

REVISED: DECEMBER 1970

NONFERROUS ALLOYS

1. GENERAL
This heat treatable cobalt base alloy was one of the foremost super alloys in the history of high temperature materials. It is primarily used as investment castings and it is also available in the form of sand castings and welding rod for use at temperatures from 1300 to 2100 F.

- 1.01 Commercial Designation. Stellite 21
1.02 Alternate Designations. Stellite 21, Haynes Stellite Alloy No. 21.
1.03 Specifications. Table 1.03.

TABLE 1.03

AMS	Form	Military
5385C	Casting, precision investment	

- 1.04 Composition. Table 1.04.

TABLE 1.04

Source	AMS (1)	
	Percent	
	Min	Max
Carbon	0.20	0.30
Manganese	-	1.00
Silicon	-	1.00
Nickel	1.75	3.75
Chromium	25.0	29.0
Molybdenum	5.00	6.00
Iron	-	3.00
Boron	-	0.007
Cobalt	Balance	

- 1.05 Heat Treatment
1.051 Solution treat for machinability. 2175 to 2200 F, rapid air cool, (3, p. 170).
1.052 Age. 1350 to 1500 F, 5 to 50 hr. AMS 5385 specifies 1465 to 1485 F, 50 hr. for 45 RC maximum. (1).
1.06 Hardenability. The response to aging of the as cast condition is practically identical with that of the solution treated condition.
1.07 Forms and Conditions Available
1.071 Investment and sand castings are available in either the as cast, the solution treated or the aged condition.
1.072 Cast welding rod in straight lengths can be supplied on special order.
1.073 Wrought forms in this alloy are no longer commercially available.
1.08 Melting and Casting Practice. Electric furnace air melt.
1.09 Special Considerations.

2. PHYSICAL AND CHEMICAL PROPERTIES

- 2.01 Thermal Properties
2.011 Melting range. 2465 F, (2, p. 3).
2.012 Phase changes. Alloy is subject to precipitations.
2.013 Thermal conductivity, Fig. 2.013.
2.014 Thermal expansion, Fig. 2.014.
2.015 Specific heat
2.02 Other Physical Properties
2.021 Density. 0.30 lb per cu in. 8.30 gr per cu cm. (2, p. 3).
2.0221 Electrical resistivity. 34.4 microhm in. (2, p. 3).
2.023 Magnetic properties. Alloy is nearly nonmagnetic, (4).
2.03 Chemical Properties
2.031 Corrosion resistance is similar to that of wrought cobalt base alloys.
2.032 Oxidation resistance. Alloy is resistant to oxidizing and

reducing atmospheres at temperatures up to 2100 F, (2, p. 2).

- 2.04 Nuclear Properties
3. MECHANICAL PROPERTIES
3.01 Specified Mechanical Properties
3.011 AMS specified mechanical properties. Hardness, as cast 34 RC maximum; aged 45 RC maximum. Tensile properties of as cast material at test temperature of 1490 to 1510 F, $F_{TU} = 52$ ksi minimum, $e(l \text{ in}) = 10$ percent minimum, (1).
3.02 Mechanical Properties at Room Temperature. See 3.03 also.
3.021 Effect of aging temperature and time on hardness of investment castings, Fig. 3.021.
3.022 Effect of solution treating and aging on impact strength of investment castings, Fig. 3.022.
3.03 Mechanical Properties at Various Temperatures
3.031 Short time tension properties. Effect of test temperature on tensile properties of investment castings, Fig. 3.031.
3.032 Short time properties other than tension
3.0321 Hor hardness of investment castings, Fig. 3.0321.
3.0322 Effect of exposure and test temperature on impact strength of investment castings, Fig. 3.0322.
3.04 Creep and Creep Rupture Properties. Creep rupture curves for investment castings at 1200 to 2000 F, Fig. 3.04.
3.05 Fatigue Properties. Table 3.05.

