

X10CrMoVNb9-1 (P91)

Mat. No. 1.4903 · 9Cr-1Mo-V-Nb creep-resistant steel

Mat. No.: 1.4903

EN designation: X10CrMoVNb9-1

ASTM/ASME equiv.: Pipes: A/SA 335 P91 · Fittings: A/SA 234 WP91 · Flanges: A/SA 182 F91

Temperature range: Up to +650 °C (long-term creep service)

Standard: EN 10216-2 · EN 10253-2

Certifications: ISO 19443 (Nuclear) · ISO 9001 · AD 2000

Delivery forms: Elbows · Tees · Reducers · Caps · Flanges · Pipes

1 Material Equivalents & Comparable Grades

International Equivalents

| Standard / Region | Designation | Mat. No. / Grade | Note |
|-------------------|---------------|------------------|-------------------------------------|
| EN | X10CrMoVNb9-1 | 1.4903 | 9Cr steel, European designation |
| ASTM | A/SA 335 P91 | – | Pipes – global power plant standard |
| ASTM | A/SA 234 WP91 | – | Fittings |
| ASTM | A/SA 182 F91 | – | Flanges |
| UNS | K91560 | – | US material number |

Alternative Materials

| Material | Mat. No. | Relation to X10CrMoVNb9-1 (P91) | When to use |
|------------------|----------|---------------------------------|--|
| 10CrMo9-10 (P22) | 1.7380 | Lower alloy | For temperatures up to 600 °C only |
| P92 | 1.4901 | W-enhanced grade | For temperatures above 620 °C or thinner walls |

2 Chemical Composition

Values in mass percent (%). Standard: EN 10216-2.

P91: dominant 9Cr-1Mo-V steel for ultra-supercritical power plants. V and Nb form fine carbonitride precipitates providing exceptional creep strength to 650 °C.

| Element | Sym. | Min. (Heat) | Max. (Heat) | Max. (Prod.) | Function |
|---------|------|-------------|-------------|--------------|----------|
| | | | | | |

| | | | | | |
|-------------------|----|-------|-------|-------|--|
| Carbon | C | 0.08 | 0.120 | 0.140 | Precise control critical |
| Chromium | Cr | 8.00 | 9.500 | 9.800 | Creep + oxidation resistance |
| Molybdenum | Mo | 0.85 | 1.050 | 1.150 | Solid solution strengthening |
| Vanadium | V | 0.18 | 0.250 | 0.280 | Carbonitride precipitation – key element |
| Niobium | Nb | 0.06 | 0.100 | 0.120 | Grain refinement, carbonitrides |
| Nitrogen | N | 0.030 | 0.070 | 0.080 | Nitride formation |

3 Mechanical Properties

Room Temperature – Minimum Requirements

Normalised + Tempered mandatory. Target hardness: 200–265 HB.

| Property | Sym. | Unit | Min. Value | Note |
|-------------------------|-------|------|------------|-------------------|
| Yield strength | Rp0.2 | MPa | ≥ 450 | N+T condition |
| Tensile strength | Rm | MPa | 630–830 | – |
| Elongation | A | % | ≥ 20 | – |
| Impact (+20 °C) | KV | J | ≥ 40 | – |
| Hardness | HB | – | 200–265 | Critical for NACE |

Elevated Temperature Yield Strength Rp0.2 in MPa (indicative values)

| Temp. | 400 °C | 500 °C | 550 °C | 600 °C | 625 °C | 650 °C |
|--------------------|--------|--------|--------|--------|--------|--------|
| Rp0.2 (MPa) | 376 | 335 | 305 | 255 | 218 | 178 |

4 Physical Properties

| Property | Sym. | 20 °C | 200 °C | 400 °C | Unit |
|------------------------------|------|-------|--------|--------|---------------------|
| Density | ρ | 7.75 | 7.66 | 7.56 | g/cm ³ |
| Modulus of elasticity | E | 218 | 203 | 185 | GPa |
| Thermal conductivity | λ | 29 | 27 | 26 | W/(m·K) |
| Thermal expansion | α | 10.8 | 11.5 | 12.2 | 10 ⁻⁶ /K |

