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TITLE ANALYSIS OF TOOLING BOSS WELD FAILURE IN THE LOWER BULKHEAD OF THE S-IC-S FUEL TANK

MODEL NO. SATURN V/S-IC CONTRACT NO. NAS8-5608

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REVISIONS

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ABSTRACT

A section of the failed tooling boss weld from the lower fuel tank bulkhead of the S-IC-S fuel tank was provided to Systems Technology of the Launch Systems Branch for analysis. Failure occurred during the Ultimate Pressure Test (D-35) at a hydrostatic pressure of 62.5 psig. Hardness tests and metallographic analysis revealed that excessive heat had been employed to produce the original weld and multiple repairs, which still contained large amounts of porosity after repair. The lessening of 2219/2319 aluminum alloy properties in the tooling boss weld area by excessive heating and weld porosities was significant enough to permit failure under Ultimate Test Pressure conditions.

KEY WORDS

Lower Bulkhead

S-IC-S Fuel Tank

Tooling Boss Weld Failure

2219 Aluminum Alloy

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1.0 **OBJECT**

The purpose of this investigation was to determine the cause of failure in the lower fuel tank bulkhead tooling boss weld of the S-IC-S.

2.0 **BACKGROUND**

On April 28, 1967, during the Ultimate Pressure Test of the S-IC-S Fuel Tank, the tooling boss weld in the lower bulkhead failed at a hydrostatic pressure of 62.5 psig. Several months later a section of this weldment was submitted to Systems Technology by R-P&VE-M for analysis of the failures.

The 2219-T87 aluminum alloy tooling boss, P/N 60B24213 was welded into the 2219-T37 aluminum alloy center piece in accordance with the requirements of drawing no. 60B24200 which invokes Class II radiographic quality for the welds.

Figure 1 is a testing log for the S-IC-S Fuel tank as reported in D5-11973 "S-IC Stage Major Structural Test Program"

3.0 **CONCLUSIONS**

The presence of much porosity in the weld and the use of extreme heat during multiple repair welding lowered the properties of the weldment to such an extent that it could not withstand the Ultimate Test Pressure of 62.5 psig after pressure cycling as shown in Figure 1. It is probable that the condition of this weld was unique to the S-IC-S Fuel Tank.

4.0 **RECOMMENDATIONS**

Since all of the stages (501 through 504) which contain the welded tooling boss have been adequately inspected, proof tested and captive fired, sufficient confidence should be placed in the current satisfactory condition of these welds and capability to sustain anticipated pressures. (Subsequent vehicles contain a mechanically fastened boss which is considered more reliable.)

5.0 **PROCEDURES AND RESULTS**

The weld specimen used in this analysis, Figure 2, was located in the tooling boss weld as shown in Figure 3. After x-raying the specimen, the fracture was broken open Figure 4 and the faces examined using a wide field stereoscope. Figure 5 shows two areas containing corrosion products and debris typical of the entire fracture length. Fracture origin could not be determined because of this condition. The x-ray indication of the crack was so massive that it obscured any other possible defects, Figure 6.

5.0 **PROCEDURES AND RESULTS** (Continued)

The weld specimen was sectioned as shown in Figure 7a and the macrographic findings are illustrated by Figures 7b through 7f inclusive. It can be noted that the weld has been repaired one or more times dependent on location and considerable porosity is evident in figures nos. 7d, e and f. The conditions present in the right end of the weld suggest that the fracture origin occurred between 7d and 7f.

Spectrographic analysis confirmed that the base metal and weld were 2219 and 2319 aluminum alloys respectively.

Hardness tests at four locations were made from the center-line of the weld out into the base metal to determine at which point base metal properties were recovered. Figure 8 contains the results of four traverses and reveal that recovery, R_c 76, is between 1.25 and 1.50 inches from the weld. This indicates that extreme heat was used in making the weld and weld repairs which in conjunction with the aforementioned porosities, lowered the mechanical properties of this weldment sufficiently to allow failure under Ultimate Test Pressure conditions.

