



## CBS-600™ VIM-VAR

### CARBURIZING BEARING AND GEAR STEEL

TYPICAL ANALYSIS	C	Mn	Si	Cr	Mo	Al
	0.19	0.60	1.10	1.45	1.00	0.06

**CBS-600 VIM-VAR** is a carburizing bearing and gear steel designed for service temperatures up to 600°F (316°C). Double vacuum melting is employed to provide optimum tensile properties as well as desirable impact and fracture toughness characteristics.

CBS 600 VIM-VAR is a natural candidate for bearing, gear, shaft, bushing and similar applications for which the standard SAE/AISI 9310 or 8620 steels do not exhibit sufficient resistance to temperature.

#### PHYSICAL PROPERTIES

	Test Temperature, °F (°C)					
	68 (20)	392 (200)	572 (300)	752 (400)	932 (500)	1022 (550)
<b>Thermal Conductivity</b> , Btu • ft/h/ft <sup>2</sup> /°F (W/m/K)	28.1 (48.6)	25.6 (44.4)	24.4 (42.3)	22.3 (38.5)	20.6 (35.6)	19.6 (33.9)
<b>Mod. Elasticity*</b> , 10 <sup>6</sup> psi (10 <sup>3</sup> MPa)	30.5 (210)	28.9 (199)	27.9 (192)	26.8 (185)	25.5 (176)	24.9 (172)
<b>Shear Modulus*</b> , 10 <sup>6</sup> psi (10 <sup>3</sup> MPa)	11.85 (81.7)	11.15 (76.9)	10.60 (73.1)	10.20 (70.3)	9.70 (66.9)	9.30 (64.1)
<b>Poisson's Ratio*</b>	0.292	0.296	0.300	0.303	0.307	0.309
<b>Specific Heat</b> , Btu/lb/°F and cal/g/°C	0.118	0.125	0.132	0.142	0.157	0.166

\*Dynamic Test Data via Ultra Pulse Technique

#### Density: (Annealed Condition)

0.282 lb/in<sup>3</sup> (7.81 g/cm<sup>3</sup>)

#### Coefficient of Thermal Expansion:

Temperature Range, °F (°C)	10 <sup>-6</sup> in/in/°F		(10 <sup>-6</sup> mm/mm/°C)	
	0.20%C	1.00%C	(0.20%C)	(1.00%C)
70-200 (21-93)	7.22	6.76	(13.0)	(12.2)
70-400 (21-204)	7.05	7.06	(12.7)	(12.7)
70-500 (21-260)	7.08	7.16	(12.7)	(12.9)
70-600 (21-316)	7.23	7.28	(13.0)	(13.1)
70-800 (21-427)	7.10	7.21	(12.8)	(13.0)

#### CRITICAL TEMPERATURES

	Ac <sub>1</sub>	Ac <sub>3</sub>
Core	1345°F (729°C)	1625°F (885°C)
Case	1345°F (729°C)	1475°F (802°C)

#### M<sub>s</sub> TEMPERATURE DATA

##### Carbon Level

0.50% C	455°F (235°C)
0.80% C	290°F (143°C)
1.00% C	*170°F (77°C)

\*Estimated; M<sub>s</sub> lowers approximately 6°F (3°C) per 0.01% C increase

#### FORGING

CBS 600 VIM-VAR can be readily forged or rolled into contoured shapes. No unique precautions are required. Guidelines are:

**Forging Temperature:** 1800-2000°F (982-1093°C).

**Finishing Temperature:** not critical.

**Cooling:** An air cool may be satisfactory. However, to guard against the possibility of strain cracking, a retarded cool is preferred. For a BHN 207 maximum hardness, cool at a rate of less than 250°F (140°C) per hour to 1100°F (593°C), then air cool to room temperature.

#### ANNEALING

A sub critical anneal is adequate for CBS-600 VIM-VAR. Temper at 1300°F (705°C) for 2 hours per inch of thickness, then air cool to room temperature. Hardness: BHN 217 maximum.



