5.12 Welding Environment

5.12.1 Maximum Wind Velocity. GMAW, GTAW, EGW, or FCAW-G shall not be done in a draft or wind unless the weld is protected by a shelter. Such shelter shall be of material and shape appropriate to reduce wind velocity in the vicinity of the weld to a maximum of five miles per hour (eight kilometers per hour).

5.12.2 Minimum Ambient Temperature. Welding shall not be done

(1) when the ambient temperature is lower than 0°F (–18°C)

(2) when surfaces are wet or exposed to rain, snow, or

(3) high wind velocities, or

(4) when welding personnel are exposed to inclement conditions.

Note: Zero°F does not mean the ambient environmental temperature, but the temperature in the immediate vicinity of the weld. The ambient environmental temperature may be below 0°F, but a heated structure or shelter around the area being welded could maintain the temperature adjacent to the weldment at 0°F or higher.

5.13 Compliance with Design

The sizes and lengths of welds shall be no less than those specified by design requirements and detail drawings, except as permitted in Table 6.1. The location of welds shall not be changed without approval of the Engineer.

5.14 Minimum Fillet Weld Sizes

The minimum fillet weld size, except for fillet welds used to reinforce groove welds, shall be as shown in Table 5.8. In both cases the minimum size applies if it is sufficient to satisfy design requirements.

5.15 Preparation of Base Metal

Surfaces on which weld metal is to be deposited shall be smooth, uniform, and free from fins, tears, cracks, and other discontinuities which would adversely affect the quality or strength of the weld. Surfaces to be welded, and surfaces adjacent to a weld, shall also be free from loose or thick scale, slag, rust, moisture, grease, and other foreign material that would prevent proper welding or produce objectionable fumes. Mill scale that can withstand vigorous wire brushing, a thin rust-inhibitive coating, or antispatter compound may remain with the following exception: for girders in cyclically loaded structures, all mill scale shall be removed from the surfaces on which flange-to-web welds are to be made by SAW or by SMAW with low-hydrogen electrodes.

5.15.1 Mill Induced Discontinuities. The limits of acceptability and the repair of visually observed cut surface discontinuities shall be in accordance with Table 5.4, in which the length of discontinuity is the visible long dimension on the cut surface of material and the depth is the distance that the discontinuity extends into the material from the cut surface. All welded repairs shall be in accordance with this code. Removal of the discontinuity

Table 5.4
Limits on Acceptability and Repair of Mill Induced Laminar Discontinuities in Cut Surfaces (see 5.15.1)

Description of Discontinuity	Repair Required
Any discontinuity 1 in. (25 mm) in length or less	None, need not be explored.
Any discontinuity over 1 in. (25 mm) in length and 1/8 in. (3 mm) maximum depth	None, but the depth should be explored.*
Any discontinuity over 1 in. (25 mm) in length with depth over 1/8 in. (3 mm) but not greater than 1/4 in. (6 mm)	Remove, need not weld.
Any discontinuity over 1 in. (25 mm) in length with depth over 1/4 in. (6 mm) but not greater than 1 in.	Completely remove and weld.
Any discontinuity over 1 in. (25 mm) in length with depth greater than 1 in.	See 5.15.1.1.

*A spot check of 10% of the discontinuities on the cut surface in question should be explored by grinding to determine depth. If the depth of any one of the discontinuities explored exceeds 1/8 in. (3 mm), then all of the discontinuities over 1 in. (25 mm) in length remaining on that cut surface shall be explored by grinding to determine depth. If none of the discontinuities explored in the 10% spot check have a depth exceeding 1/8 in. (3 mm), then the remainder of the discontinuities on that cut surface need not be explored.

may be done from either surface of the base metal. The aggregate length of welding shall not exceed 20% of the length of the plate surface being repaired except with approval of the Engineer.

5.15.1.1 Acceptance Criteria. For discontinuities greater than 1 in. (25 mm) in length and depth discovered on cut surfaces, the following procedures shall be observed.

