

Specification for Metal Cutting Machine Tool Weldments

American Welding Society

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tool weldments, metal cutting

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Specification For Metal Cutting Machine Tool Weldments

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Prepared by
AWS Machinery and Equipment Committee

Under the direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

Requirements are presented for welding during the manufacture of machine tools and components – also for the welding repair of welded machine tool structures and castings. Filler metals are recommended for the applicable base metals consisting of low alloy steels and AISI 304L and 316L stainless steels. Joint designs and unit stresses are provided for fillet and groove welds. The applicable welding processes are shielded metal arc welding (SMAW), submerged arc welding (SAW), flux cored arc welding (FCAW), oxyfuel gas welding (OFW), friction welding (FRW), resistance welding (RW), electron beam welding (EBW), electroslag welding (ESW), electrogas welding (EGW), plasma arc welding (PAW) and stud welding.



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Foreword

(This Foreword is not a part of ANSI/AWS D14.2-93 *Specification for Metal Cutting Machine Tool Weldments*, but is included for information purposes only.)

When the original version of this specification was conceived in 1969, welding and the use of weldments in machine tool design were new to most people in the industry. W. A. Maddox of Cincinnati Milacron, a pioneer in the design of weldments for machine tools, was chosen to form a committee from the industry and lead it in writing the new specification.

AWS D14.2-71 was prepared to guide designers and users in the most effective and economical use of weldments, which would deliver adequate and sustained performance of machine tools and maximum safety to personnel and equipment, and to establish clear, concise practices in fabricating that will be understood by designer, fabricator and user.

In 1975, D14.2-71 was followed by a revision identified as AWS D14.2-Rev 1-75. In 1985, further revisions were made, resulting in ANSI/AWS D14.2-86.

This current edition establishes common acceptance standards for weld performance and process application. It is intended for use in the metal cutting machine tool industry to continue the advancement of welding and increase product reliability in the area of chip making and electrical machining of machine tools. This specification is not intended for **forming** tools (brakes, punches, shear, etc.).

The use of thermosetting and thermoplastic materials for the fabrication of corrosion-resistant equipment will not be discussed in this specification. Such materials and joining procedures are beyond the scope of this specification.

The contributing companies, both manufacturers and users, realized that by joining in the preparation of this document, they would derive the benefits of a higher quality product and the most economical approach to production consistent with the capability of the manufacturer.

Comments or inquiries on this specification are welcome. They should be addressed to Secretary, AWS Committee on Machinery and Equipment, American Welding Society, 550 LeJeune Road, P.O. Box 351040, Miami, FL 33135.

Official interpretations of any of the technical requirements of this standard may be obtained by sending a request, in writing, to the Managing Director, Technical Services Division, American Welding Society. A formal reply will be issued after it has been reviewed by the appropriate personnel following established procedures.

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Specification for Metal Cutting Machine Tool Weldments

1. General Provisions

1.1 Object. The purpose of this specification is to establish practices for the design and fabrication of welded machine tool structures that will promote the following:

- (1) Economical machine tools of high-quality construction
- (2) Adequate initial and sustained performance of equipment
- (3) Safety to personnel and equipment
- (4) Clear, concise practices in fabricating that will be understood by the designer, fabricator, and user
- (5) The conservation of human and material resources in manufacturing and use of equipment
- (6) The general good of the public and of the national economy

Note: The values stated in U.S. customary units are to be regarded as the standard. The SI units are given as equivalent values to the U.S. customary units. The standard sizes and dimensions in the two systems are not identical, and for this reason conversion from a standard size or dimension in one system will not always coincide with the standard size or dimension in the other. Suitable conversions encompassing standard sizes of both can be made, however, if appropriate tolerances are applied in each case.

1.2 Introduction

1.2.1 This specification shall apply when welding is used in the manufacture of any of the following:

- (1) Chip-making machine tool or component thereof
- (2) Electrical machining machine or component thereof

It also shall apply to repair welding of welded machine tool structures.

