Part I
5. FABRICATION

5.1 Reduced Beam Sections (RBSs)

5.1.1 Holes and Attachments

No holes may be drilled or punched in either flange of the beam within the length that has received the radius cut, or between the RBS cut and the column. Shear studs and mechanical deck fasteners to the beam flange within the length of the radius cut are prohibited. Spot welds for the attachment of metal decking are permitted.

5.1.2 RBS Cut Tolerances

The tolerance on the depth of each RBS cut is plus or minus ¼ inch, measured at the mid-thickness of the flange at the narrowest point of the cut flange. The length of the cut shall be within plus or minus 15% of the specified length. The depth of cut on each side shall be balanced, with no more than 3/8 inch total variation in the depth of cut from one side to the other. (Example: plus 1/8 inch on one side, minus 1/4 inch on other side.) The balance of remaining flange width about the web of the beam is not a consideration.

5.1.3 Cut Surface Roughness

After thermal cutting, the RBS surface shall have a surface roughness of no more than 500 microinches (AWS sample 3). Grinding of thermally cut edges shall be provided only as necessary to meet this criteria. Corners between the cut RBS surface and the top and bottom of the flanges shall be ground to remove sharp edges, but a minimum radius or chamfer is not required.

5.1.4 Gouges and Notches

Gouges and notches that occur in the thermal cut RBS surface may be repaired by grinding if not more than ¼ inch deep. The gouged or notched area shall be faired by grinding so that a smooth transition exists, and the total length of the area ground for the transition shall be no less than 10 times the depth of the removed gouge. If a sharp notch exists, the area shall be inspected by MT after grinding to ensure that the entire depth of gouge or notch has been removed. Grinding may not increase the depth of the RBS cut section more than ¼ inch beyond the specified depth of cut.

5.1.5 Welded Repair of Notches and Gouges

Gouges and notches that exceed ¼ inch in depth, but not to exceed ½ inch in depth, and those notches and gouges where repair by grinding would increase the effective depth of the RBS cut beyond tolerance, may be repaired by welding. Notches and gouges exceeding ½ inch in depth may be repaired only with the approval of the Engineer. The notch or gouge shall be removed and ground to provide a smooth radius of not less than 3/8 inch for welding. The repair area shall be preheated to a temperature between 400°F and 550°F, measured at the location of the weld

repair approximately one minute after removal of the heating source. Repair welding shall be done with notch-tough electrodes meeting the requirements in Part I, Section 2.4. A repair WPS is required. Following welding, the repair weld shall be ground to a smooth contour meeting the RBS requirements, with a surface roughness not to exceed 500 microinches. The welded repair area shall be inspected using magnetic particle testing.

5.2 Heavy Sections

5.2.1 General

See AISC *Specification* sections A3.1c for materials requirements, J2.8 for preheat requirements, J1.6 for access hole requirements, and J1.5 for weld tab and backing bar removal requirements. See *AISC LRFD* Figure C-J1.2 for dimensional and fabrication requirements for standard weld access holes. See Section 4.4 of this specification for further requirements for weld access holes.

5.2.2 Access Hole Requirements

Weld access holes must be preheated to a minimum of 150°F prior to thermal cutting, ground to 500 microinches (bright metal), and inspected for cracks using either penetrant testing (PT) or magnetic particle testing (MT). Optionally, weld access holes may be made by drilling and saw-cutting without grinding, but PT or MT of the cut surface is still required.

5.2.3 Welding

For joint welding, the minimum preheat and interpass temperature shall be 350°F. Weld tabs and backing bars shall be removed after completion of the joint, ground smooth to a maximum surface roughness of 500 microinches, with reinforcement not to exceed 1/8 inch, at a transition slope not to exceed 1:10.

5.3 End Plate Moment Connections

5.3.1 Flange Welds

Beam-flange-to-end-plate welds shall be detailed and welded as CJP groove welds, except that in the area of the flange directly above and below the beam web, backgouging and backwelding of the weld root is not required.

The groove weld detail shall be such that the root of the weld is located on the beam web side of the joint. Following backgouging and backwelding of the groove weld root, a 5/16 inch reinforcing fillet weld shall be placed on the inside portion of the flange weld, at the groove root. Alternatively, the 5/16-inch reinforcing fillet weld located on the beam web side of the beam flanges may serve as a backing weld. The root of the fillet must then be backgouged to solid weld metal, and the groove weld placed. No backing is provided in the vicinity of the beam web. Using either method, no MT of the backgouged area is required prior to placement of the backweld or the groove weld.

5.3.2 Web Welds

The beam web shall be welded full length to the end plate using fillet welds on each side of the beam web. Alternatively, groove welds may be substituted for the fillet welds.

The weld detail limitations of Section 5.6 of this specification regarding the k-area are not applicable to this connection, but MT following completion of all welds in this area is required.

