



Ancorsteel® 4600V

Typical Analysis and Properties

Composition (weight %) (w/o)

C	Mo	Ni	Mn	O
0.01	0.56	1.83	0.15	0.13

Apparent Density

2.96 g /cm³

Flow Rate

25 s/ 50 g

Sieve Distribution (w/o)

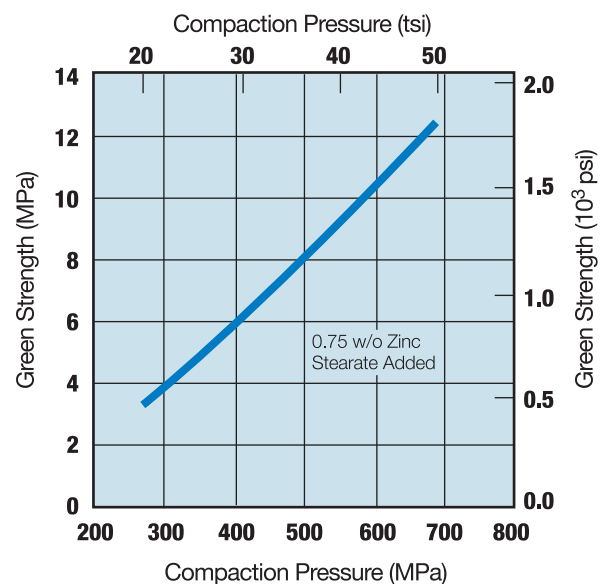
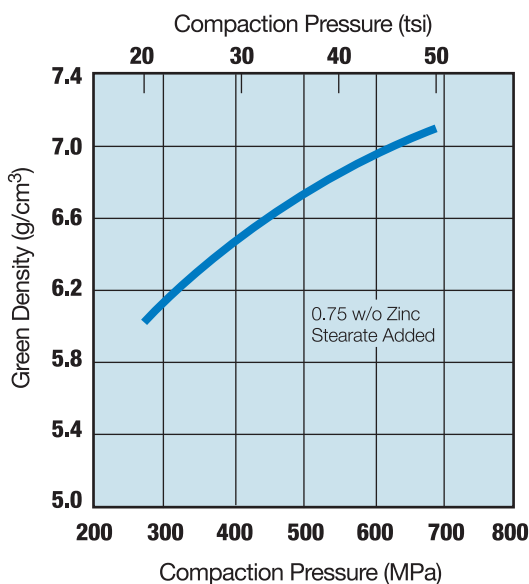
Micrometers	+250	-250 /+150	-150 /+45	-45
U.S. Standard Mesh	+60	-60 /+100	-100 /+325	-325
	Trace	11	65	24

Ancorsteel 4600V is a water atomized low alloy steel powder containing nickel, molybdenum, and manganese which satisfies Metal Powder Industries Federation (MPIF) material specification FL-4600.

Ancorsteel 4600V is particularly useful for conventional P/M parts requiring greater hardenability than is possible when using admixed or diffusion alloyed powders. It has good compressibility and green strength, enabling parts to be made easily to densities above 6.7 g/cm³. The use of nickel and molybdenum as the principal alloying elements permits Ancorsteel 4600V to be processed using conventional P/M, temperatures and atmospheres.

