DATASHEET

15CR-5NI PROJECT 70+

Applicable specifications: AMS 5659; ASTM A564, A705 [Forgings (UNS S15500, XM-12)], F899

Associated specifications: UNS S15500

Type analysis

Single figures are nominal except where noted.

Iron	Balance	**Chromium**	14.00–15.50 %	**Nickel**	3.50–5.50 %
Copper	2.50–4.50 %	**Manganese**	Max 1.00 %	**Silicon**	Max 1.00 %
Molybdenum	Max 0.50 %	**Columbium/Niobium**	0.15–0.45 %	**Carbon**	Max 0.07 %
Tantalum	Max 0.05 %	**Phosphorus**	Max 0.030 %	**Sulfur**	Max 0.015 %

Forms manufactured

Bar-Flats	**Bar-Rounds**	**Billet**	**Wire**	**Wire-Rod**

Description

15Cr-5Ni Project 70+ is an optimized 15Cr-5Ni stainless designed to provide superior machinability compared with other brands, meeting all aspects of Aerospace Material Specification AMS 5659 covering bars, wire, forgings, rings, and extrusions.

Applications have included a variety of aerospace components requiring conformance to AMS 5659, particularly those that involve significant machining operations. However, 15Cr-5Ni Project 70+ applications are not limited to the aerospace industry. The alloy may be considered for all usual 15Cr-Ni applications.

Key Properties:

- Superior machinability
- High strength and toughness
- Excellent corrosion resistance

Markets:

- Aerospace
- Energy
- Industrial
- Transportation

Applications:

- Aerospace components
- All standard 15Cr-Ni applications

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Corrosion resistance

The general corrosion resistance of 15Cr-5Ni Project 70+ approaches that of Type 304 stainless and is similar to that of 15Cr-5Ni and Custom 630 (17Cr-4Ni) stainless steels in most media.

Good resistance to stress-corrosion cracking is gained by age hardening at temperatures of 1025°F (552°C) and higher.

For optimum corrosion resistance, surfaces must be free of scale, lubricants, foreign particles, and coatings applied for drawing and heading. After fabrication of parts, cleaning and/or passivation should be considered. (See the Workability section.)

IMPORTANT NOTE:
The following 4-level rating scale is intended for comparative purposes only. 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.

Nitric Acid	Good	**Sulfuric Acid**	Restricted
Phosphoric Acid	Restricted	**Acetic Acid**	Moderate
Sodium Hydroxide	Moderate	**Salt Spray (NaCl)**	Good
Sea Water	Restricted	**Sour Oil/Gas**	Restricted
Humidity	Excellent		

