Architecturally Exposed Structural Steel

a supplement to
modern Steel construction
MAY 2003

While exposed structural steel was once the select province of a few noteworthy projects, architects today are increasingly using transparency in their design. The current trend may have started with Helmut Jahn's United Airlines Terminal in Chicago, but it has now spread to everything from small retail stores to office lobbies.

Unfortunately, existing codes and standards—even AISC's *Code of Standard Practice*—do not fully address the unique level of detail needed to successfully design, detail, fabricate and erect Architecturally Exposed Structural Steel (AESS). Further, because AESS costs more to fabricate than standard structural steel, it is critical that these designs are properly budgeted. The repercussion of not properly budgeting AESS is often the need for redesign, project delays, and ultimately even higher project costs. In addition, the members requiring special handling and finish are often poorly identified in the contract documents—and, since the EOR often specifies the steel while the architect specifies the paint and appearance, there is sometimes a built-in conflict or compatibility issue. Finally, the lack of acceptance criteria for AESS members often leads to disputes between the design team and the contractor over what is desired versus what was bid.

In response to these issues, the Steel Liaison Committee of the Structural Engineers Association of Colorado and the Rocky Mountain Steel Construction Association, with input from local contractors and architects, developed guidelines to assist in the specification of AESS. According to the Committee: "The goal of these tools is to allow the designer to communicate the desired appearance in a format that Contractors can price/budget/bid more appropriately."

The guidelines include three key elements:

Sample Board: The sample board includes small pieces of fabricated structural steel that indicate a range of finish surfaces that can be expected from structural steel fabricators. The board includes bare steel with fabrication "defects" and pieces with typical finish coats. The samples are intended to allow the designer to see how various fabrication techniques affect the final product. The goal of the sample board is to allow the designer to decide what features are important for their project. Physical samples allow the designer to evaluate how imperfections in the finished surface appear from various distances.

The photos printed here are taken from the sample board , but due to reproduction technology might not fully represent the actual appearance on the sample board. However, designers or contractors wishing to obtain an actual sample board can purchase one from Zimkor Industries for $1,780 by contacting William Zimmerman at wgzimmerman@zimkor.com or 303.791.1333.

Cost Matrix: Of course, knowing appearance of the final steel is only half the story. Equally important is knowing the budget impact of AESS. The cost matrix is designed to provide the designer with the cost premium associated with specifying the desired techniques to achieve the final appearance of an AESS project. The cost of producing work to a higher appearance standard varies greatly from fabricator to fabricator, depending on the equipment in the shop and the experience of the staff. This variation is indicated in the cost matrix as a range of cost premiums for each desired fabrication technique or finish coat item specified.

The cost premiums noted apply to the total weight of AESS for that particular line item, fabricated and erected. While the cost matrix was prepared initially by surveying fabricators in the Rocky Mountain region, the figures have been further checked through surveying a select group of national fabricators. The idea behind the cost matrix is to allow a designer to balance a project budget with the desired project scope. As a result, several design iterations might be required. Also, it is imperative that a designer contacts a local fabricator for more detailed pricing as the project becomes more defined.

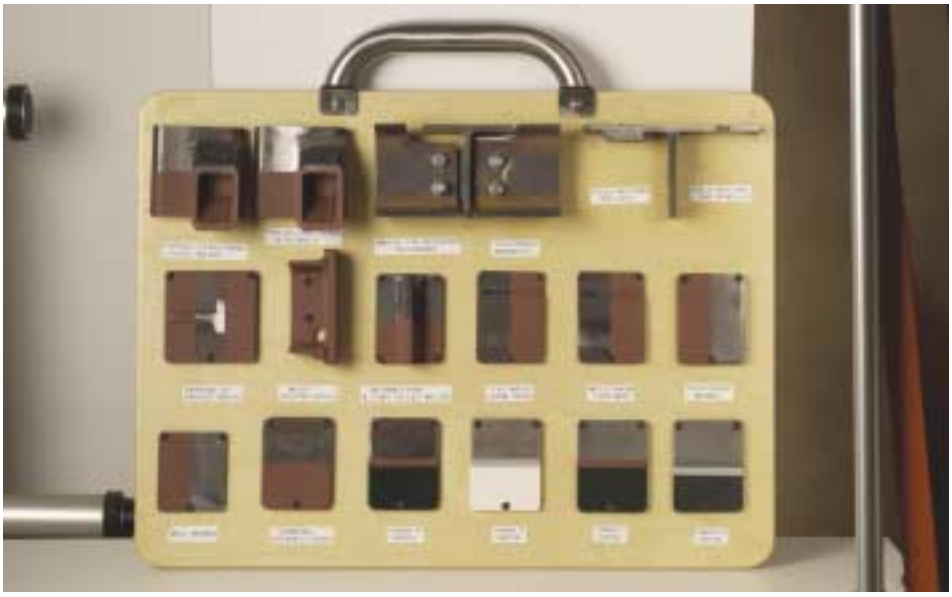
Specification: SEAC/RCSCA has prepared a generic specification that includes many common fabrication and erection techniques to help communicate a designer's expectations to the fabricator. The specification includes a number of editor's notes to provide guidance. The headings in the specification are coordinated with the line times from the cost matrix and sample board. The intent of the specification is to provide a consistent mechanism to define appearance quality requirements that were selected with the sample board and budgeted with the cost matrix. The primary scope of the project was to offer a common language to address the appearance issues of structural steel used in exposed locations.

Although many of the finish issues are common to miscellaneous metals, stairs and railings, the specification is not written to cover all of these items. Furthermore there are numerous performance topics such as jointing for thermal movements, waterproofing and fire resistance which this document does not address. Any comments or suggestions on how the Specification can be improved or modified should be sent to Jack Petersen at jpetersen@martin/martin.com. ★

Supplement cover: the recent expansion of the Austin, TX convention center includes a spectacular atrium space that features exposed structural steel framing and a cobalt-blue art-glass wall on the exterior of the building.

SAMPLE BOARD

Closeup photos of the AESS sample board are used throughout this supplement to illustrate the visual appearance of many conditions encountered when designing exposed structural steel. A photograph of the complete board appears below.



SAMPLE AESS SPECIFICATION

SECTION 05125—
ARCHITECTURALLY EXPOSED STRUCTURAL STEEL

PART 1 — GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to the Section.

1.2 SUMMARY

Editor's Note: It is critical to define to the bidders what members will be considered as Architecturally Exposed Structural Steel (AESS). Furthermore the degree to which the requirements of the AISC "Code of Standard Practice" apply must be spelled out.

A. This Section includes requirements regarding the appearance and surface preparation of Architecturally Exposed Structural Steel (AESS).

Refer to Division 5, Section "Structural Steel" for all other requirements regarding steel work not included in this section.

This section applies to any members noted on Architectural [and Structural] drawings as AESS [and in the areas defined as AESS below].

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 1 Section "Quality Control" for independent testing agency procedures and administrative requirements.
2. Division 5 Section "Structural Steel"

Editor's Note: Address alignment and location of bridging where joists are visible in Division 5 Section "Open Web Metal Joists"

3. Division 5 Section "Steel Joists"

Editor's Note: Address fastener spacing and weld show-through in areas where decking is visible in the finished structure. Coordinate paint system requirements with that of AESS

4. Division 5 Section "Metal Decking" for erection requirements relating to exposed steel decking and its connections
5. Division 5 Section "Metal Fabrications" for loose steel-bearing plates and miscellaneous steel framing.
6. Division 9 Section "Special Coatings" for finish coat requirements and coordination with primer and surface preparation specified in this section.
7. Division 9 Section "Painting" for finish coat requirements and coordination with primer and surface preparation specified in this section.

1.3 SUBMITTALS

A. General: Submit each item below according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each type of product specified.

C. Shop Drawings detailing fabrication of AESS components.

The sample on the left shows the appearance of typical structural welds. On the right, the welds have been ground smooth.

