SPECIALTY & CORROSION-RESISTANT STEEL REINFORCEMENT: PRODUCT GUIDE

Information for specification, fabrication, estimating, detailing and placement of reinforcing steel bars specified for improved corrosion resistance, or other special uses or conditions.
Prepared under the Direction of the CRSI Engineering Practice Committee
by the Committee on Durability.

1st Edition, 1st Printing

<table>
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<th>Name</th>
<th>Affiliation</th>
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</thead>
<tbody>
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</tr>
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</tr>
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<td>International Zinc Association</td>
</tr>
<tr>
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<td>Rockford Fabricators, Inc.</td>
</tr>
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<td>Gerdau Long Steel North America</td>
</tr>
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<td>Dennis J. Fontenot</td>
<td>CMC Rebar</td>
</tr>
<tr>
<td>Peter Fosnough</td>
<td>Harris Rebar - Ambassador Steel</td>
</tr>
<tr>
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<td>MMFX Steel Corporation of America</td>
</tr>
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</tr>
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<td>Western Coating, Inc.</td>
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<td>General Technologies, Inc.</td>
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<tr>
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<td>Dayton Superior Corporation</td>
</tr>
<tr>
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<td>TMR Stainless</td>
</tr>
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</tr>
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<td>Gerdau</td>
</tr>
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<td>Dayton Superior Corporation</td>
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<td>MMFX Technologies Corporation</td>
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<td>South Atlantic Galvanizing</td>
</tr>
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<td>Simcote, Inc.</td>
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<td>Re-Steel (Corrosion Control)</td>
</tr>
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<td>Epoxy Interest Group of CRSI</td>
</tr>
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<td>Concrete Reinforcing Steel Institute</td>
</tr>
<tr>
<td>Doug Rourke</td>
<td>International Zinc Association</td>
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<td>Commercial Metals Company</td>
</tr>
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<td>Axalta Coating Systems USA, Inc.</td>
</tr>
<tr>
<td>David Wasz</td>
<td>B.L. Downey Company, LLC</td>
</tr>
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<td>Brice Wager</td>
<td>Gerdau</td>
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</tbody>
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# Contents

1. Introduction and Scope ............................................................................................................. 1

2. Definitions and Usage ................................................................................................................ 1

3. Reference Standards and Publications .................................................................................. 2
   3.1. American Concrete Institute (ACI) ................................................................................. 2
   3.2. ASTM International (ASTM) ....................................................................................... 2
   3.3. American Welding Society (AWS) .................................................................................. 3
   3.4. Concrete Reinforcing Steel Institute (CRSI) ................................................................. 3

4. Epoxy-Coated Reinforcing Steel Bars ..................................................................................... 4
   4.1. Material Specification ...................................................................................................... 4
   4.2. Bar Supports .................................................................................................................... 4
   4.3. General Notes .................................................................................................................. 5
   4.4. Estimating ........................................................................................................................ 5
   4.5. Detailing ........................................................................................................................... 5
   4.6. Fabrication ....................................................................................................................... 5
   4.7. Handling and Storage ...................................................................................................... 6
   4.8. Placing .............................................................................................................................. 6
      4.8.1. Cleaning .................................................................................................................... 7
      4.8.2. Field Welding .......................................................................................................... 7
      4.8.3. Field Bending .......................................................................................................... 7
      4.8.4. Field Cutting .......................................................................................................... 7
      4.8.5. Tying ......................................................................................................................... 7
      4.8.6. Mechanical Splices ................................................................................................. 7
      4.8.7. Spiral Reinforcing Bars ......................................................................................... 7
   4.9. Contract Considerations .................................................................................................... 8

5. Galvanized Reinforcing Steel Bars ......................................................................................... 8
   5.1. Material Specification ...................................................................................................... 8
   5.2. Bar Supports .................................................................................................................... 8
   5.3. General Notes .................................................................................................................. 9
      5.3.1. Embrittlement ........................................................................................................... 9
      5.3.2. Dissimilar Metals in Concrete .................................................................................. 9
   5.4. Estimating ........................................................................................................................ 10
   5.5. Detailing ........................................................................................................................... 10
   5.6. Fabrication ....................................................................................................................... 10
   5.7. Handling and Storage ...................................................................................................... 11
   5.8. Placing .............................................................................................................................. 11
      5.8.1. Cleaning .................................................................................................................... 11
      5.8.2. Field Welding .......................................................................................................... 11
      5.8.3. Field Bending .......................................................................................................... 12
      5.8.4. Field Cutting .......................................................................................................... 12
      5.8.5. Tying ......................................................................................................................... 12
      5.8.6. Mechanical Splices ................................................................................................. 12
      5.8.7. Spiral Reinforcing Bars ......................................................................................... 12
   5.9. Contract Considerations .................................................................................................... 12

6. Dual-Coated Reinforcing Steel Bars ..................................................................................... 13
   6.1. Material Specification ...................................................................................................... 13
   6.2. Bar Supports .................................................................................................................... 13
1. **Introduction and Scope**

This Guide provides information for the specification, fabrication, estimating, detailing and placement of reinforcing steel bars specified for improved corrosion resistance, or other special uses or conditions. This document is a guide, not a standard, and appropriate project specific contractual documents should be reviewed.

This Guide does not provide guidance concerning the selection of materials for a specific purpose. The licensed design professional (LDP) or specifier should consult relevant design requirements to determine whether corrosion-resistant reinforcing bars or specialty reinforcing bars might be beneficial for a particular use or project.

2. **Definitions and Usage**

**Austenitic (microstructure)** – Within the context of this document, a steel microstructure that results in material with a very low magnetic permeability.

**Black bar** – Uncoated carbon steel reinforcing bar as received from the mill or fabricator.

**Bundle** – A number of reinforcing bars joined together using strapping material.

**Contamination** – Contamination on the stainless steel surface generally consists of particles of carbon steel or iron dust which may be sitting on or embedded in the surface, or corrosion staining from carbon steel that has been stored above or near stainless steel. Either is the result of inappropriate handling of stainless steel during fabrication, shipping or storage.

**Corrosion-resistant reinforcing bars** – Relative to uncoated carbon steel reinforcing bars (black bars), reinforcing bars having a significantly increased chloride threshold before initiation of corrosion in concrete and/or a significantly reduced rate of corrosion, as demonstrated by or predicted from ASTM testing methods for reinforcing bars or documented long-term performance in concrete. The corrosion resistance is achieved by barrier coatings or through the material’s chemical composition itself.

**Detailing** – The creation of placing drawings that illustrate the design intent and required location of the reinforcing steel bars within the concrete member.

**Dual-coated reinforcing bars** – Reinforcing bars with a dual coating of zinc alloy and epoxy. The zinc layer is applied by the thermal spray coating method followed by an epoxy coating applied by the electrostatic spray method.

**Duplex stainless steel** – Stainless steel that has both austenitic and ferritic microstructures.

**Epoxy-coated reinforcing bars** – Reinforcing bars coated with a protective fusion-bonded epoxy coating applied by the electrostatic spray method.

**Ferritic (microstructure)** – Within the context of this document, a steel microstructure that results in magnetic material.

**Galvanized reinforcing bars** – Reinforcing bars with a protective zinc coating applied by dipping the properly prepared bars into a molten bath of zinc, also known as hot-dip galvanizing.

**Heat** – A batch or cast of steel produced from a single melting operation.

**High-strength reinforcing bars** – Reinforcing bars that have a specified, nominal, yield strength greater than 80,000 psi.
Job galvanizing – Galvanized coating services provided to customers on a job-lot basis. A customer’s material is processed alongside a variety of other orders and returned to the customer when completed.

