



Weld Inspections in Building Construction

SEAC/RMSCA Steel Liaison Committee

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Introduction

The specifications of weld inspection requirements for building construction projects are often not clear, and sometimes are neglected. Welding inspectors are sometimes faced with not understanding their scope of work and being unclear in tracking which weldments have been inspected. This has resulted in the Engineer of Record (EOR) sometimes being unsure whether the intended welded connections have been completed and inspected. The Committee found the following as we developed the paper:

- A. The Codes and Standards that are most often referenced in the Contract Documents, such as the International Building Code (IBC), AISC Code of Standard Practice (COSP), and AWS D1.1, each have their own set of Quality Control (QC) and Quality Assurance (QA) requirements, which are not always comparable in terminology and in describing the types and frequencies of weld inspections. The provisions in the IBC and AISC documents have experienced significant changes in recent editions, while the AWS requirements have remained largely unchanged.
- B. If the EOR refers only to IBC Chapter 17 in the Contract Documents as a specification for weld inspection requirements, the scope of the inspection work potentially will be largely undefined.
- C. The cost to provide inspection services is generally determined through bids being submitted to the Owner. Unclear scope of services can result in a large variation in the bids and selection for services based upon an incomplete scope of services and cost only without consideration for the appropriate qualifications and experience.
- D. If the extent and locations of the inspections are not carefully monitored, it will be a challenge at the end of a project for the testing agency to confirm that the required inspections have been performed.

The SEAC/RMSCA Steel Liaison Committee has prepared this paper in response to these issues with the following goals in mind:

- A. To provide suggestions to the EOR in order to more clearly specify and communicate the project weld inspection requirements.
- B. To clarify the weld inspection terminology for Owners, Engineers, GC/CMs, Architects, Fabricators, Erectors and Inspection Agencies and to clarify some of the misconceptions about welding inspection requirements.
- C. To summarize common weld inspection requirements, entity responsibilities and the weld inspection process so that the expected requirements of the EOR and local governing authority can be met.
- D. To identify typical communication breakdowns and provide suggestions for a more effective engagement of the inspection agency by providing better in order to improve access to information.
- E. To track the inspected work more effectively.



Although similar issues occur with the inspection of bolted steel connections, this paper is limited to the discussion of weld inspections with a focus on the practices within the Rocky Mountain region. This paper also has not addressed the special QA requirements for building weld inspections in high seismic regions required in AISC 341.

1.0 Governing Code and Document Requirements (At time of paper publication)

- A. 2018 IBC, Chapter 17, which defers to AISC and AWS for all weld inspection requirements
- B. AWS D1.1 2015, Chapter 6
- C. AISC Steel Construction Manual, 15th Edition
 - 1. AISC 360-16 Specification for Structural Steel Buildings, Chapter N and Commentary
 - 2. AISC 303-16 Code of Standard Practice, Section 8
- D. Structural Drawings and Specifications (Contract Documents)

2.0 Definitions

- A. **Quality Control (QC)** - Controls and inspections implemented by the Fabricator or Erector, as applicable, to ensure that the material provided, and work performed meet the requirements of the approved Contract Documents and referenced standards. QC is to be based on approved shop and erection drawings. AISC, the IBC by reference, requires that the Fabricators and Erectors provide QC inspection on all projects.
- B. **Quality Assurance (QA)** – Monitoring and inspection tasks performed by an agency or firm other than the Fabricator or Erector, when required by the Authority Having Jurisdiction (AHJ), Applicable Building Code (ABC) and/or the EOR, to ensure that the material provided and work performed by the Fabricator and Erector meet the requirements of the approved construction documents and referenced standards. Quality assurance includes those tasks designated “special inspection” by the applicable building code. AISC 360-16 Chapter N Section 5.2 requires that the work be checked against the Contract Documents, not the shop or erection drawings. Exceptions include deferred submittals and delegated connection design.
- C. **Continuous Inspection** - Special inspection by the Special Inspector who is present continuously when and where the work to be inspected is being performed (As defined by 2018 IBC Ch. 2 Definitions).
 - 1. This term was adopted by the 2009 and earlier versions of the IBC for use in the inspection of structural steel. The term is also still applicable to open web steel joists and joist girders (IBC 2018 table 1705.2.3) The term is not used in the quality concept defined by AISC 360-16 Chapter N.
- D. **Periodic Special Inspection** – Special inspection by the Special Inspector who is intermittently present where the work to be inspected has been or is being performed (As defined by 2018 IBC Ch. 2 Definitions).
 - 1. This term was adopted by the 2009 and earlier versions of the IBC for use in the inspection of structural steel. The term is also still applicable to open web steel joists and joist girders (IBC 2018 table 1705.2.3) The term is not used in the quality concept defined by AISC 360-16 Chapter N.



