Heat

Stress Relieving Heat Treatment for Austenitic Stainless Steel

Unlike martensitic stainless steel, the austenitic stainless steel are not hardenable by heat treatment as no phase changes occur on heating or cooling. Softening is done by heating in the 1050/ 1120°C range, ideally followed by rapid cooling. This is of course the complete opposite to martensitic steel, where this sort of treatment would harden the steel.

Apart from inter-stage annealing during complex or severe forming operations, for many applications, final stress relieving austenitic stainless steel products is not normally needed.

Effect of residual stresses

Cold worked austenitic stainless steels will contain some 'strain induced' martensite, which, as well as making the steel partially 'ferro-magnetic', can also reduce the corrosion resistance. A highly stressed cold worked structure may also have lower general corrosion resistance than a fully softened austenitic structure.

The main hazard is stress corrosion cracking (SCC), which relies on tensile strength as part of the failure mechanism. Stress relieving removes such residual tensile stresses and so improves the SCC resistance.

The other main reason for stress relieving is to provide dimensional or shape stability. The risk of distortion can be reduced during forming or machining operations by stress relieving.

The approach to heat treatment selection

A full solution anneal stress-relieving heat treatment will re-transform any martensite formed back to austenite. (This will also give the lowest magnetic permeability possible for any particular grade.) Slow cooling is advisable to avoid introducing distortion problems or residual thermal tensile stresses and so the risk of sensitisation during a slow cool may have to be accepted.

The temperature ranges used in stress relieving must avoid sensitising the steel to corrosion or the formation of embrittling precipitates. As a general guideline, it is advisable that the range 480-900°C is avoided. The low carbon (304L or 316L) or the stabilised (321 or 347) types should not be at risk from corrosion sensitisation during stress relieving treatments.

Stress relieving treatments for austenitic stainless steel

The table shows alternative treatments in order of preference.

Process or Corrosion Hazard	Steel Grade Types		
	Standard Carbon 304, 316	Low Carbon 304L, 316L	Stabilised 321, 347
Annealing following severe forming	C	A,C	A,C
Forming interstage annealing	C(A,B)	A,B,C	B,A,C
Post welding heavy sections and/or high service loading applications	C	A,C,B	A,C,B
Dimensional stability	D	D	D
Severe SCC risk in service	Note 1	A,B	B,A
Some risk of SCC in service	C	A,B,C	B,A,C

Note 1
Standard carbon grades are susceptible to intergranular corrosion (ICC) on slow cooling treatments. Fast cooling treatments are not advisable as residual tensile stresses could result in SCC.

Note 2
Treatment B is also intended to reduce the risk of "knife-line" attack in the stabilised grades. This form of attack is due to the solution of titanium or niobium carbides at higher annealing temperatures.

Heat Treatment Codes

Code	Treatment Cycle
A	1050 / 1120°C, slow cool
B	900°C, slow cool
C	1050 / 1120°C, fast cool
D	210 / 475°C slow cool (approx. 4 hours per 25mm of section)

Releated References:
Austenitic Stainless Steel
Superaustenitic Stainless Steel
Austenitic stainless steel for timber fixings
Effect of Austenitic Steel Composition and Heat Treatment
Compared Austenitic and Duplex Steel strength and vulnerable
Stress Relieving Heat Treatment for Austenitic Stainless Steel
Mechanism Measurement of Work Hardening Austenitic Steel
Composition Effect Magnetic Permeability of Austenitic Steel
Effect of Cold Work and Heat Treatment of Austenitic Stainless Steel

Heat | Metal Glossary | Metals Definitions | Heat Treatment of Metals | Stress Relieving | Passivation | Annealing | Quenching | Tempering | Straightening | Heat Treatment of Steel | Heat Treating Definition | Heat Treating Stainless Steel | Technic of Metals Heat Treatment | Elements in Annealed State | Bright Anneaing | ASTM A380 | ASTM A967 | EN 2516 | 304 | 304L | 304H | 321 | 316L | 317L | 309S | 310S | 347 | 410 | 410S | 430 | Heat Transfer | Forms | Effects | Conduction | Convection | Radiation | Heat Exchanger

304 | 304L | 304H | 305 | 316/316L | 316Ti | 317L | 321/321H | 309S | 310S | 347/347H | S32101 | S32205/S31803 | S32304 | S32750 | S32760 | 904L | 405 | 409 | 410 | 410S | 416 | 420 | 430 | 630 | 660 | 254SMO | 253MA | 353MA
Incoloy: Incoloy 800 | Incoloy 800H | Incoloy 800HT | Incoloy 825 | Incoloy 901 | Incoloy 925 | Incoloy 926
Inconel: Inconel 600 | Inconel 601 | Inconel 625 | Inconel 706 | Inconel 718 | Inconel X-750
Hastelloy: Hastelloy B | Hastelloy B-2 | Hastelloy B-3 | Hastelloy C-4 | Hastelloy C-22 | Hastelloy C-276 | Hastelloy X | Hastelloy G | Hastelloy G3
Nimonic: Nimonic 75 | Nimonic 80A | Nimonic 90
Monel: Monel 400 | Monel 401 | Monel R 405 | Monel K 500
Other: A286 | 17-4PH

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