Technical Datasheet

# CarTech® Micro-Melt® NeutroSorb PLUS® Alloys

## Identification

UNS Number

• S30460-67

## Type Analysis

*Single figures are nominal except where noted.*

| | | | |
|---|---|---|---|
| **Carbon (Maximum)** | 0.08 % | **Manganese (Maximum)** | 2.00 % |
| **Phosphorus (Maximum)** | 0.045 % | **Sulfur (Maximum)** | 0.030 % |
| **Silicon (Maximum)** | 0.75 % | **Chromium** | 18.00 to 20.00 % |
| **Nickel** | 12.00 to 15.00 % | **Boron (Maximum)** | 2.250 % |
| **Nitrogen (Maximum)** | 0.10 % | **Iron** | Balance |

## General Information

Description

CarTech Micro-Melt NeutroSorb PLUS alloys are similar to conventional Type 304 stainless except that they contain a boron addition which imparts a much higher thermal neutron absorption cross section than other austenitic stainless steels. CarTech Micro-Melt NeutroSorb PLUS alloys are available with boron levels up to 2.25% as specified by customer requirements.

Increasing boron content increases the thermal neutron absorption capability of the alloys. Increasing boron content also increases hardness, tensile strength and yield strength, but decreased tensile ductility, impact toughness and corrosion resistance.

Through controlled special processing, CarTech Micro-Melt NeutroSorb PLUS alloys, ASTM A887-89 Grade "A" Alloys, suffer less decrease in ductility and impact toughness as boron content increases when compared to ASTM A887-89 Grade "B" alloys.

Applications

These alloys have been used in the nuclear industry for spent fuel storage racks and cask baskets, control rods, burnable poison, and shielding.

Boron Isotopes

The boron addition can consist of natural boron and/or the enriched boron 10 isotope, which offers a higher neutron absorption cross section at a given boron content. Boron 10 enrichment also enables use of less total boron for equivalent neutron absorption, which provides improved ductility and impact toughness. For example, the neutron absorption of Micro-Melt NeutroSorb PLUS alloy with about 0.4% boron 10 is approximately the same as Micro-Melt NeutroSorb PLUS alloy with 2.0% natural boron.

The boron is present as a finely dispersed chromium-rich boride precipitate.

## Corrosion Resistance

Micro-Melt NeutroSorb PLUS alloys possess corrosion resistance approaching that of Type 304 stainless. Laboratory testing in simulated spent fuel pool waters, containing 13,000 ppm boric acid and 10 ppm Cl-, showed that Micro-Melt NeutroSorb PLUS alloys exhibited corrosion resistance superior to ASTM grade "B" materials containing approximately one half the boron content.

While the addition of boron to a Type 304 stainless steel tends to reduce the intergranular corrosion resistance in some acidic environments, no significant intergranular corrosion has been reported in spent fuel storage applications. Laboratory testing has shown that Micro-Melt NeutroSorb PLUS alloys exhibit considerably less reduction than the standard borated stainless steels.

**Important Note:** *The following 4-level rating scale is intended for comparative purposes only. Corrosion testing is recommended; factors which affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevices, deposits, metallurgical condition, stress, surface finish and dissimilar metal contact.*

| | | | |
|---|---|---|---|
| Nitric Acid | Good | Sulfuric Acid | Moderate |
| Phosphoric Acid | Moderate | Acetic Acid | Moderate |
| Sodium Hydroxide | Moderate | Salt Spray (NaCl) | Good |

