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TECHNICAL DATA SHEET

SUH409L

Titanium-Stabilized Ferritic Heat-Resisting Stainless Steel

UNS	S40903 (S40920)
EN / DIN	1.4512
EN Name	X2CrTi12
JIS	SUH409L / SUS409L
GB (China)	022Cr11Ti / S11163
ASTM	A240 Type 409L

Compiled from JIS G 4312, ASTM A240/A240M, EN 10088-2, ISO 15510 standards and published industry technical literature.

1. Introduction

SUH409L (UNS S40903 / EN 1.4512 / X2CrTi12) is an ultra-low-carbon, titanium-stabilized ferritic stainless steel designed primarily for elevated-temperature service in moderately corrosive environments. It is the low-carbon variant of Type 409, with titanium added to stabilize the structure against intergranular corrosion and improve weldability.

With a chromium content of approximately 11%, SUH409L offers a highly cost-effective combination of **oxidation resistance**, **weldability**, and **formability** at a significantly lower material cost than austenitic grades such as 304. The titanium addition (6×C to 0.75%) ties up carbon and nitrogen, preventing chromium carbide precipitation at grain boundaries during welding and elevated-temperature exposure.

Key Characteristics

- **Excellent cost-performance ratio** — 30–50% lower cost than 304 stainless steel; zero nickel content significantly reduces raw material cost.
- **Good high-temperature oxidation resistance** — suitable for continuous service up to 650°C and intermittent service up to 850°C.
- **Superior thermal conductivity** — approximately 25 W/m·K, nearly double that of austenitic grades (304: ~15 W/m·K).
- **Lower thermal expansion** — coefficient ~11 × 10^{-6} K^{-1}, providing better dimensional stability than austenitic grades.
- **Magnetic** — ferritic microstructure makes it magnetic, enabling automated handling via robotic assembly lines.
- **Good weldability** — titanium stabilization eliminates the need for post-weld annealing in thin sections.
- **Moderate corrosion resistance** — adequate for atmospheric, automotive exhaust condensate, and mildly corrosive environments.
- **>95% recyclable** — fully sustainable material for circular economy applications.

Typical Applications

Automotive Exhaust Systems
- Exhaust manifolds
- Flex pipes & intermediate pipes
- Mufflers & resonators
- Catalytic converter shells
- DPF & SCR housings

Industrial & Energy
- Heat exchangers
- Furnace fixtures & burners
- Flue gas ducts
- Home heating systems
- Transformer cases

Other Sectors
- Agricultural machinery
- Culverts & drainage
- Microwave oven interiors
- Dryer drums
- Shipping container panels

2. Chemical Composition

The chemical composition of SUH409L per JIS G 4312 / ASTM A240 / EN 10088-2 is shown below. All values are in weight percent (wt%).

Element	Symbol	Min (%)	Max (%)	Role / Function
Carbon	C	—	0.030	Ultra-low to prevent sensitization & improve weldability
Silicon	Si	—	1.00	Deoxidizer; improves oxidation resistance
Manganese	Mn	—	1.00	Improves hot workability; minor deoxidizer
Phosphorus	P	—	0.040	Impurity — kept low
Sulfur	S	—	0.030	Impurity — kept low for purity
Chromium	Cr	10.50	11.75	Provides oxidation & corrosion resistance; forms passive film
Nickel	Ni	—	0.60	Residual only — no intentional nickel addition
Titanium	Ti	6 × C	0.75	Stabilizer: ties up carbon & nitrogen; prevents intergranular corrosion
Nitrogen	N	—	0.030	Kept low; excess nitrogen degrades toughness
Iron	Fe	Balance		Base metal

> **Note:** SUH409L is essentially an 11% Cr ferritic steel with **zero intentional nickel**, which is the primary driver of its low cost. Titanium stabilization (Ti ≥ 6×C, up to 0.75%) is mandatory to prevent sensitization and maintain ductility after welding. The titanium-to-carbon ratio is critical: insufficient titanium leaves carbon free to form chromium carbides, while excessive titanium can embrittle the steel.

3. Mechanical Properties

The following mechanical properties apply to SUH409L in the annealed condition at room temperature.

Property	JIS G 4312	ASTM A240	EN 10088-2	Unit
Tensile Strength (Rm), min	360	380	380 – 560	MPa
Yield Strength (Rp0.2), min	175	170	210	MPa
Elongation (A50), min	25	20	25	%
Hardness, HBW (max)	162	179	—	HBW
Hardness, HRB (max)	80	88	—	HRB
Hardness, HV (max)	175	180	—	HV
Elastic Modulus (20°C)	~200			GPa

Typical Tensile Properties (Cold-Rolled & Hot-Rolled)

Product Form	Tensile Strength Rm (MPa)	Yield Strength Rp0.2 (MPa)	Elongation (%)	Hardness (HV)
Cold-Rolled Sheet (annealed)	415 – 520	275 – 380	≥ 20	130 – 200
Hot-Rolled Plate (annealed)	380 – 480	170 – 275	≥ 20	130 – 180

Important: SUH409L is a ferritic grade and **cannot be hardened by heat treatment**. Strength is achieved through solid-solution strengthening from chromium and grain-size control during annealing. Cold working increases strength but reduces ductility; intermediate annealing may be required for severe forming operations.

