Technical Datasheet

CarTech® Custom 465® Stainless

Identification

U.S. Patent Number

• 5,681,528	• 5,855,844

UNS Number

• S46500

Type Analysis

Single figures are nominal except where noted.

Carbon (Maximum)	0.02 %	**Manganese (Maximum)**	0.25 %
Phosphorus (Maximum)	0.015 %	**Sulfur (Maximum)**	0.010 %
Silicon (Maximum)	0.25 %	**Chromium**	11.00 to 12.50 %
Nickel	10.75 to 11.25 %	**Molybdenum**	0.75 to 1.25 %
Titanium	1.50 to 1.80 %	**Iron**	Balance

General Information

Description

CarTech Custom 465 stainless is a premium melted, martensitic, age-hardenable alloy capable of ultimate tensile strength in excess of 250 ksi in the overaged (H 950) condition. This alloy was designed to have excellent notch tensile strength and fracture toughness in this condition.

Overaging to the H1000 condition provides a superior combination of strength, toughness and stress corrosion cracking resistance compared with other high-strength PH stainless alloys such as CarTech Custom 455 stainless or CarTech 13-8 stainless.

Applications

CarTech Custom 465 stainless has been used in a wide variety of applications including:

- Aerospace: landing gear components, flap and slat track components, torque tubes, pneumatic cylinders, braces, struts, fuse pins, gimbals, and other structural elements
- Automotive: suspension coil springs, engine valve springs, torsion bars and instrumented wheel sensors
- Medical: endoscopic instruments, scrapers, cutters, and suture needles
- Oil field: drive shafts, mud motors, and other downhole drilling tools
- Sporting goods: golf club faceplates, wire face shields for field sports, and big-bore firearms cylinders
- High performance racing: speed boat propellers

Corrosion Resistance

The general corrosion resistance of Custom 465 stainless approaches that of Type 304 stainless. Exposure to 5% neutral salt spray at 95°F (35°C) (per ASTM B117) caused little or no rusting after 200 hours regardless of condition (i.e., annealed or H900-H1100 conditions).

Double-cantilever-beam tests conducted in 3.5% NaCl (pH 6) show Custom 465 stainless to possess inherently good resistance to stress corrosion cracking which improves with increasing aging temperature.

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	Moderate	Sulfuric Acid	Restricted
Phosphoric Acid	Restricted	Acetic Acid	Restricted
Sodium Hydroxide	Moderate	Salt Spray (NaCl)	Good
Sea Water	Restricted	Humidity	Excellent

Properties

Physical Properties

Density		
Annealed/CT	0.2822	lb/in³
Condition H 900	0.2825	lb/in³
Condition H 950	0.2829	lb/in³
Condition H 1000	0.2832	lb/in³
Condition H 1050	0.2832	lb/in³
Condition H 1100	0.2840	lb/in³

Density

Condition	g/cm³
Annealed/CT	7.81
H900	7.82
H950	7.83
H1000	7.84
H1050	7.84
H1100	7.86

Mean CTE		
77 to 212°F, Annealed/CT	5.72	x 10^{-6} in/in/°F
77 to 392°F, Annealed/CT	6.00	x 10^{-6} in/in/°F
77 to 572°F, Annealed/CT	6.06	x 10^{-6} in/in/°F
77 to 752°F, Annealed/CT	6.17	x 10^{-6} in/in/°F
77 to 932°F, Annealed/CT	6.06	x 10^{-6} in/in/°F
77 to 1112°F, Annealed/CT	5.48	x 10^{-6} in/in/°F
77 to 212°F, Condition H 900	5.78	x 10^{-6} in/in/°F
77 to 392°F, Condition H 900	6.17	x 10^{-6} in/in/°F
77 to 572°F, Condition H 900	6.33	x 10^{-6} in/in/°F
77 to 752°F, Condition H 900	6.50	x 10^{-6} in/in/°F
77 to 932°F, Condition H 900	6.67	x 10^{-6} in/in/°F
77 to 1112°F, Condition H 900	6.22	x 10^{-6} in/in/°F
77 to 212°F, Condition H 1000	5.89	x 10^{-6} in/in/°F
77 to 392°F, Condition H 1000	6.17	x 10^{-6} in/in/°F
77 to 572°F, Condition H 1000	6.39	x 10^{-6} in/in/°F
77 to 752°F, Condition H 1000	6.50	x 10^{-6} in/in/°F
77 to 932°F, Condition H 1000	6.67	x 10^{-6} in/in/°F
77 to 1112°F, Condition H 1000	6.78	x 10^{-6} in/in/°F
77 to 212°F, Condition H 1100	6.28	x 10^{-6} in/in/°F
77 to 392°F, Condition H 1100	6.67	x 10^{-6} in/in/°F
77 to 572°F, Condition H 1100	6.89	x 10^{-6} in/in/°F
77 to 752°F, Condition H 1100	7.06	x 10^{-6} in/in/°F
77 to 932°F, Condition H 1100	7.17	x 10^{-6} in/in/°F
77 to 1112°F, Condition H 1100	7.28	x 10^{-6} in/in/°F

