A-21®

Associated specifications: A-21® QT130, QT160, C170, and C190; UNS S41429

Type analysis

Single figures are nominal except where noted.

Iron	Balance	**Chromium**	10.50–14.00 %	**Nickel**	2.00–3.00 %
Molybdenum	0.40–0.80 %	**Titanium**	0.15–0.75 %	**Cobalt**	Max 1.0 %
Silicon	Max 1.0 %	**Manganese**	Max 0.75 %	**Copper**	Max 0.50 %
Vanadium	Max 0.25 %	**Columbium/Niobium**	Max 0.20 %	**Carbon**	Max 0.13 %
Aluminum	Max 0.05 %	**Phosphorus**	Max 0.03 %	**Sulfur**	Max 0.03 %
Tin	Max 0.02 %	**Boron**	Max 0.01 %		

Forms manufactured

Bar	**Rod**	**Strip**
Billet	**Ring**	**Tube**
Plate	**Sheet**	**Wire**

Description

A-21 is an advanced martensitic stainless steel that offers a unique combination of high strength, excellent toughness, and outstanding stainless properties in the carburized, nitrided, and quenched & tempered conditions. It is available as VIM-VAR, VAR, or air melt. In the carburized condition, A-21 is the world's first and only truly stainless carburizing steel, developing a deep, hard, stainless case and a strong, tough, ductile core. It can be considered a stainless version of 9310, 8620, and C158, and has a core minimum ultimate tensile strength (UTS) of 170 ksi or 190 ksi. In the ferritic carbo-nitrided (a.k.a. salt bath nitrided or "QPQ") condition, A-21 retains its stainless properties and offers very high surface hardness, outstanding core toughness and strength, and excellent corrosion resistance. Nitriding is typically done on finished parts and involves minimal distortion. In the quenched & tempered condition, A-21 can be used for structural applications that require a good combination of high strength and toughness, and stainless properties. It also exhibits excellent temper resistance and is an economical alternative to 17-4 and other precipitation-hardening stainless steels.

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Key Properties:

- Outstanding corrosion resistance
- High strength
- High toughness
- High surface hardness (carburized, nitrided)
- Good thermal fatigue resistance
- Excellent temper resistance

Markets:

- Aerospace
- Defense
- Energy
- Industrial
- Transportation

Applications:

- Aerospace: Carburized bearings, gears, actuators, splines, shafts, races
- Defense: Carburized bolts and barrel extensions; nitrided gun barrels, bolt carriers, and firing pins; quenched & tempered gun barrels
- Energy: Quenched & tempered drilling and workover rotors, housings; nitrided frack pumps, valve parts
- Industrial: Carburized valve seats and trim, ball screws
- Transportation: Carburized shafts

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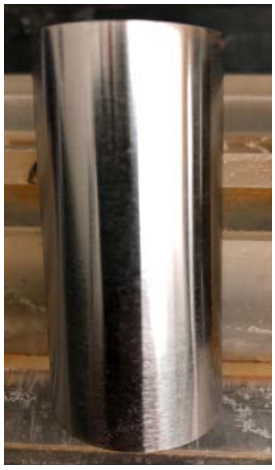
Corrosion resistance

A-21 is the world's first and only truly stainless carburizing steel. In the carburized and heat treated condition, it remains rust-free after 200-hour exposure to salt fog (ASTM B117). See below for a comparison to other stainless steels with hardness ≥ 58 HRC.

SALT FOG CORROSION TEST (ASTM B117) AFTER 200 HOURS

Conventional carburized stainless steel (62 HRC)	CPM S90V (58 HRC)	440C (58 HRC)	BG-42 (61 HRC)	Carburized A-21 (62 HRC)
				

IMPORTANT NOTE:
The following 4-level rating scale (Excellent, Good, Moderate, Restricted) is intended for comparative purposes only and is derived from experiences with wrought product. Additive manufactured material may perform differently; corrosion testing is recommended. Factors that affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevices, deposits, metallurgical condition, stress, surface finish, and dissimilar metal contact.

Humidity	Excellent (all conditions)
Salt Spray (NaCl)	Excellent (carburized, quenched & tempered, nitrided)
Sour Oil/Gas	Moderate (quenched & tempered)
Stress Corrosion Cracking	Excellent, NaCl and KCl solutions (quenched & tempered)

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Corrosion resistance (continued)

CORROSION TEST RESULTS

ASTM B117 (SALT FOG)	
TREATMENT	**AVERAGE CORROSION RATE**
Carburized and quenched & tempered, salt bath nitrided	Nil (200 hours)

ASTM D1735 (HUMIDITY)	
TREATMENT	**AVERAGE CORROSION RATE**
Carburized, salt bath nitrided	Nil (200 hours)

NACE MR-0175 / ISO 15156 (SULFIDE STRESS CRACKING)	
CONDITION	**RESULT**
Room temperature	No failure (YS ≤ 120 ksi, 27 Rc, max; pH ≥ 4.5, tubing)

