

- Firm name;
- Firm address including ZIP code;
- Firm's status as a DBE or non-DBE;
- Race and gender information for the firm's majority owner;
- NAICS code applicable to each scope of work the firm sought to perform in its bid;
- Age of the firm; and
- The annual gross receipts of the firm shown as an approximate range (i.e., \$1-3 million)

This information will be maintained as confidential to the extent allowable by federal and state law.

**Failure to submit the required bidders list documentation at the time bid will result in the bidder being deemed non-responsive and therefore ineligible for award of the contract.**

16. **DIESEL FUEL COST PRICE ADJUSTMENT FORM** is posted and part of this Bid Proposal.

17. **STEEL COST PRICE ADJUSTMENT FORM** is posted and part of this Bid Proposal.

18. **APPENDIX-A TECHNICAL SPECIFICATIONS** is posted and part of this Bid Proposal.

19. **NOTICE TO PROCEED INFORMATION:**

The Department intends to issue a partial Notice to Proceed on or about June 16, 2025, to begin material ordering and shop drawing submittal process. Full Notice to Proceed for on-site work is anticipated on or about September 8, 2025, Contract time will begin when the Full Notice to Proceed is issued.

20. **BASCULE SPAN SHOP FABRICATION, SHOP ASSEMBLY, FIELD ERECTION AND ALIGNMENT**

**DESCRIPTION:**

This work consists of shop fabrication, shop assembly, field erection and alignment of the steel Dutch-style bascule span, consisting of the bascule leaf, balance frame, counterweight box, link arms, towers, and associated mechanical components, shown in the Plans and as described herein. Develop and implement procedures necessary to obtain accurate alignment of the bascule span components to the specified tolerances. Align the structural steel components, bascule leaf heel trunnions and balance frame trunnions, hydraulic cylinder upper and lower clevises, and link arm upper and lower clevises. Design, detail and implement temporary supports, tie-downs/tie-backs, falsework, shoring, jacking, and procedures to safely erect the bascule span.

Review and approval, by the Engineer, of procedures, design and details of temporary supports, tie-downs/tie-backs, falsework, shoring, and/or jacking systems is for compliance with the minimum requirements of the Contract Documents and should not be considered relief of the Contractor's responsibilities for satisfactory alignment and safe erection of the bascule span.

Perform shop fabrication, shop assembly, field erection, and alignment of the bascule span structural steel in accordance with the provisions herein, the Plans, approved Shop Drawings, Standard Specifications Sections 604 and 615, Special Provision 615503 - Bridge Mechanical System, AASHTO/ANSI/AWS D1.5 Bridge Welding Code, and the approved procedures.

Perform bascule span shop fabrication and shop assembly by a shop certified under the 2014 AISC Quality Certification program, meeting the requirements of Certified Bridge Fabricator – Advanced (ABR) and AISC Fracture Critical Endorsement.

**MATERIALS:****A. Trunnion and Link Arm Clevis Alignment Measurement Devices**

1. Unless otherwise approved by the Engineer, use steel wires as reference axes during shop fabrication and assembly for equipment used to machine steel components that accept the trunnion assemblies, and during field erection for alignment of the trunnion assemblies, hydraulic cylinder upper and lower clevises, and link arm upper and lower clevises. Provide and implement alignment wire holding device assemblies, which support and permit accurate adjustment and alignment of the wires to the required tolerances. Provide and implement measurement tools and equipment to measure alignment and catenary sag of the wires, and alignment of the trunnion assemblies, hydraulic cylinder clevises, and link arm clevises to the wire. Provide stanchions of adequate stiffness to support the wire holding devices.
2. Other means and methods will be considered to verify accurate alignment of the machining equipment, trunnion assemblies, hydraulic cylinder clevises, and link arm clevises. Prepare and submit such requests to the Engineer with justification and sufficient details of the proposed systems and equipment, including information required to evaluate the measurement accuracy to the required tolerances, and ability to conveniently verify alignment at a frequency no less than twice daily.
3. Provide all labor, materials and equipment to satisfactorily measure and record alignment of the trunnion assemblies and link arm clevises to the provisions herein, the Plans, and Special Provision 615503 - Bridge Mechanical System.

**B. Concept for Alignment Wires and Alignment Wire Holding Devices:**

1. Utilize one alignment wire holding device at each end of the alignment wire, located outboard each of the trunnion assemblies and link arm clevises of the bascule leaf, balance frame and towers such that the alignment wire runs horizontally through the holes in the steel girders and tower legs to be machined for the trunnion assemblies, holes in the crank arms to be machined for the hydraulic cylinder upper clevises, and through the holes in trunnion shafts, hydraulic cylinder clevises, and link arm clevises during field erection. The wire holding device shall include a shaft or wheel with a machined groove to maintain the position of the wire. The wire shall deflect over the shaft or wheel and support weight(s) to tension the wire and minimize catenary sag. The shaft or wheels shall include low-friction roller bearings to minimize frictional resistance from the deflected wire. Each of the shafts or wheels shall be supported on a bracket with means to accurately adjust the wire position vertically and horizontally to machine tolerances and then positively maintain the wire position once alignment has been achieved.
2. Use alignment wires during shop fabrication to accurately align milling equipment used to machine the portions of the bascule leaf, balance frame and tower structural steel that receive the trunnions, the portions of the balance frame and bascule leaf that receive the link arm clevises and the crank arms that receive the hydraulic cylinder upper clevises.
3. Use the alignment wires during field erection to establish and verify alignment of the trunnion shafts, hydraulic cylinder clevises, link arm clevises, and associated bearings.
4. Account for trunnion shaft deflection and catenary wire sag in the alignment. Compute the wire sag based on the wire span between supports, unit weight and tension. Verify wire catenary sag by survey.
5. Provide alignment wire with a diameter between 0.020 and 0.035 inches.

**CONSTRUCTION METHODS:**

- A.** Prepare and submit to the Engineer, for review and acceptance, procedures for construction of the bascule span including bascule leaf, balance frame, counterweight box, link arms, towers, and associated mechanical components, to the required alignment requirements. Procedures shall address: shop fabrication and assembly to the required alignment, including machining of structural steel components to receive the trunnion assemblies, link arm clevises and hydraulic cylinder upper clevises; safe erection including required temporary supports and span balance to the required alignment. Address the following in each of the required submittals, as applicable:

1. For installation and alignment procedures of structural steel components, have Supervisory Erector review and approve all associated submittals.

2. For installation and alignment procedures of mechanical components, have Supervisory Millwright review and approve all associated submittals.
3. Design, detail and submit for review and acceptance, temporary supports, tie-downs/tie-backs, shoring, falsework, jacking members and other similar elements used in the erection and alignment of the bascule span. Prepare and submit to the Engineer for review and acceptance, calculations and details of these components, signed and sealed by a Specialty Engineer registered in the State of Delaware.
4. Submit to the Engineer for review and acceptance, the following items:
  - a. Detailed shop fabrication, assembly and alignment procedures for the towers, bascule leaf, balance frame, counterweight box, and link arms that meet the requirements in Section 615 and herein.
  - b. Submit adjustment procedures for bascule girder end bearing assemblies, including live load shoe and masonry plate, that meet the requirements herein.
  - c. Temporary tie-downs/tie-backs, live load shoe supports, structural supports, and jacking devices and their arrangements that meet the requirements of Section 604 and herein.
  - d. Detailed field erection and alignment procedures including sequence for the towers, bascule leaf, balance frame, link arms, counterweight, and associated mechanical components. Construction sequence shall address and coordinate safe erection and alignment of the bascule span components and associated mechanical components, grouting and anchoring, temporary supports, tie-downs/tie-backs, jacking systems, and span balance. Install link arms and hydraulic cylinders and achieve an acceptable balanced condition prior to removal of the temporary supports, tie-downs/tie-backs, and jacking systems.
  - e. Detailed mechanical equipment installation and alignment procedures to be used by the millwright per Special Provision 615503 – Bridge Mechanical System.
  - f. Detailed shop drawings, installation procedures, calculations for catenary sag, measurement tools and equipment for alignment wires and associated wire holding devices, as required herein. A mockup device may be utilized in lieu of shop drawings. Detailed shop drawings, data and information for other alternative alignment devices, measurement tools and equipment, accepted by the Engineer.
  - g. Detailed measurement and recording procedures, associated documentation measurement devices, tools and equipment with sufficient data and information to demonstrate measurement accuracy consistent to the required tolerances. Submit catalog data and/or other information with the manufacturer's published accuracy and limitations on the accuracy. Demonstrate to the Engineer that the equipment will achieve the required accuracy by way of measurement tests.
  - h. Documentation of as-built dimensions of shop fabricated structural steel and mechanical components and assemblies, that demonstrate that specified alignment and fit between components are achieved. Account for as-built dimensions of the shop fabricated structural steel and mechanical components and constructed supporting piers, to adjust assemblies during erection to achieve an acceptable alignment. Submit to the Engineer verified as-built dimensions that deviate from the dimensions in the Plans and Shop Drawings and proposed adjustments, for review and acceptance. Make all measurement data available to the Engineer for review, upon request, at any stage during shop fabrication and assembly and field erection and assembly.
  - i. Provide detailed description of means and methods to be employed by the millwrights to achieve and verify alignment and fits to the specified tolerances for both shop and field activities.
  - j. Submit scope and schedule for periodic alignment verification checks.
  - k. Develop and submit forms to the Engineer for documentation of all measurements required herein. Compare actual alignment to specified alignment. Verify and document that alignment is within specified tolerances. Submit samples of the format used to record the measurements and any calculations used to adjust measurement data, where required, prior to permitting the associated work.