5.3.3 Stiffener Welds

When Bolted Stiffened End Plate (BSEP) connections are used, the stiffener shall be welded to the end plate and the beam flange using CJP groove welds. A stiffener clip (snipe) shall be provided at the intersection of beam flange and end plate.

5.3.4 Weld Access Hole

No weld access holes are permitted at the intersection of beam web, beam flange and end plate.

5.3.5 NDT Requirements

The beam flange to end plate welds, and the welds between stiffener and beam flange and end plate, shall be inspected using MT and UT as QC/QA Category AH/T and between stiffener and beam flange BH/L. Discontinuities located at the root of the beam flange weld, at the intersection of the beam web and beam flange, shall not be cause for rejection.

Welds between the beam web and end plate shall be inspected using MT, for QC/QA Category BM/L, for their full length.

5.4 Bolted Connections

All bolts used in these connections shall be installed as in slip-critical joints with Class A faying surfaces. Bolts may be installed using any of the pretensioning methods prescribed in the RCSC *Specification*.

Bolts holes shall be standard diameter, unless otherwise noted on the drawings.

For all other bolted connections, the connection type shall be as designated on the drawings.

> *Commentary: The provisions of this section are applicable to the following types of bolted connections: Bolted Unstiffened End Plate (BUEP) connections, Bolted Stiffened End Plate (BSEP) connections, Bolted Flange Plate (BFP) connections, Double Split Tee (DST) connections.*

5.5 Repair of Discontinuities in Main Members

In lieu of AISC *Seismic Provisions* Section 7.3c, the provisions of this section shall apply to beams in steel moment frames and only to that portion of the beam between the column flange

and the following locations:

(a) for Welded Unreinforced Flange (WUF), Welded Free Flange (FF), and Improved Welded Unreinforced Flange (IWURF) connections a point away from the column face located a distance equal to one-half the depth of the beam

(b) for Reduced Beam Section (RBS) connections a point away from the centerline of the cut radius located a distance equal to one-half the depth of the beam, but no closer than the far edge of the radius cut

(c) for Welded Flange Plate (WFP) connections and Welded Cover Plated Flange (WCPF) connections from the end of the flange plate or cover plate, away from the column face, to a point located away from the end of the plate at a distance equal to one-half the depth of the beam

(d) for Welded Bottom Haunch (WBH) connections and Welded Top and Bottom Haunch (WTBH) connections from the intersection of the haunch and beam flange, to a point located away from haunch intersection a distance equal to the one-half the depth of the beam

(e) for Bolted Unstiffened End Plate (BUEP) connections to a point away from the column face located a distance equal to five-sixths the depth of the beam, plus the thickness of the end plate

(f) for Bolted Stiffened End Plate (BSEP) connections from the end of the stiffener, away from the column face, to a point located away from the end of the stiffener a distance equal to one-half the depth of the beam

(g) for Double Split Tee (DST) connections from the stem end of the tee to a point located a distance equal to one-half the depth of the beam

Commentary: It is recommended that the design drawings designate these locations and refer to this section of the specification for specific requirements.

5.5.1 Tack Welds

Tack welds are permitted if made prior to beginning welding of the joint. Tack welds for backing bars and weld tabs must be made within the groove weld joint. Tack welds for attachment of parts prior to fillet welding are acceptable, provided they are covered by the completed fillet weld.

Tack welds outside these locations must be removed by grinding or chipping. Air carbon arc gouging and thermal cutting to remove tack welds in these areas is not permitted. Following the removal of unacceptable tack welds, the weld area shall be ground to a depth of 1/16 inch, and faired to adjacent surfaces on a slope not to exceed 1:5.

5.5.2 Erection Aids

Unless requested by the Contractor and approved by the Engineer in advance, the use of welded attachments as erection aids within the designated areas is prohibited. If erection aids are placed within the designated area in error, or cannot be avoided, the Engineer's approval of the aid's placement, use, and the repair method is required.

Air carbon arc gouging is permitted for the removal of welds to within 1/8 inch of the base metal surface. Any remaining weld deposits shall be removed by grinding to a depth 1/16 inch below the surface, faired to adjacent surfaces on a slope not to exceed 1:5.

5.5.3 Air Carbon Arc Cutting and Thermal Cutting

Air carbon arc cutting (CAC-A) and thermal cutting is permitted within the above regions when required for the removal of backing bars and weld tabs, as specified in these documents. The use of these processes for repairs to or removal of base metal or welds in the above region is permitted only with the prior approval of the Engineer.

5.6 K-Area Welding Limitations

After welding of continuity plates and doubler plates, test column webs for cracking using liquid penetrant (PT) or magnetic particle testing (MT) over a zone 3 inches above and below the continuity plate or doubler plate welds. Testing may be performed after the weld has cooled to ambient temperature.