1.2.2 This specification shall not apply to the manufacture of forming machine tools such as brakes, shears, punches, and similar equipment.

1.2.3 This specification includes sections on materials, design criteria, weld joint design, workmanship, stress-relief heat treatment, inspection and quality control, modification and repair, special requirements for stainless steel, and related information (in Appendices).

1.2.4 This specification establishes the minimum acceptable practice at the time of its publication. It is not intended to restrict new developments nor to inhibit in any way advances in the art of machine tool design engineering. Deviation from this specification as a result of advances in the art should be by mutual agreement between designer and user.

1.3 Nomenclature. The following terms are defined for the purpose of this document:

1.3.1 Metal Cutting Machine Tool. A metal cutting machine tool is a power-driven machine, not portable by hand, designed to remove metal from a workpiece.

1.3.2 Electrical Machining Machine. An electrical machining machine is power driven, not portable by hand, designed to remove metal from a workpiece primarily by the action of a controlled electric current. Included are electrochemical (ECM) machines, electrolytic grinding (ELG) machines, electrodischarge (EDM) machines, and electrolytic deburring equipment.

1.3.3 Designer. The person, company, or agency responsible for the design and performance of a machine tool or machine-tool component.

1.3.4 User. The person, company, or agency that utilizes the machine tool for the intended purpose.

1.3.5 Fabricator. The person, shop, or agency responsible for performing the actual welding. This person may be employed by the designer's company, or may be an independent shop doing work on a sub-contract basis.

1.3.6 Primary Weldment. A primary weldment is one in which failure will immediately affect the performance of the machine. Failure includes breakage, distortion, creep, corrosion, erosion, or other forms of deterioration that will compromise the performance of the machine.

1.3.7 Secondary Weldment. A secondary weldment is one in which failure (as defined in 1.3.6) will not immediately affect the performance of the machine.

1.3.8 All other welding terms used in this specification shall be interpreted in accordance with ANSI/AWS A3.0, *Standard Welding Terms and Definitions*, latest edition. (Also see Appendix A.)

1.4 Welding Symbols, Welding Processes, and Stress Relief

1.4.1 Welding symbols used on drawings shall conform to the latest edition of ANSI/AWS A2.4, *Standard Symbols for Welding, Brazing and Nondestructive Testing*.

1.4.2 When drawings do not contain a complete definition of the welding required, either by explanatory notes or by approved welding symbols, the fabricator shall so advise the designer.

1.4.3 When the design requires a particular process, procedure, or sequence of operations, the drawings shall so specify.

1.4.4 When stress relief is required, the designer shall so specify. Where stress relief appears to be needed, but is not specified, the fabricator shall so advise the designer.

1.5 Safety

1.5.1 Safety shall be a primary consideration in the design and fabrication of every machine tool weldment.

1.5.2 The designer is responsible for the safety of the finished weldment as it is used in the machine tool. The provisions of this specification, plus applicable standards for piping, pressure vessels, fittings,

and safety specifications covering a particular type of machine tool, shall be considered during the design of the machine tool weldment.

1.5.3 The fabricator is responsible for the safety of the welding and other factory operations involved in the fabrication of the weldment. Federal and local regulations for safety in the work place shall be followed. ANSI/AWS Z49.1 covers *Safety in Welding and Cutting*. Additional welding safety considerations are contained in Appendix B.