(1) Where discontinuities such as W, X, or Y in Figure 5.1 are observed prior to completing the joint, the size and shape of the discontinuity shall be determined by ultrasonic testing. The area of the discontinuity shall be determined as the area of total loss of back reflection, when tested in accordance with the procedure of ASTM A435, *Specification for Straight Beam Ultrasonic Examination of Steel Plates.*[1]

(2) For acceptance of W, X, or Y discontinuities, the area of the discontinuity (or the aggregate area of multiple discontinuities) shall not exceed 4% of the cut material area (length times width) with the following exception: if the length of the discontinuity, or the aggregate width of discontinuities on any transverse section, as measured perpendicular to the cut material length, exceeds 20% of the cut material width, the 4% cut material area shall be reduced by the percentage amount of the width exceeding 20%. (For example, if a discontinuity is 30% of the cut material width, the area of discontinuity cannot exceed 3.6% of the cut material area.) The discontinuity on the cut surface of the cut material shall be removed to a depth of 1 in. (25 mm) beyond its intersection with the surface by chipping, gouging, or grinding, and blocked off by welding with a low-hydrogen process in layers not exceeding 1/8 in. (3 mm) in thickness for at least the first four layers.

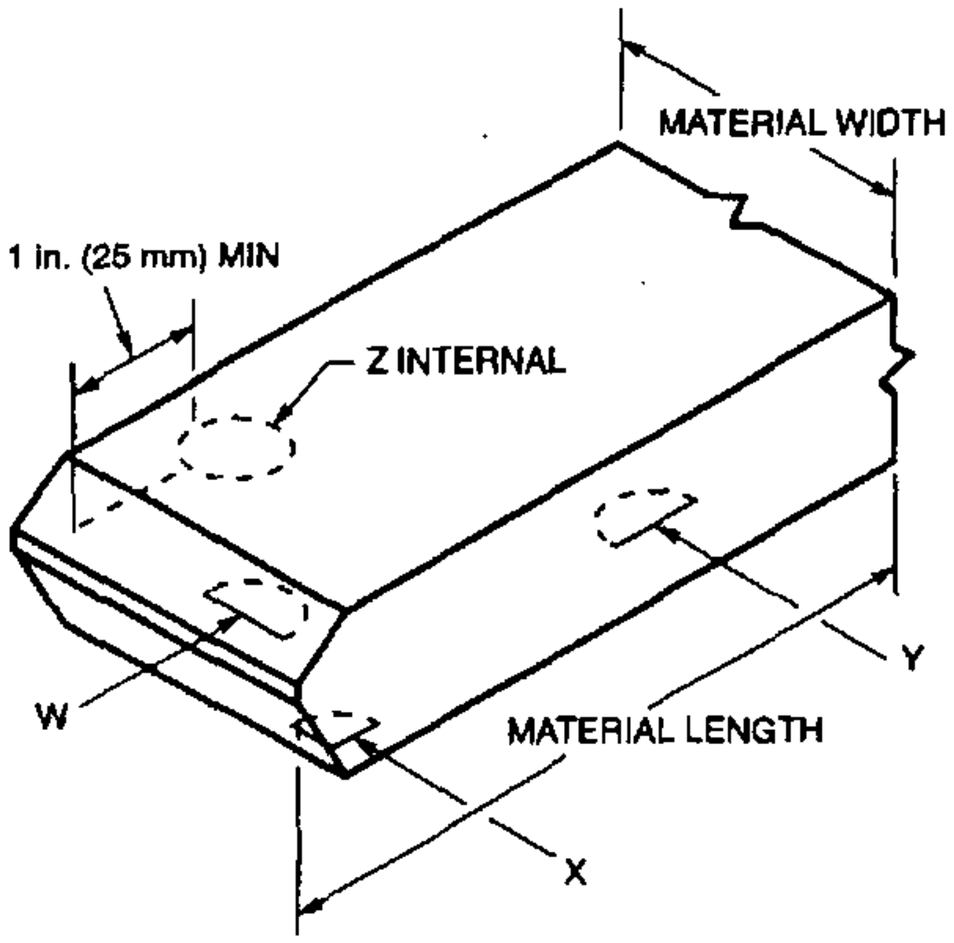


Figure 5.1—Edge Discontinuities in Cut Material (see 5.15.1.1)

(3) If a discontinuity Z, not exceeding the allowable area in 5.15.1.1(2), is discovered after the joint has been completed and is determined to be 1 in. (25 mm) or more away from the face of the weld, as measured on the cut base-metal surface, no repair of the discontinuity is required. If the discontinuity Z is less than 1 in. away from the face of the weld, it shall be removed to a distance of 1 in. from the fusion zone of the weld by chipping, gouging, or grinding. It shall then be blocked off by welding with a low- hydrogen process in layers not exceeding 1/8 in. (3 mm) in thickness for at least the first four layers.

