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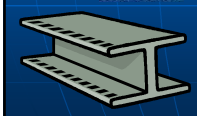
2020 EduCode

Seismic Provisions for Structural Steel Inspectors & Fabricators



Presented by:

Mark J. Hayes

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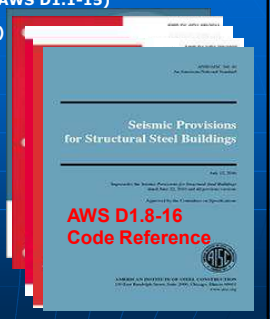
IBC REFERANCED STANDARDS

Structural Steel (AISC 360-16) (AWS D1.1-15)
Reinforcing Steel (AWS D1.4-11)
Cold-formed Steel (AWS D1.3-08)



1705.12.1 Structural steel Special Inspection (AISC 341-16)
1705.13.1 Structural steel Testing (AISC 341-16)

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REQUIRED DOCUMENTS

The permit applicant shall provide a Statement of Special Inspection, prepared by the Registered Design Professional, as a condition of permit issuance.

The statement of special inspection shall identify;

- ▸ The materials, systems, components and work requiring special inspection or testing required by the building official and/or registered design professional.
- ▸ Each special inspection type, frequency to be performed as Periodic or Continuous, and the type and extent of each special inspection and/or test.

- ❖ Designated Seismic & Seismic Force Resisting Systems

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REQUIRED DOCUMENTS

The statement of special inspection may be prepared by a qualified person approved by the building Official for construction not designed by a registered design professional.

Requirements for the seismic-force-resisting system are permitted to be excluded. Steel systems in structures assigned to *Seismic Design Category* C that are not specifically detailed for seismic resistance, with a response modification coefficient, *R*, of 3 or less, excluding cantilever column systems.

Additional requirements for seismic design include;

- Identification of the designated seismic systems and seismic-force-resisting systems requiring special inspection.
- Any additional special inspections and testing required by code or standard.

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REQUIRED DOCUMENTS

MAXIMUM CONSIDERED EARTHQUAKE GROUND MOTION
The most severe earthquake effects considered by this code.

SEISMIC DESIGN CATEGORY
A classification assigned to a structure based on its *occupancy category* and the severity of the design earthquake ground motion at the site.

SEISMIC-FORCE-RESISTING SYSTEM
That part of the structural system that has been considered in the design to provide the required resistance to the prescribed seismic forces.

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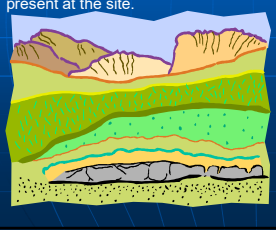
REQUIRED DOCUMENTS

Site class definitions Based on the site soil properties, the site shall be classified as either *Site Class* A, B, C, D, E or F
When the soil properties are not known in sufficient detail to determine the *site class*, *Site Class* D shall be used unless the *building official* or geotechnical data determines that *Site Class* E or F soil is likely to be present at the site.



SOIL PROFILE SITE CLASS
A: Hard rock
B: Rock
C: Very dense soil and soft rock
D: Stiff soil profile
E: Soft soil profile
F: liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils, Peats and/or highly organic clays

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REQUIRED DOCUMENTS

Each contractor responsible for the construction of seismic-force-resisting system, designated seismic system or a seismic-resisting component identified in the statement of special inspections shall submit, prior to commencement of work, a statement of responsibility to the building official.

This statement of responsibility shall acknowledge;

- ► Awareness of identified special inspection requirements and that conformance to approved construction documents is required.

This statement shall also identify procedures to be used for exercising control within the contractors organization including;

- ► Method and frequency of reporting and report distribution
- ► Identification and qualifications of person(s) in such control and their company position(s).

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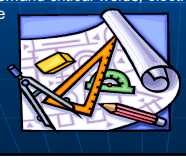
REQUIRED DOCUMENTS

CONTRACTOR DOCUMENTS

The following documents shall be submitted for review by the engineer of record or designee, prior to fabrication or erection, as applicable:

- ❖ Shop drawings
- ❖ Erection drawings
- ❖ Welding Procedure Specifications (WPS), which shall specify all applicable essential variables of AWS D1.1 and the following, as applicable
  - ❖ power source (constant current or constant voltage)
  - ❖ for *demand critical welds*, electrode manufacturer and trade name



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REQUIRED DOCUMENTS

- ❖ Copies of the manufacturer's typical certificate of conformance for all electrodes, fluxes and shielding gasses to be used. Certificates of conformance shall satisfy the applicable AWS A5 requirements.
- ❖ For demand critical welds, applicable manufacturer's certifications that the filler metal meets the supplemental notch toughness requirements, as applicable.

**Should the filler metal manufacturer not supply such supplemental certifications, the contractor shall have the necessary testing performed and provide the applicable test reports.*

- ❖ Manufacturer's product data sheets or catalog data for SMAW, FCAW and GMAW composite (cored) filler metals to be used. The data sheets shall describe the product, limitations of use, recommended or typical welding parameters, and storage and exposure requirements, including baking, if applicable.

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REQUIRED DOCUMENTS

The following documents shall be available for review by the engineer of record or designee prior to fabrication or erection, as applicable, unless specified to be submitted:

- Material test reports for structural steel, bolts, shear connectors, and welding materials
- Inspection procedures
- Nonconformance procedure
- Material control procedure
- Bolt installation procedure
- Welder performance qualification records (WPQR), including any supplemental testing requirements
- QC Inspector qualifications

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REQUIRED DOCUMENTS

QUALITY ASSURANCE AGENCY DOCUMENTS

The agency responsible for *quality assurance* shall submit the following documents to the *authority having jurisdiction*, the engineer of record, and the owner or owner's designee:

- QA agency's written practices for the monitoring and control of the agency's operations.

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REQUIRED DOCUMENTS

The written practice shall include:

- The agency's procedures for the selection and administration of inspection personnel, describing the training, experience and examination requirements for qualification and certification of inspection personnel
- The agency's inspection procedures, including general inspection, material controls, and visual welding inspection
- Qualifications of management and QA personnel designated for the project
- Qualification records for Inspectors and NDT technicians designated for the project
- NDT procedures and equipment calibration records for NDT to be performed and equipment to be used for the project
- Daily or weekly inspection reports
- Nonconformance reports

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REQUIRED DOCUMENTS

General. *Construction documents* shall show the size, section and relative locations of structural members with floor levels, column centers and offsets dimensioned. The design loads and other information pertinent to the structural shall be indicated on the *construction documents*.