Licensed design professional (LDP) – An individual who is licensed to practice structural design as defined by the statutory requirements of the professional licensing laws of the state or jurisdiction in which the project is to be constructed and who is in responsible charge of the structural design; in other documents, also referred to as registered design professional.

Low carbon, chromium steel – A microcomposite steel alloy whose properties come from its chemistry and microstructure.

Magnetic permeability – Measure of the ability of a material to avoid formation of a magnetic field. Reinforcing bars with very low magnetic permeability may be used in applications requiring non-magnetic properties.

Passivation – Defined by ASTM A967 as the chemical treatment of a stainless steel with a mild oxidant, such as a nitric acid solution, for the purpose of the removal of free iron, rust staining, or other foreign matter and the formation of a passive film.

Pickling – A chemical treatment defined within ASTM A380. Most commonly it is a nitric-hydrofluoric acid solution that removes both metallic contamination, and welding and heat-treating scales.

Pre-fabricated – Reinforcing bar that has been cut and bent to its final configuration before coating.

Pre-galvanized – Reinforcing bar that has been cut and bent to its final configuration after galvanizing.

Specialty reinforcing bars – Reinforcing bars other than uncoated carbon steel reinforcing bar.

Stainless steel – Steel conforming to a specification that requires, by mass percent, a minimum chromium content is 10.5 percent or more, and a maximum carbon content of less than 1.2 percent. These iron-based alloys may include nickel, molybdenum, manganese, or nitrogen in varying amounts.

Strain-age Embrittlement – Reduction in ductility caused when areas of high induced stress, generally a result of cold working or impurities in the steel, are exposed to high temperature.

Uncoated carbon steel reinforcing bars – Reinforcing steel bars produced to ASTM A615/A615M, A706/A706M, or A996/A996M specifications; in other words, black bars.

Zinc-coated reinforcing bars – See galvanized reinforcing bars.

3. Reference Standards and Publications

3.1. American Concrete Institute (ACI)
ACI 301 Standard Specification for Structural Concrete
ACI 318 Building Code Requirements for Structural Concrete and Commentary

3.2. ASTM International (ASTM)
ASTM A143/A143M Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
ASTM A276 Standard Specification for Stainless Steel Bars and Shapes
ASTM A380 Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A615/A615M - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706/A706M – Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A767/A767M - Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A775/A775M Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A780/A780M Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A934 / A934M Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A955/A955M Standard Specification for Deformed and Plain Stainless-Steel Bars for Concrete Reinforcement
ASTM A967 Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
ASTM A996/A996M Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM A1035/A1035M Standard Specification for Deformed and Plain, Low-carbon, Chromium, Steel Bars for Concrete Reinforcement
ASTM A1055 / A1055M Standard Specification for Zinc and Epoxy Dual-Coated Steel Reinforcing Bars
ASTM D3963/D3963M Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Steel Reinforcing Bars

3.3. American Welding Society (AWS)
ANSI/AWS Z49.1 Safety in Welding, Cutting and Allied Processes
AWS D1.4/D1.4M Structural Welding Code – Reinforcing Steel
AWS D1.6/D1.6M Structural Welding Code – Stainless Steel
AWS WZC Welding Zinc-Coated Steel (formerly AWS D19.0-72)

3.4. Concrete Reinforcing Steel Institute (CRSI)
Manual of Standard Practice
Standard for Supports for Reinforcement Used in Concrete
Voluntary Certification Program for Fusion-Bonded Epoxy Coating Applicator Plants
4. **Epoxy-Coated Reinforcing Steel Bars**

4.1. **Material Specification**

Epoxy-coated steel reinforcing bars should be specified according to ASTM A775/A775M or ASTM A934/A934M. ASTM A775/A775M specifies deformed and plain steel reinforcing bars with a protective, fusion-bonded epoxy coating applied by the electrostatic spray method. ASTM A934/A934M covers deformed and plain steel reinforcing bars that are fabricated prior to surface preparation and then coated with a protective fusion-bonded epoxy coating by electrostatic spray or other suitable method. Pre-fabricated steel may also be coated using a coating meeting ASTM A775/A775M.

The most commonly used epoxy-coated reinforcing steel bars meet ASTM A775/A775M, which is typically green in color in North America, although other colors are used. Product meeting ASTM A934/A934M is generally grey or purple in color. Reinforcing bars meeting ASTM A615/A615M, A706/A706M, or ASTM A996/A996M may be epoxy coated. Epoxy-coated reinforcing steel bars manufactured to meet ASTM A775/A775M are widely available from different manufacturers nationwide, while bars manufactured to ASTM A934/A934M have more limited geographic availability.

Quality assurance/quality control (QA/QC) procedures have been established for the bar coating process. Most of the coating plants in North America are certified through CRSI’s Voluntary Certification Program for Fusion-Bonded Epoxy Coating Applicator Plants. This certification program evaluates many aspects of the plant processes and procedures and includes personnel training, bar cleaning, and coating operations. Coating thickness and other properties of the epoxy-coated bars are also evaluated.

4.2. **Bar Supports**

Four types of bar supports are available to support epoxy-coated reinforcing steel bars. The class of the bar support should be selected based on the use.

1. Wire bar supports - supports coated entirely with dielectric material, such as epoxy or plastic that is compatible and inert in concrete.

2. Plastic bar supports – supports made of dielectric material such as plastic or other inert material.

3. Precast concrete blocks – supports made of precast concrete with embedded tie wires or precast concrete doweled blocks. For these bar supports, the wires or dowels should be epoxy-coated or plastic-coated.

4. Epoxy-coated reinforcing steel bars - in walls reinforced with epoxy-coated reinforcing steel bars, spreader bars should be epoxy-coated. Proprietary combination bar clips and spreaders used in walls with epoxy-coated reinforcing bars should be made of corrosion-resistant material or coated with dielectric material.

For epoxy-coated and plastic-coated wire bar supports, damaged coating on the supports should be repaired with patching material applied in accordance with the material manufacturer’s recommendations. The patching material should be compatible with the epoxy-coating material or plastic-coated material, and be inert in concrete. Inspection of bar supports is normally made at the manufacturer’s facility prior to shipment.
4.3. **General Notes**

The design of reinforced concrete structures containing epoxy-coated reinforcing bars is identical to that of uncoated carbon steel reinforcing bars apart from consideration of lap splices and development length. The lap lengths for epoxy-coated reinforcing bar should be increased compared with uncoated bars according to the appropriate design code.

Epoxy-coated reinforcing bars can be spliced by lapping, by using mechanical splices, or by welding. Any uncoated steel or damaged coatings should also be coated with a dielectric material after joining.

Different types of coated mechanical splices are available from various suppliers. Areas between bars and mechanical splices should be patched using a two-part epoxy repair material meeting ASTM A775/A775M.

All sizes, lengths, and grades of uncoated carbon steel reinforcing bar may be epoxy-coated. Epoxy-coated reinforcing bars should be identified in contract documents with a suffix “E” and a note stating that all bars identified as such are to be epoxy-coated. ACI 301 may be used as a standard specification for the use of epoxy-coated reinforcing bars or specific reference may be made to ASTM D3963/D3963M for field use of epoxy-coated reinforcing bars.

4.4. **Estimating**

When estimating projects using epoxy-coated reinforcing bars, longer lap lengths are required. These lengths will be noted in the contract documents.