5 Corrosion Behaviour

| Medium / Environment | Notes | Rating |
|------------------------------------|--------------------------------------|--------|
| High-pressure steam (up to 650 °C) | Primary application | + |
| High-temp. oxidation (dry) | 9Cr provides good scaling resistance | + |

| | | |
|-------------------------------|-------------------------------------|---|
| Sour service H ₂ S | Hardness ≤ 250 HB required per NACE | ○ |
| Chlorides / acids | Not suitable | - |

++ excellent
+ good
○ limited
- not suitable

CRITICAL: All P91 must be strictly N+T treated. Incorrect heat treatment is the leading cause of P91 failures worldwide.

6 Typical Applications

| Industry / Plant | Typical Application | Operating Conditions |
|----------------------------------|--|---------------------------------------|
| Ultra-supercritical power plants | Main steam, hot reheat piping | Up to 650 °C, >300 bar |
| Combined-cycle plants | High-temperature headers and transitions | Full procedure qualification required |
| Refineries | High-temperature process lines | Creep service required |

7 Delivery Forms at Nirotec

| Component | Standard (EN) | Standard (ASME/ASTM) | Note |
|-----------|-------------------|----------------------------|--------------------------|
| Elbows | EN 10253-2 | ASME B16.9 · A/SA 234 WP91 | LR/SR, 90°/45° |
| Tees | EN 10253-2 | ASME B16.9 · A/SA 234 WP91 | Equal and reducing |
| Reducers | EN 10253-2 | ASME B16.9 · A/SA 234 WP91 | Concentric and eccentric |
| Caps | EN 10253-2 | ASME B16.9 · A/SA 234 WP91 | Ellipsoidal |
| Flanges | EN 1092-1 Type 11 | ASME B16.5 · A/SA 182 F91 | PN 16–400 |
| Pipes | EN 10216-2 | A/SA 335 P91 | Seamless |

8 Standards, Approvals & Codes

| Standard / Code | Title / Application |
|-----------------|---|
| EN 10216-2 | Seamless steel tubes – elevated temperature |
| EN 10253-2 | Butt-welding fittings |
| ASME B31.1 | Power Piping – Chapter IX |
| EPRI TR-115566 | P91 welding and fabrication guidelines |
| ISO 19443 | Nuclear supply chain (Nirotec certified) |

9 Fabrication Notes

Weldability

| Parameter | Requirement / Recommendation | Note |
|----------------------------|--------------------------------------|-------------------------------------|
| Preheat | 200–250 °C mandatory | Strict pre-heat for entire duration |
| Post-weld cooling | Cool slowly to 80–100 °C before PWHT | Prevents cracking |
| PWHT | Mandatory: 750–780 °C, min. 2 h | NO EXCEPTIONS |
| Hardness after PWHT | 200–265 HB | Measure on each weld |
| Filler | ER90S-B9 / E9015-B9 | 9Cr-1Mo-V type consumables |
| Process | GTAW, SMAW | GTAW root strongly recommended |

- Delivery condition: N+T – mandatory
- CRITICAL: Never weld P91 without immediate PWHT programme in place
- Hardness must be verified after PWHT: 200–265 HB on all welds
- Qualified WPS and WPQR required for all P91 work

10 Enquiry & Contact

For a project-specific quotation, please provide:

- Standard and execution (e.g. LR 90° elbow per EN 10253-4)
- Dimensions: DN / NPS and wall thickness or schedule
- Quantity and requested delivery date
- Documentation: EN 10204 Type 3.1 / 3.2, NDT, third-party inspection
- Any project-specific specifications or special requirements

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All information is provided without warranty. Applicable standards and project specifications at time of order are authoritative.