

## Quality Assurance Procedure QAP 5900

### Structural Steel Quality Assurance Program – Bridges

#### 1. SCOPE

1.1 Quality Assurance Procedure (QAP) 5900 is used by the Colorado Department of Transportation's Quality Assurance (QA) Fabrication Inspection Unit in the Staff Bridge Branch, which serves as the procedural guide for CDOT steel bridge QA evaluations. Specific and precedent conditions may vary between projects. They are addressed by special provisions.

1.2 The purpose of this procedure is the establishment of consistent and uniform inspection and testing procedures to ensure fabricated structural steel bridge elements meet the specified quality requirements. Specific protocol for the execution of personnel duties and decisions is defined by the authority of the CDOT Staff Bridge Engineer (AASHTO/AWS D1.5M/D1.5 Current Edition, 6.1.1.2, 6.1.2.2).

1.3 Quality Assurance Inspection and Testing is performed as a systematic action to ensure the Contractors (Fabricators) Quality Control (QC) process meets the specified quality requirements. The Quality Assurance Program consists of this specified procedure, QAP 5900, and all Quality Assurance Procedures (QAP's) listed in the CDOT Fabrication Inspection Manual. Inspections, nondestructive tests, minimum inspection and testing frequencies, personnel position responsibilities (AASHTO/AWS D1.5M/D1.5, Current Edition 6.1.1.2, 6.1.2.2), communications, and documentation requirements are defined in this Procedure.

CDOT Quality Assurance Inspections, Tests, and Audits effectively: (1) establish confidence in the adequacy of the Contractors Quality Control Program, and (2) provide sound structures through evaluations based on identified quality attributes. Salient attributes are selected based on probable process defects. The attributes have

been selected to mitigate fatigue sensitive defects, particularly incipient fracture and embrittlement (AASHTO/ AWS D1.5M/D1.5 Current Edition Foreword).

#### 2. REFERENCE

##### Specification Documents

2.1 Referenced specification documents are the latest edition as revised or updated by approved supplements or interim editions published prior to the bid advertisement.

2.2 The specification and plan precedence, in accordance with Subsections 105.09 and 509.02 of the Standard Specifications for Road and Bridge Construction, is:

Project Special Provisions  
Standard Special Provisions  
Plans  
Supplemental Specifications  
Standard Specifications  
AASHTO/ AWS D1.5M/D1.5 Current Edition  
AWS D1.1/D1.1M Current Edition

##### CDOT Documents:

2.3.1 CDOT Quality Assurance Program documents are:

Quality Assurance Procedures (QAP's) listed in the CDOT Steel Fabrication Inspection Manual

##### Fabricator Documents:

2.3.2 Applicable Fabricator Quality Control documents to be reviewed prior to fabrication are:  
(1) Fabrication Plant Quality Control Manual, (2)

Approved Written Practice in accordance with ASNT SNT-TC-1A, (3) Inspector and Nondestructive Testing Personnel Qualification Records, (4) Welding Procedure Specifications, (5) Procedure Qualification Records, and (6) Welder Qualification Records.

### **3. PERSONNEL, QUALIFICATIONS, RESPONSIBILITIES, AND COMMUNICATIONS**

3.1 The Staff Bridge Engineer, or his designee, acts as the liaison between the Design Engineer of Record, CDOT Project and Resident Engineers, and the QA Inspector. All issues affecting the design are resolved at this position.

3.2 The CDOT Resident Engineer and his Project Engineer are the positions responsible for Contract Modification Orders, schedule delays, and Contractor claims. All fabrication issues that affect field construction administration are reported to the Staff Bridge Fabrication Engineer as well as these positions.

3.3 The Designer is the person responsible for clarification and resolution of design issues. The Staff Bridge Engineer, or his designee, is the primary liaison between the QA Inspector and the Structure Designer.

3.4 The Bridge Fabrication Engineer is the manager of the QA Unit and is responsible for the nondestructive evaluation procedures (QAP's), welding issues, and resolution of fabrication quality issues, other than those affecting design discrepancies and construction project administration issues.

3.5 The Steel Fabrication QA Inspector should be a Certified Welding Inspector (CWI) as specified in (AASHTO/AWS D1.5M/D1.5 Current Edition, Section 6.1.3.1

1, 2). Nondestructive testing personnel should be qualified and certified as ASNT Level II (SNT-TC-1A). Fabrication acceptance is determined by the inspector's evaluation of the Quality Control operations and product conformance verification. All non-conformances discovered should be communicated to the Bridge Fabrication Engineer and the Plant QC Manager and documented on CDOT Report QAP 5900(b).

<u>D1.5 Sect.</u>	<u>Fabrication Issue</u>
1.1.2	Production welds other than shown in plans.
1.2.2	Base metals other than listed in Code.
1.3.6	Short circuit Gas Metal Arc Welding process.
1.3.7	*Ancillary items determined by the Engineer.
1.9	Procedure Qualification Records and Welding Procedure Specifications approved.
2.7.1	Joint details used other than those prequalified, 2.9

