10705MBU, 12CrMoWVNb

10705MBU steel is a high-strength, high-temperature performance excellent martensitic heat-resistant steel, commonly used in key parts of large gas turbines (especially heavy industrial gas turbines), such as static blades and moving blades. This steel grade has good high-temperature strength, creep resistance, and oxidation resistance, suitable for long-term high-temperature and high-pressure conditions.

Referenced Standards

The following documents, effective on the date of investigation for bids, form part of this specification:

- **JIS G 0404**: Steel and Steel Products - General Technical Delivery Requirements
- **JIS G 0551**: Steel - Macroscopic Examination by Etching
- **JIS G 0555**: Steel - Microscopic Examination for Non-Metallic Inclusions

Key Characteristics:

- **High Strength at Elevated Temperatures**: Maintains structural integrity and mechanical properties in high-heat environments.
- **Excellent Fatigue Resistance**: Withstands cyclic loading conditions common in turbine and engine operations.
- **Good Corrosion and Oxidation Resistance**: Suitable for operation in aggressive atmospheric and combustion environments.
- **Stable Microstructure**: Engineered for long-term reliability under thermal and mechanical stress.

Applications

- Steam and gas **turbine blades**
- **Compressor discs** and rotors
- **Jet engine components**
- **High-temperature structural parts** in aerospace systems

Equivalent or Similar Grades - Chemical Composition

Element	Heat Analysis	Product Analysis
C	0.12 ~ 0.16	0.11 ~ 0.17
Mn	0.30 ~ 0.70	0.27 ~ 0.73
P	0.020 Max	0.025 Max

Element	Heat Analysis	Product Analysis
S	0.015 Max	0.020 Max
Si	0.06 Max	0.08 Max
Cr	10.00 ~ 11.00	9.90 ~ 11.10
Mo	0.30 ~ 0.50	0.30 ~ 0.50
Ni	0.35 ~ 0.65	0.32 ~ 0.68
W	1.50 ~ 1.90	1.42 ~ 1.98
V	0.14 ~ 0.20	0.12 ~ 0.22
Nb	0.05 ~ 0.11	0.05 ~ 0.11
N	0.040 ~ 0.080	0.040 ~ 0.080
Cu	0.50 Max	0.55 Max

Mechanical Properties

Full cross-section coupons shall conform to the properties specified below when heat treated as shown in Section 6.2.2:

Property	Value	Alternative Units
Tensile Strength	930N/mm² Min	(94.9 kgf/mm² Min) [135,000 p.s.i. Min]
0.2% Yield Strength	760N/mm² Min	(77.3 kgf/mm² Min) [110,000 p.s.i. Min]
Elongation (GL=4D)	14% Min	
Reduction of Area	32% Min	
V-notch Impact Absorbed Energy	20 J Min	(2.0 kgf-m Min)

Tensile Strength (Ultimate Strength)

- **Room Temperature (20°C):**
  ≥ 950 MPa
- **At Elevated Temperatures (e.g., 500–600°C):**
  Decreases with temperature but maintains high strength:
  - At 500°C: ~750–800 MPa
  - At 600°C: ~600–650 MPa

Creep Resistance

- **Excellent long-term creep resistance** under continuous stress at elevated temperatures.
- Typical Creep Rupture Strength:

- **At 600°C for 100,000 hours: ≥ 100 MPa**
- This makes it suitable for components in turbines where dimensional stability over time is critical.

Fatigue Strength

- **High fatigue resistance**, especially in cyclic high-stress applications such as rotating blades.
- **Fatigue Limit (Endurance Limit) at Room Temperature:**
  ~**450–550 MPa** (depending on surface finish and geometry)
- **High-Temperature Fatigue:**
  Performance declines with increasing temperature, but 10705MBU retains useful fatigue strength up to ~550°C.

Summary Table

Property	Value (Typical)
Tensile Strength (RT)	≥ 950 MPa
Yield Strength (RT)	≥ 800 MPa
Creep Rupture Strength (600°C)	≥ 100 MPa (100,000 h)
Fatigue Strength (RT)	~450–550 MPa
Service Temperature Range	Up to 600°C

Physical Properties

10705MBU is a high-performance martensitic stainless steel developed for use in turbine blades and high-temperature structural components. It exhibits excellent mechanical and thermal stability under demanding operational conditions.