(4) If the area of the discontinuity W, X, Y, or Z exceeds the allowable in 5.15.1.1 (2), the cut material or subcomponent shall be rejected and replaced, or repaired at the discretion of the Engineer.

5.15.1.2 Repair. In the repair and determination of limits of mill induced discontinuities visually observed on cut surfaces, the amount of metal removed shall be the minimum necessary to remove the discontinuity or to determine that the limits of Table 5.4 are not exceeded. However, if weld repair is required, sufficient base metal shall be removed to provide access for welding. Cut surfaces may exist at any angle with respect to the rolling direction. All welded repairs of discontinuities shall be made by:

(1) Suitably preparing the repair area

(2) Welding with an approved low-hydrogen process and observing the applicable provisions of this code

(3) Grinding the completed weld smooth and flush (see 5.24.4.1) with the adjacent surface to produce a workmanlike finish.

Note: The requirements of 5.15.1.2 may not be adequate in cases of tensile load applied through the thickness of the material.

5.15.2 Joint Preparation. Machining, thermal cutting, gouging, chipping, or grinding may be used for joint preparation, or the removal of unacceptable work or metal, except that oxygen gouging shall not be used on steels that are ordered as quenched and tempered or normalized.

5.15.3 Material Trimming. For cyclically loaded structures, material thicker than specified in the following list shall be trimmed if and as required to produce a satisfac-

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

tory welding edge wherever a weld is to carry calculated stress:

(1) Sheared material thicker than 1/2 in. (12.7 mm)

(2) Rolled edges of plates (other than universal mill plates) thicker than 3/8 in.(9.5 mm)

(3) Toes of angles or rolled shapes (other than wide flange sections) thicker than 5/8 in. (15.9 mm)

(4) Universal mill plates or edges of flanges of wide flange sections thicker than 1 in. (25.4 mm)

(5) The preparation for butt joints shall conform to the requirements of the detail drawings

5.15.4 Thermal Cutting Processes. Electric arc cutting and gouging processes and oxyfuel gas cutting processes are recognized under this code for use in preparing, cutting, or trimming materials. The use of these processes shall conform to the applicable requirements of section 5.

5.15.4.1 Other Processes. Other thermal cutting processes may be used under this code, provided the Contractor demonstrates to the Engineer an ability to successfully use the process.

5.15.4.2 Profile Accuracy. Steel and weld metal may be thermally cut, provided a smooth and regular surface free from cracks and notches is secured, and provided that an accurate profile is secured by the use of a mechanical guide. For cyclically loaded structures, freehand thermal cutting shall be done only where approved by the Engineer.

5.15.4.3 Roughness Requirements. In thermal cutting, the equipment shall be so adjusted and manipulated as to avoid cutting beyond (inside) the prescribed lines. The roughness of all thermal cut surfaces shall be no greater than that defined by the American National Standards Institute surface roughness value of 1000 μin. (25 μm) for material up to 4 in. (102 mm) thick and 2000 μin. (50 μm) for material 4 in. to 8 in. (203 mm) thick, with the following exception: the ends of members not subject to calculated stress at the ends shall not exceed a surface roughness value of 2000 μin. ANSI B46.1, Surface Texture is the reference standard. AWS Surface Roughness Guide for Oxygen Cutting (AWS C4.1-77) may be used as a guide for evaluating surface roughness of these edges. For materials up to and including 4 in. (102 mm) thick, use Sample No. 3, and for materials over 4 in. up to 8 in. (203 mm) thick, use Sample No. 2.