Earthquake Design Data. The following information related to seismic loads shall be shown:

1. Seismic importance factor, *I*, and *occupancy category*.
2. Mapped spectral response accelerations, *SS* and *S1*.
3. *Site class*.
4. Spectral response coefficients, *SDS* and *SD1*.
5. *Seismic design category*.
6. Basic seismic-force-resisting system(s).
7. Design base shear.
8. Seismic response coefficient(s), *CS*.
9. Response modification factor(s), *R*.
10. Analysis procedure used.

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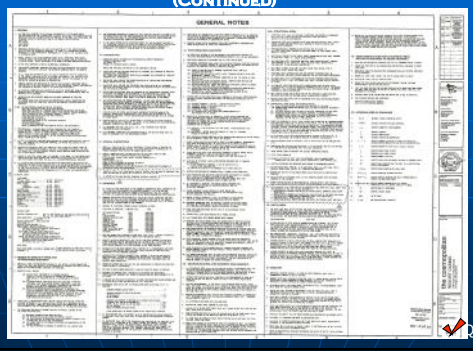
REQUIRED DOCUMENTS (CONTINUED)



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STRUCTURAL DESIGN DRAWINGS & SPECIFICATIONS (GENERAL)

Structural design drawings and specifications shall show the work to be performed, and include items required by the *Specification* and the following, as applicable:

- Designation of the *seismic load resisting system* (SLRS)
- Designation of the members and connections that are part of the SLRS
- Configuration of the connections
- Connection material specifications and sizes
- Locations of *demand critical welds*
- *Lowest anticipated service temperature* (LAST) of the steel structure, if the structure is not enclosed and maintained at a temperature of 50 °F or higher
- Locations and dimensions of *protected zones*
- Locations where gusset plates are to be detailed to accommodate inelastic rotation
- Welding requirements as specified in Appendix W, Section W2.1.

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Structural Design Drawings & Specifications (Welding)

Structural design drawings and specifications shall include, as a minimum, the following information:

- Locations where backup bars are required to be removed
- Locations where supplemental fillet welds are required when backing is permitted to remain
- Locations where fillet welds are used to reinforce groove welds or to improve connection geometry
- Locations where weld tabs are required to be removed
- Splice locations where tapered transitions are required
- The shape of weld access holes, if a special shape is required
- Joints or groups of joints in which a specific assembly order, welding sequence, welding technique or other special precautions are required

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Erection Drawings

Erection drawings shall include, as a minimum, the following information:

- Locations where backing bars to be removed
- Locations where supplemental fillets are required when backing is permitted to remain
- Locations where weld tabs are to be removed
- Those joints or groups of joints in which a specific assembly order, welding sequence, welding technique or other special precautions are required

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REQUIRED SPECIAL INSPECTIONS

The Owner or the Registered Design Professional, acting as the owner's agent shall employ a Special Inspection Inspector(s) to provide inspections during construction. The special inspector(s) shall be qualified and can demonstrate competence, to the satisfaction of Building Official, for the type(s) of construction or operation requiring special inspection.

Exceptions:

- *Building Official determines the work to be performed is of minor nature or is warranted by jurisdictional conditions.*
- *The building components design does not involve the practice of professional engineering or architecture as defined by state statutes and professional engineer or architecture registration/certification.*

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REQUIRED SPECIAL INSPECTIONS

(Continued)

Special inspection is required where fabrication of structural load-bearing members and assemblies is performed on the premises of the fabricators shop.

Special inspections are required for; seismic-force-resisting systems in structures assigned to Seismic Design Category C, D, E, or F and designated seismic systems in structures assigned to Category D, E or F.

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INSPECTOR TYPES

- Quality Control (QC) shall be provided by the fabricator, erector or other responsible contractor as applicable.

- Quality Assurance (QA) shall be provided by others when required by the authority having jurisdiction (AHJ), applicable building code (ABC), purchaser, owner or engineer of record (EOR).
- Nondestructive testing (NDT) shall be performed by the agency or firm responsible for Quality Assurance.

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SPECIFICATIONS

IV - SPECIAL INSPECTIONS

1. OWNER WILL ENGAGE AND PAY FOR AN INDEPENDENT TESTING AGENCY TO PERFORM THE FOLLOWING INSPECTION AND TESTING. IT IS THE CONTRACTOR'S RESPONSIBILITY TO PROVIDE ADEQUATE PRIOR NOTICE FOR COMPLETION OF SUCH.
2. SPECIAL INSPECTION SHALL BE REQUIRED FOR THE FOLLOWING TYPES OF WORK:
   CONCRETE WORK WITH STRENGTHS GREATER THAN 2500 PSI.
   FIELD WELDING (EXCEPT STEEL STUDS, FURRING CHANNELS,ETC.)
   MASONRY WORK.
   HIGH STRENGTH BOLTING.
   REBAR OR BOLTS ANCHORED BY EPOXIES OR GROUTS.
   MECHANICAL REINFORCING BAR SPLICES.
   ANCHOR STUDS, EMBEDDED PLATES AND EXPANSION TYPE ANCHOR BOLTS PLACEMENT OF REINFORCING STEEL AND PRESTRESSING.
3. COMPOSITE STEEL PLATE SHEAR WALLS: QUALITY CONTROL (QC) AND QUALITY ASSURANCE (QA) SHALL BE PROVIDED AS SPECIFIED IN APPENDIX Q OF AISC 341-05.
4. FIREPROOFING PER ARCHITECTURAL DRAWINGS (APPROVAL PENDING).

V - CONCRETE 26

1. ALL PHASES OF WORK PERTAINING TO THE CONCRETE CONSTRUCTION SHALL CONFORM TO THE 'BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE', ACI 318, AND THE

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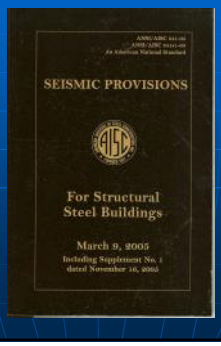
Specifications
(Continued)



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Specifications

SCOPE
The *Seismic Provisions for Structural Steel Buildings* shall govern the design, fabrication and erection of structural steel members and connections in the *seismic load resisting systems* (SLRS) and splices in columns that are not part of the SLRS, in buildings and other structures, where other structures are defined as those structures designed, fabricated and erected in a manner similar to buildings, with building-like vertical and lateral load-resisting-elements.

