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WELD PEAKING ON HEAVY ALUMINUM STRUCTURES

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16. ABSTRACT

Weld peaking is usually undesirable in any welded structure. In heavy structures, the forces involved in the welding process become very large and difficult to handle. With the Shuttle's Solid Rocket Booster, the weld peaking resulted in two major problems: (1) reduced mechanical properties across the weld joint and (2) fit-up difficulties in subsequent assembly operation. Peaking from the weld shrinkage forces can be fairly well predicted in simple structures; however, in welding complicated assemblies, the amount of peaking is unpredictable because of unknown stresses from machining and forming, stresses induced by the fixturing, and stresses from welds in other parts of the assembly.

When excessive peaking is encountered, it can be corrected using the shrinkage forces resulting from the welding process. Application of these forces is discussed in this report.

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Weld peaking adversely affects most structures by reducing the mechanical properties of the joints, by making fit-up of mating parts difficult or impossible, and by reducing the aesthetic contour of assemblies. Peaking in the Shuttle's Solid Rocket Booster (SRB) has been a problem related to mechanical properties and fit-up. These problems are primarily in the SRB aft skirt. The eight longitudinal welds on the SRB aft skirt join the skin segments to the hold-down posts. The weld joints are 1.375 in. thick and are welded from two sides. The peaking in aft skirt No. 3 reaches a maximum of 4 degrees. Although this value is within the welding specification requirements established to assure strength, the ring frame that attaches to the inside of the cone-shaped skirt will not fit without some corrective action.

An examination of SRB peaking data from aft skirt No. 3 revealed the following:

1. There are variations in the peaking values along the longitudinal weld as well as from one weld to the next. No obvious patterns could be established, leading one to conclude that variations are related to stresses other than those from welding. This conclusion is supported by previous tests, the results of which show consistent peaking on unstressed welds.

2. Welding on the inside resulted in approximately 1 degree of peaking per weld pass.

3. Welding on the outside resulted in approximately 0.375 degree of peaking per pass.

To determine the amount of peaking in unstressed panels, a 1.375 × 20 × 30 in. 2219-T37 weld panel was prepared and welded using the certified SRB joint design and welding parameters. (This joint design and welding parameters were developed by Materials and Processes Laboratory at MSFC.) The sequence of the welding (i.e., passes from inside and outside) was exactly as reported on skirt No. 3. Joint design, parameters, and pass sequence data are given in the appendix.

Measurements of the peaking after each weld pass are given in the following listing:

Sequence	Pass No.	Peaking Measured on Inside as Positive Value	Depth of Remaining Groove
Outside	Hand tacked	0°	0.500 in.
Outside	1 (Penetration)	0°	0.450 in. O.D.
Outside	2	1° 10'	0.302 in. O.D.
Outside	3	2° 30'	0.137 in. O.D.
Inside	4	1° 30'	0.290 in. I.D.
Inside	5	0°	0.133 in. I.D.
Inside	6	-1°	Buildup
Outside	7	0°	Buildup

After welding the panel, a groove was machined on the outside to a depth of 0.5 in. The groove configuration was the same as machined into the original joint. Results are given in the following listing:

Sequence	Pass No.	Peaking	Depth of Remaining Groove
Grooved weld		0°	0.5 in. O.D.
Outside	1	1°	0.325 in. O.D.
Outside	2	2°	Fusion only (no wire)
Outside	3	3° 15'	0.225 in. O.D.
Outside	4	4°	Approximately 0.031 in. slight undercut
Outside	5	5°	Buildup
Outside	6	5° 30'	Fusion only on top of weld bead
Outside	7	6°	Fusion only on top of weld bead
Outside	8	7°	Bead removed (flush surface) fusion only

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CONCLUSIONS

There are several conclusions to be drawn from the previously mentioned tests:

1. Approximately 1 degree of peaking per pass resulted from welding either the grooved joints or a flush weld joint.

2. The amount of peaking is unrelated to filler wire addition. Note that in pass No. 2, made in the grooved joint and without the addition of filler wire, there still was approximately 1 degree of peaking.

3. Welding on the crown resulted in less peaking than welding on a flush surface or in a groove.

The following sequence is offered for removing excessive peaking of a weld joint:

1. Identify areas of peaking and measure extent of peaking.

2. Shave weld bead flush on side opposite the peaked joint.

3. Support structure so as to reduce to a minimum all external forces on the joint to be straightened.

4. Make a weld pass on the weld bead centerline using the same weld parameters as was used for the fill passes of the qualified weld schedule without filler wire addition.

