



TECHNICAL DATA / ENGINEERING REFERENCE

321 Stainless Steel

Properties, titanium stabilization, elevated-temperature behavior and material specifications

Common Grade	UNS	EN Material No.	Common Type
321	S32100	1.4541	Ti-Stabilized Austenitic

Purpose Concise technical reference for preliminary material selection, elevated-temperature service review, fabrication planning and purchasing. Final design and production requirements should be verified against the applicable product standard, service temperature and actual environment.

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1. Grade Overview

321 is a titanium-stabilized austenitic stainless steel designed for welded and elevated-temperature components where good general corrosion resistance must be combined with resistance to sensitization. Titanium ties up carbon and reduces chromium-carbide precipitation during welding or thermal exposure.

Property	321 Stainless Steel
Material family	Austenitic stainless steel
Grade designation	321 / UNS S32100 / EN 1.4541
Main advantage	Titanium stabilization + elevated-temperature capability
Performance requirement	Corrosion resistant / high temperature
Machinability	Moderate
Corrosion resistance	Good general corrosion resistance
Heat treatable	No - not hardenable by heat treatment
Relative cost	\$\$\$ - High

Engineering note: 321 is selected primarily for sensitization resistance and thermal-service stability, not because it has dramatically higher room-temperature corrosion resistance than 304. It is not a specialist chloride- or seawater-resistant grade.

Typical applications

Exhaust components / heat shields / expansion joints / furnace parts / thermal ducting / manifolds / welded process components / thermal equipment / high-temperature fabricated assemblies

Grade-selection summary

Requirement / Decision	Guidance
Choose 321 when	Welding and significant elevated-temperature exposure occur in the same component.
Consider 304	General-purpose corrosion resistance and fabrication are sufficient without sustained thermal exposure.
Consider 304L	General welded fabrication needs low-carbon sensitization control but not stabilized thermal service.
Consider 316L	Chloride corrosion resistance is more important than elevated-temperature stabilization.
Consider 321H	Long-term high-temperature strength or creep resistance becomes a controlling requirement.

2. Chemical Composition & Mechanical Properties

Composition limits below are representative for UNS S32100 flat-product practice. Exact chemistry and mechanical-property requirements vary by product standard, thickness and condition; the purchasing specification remains controlling.

Element	Representative Limit
Carbon (C)	$\leq 0.08\%$
Manganese (Mn)	$\leq 2.00\%$
Phosphorus (P)	$\leq 0.045\%$
Sulfur (S)	$\leq 0.030\%$
Silicon (Si)	$\leq 0.75\%$
Chromium (Cr)	17.0-19.0%
Nickel (Ni)	9.0-12.0%
Nitrogen (N)	$\leq 0.10\%$
Titanium (Ti)	$\geq 5 \times (C + N)$, $\leq 0.70\%^*$
Iron (Fe)	Balance

*Titanium requirement wording varies by product specification. Verify the governing ASTM/EN specification and the MTR for the purchased product.

Representative room-temperature mechanical properties - annealed flat product

Property	Representative Requirement
Tensile strength	≥ 515 MPa
0.2% yield strength	≥ 205 MPa
Elongation	$\geq 40\%^*$
Hardness	Up to approx. 217 HB / 95 HRB

*Elongation requirements depend on thickness and product specification. These values are representative engineering references, not universal design allowables.

Strengthening behavior

321 is not hardenable by quenching and tempering. Strength and hardness can be increased through cold work, while solution annealing is used to restore ductility and corrosion performance. For much higher heat-treated strength, compare with 17-4 PH or 15-5 PH stainless steel.

Titanium stabilization

Titanium preferentially combines with carbon, reducing the carbon available to form chromium carbides at grain boundaries. This improves resistance to sensitization and intergranular corrosion after welding or exposure in the sensitization temperature range.

3. Physical Properties & Heat Treatment

Physical values are typical room-temperature data intended for engineering comparison rather than design-code substitution.