| | | | |
|---|---|---|---|
| Sea Water | Restricted | Humidity | Excellent |

## Properties

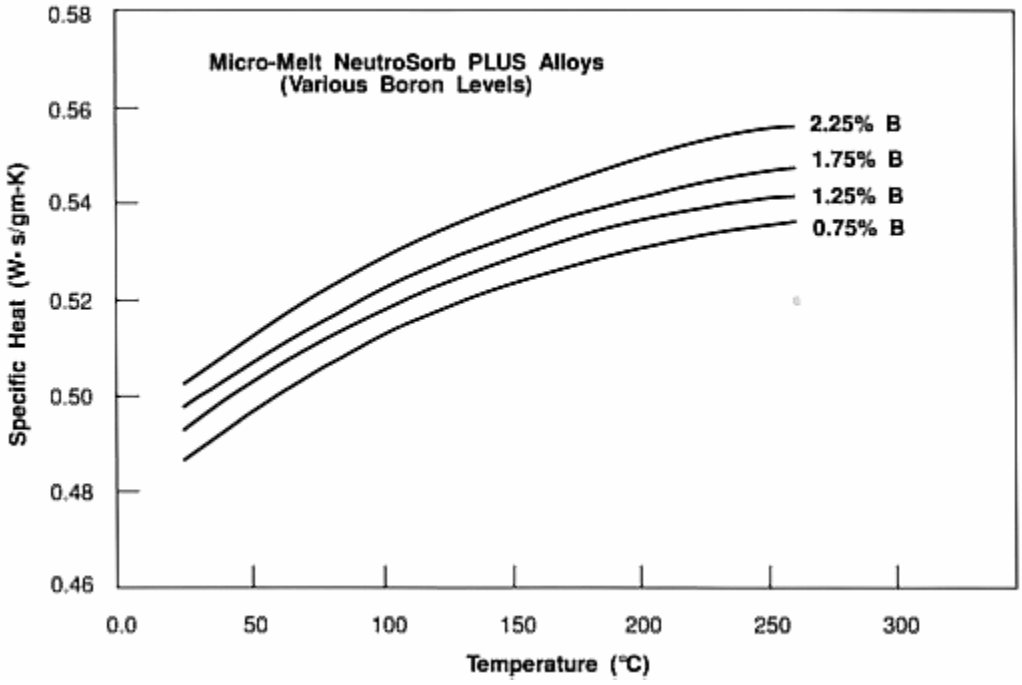
### Physical Properties

| | | |
|---|---|---|
| Specific Gravity | | |
| 0.45% Boron | 7.88 | |
| 0.72% Boron | 7.86 | |
| 0.97% Boron | 7.83 | |
| 1.20% Boron | 7.81 | |
| 1.48% Boron | 7.79 | |
| 1.75% Boron | 7.77 | |
| 2.03% Boron | 7.74 | |
| 2.23% Boron | 7.72 | |
| Density | | |
| 0.45% Boron | 0.2840 | lb/in³ |
| 0.72% Boron | 0.2840 | lb/in³ |
| 0.97% Boron | 0.2830 | lb/in³ |
| 1.20% Boron | 0.2820 | lb/in³ |
| 1.48% Boron | 0.2810 | lb/in³ |
| 1.75% Boron | 0.2800 | lb/in³ |
| 2.03% Boron | 0.2800 | lb/in³ |
| 2.23% Boron | 0.2790 | lb/in³ |

Specific gravity & density

| Percent Boron | Specific Gravity | Density | |
|---|---|---|---|
| | | lb/in³ | kg/m³ |
| 0.45 | 7.88 | 0.284 | 7880 |
| 0.72 | 7.86 | 0.284 | 7860 |
| 0.97 | 7.83 | 0.283 | 7830 |
| 1.20 | 7.81 | 0.282 | 7810 |
| 1.48 | 7.79 | 0.281 | 7790 |
| 1.75 | 7.77 | 0.280 | 7770 |
| 2.03 | 7.74 | 0.280 | 7740 |
| 2.23 | 7.72 | 0.279 | 7720 |