1. Provide erection drawings clearly indicating which members are considered as AESS members.
2. Include details that clearly identify all of the requirements listed in sections 2.3 "Fabrication" and 3.3 "Erection" of this specification. Provide connections for exposed AESS consistent with concepts shown on the architectural or structural drawings.
3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length and type of each weld. Identify grinding, finish and profile of welds as defined herein.
4. Indicate type, size, finish and length of bolts, distinguishing between shop and field bolts. Identify high-strength bolted slip-critical, direct-tensioned shear / bearing connections. [Indicate to which direction bolt heads should be oriented.]
5. Clearly indicate which surfaces or edges are exposed and what class of surface preparation is being used.
6. Indicate special tolerances and erection requirements as noted on the drawings or defined herein.

D. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects names and address, names and addresses of architects and owners, and other information specified.

[For each project, submit photographs showing detail of installed AESS.]

1.4 QUALITY ASSURANCE

A. Fabricator Qualifications: In addition to those qualifications listed in Division 5 Section "Structural Steel," engage a firm experienced in fabricating AESS similar to that indicated for this Project with a record of successful in-service performance, as well as sufficient production capacity to fabricate AESS without delaying the Work.

B. Erector Qualifications: In addition to those qualifications listed in Division 5 Section "Structural Steel," engage an experienced Erector who has completed AESS work similar in material, design, and extent to that indicted for this Project and with a record of successful in-service performance.

C. Comply with applicable provisions of the following specifications and documents:

1. AISC *Code of Standard Practice*, latest edition, Section 10 as amended herein.

The connection on the left shows a connection with the typical blocking tolerance. The connection on the right shows the same connection with tolerances minimized.

Editor's Note: The following section should be edited to define how many mock-up pieces are required. The Architect must define the size and extent of the pieces which are required and what specific finishes must be demonstrated.

D. Mock-ups: At least four weeks prior to fabricating AESS, the contractor shall construct mock-ups to demonstrate aesthetic effects as well as qualities of materials and execution. A mock-up for each of the following elements shall be constructed:

Build mock-ups to comply with the following requirements, using materials indicated for final unit of Work.

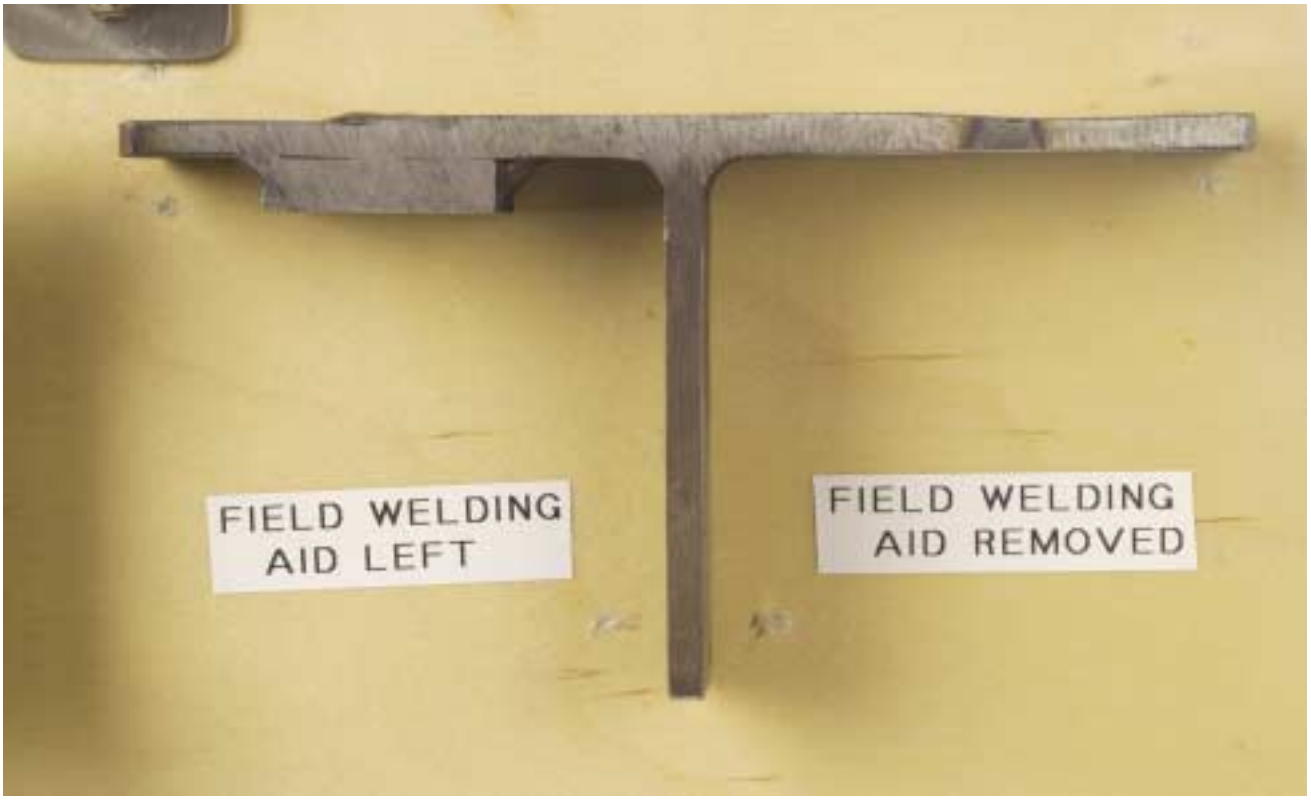
1. Locate mock-ups on-site or in the fabricator's shop as directed by Architect. Mock-ups shall be full-size pieces unless the Architect approves smaller models.
2. Notify the Architect one week in advance of the dates and times when mock-ups will be available for review.
3. Demonstrate the proposed range of aesthetic effects regarding each element listed under the fabrication heading below.
4. Mock-up will have finished surface (including surface preparation and paint system).
5. Obtain Architect's approval of mock-ups before starting fabrication of final units.
6. Retain and maintain mock-ups during construction in an undisturbed condition as a standard for judging the completed work.
    a. Approved mock-ups in an undisturbed condition at the time of Substantial completion may become part of the completed work.

E. Pre-installation Conference: The General Contractor shall schedule and conduct conference at the project site to comply with requirements of Division 1 Section "Project Meetings." As a minimum, the meeting shall include the General Contractor, Fabricator, Erector, the finish-painting subcontractor, and the Architect. Coordinate requirements for shipping, special handling, attachment of safety cables and temporary erection bracing, touch up painting and other requirements for AESS.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver AESS to Project site in such quantities and at such times to ensure continuity of installation.

B. Store materials to permit easy access for inspection and identification. Keep steel members off ground by using pallets, platforms, or other supports. Protect steel members and packaged materials from erosion and deterioration. Use special care in handling to prevent twisting or warping of AESS members.



On the left, the field-welding aid (the backing bar) has been left in place. On the right, the field-welding aid has been removed and the weld ground smooth.

C. Erect pre-painted finish pieces using padded slings or other methods such that they are not damaged. Provide padding as required to protect while rigging and aligning member's frames. Weld tabs for temporary bracing and safety cabling only at points concealed from view in the completed structure or where approved by the Architect during the pre-installation meeting. Methods of removing temporary erection devices and finishing the AESS members shall be approved by the Architect prior to erection.

1.6 PROJECT CONDITIONS

A. Field Measurements: Where AESS is indicated to fit against walls and other construction, verify dimensions by field measurements before fabrication and indicate measurements on shop drawings. Coordinate fabrication schedule with construction progress to avoid delaying the work.

1.7 COORDINATION

A. Coordinate installation of anchors for AESS members that connect to the work of other trades. Furnish setting drawings, templates, and directions for installing anchors, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to the project site in time for installation. [Anchorage concepts shall be as indicated on drawings and approved on final shop drawings.]