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Physical properties

PROPERTY	At or From	English Units	Metric Units
SPECIFIC GRAVITY	Condition A	7.75	7.75
	Condition H 900	7.80	7.80
	Condition H 1075	7.81	7.81
	Condition H 1150	7.82	7.82
DENSITY	Condition A	0.2800 lb/in^3	7750 kg/m^3
	Condition H 900	0.2820 lb/in^3	7800 kg/m^3
	Condition H 1075	0.2820 lb/in^3	7810 kg/m^3
	Condition H 1150	0.2830 lb/in^3	7820 kg/m^3
MEAN SPECIFIC HEAT	32 to 212°F (0 to 100°C) Condition A	0.1100 Btu/lb/°F	460 J/kg·K
	32 to 212°F (0 to 100°C) Condition H 900	0.1000 Btu/lb/°F	419 J/kg·K
MEAN COEFFICIENT OF THERMAL EXPANSION (CTE)	70 to 200°F (21 to 93°C) Condition A	6.00 x 10^{-6} in/in/°F	10.8 x 10^{-6} length/length/K
	70 to 400°F (21 to 204°C) Condition A	6.00 x 10^{-6} in/in/°F	10.8 x 10^{-6} length/length/K
	70 to 600°F (21 to 316°C) Condition A	6.20 x 10^{-6} in/in/°F	11.2 x 10^{-6} length/length/K
	70 to 800°F (21 to 427°C) Condition A	6.30 x 10^{-6} in/in/°F	11.3 x 10^{-6} length/length/K
	-100 to 70°F (-73 to 21°C) Condition H 900	5.80 x 10^{-6} in/in/°F	10.4 x 10^{-6} length/length/K
	70 to 200°F (21 to 93°C) Condition H 900	6.00 x 10^{-6} in/in/°F	10.8 x 10^{-6} length/length/K
	70 to 400°F (21 to 204°C) Condition H 900	6.00 x 10^{-6} in/in/°F	10.8 x 10^{-6} length/length/K
	70 to 600°F (21 to 316°C) Condition H 900	6.30 x 10^{-6} in/in/°F	11.3 x 10^{-6} length/length/K
	70 to 800°F (21 to 427°C) Condition H 900	6.50 x 10^{-6} in/in/°F	11.7 x 10^{-6} length/length/K
	70 to 200°F (21 to 93°C) Condition H 1075	6.30 x 10^{-6} in/in/°F	11.3 x 10^{-6} length/length/K
	70 to 400°F (21 to 204°C) Condition H 1075	6.50 x 10^{-6} in/in/°F	11.7 x 10^{-6} length/length/K
	70 to 600°F (21 to 316°C) Condition H 1075	6.60 x 10^{-6} in/in/°F	11.9 x 10^{-6} length/length/K
	70 to 800°F (21 to 427°C) Condition H 1075	6.80 x 10^{-6} in/in/°F	12.2 x 10^{-6} length/length/K

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MEAN COEFFICIENT OF THERMAL EXPANSION (CTE)	-100 to 70°F (-73 to 21°C) Condition H 1150	6.10×10^{-6} in/in/°F	11.0×10^{-6} length/length/K
	70 to 200°F (21 to 93°C) Condition H 1150	6.60×10^{-6} in/in/°F	11.9×10^{-6} length/length/K
	70 to 400°F (21 to 204°C) Condition H 1150	6.90×10^{-6} in/in/°F	12.4×10^{-6} length/length/K
	70 to 600°F (21 to 316°C) Condition H 1150	7.10×10^{-6} in/in/°F	12.8×10^{-6} length/length/K
	70 to 800°F (21 to 427°C) Condition H 1150	7.20×10^{-6} in/in/°F	13.0×10^{-6} length/length/K
	70 to 900°F (21 to 482°C) Condition H 1150	7.30×10^{-6} in/in/°F	13.1×10^{-6} length/length/K
THERMAL CONDUCTIVITY	300°F (149°C) Condition H 900	124.0 Btu-in/hr/ft^2/°F	17.9 W/m·K
	500°F (260°C) Condition H 900	135.0 Btu-in/hr/ft^2/°F	19.5 W/m·K
	860°F (460°C) Condition H 900	156.0 Btu-in/hr/ft^2/°F	22.5 W/m·K
	900°F (482°C) Condition H 900	157.0 Btu-in/hr/ft^2/°F	22.6 W/m·K
POISSON'S RATIO	Condition H 900	0.272	0.272
	Condition H 1075	0.272	0.272
	Condition H 1150	0.272	0.272
ELECTRICAL RESISTIVITY	73°F (23°C) Condition A	589.0 ohm-cir-mil/ft	980.0 microhm-mm
	73°F (23°C) Condition H 900	463.0 ohm-cir-mil/ft	770.0 microhm-mm

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Typical mechanical properties

TYPICAL ROOM TEMPERATURE LONGITUDINAL MECHANICAL PROPERTIES

0.625 IN. DIAMETER (15.9 MM) BAR PRODUCT

CONDITION	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 4D	REDUCTION OF AREA	CHARPY V-NOTCH IMPACT STRENGTH		HARDNESS
	ksi	MPa	ksi	MPa	%	%	FT-LBS	J	HRC
A	131	903	135	931	17	72	—	—	30
H 900	189	1303	193	1331	12	43	6	7	43
H 900-4	187	1289	192	1324	12	47	8	11	42
H 925	184	1269	188	1296	12	49	24	33	41
H 1025	156	1076	159	1096	16	64	110	149	36
H 1150	132	910	140	965	20	69	130	176	31

