



TECHNICAL DATA / ENGINEERING REFERENCE

416 Stainless Steel

Properties, free-machining behavior, heat treatment, corrosion resistance, manufacturing characteristics and material specifications.

Common grade	UNS	EN designation	Structure
416	S41600	1.4005 / X12CrS13	Martensitic

Reference: General technical reference for preliminary material selection. Values may vary by product form, heat-treatment condition and applicable specification. Final design, heat treatment and purchasing requirements should follow the governing standard and actual service environment.

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Technical Reference - September 2026



1. Grade Overview

416 is a free-machining martensitic stainless steel developed for precision components where machining productivity, chip control and heat-treatable strength are important. Sulfur additions improve machinability compared with general-purpose martensitic grades such as 410, but reduce corrosion resistance and weldability.

Property	416 Stainless Steel
Stainless steel family	Martensitic - free-machining
UNS designation	S41600
EN designation	1.4005 / X12CrS13
Primary engineering advantage	Excellent machinability + heat-treatable strength
General corrosion resistance	Moderate; below 410, 304 and 316L
Machinability	Excellent - one of the easiest conventional stainless grades to machine
Weldability	Poor; generally avoided for welding-intensive designs
Formability	Limited
Hardenable by heat treatment	Yes - hardening and tempering
Magnetic behavior	Magnetic
Relative cost	\$ \$ - Moderate

Typical applications

Shafts / pins / threaded components / fasteners / bushings / fittings / valve components / pump components / precision turned parts / automatic screw-machined components.

Selection summary

Requirement	Typical direction
Maximum machining productivity	416 is a strong candidate.
Better general martensitic corrosion balance	Consider 410.
Higher hardness and wear resistance	Consider 420 or 440C.
Free-machining austenitic behavior	Consider 303.
Higher structural strength	Consider 17-4 PH.
Strong chloride corrosion resistance	Consider 316L or duplex stainless steel.

Selection principle: 416 is most valuable when extensive machining and post-machining heat treatment are required and moderate corrosion resistance is acceptable.

2. Chemical Composition & Mechanical Properties

The chemistry below reflects representative UNS S41600 limits for free-machining bar under ASTM A582/A582M. Final acceptance should follow the exact product specification and Mill Test Report.

UNS S41600 - representative chemical composition limits

Element	Representative limit
Carbon (C)	<= 0.15%
Chromium (Cr)	12.0-14.0%
Manganese (Mn)	<= 1.25%
Silicon (Si)	<= 1.00%
Phosphorus (P)	<= 0.060%
Sulfur (S)	>= 0.15%
Iron (Fe)	Balance

Some general grade references show molybdenum as an optional addition up to approximately 0.60%. The purchasing specification and actual MTR govern the supplied chemistry.

Representative mechanical properties - bar product

Condition / property	Representative value
Annealed - tensile strength	Approx. 517 MPa
Annealed - 0.2% proof / yield strength	Approx. 275 MPa
Annealed - elongation	Approx. 30%
Annealed - hardness	Approx. up to 262 HB
Condition T - tensile strength	Approx. 758 MPa typical
Condition T - 0.2% proof / yield strength	Approx. 586 MPa typical
Condition T - elongation	Approx. 18% typical
Condition T - hardness	Approx. 248-302 HB

Engineering interpretation

Characteristic	Engineering implication
Sulfur modification	Improves chip breaking and machining productivity but reduces corrosion resistance, weldability and transverse ductility.
Martensitic structure	Allows hardening and tempering after machining.
Condition sensitivity	Strength and hardness vary significantly with heat-treatment condition.
Design values	Use the applicable product standard, heat-treatment specification and actual certification for final design.

3. Physical Properties & Heat Treatment

Physical values are typical engineering values for annealed 416 and are intended for preliminary comparison rather than specification substitution.

