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DOCUMENT NO. T5-6539-102

VOLUME 1 OF 1

TITLE INVESTIGATION OF ELECTRON BEAM WELDS IN A SENSOR TUBE

MODEL NO. SaturnV/2-15 CONTRACT NO. NAS8-5608

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ISSUE NO. M-19 ISSUED TO National Aeronautics and Space Administration

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REV. SYM.

S-406-10-3 REV. 7/64

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CHANGE RECORD

REV. SYM.	SECT.	PAGES REVISED	PAGES ADDED	PAGES DELETED	REV. SYM.	SECT.	PAGES REVISED	PAGES ADDED	PAGES DELETED

REVISIONS			
REV. SYM.	DESCRIPTION	DATE	APPROVED

ABSTRACT

A sample of electron beam welding was obtained from the Instruments and Life Support Division of the Bendix Corporation, Davenport, Iowa. The proposed weld design is intended to be used in the construction of the LOX Engine Cutoff Sensor, 60B41008-5. Two dissimilar metal tubes, made of Kovar and AISI 321 corrosion resistant steel, were welded together.

The properties of the weld were determined by visual and X-ray examination, hardness tests, and microscopic analysis.

The electron beam welds were found to be of excellent quality and use of similar quality welded tubes in the sensor assembly is considered satisfactory.

KEY WORDS

Electron Beam Welding

LOX Sensor

60B41008-5

Kovar

AISI 321

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LIST OF FIGURES

1.0 OBJECT

The object of this investigation was to determine the weld quality of an electron beam welded sensor tube when compared to the requirements of BAC 5959.

2.0 BACKGROUND

A sample tube assembly containing electron beam welds, between AISI 321 corrosion resistant steel and Kovar, obtained from the Instruments and Life Support Division of the Bendix Corporation, Davenport, Iowa, was analyzed in December, 1967.

A newly proposed LOX Engine Cutoff Sensor, 60B41008-5 (Bendix part number 1620577-1), is being reviewed. This design incorporates electron beam welds which replace a formerly brazed joint. This change was proposed because less heat is transferred to the sensor tubes by the electron beam welding process, thus producing higher reliability of a glass to Kovar seal. The weld joint consists of two welds, a melt-through and a fillet weld, The welds were evaluated by inspecting to the requirements of Electron Beam Welding Specification BAC 5959. Bendix Corporation will appraise welds to their specification, MCI-185, which has similar inspection criteria.

3.0 CONCLUSION

The fillet and melt-through welds are Class "A" welds per BAC 5959.

4.0 RECOMMENDATIONS

Sensor tube joints may be electron beam welded.

5.0 PROCEDURE AND RESULTS

5.1 Visual examination of the weld revealed no surface defects. The sample was X-rayed to determine if the welds had cracks, porosity, inclusions, or vapor pockets. Microanalysis of a longitudinal section was made to show the structure of the welds and the heat affected zones, Figure 1. Hardness tests were conducted to determine the properties of the heat affected zones, base metals and the weld metal.

5.2 Analysis of the X-rays revealed one small pore below the surface of the melt-through weld approximately .01" in diameter, Figure 2. The fillet weld had no defects.

5.2 (continued)

Microscopic study of a metallographic sample was performed on a longitudinal section across the welds. The AISI 321 was fine grained austenite with a typical amount of stringers throughout. The Kovar consisted of a single fine grained solid solution. The heat affected zones were very narrow. Owing to preferential dissolution of the two alloys during etching the weld to AISI 321 interface appears darker due to shadow effects, figures 3-5. The weld zone appears to be a combination of Kovar and 321 showing good fusion. The base metals have flowed into the weld zones, as can be observed in figures 6-8. The weld zones consisted of a large grained cast structure typical for welds of this type.

A Tukon hardness survey was made and the readings were converted to Rockwell "B", Table I. The preferential etching, forming a line between the AISI 321 and the weld zone, as well as the weld, are approximately R_b 75.

5.3 Electron beam welding is expected to produce sensor tube welds of excellent quality. Electron Beam Weld Specification BAC 5959, issued 1/18/66, was used to determine the class of each weld. The fillet and melt-through weld contained one small pore, approximately 22% of the thinner base metal thickness. Thirty percent is allowed for Class "A" welds. The weld structure was found to be satisfactory by microscopic inspection. The hardness indicated that the heat affected zones are narrow. Electron beam welding is a superior joining process imparting a minimum of heat to the sensor tubes.