When ordering epoxy-coated reinforcing bars, the weight of the coating is generally neglected for cost estimating purposes; it is considered incidental to the bar cost.

Accessories such as coated tie wire, coated couplers, and coated bar supports are readily available.

4.5. **Detailing**

Available bar lengths are the same as that for uncoated carbon steel reinforcing bar. Bend diameters for epoxy-coated reinforcing bars as specified in design codes are the same as for uncoated carbon steel reinforcing bars.

When detailing projects using epoxy-coated reinforcing bars, longer lap lengths are required. These lengths should be noted in the contract documents.

Bending of epoxy-coated reinforcing bars in the field may require the approval of the LDP. Reliance on field modifications should be minimized.

4.6. **Fabrication**

ASTM D3963/D3963M and A775/A775M cover requirements for fabrication of epoxy-coated reinforcing bars. Fabrication of epoxy-coated reinforcing bars is conducted in much the same way as uncoated carbon steel reinforcing bars. However, care should be taken to ensure that the epoxy-coated reinforcing bars are fabricated in a manner that does not damage the coating.

Material traceability should be maintained throughout distribution, fabrication, and placing of epoxy-coated reinforcing bars. Heat numbers, grades, and mill of origin should be prominently displayed on mill bar tags. If tags have been removed, the bars should be retagged after fabrication. Mill test reports should be recorded and stored for future reference.
All tooling (pins), support surfaces, and contact points on the fabrication equipment should be covered with appropriate protective covering (ultra-high molecular weight plastic or equivalent).

Epoxy-coated reinforcing bars manufactured to the requirements of ASTM A934/A934M are fabricated uncoated and then coated afterwards. These bars should not be bent after coating. Pre-fabricated reinforcing bars may be coated using materials meeting ASTM A775/A775M. Damage to the epoxy-coated reinforcing bars as a result of fabrication, bend areas and cut end in particular, should be repaired using a two-part epoxy material approved by the coating manufacturer and meeting the appropriate specifications.

Certification procedures are being developed by CRSI for fabricators of epoxy-coated reinforcing bars. The procedures are intended to ensure products are handled in a manner that minimizes damage to the coating and that any resultant coating damage is appropriately repaired.

### 4.7. Handling and Storage

When lifting individual bars or bundles of epoxy-coated reinforcing bars, spreader bars or strong backs with multiple pick-up points should be used to minimize sags.

Synthetic or padded slings should also be used and at no time should epoxy-coated reinforcing bars be lifted using bare chains or cables.

Bundles of epoxy-coated reinforcing bars should be stored off the ground on suitable materials, such as timber cribbing.

Epoxy-coated reinforcing bars should be stored separately from uncoated carbon steel reinforcing bars to prevent abrasion of coating.

During storage and shipping, all contact points (e.g. trailers, storage racks) should be wood or plastic-lined. Protection of the bars during strapping is usually accomplished through use of foam placed between the strapping and the bars.

Epoxy-coated reinforcing bars should be covered using opaque polyethylene sheeting or other suitable opaque material if they are to be stored outdoors for more than two months. The covering should be secured adequately and allow for air circulation around the bars to minimize condensation under the covering.

### 4.8. Placing

ASTM D3963/D3963M or ACI 301 should be followed for bar placement. In general, epoxy-coated bars should be protected against coating damage through appropriate lifting, handling, placing and concrete placement operations. Epoxy-coated reinforcing bars should be handled with synthetic slings during placement to reduce damage to the coating. During placement, lift and set bars in place. Epoxy-coated reinforcing bars should not be dragged into place and other materials should not be dragged across placed epoxy-coated reinforcing bars. Minimize movement of personnel and materials across the epoxy-coated bars.

Prior to concrete placement, epoxy-coated bars should be inspected and damaged coating should be repaired with a two-part epoxy material according to ASTM A775/A775M or A934/A934M. All visible damage to the coating that exposes the underlying steel or allows rust to form during construction should be repaired. Plastic-headed vibrators should be used to consolidate the concrete.
4.8.1. Cleaning
Epoxy-coated reinforcing bars should be delivered free from mud, debris, and other deleterious material. A low-pressure water spray should be used to remove mud and debris from the bars if needed. If other materials deleterious to bond are found on the bars, they should be removed by a method that does not damage the surface of the epoxy coating.

4.8.2 Field Welding
Field welding of epoxy-coated reinforcing bars is acceptable with the LDP’s authorization, provided the base steel meets ASTM A706/A706M. Welding should conform to AWS D1.4/D1.4M. Bars meeting ASTM A615/A615M may also be welded with the LDP’s authorization, but may require preheating. After welding, epoxy-coated reinforcing bars should be repaired using a two-part repair material approved by the coating manufacturer and meeting the appropriate specifications. Tack welding is not permitted.

4.8.3 Field Bending
It is not recommended to bend epoxy-coated reinforcing bars in the field due to the risk of coating damage. Where field bending cannot be avoided, surfaces of bending equipment should be padded with neoprene or other synthetic material, and should be free of steel and other abrasive particles. Any damage to coating should be repaired using a two-part epoxy approved by the coating manufacturer and meeting the appropriate specifications.

4.8.4 Field Cutting
Epoxy-coated reinforcing bars may be cut in the field either with an abrasive cut off saw or power shears. Flame cutting should not be conducted. All cut surfaces should be repaired using a two-part repair material approved by the coating manufacturer and meeting the appropriate specifications.

4.8.5 Tying
Coated steel tie wire should be used when tying epoxy-coated reinforcing bars. Typically, the tie wire is coated with PVC. Tying should hold bars in position under construction loads as required by the governing design code.

4.8.6 Mechanical Splices
Mechanical splices should be epoxy coated to resist corrosion. Once installed, exposed steel at areas between bars and couplers should be patched using appropriate repair materials.

4.8.7 Spiral Reinforcing Bars
Spiral reinforcing bars meeting ASTM A775/A775M are available. Handling and storage guidelines set forth in Section 4.7 of this guide should be observed. Spirals that are epoxy coated after fabrication may be subject to extensive handling as part of the coating process. Spiral diameters and pitches may be subject to disturbance and additional time may be required for the spirals at the job site. Spirals manufactured from reinforcing steel coated prior to fabrication are produced and shipped direct from the manufacturer and require little adjustment in the field.
4.9. Contract Considerations

Epoxy coatings may be applied to ASTM A615/A615M, A706/A706M, or A996/A996M steel. These steels are specified with overall strengths ranging from 40 to 80 ksi with sizes from #3 to #18. Under ASTM A775/A775M, the reinforcing bars are typically ordered as straight lengths, which are coated and then fabricated. Under ASTM A934/A394M, reinforcing bars are fabricated prior to coating. For bars manufactured using ASTM A934/A934M, the method of temperature reduction of hot, freshly coated bars should be specified. Epoxy-coated reinforcing bars are available in the same lengths as uncoated carbon steel reinforcing bar. ASTM A775/A775M products are readily available in straight lengths up to 64 feet. However, longer lengths and coils are also available; consult with the manufacturer for availability. Local availability and lead time requirements for ASTM A934/A934M products may differ by region.

5. Galvanized Reinforcing Steel Bars

5.1. Material Specification

Galvanized reinforcing bars should be specified according to ASTM A767/A767M. This specification covers reinforcing steel with protective zinc coatings applied by dipping the properly prepared reinforcing steel bars into a molten bath of zinc. This process is referred to as hot-dip galvanizing. The most commonly used steel for galvanized bars meets the requirements of ASTM A615/A615M or A706/A706M.