PART 2 — PRODUCTS

2.1 MATERIALS

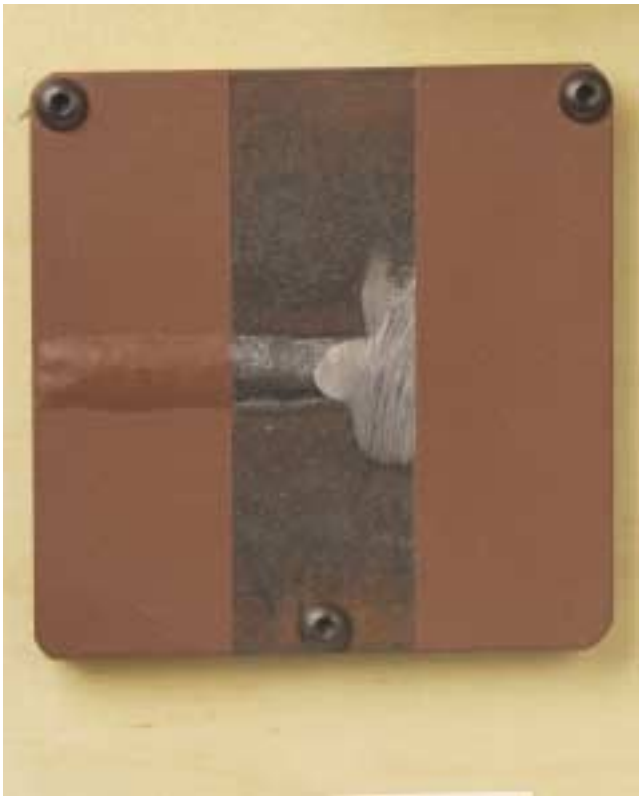
A. General: Meet requirements Division 5 Section "Structural Steel" as amended below.

B. High-Strength Bolts, Nuts, and Washers: Per section 05120 heavy hex heads and nuts [Provide rounded bolt heads with twist-off bolts]. Provide standard carbon steel [Cadmium plated] [Mechanically galvanized] finish.

2.2 PRIMERS

Editor's Note: The primer specified in section 05120 must be coordinated with the finish coat system listed in section 09900 to ensure coating compatibility. The use of the Federal Specification System (i.e. FS TT-P-6664) is obsolete since many of these specs do not address current VOC regulations and other environmental standards such as lead and chromates. Primers for steel come in a variety of resins such as alkyd, waterborne, epoxy, and zinc rich

Alkyd Primers: Typically referred to as shop coat primer, this product can come in many different levels of quality depending on the level of corrosion protect required. This would include keeping the steel from flash rusting prior to being covered by in an interior wall up to long-term corrosion protection. They are fast drying, enabling the fabricator to quickly deliver product to



The left half of this sample shows a typical groove weld. The right half shows the same weld ground smooth.

This sample shows a typical weld-access hole.

the job site. Standard alkyd primers can be finish coated with an alkyd or water-based enamel. Universal alkyd primers can be used under high-performance coatings such as epoxies or urethanes. In general, for exterior exposure, a high-quality, universal, rust-inhibitive primer should be used. The increase in cost over a standard "Shop Coat" primer is on the order of $5.00 to $10.00 per gallon. The material cost of the paint represents a small portion of the total painting cost, while the higher quality provides greater corrosion protection to the steel.

Acrylic Primer: Acrylic primers are corrosion resistant and water-soluble, often providing a lower VOC. They are available in shop-coat quality up to a universal primer for use under high performance coatings such as epoxies and urethanes.

Epoxy Primer: Epoxy primers provide excellent corrosion protection for steel and can be top coated with a variety of finishes. Epoxy primers can be applied in the shop and typically have a high film build that will hide minor imperfections.

Zinc Rich Primer: Zinc rich primer provides superior corrosion protection by providing cathodic protection to the steel. Zinc rich coatings can be specified as either organic zinc or inorganic zinc. Both inorganic and organic will meet class B slip coefficients for bolted connections. In arid regions (such as the Rocky Mountain Region) organic epoxy/zinc primers should be specified, as they do not rely on an outside source (humidity) for cure. Inorganic zinc requires a constant humidity of no less than 40% RH for proper cure. If an intermediate and finish coat are to be completed in the shop, the lack of humidity can cause delays in both the painting process and project as the zinc must be cured prior to top-coating. Although a urethane finish coat can be applied directly over an organic zinc, it is suggested that an intermediate epoxy coating be used to prevent "pin holing" in the urethane coating, promote adhesion of the system, and increase film build to hide imperfections in the steel. Alkyd finish coats should not be specified over zinc primers. For galvanizing repair, an organic zinc with not less than 90% zinc by weight in the dry film should be used for re-galvanizing welds and damage due to erection.

FINISHES

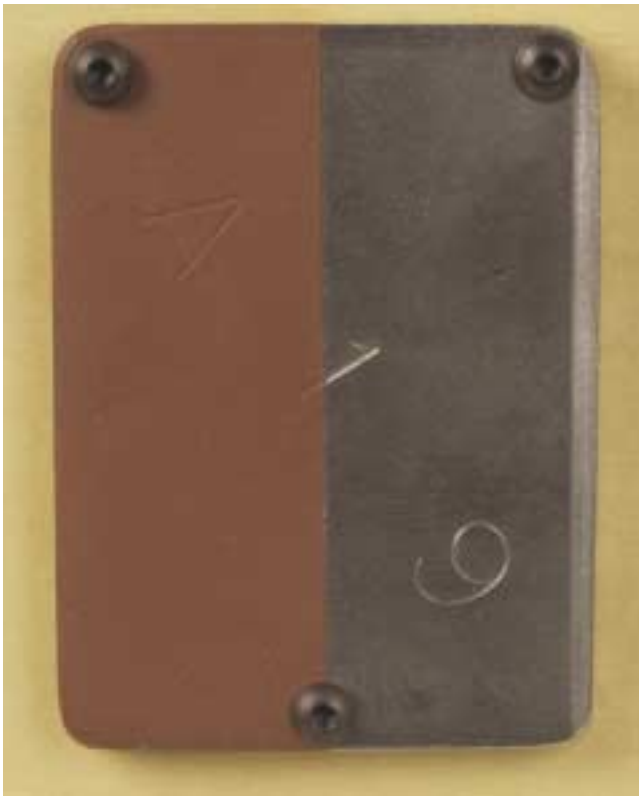
*When possible, finish coating should be done in the field after erection. Finish coats applied in the shop almost always incur damage from handling in shipping and erection. This often results in applying an additional finish coat in the field or completing costly touch up which often does not blend in with the original finish. *Note: If finish painting is to be done prior to delivery of the steel, special sections should be added to ensure proper handling and minimize damage.*

Finish coatings for commercial projects with AESS fall into the following categories

Alkyds (Oil based): Acceptable finish coat for interior applications and some exterior application. Dries to hard durable finish. When applied specified for exterior use, alkyds will chalk and fade with UV exposure in a relatively short period. Can be brush, roll, or spray applied.

Acrylics (Waterborne): Acceptable finish coat for both interior and exterior service. Acrylics provide good color and gloss re-

On the left, the fillet weld is continuous. On the right, the fillet weld is intermittent.



This sample shows the visibility of typical shop marks.

tention under UV exposure. Can be easily applied by brush, roller, or spray. Low odor and VOC for interior application.

Epoxy: Can be applied as a finish for interior use where abrasion resistance is required. High-build nature of film can help cover imperfections in the steel. Will chalk and fade with UV exposure. 4. Polyurethane: Provides high performance protection with excellent color and gloss retention. A higher film build than alkyd or acrylic helps cover imperfections in the steel. Should be sprayed applied for best appearance.