Specific heat

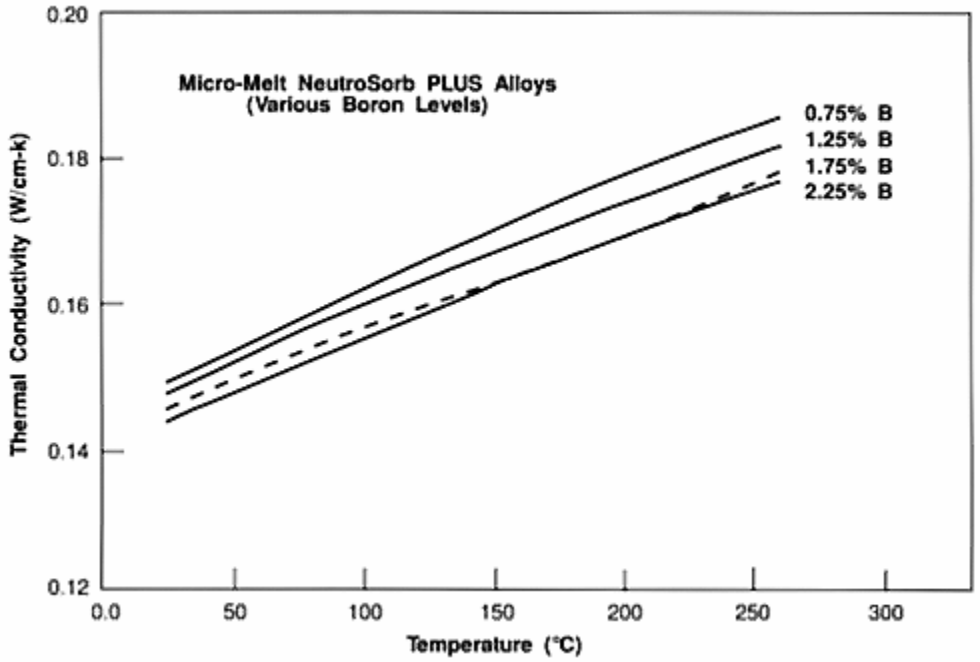



| Mean CTE | |
|---|---|
| 77 to 212°F | 9.20 x $10^{-6}$ in/in/°F |
| 77 to 392°F | 9.34 x $10^{-6}$ in/in/°F |
| 77 to 572°F | 9.60 x $10^{-6}$ in/in/°F |
| 77 to 752°F | 9.80 x $10^{-6}$ in/in/°F |
| 77 to 932°F | 9.93 x $10^{-6}$ in/in/°F |
| 77 to 1202°F | 10.5 x $10^{-6}$ in/in/°F |

Mean coefficient of thermal expansion

| Temperature | | $10^{-6}$/°F | $10^{-6}$/K |
|---|---|---|---|
| 77°F to | 25°C to | | |
| 212 | 100 | 9.20 | 16.56 |
| 392 | 200 | 9.34 | 16.89 |
| 572 | 300 | 9.60 | 17.29 |
| 752 | 400 | 9.80 | 17.65 |
| 932 | 500 | 9.93 | 17.88 |
| 1202 | 650 | 10.53 | 18.90 |