Galvanized reinforcing bars are generally available nationwide. Care should be taken in selection of a galvanizer experienced with reinforcing steel bars.

Reinforcing bars sent for galvanizing should be free of grease, oils, and paints as these materials may be difficult for a galvanizer to remove during processing and could result in extra cleaning charges.

Galvanizers provide certification that the finished product complies with ASTM A767/A767M and other requirements of the project specification. Further guidance is available from the American Galvanizers Association.

Galvanized reinforcing bars should have no bare spots and be free of blisters. Coated bars that are stuck together or exhibit sharp slivers or tears, which make the material dangerous to handle, may also be rejected.

ASTM A767/A767M lists two coating weight options, Class I and Class II, which is specified by the purchaser. While there are no guidelines within the specification regarding applications for Class I or Class II, the thicker Class I coating is typical of batch-processed material where coating weights tend to be heavier. The thinner Class II coating is more ductile and may be preferable for bars galvanized before fabrication, as it is likely to exhibit less cracking or flaking of the coating when bent.

5.2. Bar Supports

Bar supports should be galvanized, metal coated with dielectric material, plastic, or precast concrete. Galvanized reinforcing bars should not touch uncoated steel in order to avoid creating a galvanic cell that would accelerate corrosion of the surrounding zinc coating. The class of the bar support should be selected based on the use.
5.3. **General Notes**

ASTM A767/A767M lists two coating weights options, Class I or Class II. The LDP or specifier should determine the correct coating weight for the application.

Galvanized reinforcing bars that are to be embedded into concrete should be chromated in compliance with ASTM A767/A767M.

Bend diameters for reinforcing bars fabricated before galvanizing should conform to the diameters specified in Table 2 of ASTM A767/A767M. Note that these bend diameters may be larger than those used when fabricating non-galvanized bars.

Where mechanical splices are specified, the coupling devices should be hot-dip galvanized, mechanically galvanized, or otherwise coated to resist corrosion.

All sizes and grades of ASTM A615/A615M and A706/A706M reinforcing bars can be galvanized. Galvanized reinforcing bars shown on contract documents should be noted with a suffix “G”. The contract documents should have a note stating that all bars identified as such are to be hot-dip galvanized.

ACI 301 may be used as a standard specification for galvanized bars or specific reference may be made to Appendix X1 of ASTM A767/A767M.

5.3.1 **Embrittlement**

Strain-age embrittlement of galvanized reinforcing steel bars may occur when pre-fabricated bars are galvanized. ASTM A767/A767M does not require embrittlement testing. However, some state and agency specifications do call for embrittlement tests to be performed. When testing is mandated, the specification will usually reference either the ductility requirements in ASTM A615/A615M (for pre-galvanized bar) or the procedures in ASTM A143/A143M (for prefabricated bar).

In order to reduce potential strain-age embrittlement during galvanizing, minimum bend diameters should follow the requirements of Table 2 in ASTM A767/A767M. When smaller bend diameters are made, bars may be heated to relieve stresses per Section 7.1 of ASTM A767/A767M prior to galvanizing.

5.3.2 **Dissimilar Metals in Concrete**

When galvanized reinforcing bars are used in concrete, they should not be directly in contact with uncoated steel reinforcing bars, copper, or other dissimilar metal. If required, polyethylene spacers or similar dielectric tapes can be used to provide insulation between galvanized bars and other dissimilar metals.
5.4. **Estimating**

The zinc coating on galvanized reinforcing steel will add approximately six to eight percent to the original weight of the bars, although the weight increase for larger or smaller diameter bars may vary from this range. The “after galvanizing” weight is multiplied by the quoted price per pound to determine the cost the customer will be invoiced. In job batch galvanizing, it is typical for each lift of material to be weighed as it leaves the production floor with these weights totaled for customer billing. However, for highly repetitive shapes and consistent materials, many galvanizers are willing to quote a fixed, theoretical pickup rate to facilitate fixed per piece billing. The actual “after galvanizing” weights should also be considered when scheduling transportation of galvanized reinforcing bars to avoid over-weight loading of trucks. Estimators should ascertain what bar lengths are available in their local market and factor in the required number of mechanical splices if used.

5.5. **Detailing**

Bend diameters for bars fabricated before galvanizing should conform to the diameters as specified in Table 2 of ASTM A767/A767M.

In most cases, reinforcing bar lengths up to 40 feet are readily galvanized with longer lengths subject to the capacity of the local galvanizer. The limitation is a function of kettle size and will vary from company to company and by region. Bars longer than the galvanizing kettle may be coated using a double-dip method, where each end is separately immersed. This results in a narrow overlap line where the zinc coating may be thicker than on the rest of the bar.

Development and lap splice lengths for galvanized reinforcing bar are equivalent to uncoated carbon steel reinforcing bar.

5.6. **Fabrication**

Fabrication may be completed before galvanizing (pre-fabricated) or after galvanizing (pre-galvanized). Both are allowed under A767/A767M. For bars fabricated before galvanizing, Table 2 of ASTM A767/A767M lists minimum pin diameters. For bars to be fabricated after galvanizing, the coating weight options should be discussed with the galvanizer to avoid issues with flaking of the coating during fabrication. Bars with heavier than a Class II coating may also be bent, but repair of the coating should be conducted if flaking occurs in the bend area.

All damaged coating touch-up should be conducted in accordance with ASTM A780/A780M using a conforming zinc-rich spray paint that contains at least 94% solids in dry film.

Reinforcing bars galvanized prior to fabrication have the advantage of no cold work stresses prior to galvanizing, no requirement for special pin sizes for bending, and have a reduced risk of lost or mixed material, as the reinforcing bars do not leave the fabricator’s control for coating. Disadvantages of pre-galvanized reinforcing bars may include limitations in length, the necessity to touch-up cut ends, and potential for objectionable flaking on heavier coatings. Galvanizing after fabrication has the advantage of having no cut ends to touch-up, and avoids coating of bar length that may end up as unused material. However, there is a potential for mixed or lost material. There are sometimes concerns about the effects of cold working and potential development of strain age embrittlement when fabricated bars are subsequently galvanized. If tighter bend radii than those in Table 2 of ASTM A767/A767M are necessary, the standard calls for stress relieving of the material prior to galvanizing.
Material traceability should be maintained throughout distribution, fabrication, and placing of galvanized reinforcing bars. Heat numbers, grades, and mill of origin should be prominently displayed on mill bar tags. If tags have been removed, the bars should be retagged after fabrication. Mill test reports should be recorded and stored for future reference.

Adequate communication between the fabricator and galvanizer is required to ensure that proper tagging is restored to the reinforcing bars following galvanizing. The fabricator should discuss the retagging of the bars with the galvanizer before starting any job. Efficient operation of a job galvanizing plant requires the consolidation of as much similar material as possible into each processing ‘lift’. As a result, numerous ‘sub’ bundles and often several ‘master’ bundles of fabricated reinforcing bars are processed together. There are systems available that use special inks and tag material to identify reinforcing bars that will withstand the galvanizing process.

5.7. Handling and Storage
Galvanized reinforcing bar should be handled in the same manner as uncoated carbon steel reinforcing bars, taking normal precautions against rough treatment and using normal material handling equipment, bending rollers, chains, and slings. Galvanized material is not UV sensitive and may be stored outside, uncovered; but it should not be stored in contact with or beneath uncoated steel to avoid transferring rust stains. Long term storage in contact with wood dunnage may lead to surface staining in the contact areas and should be avoided.

