Quality Assurance
Procedure QAP 5910

Method of Test For

Visual Test Procedure of Bridge Weldments

1. SCOPE

1.1 This written procedure shall be used to visually inspect completed weldments in accordance with the acceptance criteria of AASHTO/AWS D1.5M/D1.5.

1.2 This procedure describes general visual scanning, direct visual examination and, when necessary, indirect visual examination. Technical understanding of the applicable fabrication process, particularly welding variables and associated probable/possible defects, is essential.

2. PERSONNEL

2.1 Personnel performing this examination shall be qualified per the Written Practice SNT- TC-1A. A yearly eye examination shall be given to determine the individual is capable of reading a minimum of Jaeger Number 1 type at a distance of not less than 12 inches on a standard Jaeger test chart. Previous successful completion of examination in accordance with the AWS QC-1 program is required at Level II.

3. REFERENCE

3.1 AASHTO/AWS D1.5M/D1.5, Sections 3, and 6.

4. APPARATUS

4.1 Double-Convex Coddington 10X magnifier with a working range of 3/4" to 6" and a resolving power of .0050".

4.2 30X hand-held microscopic wide-field tube with a field view of at least .125" and a working distance up to .25" with resolving power of .0001".

4.3 Standard fillet weld gauges capable of measuring fillet weld sizes that connect base metals forming both normal and dihedral angles.

4.4 Cambridge weld gauge.

4.5 Ruler with 1/64" increments.

4.6 Flashlights, 30fc for general inspection and 50 fc for evaluation of small discontinuities.

4.7 Brushes, fiber and wire

4.8 Mirror

4.9 Knife or pick

4.10 Grinder

4.11 General Electric Surface Roughness Gage, or AWS D4.1.

4.12 Arc strike comparator standard

5. PROCEDURE

5.1 The welds and adjacent base metal surfaces shall be free from dirt, rust, paint, oil, blasting sand, loose mill scale, and slag. (Judgement should be used when inspecting GMAW and some FCAW slag systems as to the extent removal is necessary prior to preparation for painting). Final inspection will be performed, after blast preparation for painting, unless otherwise requested by the fabricator, or to facilitate the Q.A. schedule.

5.2 The minimum ambient light intensity on the specimen surface shall be 30 fc for general visual scanning, and 50 fc for direct visual inspection. Examination of surfaces that are outside and in the shade, where possible, shall be performed by illuminating the specimen surface from reflected sunlight using a mirror. Resolution shall be optimized while ocular fatigue is minimized by avoiding glare (brightness within the field of view varying by more than 10/1).

5.3 General scanning of the weld and adjacent base metal shall be made with the eye between 36" and 72" from the examination surface. This shall be required for 100% of the welds to complement direct visual examination.

5.3.1 General scanning shall be performed on all surfaces of the bridge member. All cut edges shall be evaluated for nonconformance i.e. roughness and defects (see Fig 2, 3, & Visual Test Procedure of Base Metal Discontinuities). All die marks shall be verified as low stress (spherical indent), as well as grinding removal of all lifting marks - see Fig 4).

5.3.2 General scanning is performed to determine that: no welds have been made which are not detailed in the plans; that no unapproved repairs have been made; that no arc strikes of significance have been left unrepaired and untested in Q.C.; that all grind marks have proper roughness values and are oriented with the marks parallel to stress; that all weld sizes are correct as detailed in the plans; that gross undercut or overlap is not present (a lack of fusion type of overlap can occur at the start of welds, particularly from the lower penetrating processes e.g. FCAW, which may be insidious); that no welds are unfinished, intermittent, or missing; that flange tilt and web warp meet AASHTO/AWS D1.5M/D1.5 requirements; and that no unincorporated tack welds have been left unwelded, repaired, or tested.