<u>D1.5 Sect.</u>	<u>Fabrication Issue</u>	<u>D1.5 Sect.</u>	<u>Fabrication Issue</u>
3.1.5	* All welds on shop drawings		Table 4.1, Fifth Note test result variances
3.2.2.1	Repairs other than 10011 00W base metals.		Table 4.2, Second Note welding consumables
3.2.2.2	Repairs to 100/ 100W base metals.		Table 4.2, 4 <sup>th</sup> Note test result variances
3.2.3.6	Y Type discontinuities beyond limits as described in Code.		
3.2.3.7	W,X,Z discontinuities (3 individual cases).	4.2.1.1	Preheat/ Interpass temperatures lower than listed in Table 4.3.
3.3.1.2	Use of filler plates.		
3.2.8	Corrections to cambers in Q&T steels.	4.6.8	Vertical down weld progression.
3.3.4	Joint tolerances beyond limits in Code.	4.7.5	~Joint penetration verified by radiography.
3.3.4.2	Corrections to excessive root openings.	4.10.4	Preheat/ Interpass temperatures other than listed in 4.2.
3.3.7.3	Excessive base metal removed while extricating tack welds.	4.10.4.1	Discontinuing hardness tests on Heat Affected Zones (4.10.4).
3.4.3	*Fabricator's Distortion Control Program.	4.10.4	Multiple parallel Submerged Arc Welding preheat/interpass temperatures.
3.5.1.13	*Dimensional tolerances not addressed in the Code.	4.10.4.1	Parallel Submerged Arc Welding similar to 4.10.4.
3.6.	Reinforcement left on a faying surface on the edge.		
3.7.4	Repairs to base metals-other than listed in 3.2, delayed cracks, ESW & ESG welds.	4.12	Gas certifications.
3.7.5	*Correction to misfit parts.	4.13.1.7	Flux Cored Arc Welding progressing down.
3.7.6	*Design revisions for inaccessible deficiencies incorporated.	4.13.4	Short Circuit Gas Metal Arc Welding.
3.7.7.1	*~UT/RT to repaired holes.	4.16	ESG gas approval.
3.7.7.2(1)	Base metal subject to dynamic tensile stress: weld and WPS.	4.22.9	ESW/EGW restart positions.
3.7.7.2(2)	~NDT of (1) above.	4.28.2	Correction to calibrated meters.
3.8.1	Peening.	5.2.4	Ordering additional WPS's and PQR's.
3.13.3	Removal of backing that is parallel to stress.	5.4.3	Order weldability tests.
3.13.3.1	Removal of backing in T joints or columns.	5.5	Nonlisted welding consumables.
3.13.6	Backing materials other than listed in Code.	5.5.2	Use of active fluxes WPS's.
4.1.7	Consumables for ESW & EGW: Table 4.2, Second Note welding consumables	Fig.5.2	Testing agency approval.
		Fig.5.3	Testing agency approval.
		5.9.1	Additional macroetches for Partial Penetration welds.
		5.15	Tests other than listed approved:

D1.5 Sect.	<u>Fabrication Issue</u> Table 5.4 Travel speed variances for variable root gap openings Table 5.7 Additional macroetch tests	D1.5 Sect.	<u>Fabrication Issue</u> 5.4.3.2 Unlisted base metal WPS. 5.4.3.3 HAZ, CVN test results on unlisted base metals.
6.1.1.2	~Perform inspection and testing sufficient to verify acceptance.	3.2.2	Freehand thermal cutting.
6.1.2.2	Delegation of authority to inspector.	3.3.8	Temporary welds.
6.1.3.1	Inspector, acceptance to Engineer.	12.3.1	* Evaluate every design for FCM's.
6.1.3.5	~Verify Inspectors and NDT personnel.	12.3.1	* Ensure contract documents contain all information necessary to order materials and properly construct FCM's.
6.4.1	Acceptable supervision of welders.	12.3.2	* All FCM's are identified.
6.5.4	~ Acceptance criteria other than listed in the Code.	12.3.2	* Each FCM individually designated.
6.6.4	Acceptance decision on method to repair base metals.	12.3.2	* Units of members subject to bending stresses.
6.7.6.5	~NDT-MT report to Engineer.	12.3.3.1	* Review all shop drawings to verify all FCM's are identified by the fabricator.
6.9.2	~NDT procedure variances.	12.3.3.1	Review material lists.
6.10.3.1	Removal of run-off tabs prior to radiography.	12.3.3.1	Review all WPS's and repair procedures.
6.10.6	~Use of radiographic sources other than listed in the Code.	12.3.3.1	Show disposition on each drawing and procedure with stamp, signature, date.
Fig.6.1.A	~ IQI placement (& see Figs .6.1.B,, 6.1.C)	12.3.3.2	Approval required prior to the start of fabrication.
6.12.2	~Engineer accepts RT's.	12.4.1	Unlisted base metals.
6.12.3	~Engineer accepts RT's.	12.4.4.1	Specify low sulfur for Z tensile stressed areas.
6.13.2	~UT methodology, variances.	12.4.4.2	Normalized plate usage.
6.13.4	~Acceptance of UT tests.	12.4.5.1	CVN's if higher than 12.4.5.
6.20.2	~Acceptance of UT results.	12.5.2	GMAW on FCM's must be approved.
6.20.3	~Reports to the Engineer.	12.5.3	Designation of specific weld processes, special provisions.
7.2.6	Stud base qualifications.	12.6.1	Heat/ Lot consumable tests.
7.2.7	Weld 100/100W approval.	12.6.6.5	Extended consumable exposure.
7.3.1.1	Mechanical properties other than Code specified.	12.7.5	Acceptance of previous qualifications.
7.3.3.1	Certifications.	12.8	Evaluate acceptability of fabricator's Quality Certification Program.
7.3.4	Number of tests.	12.8.2	WPQ time limits.
7.3.5	Select samples to be tested.		
7.4.5	Clear distance between studs less than one inch.		
7.8.6	Judge adequacy of stud welds.		
5.4.3.1	Adequacy of unlisted base metals.		

D1.5 Sect.	<u>Fabrication Issue</u>
12.11.2	*Relocation of butt welds.
12.11.4	*Approve base metal replacement.
12.11.4	*Replacement length.
12.13.1.1	Tack welds outside joint.
12.13.2	Temporary welds.
12.15	PWHT to preclude cracking.
12.15.2.3	Acceptance of previous PQR-PWHT.
12.16.1	~An inspection program.
12.16.1.2	~Acceptance of equivalent NDT qualifications.
12.17.1.1	Repair procedures prior to welding FCM.
12.17.4	All critical repairs.
12.17.6	~MT and other NDT ordered to assure defect removal.
12.17.6	Order PWHT to critical repair.
12.17.6	Repaired FCM surfaces Appendix V12 stud testing agency.

#### 4. PLAN AND SPECIFICATION REVIEW

4.1 Plan and Code issues that affect welding and fabrication, stress category identification, nondestructive evaluation and acceptance criteria, base metal, and consumable requirements should be resolved by the Inspector and QA Inspection Unit Manager.

4.1.2 Issues arising during review should be resolved as follows:

4.1.2.1 Issues affecting design strength shall be communicated to the Staff Bridge Engineer, or his designee, for resolution. Resolution shall be documented in the Project Daily Log, CDOT Report QAP 5900(a).

4.1.2.2 Issues affecting the cost of the work or which may impact the project schedule shall be communicated in writing to the Resident and Project Engineers.

#### 5. INSPECTION PRIORITIZATION

5.1 Inspection priority, in order of precedence, shall be:

5.1.1 Fracture Critical Members.

5.1.2 Through thickness tension members.

5.1.3. Identified fatigue sensitive details for I, box girders, or plate, rolled beam, and plate structures by category in order: E, main member weld termini and stop-starts, D, F, C, B, A.