A. Compatibility: The General Contractor shall submit all components / procedures of the paint system for AESS as a single coordinated submittal. As a minimum, identify required surface preparation, primer, intermediate coat (if applicable) and finish coat. All of the items shall be coordinated with the finish coat specified in Division 9.

Editor's Note: The primers below are listed in order of cost from lowest to highest. Coordinate requirements with the surface preparation and finish-coat sections of the specification.

B. Primer: Fabricator's standard alkyd red oxide, rust-inhibiting primer.

C. Primer: Fast curing, universal modified alkyd, rust inhibiting shop coat with good resistance to normal atmospheric corrosion. Primer shall comply with all federal standards for VOC, lead and chromate levels

D. Primer: Acrylic water-soluble shop coat with good resistance to normal atmospheric corrosion. Primer shall comply with all federal standards for VOC, lead and chromate levels.

E. Primer: Fast-curing two-part epoxy. Primer shall comply with all federal standards for VOC, lead and chromate levels.

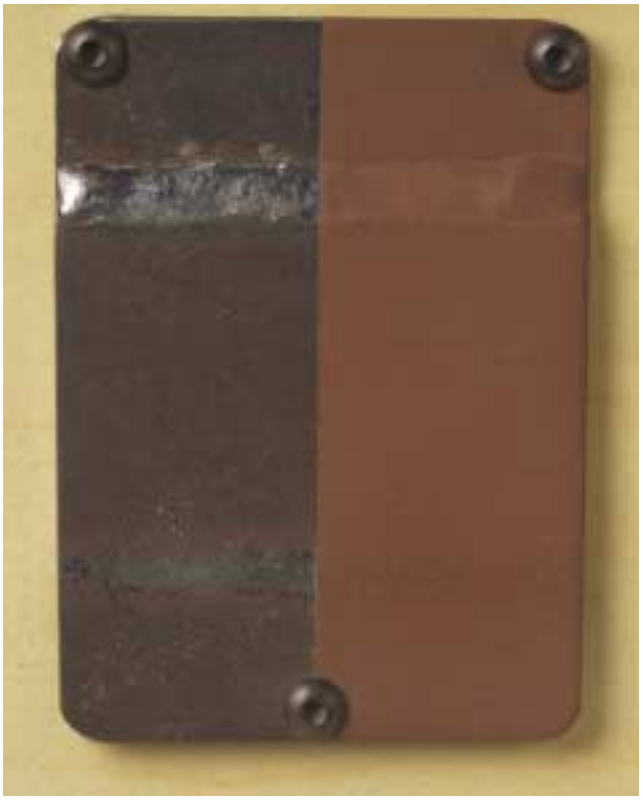
F. Primer: Organic, epoxy / zinc-rich, meeting class B surface requirements for slip-critical connections. Primer shall comply with all federal standards for VOC, lead and chromate levels.

G. Primer: Inorganic zinc-rich meeting class B surface requirements for slip-critical connections. Primer shall comply with all federal standards for VOC, lead and chromate levels.

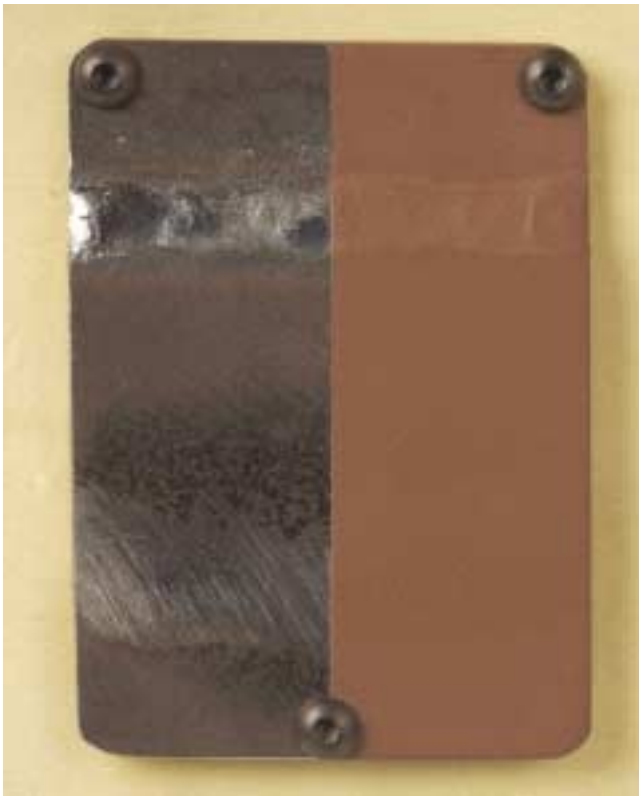
H. Galvanizing Repair Paint: High-zinc-dust-content paint for galvanizing welds and repair-painting galvanized steel, with dry-film coating not less than 90-percent zinc dust by weight.

2.3 FABRICATION

A. Fabricate and assemble AESS in the shop to the greatest extent possible. Locate field joints in AESS assemblies at concealed locations or as approved by the Architect. Detail AESS assemblies to minimize field handling and expedite erection.



This sample shows typical weld show-through from welding the connection on the far side of the piece.



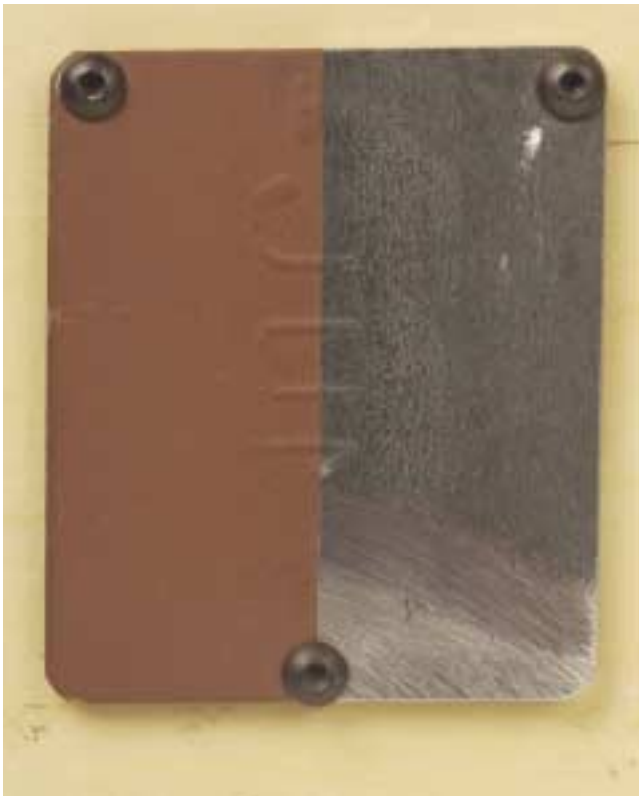
Weld show-through has been minimized.

B. Fabricate AESS with exposed surfaces smooth, square and of surface quality consistent with the approved mock-up. Use special care in handling and shipping of AESS both before and after shop painting.

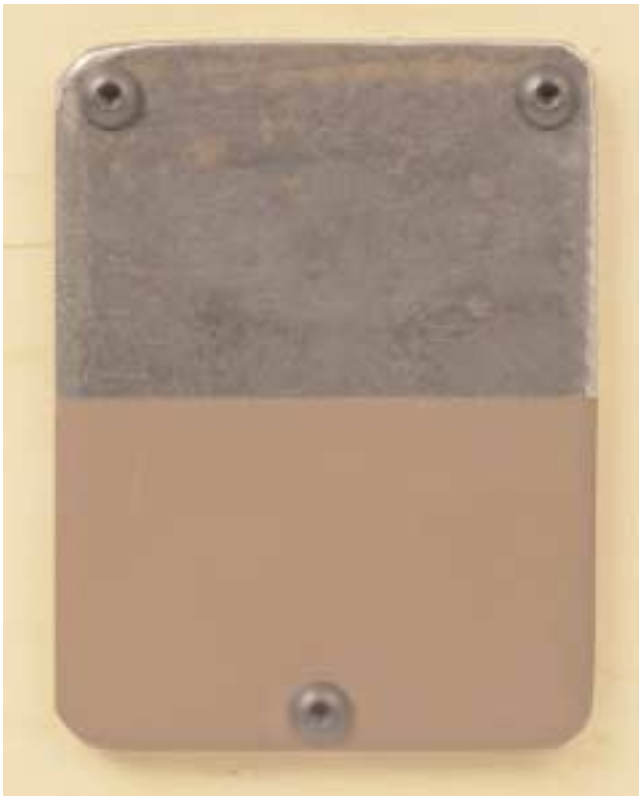
C. In addition to special care used to handle and fabricate AESS, employ the following fabrication techniques.