5.4 Direct visual inspection shall be considered inspection in which the eye to the test surface shall not be more than 12 inches and at an angle of not less than 30 degrees or at an angle not greater than 30 degrees with respect to the longitudinal center axis of the weld. The angle of the incident light source shall be varied to produce shadowing effects to accentuate discontinuities while precluding glare. A mirror shall be used when necessary to allow direct visual inspection not otherwise possible. Resolution of the image shall preclude glare, meet the minimum light intensity required, and have comparable resolution to that of the eye. Eye focusing and movement shall be continuously adjusted to resolve both gross discontinuities and fine crack-like indications.

5.4.1 Direct visual inspection shall be performed randomly as an in-process verification of quality assurance. Direct visual inspection shall be performed at final inspection on 100% of all main member splices (this includes the edges of the flanges) , 100% of all main member to main member attachments, 100% of all secondary member to main member attachments, and randomly on secondary to secondary member attachments. Any additional repairs such as: movement of members resulting in the possibility of overstressing the member, and heating to correct camber in members shall require additional direct visual inspection in the stressed area(s). This will be required, whether or not a previous final inspection has been performed, and the acceptance criteria of this inspection shall determine acceptability of the member. The maximum scanning speed for critical areas, i.e., fracture critical welds and welds in tension shall be 3 inches per second. To minimize ocular fatigue, the maximum continuous time spent at one time performing direct visual inspection, when possible, shall be one hour.

5.4.2 All crack-like indications, random stop/starts, edges of butt welds, intersections of butt welds and fillet welds e.g. splices intersecting the web to flange weld, and weld termini shall require visual examination using a 10X magnifier. Crack-like indications requiring higher resolution for interpretation shall be examined using the 30X magnifier. All suspected cracks shall then be verified by Magnetic Particle Inspection, per QAP 5930.

5.4.3 All visual inspection of undercut shall be measured using the Cambridge Weld Gage or a "pit" gage.

5.4.4 Excess convexity shall be measured using the throat dimension of the standard fillet weld gauge indicated for the maximum allowable throat in Table 1 or 2 of the Acceptance Criteria.

5.4.5 The fillet weld leg size measurements shall be made using the standard fillet weld gauges and not the Cambridge Weld Gage (this requires retrofitted fillet gauges to allow proper measurements on skewed T-joints, e.g. web- flange attachments on trapezoidal box members). The gap of the base metals connected must be inspected to determine the required weld size in accordance with AASHTO/AWS D1.5M/D1.5, Section 3.3. The fillet weld gage shall be used to measure the throat on concave weld profiles and the leg measurement on convex weld profiles. Correct application of the fillet weld gage is demonstrated in figures 1-6.

5.4.6 The surface roughness of the weld, repaired surfaces or thickness transition areas of butt splices shall be measured by using the General Electric Surface Roughness Gauge - 125 - 250 microinches. Surface roughness shall meet AASHTO/AWS D1.5M/D1.5, Sections 3.2.2 and 3.6.3.

5.4.7 Flange warp and tilt on girders, in which the web is designed to be normal to the flange, shall be measured by using a square on which one leg lies on the centerline of the web (established from a line between the centerline of the web at each end of the web) and from which the difference between the other leg of the square and the outermost edge of the flange is measured (skewed girders which the shop drawings may show the web angled from normal to correct for movement occurring applying dead load from the deck), shall be measured as follows:

5.4.8 Flange warp and tilt on webs that are designed to be other than normal to the flanges shall be measured as described in 3.5.1.7. A protractor shall be used to measure acute or obtuse angled webs.

5.4.9 Arc strikes shall be evaluated primarily using direct visual evaluation without magnification and compared to the arc strike comparator standard when questionable as to acceptance. Arc strikes shall be noted for repair. Quality Assurance verification shall randomly be performed to assure hardness and magnetic particle tests have properly been performed by Quality Control. This shall be done at least once per project.

5.4.10 Web flatness determined by measuring the distance between the surface of the internal web and a straightedge or taut string at the same distance away from the web at or adjacent to the inside (with regard to the panel) of the stiffener. The edge of the stiffeners may be used to support the straightedge or string if both supporting edges are equal distance from the surface of the web. The convex surface of the web, less often, can be measured if the exact offset of the line ends from the web at the location of the stiffener (attached to the other side of the web) is the same. Figure 7 illustrates the correct technique for measuring web flatness.