5.8. Placing
Galvanized reinforcing bars are handled and placed in the same manner as uncoated carbon steel reinforcing bars. Field cut ends should be touched up according to ASTM A780/A780M.

5.8.1 Cleaning
Galvanized reinforcing bars should be delivered free from mud, debris, and other deleterious material. A low-pressure water spray should be used to remove mud and debris from the bars if needed. If other materials deleterious to bond are found on the bars, they should be removed by a method that does not damage the surface of the zinc coating.

5.8.2. Field Welding
Galvanized reinforcing bars may be welded in the field with the approval of the LDP. Welding of galvanized reinforcing bars should conform to AWS WZC, which calls for welds to be made on steel that is free of zinc adjacent to the weld to prevent strength reduction through zinc inclusion in the weld itself. The zinc coating should be removed at least one inch from either side of the intended weld zone and on all sides of the bar by grinding or equivalent means. Once the weld is completed, the zinc coating in the area of the weld should be repaired using procedures described in ASTM A780/A780M.

Fumes from welding galvanized reinforcing bars may contain zinc, iron and other potentially noxious substances, and proper ventilation that minimizes worker exposure to fume is essential. The specific precautions are found in ANSI/AWS Z49.1 Safety in Welding, Cutting and Allied Processes. Tack welding is not permitted.
5.8.3. Field Bending
Pre-galvanized reinforcing bars kept in stock by a fabricator should be bent according to the requirements of Chapter 6 of the CRSI Manual of Standard Practice, and ACI 318. Re-bending bars that were galvanized after fabrication should be avoided, although minor positioning adjustments are allowed. All field bending should be in compliance with applicable codes and standards, and only when approved by the LDP.

5.8.4. Field Cutting
Galvanized reinforcing bars may be field cut with saws, shears, bolt cutters, or flame. Cut ends should be repaired as per ASTM A780/A780M.

5.8.5. Tying
Galvanized reinforcing bars should be installed using galvanized or coated tie wire, or plastic ties. Specially manufactured plastic clips or connectors are permitted. Tying should hold bars in position under construction loads as required by the governing design code.

5.8.6. Mechanical Splices
Where mechanical splices are specified, the coupling devices should be hot-dip galvanized, mechanically galvanized, or epoxy coated to resist corrosion.

5.8.7. Spiral Reinforcing Bars
Spiral reinforcing bars that are being hot-dip galvanized after fabrication are subject to extensive handling as part of the coating process. Spiral diameters and established pitches are subject to disturbance and additional time may be required for setting the spirals at the job site. Spirals manufactured from pre-galvanized bar will be limited by the length of straight bar available.

5.9. Contract Considerations
Under ASTM A767/A767M, reinforcing bars may be ordered in two manners: (1) as bars galvanized prior to fabrication or (2) as fabricated shapes sent to a job galvanizer for coating.

Galvanized reinforcing steel bars are generally available in standard lengths up to 40 feet. Lengths longer than 40 feet may be available through special arrangement, dependent on local galvanizing capacity. Designers and engineers should not specify galvanized bars longer than 40 feet without verifying whether the desired length can be suitably galvanized. See Section 5.4 of this guide for “after galvanizing” bar weight adjustments due to galvanizing.

Galvanized reinforcing bars may be specified according to coating thickness as Class I or Class II, as described in ASTM A767/A767M.

Local availability and lead time requirements may differ by region and galvanizer.

The galvanizer will retain process records and provide certification that the coating complies with ASTM A767/A767M. Additional testing and requirements beyond those outlined in ASTM A767/A767M should be described in contract documents and discussed with the galvanizer before work commences. The galvanizer is typically only responsible for maintaining heat lot integrity. Additional traceability requirements should be clarified with the galvanizer.
6. Dual-coated Reinforcing Steel Bars

6.1. Material Specification

Dual-coated reinforcing steel bars should be specified according to ASTM A1055/A1055M. This specification covers deformed and plain reinforcing steel bars with a thermal-spray zinc layer and an exterior epoxy coating. The steel for these bars should comply with ASTM A615/A615M, A706/A706M, or A996/A996M and the epoxy coating should comply with ASTM A775/A775M. The design of reinforced concrete structures containing dual-coated reinforcing steel bars is identical to that of uncoated carbon steel reinforcing bar; however, the lap lengths for dual-coated reinforcing bar are increased compared with uncoated carbon steel reinforcing bar according to the appropriate design code.

Quality assurance / quality control procedures are established by individual manufacturers for dual-coated reinforcing bars. These processes ensure that the bars are appropriately cleaned prior to coating to remove mill scale and other contaminants, and that the bars are appropriately coated. Coating thickness and other properties of the dual-coated bars are also evaluated.

6.2. Bar Supports

Four types of bar supports are available to support dual-coated reinforcing steel bars. The class of the bar support should be selected based on the use.

1. Wire bar supports - supports coated entirely with dielectric material, such as epoxy or plastic that is compatible and inert in concrete.
2. Plastic bar supports – supports made of dielectric material such as plastic or other inert material.
3. Precast concrete blocks – supports made of precast concrete with embedded tie wires or precast concrete doweled blocks. For these bar supports, the wires or dowels should be epoxy-coated or plastic-coated.
4. Dual-coated or epoxy-coated reinforcing steel bars - in walls reinforced with epoxy-coated reinforcing steel bars, spreader bars should be epoxy-coated. Proprietary combination bar clips and spreaders used in walls with epoxy-coated reinforcing bars should be made of corrosion-resistant material or coated with dielectric material.

For epoxy-coated and plastic-coated wire bar supports damaged coating on the supports should be repaired with patching material applied in accordance with the material manufacturer’s recommendations. The patching material should be compatible with the epoxy-coating material or plastic-coated material, and be inert in concrete. Inspection of bar supports is normally made at the manufacturer’s facility prior to shipment.

6.3. General Notes

Dual-coated reinforcing bars can be spliced by lapping, by mechanical splices, or by welding. Where mechanical splices are specified, the coupling devices should be epoxy or dual coated to resist corrosion or made from stainless steel.

The lap lengths for dual-coated reinforcing bar will be longer than for uncoated carbon steel reinforcing bars according to the appropriate design code.

Dual-coated reinforcing bars should be identified in contract documents with a suffix “D” for dual-coated or “ZE” for zinc-epoxy and a note stating that all bars identified as such are to be dual-coated.
ACI 301 may be used as a standard specification for dual-coated reinforcing bars. Bend diameters for dual-coated reinforcing bars are the same as for uncoated carbon steel reinforcing bar.

6.4. Estimating
When estimating projects using dual-coated reinforcing bars, longer lap lengths are required. These lengths will be noted on the contract documents.

When ordering dual-coated bars, the weight of the coating is generally neglected for cost estimating purposes; it is considered incidental to the bar cost.

Accessories such as coated tie wire, coated mechanical splices, and coated bar supports are readily available.

6.5. Detailing
Minimum bend diameters for dual-coated reinforcing bars are the same as for uncoated carbon steel reinforcing bars. Bending of dual-coated reinforcing bars in the field may require approval of the LDP. Reliance on field modifications should be minimized.

6.6. Fabrication
Fabrication of dual-coated reinforcing bars should comply with ASTM D3963/D3963M and A1055/A1055M. These specifications dictate the care to be taken to ensure that the bars are fabricated in a manner that does not damage the coatings.