These *Provisions* shall apply when the *seismic response modification coefficient*, *R*, (as specified in the *applicable building code*) is taken greater than 3, regardless of the *seismic design category*.

When the seismic response modification coefficient, *R*, is taken as 3 or less, the structure is not required to satisfy these *Provisions*, unless specifically required by the applicable building code.

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Specifications

These Provisions shall be applied in conjunction with the AISC *Specification for Structural Steel Buildings*. Members and connections of the SLRS shall satisfy the requirements of the applicable building code, the *Specification*, and these *Provisions*.

The applicable building code generally restricts buildings designed with an *R* factor of 3 or less to seismic design categories (SDC) A, B or C; however, some systems such as cantilever columns that have *R* factors less than 3 are permitted in SDC D and above.

Structural Steel. Special Inspection and Testing of structural steel shall be in accordance with the quality assurance plan requirements of AISC 341.

Seismic-Force-Resisting Systems
The seismic force-resisting systems in structures assigned to *Seismic Design Category* C, D, E or F.

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SPECIAL INSPECTOR DUTIES

The welding inspector shall observe welding operations during fabrication and erection operations and shall verify all fabrication and erection welding conforms to contract documents.

The inspector shall observe these functions on a random, daily basis. Operations need not be delayed Pending observations.

These inspections shall be performed prior to the final acceptance of the item.
The inspector shall prepare reports indicating that the work has been performed in accordance with the contract documents.
For shop fabrication, the report shall indicate the piece mark of the piece inspected.
For field work, the report shall indicate the reference grid lines & floor or elevation inspected. Work not in compliance with the contract documents and whether the noncompliance has been satisfactorily repaired shall be noted in the inspection report.

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TABLE J6.1
Visual Inspection Tasks Prior to Welding

Visual Inspection Tasks Prior to Welding	QC		QA	
	Task	Doc.	Task	Doc.
Material identification (Type/Grade)	O	—	O	—
Welder identification system	O	—	O	—
Fit-up of Groove Welds (including joint geometry) –Joint preparation –Dimensions (alignment, root opening, root face, bevel) –Cleanliness (condition of steel surfaces) –Tacking (tack weld quality and location) –Backing type and fit (if applicable)	P/O**	—	O	—
Configuration and finish of access holes	O	—	O	—
Fit-up of Fillet Welds –Dimensions (alignment, gaps at root) –Cleanliness (condition of steel surfaces) –Tacking (tack weld quality and location)	P/O**	—	O	—

** Following performance of this inspection task for ten welds to be made by a given welder, with the welder demonstrating understanding of requirements and possession of skills and tools to verify these items, the Perform designation of this task shall be reduced to Observe, and the welder shall perform this task. Should the inspector determine that the welder has discontinued performance of this task, the task shall be returned to Perform until such time as the Inspector has re-established adequate assurance that the welder will perform the inspection tasks listed.

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Visual Inspection Tasks During Welding

Visual Inspection Tasks During Welding	QC		QA	
	Task	Doc.	Task	Doc.
WPS followed –Settings on welding equipment –Travel speed –Selected welding materials –Shielding gas type/flow rate –Preheat applied –Interpass temperature maintained (min/max.) –Proper position (F, V, H, OH) –Intermix of filler metals avoided unless approved	O	—	O	—
Use of qualified welders	O	—	O	—
Control and handling of welding consumables –Packaging –Exposure control	O	—	O	—
Environmental conditions –Wind speed within limits –Precipitation and temperature	O	—	O	—
Welding techniques –Interpass and final cleaning –Each pass within profile limitations –Each pass meets quality requirements	O	—	O	—
No welding over cracked tacks	O	—	O	—

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Visual Inspection Tasks After Welding

Visual Inspection Tasks After Welding	QC		QA	
	Task	Doc.	Task	Doc.
Welds cleaned	O	—	O	—
Size, length, and location of welds	P	—	P	—
Welds meet visual acceptance criteria –Crack prohibition –Weld/base-metal fusion –Crater cross section –Weld profiles and size –Undercut –Porosity	P	D	P	D
k-area[1]	P	D	P	D
Placement of reinforcing or contouring fillet welds (if required)	P	D	P	D
Backing removed, weld tabs removed and finished, and fillet welds added (if required)	P	D	P	D
Repair activities	P	—	P	D

1 When welding of doubler plates, continuity plates or stiffeners has been performed in the *k*-area, visually inspect the web *k*-area for cracks within 3 in. (75 mm) of the weld. The visual inspection shall be performed no sooner than 48 hours following completion of the welding.

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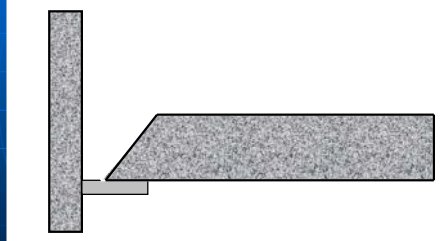
Standard AWS Groove Weld Qualification Test Specimen



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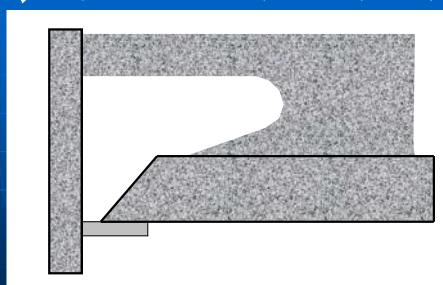
Seismic AWS Groove Weld Qualification Test Specimen



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Welding Requirements

Welded Joints
Welding shall be performed in accordance with a welding procedure specification (WPS) as required in AWS D1.1 and approved by the engineer of record. The WPS variables shall be within the parameters established by the filler metal manufacturer.

General Requirements
All welds used in members and connections in the SLRS shall be made with a filler metal that can produce welds that have a minimum Charpy V-Notch toughness of 20 ft-lb (27 J) at 0 °F (minus 18 °C), as determined by the appropriate AWS A5 classification test method or manufacturer certification.