5.15.4.4 Gouge or Notch Limitations. Roughness exceeding these values and notches or gouges not more than 3/16 in. (5 mm) deep on other wise satisfactory surfaces shall be removed by machining or grinding. Notches or gouges exceeding 3/16 in. deep may be repaired by grinding if the nominal cross-sectional area is not reduced by more than 2%. Ground or machined surfaces shall be fared to the original surface with a slope not exceeding one in ten. Cut surfaces and adjacent edges shall be left free of slag. In thermal-cut surfaces, occasional notches or gouges may, with approval of the Engineer, be repaired by welding.

5.16 Reentrant Corners

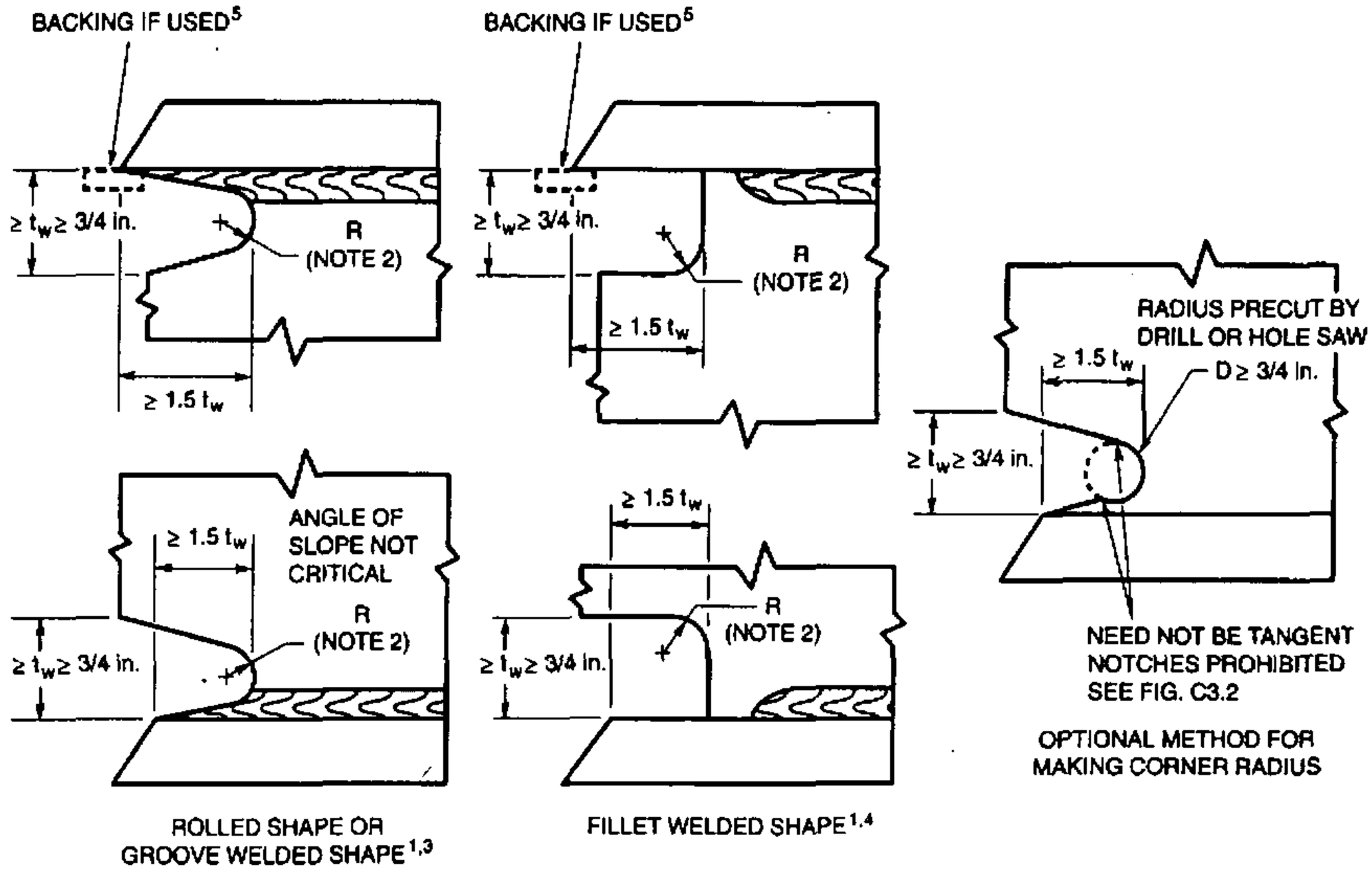
Reentrant corners of cut material shall be formed to provide a gradual transition with a radius of not less than 1 in. (25 mm). Adjacent surfaces shall meet without offset or cutting past the point of tangency. The reentrant corners may be formed by thermal cutting, followed by grinding, if necessary, to meet the surface requirements of 5.15.4.3.

