SOCIALIST REPUBLIC OF VIETNAM
Ministry of Industry and Trade (MOIT)

Guideline for Technical Regulation Volume 2

Design of Thermal Power Facilities

Book 2/12

« Steam Turbine »

Final Draft

June 2013

Japan International Cooperation Agency

Electric Power Development Co., Ltd.
Shikoku Electric Power Co., Inc.
West Japan Engineering Consultants, Inc.

IL
CR(2)
13-092

Table of Contents

List of Tables

List of Figures

<u>List of Photos</u>

List of Acronyms/Abbreviations

ACFTD	Air Cleaner Test Dust
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
APC	Automatic Particle Counter
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
ASME	American Society of Mechanical Engineers
CDA	Controlled Diffusion Airfoil
IGCC	Integrated Coal Gasification Combined Cycle
ISO	International Organization of Standardization
IEC	International Electrotechnical Commission
JEAC	Japan Electric Association Code
JESC	Japan Electric Association Guide
JIS	Japanese Industrial Standard
MIL	Military Standard
NAS	National Aerospace Standard
NEGA	Nippon Engine Generator Association
NFPA	National Fire Protection Association
NOx	Nitrogen Oxide
NPF	Nozzle Passing Frequency
RAMS	Reliability Availability Maintainability and Safety
SAE	Society of Automotive Engineers

Chapter-1. Comparison between Technical Regulation and Technical Guideline of steam turbine

The article number of this guideline is shown in the Table-1 contrasted technical regulation with technical guideline for easy understanding.

Table- 1: Comparison between Technical Regulation and Technical Guideline of steam turbine

Technical Regulation		Technical Guideline	
Article 29.	General Provision	Article 29.	General Provision
-1.	—	—	—
-2.	—	—	—
—	—	-1.	Classification of Types for Steam Turbine
		-2.	Typical Construction of Steam Turbine
		-3.	Steam Condition for Steam Turbine
		-4.	Materials for Main Part of Steam Turbine
		-5.	Material Application for Hot Part
Article 30.	Material for Auxiliary Facilities of Steam Turbine	Article 30.	Material for Auxiliary Facilities of Steam Turbine
-1-1.	Pressure Part	-1-1.	Pressure Part
-1-2.	Stable Chemical Composition and Mechanical Strength	-1-2.	Stable Chemical Composition and Mechanical Strength
Article 31	Structure of Steam Turbine, etc.	Article 31.	Structure of Steam Turbine, etc.
-1.	Rotation Speed When Emergency Governor Operates	-1.	Rotation Speed when Emergency Governor Operates
-2.	Maximum Vibration	-2.	Maximum Vibration
-3.	Abnormal Wear, Transformation and Over-heat	-3-1.	Abnormal Wear, Transformation and Over-heat
—	—	-3-2.	Self-lubrication Equipment
		-3-3.	Bearing
		-3-4.	Jacking Oil Pump
		-3-5.	Clearance Adjustment of Turbine Bearing and Other Parts
		-3-6.	Turbine Bearing Catenaries
		-3-7.	Turbine Blade
		-3.8.	Turbine Grand
		-3-9.	Turning Gear
		-3-10.	Turbine Lubrication Oil
		-3-11.	Lubrication Oil Purifier
		-3-12.	Vapor Extraction System for Turbine Lubrication Oil
		-3-13.	Fir-fighting System for Bearing

Technical Regulation		Technical Guideline	
-4-1.	Minimum Rotation Speed	-4-1.	Minimum Rotation speed
-4-2.	Sufficient Measure	-4-2.	Sufficient Measure
—	—	-4-3.	Natural Frequency
—	—	-4-4.	Turbine Rotor and Coupling
—	—	-4-5.	Field Balancing
-5.	Safety Structure	-5-1.	Safety Structure
—	—	-5-2.	Casing, Pedestal, and Support
Article 32.	Speed Governing Device for Steam Turbine, etc.	Article 32.	Speed Governing Device for Steam Turbine, etc.
-1.	—	—	—
—	—	-1-1.	Terms Related with Rotation Speed
		-1-2.	Instantaneous Maximum Speed
		-1-3.	Maximum Speed Rise
		-1-4.	Steady State Speed Regulation
		-1-5.	Incremental Speed Variation
		-1-6.	Governor Test
		-1-7.	Over-speed Trip Setting of Emergency Governor
		-1-8.	Over-speed Test
		-1-9.	Concept of Rotation Speed
Article 33.	Emergency Stop Device for Steam Turbine, etc.	Article 33.	Emergency Stop Device for Steam Turbine, etc.
-1-1.	Alarm Device	-1-1.	Alarm Device
-1-2.	Harmful Vibration during Operation	-1-2.	Harmful Vibration during Operation
-2-1.	Emergency Stop Device	-2-1.	Emergency Stop Device
-2-2.	Immediately	-2-2.	Immediately
-2-3.	Over-speed and Other Abnormal Situation	-2-3.	Over-speed and Other Abnormal Situation
—	—	-2-4.	Main Valves
Article 34.	Pressure Relief Device for Steam Turbine, etc.	Article 34.	Pressure Relief Device for Steam Turbine, etc.
-1-1.	Over-pressure	-1-1.	Over-pressure
-1-2.	Appropriate Pressure Relief Device	-1-2.	Appropriate Pressure Relief Device
Article 35.	Instrument Equipment for Steam Turbine, etc.	Article 35.	Instrument Equipment for Steam Turbine, etc.
-1.	Instrument Device to Monitor the Operation Status	-1-1.	Instrument Device to Monitor the Operation Status
—	—	-1-2.	Turbine Supervisory Instrument

Article 29. General Provision

Article 29-1. Classification of Steam Turbine by Types

The general features and selection criteria and use depending on the type of steam turbine are summarized in following Table-2~Table-11. The appropriated type of turbine must be selected depending on the purpose, required output and circumstances.

1. Classification of Steam Turbine by Types

Table- 2: Classification of types for steam turbine

No.	Type of turbine	Features	Selection criteria	Use for
1	Condensing	The turbines which work fully inflated to low pressure by obtained high vacuum in order to condense turbine exhaust steam in the condenser.	(1)When only electricity or power required, (2) When cooling water to condensate exhaust steam is available.	Machine drive, geothermal power, heat recovery
2	Regenerative	The condensing turbine which is obtained high efficiency of turbine cycle by utilizing extracted steam from middle stage for heating of boiler feed-water by feed-water heater.	(1)When small and middle output and high efficiency is required, (2) When cooling water to condensate exhaust steam is available.	Power generation for cement, ironworks, mine
3	Reheat	The turbines which extract steam from middle expansion stage, re-heat, back to turbine and expand further.	(1)When large output and high efficiency is required, (2)In general, it is used as regenerate and reheat turbine.	Large scale power generation
4	Back pressure	The turbines that exhaust pressure are above atmospheric pressure and utilize steam as utility steam. In some cases, it may be operated exhaust released into the atmosphere.	(1)When the large amount of utility steam of a type is required, (2)It is necessary to operate electricity and steam in parallel due to excess and deficiency between generated electricity and power demand of plant.	Private power generation, machine drive, cogeneration
5	Extraction condensing	The turbines which extract steam from middle stage of condensing turbine after adjusting pressure by control valve and utilize steam and exhaust steam as utility steam for works and others.	(1)When the large amount of utility steam of one or more types are required, (2)When the power demand is less than the amount of utility steam.	Private power generation, machine drive, cogeneration

No.	Type of turbine	Features	Selection criteria	Use for
6	Extraction back pressure	The turbines which extract steam from middle stage of back pressure turbine after adjusting pressure by control valve and utilize steam and exhaust steam as utility steam for works and others.	(1)When the large amount of utility steam of more than two types are required, (2)It is necessary to operate electricity and steam in parallel due to excess and deficiency between generated electricity and power demand of plant.	Private power generation, machine drive
7	Mixed pressure	The turbines which are made work into same turbine different pressure steam.	(1)When only electricity or driving power is required. (2)When it is necessary to collect low pressure steam. (3)When it is capable to get cooling water for condensation of exhaust steam.	Private power generation by heat recovery, machine drive

Reference: P-235 of Handbook for thermal and nuclear power engineers JapaneseVer.7 (Extracted from JIS B0127-2004)

2. Classification by Shape of Turbine Blade and Principle of Force Generation

Table- 3: Classification by type of turbine stage (blade compound)

Impulse Type	➢ The vanes spout high-speed steam flow as nozzle. The blades rotate by only the impact force without the expansion of steam.
Reaction Type	➢ The vane and blade have almost same profile; the blades rotate by impulse force and reaction force which is generated by the expansion of steam. In generally, the 50% of output power is obtained from the impact force and the remaining 50% of output power is obtained from the reaction force by the expansion of steam. ➢ The reaction type has 1.5~2.0 times stage numbers compared with the impulse type under same heat supply, because the heat consumption a stage of the reaction type is nearly half of the impulse type. The single stage reaction turbine does not exist.

3. Classification by Type of Blade Row

Table- 4: Classification by type of blade row

Rateau Type (Pressure compounded stages)	➢ An impulse stage is composed by a pair of vanes and blades. The multistage type would be repeated multiple times. The Rateau type is applied to the multistage turbine overwhelmingly; however in almost case the Curtis type may selected for first stage. The large amount heat consumption by Curtis type makes it easier the structural design of down stream. The Rateau type is used when high-speed rotation is required at low pressure and temperature supply steam with high exhaust pressure.

Curtis Type (Velocity compounded stage)	➢ There is the one set of impulse stage which is composed by a stationary nozzle with one row of vane and two rows of blades “blade-vane-blade”, or the one set of impulse stages which is composed by the stationary nozzles with many rows of blades and vanes. For example of the blade-vane-blade arrangement, the first blades generate 70% of power, and the second blades generate 30% of power after changing direction in the next vane. Even if there are third column blades, it can be got only few % of power. The Curtis turbine is adopted to relatively small turbine “single-stage turbine”. The two- stage Curtis turbine is also produced, when it is capable to obtain plenty heat supply and the low pressure by condenser. ➢ There is a difference of maximum internal efficiency about 5~6% between Rateau type: 80~85% and Curtis type: 75~80%, if designed appropriately. The Curtis type is capable to take a large heat consumption, though the efficiency of Curtis type is less than Rateau type. There are demands for emergency use and stand-by use which has 1,000Hp or less than 4,500rpm. The only Japanese manufacturers produce the Curtis turbine.
Reaction stage Type	➢ The steam expands and the pressure drops not only in the vane but also in the blade, and the power is generated by the action of both impulse and reaction.

4. Classification by the Direction against Rotation Direction

Table- 5: Classification by the direction against rotation direction

Axial-flow Type	➢ The energy is obtained by the blade during the steam flows parallel to the axis of rotation. There is a relatively small engineering constraint on axial-flow type because of the longitudinal direction centrifugal force on rotor.
Radial-flow Type	➢ The energy is obtained by the blade during the steam flows a direction away from the axis of rotation. It is difficult to manufacture turbine blades for the radial flow type as a long thin while maintaining strength of large diameter and low pressure in the stage, because of the lateral centrifugal force on blades. The Ljungstroem turbine produced in Europe was remaining ones, only axial -flow is remaining now.

5. Classification by Quantity of Impeller

Table- 6: Classification by quantity of impeller

Single Stage Type	➢ The “stage” single stage or multi stages mean “stage”; the single stage means one impeller.
Multi Stage Type	➢ The section diameter of each impeller is the center diameter of cylindrical flow part of steam turbine and one of the indexes which shows the size of steam turbine.

6. Classification by Exhaust Flow

Table- 7: Classification by exhaust flow

Single-flow Exhaust Type	➢ The pressure of steam would reduce and the volume increases its volume during passing through multiple stages. In response to this, the diameter of turbine increase and will eventually reach to the engineering limits to withstand against centrifugal force. In order to achieve large-scale condensing turbine which available to massive steam is under this constraint, the LP which the blade area is expanded by providing separated multiple groups of LP blades with groups HP blades. The HP and IP turbine which has a steam inlet and a steam outlet is called as Single‐flow Exhaust type.
Multi-flow Exhaust Type	➢ It is divided into not only HP and LP but also HP, IP and LP for large turbine according to the properties of steam. The inlet of LP turbine is placed in the center of casing, the steam flow along with axis oppositely and is exhausted from both end rooms. It is called double-flow exhaust type in such an arrangement. ➢ If the double-flow is applied, it is possible no only to simplify LP turbine than two casing type, but also is possible to reduce the burden and friction losses on the thrust bearing because of the offset of axial thrust force.

7. Classification by Direction of Shaft

Table- 8: Classification by direction of shaft

Transverse Type	➢ The 99% of commercial steam turbines are the transverse type.
Vertical Type	➢ It can be seen in the marine oil pump driving by steam turbine.

8. Classification by Existence of Reducer

Table- 9: Classification by existence of reducer

Direct-drive Type	➢ When the rotation speed of follower is same as turbine speed, the shaft is directly connected to each other as it is.
Reduction Type	➢ When the rotation speed of turbine is faster than follower, the turbine speed is reduced by reducing gear.

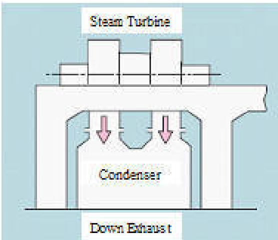
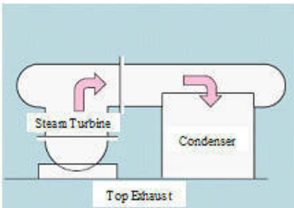
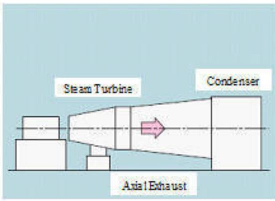
9. Classification by Quantity of Inlet Valves

Table- 10: Classification by quantity of inlet valves

Single Valve Type	➢ The only one inlet valve controls the supply of steam over the entire output. ➢ The single valve type causes output loss due to the pressure drop when through the valve compared with multi valve type with 3 or 4 valves. This is the reason why there is an fully open valve in multi valve type and be capable to minimize pressure loss in case of half flow, and the half steam flow cause pressure drop correspondingly.
Multi Valve Type	➢ The multi valve type controls the steam flow by 3or 4 inlet valves. For example, the first valve of 4 valves is responsible for up to 0~25% and the other remaining valves close in multi valve type. The second valve of 4 valves is responsible for up to 25~50%, the first valve is open fully and the other valves close. The third valve is responsible for up to 50~75%, the first and second valves are open fully and the other valves close. The fourth valve is responsible for up to 75~100%, the first, second and third valves are open fully.

10. Classification by Exhaust Direction

Table- 11: Classification by exhaust direction

Down Exhaust	➢ The down exhaust is applied for almost condensate turbine for generation, and it is necessary to provide the turbine pedestal and dug deep pit which the condenser is stored. It has not much pressure loss on this type; however it is not capable to expect the pressure recovery more than axial exhaust.	
Top Exhaust	➢ The exhaust steam is discharged upward to turbine, and then will be turned 90 degree and turned down 90 degree again and is guided to the condenser. The pressure drop due to the change of direction in the two places and in the horizontal exhaust pipe affects the performance of turbine.	
Axial Exhaust	➢ The exhaust loss is less than other type. It is expected the much pressure recovery applying the diffuser shape for exhaust duct. It is possible to arrange the equipments including condenser on the basement and to reduce turbine pedestal, height of power house and exhaust pipe, structure and supporting rack.	

11. Typical Construction of Steam Turbine

The typical construction of steam turbine is illustrated as shown in Photo-1~8 and Fig-1~Fig-4. The appropriate type must be selected to suit location, arrangement, purpose for use or installed capacity.

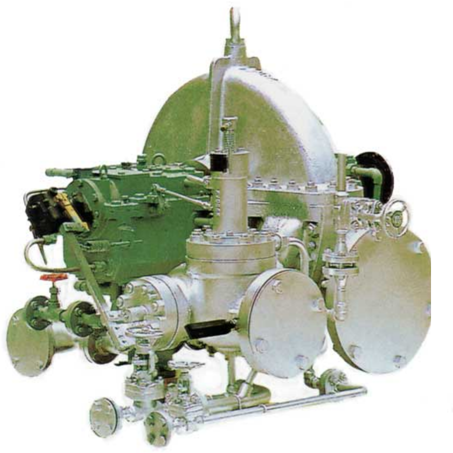


Photo- 1: 25kW class ST

http://macken.en.made-in-china.com/product/BbqQxCeUEIWN/China-Small-Steam-Turbine.html

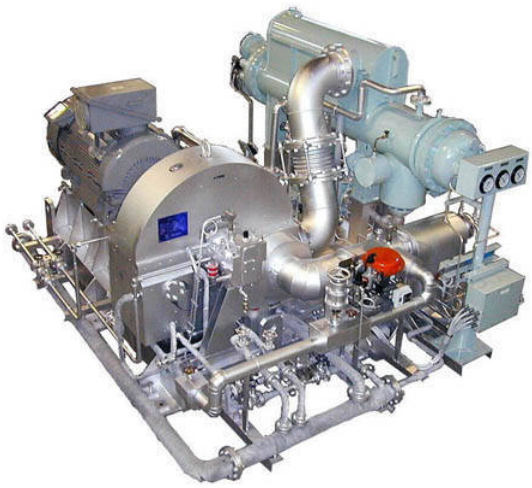


Photo- 2: 200kW class ST

http://www.shinkohir.co.jp/plant-un/photo/dcm81l.jpg

Photo- 3: 1,900kW class ST

http://www.city.fujiyoshida.yamanashi.jp/div/bika/img/204_tabin.jpg

Photo- 4: 8,000kW class ST

http://www.akashi-e-gomi.info/10015/25.html

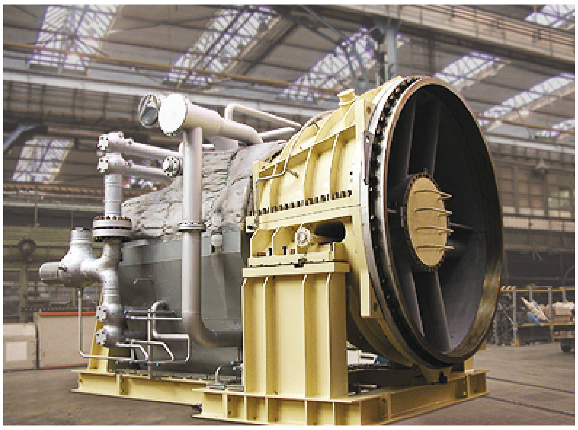


Photo- 5: 30MW class ST

http://www.turbocare.com/used_steam_turbines.html

Photo- 6: 65MW class ST (Siemens)

http://www.ecool.jp/foreign/2012/02/siemens12-st1463.html

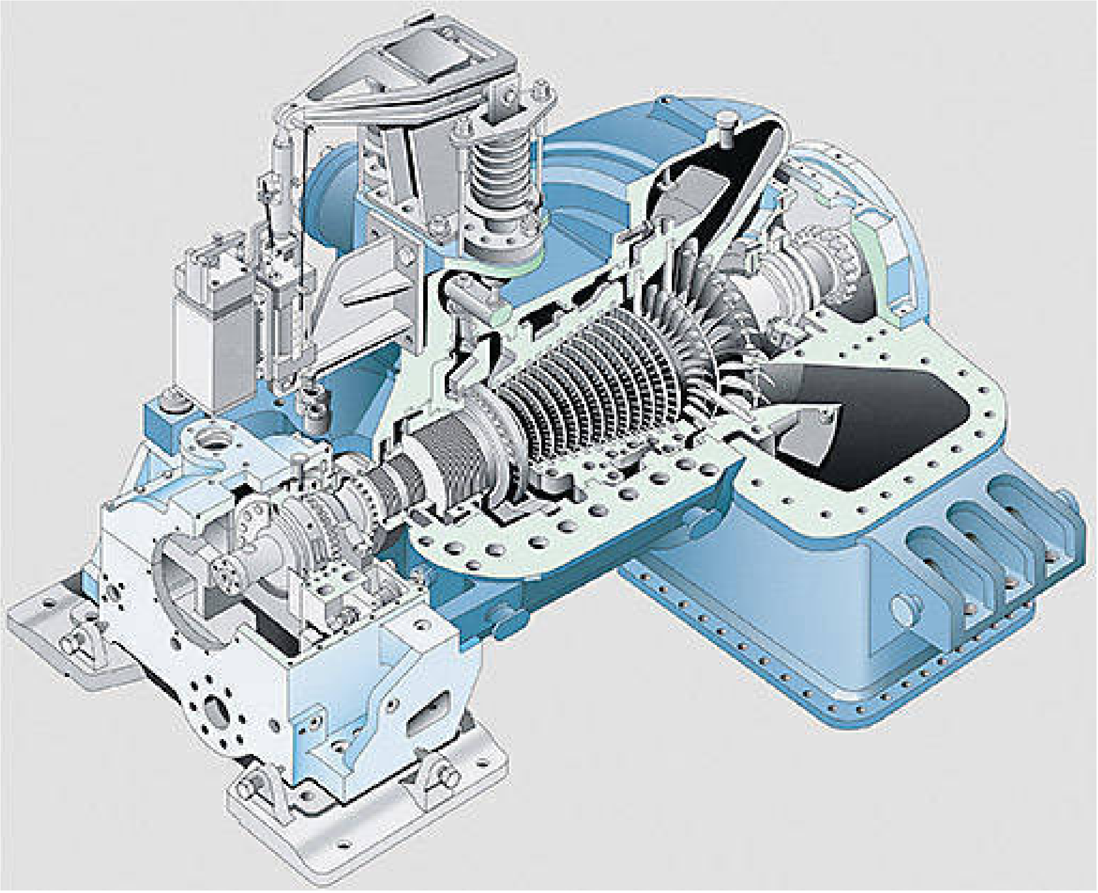


Fig- 1: Typical Construction of steam turbine (single casing)

http://mogalddinsmore.blogspot.com/2010/06/steam-turbines.html

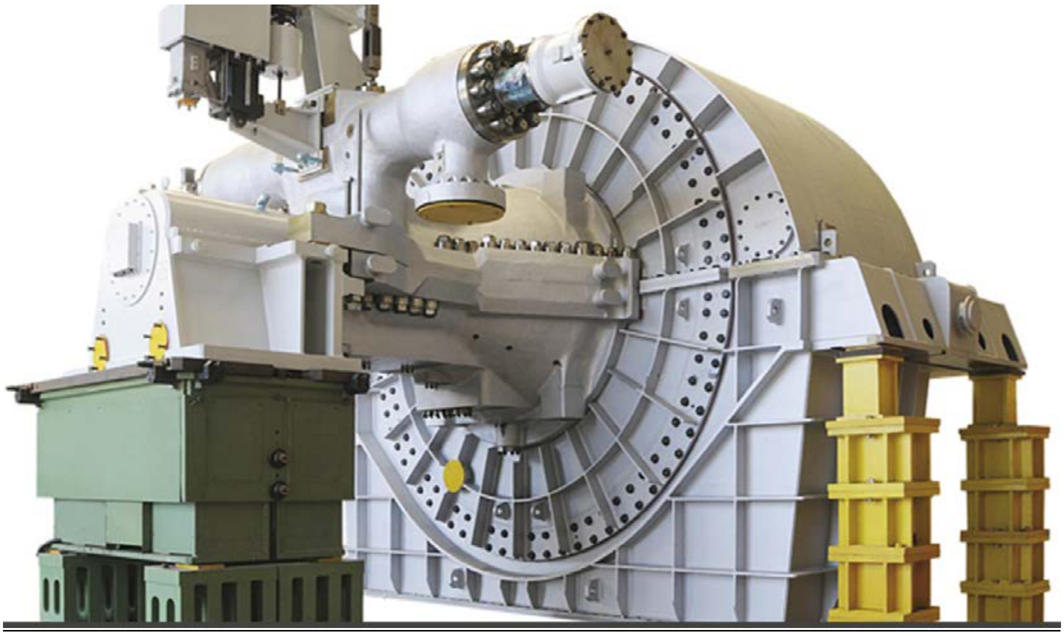


Photo- 7: 65MW class axial flow steam turbine (GE)

http://www.ge-energy.com/products_and_services/products/steam_turbines/iwpp_steam_turbine.jsp