6.0 **REFERENCES**

1. D5-11973 - "S-IC Stage Major Structural Test Program."

2. LSR 0337 - Spectrographic Analysis of Base Metal and Weld Samples.

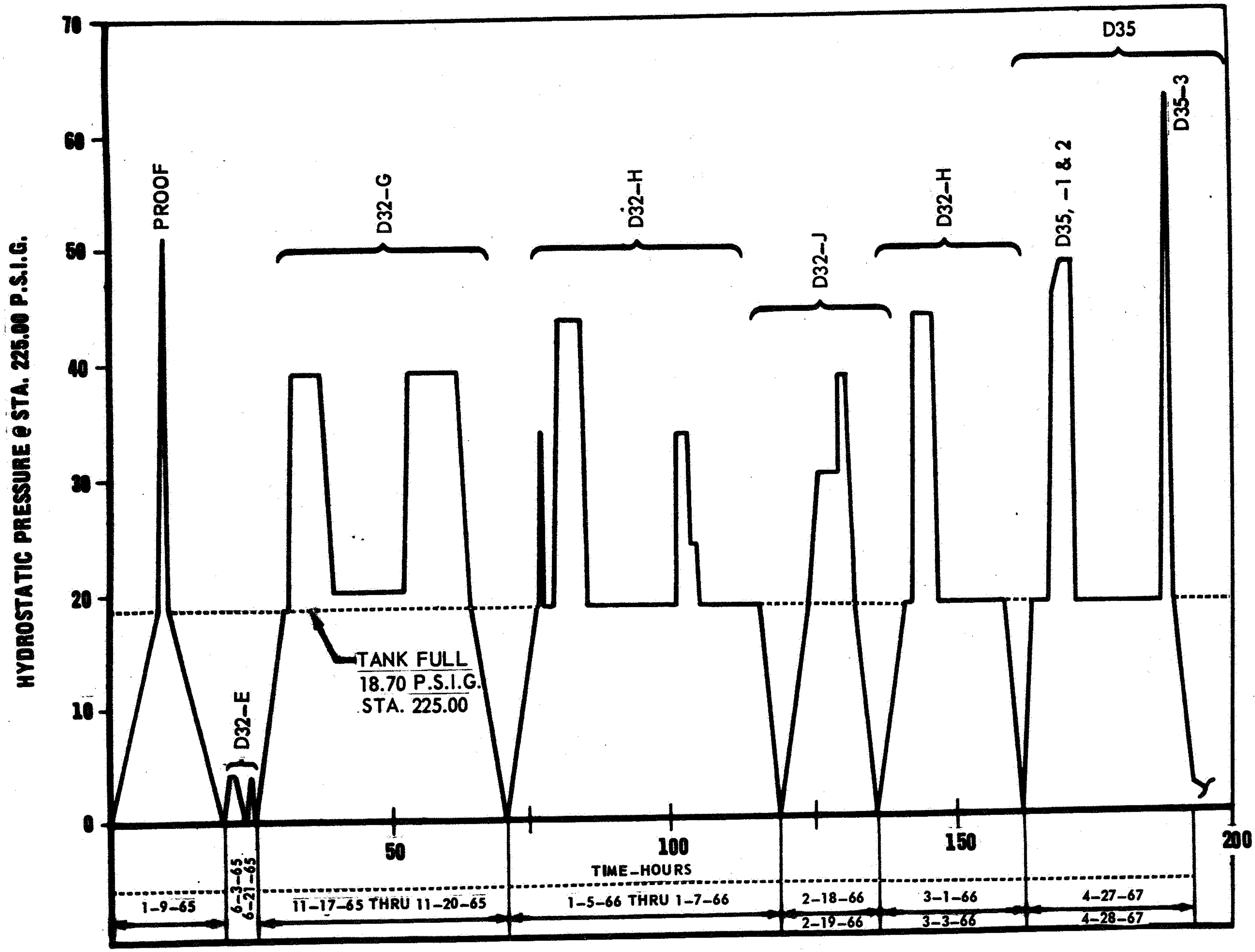