# 1. Certifications.

- i. For structural steel, provide documentation that the fabricator has the AISC Certified Steel Bridge Fabricator – Advanced Certification (ABR).
- ii. For fracture-critical bridges, provide additional documentation that the fabricator has the AISC Fracture Critical Endorsement.
- iii. For welding, all welders shall possess a current AWS welder's qualification card, which shall be available upon request at all times.

## B. Protection

1. Provide protection as necessary to prevent contaminants, including dust, debris and moisture, from settling upon or entering into mechanical, fluid power, or electrical components, during any stage of the work.
2. Prior to completion of bascule leaf live load shoe assembly, including placement and curing of masonry plate grout, do not permit live loads on the bascule leaf, when temporary supports are not in place. Do not permit bascule span support on anchor bolts prior to placement and curing of grout. Repair damaged anchor bolts and pedestals at no cost to the Department.

## C. Bascule Leaf Shop Fabrication and Assembly

### 1. Dimensional Controls

- a. Mark horizontal and vertical control lines on the bascule girder web plates through the heel trunnion centerline, as primary reference axes. Use the primary control lines to mark inclined control lines on the web at the centers of heel trunnion, each floorbeam, link arm clevis pin, live load shoe, and toe end, with the top and bottom offsets from the primary control lines consistent with the cambered profile. Use the control lines for accurate web cutting and subsequent fabrication. Control lines shall be within 0.060 inches of dimensions in the approved Shop Drawings.
- b. Prior to bascule leaf shop assembly, establish additional control points and control lines for use in establishing and maintaining alignment of the bascule leaf during shop assembly and subsequent erection. Control points shall consist of a combination of semi-permanent fixed points on the shop floor and corresponding permanent fixed points on the structural steel. Control lines shall connect the control points. Where applicable, use plumb lines between corresponding control points on the steel and floor to verify alignment.
- c. Control points on the shop floor shall consist of clearly marked and labeled targets on semi-permanent, rigid, and stable fixtures (e.g., clearly labeled punch marks on a steel plate securely bolted to a concrete floor). Mark control lines on the floor between control points. Alternatively, use intersecting alignment wires to establish the control points and control lines. If used, provide semi-permanent means to maintain and reestablish alignment wire locations in the event that a wire breaks or inadvertently moves.
- d. Control points on the structural steel shall consist of clearly labeled punch marks. Provide means of preserving the control points on the structural steel (e.g., masking), so that these points are readily identifiable following structural steel cleaning and metallizing/galvanizing and so that they may be used during erection to reestablish the shop alignment. Label each control point with a unique designation. Use low-stress die-stamps to minimize stress risers. Control lines on the steel shall consist of scribe lines between the control points. Preservation of the scribe lines is not required. However, it may be necessary to periodically reestablish the scribe lines. Establish these control point locations so that the control lines represent the best fit centerline of the fabricated members.
- e. Establish control points for the bascule leaf, at the following locations on both the floor and underside of the structural steel, using the horizontal dimensions from the approved Shop Drawings. Dimensions shall be consistent with members in their fully cambered profiles, which accounts for increased or decreased member lengths.

- i. Intersections of the centerline of each bascule girder and heel trunnion,
  - ii. Intersections of the centerline of each bascule girder and Floorbeam FB5 centerline,
  - iii. Intersections of the centerline of each bascule girder and centerline of the link arm lower clevis pin,
  - iv. Intersection of the centerlines of each bascule girder and Floorbeam FB0 centerline.
- f. Establish additional control points for the bascule leaf, at the following locations on both the floor and underside of the floorbeams or deck steel to establish the bascule leaf centerline, using the horizontal dimensions from the approved Shop Drawings:
- i. Intersection of a line parallel and midway between the bascule girders and the centerline of Floorbeam FB0,
  - ii. Intersection of a line parallel and midway between the bascule girders and the centerline of Floorbeam FB5,
  - iii. Intersection of a line parallel and midway between the bascule girders and the heel trunnion centerline.
- g. Establish additional control points along the centerline of the bascule girder top flanges and top of the steel deck plate along the bascule span centerline and both gutter lines, at the heel trunnion, centerline of each floorbeam, and centerline of the link arm clevis pin, for purpose of verifying elevations and vertical profile during assembly.
- h. Accurately locate floor and steel control points to within 0.060 inch (0.005 feet) of their specified theoretical dimensions.
- i. During shop assembly, using the series of control points, measure and record the following bascule span steel horizontal dimensions and verify that the dimensions are within specified plan dimensions including tolerances:
- i. Longitudinal distance between the centerline of the heel trunnion and centerline of Floorbeam FB0, at both bascule girders,
  - ii. Longitudinal distance between the centerline of the heel trunnion and centerline of Floorbeam FB5, at both bascule girders,
  - iii. Lateral distances between centerlines of bascule girders and between the bascule span centerline and centerlines of each bascule girder, at the heel trunnion, Floorbeam FB0, and Floorbeam FB5,
  - iv. Diagonal distances from the intersection of the heel trunnion centerline with the centerline of one bascule girder to the intersection of Floorbeam FB0 with the centerline of the opposite bascule girder (both diagonals).
- j. Measure and record elevations of the center of the heel trunnion at each bascule girder as a baseline reference elevation and verify that the dimensions are within specified tolerances.
- k. Prior to assembly, coordinate with the Engineer, independent verification of the locations of control points on the floor and steel.
2. Shop Assembly and Alignment
- a. Do not shop assemble the bascule leaf until the control points are properly established and verified. During layout and assembly, adjust the positions of the bascule girders until they are aligned within the specified tolerances, and aligned with the fabricated integral orthotropic steel deck and floorbeams. Take measurements of the control dimensions (i.e., distances between the control points) to verify alignment. As a minimum, measure and record control dimensions at the beginning and end of each working day that work is performed on the bascule leaf. Measure and verify the alignment by dropping plumb lines from the control points on the structural steel over the control points on the floor.



- b. Set and align the bascule girders, orthotropic deck and floorbeams above the assembly floor on falsework to the fully cambered profile. Provide falsework of substantial construction to limit the amount of displacement (horizontal and vertical) to less than 0.060 inch during the complete assembly. Adequately secure the falsework and bascule girders to minimize the risk of inadvertent movement during assembly. Do not use unsecured stacks of plate or other material to support or adjust the girder elevation. As a minimum, locate the supports near the toe, heel trunnion, and at a position mid-length between the heel trunnion and bascule girder toe. In addition, locate supports below each end of each floorbeam. Locate the supports offset from the control points to permit the use of plumb lines from the underside of the steel to the floor without interference. Brace members as required for stability. Provide and use jacks or other devices to adjust and align the bascule leaf components as required. Exercise care not to distort the steel members during jacking and locking in the distorted conditions. Upon request from the Engineer, demonstrate that the members are not distorted by temporarily releasing braces.
- c. Adjust the location of the bascule girders such that the control points on the bottom flanges will be located over the control points on the floor. Drop plumb lines from the control points on the structural steel to verify the location of the bascule girders with respect to the control layout on the floor. Locate the bascule leaf control points within 0.125 inch (measured horizontally) of the control points on the floor.
- d. Survey the elevations of control points on the top of the bascule girders and top of deck. Adjust the bascule girders such that the elevations at the control points are within 0.125 inch of their relative theoretical elevations. Locate the orthotropic steel deck relative to the bascule girders such that the top of the deck surfaces along the toe and heel joints are within 0.060 inch of the plan elevation and all other intermediate surfaces are within 0.125 inch of plan elevations.
- e. Align the webs of the bascule girders parallel to an accuracy that minimizes the amount of material removed during machining, while meeting the other bascule leaf alignment requirements herein, within the Plans, and Section 615 of the Standard Specifications.
- f. With the bascule girders aligned within specified tolerances and verified by the Engineer, establish the balance frame trunnion axis with an alignment wire as specified herein. Install and align the milling equipment to the alignment wire. Line bore the webs of the bascule girders to the specified alignment and fit for the trunnion bearing hubs. Coordinate the bore diameter and fits with the as-built dimensions of the trunnion hubs. Machine the faces of the webs to the specified flatness and perpendicularity requirements about the same alignment wire. See Plans for dimensional tolerances.
- g. Install the trunnion bearing hubs into the webs of the bascule girders using an approved shrink fit operation. Drill and ream holes, install and tension bolts for the heel trunnion hubs.
- h. Do not drill holes full size for any bolted connections until the alignment of the full bascule leaf assembly is verified and accepted by the Engineer. Maintain alignment of the components with a combination of drift pins and temporary bolts in undersized holes until all holes can be drilled and/or reamed full size. Use a minimum of two drift pins per connection. Denote the specific location of the drift pins on the shop drawings and document with photographs that the drift pins are as denoted in the shop drawings for use during field erection.
- i. Machine the top flange of the bascule girders to receive the link arm clevises and bottom flange of the bascule girders to receive the live load shoes to the specified flatness requirements in the Plans.

#### D. Balance Frame Shop Fabrication and Assembly

##### 1. Dimensional Controls

- a. Mark horizontal and vertical control lines on the balance frame main girder web plates through the counterweight trunnion centerline, as primary reference axes. Use the primary control lines to mark inclined control lines on the web at the centerlines of counterweight trunnion, each counterweight box vertical connection, bolted field splice (if utilized), intermediate and forward struts, and link arm

clevis pin, with the top and bottom offsets from the primary control lines consistent with the cambered profile. Use the control lines for accurate web cutting and subsequent fabrication. Control lines shall be within 0.060 inches of dimensions in the approved Shop Drawings.

