

CRUCIBLE

Crucible 416R is a pre-hardened chromium stainless steel which is suitable for use in precision match-grade rifle barrels. It can be supplied in various hardness ranges according to your specific requirements (HRC 24/28, 28/32, or 32/36). Crucible 416R was specifically designed by Crucible engineers in collaboration with barrel makers and rifle manufacturers to provide consistency, high quality and the following characteristics:

- 1) Good machinability for gun drilling and reaming, plus excellent polishability for uniform lapping, necessary for bore accuracy.
- 2) A homogeneous microstructure which responds to heat treat providing a uniform hardness along the length of the bar, necessary for accurate button rifling to precise groove dimensions.
- 3) An optimum combination of high tensile strength along with adequate toughness to withstand the typical chamber pressures encountered during firing.
- 4) Good corrosion resistance to inhibit rusting and which also helps to minimize fouling. Crucible 416R provides a durable finish which does not pit when properly maintained.
- 5) Precision straightened and stress relieved bars, either mill length or mult length, ready to be cut to length and gun drilled.
- 6) 100% ultrasonic testing for reliable barrels.

Crucible 416R stainless steel is manufactured using very stringent controls from initial melting, through hot rolling, heat treating, cold finishing and final bar inspection. Barrels made from Crucible 416R are used at all levels of competition and in all conditions dry, damp or salty. Although all martensitic stainless steels have reduced ductility at very low temperatures, Crucible 416R can be safely used down to minus 40°F (-40°C).

For more than 25 years, Crucible 416R, produced in Syracuse, NY, has been the choice of custom barrelmakers and champion shooters.

Typical Applications

High Powered Small Caliber Rifles
Bench Rest Rifles
Hunting Rifles
Tactical Rifles
Sport Rifles

Crucible Industries LLC

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DATA SHEET

CRUCIBLE 416R Stainless Precision Rifle Barrel Stock

Issue #1

Carbon	0.12%
Manganese	0.40%
Silicon	0.40%
Chromium	12.50%
Molybdenum	0.40%
Sulfur	0.13%

Physical Properties

Elastic Modulus (<i>tension</i>)	29.0 X 10 ⁶ psi	(200 GPa)	
(<i>torsion</i>)	10.5 X 10 ⁶ psi	(72.3 GPa)	
Density	0.28 lbs./in ³	(7.75 g/cm ³)	
Specific Heat	BTU/lb/°F	W/kg/°C	
From 32-212°F (0-100°C)	0.11	0.039	
Thermal Conductivity	BTU/hr-ft-°F	W/m-°K	cal/cm-s-°C
200°F (93°C)	14.4	25.1	0.0599
1000°F (538°C)	16.5	28.5	0.0682
Coefficient of Thermal Expansion	<i>in/in/°F</i>	<i>mm/mm/°C</i>	
21 to 212°F (-6) to 100°C	5.5X10 ⁻⁶	9.9X10 ⁻⁶	
32 to 600°F 0 to 315°C	5.6X10 ⁻⁶	10.1X10 ⁻⁶	
32 to 1000°F 0 to 100°C	6.4X10 ⁻⁶	11.5X10 ⁻⁶	
32 to 1200°F 0 to 315°C	6.5X10 ⁻⁶	11.7X10 ⁻⁶	

Corrosion Resistance

The corrosion resistance of Crucible 416R was evaluated in a variety of corrosion tests normally used for this type of stainless. The corrosion resistance is comparable to that of standard AISI Type 416.

NOTE: Crucible 416R forms an oxide scale at approximately 1250°F (677°C). This temperature may vary with atmosphere and application.

Passivation

It is recommended that Crucible 416R finished-machined parts be passivated for optimum corrosion resistance.

Recommended passivation parameters are shown below:

Acid Concentration (by volume of concentrated nitric acid):	40-60%
Sodium Dichromate (by weight):	2.0%
Immersion Time (in minutes)	15-30
Bath Temperature:	110-140°F (43-60°C) Typical 120°F (49°C)

Note: Properties shown throughout this data sheet are typical values. Normal variations in chemistry, size and heat treat conditions may cause deviations from these values.

Thermal Treatments

Crucible 416R is supplied pre-hardened and stress relieved after straightening, so normally there is no need for further heat treatment, except possibly a further stress relief after machining, when required.