- E. **Observe and Perform** - Observe and Perform were new terms introduced in AISC 360-10 Chapter N5.4 and remain unchanged in AISC 360-16. These terms are to be used in conjunction with Tables N5.4-1 through N5.4-3.
 - 1. **Perform** - These tasks shall be performed for each welded joint
 - 2. **Observe** – The inspector shall observe these items on a random basis, based on a pre-determined frequency or percentage of a group of like welds.
 - a. Operations need not be delayed pending these inspections.
 - b. AISC uses language like “suitable intervals”, “random basis”, and “necessary to ensure” in their description of the Observe function.
- F. **Welding Procedure Specifications (WPS)** - A document indicating the required welding variables for a specific application to assure repeatability by properly trained welders and welding operators. All structural welds, including prequalified welds, require a WPS, and all welding procedures are required to be written. Welding procedures may either be prequalified, the most common case, or qualified by test.
- G. **Welding Procedure** - The detailed methods and practices involved in the production of a weldment.
- H. **AISC Certified Steel Fabricator or Erector** – A steel Fabricator or Erector that has implemented a quality control program approved by AISC for the processes necessary to fabricate or erect structural steel components and assemblies. This includes an initial evaluation and annual on-site audits of the company’s day-to-day operations that are compared to the documented procedures.
- I. **Special Inspection** – Inspection of construction requiring the expertise of an approved Special Inspector in order to ensure compliance with the governing building code and the approved Contract Documents.
- J. **Coordinated Inspection** - The allowance for specified QA tasks to rely upon QC functions when authorized by the EOR and AHJ.

3.0 Owner Role

- A. Responsibilities
 - 1. Retain the quality assurance agency (QAA) or hire the EOR to either retain or self-perform the quality assurance (QA). Agreement with QAA must be based on the specified QA tasks.
- B. Current Practice & Problems
 - 1. The QA Inspector is generally retained by the Owner.
 - 2. The cost to provide inspection services is generally determined through bids being submitted to the Owner.
 - 3. Owners tend not to be engaged in understanding the importance and role of the Inspector. The Inspector works for the Owner, but rarely speaks with his client. Generally, conversations and directives for work on site occur with the Contractor.



4. Unclear scope of services can result in a large variation in the bids and an uninformed a selection for services based upon an incomplete scope of services and cost only without consideration for the appropriate qualifications and experience.