5.1.4. Identified fatigue sensitive details for tubular structures by category in order: K2, ET, K1, main member weld termini and stop-starts, E, FT, D, C2 and X2, F, C1, and X1, B, A.

#### 6. SHOP DRAWING REVIEW

6.1 Review plans and shop drawings. Deviations from the plans and specifications shall be resolved by the Inspector and the QA Inspection Unit Manager. Exceptions to plans and reviewed shop drawings or issues affecting design strength shall be discussed with the Staff Bridge Engineer, or his designee, to determine resolution. Weldment details that can not be performed or promote defect inclusion shall be noted and resolved. Written resolution shall be recorded on the Project Daily Log, CDOT Report 5900(a) and maintained with the project records.

6.2 Welding Procedure Specifications (WPS), Procedure Qualification Records (PQR), and Welder Qualification Records (WQR) shall be reviewed as part of the shop drawings prior to the prefabrication meeting and/or fabrication. All Welding Procedure Specifications shall be supported by qualification tests and documented on Procedure Qualification Records. All variables shall be verified to conform within the qualified

range. Essential variables of the qualified welding specification are defined in the AWS D1.5, Bridge Welding Code, and shall be listed on the Welding Procedure Specification. Review the WPS using the WPS Appendix Checklists to determine acceptance. All essential and non-essential variables shall be listed by the fabricator in the WPS as indicated in Appendix E of AWS D1.5. Any changes in variables made by the fabricator shall require a new written procedure specification and possibly requalification, if the variable is a Code listed essential variable and is outside of the qualified range of the existing WPS.

6.3 PQR welding and test procedures shall be witnessed by the CDOT inspector or CDOT designated representative. A State representative witness signature is required on all PQR Test reports.

## **7. PREFABRICATION MEETING**

7.1 A prefabrication meeting will be scheduled for: (1) new fabricators, (2) when the complexity of a project requires clarification, or (3) fabrication details warrant special consideration. The QA Inspector assigned the primary responsibility for the project and the QA Unit Manager will attend the prefabrication meeting. CDOT Project Daily Diary, Report QAP 5900(a) shall be kept of all correspondence.

7.2 Inspect the facilities and all intervals of fabrication, including material handling processes prior to the prefabrication meeting. Verify general weld quality acceptance; note any contract deviant weld processes and fabrication techniques (from the WPS or other Code requirements). Review shop crane capacities, methods of clamping and chaining materials, method of moving, loading and transporting members to ensure preclusion of overstressing and distortion. List reported issues and resolutions on CDOT Project Daily Log, Report QAP 5900(a), and if applicable, the WPS/PQR.

7.3 All deficiencies or concerns discovered during inspection shall be addressed with the Fabricator at the prefabrication meeting. All Fabricator questions or concerns regarding specification requirements or fabrication details will be addressed during the meeting, or as soon as disposition can be determined. Issues affecting design changes shall be noted and communicated to the Staff Bridge Engineer, or his designee, for resolution. Resolution shall be in writing from the Staff Bridge Engineer and /or recorded on the Project Daily Log, CDOT Report QAP 5900(a).

7.4 Fabricator administration, inspection, and nondestructive testing qualifications shall be submitted by the fabricator and reviewed for contract compliance. The AISC Certification, Quality Control Program - including the Written Practice, attendant Nondestructive Testing and Inspection Certifications, and Organizational Chart shall be submitted to the CDOT QA Inspection Unit Manager for review, disposition, and acceptance or amendment. This disposition shall be determined prior to fabrication, and preferably, when applicable, prior to the prefabrication meeting.

## **8. SHOP SAFETY**

8.1 The QA Inspector shall review the fabricators Safety Manual and comply with all Fabricator and CDOT safety policies.

## **9. APPARATUS**

9.1 *Quality Assurance Inspection Equipment-Tools* used to determine acceptance must be used correctly to perform accurate appraisals. The applicable QAP shall be referenced for the respective evaluation.

## **10. MATERIALS AUDIT**

10.1 Material Identification - Audit Certified Mill Test Reports (CMTR) for Consumables, Coating, and Fasteners. Inspect and record main member

heat numbers. Verify that heat numbers on main members incorporated into the structure have appropriate grade mill test reports and statements of domesticity. When material cannot be confidently identified, chemical and physical tests, including CVN shall be performed by the Fabricator prior to incorporation into the bridge. Sampling shall comply with the AASHTO M 160 requirements. Discrepancies must be clarified by the mill to the extent the QA Inspector is confident the material is properly identified. If material identity is questionable, mechanical and chemical tests will be required prior to incorporation of the material into the structure. Include the heat numbers from all major items. Verify that the specific steel grades specified on the plans have been used and are in the proper location. Verify heat numbers on all material incorporated into the structure. QC shall retain heat number traceability on any material previously cut, stored, and later incorporated into the structure. Rolling direction shall be indicated on all main members.

Material designation, grade, type, chemical, and physical properties shall meet the requirements of the contract specifications.

Verification shall be performed at the following frequency:

- 100% Fracture Critical Members and consumables.
- 100% Shop Installed Rotational Capacity Fastener Lots.
- 30% Redundant Main Members and consumables, unless the Main Members are Hybrid, i.e. the webs and flanges are a different grade of steel, then:
  - 100% Hybrid main member web and flanges.
  - 5% Secondary members.
- 100% Field Installed Rotational Capacity Fastener Lots.
- 25% Paint.

The QA Inspection Unit Manager will review CMTRs for chemical and physical property

conformance at this same frequency.

10.2 All deviations shall be noted on the fabricators submitted cut list and the respective CMTR. Ancillary steel shall be listed on CDOT Report QAP 5900(g). Note any deficiencies. Deficiencies impacting the design shall be communicated to the Staff Bridge Engineer, or his designee, for resolution. Resolution shall be recorded on Report QAP 5900(a) and/or QAP 5900(g). Traceability of all material shall be documented and collected from the fabricator.

10.3 Consumables and Fluxes - Review consumable CMTR's. Determine consumable specification compliance relevant to Code, specifications, WPS/PQR, and AWS class designation / brand. These tests are only valid if less than one year old. Verify additional lot tests required for Fracture Critical Members comply with the specification requirements.

