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## INVAR DATA SHEET FOR COMPOSITE TOOLING

### CHEMISTRY

|                 |         |
|-----------------|---------|
| Carbon.....     | 0.02%   |
| Manganese.....  | 0.35%   |
| Silicon.....    | 0.20%   |
| Nickel.....     | 36.00%  |
| Iron.....       | Balance |
| Sulfur.....     | 0.002%  |
| Phosphorus..... | 0.002%  |

Age Hardening Chemistry available upon request.

### APPLICATION

Service Steel's product has been specifically manufactured for fabricating composite tooling. Our Invar is produced in accordance with the Boeing and Lockheed tooling specifications D33028 and TPS-82, respectively. This chemistry limits the sulfur and phosphorus contents for better weldability.

### INVENTORY LIST

#### PLATE PRODUCTS

- ..... 250 x 96 x 240
- ..... .375 x 96 x 240
- ..... .500 x 96 x 240
- ..... 1 x 96 x 240
- ..... 1-1/2 x 96 x 240
- ..... 2 x 96 x 240
- ..... 3 x 96 x 240
- ..... 4 x 96 x 240

#### FLAT BAR PRODUCTS

SSA is stocking Invar 36 Billets to be converted into various flat bar sizes as needed by the customer. Lead time is 3-4 weeks on these products.

**WELD WIRE**..... .097 x 36 TIG



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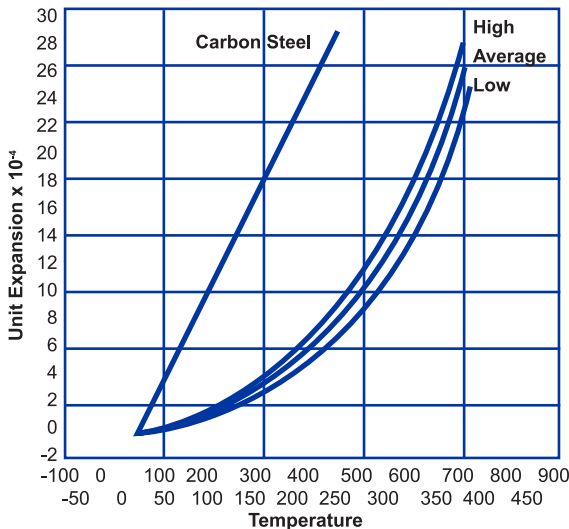
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## THERMAL EXPANSION PROPERTIES



## COMPARATIVE EXPANSION CURVES - INVAR VS CARBON STEEL

## HEAT TREATMENT

Heat to 1450°F (790°C) and hold at heat 30 minutes per inch of thickness, then air cool. Heating to temperatures above 1000°F (536°C) relieves the presence of cold work stresses. The higher the temperature, the lower the annealed hardness, as show in the following table.

Specimen held for 5 minutes at heat:

| Temperature Air Treat |      | Hardness Rockwell B |
|-----------------------|------|---------------------|
| °F                    | °C   |                     |
| 1200                  | 850  | 87/88               |
| 1500                  | 815  | 77/78               |
| 1800                  | 980  | 70/71               |
| 1800                  | 1040 | 66/68               |

### Heat Treatment for Optimal Dimensional Stability:

The presence of cold work stresses causes very slight changes in dimensional stability with respect to time and temperature. This change can be detected only with exceedingly sensitive devices. To assure optimal dimensional stability, heat to 1500°F (815°C), hold at heat for 30 minutes per inch of thickness, water quench, reheat to 600°F (315°C) holding one hour at heat, then air cool. To promote temporal stability (when necessary), Invar has been aged for 24 to 48 hours at 200°F (63°C).

## MACHINING

| Tool                 | Turning S3 or S4 Carbide | Milling Sup. High Speed Steel | Drilling High Speed Steel |
|----------------------|--------------------------|-------------------------------|---------------------------|
| Lubricant            | Water soluble oil        | Water soluble oil             | Water soluble oil         |
| True rake angle      | 12-17°                   | 15°                           |                           |
| Tool clearance       | 5-8°                     | 3-7°                          | 9-13°                     |
| Cutting speed (m/mm) | 50-75                    | 10-15                         | 10                        |
| Feed mm/             | 02-0.5/rev               | 0.05-0.10/rev                 | 0.10/rev                  |