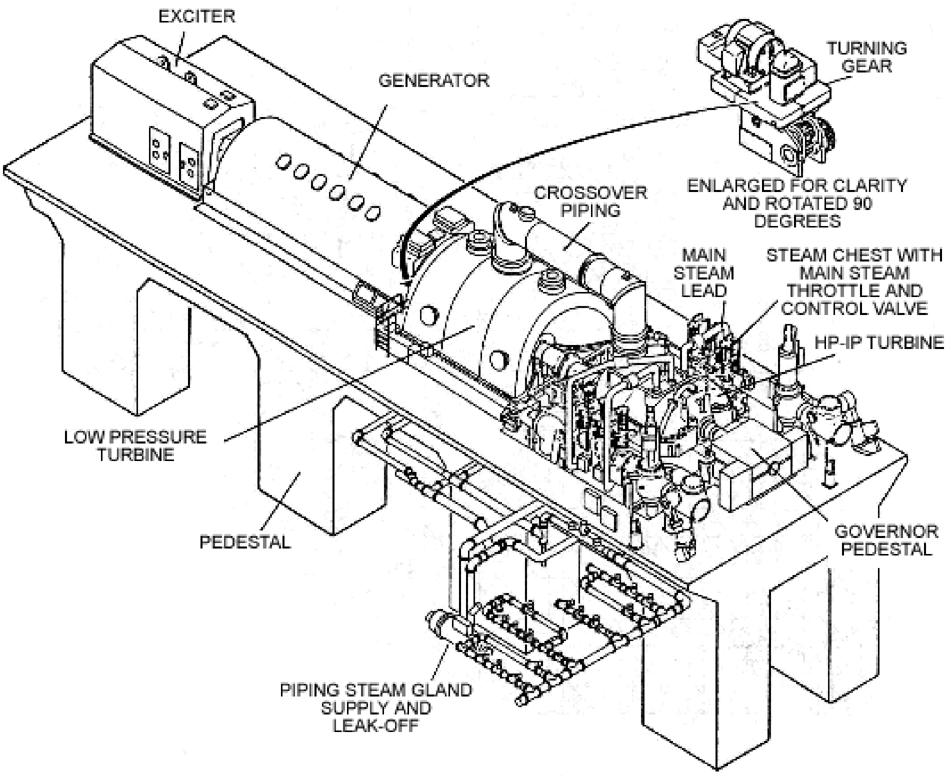


Fig- 2: Typical Construction of steam turbine (double casings 375MW class)

http://www.emt-india.net/process/power_plants/steam_turbine.htm

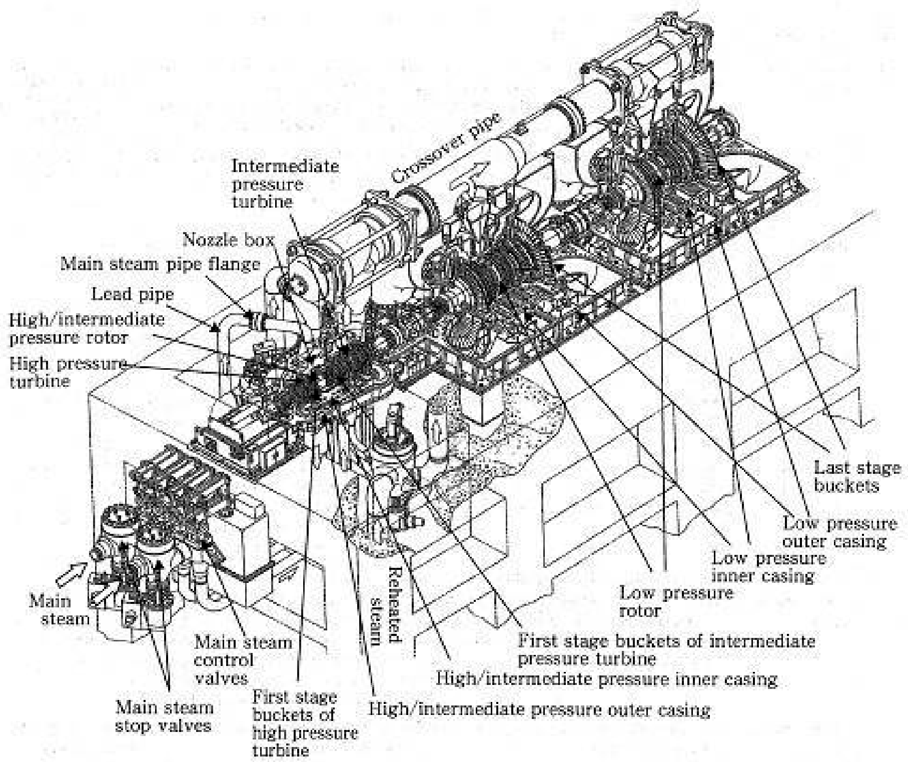


Fig- 3: Typical construction of steam turbine (triple casings 600MW class)

Reference: P-239 of Handbook for thermal and nuclear power engineers English Ver.7

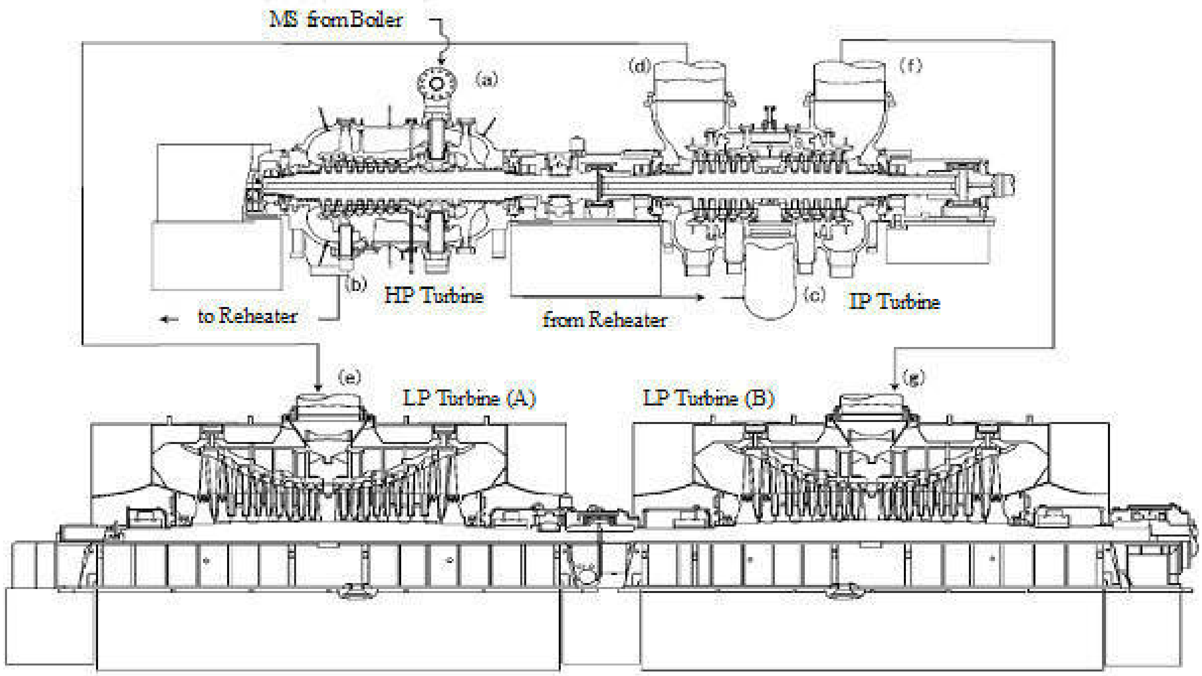


Fig- 4: Typical construction of steam turbine (cross compound type 1,000MW class)

Reference: P-67 of Journal (No.574: Jul. /2004): TENPES

Photo- 8: Typical construction of steam turbine (cross compound type 1,000MW class)

http://www.hitachi.co.jp/products/power/large-generator/product/lineup/1000.jpg

Turbines are often described by the number of stages. For example, single stage turbines are usually small units that drive pumps, fans, and other general purpose equipment in a facility. For medium size steam turbines that drive air conditioning chillers or generators, 4 to 10 stages may be utilized. Anyway every size is available for the power generation, if the steam is available. In large size units, there may be 12 to 40 stages driving generators or other equipment. These stages may be grouped into different sections of the turbine. The section with the highest pressure levels is called the high pressure (HP) section. The intermediate pressure (IP) section has the mid-level pressure levels. The low pressure (LP) section has the lowest pressure levels and discharges to the condenser or backpressure system. The turbine sections can be packaged into separate sections in a single turbine casing, into separate casings for each section, or in combination (HP/IP turbines in one casing and LP turbine in another). In addition, in many LP turbines and some HP and IP turbines, there are two turbines connected together in the same casing but in opposing directions to balance the thrust loads. Flow to these turbines is through the center of the casing and exits from each end of the turbine. These are referred to as turbines with double flows (i.e., opposing flow-paths on same shaft). The MW rating of the steam turbine, however, may not be indicative of the number of sections or casings which make up the turbine. This is exemplified in Fig-2~4 where a 750 MW turbine could consist of 2, 3 or 4 casings. Of course the fewer number of casings and stages for the same steam conditions results in high loadings and larger size blading for these model turbines, particularly in the last stage. The selection of which configuration is utilized is dependent on economics (cost and efficiency) and customer desires.

The typical numbers of turbine casing is shown in Fig-5and 6 depending on the output.

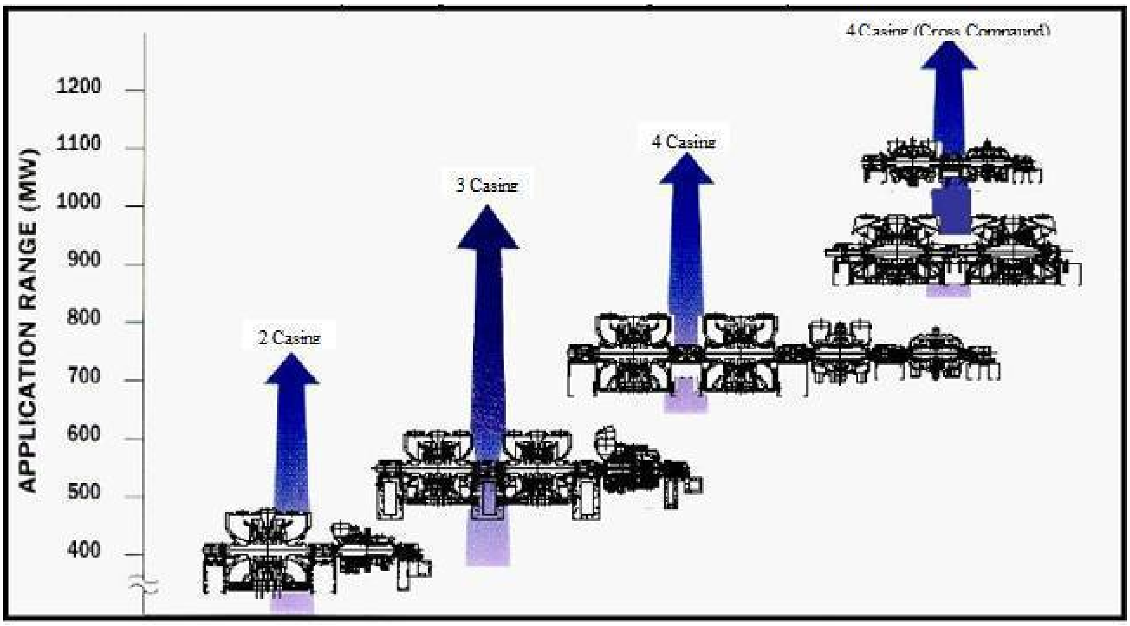


Fig- 5: Number of turbine casings as a function of steam turbine size (MHI)

Reference: P-14 of "Maintenance and Overhaul of Steam Turbines" IMIA-WGP 42-2005

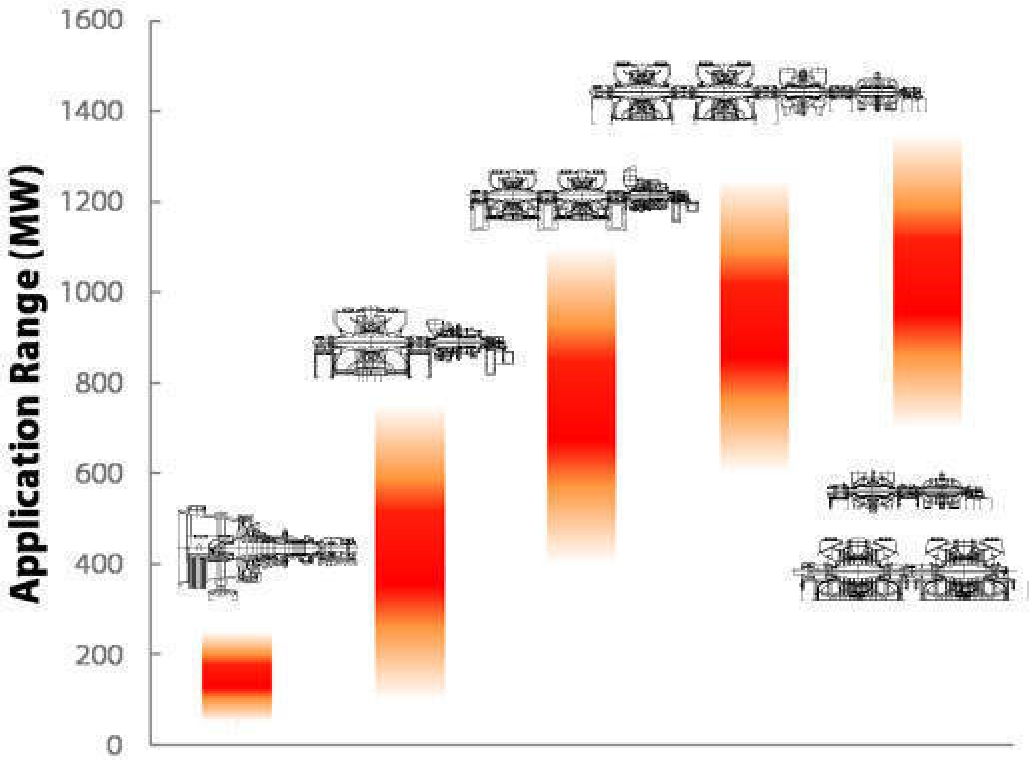


Fig- 6: Number of turbine casings as a function of steam turbine size (MHI)

http://www.mpshq.com/sys/img/pic/st_app_range.jpg

12. Steam Condition for Steam Turbine

The combination of steam condition, for instance, main steam pressure, and main steam temperature and reheat steam temperature are depending on the type, kind and use, and are not stipulated. The general condition is organized as shown in Table-12 for reference.

Table- 12: Steam condition for steam turbine

Steam condition	Type / Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
MS press.	MPa (g)	5.9	8.6	10.0	10.0	12.5	16.6	16.6	18.6	24.1	24.1	24.1	31.0	24.1	24.1	24.0	25.0
MS temp.	°C	485	510	538	538	538	566	566	538	538	538	538	566	538	566	593	600
RS temp.	°C	–	–	–	538	538	538	566	538	538	566	552	566	593	593	593	610
		–	–	–	–	–	–	–	–	–	–	566	566	–	–	–	–

Note-1: It may be dealt with as being conformed to this table, if the main steam pressure is within ±5% of listed above and main steam temperature is within ±5% °C.:

Note-2: Type 11 and 12 show the example of the two-stage reheat type.

Reference: P-257 of Handbook for thermal and nuclear power engineers JapaneseVer.7

13. Materials for Main Part of Steam Turbine

The general application of materials for steam turbine is listed as in Table-13 for reference. The exact materials to be applied for each steam turbine shall be determined depending on the operating condition required by purchaser under the responsibility of manufacturer.

Table- 13: Materials for main part of steam turbine

Part		Representative material and equivalent standard	Required characteristics
HP and IP turbine	Rotor	1Cr-Mo-V alloy steel（ASTM A470 Cl, 8） 12Cr-Mo-V-Nb-N alloy steel, 12Cr-Mo-V-Ta-N alloy steel 12Cr-Mo-V-W-Nb-N alloy steel, 12Cr-Mo-V-W-Nb-B-N alloy steel 12Cr-Mo-V-W-Co-Nb-B-N alloy steel 2.5Cr-Mo-V steel*, 2.25Cr-Ni-Mo-V(W) alloy steel*	Creep (fracture) toughness, ductile strength, thermal fatigue strength, high temperature stability, productivity of large forgings
	Blade and nozzle	12Cr alloy steel（AISI 430, SUS 403） 12Cr-Mo-V alloy steel 12Cr-Mo-V-W alloy steel（AISI 422, SUS616） 12Cr-Mo-V-Nb-N alloy steel（H46） 12Cr-Mo-V-W-Nb-N alloy steel, 12Cr-Mo-V-W-Nb-B-N alloy steel	Creep (fracture) toughness, ductile strength, fatigue, ant-corrosion, high temperature stability

Part		Representative material and equivalent standard	Required characteristics
		12Cr-Mo-V-W-Co-Nb-B-N alloy steel Ni based super-alloy（R26, Nimonic80A，DINI7740）	
	Casing and main valve	1Cr-Mo alloy steel（ASTM A356 Gr6，SCPH21，22） 1Cr-Mo-V alloy steel（ASTM A356 Gr8・9，SCPH23） 2.5Cr-Mo alloy steel（ASTM A356 Gr10，SCPH32） 12Cr-Mo-V alloy steel（DINI7245） 12Cr-Mo-V-W-Nb-N alloy steel 12Cr-Mo-V-W-Co-Nb-B-N alloy steel 9Cr-1Mo alloy steel（ASTM A182 F91） 12Cr alloy steel, Ductile cast iron（DINI693）	Creep (fracture) toughness, ductile strength, fatigue, thermal fatigue strength, high temperature stability, weldability
	Bolt	1Cr-Mo-V alloy steel 12Cr-Mo-V-W alloy steel（AISI 422，SUS616） 12Cr-Mo-V-Nb-N alloy steel（H46，DINI7240） 12Cr-Mo-V-Nb-W-N alloy steel 12Cr-Mo-V-Nb-W-B-N alloy steel Ni base super-alloy（R26，Nimonic80A，Incone1718）	Creep (fracture) toughness, ductile strength, fatigue, stress relaxation characteristic, fatigue strength
LP turbine	Rotor	3.5Ni-Cr-Mo-V alloy steel（ASTM A470 C1.7） 2.5Ni-Cr-Mo-V alloy steel	Tensile strength, ductile strength, fatigue, productivity of large forgings
	Blade and nozzle	12Cr alloy steel（AISI 403，405，SUS 403，405） 12Cr-Mo-V alloy steel（X20Cr-Mo-V121） 12Cr-Ni-Mo-V-N allot steel (JETHEAT，M152，M153，M165） 17-4PH alloy steel（SUS630） 12Cr-Ni alloy steel, 15CrPH alloy steel, Ti	Tensile strength, ductile strength, fatigue strength
	Casing	Carbon steel	Tensile strength, ductile strength, weldability

Note: (*) integrated rotor HP with LP

Reference: Thermal and nuclear generation: feature article-design and material of steam turbine: Oct. /2002

14. Material Application for Hot Part

The general application of materials for steam turbine hot part is listed as in Table-14 for reference. The exact materials to be applied for each steam turbine shall be determined depending on the operating condition required by purchaser under the responsibility of manufacturer.

Table- 14: Material application for hot part of steam turbine

Steam condition	MS press.	24.1MPa	24.1MPa	24.1/25.1MPa
	MS temp.	538°C	566°C	593/600°C
	RS temp.	566°C	593°C	593/610°C
High pressure rotor		Cr-Mo-V alloy forged steel		12Cr alloy forged steel Improved 12Cr alloy forged steel
HP1st stage blade		12Cr alloy forged steel		Improved 12Cr alloy forged steel Ni base super-alloy
HP nozzle box		Cr-Mo-V alloy cast steel		12Cr alloy cast steel High Cr forged steel
HP outer casing		Cr-Mo-V alloy cast steel Cr-Mo alloy cast steel		12Cr alloy cast steel Improved 12Cr alloy cast steel
HP inner casing		Cr-Mo-V alloy cast steel		12Cr alloy cast steel Improved 12Cr alloy cast steel
IP rotor		12Cr alloy forged steel	Improved 12Cr alloy forged steel	
IP1st stage blade		12Cr alloy forged steel	Improved 12Cr alloy forged steel Ni base super-alloy	
IP outer casing		Cr-Mo-V alloy cast steel Cr-Mo alloy cast steel		
IP inner casing		Cr-Mo-V alloy forged steel	12Cr alloy cast steel Improved 12Cr alloy cast steel	
Main stop valve Steam governor valve		Cr-Mo-V alloy cast steel Cr-Mo-V alloy forged steel	Cr-Mo-V alloy forged steel 9Cr alloy forged steel	12Cr alloy cast steel 9Cr allow forged steel Improved 12Cr alloy cast steel
Reheat stop valve		Cr-Mo-V alloy cast steel	9Cr allow forged steel 12Cr alloy cast steel 12Cr alloy forged steel Improved 12Cr alloy cast steel	

Reference: Thermal and nuclear generation: feature article-design and material of steam turbine: Oct. /2002

Article 30. Materials of Auxiliary Facility for Steam Turbine

Article 30-1-1. Pressure Part

1. The "**pressure part**" stipulated in Article 30-1 of design technical regulation must be considered the part which is exposed inside the pressure of exceed 0MPa.

Article 30-1-2. Stable Chemical Composition and Mechanical Strength

1. The material which have "**stable chemical composition and mechanical strength**" stipulated in Article 30-1 of design technical regulation must be the material which is excellent in welding performance, strain strength, ductility, toughness and hardness, etc. and it may use the materials listed in Appendix-1-1. "Ferrous material", Appendix-1-2-1 "ASME Sec. II Part-D Standard Material", Appendix-1-2-2 "ASME B31.1 Standard Material", and Appendix-2-1 "No-ferrous material", Appendix-2-2-1 "ASME Sec-II Part-D Material".

Article 31. Structure of Steam Turbine, etc.

Article 31-1. Rotational Speed when Emergency Governor Operates

1. The **"rotational speed when emergency governor operates**" stipulated in Article 31-1 of design technical regulation means including further boost rotational speed more than the time when the emergency speed governor is operating.

Article 31-2. Maximum Vibration

1. The "**maximum vibration**" stipulated in Article 31-2 of technical regulation means the largest one during the all operation process including start and stops of the steam turbine.