1.6 References. When specified, the following standards apply and become a part of this specification:

ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels, and Section IX, Welding Qualifications¹

ANSI B16.5 Steel Pipe Flanges and Flanged Fittings²

ANSI B16.9 Factory Made Wrought Steel Butt Welding Fittings

ANSI B16.11 Forged Steel Fittings, Socket Welding and Threaded

ANSI B16.28 Wrought Steel Butt Welding Short Radius Elbows and Returns

ANSI B31.0 Code for Pressure Piping

ANSI B31.1 Code for Pressure Piping

ANSI B31.1a Code for Pressure Piping

ANSI Z49.1 Safety in Welding and Cutting

ASTM A380 Abrasive blasting³

AWS A2.4 Standard Symbols for Welding, Brazing and Nondestructive Testing

AWS A3.0 Standard Welding Terms and Definitions

AWS A5.1 Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

AWS A5.4 Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding

AWS A5.5 Specification for Low Alloy Steel Covered Arc Welding Electrodes

AWS A5.9 Specification for Bare Stainless Steel Welding Electrodes and Rods

1. The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.

2. American National Standards Institute, 11 W. 42nd Street, 13th Floor, New York, NY 10036

3. American Society for Testing and Materials, 1919 Race Street, Philadelphia, PA 19103.

AWS A5.17	Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
AWS A5.18	Specification for Carbon Steel Filler Metals for Gas Shielded Arc Welding
AWS A5.20	Specification for Carbon Steel Electrodes for Flux Cored Arc Welding
AWS A5.23	Specification for Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding
AWS A5.28	Specification for Low Alloy Steel Filler Metals for Gas Shielded Arc Welding
AWS A5.29	Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding
AWS B2.1	Welding Procedure and Performance Qualification
AWS D1.1	Structural Welding Code—Steel

2. Materials

2.1 Introduction

2.1.1 This section describes base and filler metals that are normally used in machine tool weldments. The use of materials not covered by this specification shall be approved by the designer.

2.1.2 Electrical machining units covered by this specification shall include equipment for electrochemical machining, electrolytic grinding, and electrolytic deburring. This specification will consider electrodischarge equipment as a conventional machine tool because low-carbon steel is primarily used in its weldments.

2.1.3 Electrical machining equipment makes use of working fluids (electrolytes) that are corrosive to many metals. It is, therefore, necessary to substitute corrosion-resistant materials for the conventionally used structural materials.

2.2 Base Metals

2.2.1 Unalloyed steel covered by this specification shall be low carbon steel (generally AISI 1010 to 1024, or equivalent ASTM grade).

2.2.2 Stainless steel used for tank structures, piping, valves, or any part that is continuously submerged in or contains an electrolyte shall be AISI No. 316L, or an adequately corrosion-resistant grade.

2.2.3 AISI 304L, or an adequately corrosion-resistant grade, may be used for fixtures, tables, or other

components not subject to corrosion conditions as severe as those described in 2.2.2.

2.2.4 When mutually agreed by the designer and user, steel clad with an acceptable grade of stainless steel may be used as a substitute for the similar grade of solid stainless steel plate. The minimum thickness of the stainless steel shall be 20 percent of the composite plate thickness, but in no case less than 0.062 in. (1.6 mm).

2.3 Filler Metals

2.3.1 Filler metals used for low carbon steel shall be compatible with the process and base metal as specified in ANSI/AWS A5.1, A5.5, A5.17, A5.18, A5.20, A5.23, A5.28, or A5.29, latest editions.

2.3.2 Filler metal for welding 316L stainless steel shall be compatible with the process and shall meet, or exceed, the requirements for one of the following AWS electrode classifications: (1) E316L-XX, as specified in A5.4, or (2) ER316L, as specified in A5.9.

2.3.3 Filler metal for welding 304L stainless steel shall be compatible with the process and shall meet, or exceed, the requirements for one of the following AWS electrode classifications: (1) E308L-XX, as specified in A5.4, or (2) ER308L, as specified in A5.9.

2.3.4 Filler metal for stainless steel clad stock should be that recommended by the manufacturer of the clad stock.

3. Design Criteria

3.1 Introduction

3.1.1 This section will describe the general principles by which machine tool components should be designed in order to carry their loads within certain limits of stress and deflection.

3.1.2 In the design of machine tool components, for which rigidity is usually the governing factor, the stresses are generally low [under 3000 psi (20 kPa)] because of the heavy construction used to minimize deflections. In some designs, however, the stresses are much higher and should be computed to ensure that the allowable unit stress of the material and the required deflection limits are not exceeded.