C. Expectations of the project team

1. The Owner will hire the QAA.
2. The QAA will be selected based on the specified QA weld inspection requirements.

4.0 Engineer of Record (EOR) Role

A. Responsibilities

1. The EOR's focus is to specify QA provisions that ensure compliance with the Contract Documents.
2. Prepare a Statement of Special Inspections (SSI). The SSI may be placed in the Contract Documents (plans, specifications, general notes, details, weld symbols), or it may be a separate document.
3. When determining the QA requirements, the EOR may consider the Fabricator's and Erector's QC programs and the complexity of the work. If it is determined that the steel Fabricator or Erector have strong QC programs, the EOR and AHJ may waive (portions of the) QA. This can be accomplished by a QAI (Quality Assurance Inspection) review of QC program and QCI documentation.
4. The minimum QA (Special Inspection) requirements are indicated in AISC Chapter N. However, to ensure that the requirements are understood, the EOR should determine and specify the overall QA scope. The EOR specification should require:
 - a. Identification of the work (welds) that requires QA. Consideration should be given to deferred submittals unless QA is not required.
 - b. Identification of the types and extents of inspections and tests including the randomness and frequency of "Observe" and "Perform" tasks. The 2018 IBC defers to AISC 360 for all specific QA requirements for structural steel. The appropriate non-destructive testing (NDT) requirements, including locations, types, and frequencies of testing, should be identified.
 - c. That the CM/GC furnish Contract Documents to the inspector or indicate the responsible party for this task.
 - d. Require that EOR be copied with all QAI reports.
5. Require the submittal of the project-appropriate documents identified in N3.2.
6. In some cases, either employ the QA agency (QAA) or act as the QAA by self-performing QA inspections.
7. Review inspection and testing reports, and take appropriate actions when deficiencies are identified.



B. Current Practice & Problems

1. EOR's rarely review Fabricator's and Erector's QC programs. Consequently, QA requirements are not streamlined to take advantage of AISC certified contractors.
2. EOR typically relies upon others to furnish Contract Documents to the QAA. It is common for the QAA to not have current or complete documents when the inspections are performed.
3. Conflicts are minimized when the Contract Documents provide the correct welding symbols, the correct locations of welding requirements and the appropriate use of welds and when the inspector follows AWS.
4. Types of welds in EOR drawings are sometimes incorrectly specified or difficult to fully achieve. Common examples are depth of flare bevel welds, butt joint weld requirements (PJP or CJP), or CJP welds at HSS.

C. Expectations of the project team

1. The QA weld inspection requirements will be clearly defined and, when the Fabricator and/or Erector are on board early enough, their QC programs have been reviewed by the EOR to accommodate a streamlined QA program.
2. Welding symbols should be correct. The details should be constructible and accessible.
3. Steel Fabricator and Erector concerns have been raised concerning incorrect welding symbols in the EOR drawings.

5.0 CM/GC Role

A. Responsibilities

1. Provide safe accessibility to the work until completion of required QA tasks. This requires the CM/GC to successfully coordinate their work and the QAA. The CM/GC may delegate coordination to the Fabricator and/or Erector.

B. Current Practice & Problems

1. Coordination of the QA process defaults to the General Contractor but generally not by assignment. This undefined role can result in concerns regarding the completeness of the QA inspection process.
2. Hand written reports when the Inspector leaves the site are desirable. These reports should be left with the GC, not the subcontractor.
3. The CM/GC generally coordinates the timing of the inspections based upon the need to maintain progress in the project and in discussions with the steel Erector.



C. Expectations of the project team

1. Have a QC program in place.
2. To keep the Fabricator, Erector, inspector up to date with current Contract Documents.
3. To submit weld qualification submittals in a timely manner.
4. Coordinate QAI for field inspection and provide adequate notice to the inspector.
5. Monitor welds that need to be inspected and what has been inspected.
6. The CM/GC should keep a record of what has been inspected.

6.0 Steel Fabricator Role

A. Responsibilities

1. To provide a structural steel package representative of the design intent based upon the approved Contract Documents using qualified detailers.
2. QC
 - a. Establish and maintain fabrication QC procedures.
 - b. Perform inspections of all welds and welding tasks in accordance with QC procedures, Tables N5.4-1 through N5.4-3, and AWS D1.1.
 - c. Ensure that the qualifications of their inspectors comply with the QC program.
 - d. Maintain a tracking system so that a welder can be associated with each weld.
3. QA
 - a. Make the QC program available to the EOR and the QAA.
 - b. Be familiar with the QA requirements for the project.
 - c. Coordinate the inspection schedule with the QAA.
 - d. Provide safe access for QAA to perform their work.
 - e. Follow up on corrections of discrepancies and coordinate re-inspections.

