20X12ВНМФ, ЭП428

20X12ВНМФ (ЭП428) is a **martensitic heat-resistant steel** developed in Russia for high-temperature applications (up to **600–650°C**). It is widely used in **power generation, gas turbines, and aerospace** due to its **creep resistance, high strength, and oxidation resistance**.

International Equivalents

Country	Standard	Equivalent Grade
USA	ASTM A565	AISI 422
EU	EN 10095	DIN X20CrMoV12-1
Japan	JIS G4311	SUH 600
China	GB/T 1221	1Cr12WMoV

Applications

- **Power Plants**: Turbine blades, rotors, bolts.
- **Aerospace**: Jet engine components.
- **Oil & Gas**: High-pressure valve parts.

Equivalent or Similar Grades - Chemical Composition

Element	20X12ВНМФ, ЭП428	AISI 422	X20CrMoV12-1	SUH 616
C	0.17–0.23	0.20–0.25	0.17–0.23	0.15–0.25
Cr	11.0–13.0	11.0–13.0	10.0–12.5	10.0–13.0
Ni	0.50–0.90	0.50–1.00	0.30–0.80	≤1.00
Mo	0.70–1.00	0.75–1.25	0.80–1.20	0.80–1.20
V	0.20–0.40	0.20–0.40	0.25–0.35	0.20–0.40
W	0.70–1.10	–	–	–
Mn	0.50–0.90	≤1.00	0.30–0.80	≤1.00
Si	0.30–0.60	≤0.75	0.15–0.50	≤0.75

Key Features:

- **High Cr (11–13%)** provides **oxidation resistance** at high temperatures.
- **Mo & V** enhance **creep strength** by forming stable carbides.
- **W (Tungsten)** in **20X12ВНМФ** improves **hot hardness** (unique to Russian grade).

Mechanical Properties

Room Temperature (Delivery Conditions: +A, +QT, +HT)

Condition	σ_x (MPa)	$\sigma_{0.2}$ (MPa)	δ (%)	HB	Impact (J)
Annealed (+A)	650–850	≥490	≥15	200–250	≥40
Quenched & Tempered (+QT)	880–1080	≥735	≥12	270–330	≥30

High-Temperature Strength (500–650°C)

Temp (°C)	σ_x (MPa)	Creep Limit (10^5 h, MPa)
550	550–650	120–150
600	450–550	80–100
650	350–450	40–60

Physical Properties

Property	Value
Density (g/cm³)	7.8
Melting Point (°C)	1450–1500
Thermal Conductivity (W/m·K)	26.0 (20°C), 28.5 (600°C)
Coefficient of Expansion (10^{-6}/K)	11.5 (20–600°C)

Heat Treatment

- **Annealing (A)**: 850–900°C → slow cooling (for machinability).
- **Quenching (Q)**: 1000–1050°C → oil/air cooling.
- **Tempering (T)**:
  - **Standard Tempering**: 650–700°C → air (for balanced strength/toughness).
  - **High-Temperature Tempering**: 720–780°C → improved ductility.

Processing Performance

Machining

- **Pre-annealing** recommended for better machinability.
- **Carbide tools** preferred due to high hardness.

Welding

- **Preheating**: 250–300°C (to avoid cracking).
- **Post-Weld Heat Treatment (PWHT)**: 700–750°C → slow cooling.
- **Filler Metals**: Matching electrodes (e.g., ЦЛ-17 in Russian standards).