Mean coefficient of thermal expansion

Temperature Range		Coefficient of Expansion (10^{-6}/°C)			
°F	°C	Annealed/CT	H900	H1000	H1100
77/212	25/100	10.30	10.40	10.60	11.30
77/392	25/200	10.80	11.10	11.10	12.00
77/572	25/300	10.90	11.40	11.50	12.40
77/752	25/400	11.10	11.70	11.70	12.70
77/932	25/500	10.90	12.00	12.00	12.90
77/1112	25/600	9.86	11.20	12.20	13.10

Thermal Conductivity

73°F, Annealed/CT	97.60	BTU-in/hr/ft²/°F
212°F, Annealed/CT	108.6	BTU-in/hr/ft²/°F
392°F, Annealed/CT	122.9	BTU-in/hr/ft²/°F
572°F, Annealed/CT	134.4	BTU-in/hr/ft²/°F
752°F, Annealed/CT	148.7	BTU-in/hr/ft²/°F
932°F, Annealed/CT	165.5	BTU-in/hr/ft²/°F
1112°F, Annealed/CT	178.7	BTU-in/hr/ft²/°F
73°F, Condition H 900	103.0	BTU-in/hr/ft²/°F
212°F, Condition H 900	117.2	BTU-in/hr/ft²/°F
392°F, Condition H 900	133.3	BTU-in/hr/ft²/°F
572°F, Condition H 900	145.5	BTU-in/hr/ft²/°F
752°F, Condition H 900	156.0	BTU-in/hr/ft²/°F
932°F, Condition H 900	170.1	BTU-in/hr/ft²/°F
1112°F, Condition H 900	182.6	BTU-in/hr/ft²/°F
73°F, Condition H 1000	109.8	BTU-in/hr/ft²/°F
212°F, Condition H 1000	125.0	BTU-in/hr/ft²/°F
392°F, Condition H 1000	140.5	BTU-in/hr/ft²/°F
572°F, Condition H 1000	150.6	BTU-in/hr/ft²/°F
752°F, Condition H 1000	163.4	BTU-in/hr/ft²/°F
932°F, Condition H 1000	177.5	BTU-in/hr/ft²/°F
1112°F, Condition H 1000	191.6	BTU-in/hr/ft²/°F
73°F, Condition H 1050	109.6	BTU-in/hr/ft²/°F
212°F, Condition H 1050	125.5	BTU-in/hr/ft²/°F
392°F, Condition H 1050	141.7	BTU-in/hr/ft²/°F
572°F, Condition H 1050	152.6	BTU-in/hr/ft²/°F
752°F, Condition H 1050	163.1	BTU-in/hr/ft²/°F
932°F, Condition H 1050	175.5	BTU-in/hr/ft²/°F
1112°F, Condition H 1050	186.7	BTU-in/hr/ft²/°F

Thermal conductivity

Temperature Range		W/m•K (BTU•in/ft²•h•F)			
°F	°C	Annealed/CT	H900	H1000	H1050
73	23	14.06 (97.6)	14.85 (103.0)	15.83 (109.8)	15.80 (109.6)
212	100	15.65 (108.6)	16.89 (117.2)	18.01 (125.0)	18.09 (125.5)
392	200	17.71 (122.9)	19.21 (133.3)	20.25 (140.5)	20.42 (141.7)
572	300	19.37 (134.4)	20.97 (145.5)	21.71 (150.6)	21.99 (152.6)
752	400	21.43 (148.7)	22.49 (156.0)	23.55 (163.4)	23.51 (163.1)
932	500	23.85 (165.5)	24.52 (170.1)	25.58 (177.5)	25.29 (175.5)
1112	600	25.76 (178.7)	26.32 (182.6)	27.61 (191.6)	26.91 (186.7)

Modulus of Elasticity (E)		
Condition H 1000	28.8	x 10 ³ ksi
Condition H 1100	28.4	x 10 ³ ksi

Modulus of Elasticity (E)

Condition	X10³ ksi
H1000	28.8
H1100	28.4

Electrical Resistivity		
70°F, Annealed/CT	569.0	ohm-cir-mil/ft
70°F, Condition H 900	496.0	ohm-cir-mil/ft
70°F, Condition H 1000	494.0	ohm-cir-mil/ft
70°F, Condition H 1100	464.0	ohm-cir-mil/ft

Electrical resistivity

Condition	Ohm-Cir mil/ft	Microhm/mm
Annealed/CT	569	946
H900	496	824
H1000	494	822
H1100	464	772

Magnetic Properties

DC Magnetic Properties

Condition	Coercivity, H_c (Oe)	Saturation Induction, B_s (kG)
Annealed/CT	25.5	13.4
H900	23.3	13.8
H950	24.0	13.6
H1000	28.1	13.3
H1050	34.2	12.4
H1100	53.0	10.1

Saturation Flux Density		
Annealed/CT	13400.0	G
H900	13800.0	G
H950	13600.0	G
H1000	13300.0	G
H1050	12400.0	G
H1100	10100.0	G

Coercivity		
Annealed/CT	25.5	Oe
H 900	23.3	Oe
H 950	24.0	Oe
H 1000	28.1	Oe
H 1050	34.2	Oe
H 1100	53.0	Oe

Typical Mechanical Properties

Effects of -65°F (-54°C) Test Temperature on Longitudinal Mechanical Properties —Custom 465 Stainless