FIG. 1 S-IC-S FUEL TANK COMPOSITE LOG

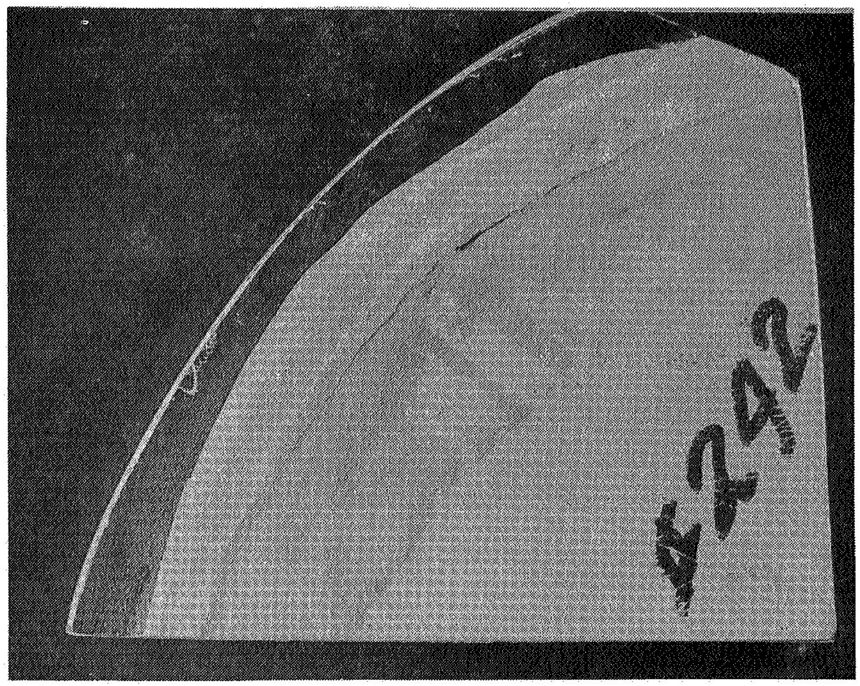

FIGURE 2 - WELD SPECIMEN FROM TOOLING BOSS 1X

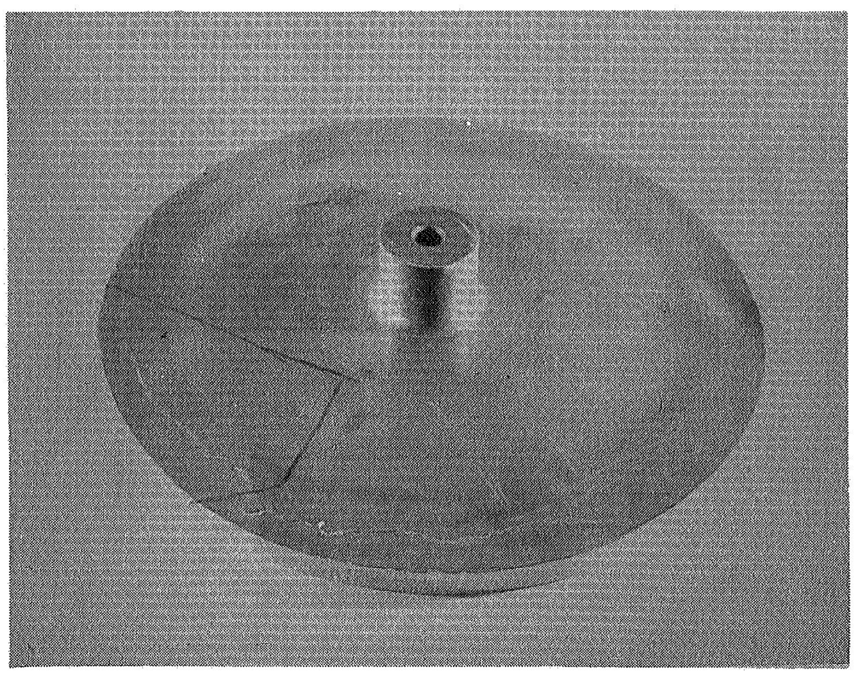