5.4.11 Indirect visual examination (greater than 30 degrees from normal or parallel to the weld axis) shall be performed on those areas that do not allow direct visual inspection.

5.4.12 Piping porosity (elongated porosity whose major dimension lies in a direction approximately normal to the weld surface) shall be measured for greatest dimension exceeding 3/32 inches using the porosity go-no go gauge. For summation of the greatest diameters of each porosity in each linear inch or foot, measurement may be made using any known diameter probe (go-no go gauge, tip of a mechanical pencil) or the ruler with 1/64th inch increments. Porosity greater than or equal to 3/32 inch shall be evaluated for underlying vermicular or wormholing porosity. When extensive amounts (beyond code limits) of vermicular porosity occur in the proximity of the root, this discontinuity is considered a fusion type defect (See AASHTO/AWS D1.5M/D1.5 Annex V, 6.26.1.2 and also the Commentary). Using ductile wire less than 0.20 inch diameter, "fish" one end into the hole in the surface of the fillet weld, manipulate the wire in an attempt to move the end laterally to follow the "tunnel of porosity" (which usually lies in the proximity of the root). If a fusion type discontinuity exists and has significant dimension, exploratory excavation is warranted.

6. ACCEPTANCE CRITERIA

6.1 The surface of welds and base metals shall be free of cracks (AASHTO/AWS D1.5M/D1.5-3.7.2.4; 6.26.1.1)

6.2 Thorough fusion shall exist between adjacent layers of weld metal and between weld metal and base metal (AASHTO/AWS D1.5M/D1.5, 6.26.1.2.).

6.3 Overlap in welds shall be acceptable if it is less than or equal to the Overlap Comparator Gauge No. 3. The severity of the notch effect at the juncture of the filler metal and base metal is the property to be evaluated. However, this evaluation shall also apply to the notch effect created by one weld on top of or terminating into another weld, as well as filler metal puddle in homogeneities creating an overlap situation (AASHTO/AWS D1.5M/D1.5, Fig. 3.3 and 3.6.5) see attached Fig. 1A. A sharp separation line at the toe of the fillet weld, particularly at the start of the weld and especially when the process is FCAW, may indicate a lack of fusion type defect which has been observed to run to the root. Magnetic Particle (QAP 5930) testing shall be used to evaluate possible lack of fusion. Any linear indication shall be explored by contour grinding in conjunction with magnetic particle verification of its removal. The suspect areas of this condition are primarily the start areas of the transverse stiffener attachment welds.

Whiskers (wire electrode fused and propagating from the weld due to poor workmanship) shall not be allowed, and may require requalification of the welder if extensive (this applies to tack welds as well).

6.4 Undercut in the main member base metal from a weld shall be: no more than 0.10 inches deep when the weld is transverse to the direction of tensile stresses under any design load condition; no more than 1/32 inches deep under all other conditions. Repair by proper contour grinding technique i.e. grinding to not reduce the thickness of the base metal by more than 1/32 inches for the first case nor more than 1/16 inches in the second case shall be encouraged, though it is not an AASHTO/AWS D1.5M/D1.5 requirement. This undoubtedly results in a higher quality repair. However, undercut deeper than or resulting in reduction of the base metal thickness beyond the contour grinding depth limit, or improper and poor workmanship repairs shall require weld repairs, at once, in accordance with Section 3 of AASHTO/AWS D1.5M/D1.5. See attached Fig. 1A (AASHTO/AWS D1.5M/D1.5 Fig.3.3).