Article 31-3-1. Abnormal Wear, Transformation and Over-heat

1. The facility which **"shall not occur abnormal wear, deformation and over-heat**" stipulated in Article 31-3 of design technical regulation means the facility which has following equipments. However, it is not necessary to provide the equipment mentioned in item-(3) for steam turbine 10MW or less.

(1) main oil pump to supply oil for steam turbine during usual operation
(2) back-up oil pump to supply oil automatically for steam turbine if discharge pressure of main oil pump dropped
(3) emergency oil pump or manual auxiliary pump to stop steam turbine safely if main oil pump and auxiliary oil pump were failed
(4) main oil tank to reserve full lubrication oil required for usual operation of steam turbine including inactive situation
(5) equipment to keep lubrication oil clean (the strainer of bearing inlet must have standby one and be capable to switch during operation)
(6) equipment to adjust lubrication oil temperature

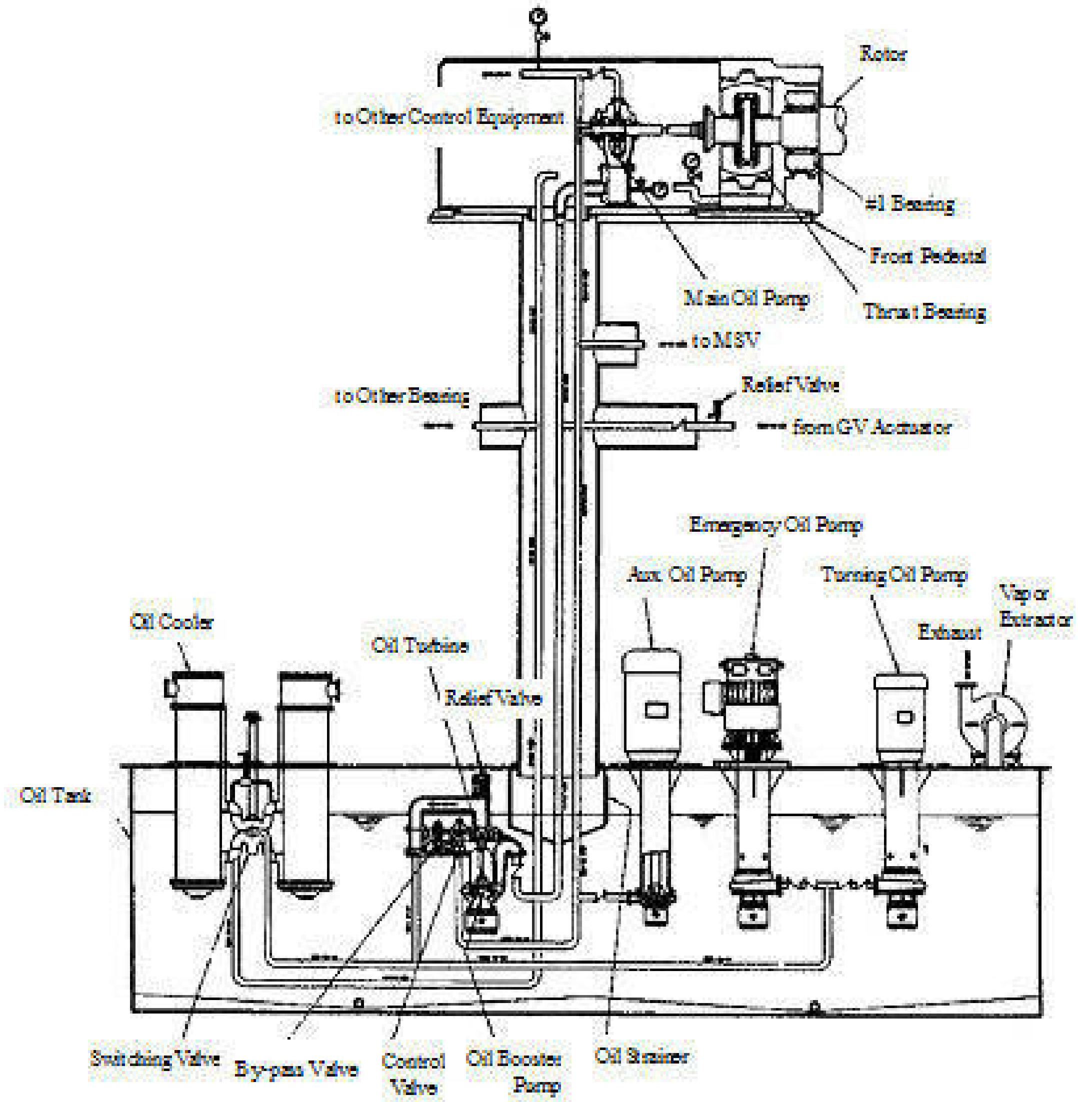


Fig- 7: Typical lubrication oil system

Reference: P-79 of Journal (No.574: Jul. /2004): TENPES

Fig-7 is the example of the lubrication oil system for steam turbine and generator. Traditionally, the lubrication oil source is shared for lubrication for bearing and control in the turbine. However, the other high pressure oil system is provided for control system which is applied EHC (Electric Hydraulic Control Method). In the general oil system, oil supplied from the oil tank goes to the main oil pump through the oil cooler. Generally, the oil pump which coupled with turbine shaft is driven by a turbine shaft. The discharge oil from the main oil pump is distributed to lubrication oil system and control oil system.

The lubrication oil passed through bearings rise its temperature 10~20^{o}C and return to oil tank through return pipe, and finish one cycle. It is very important for turbine whatever the control oil or lubrication oil. The auxiliary electric oil pump will start automatically, if the oil pressured drops by any reason, and DC emergency oil pump is provided for electric power outage. Moreover, the turning oil pumps for turning during stoppage of turbine. These pumps are usually installed in the oil tank.

Article 31-3-2. Self-lubrication Equipment

1. When the "paragraph-2 of JESC T4001-1998: Self-lubrication Equipment by Oil Ring for Small Multipurpose Steam Turbine" as shown in Fig-8 and 9 is applied for the steam turbine 10MW or less, the paragraph-1of this article is not applied.

Fig- 8: Oil ring

http://www.machinerylubrication.com/Read/652/black-oil-causes

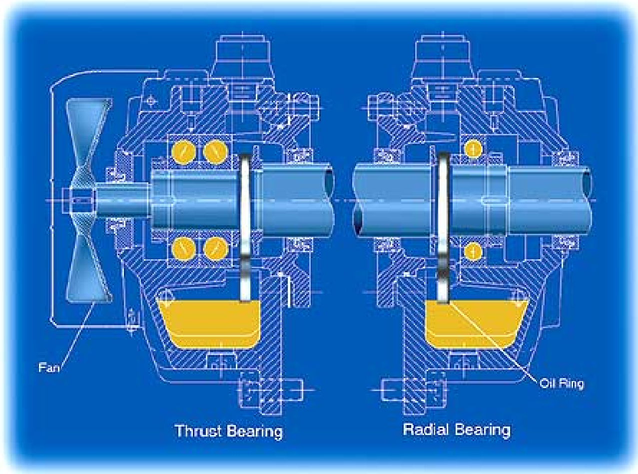


Fig- 9: Self-lubrication mechanism

http://media.noria.com/sites/archive_images/Backup_200409_BlackOi-Fig1.jpg

Article 31-3-3 Bearing

1. Fig-10 and Photo-9 shows the typical journal bearing which supports rotor as main bearing. The bearing body is separated in two horizontal planes, the lubricant oil is force feed into lower half and the frictional heat is removed with them. The bearing connected to pedestal through a sphere with upper housing and deal with the movement of the rotor. The contact surface with the rotor is covered by white metal alloy (Babbitt metal) which is mainly composed of tin. This alloy is applied to the bearing, because it has a less coefficient of friction, fit well and is easy to repair because of the low melting temperature.

   The pad bearing which has excellent stability is applied to, if the occurrence of pressure pulsation attributed to the oil film is concerned. This bearing has a construction which end surface is separated in several segments (Pads). The bearing shown as Fig-11 and Photo-10 is the one type of it and it is called the double tilting pad bearing. The back of the pad itself is dressed in sphere and has simple construction. The thrust bearing is responsible for maintaining the longitudinal position of the rotor and is an important mechanism in maintaining a predetermined value of the stationary and rotating parts clearance as shown in Fig-12~13. The Mitchell type, Kingsbury type or Taper-land type are mainly applied to, however, every types are common to being considered to formulate oil wedge film. Fig-14, 15 and Photo-11, 12 shows the plain image of each Mitchell type and Taper-land type.

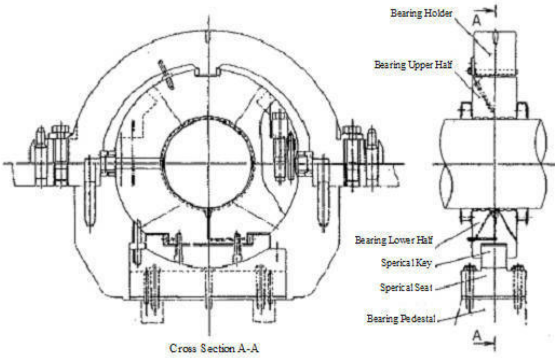


Fig- 10: Turbine journal bearing

Reference: P-78 of Journal (No.574: Jul. /2004): TENPES

Photo- 9: Turbine journal bearing

http://www.mdaturbines.com/wp-content/uploads/2010/01/Tilt-Pad-Journal-Bearing-1-1024x759.jpg

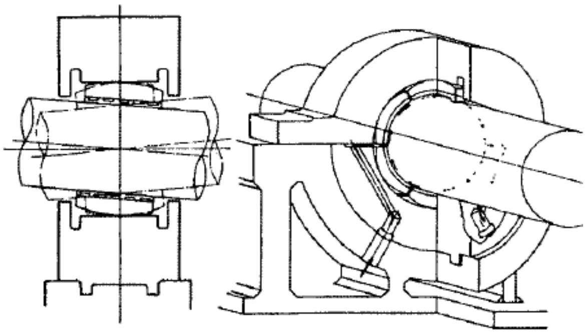


Fig- 11: Double tilting pad bearing

Reference: P-78 of Journal (No.574: Jul. /2004): TENPES

Photo- 10: Double tilting pad bearing

http://www.jhrichards.co.uk/#/repair/4527363397

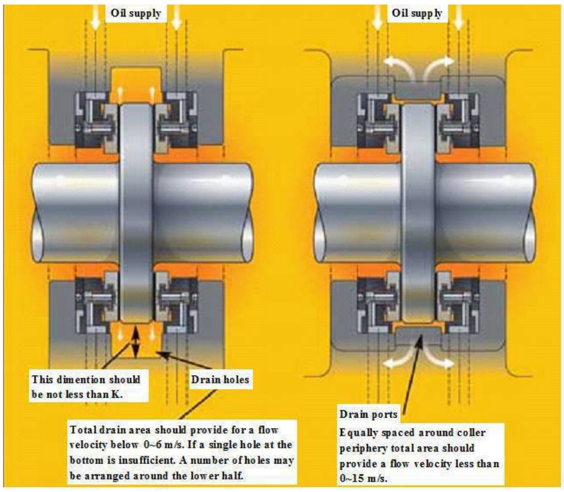


Fig- 12: Thrust bearing

http://media.noria.com/sites/archive_images/Backup_200607_Lube101Fig2.jpg

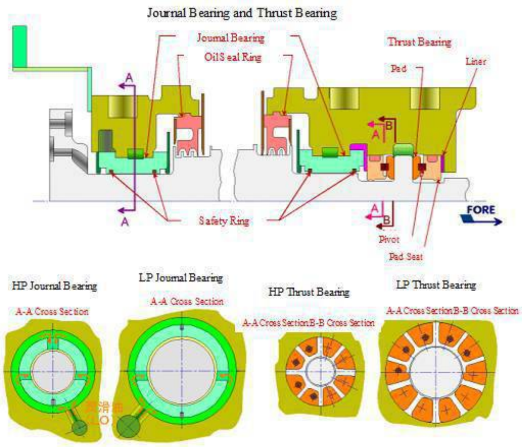


Fig- 13: Turbine bearings

http://www004.upp.so-net.ne.jp/hyoshi/ship/t-plant/t-bearing.gif

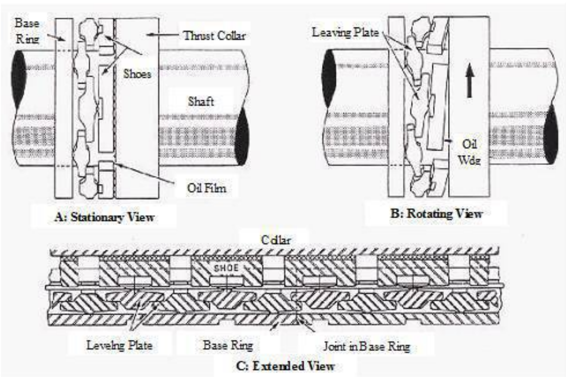


Fig- 14: Kingsbury thrust bearing

http://www.tpub.com/engine3/en33-20.htm

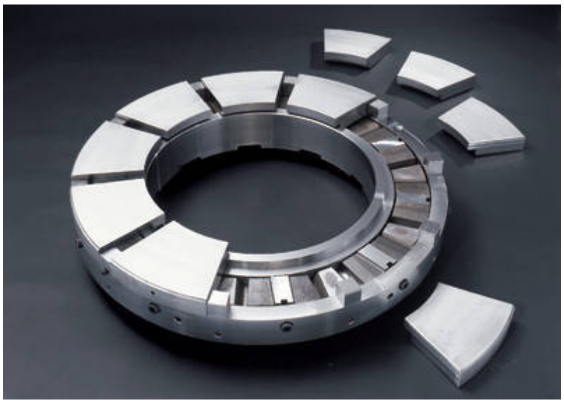


Photo- 11: Kingsbury thrust bearing

http://www.marunda.com.sg/power/images/stories/products/waukesha/tilting_pad_thrust.gif

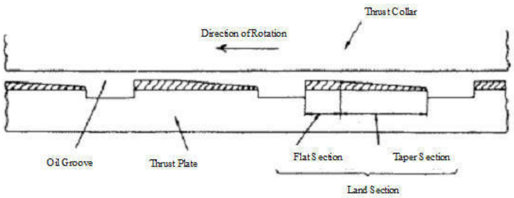


Fig- 15: Taper-land thrust bearing

Reference: P-78 of Journal (No.574: Jul. /2004): TENPES

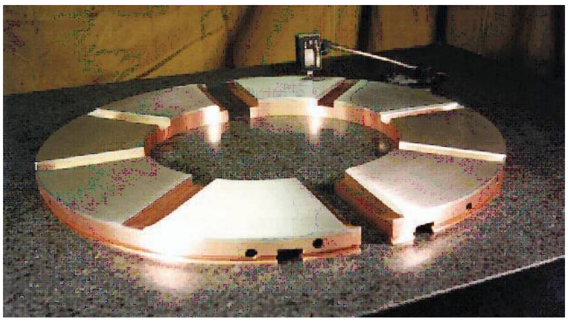


Photo- 12: Taper-land thrust bearing

http://www.mdaturbines.com/wp-content/uploads/2010/01/RenewalPartsMaintenance_Brochure.pdf

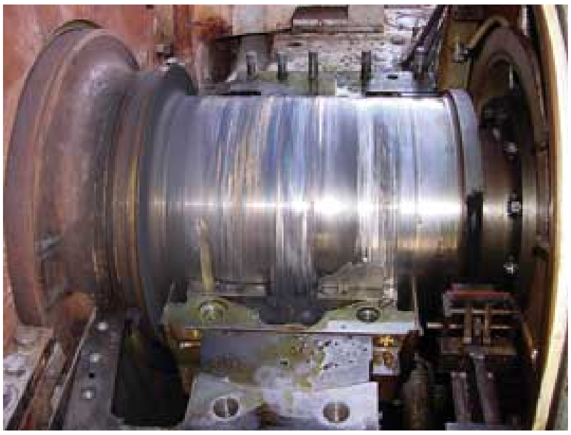


Photo- 13: Damaged journal bearing

http://www.machinerylubrication.com/Read/865/turbine-lube-system

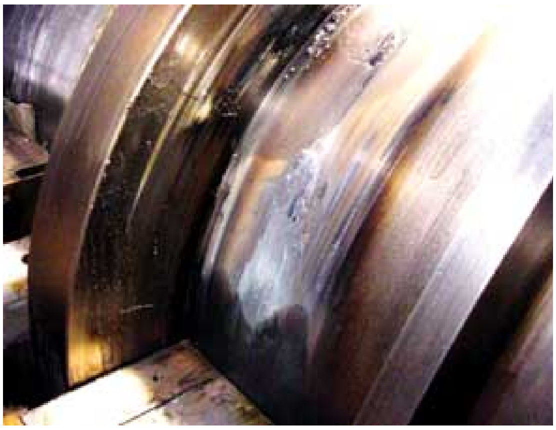


Photo- 14: Damaged thrust bearing

http://www.machinerylubrication.com/Read/865/turbine-lube-system

Article 31-3-4. Jacking Oil Pump

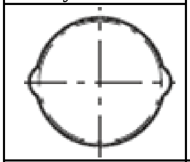
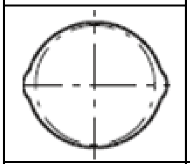
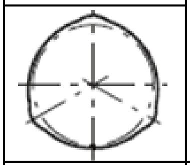
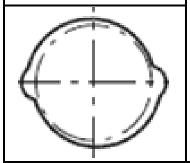
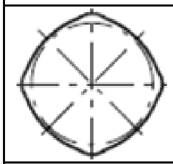
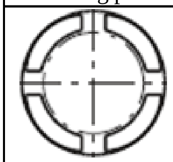
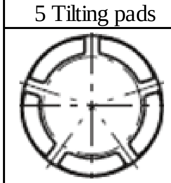
1. A jacking oil pump also called a lift pump is commonly used on rotor shafts of steam driven Turbine Generators prior to startup or after shutdown to provide even cooling of the shaft and eliminate rotor distortion caused by sags due to weight and bows due to uneven cooling. The jacking oil pump uses high pressure oil supplied at the bearing journals to initiate an oil film and lift the shaft off its bearings. The rotor can then be put on a turning gear and rotated slowly to create even cooling and or roll out any distortions caused by the weight of the shaft while at rest. It also helps to maintain the oil film between shaft and the bearing till the rotor speed is adequate enough to maintain the film thickness and protects the shaft & bearing.

   They are necessary today because of the large turbines with multiple low pressure shells. The longer the rotor the more likely to do damage to it as it rolls off of turning gear. The turbines containing only two low pressure wheels can be started with an auxiliary oil pump that supplies higher pressure than turning gear pumps. Most large turbines have been retrofitted with lift pumps because they prevent damage to the rotor and journals free from the damage like Photo-13 and 14.

Article 31-3-5. Clearance Adjustment of Turbine Bearing and Other Parts

1. The type and application criteria of journal bearing are recommended as shown in Table-15.

Table- 15: Bearing bore configuration selection table

Bore shape	Peripheral speed	Surface pressure 1MPa=1N/mm^2	Sommerfield number	Stiffness/ damping	Relative costs	Applications
Cylindrical 	0…30 (35)m/s	0.2…4.5 (5) Mpa	0.5…10	● ●●●●●	●	Gearboxes Steam tudbines Electric motors Generators
Lemon bore 	25…70 (80)m/s	0.2…3.5 (4) Mpa	0…1.5	●● ●●●●	●●	Gearboxes Steam tudbines Electric motors Generators
3 Lobe 	30…90 (100)m/s	0.1…3.0 (3.5) Mpa	0…1.0	●●● ●●●	●●	General information: Small shaft diameter at high speeds Turbochargers
Offset halves 	20…90 (100)m/s	0.2…3.5 (4.0) Mpa	0…2.0	●●● ●●●●	●●	Gearboxes High-speed pumps Expansion turbines Refrigeration turbines Machine tool spindles
4 Lobe 	30…90 (100)m/s	0.1…2.0 (2.5) Mpa	0…1.0	●●● ●	●●	Gearboxes High-speed pumps Expansion turbines Refrigeration turbines Machine tool spindles
4 Tilting pads 	30…100 (120)m/s	0…2.5 (3.0) Mpa	0…1.0	●●●● ●●●●	●●●●	Gearboxes Steam turbines Single shaft compressors
5 Tilting pads 	30…100 (120)m/s	0…3.0 (3.5) Mpa	0…1.0	●●●●● ●●●●	●●●●	Turbo gear boxes Turbo compressors Steam turbines Gas turbines

http://www.johncrane.co.uk/PDFs/12115TiltingPadJournal_web%5B1%5D.pdf

2. The bore clearance of turbine bearing affects to the good supporting of rotor and rubbing blades and vanes. The diameter of shaft and bore diameter are designed and machined precisely in the design and manufacturing stage. The typical value of large scale 50Hz machine is shown in following Fig-16 and Table-16. The exact value must be determined by manufacturer correctly.

Table- 16: Clearance adjustment of turbine bearing and other parts

(mm)

Rotation Speed				1,500rpm	3,000rpm	
Rate Output				1,100MW	600MW	1,000MW
Steam Condition	Main Steam		Pressure	6.55Mpa	24.1MPa	24.1MPa
			Temperature	282.4^{o}C	538^{o}C	538^{o}C
	Reheat Steam		Temperature	—	566^{o}C	566^{o}C
Radial Clearance	Diameter of Journal and Value "A"	HP	Front	558	305	406
				0.50~0.60	0.40~0.50	0.53~0.63
			Rear	558	381	508
				0.50~0.60	0.50~0.60	0.66~0.76
		IP	Front	—	305	533
				—	0.40~0.50	0.69~0.79
			Rear	—	381	533
				—	0.50~0.60	0.69~0.79
		LP	Front	736	432	686
				0.66~0.76	0.56~0.66	0.89~0.99
			Rear	787	508	737
				0.71~0.81	0.66~0.76	0.96~1.06
		Reference Value		$\frac{1.0}{1000}D$	$\frac{1.3}{1000}D$	$\frac{1.3}{1000}D$
		Tolerance		$\frac{2.0}{1000}D$	—	—
	Minimum Value between Blade and Vane			1.50~3.00	1.27	1.27
	Grand Part (HP~LP)			0.65~1.00	0.38~0.64	0.64~0.89
Axial Clearance	Clearance of Thrust Bearing (Front-Rear Total)			0.31~0.36	0.46~0.51	0.30~0.36 0.46~0.51
	Minimum Value between Blade and Vane			1.8	2.3	2.5
Centering	Tolerance			2.5/100	2.0/100	2.5/100

Reference: P-235 of Handbook for thermal and nuclear power engineers JapaneseVer.7

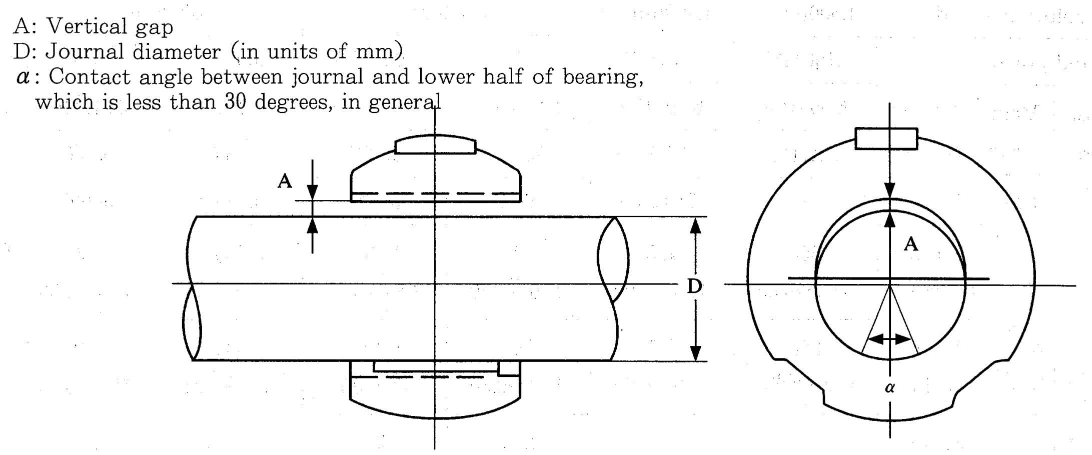


Fig- 16: Clearance of journal bearing

Article 31-3-6. Turbine Train Bearing Catenaries (alignment)

1. It is important to design the bearing alignment so that the assembled rotor become the most stable situation during operation since the position of bearing pedestal during operation, (affected by vacuum and temperature), and in stopped. Fig-17 shows the example of the alignment for 600MW steam turbine.