6.0 **REFERENCES**

Boeing Process Specification: BAC 5959, "Electron Beam Welding", January 18, 1966

Bendix Corporation Specification: MCI-185, "Electron Beam Welding", December 20, 1967

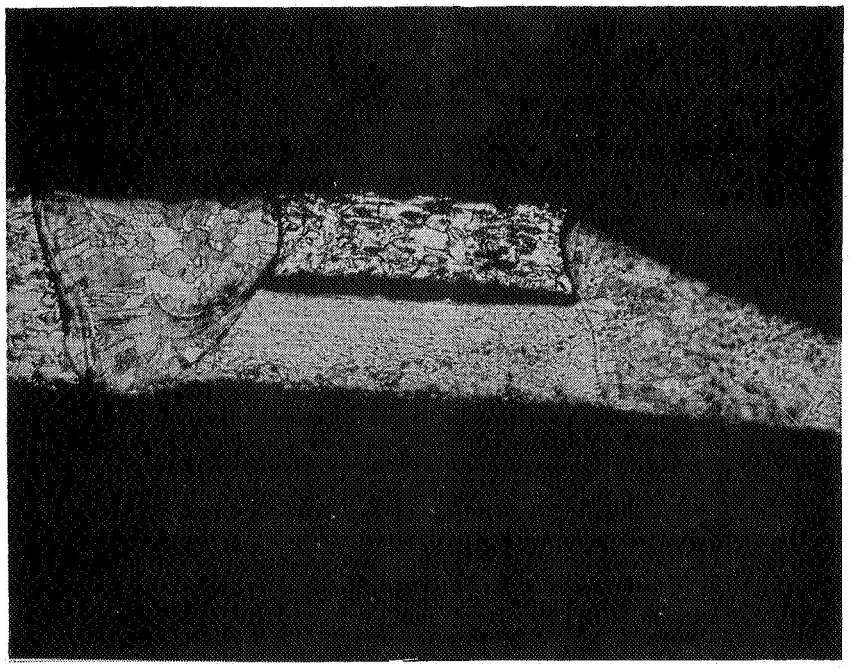


FIGURE 1

ELECTRON BEAM WELDS, MAG. 35X McNeece Etch

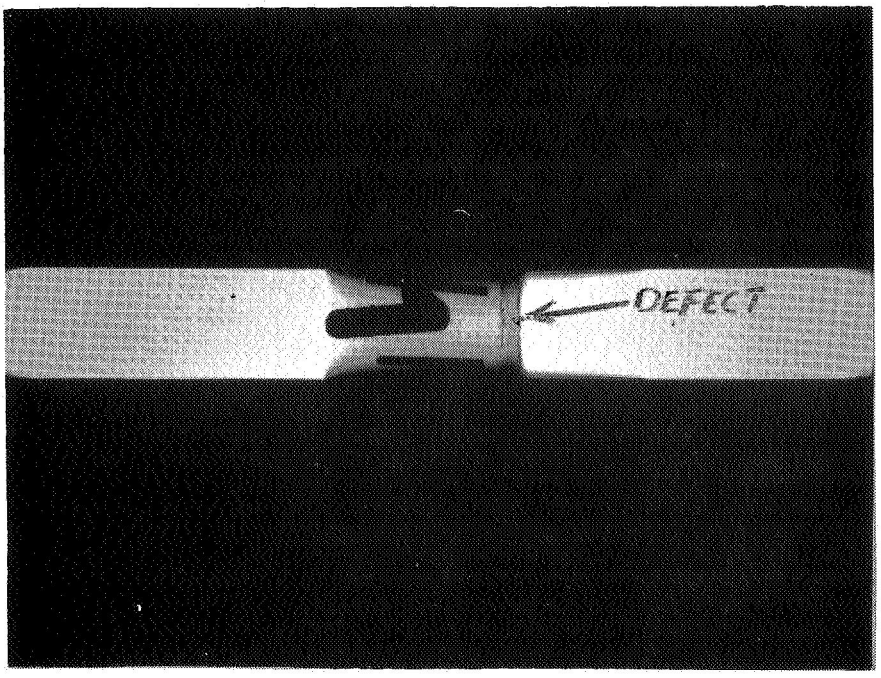