10.3.1 Verify consumable low hydrogen handling and storage practices comply with the specification requirements at least two times during the course of fabrication. Acceptability of QC methods of material traceability and storage shall be determined prior to the start of fabrication. The inspector shall list inspection results on the Project Daily Log, CDOT Report QAP 5900(a).

10.4 Plate Material Inspection - Inspect cut plate surfaces for the presence of miscuts, delaminations, and gouges. Discontinuities discovered require aggressive investigation on all other pieces cut from the same heat number. Determine the extent of the problem and the level of inspection provided by QC. Inspect plate repair procedures performed to ensure compliance with preapproved repair procedures. Inspect the first possible repair, if and when it occurs. Verify procedural adherence to the prequalified minimum TCE temperature, joint preparation, welding procedure parameters, and nondestructive tests.

10.5 Audit QC records for compliance with preapproved procedures.

10.6 Review QC hardness test results on tension main member thermal cut edges (TCE's).

10.7 Verify AS early as practicable, that the tension flange base metal hardness is acceptable and the edges are absent of defects. Inspect for the absence of defects using QAP 5915. Perform this verification initially and:

1. Once for every FCM heat.
2. Once for every redundant main member heat.

## 11. Welding

11.1 Equipment - Welding equipment calibration records shall be reviewed at commencement of fabrication, and at suitable intervals throughout production to determine compliance. Review each welding process at least twice during fabrication. Verify that QC calibrates voltage and amperage with external tongs every ten work days and has recorded the results. Welding equipment should be maintained in such condition that welders and welding operators are producing acceptable welds. Inspection includes gas flow, work and ground leads, and meters. Automatic and semi-automatic machines shall be operated within the welding procedure specification essential variables. Witness QC equipment tests or perform QA verification tests at the commencement of fabrication and when noticeable weld quality changes occur. Verify at least twice during fabrication on each project. Record the results on the CDOT Project Daily Log, Report QAP 5900(a).

## 12. IN PROCESS AUDIT OF SHOP WELD PREPARATION, SETUP, AND INTERMEDIATE WELD PASS PROCEDURES

12.1 Base metal inspection- Plate edges, weld joint fit-up and base metal surfaces shall be inspected in accordance with QAP 5915 and QAP 5916. Perform this base metal inspection daily during the first week of fabrication. Subsequently, inspect minimally each joint type and flange heat once per week. Record results on the Project Daily Log, CDOT Report QAP 5900(a).

12.2 Welding compliance to the Welding Procedure Specification - WPS's and the supporting PQR's shall be submitted and approved prior to fabrication (see 6.2). Verify in process welding compliance to the Welding Procedure Specification limitation of variables at the commencement of fabrication and at least two times per process during fabrication. Record results on the Project Daily Log, CDOT Report QAP 5900(a).

12.3 Welder Qualifications - Review the welders, welding operators, and tackers qualification records (WQR's). Qualification is required for each specific individual, process, position, type of weldment, base metal, and filler metal. Verify welders, welding operators, and tackers perform operations within the parameters of their respective qualifications. The duration of the WQR is three years, unless QC has maintained acceptable performance continuity records. Evidence of recurring unacceptable weld quality shall require removal of the welder from production until additional training is received and requalification tests are performed. All finished welds shall be identified by the welders mark listed on the WQR. The mark shall not be placed closer than one inch from the weld heat affected zone. Welder identification marks shall be made with a "low stress" die stamp. QA shall randomly audit welders once/week. Recurring deficiencies attributable to a welder requires verification of the welders qualifications. Record results on the WQR list. The fabricator's WQR's shall be kept current and submitted to the Quality Assurance inspector, as updated.



12.4. Joint Fit-up verification - Joint design and fit-up tolerance is indicated in the approved welding specification. AWS D1.5 joint design and fit up tolerances shall be verified.

Visually inspect joint fit-up using QAP 5916. Joint parameters to be inspected include bevel angle, joint root face and opening (Note design and "as built" tolerances are accumulative), surface preparation, alignment and placement of backing strips and run-off tabs. Check the angles for accuracy on set up jigs. Ensure the absence of laminations and occlusions on joint surfaces. Verify base metal and weld joint surface preparations; inspect initial and intermediate weld pass width, depth, and contour; note any undercut, overlap, crater cracks; check arc stability and that proper lead grounds are used (i.e., absence of induced arc strike copper occlusions).

Inspect finished weld morphology and presence of defects. These inspections shall be performed randomly or attributively commensurate with production quality, but at least twice for each typical joint, or alternatively, at least once every two visits to the fabrication facility. (Visual inspection at this phase is not the required 100% QA final visual inspection.) Results shall be recorded on the Project Daily Log, CDOT Report QAP 5900(a).

### **13. IN PROCESS VISUAL WELD INSPECTION**

13.1 *Weld Inspection* -In process welding shall be inspected by QC, or if approved, inspection by an individual directly supervised by the QC Certified Welding Inspector (CWI).

13.2 Effective "in process" QC-QA inspection mitigates insidious defects otherwise missed. All intervals of each fabrication work shift shall be monitored by the QC-CWI. QC shall intervally and on a continuum throughout fabrication inspect tack and production welds. The QC CWI is responsible

for signature approval of all completed weldments. This includes 100% final weld visual inspection (see 13.3). Verify QC is performing continuous inspections. Concurrently, QA shall intervally, and on a continuum throughout fabrication, inspect tack and final welds in accordance with QAP 5910. Attributed defect probable locations identified in section 13 shall be aggressively inspected during fabrication welding. This is normally performed after acceptance of all welds by QC. However, the prerogative for the convenience of inspection scheduling, inspection may be made prior to acceptance by QC. In such case, all defects shall be noted on the Shop Inspection Report, Report QAP 5900(b) for later review of the adequacy of QC inspections. Fracture critical, fatigue sensitive, and main member welds shall be prioritized (see 5.1). Perform this QA verification of QC and inspection of welds daily. Randomly inspect each working shift.

13.3 In process QC/QA inspection includes: base and filler metals; storage and collection of consumables; base metal preparation; ambient weather conditions in the immediate vicinity of welding, including wind velocity effecting gas shielding; fit-up and proper joint configuration this includes: minimum gap in the stiffener to flange weldment; minimum preheat of base metal, interpass and post heat requirements; mitigation of excessive arc strikes; repair and evaluation of induced arc strikes; proper lead grounds and the absence of arcing and copper inclusion fracture; proper weld start and termination techniques; absence of fracture, acceptable weld porosity, undercut, overlap, concavity, convexity, and absence of craters and associated cracking.