4.25" diameter bar

Condition	Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 4D	% Reduction of Area	Notch Tensile Strength(1)		NTS/ UTS	Charpy V-Notch Impact	Hardness(2) (HRC)	Fracture Toughness(3) K_{Ic} (ksi√in)
	°F	°C	ksi	MPa	ksi	MPa			ksi	MPa		ft-lbs		
H950	73	23	242	1669	256	1765	13	62	372	2565	1.5	22	49.5	95
	-65	-54	258	1779	272	1875	12	53	240	1655	0.9	6	49.5	53
H975	73	23	235	1620	247	1703	13	61	372	2565	1.5	27	48.0	109
	-65	-54	249	1717	261	1800	14	58	305	2103	1.2	8	48.0	74
H1000	73	23	219	1510	231	1593	15	63	357	2461	1.5	41	47.5	129
	-65	-54	233	1606	245	1689	15	63	363	2503	1.5	15	47.5	87
H1050	73	23	201	1386	215	1482	17	66	330	2275	1.5	52	45.5	139
	-65	-54	210	1448	231	1593	18	63	343	2365	1.5	28	45.5	110

(1) $K_t = 10$
(2) Hardness measurements made at room temperature on fractured CVN specimens
(3) 1¼" - thick compact tension specimens

Effects of Exposure at Elevated Temperatures on Room Temperature Mechanical Properties—Custom 465 Stainless Bar*

Thermal Stability, 10" Diameter Bar

Condition	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 4D	% Reduction of Area	Notch Tensile Strength**		Charpy V-Notch Impact		Hardness (HRC)
	ksi	MPa	ksi	MPa			ksi	MPa	ft-lbs	J	
H1025	214	1475	227	1565	15	67	353	2434	36	49	47
H1025 + 600°F (316°C), 1000 hrs, AC	217	1496	230	1586	15	68	353	2434	32	43	47
H1025 + 700°F (371°C), 1000 hrs, AC	224	1544	235	1620	15	68	349	2406	23	31	48
H1025 + 800°F (427°C), 1000 hrs, AC	231	1593	244	1682	14	63	344	2372	13	18	49
H1025 + 900°F (482°C), 1000 hrs, AC	219	1510	232	1600	16	66	331	2282	25	34	48
H1050	205	1413	220	1517	17	66	336	2317	43	58	46
H1050 + 600°F (316°C), 1000 hrs, AC	205	1413	220	1517	17	68	337	2324	39	53	46
H1050 + 700°F (371°C), 1000 hrs, AC	210	1448	225	1551	17	66	338	2330	28	38	47
H1050 + 800°F (427°C), 1000 hrs, AC	221	1524	234	1613	15	60	334	2303	18	24	48
H1050 + 900°F (482°C), 1000 hrs, AC	206	1420	221	1524	17	65	322	2220	30	41	46.5

* All longitudinal properties
**Notch tensile strength with $K_t = 10$

Effects of Exposure at Elevated Temperatures on Room Temperature Mechanical Properties—Custom 465 Stainless Bar*

Thermal Stability, 4½" x 1½" Forged Bar

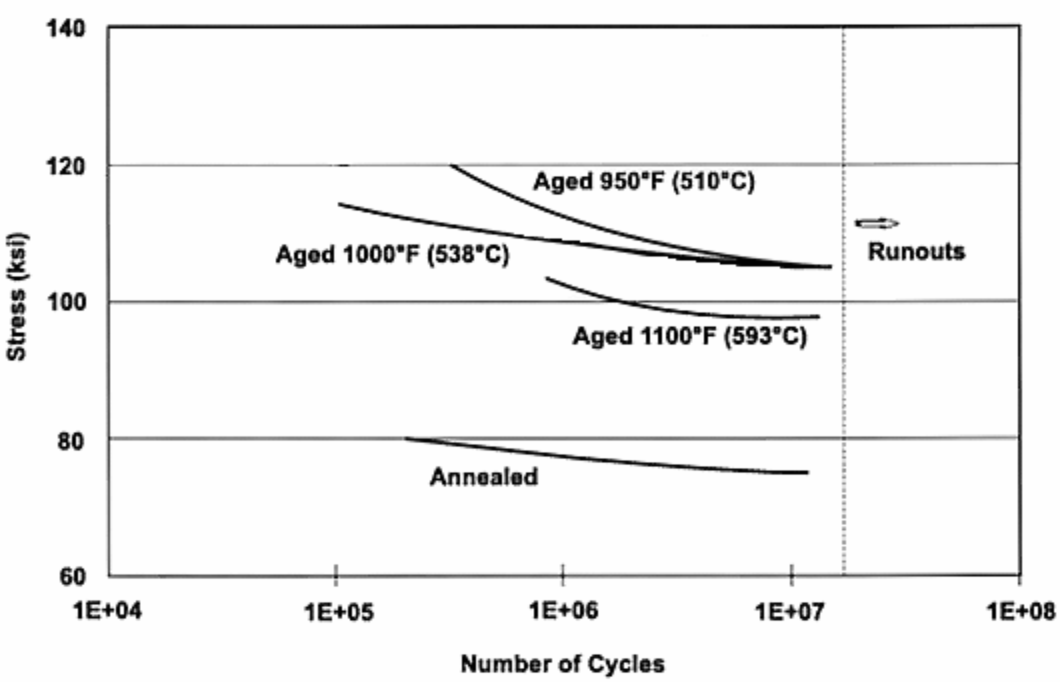
Condition	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 4D	% Reduction of Area	Notch Tensile Strength**		Charpy V-Notch Impact		Hardness (HRC)
	ksi	MPa	ksi	MPa			ksi	MPa	ft-lbs	J	
H950	239	1648	255	1758	14	62	367	2530	20	27	49
H950 + 600°F (316°C), 1000 hrs, AC	242	1669	259	1786	16	59	354	2441	12	16	49.5
H950 + 700°F (371°C), 1000 hrs, AC	250	1724	268	1848	14	56	285	1965	11	15	51
H950 + 800°F (427°C), 1000 hrs, AC	253	1744	272	1875	13	54	271	1868	9	12	51.5
H950 + 900°F (482°C), 1000 hrs, AC	211	1455	223	1538	19	67	332	2289	34	46	46
H1000	218	1503	231	1593	16	66	355	2448	38	52	47
H1000 + 600°F (316°C), 1000 hrs, AC	219	1510	232	1600	18	65	354	2441	30	41	47
H1000 + 700°F (371°C), 1000 hrs, AC	226	1558	240	1655	16	65	350	2413	25	34	47.5
H1000 + 800°F (427°C), 1000 hrs, AC	229	1579	245	1689	15	62	347	2392	18	24	48
H1000 + 900°F (482°C), 1000 hrs, AC	210	1448	222	1531	20	66	327	2255	32	43	46