- b. Prior to balance frame shop assembly, establish additional control points and control lines for use in establishing and maintaining alignment of the balance frame during shop assembly and subsequent erection. Control points shall consist of a combination of semi-permanent fixed points on the shop floor and corresponding permanent fixed points on the structural steel. Control lines shall connect the control points. Where applicable, use plumb lines between corresponding control points on the steel and floor to verify alignment.
- c. Control points on the shop floor shall consist of clearly marked and labeled targets on semi-permanent, rigid, and stable fixtures (e.g., clearly labeled punch marks on a steel plate securely bolted to a concrete floor). Mark control lines on the floor between control points. Alternatively, use intersecting alignment wires to establish the control points and control lines. If used, provide semi-permanent means to maintain and reestablish alignment wire locations in the event that a wire breaks or inadvertently moves.
- d. Control points on the structural steel shall consist of clearly labeled punch marks. Provide means of preserving the control points on the structural steel (e.g., masking), so that these points are readily identifiable following structural steel cleaning and metallizing/ galvanizing and so that they may be used during erection to reestablish the shop alignment. Label each control point with a unique designation. Use low-stress die-stamps to minimize stress risers. Control lines on the steel shall consist of scribe lines between the control points. Preservation of the scribe lines is not required. However, it may be necessary to periodically reestablish the scribe lines. Establish these control point locations so that the control lines represent the best fit centerline of the fabricated members.
- e. Establish control points for the balance frame, at the following locations on both the floor and underside of the structural steel, using the horizontal dimensions from the approved Shop Drawings. Dimensions shall be consistent with members in their fully cambered profiles, which accounts for increased or decreased member lengths.
  - i. Intersections of the centerline of each balance frame main girder and the centerlines of the counterweight box vertical connection points,
  - ii. Intersections of the centerline of each balance frame main girder and counterweight trunnion/trunnion strut centerline,
  - iii. Intersections of the centerline of each balance frame main girder and the intermediate strut centerline,
  - iv. Intersections of the centerline of each balance frame main girder and centerline of the link arm clevis pin,
  - v. Intersections of the centerline of each balance frame main girder and the forward strut centerline.
- f. Establish additional control points for the balance frame, at the following locations on both the floor and underside of the counterweight box, trunnion strut, intermediate strut and forward strut to establish the balance frame centerline, using the horizontal dimensions from the approved Shop Drawings:
  - i. Intersections of a line parallel and midway between the centerlines of the balance frame main girders and centerlines of the counterweight box vertical connections,
  - ii. Intersection of a line parallel and midway between the centerlines of the balance frame main girders and the centerline of the counterweight trunnion/trunnion strut,
  - iii. Intersection of a line parallel and midway between the centerlines of the balance frame main girders and the intermediate strut centerline,
  - iv. Intersection of a line parallel and midway between the centerlines of the balance frame main girders and a line through the centerline of the link arm clevis pins,

- v. Intersection of a line parallel and midway between the centerlines of the balance frame main girders and the forward strut centerline.
- g. Establish additional control points along the centerline of the top flanges of the balance frame main girders at the centerlines of the counterweight box vertical connections, counterweight trunnion/trunnion strut, bolted field splice, intermediate strut, link arm upper clevis pin, and forward strut, for purpose of verifying elevations and camber.
- h. Accurately locate floor and steel control points to within 0.060 inch (0.005 feet) of their specified theoretical dimensions.
- i. During shop assembly, using the series of control points, measure and record the following bascule span steel horizontal dimensions and verify that the dimensions are within specified plan dimensions including tolerances:
  - i. Longitudinal distances between centerline of counterweight trunnion/trunnion strut and the centerlines of the counterweight vertical connections, bolted field splice (if utilized), intermediate strut, link arm upper clevis pin, and the forward strut, at both balance frame main girders,
  - ii. Lateral distances between centerlines of balance frame main girders and between the balance frame centerline and centerlines of each of the balance frame main girders, at the centerlines of the counterweight vertical connections, counterweight trunnion, bolted field splice (if utilized), intermediate strut, link arm upper clevis pin, and forward strut,
  - iii. Diagonal distances from the intersection of the counterweight trunnion centerline with the centerline of one balance frame main girder to the intersection of the forward strut centerline with the centerline of the opposite balance frame main girder (both diagonals),
- j. Measure and record elevations of the center of the counterweight trunnion at each balance frame main girder as a baseline reference elevation and verify that the dimensions are within specified tolerances.
- k. Prior to assembly, coordinate with the Engineer, independent verification of the locations of control points on the floor and steel.

## 2. Shop Assembly and Alignment

- a. Do not shop assemble the balance frame until the control points are properly established and verified. During layout and assembly, adjust the positions of the balance frame main girders, and align with the counterweight box, counterweight trunnion/trunnion strut, intermediate strut and forward strut, within the specified tolerances. Take measurements of the control dimensions (i.e., distances between the control points) to verify alignment. As a minimum, measure and record control dimensions at the beginning and end of each working day that work is performed on the balance frame. Measure and verify the alignment by dropping plumb lines from the control points on the structural steel over the control points on the floor.
- b. Set the balance frame main girders above the assembly floor on falsework to the fully cambered profile. Provide falsework of substantial construction to limit the amount of displacement (horizontal and vertical) to less than 0.060 inch during the complete assembly. Adequately secure the falsework and balance frame girders to minimize the risk of inadvertent movement during assembly. Do not use unsecured stacks of plate or other material to support or adjust the girder elevation. As a minimum, locate supports near the heel, counterweight trunnion, intermediate strut, and forward strut of each balance frame main girder. In addition, locate supports below the counterweight box, and each end of the trunnion strut, intermediate strut and forward strut. Locate the supports offset from the control points to permit the use of plumb lines from the balance frame girders to permit the use of plumb lines from the underside of the steel to the floor without interference. Brace members as required for stability. Provide and use jacks or other devices to adjust and align the balance frame components as required. Exercise care not to distort the steel members during jacking and locking in the distorted conditions. Upon request from the Engineer, demonstrate that the members are not distorted by temporarily releasing braces.



- c. Adjust the horizontal location of the balance frame main girders such that the control points on the bottom flanges are located over the control points on the floor. Drop plumb lines from the control points on the structural steel to verify the location of the balance frame main girders with respect to the control layout on the floor. Locate the balance frame control points within 0.125 inch (measured horizontally) of the control points on the floor.
- d. Survey and record the elevations of control points on the top of the balance frame main girders. Adjust the balance frame main girders such that the elevations at the control points at the counterweight trunnion are within 0.060 inches and at all other locations are within 0.125 inches of their relative theoretical elevations.
- e. Align the balance frame main girders such that the outer trunnion strut flange surfaces are parallel to an accuracy that minimizes the amount of material removed during machining, while meeting the other balance frame alignment requirements herein, within the Plans, and the requirements of Section 615 of the Standard Specifications.
- f. Locate the counterweight box, intermediate strut, and forward strut relative to the balance frame main girders such that they are within 0.125 inch of plan dimensions and such that they properly fit-up with the balance frame main girders.
- g. With the balance frame main girders aligned within specified tolerances and verified by the Engineer, establish the balance frame trunnion axis with an alignment wire as specified herein. Install and align the milling equipment to the alignment wire. Line bore the holes in the trunnion strut flanges for the counterweight trunnions and holes in the crank arms for the hydraulic cylinder upper clevis bearings to the specified alignment and fits. Coordinate the bore diameter and fits with the as-built dimensions of the trunnion hubs and bearings. Machine the faces of the trunnion strut flanges and crank arms to the specified flatness and perpendicularity requirements relative to the same alignment wire. See Plans for dimensional tolerances of trunnion and hub assemblies.
- g. Install the trunnion hubs and shafts into the trunnion strut flanges and the hydraulic cylinder upper clevis bearings into the crank arms using approved shrink fit procedures. Drill and ream holes, install and tension bolts for the counterweight trunnion hubs.
- h. Machine the surfaces of the inner trunnion strut flanges to the specified flatness and parallelism. Install the inner trunnion strut between the outer trunnion struts. Adjust shims between the flanges as required for proper fit-up.
- i. Do not drill holes full size for any bolted connections until the alignment of the full balance frame assembly is verified and accepted by the Engineer. Maintain alignment of the components with a combination of drift pins and temporary bolts in undersize holes until all holes can be drilled and/or reamed full size. Use a minimum of two drift pins per connection. Denote the specific location of the drift pins on the shop drawings and document with photographs that the drift pins are as denoted in the shop drawings for use during field erection.
- j. Machine the bottom surfaces of the balance frame main girder flanges to receive the link arm clevises to the specified flatness requirements.

#### E. Tower Shop Fabrication and Assembly

##### 1. Dimensional Control Points

- a. Mark a series of primary and secondary control lines on the tower web plates for accurate web cutting. Primary control lines shall be located along the centerlines of the tower legs and struts and a series of secondary control lines shall be perpendicular to and reasonably spaced, no more than 2.0 feet apart, along the primary control lines with offsets to each edge to define the web cutting geometry. Control lines and offsets shall be within 0.060 inches of dimensions in the approved Shop Drawings.
- b. Prior to shop assembly of the towers, establish additional control points and control lines for use in establishing and maintaining the alignment of the tower during shop assembly and subsequent

erection. Control points shall consist of permanent fixed points on the structural steel and corresponding control lines between the control points, to permit convenient daily verification of the tower alignment during fabrication.

