**SECTION 03 21 XX**

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Cryogenic Reinforcing Steel

Plain and Deformed Bars for Concrete Reinforcement

**PART 1 GENERAL**

* 1. Specification Scope
1. This specification covers CryoSteel® deformed reinforcing steel bars in cut lengths used for the design of reinforced concrete components exposed to
either service or accidental cryogenic conditions where additional mechanical properties are required for compatibility with exposure to temperatures down to -274ºF [-170ºC].
2. It shall be the responsibility of the engineer of record to specify the Cryogenic Design Temperature to which CryoSteel® will be certified.
	1. Related Work
3. Section 03 30 00 – Cast-in-Place Concrete
4. Section 03 40 00 – Pre-cast Concrete
	1. References
5. Codes and Standards
6. American Concrete Institute (ACI)
7. Code Requirements for Design and Construction of Concrete Structures for Containment of Refrigerated Liquefied Gases (ACI 376-11)
8. Building Code Requirements for Structural Concrete (ACI 318-19)
9. American Society for Testing and Materials (ASTM)
10. Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement (ASTM A 615-20)
11. Concrete Reinforcing Steel Institute (CRSI)
12. CRSI Manual of Standard Practice, 28th Edition
13. British Standards Institute (BSI)
14. Design and Manufacture of Site Built, Vertical, Cylindrical, Flat-Bottomed, Steel Tanks for Storage of Refrigerated, Liquefied Gases with Operating Temperatures Between 0 degrees C and -165 degrees C (EN 14620-3:2006)
	1. Design Requirements
15. Design of concrete structures reinforced with CryoSteel® bars shall be based in accordance with the provisions of ACI 318-19 and ACI 376-11 design guides.
16. CryoSteel® reinforcing steel bars can be directly substituted for conventional carbon steel Grade 60 reinforcing steel bars on an equal area basis, except as noted on the plans or approved by the Engineer.
	1. Submittals
17. Comply with Specification – Submittal Procedures
18. Product Data: Submit manufacturer’s product data, including material and mechanical properties.
19. Test Reports: Submit manufacturer’s mill certifications for material and mechanical properties for each bar size used on the project.
20. Mechanical Couplers: Submit manufacturer’s product data for use with
CryoSteel® bars.
	1. Deliveries, Storage and Handling
21. Delivery and Storage:
22. CryoSteel® bars shall be stored off the ground and protected from dirt, oil and other deleterious materials.
23. Handling of CryoSteel® bar shall be in accordance with conventional steel bars as noted in the CRSI Manual of Standard Practice.

**PART 2 PRODUCTS**

2.1 Supplier

A. CMC

CMC Steel Arizona
11444 East Germann Rd.
Mesa, AZ 85212
phone: 888.641.8956
email: cryosteel@cmc.com

* 1. Material
1. Non-prestressed deformed reinforcing steel bars shall be CryoSteel ® conforming to the requirements of ASTM A615, Grade 60 for all ambient temperature tests, modified to also meet the additional requirements contained in this specification.
2. CryoSteel ® reinforcing steel bars shall conform to the supplemental requirements of the following standards for cryogenic applications:
3. EN14620-3:2006, Section 6.3.2 and Annex A.3
4. ACI 376-11
5. CryoSteel ® Technical Requirements
6. Tensile strength, min. – 90,000 psi
	1. If the as-tested yield strength at room temperature times 1.15 (See item C.3 below) is greater than 90,000 psi, then the minimum tensile strength shall be the as-tested yield strength at room temperature times 1.15.
7. Yield strength, min. – 60,000 psi
	1. The purchaser may optionally request a minimum yield strength of 72,000 psi, corresponding to 500 MPa, based on international standards and specifications.
8. Ratio actual tensile strength divided by actual yield strength – 1.15
9. Elongation in 8 in., min.
10. Bar Designation Nos. 4, 5, 6 – 12% at ambient temperature and 3% at cryogenic design temperature.
11. Bar Designation Nos. 8, 10 – 12% at ambient temperature and 3% at cryogenic design temperature.
12. Notch Sensitivity Ratio (NSR), min. – 1.00\*
13. Strain at Ultimate Stress (Un-Notched Bar), min. – 3%\*

**\*** The indicated test shall be performed at Cryogenic Design Temperature +/- 9ºF [5ºC]. The result and the actual sample temperature during testing shall be reported on the Material Test Report (MTR).

1. Identification of CryoSteel ®
2. Type of Steel – a six-pointed snowflake symbol “**❆**” shall be rolled into the bar with the mill marks. Optionally, also a letter “**S**” may be rolled into the bar, indicating that the bar was produced to meet both this specification and Specification ASTM A615.
3. Minimum Yield Strength Designation – for Grade 60 bars, the marking shall be the number “60”.
	1. If the purchaser opts to request the 72,000 psi minimum yield strength, the bar shall be marked with “60” in order to certify the steel to A615.
4. Certification of CryoSteel ®
5. Upon request, a certified copy of a mill certification report shall be provided for each heat of bars delivered, showing:
6. Chemical analysis
7. Tensile properties, tested at room temperature
8. Tensile properties, tested at cryogenic design temperature, +/- 9ºF [5ºC]
9. Actual temperature of test environment during testing of cryogenic design temperature requirements. Room temperature test conditions are not required on the MTR.
10. Bend test results.