* All longitudinal properties

**Notch tensile strength with K_t = 10

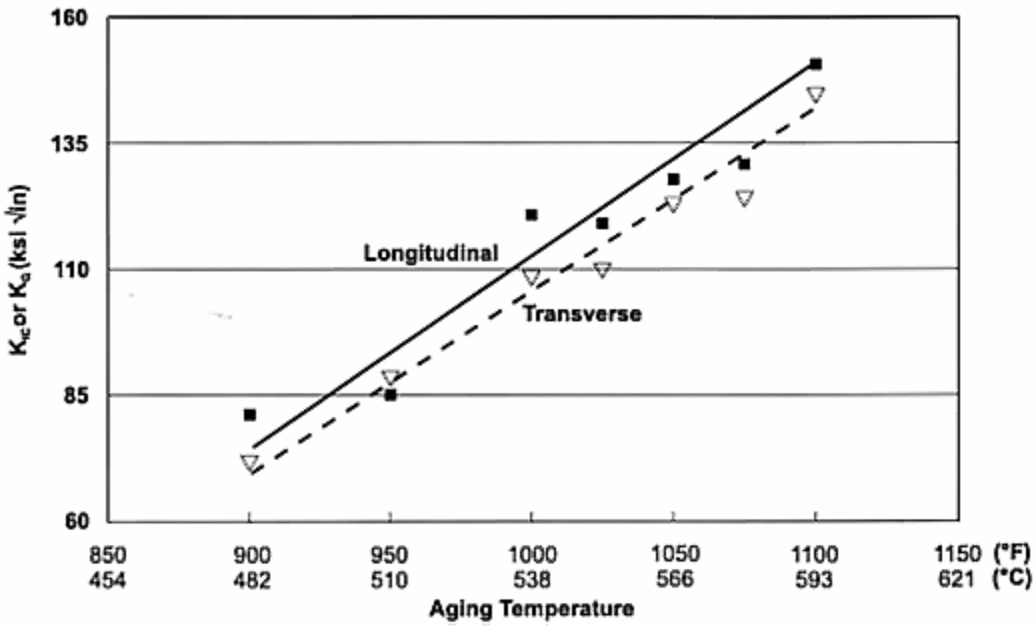
Fatigue Strength—Custom 465 Stainless

Effects of aging temperature on the smooth rotating beam fatigue (R.R.Moore) strength of Custom 465 stainless are shown below. Data were developed from longitudinal specimens obtained from 4-1/2" x 1-1/2" forged bar. Specimens surviving at least 17 million cycles at 10 thousand cycles/minute were defined as "Runouts."



