North American Stainless

Flat Products Stainless Steel Grade Sheet

304 (S30400)/ EN 1.4301
304L (S30403) / EN 1.4307
304H (S30409)

Introduction:
Types 304, 304L and 304H are the most versatile and widely used of all the stainless steels. Their chemical composition, mechanical properties, weldability and corrosion/oxidation resistance provide the best all-round performance stainless steels at relatively low cost.

They have excellent low-temperature properties and respond well to hardening by cold working. The carefully controlled chemical composition of the 304 types SS enables them to be deep drawn more severely than AISI types 301, without intermediate annealing. This has made them dominant in the manufacture of drawn stainless steel parts such as sinks and saucepans. They are readily press-braked or roll formed into a variety of shapes for applications in the industrial, architectural and transportation fields.

The 304 types SS have good welding characteristics. Post-weld annealing is not normally required to restore the excellent performance of these grades in a wide range of mildly corrosive conditions. Type 304L SS does not require post- weld annealing and finds extensive use in heavy-gauge components where freedom from carbide precipitation is often required.

Type 304H, with higher carbon content, is normally specified where good mechanical properties at elevated temperatures are required. The higher carbon content may lead to sensitization with a concomitant loss of corrosion resistance in a corrosive environment. Welding procedures should be selected with care.

Additionally, 304/304L is also available in pipe and tube chemistry specification.

Product Range:
Product is available in Cold Rolled, Continuous Mill Plate and Plate Mill Plate form up to 60" wide in various thicknesses.

For inquiry about minimum quantity, specific thickness and tolerances, contact inside sales at NAS.

Certification:
ASTM A240, A480, A666, ASME SA240, SA480, SA666, ASTM A262, EN 10088-2, EN 10028-7.

Chemical Composition :

UNS	Astm/Euro	Carbon	Manganese	Phosphorous	Sulfur	Silicon	Chromium	Nickel	Nitrogen
S30400	304/1.4301	0.07 max	2 max	0.045max	0.03 max	0.75	17.5-19.5	8.0-10.5	0.1 max
S30403	304L/1.4307	0.03 max	2 max	0.045 max	0.03 max	0.75	17.5-19.5	8.0-12.0	0.1 max
S30409	304H	0.04-0.1	2 max	0.045 max	0.03 max	0.75	18-20	8-10.5	

Note: Higher nickel grade available upon request. Availability and minimum quantities vary.

Mechanical Properties :

	Tensile strength min	Yield Strength min	Elongation min	Hardness max
304	75 ksi	30 ksi	40%	95 HRB
304L	70ksi	25 ksi	40%	95 HRB
304H	75 ksi	30 ksi	40%	95 HRB

Note: Enhanced properties available upon request.

PROPERTIES AT ELEVATED TEMPERATURE

The properties quoted below are typical of annealed 304 and 321 only, as strength values for 304L fall rapidly at temperatures above 425°C. These values are given as a guideline only, and should not be used for design purposes.

SHORT TIME ELEVATED TEMPERATURE TENSILE PROPERTIES

		Temperature (°C)								
Property	Type	100	300	500	600	700	800	900	1 000	1 100
Tensile Strength (MPa)	304	510	435	410	360	245	135	75	40	20
	321	525	405	380	335	265	175	100	60	25
0.2% Proof Stress (MPa)	304	220	145	125	110	95	70			
	321	210	165	140	130	115	95			
Elongation (% in 50mm)	304	52	40	36	35	35	37	42	73	96
	321	50	43	37	37	48	68	62	62	87

MAXIMUM RECOMMENDED SERVICE TEMPERATURE

(In oxidising conditions)

Operating Conditions	Temperature (°C)	
Type	304	321
Continuous	830	830
Intermittent	800	800

REPRESENTATIVE CREEP RUPTURE PROPERTIES

	Stress (MPa) to Produce 1% Strain				Stress (MPa) to Produce Rupture			
	10 000 hours		100 000 hours		1 000 hours		10 000 hours	
Temperature (°C)	304	321	304	321	304	321	304	321
550	160		115		315	345	225	255
600	110	125	75	80	200	230	145	160
650	75	85	50	50	130	135	95	105
700	50	50	30	30	85	100	60	65
750	35	30	20	20	60	65	40	40
800	25	20	15	10	35	45	25	25