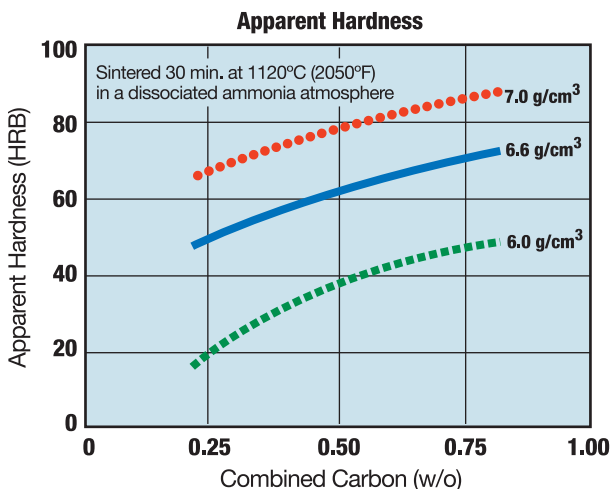
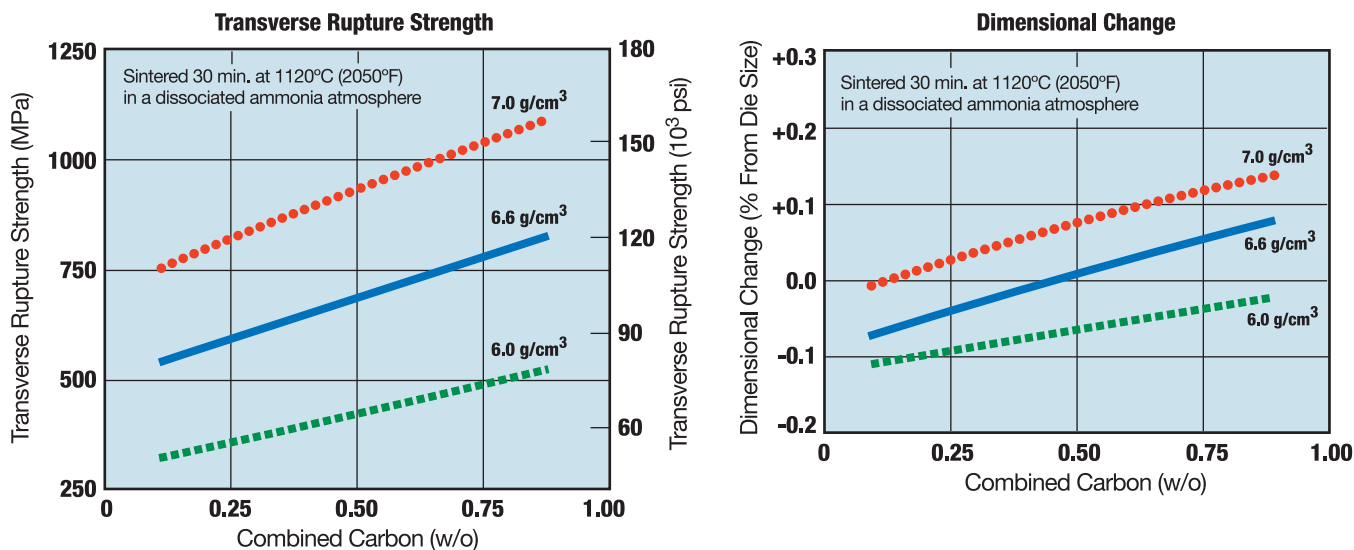
Ancorsteel 4600V, because of its high degree of cleanliness and uniform chemistry, is ideally suited for powder forging (P/F) applications that require the hardenability and mechanical properties associated with cast and wrought steels. Part densities of 7.60 to 7.86 g/cm³ can be obtained using hot forming pressures of 415–1100 MPa (30–80 tsi).