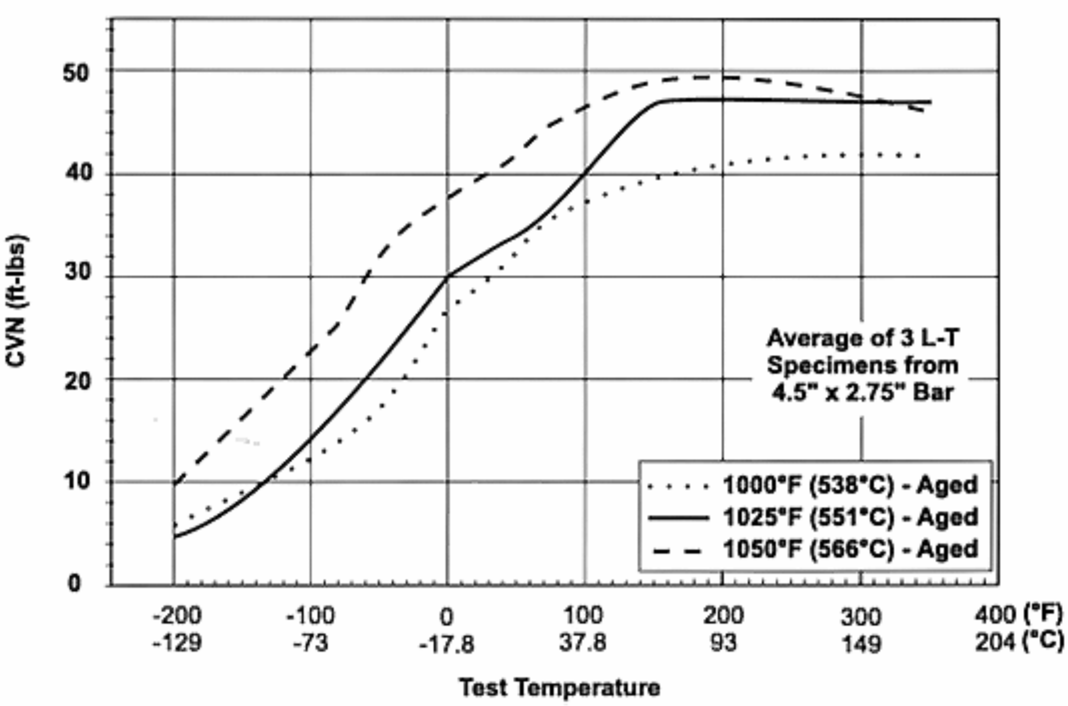
Fracture Toughness—Custom 465 Stainless

The fracture toughness, or resistance to rapid crack growth, of Custom 465 stainless is influenced by aging temperature and, to a lesser extent, by orientation. The effects of aging temperature (4 hrs., AC) are illustrated below for longitudinal (L-T) and transverse (T-L) compact tension specimens obtained from 4-1/2" x 1-1/2" forged bar. Because the specimen size was limited by the section size (i.e., 1-1/2" thick), data for aging temperatures of 1050-1100°F (566-593°C) are K_Q values rather than K_{Ic}.



Impact Properties—Custom 465 Stainless

Effects of aging temperature and test temperatures on the Charpy V-notch impact energy of Custom 465 stainless forged bar are illustrated below.



Shear Strength at Room Temperature – Custom 465® Stainless

Double-Restrained Shear Strength

Condition*	Ultimate Tensile Strength		Shear Strength	
	ksi	MPa	ksi	MPa
Annealed	146	1007	90	621
Annealed + 950°F (510°C) Age	253	1744	154	1062
Annealed + 1000°F (538°C) Age	232	1600	141	972
Annealed + 1050°F (566°C) Age	219	1510	133	917
Annealed + 1100°F (593°C) Age	195	1344	124	855
Annealed + 32% Cold Drawn	160	1103	96	662
32% Cold Drawn + 950°F (510°C) Age	280	1931	169	1165
32% Cold Drawn + 1000°F (538°C) Age	255	1758	159	1096
32% Cold Drawn + 1025°F (552°C) Age	246	1696	154	1062
71% Cold Drawn + 950°F (510°C) Age	288	1986	166	1145

*Aged at indicated temperature, 4 hours, AC

Short-Term Elevated-Temperature Longitudinal Tensile Properties – Custom 465® Stainless

2.00" diameter bar

Condition	Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		% Elong. in 4D	% Reduction of Area
	°F	°C	ksi	MPa	ksi	MPa		
H1000	73	23	226	1558	235	1620	14	66
	500	260	191	1317	202	1393	14	67
	600	316	187	1289	199	1372	14	68
	700	371	183	1262	190	1310	15	69
	800	427	172	1186	178	1227	16	70

Typical Room Temperature Mechanical Properties – Custom 465® Stainless Bar

(3" to 9" Round)

Condition	Orientation	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 4D	% Reduction of Area	Notch Tensile Strength(1)		NTS/UTS	Charpy V-Notch Impact	Hardness (HRC)
		ksi	MPa	ksi	MPa			ksi	MPa		ft-lbs	
H950	Long.	240	1655	256	1765	12	57	359	2475	1.40	16	49.5
	Trans.	239	1648	256	1765	11	49	346	2386	1.35	13	49.5
H1000	Long.	217	1496	231	1593	14	63	352	2427	1.52	35	47.5
	Trans.	218	1503	232	1600	13	57	347	2392	1.50	28	47.5

Typical Room Temperature Mechanical Properties—Custom 465 Stainless Strip
(.140"-Thickness and Under)

Condition	Orientation	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 2"	Rockwell Hardness (HRC)
		ksi	MPa	ksi	MPa		
Annealed/CT	L	105	724	145	1000	7	30
	T	110	758	150	1034	6	—
H900	L	245	1689	260	1793	5	51
	T	250	1724	265	1827	5	—
H950	L	240	1655	250	1724	6	50.5
	T	245	1689	260	1793	5	—
H1000	L	215	1482	225	1551	7	48
	T	220	1517	230	1586	6	—
H1050	L	195	1344	210	1448	8	45.5
	T	200	1379	215	1482	7	—
H1100	L	155	1069	190	1310	10	42
	T	160	1103	195	1344	9	—

