1/16 in. partial penetration welds along the entire length. Visual inspection criteria were imposed on these welds. ~~All welds which had been made previously with shielded metal arc were mechanically removed and replaced thereby eliminating the probable initiator of some of the cracks in the failed shroud. All three of these shrouds were further modified as described in the following.~~

Page 5-1 Last Paragraph

Replace the deleted portion with the following: "All fillet, double fillet, or partial penetration welds which had been made previously with shielded metal arc (SMA) were mechanically removed and replaced with a full penetration weld or with a weld using a gas metal arc (GMA) or a gas tungsten arc (GTA) process thereby eliminating the probable initiation cause for stress corrosion cracks in the failed shroud. All three of these shrouds were further modified as described in the following."

