HAYNES® 233™ alloy

HAYNES® 233™ alloy is a new Ni-Co-Cr-Mo-Al alloy that offers excellent oxidation resistance at temperatures up to 2100°F (1149°C) or higher coupled with superior creep strength - a combination of properties never before achieved in a readily fabricable alloy. The alloy obtains its exceptional oxidation resistance through the formation of a protective alumina layer, while the high creep strength is a result of solid-solution and carbide strengthening. Additionally, for use in intermediate temperature applications the alloy can be age-hardened by heat treatment to produce even greater strength. Finally, the alloy can be readily fabricated using conventional methods since it exhibits good hot workability, cold formability, and weldability. Potential applications include hot gas components in aerospace and industrial gas turbines, industrial heating fixtures and sensors, and various structural components in the emerging technology market. Preliminary results from mill products are provided below.

Oxidation Resistance:

2100°F (1149°C) in Air for 1,008 h – Cycled Weekly

Alloy	Metal Loss mils/side (µm/side)	Avg. Metal Affected mils/side (µm/side)
233™	**0.2 (5)**	**0.5 (13)**
214®	0.1 (3)	0.5 (13)
230®	1.2 (30)	4.4 (112)
617	1.0 (25)	5.2 (132)
X	3.6 (91)	6.1 (155)

Nominal Composition (wt%):

Ni	Cr	Co	Mo	Ti	Al	Fe	Mn	Si	C	B	Ta	W	Y	Zr
48[a]	19	19	7.5	0.5	3.3	1.5*	0.4*	0.20*	0.10	0.004	0.5	0.3*	0.025*	0.03

[a]As Balance *Maximum

Solution Annealing:

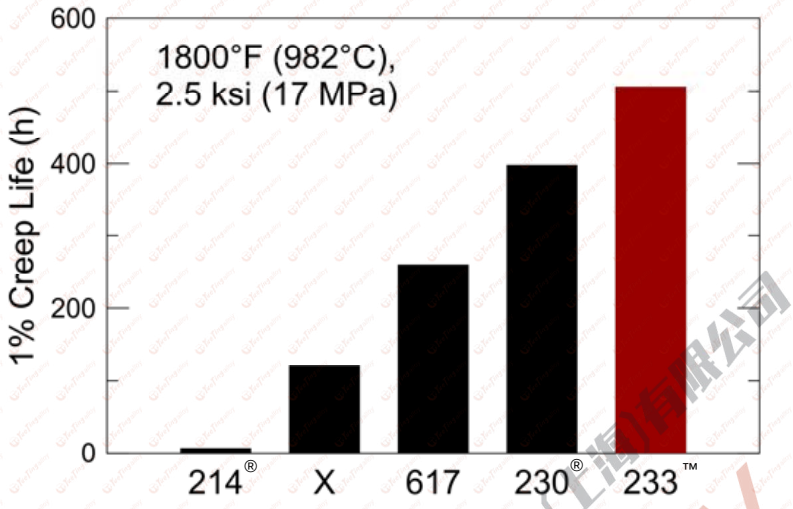
Typical Solution Annealing Temperature: 2125 to 2150°F (1163 to 1177°C)

Material Properties:

Density	0.296 lb/in^3	8.18 g/cm^3
Melting Range	2422 - 2532°F	1328 - 1389°C
Gamma-Prime Solvus	1767°F	964°C

Creep Strength:

Comparative Time to Produce 1% Creep (Sheet)



Physical Properties:

Temperature (°F)	Specific Heat (BTU/lb-°F)	Thermal Conductivity (BTU-in./ft^2-hr.-°F)	Thermal Diffusivity (ft^2/h)	Electrical Resistivity (microhms-in.)	Mean Coefficient of Thermal Expansion (µmin/in-°F)
1200	0.131	138	0.173	54.4	7.8
1400	0.135	153	0.187	53.8	8.2
1600	0.137	148	0.177	52.5	9.0
1800	0.139	157	0.185	51.3	9.7
2000	0.142	166	0.193	51.5	10.0
Temperature (°C)	**Specific Heat (J/kg-°C)**	**Thermal Conductivity (W/m-°C)**	**Thermal Diffusivity (cm^2/s)**	**Electrical Resistivity (microhms-cm)**	**Mean Coefficient of Thermal Expansion (µm/m-°C)**
600	541	19.1	0.0407	137	13.8
700	555	21.0	0.0446	138	14.4
800	566	21.8	0.0486	136	15.3
900	575	21.7	0.0481	133	16.6
1000	584	22.9	0.0501	130	17.6

Tensile Properties (Age-Hardened):

HAYNES® 233™ alloy can be age-hardened to increase strength at temperatures below the gamma-prime solvus. The data below was from HAYNES® 233™ sheet material age-hardened at 1650°F/4h/AC + 1450°F/8h/AC (899°C/4h/AC + 788°C/8h/AC).

Temperature		0.2% Yield Strength		Ultimate Tensile Strength		Elongation
°F	°C	ksi	MPa	ksi	MPa	%
RT	RT	112.9	778	172.2	1187	27.3
1000	538	102.2	704	147.0	1014	25.8
1200	649	95.5	658	156.6	1079	25.5
1400	760	97.4	671	116.5	804	27.4
1500	816	82.0	565	92.3	637	21.6

This product is available in various forms including sheet, plate, billet, bar, wire, etc. Sample material is available upon request. For more information on 233™ alloy, please contact Ron Block at (765) 456-6170 or rblock@haynesintl.com.

HAYNES International
1020 W. Park Avenue P.O. Box 9013 Kokomo, Indiana USA 46904-9013
Telephone: 765-456-6012 800-354-0806 FAX: 765-456-6905 haynesintl.com