

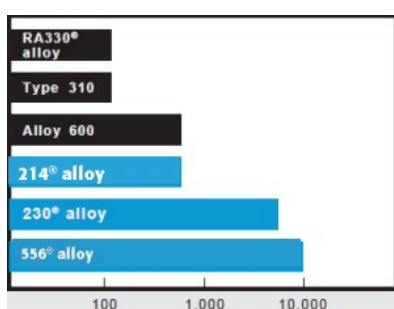
## High-temperature Alloys for Thermocouple Protection Tubes Tech Brief

### Thermocouple Protection Tubes and Thermowells

When it comes to finding a thermocouple protection tube material to withstand aggressive environments or high stress at elevated temperatures, turn to HAYNES® alloys for the long-term performance that means a cost-effective solution. A full range of alloys is available to solve those problems which force stainless steels, nickel-chromium alloys, and iron-nickel-chromium alloys into an “early retirement”. Whether the application is in a chemical waste incinerator, a forging furnace, a brick kiln or a gas turbine - there’s a HAYNES® alloy suited to the application. Look to 214®, 230®, or 556® alloys for all your T/C tube needs.

#### Stress Rupture 1800°F/2.0 ksi

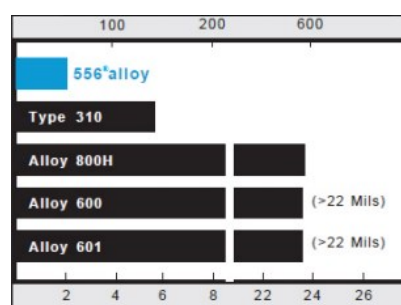
(980°C / 14 MPa)



Stress Rupture Life (Hours)

#### 1800°F (980°C) Sulfidation Resistance

Average Metal Affected, µm\*



Average Metal Affected, Mils\*

215 hour exposures in H<sub>2</sub>S-bearing reducing environment test gas at 1800°F (980°C).

\*Wastage + internal attack.

### Resistance to Combustion Gas Environment 2000°F (1095°C) for 500 Hours

Alloy	Metal Loss		Maximum Metal Affected**	
	mils	µm	mils	µm
-				
214®	0.5	13	1.8	46
230®	2.2	56	5.7	145
RA330®	10.9	277	13.6	345
600	17.2	437	20.7	526
Type 310	21.2	538	24.1	612
601	10.7	272	>24.0	>610

### Nominal Composition wt. %

Alloy	Ni	Fe	Co	Cr	Mo	W	Si	Mn	Al	C	Other
230®	Balance	3 max.	5 max.	22	2	14	0.4	0.5	0.3	0.10	0.015B, 0.01La
214®	Balance	3	2 max.	16	-	-	0.2 max.	0.5 max.	4.5	0.04	0.01Y, 0.1 max.Zr
556®	20	Balance	18	22	3	2.5	0.4	1	0.2	0.10	0.2N, 0.6Ta, 0.02La, 0.017Zr

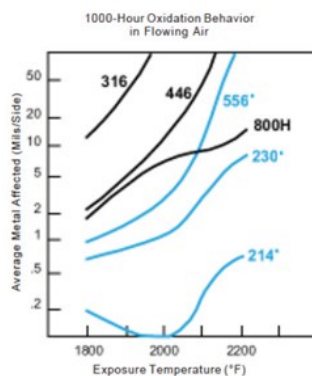
### Product Description

HAYNES® 230® alloy combines excellent high-temperature strength, outstanding resistance to

oxidizing environments up to 2100°F (1150°C) for prolonged exposures, premier resistance to nitriding environments, and excellent long-term thermal stability. It is readily fabricated and formed. Other attractive features include lower thermal expansion characteristics than most high-temperature alloys, and a pronounced resistance to grain coarsening with prolonged exposure to high-temperatures.

HAYNES® 556® alloy combines effective resistance to sulfidizing, carburizing and chlorine-bearing environments at high temperatures with good oxidation resistance, fabricability, and excellent high-temperature strength. It has also been found to resist corrosion by molten chloride salts, molten zinc, and other aggressive environments.

HAYNES® 214® alloy is the most oxidation-resistant, carburization-resistant, and chlorination-resistant alloy available as a fabricable material. Its effective use temperature limit is in excess of 2200°F (1204°C) for prolonged exposure, and up to 2400°F (1316°C) for shorter exposures.



### Typical Tensile Properties (Plate)

Test Temperature		Ultimate Tensile Strength			0.2% Yield Strength			Elongation		
		ksi			ksi			%		
°F	°C	230®	556®	214®	230®	556®	214®	230®	556®	214®
70	21	124.9	118.1	145.0	56.9	59.5	82.0	48	48	37
1200	649	97.2	85.4	120.0	39.0	32.8	85.0	55	52	31
1400	760	84.9	68.5	102.0	41.2	32.0	79.0	46	49	15
1600	871	58.3	47.6	60.0	32.4	28.6	47.0	59	53	15
1800	982	32.5	28.0	15.0	17.3	15.5	8.0	71	63	72
2000	1093	17.3	14.8	8.3	8.2	8.0	3.9	50	55	99
2100	1149	11.4	-	4.5	5.6	-	2.0	40	-	99
2200	1204	8.0	-	4.4	3.7	-	1.4	31	-	99