- c. Control points on the shop floor shall consist of clearly marked and labeled targets on semi-permanent, rigid, and stable fixtures (e.g., clearly labeled punch marks on a steel plate securely bolted to a concrete floor). Mark control lines on the floor between control points. Alternatively, use intersecting alignment wires to establish the control points and control lines. If used, provide semi-permanent means to maintain and reestablish alignment wire locations in the event that a wire breaks or inadvertently moves.
- d. Control points on the structural steel shall consist of clearly labeled punch marks. Provide means of preserving the control points on the structural steel (e.g., masking), so that these points are readily identifiable following structural steel cleaning and metallizing/ galvanizing and so that they may be used during erection to reestablish the shop alignment. Label each control point with a unique designation. Use low-stress die-stamps to minimize stress risers. Control lines on the steel shall consist of scribe lines between the control points. Preservation of the scribe lines is not required. However, it may be necessary to periodically reestablish the scribe lines. Establish these control point locations so that the control lines represent the best fit centerline of the fabricated members.
- e. Establish control points on the floor at the intersections of the centerlines of the forward and rear tower leg bases in each direction, using the dimensions from the approved Shop Drawings.
- f. Establish control points, at the following locations on the tower structural steel, using the dimensions from the approved Shop Drawings:
  - i. Each end of the centerlines of each forward tower leg through the centerline of the bascule leaf heel trunnion and balance frame counterweight trunnion, marked on the tower leg web plates and extended to the bottom of the tower leg base plates,
  - ii. Each end of the centerlines of each rear tower leg through the centerline of the balance frame counterweight trunnion and the centerline of the tower base, marked on the tower leg web plates and extended to the bottom of the tower leg base plates,
  - iii. Each end of a line through the bascule leaf heel trunnion, perpendicular to the tower leg centerlines, marked on the tower leg web plates,
  - iv. Intersection of the centerlines of each tower leg and the tower strut, marked on the tower leg web plates,
  - v. Each end of the centerlines of both tower legs, in line with the centerline of the balance frame counterweight trunnion bearing, marked on the tower leg flanges and extended to the bottom of the tower leg base plates,
  - vi. Each end of the centerlines through the center of the counterweight trunnion bearing in both directions, marked on the top of tower base plate,
  - vii. Each end of the centerlines of both tower legs, in line with the centerline of the hydraulic cylinder lower clevis, marked on the tower leg flanges,
  - viii. Each end of the centerlines through the center of the hydraulic cylinder lower clevis in both directions, marked on the hydraulic cylinder support plate.

## 2. Shop Assembly and Alignment

- a. Shop assembly of the entire bascule span including towers, balance frame, counterweight, bascule leaf and link arms is not required. However, shop assembly of the pair of towers in the upright position is required to machine the towers together as a unit. Do not shop assemble the trunnion towers until the control points are properly established and verified. During shop assembly, set-up the pair of towers in the upright position, adjacent and parallel to each other. Adjust the towers until they are plumb and spaced apart to each other within the specified tolerances. Towers may be shop assembled closer together than the offset distance shown in the Plans but must be parallel and at a

consistent offset distance within tolerances. Measure and record the plumbness of the control lines along both tower leg flanges, plumbness of the control lines along rear tower leg webs, and distances between the control lines along the tower leg flanges of adjacent towers. As a minimum, measure and record control dimensions at the beginning and end of each working day that work is performed on the towers. Measure tower plumbness by survey or by dropping plumb lines from the control points from the tops of the towers and measure the offset from the plumb lines to the control lines at the bottom of the towers.

- b. Set the trunnion towers above the floor on falsework. Provide falsework of substantial construction for stability. Adequately brace the towers to minimize the risk of inadvertent movement during assembly. Do not use unsecured stacks of plate or other material to support or adjust the tower alignment. Provide and use jacks or other devices to adjust and align the towers as required. Exercise care not to distort the steel members during jacking and locking in the distorted conditions. Upon request from the Engineer, demonstrate that the members are not distorted by temporarily releasing braces.
- c. Adjust the location of the trunnion towers such that the control points on the tower leg bases are located over the control points on the floor. Drop plumb lines from the control points at edges of the tower leg bases to the control lines on the floor in each direction to verify the location of the tower members with respect to the control layout on the floor. Verify that the control points on the tower leg bases are within 0.125 inches (measured horizontally) of the control lines on the floor.
- d. Set and align the towers such that the webs of the tower legs to receive the bascule leaf heel trunnions are plumb and parallel to an accuracy that minimizes the amount of material removal during machining. At all other locations set and align the tower legs plumb to within 0.030 inches per foot and offset within the tolerances shown in the Plans and Section 615 of the Standard Specifications. The permissible rotation/tilt of the spherical plain bearings and shims for the counterweight trunnions and hydraulic cylinder clevises accommodate normal structural steel tolerances.
- e. With the towers aligned within specified tolerances and verified by the Engineer, establish the bascule leaf heel trunnion axis in the forward tower legs with an alignment wire as specified herein. Install and align the milling equipment to the alignment wire. Line bore the holes in the tower leg webs to the specified alignment and fits. Coordinate the bore diameter and fits with the as-built dimensions of the trunnion hubs. Machine the faces of the webs to the specified flatness and perpendicularity requirements. See Plans for dimensional tolerances.
- f. Install the bascule leaf heel trunnion bearing hubs into the webs of the tower leg web plates using an approved shrink fit operation. Drill and ream holes, install and tension bolts for the heel trunnion hubs.
- g. Machine the top surfaces of the hydraulic cylinder clevis support plates and the top surface of the top of tower base plates for the counterweight trunnion bearings to the specified flatness requirements.
- h. Do not drill holes in the top of tower base plate for the counterweight trunnion bearings until field erection. Leave the base plate blank until erection to maximize field adjustment and alignment. The oversized holes in the tower leg base plates for the anchor bolts may be drilled.

## F. Link Arm Shop Fabrication and Assembly

### 1. Dimensional Control Points

- a. Fabricate the link arms and pairs of upper and lower clevises and clevis pins in accordance with the approved Shop Drawings.
- b. Separately bore the holes in the clevis blades to the specified fit with the clevis bearings and pins, as shown in the Plans. Mill the surfaces of the clevis blades for the specified flatness and perpendicularity requirements, relative to the bore holes, as shown in the Plans. Mill the surfaces of the clevis bases to the flatness and parallelism requirements, as shown in the Plans. Mill the surfaces of the link arm end plates to the flatness and perpendicularity requirements, relative to the axis of the link arm tube.

- c. Insert the bearing bushings into the clevis blades using an approved shrink fit installation procedure.

## 2. Shop Assembly and Alignment

- a. Drill and ream the holes for the bolts that connect the link arm clevises to the link arm tube end plates.
- b. Bolt the link arm upper and lower clevises to the link arm tube end plates with the specified nominal shims and turned bolts. Do not tension the turned bolts until erection, after final alignment has been verified and approved by the Engineer.

## G. Bascule Span Field Erection and Alignment

1. In addition to other functional and operational conditions specified in the Contract Documents, bascule span will be considered satisfactory when all of the following alignment conditions are achieved for the completed span:
  - a. Alignment Condition No. 1 (Bascule Leaf Heel Trunnions, Balance Frame Counterweight Trunnions, and Link Arm Upper and Lower Clevis Pins): The four pivot axes for the bascule leaf heel trunnions, balance frame counterweight trunnions, and link arm upper and lower clevis pins establish a pair of parallelograms, each within a plane that encompasses the trunnion and link arm bearings on one side of the roadway. The four pivot axes for each parallelogram, established using alignment wires or other approved means and methods, shall be aligned, in both the lowered and raised positions, within the tolerances specified in the Plans, including horizontal and vertical distances between pivot axes and angles between lines that connect the pivot axes. In addition, the lateral distances of the centers of the bearings, shall be offset from a theoretical bridge centerline within the specified tolerances in the Plans.
  - b. Alignment Condition No. 2 (Bascule Leaf and Approach Spans): Opposing surfaces of deck, curbs and traffic railings, at the joints between the bascule leaf and approach span shall align vertically and horizontally, within 0.125 inches, when the bridge is completed and in the lowered (seated) position, with the live load shoes (bearing shoe and masonry plate) properly adjusted with equal reactions, the centering device aligned with no contact and approximately equal gap between shoes on each side, and span locks driven with no contact between the lock bars and receiver shoes.
  - c. Alignment Condition No. 3 (Bumper Blocks and Hydraulic Cylinders): Hydraulic cylinders shall be aligned with specified minimum reserve stroke at each end of travel in both the fully raised and fully lowered conditions, and with the specified gap at the bumper blocks shown in the Plans.
  - d. Alignment Condition No. 4 (Bascule Leaf Heel Trunnions and Balance Frame Counterweight Trunnions): The radial deviation of the centerline of each end of the bascule leaf heel trunnions and balance frame counterweight trunnions relative to the established axes of rotation using an alignment wire, as specified herein, shall not exceed 0.010 inches, with the trunnions in the unloaded condition, (i.e., prior to transfer of load to the trunnions and corresponding trunnion shaft deflection).
  - e. Alignment Condition No. 5 (Live Load Bearings): Live load bearings shall achieve uniform line contact between the bearing shoe and masonry plate across the width of the bearings, with approximately equal dead load reaction on the bearings.
  - f. Alignment Condition No. 6 (Centering Device): After the bascule leaf alignment has been verified and approved, and the centering device installed and aligned, verify that there is equal clearance of 0.060 inches between the shoes on each side.
  - g. Alignment Condition No. 7 (Span Lock Assembly): After the bascule leaf alignment has been verified and approved, and span lock assemblies installed and aligned, verify that the clearance between the lock bars and shoes is as specified in the Plans.

## H. Construction Sequence, Field Erection and Alignment Concepts

1. General: The suggested construction sequence in the Plans is supported by the following narrative that expands upon these assumed general erection and alignment premises .