The Effect of Compaction Pressure on Green Properties

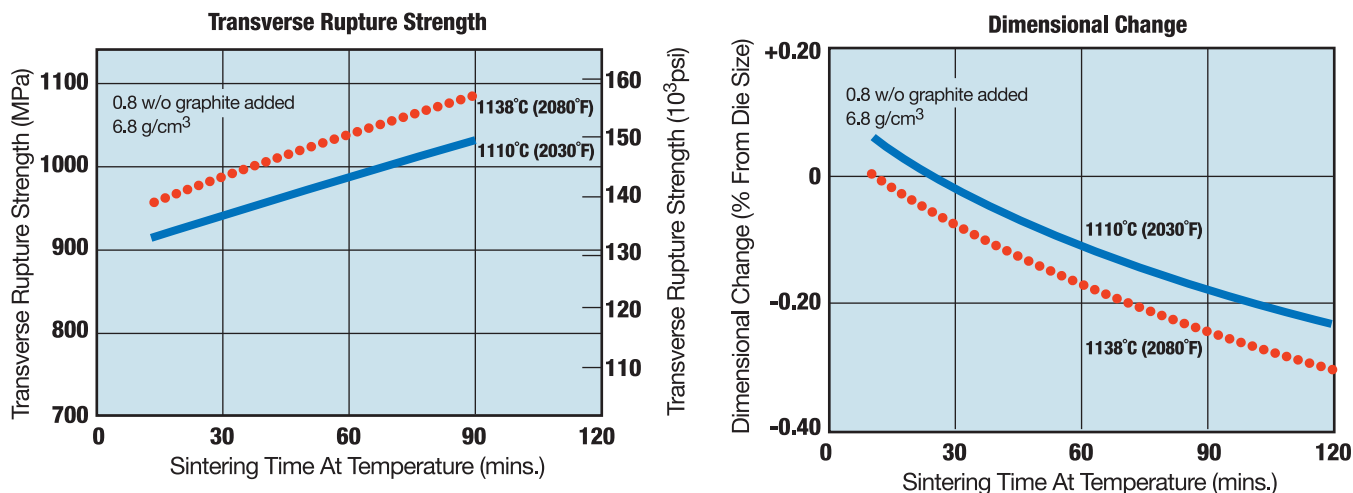


Ancorsteel® 4600V

The Effect of the Combined Carbon on Sintered Properties



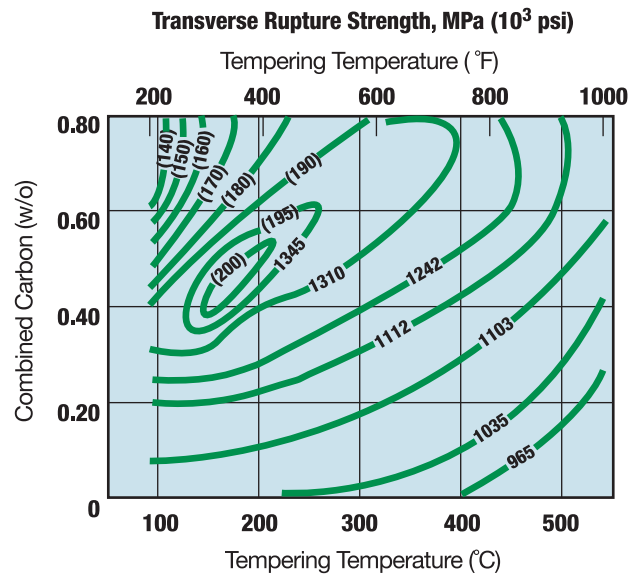
The Effect of the Sintering Temperature and Time on Properties



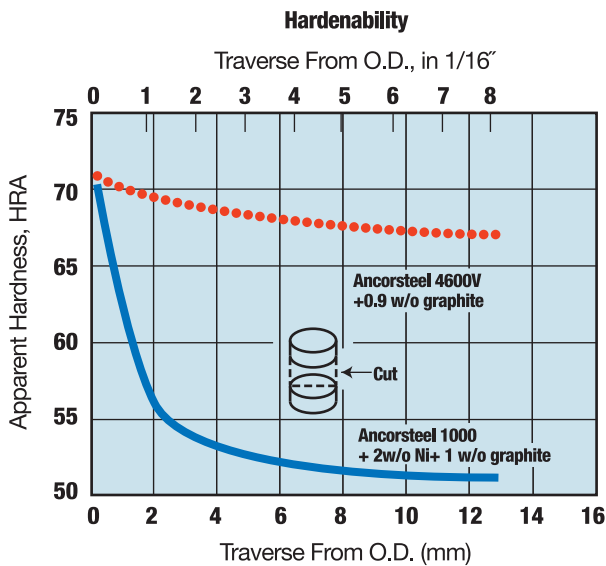
Test specimens were sintered in an endothermic gas atmosphere.