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Welding Requirements
(Continued)

Demand Critical Welds
- Where welds are designated as *demand critical*, they shall be made with a filler metal capable of providing a minimum Charpy V-Notch (CVN) toughness of 20 ft-lb (27 J) at -20 °F (29 °C) as determined by the appropriate AWS classification test method or manufacturer certification.

- For structures when the steel frame is normally enclosed and maintained at a temperature of 50 °F (10 °C) or higher 40 ft-lb (54 J) at 70 °F (21 °C)

- For structures with service temperatures lower than 50 °F (10 °C), the qualification temperature shall be 20 °F (11 °C) above the *lowest anticipated service temperature*, or at a lower temperature.

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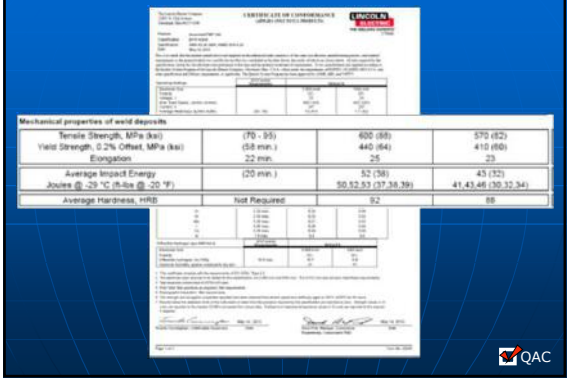
Welding Wire Certificate of Conformance



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Welding Requirements
(Continued)

Complete-joint-penetration (CJP) groove welds between columns and base plates should be considered demand critical similar to column splice welds, when CJP groove welds used for column splices in the designated SLRS have been designated demand critical.

For ordinary, special and intermediate moment frames, typical examples of demand critical welds include the following CJP groove welds:

- Welds of beam flanges to columns
- Welds of single plate shear connections to columns
- Welds of beam webs to columns
- Column splice welds, including column bases (special and intermediate moment frames Only)

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Welding Requirements
(Continued)

For eccentrically braced frames (EBF), typical examples of demand critical welds include:

- CJP groove welds between link beams and columns.
- Welds joining the web plate to flange plates in built-up EBF
- Link beams, and column splice welds when made using CJP groove welds, should be considered for designation as demand critical welds.

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Welding Requirements
(Continued)

Protected Zone

Where a *protected zone* is designated by these *Provisions* or ANSI/AISC 358, it shall comply with the following:

- Within the protected zone, discontinuities created by fabrication or erection operations, such as tack welds, erection aids, air-arc gouging and thermal cutting shall be repaired as required by the engineer of record.
- Welded shear studs and decking attachments that penetrate the beam flange shall not be placed on beam flanges within the protected zone. Decking arc spot welds as required to secure decking shall be permitted.
- Welded, bolted, screwed or shot-in attachments for perimeter edge angles, exterior facades, partitions, duct work, piping or other construction shall not be placed within the protected zone.

Exception: Welded shear studs and other connections shall be permitted when designated in the *Prequalified Connections for Special and Intermediate Moment Frames for Seismic Applications.*

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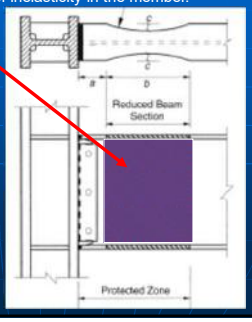
Welding Requirements

(Continued)

Reduced Beam Section. Reduction in cross section over a discrete length that promotes a zone of inelasticity in the member.

Plastic Hinge Location. Location in a beam column assembly where inelastic energy dissipation is assumed to occur through the development of plastic flexural straining.

Whats Going On ?



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Welding Requirements

(Continued)

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Welding Requirements

(Continued)

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Welding Requirements

(Continued)

Continuity Plates and Stiffeners

Corners of *continuity plates* and stiffeners placed in the webs of rolled shapes shall be clipped as described below. Along the web, the clip shall be detailed so that the clip extends a distance of at least 1½ in. (38 mm) beyond the published *k* detail dimension for the rolled shape. Along the flange, the clip shall be detailed so that the clip does not exceed a distance of ½ in. (12 mm) beyond the published *k*1 detail dimension. The clip shall be detailed to facilitate suitable weld terminations for both the flange weld and the web weld. If a curved clip is used, it shall have a minimum radius of ½ in. (12 mm).

At the end of the weld adjacent to the column web/flange juncture, weld tabs for continuity plates shall not be used, except when permitted by the engineer of record. Unless specified by the engineer of record that they be removed, weld tabs shall not be removed when used in this location.

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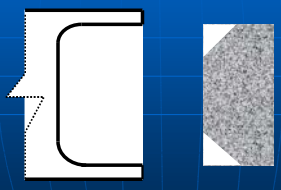
Welding Requirements

(Continued)



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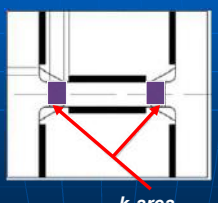
Welding Requirements

(Continued)

k-area. The *k-area* is the region of the web that extends from the tangent point of the web and the flange-web fillet (AISC "*k*" dimension) a distance of 1 ½ in. (38 mm) into the web beyond the "*k*" dimension.



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TYPES OF SLRS SYSTEM ELEMENTS

Seismic Load Resisting System (SLRS)
Assembly of structural elements in the building that resists seismic loads, including struts, collectors, chords, diaphragms and trusses.

SPECIAL MOMENT FRAMES (SMF)
INTERMEDIATE MOMENT FRAMES (IMF)
ORDINARY MOMENT FRAMES (OMF)

SPECIAL CONCENTRICALLY BRACED FRAMES (SCBF)
ORDINARY CONCENTRICALLY BRACED FRAMES(OCBF)
ECCENTRICALLY BRACED FRAMES (EBF)
BUCKLING-RESTRAINED BRACED FRAMES (BRBF)

SPECIAL TRUSS MOMENT FRAMES (STMF)

SPECIAL PLATE SHEAR WALLS (SPSW)

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MOMENT FRAMES

Special Moment Frames (SMF) are expected to withstand significant inelastic deformations when subjected to the forces resulting from the motions of the *design earthquake*.

Intermediate Moment Frames (IMF) are expected to withstand limited inelastic deformations in their members and connections when subjected to the forces resulting from the motions of the *design earthquake*.