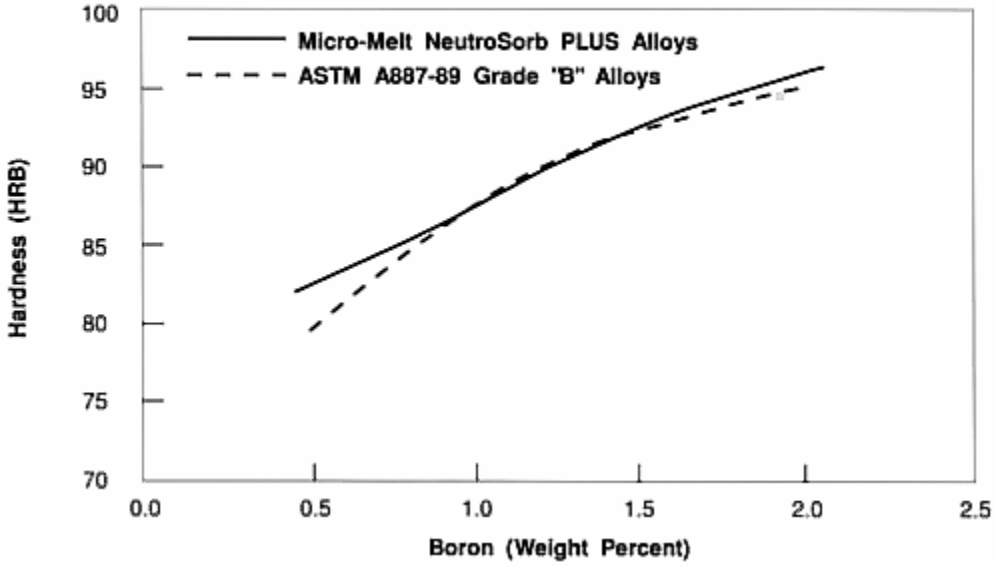
Thermal conductivity



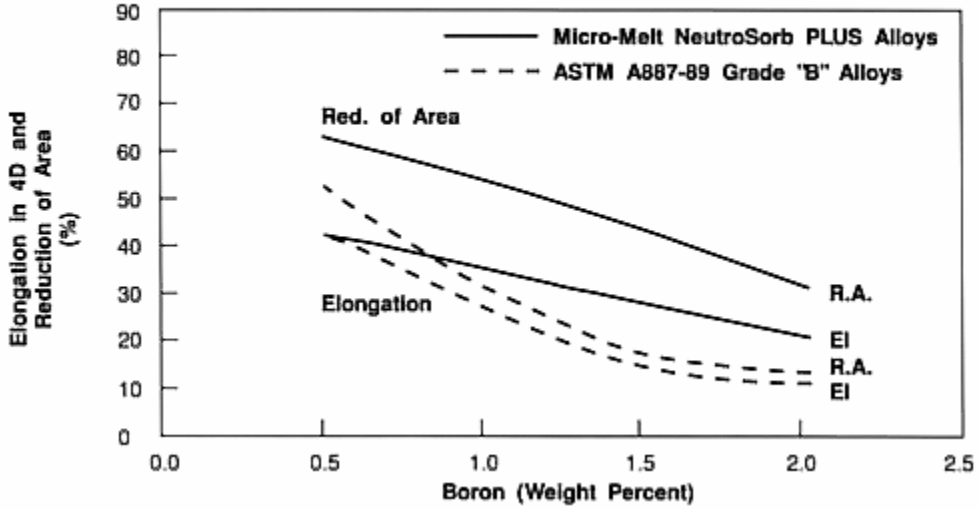

| | | |
|---|---|---|
| Modulus of Elasticity (E) (In Tension (E)) | 30.5 | x 10 ³ ksi |
| Electrical Resistivity (70°F) | 445.0 | ohm-cir-mil/ft |

## Typical Mechanical Properties

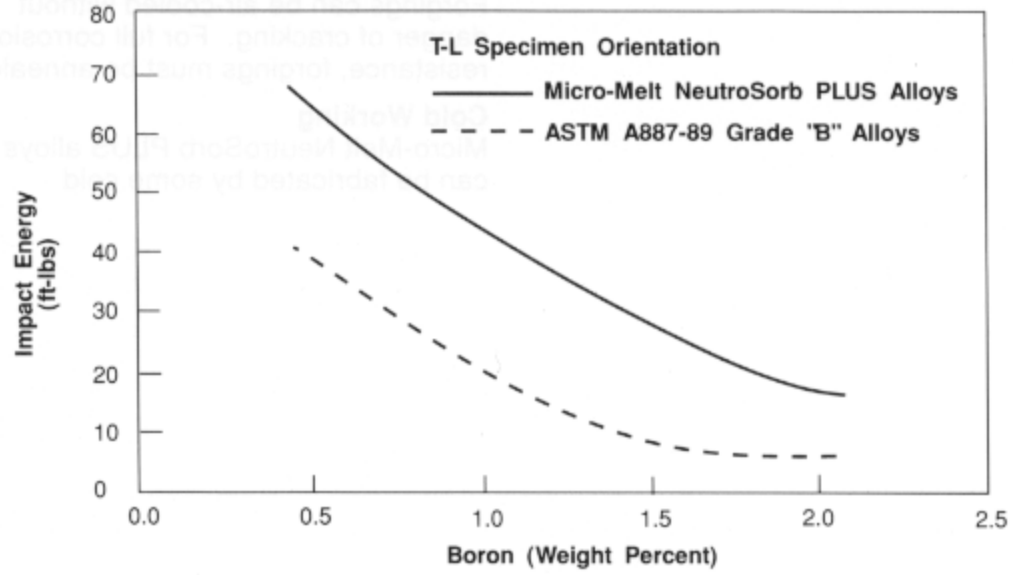
**Effect of Boron Content on Annealed Hardness - Modified Type 304 Stainless Steel**



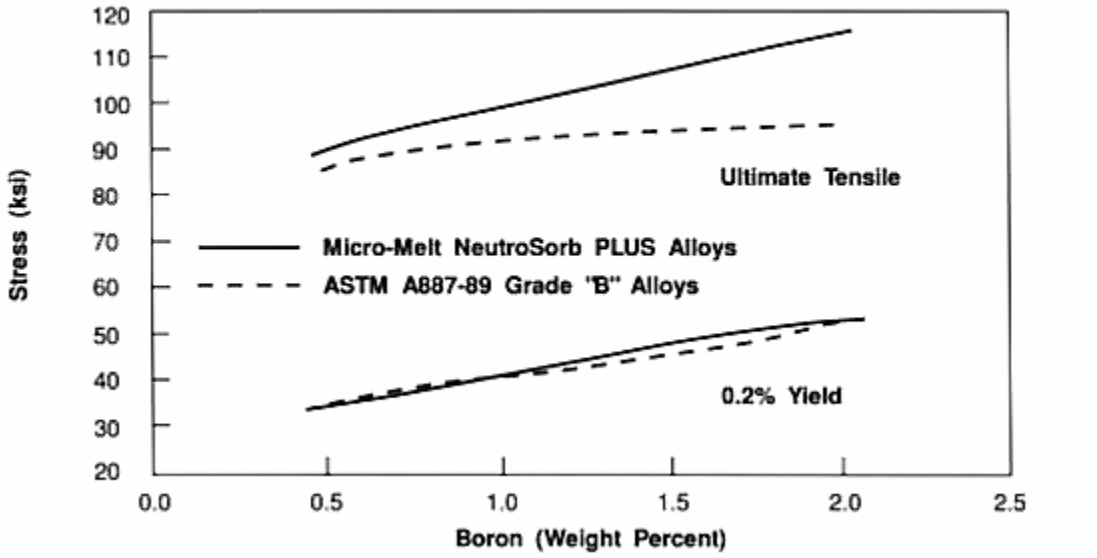
**Effect of Boron Content on Room-Temperature Transverse Tensile Ductility - Modified Type 304 Stainless Steel**