13.4 The quality assurance inspector shall perform in-process visual weld inspection daily. Record the results on the Project Daily Log, CDOT Report QAP 5900(a).

### **14. NONDESTRUCTIVE TESTING**

14.1 *General*- Competent surface and

subsurface nondestructive evaluation is critical to ensure structural soundness. Verify the QC NDT is in conformance with specification procedures, the fabricator's CDOT approved Written Practice, and the applicable Quality Assurance Procedure. All QC procedures must be reviewed and accepted by the QA Unit Manager prior to QC performing evaluations.

14.1.1 Regardless of the interrogation method, trends indicating process defects shall be brought to the attention of the QA Unit Manager.

14.1.2 The listed CDOT QAP's define applicability of the respective test methods. However, QA may select condition-specific appropriate NDT method's in order to ensure soundness. Indicated potential procedure defects shall be brought to the attention of the QA Unit Manager. Selected NDT methods will be described as a function of the weld process attributes, weld and material selection history, and cost/benefit considerations.

14.1.3 Complimentary methods may be necessary to determine structural soundness of specific weldments. Evaluations not performed in accordance with the applicable QAP are invalid.

14.2 Repairs - Repair welds shall be a QA inspection priority. Repairs, especially short welded repairs, are inherently more likely to exhibit fracture.

14.2.1 Fracture Critical - Repairs in designated Fracture Critical Members and tension zones in redundant members are prioritized for aggressive interrogation. In addition, the fabricator shall submit repair procedure for review and approval. Fracture Critical repairs require QA signature approval. Repairs affecting any change to Plan details shall require preapproval from the Staff Bridge Engineer, or his designee. QC shall review and document all weld and arc strikes. QA shall audit identified repairs to verify required QC tests were performed. All FCM repairs shall be

reviewed, approved, and signed by QA. This audit is required on all FCM repairs.

14.2.2 All repairs - Record selected (by QA) repaired areas; audit QC records to verify weld repairs were performed to preapproved procedures and QC inspected. All QC documented repairs shall be submitted to the QA inspector for review, acceptance, and signature. Verify approved preheat and WPS's were used to make the repair. Repaired areas are tested using the same methods and acceptance criteria originally required for the stress category of the member. Multiple repairs that induce more than two heat cycles is prohibited. Select a minimum of two repairs during project fabrication, the first as early in fabrication as practical. All QC records shall be reviewed prior to member acceptance. Note inspection and audit results on the Project Daily Log, CDOT Report QAP 5900(a).

14.2.3 Gouges - Gouges in flame cut plate edges, especially on flanges, which are less than 7/16" deep shall not be repaired by welding without the QC inspector's knowledge and QA approval. These discontinuities shall be contour blended to 1/10 slope. Occasional notches or gouges greater than 7/16" deep repaired by welding shall be tested by the Magnetic Particle Method, ASTM E 709. Verify QC has performed and documented these tests. Verify QC hardness tests were performed. Perform QA tests at least once per project. Record inspection results on the Project Daily Log, CDOT Report QAP 5900(a).

14.3 Visual inspection - Visual inspection shall be performed in accordance with QAP 5910. Visual inspection shall be performed and acceptance determined prior to performing any other nondestructive evaluation method.

14.4 Magnetic Particle Inspection - The Enhanced Magnetic Particle Method, QAP 5930 shall be used to evaluate, and as necessary to verify, suspected fracture (visible or process attribute). It is critical that QC/QA magnetic

particle evaluations be performed using alternating current (a.c.) The Magnetic Particle Method, ASTM E 709, shall be used to evaluate stop-start and termini fillet welds on main members in tension. Random Q.C. testing 10% of the fillet weld is inadequate. Test location and frequency shall be determined based on areas attributed to exhibit greater probability of fracture. The test frequency shall be:

1. Start and Stop - Starts in main member SAW weldments. Run off tabs are required or these areas are cut off. However, unavoidable termini connecting stiffeners to webs/ flanges, et. al. require QC/QA inspection. Particular attention shall be given to evaluate the weld root for centerline fracture in incorporated start areas. Stop-start areas shall be evaluated for any crater, centerline, transverse, and heat affected zone fracture. Record results on the Nondestructive Testing Verification, CDOT Report QAP5900(c).

2. Start and Stop start areas in main member FCAW weldments - Unavoidable termini shall be evaluated with particular attention to lack of fusion in the weld toe area. This may be aggravated by exclusive carbon dioxide shielding, inadequate preheat, and/ or failure to remove mill scale or oxides from the base metal.

3. Welds after the removal of back-up bars. CDOT prohibits back-up bars on butt splices. Back-up bars are indicated as influencing a high incidence of fracture (not resolved by conventional magnetic particle tests). In the case of unavoi ded welds made with back-up bars in tension or stress reversal locations, the back-up bars shall be removed and the weld tested using the Magnetic Particle Method. Tested edges of tension flanges shall be evaluated.

The listed Magnetic Particle Method tests shall be performed by the QA at least once for every five girders. In the event fracture is discovered, all similar welds shall be evaluated. The QA Unit Manager shall be notified. QA

review of QC tests shall be performed each inspection trip. Results of these audits shall be recorded on the Nondestructive Testing Verification, CDOT Report QAP 5900(c).

#### 14.5 Ultrasonic Evaluation

14.5.1 Properly performed, this is the most effective nondestructive subsurface evaluation method. Competent ultrasonic evaluation is essential to ensure structural absence of subsurface fracture.

14.5.2 The quality control performed test frequency is specified in the Standard Specification. QC-NDT disposition test results are indicated by marking the weldment, as well as the documented report.

14.5.3 All ultrasonic tests shall be performed initially 100% on all joints. The testing frequency may be reduced commensurate with the confidence level established for each QC operator as follows:

25 Correct Calls, repairs inclusive, on reflectors QA rated Class A or B- Minimum QA frequency 50% on tension and 25% on compression weldments.

50 Correct Calls, repairs inclusive, on reflectors QA rated Class A or B- Minimum QA frequency 25% on tension and 10% on compression weldments.

100+ Correct Calls, repairs inclusive, on reflectors QA rated Class A or B- Minimum QA frequency 10% on tension and 5 % on compression weldments.