Physical Property	Typical Value
Density	Approx. 8.0 g/cm ³
Elastic modulus at 20 C	Approx. 193 GPa
Mean thermal expansion, 20-100 C	Approx. 16-17 $\mu\text{m/m.K}$
Thermal conductivity near room temperature	Approx. 16 W/m.K
Specific heat near room temperature	Approx. 500 J/kg.K
Electrical resistivity near room temperature	Approx. 0.72-0.75 $\text{ohm.mm}^2/\text{m}$
Magnetic behavior	Generally non-magnetic when annealed

Heat-treatment guidance

Treatment / Condition	Representative Guidance
Solution annealing	Approx. 950-1120 C followed by sufficiently rapid cooling; exact temperature and cooling route depend on product specification and section size.
Stabilizing heat treatment	Approx. 870-900 C may be specified for selected high-temperature applications; not automatically required for every 321 component.
Hardening	Not applicable. 321 cannot be conventionally hardened by heat treatment.
Cold work	Can substantially increase yield strength and hardness while reducing ductility.

Heat-treatment note: Exact solution-annealing or stabilization requirements should follow the governing material specification and service requirement. Avoid assuming a generic thermal cycle is suitable for every product form.

Elevated-temperature behavior

321 is commonly selected for welded components exposed to repeated or sustained elevated temperatures, particularly where sensitization control is important. Suitability still depends on operating temperature, applied stress, oxidation, thermal cycling, exposure duration and creep requirements.

321 vs 321H

321H is the higher-carbon variant of the stabilized family and is used where long-term elevated-temperature strength or creep resistance is more important. Standard 321 and 321H should not be interchanged without reviewing the applicable design and material specification.

4. Corrosion & Environmental Performance

321 provides good general corrosion resistance similar to 304 in many environments. Its principal corrosion advantage is improved resistance to sensitization-related intergranular corrosion after welding or thermal exposure, not a major increase in chloride pitting resistance.

Environment	General Suitability	Engineering Note
Dry indoor service	Excellent	Strong general stainless performance.
Outdoor atmosphere	Excellent	Suitable for many general industrial environments.
Freshwater	Excellent	Review chloride level, deposits and crevice geometry.
Mild industrial environment	Good-Excellent	Confirm contaminants, wetting cycle and surface condition.
Welded thermal service	Good	A key application area for titanium-stabilized 321.
Coastal atmosphere	Evaluate	Airborne chlorides and sustained wetting reduce corrosion margin.
Chloride process environment	Limited / evaluate	316L or duplex grades may provide a stronger pitting/crevice-corrosion margin.
Direct seawater immersion	Not preferred	Consider 316L, 2205, 2507 or another seawater-capable alloy based on conditions.
Aggressive chemical service	Evaluate	Select alloy based on chemistry, concentration, temperature and pH.

Key corrosion considerations

Sensitization: Titanium stabilization reduces chromium-carbide precipitation and helps preserve grain-boundary corrosion resistance after thermal exposure.

Chlorides: 321 is not a molybdenum-alloyed chloride grade; pitting and crevice corrosion remain important in saline environments.

Surface condition: Embedded iron, rough crevices, weld heat tint and contamination can reduce practical corrosion performance.

Selection principle: Choose 321 for stabilized thermal service. When chloride resistance dominates, compare with 316L, 2205 or 2507 based on severity and required strength.

5. Manufacturing Characteristics

321 is well suited to sheet fabrication, forming and welding. Its machining behavior is similar to other austenitic stainless steels: work hardening and tough chips require rigid setups, sharp tooling and stable cutting engagement.

Process	Compatibility	Material Consideration
CNC machining	Moderate	Work hardening and tough chips require positive cutting action and good coolant.
Turning / milling	Moderate	Avoid rubbing; maintain feed and rigid workholding.
Drilling / tapping	Good*	Sharp tools and stable feed help prevent work-hardened surfaces.
Sheet forming / bending	Good-Excellent	Austenitic ductility supports fabricated thermal components.
Deep drawing / stamping	Good*	Feasible in suitable annealed sheet; not always selected specifically for maximum drawability.
Welding	Good-Excellent	Titanium stabilization is valuable when welded parts see later thermal exposure.
Laser cutting	Good	Remove oxide/heat tint where corrosion or subsequent welding requires it.
Forging	Good	Requires appropriate hot-working and subsequent heat treatment.
Heat treatment	Solution anneal only	Not a hardening process; stabilization treatment may be specified for selected service.
Metal 3D printing	Qualified route*	Additive routes require separate chemistry, density, microstructure and heat-treatment qualification.