FIGURE 3 - TOOLING BOSS WITH FAILED WELD 1/3 SIZE

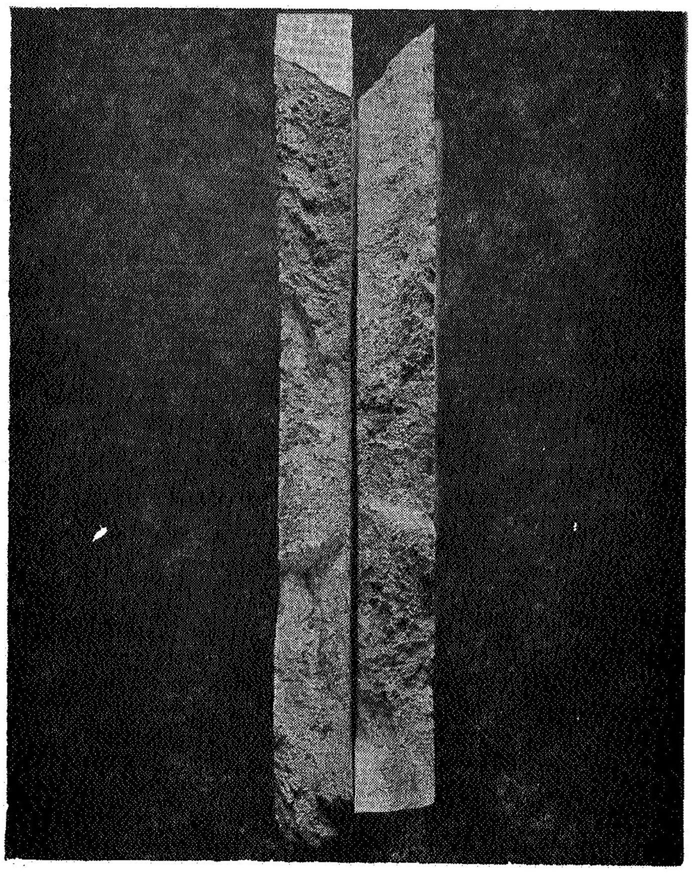

FIGURE 4 - FRACTURE FACES 1X

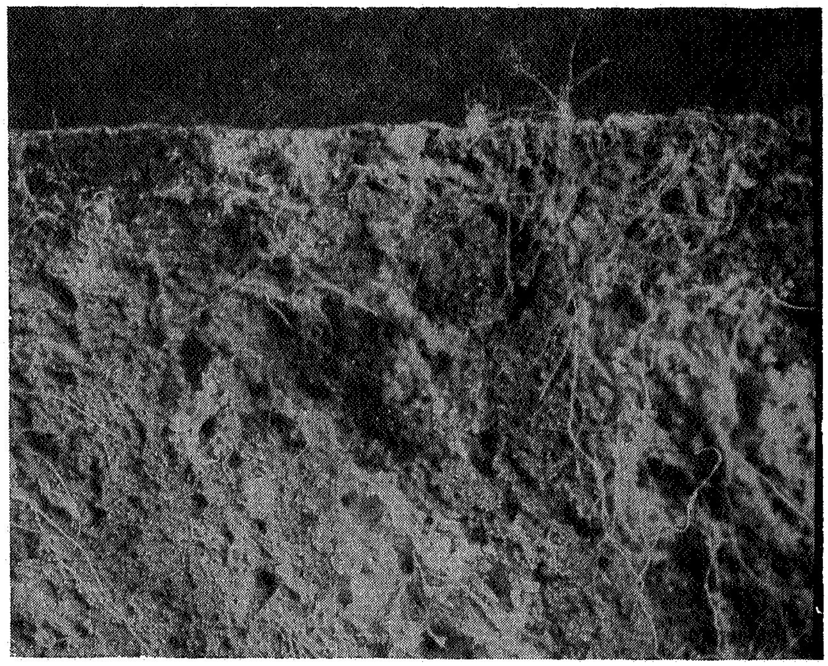

FIGURE 5 - FRACTURE FACE CORROSION AND DEBRIS 8X