PROPERTIES AT SUB-ZERO TEMPERATURES

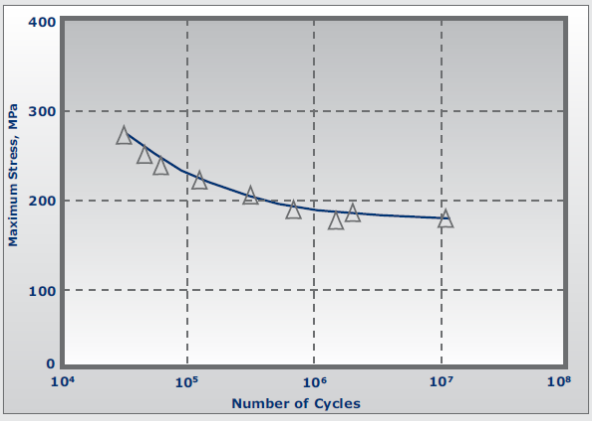
The properties quoted below are typical of annealed CS304 only

Temperature (°C)	20	0	-10	-50	-100	-140	-196
Tensile Strength (MPa)	616	885	976	1101	1281	1368	1609
0.2% Proof Stress (MPa)	255	242	240	236	222	246	231
Elongation (%)	70	64	55	50	42	41	38
Impact Energy (J)	217	204	194	194	168	160	168

FATIGUE PROPERTIES

When looking into the fatigue properties of austenitic stainless steels, it is important to note that design and fabrication—not material, are the major contributors to fatigue failure. Design codes (e.g., ASME) use data from low-cycle fatigue tests carried out on machined specimens to produce conservative S-N curves used with stress concentration factors (k1c) or fatigue strength reduction factors (kt). In essence, the fatigue strength of a welded joint should be used for design purposes, as the inevitable flaws (even only those of cross-sectional change) within a weld will control the overall fatigue performance of the structure.

The curve below shows a typical S-N curve for 304 stainless steel.



Physical Properties:

	CS304	CS321
Density	7 900kg/m³	7 800kg/m³
Modulus of Elasticity in Tension	193GPa	193GPa
Modulus of Elasticity in Torsion	86GPa	86GPa
Poisson's Ratio	0.26	0.24
Specific Heat Capacity	500J/kgK	500J/kgK
Thermal Conductivity: @ 100°C	16.2W/mK	16.1W/mK
@ 500°C	21.5W/mK	22.2W/mK
Electrical Resistivity	720ηým	720ηým
Mean Co-efficient of Thermal Expansion: 0 – 100°C	17.2µm/mK	16.6µm/mK
0 – 315°C	17.8µm/mK	17.2µm/mK
0 – 540°C	18.4µm/mK	18.6µm/mK
0 – 700°C	18.9µm/mK	19.0µm/mK
Melting Range	1 400–1 450°C	1 400–1 450°C
Relative Permeability	1.02	1.02
(**Note:** this grade is non-magnetic becoming slightly magnetic after cold working)		

THERMAL PROCESSING & FABRICATION

ANNEALING

Annealing of types SS304 and SS304L is achieved by heating to above 1900°F and for 90 minutes per 25mm thickness followed by water or air quenching. The best corrosion resistance is achieved when the final annealing temperature is above 1900°F. Controlled atmospheres are recommended in order to avoid excessive oxidation of the surface.

STRESS RELIEVING

The lower-carbon-grade 304L can be stress relieved at 450°C to 600°C for 60 minutes with little danger of sensitization. A lower stress relieving temperature of 400°C maximum must be used with 304 SS with longer soaking times. If, however, stress relieving is to be carried out above 600°C, there is a serious threat of grain boundary sensitization occurring with a concomitant loss in corrosion resistance.

COLD WORKING

304 types, being extremely tough and ductile, can be readily deep drawn, stamped, headed and upset without difficulty. Since 304 types work harden, severe cold-forming operations should be followed by annealing.