Typical Room Temperature Mechanical Properties—Custom 465 Stainless Wire

Condition	0.2% Yield Strength		Ultimate Tensile Strength		% Elongation in 4D	% Reduction of Area	Hardness (HRC)
	ksi	MPa	ksi	MPa			
Annealed/CT	112	772	138	951	20	75	29.5
H900	247	1703	258	1779	14	51	50
71% Cold Drawn	163	1124	174	1200	12	74	38.5
71% Cold Drawn + 900°F (482°C) Age	293	2020	303	2089	10	57	55

Typical Room Temperature Mechanical Properties – Custom 465® Stainless
4-1/2" x 1-1/2" and 4-1/2" x 2-3/4" Forged Bars

Condition	Orientation	0.2% Yield Strength		Ultimate Tensile Strength		% Elong. in 4D	% Reduction of Area	NTS*		NTS/UTS	Hardness (HRC)
		ksi	MPa	ksi	MPa			ksi	MPa		
Annealed/CT	L	99	683	138	951	20	80	--	--	--	28
H950	L	235	1620	254	1751	14	63	362	2496	1.43	49
	T	230	1586	250	1724	12	53	355	2448	1.42	
H1000	L	217	1496	231	1593	15	65	352	2427	1.52	47
	T	211	1455	227	1565	15	61	349	2406	1.54	
H1025	L	204	1407	218	1503	17	65	343	2365	1.57	46
	T	204	1407	218	1503	16	61	341	2351	1.56	
H1050	L	198	1365	215	1482	18	67	326	2248	1.52	45
	T	196	1351	213	1469	17	63	324	2234	1.52	
H1075	L	179	1234	203	1400	20	69	313	2158	1.54	43
	T	180	1241	202	1393	19	67	309	2130	1.53	
H1100	L	159	1096	190	1310	22	71	280	1931	1.47	40
	T	158	1089	190	1310	21	65	278	1917	1.46	
H1150	L	98	676	170	1172	24	72	243	1675	1.43	36
	T	104	717	172	1186	22	66	241	1662	1.40	--
H1150M	L	77	531	156	1076	25	72	223	1538	1.43	30
	T	78	538	159	1096	22	62	221	1524	1.39	--

*Notch tensile strength with K_t= 10

Heat Treatment

Solution Treatment

Condition A (Solution Annealed)

Heat to 1800°F±15°F (982°C±8°C), hold one hour at heat and cool rapidly. Sections up to 12" can be quenched in a suitable liquid quenchant. Sections over 12" should be cooled rapidly in air. For optimum aging response, solution annealing should be followed by refrigerating to -100°F (-73°C), holding eight hours, then warming to room temperature (CT). Subzero cooling should be performed within 24 hours of solution annealing.

Custom 465 stainless normally will be supplied from the mill in the solution annealed/cold treated condition (annealed/CT), ready for the one-step hardening treatment. Billet product will be provided in the hot finished condition.

Average Size Change (Contraction)—Custom 465 Stainless
Solution annealed/CT to aged condition

Condition	Contraction in/in (m/m)	
	Longitudinal	Transverse
H900	.0008	.0007
H950	.0011	.0010
H1000	.0014	.0013
H1050	.0016	.0016
H1100	.0023	.0023
H1150M	.0053	.0053

Age

Condition H 900, H 950, H 1000, H 1050 and H 1100

The high strength levels of Custom 465 stainless are derived from a single age hardening step consisting of heating to a selected temperature between 900/1150°F (482/621°C) and holding for four to eight hours. A water or oil quench is suggested for optimum toughness. Slower cooling methods are not preferred, and are likely to result in reduced toughness. Aging temperature will depend upon the desired combination of strength, toughness and stress corrosion cracking resistance. While the alloy does develop maximum strength after a 900°F age, it is not recommended because toughness is significantly degraded compared to aging at higher temperatures. The best combination of properties is obtained after aging at 950°F (510°C) and above and quenching in a suitable liquid, the severity of which should in part be based on the geometry and complexity of the part being aged.

Condition H 1150M

While the alloy typically will be machined in the annealed/CT condition, optimum machinability of Custom 465 stainless can be achieved by overaging to the H 1150M condition. Material is heated to 1400°F±15°F (760°C±8°C) for two hours, air cooled, then reheated to 1150°F±15°F (621°C±8°C) for four hours and air cooled. If this practice is used, parts must be reannealed at 1800°F (982°C), cold treated at -100°F (-73°C) and aged at a selected temperature.

Workability

Hot Working

Custom 465 stainless typically is forged within the temperature range of 1850/2000°F (1010/1093°C), followed by air cooling. Forgings must be solution annealed prior to age hardening.

Cold Working

Because of a relatively low annealed yield strength and low work hardening rate, Custom 465 stainless can be readily cold formed by drawing or rolling. Single step aging of cold worked material results in enhanced strengthening response as illustrated in the diagram and table.