- a. After the substructure construction is complete, with blockouts for the tower anchor bolts, anchor bolts for the towers are to be installed, temporarily supported and secured from movement into the precast footing caps, and accurately aligned by survey and templates. The anchor bolt locations and alignment are to consider and be adjusted for as-built dimensions. After the anchor bolt alignment has been verified and accepted by the Engineer, the anchors are to be grouted within the blockouts.
- b. Towers are to be shipped to the site by barge and erected by a crane staged on either the west embankment or on a barge, with the channel temporarily closed for navigation. The towers are to be set on top of the bascule pier footing caps in the upright position, over the anchor bolts, and temporarily supported on leveling bolts or jacks and blocking and stabilized with temporary braces. Once the towers are secure, the channel may be reopened for navigation. The towers are to be adjusted vertically, leveled and plumbed using either leveling bolts or jacking and blocking and adjusted horizontally with jacks and blocking. Tower alignment is to be verified with a combination of accurate survey, using the tower control points and control lines, and alignment wires for the bascule leaf heel trunnion and balance frame counterweight trunnion. The tower locations and alignment are to consider and adjust for as-built dimensions. After tower alignment is verified and accepted by the Engineer, the tower bases are to be grouted. After the grout has fully cured, the leveling bolts, jacks and blocking, and braces are to be removed.
- c. The bascule leaf is to be shipped to the site on a barge, as one complete assembly, with the trunnion bearings installed into the bascule girders. With the channel temporarily closed for navigation, the bascule leaf is to be erected in the horizontal position by a pair of cranes, with one staged on the west embankment and one staged on either the east embankment or a barge. Alternatively, the bascule leaf may be floated into position on sectional barges, configured to fit between the bascule pier and rest pier. The bascule leaf is to be temporarily supported at the bascule pier and rest pier on jacks and blocking. The bascule leaf is to be adjusted vertically and horizontally with the jacks and blocking, until the trunnion bearings in the bascule girders are properly aligned with the bore holes in the tower forward legs for the trunnion shafts, using an alignment wire. The trunnion assemblies are then to be installed into the tower forward legs and trunnion bearings in the bascule girders. The bascule leaf is then to be rotated to the raised position with a crane staged on the west embankment and secured with temporary tie-backs attached near the toe end of the bascule leaf and anchored to the abutments. Once the bascule leaf is raised and secured, the channel may be reopened for navigation.
- d. A temporary erection tower, with jacks and blocking, is to be erected on the west embankment below the counterweight. The balance frame components are to be shipped to the site on trucks or barge and erected as separate components. Alternatively, the balance frame may be shipped by barge as one complete assembly or two assemblies, separated at the optional bolted field splice in the main girders, and erected as larger assemblies. With the channel closed to navigation, the bascule leaf is to be lowered, using a crane, staged on the west embankment, with the toe supported at the rest pier on jacks and blocking. The counterweight box is to be erected in the horizontal position, by a crane staged either on the west embankment or on a barge and supported on the temporary erection tower, adjusted and aligned, as required, with jacks and blocking. The balance frame main girders are to be erected in the horizontal position, by a crane staged on the west embankment and/or a barge with the trunnion bearings mounted on the trunnion shafts. The main girders are to be pinned and bolted to the counterweight box with temporary undersize bolts, while supported by the crane, and trunnion bearings supported on top of the towers. The inner section of the trunnion strut, intermediate strut, and forward strut are then to be erected, by a crane staged on the west embankment, barge and/or east embankment, pinned and bolted with temporary undersize bolts to the main girders. The balance frame assembly is then to be adjusted vertically and horizontally using the jacks and blocking at the temporary erection tower and at the trunnions, until properly aligned. Balance frame alignment is to be verified with a combination of accurate survey, using the control points and control lines, and an alignment wire for the trunnions. Shims at the trunnion bearing bases are to be adjusted as required. Once alignment is verified and accepted by the Engineer, holes for the trunnion bearing bases are to be drilled and reamed to full size, and full size bolts installed in all the connections and tightened. Steel or lead and concrete ballast and balance blocks are to be installed in the counterweight box, and balance blocks installed in the adjustment pockets. As-built geometry of the trunnions and upper clevis attached to the balance frame are to be verified with accurate survey, using the control points,

control lines, and alignment wires. The lower clevises on the bascule girders are then to be installed, surveyed and accurately aligned, bolt holes drilled and reamed, and bolts installed and tensioned. Link arms are to be adjusted to required lengths using the clevis shims, bolts installed and fully tensioned. Link arms are then to be connected to the upper and lower clevises. The temporary erection towers are to be removed. The bascule span is then to be rotated to the raised position, using a crane staged on the west embankment, and secured with temporary tie-backs, anchored to the abutments. Once the bascule span is raised and secured, the channel may be reopened for navigation.

- e. Lower clevises for the hydraulic cylinders are to be installed, accurately surveyed relative to the crank arm bearings, adjusted and aligned, to provide the required reserve stroke at each end of travel. Hydraulic cylinders are then to be installed and connected to the lower clevises and crank arms. Hydraulic cylinder drive system and electrical power and controls is then to be tested and commissioned. Bascule span is then to be raised and lowered as required. Preliminary and final span balance testing is to be performed using pressure transducers on the hydraulic cylinders and a data acquisition system. Balance blocks are to be adjusted. Bumper blocks are to be adjusted. Live load bearing assemblies are to be installed, dead load reactions equalized, and adjusted. Centering devices are to be installed, aligned and shoes adjusted. The approach span superstructure precast, prestressed concrete slabs and cast-in-place concrete deck and curbs, abutment backwalls, and steel traffic railings, are to be constructed and aligned with the corresponding bascule leaf deck curbs and traffic railings.
2. The following falsework is anticipated for the bascule span erection:
    - a. Tower Temporary Support, Stabilization and Adjustment: Design, detail and provide temporary falsework consisting of leveling screws, jacks and blocking, and braces for support, adjustment and alignment of the towers during erection, in accordance with Section 604. Falsework shall remain in place until the specified alignment has been verified, accepted by the Engineer, and grout installed below the tower bases and cured.
    - b. Bascule Leaf Temporary Support and Adjustment: Design, detail and provide temporary falsework consisting of temporary jacks and blocking at the rest pier and bascule pier for support, adjustment and alignment of the bascule leaf during erection, in accordance with Section 604. Falsework shall remain in place until the specified alignment has been verified, accepted by the Engineer, and the trunnion assemblies and live load bearings have been installed.
    - c. Balance Frame Temporary Support and Adjustment: Design, detail and provide temporary falsework consisting of erection towers below the counterweight, jacks and blocking on the erection towers and towers by the trunnion bearings for support, adjustment and alignment of the balance frame components during erection, in accordance with Section 604. The falsework shall remain in place until the specified alignment has been verified by the Engineer, all connections have been properly bolted, link arms installed, counterweight ballast installed, and bascule span is in an acceptable balanced condition.
    - d. Bascule Leaf/Span Temporary Restraint: Design, detail and provide temporary tie-downs/tie-backs to secure the raised bascule leaf and/or bascule span, in accordance with Section 604.
  3. Alignment Pins and Temporary Undersize Bolts: Use alignment pins and temporary undersize bolts in the bolted connections until alignment of the assemblies have been verified and accepted by the Engineer. Provide a minimum of two alignment pins per connection. Document the location of the alignment pins in the shop, so that alignment pins can be installed in the same locations in the field, to repeat shop alignment. Replace temporary undersize bolts with full size bolts and properly tension, with the alignment pins in place. Only replace the alignment pins with full size bolts after all other bolts in the connections have been installed and tensioned.
  4. Counterweight Ballast: Install lead, steel and/or concrete ballast in the counterweight box only after erection of all balance frame struts, and after balance frame alignment has been verified and accepted by the Engineer, and while the counterweight box is supported on the temporary erection tower. Verify the amount and location of lead or steel ballast in the counterweight box and document before concrete ballast placement. Measure and record the unit weight of counterweight concrete before placement. Only place concrete if the unit weight is within the specified tolerance.



## 5. Alignment Wire Calibration Procedure

- a. Install alignment wire holding devices in accordance with the approved shop drawings and procedures.
- b. Install the alignment wire onto the wire holding devices and corresponding supports attached to one or both ends of the wire for weights used to tension the wire.
- c. Estimate the maximum safe weight that the wire can support, calculated as 80% of the weight required to exceed the wire tensile strength.
- d. Verify the maximum safe weight by incrementally adding a small amount of weight until failure of the wire occurs. Measure and record the weight and corresponding maximum tension in the wire at the point of failure. Use 80 percent of the weight that resulted in wire failure as the maximum safe weight.
- e. Utilize the maximum safe load to compute catenary sag of the wire. Verify the sag by way of accurate survey.

## 6. General Erection and Alignment Requirements

- a. Monitor and record trunnion alignments a minimum of twice daily at the beginning and end of any work day erection operations are performed on the bascule span and prior to any critical operations that may lock in alignment such as final bolting and placement of counterweight concrete.
- b. Use component match marks and as-built dimensions, established during shop assembly, and corresponding documentation for reestablishment of component pieces in the same locations and orientation and same alignment in the shop.
- c. Account for temperature movement from corresponding points of restraint in evaluation of alignment. To minimize the effects of temperature movement, alignment verification is best performed similar times each day with similar temperature conditions, such as early morning or late afternoon, when the effects of the sun are lessened.

## 7. General Erection Sequence and Alignment

- a. See the Construction Sequence in the Plans for a suggested field erection sequence and alignment operation. Develop and submit to the Engineer for review and acceptance, a proposed erection and alignment procedure, consistent with and in accordance with requirements herein, the Plans, Special Provision 615503 – Bridge Mechanical Systems, Specifications Sections 615 and 604.