   The rotor-coupling is the joint which couple each rotor in order to transmit the torque generated by the generator to the turbine blades. The carved into the edge of the rotor flange are mainly applied, however, if the method to fit disk with shrink-fit method, coupling joint shall be the shrink-fit method. At least for large scale steam turbine, the rigid coupling which tighten flange bolt directly to each other is applied, although there is a flexible coupling axis to meet discrepancy. In case of relatively low-capacity steam turbine, the torque may be capable to transmit by flange friction; however, it will be necessary shear strength of bolts in increasing torque to transmit. In addition, even if the instantaneous torque is applied several times of normal situation, it is necessary to prevent disconnection bolt and phase shift at coupling surface as when the transmission torque steady reclosing time or asynchronous inputs.

   Therefore, large scale steam turbines are often used to reamer bolt as shown in Photo-15~20, and recently, the adoption of hydraulic coupling bolts has increased up since easily disassembled and reassembled.

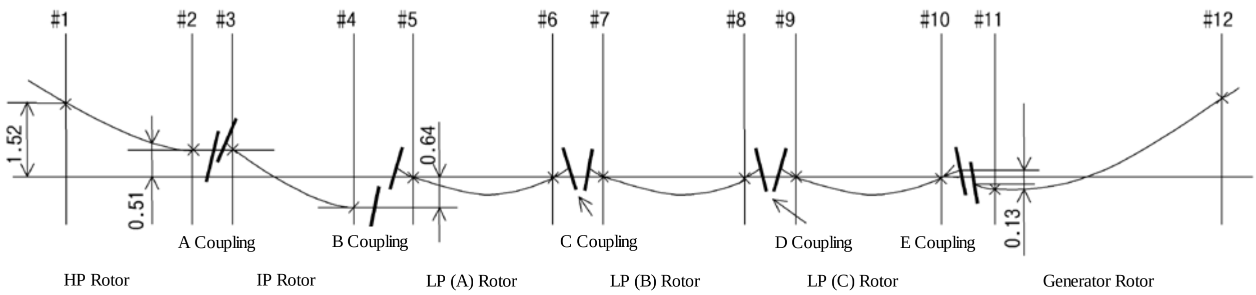


Fig- 17: Turbine train bearing catenaries (alignment)

Reference: P-75 of Journal (No.574: Jul. /2004): TENPES

Photo- 15: Coupling bolt

http://superbolt.com/applications/expansion-bolts-radial-coupling.php

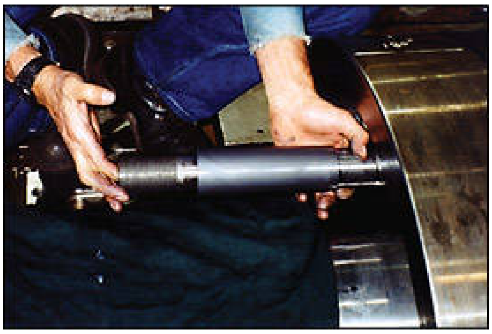


Photo- 16: Coupling bolt

http://superbolt.com/applications/expansion-bolts-radial-coupling.php

Photo- 17: Coupling bolt

http://images.vertmarkets.com/crlive/files/images/111698akturning.jpg

Photo- 18: Coupling bolt

http://superbolt.com/products-EB.php

Photo- 19: Coupling bolt MHI-M501F/G

http://www.samjinmetal.com/bbs/board.php?bo_table=j_bolt_nut&wr_id=69

Photo- 20: Coupling and coupling bolt

http://www.watermarkpacific.com/userfiles/20100910%2002%20INTER_%20SHAFT%20&%20TAIL%20SHAFT%20COUPL'G%20BOLT%20FITTING.JPG

Article 31-3-7. Turbine Blade

1. The turbine blade absorbs the energy of steam velocity and conveys it to rotor. The shape of it affects not only significant impact to the performance of turbine, it is extremely important on the designing and processing because it is required high reliability for a rotating body. Structurally, it is consist of two major components of “effective portion” which is contact with the mainstream, “root portion” which is coupled to the rotor. Fig-18 shows the outline of the various blades.

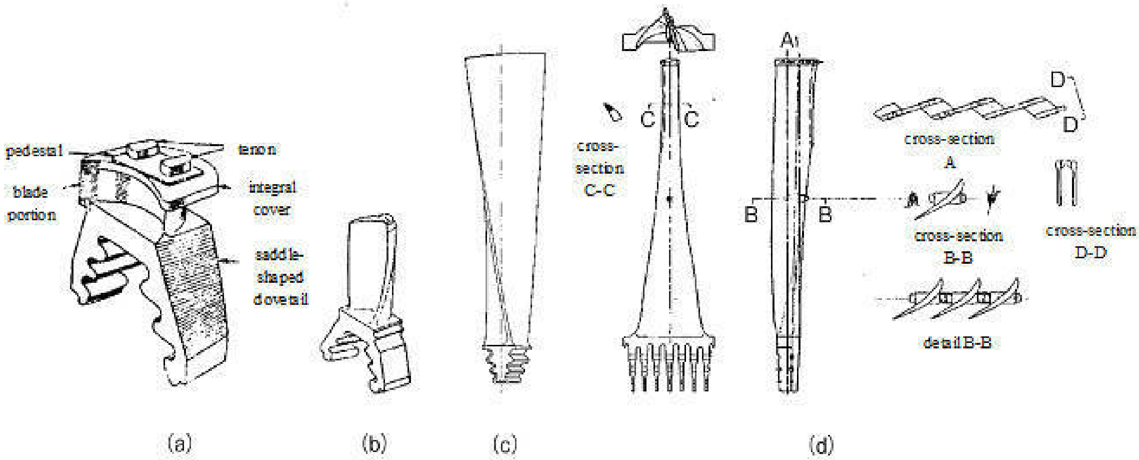


Fig- 18: Typical construction of turbine blade

Reference: P-70of Journal (No.574: Jul /2004): TENPES

The conceptual shape of “effective portion” will change depending on the degree of reaction as shown in Fig-21. In other word, the impulse blade with tick half-moon symmetrical shape becomes the asymmetric and thin crescent shape with increasing the degree of reaction. Inevitability of these shapes can be understood when comparing the direction of relative velocity w1 and w2 against inlet and outlet of vane in the velocity triangle as shown in Fig-19. The shape blade which is connected tailored lines of inlet and outlet in the velocity triangle by an arc shape in the halfway because it was easy to produce. However, in recent years, the airfoil with the special shape which was analyzed in terms of hydrodynamic performance-oriented and was supported by experiments is used. The cross-section shape and the characteristic of the dissipation factor are shown in Fig-20 as the impulse type airfoil blade. Those marked “C” in the figure is the simple blade which is modeled just line and arcs. In addition, such criteria do not meet the actual steam flow (flow pattern) just when the same cross section as it was common to fit from the root (root potion) to the tip (tip portion) because the velocity triangle is drawn only in the specific radial location (usually part of the pitch circle diameter

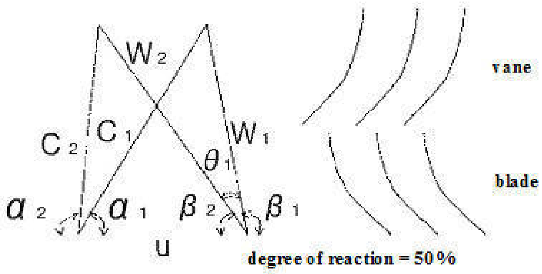


Fig- 19: Velocity triangle and shape of vane & blade

Reference: P-69 of Journal (No.574: Jul /2004): TENPES

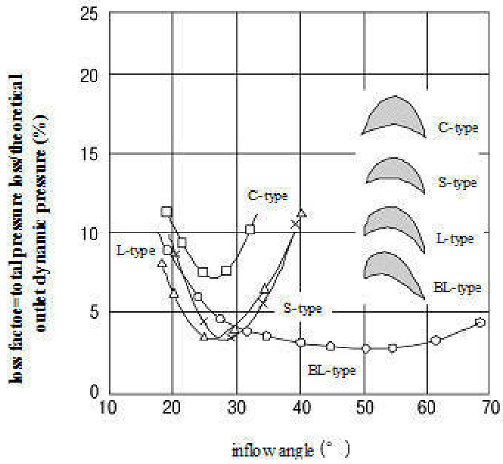


Fig- 20: Cross section and characteristics of loss

Reference: P-71 of Journal (No.574: Jul /2004): TENPES

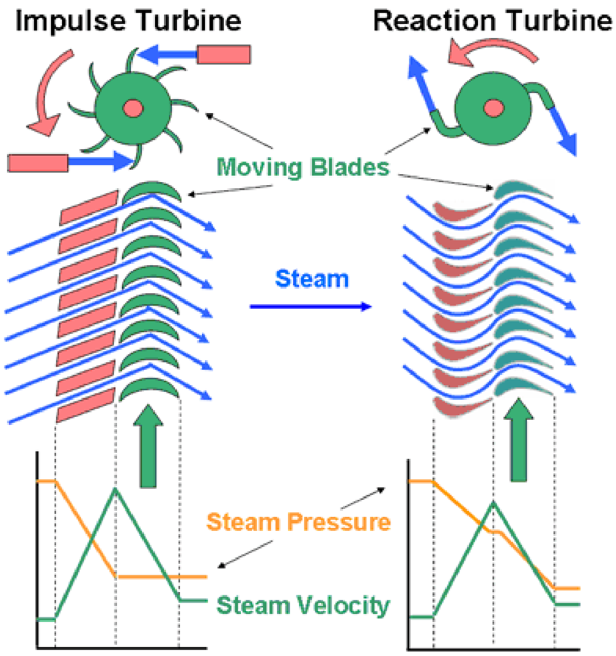


Fig- 21: Operation principle of steam turbine

http://www.mpoweruk.com/steam_turbines.htm

There is no significant effect on HP stage which has a low profile blade. However, as longer blades of the IP part, the "Free vortex design" which determine the velocity triangle at the each part of blade height and the "Three-dimensional design" which is considered the radial component of flow come to adopt the blade section which is added torsion varying the cross section along the height of blades in order to match the expected flow pattern. Usually, the shroud band which has width roughly equivalent to the root of blade is often imposed to the blade tip. This is the measures to mitigate steam leakage from blade tip and is adopted to improve performance. The tip of blade as shown in Fig-23-(a) and Fig-23-(b) are visible protrusions called "Tenon". The tenon shaped holes are drilled for each pitch of blades on the shroud a pair of blades covered with 4~10 blades, crush (tighten) and fix. The Fig-22 shows like that construction.

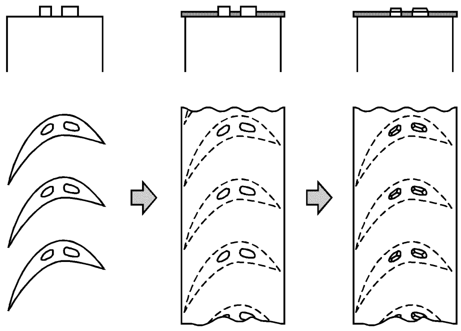


Fig- 22: Shroud assembly

Reference: P-71 of Journal (No.574: Jul /2004): TENPES

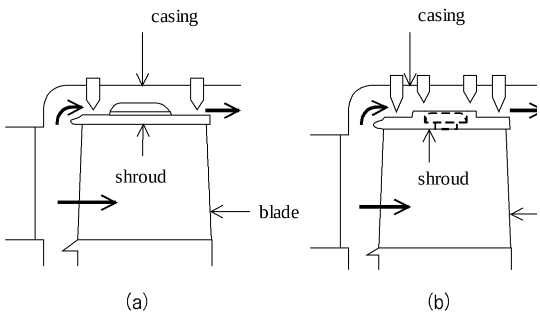


Fig- 23: Steam leakage from shroud tip

Reference: P-71 of Journal (No.574: Jul /2004): TENPES

As seen from this structure, it represents the spot of the shroud also effective to increase the rigidity of the blade group. Even if there is a shroud as shown in Fig-23, steam leaks through the gap between casings. Therefore, a large pressure difference before and after the reaction turbine blades as well as in the impulse turbine actually incorporates elements so reactionary, the measure for steam leakage at the blade tip cannot be omitted to improve performance. Usually, the fin which is called the radial stop is equipped on the casing or the projection of nozzle diaphragm is adopted, the example of the reaction turbine is shown in Fig-24 and the example of impulse turbine is shown in Fig-25. The Fig-23(b) shows the construction that the tenon is sinking in the shroud. It is an effective method to prevent erosion due to the boiler scale and drainage because there is no obstacle on the top of shroud and increasing the number of strips, in addition to aim for greater performance. More recently, the production method to make of shaving blades and shroud together without tenon is adopted widely in order to improve reliability and performance as shown in Photo-21~22.

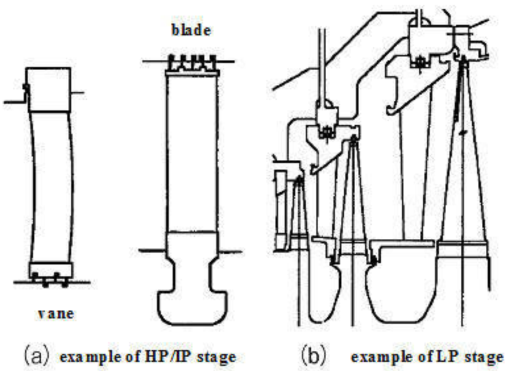


Fig- 24: Vane & blade of reaction turbine

Reference: P-69 of Journal (No.574: Jul /2004): TENPES

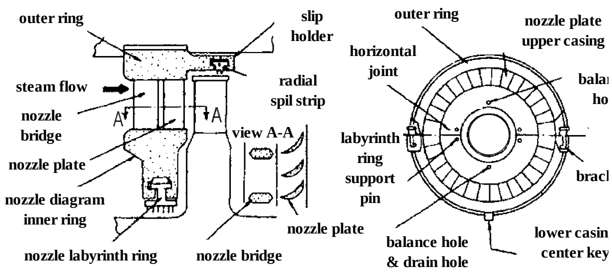


Fig- 25: Vane & blade of impulse turbine

Reference: Reference: P-69 of Journal (No.574: Jul /2004): TENPES

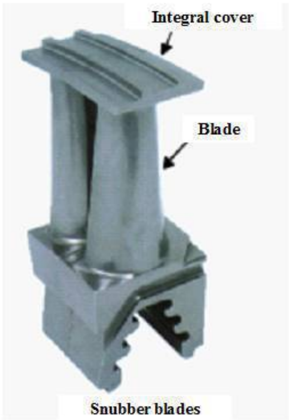


Photo- 21: Snubber blade

http://www3.toshiba.co.jp/power/english/thermal/service/turbines/advtch08.htm

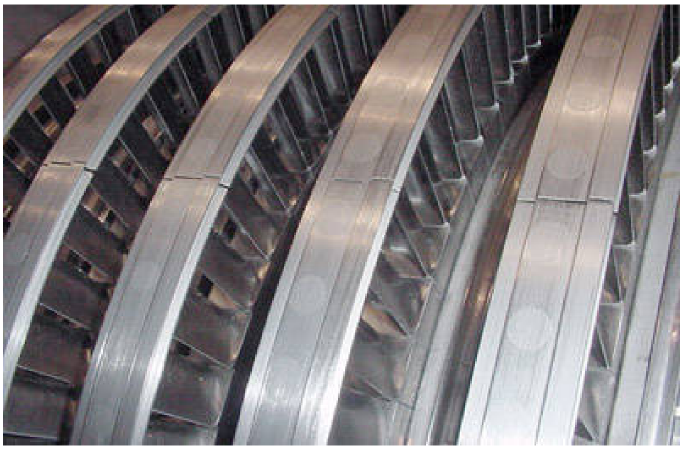


Photo- 22: Shroud

http://www.regencoservices.com/Images/gallery/STimages05.jpg

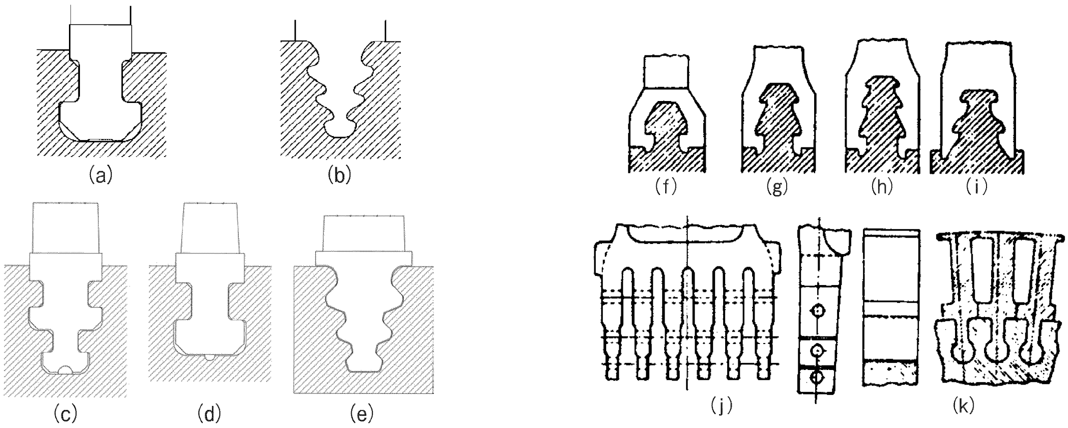


Fig- 26: Dovetail of blades

Reference: P-72 of Journal (No.574: Jul /2004): TENPES

Photo- 23: HP turbine blade (Siemens)

http://images.pennnet.com/articles/pe/cap/cap_0403pef2d2.jpg

Photo- 24: LP turbine blade (Siemens)

http://www.siemens.com/innovation/pool/en/publikationen/publications_pof/pof_fall_2007/materials_for_the_environment/optimizing_turbine_blades/pof207art18_bild1_1466134.jpg

The dovetail is taken to the centrifugal force of the blades as a part which secures the blades with rotor, and has been developed and devised a variety of shapes as shown in Fig-26 and Photo-23, 24. With regard to the strength against the rotation, the stress at the root portion usually tend to be the critical state because the steam temperature is high and the allowable stress of material is limited and also near the low pressure final stage must withstand a large centrifugal force.

The optimum type of root portion is selected in the aspect of overall decision considering the effect of vibration stress as well as the centrifugal stress. The cooling method or dividing method may be adopted to avoid the harsh conditions of the dovetail due to scale-up capacity of turbine. Particularly, the importance of cooling technology is glowing with the recent rise in steam temperature. The cooling target is around the dovetail of blades including rotor, it is intended to keep the higher allowable stress of material by means of lower temperature of the substance with high stress. There are two methods, one is external cooling system and the other is internal self-cooling system. The former will obtain cooling steam from other portion. For example, 50~60^{o}C temperature fall can be expected by squeezing effect of the steam by means of extraction from the outlet of HP1st stage, lead it to IP 1st stage and cool the upper portion of the impeller. Alternatively, the construction to cool the IP turbine rotor by extracted steam from HP exhaust turbine as shown in Fig-27.

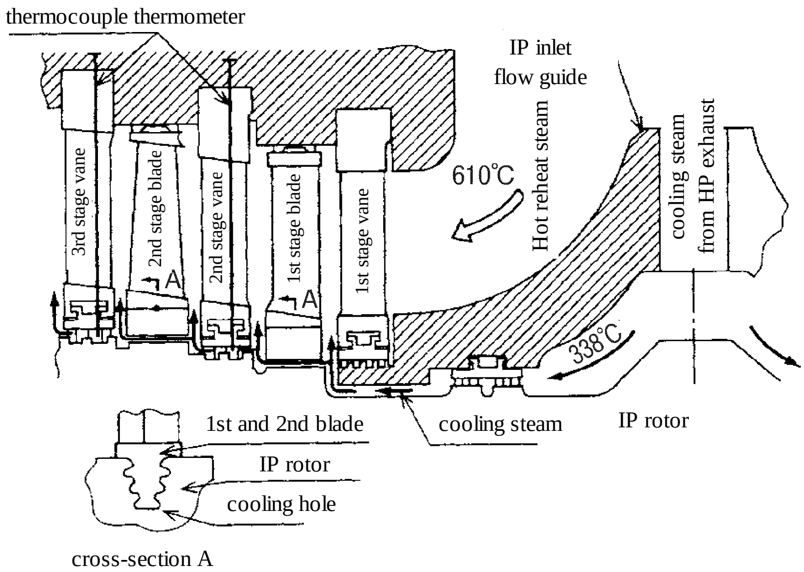


Fig- 27: Cooling construction of IP rotor

Reference: P-72 of Journal (No.574: Jul. /2004): TENPES

The internal self-cooling system is the method to cool the dovetail which blade is exposed high temperature by flowing back the outlet steam of some stage. This method, so that the degree of reaction is negative at the root of blade when designing nozzles and blades, and in other words so that keeping the outlet pressure of blade higher than the outlet pressure of nozzle, the cooling steam is flown around the impeller with the pressure difference. At this time, the special-shaped bracket attached to the balance hole provided in the impeller will make easier to inhale the low temperature steam. Whether any of these methods, when adopting the cooling method, it has become an important to select clearance of each part as to which is capable to obtain a calculated balance, to grasp the accurate flow coefficient and be the issue of internal efficiency and decrease.

The diversion of steam is one of the major factors to achieve large capacity mentioned above, it has been widely used in the IP and LP turbine and it is necessary to HP turbine exceed 700Mw thermal power turbine. However, the designed has been employing a double-flow shaped nozzle box as shown in Fig-29 because the impulse turbine has small thrust force, the temperature drops in the following of the 2nd stage and the centrifugal force has been afford to. The HP 1st stage is usually said to be the governing stage because it is designed according to the turbine governing system. There are “Aperture speed control system” and “Nozzle closing speed control system” for the turbine governing system. Former one is the method to control the velocity of turbine only by governor valve opening, and the latter one is the method to control the velocity of turbine by opening and closing one by one for each of the 1st stage nozzle segments classified in 4~8. The width of 1st stage turbine blade of nozzle closing speed control system has wider than the one of aperture speed control system and sufficient rigidness because the bending stress becomes larger than those in case all valves of aperture speed control system are fully open at the point of admission. On the other hand, since the centrifugal stress becomes too severe in terms of blade width increase, the shared output of a blade can be half by double-flow. While the double-flow method is associated with increasing the span of the columns and bearing, it is capable to use the proven short blades and effective to ensuring the reliability of large capacity.