Bending of dual-coated reinforcing bars should be conducted per ASTM A1055/A1055M. ASTM A1055/A1055M suggests that bending should be performed within the prescribed temperature range of 158 to 176°F (70 to 80°C) to minimize the potential for damage to the coating.

Material traceability should be maintained throughout distribution, fabrication, and placing of dual-coated reinforcing bars. Heat numbers, grades, and mill of origin should be prominently displayed on mill bar tags. If tags have been removed, the bars should be retagged after fabrication. Mill test reports should be recorded and stored for future reference.

During storage and shipping, all contact points (e.g. truck beds and storage racks) are to be wooden or plastic lined. Bundles are to be placed on wooden or other soft dunnage. During strapping the bars should be protected and isolated using wood or foam placed between strapping and bars.

Tooling (pins), support surfaces, and contact points between bars and equipment should be covered with a soft, non-metallic material (neoprene, wood) to reduce damage to coatings.

6.7. Handling and Storage
When lifting individual bars or bundles of dual-coated reinforcing bars, spreader bars or strong backs with multiple pick-up points should be used to minimize sags.

Synthetic or padded slings should also be used and at no time should dual-coated reinforcing bars be lifted using bare chains or cables.

Bundles of dual-coated reinforcing bars should be stored off the ground on suitable materials, such as timber cribbing.

Dual-coated reinforcing bars should be stored separately from uncoated carbon steel reinforcing bars to prevent abrasion of coating.
During storage and shipping, all contact points (e.g. trailers, storage racks) should be wood or plastic-lined. Protection of the bars during strapping is usually accomplished through use of foam placed between the strapping and the bars.

Dual-coated reinforcing bars should be covered using opaque polyethylene sheeting or other suitable opaque material if they are to be stored outdoors for more than two months. The covering should be secured adequately and allow for air circulation around the bars to minimize condensation under the covering.

### 6.8. Placing

ASTM A1055/A1055M, Appendix X1 provides guidelines for job-site practices for dual-coated reinforcing bars. In general, the bars should be protected against damage through appropriate lifting, handling, placing, and concrete placement operations. Dual-coated reinforcing bars should be handled with synthetic slings during placement to reduce damage to the coating. During placement, lift and set bars in place. Dual-coated reinforcing bars should not be dragged into place and other materials should not be dragged across placed dual-coated reinforcing bars. Minimize movement of personnel and materials across the dual-coated bars.

Prior to concrete placement, dual-coated bars should be inspected and damaged coating should be repaired with a two-part epoxy material according to ASTM A1055/A1055M. All visible damage to the coating that exposes the underlying steel or allows rust to form during construction should be repaired. Plastic-headed vibrators should be used to consolidate the concrete.

#### 6.8.1. Cleaning

Dual-coated reinforcing bars should be delivered free from mud, debris, and other deleterious material. A low-pressure water spray should be used to remove mud and debris from the bars if needed. If other materials deleterious to bond are found on the bars, they should be removed by a method that does not damage the surface of the coatings.

#### 6.8.2. Field Welding

Dual-coated reinforcing bars using ASTM A706/A706M steel may be welded according to AWS D1.4/D1.4M with the LDP’s authorization. Dual-coated reinforcing bars manufactured using ASTM A615/A615M may also be welded with the LDP’s authorization, but may require preheating. Both coatings (zinc and epoxy) should be removed at least one inch away from the extent of welds by burning or grinding. After welding, remove flux residue, spatter, and slag to expose clean steel and repair the coating using a two-part repair material approved by the coating manufacturer and meeting the appropriate specifications. Tack welding is not permitted.

#### 6.8.3. Field Bending

Field bending should be avoided. Where bending cannot be avoided, protect the coating from damage due to contact with steel surfaces with neoprene matting or with other appropriate surface protection. Bending should be conducted according to Note 10 in ASTM A1055/A1055M. ASTM A1055/A1055M suggests that bending should be performed within the prescribed temperature range of 158 to 176°F (70 to 80°C) to minimize the potential for coating damage.

Damaged coating should be repaired using a two-part epoxy approved by the coating manufacturer and meeting the appropriate specifications.
6.8.4. Field Cutting
Dual-coated reinforcing bar may be cut in the field with an abrasive cut off saw. In no instance should flame cutting be permitted. All cut surfaces should be repaired using a two-part repair material approved by the coating manufacturer and meeting the appropriate specifications.

6.8.5. Tying
Coated steel tie wire should be used when tying dual-coated reinforcing bars. Typically, the tie wire is coated with PVC. Tying should hold bars in position under construction loads as required by the governing design code.

6.8.6. Mechanical Splices
Mechanical splices should be epoxy or dual coated to resist corrosion. Once installed, exposed steel at areas between bars and couplers should be patched using appropriate repair materials.

6.8.7. Spiral Reinforcing Bars
Spiral reinforcing bars meeting ASTM A1055/A1055M are available. Handling and storage guidelines set forth in Section 6.7 of this guide should be observed. Dual-coated spirals are produced and shipped direct from the manufacturer and require little adjustment in the field.

6.9. Contract Considerations
Lead times may be longer for dual-coated reinforcing bars than for uncoated carbon steel reinforcing bars, depending on where the project and fabricator are located. Because special precautions are taken to reduce damage to coatings, fabrication may require special scheduling, potentially increasing delivery time. Local availability and lead time requirements may differ by region.

7. Stainless Steel Bars
7.1. Material Specification
In North America, stainless steel reinforcing bars should be specified according to ASTM A955/A955M. This specification covers deformed and plain stainless steel bars for concrete reinforcement used in applications requiring resistance to corrosion or controlled magnetic permeability. It includes a range of stainless steel alloys, which provide varying levels of corrosion resistance, strength, and magnetic permeability.

The stainless steel alloys used for reinforcing bars fall into two alloy families, austenitic or duplex, which describes their microstructure. Duplex stainless steel reinforcing bars are magnetic. Austenitic stainless steel reinforcing bars have low magnetic permeability and are used where non-magnetic properties are required. Reinforcing bars produced to ASTM A955/A955M must meet the chemical composition requirements of Table 1 in ASTM A276/A276M, which is the general standard for stainless steel bars. ASTM A955/A955M requires stainless steel reinforcing bars to be pickled after production unless waived. The elongation requirements for stainless steel reinforcing bars outlined in ASTM A955/A955M are greater than those for uncoated carbon steel reinforcing bars.
7.2. Bar Supports
All stainless steel reinforcing bars should be placed on stainless steel, plastic or precast concrete bar supports only. All accessories used in contact with stainless steel reinforcing bars should be plastic, coated steel, precast, or stainless steel. The class of the bar support should be selected based on the use.

7.3. General Notes
The LDP must indicate the applicable standard (e.g., ASTM A955/A955M) and the specific stainless steel alloy(s) or properties that are desired for the project.
Stainless steel reinforcing bars have rolled markings that indicate the producer, size, and grade. The markings “CR” or “SS” are used to indicate compliance with ASTM A955/A955M.
Stainless steel reinforcing bars can be spliced by lapping, by using stainless steel mechanical splices, or by welding.
Stainless steel reinforcing bars shown on contract documents should be noted with a suffix “S” or “SS”. The contract documents should have a note stating that all bars identified as such are to be stainless steel of a specific alloy.
The lap and development lengths for stainless steel reinforcing bar are the same as for uncoated carbon steel reinforcing bar. Stainless steel reinforcing bars can be used in direct contact with uncoated carbon steel reinforcing bar embedded in concrete without concern for galvanic corrosion.