Editor's Note: The following is a list of special fabrication methods that may impact the final appearance of the AESS. Many of these items have significant cost premiums and should not be used indiscriminately. Refer to the cost matrix for anticipated range of added cost associated with each line item.

1. Fabrication Tolerance: Fabricate steel to one half the normal tolerance as specified in the *Code of Standard Practice* Section 10.
2. Welds ground smooth: Fabricator shall grind welds of AESS smooth. For groove welds, the weld shall be made flush to the surfaces each side and be within $+^{1}/_{16}$", –0" of plate thickness.
3. Contouring and blending of welds: Where fillet welds are indicated to be ground-contoured, or blended, oversize welds as required and grind to provide a smooth transition and to match profile on approved mock-up.
4. Continuous Welds: Where welding is noted on the drawings, provide continuous welds of a uniform size and profile.
5. Minimize Weld Show Through: At locations where welding on the far side of an exposed connection occurs, grind distortion and marking of the steel to a smooth profile with adjacent material.
6. Coping and Blocking Tolerance: Maintain a uniform gap of $^{1}/_{8}$" ± $^{1}/_{32}$" at all copes and blocks.
7. Joint Gap Tolerance: Maintain a uniform gap of $^{1}/_{8}$" ± $^{1}/_{32}$".
8. Piece Marks Hidden: Fabricate such that piece marks are fully hidden in the final structure or made with such media to permit full removal after erection.
10. Mill Mark Removal: Fabricator shall deliver steel with no mill marks (stenciled, stamped, raised etc) in exposed locations. Mill marks shall be omitted by cutting of mill material to appropriate lengths where possible. Where not possible, the fabricator can fill and/or grind to a surface finish consistent with the approved mock-up.



A typical mill mark.



The appearance of sheared edges that have been ground.

11. Grinding of sheared edges: Fabricator shall grind all edges of sheared, punched or flame-cut steel to match approved mock-up.

12. Rolled Members: Member specified to be rolled to a final curved shape shall be fully shaped in the shop and tied during shipping to prevent stress relieving. Distortion of the web or stem, and of outstanding flanges or legs of angles shall be visibly acceptable to the Architect from a distance of 20' under any lighting condition determined by the Architect. Tolerances for the vertical and horizontal walls of rectangular HSS members after rolling shall be the specified dimension ± ½".

13. Seal weld open ends of round and rectangular hollow structural section with $^3/_8$" closure plates. Provide continuous, sealed welds at angle to gusset-plate connections and similar locations where AESS is exposed to weather.

2.1 SHOP CONNECTIONS

A. Bolted Connections: Make in accordance with Section 05120. Provide bolt type and finish as noted herein and align bolt heads as indicated on the approved shop erection drawings.

B. Welded Connections: Comply with AWS D1.1 and Section 05120. Appearance and quality of welds shall be consistent with the mock-up. Assemble and weld built-up sections by methods that will maintain alignment of members without warp exceeding the tolerance of this section.

2.2 SHOP PRIMING

A. Shop-prime steel surfaces, except the following:

1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2".

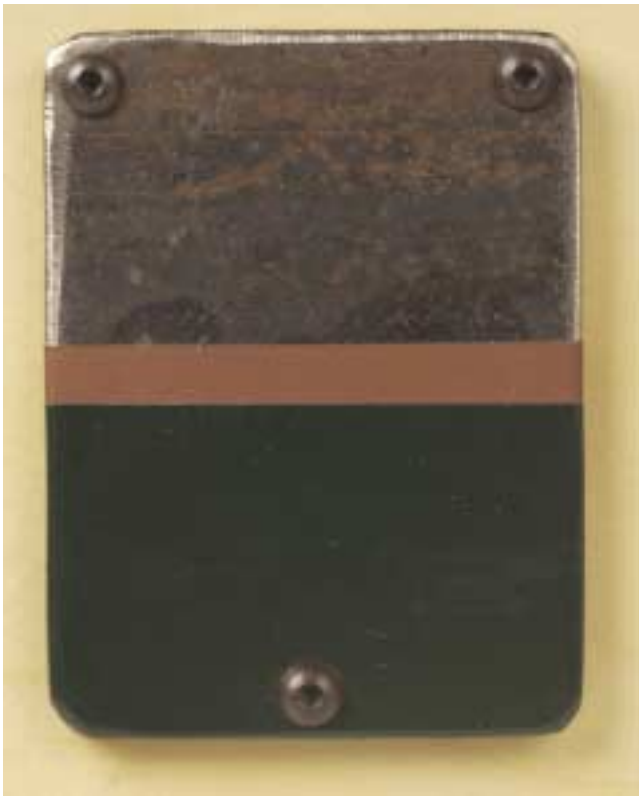
2. Surfaces to be field welded.

3. Surfaces to be high-strength bolted with slip-critical connections, if primer does not meet the specified AISC slip coefficient.

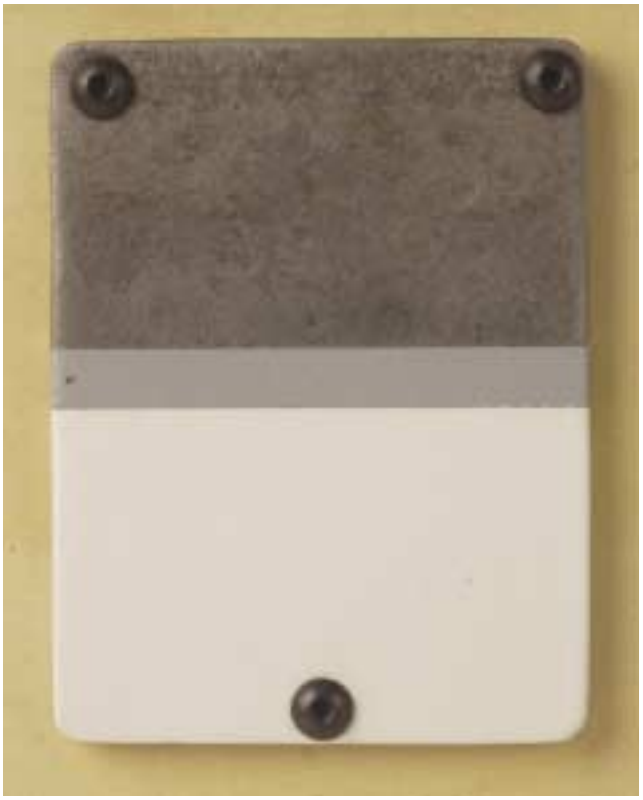
B. Surface Preparation: Clean surfaces to be painted. Remove loose rust, loose mill scale, and spatter, slag, or flux deposits. Prepare surfaces according to SSPC Specifications as follows:

Editor's Note: Surface preparation is the most important (and often the most costly) step in providing a good finish on AESS. A level of surface preparation is associated with each type of finish coat. It is critical that the correct level of preparation be specified on the contract documents to avoid change orders during construction. Each level of SSPC specification includes the levels below (i.e., SSPC-6 includes the requirements of SSPC-3).