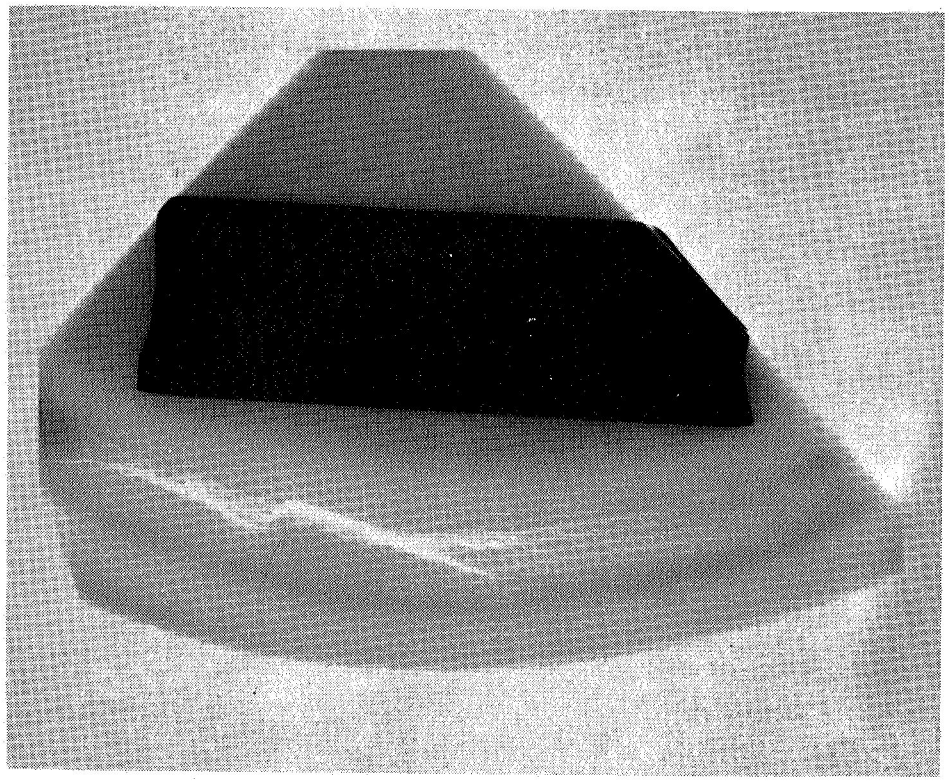

FIGURE 6 - X-RAY OF CRACK

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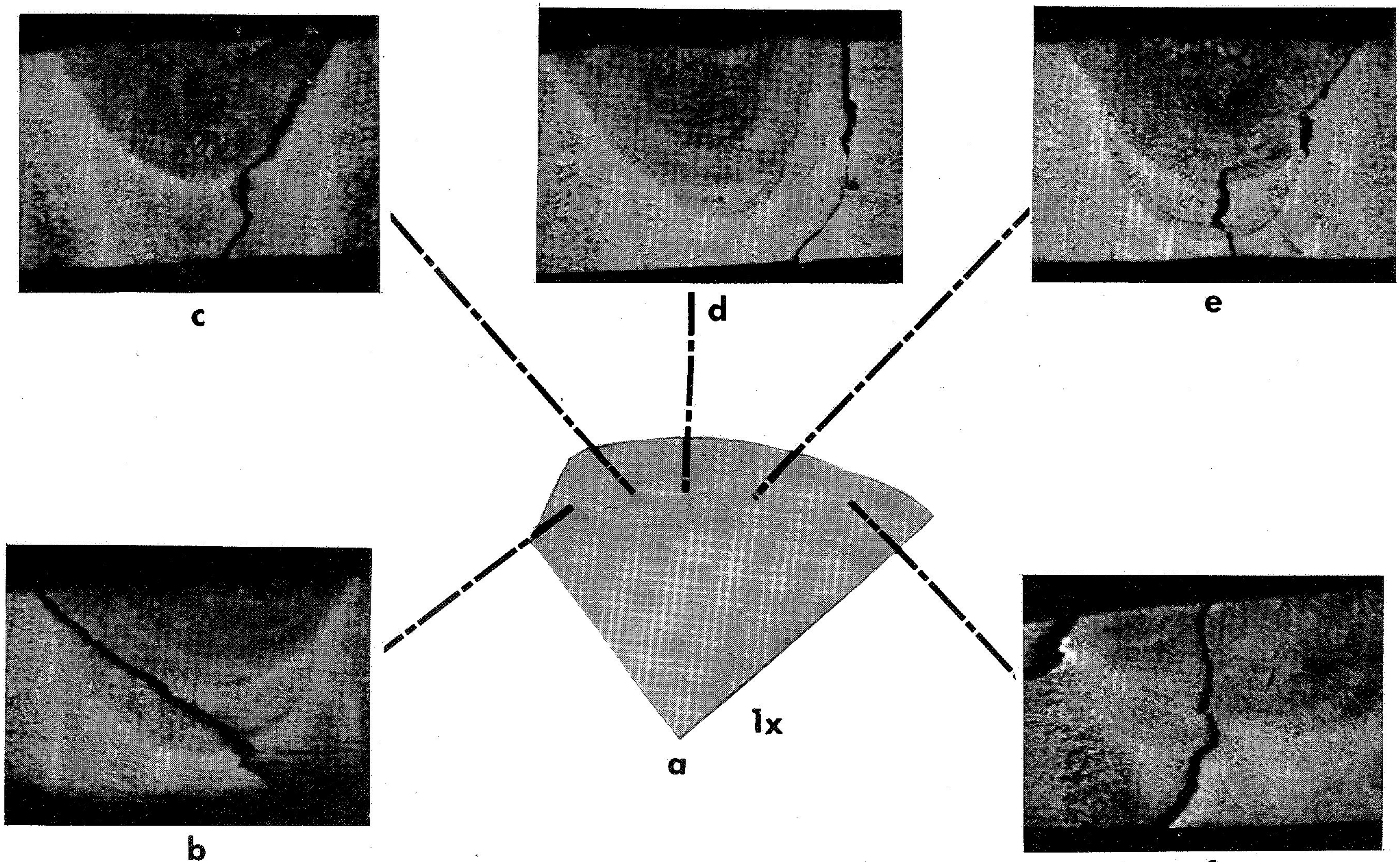