Welds
Unless otherwise designated, all complete joint- penetration groove welds of beam flanges, shear plates, and beam webs to columns shall be *demand critical welds*.

Protected Zones
The region at each end of the beam subject to inelastic straining shall be designated as a *protected zone*.

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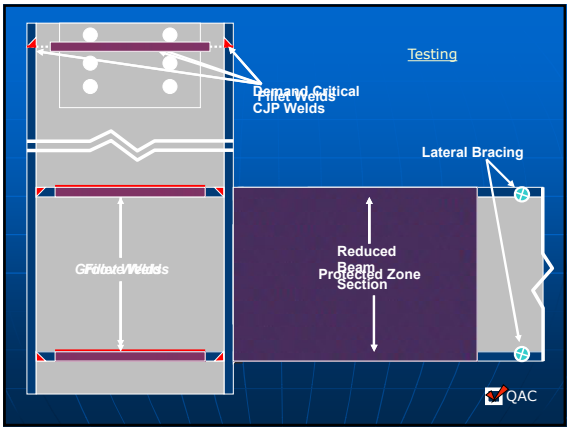

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MOMENT FRAMES
(Continued)

Ordinary Moment Frames (OMF) are expected to withstand minimal inelastic deformations in their members and connections when subjected to the forces resulting from the motions of the *design earthquake*.

Welds
Complete joint- penetration groove welds of beam flanges, shear plates, and beam webs to columns shall be *demand critical welds*.

Protected Zones
The region at each end of the beam subject to inelastic straining shall be designated as a *protected zone*.

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BRACED FRAMES

Eccentrically Braced Frames (EBFs) are expected to withstand significant inelastic deformations in the *links* when subjected to the forces resulting from the motions of the *design earthquake*. The diagonal braces, columns, and beam segments outside of the links shall be designed to remain essentially elastic under the maximum forces that can be generated by the fully yielded and strain hardened links.

Demand Critical Welds
Complete-joint-penetration groove welds attaching the *link* flanges and the link web to the column are *demand critical welds*.

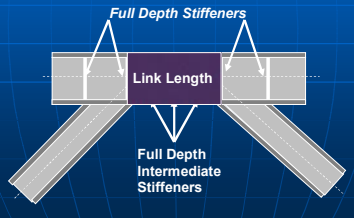
Protected Zone
Links in EBFs are a *protected zone*. Welding on links is permitted for attachment of link stiffeners.

QAC

47

BRACED FRAMES
(Continued)

Link. In EBF, the segment of a beam that is located between the ends of two diagonal braces or between the end of a diagonal brace and a column. The length of the *link* is defined as the clear distance between the ends of two diagonal braces or between the diagonal brace and the column face. *Link intermediate web stiffeners*. Vertical web stiffeners placed within the link in EBF.



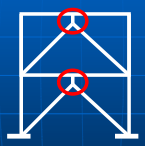
QAC

48

BRACED FRAMES

(CONTINUED)

Y-braced frame. *Eccentrically braced frame* (EBF) in which the stem of the Y is the *link* of the EBF system.



QAC

49

BRACED FRAMES

(CONTINUED)

Special Concentrically Braced Frames (SCBF) are expected to withstand significant inelastic deformations when subjected to the forces resulting from the motions of the *design earthquake*.

Protected Zone

The *protected zone* of bracing members in SCBF shall include the center one quarter of the brace length, and a zone adjacent to each connection equal to the brace depth in the plane of buckling. The protected zone of SCBF shall include elements that connect braces to beams and columns.

Ordinary Concentrically Braced Frames (OCBF) are expected to withstand limited inelastic deformations in their members and connections when subjected to the forces resulting from the motions of the *design earthquake*.

Protected Zone

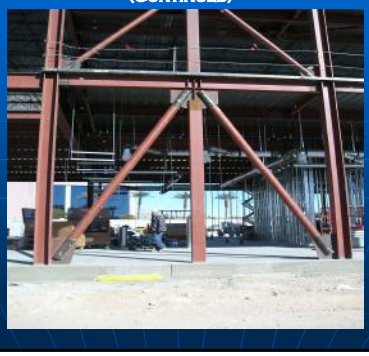
N/A

QAC

50

BRACED FRAMES

(CONTINUED)



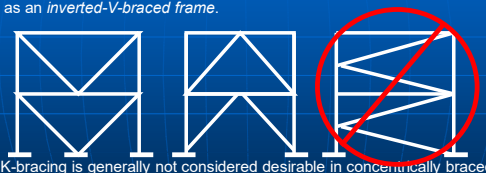
QAC

51

BRACED FRAMES

(CONTINUED)

V-braced frame. Concentrically braced frame (SCBF, OCBF or BRBF) in which a pair of diagonal braces located either above or below a beam is connected to a single point within the clear beam span . Where the diagonal braces are below the beam, the system is also referred to as an *inverted-V-braced frame*.



K-bracing is generally not considered desirable in concentrically braced frames and is prohibited entirely for SCBF because it is considered undesirable to have columns that are subjected to unbalanced lateral forces from the braces, as these forces may contribute to column failures.

QAC

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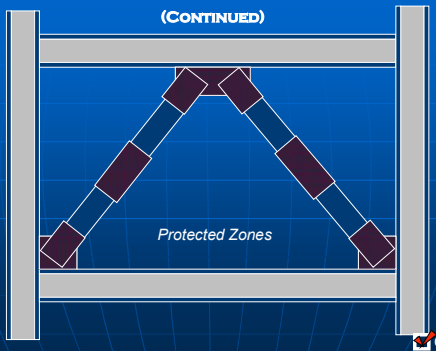
BRACED FRAMES

(CONTINUED)

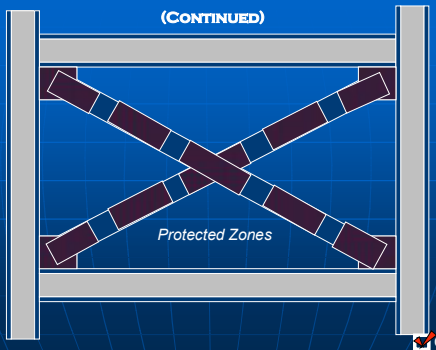


QAC

53

BRACED FRAMES

(CONTINUED)



QAC

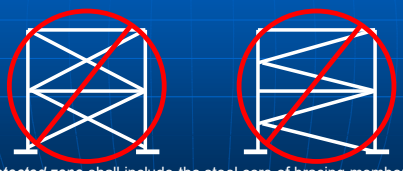
54

BRACED FRAMES

(CONTINUED)

Buckling-Restrained Braced Frames (BRBF) are expected to withstand significant inelastic deformations when subjected to the forces resulting from the motions of the *design earthquake*.

