AEROSPACE MATERIAL SPECIFICATION

AMS2680™	REV. C

Issued 1981-04
Revised 2001-06
Reaffirmed 2019-01

Superseding AMS2680B

Electron-Beam Welding For Fatigue Critical Applications

1. SCOPE:

1.1 Purpose:

This specification defines the procedures and requirements for joining metals and alloys using the electron beam welding process.

1.2 Application:

These procedures are used typically for high quality, electron-beam welding of aerospace components, the failure of which could cause loss of the aerospace vehicle or one of its major components, loss of control, or significant injury to occupants of a manned aerospace vehicle, but usage is not limited to such applications.

1.2.1 The procedure covered by this specification is recommended for square groove and square scarf-butt joints for fatigue critical applications.:

2. APPLICABLE DOCUMENTS:

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been canceled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications:

Available from SAE, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2630	Ultrasonic Inspection, Product Over 0.5 Inch (12.5 mm) Thick
AMS 2631	Ultrasonic Inspection, Titanium and Titanium Alloy Bar and Billet
AMS 2632	Ultrasonic Inspection of Thin Materials, 0.5 Inch (13 mm) and Thinner
AMS-STD-1595	Qualification of Aircraft, Missile and Aerospace Fusion Welders
ARP1333	Nondestructive Testing of Electron Beam Welded Joints in Titanium-Base Alloys

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

SAE values your input. To provide feedback on this Technical Report, please visit
http://standards.sae.org/AMS2680C

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 1444	Magnetic Particle Examination
ASTM E 1417	Liquid Penetrant Examination
ASTM E 1742	Radiographic Examination

2.3 ANSI Publications:

Available from American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

ANSI B46.1 Surface Texture

2.4 AIA Publications:

Available from National Standards Association, Inc., 5161 River Road, Bethesda, MD 20812.

NAS 976 Electron Beam Welding Machine

3. TECHNICAL REQUIREMENTS:

3.1 Materials:

3.1.1 Parent Materials: Shall be as specified on the applicable part drawing.

3.1.2 Filler Materials: When required, filler metal shall be as specified on the part drawing.

3.1.3 Cleaning Materials: Cleaning materials, chemical solvents, or etching solutions shall be as specified on the part drawing or in the certified welding procedure.

3.2 Equipment:

3.2.1 Electron-Beam Welding Equipment: Shall be capable of producing welds meeting the requirements of 3.6 and 3.7. Equipment conforming to NAS 976 is accepted as meeting this requirement.

3.2.2 Jigs and Fixtures: All holding fixtures shall be capable of maintaining the desired configuration and tolerances during welding, providing back-up as required, and allowing required work space between the work piece and the electron gun. Back-up material used to deflect or absorb residual electron-beam energy shall be of the same alloy as the part being welded except that alternate back-up materials may be used when approved by procedure certification as in 3.4.2. Tooling within 6 inches (152 mm) of the weld joint shall be made from nonmagnetic materials or be degaussed to acceptable limits (See 3.2.3).

3.2.3 Degaussing: Ferromagnetic materials and tooling shall, prior to welding, be demagnetized to a level established by procedure certification (3.4.2) which prevents electron beam deflections while welding the joint.

3.3 Preparation:

Joint and surface preparation, prior to welding, shall be as follows and shall be included as part of the approved procedure certification:

3.3.1 Joint Preparation: Joints shall be prepared to conform to requirements specified on the part drawing.

3.3.2 Edge Preparation: Edges shall be machined square and parallel to ensure proper fit-up. Joints shall have no rounded-off edges, but shall be deburred after machining. Unless otherwise specified, faying surfaces of joints shall have a surface texture not greater than 125 microinches (3.2 µm), determined in accordance with ANSI B46.1. Witness lines, when specified, shall be applied in accordance with part drawing requirements (See ARP1333 for guidelines). Dry machining is recommended for edge preparation of reactive metals.