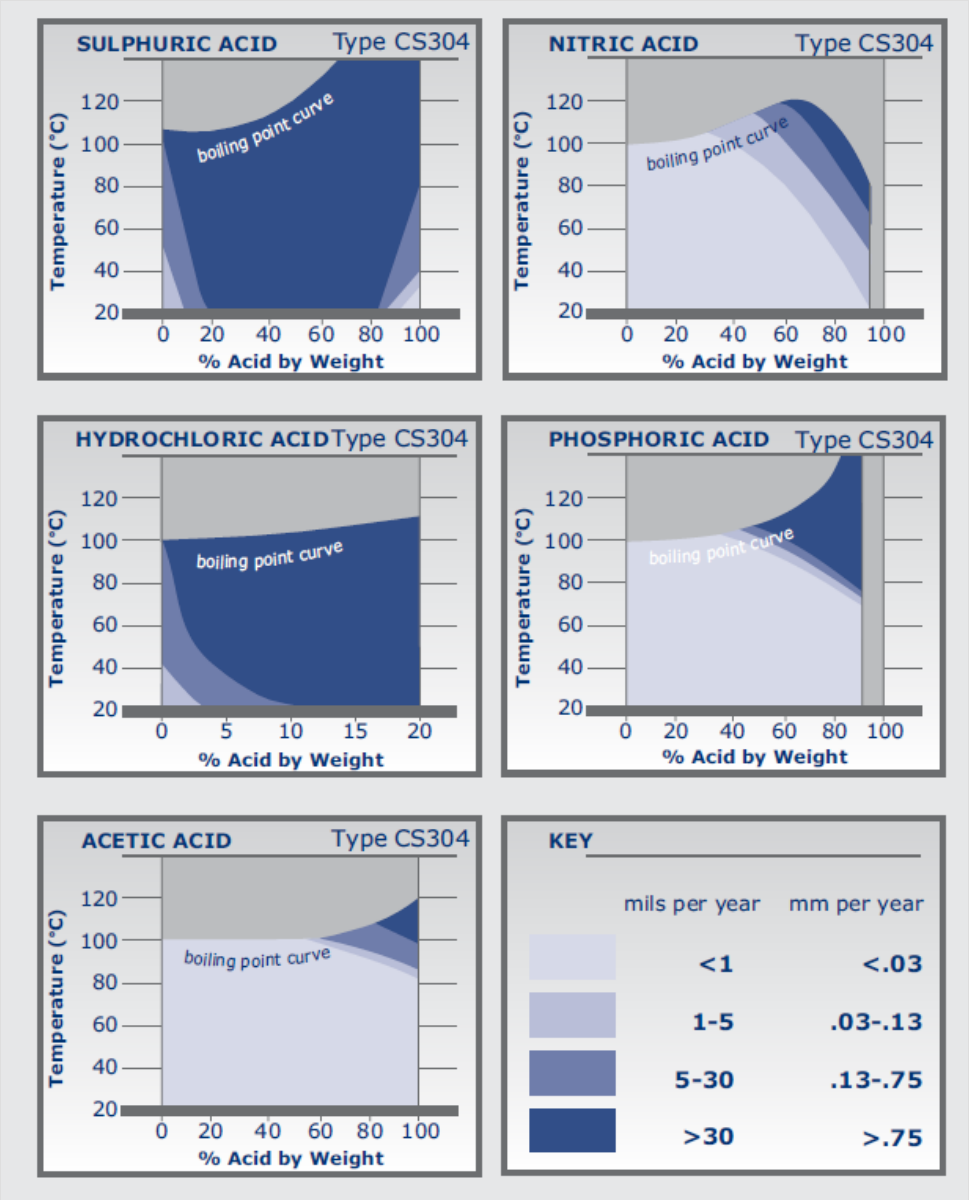
WELDING

304 SS types have good welding characteristics and are suited to all standard welding methods. Either matching or slightly over-alloyed filler wires should be used. For

maximum corrosion resistance, the higher carbon type SS304 should be annealed after welding to dissolve any chromium carbides which may have precipitated. The weld discoloration should be removed by pickling and passivation to restore maximum corrosion resistance.

Corrosion Resistance:

304 SS has excellent corrosion resistance in a wide variety of corrosive media, including foodstuffs, sterilizing solutions, most organic chemicals and dyes and a wide variety of inorganic chemicals. Iso-corrosion diagrams for 304 in sulfuric, nitric, hydrochloric, phosphoric and acetic acids are shown below.