X-bracing and K-bracing are not options for a BRBF system.



The *protected zone* shall include the steel core of bracing members and elements that connect the steel core to beams and columns.

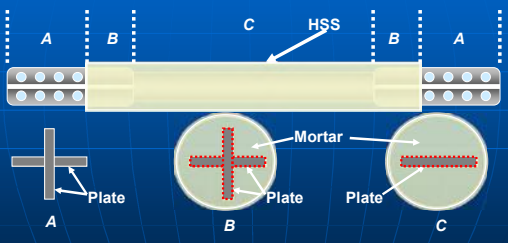
QAC

55

BRACED FRAMES

(CONTINUED)

Buckling-Restrained Braced Frames (BRBF)



QAC

56

BUCKLING-RESTRAINED BRACED FRAMES (BRBF)

QAC

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INSPECTIONS

INSPECTION POINTS AND FREQUENCIES

Inspection points and frequencies of quality control (QC) and quality assurance (QA) tasks and documentation for the *seismic load resisting system (SLRS)*

- The inspector shall observe these functions on a random, daily basis. Welding operations need not be delayed pending observations.
- These inspections shall be performed prior to the final acceptance of the item. Where a task is noted to be performed by both QC and QA, it shall be permitted to coordinate the inspection function between QC and QA so that the inspection functions need be performed by only one party.
- Where QA is to rely upon inspection functions performed by QC, the approval of the engineer of record and the *authority having jurisdiction* is required.

QAC

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INSPECTIONS

(CONTINUED)

- The inspector shall prepare reports indicating that the work has been performed in accordance with the contract documents. The report need not provide detailed measurements for joint fit-up, WPS settings.
- For shop fabrication, the report shall indicate the piece mark of the piece inspected.
- For field work, the report shall indicate the reference grid lines and floor or elevation inspected.
- Work not in compliance with the contract documents and whether the noncompliance has been satisfactorily repaired shall be noted in the inspection report.

QAC

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INSPECTIONS

(CONTINUED)

Visual Welding Inspection

Visual inspection of welding shall be the primary method used to confirm that the procedures, materials, and workmanship incorporated in construction are those that have been specified and approved for the project. As a minimum, tasks shall be as follows:

- Material identification (Type/Grade)
- Fit-up of Groove Welds (including joint geometry)
- Joint preparation
- Dimensions (alignment, root opening, root face, bevel)
- Cleanliness (condition of steel surfaces)
- Tacking (tack weld quality and location)
- Backing type and fit (if applicable)
- Configuration and finish of access holes
- Fit-up of Fillet Welds
- Dimensions (alignment, gaps at root)
- Cleanliness (condition of steel surfaces)
- Tacking (tack weld quality and location)

QAC

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Inspections
(Continued)

- WPS followed
- Settings on welding equipment/Travel speed
- Selected welding materials/Shielding gas type/flow rate
- Preheat applied/Interpass temperature maintained (min./max.)
- Proper position (F, V, H, OH)
- Intermix of filler metals avoided unless approved
- Use of qualified welders
- Control and handling of welding consumables
- Packaging
- Exposure control
- Environmental conditions
- Wind speed within limits
- Precipitation and temperature
- Welding techniques
- Interpass and final cleaning
- Each pass within profile limitations, meets quality requirements
- No welding over cracked tacks

QAC

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Inspections
(Continued)

Other Inspections

Where applicable, the following inspection tasks shall be performed:

- Reduced beam section (RBS) requirements, if applicable
- Contour and finish
- Dimensional tolerances
- Protected zone – no holes and unapproved attachments made by contractor

QAC

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Nondestructive Testing (NDT)
(Continued)

Nondestructive testing shall be performed by QA personnel.

- ***k-Area NDT***

  When welding of doubler plates, continuity plates, or stiffeners has been performed in the k-area.
  - The web shall be tested for cracks using magnetic particle testing (MT).
  - The MT inspection area shall include the k-area base metal within 3" of the weld.
- ***CJP Groove Weld NDT***

  Ultrasonic testing shall be performed on 100% of CJP groove welds in materials 5/16" thick or greater.
  - Ultrasonic testing in materials less than 5/16" thick is not required.
  - Magnetic particle testing shall be performed on 25% of all beam-to-column CJP groove welds.

Exception: For ordinary moment frames, ultrasonic and magnetic particle testing of complete joint penetration groove welds are only required for demand critical welds.

QAC

63

Nondestructive Testing (NDT)

(Continued)

► ***Base Metal NDT for Lamellar Tearing and Laminations***

After joint completion, base metal thicker than 1½", loaded in tension in the through thickness direction in tee and corner joints, where the connected material is greater than ¾", and contains CJP groove welds, shall be ultrasonically tested for discontinuities behind and adjacent to the fusion line of such welds.

- ❖ Any base metal discontinuities found within *t*/4 of the steel surface shall be accepted or rejected on the basis of criteria of AWS D1.1, where *t* is the thickness of the part subjected to the through thickness strain.

► ***Beam Cope and Access Hole NDT***

At welded splices and connections, thermally cut surfaces of beam copes and access holes shall be tested using magnetic particle testing or penetrant testing, when the flange thickness exceeds 1½", for rolled shapes, or when the web thickness exceeds 1½", for built-up shapes.

QAC

64

Nondestructive Testing (NDT)

(Continued)

► ***Reduced Beam Section Repair NDT***

Magnetic particle testing shall be performed on any weld and adjacent area of the *reduced beam section (RBS)* plastic hinge region that has been repaired by welding, or on the base metal of the RBS plastic hinge region if a sharp notch has been removed by grinding.

► ***Weld Tab Removal Sites***

Magnetic particle testing shall be performed on the end of welds from which the weld tabs have been removed, except for continuity plate weld tabs.