5. Measure peaking and repeat operations as required. Approximately 1 degree change per pass can be expected in 1.375 in. thicknesses exclusive of stresses from outside the weld joint area. Full refinement of this technique in only the peaked areas could result in near zero peaking conditions.

6. When the peaking varies along the length of the joint, the weld energy can be varied to obtain the desired results. Caution should be taken not to exceed the weld energy of the original certified weld schedule.

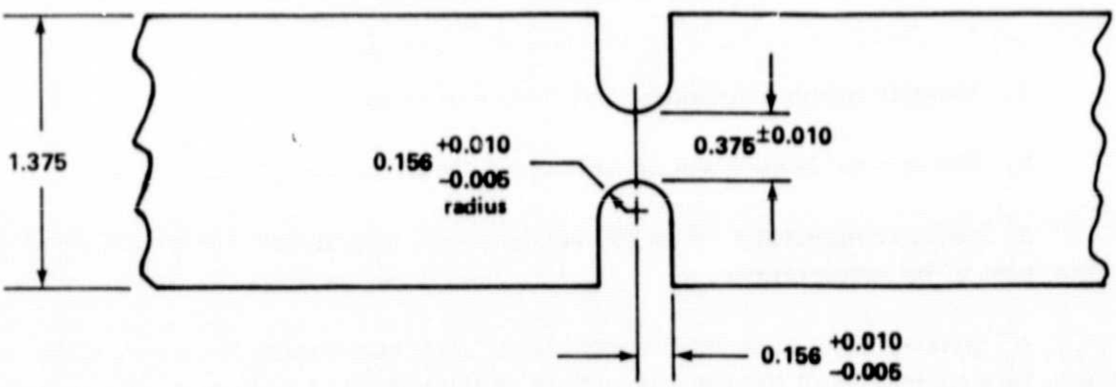
APPENDIX. SRB WELD SCHEDULE NO. 15

(Mechanized double U-groove butt weld on 1.375 in. thick aluminum — complete penetration of the land is made by the first pass.)

Material: 1.375 in. 2219-T37 plate to 1.375 in. thick 2219-T352 forging

Position: Vertical up

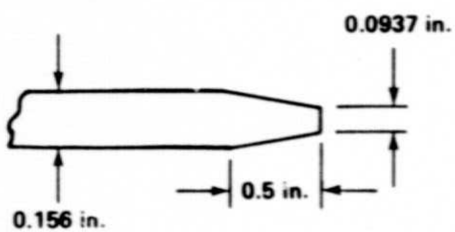
Joint configuration:



Process: GTAW — DCSP

TABLE A-1. SRB WELD SCHEDULE NO. 15

Parameters	Pass No. 1	Pass No. 2	Pass No. 3	Pass No. 4	Pass No. 5	Pass No. 6	Pass No. 7
Amps	398	330	330	330	330	280	280
Volts	12.5	13.5	13.5	13.5	13.5	13.5	13.5
Travel speed (IPM)	4.5	6.5	6.5	6.5	6.5	6.5	6.5
Electrode size	0.156 in.	0.156 in.	0.156 in.	0.156 in.	0.156 in.	0.156 in.	0.156 in.
Electrode configuration	(see sketch)						
Electrode extension	0.75 in.	0.75 in.	0.625 in.	0.75 in.	0.625 in.	0.625 in.	0.625 in.
Gas and rate (CFH)	He-100	He-100	He-100	He-100	He-100	He-100	He-100
Wire	N/A	2319	2319	2319	2319	2319	2319
Wire size	N/A	0.0625 in.	0.0625 in.	0.0625 in.	0.0625 in.	0.0625 in.	0.0625 in.
Wire rate	N/A	65	70	60	60	65	70
Cup size	10	10	10	10	10	10	10
Torch angle (deg)	3	3	3	3	3	3	3



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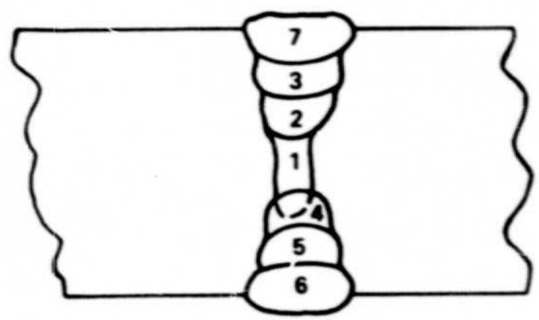

WELD PASS SEQUENCE

APPROVAL

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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Director, Materials and Processes Laboratory

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