1.4913, X19CrMoNbVN11-1, 403Cb+

The 1.4913/X19CrMoNbVN11-1/403Cb+ family of alloys represents an optimized balance of properties for critical turbine applications. Their carefully controlled chemistry and processing requirements ensure reliable performance in demanding high-temperature environments. The GE B50A365 specification in particular demonstrates the rigorous quality standards needed for power generation components, with comprehensive requirements covering chemistry, heat treatment, mechanical properties, and quality assurance.

For engineers selecting materials for turbine blades or other high-temperature components, these alloys offer an excellent combination of strength, creep resistance, and corrosion resistance - particularly in the 500-650°C service range. Their proven performance in power generation applications makes them a preferred choice when reliability and long service life are paramount.

This comprehensive guide provides metallurgical professionals, engineers, and researchers with detailed technical data on these important materials, including:

- Material specifications and international designations
- Chemical composition comparisons
- Mechanical properties across temperature ranges
- Heat treatment requirements
- High-temperature performance characteristics
- Processing and fabrication considerations

Material Specifications and Designations

These chromium-niobium alloy steels are known under various designations in different standards:

Material Number	EN/DIN	AFNOR	GOST	ISO	GE Specification	UNS
1.4913	X19CrMoNbVN11-1	NF Z20CDNbV11	18Ch11MNFB (18Х11МНФБ)	-	-	-
1.4916	-	NF Z21CDNbV11	2Х11МФБН, ЕП291	ISO X18CrMnMoNbVN12	-	-
-	-	56T5	-	-	B50A365 (403Cb+)	-

The GE specification B50A365 (403Cb+) represents General Electric's proprietary version of this alloy class with particularly stringent requirements for turbine applications.

Applications

Applications

These alloys are specifically designed for:

- Steam Turbine Components:
  - High-pressure blades
  - Rotor blades
  - Buckets
  - Partitions
- Gas Turbine Components:
  - Compressor blades
  - Variable inlet guide vanes
  - Rotor disks
- Other High-Temperature Applications:
  - Fasteners
  - Valve components
  - High-pressure piping

Equivalent or Similar Grades - Chemical Composition

Grade	Chemical Composition %														
	C	Mn	Si	P	S	Cr	Ni	Mo	V	Nb	Al	W	B	N	Cu	Ti
EN 1.4913, X19CrMoNbVN11-1	0.17 - 0.23	0.4 - 0.9	Max 0.5	Max 0.025	Max 0.015	10.0 - 11.5	0.2 - 0.6	0.5 - 0.8	0.1 - 0.3	0.25 - 0.55	Max 0.02	Max 0.7	0.005 - 0.015	0.05 - 0.10	-	-
NF Z20CDNbV11, 56T5	0.18 - 0.25	0.3 - 0.8	0.1 - 0.5	Max 0.025	Max 0.015	10.0 - 12.0	Max 1.0	0.5 - 1.0	0.1 - 0.3	0.25 - 0.55	-	-	-	0.05 - 0.10	-	-
NF Z21CDNbV11	0.16 - 0.25	0.3 - 0.8	0.1 - 0.5	Max 0.030	Max 0.015	10.0 - 12.0	Max 1.0	0.5 - 1.0	0.1 - 0.3	0.25 - 0.55	-	-	-	0.05 - 0.10	-	-
X18CrMnMoNbVN12, 1.4916	0.15 - 0.20	0.5 - 1.0	Max 0.5	Max 0.040	Max 0.030	10.0 - 13.0	Max 0.6	0.3 - 0.9	0.1 - 0.4	0.2 - 0.6	-	-	-	0.05 - 0.10	-	-
18Ch11MNFB, 18Х11МНФБ, 2Х11МФБН, ЕП291	0.15 - 0.21	0.6 - 1.0	Max 0.6	Max 0.030	Max 0.025	10.0 - 11.5	0.5 - 1.0	0.8 - 1.1	0.2 - 0.4	0.20 - 0.45	-	Max 0.2	-	-		
B50A365 403Cb+	0.15-0.20	0.20-0.60	0.50-0.80	≤0.020;≤0.025	≤0.010;≤0.025	10.0-11.0	0.80-1.10	0.35-0.55	0.15-0.25	0.20 - 0.45	0.04-0.08	0.30-0.60	-	-		

Key features of the chemistry:

- Chromium provides oxidation resistance and solid solution strengthening
- Molybdenum enhances high-temperature strength
- Niobium (columbium) forms stable carbides for creep resistance
- Vanadium contributes to precipitation hardening
- Nitrogen strengthens the matrix and stabilizes austenite during heat treatment