Typical physical properties

Physical property	Typical value
Density	Approx. 7.8 g/cm ³
Elastic modulus	Approx. 200 GPa
Thermal conductivity at 100 C	Approx. 24.9 W/m-K
Specific heat, 0-100 C	Approx. 460 J/kg-K
Electrical resistivity	Approx. 0.57 micro-ohm-m
Thermal expansion, 0-100 C	Approx. 9.9 micrometre/m-C
Magnetic behavior	Magnetic

Heat-treatment guidance

Stage	Representative guidance
Full annealing	Approx. 815-900 C; controlled cooling followed by air cooling.
Sub-critical annealing	Approx. 650-760 C; air cool. Often useful for machinability.
Hardening	Approx. 925-1010 C followed by suitable quenching, commonly oil quenching for bar products.
Tempering	Select temperature to achieve the required hardness / strength / toughness balance.
Caution range	Tempering roughly in the 400-580 C range is commonly avoided because impact toughness can be reduced.
Finish operations	Precision parts may require finish grinding after heat treatment to correct distortion and reach final tolerances.

Typical manufacturing route

Annealed Bar -> CNC Machining -> Hardening -> Tempering -> Finish Grinding if Required

Engineering caution: Heat-treatment distortion depends on geometry, section changes, quenching practice and required hardness. Long shafts, thin sections and asymmetric parts may require machining allowance for final grinding.

4. Corrosion Resistance & Environmental Performance

416 provides moderate corrosion resistance for many indoor, atmospheric, fresh-water and mildly corrosive mechanical applications. The sulfur addition that improves machinability also creates a lower corrosion margin than 410 and substantially lower resistance than 304 or 316L.

Environment	General suitability	Selection note
Dry indoor service	Good	Typical mechanical application.
Atmospheric exposure	Good	Surface condition and contaminants still matter.
Freshwater	Good / evaluate	Temperature, deposits and crevices can influence performance.
Mild industrial environment	Moderate-Good	Suitable where chlorides and aggressive chemicals are limited.
Coastal atmosphere	Limited	Salt deposition increases localized-corrosion risk.
Chloride process environment	Limited	416 is not a chloride-service stainless grade.
Direct seawater	Not preferred	Use a higher-corrosion-resistance alloy.
Aggressive chemical service	Evaluate another grade	Chemistry-specific material selection is required.
Long-term high-temperature service	Limited	Strength and tempering condition may change with prolonged exposure.

Key corrosion considerations

Factor	Engineering implication
Sulfur inclusions	Improve machinability but can become preferential sites for localized corrosion.
Surface finish	Smooth, clean surfaces generally perform better than rough or contaminated surfaces.
Heat treatment	Best corrosion performance is typically associated with correctly hardened / tempered and properly finished material.
Chlorides	Marine and chloride-rich environments are generally outside the preferred application range of 416.
Carbon-steel contamination	Embedded iron from handling or finishing can create rust staining and should be controlled.

Selection note: If corrosion resistance dominates the design, consider 410, 304, 316L or another environment-specific stainless grade rather than selecting 416 primarily for its machining advantage.

5. Manufacturing & Machining Characteristics

416 is primarily a bar-stock machining grade. Its strongest manufacturing value is efficient cutting before final heat treatment.

Process	Compatibility	Engineering note
CNC turning	Excellent	Strong fit for round / hex bar production and repetitive precision parts.
Milling	Good	Suitable for flats, slots, keyways and secondary features.
Drilling / threading	Excellent	Sulfur modification supports chip breaking and thread production.
Grinding	Good	Common after heat treatment for precision diameters and sealing / bearing surfaces.
Heat treatment	Excellent	Hardening and tempering are central to the grade's value proposition.
Forging	Possible	Requires controlled hot working and suitable post-forging treatment.
Forming / bending	Limited	Not selected for extensive cold forming.
Welding	Poor	Cracking risk and hard HAZ make welding generally undesirable.
Sheet-metal processing	Not typical	416 is usually selected as bar, not as formed sheet.
Casting / metal AM	Not typical	Use purpose-designed cast or additive alloys when required.