B. Current Practice & Problems

1. From bidding through construction, the Fabricator is often uncertain that he has the most recent approved Contract Documents including all changes issued via RFIs, etc. and if the CM/GC, Architect and EOR understand his scope of work and exclusions.
2. Fast track projects generally result in incomplete Contract Documents with conflicting information found between the plans, general notes, and specifications. The Fabricator's scope letter is important in that it helps to convey the basis of the structural steel bid.
3. During the shop drawing preparation and approval process, a Request for Information (RFI) is issued to clarify areas that are unclear or require more information. The RFI responses sometimes result in an Addendum, Architectural Supplemental Instruction (ASI) or Construction Change Directive (CCD).
4. Welded connections sometimes are questioned by the inspector either when his/her interpretation is not consistent with AWS or when the indicated welding symbols are not correct.



C. Expectations of the project team

1. The inspections are based upon the approved shop and erection drawings used for construction which have accounted for all project changes and clarifications.
2. The extent and type of weld inspections have been clearly defined and coordinated between the Fabricator, CM/GC and Erector.
3. Noncompliance issues are discussed and resolved in a timely manner between the CM/GC, Fabricator and Erector.
4. The Fabricator will produce welds that comply with the project requirements and Contract Documents.
5. The EOR will be notified of deviations for evaluation.

7.0 Steel Erector Role

A. Responsibilities

1. QC
 - a. Establish and maintain QC procedures.
 - b. Perform inspections of all welds and welding tasks in accordance with QC procedures, Tables N5.4-1 through N5.4-3, and AWS D1.1.
 - c. Ensure that the qualifications of their inspectors comply with the QC program.
 - d. Maintain a tracking system so that a welder can be associated with each weld.
2. QA
 - a. Make the QC program available to the EOR and QAA.
 - b. Be familiar with the QA requirements for the project.
 - c. Coordinate the inspection schedule with the QAA (when CM/GC defers to the Erector).
 - d. Follow up on corrections of discrepancies and coordinate re-inspections (when CM/GC defers to the Erector).

B. Current Practice & Problems

1. Random inspection frequencies of observed tasks sometimes occur at the CM/GCs construction sequence and may not result in the intended systematic sampling of the work.
2. The Erector may not understand the Inspector's scope of work.
3. The Erector sometimes is not invited to the pre-construction meeting.
4. There is not an established protocol to resolve disagreements between the Erector and the Inspector.

C. Expectations of the project team

1. The Erector will produce welds that comply with the project requirements, weld procedures, and Contract Documents and that the EOR will be notified of discrepancies for evaluation.
2. The Erector will provide a qualified person to walk the project with the inspector.
3. The Erector will keep a record of what has been inspected.



4. The Erector will have an assigned QC person in accordance with AISC 360, Chapter N.
5. Erector will attend pre-construction meetings to understand the project requirements.

8.0 Quality Assurance Inspection Agency Role

A. Responsibilities (Applicable to shop and/or field conditions)

1. Understand the type, extent, location, and frequency of QA inspections, including NDT.
2. Review material test reports and certifications listed in AISC Chapter N3.2
3. Inspection tasks before welding
 - a. Review drawings and specifications (Contract Documents)
 - b. Review WPSs
 - c. Review material and filler metal certifications and identifications
 - d. Check for base metal discontinuities
 - e. Check weld surface preparations, dimensions, fit-up, alignment, tack welding, and backing
4. Inspection tasks during welding
 - a. Review welder qualifications
 - b. Check for proper control and handling of consumable materials
 - c. Check environmental conditions
 - d. Verify WPSs are followed
 - e. Verify welding techniques
5. Inspection tasks after welding
 - a. Inspect weld cleaning
 - b. Inspect weld size, length, location. Confirm required welds have been made, and report unauthorized welds
 - c. Check weld quality based on AWS D1.1 visual acceptance criteria
 - d. Inspect repair activities
 - e. Document acceptance or rejection of work
6. Non-destructive testing
 - a. Perform NDT (UT, MT, PT, RT) when specified in the contract documents.
7. Maintain records of inspections. Furnish reports indicating that work either was or was not completed in conformance to the Contract Documents. Bring discrepancies to CM/GCs immediate attention. Furnish final report documenting the required inspections and corrections of discrepancies.
8. Verify that the Fabricator maintains detailed fabrication and QC procedures.
9. Maintain a method of tracking inspection locations, results, and re-inspections.