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## CARBURIZING BEARING AND GEAR STEEL

### CARBURIZING/HEAT TREATMENT

The carburizing characteristics of CBS-600 VIM-VAR, given equivalent carburizing times, temperatures and carbon potential, are such that the resulting case depth is slightly less than for SAE/AISI 8720 and slightly deeper than for

SAE/AISI 9310. CBS-600 VIM-VAR can be processed via double or single (direct from carburizing) quench practices. Recommendations are detailed here:

### CARBURIZING AND HEAT TREATING PROCEDURES

#### DOUBLE QUENCH PRACTICES

Operation	to produce duplex core structure for max. toughness	to produce 100% martensite in core
Preoxidize***	1750°F (954°C)— 30 min. in air Air Cool	
Carburize	1650/1750°F (899/954°C)  Case depth vs. time equal to 9310 type. Carbon potential should not exceed 1.1% C.	
Quench	Oil quench whenever section permits Thin parts which might distort excessively if oil quenched, may be cooled to <i>black heat in the protective atmosphere of the furnace vestibule</i> , then in air to room temperature. <i>Do not slow cool in furnace.</i>	
Conditioning	1100/1200°F— 4 hours (593/649°C)  This operation conditions retained austenite to yield maximum grain refinement in next reheat operation.	
Austenitize	1550/1575°F (843/857°C)	1650/1675°F (899/913°C)
Quench	Oil Thin parts may be mechanically restricted to control distortion.	
Cold Treatment	Not ordinarily required*	-110°F (-79°C) for 2 hours Within 4 hours**
Double Temper	600°F (316°C) 2 + 2 hours	
<b>Expected Results</b> Hardness, HRC:		
Case	58/64	59/64
Core	37/42	43/45
Microstructure:		
Case	Fine tempered martensite	Fine tempered martensite
Core	Fine tempered martensite with 15/30% Ferrite	Fine tempered martensite

#### DIRECT QUENCH PRACTICES

Operation	Direct Quench	Delayed Quench
Preoxidize***	1750°F (954°C) 30 min. in air	
Carburize/ Austenitize	1650/1750°F (899/954°C) to 1% carbon max.	
Quench	Oil quench to room temperature	Cool to 1525/1575°F (829/857°C) then oil quench to room temperature
Cold Treatment	-110°F (-79°C) for 2 hours within 4 hours**	
Double Temper	600°F (316°C) 2 + 2 hours	
<b>Expected Results</b> Hardness, HRC:		
Case	58/64	
Core	43/46	
Microstructure:		
Case	Fine tempered martensite	
Core	Fine tempered martensite	

#### RETAINED AUSTENITE DATA

As Hardened, Followed By	Simulated Case Properties % Retained Austenite/HRC	
	0.70% C	1.00% C
—	12.7/66.0	18.9/67.0
<b>Cold Treatment</b>	8.0/67.0	9.6/68.5
<b>Temper 300°F (149°C)</b>	12.3/63.5	18.9/64.5
<b>Temper 400°F (204°C)</b>	11.5/61.5	14.0/62.5
<b>Temper 500°F (260°C)</b>	8.7/60.5	9.0/62.5
<b>Temper 600°F (316°C)</b>	8.7/60.0	8.4/62.0
<b>Cold Treatment and Temper 600°F (316°C)</b>	3.4/62.5	2.9/63.5

Treatment: Mock Carburize: 1700°F (927°C)

Quench: oil

Temper: 1100°F (593°C)/ 5 hrs/AC

Harden: 1550°F (843°C)/ oil quench

Cold Treatment Where Indicated:

-110°F (-79°C) /AW

Temper: 2 + 2 hours/AC

\*Retained austenite can be held under 10% without cold treatment. If R.A. must be reduced to absolute minimum, cold treatment may be applied. Cold treatment is always recommended for the other three treatments.

\*\*If cold treatment cannot be started within 4 hours temper parts at 300°F (149°C), then follow with cold treatment when convenient.

\*\*\*Not needed when carburized in vacuum furnace. Also used are: (1) steam preoxidizing at approximately 1000°F (538°C) or preoxidizing in an acid bath of 6% H<sub>2</sub>NO<sub>3</sub> + 1% HCl.