6.5 The surface of welds and the base metal shall be free of arc strikes (AASHTO/AWS D 1.5 - 3.10; 3.3.7.4) more severe than No. 3 on the Arc Strike Comparator Standard. All repaired arc strike areas shall exhibit the indentations of a Q.C. hardness test (MT or PT by Q.C. is also required in tension areas). Any suspect grind areas on the member not evidencing the Rockwell indentations may be verified by acid etching using picric or HCL, 50% heated, to reveal any heat affected zones from coalescence of the base metal.

6.6 All welds shall be free of craters that have not been filled to full cross section. See AASHTO/AWS D1.5M/D1.5 - 6.26.1.3. (Exception: in the rare case of intermittent fillet welds detailed in the plans, in which case they are acceptable outside of the effective length required).

6.7 Prior to nondestructive testing, the surface finish of completed welds shall be free from slag weld spatter, arc strikes, excessive roughness (greater than 250 microinches), misalignment and other discontinuities that would prevent proper evaluation.

6.8 Final visual inspection shall verify that butt joint surfaces meet the requirements of Fig. 1A (modified AASHTO/AWS D1.5M/D1.5 Fig. 3.3) In addition, surfaces of butt joints that are required to be flush, the thickness of the member shall not: be reduced by more than 1/32 inch or 5% of the thickness, whichever is less; reduce the required or actual section width, whichever is greater by more than 1/8 inch, or have reinforcement at the edge that exceeds 1/8 inch. All reinforcement of butt joints at faying surfaces shall be smooth. Where finishing flush is not required, butt joint and corner joint reinforcement shall not exceed 1/8 inch in height and shall have a gradual transition to the plane of the base metal (AASHTO/AWS D1.5M/D1.5 - 3.6.2; 3.12.4). Of course, intimate coupling of the ultrasonic search unit would be necessary in the areas requiring ultrasonic testing.

6.9 Piping porosity in fillet welds shall not exceed more than one indication in 4 in. or six indications in 4 ft. Any one indication, with its greatest dimension diameter equal to or greater than 3/32 in. is rejectable and requires repair in accordance with AASHTO/AWS D1.5M/D1.5 - 3.7.2.3. When either: (1) four or more porosity indications, both having greatest diameter dimensions of 3/32 in. or greater occur in 12 in. or less intervals over a minimum distance of four feet or (2) the subsurface investigation detailed in this procedure and/or the evidence of the electrodes and flux conditions, base metal conditions (rust at the time of welding, etc.) and cracking indicates there may be a problem with gross subsurface porosity, the following excavated subsurface criteria applies:

At the mid-throat of the weld, the sum of the diameters of all porosity shall not exceed 3/8 inch in any linear inch of weld nor 3/4 inch in any 12 in. weld length. Vermicular porosity at the root shall be considered a fusion type defect and removed (AASHTO/AWS D1.5M/D1.5 Annex V, 6.26.1.2 and 6.26.1.6).

7. RECORDS

7.1 The results of all visual tests shall be recorded on CDOT Form #1154. The location of all cracks and other fusion type defects, and other defect locations to facilitate the final visual inspection shall be shown. Photographs shall be taken as necessary for project records. All cracks shall be recorded as to location, orientation (especially with regard to the weld axis), frequency, and description (sharp and open, sharp and tight, jagged, linear or arcing). The inspection leader shall be informed of all cracks found for disposition.

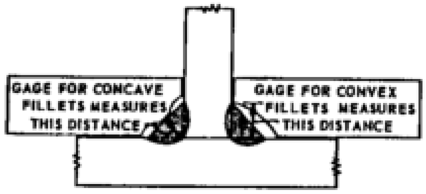


Fig. 1 Two types of fillet weld gages. Convex fillets may be measured with gage of type shown on the right; in this case it measures the leg size. Concave fillets are measured with a gage like the one on the left; in this case it measures the weld throat.

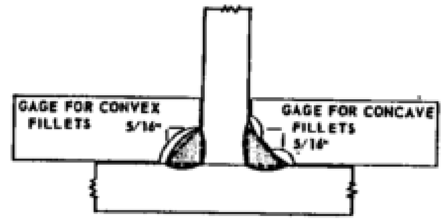


Fig. 2 With equal legged 45° fillets, either type gage (concave or convex) may be used. Both will indicate the same size fillet.