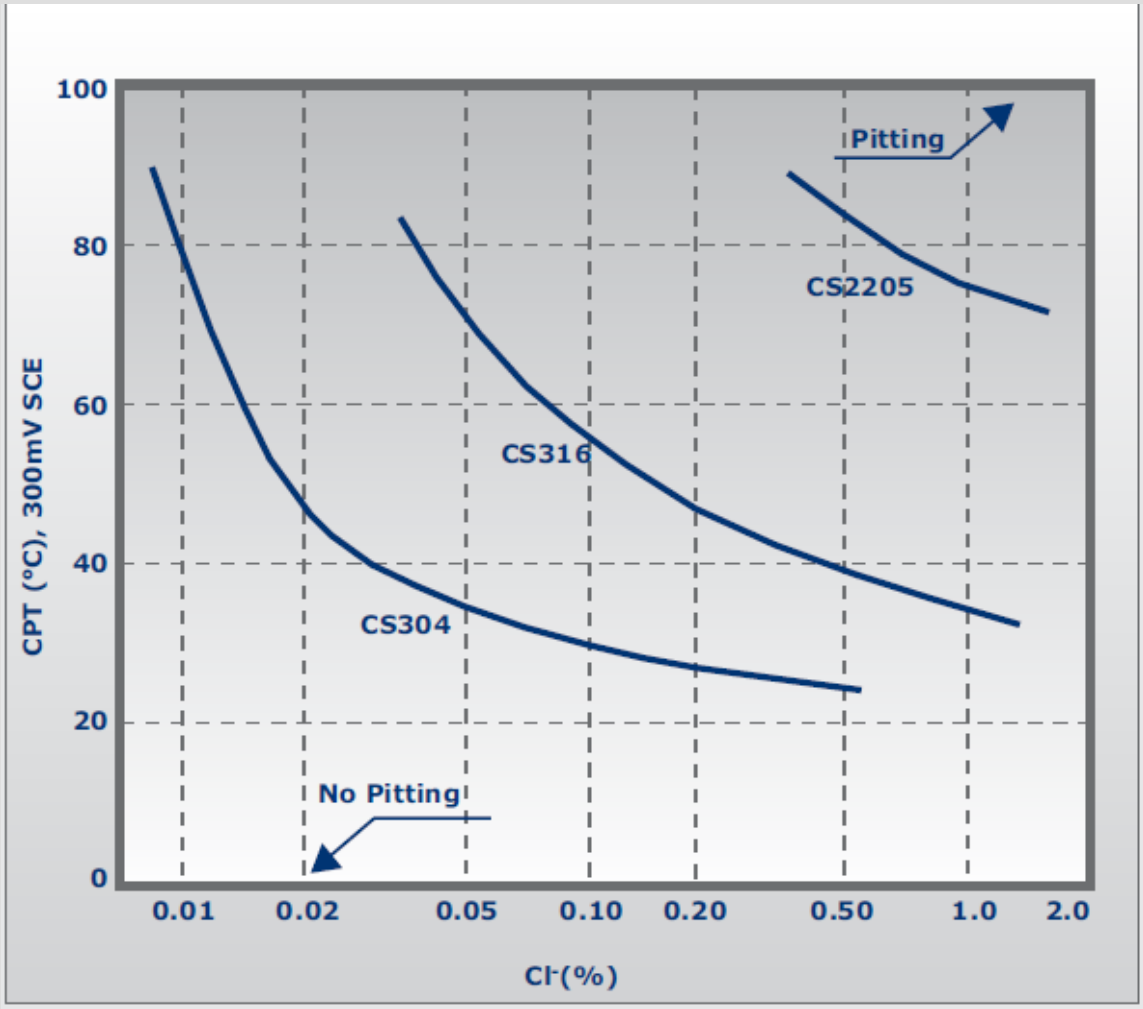
In service, acid corrosion may be either inhibited or accelerated in the presence of other chemicals or contaminants. The reaction of a material to all the possible service variables cannot be fully assessed in the laboratory. Consequently, tests have been carried out in pure acid solutions and are intended only to

provide a guide to general uniform corrosion in these media. In situ testing will provide more reliable data for material selection.

Pitting Resistance:

Pitting resistance is important, mainly in applications involving contact with chloride solutions, particularly in the presence of oxidizing media. These conditions may be conducive to localized penetration of the passive surface film on the steel, and a single deep pit may well be more damaging than a much greater number of relatively shallow pits. Where pitting corrosion is anticipated, steels containing molybdenum (such as 316L) should be considered.