NACE TM-0177, Method A

ASTM G129 (STRESS CORROSION CRACKING)	
CONDITION	**RESULT**
Room temperature	No decrease in elongation, time to failure, or reduction of area vs. control

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Specification: A-21 QT160/QT130 for quenched & tempered and nitrided applications

MINIMUM PROPERTIES, Ø < 3.5 IN (90 MM)

A-21 SPECIFICATION	TEMPER TEMPERATURE		0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 4D	REDUCTION OF AREA	CHARPY IMPACT ENERGY, FT-LB (J)		HARDNESS
	°F	°C	ksi	MPa	ksi	MPa	%	%	RT	-40°F (-40°C)	HRC
QT160	950	510	150	1034	160	1103	16	50	40 (54)	—	33–38
QT130	1075	579	125	862	130	896	18	60	80 (108)	40 (54)	29–34

Typical mechanical properties: Quenched & tempered, mid-radius (1/4 T), longitudinal, air melt

1.25 IN (32 MM) BAR

TEMPER TEMPERATURE		TEMPER TIME	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 4D	REDUCTION OF AREA	CHARPY IMPACT ENERGY, FT-LB (J)		HARDNESS
°F	°C	HOURS	ksi	MPa	ksi	MPa	%	%	RT	-40°F (-40°C)	HRC
350	177	2	155	1069	175	1207	16	63	50 (68)	—	35
925	496	2	159	1096	166	1145	20	70	55 (75)	—	36
950	510	2	160	1103	165	1138	20	66	63 (85)	—	35
975	524	2	159	1096	164	1131	20	69	63 (85)	—	35
1000	538	1	161	1110	164	1131	20	69	65 (88)	—	34
1025	552	1	157	1083	160	1103	21	69	69 (94)	—	34
1050	566	1	152	1048	154	1062	21	69	81 (110)	—	32
1075	579	1	139	958	144	993	22	70	90 (122)	71 (96)	31
1075	579	3	129	889	134	924	23	68	112 (152)	81 (110)	31
1100	593	1	132	910	138	952	23	70	101 (137)	68 (92)	30
1125	607	1	129	889	136	938	23	70	87 (118)	77 (104)	29
1125	607	4	122	841	134	924	24	72	91 (123)	80 (108)	29
1125	607	8	117	807	133	917	23	70	98 (133)	82 (111)	29

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Specification: A-21 C190/C170 for carburized applications (VAR and VIM-VAR)

MINIMUM PROPERTIES

A-21 SPEC.	BAR DIAMETER		ORIENT.	TEMPER TEMP.		0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONG. IN 4D	REDUCTION OF AREA	CHARPY IMPACT ENERGY		HARD-NESS	GRAIN SIZE
	IN	MM	T OR L	°F	°C	ksi	MPa	ksi	MPa	%	%	FT-LB	J	HRC	ASTM #
C190	<3.5	< 90	L	350 +/- 50	177 +/- 28	145	1000	190	1310	14	45	25	34	39	3
	3.5–12	90–305	T							12	40	12	16		
C170	< 3.5	< 90	L			135	1034	170	1172	14	45	25	34	35	5
	3.5–12	90–305	T							12	40	12	16		

Typical mechanical properties: Pseudo-carburized, core, mid-radius (1/4 T)

BAR, VAR OR VIM-VAR

A-21 SPEC.	MELT TYPE	BAR DIAMETER		ORIENT.	TEMPER TEMP.		0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONG. IN 4D	REDUCT. OF AREA	CHARPY IMPACT ENERGY		HARD-NESS	GRAIN SIZE
		IN	MM	T OR L	°F	°C	ksi	MPa	ksi	MPa	%	%	FT-LB	J	HRC	ASTM #
C190	VAR	0.3125	7.9	L	325	163	152	1048	200	1379	17	50	—	—	40.5	5
C190	VAR	1.625	41.3	L	350	177	158	1089	197	1358	17	61	63	85	40.0	6
C190	VAR	8.25	210	T	350	177	157	1083	198	1365	16	59	22	30	43.0	6.5
C170	VV	0.75	19	L	350	177	141	972	178	1227	18	64	60	81	38.8	6
C170	VV	2.50	64	L	350	177	147	1014	174	1200	18	65	48	65	38.0	6.5
C170	VV	5.25	133	T	350	177	141	972	174	1200	17	51	22	30	38.0	5.5
C170	VV	10.5	267	T	350	177	143	986	175	1207	15	52	19	26	37.6	6

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Heat treatment

Annealing	1100–1200°F (593–649°C)
Hardening	1550–1600°F (843–871°C)
Normalizing	1600–1650°F (871–899°C)
Tempering	200–1200°F (93–649°C)

For additional information, please contact your nearest sales office:
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