## 8. Span Balance

- a. Achieve the specified bascule span balanced condition in accordance with Special Provision 615503 – Bridge Mechanical System.

## 9. Live Load Bearing Equalization

- a. Achieve approximately equal reactions on the live load bearings using the following procedure:
  - i. Perform live load bearing adjustments with the bascule span in the specified final balanced condition, with a combined dead load reaction on the bearings of approximately 4 kips. See Special Provision 615503 – Bridge Mechanical System.
  - ii. Bolt the steel bearing shoes to the underside of the bascule leaf main girders using full nominal shims. Temporarily support the masonry plates on leveling bolts and adjust until the tops are both at the specified elevation and aligned to produce uniform contact with the bearing shoes. Do not install non-shrink grout between the masonry plate and pier until after equal reactions and proper bearing contact alignment is achieved.
  - iii. Verify that the hydraulic cylinders are released with no pressure and full support on the temporary jacks.

- iv. Set the tip end of the bascule leaf on temporary jacks supported on the rest pier and symmetrically located each side of the bascule span centerline. Lift the tip end of the bascule leaf with the jacks until there is approximately 1.0 inch of clearance between the bearing shoe and masonry plate. Insert a temporary 0.5-inch thick plate on top of the north masonry plate.
- v. Lower the tip end of the bascule span with the jacks until the north bearing shoe is fully supported on the temporary plate. Measure the clearance (Cs) between the south masonry plate and corresponding bearing shoe.
- vi. Raise the bascule span with the jacks, approximately 1.0 inch, remove the temporary 0.5-inch plate, and insert it on top of the south masonry plate.
- vii. Lower the tip end of the bascule span with the jacks until the south bearing shoe is fully supported on the temporary plate. Measure the clearance (Cn) between the north masonry plate and corresponding bearing shoe.
- viii. If the measured clearances, Cs and Cn, are equal, no additional adjustments to the live load bearings are required to achieve equal reactions. If Cs is greater than Cn, insert additional shims at the south bearing shoe with a thickness,  $T_s = (C_s - C_n)/2$ . If Cn is greater than Cs, insert additional shims at the north bearing shoe with a thickness,  $T_n = (C_n - C_s)/2$ .
- ix. Repeat this procedure, making further shim adjustments in a similar manner, until Cn equals Cs, which signifies that equal reactions are achieved.
- x. Once equal adjustments are achieved, make equal shim adjustments to the two live load bearings to raise or lower to the tip end of the bascule span until the deck is at the specified elevation and aligned with the approach span deck.
- xi. Verify that the specified uniform bearing contact has been achieved, which is considered 80 percent line contact across the width of the bearing. The bearing will be in contact if a 0.002-inch feeler gauge cannot be inserted between the bearing shoe and masonry plate. If required, adjust the masonry plate leveling bolts, to achieve uniform contact before grouting. If adjustments are made to the shims or masonry plate leveling bolts, perform the live load bearing equalization procedure again. If the masonry plates have already been grouted and uniform contact is not achieved, provide and install tapered shims as required to achieve the contact, at no additional payment from the Department.

#### **METHOD OF MEASUREMENT:**

A. The Department will not measure the Bascule Span Shop Fabrication, Shop Assembly, and Field Erection and Alignment work described in this Section.

#### **BASIS OF PAYMENT:**

A. No separate payment will be made for the Bascule Span Shop Fabrication, Shop Assembly, and Field Erection and Alignment work described in this Section. The Department will pay for this work as part of Item No. 615001 Steel Structures.

### **21. THERMALLY SPRAYED (METALLIZED) STRUCTURAL STEEL**

#### **DESCRIPTION:**

The work under this section consists of the application of a thermal spray coating TSC (i.e. metallizing) as part of a three-coat paint system to specified structural steel components.

For structural steel that is metalized per this Technical Special Provision, the metallizing is equivalent to the "prime" coat as defined in the Standard Specifications, the seal coat (epoxy sealer) is equivalent to the

“intermediate coat” defined in the Specifications and the top coat (aliphatic polyurethane) is equivalent to the “finish coat”. Note that the interior of closed steel sections to be metallized in stages shall also receive the seal coat but will not receive a top coat. Provide finish coat color per the requirements of the Contract Documents.

## **MATERIALS:**

### **A. Quality Assurance**

1. The Contractor’s QC/QA Specialist shall provide quality assurance and shall be responsible for testing the production target bond strength during the preliminary tests for the TSC. The Specialist shall oversee the quality of the metallizing, and shall train the Contractor’s and Department personnel in performing the required QC testing. The Specialist shall also conduct random QA testing on a minimum of 50% of the components metallized in the Specialist’s absence. These random tests shall be in addition to the tests specified in “Test Sections” sub-article of this Technical Special Provision. Random testing shall be conducted at a minimum frequency of once every 15 days during the period when metallizing work is performed and satisfactory approval shall be required for partial payments of the metallizing work when applicable. The Specialist shall provide periodic updates directly to the Engineer regarding the quality of the work.

### **B. Quality Control Plan**

1. Submit to the Department for approval a QC/QA Plan certified by the QC/QA Specialist and approved by the Contractor for the work. Such plan shall include method of verifying cleanliness, testing anchor profile, bond, thickness, texture equipment for testing, and methods of ensuring calibration of such equipment. The Specialist shall also provide a final report to the Engineer describing the general characteristics of the metallizing work for the project including the thickness and bond strength results for each metallized component. Report and all collected data shall be in typed form and a digital version of the report must be provided along with 4 bound hard copies. Submit the Quality Control Plan for approval prior to commencing any of the fabrication work.
2. Submit a separate Quality Control Plan and certifications for the applications of the finish coats system as required by Section 616 except for items with different requirements included in this Special Provision.

### **C. Certifications**

1. Submit Manufacturer Certification of Compliance with the Contract Documents for metallizing and paint system materials and a Contractor’s Certification for Proper Application.
2. Perform all required quality control testing for the materials and/or application with verification by the Engineer and/or the QC/QA Specialist.
3. Only use manufacturer certified materials or materials from a Department approved source as applicable.
4. Submit certification from the manufacturer for the metallizing wire. Certification of the wire shall indicate chemical composition, wire diameter, lot number, manufacturing date and relative manufacturing data where applicable.
5. Provide manufacturer certification indicating that the paint system is compatible for application over thermally applied coating substrates in addition to the requirements of Section 616.
6. Primers for faying surfaces and inaccessible areas shall meet the requirements of Section 616.
7. Provide manufacturer’s technical specifications for the blasting, metallizing and testing equipment. Application and testing equipment shall be approved by the Department prior to use. Provide calibration certificate for all testing equipment.

### **D. Thickness Measurements**

1. Coating thickness measurement for metallizing shall be made using a coatings thickness gauge meeting the requirements of SSPC-PA 2 – Type 2. Obtain thickness measurements by averaging the results of a minimum of 5 readings obtained at 1 inch intervals. Establish a frequency of readings as specified in NACE 12/AWS C2.23/SSPC-CS 23 Joint Standard (2016), article 7.1.5.

#### E. Bond Strength Measurements

1. Pull-off tests for metallizing shall be conducted using a self-aligning adhesion tester as per ASTM D 4541 – Test Method E (Type V tester) using 20 mm dollies. Pull-off strength requirements for production acceptance shall be a minimum of 90% of the target value of 700 psi.
2. A bond test shall consist of three spot tests within the same area and the results of each averaged to provide the bond test result. Provide all equipment and materials necessary to perform all QC Testing as required by this Technical Special Provision.
3. Do not conduct acceptance production tests to coating failure when the measured bond strength has exceeded the minimum target strength for production.
4. Remove test dolly and adhesive prior to sealcoat application. Re-metallize areas tested to coating failure.

#### F. Soluble Salts Test

1. Test for soluble salts using an extraction method in accordance with SSPC-Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts and Other Nonporous Substrates.
2. Use a Class A Retrieval Method. Ensure that the test sleeve or cell creates a sealed, encapsulated environment during ion extraction and is suitable for the testing of the following steel surfaces: horizontal, vertical, smooth, pitted, and rough.

#### G. Blast Material

1. Blast material must be plant packaged and maintained in a clean and dry condition at all times. Material stored in blast pots overnight shall not be used.
2. Recycled material shall be inspected on a daily basis and replaced when the original physical properties cannot be documented after testing.
3. Provide a copy of the daily test reports to the Engineer. Angular blast media and surface testing shall conform to the requirements of NACE 12/AWS C2.23/SSPC-CS 23 Joint Standard (2016), article 5.3. Angular blast media shall be steel grit, evaluated per SSPC-AB 3 for new abrasive material. If abrasive material is to be recycled, the abrasive material must be evaluated prior to each reuse per the requirements of SSPC-AB 2.
4. Provide a copy of the material safety data sheet (MSDS) for the blasting material(s) to the Engineer prior to performing any blasting.

#### H. Anode Wire

1. The metallizing material shall be 85/15 Zn/Al alloy produced in wire form which can be molten and sprayed with the equipment described in this specification. The wire shall be available on a commercial basis and meet the requirements of ASTM B833.

#### I. Bend Test

1. A Bend Test shall be conducted at the beginning of each work shift or crew change. Carbon steel coupons of approximately 2" x 4"-8" x 0.05" thick shall be used. Surface preparation shall be according to this Special Provision for base metal. The test shall be conducted as follows:
  - a. Spray 10-mil to 15-mil thick metalizing in crossing passes, laying down approximately 3 to 4 mils for each pass.
  - b. Bend coupons 180° around a 0.5-in. diameter mandrel.
  - c. Bend test passes if there is no cracking or only minor cracks with no spalling or lifting by a knife blade from the substrate.
  - d. Bend test fails if the coating cracks with lifting by a knife blade from the substrate.
2. Perform bend test on coupons without sealant coats.