TABLE 3.05

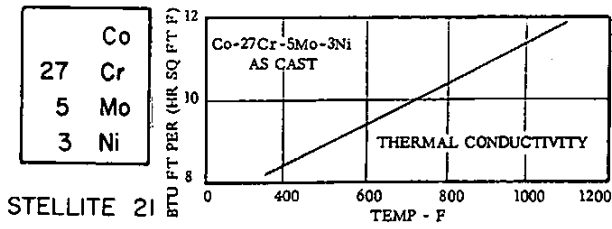
Source	(2, p. 13)			
	Investment Castings			
Form	Condition			
	As Cast			
Temp F	Method	Stress Ratio		Fatigue Strength-ksi at 10^8 Cycles
		A	R	
RT	Rev bend	∞	-1	35 to 40
1500	(120 cps)			33

- 3.06 Elastic Properties
3.061 Modulus of elasticity at room and elevated temperatures, Fig. 3.061.
4. FABRICATION
4.01 Forming and Casting. The castability of the cobalt base high temperature alloys is very good and superior to that of austenitic stainless steels.
4.02 Machining
4.021 General. Machinability of this alloy is best in the solution treated condition. Carbide tools with reduced speeds and feeds should be used. Lubrication is normally applied in all machining operations. (3, p. 170).
4.022 Drilling is accomplished with carbide tipped tools. Constant positive feed is necessary to avoid burnishing. (3, p. 170).
4.023 Grinding is generally used to finish castings to size. (3, p. 170).
4.03 Welding. See Stellite 31.
4.04 Heating and Heat Treating
4.05 Surface Treating

	Co
27	Cr
5	Mo
3	Ni

STELLITE 21

CODE 4306
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STELLITE 21

FIG. 2.013 THERMAL CONDUCTIVITY (2, p. 3)

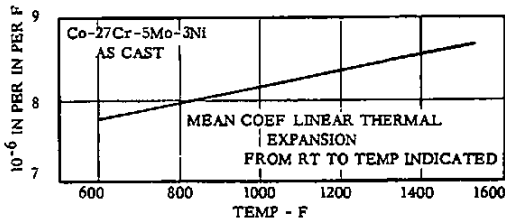


FIG. 2.014 THERMAL EXPANSION (2, p. 3)

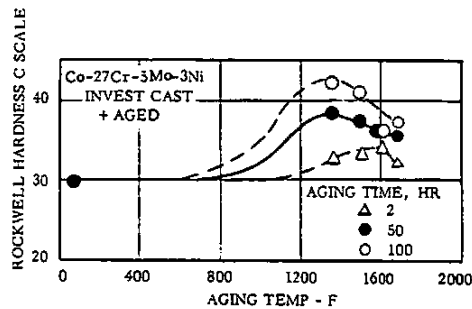


FIG. 3.021 EFFECT OF AGING TEMPERATURE AND TIME ON HARDNESS OF INVESTMENT CASTINGS (2, p. 4)

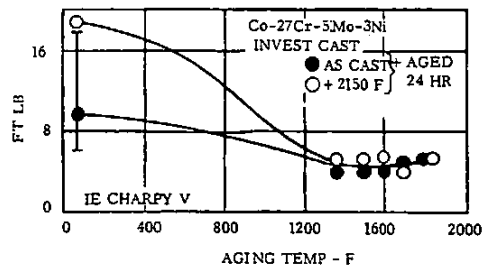


FIG. 3.022 EFFECT OF SOLUTION TREATING AND AGING ON IMPACT STRENGTH OF INVESTMENT CASTINGS (2, p. 5)

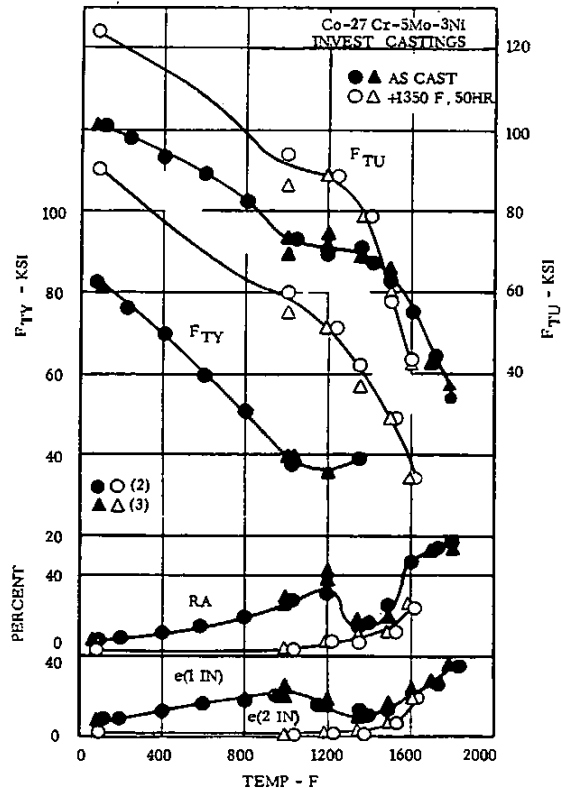


FIG. 3.031 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF INVESTMENT CASTINGS (2, p. 7)(3, p. 177)

