1.4923, X22CrMoV12-1, Z20CDNbV11, St12T

X22CrMoV12-1, designated as EN 1.4923, is a high-strength, creep-resistant martensitic stainless steel engineered for applications requiring exceptional performance at elevated temperatures up to 600°C. Known by various standards such as St12T, AFNOR Z20CDNbV11, ČSN 17134, BS 762, and SEW 555 X 21 CrMoV 12-1, X21CrMoV12-1, 1.4926, this steel is widely used in the production of turbine blades, steam turbine components, and other high-temperature structural parts in power generation, aerospace, and petrochemical industries. Its robust mechanical properties, excellent creep resistance, and good fatigue performance make it a preferred choice for critical applications. This article provides a detailed analysis of X22CrMoV12-1, covering its chemical composition, mechanical properties, heat treatment regimes, physical properties, high-temperature and creep performance, processing, welding characteristics, and equivalent grades.

Manufacturer	Trade Name	Steel Type	Market Specification	AISI	UNS	Werkstoff	Designation (JIS)	GOST	Advantages
VALBRUNA	VAL2MV	Martensitic	-	-	-	1.4923	X22CrMoV12-1	-	High strength, wear resistance
SIEMENS	1.4923	Martensitic	0-2813-4923-00, 1CWW00030, TLV 9248 (03, 02, 06, 08, 07), 203W343, WTLV8248 (21, 41, 06, 07)	-	-	1.4923	X22CrMoV12-1	-	Precision engineering, reliability
ANSALDO	1.4923	Martensitic	WTLV8248 (21, 41, 06, 07)	-	-	1.4923	X22CrMoV12-1	-	Versatility, industrial use
ABB	1.4923	Martensitic	23 90 95, HZLM 00036	-	-	1.4923	X21CrMoNiV12-1	-	Durability, high-temperature use
ALSTOM	1.4923	Martensitic	ATD1231001, ATM1230001, 9ANA370206, NB 00141	-	-	1.4923	-	-	Specialized applications
NUOVO PIGNONE	1.4923	Martensitic	STV M14105, STV M23002, ITN 07763.08/A	-	-	1.4923	-	-	High precision, custom solutions
MAN	1.4923	Martensitic	QSTD-51-216/000	-	-	1.4923	-	-	Toughness, industrial versatility
SKODA	1.4923	Martensitic	TP 0009 M	-	-	1.4923	-	-	Cost-effective, reliable

Detailed Comparison of Steel Grades

1. **Material Composition and Type**
    - **VAL2MV (VALBRUNA)**: A martensitic steel with the Werkstoff number 1.4923, known for its high strength and wear resistance. The X22CrMoV12-1 designation indicates a composition with chromium, molybdenum, and vanadium, ideal for high-stress applications.
    - **SIEMENS, ANSALDO, ABB, ALSTOM, NUOVO PIGNONE, MAN, SKODA**: All

share the same Werkstoff number (1.4923), indicating a similar base composition to VAL2MV. However, their market specifications and designations vary, reflecting differences in processing and intended applications.

2. **Werkstoff and Designations**
    - The Werkstoff number 1.4923 is consistent across all manufacturers, confirming that these steels are equivalents with minor variations. The JIS designation X22CrMoV12-1 (VALBRUNA, SIEMENS, ANSALDO) and X21CrMoNiV12-1 (ABB) suggest slight differences in nickel content or naming conventions.
3. **Market Specifications**
    - **SIEMENS** provides a wide range of specifications (e.g., TLV 9248 series, WTLV8248 series), indicating its use in precision engineering and diverse industrial applications.
    - **ABB** and **ALSTOM** focus on specific standards (e.g., HZLM 00036, ATD1231001), likely for high-temperature or specialized uses.
    - **MAN** and **SKODA** emphasize broader industrial applications with simpler specifications (e.g., QSTD-51-216/000, TP 0009 M).

Applications

X22CrMoV12-1 (1.4923) is primarily used in high-temperature environments where components are subjected to mechanical stress, thermal cycling, and fatigue. Key applications include:

The steel grades covered in this article (EN 1.4923, X22CrMoV12-1, St12T, Z20CDNbV11, ČSN 17134, BS 762, and X21CrMoV12-1) share several important characteristics:

- **Turbine Blades**: Used in steam and gas turbines for power generation due to its creep resistance and high-temperature strength.
- **Compressor Blades**: Employed in jet engines and industrial compressors.
- **Power Industry Components**: Includes turbine discs, shafts, bolts, and screws for thermal engines and power plants.
- **Petrochemical Industry**: Used in high-pressure vessels and fittings for oil and chemical processing.
- **Aerospace**: Components requiring elevated strength and fatigue resistance at high temperatures.