QAC

65

Nondestructive Testing (NDT)

(Continued)

► ***Reduction of Percentage of Ultrasonic Testing***

The amount of ultrasonic testing is permitted to be reduced if approved by the engineer of record and the *authority having jurisdiction.*

- ❖ The nondestructive testing rate for an individual welder or welding operator may be reduced to 25%, provided the reject rate is demonstrated to be 5% or less of the welds tested for the welder or welding operator.
- ❖ A sampling of at least 40 completed welds for a job shall be made for such reduction evaluation.
- ❖ Reject rate is the number of welds containing rejectable defects divided by the number of welds completed.

QAC

66

Nondestructive Testing (NDT)
(Continued)

- For evaluating the reject rate of continuous welds over 3' in length where the effective throat thickness is 1" or less, each 12" increment or fraction thereof shall be considered as one weld.
- For evaluating the reject rate on continuous welds over 3' in length, where the effective throat thickness is greater than 1" each 6" of length or fraction thereof, shall be considered one weld.

QAC

67

Nondestructive Testing (NDT)
(Continued)

► ***Reduction of Percentage of Magnetic Particle Testing***

The amount of MT on CJP groove welds is permitted to be reduced if approved by the engineer of record and the authority having jurisdiction.

- The MT rate for an individual welder or welding operator may be reduced to 10%, provided the reject rate is demonstrated to be 5% or less of the welds tested for the welder or welding operator.
- A sampling of at least 20 completed welds for a job shall be made for such reduction evaluation.
- Reject rate is the number of welds containing rejectable defects divided by the number of welds completed.
- This reduction is not permitted on welds in the *k*-area, at repair sites, weld tab and backing removal sites and access holes.

QAC

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Nondestructive Testing (NDT)
(Continued)

► ***Documentation***

All NDT performed shall be documented.

- For shop fabrication, the NDT report shall identify the tested weld by piece mark and location in the piece.
- For field work, the NDT report shall identify the tested weld by location in the structure, piece mark, and location in the piece.

QAC

69

ADITIONAL WELDING PROVSIONS

Gas-Shielded Welding Processes
GMAW and FCAW-G shall not be performed in winds exceeding 3 mph. Windscreens or other shelters may be used to shield the welding operation from excessive wind.

The AWS Structural Welding Code allows a maximum wind speed limit of 5 mph. The more conservative value of 3 mph has been imposed to ensure adequate CVN toughness in welds that are part of the SLRS. Wind speed is to be estimated in the immediate vicinity of the weld, where the shielding gas may be affected. Precise monitoring of wind speed is not intended. Three mile per hour winds (5 kph) will cause modest drifting of smoke or welding fume. Higher wind speeds can be felt on the face and as well as cause modest rippling of water surfaces.

Even before porosity is noted in visual inspection, notch toughness has been shown to decrease in gas-shielded welds. Self-shielded processes (SMAW, SAW, FCAW-S) are considerably more tolerant of air movement.

QAC

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ADITIONAL WELDING PROVSIONS

(CONTINUED)

Maximum Interpass Temperatures
Very high interpass temperatures cause very slow weld cooling rates that adversely affect weld and heat-affected zone (HAZ) mechanical properties, particularly notch toughness and strength, and therefore may need to be limited to ensure adequate performance. In contrast, minimum preheat and interpass temperatures are based on avoidance of cracking.

The 550 °F (300 °C) maximum temperature is a conservative value selected based upon the type of steels used in the SLRS. Higher interpass temperatures may be acceptable, and are permitted if the higher value is established by testing.

QAC

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ADITIONAL WELDING PROVSIONS

(CONTINUED)

Filler Metal Diffusible Hydrogen
All welding electrodes and electrode/flux combinations are expected to meet the diffusible hydrogen requirements that the filler metals used not exceed a hydrogen content of 16 ml/100 g of deposited weld metal.

- ❖The manufacturer's standard test for conformance with the H16 limit is adequate, provided the manufacturer's certificate of conformance contains the test results.
- ❖Solid electrodes for GMAW routinely deposit weld metal well within the limits of H16, and therefore testing is waived. GMAW with composite (metal-cored) electrodes require testing.
- ❖The applicable filler metal specifications for FCAW, and GMAW when performed with composite electrodes, do not require testing to determine diffusible hydrogen content. This testing is beyond that required by the filler metal specifications for these filler metals.

QAC

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ADITIONAL WELDING PROVSIONS

(CONTINUED)

Rather than test for diffusible hydrogen, SMAW electrodes with low hydrogen coatings are required by the applicable filler metal specifications to have the coating moisture content measured as part of the classification testing.
The results are expressed as a percent moisture content, on a weight (mass) basis.
Satisfactory conformance with these moisture content requirements is a suitable substitute for diffusible hydrogen testing, and such electrodes should be deemed to comply with the H16 requirement.

QAC

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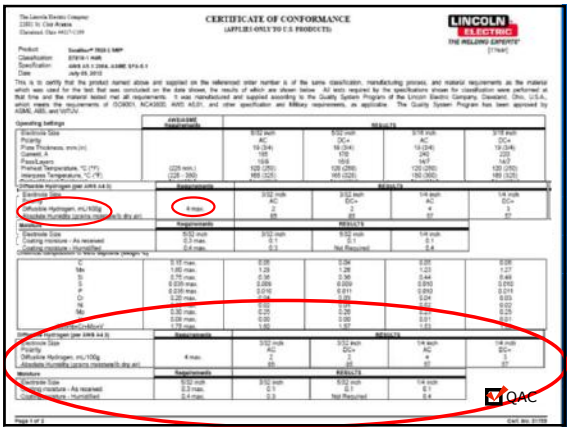

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ADITIONAL WELDING PROVSIONS

(CONTINUED)

Weld Tabs

Welds are sometimes specified for the full length of a connection. Weld tabs are used to permit the starts and stops of the weld passes to be placed outside the weld region itself, allowing for removal of the start and stop conditions and their associated discontinuities. Because the end of the weld, after tab removal, is an outside surface that needs to be notch-free, proper removal methods and subsequent finishing is necessary.

At continuity plates, the end of the continuity plate to column flange weld near the column flange tip permits the use of a full weld tab, and removal is generally efficient if properly detailed. At the opposite end of the continuity plate to column flange weld, near the column radius, weld tabs are not generally desirable and may not be practicable because of clip size and k-area concerns. Weld tabs at this location, if used, should not be removed because the removal process has the potential of causing more harm than good.