Fig.7Macrographs of weld at several locations (Keller's etch - 6.5x)

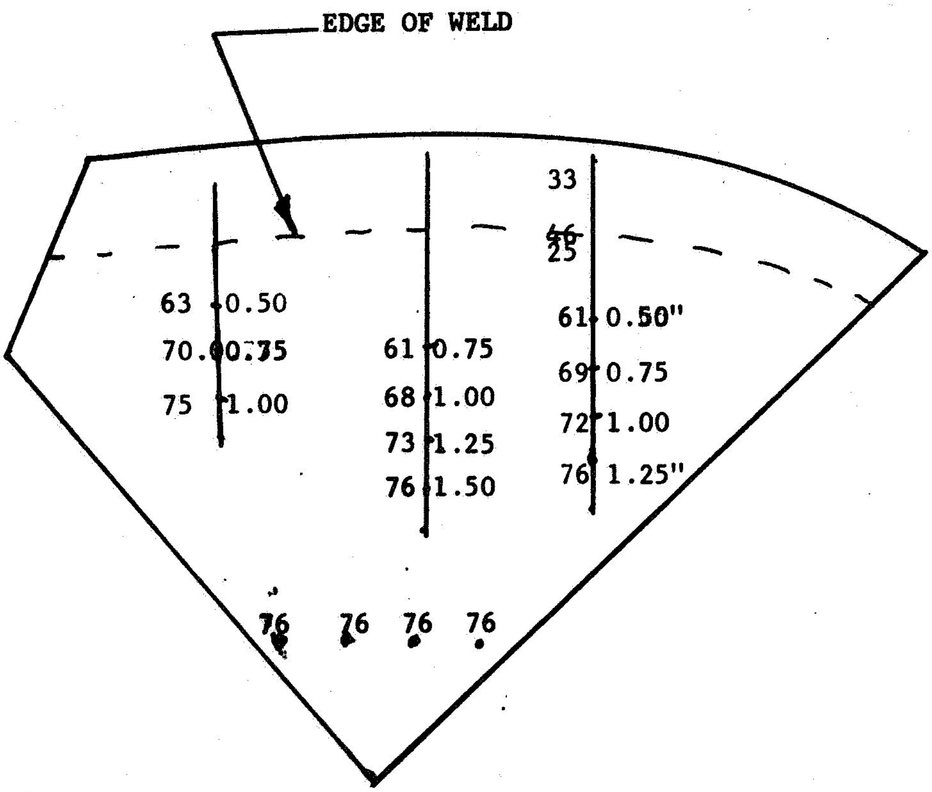

FIGURE 8 - HARDNESS READINGS R_b