4. Physical Properties

Property	Typical Value	Unit
Density	7.70 – 7.75	g/cm^3
Melting Range	1427 – 1510	°C
Specific Heat (0–100°C)	460	$J \cdot kg^{-1} \cdot K^{-1}$
Thermal Conductivity (20°C)	25.0 – 26.0	$W \cdot m^{-1} \cdot K^{-1}$
Thermal Conductivity (100°C)	25.8	$W \cdot m^{-1} \cdot K^{-1}$
Thermal Conductivity (500°C)	25.8	$W \cdot m^{-1} \cdot K^{-1}$
Thermal Expansion (0–100°C)	10.6 – 11.0	$\times 10^{-6}\ K^{-1}$
Thermal Expansion (0–315°C)	11.7	$\times 10^{-6}\ K^{-1}$
Thermal Expansion (0–538°C)	12.4	$\times 10^{-6}\ K^{-1}$
Elastic Modulus (20°C)	200 – 208	GPa
Electrical Resistivity (20°C)	0.60 – 0.65	μΩ·m
Magnetic Permeability	Ferromagnetic	— (magnetic)
Poisson's Ratio	~0.30	—

Key Physical Advantages vs. Austenitic Grades: SUH409L offers **~70% higher thermal conductivity** and **~35% lower thermal expansion** compared to 304 stainless steel. These properties make it especially suitable for thermal-cycling applications such as automotive exhaust systems, where rapid heating and cooling cycles occur. The ferromagnetic nature also enables automated robotic handling in high-volume manufacturing lines.

5. Heat Treatment

As a ferritic stainless steel, SUH409L **cannot be hardened by thermal treatment** and does not undergo phase transformation during heating. The primary heat treatment is **annealing**, which relieves internal stresses from cold working, restores ductility, and optimizes the grain structure.

Annealing Parameters

Parameter	Specification
Temperature Range (JIS G 4312)	780 – 950°C (1436 – 1742°F)
Recommended Range	790 – 900°C (1454 – 1652°F)
Soaking Time	Based on section thickness; typically 15 – 60 minutes

Parameter	Specification
Cooling Method	Rapid cooling (air or water) or slow cooling — both acceptable
Purpose	Recrystallize cold-worked structure; relieve stresses; optimize grain size

Hot Working

Parameter	Specification
Hot Forming Temperature	700 – 900°C (for thin sections)
Forging Temperature	1040 – 1120°C (start); ≥ 705°C (finish)
Pre-heating (heavy sections)	200 – 400°C recommended
Post-Forming Treatment	Anneal at 780–950°C to restore ductility

Welding Guidelines

- **All conventional welding methods** are suitable: GTAW (TIG), GMAW (MIG), resistance spot welding, and laser welding.
- **Pre-heating:** 150 – 260°C is recommended, especially for thicker sections (>3 mm).
- **Filler metal:** ER409L or ER430 wire (matching filler); austenitic fillers (ER309L) may be used to improve weld ductility.
- **Post-weld annealing:** 760 – 815°C improves weld ductility but is NOT required for thin sections (typical automotive exhaust tubing is welded autogenously without PWHT).
- **Heat input control:** Minimize heat input to limit grain growth in the heat-affected zone (HAZ). Excessive grain growth reduces toughness.
- **Post-weld cleaning:** Remove oxide scale and heat tint via pickling, grinding, or sand blasting to restore corrosion resistance.

> **Avoid overheating:** Prolonged exposure above 950°C causes excessive grain growth in ferritic steels, which cannot be reversed by subsequent heat treatment and permanently degrades toughness and ductility.

6. Comparison with Other Stainless Steel Grades

The following tables compare SUH409L with commonly specified alternative grades: **304** (standard austenitic), **316L** (molybdenum-bearing austenitic), **430** (standard ferritic), **439** (titanium-stabilized ferritic), and **441** (dual-stabilized ferritic).