QAC

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ADITIONAL WELDING PROVSIONS

(CONTINUED)

Bottom Flange Welding Sequence

When using weld access holes to facilitate CJP groove welds of beam bottom flanges to column flanges or continuity plates, the groove weld shall be sequenced as follows:

- As far as is practicable, starts and stops shall not be placed directly under the beam web.
- Each layer shall be completed across the full width of the flange before beginning the next layer.
- For each layer, the weld starts and stops shall be on the opposite side of the beam web, as compared to the previous layer.

Staggering the weld starts and stops on opposite sides of the beam web, and completion of each weld layer prior to starting the next layer, avoids the problem of incomplete fusion and trapped slag under the beam web against the column face, provided proper weld cleaning is performed after each weld pass is deposited.

QAC

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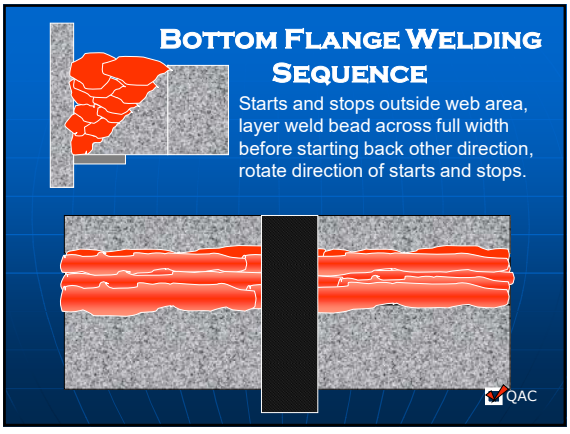

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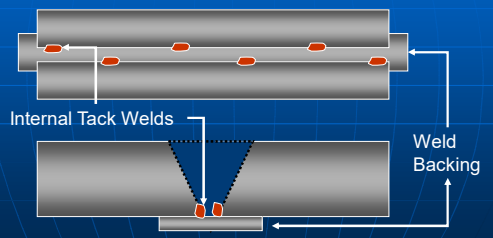
ADITIONAL WELDING PROVSIONS

(CONTINUED)

Tack Welds
Tack welds attaching backing bars and weld tabs shall be placed where they will be incorporated into a final weld.



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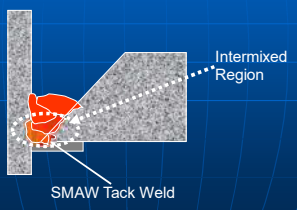
ADITIONAL WELDING PROVSIONS

(CONTINUED)

Intermixed Filler Metals When intermixing weld deposits made using self-shield flux-cored welding (FCAW-S) electrodes with weld deposits made using other welding processes, the weld where the intermix has occurred may exhibit degradation of notch toughness in the intermixed deposit.



QAC

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ADITIONAL WELDING PROVSIONS

(CONTINUED)

Testing is done to ensure the minimum notch toughness requirements of these provisions are met in this intermixed region.

- Testing of intermixed weld metal is only required when the FCAW-S process is used in combination with another welding process, which includes FCAW-G.
- It is not required when welding one FCAW-S electrode over another FCAW-S electrode.
- It is not required when welding processes other than FCAWS are used, regardless of combination.

QAC

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ADDITIONAL WELDING PROVISIONS (DEMAND CRITICAL WELDS)

Welding Processes
SMAW, GMAW (except short circuit transfer), FCAW and SAW may be used to fabricate and erect members governed by this specification.

The SMAW and FCAW processes have been successfully used for connection qualification testing in the SAC project and numerous other connection qualification tests.

In Japan, GMAW has also been used.

The SAW process, although not specifically used in seismic moment connection testing, has been included as an acceptable process for *demand critical welds* because the heat input levels may be similar to those of the other three processes and because appropriate mechanical properties can be achieved.

QAC

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ADDITIONAL WELDING PROVISIONS (DEMAND CRITICAL WELDS)

(CONTINUED)

Filler Metal Packaging
FCAW electrodes may contain a seam along the electrode length as a part of the manufacturing process. The seam may allow the flux core to absorb moisture when exposed to humid conditions during storage.

FCAW electrode packaging ranges from simple cardboard boxes and plastic bags, which provide little protection from moisture, to hermetically sealed foil bags that are moisture resistant. Some electrode lubricants may increase the level of diffusible hydrogen during welding, increasing the risk of hydrogen-assisted cracking.

Lubricants not associated with the original electrode manufacturer's product are not permitted.

QAC

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ADDITIONAL WELDING PROVISIONS (DEMAND CRITICAL WELDS)

(CONTINUED)

Exposure Limitations on FCAW Electrodes
The rate of moisture absorption is dependent on many factors, including the manufacturing process of the FCAW wire and the nature of the flux contained within the wire, and therefore these provisions are specific to the filler metal manufacturer's brand and type of electrode.

In the absence of specific manufacturer's recommendations, 72 hours is a conservative upper limit for electrode exposure. This limit is based upon tests on a variety of FCAW wires from various manufacturers.

When welding is suspended, one may store the electrode in protective packaging, where no additional accumulation of moisture is expected to occur. The type of protective packaging needed depends upon the conditions that the electrodes will be exposed to. The exposure time resumes when the filler metal is removed from the protective packaging and put back onto the welding machine.

QAC

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ADDITIONAL WELDING PROVISIONS (DEMAND CRITICAL WELDS)

(CONTINUED)

Commonly, SMAW low-hydrogen electrodes packaging is hermetically sealed metal boxes that prevent moisture penetration. If the container has been damaged or torn, the electrodes must be baked dry prior to use.

QAC

85

ADDITIONAL WELDING PROVISIONS (DEMAND CRITICAL WELDS)

(CONTINUED)

Tack Welds

By placing the tack welds within the joint, the potential for surface notches and hard heat-affected zones is minimized. The HAZ of the tack weld will be tempered by subsequent passes when placed within the joint.

Tack welds for beam flange to column welds are to be made in the weld groove. Steel backing may be tack welded to the column under the beam flange, where a reinforcing fillet weld will be placed.

Tack welds between steel backing and the underside of beam flanges are prohibited, as they create a notch effect in the beam flange. Any tack welds holding weld tabs, if made on the outside of the joint, are required to be removed.

QAC

86

END

Thank You

QAC

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