3.3.3 Weld Start and Run-Off Tabs: Tabs, when used, shall be of the same alloy as the detail parts being welded and shall be cleaned in the same manner as the parts. Tabs shall be integral with the part, either being machined in, or welded to, the part pieces prior to assembly.

3.3.4 Surface Preparation: Prior to welding surfaces of parts shall be prepared using a suitable cleaning agent and method consistent with the alloys being welded. If solvents are used on titanium alloys, they must be nonhalogenated (See 8.2). Welding shall commence within 40 hours after surface preparation, unless otherwise permitted or restricted by purchaser.

3.3.4.1 Parts, after surface preparation, shall be handled in the joint area with clean, lint-free gloves and shall be covered or otherwise protected to prevent contamination, except during set-up, welding, and inspection.

3.3.5 Accessory Equipment Preparation: Jigs, fixtures, and measuring devices shall be free of scale, grease, protective coatings, oxides, dust, oil, and other foreign material detrimental to the welding process.

3.3.5.1 Cleaned surfaces shall be handled only with clean, lint-free gloves.

3.3.6 Pre-Weld Fit-Up: Gaps for production welding shall not exceed gap distance used for procedure certification as in 3.4.2. For small diameter electron beams (high voltage guns), a suggested maximum allowable gap is 0.001 inch (0.03 mm). For larger diameter electron beams (low or medium voltage guns), the suggested maximum allowable gaps are 0.001 inch (0.03 mm) for material thicknesses up to 0.020 inch (0.51 mm) and 0.005 inch (0.13 mm) for thicker material.

3.4 Procedure:

3.4.1 Qualification of Welding Operators: Electron-beam welding shall be performed by certified operators, qualified in accordance with procedures approved by purchaser.

3.4.1.1 Personnel performing welding in accordance with this specification shall be qualified under the cognizance and supervision of the designated welding activity and approved by the cognizant quality control activity. Qualified personnel shall be assigned a stamp with a number or symbol that shall be used to identify all weldments made by such personnel.

3.4.1.2 An operator undergoing qualification testing may weld a certification plate in accordance with 3.4.2 according to a pre-established schedule as part of the test. If the operator successfully qualifies, the weld procedure shall be considered certified. All parameters used for welding the certification plate shall be recorded in the weld procedure, Table 1.

3.4.1.3 Operators certified in accordance with AMS-STD-1595 (as applicable to electron beam welding) shall be considered qualified to weld in accordance with this specification.

3.4.2 Procedure Certification: Prior to production, a separate weld schedule shall be established for each joint and alloy or alloy combination to be welded. The schedule shall be prepared for each penetration weld joint configuration, and for each cosmetic pass configuration, if required, showing all applicable items listed in Table 1.

3.4.2.1 For full penetration weld joints, a test plate conforming to Figure 1 shall be welded in accordance with the prepared weld procedure. Where the test plate of Figure 1 is not an appropriate representation of the parts to be welded, as in the case of forgings, castings, tubing, or other geometric considerations, the procedure shall be established on actual or simulated parts as agreed upon by purchaser and vendor.

3.4.2.2 For any cosmetic pass configurations, a test plate conforming to Figure 2 shall be welded in accordance with the prepared weld procedure and submitted for metallurgical examination in accordance with 3.6.2.2. Cosmetic pass configurations shall be made as a bead-on-previously-deposited full-penetration weld. The cosmetic pass configuration test sample may also be taken from a simulated or actual part as specified by purchaser.

3.4.2.3 Test Piece Preparation and Testing: The weld schedule certification test piece (either Figure 1, actual part, or simulated part) shall be of the same material and condition and shall be prepared and cleaned in the same manner as the production part. Welding shall be performed using the same welding position and joint configuration (thickness and angle) representative of that used on the production part. The welding operator's ID number shall be marked on each test piece welded for certification. Testing shall be accomplished in accordance with 3.6 and 3.7.

3.4.2.4 Upon acceptance of the test piece(s) (either Figure 1, actual part, or simulated part) for either a full-penetration or (Figure 2) a cosmetic-pass weld, the cognizant quality control activity shall certify the weld procedure.