7.4. Estimating
Producing mills may require a minimum order quantity, which varies with the particular mill. Inquiries regarding these requirements should be made as soon as possible in the project schedule.
Stainless steel reinforcing bars are available in standard diameters as outlined in ASTM A955/A955M. Bars of size #7 through #18 are available in lengths up to 40 feet. Smaller diameter bar sizes are often straightened to 60 feet from coiled bar.
Compatible accessories such as tie wire, mechanical splices, and bar supports are available through various suppliers.

7.5. Detailing
Details for stainless steel reinforcing bars are the same as for uncoated carbon steel reinforcing bar, and should follow the project plans and specifications.

7.6. Fabrication
Fabrication of stainless steel reinforcing bars is the same as for uncoated carbon steel reinforcing bars, except for springback, which may require tooling adjustment.
Stainless steel reinforcing bars should be stored and fabricated so that they are not exposed to carbon steel particles (e.g. carbon steel, iron, or mill scale) from the point of pickling to the point of concrete placement.
Ideally, fabrication equipment should be dedicated only to stainless steel reinforcing bar fabrication. If equipment is also used for fabrication of any other type of reinforcing bar the equipment should be thoroughly cleaned to remove all surface particle contamination before the stainless steel reinforcing bars are fabricated. If carbon steel surface contamination occurs because of inadequate cleaning, the stainless steel should be cleaned in accordance with ASTM A380 or A967 depending on the level of contamination.

Contact points on lifting equipment, storage racks, and transport equipment should be stainless steel, synthetic, wood- or plastic-lined. Bundles should be placed on wood or other dunnage that has not been contaminated by carbon steel. Strapping for bundles should be coated or stainless steel.

Tooling (pins), support surfaces and contact points on equipment should be covered with stainless steel or ultra-high molecular weight plastic. Grinding tools and/or abrasive cut off discs should be used only for stainless steel reinforcing bars. Any embedded iron contamination should be removed by pickling paste in accordance with ASTM A380. Superficial carbon steel or other dust contamination should be removed by chemical passivation in accordance with ASTM A967.

Mechanized tools and handling devices (such as rollers, shears, chasers or threading) may be carbon steel provided that they are free from residual carbon steel, iron, and mill-scale and have a minimum hardness of Rockwell C35.

Material traceability should be maintained throughout distribution, fabrication and placing of stainless steel reinforcing bars. Heat numbers, grades, and mill of origin should be prominently displayed on mill bar tags. If tags have been removed, the bars should be retagged after fabrication. Mill test reports should be recorded and stored for future reference.

7.7. Handling and Storage

Stainless steel reinforcing bars should be stored separately from carbon steel to prevent contamination from mill scale or other ferrous metals. When bundles of uncoated carbon steel reinforcing bars and stainless steel reinforcing bars must be shipped together, the stainless steel reinforcing bars should be loaded on top. Non-ferrous dunnage should be used to separate the two materials.

Bundling wire should be plastic coated or stainless steel. Carbon steel wire ties should be avoided. Wood or other soft materials, such as thick cardboard, should be placed under tie downs. Otherwise, synthetic straps should be used. Synthetic straps should also be used to lift bundles. Carbon steel lifting devices should be avoided. If chains or steel bands are used, they should be isolated and not come into direct contact with the stainless steel bars.

Stainless steel reinforcing bars should be stored off the ground on non-ferrous dunnage. Stainless steel reinforcing bars stored outdoors should be covered with polyethylene sheeting or other appropriate material. Storage racks should be lined to protect bars from contaminations with carbon steel particles during handling. Stainless steel reinforcing bars that require movement by a fork truck should be adequately protected to prevent contamination by the carbon steel of the forks.

7.8. Placing

All equipment in contact with stainless steel reinforcing bars should be synthetic or stainless steel; alternatively, contact surfaces should be protected using a polymer, neoprene, or wood. Non-stainless steels may be used where the surface hardness is Rockwell C35 or greater.
Stainless steel reinforcing bars should be staged and stored off the ground on wood dunnage. Stainless steel reinforcing bars should be stored separately from uncoated carbon steel reinforcing bars and covered until placement with polyethylene sheeting or other appropriate material.

Stainless steel or plastic coated tie wire should be used when tying stainless steel reinforcing bars.

Ideally, hand tools should be dedicated for use on stainless steel reinforcing bars and should not have been used previously with carbon steel. In the event that dedicated tools are not available, all steel hand tools and placing devices should be wiped down with clean rags and cleaning agents prior to being used for stainless steel reinforcing bars.

7.8.1. Cleaning

Stainless steel reinforcing bars received in the pickled condition may be cleaned with mild soap, degreaser, and/or water. In cases where contamination has occurred or weld oxide is to be removed, stainless steel brushes or commercial pickling paste should be used in accordance with ASTM A380.

7.8.2. Field Welding

Field welding of stainless steel reinforcing bars is discouraged due to the difficulty in preventing weld contamination, controlling pre- and post-weld procedures, and ensuring quality control of welds. LDP authorization should be obtained for field welding. Preheating should not be used as it may lead to deterioration of the properties of the stainless steel.

Stainless steel reinforcing bars should be welded in conformance with AWS D1.6/D1.6M. Pre-weld and/or post-weld procedures that are suitable to the chemical composition of the steel, ambient conditions, and intended use or service should be followed. The electrode requirements are different when welding stainless steel to stainless steel compared to welding stainless steel to carbon steel.

In practice, stainless steel reinforcing bars can be welded using various welding techniques, and similar stainless steel grades, or different grades, or even stainless steel to carbon steel grades are weldable. When stainless steel and carbon steel are welded, any coating must be completely removed from the carbon steel weld area in advance. Coatings should only be reapplied after the weld area has returned to ambient temperature.

Prior to welding, dirt, grease, and oil should be removed from surfaces to be welded. After welding, any heat tint should be removed by stainless wire brush or use of an approved pickling paste in accordance with ASTM A380. Tack welding is not permitted.

7.8.3. Field Bending

It is not recommended to bend stainless steel reinforcing bar in the field.

If field bending is required, surface contamination should be prevented by use of equipment used exclusively with stainless steel, or by covering all contact points with clean neoprene, wood, or synthetic materials.

If the surfaces are not protected, carbon steel surface contamination is likely and the contaminations should be removed using a stainless steel brush or pickling paste in accordance with ASTM A380.
7.8.4. Field Cutting
Stainless steel reinforcing bars may be cut in the field using shears, saws, abrasive cutoff, or torch. Grinding tools and cutoff discs should be used only for stainless steel reinforcing bars to avoid contamination. When cutting, water cooling may be used to avoid thermal oxidation (bluing). If thermal oxidation occurs, it should be removed with pickling paste in accordance with ASTM A380.

Care should be taken to protect stainless steel reinforcing bars against sparks when cutting ferrous materials and carbon steel filings in proximity to the stainless steel.

7.8.5. Tying
Stainless steel tie wire that is compatible with the stainless steel reinforcing bars should be used for tying the stainless steel reinforcing bars. Tying should hold bars in position under construction loads as required by the governing design code.

7.8.6. Mechanical Splices
Mechanical splices should be manufactured from stainless steel compatible with the bars being coupled.

7.8.7. Spiral Reinforcing Bars
Spiral reinforcing bars meeting ASTM A955/A955M are available. Handling and storage guidelines set forth in Section 7.7 of this guide should be observed.

7.9 Contract Considerations
Any special contract requirements, in addition to the provisions outlined in ASTM A955/A955M, should be by written agreement between the manufacturer and the purchaser. Local availability and lead time requirements may differ by region.