Recommended fabrication route

Cut / form / machine -> weld or assemble -> remove weld oxide and heat tint where required -> pickle/passivate or finish -> final inspection

Machining behavior

Use rigid workholding, sharp tools, positive geometry, consistent feed and effective coolant. 321 is not a free-machining grade; where machining productivity dominates, 303 or 416 may provide a better fit.

Welding behavior

321 can be welded by conventional stainless processes using a qualified procedure. Filler selection, heat input, joint design and final service temperature should be considered together. Post-weld heat treatment is not automatically required for every 321 component.

Surface restoration

Grinding, polishing, pickling and passivation may be used as specified. Where corrosion performance matters, remove heavy heat tint and avoid carbon-steel contamination or embedded iron.

6. Standards, Material Forms & Surface Conditions

Grade designation alone is not a complete purchasing specification. Product form, condition, dimensions, surface finish and certification should be defined where relevant.

Designation System	321 Designation
Common grade name	321 Stainless Steel
UNS	S32100
EN material number	1.4541
Common EN designation	X6CrNiTi18-10

Common product specifications

Specification	Typical Scope
ASTM A240 / A240M	Plate, sheet and strip; commonly used for UNS S32100 flat products.
ASTM A276 / A276M	Stainless steel bars and shapes where the grade is covered.
ASTM A479 / A479M	Bars and shapes for boilers and pressure-related applications.
ASTM A312 / A312M	Seamless and welded austenitic stainless steel pipe, including applicable 321 product grades.
ASTM A213 / A213M	Seamless ferritic and austenitic alloy-steel boiler, superheater and heat-exchanger tubes, including TP321 where applicable.
ASTM A182 / A182M	Forged or rolled alloy and stainless flanges, fittings and related pressure components; includes applicable 321 grades.
EN 10088 series	European stainless steel grade and product references; verify product form and condition.

Common material forms

Sheet / Plate / Coil / Strip / Round Bar / Flat Bar / Pipe / Tube / Forged Stock / Fittings

Common surface and purchase conditions

Category	Examples
Material condition	Solution annealed / cold worked where specified
Sheet / plate surfaces	Hot rolled / cold rolled / pickled / brushed / polished as product and project require
Post-fabrication finishes	Pickling / passivation / polishing / bead blasting / laser marking / cleaning

Purchasing note: For controlled parts, specify the complete requirement, for example: 321 / UNS S32100 / ASTM A240 / solution annealed / thickness as drawing, together with surface condition, certification and heat/lot traceability.

7. Material Quality, Traceability & Technical References

For controlled projects, material grade, titanium stabilization, product condition, certification and traceability should be agreed before production.

Control Point	Recommended Practice
Grade verification	Check 321 / UNS S32100 identity and applicable product standard against drawing and purchase requirement.
Material certification	MTR / material certificate and CoC where specified; review chemistry, mechanical properties and product condition.
Heat / lot traceability	Maintain heat, lot or batch identification where project traceability applies.
Titanium stabilization	Review Ti together with C/N requirements from the governing specification; do not rely on the commercial grade name alone.
Incoming inspection	Verify identification, dimensions, surface condition, material condition and documentation.
Welding documentation	Retain WPS/PQR and weld inspection records where project requirements apply.
Additional alloy verification	PMI may confirm major Cr/Ni/Ti alloy chemistry where required, but does not verify carbon/nitrogen, sensitization state or mechanical properties.

Technical references

- ASTM A240/A240M - chromium and chromium-nickel stainless steel plate, sheet and strip.
- ASTM A276/A276M - stainless steel bars and shapes.
- ASTM A479/A479M - stainless steel bars and shapes for pressure applications.
- ASTM A312/A312M - seamless, welded and heavily cold-worked austenitic stainless steel pipe.
- ASTM A213/A213M - boiler, superheater and heat-exchanger tubing, including applicable TP321 products.
- ASTM A182/A182M - forged/rolled stainless flanges, fittings and pressure components.
- EN 10088 series - European stainless steel grade and product references.
- Industry and producer technical datasheets for UNS S32100 physical properties, fabrication and elevated-temperature guidance.

Important: This document is a general engineering reference, not a material certificate, design-code substitute or final application specification. Corrosion suitability, elevated-temperature limits, allowable stresses and fabrication requirements must be verified for the actual product form, condition and service environment.

Need a material review for your project?

Send your drawing, operating temperature, fabrication requirements and service environment to NAITE TECH.

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