Stress Relieving

Stress Relieve after machining at 950-1000°F (510-540°C). Hold 2-4 hrs. Air cool. (Higher temperatures may be used if desired.)

For reannealing or rehardening, follow these guidelines:

Annealing

Crucible 416R may be annealed for maximum softness at 1550°F (843°C), followed by a furnace cool. For better machinability, a subcritical anneal at 1300°F (704°C) is recommended.

Annealed hardness: Approximately 170 BHN

Hardening

Preheat: 1400-1450°F (760-788°C). Equalize

Austenitize: 1750-1850°F (954-1010°C). For maximum corrosion resistance and strength, austenitize high in the range.

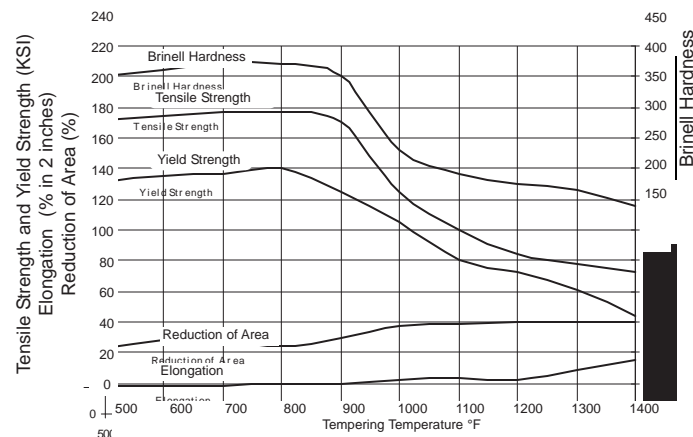
Hold time at temperature: 30 - 60 minutes.

Quench: Oil or salt quench to below 125°F (50°C).

As-quenched hardness: BHN 375/415 (HRC 40/45)

Tempering: Temper 4 hrs. at the appropriate temperature for the desired properties shown in the following graph.

(Graph based on data for 1" Rd. austenitized at 1800°F (982°C), oil quench, tempered 4 hrs. at temperature).



Machining

The machining of all high-chromium steels is characterized by the tendency of the chip to gall or build up on the cutting edges and radii of the tool. However, the special composition and the precision heat treatment of Crucible 416R tend to minimize the galling and build-up. The chips produced are short and brittle, resulting in relatively easy chip control.

Turning - Single Point and Box Tools

Depth of Cut (inches)	CPM High Speed Steel Tooling		
	Tool Material	Speed (fpm)	Feed (ipr)
.040	T15, Rex 76	100	.007
.150	T15, Rex 76	80	.015
.300	T15, Rex 76	60	.020
Depth of Cut (inches)	Carbide Tooling (Coated)		
	Tool Material	Speed (fpm)	Feed (ipr)
.040	C7	575	.007
.150	C6	525	.015
.300	C6	400	.020

Turning - Cut-off and Form Tooling

Cutoff Tool Width (inches)	CPM High Speed Steel Tooling		
	Tool Material	Speed (fpm)	Feed (ipr)
.062	T15, Rex 76	80	.0015
.125	T15, Rex 76	80	.002
.250	T15, Rex 76	80	.0025
Form Tool Width (inches)	CPM High Speed Steel Tooling		
	Tool Material	Speed (fpm)	Feed (ipr)
.500	T15, Rex 76	80	.0015
.750	T15, Rex 76	80	.0012
1.00	T15, Rex 76	80	.0010
1.50	T15, Rex 76	80	.0008
2.00	T15, Rex 76	80	.0007

When using carbide tooling you can increase the speed to 250 fpm with the same feed rates.

Gun Drilling

Hole Diameter (inches)	Carbide Tool Material	Speed (fpm)	Feed (ipr)
.078 - .156	C2	250	.00015 - .00025
.156 - .250	C2	250	.0003 - .0005
.250 - .500	C2	250	.0005 - .0008
.500 - .750	C2	250	.0008 - .0010
.750 - 1.00	C2	250	.0010 - .0015
1.00 - 2.00	C2	250	.0015 - .0020

Welding

Welding is not recommended for Crucible 416R.



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