Tioga

Understanding Creep Failure & A312 Stainless H Grades

WHITEPAPER

In a nutshell…

Austenitic 300 Straight grade materials (i.e. 304, 316, 321 & 347) are excellent choices for general purpose use and provide a combination of good corrosion resistance and strength properties.

Austenitic 300 "L" grade materials (i.e. 304L & 316L) offer better corrosion resistance as the maximum carbon content has a lower concentration but has reduced strength as a result.

Austenitic 300 "H" grade materials (i.e. 304(H), 310(H), 316(H), 321(H) & 347(H)) provide increased strength at elevated temperatures generally due to added alloys but may be less resistant to corrosion, especially Stress-Corrosion Cracking (SCC).

Dual certified materials (i.e. 304/304L & 316/316L) are common and occur when a manufacturer produces material that meets the more stringent requirements between the specifications involved; including, but not limited to, melt practice and processing, chemistry control, tensile strength, and heat treatment.

When one looks at the specification A312/A312M – 17, it is defined as the standard specification for seamless, welded and heavily cold worked austenitic stainless steel pipe and is intended for high-temperature and general corrosive service.

Under the notes in the specification, it states that for Grades H listed in Chart 1 and Chart 2 below (304H, 310H, 316H, 321H & 347H), these are modifications of their namesake grades and "are intended for service at temperatures where creep and stress rupture properties are important."

Creep is an occurrence whereby deformation of material takes place under a sustained load below the yield strength (one example is the failure of a high pressure boiler tube after extended service at high temperature). So, for example, in 304H creep would occur when the stress in the material is under 30ksi (kilopounds per square inch). Creep is accelerated in materials that are exposed to high temperatures for extended time periods. If creep continues, it can ultimately cause a fracture or rupture of the material.

Applications where creep may come into play include, but are not limited to, steam power plants, refineries, process plants, steam turbines, heat exchanger tubing, condensers, nuclear applications and catalytic crackers. Modern power boilers, for example, can operate at over 5,000psi and at temperatures greater than 1,000 degrees Fahrenheit.

As one can see in the charted materials below, there are indeed a few requirements that are different for the manufacture of H grade materials to provide that added corrosive resistance. The major difference is in the carbon content between straight grade, "L" grade (extra low carbon) and H grades. There are carbon ranges instead of maximum % requirements. Also in 321 and 321H, there are range requirements for titanium where, comparatively, titanium in not in the other grades. The titanium works in combination with the carbon for fuller corrosion resistance.

Aside from operating and exposure temperature ranges and chloride stress (and dozens of other factors), design engineers will also look at the specifications that best match the welding needs.

Chart 1

Stainless Steel Composition %

Type	UNS	Carbon (C)	Manganese (Mn)	Phosphorus (P)	Sulfur (s)	Silicon (Si)	Chromium (Cr)	Nickel (Ni)	Molybdenum (Mo)	Titanium (Ti)	Nitrogen (N)	Niobium (Nb)
304	S30400	.08 max	2.00 max	.045 max	.030 max	1.00 max	18.0 – 20.0	8.0 – 13.0				
304L	S30403	.035 max	2.00 max	.045 max	.030 max	1.00 max	18.0 – 20.0	8.0 – 20.0				
304H	S30409	.04 - .10	2.00 max	.045 max	.030 max	1.00 max	18.0 – 20.0	8.0 – 20.0				
310S	S31008	.08 max	2.00 max	.045 max	.030 max	1.00 max	24.0 – 26.0	19.0 – 22.0	0.75			
310H	S31009	.04 - .10	2.00 max	.045 max	.030 max	1.00 max	24.0 – 26.0	19.0 – 22.0				
316	S31600	.08 max	2.00 max	.045 max	.030 max	1.00 max	16.0 – 18.0	10.0 – 14.0	2.00-3.00			
316L	S31603	.035 max	2.00 max	.045 max	.030 max	1.00 max	16.0 – 18.0	10.0 – 14.0	2.00-3.00			
316H	S31609	.04 - .10	2.00 max	.045 max	.030 max	1.00 max	16.0 – 18.0	10.0 – 16.0	2.00-3.00			
321	S32100	.08 max	2.00 max	.045 max	.030 max	1.00 max	17.0 – 19.0	9.0 – 12.0		(i)	.10	
321H	S32109	.04 - .10	2.00 max	.045 max	.030 max	1.00 max	17.0 – 19.0	9.0 – 12.0		(ii)	.10	
347	S34700	.08 max	2.00 max	.045 max	.030 max	1.00 max	17.0 – 19.0	9.0 – 13.0				(iii)
347H	S34709	.04 - .10	2.00 max	.045 max	.030 max	1.00 max	17.0 – 19.0	9.0 – 13.0				(iv)

(i) TP321- The titanium content shall not be less than 5 times the carbon + nitrogen content and 0.70 max.
(ii) TP-321H- The titanium content to be not less than 4 times the carbon + nitrogen content and 0.70 max.
(iii) TP347- The niobium content shall be not less than ten times the carbon content and not more than 1.00 %.
(iv) TP347H- The niobium content shall be not less than eight times the carbon content and not more than 1.0%
(v) The terms Niobium (Nb) and Columbium (Cb) are alternate names for the same element.

KSI (min)	304	304L	304H	310S	310H	316	316L	316H	321*	321H*	347	347H
Tensile	75	70	75	75	75	75	70	75	75	75	75	75
Yield	30	25	30	30	30	30	25	30	30	30	30	30

*For pipe wall thickness of .375” or less; values for thicker walls are 70 and 25 respectively.

Chart 2

Heat Treatment and Grain Size

Type	Heat Treatment Temperature	Grain Size Requirements
304H	1900°F [1040°C] min	7 or coarser
316H	1900 °F [1040 °C]	7 or coarser
321H Cold Finished	2000°F [1040°C] min	7 or coarser
321H Hot Finished	1925°F [1040°C] min	7 or coarser
347H Cold Finished	2000°F [1040°C] min	7 or coarser
347H Hot Finished	1925°F [1040°C] min	7 or coarser
310H	1900 °F [1040 °C]	6 or coarser

Tioga has some of the largest inventory of stainless H grade pipe, fittings and flanges in the USA especially in 316(H) grade materials. Quick delivery is available lickety-split out of our Houston warehouse. **Disclaimer: Tioga makes no recommendation of specification or particular grade for any general or specific application; this article is for informational reference purposes only.**