FIGURE 2

PRINT OF X-RAY SHOWING WELD DEFECT ACTUAL SIZE

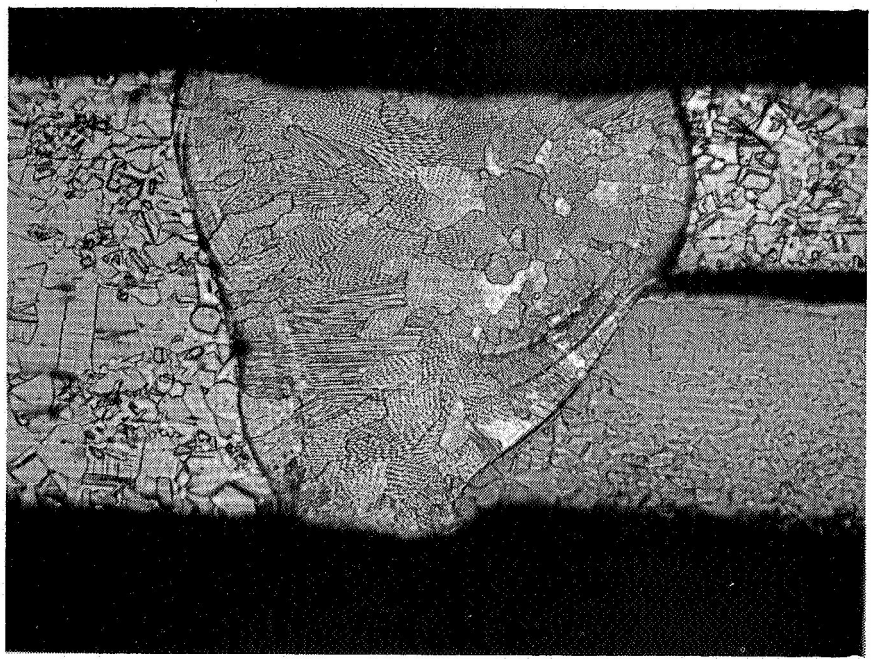


FIGURE 3

MELT-THROUGH WELD, MAG. 50X McNeece Etch

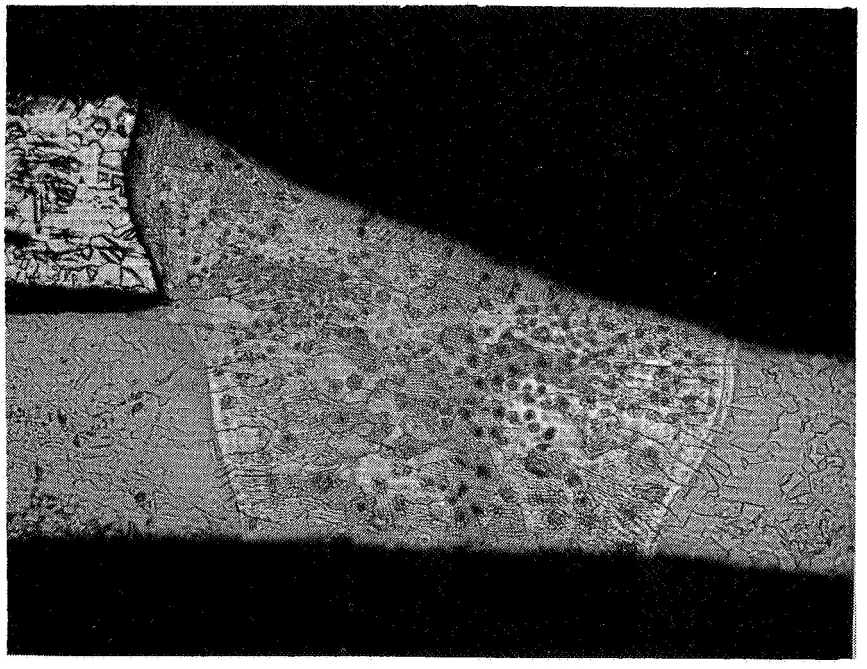


FIGURE 4

FILLET WELD, MAG. 50X McNeece Etch

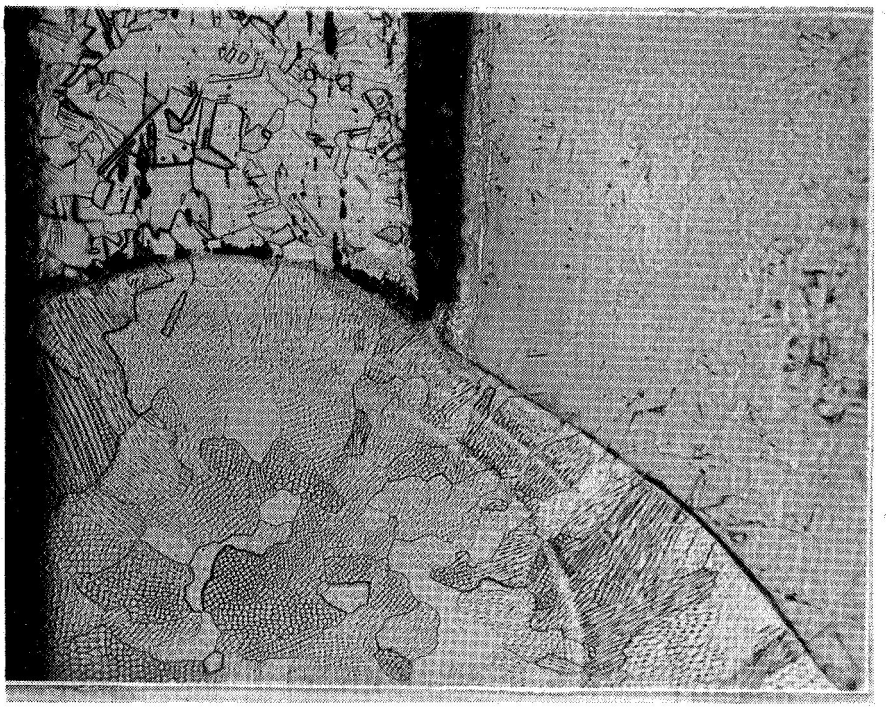


FIGURE 5

MELT-THROUGH WELD, MAG. 100X McNeece Etch