- **High-temperature strength**: These materials maintain excellent mechanical properties at temperatures up to 600°C, with some grades usable up to 650°C
- **Good creep resistance**: Essential for components subjected to long-term stress at

elevated temperatures
- **Moderate corrosion resistance**: While not as corrosion-resistant as austenitic stainless steels, their chromium content (11-12.5%) provides adequate protection in many environments
- **Excellent fatigue resistance**: Critical for rotating components like turbine blades
- **Hardenability**: These steels achieve high strength through quenching and tempering heat treatments

Primary Applications

1. **Power generation**:
    - Steam turbine blades and rotors
    - Bolts and fasteners for high-temperature service
    - Valve components in power plants
2. **Aerospace**:
    - Engine components
    - High-stress fasteners
3. **Petrochemical industry**:
    - Reactor components
    - High-temperature piping systems
    - Valve bodies and stems
4. **General engineering**:
    - High-strength fasteners
    - Pump shafts
    - Bearing components

The specific choice of grade depends on the operating temperature, stress levels, and environmental conditions. For example, X22CrMoV12-1 is particularly suited for turbine blades operating in the 500-600°C range , while Z20CDNbV11 may be preferred for certain high-temperature fastener applications.

The steel's versatility and ability to perform under demanding conditions make it a cornerstone material in industries requiring reliability and durability.

Equivalent or Similar Grades - Chemical Composition

The chemical composition of **X22CrMoV12-1 (1.4923)** and its equivalent grades is tightly controlled to ensure optimal creep resistance, strength, and corrosion resistance. Below is a comparison of the chemical composition based on available data and standards (e.g., EN 10302, EN 10269, and TLV 9367 05 for similar grades like X19CrMoNbVN11-1).

Element	X22CrMoV12-1, 1.4923	X19CrMoNbVN11-1, 1.4913 - TLV 9367 05	Z20CDNbV11 - AFNOR	ČSN 17134	Notes
C	0.18–0.24%	0.17–0.23%	0.18–0.24%	0.18–0.24%	Carbon enhances strength but is limited to maintain toughness.
Si	≤0.50%	≤0.50%	≤0.50%	≤0.50%	Silicon improves oxidation resistance.
Mn	0.40–0.90%	0.40–0.90%	0.40–0.90%	0.40–0.90%	Manganese improves ductility and toughness.
P	≤0.025%	≤0.025%	≤0.025%	≤0.025%	Low phosphorus ensures better toughness.
S	≤0.015%	≤0.015%	≤0.015%	≤0.015%	Low sulfur minimizes inclusions.
Cr	11.0–12.5%	10.0–11.5%	11.0–12.5%	11.0–12.5%	Chromium provides corrosion and oxidation resistance.
Mo	0.80–1.20%	0.50–0.80%	0.80–1.20%	0.80–1.20%	Molybdenum enhances creep resistance.
Ni	0.30–0.80%	0.20–0.60%	0.30–0.80%	0.30–0.80%	Nickel improves toughness and corrosion resistance.
V	0.25–0.35%	0.10–0.30%	0.25–0.35%	0.25–0.35%	Vanadium contributes to creep strength.
Nb	0.15–0.30%	0.25–0.55%	0.15–0.30%	0.15–0.30%	Niobium improves high-temperature strength.
N	≤0.040%	0.05–0.10%	≤0.040%	≤0.040%	Nitrogen enhances strength in some grades.

Element	X22CrMoV12-1, 1.4923	X19CrMoNbVN11-1, 1.4913 - TLV 9367 05	Z20CDNbV11 - AFNOR	ČSN 17134	Notes
B	-	≤0.0015%	-	-	Boron (if present) improves hardenability.
Al	-	≤0.020% (target ≤0.010%)	-	-	Aluminum is minimized to reduce inclusions.

Sources: TLV 9367 05

Note: The slight variations in composition (e.g., Nb and N content) between **X22CrMoV12-1** and **X19CrMoNbVN11-1** reflect differences in specific standards or applications, but the grades are closely related and often interchangeable.

Mechanical Properties

The mechanical properties of **X22CrMoV12-1 (1.4923)** vary depending on the delivery condition (e.g., annealed (+A), heat-treated (+HT), or quenched and tempered (+QT)) and the applicable standard. Below is a summary based on EN 10302, EN 10269, and referenced sources.