3.4.2.5 Tacking/Locking Passes: A tacking pass may be used to restrict relative motion in the weld assembly prior to the first full penetration pass. Weld schedule certification of a tacking pass is not required provided all evidence of the tack welding is obliterated by the actual weld through fusion.

3.4.2.5.1 A tacking pass, other than a full-penetration pass, made with a power density setting substantially reduced from the certified settings, may be used over any portion of the weld joint up to and including the full length of the weld.

3.4.2.5.2 A full-penetration tacking pass using certified parameters may be utilized but shall not exceed 10% of the weld joint length. This locking pass shall terminate in the starting or stopping tabs, when applicable.

3.4.2.6 Cosmetic Pass: Cosmetic passes for the purpose of correcting unacceptable underfill conditions may be applied at any time after completion of the initial full-penetration pass. Cosmetic passes, if used, shall be certified in accordance with 3.4.2.2.

3.4.3 Procedure Recertification: Recertification of weld schedules shall be required for failed test welds and when any change is made to the following parameters:

3.4.3.1 When a change is made in base metal composition or a change is made in thickness in excess of ±10% (not applicable to cosmetic-pass-weld configuration).

3.4.3.2 When a change is made in joint design (not applicable to cosmetic-pass-weld configuration), but not necessarily after changes in length of diameter of joint.

3.4.3.3 When the welding position (relationship between the gun angle and the work angle) is changed in excess of 10 degrees.

3.4.3.4 When a change is made in any one of the machine settings, items 12 and 14 through 20, or in the energy input, item 23 of Table 1.

3.4.3.4.1 The use of the beam-deflection switch, item 19 of Table 1, need not be considered when used for the purpose of scanning or beam alignment.

3.4.3.5 When the weld machine, weld gun, or filament shape are different from that used to certify the welding procedure.

3.4.4 Production Welding: Production parts shall be welded in accordance with the parameters established in the weld procedure certification of 3.4.2.

3.4.4.1 Welding Environment: Electron-beam welding shall be performed in a vacuum at a partial pressure not higher than 1×10^{-4} millimeters of mercury. Venting of the chamber after welding shall not occur less than two minutes after completion of welding, unless otherwise established in the weld procedure certification.

3.4.5 Rework: A rework shall be a full or partial electron beam penetration weld accomplished subsequent to the full-penetration weld. Rework of imperfections, such as cosmetic passes for correction of underfill or bead appearance improvement, as well as full-penetration passes for correction of a missed joint, and other defects may be accomplished by electron beam welding in accordance with a certified welding schedule. Restarting the electron beam after an arc-out shall not be classified as a rework but the reason, location, and method shall be recorded. Only one reweld is permitted.

3.5 Post Treatment:

3.5.1 Finishing: Post weld machining of face or root surfaces, or both shall be as described on the applicable part drawing and/or the certified weld schedule. Post weld blending shall not decrease the parent material by more than 10% of the joint thickness, for full penetration welds, or more than 5% of the maximum depth of penetration for partial penetration welds.

3.5.2 Heat Treatment: Weldments requiring heat treatment shall be processed in accordance with part drawing requirements.

3.6 Properties:

Specimens taken from test plates, actual parts, or simulated parts produced for procedure certification as in 3.4.2.1 and 3.4.2.2 shall conform to the following requirements:

3.6.1 Tensile Strength: When required, specimens shall conform to and be tested in accordance with ASTM E 8 or ASTM E 8M. The weld is acceptable when failure occurs at a stress equal to or greater than the minimum tensile strength specified by purchaser. Specimens failing at the bond line of the weld or in the weld metal are acceptable only when examination of the fracture surface at 15X magnification reveals it to be free of defects.

3.6.2 Metallurgical Examination for Soundness and Bead Shape:

3.6.2.1 Macro-sections of the weld shall conform to the requirements of 3.7. Sections shall be taken transverse to the weld direction and shall be examined at 3 to 10X magnification. When required, witness line acceptance criteria for scarf joints shall also be noted for full penetration welds.