**J. Job Reference Standard (JRS)**

1. Provide a pass/fail job reference standard plate per NACE 12/AWS C2.23/SSPC-CS 23 Joint Standard (2016), section 7 for every type of steel shape to be metalized. Apply a clear coat over the standard to preserve its condition for the duration of the project. Prepare all standards in advance of production metallizing.
2. For steel assemblies having acute angles between structural components to be metalized after assembly, a similarly scaled steel blasted mockup must be put together simulating the angles encountered. The coating applicator shall be required to metalize this mockup, disassemble and perform adhesion testing on the metalizing in the acute angle. If the mockup fails the adhesion test, the applicator must change the application technique and/or adjust equipment to obtain proper adhesion results, thickness measurements and appearance requirements in acute angles.

**K. Job Control Record (JCR)**

1. The Contractor is required to keep a Job Control Record, detailing the essential job information and the in-process quality control checkpoints required by this Special Provision. Within the JCR include information on safety precautions, and the equipment, parameters, and procedures for surface preparation, thermal spraying, and sealing.

**L. Additional Tests**

1. Any testing required for accidental damages shall be secured by the Contractor at no cost to the Department. Other testing may be required as further described in this Technical Special Provision.

**CONSTRUCTION METHODS:****A. Shop Application**

1. When possible, complete surface preparation, metallizing and metallizing application services, seal coat application, and top coat application (all painting) in the same fabrication shop.
2. No field metallizing or painting will be permitted except for required touch-ups and areas specifically designated.

**B. Field Application**

1. Bearing/faying surfaces shall be metalized only. These areas shall be properly masked prior to application of the seal coat to prevent reduction of the slip coefficient by the paint system.
2. Field application of the seal and top coats will be required around the bearing/faying areas after the structural component is installed and loaded.
3. Field application will require the application of caulking around the bearing assemblies and faying surfaces prior to the application of the field seal and top coats.
4. Use caulks as described in the DelDOT Specifications for paint systems.

**C. Qualifications****1. Metallizer**

- a. Provide evidence of a minimum of 3 years of previous verifiable experience in providing surface preparation for metallizing and metallizing application.
- b. Provide evidence of completion of at least three similar bridge projects within the past 5 years and provide documentation with description of the projects and contact information for such projects.
- c. The Superintendent must show a certified experience record indicating at least 3 years of experience on work of similar type. Determination of satisfactory qualifications will be at the sole discretion of the Department.

## 2. Paint Specialist

- a. Make arrangements with a coating manufacturer to assist in the determination of suitable seal and top coat (paint) system to be used. Such paint coating materials shall be suitable for spraying over metallizing and shall be approved by the Department.

## 3. Quality Control / Quality Assurance (QC/QA) Specialist

- a. Secure the services of a NACE or SSPC-QP 6 certified Coatings Specialist to provide quality assurance of the overall application of the TSC. Such specialist shall have a minimum of 5 years of certifiable experience in the inspection of TSC on steel and a minimum of 5 years of experience in the field of corrosion control coatings and blast cleaning on steel structures. Alternatively, a Registered Professional Engineer meeting similar requirements as for the certified Coatings Specialist; a corrosion practitioner with a minimum of 5 years of experience on inspection of TSC and 15 years of verifiable experience in the field of corrosion control on steel structures; or a NACE certified Cathodic Protection Specialist with 5 years of metallizing inspection experience may be acceptable. The QC/QA Specialist shall be independent and shall not be associated with the Contractor, Sub-Contractor, or a manufacturer/distributor of any of the metallizing materials. Cost of the QC/QA Specialist shall be incidental to the metallizing.

## 4. Applicator

- a. The Thermal Spray Technician shall have a minimum of 1 year of experience in the operation of Thermal Spray Equipment. Present documentation of the technician's prior experience using a wire metallizing arc unit on at least one project of similar scope.
- b. Submit qualifications of the QC/QA Specialist(s) and the Thermal Spray Technician for approval prior to commencing any work on the components to be metalized.

## D. Protection of the Environment, Public, and Workers During Coating Operations

### 1. Regulatory Conditions

- a. Utilize all necessary precautions to prevent the dispersal of material outside the work area.
- b. During all project activities, isolate the work area with appropriate containment devices (canvases, tarpaulins, screens, etc.) or use specially fabricated sealed chambers.

### 2. Environmental Conditions

- a. Environmental conditions shall be constantly monitored for shop application operations. In addition, a rebound material collection system is required at all times, unless approved otherwise by the Engineer. Blast media dust collected by the containment system shall be extracted by the method approved by the Engineer prior to the removal of the containment.
- b. Monitor all rebound dust during the application of the TSC and stop operation if the dust contaminates the cleaned steel surface. Submit containment or shop facility plans for approval. Take sufficient precautions to prevent blasting material from being deposited outside of the work area. Install adequate dehumidifiers as necessary to prevent delay of work due to high humidity environments.

## E. Application Methods

### 1. General

- a. The TSC system requires the application of sprayed zinc to selected areas of specified bridge components. This application shall be performed by thermal spraying (metallizing) the specified components with the required surface preparation necessary to produce a good bond between the zinc and the steel. A good bond is essential to provide an efficient system.
- b. The texture of the metalized surfaces shall be adequate to accept and provide a good bond to the overcoat paint system specified for the designated components. Provide all the necessary materials and equipment to perform the job as required in the Contract Documents.
- c. Prior to commencing work, submit a list of equipment and consumables proposed to complete the work to the Engineer. Such list shall include brand names, model numbers and manufacturer's technical specifications.



## 2. Surface Preparation

- a. Locate and inspect all the areas indicated for metallizing in the Contract documents.
- b. All surfaces to be metalized shall be thoroughly blasted with blast media prior to TSC application.
- c. The steel shall receive an abrasive blast to remove any mill scale, rust, oil and/or other foreign matter present in compliance with NACE No.1/SSPC-SP5 White Metal Blast Cleaning. Use SSPC Vis 1 as an aid in establishing substrate cleanliness standards. Before blasting, ensure that all surfaces meet the requirements of SSPC SP12, Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra High pressure Water Jetting, Table A1, NV2 for chloride, soluble ferrous iron, and sulfate. In addition, the maximum allowable surface concentration of nitrate shall be 7 micrograms/cm<sup>2</sup>.
- d. The steel surface shall have a minimum of 3 mil of angular profile depth with a sharp angular shape. Angular profile should not exceed the coating thickness for metalized and non- metalized areas in order to avoid unfilled valleys and low areas in the film. The profile depth shall be measured according to ASTM D4417, Method B and/or Method C. Profile depth measurements shall be obtained at least every 10 to 20 ft<sup>2</sup> for manual blasting or 1,000 to 2,000 ft<sup>2</sup> for automated blasting.
- e. Multiple blast types of media may be necessary to achieve the cleanliness and angular profile that will produce the minimum requirements. Grinding of the steel surface may also be required to remove surface deficiencies on the steel to achieve the required profile and angularity required for the metallic coating.

## 3. Arc-Sprayed Application

- a. Perform the coating application employing multiple spray passes to achieve a coating thickness of 8 to 12 mils as determined by thickness measurements on the metalized components or by other means acceptable to the Engineer.

## 4. Test Sections

- a. Prior to commencing the arc-spraying operation, metalize a minimum of three on-site test sections with minimum dimensions of two square feet each. These test sections shall serve as the JRS and shall be used to determine the application rate for the specified thickness and the grain size, texture acceptability and acceptance adhesion strength. The test sections shall be representative of all the conditions present on the component but must not be part of the production schedule. Adhesion strength shall be measured on test sections to determine the target production acceptance bond strength between the steel surface and the Zn/Al coating. Target bond will be determined based on the average of the bond of the test areas as the TSC is applied as per specification and witnessed by the Engineer. Bond strength on the test sections shall be measured as described by ASTM D4541 and Article 3.5 of this Special Provision.
- b. Preliminary test areas and adhesion tests shall be performed prior to production metallizing. Metalized products with less than 700 psi of bond strength will not be acceptable. The final target bond strength value shall be the highest value obtained on the metalized coating applied in accordance with this Special Provision. Provide a minimum of 14 days advance notice for the application of the test patches so that the QC/QA Specialist and appropriate Department personnel may be present for the initial application and testing.

## 5. Production

- a. Arc sprayed coatings are mechanically bonded to the substrate. The need for substrate preheating shall be anticipated and shall be implemented as required to improve the coating tensile bond of the Zn/Al to the substrate by reducing internal stresses. Maintain environmental conditions including humidity and steel surface temperature per NACE 12/AWS C2.23/SSPC-CS 23 Standards.
- b. Air blast areas to be metalized immediately prior to TSC application to remove any dust or blast media residue. Air stream shall be 100% oil and moisture free. Compressed air must be free of oil and water and must meet ASTM D4285, "Method for Indicating Oil or Water in Compressed

Air". Utilize a compressed air system capable of delivery at the nozzle of 125 cfm at 120 psi. To minimize any contamination, use an oil/water separator on the airline. 120 psi of compressed air maintains the proper atomization of the molten wire producing the optimum spray pattern.