Room Temperature Mechanical Properties(+QT1)

Property	X22CrMoV12-1 (1.4923)	X19CrMoNbVN11-1 (1.4913)(TLV 9367 05)
0.2% Proof Strength (MPa)	≥650	≥780
Tensile Strength (MPa)	800–950	900–1050
Elongation A5 (%)	≥14	≥12 (longitudinal), ≥10 (transverse)
Reduction of Area (%)	≥40	≥40 (longitudinal), ≥25 (transverse)
Impact Energy KV_2 (J)	≥20 (longitudinal)	≥20 (longitudinal, avg. of 3, min. 14 J), ≥12 (transverse, min. 10 J)
Hardness (HBW)	240–300	265–310

High-Temperature Mechanical Properties (550°C, +QT)

Property	X22CrMoV12-1 (1.4923)	X19CrMoNbVN11-1 (1.4913)(TLV 9367 05)
0.2% Proof Strength (MPa)	≥450	≥475
Tensile Strength (MPa)	≥500	≥520

Property	X22CrMoV12-1 (1.4923)	X19CrMoNbVN11-1 (1.4913)(TLV 9367 05)
Elongation A5 (%)	≥15	≥16
Reduction of Area (%)	≥50	≥55

Transverse Impact Properties at 100°C

- **X19CrMoNbVN11-1 (1.4913)**: Impact energy >20 J (3 samples, TLV 9367 05).
- **FATT (Fracture Appearance Transition Temperature)**: Target <50°C.

High-Temperature and Creep Performance

X22CrMoV12-1 excels in high-temperature environments due to its creep resistance, enhanced by vanadium and niobium additions. Key performance metrics include:

- **Creep Rupture Strength**: The steel maintains structural integrity under prolonged stress at temperatures up to 600°C. Creep tests (as per TLV 9367 05 for 1.4913) indicate stable performance for extended durations.
- **High-Temperature Strength**: At 550°C, the steel retains significant strength (≥450 MPa proof strength, ≥500 MPa tensile strength), making it ideal for **turbine blades**.
- **Fatigue Resistance**: The material's martensitic structure and low delta ferrite content (<5%) ensure excellent resistance to cyclic loading.

Physical Properties

The physical properties of **X22CrMoV12-1 (1.4923)** ensure its suitability for high-temperature applications:

- **Density**: ~7.7 g/cm³
- **Thermal Conductivity**: ~25 W/(m·K) at 20°C, decreasing at higher temperatures.
- **Thermal Expansion**: ~10.5–11.5 × 10^{-6}/K (20–600°C).
- **Specific Heat Capacity**: ~460 J/(kg·K) at 20°C.
- **Modulus of Elasticity**: ~215 GPa at 20°C, reducing to ~180 GPa at 600°C.

Heat Treatment

The heat treatment of **X22CrMoV12-1 (1.4923)** is critical to achieving its desired properties. Common delivery conditions include:

Annealed (+A)

- **Process**: Soft annealing at 750–800°C, slow cooling.
- **Purpose**: Reduces hardness for improved machinability.
- **Properties**: Lower strength and hardness, suitable for further processing.

Heat-Treated (+HT)

- **Process**: Normalizing at 1000–1050°C, followed by air cooling.
- **Purpose**: Refines microstructure and improves toughness.

Quenched and Tempered (+QT)

- **Hardening**: 1000–1050°C, followed by oil or air quenching.
- **Tempering**: 650–750°C, minimum 2 hours, air cooling.
- **Stress Relieving**: As per TLV 0110 (for similar grades like 1.4913, 670–750°C).
- **Properties**: High strength, creep resistance, and toughness for **turbine blades**.

Processing Performance

X22CrMoV12-1 is typically supplied as hot-rolled or forged bars, peeled bars, or seamless tubes. Its processing characteristics include:

- **Machinability**: Good in the annealed condition, but requires robust tools in the +QT state due to high hardness (240–300 HBW).
- **Formability**: Suitable for forging and rolling, with cast ingots as the starting material (TLV 9367 05).
- **Surface Quality**: Meets strict cleanliness requirements (e.g., thin series inclusions: Type A, B, C max. 2; Type D max. 2.5; IR(D) ≤10).
- **Non-Destructive Testing**: Ultrasonic inspection per TWP 1204 ensures internal quality.

Welding Performance

X22CrMoV12-1 has limited weldability due to its high carbon and alloy content, which can lead to cracking in the heat-affected zone (HAZ). Key considerations include:

- **Welding Methods**: TIG or shielded metal arc welding (SMAW) with matching filler materials.
- **Preheating**: 200–300°C to reduce thermal stresses.
- Post-Weld Heat Treatment (PWHT): Tempering at 650–700°C to relieve residual stresses and

restore toughness.

- **Challenges**: Risk of martensite formation in the HAZ requires careful control of welding parameters.

For critical applications like **turbine blades**, welding is often minimized, and components are typically machined from forged or rolled stock.

Equivalent Grades

X22CrMoV12-1 (1.4923) is equivalent or closely related to the following grades:

Standard	Grade
EN	X22CrMoV12-1, 1.4923
AFNOR	Z20CDNbV11
ČSN	17134
BS	762
SEW 555	X21CrMoV12-1, 1.4926
PN-H-84024	St12T
DIN	X20CrMoV12-1 (1.4922, similar)