Custom 465 Stainless is supplied in the following conditions:

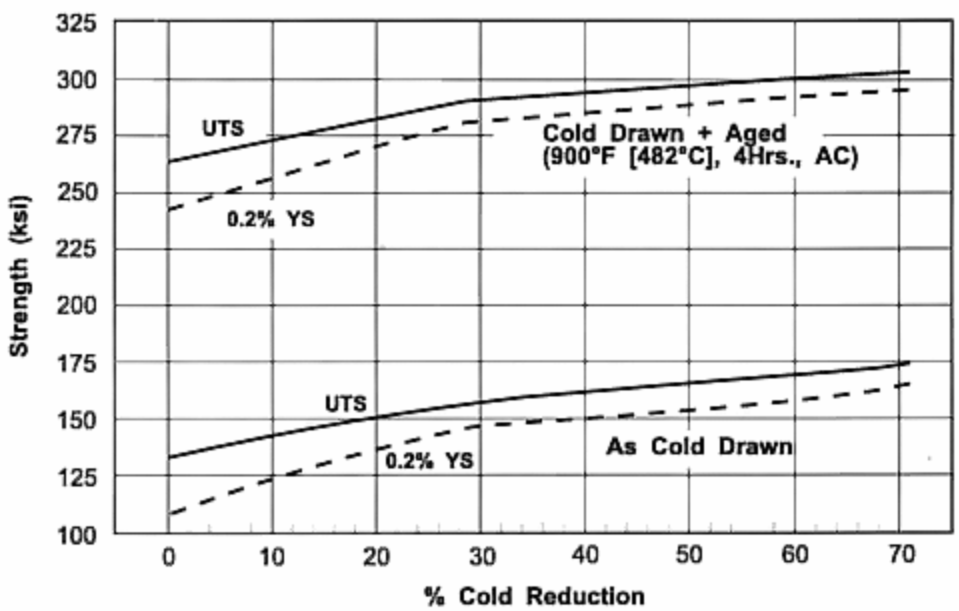
1. Solution Annealed, Cold Treated, Cold Worked and Ground - This condition is available in diameters up to and including 0.625” round. The exact amount of cold work varies by bar diameter but will be a minimum of 60 percent cold work.

2. Solution Annealed, Cold Treated.

In either condition, the material will be manufactured to the maximum hardness associated with industry specifications such as AMS and ASTM.

Other conditions available upon request
Modified cold work ranges may be requested on a custom order basis.

Effects of Cold Work and Aging on Yield and Ultimate Tensile Strengths—
Custom 465 Stainless Wire



Effects of Cold Working Prior to Aging on Tensile and Charpy V-Notch Properties - Custom 465® Stainless Bar*

Age	% C.R.	0.2% Yield Strength		Ultimate Tensile Strength		% Elong.	% R.A.	Charpy V-Notch Impact
		ksi	MPa	ksi	MPa			ft-lbs
H950	0	258	1779	267	1841	11.5	63.5	17.5
	60	276	1902	282	1944	11.5	61.5	31
	70	286	1972	293	2020	11	58.5	57
H1000	0	228	1572	238	1641	13.5	67	44.5
	60	249	1717	257	1772	13	64	52
	70	256	1765	265	1827	12.5	61	55
H1025	0	220	1517	233	1606	15	68.5	50
	60	236	1627	247	1703	14.5	64.5	54
	70	243	1675	256	1765	14	61.5	53
H1050	0	204	1407	220	1517	15.5	68.5	52.5
	60	221	1524	236	1627	15	65	53.5
	70	224	1544	241	1661	14.5	62.5	54.5

* All longitudinal properties
0% Cold Work data taken from bars 1.00-1.25"rd.
70% Cold Work data taken from bar product 0.250-0.637"rd.
60% Cold Work data taken from bar product 0.3125-0.637"rd.

Machinability

Custom 465 stainless can be machined in both the solution-treated and various age-hardened conditions. In Condition A the alloy gives good tool life and surface finish when machined at speeds 20 to 30% lower than those used for Carpenter Custom 630 (17Cr-4Ni) or 20 to 30% lower than used for Stainless Types 302 and 304. The machinability as age-hardened will improve as the hardening temperature is increased.

Condition H 1150M provides optimum machinability. Having procured Condition H1150M for best machinability, higher mechanical properties can be developed only by solution treating and heat treating at standard hardening temperatures.

Following are typical feeds and speeds for Custom 465 stainless.

Typical Machining Speeds and Feeds – Custom 465® Stainless

The speeds and feeds in the following charts are conservative recommendations for initial setup. Higher speeds and feeds may be attainable depending on machining environment.

Turning—Single-Point and Box Tools

Depth of Cut (Inches)	Micro-Melt® Powder High Speed Tools			Carbide Tools			
	Tool Material	Speed (fpm)	Feed (ipr)	Tool Material	Speed (fpm) Uncoated	Speed (fpm) Coated	Feed (ipr)
Annealed							
.150	M48, T15	72	.015	C6	270	350	.010
.025	M48, T15	84	.007	C7	325	425	.005
Aged							
.150	M48, T15	48	.010	C6	190	250	.010
.025	M48, T15	54	.005	C7	225	290	.005

Turning—Cut-Off and Form Tools

Tool Material		Speed (fpm)	Feed (ipr)						
			Cut-Off Tool Width (Inches)				Form Tool Width (Inches)		
Micro-Melt® Powder HS Tools	Car-bide Tools		1/16	1/8	1/4	1/2	1	1 ½	2
Annealed									
M48, T15		72	.001	.0015	.002	.0015	.001	.0007	.0005
	C6	216	.003	.003	.007	.005	.004	.0035	.0035
Aged									
M48, T15		36	.001	.001	.0015	.0015	.001	.0005	.0005
	C6	132	.003	.003	.0045	.003	.002	.002	.002