8. Low Carbon, Chromium Reinforcing Steel Bars

8.1. Material Specification
Low carbon, chromium steel reinforcing bars should be specified according to ASTM A1035/A1035M. This specification covers deformed and plain bars for concrete reinforcement in cut lengths and coils.

The ASTM A1035/A1035M specification outlines the chemical composition for the specified alloy.

8.2. Bar Supports
Bar supports for low carbon, chromium reinforcing bars should be the same as approved for uncoated carbon steel reinforcing bars. Bar support guidelines are the same as those for uncoated carbon steel reinforcing bar, including but not limited to wire supports, plastic supports, or precast concrete blocks with wire ties. The class of the bar support should be selected based on the use.

8.3. General Notes
Design of structures using the high strength properties of ASTM A1035/A1035M materials should comply with design provisions in relevant design codes.
Low carbon, chromium reinforcing bars shown on contract documents should be noted with a suffix “C” or “LCC”. The contract documents should have a note stating that all bars identified as such are to be low carbon, chromium.

ASTM A1035/A1035M reinforcing bars may be spliced by lapping or by using mechanical splices in accordance with design codes. Welded splices are not currently permitted, due to the current lack of welding procedure suitable for the chemical composition of the material.

8.4. Estimating

Low carbon, chromium reinforcing bars are available in standard diameters as outlined by ASTM A1035/A1035M. Low carbon, chromium reinforcing bars are readily available in standard stock lengths of 40 feet for #3 bar, and 40 and 60 feet for #4 through #11 bars. #14 and #18 bars, metric sizes, non-standard lengths, lengths in excess of 60 feet, and #3 through #5 in coils require a minimum order quantity.

Accessories such as tie wire, mechanical splices, and bar supports are available through uncoated carbon steel suppliers with mechanical splices appropriate to the design strength used. The requirements are the same as those of uncoated carbon steel reinforcing bar.

8.5. Detailing

Details for low carbon, chromium reinforcing bars complying with ASTM A1035/A1035M steel reinforcing bars are the same as for uncoated carbon steel reinforcing bars.

8.6. Fabrication

Low carbon, chromium reinforcing bars should be fabricated using the same bend diameters as uncoated carbon steel reinforcing bars.

Bars should be bent at ambient temperature. Heating of the bars to facilitate bending is not permitted.

Bar cutting should be accomplished by shearing or with a fluid-cooled saw. Torch cutting is not permitted.

Due to the high strength, these bars will require more force to bend than uncoated carbon steel reinforcing bars.

Material traceability should be maintained throughout distribution, fabrication and placing of low carbon, chromium steel reinforcing. Heat numbers, grades and mill of origin should be prominently displayed on mill bar tags. If tags have been removed, the bars should be retagged after fabrication. Mill test reports should be recorded and stored for future reference.

8.7. Handling and Storage

Low carbon, chromium reinforcing bars can be handled in the same manner as uncoated carbon steel reinforcing bars, using normal material handling equipment, chains, and slings.

When bars are to be stored outside for more than two months, polyethylene sheeting or other appropriate material over the bars is recommended. Wood or other appropriate dunnage should be used, elevating the bars above the outside storage surfaces, to help prevent mud or other bar contamination.
8.8. **Placing**
Low carbon, chromium reinforcing bars should be free of loose mill scale oxidation, dirt, oil or other deleterious coatings that could reduce bond with the concrete. Surface rust of the bar's mill scale may occur and is not cause for rejection.

8.8.1. **Cleaning**
Low carbon, chromium reinforcing bars should be delivered free from mud, debris, and other deleterious material. A low-pressure water spray should be used to remove mud and debris from the bars if needed.

8.8.2. **Field Welding**
No AWS welding procedure for low carbon, chromium steel reinforcing bars existed at the time of publication of this document. The manufacturer should be consulted as to the status of its development.

8.8.3. **Field Bending**
When required, field bending of low carbon, chromium reinforcing bars should be conducted according to Section 8.6 of this guide. Reinforcing bars partially embedded in concrete should not be field bent. Fabricated bent bars should not be straightened and re-bent in the field.

8.8.4. **Field Cutting**
When required, field cutting of low carbon, chromium reinforcing bars should be conducted according to Section 8.6 of this guide.

8.8.5. **Tying**
All tying of low carbon, chromium reinforcing bars should be as indicated in the contract documents using metallic or other approved ties. Tying should hold bars in position under construction loads as required by the governing design code.

8.8.6. **Mechanical Splices**
Mechanical splices should be made to comply with the design requirements and should be installed per coupler manufacturer’s recommendations.

8.8.7. **Spiral Reinforcing Bars**
Spiral reinforcing bars meeting ASTM A1035/A1035M are available.

8.9. **Contract Considerations**
Low carbon, chromium reinforcing bars are available in standard diameters as outlined by ASTM A1035/A1035M. Low carbon, chromium reinforcing bars are readily available in standard stock lengths of 40 feet for #3 bar, and 40 and 60 feet for #4 through #11 bars. #14 and #18 bars, metric sizes, non-standard lengths, lengths in excess of 60 feet, and #3 through #5 in coils require a minimum order quantity. Local availability and lead time requirements may differ by region.
## ASTM STANDARD **INCH-POUND** REINFORCING BARS

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<tbody>
<tr>
<td></td>
<td>AREA (IN.²)</td>
</tr>
<tr>
<td>#3</td>
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<td>#4</td>
<td>0.20</td>
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<td>#5</td>
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<td>#6</td>
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<td>#7</td>
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<td>#8</td>
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<td>#9</td>
<td>1.00</td>
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<tr>
<td>#10</td>
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<tr>
<td>#11</td>
<td>1.56</td>
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<tr>
<td>#14</td>
<td>2.25</td>
</tr>
<tr>
<td>#18</td>
<td>4.00</td>
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</tbody>
</table>

The current ASTM A615 specification covers bar sizes #3 and #18 in Grades 60 and 75, and bar sizes #3 through #6 in Grade 40. The current A706 specification covers bar sizes #3 through #18 in Grade 60.

## ASTM STANDARD **METRIC** REINFORCING BARS

<table>
<thead>
<tr>
<th>BAR SIZE</th>
<th>NOMINAL DIMENSIONS</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>AREA (mm²)</td>
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<tr>
<td>#13</td>
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<td>#22</td>
<td>387</td>
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<td>#25</td>
<td>510</td>
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<td>645</td>
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<td>#32</td>
<td>819</td>
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<td>#36</td>
<td>1006</td>
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<td>#43</td>
<td>1452</td>
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<td>#57</td>
<td>2581</td>
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</table>

The current ASTM A615M specification covers bar sizes #10 and #57 in Grades 420 and 520, and bar sizes #10 through #19 in Grade 280. The current A706M specification covers bar sizes #10 through #57 in Grade 420.

**Disclaimer Statement:**

This CRSI document contains requirements that can, at the time of the document’s adoption by CRSI, be satisfied only by use of a patented material, product, process, procedure, or technology. During the document preparation and balloting, the committee and Engineering Practice Committee (EPC) were informed in writing that the document under consideration involves the potential use of patented technology. The specific patented products being referenced include the following: reinforcing steel bar produced to ASTM A1035/A1035M and certain stainless steel alloys listed in Table 1 of ASTM A276.

Reference: CRSI Policy Requirements for Specialty and Proprietary Reinforcing Steel, Products, and Accessory Materials