1.00 IN. DIAMETER (25.4 MM) BAR PRODUCT

CONDITION	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONGATION IN 4D	REDUCTION OF AREA	CHARPY V-NOTCH IMPACT STRENGTH		HARDNESS
	ksi	MPa	ksi	MPa	%	%	FT-LBS	J	HRC
A	120	827	141	972	16	74	—	—	30
H 900	183	1262	195	1344	15	53	7	9	43
H 900-4	179	1234	193	1331	15	55	10	14	42
H 925	178	1227	189	1303	15	55	29	39	41
H 1025	156	1076	162	1117	17	68	110	149	36
H 1150	128	883	141	972	20	71	130	176	31

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TYPICAL ROOM TEMPERATURE MECHANICAL PROPERTIES

3 IN. SQUARE (76.2 MM) BAR PRODUCT

CONDITION	ORIEN.	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONG. IN 4D	REDUCTION OF AREA	CHARPY V-NOTCH		HARDNESS	FRACTURE TOUGHNESS (K_{IC})	
		ksi	MPa	ksi	MPa	%	%	FT-LBS	J	HRC	ksi√in	MPa√m
A	Long	118	814	146	1007	16	72	—	—	30	—	—
	Trans	119	820	146	1007	14	61	—	—	30	—	—
H 900	Long	184	1269	197	1358	15	56	13	18	43	55	61
	Trans	175	1207	195	1344	14	50	10	14	43	50	55
H 900-4	Long	180	1241	195	1344	15	54	20	27	42	81	89
	Trans	176	1213	194	1338	14	51	20	27	42	75	83
H 925	Long	177	1220	190	1310	15	58	49	66	41	110	121
	Trans	172	1186	188	1296	14	53	30	41	41	86	95
H 1025	Long	158	1089	166	1145	17	67	100	136	36	>146(K_Q)	>161(K_Q)
	Trans	156	1076	164	1131	15	59	53	72	36	115(K_Q)	127(K_Q)
H 1150	Long	126	869	141	972	21	71	130	176	31	—	—
	Trans	124	855	140	965	18	62	79	107	31	—	—
H 1150-M	Long	91	627	130	896	23	74	—	—	25	—	—
	Trans	89	613	129	889	21	64	—	—	25	—	—

5 IN. SQUARE (127 MM) BAR PRODUCT

CONDITION	ORIEN.	0.2% YIELD STRENGTH		ULTIMATE TENSILE STRENGTH		ELONG. IN 4D	REDUCTION OF AREA	CHARPY V-NOTCH		HARDNESS	FRACTURE TOUGHNESS (K_{IC})	
		ksi	MPa	ksi	MPa	%	%	FT-LBS	J	HRC	ksi√in	MPa√m
A	Long	128	883	146	1007	17	73	—	—	30	—	—
	Trans	127	876	145	1000	16	69	—	—	30	—	—
H900	Long	185	1276	194	1338	15	51	7	9	43	55	61
	Trans	181	1248	194	1338	15	51	8	11	43	50	55
H900-4	Long	179	1234	193	1331	16	56	18	24	42	71	78
	Trans	182	1255	191	1317	15	54	24	33	42	65	72
H925	Long	179	1234	184	1269	16	57	47	64	41	86	95
	Trans	176	1213	185	1276	15	56	34	46	41	71	78
H1025	Long	158	1089	164	1131	17	67	77	104	36	>150(K_Q)	>165(K_Q)
	Trans	158	1089	163	1124	17	63	63	85	36	130(K_Q)	143(K_Q)
H1150	Long	137	945	143	986	21	71	120	163	31	—	—
	Trans	134	924	143	986	20	69	95	129	31	—	—

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Heat treatment

15Cr-5Ni Project 70+ is normally supplied in the solution-treated condition (Condition A). It can be age hardened by heating solution-treated material to a temperature of 900°F (482°C) to 1150°F (621°C) for 1 to 4 hours, depending upon the desired mechanical properties, then air cooled to room temperature. If specified, fully aged products also can be ordered.