1. SSPC-SP 1 "Solvent Cleaning"



Low-end primer/finish coating: alkyd (oil-based) finish coat with a shop-coat primer over an SSPC-3 surface preparation.



High-end primer/finish coating: epoxy finish coat with an epoxy or zinc rich primer, over an SSPC-3 surface preparation.

2. SSPC-SP 2 "Hand Tool Cleaning." (This level of surface preparation will not be adequate for most paint systems for AESS construction.)
3. SSPC-SP 3 "Power Tool Cleaning." (This level of surface prep is the minimum for most AESS projects. It may be acceptable for alkyd primers and acrylic or alkyd finish coats, particularly in interior applications.)
4. SSPC-SP 6 "Commercial Blast Cleaning." (This level of surface prep adds significantly to the total cost of the steel. It is required for epoxy primers to allow adequate bonding to the steel. Recommended for locations where a rust inhibitive primer will be used in an exterior application. It is also required where polyurethane finish coats will be used over the primer.)
5. Coordinate the required blast profile with the approved paint submittal prior to beginning surface preparation.

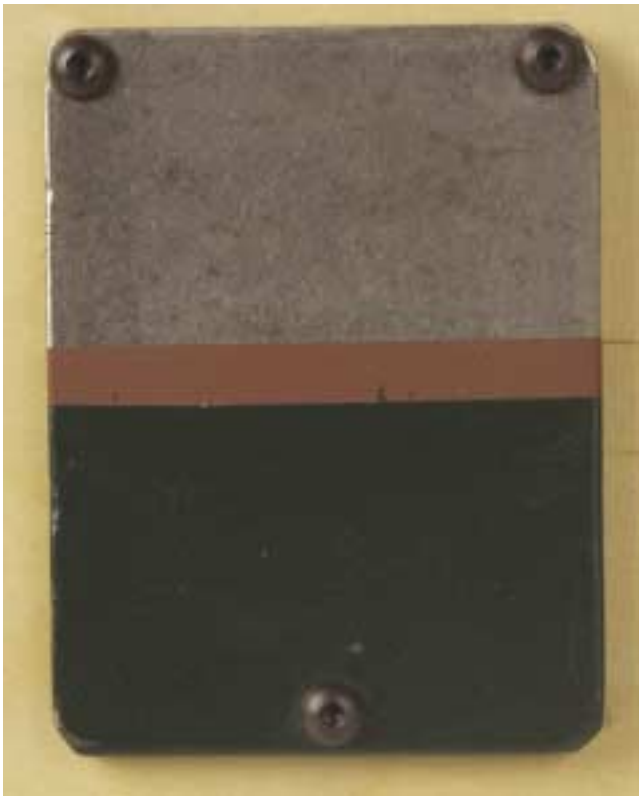
C. Priming: Immediately after surface preparation, apply primer according to manufacturer's instructions to provide a dry film thickness of not less than 1.5 mils (0.038 mm). Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
2. Apply two coats of shop primer to surfaces that are inaccessible after assembly or erection.

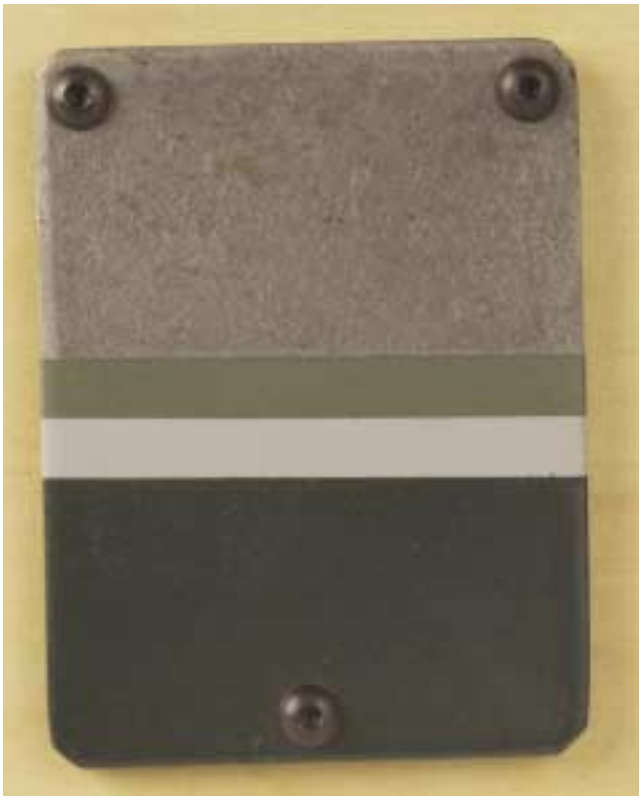
Editor's Note: Finish painting in the shop is not recommended by either the fabrication or painting community that contributed to this specification. If finish painting is to be done prior to delivery of the steel, special sections should be added here.

2.3 GALVANIZING

Editor's Note: Galvanized steel should not be painted with alkyd top coats as loss of adhesion will occur. An intermediate coat of high-build epoxy should be used if an alkyd paint is described as the finish coat. Zinc coatings produced by the hot-dip galvanizing process are excellent corrosion-protection systems. When the coating becomes very thick or dull gray, the coating might not be suitable for architectural applications. The appearance can become blotchy with sections of dull finish and sections with bright finish. Almost all of these surface effects last for the first couple of years and then the coating becomes uniformly dull gray as the protective layer of corrosion products is formed on the surface of the galvanized steel. The cause of the irregular surface finishes is the variation in steel chemistry of the parts to be hot-dip galvanized. ASTM A 385 describes the effects of steel chemistry on the hot-dip galvanized finish. The two elements with the most influence are silicon and phosphorus. If these elements are controlled to recommended



Low-end primer/finish coating: acrylic (water-based) finish coat with a shop coat primer over an SSPC-6 surface preparation.



High-end primer/finish coating: polyurethane finish coat with an epoxy intermediate coat and zinc rich primer over an SSPC-6 surface preparation.

levels, the finish will be bright and shiny. Many steel makers control the overall impurity content but not these two specific elements, so there might be some parts that are bright and shiny and some that are dull gray. Care should be taken when specifying a particular steel for hot-dip galvanizing if an architectural finish is expected.

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to AESS indicated for galvanizing according to ASTM A 123. Fabricate such that all connections of assemblies are made in the field with bolted connections. Provide galvanized finish or members and assemblies within the range of color and surface textures presented in the mock ups.

PART 3 — EXECUTION

3.1 EXAMINATION

A. The erector shall check all AESS members upon delivery for twist, kinks, gouges or other imperfections which might result in rejection of the appearance of the member. Coordinate remedial action with fabricator prior to erecting steel.

3.2 PREPARATION

A. Provide connections for temporary shoring, bracing and supports only where noted on the approved shop drawings. Temporary connections not shown shall be made at locations not exposed to view in the final structure or as approved by the Architect. Handle, lift and align pieces using padded slings and/or other protection required to maintain the appearance of the AESS through the process of erection.

3.3 ERECTION

A. Set AESS accurately in locations and to elevations indicated, and according to AISC specifications referenced in this Section.

B. In addition to the special care used to handle and erect AESS, employ the following erection techniques:

Editor's Note: The following is a list of special erection issues that can impact the final appearance of the AESS. Many of these items have significant cost premiums and should not be used indiscriminately. Refer to the cost matrix for anticipated range of added cost associated with each line item.

Editor's Note: The AISC Code of Standard Practice *specifies that AESS framing shall be constructed to one-half the tolerance of typical structural steel frames. This requirement is intended to improve fit up when the exposed steel interfaces with other materials such as curtain wall masonry, etc. If this is not the case, standard tolerances are more economical. The variations permitted under the standard frame tolerances noted in Chapter 7 will typically be acceptable when viewed by eye (without instruments).*

1. AESS erection tolerances: Erection tolerances shall meet the requirements of standard frame tolerances for structural steel per Chapter 7 of the AISC *Code of Standard Practice*.