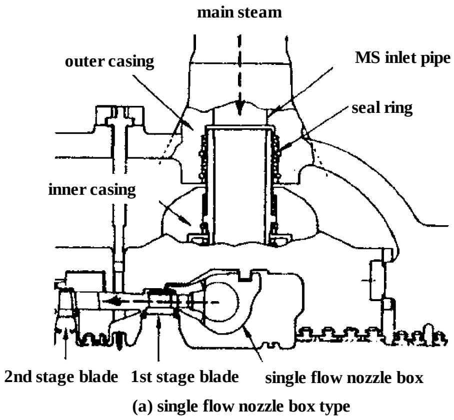


Fig- 28: Construction around nozzle box (single)

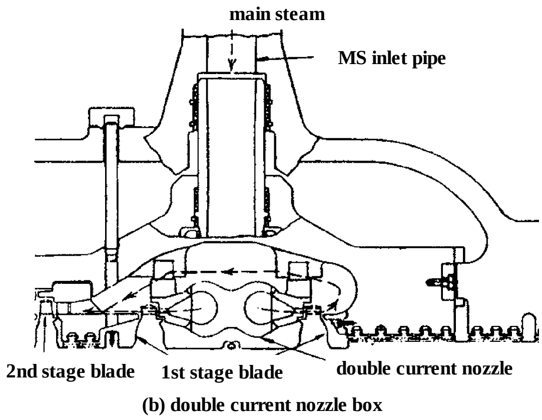


Fig- 29: Construction around nozzle box (double)

Reference: P-70 of Journal (No.574: Jul. /2004): TENPES

Also, such as increasing the partial proportion of steam admission at 1st admission point have been devised in order to reduce the increase in blade width by reducing the output per one blade. The vibration problems cannot be ignored as well as simply dealing with centrifugal stress because the turbine blade is a rotating body. There are two excitation frequencies, one of which is based on the rotation itself (50Hz or 60Hz and multiples thereof) and the other is a nozzle pulse jet acting on rotating blades. This is said NPF (Nozzle Passing Frequency) that the rotational speed equivalent to the number of nozzles per circle is multiplied by the rotation speed (rps). The measure for vibration aimed at NPF must be taken because the blade for HP and IP part is relatively short and has high level natural frequencies. The natural frequency of short blades group (binded blades in a few segment by shroud) appear across a wide frequency range by various modes. The Fig-30 is an example of the vibration mode, and Fig-34 illustrates the extent of occurrence frequency and amplitude of these modes. The content of Fig-30 will change depending on the changing of height, binding number by shroud and the shape of tenon, however it is usual that the natural frequency of some mode is distributed almost seamlessly in any case. In general, the design method to have a rigid enough not to destroy but resonate with one of those tight stress parts is taken in case of short blades. However, it is important to avoid stress as much as possible the additional element vibration because the stress of root portion are becoming increasingly large due to centrifugal force in the process to scale-up.

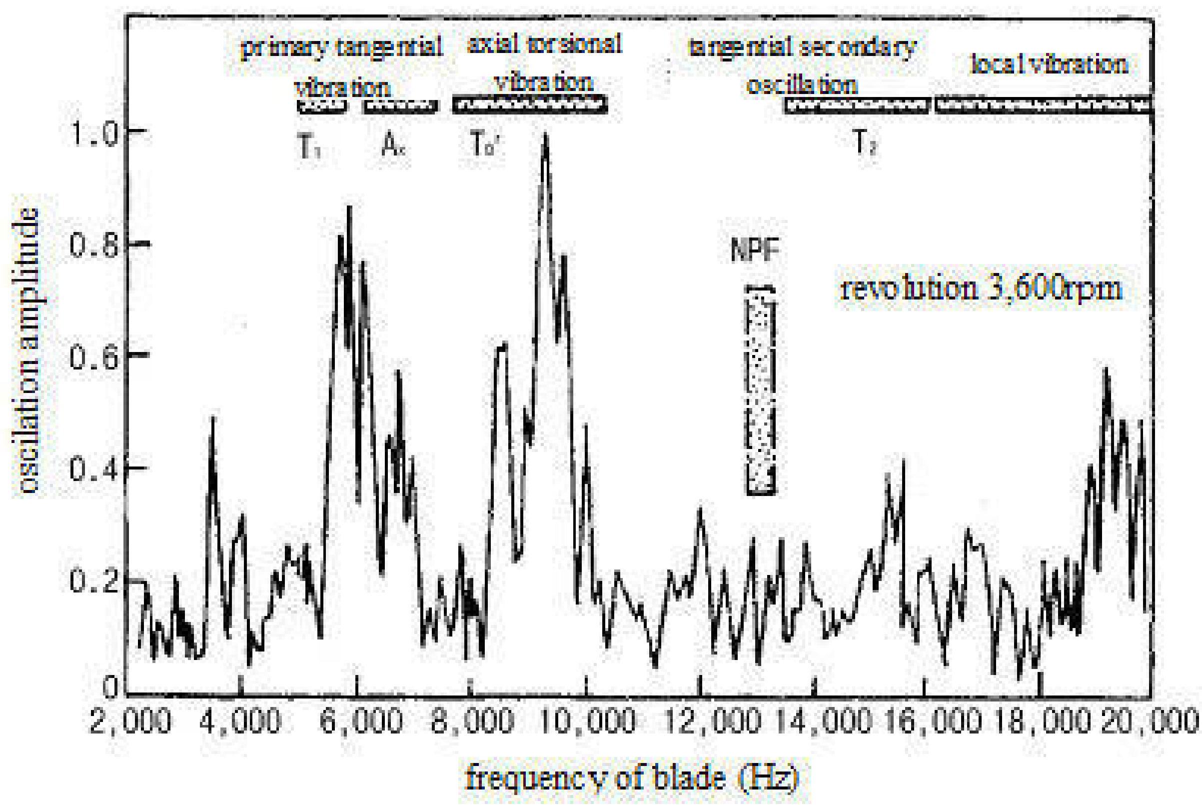


Fig- 30: Vibration mode and frequency of appearance

Reference: P-73 of Journal (No.574: Jul /2004): TENPES

Recently, the prediction accuracy has been improved at the design stage of the natural frequency; however, the management may also be made to measure the detuning of the NPF and even at the assembly. Especially in 1st HP stage, the application of the same size or similar blade which has been identified in advance detuning is reliable way, although some natural frequency can be varied by adjusting the way of calking tenon.

The long blades of final stage has the low effective natural frequency and the greater vibration stress when the resonance is made to ensure that the same administration to avoid resonance with multiples of the number of revolutions. There are natural vibrations modes of the final stage blade group as shown in Fig-34 and Fig-35 and are distributed to low-frequency band as shown in Fig-31 (a Campbell diagram representation of such a diagram). Therefore, it is not quite easy to adjust the cycle far enough from all dividing resonance, the measure to change vibration characteristics and to improve damping characteristics by means of the binding method, connection method by tie wire (with loose type and fix type) as well as cross-section shape of blade.

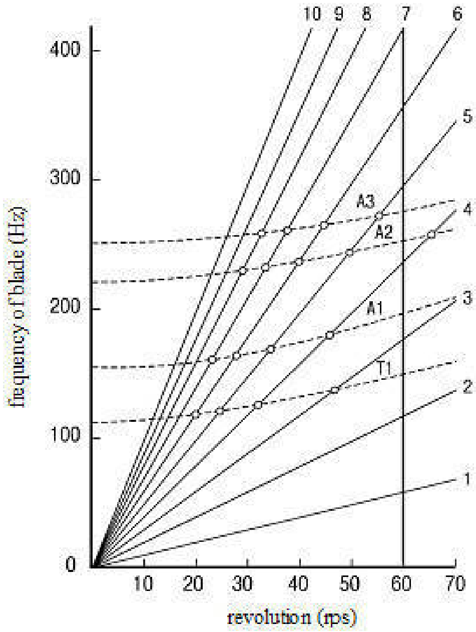
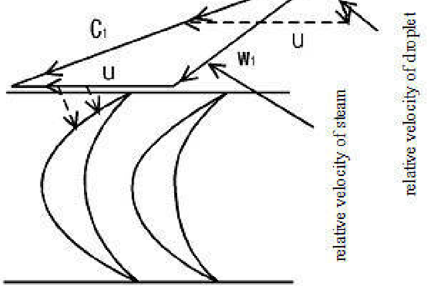


Fig- 31: Campbell diagram

Reference: P-74 of Journal (No.574: Jul /2004): TENPES

The droplet velocity in the steam ejected from the nozzle is said to be about 1/10 of the velocity of steam. Therefore, the droplets collide with the rear entrance of the blades as well as lead to poor performance due to the breaking action and the erosion as shown in the velocity triangle as shown in Fig-32. The measures against erosion has been taken such as applying the drain removal structure as shown in Fig-33, a erosion-resistant hard metal tip to rear part of the entrance (stellite) or welded or attached with silver solder, and flame quenching (frame hardening) or subject to the final stage nozzle in front because the last stage blades have particularly high degree of wetness and rotate at high peripheral speed.



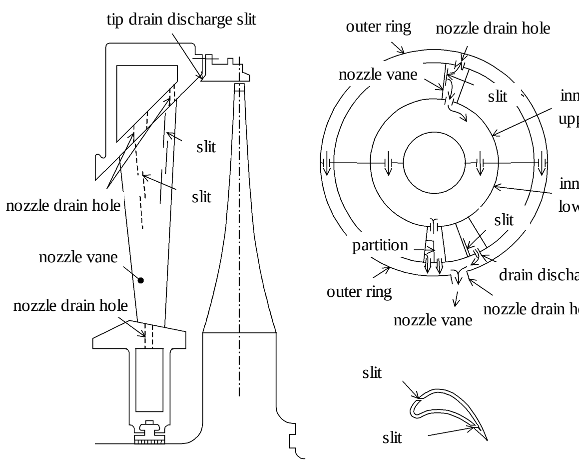


Fig- 32: Velocity triangle of steam droplet

Fig- 33: Slit nozzle

Reference: P-74 of Journal (No.574: Jul /2004): TENPES

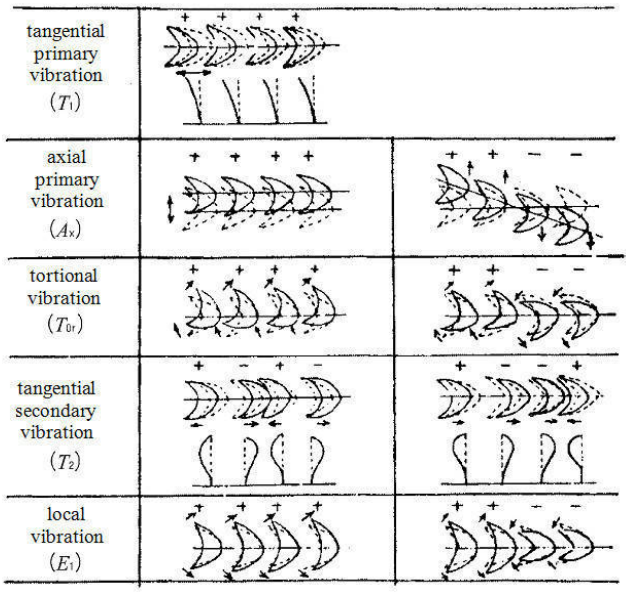


Fig- 34: Vibration mode (1)

Reference: P-73 of Journal (No.574: Jul /2004): TENPES

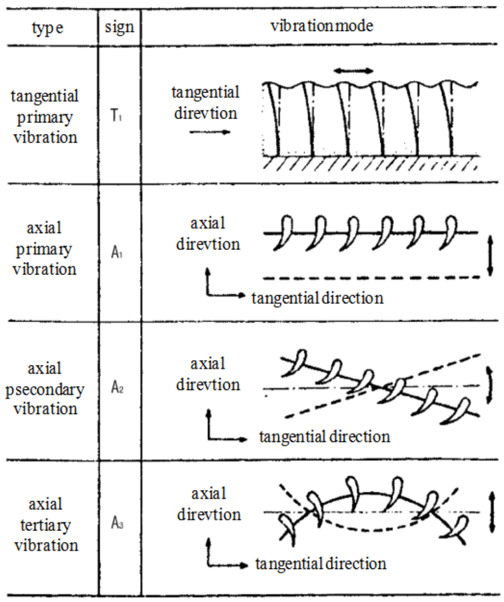


Fig- 35: Vibration mode (2)

Reference: P-73 of Journal (No.574: Jul /2004): TENPES

Article 31-3-8. Turbine Gland

1. Glands at the end of the rotors and between stages shall be of suitable material to minimize distortion or growth at the operating temperature. Construction of the glands shall be such as to minimize damage to the rotor in the event of rubbing which in operation.

The turbine gland is the airtight mechanism which prevent steam leakage of steam and air flow in from the part where rotor penetrating casing. The prevention of steam leakage is subjected at the end of HP and IP turbine casing, the prevention of air flow in is subjected at the end of LP turbine casing to maintain vacuum. The Fig-36 shows an example of a turbine gland. The part of comb which has sharp tip is the labyrinth; the amount of flow rate is reduced by diminishing the velocity energy when the leaked fluid repeat aperture and expansion.

It is required at least two pockets for turbine gland, one is connected to steam header which is regulated constant pressure (about 30kPa) by steam seal regulator, and the other is connected to gland steam condenser which is maintained slightly negative pressure than atmosphere. Fig-36 shows HP or IP gland. Air and steam which is always flowing into from both negative pockets is guided to gland steam condenser, and steam is collected and recovered as drain. Air is discharged from the gland steam exhaust blower, thereby being prevented from flowing into the steam leakage and air flow in. The labyrinth packing is also equipped with penetration of nozzle diaphragm the turbine rotor in the impulse turbine.

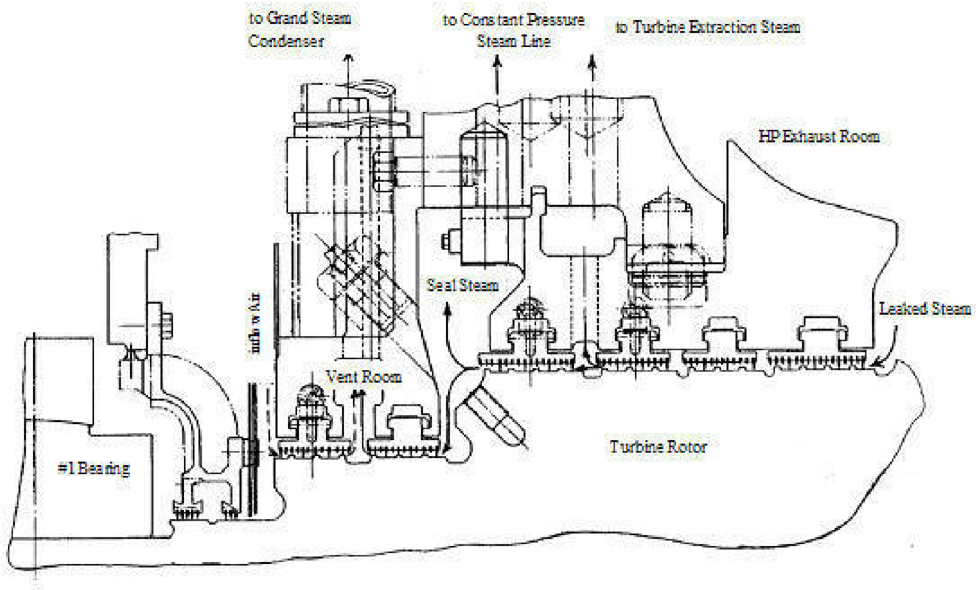


Fig- 36: General construction of turbine gland

Reference: P-77 of Journal (No.574: Jul /2004): TENPES

Labyrinth packing is used for the gland part of the turbine and for the inner surface of the nozzle diaphragm. It consists of several circular segments fitted into the grooves of their mating parts and equipped with leaf springs on their backs. If the rotor and the labyrinth packing should contact each other, local heating of the rotor due to such contact can be reduced. The labyrinth packing for high-temperature parts consists of an alloy steel labyrinth body inserted with Cr-Mo steel strips; that for low-temperature parts consists of a labyrinth body and strips integrally formed on nickel silver or phosphor bronze stock. When the gland seal is a steam seal type, a gland condenser and a gland exhaust fan are installed. Steam leakage and air from the gland are led to the gland condenser, where the steam is condensed, and the air and gases are discharged into the atmosphere by the gland exhaust fan. Turbine condensation is used as cooling water for the condenser to reclaim heat. The typical construction is shown in Fig 37 and 38.

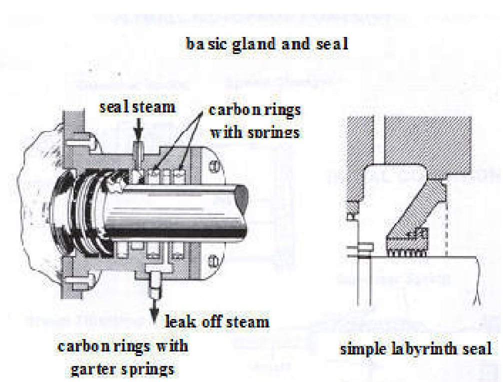


Fig- 37: Basic gland and seal

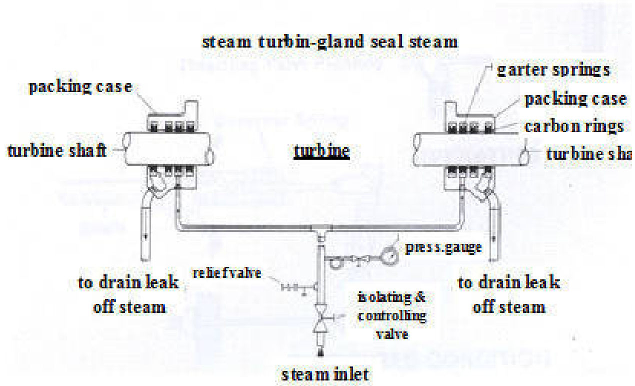


Fig- 38: Gland seal system

http://www.area4.info/Area4%20Informations/Eq%20Photos/Scan0038.jpg

Article 31-3-9. Turning Gear

1. Turning gear must be provided to rotate the rotor system slowly (continuously or discontinuously) to limit thermal distortion of when not turning under steam. Interlocks shall be provided, if necessary, to ensure that turning cannot commence until an adequate supply of lubricating oil is available and the drive is fully engaged. The turning gear must disengage automatically when the speed increase above the turning gear speed.

   The bending of rotor cause rubbing in the next start due to the cooling down from lower half first because of the heat accumulated in the upper half portion of turbine, if being leaved the rotor without keeping intact after stopping the turbine. And also, it is necessary to preheat the rotor slowly and uniformly when the turbine from cold situation starts. The turning gear is provided for rotate rotor to rotate in low speed (2~10rpm) before starting and after stopping from the consideration of such design aspect. In general, it is placed between the steam turbine and generator. The torque is transmitted to the ring gear which is inserted thermally on the coupling or sandwiched between coupling flanges through the chain from the motor and gear train for turning like a construction of following Fig-39, 40at startup, the gear will be disconnected automatically and the motor stop when speed boost. There is some model which is obtained the turning torque directly from the oil turbine direct connected with turbine.

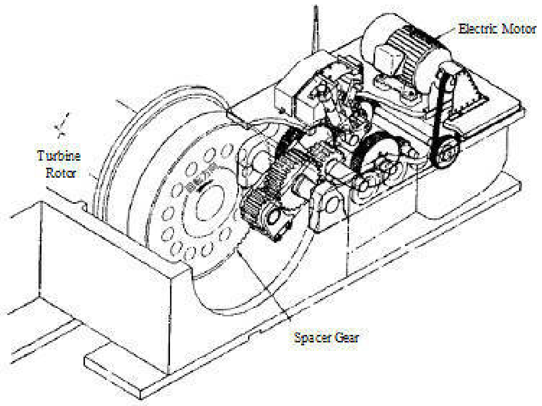


Fig- 39: General construction of turning gear

Reference: P-76 of Journal (No.574: Jul /2004): TENPES

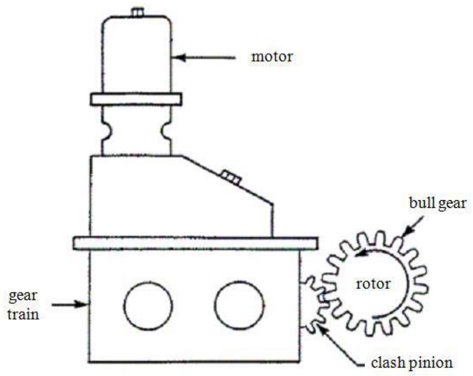


Fig- 40: General construction of turning gear

http://arab-training.com/vb/t20309.html

Article 31-3-10. Turbine Lubrication Oil

1. The lubrication oil for turbine is required important role and performance over the range, for instance, lubrication of turbine, lubrication of generator, cooling and sealing. Moreover, turbine oil is required to maintain long term quality unlikely other lubrication oil while over 10years by replacing parts of them “called make-up”. The required performance of lubrication oil used for steam turbine, gas turbine and hydro turbine is characterized according to following Table-17, although the standard of fortified turbine oil is stipulated in JIS K2213. Currently, from the small units of 100MW to latest 1000MW super-critical

large units have been driving. The operation condition of turbine oil for latest steam turbine has become more severe conditions due to the hot steam with temperature about 600 °C. The appropriate lubrication oil for steam turbine which is added corrosion inhibitors, antifoam to main phenol antioxidants and removed to the limit to impurity in order to improve the oxidation stability by combined with hydro-cracked based oil must be selected.

Table- 17: Required performance of turbine oil

	Oxidation stability	Thermal stability	Anti corrosion	Off foaming	Anti sludging	Resistance for extreme pressure
Steam turbine	○	○	○	○	–	Δ
Gas turbine	○	*	○	○	–	Δ
Hydro turbine	○	–	○	○	*	Δ

(*):Particularly important   *Δ:in case when speed reducer is equipped*

【Reference Standard】			
1.	JIS K2213	1983	Turbine oils
2.	ISO 6743-Part5		Turbine oils
3.	ISO/CD 8068	2006	Petroleum products and lubricants -- Petroleum lubricating oils for turbines (categories ISO-L-TSA and ISO-L-TGA) -- Specifications
4.	DIN51515 Part-1	2001	Lubricants and governor fluids for turbines - Specifications - Part 1: L-TD for normal service; Specifications
5.	DIN51515 Part-2	2004	Lubricants and governor fluids for turbines - Part 2: L-TG for higher temperature service, Specifications
6.	HTGD 90117	2009	ABB/Alstom: Lubricating and control oil for turbines
7.	GEK 28143A		GE: Hydrocarbon Base Lubricating Oil Recommendations For Gas Turbines
8.	GEK 32568f		GE: Lubricating Oil Recommendation for Gas Turbines with Bearing Ambients Above 500°F(260°C)
9.	GEK 46506D		GE: Turbine Lube Oil (Recommended Properties & Maintenance Practices)
10.	GEK 101941A		GE: Lubrication oil recommendations with antiwear additives for gas turbines with bearing ambient above 500°F(260°C)
11.	GEK 107395A		GE: Lubricating oil recommendations single shaft STAG units with bearing ambient above 500°F(260°C)
12.	NS04-MA-CL001		MHI: Lubricating Oil Recommendations for Steam and Low-Temperature Gas Turbine Applications
13.	TLV 9013-04		Siemens: List of approved turbine oils
14.	TLV 9013-05	2010	Siemens: Turbine oil specification (turbine oils with higher thermal stability)

Article 31-3-11. Lubrication Oil Purifier

1. In general, the journal bearing is applied to large scale steam turbine. It is essential to provide lubrication oil purifier to maintain oil purity and oil cooler to prevent abnormal wear and over-heat of bearing. The standards for oil cleanliness are shown in Table-18, 20, 21. In general, it is recommended to provide oil purifier equipment to maintain **oil purity below NAS-7grade** as shown in Table-19.