Various heat treatments are described here. If practical, faster cooling rates from the aging temperature, such as oil or water quenching, can be employed for optimum impact and fracture toughness properties.

Solution treatment	Condition A (solution treated or annealed): Heat at 1900°F (1038°C) ±25°F (±14°C) for 30 to 60 minutes, cool to below 90°F (32°C) so that the material is completely transformed to a martensitic microstructure. Sections 7 in (178 mm) and under can be quenched in a suitable liquid quenchant. Sections over 7 in (178 mm) should be rapidly air cooled.
Deformation (size change) in hardening	Upon aging, a predictable size change will occur for 15Cr-5Ni Project 70+. For the H 900 treatment, a contraction of 0.0004 to 0.0006 in/in (mm/mm) is obtained from the solution-annealed condition. Aging at higher temperatures will cause slightly greater amounts of contraction. For example, aging at 1150°F (621°C) causes a contraction of 0.0008 to 0.0010 in/in (mm/mm).
Age	Condition H 900 (precipitation or age hardened): Heat solution-treated material at 900°F (482°C) ±10°F (6°C) for 1 hour and air cool. Condition H 900-4 (modified condition H 900/precipitation or age hardened): Heat solution-treated material at 900°F (482°C) ±10°F (6°C) for 4 hours and air cool. This treatment should be considered in lieu of the standard H 900 condition to enhance toughness and notch ductility while having minimal effect on strength capability. Condition H 925, H 1025, H 1075, H 1100, and H 1150 (precipitation or age hardened): Heat solution-treated material to 925°F (496°C), 1025°F (552°C), 1075°F (579°C), 1100°F (593°C) or 1150°F (621°C) ±10°F (6°C) for 4 hours and air cool. Condition H 1150M (overaged): Heat solution-treated material at 1400°F (760°C) ±10°F (6°C) for 2 hours, air cool to room temperature followed by reheating to 1150°F (621°C) ±10°F (6°C) for 4 hours air cool to room temperature. This treatment can be utilized to achieve low yield strengths in 15Cr-5Ni Project 70+ for enhanced formability such as those that have been used in cold heading applications. Material in the H 1150M condition must be resolution annealed at 1900°F (1038°C) if the component is to be placed into service in some other age-hardened condition.

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Workability

Forging	Heat work piece uniformly to 1950/2050°F (1066/1121°C) and hold 1 hour at temperature before forging. Do not forge below 1800°F (982°C). To obtain optimum grain size and mechanical properties, forgings should be air cooled to below 90°F (32°C) before further processing. Forgings must be solution treated prior to age hardening for the material to respond properly.
Cold working	15Cr-5Ni Project 70+ can be formed by cold working (i.e., heading, rolling, etc.) to an extent, which is limited by the high initial yield strength. For such cold-forming operations, the H 1150M condition should be considered. This alloy is generally used in the form of bars and forgings not requiring much forming.
Machinability	15Cr-5Ni Project 70+ is processed to optimize the machinability of the 15Cr-5Ni analysis in the solution-annealed as well as age-hardened conditions. The machinability of age-hardened material will improve as the aging temperature increases.

