High Performance
Copper-Precipitation-Strengthened Steel
With Low Carbon Equivalent

NUCu STEEL

ASTM A-710 GRADE B

70 ksi Grade
Low Temperature Tough
Improved Weldability
Improved Weatherability
Life Cycle Cost Effective

TABLE OF CONTENTS

Front Cover:
Bridge in Lake Villa, Illinois, build with NUCu 70W (ASTM A710 Grade B) Steel

Right:
NUCu 70W (ASTM A710 Grade B) Steel Beams used in the construction of the Lake Villa Bridge

Page 10:
Semi-automatic welding of NUCu 70W (ASTM A710 Grade B) without pre-heat.

DISCLAIMER

WHAT IS NUCu STEEL?

A copper-precipitation-hardened, high-performance Grade 70 weathering steel, NUCu 70W (Northwestern University Cu-Precipitation-Strengthened) steel, now standardized as ASTM A710 Grade B, was developed at Northwestern University with the support of the Federal Highway Administration, the Illinois Department of Transportation, and Northwestern University's Infrastructure Technology Institute.

The steel was designed to achieve a minimum of 70 ksi yield strength on air cooling from hot rolling without quenching and tempering (Q&T), accelerated cooling or thermomechanically-controlled processing (TMCP). This allows for elimination of alloying elements needed for hardenability as well as a low carbon content, resulting in a very low carbon equivalent for welding. As a result, its processing cost is less than for Q&T or TMCP steels. For steelmakers, this means that special equipment for Q&T or TMCP is not required.

NUCu 70W (ASTM A710 Grade B) steel possesses high Charpy absorbed impact fracture energies at very low temperatures. By adding titanium (up to 0.1%) which combines with interstitial atoms, the absorbed impact fracture energy further increases. This addition lowers the yield stress to 60 Ksi minimum but increases the Charpy Absorbed Impact Fracture Energy to more than 265 ft-lbs at -80°F.

Due to its very low carbon equivalent, NUCu 70W (ASTM A710 Grade B) steel generally does not require pre-heat or post-heat during welding with matching welding consumables.

Weatherability of NUCu 70W (ASTM A710 Grade B) steel is better than that of any other commercially available weathering steel. Paint on this steel resists degradation much better than on other weathering steels.

NUCu steel does not contain intentional additions of chromium. This is of interest because of health and environmental hazards due to formation of carcinogenic Cr^{+6} during welding.

The combination of these properties can result in significant cost savings when NUCu steel is used instead of other structural steels.

CURRENT AND POTENTIAL APPLICATIONS

NUCu 70 (ASTM A710 Grade B) steel was used in 2000 to retrofit the I-55/I-64/I-70/US-40 Poplar Street Bridge Complex over the Mississippi River, East St. Louis, Illinois. High strength steel was required for the retrofit because of weight limitations and for the high fracture energy that was required for seismic redundancy.

In 2006 this steel was used for construction of a bridge in Lake Villa, Illinois. For the north Milwaukee Avenue Bridge, 500 tons of steel plates were produced and fabricated into girders. The bridge was not painted, resulting in a significant savings in construction and maintenance costs.

NUCu 70W (ASTM A710 Grade B) steel can be used in applications that require high strength, good fracture toughness at low temperatures, easy welding, good weatherability and corrosion resistance. These potential applications include:

- bridges
- ships
- tank cars
- pipe lines
- oil platforms
- guard rails and sign poles
- tall buildings for wind and seismic resistance
- power and illumination towers
- construction and mining equipment

CHEMICAL COMPOSITION AND STEEL PROCESSING

The chemical composition of NUCu 70W (ASTM A710 Grade B) steel is given in Table 1. After hot rolling it has a fine-grained ferritic microstructure.

NUCu 70W (ASTM A710 Grade B) steel is produced by ingot or continuous casting. It is hot rolled at temperatures that do not exceed 1120°C (2050° F) followed by air-cooling.

If the hot-rolling temperature exceeds 1120° C (2050° F), the Charpy impact fracture energies may be reduced. Normalizing of the hot rolled steel by reheating to 930-1050° C (1705-1920° F) followed by air-cooling restores the reduced Charpy absorbed impact fracture energies. If needed, the strength of A710 Grade B can be further increased by aging at 500-550° C (930-1020° F) after air cooling from hot-rolling.

Although NUCu 70W (ASTM A710 Grade B) steel has been produced to date in plates up to 2 inches thick, there are no technical limitations to production of thicker plates.

TABLE 1 : COMPOSITION OF NUCu 70W (A710 GRADE B)

	C	Mn	P	S	Si	Cu	Ni	Nb	Ti
Min.	0.03	0.40	–	–	0.40	1.30	0.65	0.002	–
Max.	0.08	0.80	0.035	0.040	0.60	1.50	1.00	0.006	0.03

MECHANICAL AND FRACTURE PROPERTIES

TABLE 2 : MECHANICAL AND FRACTURE PROPERTIES OF NUCu 70W (A710 GRADE B)

Yield Strength Minimum	70 ksi (488 MPa)
Ultimate Tensile Strength Minimum	82 ksi (575 MPa)
Elongation in 2 in. (50 mm) Minimum	25%
Charpy V–Notch Absorbed Impact Energy	100 ft-lbs (136J) at -40° C (-40° F)

CORROSION

Unpainted Steel
NUCu steel has the lowest loss in thickness among commercial construction and weathering steels in the accelerated automotive SAE J2334 salt, wet/dry, eight-week corrosion tests performed by Bethlehem Steel Corporation as shown in Figure 1.