1 Incorrect Call - Undetected unacceptable flaws discovered by QA (a Type I Q.C. error, or a QC Type II false alarm error) shall require resolution

and reported disposition to the CDOT QA Level III. The QA audit frequency shall be increased to 100%.

14.5.4 All QA results shall be compared to the QC results. Causes of erroneous QC interpretation shall be determined and documented on the Ultrasonic Test Report. Significant test result or interpretation discrepancies require resolution. The Level III ~~and/or QA Unit Manager~~ shall be notified and consulted. Any unacceptable defects discovered in complete penetration butt welds shall be repaired.

14.5.5 Verify QC tests per 509.18 and AWS D1.5, especially the inclusion of straight beam scanning prior to angle beam testing of the weldment. QC test results shall be indicated on the weldment and the QC report. Review QC NDT reports once per week. Determine QC test frequency conformance relative to the current rejection rate.

14.5.6 Perform QA ultrasonic tests as specified by 509.18 and QAP 5951 for Butt Welds. QA test results shall be recorded on CDOT Ultrasonic Test Report QAP 5900(d) or Ultrasonic Discrepancy Report QAP 5900(e), as applicable.

14.5.7 When attachments are fillet welded to main stress carrying members which (1) subject the parent metal to higher possibility of lamellar tearing, such as cruciform bearing stiffeners welded to webs or diaphragms, and (2) are not attached NORMAL to the web or diaphragm, thus effecting a significant amount of filler metal and heat input, or (3) fillet welds in excess of 3/4"; the QA operator shall determine soundness of the parent metal to which the attachment is welded by ultrasonic straight beam (longitudinal wave) method (QAP 5951). This shall be performed on each main member heat after the weldment is complete to ensure absence of delamination. See CDOT Standard Specification 509.18. Report tests on CDOT Report QAP 5900(d).

14.6 Radiography- Review all QC radiographs. The QC NDT test records shall be reviewed by the QA NDT Level II, at least once on each visit to the fabrication facility. Determine the rejection rate of each type of weldment tested, and subsequent compliance with section 6.7 of the AASHTO revision to AWS D1.1, or to AWS D1.5, whichever is applicable.

## 15. FINAL WELD INSPECTION

15.1 QA shall perform 100% final visual inspection on all welds. Results shall be reported on the Shop Inspection Report, Report QAP 5900(b). Final QA inspection shall ensure absence of fracture, unincorporated tack welds, unacceptable profile, arc strikes, and unapproved weld repairs.

## 16. CONNECTIONS

16.1 Holes - Thermal cut holes are prohibited, unless subsequently reamed or drilled. Full size die punched holes on main members and splice plates are not allowed due to resultant suppressed CVN values in the cold worked metal adjacent to the hole periphery. Burrs exceeding approximately 1/32 inch must be removed. Holes for bolted connections shall be produced in accordance with the CDOT Standard Specifications.

## 17. WELDED STUD SHEAR CONNECTORS

17.1 Verify proper preheat is used when the base metal is less than zero degrees Fahrenheit. All ceramic ferrules shall be removed. Verify QC performs the minimum bend test frequency. Check the resultant bend does not reduce concrete cover to less than the minimum required, and/or interference with deck forms and concrete reinforcement is not adversely impacted. Sound three studs on each member during fabrication or final inspection. Suspected deficient studs shall be QA bend tested. Any failure shall require three additional bend tests. Any additional failures shall require impacting all studs to assess fusion.

Record results on CDOT Report QAP 5900(a) or QAP 5900(b) as applicable.

## **18. PROJECT SITE / FABRICATION SHOP TESTING OF FASTENERS**

18.1 Inspect fastener containers for manufacturer's identification, assembly fastener contents, component set lot numbers, and rotational capacity test lot numbers. All data on the containers must be legible and permanently marked. Bolts, nuts, and washers should be assembled in sets as an RC lot and tested at the manufacturer/suppliers facility. Check for container damage and/or possible contamination. Black bolts must have adequate lubrication (indicated by touch); in the case of galvanized fasteners (A325), the nut must be lubricated (indicated by visible dye). All fasteners shall be stored in the original containers, and properly sealed to protect / prevent contamination and corrosion.

18.2 Verify manufacturer's test reports represent the supplied fasteners identified on the containers. Review the manufacturer's test reports for each component and assembly. Review test result test data specification compliance (chemistry, proof load, wedge tests, HRc values, and zinc coating thickness -applicable only on zinc coated fasteners). The test data shall indicate the original heat number of the steel and be traceable to the original CMTR. All lot numbers shall be listed. All set lots shall have rotational capacity tests by the manufacturer or supplier (this is the Rotational Capacity Test of the married components, viz. Rotational Capacity Lot) as required by the Contract Specifications, not the ASTM designated test.

**Note:** Galvanized fasteners must be tested AFTER the coating is applied.

18.3 On-Site Field or Shop Rotational Capacity tests are also required. These tests are performed immediately prior to the time of installation to

judge the effects of shipment and storage on fastener lubrication. The Contractor, Fabricator or Supplier shall perform the Rotational Capacity and Installation Verification Tests in accordance with QAP 5924, and QAP 5925. Two sets per RC lot shall be tested. The QA inspector shall witness Contractor Installation Verification Tests.

18.4 Installation/Verification Tests - Prior to installation, the Contractor or Fabricator shall perform Installation Verification Tests. These tests shall be performed in accordance with the Installation/Verification Test Procedure, QAP 5926. During assembly verify that washers are properly located (in the case of load indicating washers a holding element to preclude washer turning, and correct position of the load indicating washer).

## **19. PAINT**

19.1 Preparation of surfaces to be painted shall comply with Section 509.24 of the Colorado Standard Specifications. Welds shall be cleaned accordance with AASHTO/AWS D1.5M/D1.5, Section 3, Bridge Welding Code.

19.2 The paint to be applied shall conform to section 708 of the Colorado Standard Specifications, and/or the project special provisions.

19.3 The application of paint shall conform to Section 509.24 and 509.29 of the Colorado Standard Specifications, as amended by the project Special Provisions. The manufacturers preparation, mixing, and painting procedures shall comply with the information listed on the Material Safety Data Sheet.

19.4 Perform random inspections of each phase of the painting operations to determine specification conformance. Verify: acceptable surface preparation, paint and thinner (if allowed) conforms to the manufacturers Material Safety

Data Sheet, storage of paint is adequate, ambient weather conditions are acceptable during painting, and acceptable film coating thickness has been achieved. Record results on Report QAP 5900(b).

