1.4938, X12CrNiMoV12-3, UNS S64152, Z12CNDV12-03

High-temperature martensitic stainless steels are critical materials for power generation and aerospace applications, offering exceptional creep resistance, oxidation resistance, and mechanical properties at elevated temperatures. This guide provides a comprehensive technical analysis of 1.4938 (X12CrNiMoV12-3) and its equivalent grades across major OEM specifications.

1.4938/X12CrNiMoV12-3 represents a premium martensitic stainless steel specifically developed for critical high-temperature applications in turbines and aerospace. Its balanced composition provides an excellent combination of strength, creep resistance, and corrosion resistance at temperatures up to 600°C. The strict quality control requirements across OEM specifications ensure reliable performance in demanding applications.

For manufacturers and researchers, understanding the detailed requirements of these materials is essential for proper application and processing. The comprehensive testing and qualification procedures outlined in specifications ensure that only material meeting the highest quality standards is used in critical components.

Designation	Structure	Trade Name / Alloy	OEM Part Numbers	EN Number
X122MV	Martensitic	XM-32	**Siemens** 29A, 29H, MAT239204, TLV 9251 01 **Alstom** HRLM600080, ITP00716, STV M14101, STV M23004, STV M23022 **Nuovo Pignone** ITN 07744.08/A **Škoda** TP 0010 **MAN** QSTD-51-231/000	S64152

Applications

X12CrNiMoV12-3, 1.4938 Applications

- **Classification:** 12%Cr martensitic stainless steel with Mo-V-Nb additions
- **Key Specifications:**
  - GE/Alstom: STV M14101, STV M23004, STV M23022
  - Siemens: 29A/H, MAT239204, TLV 9251 01
  - MAN: QSTD-51-231/000
  - AMS: 5718, 5719
- **Applications:**
  - Gas and steam turbine blades
  - Compressor discs and rotors

- High-temperature fasteners
- Aerospace components

- **Key Features:**
  - Excellent creep resistance up to 600°C
  - Good oxidation resistance
  - Typically supplied in quenched and tempered condition (+QT)
  - Fully martensitic microstructure after heat treatment

Equivalent or Similar Grades - Chemical Composition

Grade	Chemical Composition WT %									
	C	Mn	Si	P	S	Cr	Mo	Ni	V	N
M152	0.08-0.13	0.50-0.90	Max 0.35	Max 0.030	Max 0.025	11.0 - 12.5	1.5 - 2.0	2.0 - 3.0	0.25 - 0.40	0.02 - 0.04
X12CrNiMoV12-3	0.08 - 0.15	0.50-0.90	Max 0.35	Max 0.020	Max 0.015	11.0 - 12.5	1.5 - 2.0	2.0 - 3.0	0.25 - 0.40	0.02 - 0.04
X12CrNiMoV12-3, 1.4938	0.08 - 0.15	0.4 - 0.9	Max 0.5	Max 0.025	Max 0.015	11.0 - 12.5	1.5 - 2.0	2.0 - 3.0	0.25 - 0.40	0.02 - 0.04
X12CrNiMo12, 1.4939, X12CrNiMoN12	0.08 - 0.13	0.5 - 0.9	Max 0.35	Max 0.025	Max 0.020	11.0 - 12.5	1.5 - 2.0	2.0 - 3.0	0.25 - 0.40	0.02 - 0.04
X11CrNiMoN12	0.08 - 0.15	0.4 - 0.9	Max 0.50	Max 0.025	Max 0.015	11.0 - 12.5	1.5 - 2.0	2.0 - 3.0	0.25 - 0.40	0.02 - 0.04
AMS UNS S64152	0.08 - 0.15	0.5 - 0.9	Max 0.35	Max 0.025	Max 0.025	11.0 - 12.5	1.5 - 2.0	2.0 - 3.0	0.25 - 0.40	0.01 - 0.05
Z12CNDV12-03	0.08 - 0.15	0.5 - 0.9	Max 0.35	Max 0.030	Max 0.015	11.0 - 12.5	1.5 - 2.0	2.0 - 3.0	0.25 - 0.40	0.02 - 0.04
XM-32	0.08 - 0.13	0.5 - 0.9	Max 0.40	Max 0.030	Max 0.025	11.0 - 12.5	1.5 - 2.0	2.0 - 3.0	0.25 - 0.40	0.02 - 0.04

Note: Trace elements (Cu, As, Sb, Sn) are typically controlled to ≤0.10% each

Mechanical Properties

Room Temperature Mechanical Properties

Property	1.4938 (QT)	AMS 5719	GE STV M23004	Siemens TLV 9251 01	MAN QSTD-51-231/000
0.2% Proof Strength (MPa)	785-930	785-930	785-930	785-900	785-930
Tensile Strength (MPa)	900-1100	900-1100	900-1100	900-1100	900-1100
Elongation A5 (%)	≥14	≥14	≥14	≥14	≥14
Reduction of Area (%)	≥40	≥40	≥40	≥40	≥40
Impact Energy (J)	≥40	≥40	≥40	≥40	≥40
Hardness (HB)	270-330	270-330	270-330	270-310	270-330