Typical feeds and speeds

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

TURNING — SINGLE-POINT AND BOX TOOLS

CONDITION	DEPTH OF CUT, IN	HIGH-SPEED TOOLS			CARBIDE TOOLS (INSERTS)			
		SPEED, FPM	FEED, IPR	TOOL MATERIAL	SPEED, FPM		FEED, IPR	TOOL MATERIAL
					UNCOATED	COATED		
Solution treated	.150	85	.015	M-48, T-15	340	440	.019	C-6
	.025	100	.010	M-48, T-15	420	520	.009	C-7
Aged[1]	.150	85	.013	M-48, T-15	240	340	.013	C-6
	.025	105	.008	M-48, T-15	290	390	.006	C-7

[1] Adjust speeds downward as the alloy is aged into harder conditions.

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TURNING — CUT-OFF AND FORM TOOLS

CONDITION	SPEED, FPM	FEED, IPR							TOOL MATERIAL	
		CUT-OFF TOOL WIDTH, IN			FORM TOOL WIDTH, IN				HIGH-SPEED TOOLS	CARBIDE TOOLS
		1/16	1/8	1/4	1/2	1	1-1/2	2		
Solution treated	80	.0017	.0020	.0025	.0028	.0022	.0019	.0007	M-48, T-15	—
	260	.0021	.0024	.0029	.0032	.0024	.0021	.0019	—	C-6
Aged	70	.0014	.0017	.0022	.0025	.0019	.0016	.0014	M-48, T-15	—
	240	.0016	.0019	.0024	.0027	.0020	.0017	.0015	—	C-2

ROUGH REAMING

CONDITION	HIGH-SPEED TOOLS		CARBIDE TOOLS		FEED, IPR, REAMER DIAMETER, IN					
	SPEED, FPM	TOOL MATERIAL	SPEED, FPM	TOOL MATERIAL	1/8	1/4	1/2	1	1-1/2	2
Solution treated	75	M-48, T-15	—	—	.0033	.0053	.0083	.0106	.0127	.0159
	—	—	95	C-2	.0043	.0086	.0128	.0164	.0206	.0247
Aged	55	M-48, T-15	—	—	.0033	.0056	.0089	.0110	.0136	.0161
	—	—	75	C-2	.0043	.0066	.0099	.0156	.0191	.0209

DRILLING — HIGH-SPEED TOOLS

CONDITION	SPEED, FPM	FEED, IPR								TOOL MATERIAL
		NOMINAL HOLE DIAMETER, IN								
		1/16	1/8	1/4	1/2	3/4	1	1-1/2	2	
Solution treated	70	.0014	.0024	.0044	.0074	.0084	.0104	.0124	.0154	M-42, T-15
	125	.001	.002	.004	.006	.0068	.008	.009	.009	C-2 Uncoated
	140	.001	.002	.004	.006	.0068	.008	.009	.009	C-2 Coated
Aged	70	.001	.001	.002	.003	.004	.004	.004	.004	C-2 Uncoated
	75	.001	.001	.002	.003	.004	.004	.004	.004	C-2 Coated
	60	—	.0022	.0042	.0072	.0082	.0102	.0122	.0152	M-42, T-15

DIE THREADING — HIGH-SPEED TOOLS

CONDITION	SPEED, FPM				TOOL MATERIAL
	7 OR LESS, TPI	8 TO 15, TPI	16 TO 24, TPI	25 AND UP, TPI	
Solution treated	5–12	8–15	10–20	25–30	M-7, M-10

MILLING — END PERIPHERAL

CONDITION	DEPTH OF CUT, IN	HIGH-SPEED TOOLS						CARBIDE TOOLS					
		SPEED, FPM	FEED, IN PER TOOTH				TOOL MATERIAL	SPEED, FPM	FEED, IPT				TOOL MATERIAL
			CUTTER DIAMETER, IN						CUTTER DIAMETER, IN PER TOOTH				
			1/4	1/2	3/4	1-2			1/4	1/2	3/4	1-2	
Solution treated	.060	110	.0014	.0028	.0042	.0056	M-48, T-15	380	.0019	.0032	.0059	.0074	C-2
Aged	.060	90	.0012	.0026	.0040	.0052	M-48, T-15	290	.0017	.0026	.0055	.0071	C-2