3.6.2.2 Micro-sections of cosmetic welds, examined at not less than 100X magnification, shall meet the acceptance criteria of 3.7. Sections shall be taken parallel to and transverse to the weld direction.

3.6.3 Special Properties: When special tests are required to establish nondestructive acceptance criteria as in 3.7.2, the tests and specimens shall be established as agreed upon by purchaser and vendor, and shall apply to both weld certification test pieces and parts.

3.7 Quality:

Electron-beam welds shall conform to the following requirements, unless otherwise specified (See 8.2 for defect definitions):

3.7.1 Visual Inspection: All weldments, examined at 10X magnification or greater, shall meet the following:

3.7.1.1 Color: The weld bead and adjacent parent metal shall have a color similar to that of the unwelded parent material. In the case of titanium, this color shall have a bright silver or light straw-colored appearance; blue-gray or gray discoloration or the presence of loose scale is not acceptable. Discoloration due to vapor deposition is acceptable. Cosmetic passes shall not be used to change color.

3.7.1.2 Penetration: Joints shall have complete penetration unless a partial penetration weld is specified. On special designs, however, complete penetration may be achieved by post-weld machining.

3.7.1.3 Incomplete Fusion: Incomplete fusion of full penetration joints, insufficient penetration of partial penetration welds, and missed joints are not acceptable.

3.7.1.4 Cracks: Not acceptable in the weld, weld-heat affected zone or adjacent parent metal except where microfissuring is specifically permitted by the engineering drawing (See 3.7.2.1).

3.7.1.5 Voids and Pores: Voids and pores open to the surface are not acceptable unless they are subsequently to be removed by machining or blending.

3.7.1.6 Underfill and Concave Root Surface: The cumulative depths of underfill on face and root surfaces shall not exceed the post-weld machining allowances specified on the part drawing. The allowable underfill for each surface not machined after welding shall be 10% of the joint thickness or as specified on the drawing.

3.7.1.7 Undercut and Root Notches: Where permissible, shall not exceed engineering drawing tolerances. When not specifically noted, undercut or root notches shall not exceed 10% of material thickness total and shall be blended to have not less than 0.06 inch (1.5 mm) root radius.

3.7.1.8 Mismatch: For plate over 0.250 inch (6.35 mm) in nominal thickness, mismatch shall not exceed 10% of the joint thickness or 0.030 inch (0.76 mm), whichever is less. For sheet and plate over 0.150 inch (3.81 mm) and up to 0.250 inch (6.35 mm) in nominal thickness, mismatch shall not exceed 10% or 0.020 inch (0.51 mm), whichever is less. For sheet and plate up to 0.150 inch (3.81 mm) in nominal thickness, mismatch shall not exceed 10% or 0.010 inch (0.25 mm), whichever is less.

3.7.1.9 Overlaps: Not acceptable.

3.7.1.10 Peaking: Distortion, usually in sheet metal in thin configurations, which causes the weld, measured from each weld toe or edge, to move out of the plane of the parent metal by more than 30% of the parent metal thickness, is unacceptable.

3.7.1.11 Witness Lines: When specified on the part drawing, witness lines shall be applied to the face and root sides of the weld joint (See ARP1333 for procedure).

3.7.1.11.1 Face Side: Joint interface (seam) as established by witness lines shall fall within the central one-third of the weld beam. If the face side witness line examination indicates that the joint interface does not fall within the central one-third of the weld bead, the witness line data shall be evaluated for acceptance by the cognizant engineering or quality activity to ensure compliance with 3.7.1.3.

3.7.1.11.2 Root Side: Joint interface (seam), as established by witness lines, shall fall at least one-half space within the weld bead width. In addition, the difference between unmelted witness line spaces on each side of the weld bead shall be one space or less. Weld bead locations which show a difference of more than one space (0.030 inch (0.76 mm) displacement) shall be evaluated for acceptance to ensure compliance with 3.7.1.3.