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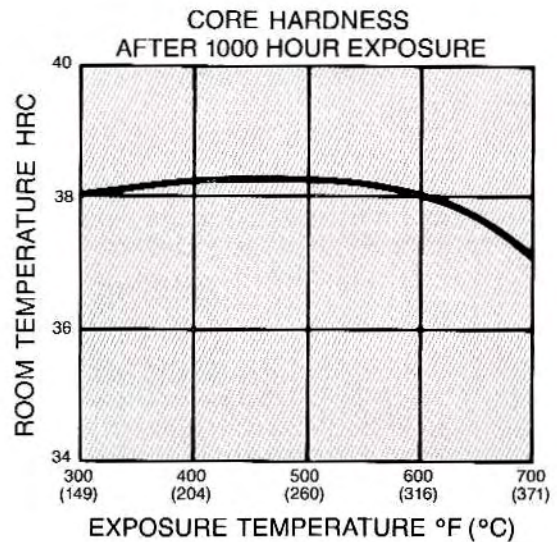
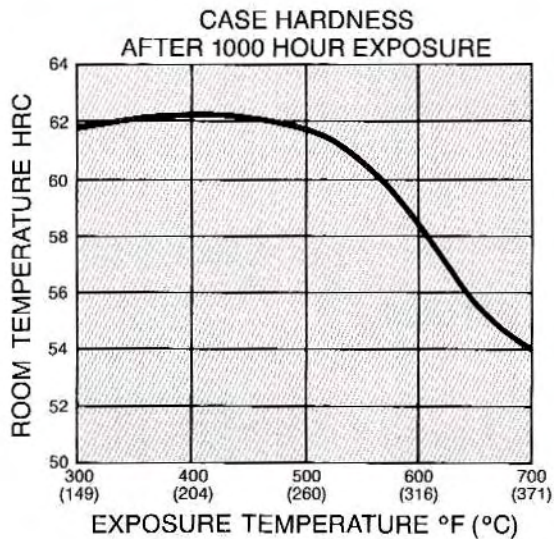
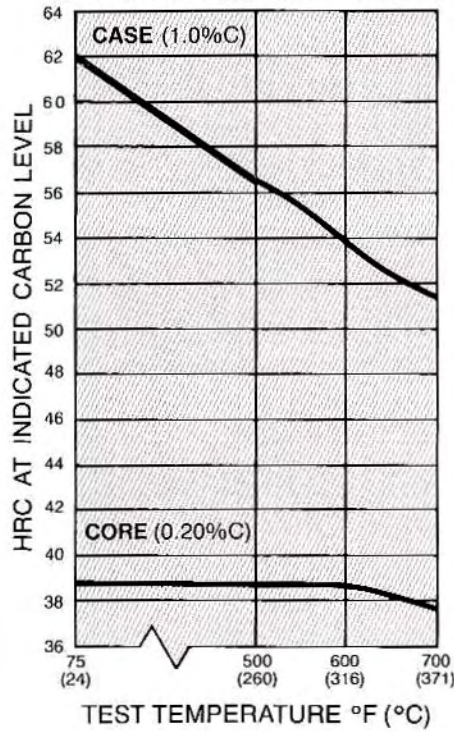
## CARBURIZING BEARING AND GEAR STEEL

### CORE TENSILE PROPERTIES

Test Temp. °F (°C)	Hardening Temp.* °F (°C)	0.2% Y.S. ksi (MPa)	U.T.S. ksi (MPa)	EI %	Reduction of Area %
75 (24)	1550 (843)	183.5 (1265)	220.0 (1515)	11.4	43.5
	1700 (927)	181.0 (1250)	220.0 (1515)	12.5	54.9
400 (204)	1550 (843)	163.0 (1125)	227.4 (1570)	11.7	33.9
	1700 (927)	172.0 (1185)	235.3 (1620)	16.0	42.8
500 (260)	1550 (843)	173.9 (1200)	224.0 (1544)	16.5	35.3
	1700 (927)	184.0 (1270)	231.0 (1595)	19.3	51.4
600 (316)	1550 (843)	148.0 (1020)	215.0 (1480)	17.5	54.0
	1700 (927)	156.0 (1075)	219.0 (1510)	18.2	54.0
700 (371)	1550 (843)	140.0 (965)	203.5 (1405)	17.5	53.6
	1700 (927)	148.2 (1020)	206.2 (1420)	18.2	53.6

\*2.25 in (57.2 mm)  $\pm$  quenched in oil from indicated temperature, then tempered 2 + 2 hours at 600°F (316°C).