Ancorsteel® 4600V

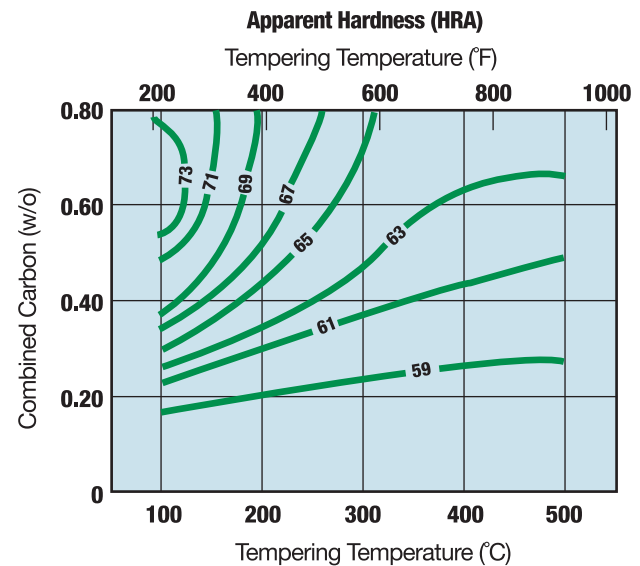
The Effect of Heat Treatment



6.8 g/cm³ test bars austenitized in endothermic atmosphere at 790–870°C (1450–1600°F), oil quenched.



6.8 g/cm³ test bars sintered 30 mins. at 1120°C (2050°F) in dissociated ammonia. Oil quenched from 815°C (1500°F).



6.8 g/cm³ test bars austenitized in endothermic atmosphere at 790–870°C (1450–1600°F), oil quenched.

Ancorsteel® 4600V

The Effect of Sintering Time and Temperature on the Tensile and Impact Properties of Ancorsteel 4600V Compacted to 6.8 g/cm³

Sintering Temperature		Time minutes	Yield Strength 2% Offset		Tensile Strength		Elongation % in 25.4 mm (1 inch)	Unnotched Charpy Impact Energy	
°C	°F		MPa	psi	MPa	psi		Joules	ft.lbf
1120	2050	30	270	39,300	320	46,200	2.3	12	8.5
1260	2300	15	300	43,300	365	53,200	2.1	9	6.8
		30	300	43,500	370	54,000	2.8	10	7.6
		45	300	43,800	395	57,000	3.2	12	8.6

The lubricant used in each case was 0.75 w/o zinc stearate. Graphite additions were adjusted until the sintered carbon analysis was 0.4 w/o.

Sinter-Hardening Characteristics of Ancorsteel 4600V Premixed with 2 w/o Copper

Graphite Addition w/o	Compaction Pressure		Tempering Temperature 60 min.		Dimensional Change %	Hardness HRB	Transverse Rupture Strength		Tensile Strength		% Martensite
	MPa	tsi	°C	°F			MPa	psi	MPa	psi	
0	530	38.4	—	—	+0.52	46	550	80,100	—	—	0
0.3	530	38.4	—	—	+0.54	66	780	113,100	—	—	0
0.6	530	38.4	—	—	+0.62	91	1005	145,600	—	—	50
0.6	530	38.4	150	300	+0.62	90	1065	154,300	—	—	50
1.0	540	39.2	—	—	+0.28	104	680	98,300	370	53,500	75
1.0	540	39.2	150	300	+0.21	101	915	132,500	480	69,700	75
1.0	540	39.2	205	400	—	100	—	—	595	86,300	—
1.0	540	39.2	260	500	—	100	—	—	740	107,300	—

All mixes include 0.75 w/o zinc stearate. They were compacted to 6.8 g/cm³ and were sintered 30 minutes at 1120°C (2050°F) in a dissociated ammonia atmosphere.

Fatigue Endurance Limit of Heat Treated Ancorsteel 4600V + 0.6 w/o Graphite

Austenitized 840°C (1550°F) in D.A. for 30 min., oil quenched. Tempered 230°C (450°F) for 1 hr. in air.

Compaction Pressure		Dimensional Change (%)	Sintered Density g/cm ³	Rockwell Hardness	Yield Strength 0.2% Offset		Tensile Strength		Elongation % in 25.4 mm (1 inch)	Endurance Limit		Endurance Ratio
MPa	tsi				MPa	psi	MPa	psi		MPa	psi	
620	45	-0.11	6.95	72 HRB	—	No Yield	805	116,800	<1	290	41,800	0.36
DP-DS*		-0.13	7.25	35 HRC	1140	165,300	1140	173,300	<1	395	57,500	0.33

*DP-DS = Pressed at 620 MPa (45 tsi), pre-sintered at 840°C (1550°F) for 30 minutes in a dissociated ammonia atmosphere, repressed at 620 MPa (45 tsi), and finally sintered at 1120°C (2050°F) for 30 minutes in a dissociated ammonia atmosphere.