   OR

1. AESS erection tolerances: Erection tolerances shall meet the requirements of Chapter 10 of the AISC *Code of Standard Practice*.

2. Welds ground smooth: Erector shall grind welds smooth in the connections of AESS members. For groove welds, the weld shall be made flush to the surfaces of each side and be within + 1/16", -0" of plate thickness.

3. Contouring and blending of welds: Where fillet welds are indicated to be ground contoured, or blended, oversize welds as required; grind to provide a smooth transition and to match profile on approved mock-up .

4. Continuous welds: Where noted on the drawings, provide continuous welds of a uniform size and profile.

5. Minimize weld show-through: At locations where welding on the far side of an exposed connection occurs, grind distortion and marking of the steel to a smooth profile with adjacent material.

6. Bolt head orientation: All bolt heads shall be oriented as indicated on the contract documents. Where bolt-head alignment is specified, the orientation shall be noted for each connection on the erection drawings. Where not noted, the bolt heads in a given connection shall be oriented to one side.

7. Removal of field connection aids: Run-out tabs, erection bolts and other steel members added to connections to allow for alignment, fit-up, and welding in the field shall be removed from the structure. Field groove welds shall be selected to eliminate the need for backing bars or to permit their removal after welding. Welds at run-out tabs shall be removed to match adjacent surfaces and ground smooth. Holes for erection bolts shall be plug welded and ground smooth.

8. Filling of weld access holes: Where holes must be cut in the web at the intersection with flanges on W shapes and structural tees to permit field welding of the flanges, they shall be filled. Filling shall be executed with proper procedures to minimize restraint and address thermal stresses in group 4 and 5 shapes.

C. Field welding: Weld profile, quality, and finish shall be consistent with mock-ups approved prior to fabrication.

D. Splice members only where indicated.

E. Obtain permission for any torch cutting or field fabrication from the Architect. Finish sections thermally cut during erection to a surface appearance consistent with the mock up.

F. Do not enlarge unfair holes in members by burning or by using drift pins. Ream holes that must be enlarged to admit bolts. Replace connection plates that are misaligned where holes cannot be aligned with acceptable final appearance.

3.4 FIELD CONNECTIONS

A. Bolted Connections: Install bolts of the specified type and finish in accordance with Division 5 section "Structural Steel."

B. Welded Connections: Comply with AWS D1.1 for procedures, and appearance. Refer to Division 5 section "Structural Steel" for other requirements.

   1. Assemble and weld built-up sections by methods that will maintain true alignment of axes without warp. Verify that weld sizes, fabrication sequence, and equipment used for AESS will limit distortions to allowable tolerances.

   2. Obtain Architect's approval for appearance of welds in repaired or field modified work.

3.5 FIELD QUALITY CONTROL

A. Structural requirements: The Owner will engage an independent testing and inspecting agency to perform field inspections and tests and to prepare test reports. Refer to Division 5 section "Structural Steel" for detailed bolt and weld testing requirements.

B. AESS acceptance: The Architect shall observe the AESS steel in place and determine acceptability based on the mock-up. The Testing Agency shall have no responsibility for enforcing the requirements of this section.

3.6 ADJUSTING AND CLEANING

A. Touch-up Painting: Cleaning and Touch-up painting of field welds, bolted connections, and abraded areas of shop paint shall completed to blend with the adjacent surfaces of AESS. Such touch up work shall be done in accordance with manufacturer's instructions as specified in Division 9, Section "Painting."

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780. ★

ARCHITECTURALLY EXPOSED STRUCTURAL STEEL (AESS) FABRICATION, ERECTION, AND COATING RELATIVE COST MATRIX

Specification Section (Fabrication)	Specification Section (Erection)	AISC Code of Standard Practice Section	PROCESS
			FABRICATION AND ERECTION CLASSIFICATIONS
2.2	2.2	10.4.1	SPECIAL CARE IN PROCESSING AESS
2.2.1	3.3.1	10.2.1, 10.4.2	TOLERANCES: ONE-HALF STANDARD
2.2.2	3.3.2	10.2.5	WELDS GROUND SMOOTH
2.2.3	3.3.3	---	WELDS CONTOURED & BLENDED
2.2.4	3.3.4	---	CONTINUOUS WELDS
2.2.5	3.3.5	10.2.3	WELD SHOW THROUGH MINIMIZED
2.2.6	---	---	COPING AND BLOCKING TOLERANCES MINIMIZED
2.2.7	---	10.2.4	JOINT GAP TOLERANCES MINIMIZED
2.2.8	---	10.2.6	PIECE MARKS HIDDEN
2.2.9	---	10.2.8	SURFACE DEFECTS MINIMIZED
2.2.10	---	10.2.7	MILL MARKS REMOVED
2.2.11	---	---	GRINDING OF SHEARED EDGES
2.2.12	---	---	ROLLED MEMBERS: MINIMIZE DISTORTION
2.2.13	---	---	SEAL WELDS TO CLOSE OPEN GAPS
---	3.3.6	---	BOLT HEAD ORIENTATION DICTATED
---	3.3.7	---	FIELD WELDING AIDS REMOVED
---	3.3.8	---	CLOSE WELD ACCESS HOLES AT FULL PEN WELDS
			RANGE IN COST INCREASE OVER STANDARD STRUCTURAL STEEL

SURFACE PREPARATION CLASSIFICATIONS
POWER TOOL CLEANING CLEANING (SSPC-SP3)
COMMERCIAL BLAST CLEANING (SSPC-SP6)
RANGE OF COST INCREASE OVER POWER TOOL CLEANING (SSPC-SP3)

PRIMER AND FINISH COATING CLASSIFICATIONS
FINISH A: INTERIOR ENVIRONMENT - LOW END FINISH
FINISH B: INTERIOR ENVIRONMENT - HIGH END FINISH
FINISH C: EXTERIOR ENVIRONMENT - LOW END FINISH
FINISH D: EXTERIOR ENVIRONMENT - HIGH END FINISH
FINISH E: GALVANIZING
RANGE OF COST INCREASE SHOP PRIMED WITH NO FINISH COAT

ACCUMULATED RANGE OF COST INCREASE

COST MATRIX NOTES:

1. THE ABOVE COST INCREASE PERCENTAGES APPLY TO THE ARCHITECTURAL EXPOSE
2. THE ABOVE COST INCREASE PERCENTAGES ARE INTENDED TO GIVE THE DESIGNER I
THEY ARE ESTIMATES AND WILL VARY
FOR EACH PROJECT. CONTACT A FABRICATOR TO OBTAIN SPECIFIC PRICING FOR EA

BLUE DESIGNATES USER INPUT CELLS.

GREEN DESIGNATES RESULTS CELLS.

NOTES	STANDARD AISC Code of Standard Practice Section 10 for AESS (pre-set)	CATEGORY 3 High profile conditions that are out of reach to touch and can be viewed from a distance 20 feet or more (pre-set)	CATEGORY 2 High profile conditions that are out of reach to touch and can be viewed in close proximity within 20 feet (pre-set)	CATEGORY 1 High profile conditions that are within reach to touch and can be viewed in close proximity (pre-set)	USER Custom selected by the user (interactively input)	ADDED COST RANGE TO AESS
a	X	X	X	X	X	10% to 20%
b	X			X		5% to 10%
c			X	X		10% to 20%
d			X	X		20% to 30%
e				X		5% to 10%
f			X	X		5% to 10%
g	X			X		5% to 10%
h	X			X		5% to 10%
i	X	X	X	X		1% to 5%
j	X			X		1% to 5%
k				X		1% to 5%
l				X		2% to 10%
m		X	X	X		10% to 15%
n				X		5% to 10%
o		X	X	X		1% to 5%
p			X	X		5% to 10%
q			X	X		5% to 10%
	27% TO 60%	22% TO 45%	67% TO 125%	96% TO 195%	10% TO 20%	
r	CLASSIFICATION, SSPC-SP# = 6					0% to 0%
s						10% to 20%
	10% TO 20%	10% TO 20%	10% TO 20%	10% TO 20%	10% TO 20%	
t	CLASSIFICATION, FINISH = A					5% to 10%
u						35% to 50%
v						10% to 20%
w						45% to 60%
x						10% to 20%
	5% TO 10%	5% TO 10%	5% TO 10%	5% TO 10%	5% TO 10%	
	42% TO 90%	37% TO 75%	82% TO 155%	111% TO 225%	25% TO 50%	

D STRUCTURAL STEEL PORTIONS OF THE FRAME ONLY.