Mechanical Properties

Room Temperature Properties

Property	403Cb+ (B50A365)	1.4913	NF Z20CDNbV11	Test Standard
Tensile Strength (min)	140 ksi (965 MPa)	900-1100 MPa	900-1100 MPa	ASTM A370
Yield Strength (0.2% offset, min)	100 ksi (690 MPa)	700 MPa	700 MPa	ASTM A370
Elongation (min)	15%	15%	15%	ASTM A370
Reduction of Area (min)	45%	50%	50%	ASTM A370
Hardness (Brinell)	285-321 HB	270-330 HB	270-330 HB	ASTM E10
Charpy Impact (min)	8 ft-lbs (11 J)	30 J	30 J	ASTM E23

High Temperature Mechanical Properties

These alloys maintain excellent strength at elevated temperatures:

Temperature	0.2% Proof Stress (MPa)	Tensile Strength (MPa)
400°C	550	700
500°C	500	650
600°C	400	550

Creep and Stress Rupture Properties

The 403Cb+ specification requires:

- Stress rupture testing at 650°C (1200°F) with minimum 33 ksi (228 MPa) stress
- Minimum time to rupture of 25 hours
- Combination smooth and notched specimen testing

Typical stress rupture performance:

- 100,000 hours rupture strength at 600°C: ~120 MPa
- 100,000 hours rupture strength at 650°C: ~80 MPa

Grain Size Requirements

- Average prior austenitic grain size of ASTM No. 4 or finer
- Maximum individual grain size of ASTM No. 2

- Maximum 1% delta ferrite

Physical Properties

Property	Value
Density	7.8 g/cm³
Melting Range	1420-1460°C
Thermal Conductivity (20°C)	28 W/m·K
Specific Heat (20°C)	460 J/kg·K
Electrical Resistivity	0.75 μΩ·m
Coefficient of Thermal Expansion (20-600°C)	12.5×10^{-6}/K
Elastic Modulus	210 GPa
Poisson's Ratio	0.29

Heat Treatment

The heat treatment of these alloys is critical for achieving optimal properties. The B50A365 specification provides detailed requirements:

For Final Properties (Classes A, B & C)

- Austenitizing: 2000-2050°F (1093-1121°C), hold for uniform temperature
- Quenching: In oil or rapidly moving air below Mf temperature
- Tempering: Minimum 1185°F (640°C) to achieve required properties

For Annealed Condition (Classes A1 & B1)

- Maximum hardness of 302 HB
- Capable of subsequent heat treatment to final properties

Special Considerations for Class B (Straightened Material)

- Additional heat treatment cycle after straightening:
  - Austenitize → Quench → Temper at 615°C → Straighten → Final temper ≥640°C
- Straightening after final temper prohibited without approval

Processing Performance

Forging

- Recommended forging temperature range: 1050-850°C
- Requires controlled cooling after forging to prevent cracking
- Forging reduction ratio should be ≥3:1 for optimal properties

Machining

- Best machined in annealed condition
- Use positive rake tools with carbide inserts
- Recommend cutting speeds of 30-50 m/min for turning
- Requires rigid setups due to material toughness

Welding

- Weldable using matching composition filler metals
- Preheat to 250-350°C recommended
- Post-weld heat treatment required (typically 700-750°C)
- Susceptible to HAZ cracking if procedures not followed

Non-Destructive Testing

- Ultrasonic testing per P3C-AL-0013 for forgings
- Magnetic particle inspection per P3C-AL-0003
- Liquid penetrant examination for surface defects

Quality Assurance Requirements

The **B50A365 specification** includes stringent QA provisions:

Chemical Analysis:

- Class A/A1: Master heat analysis
- Class B/B1/C: Every remelted ingot analysis

Mechanical Testing:

- Hardness testing for all classes
- Tensile testing (location and orientation specified)

- Stress rupture testing for heat-treated material
- Charpy impact for forgings

Metallographic Examination:

- Grain size measurement (ASTM E112)
- Delta ferrite content
- Cleanliness rating (ASTM E45)

Comparative Analysis with Similar Alloys

While 403Cb+ and related alloys share many characteristics with conventional 12%Cr steels, key differences include:

Superior to **410 stainless steel** in:

- Creep resistance
- Toughness
- High-temperature strength

Compared to **17-4PH**:

- Better thermal stability
- Higher creep strength
- More suitable for rotating components

Advantages over **cobalt-based alloys**:

- Lower cost
- Better fabricability
- Adequate for many intermediate temperature applications