3.2 Designing for Rigidity

3.2.1 Thick plates are often used to keep deflections low, and in such cases, full-strength welds are unnecessary. Due to the rapid cooling of the weld metal

or the high restraint imposed by thick plates, or both, cracks may start in welds which are too small (see Tables 1 and 2). Preheating of the heavy plates in the weld area will retard rapid cooling of the weld metal.

3.2.2 Intermittent fillet welds may be used, provided they agree with 4.4.16.

3.2.3 Partial joint penetration groove welds shall have minimum sizes as shown in Table 2.

3.2.4 Partial joint penetration welds shall have the effective throat determined as shown in Figures 1 and 2. Partial joint penetration submerged arc welds may be assigned a effective throat (E) equal to the full value of "S" for joints shown in Figures 1 and 2.

3.3 Designing for Strength

3.3.1 When the weld is designed for strength, the various types of loading and stresses the weld will be subject to shall be considered.

3.3.2 Base metal sizes and weld sizes shall be computed using the allowable unit stresses.

3.3.3 The designer may apply a greater safety factor to these allowable unit stresses, if so desired.

3.4 Types of Loading

3.4.1 Stresses may result from bending, tension, compression, shear, torsion, or any combination of these factors.

3.4.2 Variable or fatigue loads are loads that cause the welds to be subjected to alternating or cycling (varying) stresses.

3.4.3 Static or steady loads will not cause varying stresses in the welds.

3.5 Allowable (Maximum) Unit Stresses

3.5.1 Allowable unit tensile stress for base metal with static loading shall be 60 percent of the minimum tensile strength of the base metal, as specified in the applicable material specification.

3.5.2 Allowable unit shear stress for base metal with static loading shall be 40 percent of the minimum tensile strength of the base metal, as specified in the applicable material specification.

3.5.3 Allowable unit stresses for static loading on the effective areas (see 3.8) of weld metal shall be as listed in Table 3.

3.5.4 Members subject to repeated variations, or reversals, of stress shall be designed so that the max-

Table 1
Minimum Size of Fillet Welds

Material Thickness of Thicker Part Joined		Minimum Size* of Fillet Weld	
in.	mm	in.	mm
To 1/2 incl.	12.7	3/16	4.8
Over 1/2 to 3/4	12.7–19.0	1/4	6.4
Over 3/4 to 1–1/2	19.0–38.1	5/16	7.9
Over 1–1/2 to 2–1/4	38.1–57.2	3/8	9.5
Over 2–1/4 to 6	57.2–212.4	1/2	12.7
Over 6	212.4	5/8	15.9

*Except that the weld size need not exceed the thickness of the thinner part joined.

Table 2
Minimum Size of Partial Joint Penetration Welds

Material Thickness of Thicker Part Joined		Minimum Size* (E) of Partial Penetration Weld (See Figure 1)	
in.	mm	in.	mm
To 1/2 incl.	12.7	3/16	4.8
Over 1/2 to 3/4	12.7–19.0	1/4	6.4
Over 3/4 to 1–1/2	19.0–38.1	5/16	7.9
Over 1–1/2 to 2–1/4	38.1–57.2	3/8	9.5
Over 2–1/4 to 6	57.2–212.4	1/2	12.7
Over 6	212.4	5/8	15.9

*Except that the weld size need not exceed the thickness of the thinner part joined.

imum stress does not exceed the basic allowable stresses of Table 3, nor the allowable unit stress for fatigue loading given in Figure 3.

3.6 Fatigue Loading. Welds subjected to fatigue loading shall be designed so as not to exceed the fatigue strength of the thinner member.

3.7 Combining Unit Stresses

3.7.1 In the case of axial stress combined with bending, the allowable unit stress of each kind shall be governed by the requirements of Table 3, and