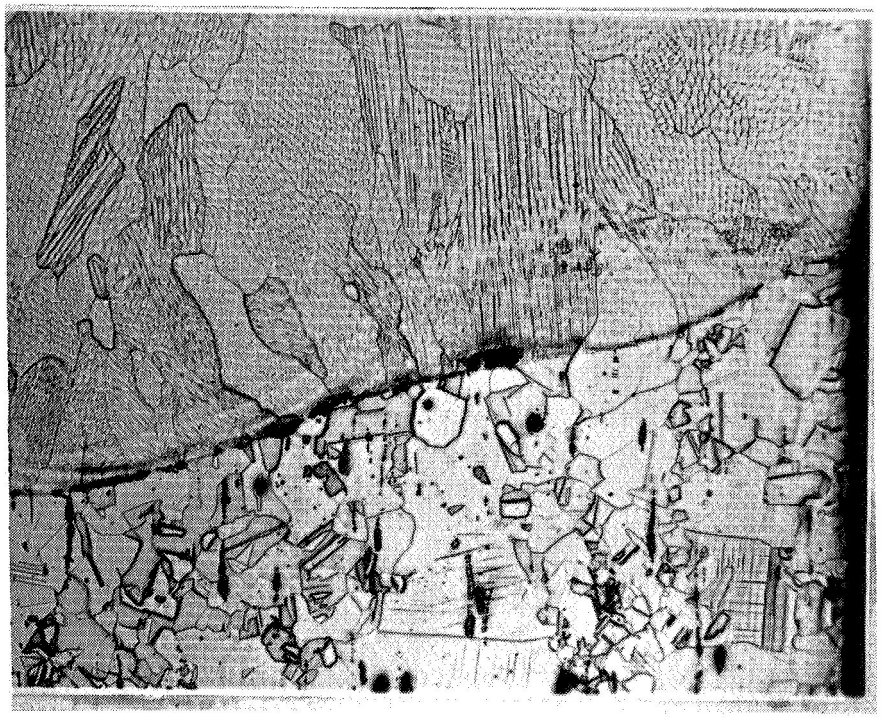


FIGURE 6

WELD ZONE AND AISI 321, MAG. 100X McNeece Etch

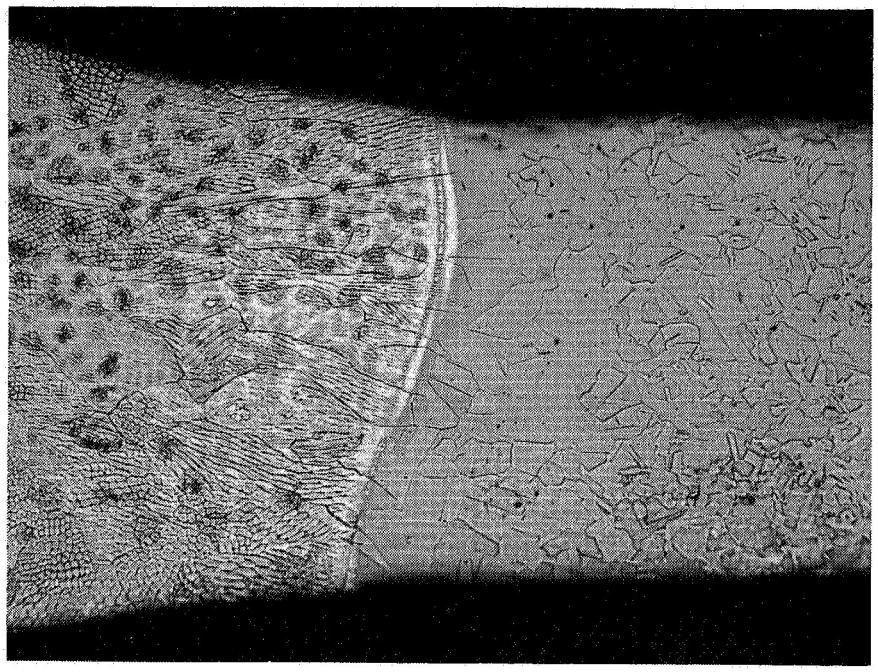


FIGURE 7

WELD ØONE AND KOVAR, MAG. 100X McNeece Etch

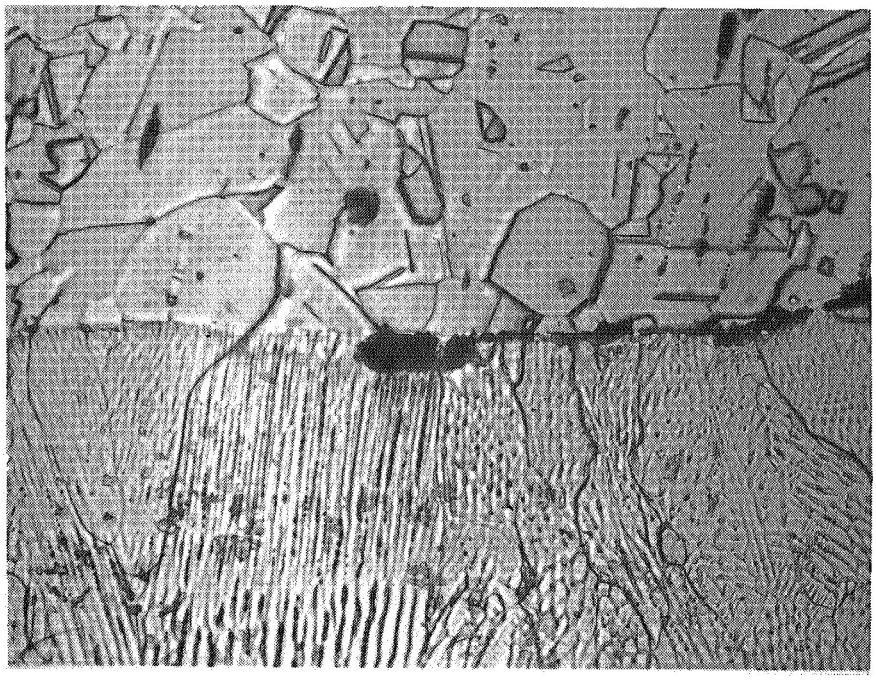


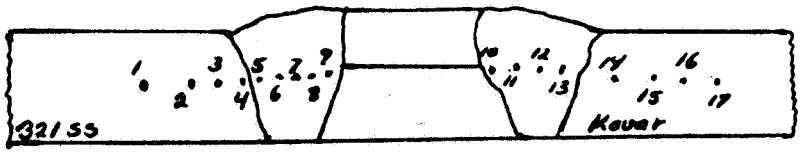
FIGURE 8

WELD ZONE AND AISI 321, MAG. 200X McNeece Etch

TABLE I

TUKON AND ROCKWELL "B" HARDNESS BY CONVERSION

	DPH*	R_B		DPH	R_B
1.	207	94.5	11.	134	74.0
2.	200	93.0	12.	128	71.0
3.	158	82.5	13.	134	74.0
4.	153	81.0	14.	162	84.0
5.	136	74.5	15.	172	87.0
6.	140	77.0	16.	176	88.0
7.	137	75.0	17.	176	88.0
8.	137	75.0			
9.	137	75.0			
10.	136	75.0			



*500 gram Load