6.1 Chemical Composition Comparison (wt%)

Element	409L	430	439	441	304	316L
Type	Ferritic	Ferritic	Ferritic	Ferritic	Austenitic	Austenitic
C (max)	0.03	0.12	0.03	0.03	0.08	0.03
Cr	10.5–11.75	16–18	17–19	17.5–18.5	18–20	16–18
Ni	≤0.6	≤0.75	≤0.5	≤1.0	8–10.5	10–14
Mo	—	—	—	—	—	2–3
Ti	6×C–0.75	—	0.2+4(C+N)–1.1	0.1–0.6	—	—
Nb	—	—	—	0.3–0.9	—	—
Stabilization	Ti	None	Ti	Nb + Ti	None (LC)	Low C

6.2 Mechanical Properties Comparison (Annealed Condition)

Property	409L	430	439	441	304	316L
Tensile Rm (MPa), min	380	450	420	450	515	485
Yield Rp0.2 (MPa), min	170	205	230	250	205	170
Elongation (%), min	20	22	23	23	40	40
Hardness (HRB), max	88	89	89	90	92	95
Elastic Modulus (GPa)	200	200	200	200	193	193
Density (g/cm^3)	7.75	7.70	7.70	7.70	8.00	7.98

6.3 Physical Properties & Service Capabilities Comparison

Property	409L	430	439	441	304	316L
Thermal Conductivity (W/m·K)	25.8	26.1	24.0	23.0	15.0	15.0
Thermal Expansion (×10^{-6}/K)	10.6	10.4	10.6	10.5	17.3	16.0
Magnetic	Yes	Yes	Yes	Yes	No	No
Max Continuous Temp. (°C)	650	700	800	850	870	870

Property	409L	430	439	441	304	316L
Max Intermittent Temp. (°C)	850	870	900	950	925	870
PREN (typical)	~12	~17	~18	~19	~19	~25
Weldability	Good	Fair	Good	Excellent	Excellent	Excellent
Formability	Good	Good	Good	Good	Excellent	Excellent
Relative Cost (vs. 304)	0.4–0.5×	0.5–0.6×	0.5–0.6×	0.6–0.7×	1.0×	1.4–1.6×

6.4 Corrosion Resistance Comparison

Environment / Medium	409L	430	439	441	304	316L
Atmospheric Corrosion	Good	Good	Good	Good	Excellent	Excellent
Automotive Exhaust Condensate	Excellent	Good	Excellent	Excellent	Excellent	Excellent
5% NaCl Salt Spray (500 h)	Light rust	Visible rust	Light rust	Slight rust	No rust	No rust
Mild Acids (organic)	Fair	Fair	Good	Good	Good	Excellent
Strong Acids (H_2SO_4, HCl)	Poor	Poor	Poor	Poor	Good	Excellent
Stress Corrosion Cracking	Good	Good	Good	Good	Moderate	Moderate
High-Temp Oxidation	Good	Good	Very Good	Excellent	Very Good	Very Good
Seawater	Poor	Poor	Poor	Poor	Fair	Good

6.5 Global Standard Designations

Standard Body	System	SUH409L	430	439	441	304	316L
UNS (USA)	UNS No.	S40903	S43000	S43035	S43940	S30400	S31603
EN (Europe)	EN No.	1.4512	1.4016	1.4510	1.4509	1.4301	1.4404
JIS (Japan)	JIS Grade	SUH409L	SUS430	SUS430LX	SUS441	SUS304	SUS316L
GB (China)	GB Grade	022Cr11Ti	10Cr17	022Cr18Ti	019Cr18MoTi	06Cr19Ni10	022Cr17Ni12Mo2

6.6 Selection Guide — When to Choose SUH409L

If your requirement is...	Recommended Grade	Reason
Lowest cost heat-resisting stainless	**409L**	Zero nickel content; 40–50% cheaper than 304
Automotive exhaust systems	**409L**	Industry standard; optimized for exhaust condensate & thermal cycling
High thermal cycling (fast heat/cool)	**409L**	High thermal conductivity + low expansion = best thermal fatigue resistance

If your requirement is...	Recommended Grade	Reason
General purpose + low cost	430	Higher Cr (16–18%) for modest cost premium
Higher temp oxidation (800–950°C)	441 / 439	Higher Cr + dual stabilization extends oxidation life
Food-grade / general corrosion	304	Best balance of corrosion resistance & cost; industry standard
Chloride / marine / acid service	316L	Molybdenum addition provides essential pitting resistance
Magnetic + heat resistant + weldable	**409L**	Ferritic = magnetic; Ti-stabilized = weldable without PWHT
Stretch forming / deep drawing	304	Austenitic structure gives superior formability

Summary: SUH409L is the *dominant material in global automotive exhaust systems*, with each vehicle containing 40–65 kg of this grade. It delivers the essential combination of moderate oxidation resistance, good weldability, and excellent thermal fatigue performance at the lowest possible stainless steel cost. Its limitations are in aggressive corrosion environments (acids, chlorides, seawater) where higher-alloy grades are required. Within its design envelope — automotive exhaust, heat exchangers, furnace components, and general heat-resisting applications — 409L remains the undisputed cost-performance benchmark.

This technical data sheet is compiled from JIS G 4312, ASTM A240/A240M, EN 10088-2, ISO 15510 standards and published industry technical literature. Values are typical and should be verified against certified Material Test Reports (MTR) for specific applications.