Table- 18: NAS 1638 contamination classification system

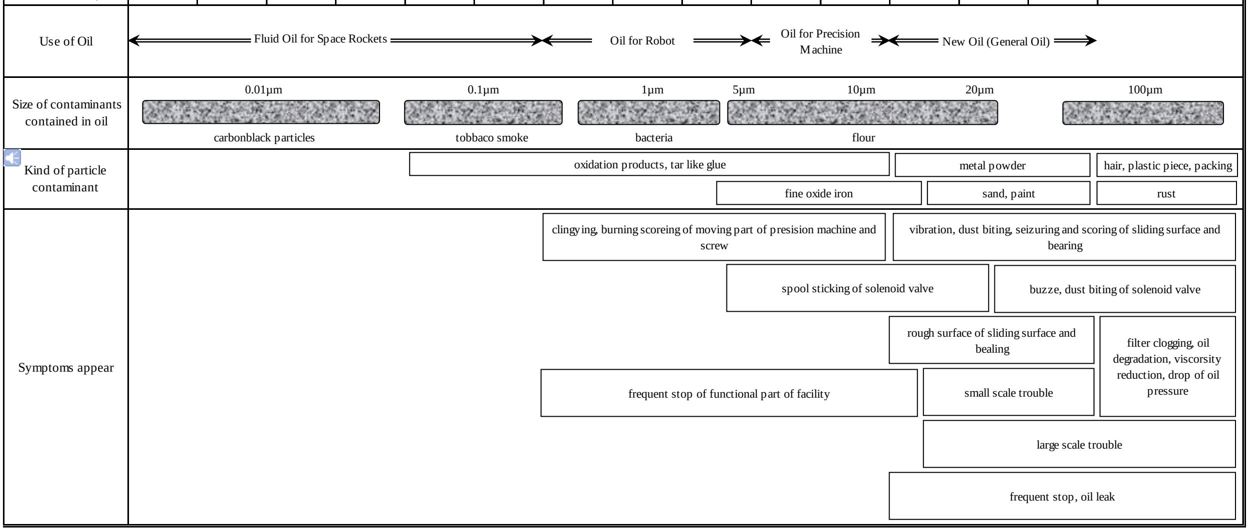
Class	Maximum Particles/100ml in Specified Size Range (μm)				
	5~15	15~25	25~50	50~100	≥100
00	125	22	4	1	0
0	250	44	8	2	0
1	500	89	16	3	1
2	1,000	178	32	6	1
3	2,000	356	63	11	2
4	4,000	712	126	22	4
5	8,000	1,425	253	45	8
6	16,000	2,850	506	90	16
7	32,000	5,700	1,012	180	32
8	64,000	11,400	2,025	360	64
9	128,000	22,800	4,050	720	128
10	256,000	45,600	8,100	1,440	256
11	512,000	91,200	16,200	2,880	512
12	1,024,000	182,400	32,400	5,760	1,024

http://www.oilservethai.com/images/column_1285479576/NAS%20table(1).jpg

The broad concept of oil purity of lubrication oil or fluid oil for hydraulic equipment, relation with trouble to appear and general scope of application is shown as below in order to recognize grade7 of NAS grade.

Table- 19: NAS grade and symptoms appearing in oil administration

	NAS Grade														Irregular Class
	00	0	1	2	3	4	5	6	7	8	9	10	11	12	
5~15μm	125	250	500	1,000	2,000	4,000	8,000	16,000	32,000	64,000	128,000	256,000	512,000	1,024,000	
15~25μm	22	44	89	178	356	712	1,425	2,850	5,700	11,400	22,800	45,600	91,200	182,400	
25~50μm	4	8	16	32	63	126	253	506	1,012	2,025	4,050	8,100	16,200	32,400	
50~100μm	1	2	3	6	11	22	45	90	180	360	720	1,440	2,880	5,760	
more than 100μm	0	0	1	1	2	4	8	16	32	64	128	256	512	1,024	



The replacement table to replace with old and new oil contamination of ISO is shown as below.

Table- 20: Equivalent APC sizes relating to calibration method

Standard	Particle Sizes					
ISO 11171 Size (μm)	> 4	> 6	> 14	> 21	> 38	> 70
ISO 4402 Size (μm)	> 1	> 5	> 15	> 25	> 50	> 100

http://www.machinerylubrication.com/Read/409/nas-1638

It is organized the comparison of standards regarding oil contamination in the following table.

Table- 21: Comparison of standards

ISO4009 -1991	No. of particle over 10μ	ACFTD (mg/l)	MIL Standard	NAS Grade	SAE-T490
26/23	140,000	1,000			
25/23	85,000		1000		
23/20	14,000	100	700		
21/18	4,500			12	
20/18	2,400		500		
20/17	2,300			11	
20/16	1,400	10			
19/16	1,200			10	
18/15	580			9	6
17/14	280		300	8	5

ISO4009 -1991	No. of particle over 10μ	ACFTD (mg/l)	MIL Standard	NAS Grade	SAE-T490
16/13	140	1		7	4
15/12	70			6	3
14/12	40		200		
14/11	35			5	2
13/10	14	0.1		4	1
12/9	9			3	0
11/8	5			2	
10/8	3		100		
10/7	2.3			1	
10/6	1.4	0.01			
9/6	1.2			0	
8/5	0.6			00	
7/5	0.3		50		
6/3	0.14	0.001			
5/2	0.04		25		
2/0.8	0.01		10		

【Reference Standard】			
1.	JIS B9933	2000	Hydraulic fluid power－Fluids－Code for defining the level of contamination by solid particles
2.	NAS1638	2001	National Aerospace Standard-- Contamination Classification System
3.	ISO 4402	1991	Hydraulic fluid power -- Calibration of automatic-count instruments for particles suspended in liquids -- Method using classified AC Fine Test Dust contaminant
4.	ISO4406	1999	Hydraulic fluid power -- Fluids -- Method for coding the level of contamination by solid particles
5.	ISO 11171	1999	Hydraulic fluid power -- Calibration of automatic particle counters for liquids

Article 31-3-12. Vapor Extraction System for Turbine Lubrication Oil

1. The evaporation of lubrication oil occurs in the bearing housing, lubrication return piping and main oil tank of stream turbine. If vaporized gas leaked to outside, it may cause a fire and explosion. Therefore, it is recommended to provide the extraction system to extract vaporized gas from oil return line and main oil tank shown in Fig-41 to safety area and remove possibility of fire and explosion.

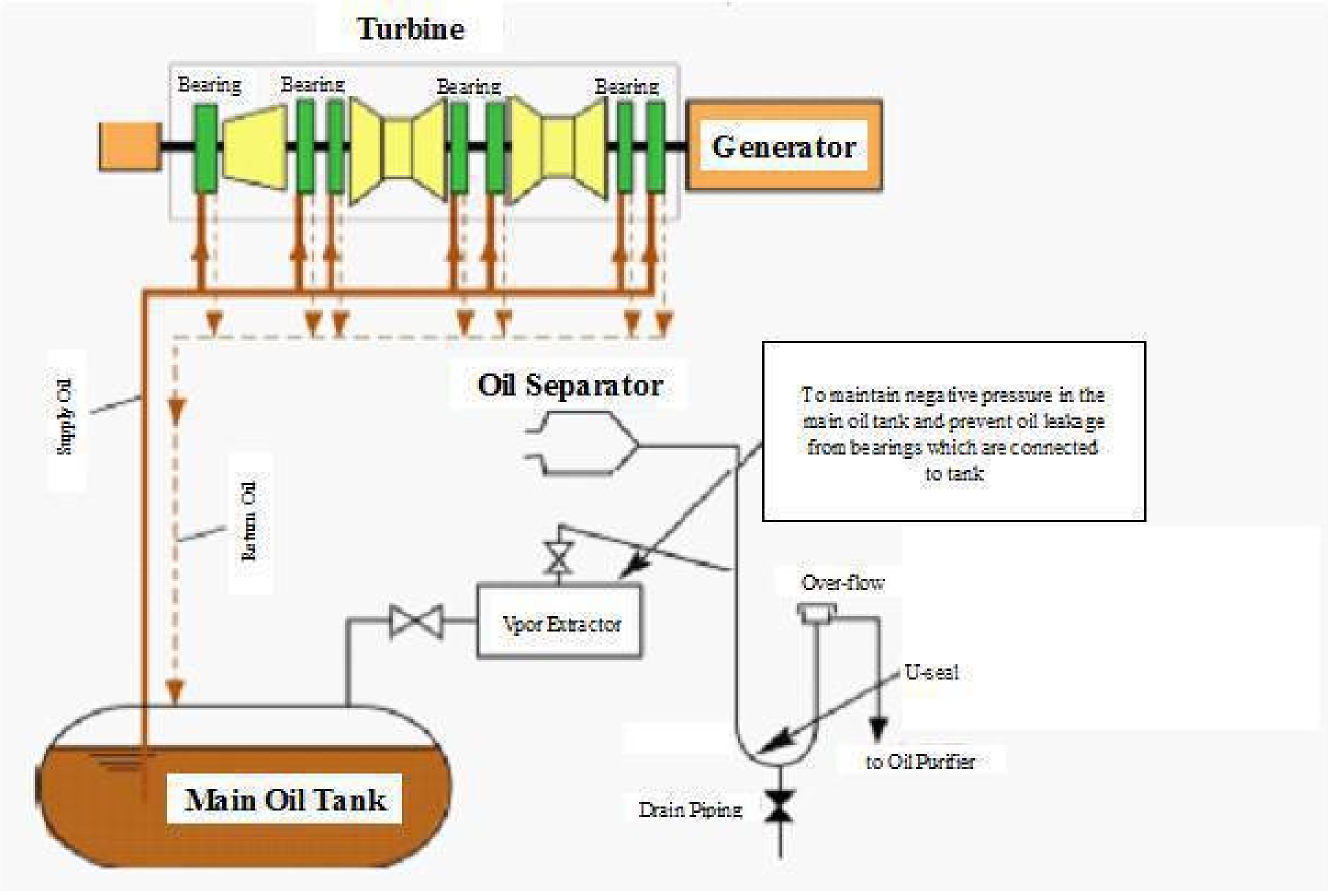


Fig- 41: Vapor extraction system of turbine lubrication oil

http://www.jaea.go.jp/04/turuga/cases/operation/pdf/case06-2-01.pdf

Article 31-3-13. Fire- fighting System for Bearing

1. The temperature of lubricant that is supplied from main oil tank to each bearing will rise during circulation. If the a part of oil splashed due to the high speed rotation of turbine and leaked oil touched to the hot part of insulated piping, it may be evaporated and ignited with, although the risk of fire is not high because of the low flash point of lubrication oil. It is recommended to provide a **carbon dioxide fire-extinguishing system** which is consisted by agent storage vessel, jet head, starting equipment, control box, control panel, alarm system, etc.

Article 31-4-1. Minimum Rotation Speed

1. The "**minimum rotation speed which can be adjustable**" stipulated in Article 31-4 of design technical regulation must mean the minimum rotation speed which is defined according to the speed regulation of steam turbine, exclude steam turbine coupled with induction generator. The minimum rotation speed which is capable to generate under grid frequency in case steam turbine coupled with induction generator.

Article 31-4-2. Sufficient Measure

1. "**The case being taken sufficient measure**" stipulated in Article31-4 of design technical regulation means the case which has been demonstrated sufficient safety by the measure, etc. to reduce resonance factor at over second vibration mode.
2. The blades of turbine rotor generate vibration, if the blades are not bound by shroud. Therefore, it is necessary appropriate measure to eliminate resonance of the element of Natural Frequency at rated speed shown in Fig-42.

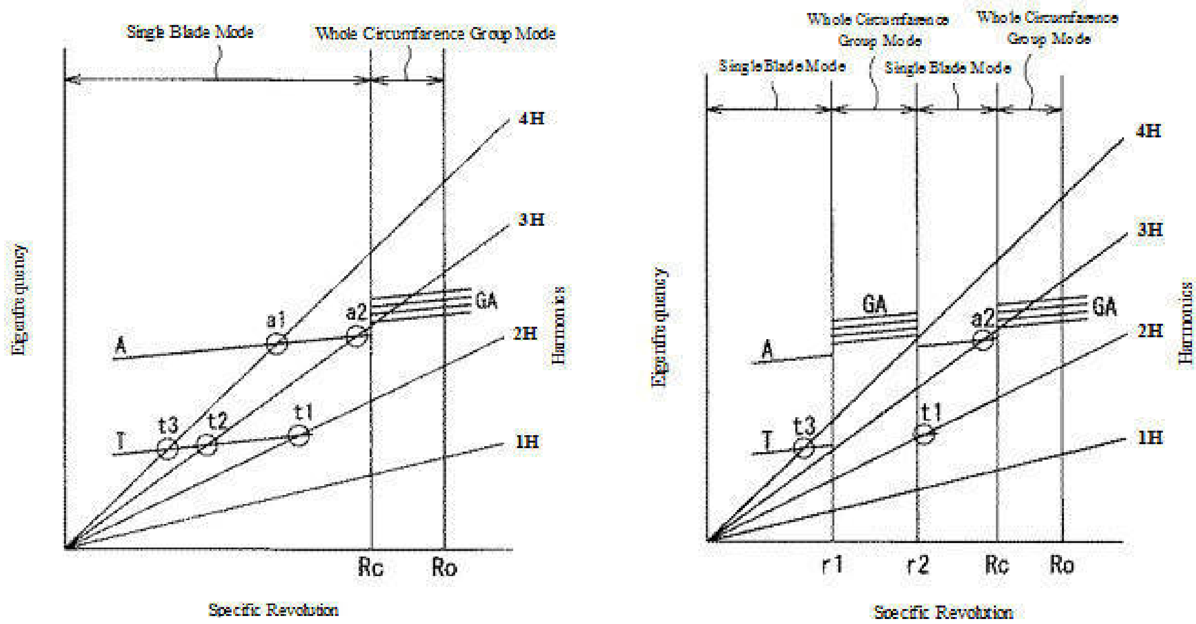


Fig- 42: Campbell diagram of turbine rotor

http://image.astamuse.com/image/JP/2010/065/666/A/000021.png

Article 31-4-3. Natural Frequency

1. There are two types for the turbine foundation shown in Fig-43. One is the rigid type which is made of reinforced concrete provided from basement, and the other is the flexible type which the foundation plate is installed on the spring elastic support, shown in Photo-25, on the top of column provided from basement. The natural frequencies of the foundation should not correspond to any low multiple of the operating speed of the unit.

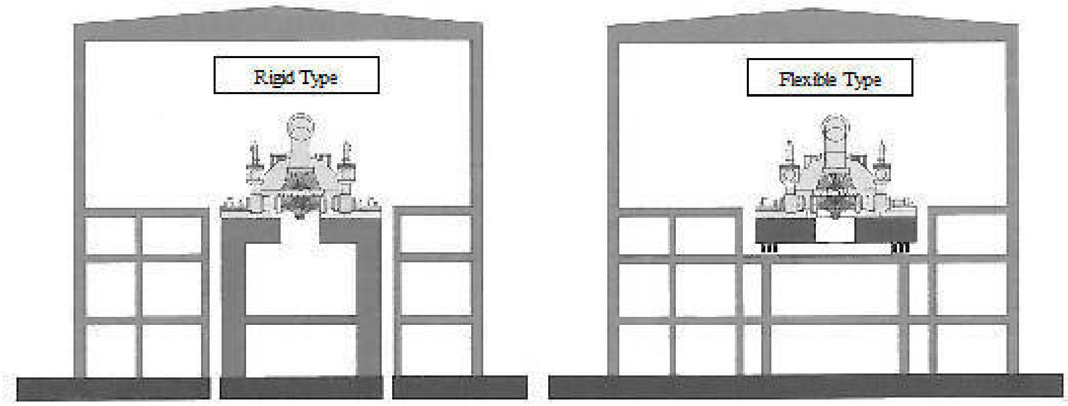


Fig- 43: Typical foundation of steam turbine

Photo- 25: Application of elastic support for steam turbine bed

http://www.gerb.com/en/arbeitsgebiete/arbeitsgebiete.php?ID=113&kategorie=8

Article 31-4-4. Turbine Rotor and Coupling

1. The natural frequency of the entire rotor, including blade and rotor is called critical speed, and it is necessary to keep the rotation speed apart from critical speed sufficiently (15~20% or more) in the long sustainable area as well as the rated speed. Typically, the rotor which has critical speed above the rated speed is rigid shaft, and the rotor which has critical speed below the rated speed is flexible shaft. The critical speed is determined depending on the rotor-span (the distance between the bearings), diameter and added mass of blade. The two-pole machine is generally the flexible shaft and the four-pole machine is often rigid one. The critical speed varies with whether the pedestal is rigid or not, whether the rotor is constraint with other rotor coupled with each other. Therefore, to estimate the real critical speed, it is calculated by given condition that the whole rotor to generator are coupled and supported by flexible support so called pedestals.
2. Rotors and their couplings must be designed to withstand those conditions imposed by generator short-circuits or by other specified disturbances within the electrical system. To minimize the effects of electrical currents generated by electrostatic friction effects, the shafts of the turbine must be earthed or grounded shown in Fig-44 and Photo-26. The quick damage caused by shaft current as shown in Photo-27

must be avoided.

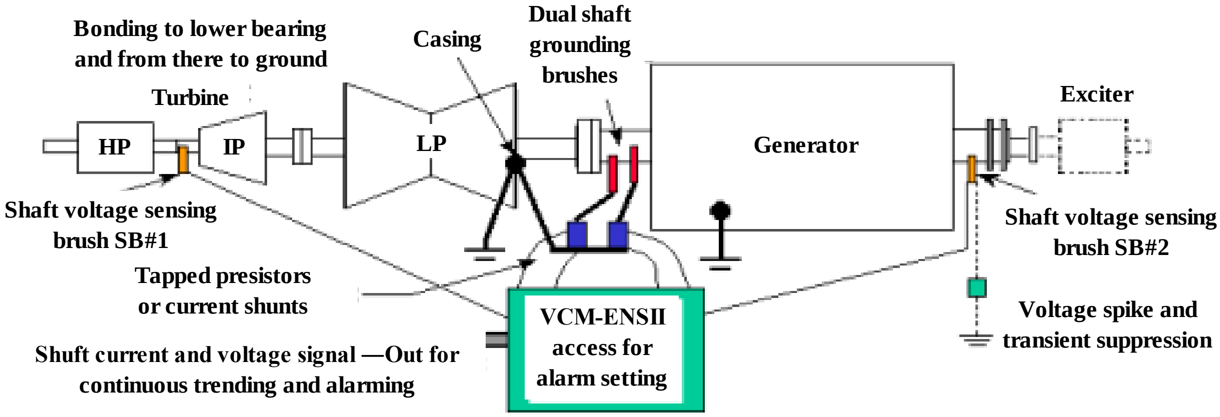


Fig- 44: Shaft grounding brush of rotor

http://www.nippes-bell.com/scm.html

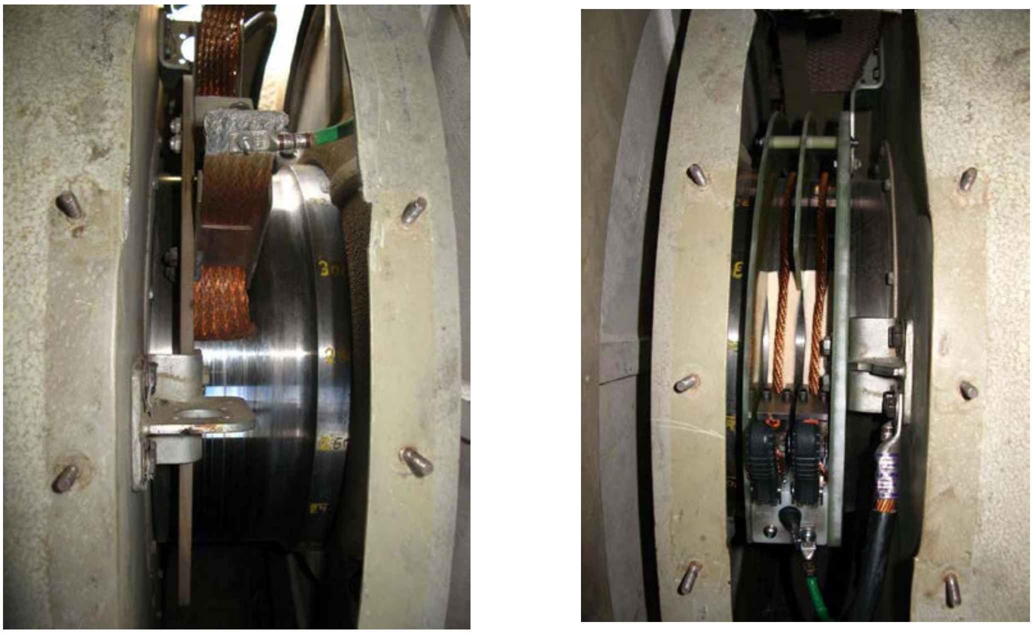


Photo- 26: Photos of dual shaft grounding brushes

http://www.cutsforth.com/shaftgrounding.php

Photo- 27: HP bearing quickly destroyed by shaft current

http://www.maintenance-alternateur.com/incidents-ang.html

Article 31-4-5. Field Balancing

1. The International Standards Organization, ISO, published Standard 1940/1 “Balance Quality Requirements of Rigid Rotors”, which has been adopted by the American National Standards Institute, ANSI, as S2.19-1975, “Balance Quality Requirements of Rotating Rigid Bodies.” It has also been adopted by British Standards as BS6861: Part 1 and by German Standards as VDI2060. ISO 1940/1 requires an understanding of balancing and its terminology if the standard is to be understood and used properly. The steam turbine must be designated to **maintain imbalance less than G2.5** as shown Table-22, 23 and Fig-45 and the adjustment method is designated.

   The imbalance of each rotor is to correct after checking the disproportionate by low speed and high speed balance as shown in Photo-28, 29, 30 and 31. The residual disproportionate is modified by balance weight after integration of rotors in the field as shown Fig-46.