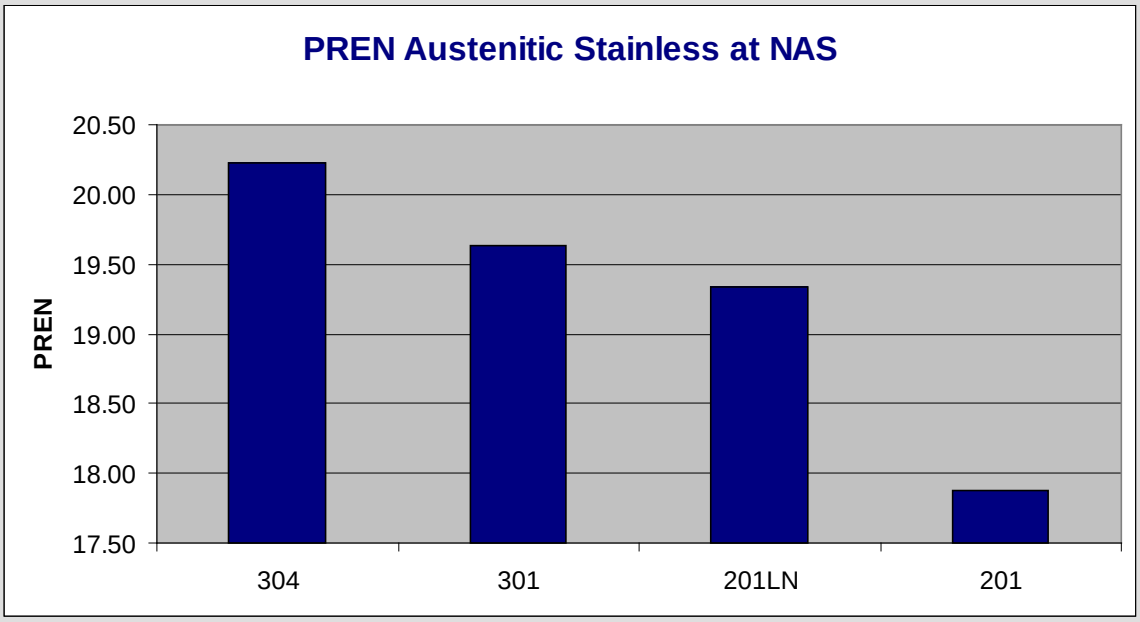
The diagram below shows the critical temperature for initiation of pitting (CPT) at different chloride contents for SS304, SS316 and SS2205 types.



Critical pitting temperatures (CPT) for CS304, CS316 and CS2205 at varying concentrations of sodium chloride (potentiostatic determination at + 300mV SCE). pH = 6.0.

Pitting-resistance equivalent numbers (PREN) are a theoretical way of comparing the pitting corrosion resistance of various types of stainless steels, based on their chemical compositions. The PREN (or PRE) numbers are useful for ranking and comparing the different grades, but cannot be used to predict whether a particular grade will be suitable for a given application, where pitting corrosion may be a hazard.

Typical PREN on NAS grades and comparison are shown below.



INTERGRANULAR CORROSION

Sensitization may occur when the heat-affected zones of welds in some austenitic stainless steels are cooled through the sensitizing temperature range of between 450°C and 850°C. At these temperatures, a compositional change may occur at the grain boundaries. If a sensitized material is then subjected to a corrosive environment, intergranular attack may be experienced. This corrosion takes place preferentially in the heat-affected zone away from and parallel to the weld. Susceptibility to this form of attack, often termed “weld decay”, may be assessed by the following standard tests: Boiling copper sulphate/sulphuric acid test as specified in ASTM A262, Practice A & E.

In the more severe nitric acid test, some weldments in plates of 304 may exhibit slight intergranular corrosion. For service in the as-welded condition in severe chemical environments, 304L would be recommended in preference to 304.