1. Density:

- **~7.75 g/cm³** (7750 kg/m³)

2. Thermal Conductivity:

- **~20–25 W/m·K** at room temperature
  (Varies slightly depending on tempering condition and exact alloy composition)

3. Specific Heat Capacity:

- **~460–500 J/kg·K**

4. Coefficient of Thermal Expansion:

- **~11.5–12.5 × 10^{-6} /K** (from 20°C to 600°C)
  (This is important for dimensional stability under thermal cycling.)

5. Electrical Resistivity:

- **~0.65–0.75 µΩ·m** at room temperature

6. Magnetic Properties:

- **Magnetic** in quenched and tempered condition
  (Due to its martensitic microstructure)

7. Oxidation Resistance:

- Good up to **600–650°C** in air
  (Exact performance depends on surface finish and operating environment)

These physical properties make **10705MBU** suitable for high-temperature and high-stress environments, such as turbine engines and compressor stages.

Heat Treatment

The heat treatment of **10705MBU blade steel** is critical to achieving its optimal mechanical properties, particularly for applications requiring high strength, toughness, and thermal stability. The typical heat treatment process includes **annealing (if needed), quenching, and tempering**.

Typical Heat Treatment Regimen:

Forging (if applicable)

- **Forging Temperature:** 1000–1150°C
- **Final Forging Temperature:** Not below 850°C
- After forging, slow cooling in furnace or insulating material is recommended to avoid cracking.

Normalizing / Pre-heat Treatment (optional):

- **Temperature:** 880–920°C

- **Holding Time:** 1 hour per 25 mm thickness
- **Cooling:** Air cool
  (Used to refine grain structure before hardening.)

Quenching (Austenitizing):

- **Temperature:** 950–980°C
- **Holding Time:** 30–60 minutes depending on thickness
- **Cooling Medium:** Oil or air (depending on part size and required hardness)
- Purpose: Achieves martensitic structure for high strength.

Tempering:

- **Temperature:** 620–700°C
- **Holding Time:** 1–2 hours depending on section size
- **Cooling:** Air cool
- Purpose: Improves toughness, reduces brittleness, and relieves internal stress.

Optional Secondary Tempering (for stress relief or dimensional stability):

- Often conducted at 650–680°C

Resulting Mechanical Properties (Typical After Heat Treatment):

- **Tensile Strength:** ≥ 950 MPa
- **Yield Strength:** ≥ 800 MPa
- **Impact Toughness:** ≥ 50 J (at room temperature)
- **Hardness:** ~260–320 HB (Brinell Hardness)

Note: The actual heat treatment parameters may vary depending on component geometry, service conditions, and manufacturer-specific specifications. Always refer to technical datasheets or consult metallurgical engineers for final treatment standards.

Processing Performance

Processing Properties of 10705MBU Blade Steel

1. Hot Workability (Hot Forming Performance)

- **Excellent hot workability** within the temperature range of **1000–1150°C**.
- Should be forged or hot rolled within this range; avoid working below **850°C** to prevent cracking or damage to the microstructure.

- **Good resistance to thermal fatigue** and **low risk of hot cracking** if proper forging practices are followed.
- After hot working, slow cooling in the furnace or dry ash is recommended to prevent internal stresses or unwanted phase transformations.

2. Cold Workability (Cold Forming Performance)

- **Moderate cold formability**. Due to its strength and alloy content, it has **higher deformation resistance** compared to low-alloy steels.
- Cold forming operations such as bending or drawing should be done with caution, and **preheating may be recommended** for complex shapes to reduce risk of cracking.
- Intermediate annealing may be required for large deformations.
- Generally used in the heat-treated condition, not widely used for extensive cold forming.

3. Weldability

- **Fair weldability**, but **not classified as an easy-to-weld steel** due to its alloying elements and hardened microstructure.
- **Preheating before welding (typically 200–350°C)** is recommended to reduce the risk of cold cracking.
- **Post-weld heat treatment (PWHT)** such as tempering at 600–680°C is often necessary to restore toughness and relieve residual stresses.
- Recommended welding methods: **TIG**, **MIG**, or **submerged arc welding**, using filler materials with compatible composition.
- Cleanliness and proper joint preparation are critical to avoid porosity and weld defects.

Additional Machinability Notes:

- **Machinability** is considered **moderate to difficult** due to its hardness and strength after heat treatment.
- Use **high-speed steel or carbide tools** with controlled cutting parameters.
- Optimal to machine in the **annealed condition** before final heat treatment when tight tolerances are required.