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TAPPING — HIGH-SPEED TOOLS		
CONDITION	**SPEED, FPM**	**TOOL MATERIAL**
Solution treated	25	M-7, M-10
Aged	25	M-7, M-10

Additional machinability notes

The use of tool coatings is highly suggested, especially when machining this material in the age-hardened condition. TiCN and TiAlN are two suggestions. See your tool supplier for more information. Figures used for all metal removal operations covered are starting points. 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	15Cr-5Ni Project 70+ can be satisfactorily welded by the shielded fusion and resistance welding processes. Oxyacetylene welding is not recommended, since carbon pickup in the weld may occur. When a filler metal is required, AWS E/ER630 welding consumables should be considered to provide welds with mechanical properties matching those of the base metal. When designing the weld joint, care should be exercised to avoid stress concentrators, such as sharp corners, threads, and partial-penetration welds. When high weld strength is not needed, a standard austenitic stainless filler, such as E/ER308L, should be considered. Normally, welding in the solution-treated condition has been satisfactory. The weld then can be directly aged to the desired strength level. However, the optimum combination of strength, ductility, and corrosion resistance is obtained by solution treating the welded part before aging. Where high welding stresses are anticipated, it may be advantageous to weld in the H 1150 or H 1150M conditions. If welding is performed in anoveraged condition, the weld must be resolution treated prior to aging at the desired temperature. Preheating prior to welding usually is not required to prevent cracking.
Passivation	Passivation is a chemical treatment of a stainless steel with a mild oxidant for the purpose of removal of free iron or other foreign matter that may interfere with the formation of a uniform passive film. One of several nitric or citric acid treatments can be used to passivate 15Cr-5Ni Project 70+. Two of the more traditional nitric acid treatments suggested are described as follows: a) 20% by volume nitric acid plus 22 grams per liter (3 ounces per gallon) sodium dichromate at 120 to 140°F (49 to 60°C) for 30 minutes, or b) 50% by volume nitric acid at 120 to 140°F (49 to 60°C) for 30 minutes. Citric acid passivation treatments are becoming more popular for fabricators who prefer avoiding the use of mineral acids or solutions containing sodium dichromate. A citric acid passivation treatment that has been useful is described as follows: 10% by weight citric acid at 130 to 150°F (54 to 66°C) for 30 minutes. The ultimate choice of a passivation treatment will depend upon the imposed acceptance criteria. For more information, refer to ASTM A967, “Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.”

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Other information

Descaling (cleaning)	Descaling following forging and annealing can be accomplished by acid cleaning or grit blasting. The acid treatment consists of 2 minutes in 50% by volume muriatic acid at 180°F (82°C) followed by 4 minutes in a mixture of 15% by volume nitric acid plus 3% by volume hydrofluoric acid at room temperature. Water rinse and desmut in 20% by volume nitric acid at room temperature. Repeat cleaning procedure as necessary, but decrease the times by 50% (i.e., 1 and 2 minutes, respectively.) The heat tint from aging can be removed by polishing, vapor blasting, or pickling 4 to 6 minutes in a mixture of 15% by volume nitric acid plus 3% by volume hydrofluoric acid, followed by a water rinse. Repeat the acid cleaning procedure if necessary, but decrease the time by 2 to 3 minutes. Desmut in 20% by volume nitric acid at room temperature. After acid cleaning, parts should be baked 1 to 3 hours at 300/350°F (149/177°C) to remove hydrogen.
High temperature exposure	15Cr-5Ni Project 70+ displays excellent resistance to oxidation up to approximately 1100°F (593°C). Long-term exposure to elevated temperatures can result in reduced toughness in precipitation hardenable stainless steels. The reduction in toughness can be minimized in some cases by using higher aging temperatures. Short exposures to elevated temperatures can be considered, provided the maximum temperature is at least 50°F (28°C) less than the aging temperature.

For additional information, please contact your nearest sales office:

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