Painted Steel
The same set of steels shown in Figure 1 were coated with epoxy-based Carboguard 890 bridge paint from the Carboline Company and tested. The painted panels were scratched and exposed to salt-fog at 35° C for 3 weeks (ASTM B-117 Standard). Test results are shown in Figure 2. Similarly to unpainted steels, coated and scratched NUCu steel demonstrated the best corrosion resistance of the four steels tested.

WELDING

Due to its very low carbon equivalent, pre-heating is generally not needed before welding. All welding procedures are suitable for joining NUCu 70W (ASTM A710 Grade B) steel with matching consumables.

Welding of several different heats of NUCu 70W (ASTM A710 Grade B) steel was evaluated without pre-heat or post-heat by a submerged arc (SAW) process and also by a manual process in a construction shop environment. Matching consumables were used. No brittle heat-affected zone was formed. Depending on heat input during welding (from 35 to 120 kJ/inch), Charpy absorbed impact energy varied from 60 to 150 ft-lbs in -30 to -40°F temperature range.

In Procedure Qualification (PQR) SAW tests without pre-heat and post-heat using Lincoln LA85 electrodes and MIL800-HPNi flux with the heat input of 60 KJ/inch the average, Charpy absorbed impact energy was 91 ft-lb at -22°F. The requirement by the ASTM Standard A709 is 25 ft-lbs at -10° F.

Duplicate Gapped Bead-On-Plate (G-BOP) tests using a heat input of 35 kJ/inch with low hydrogen AWS E7018 and E9018 electrodes without pre-heat did not show any cracks in the weld metal, fusion or heat-affected zone, or in the adjacent base plates.

FIGURE 1:
UNPAINTED STEEL

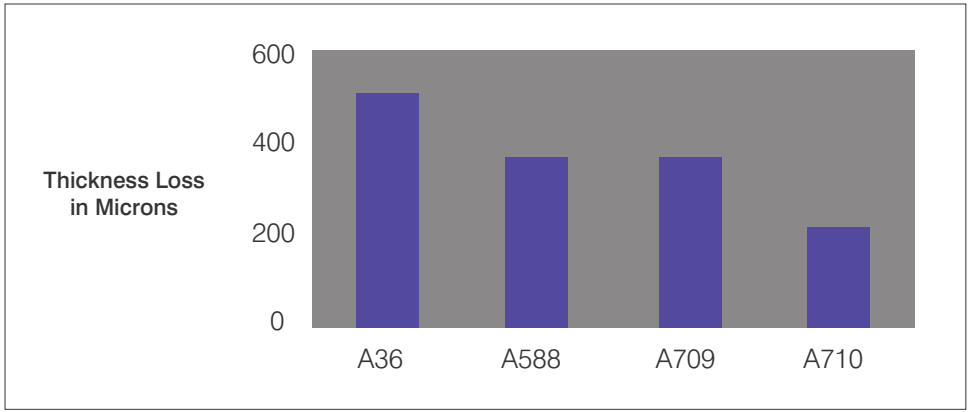
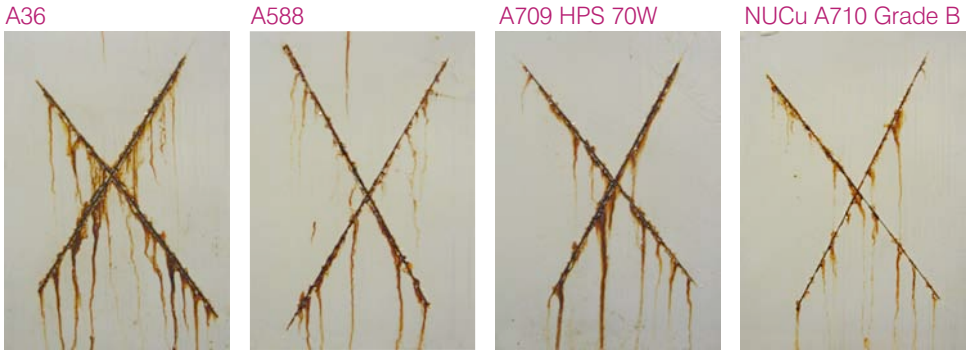


FIGURE 2:
PAINTED STEEL



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CONTACT

Morris E. Fine
Professor
Northwestern University
Department of Materials Science
And Engineering
Evanston, IL 60208
(847) 491-4322
m-fine412@northwestern.edu

Semyon Vaynman
Research Professor
Northwestern University
Department of Materials Science
And Engineering
Evanston, IL 60208
(847) 491-4322
svaynman@northwestern.edu

Christopher Hahin, MetE, CorrE, PE
Illinois Department of Transportation
Bureau of Materials & Physical Research
126 East Ash St.
Springfield, IL 62704
(217) 782-0574
Chris.Hahin@illinois.gov

For further information visit http://www.nucu-steel.org

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