ATMOSPHERIC CORROSION

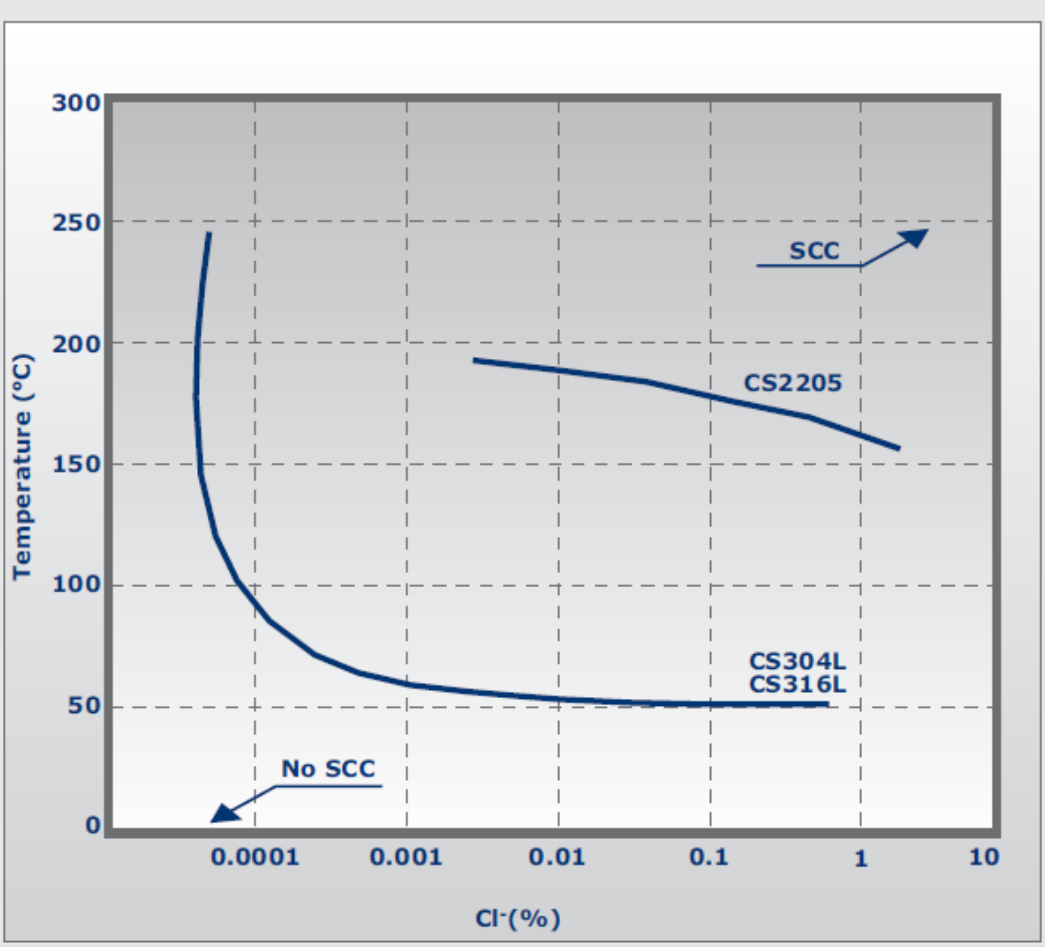
The atmospheric corrosion resistance of austenitic stainless steel is unequalled by virtually all other uncoated engineering materials. Stainless steel develops maximum resistance to staining and pitting with the addition of molybdenum. For this reason, it is common practice to use the SS316 molybdenum-bearing grade in areas where the atmosphere is highly polluted with chlorides, sulfur compounds and solids, either singly

or in combination. However, in urban and rural areas, 304 generally performs satisfactorily.

STRESS CORROSION CRACKING

Stress corrosion cracking (SCC) can occur in austenitic stainless steels when they are stressed in tension in chloride environments at temperatures in excess of about 60°C. The stress may be applied, as in a pressure system, or it may be residual arising from cold working operations or welding. Additionally, the chloride ion concentration need not be very high initially, if locations exist in which concentrations of salt can accumulate. Assessment of these parameters and accurate prediction of the probability of SCC occurring in service is therefore difficult.

Where there is a likelihood of SCC occurring, a beneficial increase in life can be easily obtained by a reduction in operating stress and temperature. Alternatively, specially designed alloys, such as duplex stainless steels, will have to be used where SCC cracking is likely to occur.



Resistance to Stress Corrosion Cracking (Laboratory results) for SS304L, SS316L and SS2205.

Technical Service: For further information, email
qualitycontrol@northamericanstainless.com
For new product development requirements, contact sales@northamericanstainless.com.

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