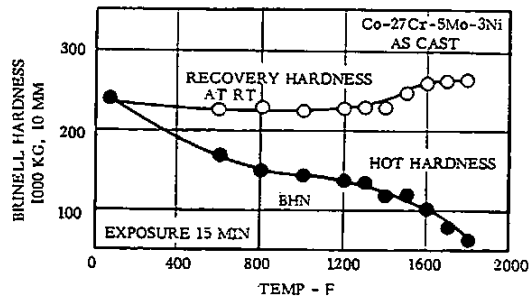


FIG. 3.032 HOT HARDNESS OF INVESTMENT CASTINGS (2, p. 4)

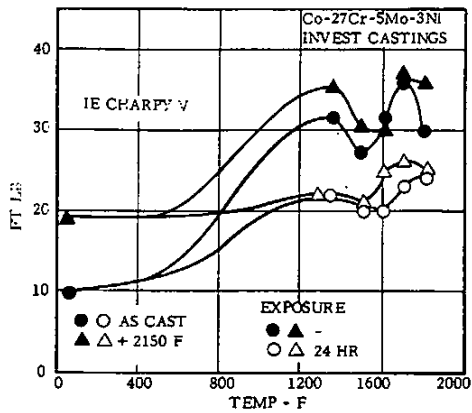
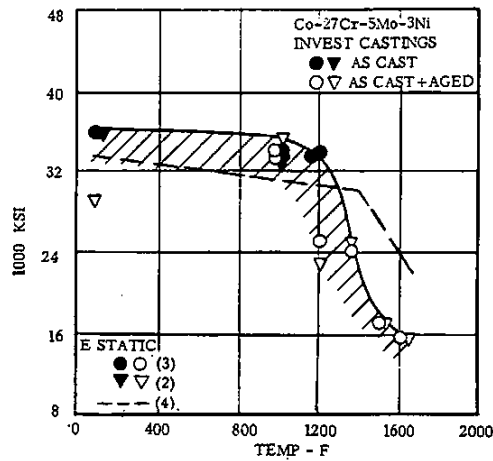


FIG. 3.0322 EFFECT OF EXPOSURE AND TEST TEMPERATURE ON IMPACT STRENGTH OF INVESTMENT CASTINGS (2, p. 5)



Co
27 Cr
5 Mo
3 Ni

STELLITE 21

FIG. 3.061 MODULUS OF ELASTICITY AT ROOM AND ELEVATED TEMPERATURES (2, p. 7)(3, p. 177)(4)

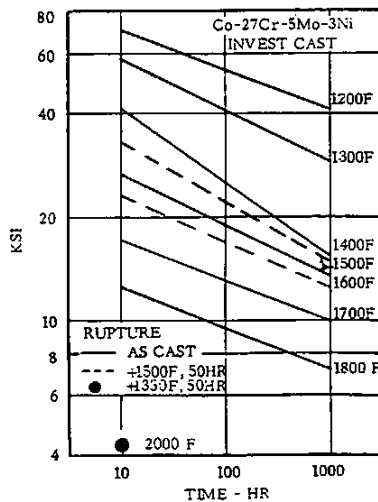


FIG. 3.04 CREEP RUPTURE CURVES FOR INVESTMENT CASTINGS AT 1200 TO 2000 F (2, p. 10)

REFERENCES

- 1 AMS 5385 C, (March 1, 1955)
- 2 Haynes Stellite Company, "Haynes Stellite Alloy No. 21", (April 1958)
- 3 ASTM, "Report on the Elevated-Temperature Properties of Selected Super-Strength Alloys," STP No. 160, (1954)
- 4 North American Aviation, Inc., Missile Development Division, "Cobalt Base Alloy H. S. 21", Data Sheet 2604, (1957)