REAFFIRMED

The Engineering Society For Advancing Mobility Land Sea Air and Space

400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

ARP 1330A

Issued 3-1-74
Revised 7-1-87

Superseding ARP 1330

WELDING OF STRUCTURES FOR GROUND SUPPORT EQUIPMENT

1. PURPOSE:

1.1 This recommended practice provides general recommendations for welding structural assemblies for aerospace ground support equipment.

1.2 The recommendations are based on practical engineering experience and reflect design practices and fabricating procedures which have been found to be effective in providing good strength and structural rigidity.

2. APPLICABLE DOCUMENTS: The following publications form a part of this document to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

2.2 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.2.1 Military Standards:

MIL-STD-1595 - Qualification of Aircraft, Missile and Aerospace Fusion Welders

3. RECOMMENDATIONS:

3.1 Base Materials and Condition:

3.1.1 Ground support structures that are to be assembled by welding should specify materials that can be readily welded and require a minimum of preheat or postweld stress-relief. Materials that meet these criteria are listed in Table I. Materials within a given category can be welded in any combination.

3.1.2 Materials should be welded in the annealed or normalized condition. Heat treatment of 4130 low-alloy steel and of 6061 and 6063 aluminum alloys after welding is recommended if maximum properties in the base material and the weld are desired. Welding of heat-treatable material to non-heat-treatable material will result in only the heat-treatable material being capable of responding to postweld heat treatment. Aluminum alloys and corrosion-resistant steels can be welded in the heat treated or strain hardened condition but the base material properties will be reduced in the area of the weld. Welding of 4130 steel in the heat treated condition is not recommended.

3.2 Assembly Design: Several factors must be considered when designing welded assemblies. These include, but are not limited to, the following:

3.2.1 Weld joint configuration will dictate assembly and edge preparation requirements and will influence inspection and test requirements. Joints designed for fillet welding require a minimum of special edge preparation. Butt joint square groove welds in thin material require no edge preparation. Full penetration groove welds offer optimum joint strength with a minimum of stress raisers. Prepared groove joints may be required where joint strength cannot be attained because the material thickness is such that the desired joint penetration cannot be achieved without a prepared groove. Special edge preparation, which is costly, time consuming, and in some cases extremely difficult, is required for groove welds, except square groove. Double grooves are more difficult to prepare than single grooves but help reduce weld distortion when welding thick material. Double-fillet welds are preferred over single-fillet welds because they tend to neutralize the effects of the built-in crack. The effects of such cracks can also be eliminated by using a groove weld, with a prepared joint if necessary, to give full penetration in combination with either a single-fillet or double-fillet weld. Joints should be designed for complete welding, i.e., full penetration, where the assembly is to be heat treated after welding. Intersecting joints should be kept to a minimum because they create problems in joint preparation and assembly and often cause distortion. Intermittent welds should also be kept to a minimum as they do not afford a continuous load path between the two joined members. Joint configurations and joint preparation are described and explained in the structural welding code (AWS D1.1) prepared by the American Welding Society.

3.2.2 Material thickness dictates both the joint configuration and the welding process. Thin materials require processes that afford low heat and normally no special edge preparation. Thick materials require processes that produce high heat and may require prepared grooves.

3.2.3 Weld joint accessibility must be considered when designing the assembly. Accessibility requirements vary greatly with the welding process to be used. The maximum practicable clearance should be provided around each joint.

3.2.4 Inspection test requirements must be considered when the joint configuration is being determined. Designs should be such that a minimum of nondestructive testing (NDT) is required. Conservative designs and proof testing will, in most cases, eliminate the need for costly and time-consuming nondestructive testing. Visual inspection should be made of each weld but, where additional nondestructive test methods are required, they should be specified on the drawing. Specific welds may require more inspection than others and these requirements should be indicated on the drawing. The type, direction, and load for proof testing should be indicated on the drawing when used in lieu of, or as a supplement to, NDT methods. Penetrant and magnetic particle inspection methods can be used on most joint configurations. Radiographic inspection should be used only on critical weldments and only when straight-through, single-wall radiography can be employed. Use of radiographic inspection on "T" type joints is not recommended as results are often misleading and may lead to unnecessary rework.

3.3 Welding Processes: Most welding of ground support equipment is performed with gas-tungsten-arc welding (GTAW), gas-metal-arc welding (GMAW), and shielded-metal-arc welding (SMAW). In addition to these three, oxyacetylene welding (OAW) and oxyhydrogen welding (OHW) have limited applications for welding thin steel and thin aluminum, respectively.

3.3.1 Gas-tungsten-arc welding (GTAW) is probably the most versatile welding process because it can be used for welding all the materials in Table I. GTAW is normally used for welding thin material but can be used for welding thick material when heavy duty equipment is available. However, it requires more welding time than GMAW or SMAW when welding thick material.

3.3.2 Gas-metal-arc welding (GMAW) is more limited in use than GTAW, because it is normally used for welding carbon steel, aluminum alloys, and sometimes low-alloy steel but is not commonly used for welding corrosion-resistant steel. GMAW is normally used for welding thick material but can be used on thin material by a skilled welder.

3.3.3 Shielded-metal-arc welding (SMAW) is similar in application to GMAW with the exception that corrosion-resistant steels can be welded but aluminum alloys are not normally welded with this process. SMAW is also used for welding thick material although skilled welders can weld thin material.

3.4 Filler Materials: The welding process, base material, strength requirements and, in some cases, color match, will dictate which filler wire is to be used. The filler materials listed in Table I represent an optimization of these factors.

3.5 Cleaning: Welds in ground support equipment do not normally require cleaning. Detail parts and weld joints should, however, be free of oil, grease, and scale prior to welding to ensure a quality weld. Post-weld cleaning is required only on welds made by the SMAW process and consists of removing the solidified weld slag.

3.6 Post-Weld Thermal Treatment: It is desirable to stress-relieve carbon and low-alloy steel parts, particularly when the part will be extensively machined after welding. Stress-relief can be omitted on parts that will be subsequently heat treated. Aluminum alloys and corrosion-resistant steels do not require stress relief after welding. Low-alloy steels and 6061 and 6063 aluminum alloys can be heat treated to higher strength after welding.

3.7 Welding Procedures: It is desirable to prepare written welding procedures which will guide the fabricator and give better assurance of a satisfactory product. These procedures should include, but need not be limited to, the following:

Base materials for each member, including specifications
Filler metal for each joint, including specification
Joint preparation
Precleaning procedures
Welding method for each joint
Inspection methods and procedures
Quality requirements
Postweld stress-relief (temperature and time)
Postweld cleaning procedures

3.8 Welder Qualification: Prior to production welding, the welder should be required to prove welding proficiency by welding test samples in accordance with MIL-STD-1595. The test samples should include a groove joint (sheet-to-sheet or plate-to-plate), a "T" type joint (fillet welds), an intersecting tube and plate with gusset reinforcement, and a joint representative of the most frequently welded production joint if it does not fit into one of the previous categories. These test samples should be tested nondestructively, then sectioned and examined for root penetration, lack of fusion, excessive porosity or inclusions, undercutting, and cracks. Test samples should be welded for each category of base material and each type of filler metal (Table I) that will be welded in production. The proficiency test should be repeated every five years or after a welder has not welded for three months.

3.9 Inspection Requirements: All welds in each assembly should be visually inspected. The additional non-destructive test methods specified on the drawing should be performed after the visual inspection.