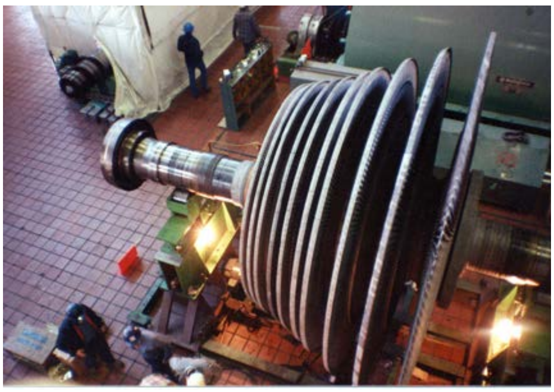


Photo- 28: Balancing and vibration analysis

http://www.mdaturbines.com/services/turbine-generator-engineering-services

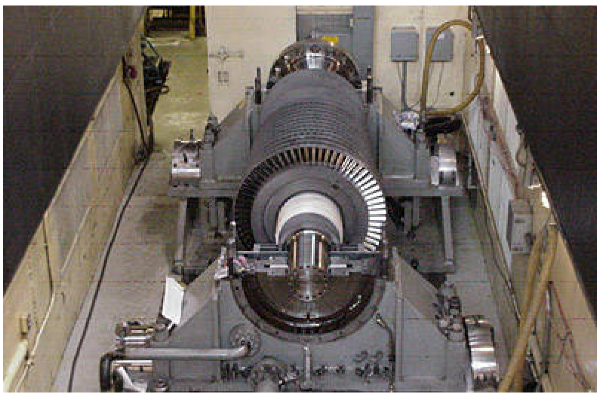


Photo- 29: High-speed balancing

http://www.regencoservices.com/Images/gallery/STimages06.jpg

Table- 22: Grade of good balancing

(mm/s)

Grade of good balancing	G0.4	G1	G2.5	G6.3	G16	G40	G100	G250	G630	G1600	G4000
Upper limit of good balancing	0.4	1	2.5	63	16	40	100	250	630	1600	4000

Reference: JIS B0905-1992 “Rotating machines-Balance quality requirements of rigid rotors”

Table- 23: Balance quality grades for various groups of representative rigid rotors

Balance Quality Grade	Product of the Relationship $(e_{per} \times \omega)^{(1)(2)}$ mm/s	Rotor Types / General Examples
G4000	4000	• Crankshaft/drivers of rigidly mounted slow machine diesel engines with uneven number of cylinders
G1600	1600	• Crankshaft/drivers of rigidly mounted large two-cycle engines
G630	630	• Crankshaft/drivers of rigidly mounted large four-cycle engines • Crankshaft/drivers of elastically mounted machine diesel engines
G250	250	• Crankshaft/drivers of rigidly mounted fast four-cylinder diesel engines
G100	100	• Crankshaft/drivers of fast diesel engines with six or more cylinders • Complete engines (gasoline or diesel) for cars, trucks and locomotives
G40	40	• Car wheels, wheel rims, wheel sets, drive shafts • Crankshaft/drivers of elastically mounted fast four-cycle engines with six or more cylinders • Crankshaft/drivers of engines of cars, trucks and locomotives
G16	16	• Drive shafts (propeller shafts, cardan shafts) with special requirements • Parts of crushing machines • Parts of agricultural machinery • Individual components of engine (gasoline or diesel) for cars, truck and locomotives • Crankshaft/drivers of engines with six or more cylinders under special requirements
G6.3	6.3	• Parts of process plant machines • Marine main turbine gears (merchant service) • Centrifuge drums • Paper machinery rolls, print rolls • Fans • Assembled aircraft gas turbine rotors • Flywheels • Pump impellers • Machine-tool and general machinery parts • Medium and large electric armatures (of electric motors having at least 80mm shaft • height) without special requirements • Small electric armatures, often mass produced, in vibration insensitive applications and/or with vibration-isolating mountings • Individual components of engines under special requirements

Balance Quality Grade	Product of the Relationship $(e_{per} \times \omega)^{(1)(2)}$ mm/s	Rotor Types / General Examples
G2.5	2.5	• Gas and steam turbines, including marine main turbines (merchant service) • Rigid turbo-generator rotors • Computer memory drums and discs • Turbo-compressors • Machine-tool drives • Medium and large electric armatures with special requirements • Small electric armatures not qualifying for one or both of the conditions specified for small electric armatures of balance quality grade G6.3 • Turbine-driven pumps
G1	1	• Tape recorder and phonograph (gramophone) drives • Grinding-machine drives • Small electric armatures with special requirements
G0.4	0.4	• Spindles, discs and armatures of precision grinders • Gyroscopes

Note:

1) $\omega = 2\pi n/60 \approx n/10$, if n is measured in revolutions per minute and ω in radians per second.

2) For allocating the permissible residual unbalance to correction planes, refer to "Allocation of U_{per} to correction planes."

3) A crankshaft/drive is an assembly which includes a crankshaft, wheel, clutch, pulley, vibration clamper, rotating portion of connecting rod, etc.

4) For the purposes of this part of ISO1940-1, slow diesel engines are those with a piston velocity of less than 9m/s; fast engines are those with a piston velocity of greater than 9m/s.

5) In complete engines, the rotor mass comprises the sum of all masses belonging to the crankshaft/drive descried in note 3 above.

Reference: JIS B0905-1992 "Rotating machines-Balance quality requirements of rigid rotors"

ISO 1940-1-2003 "Mechanical vibration – Balance quality requirements of rigid rotors"

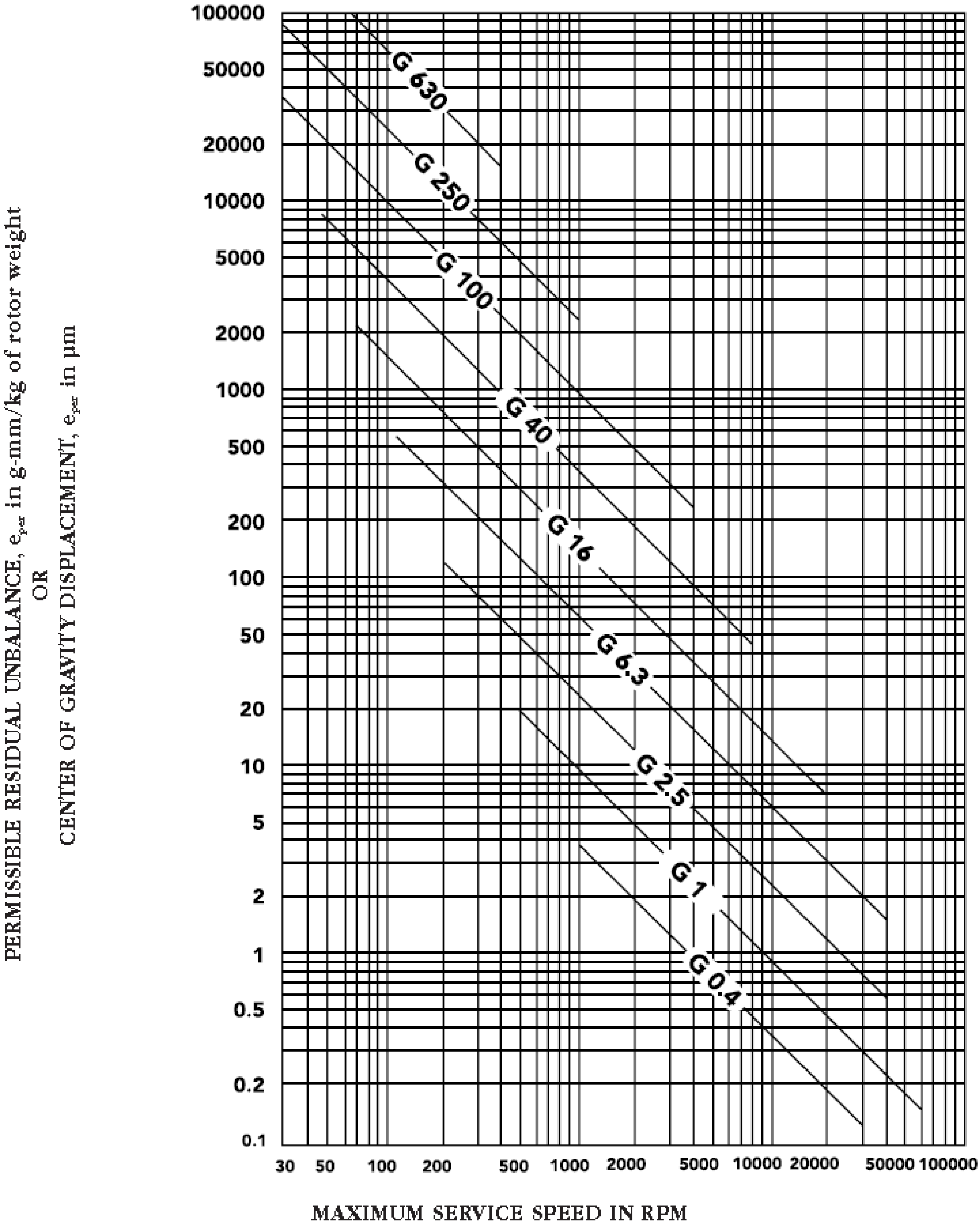


Fig- 45: Maximum permissible residual imbalance

Reference: JIS B0905-1992 “Rotating machines-Balance quality requirements of rigid rotors”

ISO 1940-1-2003 “Mechanical vibration – Balance quality requirements of rigid rotors”

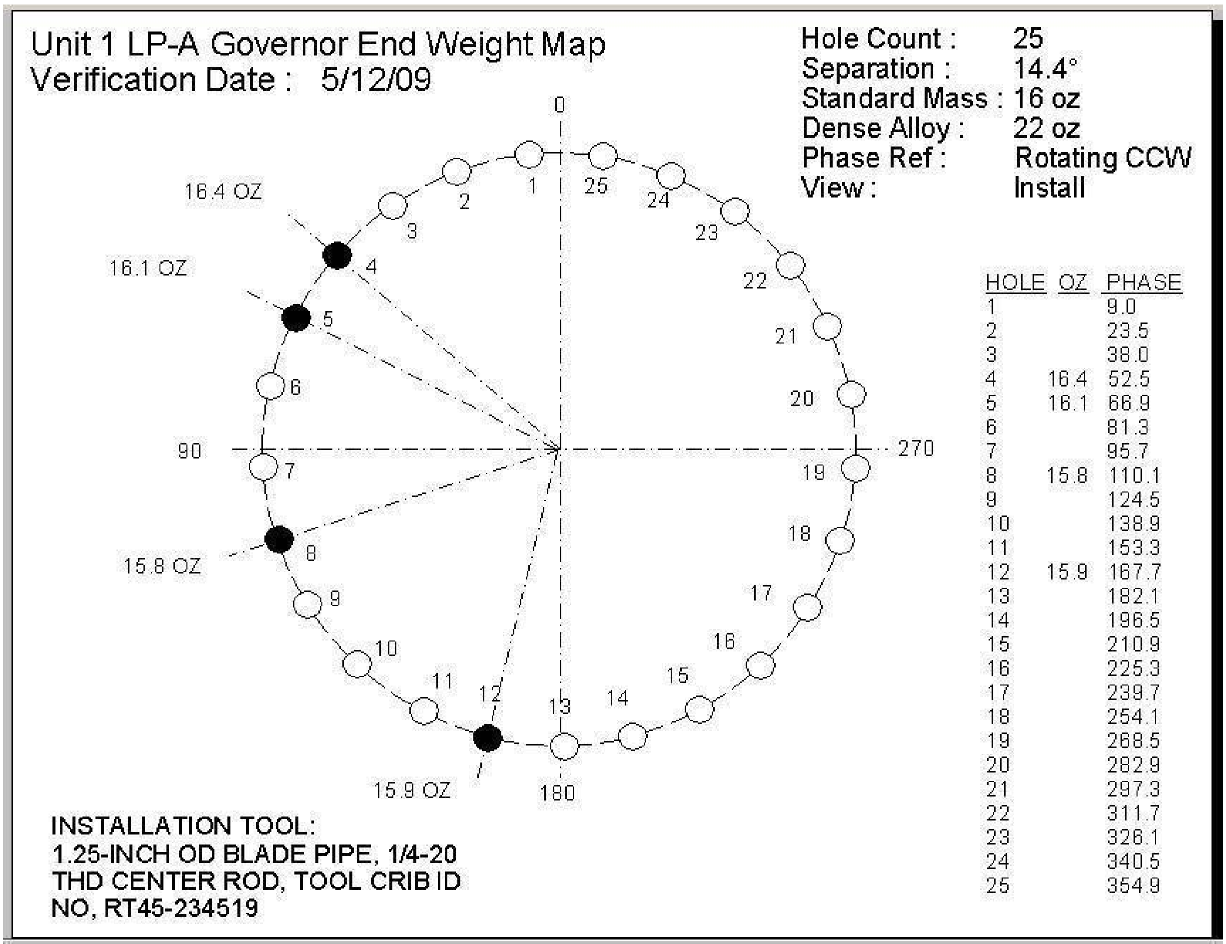


Fig- 46: Typical balancing weigh for steam turbine

http://www.lovejoycontrols.com/img/image009.jpg

Photo- 30: Installation of balancing weight

http://www.johnbrownasia.com/wp-content/gallery/balancing/balancing-weight.jpg

Photo- 31: Balancing weight

【Reference Standard】			
1.	JIS B0905	1992	Rotating machines－Balance quality requirements of rigid rotors
2.	ISO8821	1989	Mechanical Vibration-Balancing-Shaft and fitment key conversion
3.	ISO1940-1	2003	Mechanical vibration -- Balance quality requirements for rotors in a constant (rigid) state -- Part 1: Specification and verification of balance tolerances
4.	ISO1940-2	1997	Mechanical vibration -- Balance quality requirements of rigid rotors -- Part 2: Balance errors

Article 31-5-1. Safety Structure

1. The **"safety structure"** of steam turbine and its auxiliary equipment stipulated in Article 31-5 of design technical regulation must be conformed to the following articles of the guideline of boiler.

(1) pressure vessel and pressure piping of steam turbine and its auxiliary facility (excluding steam turbine casing, valve body, condenser shell, condenser water box and boiler)

1) Article 23-1: Structure of boiler, etc.
2) Article 23-2: Allowable stress of material
3) Article 23-4: Body of vessel
4) Article 23-5: Rectangle header
5) Article 23-6: Head for vessel
6) Article 23-7: Flat head of vessel
7) Article 23-8: Dish cover plate with flange for vessel
8) Article 23-9: Tube sheet for vessel
9) Article 23-10: Pipe and stub
10) Article 23-11: Flange

Article 31-5-2. Turbine Casing, Pedestal and Support

1. Casing, pedestals and supports shall be designed to withstand all normal and emergency service loads, allowable piping forces and moments caused by temperature. The casing design shall be such that thermal stresses in service are minimized. Turbine casing shall be adequately supported to maintain good alignment with rotor.

The container housing to store rotor and blade wheels of turbine. As can be seen Fig-47, 48 and Photo-32, the HP and IP casing is made of cast steel, the LP casing is made of steel plate. Both casings shall be easy to assemble, have sufficient strength and rigidity be made freely and uniformly heat expansion. Especially for HP and IP casing, it is required the consideration to heat distortion and heat stress, and the attention for the information of thickness and simplification of shape due to the exposure by high pressure and high temperature steam.

It is the countermeasure to apply nozzle box for a lot of large steam turbines and to install governor valve separated with turbine body in order to simplification of the hot steam inlet portion susceptible to heat stress. The double casing structure which is consist of internal external casings is applied to as the other measure for high pressure steam, and the turbine exhaust pressure is act to the chamber between casings. It is possible to reduce the thickness when compared to the single casing, because the differential pressure of each casing is reduced approximately halved. Besides, it would be beneficial on the thermal deformation and thermal stress because that the inner casing is heated from both internal and external.

The most casing is divided into upper and lower two horizontally in order to facilitate over-haul, re-assemble and removal of rotor. However, the flange joint which is used under high pressure steam is very thick shown as Fig-47. In order to reduce heat stress and simplify the casing by eliminate thick flange, the barrel type casing is applied. The inner casing is same as normal two split type casing but the outer casing is barrel type shown as Fig-48.

The LP casing is a vessel which is exposed external pressure; because of the internal vacuum same as condenser. There is less structural problem than HP casing because of the many reinforcement stiffeners everywhere and the low temperature. The shape of channel fall into the condenser is taken care to reduce exhaust loss of exhaust by recovering speed energy and to avoid vortex. The thin copper or lead atmospheric pressure relief plate is provided on the LP casing, steam will be relieved to atmosphere (work at 32~39kPa) when the pressure in the exhaust room is raised more than atmospheric pressure due to cooling water stop or other the reasons, is pushed off to outside and cut off by knife-edge. However, in practice, the vacuum trip device is provided as the safety trip devices in order to trip turbine above a certain deterioration of vacuum, there is less opportunity to the atmospheric pressure relief plate works.

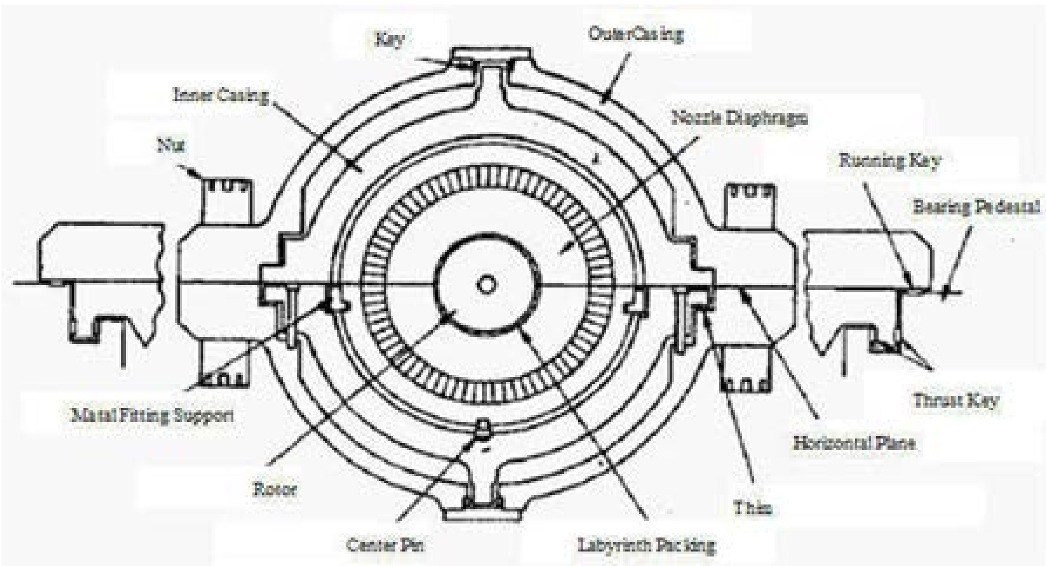


Fig- 47: Typical construction of HP steam turbine

Reference: P-76 of Journal (No.574: Jul /2004): TENPES

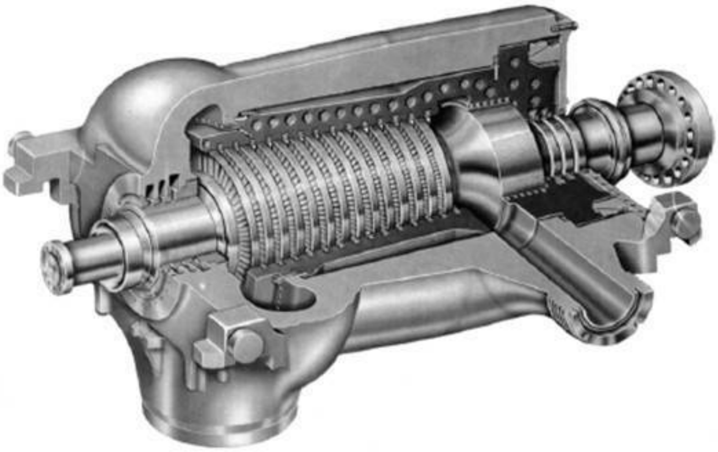


Fig- 48: Typical construction of HP steam turbine

Reference: P-76 of Journal (No.574: Jul /2004): TENPES

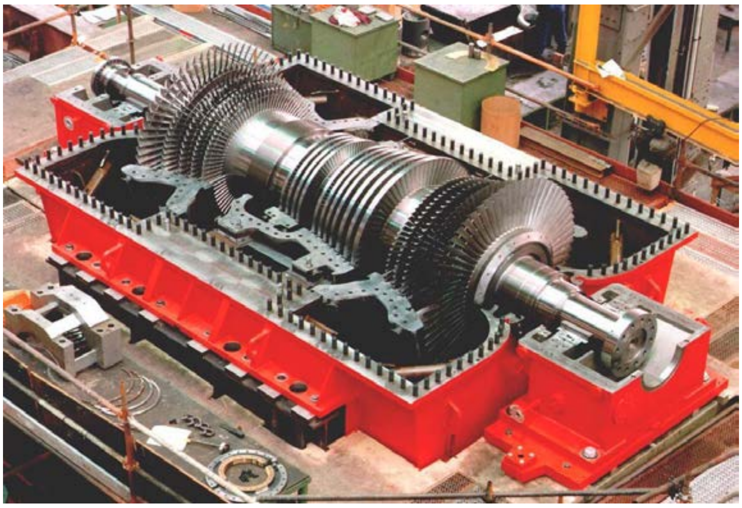


Photo- 32: Typical construction of LP steam turbine

http://mirror.enha.kr/wiki/%EC%A6%9D%EA%B8%B0%ED%84%B0%EB%B9%88

2. The safety structure of steam turbine and its auxiliary facility shall be conformed to the provision which stipulates the hydraulic examination of boiler pressure part mutatis mutandis.

Article 32. Speed Governing Device for Steam Turbine, etc.

Article 32-1-1. Terms Related with Rotation Speed.