Rough Reaming

Micro-Melt® Powder HS Tools		Carbide Tools (inserts)		Feed (ipr) Reamer Diameter (inches)					
Tool Material	Speed (fpm)	Tool Material	Speed (fpm)	1/8	1/4	1/2	1	1 ½	2
Annealed									
M48, T15	72	C2	190	.003	.005	.008	.011	.015	.018
Aged									
M48, T15	36	C2	100	.001	.001	.001	.001	.001	.001

Drilling

High Speed Tools									
Tool Material	Speed (fpm)	Feed (inches per revolution) Nominal Hole Diameter (inches)							
		1/16	1/8	1/4	1/2	3/4	1	1 ½	2
Annealed									
M42	50	.001	.002	.004	.007	.008	.010	.012	.015
Aged									
M42	35	-	.001	.002	.003	.004	.004	.004	.004

Die Threading

FPM for High Speed Tools				
Tool Material	7 or less, tpi	8 to 15, tpi	16 to 24, tpi	25 and up, tpi
Annealed				
M2, M7, M10	5 – 12	8 – 15	10 – 22	15 – 27
Aged				
T15, M42	4 – 8	6 – 10	8 – 12	10 – 15

Milling, End-Peripheral

Depth of Cut (Inches)	Micro-Melt® Powder High Speed Tools						Carbide Tools					
	Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)				Tool Material	Speed (fpm)	Feed (ipt) Cutter Diameter (in)			
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2
Annealed												
.050	M48, T15	108	.001	.002	.003	.004	C2	275	.001	.002	.004	.006
Aged												
.050	M48, T15	72	.0005	.001	.002	.003	C2	90	.001	.002	.003	.004

Tapping

High Speed Tools	
Tool Material	Speed (fpm)
Annealed	
M7, M10	12 – 25
Aged	
M7, M10 Nitrided	5 – 15

Broaching

Micro-Melt® Powder High Speed Tools		
Tool Material	Speed (fpm)	Chip Load (ipt)
Annealed		
M48, T15	9.6	.002
Aged		
M48, T15	12	.002

Additional Machinability Notes

When using carbide tools, surface speed feet/minute (SFPM) can be increased between 2 and 3 times over the high-speed suggestions. Feeds can be increased between 50 and 100%

Figures used for all metal removal operations covered are average. On certain work, the nature of the part may require adjustment of speeds and feeds. Each job has to be developed for best production results with optimum tool life. Speeds or feeds should be increased or decreased in small steps.

Weldability

Custom 465 stainless can be satisfactorily welded by the GTA process using matching filler metal. When the GMA process is employed, Pyromet® X-23 alloy filler metal is suggested to provide high strength and avoid weld-bead cracking associated with this higher-heat-input process.

Welds should be fabricated employing the minimum amount of heat-input required to achieve complete penetration. If lower strength can be tolerated, Custom 450® stainless or Custom 630 stainless filler metal may be used. Oxyacetylene welding is not recommended, since carbon pickup in the weld may occur. Preheating is not required to prevent cracking during the welding of this alloy.

The material has been welded satisfactorily in the overaged or solution annealed/cold treated condition. Welding in the overaged (H1150M) condition requires subsequent solution annealing with cold treating and aging. Direct aging of weldments on annealed base metal is possible, but hardness throughout the weld is not uniform. The optimum combination of properties is obtained by solution annealing and cold treating the weldment and then aging.

Other Information

Applicable Specifications

- AMS 5936
- ASTM A564
- ASTM A693
- ASTM F899
- MMPDS-01

Forms Manufactured

- Bar-Flats
- Bar-Rounds
- Bar-Squares
- Billet
- Strip
- Wire

Technical Articles

- A Guide to Etching Specialty Alloys for Microstructural Evaluation
- Advanced Stainless Offers High Strength, Toughness and Corrosion Resistance Wherever Needed
- An Evaluation of Alloys for Golf Club Face Plates
- Higher Performance Material Solutions for a Dynamic Spine Market
- How to Passivate Stainless Steel Parts
- Improved Stainless Steels for Medical Instrument Tubing
- New Ideas for Machining Austenitic Stainless Steels
- New Ph Stainless Combines High Strength, Fracture Toughness and Corrosion Resistance
- New Requirements for Ferrous-Base Aerospace Alloys
- New Stainless Hand Tools Have High Strength, Toughness for Service in Corrosive or Clean Room Environments
- New Stainless Steel for Instruments Combines High Strength and Toughness
- One of the Word's Most Powerful Revolvers Gets Lift From Aerospace Alloys
- Steels for Strength and Machinability
- Passivating and Electropolishing Stainless Steel Parts
- Selecting New Stainless Steels for Unique Applications
- Selecting Stainless Steels for Valves
- Selection of High Strength Stainless Steels for Aerospace, Military and Other Critical Applications
- Specialty Alloys And Titanium Shapes To Consider For Latest Medical Materials Requirements

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