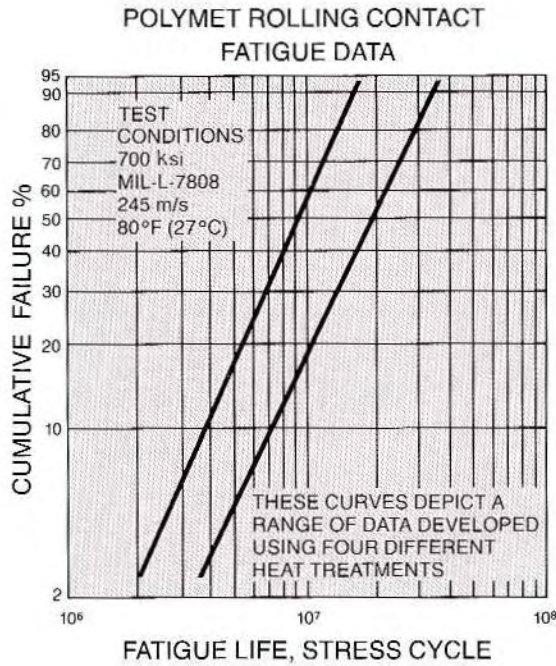
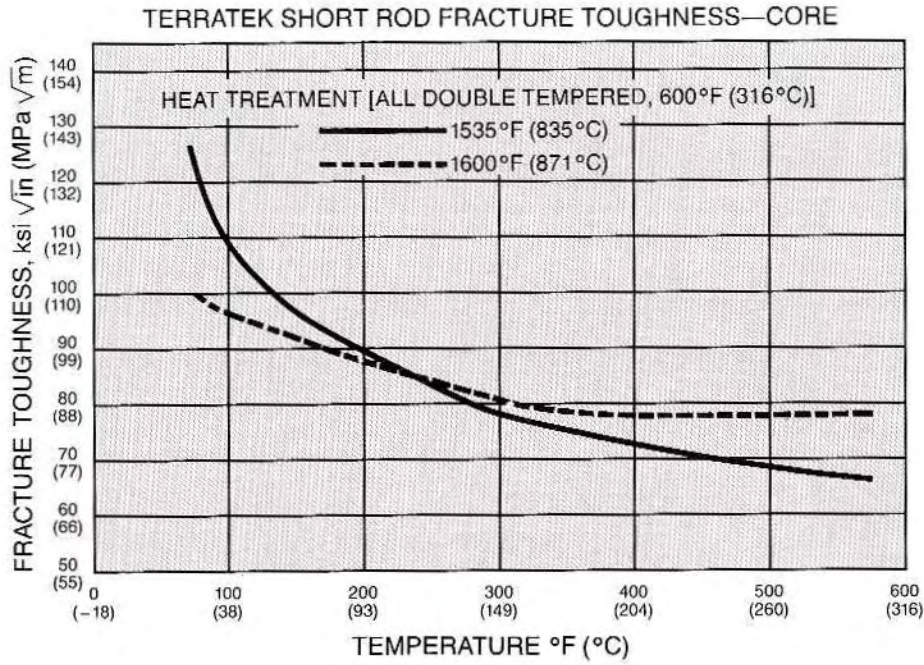
### HOT HARDNESS—CASE & CORE





# CBS-600™ VIM-VAR

## CARBURIZING BEARING AND GEAR STEEL



### AVAILABLE FORMS

Billets; hot rolled bars, cold-drawn and centerless ground bars; forgings.

### SPECIFICATIONS

The popular industry specification is AMS 6255.



**LATROBE SPECIALTY  
STEEL COMPANY**

The data presented herein are typical values, and do not warrant suitability for any specific application or use of this material. Normal variations in the chemical composition, the size of the product, and heat treatment parameters may result in different values for the various physical and mechanical properties.