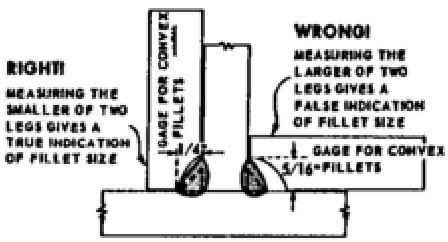


Fig. 3 Measuring convex fillets. Notice that the largest isosceles right triangle which can be inscribed within the cross-section of the fillet is determined by the shorter leg's dimension.

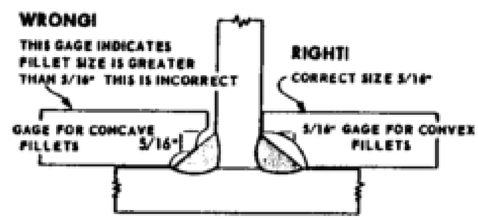


Fig. 4 It may not be readily apparent whether the above fillet is flat, slightly concave, or convex. But by checking the fillet with both types of gages, it would be apparent that the vertical leg is smaller than the bottom leg and that this is the true fillet size. The concave gage would give the impression that the fillet is larger than 5/16" and this would be incorrect.

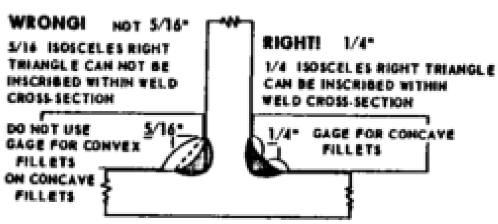


Fig. 5 Right and wrong method of gaging a concave fillet.

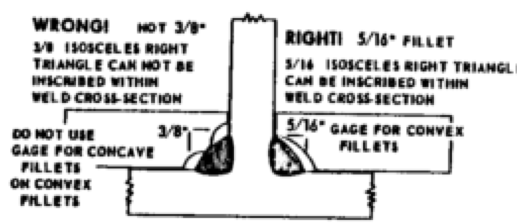
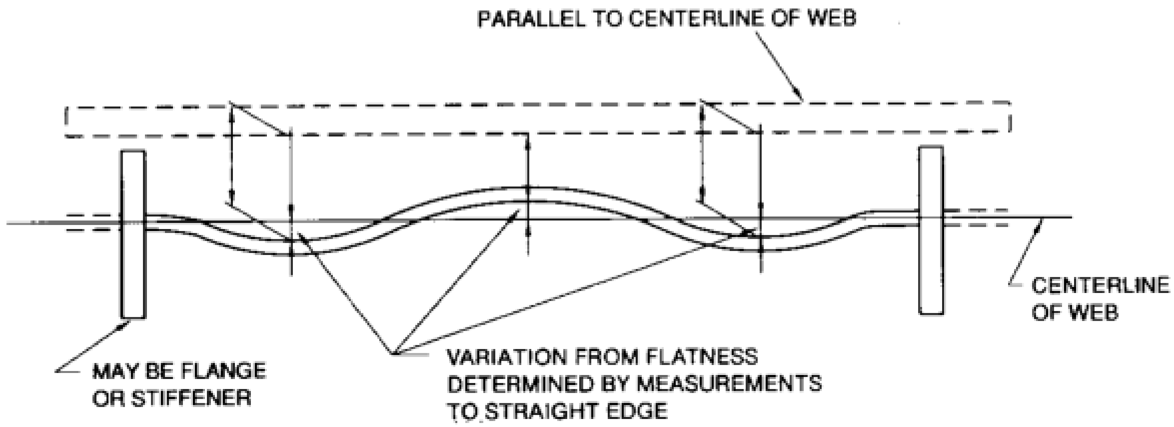


Fig. 6 Right and wrong method of gaging a convex fillet.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MAY BE FLANGE
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