

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 scale. 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.

Principal Features

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.

This product will be 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 Vinay Deodeshmukh at (765) 456-6212 or VDeodeshmukh@haynesintl.com.

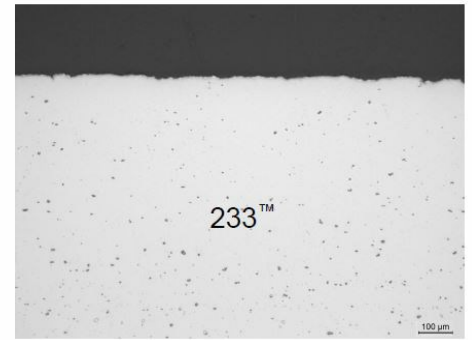
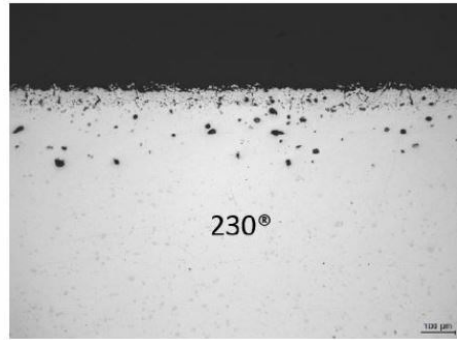
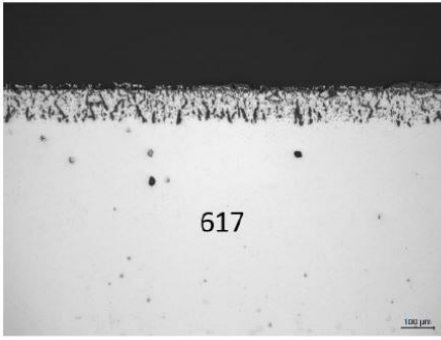
Nominal Composition

Weight %

Nickel:	48 (Balance)
Chromium:	19
Cobalt:	19
Molybdenum:	7.5
Titanium:	0.5
Aluminum:	3.3
Iron:	1.5 max.
Manganese:	0.4 max.
Silicon:	0.20 max.
Carbon:	0.1
Boron:	0.004
Tantalum:	0.5
Tungsten:	0.3 max.
Yttrium:	0.025 max.
Zirconium:	0.03

Oxidation Resistance

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



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

*Average Metal Affected = Metal Loss + Internal Attack

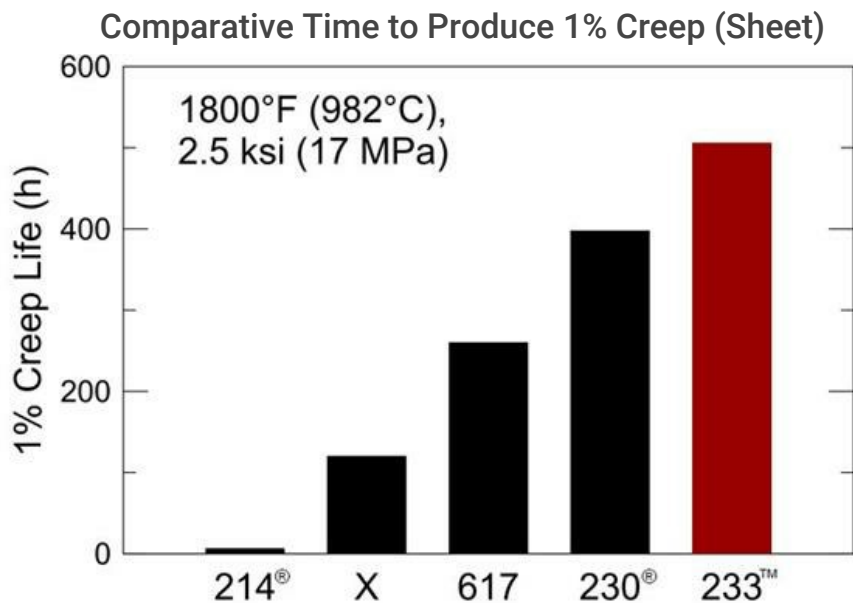
Solution Annealing

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



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 (min/in-°F)
1000	0.127	125	0.162	53.5	7.5
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
1800	0.139	157	0.185	51.3	9.7
2000	0.142	166	0.193	51.5	10
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 (mm/m-°C)
500	526	17.6	0.043	135	13.4
600	541	19.1	0.0407	137	13.8
700	555	21	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	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	565	92.3	637	21.6

Disclaimer

Haynes International makes all reasonable efforts to ensure the accuracy and correctness of the data displayed on this site but makes no representations or warranties as to the data's accuracy, correctness or reliability. All data are for general information only and not for providing design advice. Alloy properties disclosed here are based on work conducted principally by Haynes International, Inc. and occasionally supplemented by information from the open literature and, as such, are indicative only of the results of such tests and should not be considered guaranteed maximums or minimums. It is the responsibility of the user to test specific alloys under actual service conditions to determine their suitability for a particular purpose.

For specific concentrations of elements present in a particular product and a discussion of the potential health affects thereof, refer to the Safety Data Sheets supplied by Haynes International, Inc. All trademarks are owned by Haynes International, Inc., unless otherwise indicated.