5.17 Beam Copes and Weld Access Holes

Radii of beam copes and weld access holes shall provide a smooth transition free of notches or cutting past the points of tangency between adjacent surfaces and shall meet the surface requirements of 5.15.4.3.

5.17.1 Weld Access Hole Dimensions. All weld access holes required to facilitate welding operations shall have a length from the toe of the weld preparation not less than 1-1/2 times the thickness of the material in which the hole is made. The height of the access hole shall be adequate for deposition of sound weld metal in the adjacent plates and provide clearance for weld tabs for the weld in the material in which the hole is made, but not less than the thickness of the material. In hot rolled shapes and built-up shapes, all beam copes and weld access holes shall be shaped free of notches or sharp reentrant corners except that when fillet web-to-flange welds are used in built-up shapes, access holes are permitted to terminate perpendicular to the flange. Fillet welds shall not be returned through weld access holes. See Figure 5.2.

5.17.2 Group 4 and 5 Shapes. For ASTM A6 Group 4 and 5 shapes and built-up shapes with web material thickness greater than 1-1/2 in. (38.1 mm), the thermally cut surfaces of beam copes and weld access holes shall be ground to bright metal and inspected by either magnetic particle or dye penetrant methods. If the curved transition portion of weld access holes and beam copes are formed by predrilled or sawed holes, that portion of the access hole or cope need not be ground. Weld access holes and beam copes in other shapes need not be ground nor dye penetrant or magnetic-particle inspected.



Notes:
1. For ASTM A6 Group 4 and 5 shapes and welded built-up shapes with web thickness more than 1-1/2 in. (38.1 mm), preheat to 150°F (66°C) prior to thermal cutting, grind and inspect thermally cut edges of access hole using magnetic particle or dye penetration methods prior to making web and flange splice groove welds.
2. Radius shall provide smooth notch-free transition; R ≥ 3/8 in. (9 mm) [Typical 1/2 in. (13 mm)].
3. Access opening made after welding web to flange.
4. Access opening made before welding web to flange. Weld not returned through opening.
5. These are typical details for joints welded from one side against steel backing. Alternative joint designs should be considered.

Figure 5.2—Weld Access Hole Geometry (see 5.17.1)

5.18 Temporary and Tack Welds

5.18.1 Temporary Welds. Temporary welds shall be subject to the same welding procedure requirements as the final welds. These shall be removed, when required by the Engineer. When they are removed, the surface shall be made flush with the original surface.

For cyclically loaded nontubular connections, there shall be no temporary welds in tension zones of members made of quenched and tempered steel except at locations more than 1/6 of the depth of the web from tension flanges of beams or girders; temporary welds at other locations shall be shown on shop drawings.

5.18.2 General Requirements for Tack Welds. Tack welds shall be subject to the same quality requirements as the final welds, with the following exceptions:

(1) Preheat is not mandatory for single-pass tack welds which are remelted and incorporated into continuous submerged arc welds.

(2) Discontinuities, such as undercut, unfilled craters, and porosity need not be removed before the final submerged arc welding.

5.18.2.1 Incorporated Tack Welds. Tack welds which are incorporated into the final weld shall be made with electrodes meeting the requirements of the final welds and shall be cleaned thoroughly. Multiple-pass tack welds shall have cascaded ends.

5.18.2.2 Nonincorporated Tack Welds. Tack welds not incorporated into final welds shall be removed, except that, for statically loaded structures, they need not be removed unless required by the Engineer.