3.7.1.11.3 Witness line joint interface locations on the weld face shall be evaluated and accepted before any cosmetic passes are made.

3.7.1.11.4 For scarf joints, the requirements of 3.7.1.11.1 and 3.7.1.11.2 shall apply, unless otherwise specified. Witness line acceptance criteria for all scarf joints shall be as specified on the pertinent electron-beam certification (EBC).

3.7.1.12 Welder's Identification: Each individual weld shall be positively identifiable or traceable to the weld operator who made that weld and the date welded, using the stamp or symbol provided in 3.4.1.1. The method for applying the welder's identification and date shall be as specified on the part drawing or by purchaser. The method selected should ensure that the identification cannot be lost or obliterated during subsequent processing. When approved by purchaser the source may maintain traceability of the welded parts to the individual who performed the welding and the date welded using systems other than part marking such as operator signed off and dated routings that indicate which parts the individual welded.

3.7.2 Radiographic Inspection: All welds shall be radiographically inspected in accordance with ASTM E 1742 to determine conformance to the following acceptance standards. In addition, radiographic inspection shall be used as the referee technique for identifying, locating, and determining the size of indications disclosed by ultrasonic inspection as in 3.7.3.

3.7.2.1 Cracks: The presence of cracks, as a result of welding, in the weld metal, weld-heat-affected zone or adjacent parent metal are not acceptable. Should microfissuring be acceptable in any specific alloy (e.g. precipitation hardenable nickel alloys), acceptance criteria shall be specified by purchaser.

3.7.2.2 Porosity, Voids, and Inclusions: Weld discontinuities, such as porosity, voids, and inclusions (metallic and nonmetallic), within the weld metal or immediately adjacent in the parent metal shall be restricted and sized as follows:

3.7.2.2.1 The size of internal porosity, cavities, voids, and inclusions shall be determined by its largest dimension.

3.7.2.2.2 Inclusions (metallic or nonmetallic) shall be treated the same as porosity.

3.7.2.2.3 Interconnected porosity, inclusions, and cavities (voids) shall be considered as one single pore for sizing purposes.

3.7.2.2.4 Pores and voids identified with the welding operation are acceptable provided they do not exceed the limits of 3.7.2.3.

3.7.2.3 Internal Discontinuity Limits:

3.7.2.3.1 Maximum Pore Diameter: Two or more adjacent discontinuities, other than aligned (3.7.2.3.3), shall be treated as a single discontinuity (excluding the space between them) when the spacing between them is less than three times the greatest dimension of the smaller adjacent discontinuity. The allowable limits for various parent metal thicknesses are established in Table 2, Column B(2), for aluminum alloys, and in Table 2, Column B(1), for all other materials covered by this specification.

3.7.2.3.2 Maximum Defect Area: Shall be the sum of the areas of the pores totally within a 1.0-inch (25-mm) length of weld not to exceed the limits of Table 2, Column C(2), for aluminum alloys, and Table 2, Column C(1), for all other materials.

3.7.2.3.2.1 Pores under 0.010 inch (0.25 mm) shall not be considered in calculating total defect area for thicknesses 0.25 inch (6.4 mm) or over.

3.7.2.3.3 Maximum Aligned Defect Area: Shall be any group of five or more individual pores within a 1.0-inch (25-mm) length of weld whose images can be intersected by a straight line (regardless of orientation within the weld) and the distance between adjacent discontinuities within the group being considered is less than four times the longest dimension of the smaller adjacent discontinuity. The limits of aligned defects are established in Table 2, Column C(4), for aluminum alloys, and in Table 2, Column C(3), for all other materials (See 3.1.1).

3.7.3 Ultrasonic Inspection: When specified by purchaser, all welds, including weld certification tests, shall be ultrasonically inspected in accordance with AMS 2630, AMS 2632 or, for titanium and titanium alloys, AMS 2631. Acceptance criteria shall be as specified in 3.7.2.1 and 3.7.2.2.