5.7 Surface Finish

5.7.1 Flush Surfaces

Welds in butt joints required to be flush shall be finished so as to not reduce the thicknesses of the thinner base metal or weld metal by more than 1/16 inch, or 5% of the material thickness, whichever is less. Remaining reinforcement shall not exceed 1/32 inch in height. However, all reinforcement shall be removed where the weld forms part of a faying or contact surface. All reinforcement shall blend smoothly into the plate surfaces with the transition areas free from undercut.

5.7.2 Finish Methods and Values

Chipping and gouging may be used, provided these methods are followed by grinding. Where surface finishing is required, surface roughness values shall not exceed 500 microinches, unless otherwise noted or specified in this document. Regardless of the surface finish required, the direction of grinding marks may be in any direction.

Measurement of surface finish values by visual appearance or tactile comparison is acceptable.

5.8 Weld Acceptance Criteria

5.8.1 Engineer's Authority

Welds or portions of welds that fail to meet the acceptance criteria of *AWS D1.1* shall be repaired or replaced. The Contractor may request acceptance by the Engineer of a weld discontinuity, without repair or replacement, when it can be determined that the effect of the discontinuity will not be detrimental to the performance of the structure. The Engineer is the final authority for acceptance of such welds.

5.8.2 Magnetic Particle Testing

If a surface discontinuity or near-surface discontinuity, within 1/8 inch of the surface, is detected, the discontinuity shall be rejected and removed. If the separation from the surface cannot be determined, the discontinuity shall be categorized as a surface flaw, rejected and removed.

Regions of welds that cannot be inspected shall be identified and recorded, and the Engineer shall be notified.

5.8.3 Ultrasonic Testing - Flaw Detection

When ultrasonic testing is required, the joint shall be scanned for flaw detection purposes following the procedures prescribed in *AWS D1.1*, Annex K, with exceptions as noted below. Joints that fail the acceptance criteria described below may be inspected using the Ultrasonic Testing - Flaw Sizing methods as prescribed in Section 5.8.4 of this specification, or, at the Contractor's option, may be excavated for further investigation and repaired, then reinspected using these Flaw Detection procedures.

When ultrasonic testing is required, CJP and PJP groove welds in Seismic Weld Demand Categories A, B and C shall be scanned for flaw detection. Acceptance criteria shall be as for statically loaded welds in Annex K, Table K-1, of *AWS D1.1.*

> *Commentary: As an alternative, The engineer may elect to permit CJP and PJP groove welds in Seismic Weld Demand Categories A, B and C to be scanned for flaw detection purposes using AWS D1.1, Table 6.2 as the acceptance criteria. In this case, Note 3 regarding "tension welds" is not applicable.*

Joints with backing bars remaining in place shall not be rejected on the basis of indication ratings (db values) from the interfaces between backing bar and base metal or backing bar and weld. The UT Procedure shall prescribe methods for distinguishing between backing bar indications and root discontinuities.

PJP groove weld joints shall not be rejected on the basis of indication ratings (db values) from the root area of the weld. Notches within the weld, located a distance more than 1/8 inch from the as-welded root, shall be scanned for acceptance using the criteria above.

Regions of welds that cannot be inspected shall be identified and recorded, and the Engineer shall be notified.

Regions of welds adjacent to cope holes may be inspected with multiple probe techniques.

5.8.4 Ultrasonic Testing – Flaw Sizing

Ultrasonic testing for flaw sizing shall be performed following written procedures as required by *AWS D1.1,* Annex K. When flaw-sizing techniques are implemented, the following acceptance criteria applies to groove welds:

1. If a surface flaw or near-surface flaw (within 1/8 inch of the surface) is detected, the flaw shall be rejected and removed. If the separation from the surface cannot be measured, the flaw shall be categorized as a surface flaw, rejected and removed.
2. When backing bars remain in place, the position of notch tips that extend into the weld metal shall be determined. The notch shall be rejected if it extends greater than 1/8-inch into the thickness of the weld. The weld present between the backing bar and column face shall not be considered a part of the weld thickness in determining the depth of notch or thickness of weld.
3. Embedded flaws, defined as those that do not come within 1/8 inch of the surface, shall be rejected if their height exceeds ¼ inch.
4. Embedded flaws shall be rejected if their area, as calculated by multiplying the maximum discontinuity height by the maximum discontinuity length, exceeds the thickness of the thinner parent metal multiplied by the thickness of the thicker parent metal.
5. Embedded flaws, either individually or as a group within a length of weld 12 inches or less, shall be rejected if they exceed a total area (the sum of the areas of individual discontinuities) equal to 10% of the thickness of the thinner parent metal multiplied by the weld length. The weld length used for this calculation shall not exceed 12 inches, with longer welds being evaluated in multiple parts.
6. Aligned discontinuities of lengths L1 and L2 separated by less than (L1+L2)/2 shall be evaluated as continuous.
7. Parallel discontinuities of heights H1 and H2 separated by less than (H1+H2)/2 shall be evaluated as continuous.