B. Current Practice & Problems

1. The Inspector often is unable to state that all specified items targeted for inspection were actually inspected. This occurs when effective tracking records have not been implemented.
2. The inspector generally has not reviewed Contract Documents prior to the initial site visit.
3. QAIs are often selected based on bidding from an inadequately defined scope of work.



4. Since the welding certifications are usually not made available to the Inspector before the initial inspection, much of the time spent during the first inspection is generally allotted to review of the paperwork.
5. Welding inspectors are not always consistent in their interpretation of the AWS requirements. Some areas where disagreements occur:
 - a. Inspection of "Seal Welds." AISC 15th Edition, p. 8-53
 - b. Flare Bevel Welds, p. 8-62, Notes e, g, j, and i.
 - c. A difference between the specified weld size and the Inspector requiring the space to be filled.
 - d. A difference between the effective weld size for flare bevel groove welds for SMAW in AWS D1.1 (5r/16) and AISC (5T/8).
 - e. Skewed fillet welds
 - f. Butt, square-groove welds
 - g. Grinding the weld smooth
6. Inspectors may not be afforded the time to perform all required inspections.
7. When project changes occur, the Inspector must depend on the CM/GC to provide the approved documents.

C. Expectations

1. The QAA will provide consistency in inspections, even when different personnel are utilized.
2. The QAA will be familiar with the Contract Documents and the inspection requirements.
3. The QAA will mark passed/ not passed work.
4. The QAA will monitor the status of the inspections, keeping track of what has been inspected and what needs to be inspected.
5. The QAA will interpret the documents in accordance with the approved standards, will only report discrepancies, and will not direct changes.
6. The QAA will re-inspect all discrepancies.
7. All reports will be timely and will be sent to the Owner, Architect, EOR, Fabricator, Erector and CM/GC.
8. The QAA will report completion of inspections in accordance with IBC 1704.2.4 stating that all required QA inspections were performed, and that the welding work complied with the requirements of the Contract Documents.

9.0 Opportunities for Improvement

- A. The EOR Special Inspection requirements for welding should be specific, not general such as, "Inspect according to Chapter 17" or "Inspect according to AWS." The documents should include:
 1. The types of welded connections that are to be inspected
 2. The acceptable NDT testing methods that can be implemented
 3. The parameters for coordinated inspection, such as consideration for an AISC Certified Program.
 4. The randomness and frequency of "observe" inspection tasks
 5. Assignment of the party responsible to provide the QAA with current Contract



- Documents including relevant RFIs
6. Assignment of the party responsible to track both the inspections to be completed and the results of the completed inspections
- B. Steel erection pre-con meetings are very important, especially for complex projects. Those in attendance should be the CM/GC, EOR, steel Fabricator, steel Erector and testing agency, preferably the inspector providing the QAA services. This meeting will help establish good communication between the CM/GC, EOR, Fabricator, Erector and inspector including a clear understanding of inspection timing and scope of work.
- C. Fabricator/Erector QC programs are not fully leveraged in today's practice. Potential savings can be realized where overlaps in inspections occur.

10.0 References

Organizations

American Institute of Steel Construction
(AISC) American Society of Civil Engineers
(ASCE) American Welding Society (AWS)
International Building Code
(IBC) Steel Deck Institute (SDI)
Steel Joist Institute (SJI)

Reference Materials

AISC 303-16 Code of Standard Practice (COSP)
AISC 360-16 Specification for Structural Steel Buildings, Chapter N
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