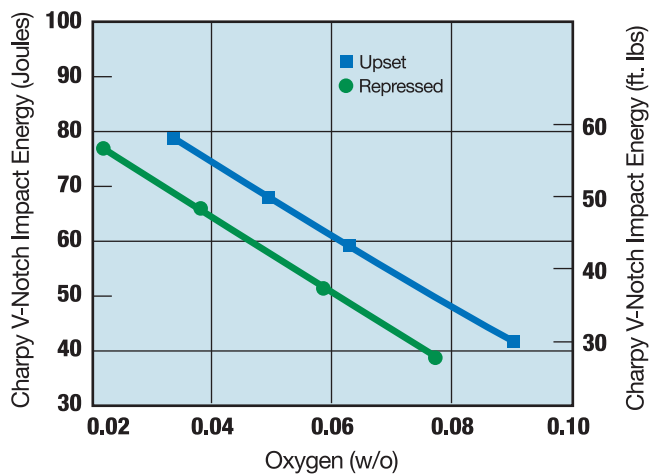
Ancorsteel® 4600V

Powder Forging

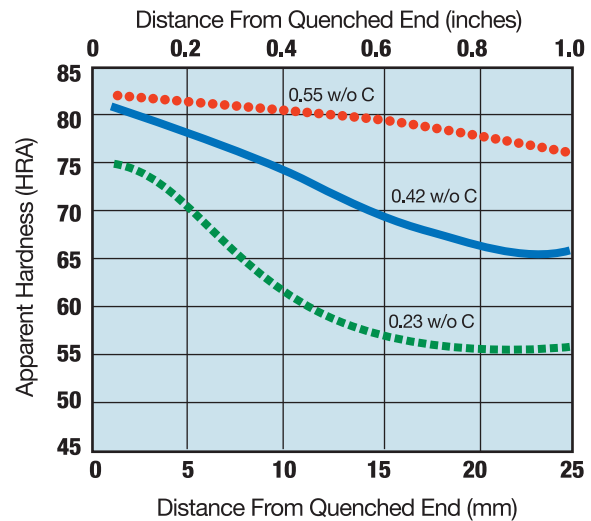
Power forging (P/F) is a natural extension of the conventional press and sinter (P/M) process, which has long been recognized as an effective technology for producing a great variety of parts to net or near-net shape. In essence, a porous preform is densified by means of hot forming in a single operation. Forging is carried out in heated, totally enclosed dies, and virtually no flash is generated.

Powder forging, therefore, is a deformation processing technology aimed at increasing the density of P/M parts and thus their performance characteristics.

The Effect of Oxygen Content on the Impact Energy of the Finished P/F Part



The Effect of P/F Carbon Content on Hardenability



Tensile and Impact Properties for Heat Treated Ancorsteel 4600 P/F with Various Forged Carbon Levels

Heat Treatment	Forged Carbon	Yield Strength 0.2% Offset		Ultimate Tensile Strength		Elongation	Reduction in Area	R.T. Charpy V-Notch Impact Energy		Core Hardness HRA
		MPa	psi	MPa	psi			Joules	ft. lbf	
175 °C / 350 °F	0.24	1425	207,000	1565	227,000	13	42	16	12	75
175 °C / 350 °F	0.38	1505	218,000	1985	288,000	11	33	11	8	77
175 °C / 350 °F	0.57	—	—	2275	330,000	3	6	7	5	80
370 °C / 700 °F	0.38	1340	194,000	1490	216,000	10	40	28	21	74
440 °C / 825 °F	0.60	1170	170,000	1455	211,000	10	32	14	10	74
680 °C / 1255 °F	0.39	745	108,000	825	120,000	21	57	62	46	63
680 °C / 1255 °F	0.58	760	110,000	860	125,000	20	50	45	33	63

IMPORTANT NOTICE: The data shown are based on laboratory processing standard test specimens. Results may vary from that obtained in production processing.