NFORMATION TO MAKE PRELIMINARY COST ESTIMATING JUDGEMENTS.

CH PROJECT.

COST MATRIX NOTES

a **Special Care in Processing AESS:** Upgraded care in the process of fabricating, trucking, handling, storing, and erecting the material is required to obtain minimally acceptable AESS. This classification is required whenever AESS is specified.

b **Tolerances:** One-Half Standard: The tolerances for structural steel frames are set by AISC Code of Standard Practice. If AESS is specified, these tolerances are required to be one-half of those of a standard structural steel. These reduced tolerances should be carefully reviewed to see if they are required, as they add significant cost to the project.

c **Welds Ground Smooth:** In a standard structural steel frame, the welds are left in an as welded condition with the slag and weld spatter removed. For AESS frames, the process is the same. Should smooth grinding of the welds be required, this classification should be specified. It is important to note that in many cases, grinding the weld will leave a blemish that is more obvious than the unground weld.

d **Welds Contoured and Blended:** The comments under item k. apply here, but the requirements of contoured and blended welds add an additional complexity. If transitions of smoothly ground welds are required to contoured and blended, this process will be done by hand and will leave blemishes around the weld area that may be more noticeable than the as-welded condition. Samples of this process should be submitted for review prior to fabrication.

e **Continuous Welds:** Many welds in standard structural steel and AESS frames are specified for strength to be intermittent. Some AESS structures may require that these welds be continuous for aesthetic reasons. Special care is required to avoid distortion of the member. If this is the case, this classification should be specified.

f **Weld Show Through Minimized:** In standard structural steel frames, there is no attempt to minimize the show through on the back face of the welded element caused by the welding process. Typically in AESS frames, the weld show through is left the same as a standard frame. If minimized show through is required, this can be done by hand grinding the backside of the weld. It is important to note that this process may leave a blemish that in most cases is more objectionable than the show through.

g **Coping and Blocking Tolerances Minimized:** The AISC *Code of Standard Practice* Section 10.24 requires all copes, miters, and cuts in AESS material are to be made with a uniform gap of $^1/_8$". This tolerance is more stringent than the tolerances that fabricators are held to for standard structural steel material. In many cases, this requires the fabricator to custom cut and fit each member, adding significant cost to the project. This classification is not recommended for standard AESS. It is recommended to specify this classification only where joints are within a close viewing proximity and only if completely necessary.

h **Joint Gap Tolerances Minimized:** This classification is similar to item b. above. A clear distance between abutting members of $^1/_8$" is required. Again, this is more stringent than the tolerances that fabricators are held to for standard structural steel. This classification is difficult to achieve both in the shop and field due to material size consistency and erection fit up tolerances, adding significant cost to the project.

i **Piece Marks Hidden:** During the fabrication and erection processes, members are marked with specific piece numbers. These numbers are usually left on the piece after erection is complete. AESS pieces are marked in inconspicuous places whenever possible, but there are many cases where these marks will be seen. If removal of these marks is required for aesthetic reasons, this classification should be specified.

j **Surface Defects Minimized:** In the process of handling the materials, the flanges of the beams and columns will inevitably be deformed and scarred. If this classification is specified, these deformities and scars will be removed.

k **Mill Marks Removed:** All steel mills mark their material with heat numbers and producer information to identify the material chemistry and strength and the producer. These marks can be stenciled, stamped or taped on to the member. Most mills now stamp the markings on the piece. Removal of the stenciled or taped marking is a simple process, but removing the stamped marking is a difficult process. The common method to remove a stamped mark is to grind it out, leaving a large blemish where the marking was. This blemish is more obvious to the viewer than the mill mark. It is important to note that whenever the mill marks are removed, the traceability for those pieces is usually lost.

l **Grinding of Sheared Edges:** In the process of fabrication, some types (plate and sheet specifically) of material are sheared. The sheared edge leaves a rough surface with burrs, which is not usually ground for standard structural steel pieces, except where it interferes with the fit-up. AESS requirements may demand that the rough surface be deburred and ground smooth for aesthetic reasons.

m **Rolled Members: Minimize Distortion:** In the process of fabrication, some members may be rolled into various shapes. When rolling the member, it will distort. If AESS requirements dictate that the distortion shall be minimized, this classification should be specified. The added cost range percentages noted assume that 10% of the AESS tonnage is to be rolled.

n **Seal Welds To Close Open Gaps:** In standard structural steel frames, seal welding to close joints and gaps is normally not required. AESS frames may require welds to seal gaps from environmental implications or for aesthetic reasons. Should seal welding be required, this classification should be specified. It is important to note that seal welding of members can distort them.

o **Bolt Head Orientation Dictated:** For standard structural steel frames, the orientation of the bolt heads is left up to the erector. Ease of access for placing and tightening the bolt will dictate the bolt head orientation. Should the bolt heads be required to all be on the same surface, special attention is required in the shop and field.

p **Field Welding Aids Removed:** In a standard structural steel frame, the aids used in the process of field welding are not removed. Often times they are not removed due to structural integrity issues. Should they be removed from AESS frames due to aesthetic concerns, special attention is required in the shop and in the field.

q **Close Weld Access Holes at Full Pen Welds:** The comments under item p above also apply here. Weld access holes are the holes in the web of beams and columns to allow the welder to weld in the areas of the member's web. If they are required to be closed for aesthetic reasons, special attention is required in the shop and in the field.

r **Power Tool Cleaning (SSPC-SP3):** Power tool cleaning removes all loose mill scale, loose rust, loose paint and other loose detrimental foreign matter using power tools. This process requires that Solvent Cleaning (SSPC-SP1) be performed prior. It is not intended that adherent mill scale, rust and paint be removed by this process. Mill scale, rust and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.

s **Commercial Blast Cleaning (SSPC-SP6):** A commercial blast cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter.

t **Interior Environment - Low End Primer/Finish Coating:** Alkyd (oil-based) finish coat with a shop coat primer.

u **Interior Environment - High End Primer/Finish Coating:** Epoxy finish coat with an epoxy or zinc rich primer.

v **Exterior Environment - Low End Primer/Finish Coating:** Acrylic (water-based) finish coat with a shop coat primer.

w **Exterior Environment - High End Primer/Finish Coating:** Polyurethane finish coat with an epoxy intermediate coat and zinc rich primer.

x **Galvanizing (ASTM A385):** Care should be taken when specifying hot dip galvanizing for AESS. Zinc coatings produced by the hot dip galvanizing process are excellent corrosion protection systems, but when the coating becomes very thick or dull gray, the coating may not be suitable for architectural applications. The appearance can become blotchy with sections of dull finish and sections with bright finish. Almost all of these surface effects last for the first couple of years and then the coating becomes uniformly dull gray as the protective layer of corrosion products is formed on the surface of the galvanized steel. ASTM A385 describes the effects of steel chemistry on the hot dip galvanized finish, and also states that experienced galvanizers can in many instance exercise some control over coating structure. If cosmetic (aesthetic) appearance is of concern, the purchaser should select an experienced galvanizer and discuss any concerns about aesthetics (surface appearance) prior to any galvanizing.