3.7.3.1 Discontinuities or isolated ultrasonic responses compliant with 3.7.2.1 and 3.7.2.2, which by a reanalysis of witness line data and reinspection are shown not to be missed joints, shall be acceptable. Discontinuities which cannot be confirmed by radiographic inspection as in 3.7.2 in the area of the ultrasonic indication shall be referred to the cognizant engineering activity for disposition.

3.7.4 Fluorescent Penetrant Inspection: All welds, including weld certification tests, of non-magnetic materials shall be fluorescent penetrant inspected in accordance with ASTM E 1417 to locate imperfections open to the surface. No defects are permissible except as permitted by 3.7.1.5, unless otherwise authorized by the cognizant engineering activity.

3.7.5 Magnetic Particle Inspection: All welds, including weld certification tests, of magnetic materials shall be magnetic particle inspected in accordance with ASTM E 1444. No defects are permissible unless otherwise authorized by the cognizant engineering activity.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The welding processor shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that welded assemblies conform to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Quality (3.7) are acceptance tests and shall be performed on each weld.

4.2.2 Preproduction Tests: Weld procedure certification (3.4.2) and properties (3.6 and 3.7) are preproduction tests and shall be performed on the first-article shipment of a welded part to a purchaser, when a change in processing requires reapproval of the welded part as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.3 Sampling and Testing:

Shall be in accordance with the following; a lot shall be all parts or assemblies of the same alloy(s) of one configuration processed at one time in sequence and presented for vendor's inspection at one time:

4.3.1 For Acceptance Tests: All production weldments.

4.3.2 For Preproduction Tests: Not less than three welds for procedure certification (3.4.2) representative of each joint in the part or assembly using production facilities or facilities representative of those to be used in production. When preproduction test welds are made on actual or simulated hardware, the number and location of test specimens shall be as designated by purchaser.

4.4 Approval:

4.4.1 Purchaser shall approve the processor's facilities, inspection methods, and process controls before production parts are supplied and these shall be available for purchaser's inspection during the period of production part manufacture.

4.4.2 When specified, sample parts and the welding procedure shall be approved by purchaser before welded parts for production use are supplied. If necessary to make any change in procedures or methods of inspection, the welding processor shall submit for reapproval details of proposed changes and, when requested, sample welded parts.

4.5 Reports:

The processor of welded parts shall furnish with each shipment a report showing the results of tests on each lot to determine conformance to the acceptance test requirements and stating that the parts have been processed in accordance with the certified welding procedure by certified welding operators. This report shall include the purchase order number, AMS 2680C, part or assembly number, and quantity.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

Welded parts shall be identified as specified on the part drawing or as agreed upon by purchaser and vendor.

5.2 Protective Treatment:

When required, welded parts shall be given a suitable protective treatment as specified in the purchase order or by the part drawing.

5.3 Packaging:

5.3.1 Welded parts shall be handled and packaged to ensure that the required physical characteristics of the parts are preserved.

5.3.2 Packages of parts shall be prepared for shipment in accordance with, commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the parts to ensure carrier acceptance and safe delivery.

6. ACKNOWLEDGMENT:

A processor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

Parts not welded in accordance with this specification, or with modifications authorized by purchaser, will be subject to rejection.

8. NOTES:

8.1 A change bar (**l**) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this specification. An (R) symbol to the left of the document title indicates a complete revision of the specification, including technical revisions. Change bars and (R) are not used in original publications, nor in specifications that contain editorial changes only.

8.2 Joint Edges:

Immediately prior to assembly for welding, joint edges may be additionally prepared, depending on the alloy being welded, by either alkaline cleaning, acid pickling, solvent cleaning (non-halogenated for titanium alloys), wire brushing with a stainless steel brush and solvent (non-halogenated for titanium alloys) cleaning, or, for aluminum alloys, scraping of joint faying surfaces.

8.3 Defect Definitions:

Shall conform to standard definitions as shown in AWS A3.0.

8.4 Dimensions in inch/pound units are primary; dimensions in SI units are shown as the approximate equivalents of the primary units and are presented only for information.