High-Temperature Mechanical Properties (600°C)

Property	1.4938	AMS 5719	GE STV M23004
0.2% Proof Strength (MPa)	≥405	≥405	≥405
Tensile Strength (MPa)	≥420	≥420	≥420
Elongation A5 (%)	≥18	≥18	≥18
Reduction of Area (%)	≥65	≥65	≥65

Creep and Rupture Properties

Creep Performance at 600°C

Creep Rupture Strength:

- 10,000 hours: ≥120 MPa
- 100,000 hours: ≥90 MPa
- **Creep Rate:** Typically $<1\times10^{-7}$ %/h under 100 MPa stress
- **Larson-Miller Parameter (C=20):** ~24 at 100 MPa/10,000h

Oxidation Resistance

- Continuous service: Up to 650°C
- Intermittent service: Up to 700°C

- Weight gain: <2 mg/cm² after 1000h at 600°C

Physical Properties

Property	1.4938 / X12CrNiMoV12-3
Density (g/cm³)	7.8
Thermal Conductivity (W/m·K)	25 (20°C), 28 (600°C)
Specific Heat (J/kg·K)	460 (20°C), 600 (600°C)
Thermal Expansion (10^{-6}/K)	10.5 (20-100°C), 12.8 (20-600°C)
Electrical Resistivity (Ω·m)	0.85×10^{-6}
Elastic Modulus (GPa)	210 (20°C), 170 (600°C)

Heat Treatment

Standard Heat Treatment

Hardening:

- Temperature: 1000-1050°C
- Quenching: Oil or air cooling
- Must be cooled to ≤100°C to ensure complete martensitic transformation

Tempering:

- Double tempering at 650-720°C
- Minimum tempering time: 2 hours (or 2 min/mm thickness)
- Stress relief after machining: 30-50°C below last tempering temperature

Final Condition: Quenched and Tempered (+QT)

Alternative Heat Treatment Conditions

- **+A (Annealed):** 850-900°C, slow cooling (for machining)
- **+HT (Hardened & Tempered):** Single temper at higher temperature (for specific applications)
- **+SR (Stress Relieved):** 600-650°C after machining

Processing Performance

Forging and Hot Working

- Recommended hot working temperature: 1100-900°C
- Forging reduction ratio: ≥5:1 required
- Post-forging cooling: Slow cooling to prevent cracking

Machinability

- Machinability rating: ~45% of free-cutting steels
- Recommended tools: Carbide tools with positive rake angles
- Cutting speeds: 30-50 m/min for turning operations
- Requires generous use of cutting fluids

Welding Characteristics

- **Weldability:** Fair with proper precautions
- **Recommended Processes:** GTAW (TIG), SMAW with matching filler
- **Preheat:** 200-300°C
- **Post-Weld Heat Treatment:** Full heat treatment cycle recommended
- **Filler Metals:** Matching composition or higher alloy grades

Microstructural Requirements

- **Martensitic Structure:** Fully martensitic after heat treatment
- **Delta Ferrite:** ≤5% allowed (typically ≤2% preferred)
- **Grain Size:** ASTM 4 or finer
- **Inclusions:**
  - Type A (Sulfide): ≤2.0
  - Type B (Alumina): ≤2.0
  - Type C (Silicate): ≤2.0
  - Type D (Globular oxide): ≤2.0
- **Homogeneity:** Must be free from porosity, excessive segregation

Quality Control and Testing Requirements

- **Chemical Analysis:** Melt and product analysis required
- **Mechanical Testing:**

Non-Destructive Testing:

- Tensile, impact, hardness testing required
- Testing from 1/4 thickness location
- Ultrasonic testing per SEP 1923 or equivalent
- Magnetic particle inspection for surface defects

High-Temperature Testing:

- Elevated temperature tensile tests
- Creep rupture testing for qualification

Microstructural Examination:

- Delta ferrite content
- Grain size determination
- Inclusion rating

Equivalent Grades and Specifications

Organization	Specification Numbers	Equivalent Grade Designations
GE/Alstom	STV M14101, STV M23004, STV M23022	X12CrNiMoV12-3
Siemens	29A/H, MAT239204, TLV 9251 01	1.4938
MAN	QSTD-51-231/000, TLV1216	X12CrNiMo12 + QT900
Škoda	TP 0010	14Cr12Ni2WMoV
AMS	5718, 5719	UNS S64152
ASTM	A565 Grade XM-32	XM-32
DIN	1.4938	X12CrNiMoV12-3
EN	-	X12CrNiMoV12-3
GB	1Cr12Ni2W1Mo1V	14Cr12Ni2WMoV

Recent Developments and Modifications

- **GE/Alstom:** Updated requirements for cleaner steel (lower S, P)
- **Siemens:** Modified tempering temperature ranges for improved creep resistance
- **MAN:** Enhanced NDT requirements (UT sensitivity to 0.7mm DSR)
- **AMS 5719:** Revised delta ferrite limits to ≤5%