Machining guidance

Topic	Practical consideration
Material condition	Machining is best in an annealed or sub-critical annealed condition.
Tooling	Use sharp, rigid tooling and stable setups; optimize for good chip evacuation.
Bar-fed production	The grade is well suited to automatic screw machining and repetitive CNC turning.
Heat-treatment allowance	Leave suitable stock where post-hardening grinding is required.
Surface finish	416 can achieve good machined surfaces, but the final corrosion requirement still governs finishing.

Welding limitation

Welding is generally avoided. If unavoidable, procedure development may require preheat, controlled filler selection and post-weld heat treatment. For welding-intensive components, 304L, 316L or another more weldable grade is usually a better starting point.

6. Standards, Product Forms & Surface Finishes

416 should be purchased to the specification that matches the actual product form and required condition. The grade name alone is not sufficient for a controlled engineering purchase.

Common designations

System	Designation
AISI / common grade	416
UNS	S41600
EN material number	1.4005
EN designation	X12CrS13
JIS	SUS 416

Common product specifications

Specification	Typical product scope
ASTM A582 / A582M	Free-machining stainless steel bars - especially relevant to 416.
ASTM A276 / A276M	Stainless steel bars and shapes where the grade / product is covered.
EN 10088-3	Stainless steel long products such as bars, rods and sections.
JIS product standards	Use the applicable JIS specification when SUS 416 is required.

Common material forms

Form	Typical use
Round bar	Shafts, pins, bushings, turned components, valve parts.
Hex bar	Fasteners, fittings and bar-fed machining.
Square / flat bar	Machined blocks, fittings and mechanical components.
Ground / precision bar	Tight stock tolerances and precision turned / ground parts.

Surface finish compatibility

Finish	Engineering note
Machined finish	Strong compatibility; one of the grade's main advantages.
Grinding	Useful after hardening for final dimensions and surface quality.
Polishing	Can improve appearance and roughness; does not change the grade's fundamental corrosion limit.
Passivation	May be used after fabrication where a clean stainless surface is required.
Bead blasting / laser marking	Possible when compatible with dimensional and surface requirements.

Typical purchasing callout: 416 / UNS S41600 / ASTM A582 / annealed bar / diameter as drawing. Add hardness, heat-treatment, certification and traceability requirements where applicable.

7. Material Quality, Traceability & Technical References

For precision components, material identity, heat-treatment condition and traceability should be confirmed before production where project requirements apply.

Control	Typical scope
Material grade verification	Confirm 416 / UNS S41600 against drawing and purchase requirements.
Mill Test Report (MTR)	Review heat number, chemistry, material specification and supplied condition.
Heat / lot traceability	Maintain traceability where required for controlled or repeat production.
Incoming inspection	Check dimensions, form, identification, certification and visible condition.
Heat-treatment certification	Where required, confirm treatment batch, hardness result and final condition.
Hardness verification	May be used to confirm specified heat-treated condition.
PMI - only where required	May support alloy verification, but does not confirm complete chemistry or heat-treatment condition.
Dimensional inspection	Verify final dimensions after heat treatment / grinding where applicable.

Technical references

ASTM A582/A582M - Free-Machining Stainless Steel Bars.

ASTM A276/A276M - Stainless Steel Bars and Shapes.

EN 10088-3 - Stainless steels - technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products.

Industry technical data - Representative physical, heat-treatment and fabrication values from established stainless-steel technical references.

Engineering disclaimer: This document is a general engineering reference for preliminary material selection. Actual properties depend on product form, section size, heat treatment and specification. It does not replace design codes, customer specifications, qualified heat-treatment procedures or material certificates.

Need help reviewing 416 Stainless Steel?

NAITE TECH can help review drawings, material requirements, heat-treatment condition, machining requirements and documentation needs before production.

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