- c. The specified coating thickness shall be applied in several crossing passes. The coating tensile bond strength is greater when the spray passes are kept thin. The use of excessively thick spray passes that increase the internal stresses in the coating and decrease the ultimate tensile-bond strength of completed coating shall be avoided. Confirm the suitability of the crossing-pass thickness with a bend test or tensile bond measurement, or both prior to commencing production work. The Department may request bend test coupons of thickness and metal composition same as the structural components being metalized. For manual spraying, use right angle crossing passes to minimize the thin areas in the coating. For mechanized spraying (mechanized movement of the gun or workpiece, or both), program the overlapping and crossing passes to eliminate thin spots and stay within the specified coating thickness.
- d. Conduct a minimum of one coating adhesion strength test (pull-off test) on each metalized element or at every 100 ft<sup>2</sup> as applicable (should the metalized area be larger than 100 ft<sup>2</sup>). Tests shall be made in triplicate and the values averaged. Tests shall be conducted prior to application of the seal coat. Results shall be recorded on the JCR by the Contractor and shall be subject to verification by the Engineer.

## 6. Restrictions

- a. The time interval between the completion of abrasive blasting to achieve the specified anchor profile (or final brush blasting) and the completion of the thermal spraying should be no greater than 6 hours for steel substrates with the exception that a shorter holding period may be used in high humidity and damp environments. If rust bloom or a degraded coating appears at any time while spraying, stop and follow the procedures described NACE 12/AWS C2.23/SSPC-CS 23 Standard, article 7.3.2.

## 7. Application Time

- a. Metallizing aluminum shall only be applied to surface areas that have been properly prepared as per Article 5.2 of this Technical Special Provision and approved by the Engineer. Complete the metallizing within 6 hours following sandblasting and before any visible rust bloom develops. Implement phased work for large components where required time for blasting would not allow completion within the 6 hours window. For field application, if necessary, apply the metallizing within 2 hours following blasting and before any visible rust bloom develops. Metallizing shall be continuous and un-interrupted within each component. Cold overlaps of the coating will not be permitted unless specifically allowed by the Engineer for phased work.
- b. A 1-mil to 2-mil flash coat of the metalizing may be applied within 6 hours of completing surface preparation to extend the holding period for up to 4 further hours beyond the complete application of the flash coat. The final metalizing thickness, however, must be applied within 4 hours of the completion of the flash coat provided the metalizing can be maintained free of contamination.

## 8. Temperature

- a. The steel surface temperature shall be at least 5°F [3°C] above the dew point when metallizing.
- b. The surface temperature and ambient air temperature are as recommended by the coating equipment's manufacturer except in no case will coating work be performed when surface and ambient air temperatures are less than 40°F or greater than 100°F.

## 9. Deficiencies

- a. Where deficient metallizing thickness values are found, the deficient test section and the immediate surface around (one square foot minimum), shall receive additional coating so that the total thickness of the repaired area will reach a minimum of 8 mils. This shall be performed immediately (not to exceed 6 hours) following the first application or the entire element shall be returned to an SSPC SP-5 white metal blast and re-metalized.
- b. In areas difficult to metalize, such as inside stiffener copes or other similar details, cold galvanizing shall be applied per manufacturer's written recommendations.

## 10. Rejection

- a. Areas not meeting the required bond strength shall be blasted clean of all sprayed metal prior to re-spraying as directed by the Engineer.

## 11. Appearance

- a. Surfaces of the coated sections shall be uniform in appearance, free of visible coating defects such as; cracking, burning, blistering and un-coated areas and/or other defects that will affect the function and/or durability of the coating. If a defective coating area is found, the correction shall be performed in the same manner as for deficient bond strength correction. Cold overlaps during re-application may be necessary. However, re- application of coating over previously metalized areas shall not blister, burn or otherwise damage the bottom coat layer. Should this occur, the entire element shall be fully blasted and re- metalized.

## 12. Un-Coated Surfaces

- a. Surfaces specified not to be metalized that are adjacent or in close proximity to the surface to be metalized, shall be protected with suitable masking during the coating application. The masked surfaces shall form neat horizontal and vertical lines and shall conform to the dimensions specified not to be coated. Material applied to areas not to be coated shall be removed.

## F. Finish Coat System

### 1. General

- a. After the TSC is approved by the Engineer, apply a paint seal coat over the metalized areas. Sealers and topcoats shall meet local, state and federal restrictions on volatile organic compound (VOC) content. Sealer and topcoats shall be applied per the paint manufacturer's instructions for use with arc sprayed coatings or as specified by the DelDOT Specifications. Sealer must be a urethane or epoxy polyamide penetrating sealer, type as recommended by the supplier for use on metalized surfaces.
- b. Refer to the Bridge Project Notes included with the Contract Plans for the finished paint coat color and details.

### 2. Finish Coat System Application

- a. The seal first coat shall be a mist coat and shall be thin enough when applied to penetrate into the body of the thermal spray coating and seal the porosity followed by a coat(s) as per manufacturer recommendations for the required thickness. Added thickness to a porous coating should not be measurable. The seal coat shall generally be applied at a spreading rate resulting in a theoretical 1.5 mils dry film thickness, unless otherwise specified by the paint system's manufacturer specifications, to completely cover the sprayed aluminum angularity.
- b. Sealers shall be applied within 8 hours after thermal spraying. If sealer cannot be applied within 8 hours and if approved by the Engineer, wrap the metalized component in plastic sheeting immediately after metallizing and protect it from weather. Then prior to sealer application, verify that the coating; (a) has not been oxidized or otherwise contaminated by visual inspection using a magnified lens and (b) is dust free using the clear cellophane tape test (ISO 8502-3), before applying the sealer. Use air or media blast to remove any found contamination.
- c. If moisture is present or suspected in the pores of the metalizing, the steel should be heated to 250 °F to remove the moisture prior to seal coat application. When possible, heat the steel from the reverse side of the metalizing to minimize oxidation and contamination of the metalizing prior to sealing.
- d. Areas not to be coated shall be properly masked to protect them from over-spray or overrun. Masking shall form neat horizontal or vertical lines. Do not apply a polymeric coating (finish/top coat) over an unsealed metallizing unless directed by the Engineer.
- e. All polymeric coatings shall be applied according to SSPC-PA 1, "Shop, Field and Maintenance Painting", the DelDOT Specifications, and the paint manufacturer's recommendations for use with an arc sprayed Zn/Al base coat. Topcoats shall be chemically compatible with the sealer.

## G. Metallizing Equipment

### 1. General

- a. Prior to commencing work, submit a list of the equipment intended to be used for the TSC application. No metallizing shall be performed prior to equipment approval by the Engineer. At the discretion of the Engineer, a representative of the spray equipment manufacturer may be required to observe the application of the thermal spray for a sufficient time to provide a letter to the Department certifying that the person(s) using the equipment is qualified to operate the equipment and that this person is obtaining a work product that is representative of his equipment's capability. If the person(s) named in the Manufacturer's certification leaves the job, or if the spray equipment changes, the equipment manufacturer will be required to return and re-certify the equipment operator.
- b. Metallizing equipment must meet the following minimum requirements:

### 2. Metallizing Unit

The metallizing unit shall be a portable, electric arc spray unit capable of spraying Zn/Al wire of 3/16 inch. The unit shall meet the following minimum requirements:

- a. The application gun shall be provided with a self-contained electric arc.
- b. Spray pattern shall be elliptical in shape and have provisions for adjustments to circular pattern.
- c. The application gun shall be capable of operating remotely from the wire feed unit at a distance of no less than 10 feet.
- d. The wire feed unit must have moisture/oil separators provided within the unit itself.
- e. The wire feed method shall be dual drive wheel, push type system only. Other wire feed systems may only be given temporary approval by the Engineer based on performance.
- f. The system shall be capable of operation at 500 amps continuous duty cycle.
- g. The system shall be able to operate remotely from the power supply unit for a minimum distance of 50 feet as to maintain the power supply outside the controlled environment chamber.

### 3. DC Power Supply Unit

- a. The power supply unit shall be a gasoline or diesel engine driven, direct current power source with a minimum NEMA output rating of 600 amps at 40 volts operating at 80 percent duty cycle. Alternate similar output rectifiers connected to the shop existing power source may be used as approved by the Engineer. The power supply shall be capable of operation at constant current or constant voltage modes with fully adjustable output over the entire voltage and current range. Ammeter and voltmeter gauges shall be mounted in the control panel of the unit. The gauges shall be maintained clean and readable at all times during the metallizing operation.

### 4. Air Supply Equipment

- a. The air supply unit shall be capable of delivering a minimum of 250 CFM of air at 100 pounds of pressure and having an adjustable pressure range of 70 to 125 psi. When used in conjunction with the metallizing unit and an operator temperature control unit, the system shall be capable of maintaining a minimum air volume of 175 CFM at 90 pounds of pressure at the gun head.

### 5. Air Filters

- a. The air compressor shall be provided with a moisture/oil separator mounted within the unit. Air shall be tested on a daily basis and separator(s) shall be serviced.

### 6. Abrasive Blast Equipment

- a. The blasting equipment shall be a conventional force fed pressure type stationary abrasive blaster. The nozzle size shall be such that a minimum of 100 psi is maintained at the blast nozzle.

7. Alternate Equipment

- a. Automated application or alternate equipment may be approved if requested by the Contractor based on shop facilities and Contractor's experience with such equipment under similar conditions. Submit proposed alternate equipment for approval by the Engineer.

**METHOD OF MEASUREMENT:**

B. The Department will not measure the Thermally Sprayed (Metallized) Structural Steel work described in this Section.

**BASIS OF PAYMENT:**

B. No separate payment will be made for the Thermally Sprayed (Metallized) Structural Steel work described in this Section. The Department will pay for this work as part of Item No. 615001 Steel Structures

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