8.5 Purchase documents should specify not less than the following:

AMS 2680C
Part or assembly number of parts to be welded
Quantity of parts to be welded.

TABLE 1 - Minimum Parameters To Be Recorded in Welding Procedure

1.	Applicable Electron-Beam Certification (EBC) Number
2.	Parent Metal
3.	Parent Metal Thickness
4.	Pre-Weld Cleaning Procedure, Applicable Cleaning Specification, or both
5.	Surface Preparation at Weld Joint
6.	Filler Metal Type, Specification, or both
7.	Automatically Fed Filler Metal Diameter
8.	Filler Wire Feed Speed (±10%)
9.	Operator and ID Stamp
10.	Welding Speed, inches/minute (mm/s) (±5%)
11.	Sketch of Set-Up Including All Angles (±0.5 degree)
12.	Distance of Gun to Work (±1/8 inch (±3.2 mm))
13.	Beam Current (±5%)
14.	High Voltage (±5%)
15.	Focusing Current (±5%)
16.	Vacuum Level
17.	Welding Schedule
18.	Tacking/Locking Passes
19.	Beam Deflection - On/Off _____Type or Shape_____; Amplitude_____Frequency
20.	Cathode to Anode Spacer
21.	Witnessing Inspector's Name and Stamp
22.	Quality Control Certification
23.	Maximum Residual Magnetism, gauss
24.	Weld Machine Identification
25.	Weld Gun Identification
26.	Filament Type

TABLE 2A - Internal Discontinuity Limits, Inch/Pound Units

Final Weld Thickness Inch	Maximum Pore Diameter (3.7.2.3.1) Inch	Maximum Pore Diameter (3.7.2.3.1) Inch	Plan Area of Image, Square Inches x 10,000 Total Discontinuities (3.7.2.3.2)	Plan Area of Image, Square Inches X 10,000 Total Discontinuities (3.7.2.3.2)	Plan Area of Image, Square Inches x 10,000 Aligned Discontinuities (3.7.2.3.3)	Plan Area of Image, Square Inches x 10,000 Aligned Discontinuities (3.7.2.3.3)
Column A	B-1	B-2	C-1	C-2	C-3	C-4
0.010	0.0010	0.0025	3	7	1	3
0.025	0.0025	0.0063	8	16	3	6
0.050	0.0050	0.0125	15	32	5	13
0.075	0.0075	0.0188	18	47	8	18
0.100	0.010	0.025	25	63	10	25
0.125	0.013	0.031	31	78	13	31
0.150	0.015	0.038	37	94	15	38
0.175	0.018	0.044	43	109	18	44
0.200	0.020	0.050	50	125	20	50
0.225	0.023	0.056	56	125	23	56
0.250	0.025	0.063	62	125	25	63
0.500	0.050	0.063	125	125	50	63
0.750 & Over	0.050	0.063	125	125	63	63

NOTES:
1. Interpolate between final weld thicknesses where necessary.
2. The effective image areas for various discontinuities are shown in Table 3.
3. Example for use of Table 2:

a) For final weld thickness of 0.500 inch in titanium.
b) Radiograph indicates that the greatest concentration and magnitude of internal discontinuities in any one linear inch of weld includes:
   - 1 discontinuity 0.041 - 0.050 inch diameter
   - 4 discontinuities 0.031 - 0.040 inch diameter
   - 5 discontinuities 0.010 - 0.020 inch diameter
c) Calculate the sum of the areas of the discontinuities, using the factors in Table 3.
   - 1 x 20 = 20
   - 4 x 10 = 40
   - 5 x 2 = <u>10</u>
   - 70
d) From Table 2, Column C(1), the acceptable area of total discontinuities in titanium is 125; because the calculated area was 70, the weld is acceptable from the standpoint of total discontinuities.
e) If, however, the discontinuities were so aligned that they could be intersected by a straight line (3.7.2.3.3), the allowable limit for the titanium example weld (Column C(3)) is 50 while the calculated area was 70 and the weld would not be acceptable.