## 20. ZINC COATING

20.1 Zinc coated steel shall conform to the requirements of AASHTO M111 and the Standard /Special Provision Specifications. Successful galvanizing requires proper cleaning preparation. Grease, identification markings, or oil is often not sufficiently removed by sandblasting or acid etching. Therefore, black steel must be cleaned prior to galvanizing to achieve acceptable results. Randomly inspect materials prior to shipment to or at the galvanizing facility. Verify QC has performed coating thickness tests and the results meet specifications. Coating thickness tests are performed randomly on each manufacturer's product.

20.2 Repairs to galvanized surfaces shall comply with section 509.23, of the Standard Specifications.

20.3 Report the results of inspections on the Project Daily Log, CDOT Report QAP 5900(a).

## 21. DOCUMENTATION

21.1 QC shall forward all inspection and test reports to the QA inspector prior to shipment of the member(s). Reports for each member shall be reviewed prior to acceptance. Bridge member QA acceptance shall be indicated by the CDOT/QA stamp mark placed on the Near Side Layout web. In the case of any member noted for repair, and the repair was not confirmed as acceptable prior to shipment, an inspection on the project site shall be performed.

21.2 Record the QA inspection and test results in accordance with this procedure. Report distribution shall be:

1. Hard copy reports including inspection notes on Plans, Certified Mill Test Reports, Nondestructive Test Reports, Material Guarantees, and QC reports shall be forwarded to the Project Engineer during fabrication if necessary to achieve noncompliance resolution, or otherwise, at the completion of the Project.

2. QA reports are retained electronically or hard copy and a copy shall be forwarded to the Project Engineer. One copy will be retained in the CDOT Bridge archival system.

Documentation includes: general correspondence, approvals, directives, change orders, revisions, nondestructive test results, daily diaries during fabrication inspection, girder inspection reports, fabrication progress reports, dimensional verification reports

Records will be filled out on a daily basis and retained in the QA project file.

**Note:** Inspection and test reports are listed in the Appendix.

Documentation by the quality assurance inspector should provide comprehensive information for future reference, especially in the case of claims and / or an audit and failure analysis. Items of particular importance to be documented include; general correspondence, approvals, directives, change orders, revisions, nondestructive test results, daily diaries during fabrication inspection, girder inspection reports, fabrication progress reports, and dimensional verification reports.

21.3 The Appendix lists the QA documentation forms. The purpose of using these forms is to provide associate inspectors with information on fabrication status in the case of filling in for you in your absence. When these forms are filled out on a daily basis, enough information would be available to your replacement for performing an inspection. Also, these forms will be included in

the final project file to be placed in the archives for future reference.

## **22. SHOP INSPECTION FORMS**

These forms are titled: SHOP INSPECTION REPORT for box girders, FABRICATION PROGRESS LIST for girders, WPS/PQR INSPECTION RECORD, NDT DISPOSITION REPORT for box girder, ULTRASONIC TEST REPORT to be filled out in its entirety when performing ultrasonic testing. These forms are in addition to the DAILY DIARY reports.

22.1 The attached forms will be filled out on a daily basis, when performing shop fabrication inspection, and be kept in the QA project inspection files, available for review at any given time. QC shall provide the inspection and test results required. These results shall be forwarded to the QA prior to shipment of the member(s).

22.2 Record QA inspection and test results performed in accordance with this procedure. Distribution of these reports shall be:

1. CDOT Report #193, inspection reports impacting construction schedules, Plan notes, Certified Mill Test Reports, Material Guarantees, and QC reports shall be forwarded to the Project Engineer.
2. All other QA reports shall be forwarded to the Project Engineer. Documentation includes: general correspondence, approvals, directives, change orders, revisions, nondestructive test results, daily diaries during fabrication inspection, girder inspection reports, fabrication progress reports, and dimensional verification reports.

**APPENDIX A**

**INSPECTION CHECKLIST**

<b><u>Item</u></b>	<b><u>Specification</u></b>	<b><u>Inspection Point/ Frequency</u></b>	<b><u>Accept/ Reject</u></b>	<b><u>Shop Facility Review</u></b>
AISC Category	(509.16)	Prior to fabrication		
Quality Control Plan	(509.17-a)	Prior to fabrication		
Written Practice	(509.18-a)	Prior to fabrication		
QC Inspectors	(D1.5, 6.1.3)	Prior to fabrication		
QC Nondestructive Testing Personnel	(D1.5, 6.1.3.2)	Prior to fabrication		
Procedure Qualification Records	(D1.5, 6.1 – 6.7)	Prior to fabrication		
Welding Procedure Specification	(D1.5, 6.1 – 6.7)	Prior to fabrication		
<b><u>Plan and Specification Review</u></b>				
Bearing Faying Surface Flatness	1 / 32"(509.19 j)			



**APPENDIX B**

**Schedule of Quality Assurance Structural Steel Inspection**

<b><u>Inspection</u></b>	<b><u>Frequency</u></b>	<b><u>Report</u></b>
Prefabrication	1/new fabricator	5900(a)
Materials Inspection	FCM 100%	Fabricators CutList, CMTR
	Hybrid Main Members 100%	Fabricators Cut List, CMTR
	Rotational Capacity Fasteners-both shop and field 100% each RC lot, Installed- random each RC lot each Member, Paint 20%	Fabricators Cut List, CMTR  5900(b)
	Consumable storage and recovery 2 / project	5900(b)
	Material Storage and Traceability	5900(b), CMTR
	WPS, PQR, WQR	Submitted and approved prior to fabrication, audited in process:
	WPS: Welding to WPS, 2 times minimum during fabrication: WQR/ PQR: 1 / week	5900(b)
Main Member Tension	Initially Daily at lowest temperature, 2 / process / project	5900(b)
Joint Fit-Up	2 / joint type/project	5900(b)
In-Process Visual Weld	Daily/each shift Record 1 /week	5900(b)

QC NDT	Review weekly and all NDT prior to shipment or acceptance, Review all submitted repairs for Approval	5900(b)
QA NDT	All methods: Frequency commensurate with Attribute defect probability	5900(d), 5900(e), 5900(b)
VT	Prior to all other NDT Daily during fabrication 100% final inspection	5900(d) 5900(b)
MT	1 of every five Members	5900(b)
PT	As necessary to substitute for MT	5900(b)
UT	See CP-L 5900, 14.5.3	# 5900(d), 5900(e)
RT	100%, 1/week	QC RT report
Welded Stud Shear Connectors	Each Member	5900(b)