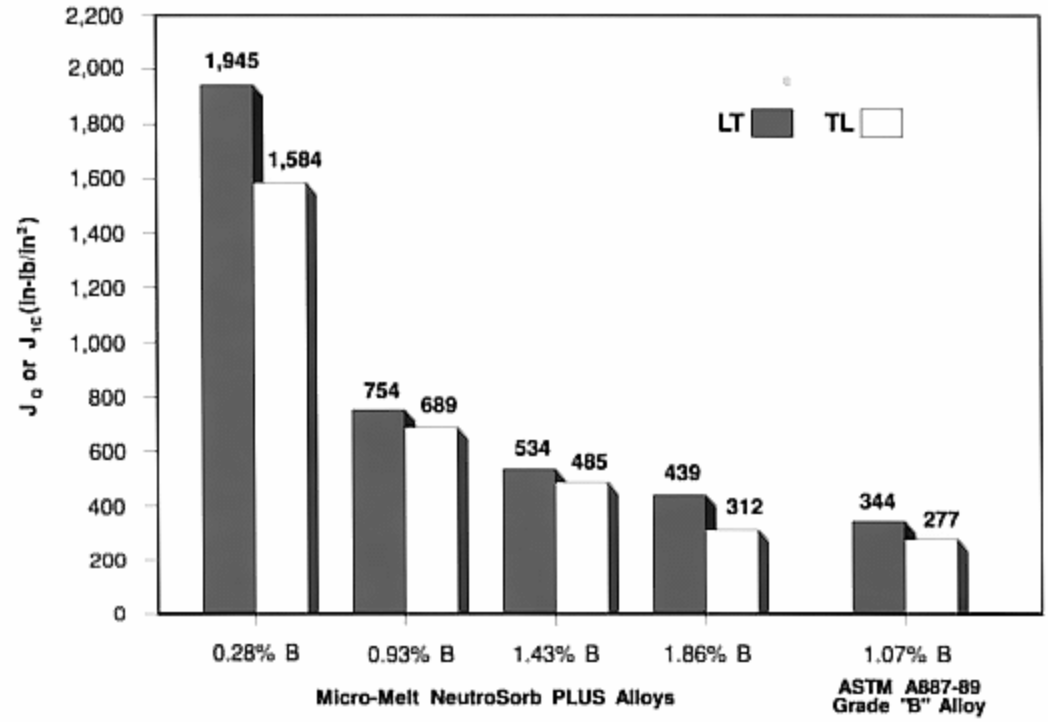

**Effect of Boron Content on Room-Temperature Transverse Charpy V-Notch Impact Energy - Modified Type 304 Stainless Steel**



**Effect of Boron on Room-Temperature Transverse Yield and Tensile Strength - Modified Type 304 Stainless Steel**




**Room Temperature Fracture Toughness - Micro-Melt NeutroSorb PLUS Alloys**




## Heat Treatment

Annealing

Heat to 1900/2000ºF (1038/1093ºC), hold 15-30 minutes and quench in water.

## Workability

Most forming operations, including hot and cold rolling, offer little difficulty up to 1.0% boron content. The working of higher boron contents should be discussed with Carpenter's Technical Department.

Hot Working

Heat uniformly to 2050/2100ºF (1121/1149ºC). Do not hot work below 1700ºF (927ºC). Because of the higher hot hardness of these alloys, more power for a given reductions is required than for regular Type 304. Forgings can be air-cooled without danger of cracking. For full corrosion resistance, forgings must be annealed.

Cold Working

Micro-Melt NeutroSorb PLUS alloys can be fabricated by some cold working. With lower boron contents, the cold workability approaches that of regular Type 304.

Machinability

Compared with AISI B1112, the machinability ratings of these alloys vary from 20% (2.0% boron) to 50% (very low boron). The higher boron contents cause greater tool wear.

Weldability

Micro-Melt NeutroSorb PLUS alloys can be welded; however, the welds will possess limited ductility. If these alloys must be welded, consider using AWS E/ER308 or 309 welding consumables. Use minimum heat inputs and limit the base metal dilution.

## Other Information

### Applicable Specifications

• ASTM A887 (Grade A Alloys)

### Forms Manufactured

• Bar-Rounds
• HIP'd Shapes
• Plate
• Sheet
• Strip
• Wire



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