**APPENDIX C**  
**CDOT Reports**

<b><u>CDOT Report Number</u></b>	<b><u>CDOT Report Name</u></b>
193	Quality Assurance Inspection Report
QAP 5900(a)	Project Daily Log
QAP 5900(b)	Shop Inspection Report
QAP 5900(c)	Nondestructive Testing Verification
QAP 5900(d)	Ultrasonic Test Report
QAP 5900(e)	Ultrasonic Discrepancy report
QAP 5900(f)	Welder Verification Record
QAP 5900(g)	Fabrication Inspection Report / Miscellaneous Structural Steel
QAP 5900(h)	Equipment Qualification Log
QAP 5900(i)	Rotational Capacity Test & Installation Verification Record



Colorado Department of Transportation  
Shop Inspection Report

Subaccount: \_\_\_\_\_  
Project: \_\_\_\_\_  
Girder ID: \_\_\_\_\_  
Fabricator: \_\_\_\_\_

		INIT	DATE			INIT	DATE
1	Bottom Flange/Web (NS) Fitup & Tacks (NS) (FS)			15	Stud Welding		
2	Bottom Flange/Web (NS) Welds (NS) (FS)			16	Butt Joint Surfaces (FS)		
3	Bottom Flange/Web (NS) Fitup & Tacks (FS) (FS)			17	Butt Joint Surfaces (NS) Bottom Flange (FS)		
4	Bottom Flange/Web (NS) Welds (FS) (FS)			18	Top Flange (NS) Warp & Tilt (FS)		
5	Top Flange/Web (NS) Fitup & Tacks (NS) (FS)			19	Web Flatness (NS) (FS)		
6	Top Flange/Web (NS) Welds (NS) (FS)			20	Hole Locations & (NS) Dimensions (FS)		
7	Top Flange/Web (NS) Fitup & Tacks (FS) (FS)			21	Oxygen Cut Edges		
8	Bottom Flange/Web (NS) Welds (FS) (FS)				Top Flange (NS) Top Flange (FS) Bottom Flange		
9	Stiffener (NS) Fitup & Tacks (FS)			22	Bearing Flatness		
10	Stiffener Welds (NS) (FS)			23	Blocking Check		
11	Diaphragm (NS) Fitup & Tacks (FS)			24	Surface Finish SSP		
12	Diaphragm Welds (NS) (FS)			25	Paint DFT		
13	End/Cap Diaphragm Fitup & Tacks			26	QC Paperwork Checked		
14	End/Cap Diaphragm Welds			27	Shipping Date		

Final Acceptance: \_\_\_\_\_

By: \_\_\_\_\_

Girder Remarks


Colorado Department of Transportation  
Nondestructive Testing Verification

Subaccount: \_\_\_\_\_  
Project: \_\_\_\_\_  
Girder ID: \_\_\_\_\_  
Fabricator: \_\_\_\_\_

QC-MT	REPORT	QA-MT	REMARKS
Web-Flange			
Stiffener-Web			
Longitudinal			
Stiff-Flange			
End/Cap Diaphragm			
FCM Flange Edges			
QC-UT	REPORT	QA-MT	REMARKS
Web Splice			
#1			
#2			
#3			
#4			
Flange Splice			
#1			
#2			
#3			
#4			
QC-RT	REPORT	QA-RT	REMARKS
#1			
#2			
#3			
#4			

Colorado Department of Transportation  
Ultrasonic Test Report

Subaccount: \_\_\_\_\_  
Project: \_\_\_\_\_  
Girder ID: \_\_\_\_\_  
Fabricator: \_\_\_\_\_

Equipment: \_\_\_\_\_  
Transducer: \_\_\_\_\_

SUMMARY OF ULTRASONIC TESTS

D A T E	I N S P E C T O R	W J E O L I D N T	W E L L D  M A R K	T H I C K N E S S	R A N G E	S S C A N S  I T I V I T Y	REMARKS

Colorado Department of Transportation  
 Ultrasonic Discrepancy Report

Subaccount: \_\_\_\_\_  
 Project No.: \_\_\_\_\_  
 Fabricator: \_\_\_\_\_  
 Thickness D1: \_\_\_\_\_  
 Thickness D2: \_\_\_\_\_

INFO			DECIBLES				DISCONTINUITY					INDEX	
LINE #	FACE	LEG	INDICATOR	REFERENCE LEVEL	ATTENUATION	INDICATOR	SOUND PATH	DEPTH	LENGTH	FORM	FORM	POINT	
	A/B	1/2	a	b	c	d				D1	D2	X	Y
1													
2													
3													
4													
5													
6													
7													
8													
9													


Equipment: \_\_\_\_\_  
 Transducer: \_\_\_\_\_  
 Range: \_\_\_\_\_  
 Weld Mark: \_\_\_\_\_  
 Weld Joint: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 QA Operator: \_\_\_\_\_  
 QC Operator: \_\_\_\_\_



Colorado Department of Transportation  
Welder Verification Record

Subaccount: \_\_\_\_\_  
Project: \_\_\_\_\_  
Fabricator: \_\_\_\_\_

DATE	INSPECTOR	WELD MK.	PROCESS	POSITION	WQR

Colorado Department of Transportation  
 Fabrication Inspection Report  
 Miscellaneous Structural Steel

Subaccount: \_\_\_\_\_  
 Project No.: \_\_\_\_\_  
 Fabricator: \_\_\_\_\_  
 Item: \_\_\_\_\_  
 Date: \_\_\_\_\_

PIECE#	SIZE	HEAT#	NUMBER OF PIECES			REMARKS
			CHECKED	REJECTED	ACCEPTED	



Colorado Department of Transportation  
 Rotational Capacity Test &  
 Installation Verification Record

Subaccount: \_\_\_\_\_

Project No.: \_\_\_\_\_

Fabricator: \_\_\_\_\_

Date: \_\_\_\_\_

Lot #	Bolt Size	Torque Reading	Torque Maximum	Step 7 Reading	Step 7 Minimum	Pass Fail	Inspector

Lot #	Bolt Size	Tension	Required Minimum	Pass/Fail