Table- 24: Definition of terms regarding speed

Term	Meaning
rated speed	Design rotation speed at nominal output
maximum continuous speed	Upper limit of rotation speed to operate continuously
over-speed trip setting	Rotation speed which emergency governor operates

Term	Meaning
instantaneous maximum speed	The rotation speed to reach immediately after suddenly cut off the load when the turbine governor control devices are operated at the rated speed of the load conditions in a given
permanent speed rise	It is called “permanent speed raise at that load” which is automatically stabilized after load isolation when the turbine is operated with rated rotation speed at any load without changing the configuration of the governor.
maximum speed rise	The transient maximum turbine speed in the calculation when the governor does not work but emergency governor work after nominal load interception.
steady state speed regulation, permanent speed change, permanent speed variation, overall speed droop	The speed variation expressed as a percentage of the rated speed when the load is varied from no load to nominal of turbine output without changing the configuration of the governor
incremental speed variation, incremental permanent speed variation	R_1(%) は is given by: $R_1=(d_n \div d_P)\times(P \div n_r)\times 100$ where $(d_n \div d_P)$: Inclination at Any Output on the Characteristic between Output and Rotation Speed (min^{-1}/kW) P : Nominal Output (kW) n_r : Rated Speed (min^{-1})
maximum momentary speed variation, instantaneous speed change	R_2(%) is given by: $R_2=(n_m-n_r)\div n_r\times 100$ where n_m : Instantaneous Maximum Speed After Load Interception (min^{-1}) n_r : Rated Speed (min^{-1})
Dead band of the speed governing system	The ratio of variation speed with the rated speed without changing of governor valve opening during operation under rated speed.
percentage maximum momentary speed variation	R_m(%) is given by: $R_m=(n_u-n_r)\div n_r\times 100$ where n_u : Raised Speed (min^{-1}) n_r : Rated Speed (min^{-1})
percentage speed variation	R_c(%) is given by: $R_c=(n_c-n_r)\div nr\times 100$ where n_c : Dropped or Raised Speed (min^{-1}) n_r : Rated Speed (min^{-1})
percentage emergency speed variation	R_e(%) is given by: $R_e=(n_e-n_r)\div n_r\times 100$ where n_e : Working Speed of Emergency governor (min^{-1}) n_r : Rated Speed (min^{-1})

Article 32-1-2. Instantaneous Maximum Speed

$$n_o = \sqrt{\frac{7.3\times10^5}{GD^2}\times\left(E_R + \Delta E_1 + \Delta E_2 + \Delta E_3\right)}$$

n_o	: Maximum speed	(min^{-1})
E_R	: Rotational energy at rated speed $=1.37\times10^{-6}\times GD^2\times n_r^2$	(kJ)
n_r	: Rated speed	(min^{-1})
GD^2	: Inertia moment of rotating parts of turbine and generator	(kgm^2)
ΔE_1	: The energy flow into turbine during the delay time of valve opening operation after load interception	(kJ)
ΔE_2	: The energy flow into turbine during the time of valve closure after the load interception	(kJ)
ΔE_3	: The energy used to increase speed by the remaining in turbine and steam pipe at the load interception	(kJ)

Article 32-1-3. Maximum Speed Rise

$$n_E = \sqrt{\frac{7.3\times10^5}{GD^2}\times\left(E_E + \Delta E_{1E} + \Delta E_{2E} + \Delta E_{3E}\right)}$$

n_E	: Maximum speed (the rotation speed which emergency governor operates)	(min^{-1})
E_R	: Rotational energy at emergency governor operates $=1.37\times10^{-6}\times GD^2\times n_E^2$	(kJ)
GD^2	: Inertia moment of rotating parts of turbine and generator	(kgm^2)
ΔE_{1E}	: The energy flow into turbine during the delay time of valve opening operation after load interception	(kJ)
ΔE_{2E}	: The energy flow into turbine during the time of valve closure after the load interception	(kJ)
ΔE_{3E}	: The energy used to increase speed by the remaining in turbine and steam pipe at the load interception	(kJ)

Article 32-1-4. Steady State Speed Regulation

$$R_s[\%] = \frac{n_o - n_r}{n_r}\times100$$

n_o	: The permanent speed rise at no load operation after intercept of rated output	(min^{-1})
n_r	: Rated speed	(min^{-1})

R_s are generally in the range of 3~5%, ht actual adjustment of R_s=5% at full throttle of governor valve

Article 32-1-5. Incremental Speed Variation

$$R_r[\%] = Knp \times \frac{P}{n_r} \times 100$$

Knp	: Inclination at any output point of output-rotation speed characteristic	(min^{-1}/kW)
P	: Nominal output	(kW)
n_r	: Rated speed	(min^{-1})

Table- 25: The incremental speed variation of governor

Type of governor		Mechanical			Electric-hydraulic		
Nominal output (kW)		Less than 20,000	20,000~ 150,000	More than 150,000	Less than 20,000	20,000~ 150,000	More than 150,000
Speed variation ratio (%)		3~5					
Incremental speed variation (%)	0~90 (%) of Nominal output	Maximum Value : No limitation Minimum Val : 40% of steady state speed regulation				2~10	
	90~100 (%) of Nominal output					Less than 12	
Mean incremental speed variation (1) %within the range 90~100 (%) of nominal output		Less than 15				Less than 10	
Dead band of speed governing system (%)		0.4	0.20	0.10	0.15	0.10	0.06

Note-1: In case of partial-arc admission turbine, the mean incremental speed within the range 90~100 (%) of nominal output shall not exceed 3 times of steady state speed regulation.

Reference: JIS B8101-2003 “General specification for steam turbines”

Article 32-1-6. Governor Test

1. The speed control range: The speed control range of turbine at no-load shall be within ±6% of rated speed. (IEC6045-1 stipulates±5% of rated speed.) If there is special necessity, it can be modified by agreement of the parties. For instance, −5 ~＋7%.

Article 32-1-7. Over-speed Trip Setting of Emergency Governor

1. Over-speed Trip Setting of Emergency Governor: The maximum speed reached when the emergency governor operates shall not exceed the safety limit of turbine and followers. (JIS stipulates less than 111% of rated speed and IEC60045-1 stipulates 110±1% of rated speed.) In case of large scale turbine, it shall be capable to reset before turbine speed drop to rated speed.

    1) The maximum momentary speed variation at load interception

    This means the speed variation reaching momentary when intercepts any load as it has operated at the rated speed under certain condition.

    2) The percentage emergency speed variation

    The percentage emergency speed variation is the maximum speed rise which the maximum momentary speed variation exceeds the over-speed trip setting and reaches to maximum speed. The variation of maximum speed rise shall be less than 120% of rated speed.

Article 32-1-8. Over-speed Test

1. The maximum speed at the over-speed test: When carrying out the over-speed test of rotor in the factory, the test speed shall not exceed 115% of rated rotation speed; duration of test shall be within 2 minutes under no load operation and is limited one time.

Article 32-1-9. Concept of Rotation Speed

1. The control device is broadly divided into a governor device and a safety device. The governor device regulates the output and speed of the turbine generator, while the safety device stops the turbine generator quickly and safety should it has developed an abnormal condition during operation. The governor device is further divided into a conventional mechanical hydraulic governor and a new-type electro hydraulic governor used for large-capacity turbines.

    The turbine governor is a device to adjust the turbine rotation speed within a certain range regardless of load. It is consisted by adjusting actuator which moves sensitively depending on the changes of turbine speed and the governor valve which adjust the steam supply for turbine shown in Fig-49, 51 and 52. The centrifugal weight method is applied to the small turbine. The centrifugal oil pump method is applied to the latest large scale turbine, which the impeller is attached to the end of rotor and is detected the variation of rotation from the variation of oil discharge pressure depending on the variation of rotation. The variation of hydraulic oil pressure open and close the governor valve by oil piston which the force and movement is amplified through the pilot valve.

The emergency governor is the emergency stop device to prevent the risk due to over-speed by isolate the steam from boiler by means of isolating the main stop valve, governor valve, intercept valve and reheat stop valve immediately as shown in Fig-50 and 52. The eccentric bodies (plunger type or ring type) attached to one end of the turbine rotor have slight deviation from the center of gravity of the rotating shaft and centrifugal force works. The plunger or ring is supported in place by spring force when the turbine speed is constant, however, the they act to overcome the sticking force of the spring outward, when rotating speed exceed a certain limit (Fig-53). The turbine governor and the emergency governor are both important devices, the type of them shall be selected reliable ones and the redundancy shall be considered. In addition, the relationship of speed and restrictions shall be organized as follow.

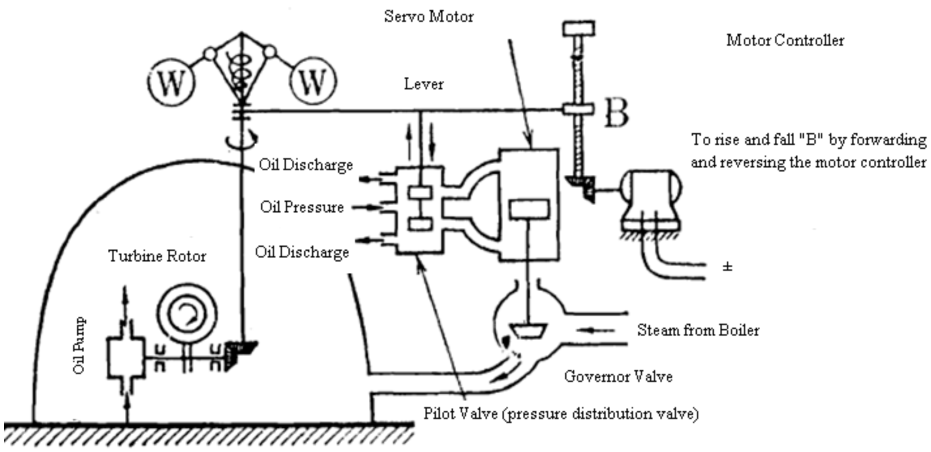


Fig- 49: Typical construction of governor

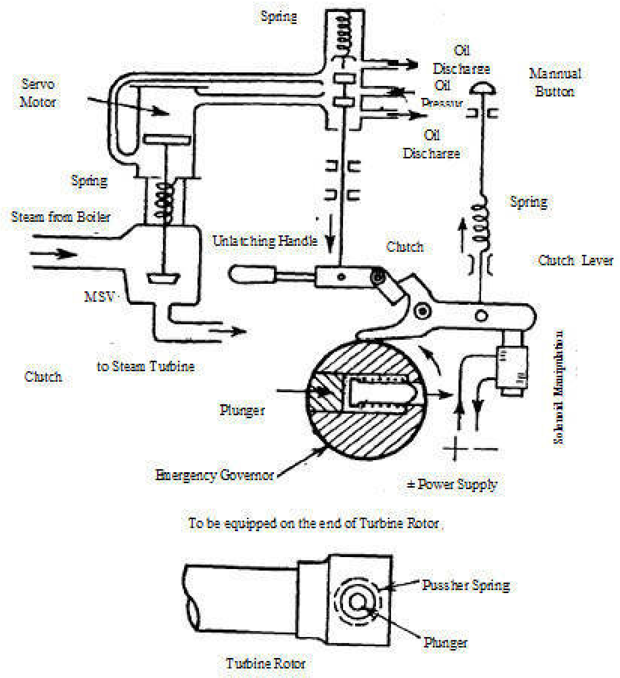


Fig- 50: Typical construction of emergency governor

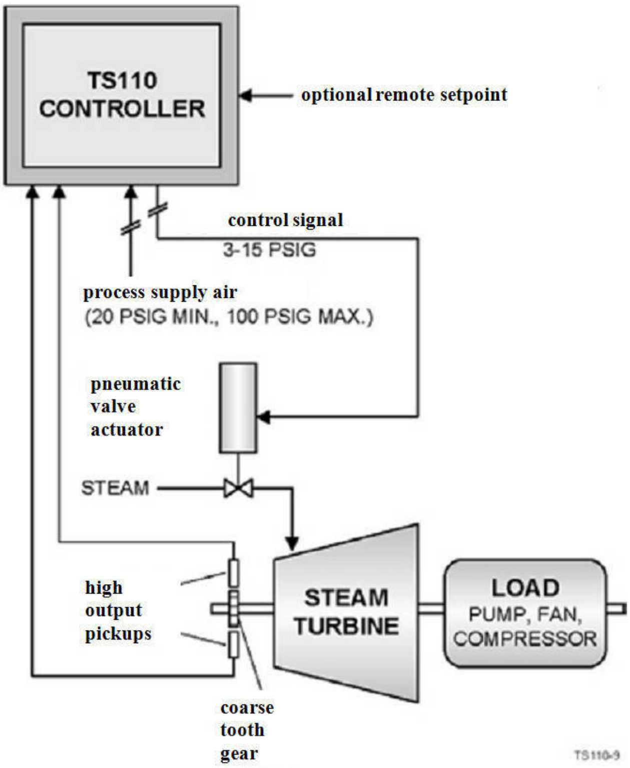


Fig- 51: Typical electronic turbine speed controller

http://jriesen.dyndns.org:6200/products-services/ts110/

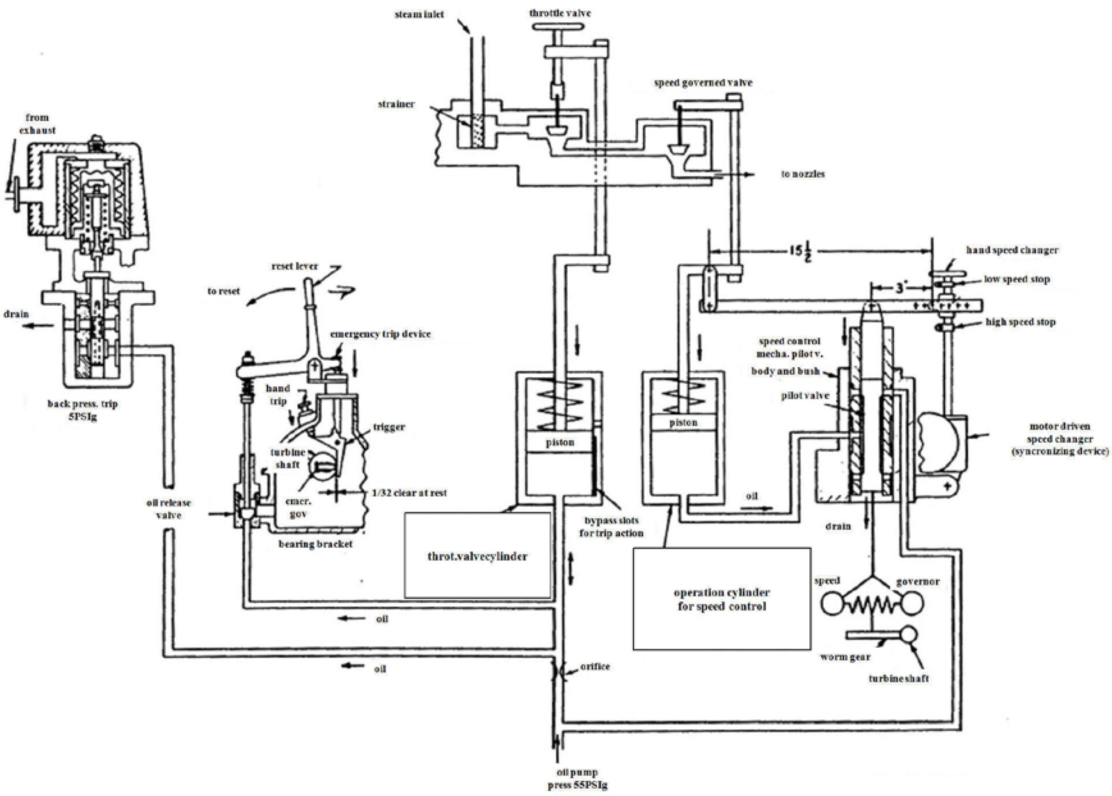


Fig- 52: Typical turbine governor

http://weh.maritime.edu/campus/tsps/manual/images/big/tsps086.jpg

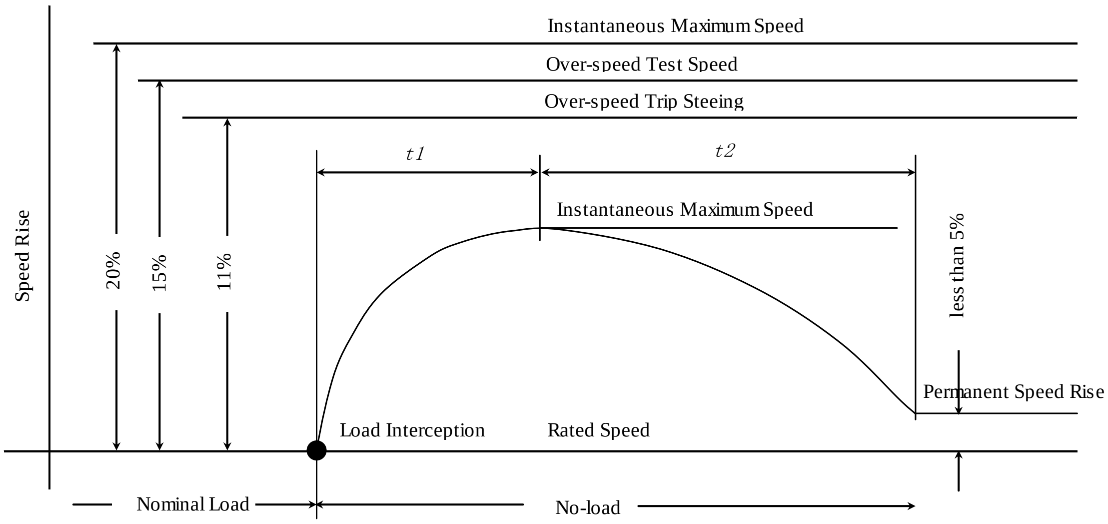


Fig- 53: Concept of rotation speed

Article 33. Emergency Stop Device for Steam Turbine, etc.

Article 33-1-1. Alarming Device

1) Wear of thrust bearing
2) LP casing exhaust steam temperature high
3) Bearing temperature high (discharge oil or metal)

(IEC60045-1 stipulating the maximum temperature 75°Cand JIS stipulating 77°C)

4) High vibration

5) Drop of condenser vacuum

Article 33-1-2. Harmful Vibration during Operation

1. The "**harmful vibration during operation**" stipulated in Article 33-1 of design technical regulation means the case when maximum total amplitude of vibration occur on main bearing and shaft around it and when total amplitude exceeded the warning value listed as following Table-26 of steam turbine and coupled with other rotor which rated output exceed 400MW.

Table- 26: Warning value of vibration

Measuring Point	Rated Rotation Speed	Warning Value	
		Rotation Speed ＜ Rated Rotating Speed	Rated Rotating Speed ≦Rotation Speed
Bearing	3,000rpm or 3,600rpm	0.075mm	0.062mm
	1,500rpm or 1800rpm	0.105mm	0.087mm
Rotor	3,000rpm or 3,600rpm	0.15mm	0.125mm
	1,500rpm or 1800rpm	0.21mm	0.175mm

Reference: Article 24 of Interpretation of technical regulation for thermal power facility (10/Jul/2007): NISA of METI Japan

(1) The evaluation standard for vibration is stipulated as the vibration velocity according to the IEC60045-1, 2, 3 and is stipulated within 2.8mm/s as good vibration at the steady state and rated speed. The shaft vibration is kept in regular expression "more than twice of the bearing vibration", and omitted from the standard of evaluation.

(2) The idea to evaluate the vibration of turbine as full amplitude of the bearing or shaft is established in Japan and the upper limit of alarm for operation is stipulated in JIS with reference to JESC T0003-2000（Rules of Steam Turbine for Power Generation：JEAC 3703）. Although there is no stipulation about the stop of turbine when the vibration increase, it is recommended to stop or automatically stop steam turbine when the total amplitude of shaft exceed the twice of alarm value according to JESC T0003-2000（Rules of Steam Turbine for Power Generation：JEAC 3703） as shown in Fig-54.

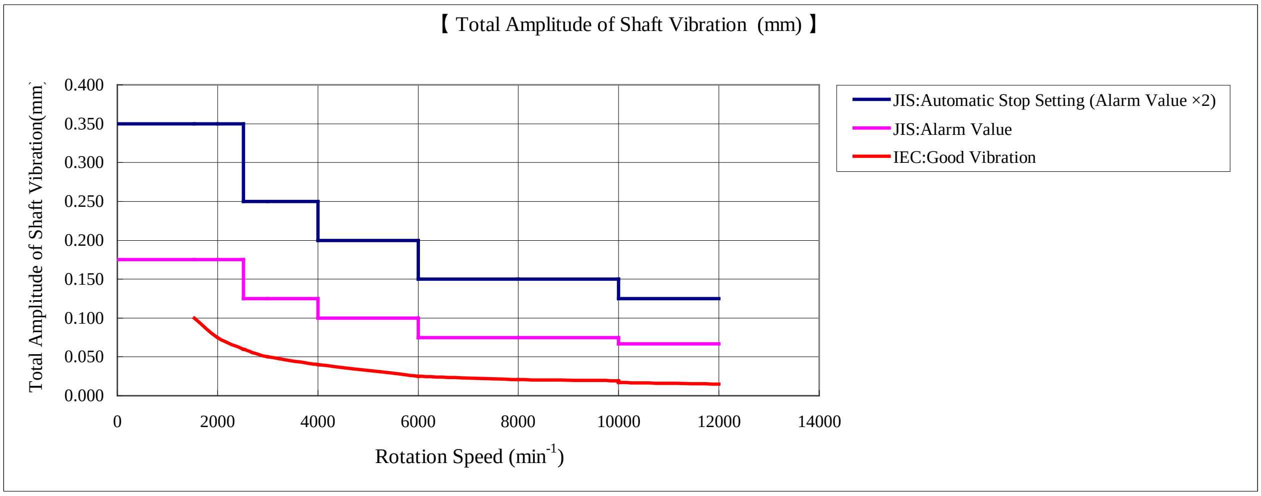


Fig- 54: Allowable value of vibration

【Reference Standard】			
1.	JIS B8101	2003	General Specification of Steam Turbine-Shutoff and Alarm Equipment
2.	JEAC 3703	2010	Regulation of Steam Turbine for Generation
3.	ISO 7919-1	1996	Mechanical Vibration of non-reciprocating machines
4.	ISO 7919-2	2001	Mechanical Vibration Evaluation of machine vibration by measurements on rotating shafts Part2.
5.	ISO 7919-3	2009	Mechanical Vibration Evaluation of machine vibration by measurements on rotating shafts Part3.
6.	IEC6005-1	1997	Direct Acting Indicating Analogue Electrical Measuring Instruments And Their Accessories--Part 1: Definitions And General Requirements Common To Part S
7.	IEC6104	1991	Acceptance tests for steam turbine speed control system

Article 33-2-1. Emergency Stop Device (Trip device)

1. The steam turbine must have following independent protection equipment. These equipment work immediate following to the trip signal, close rapidly all main steam valves, for instance, main stop valve, governor valve, re-heat stop valve and intercept valve, and close re-heat check valve which is provided on the cold reheat steam piping, if any, or close forcibly extraction check valve which is provided to supply steam for feed –water heat-exchanger or other system. The steam turbine shall be stopped safely without any damage of turbine and its auxiliary equipment when an accident.
2. The protection equipment must be designated to immediately close the main stop valve, governor valve, re-heat stop valve and intercept valve when the control oil were lost.
3. The trip equipment must not be re-set and stem valves shall not be opened even if the conditions to work trip equipment are released. The trip equipment shall be designated to always re-set by manual.
4. Trip device must include following equipments.

1) Emergency governor device
2) Manual trip device to operate at site
3) Solenoid trip device to operate at site or remote
4) Vacuum trip device
5) Low main steam pressure trip device (if required)
6) Low bearing oil pressure trip device
7) Governor failure trip device (incase of electric type)
8) Generator failure trip device
9) Electric system failure trip device

Article 33-2-2. Immediately

1. "**Immediately**" stipulated in Article 33-2 of design technical regulation means the previous time point when rotation speed exceeded the 1.11 times of the rated rotation speed in case of the rotation speed of steam turbine exceeded the rated rotating speed. In other case, the time point when abnormal situation occurred.

Article 33-2-3. Over-speed and Other Abnormal Situation

1. The "**over-speed**" stipulated in Article 33-2 of design technical regulation must mean in case rotation speed of steam turbine exceeded above rated speed and **"any abnormal situation**" means following situation.

(1) internal fault of generator more than 10,000kVA capacity
(2) significant decline of condenser vacuum of steam turbine more than 10,000kW rated capacity
(3) significant wear of thrust bearing and significant rise of temperature of steam turbine more than 10,000kW rated capacity

2. Protection Devices against Reverse Water Flow from Feed-water Heaters
At least following devices must be provided in order to protect reverse water flow into turbine from feed-water heater system.

(1) Every extraction steam piping must be arranged in order that each drum of feed-water heaters is filled up before reverse water flow may come into turbine casings.
(2) Two independent devices must be provided on every feed-water heaters on order to protect reverse water flow from extraction steam piping into turbine casings in the following way.

Combination Ⅰ : 2) and 1A) or 1B)
Combination Ⅱ : 3) and 1A) or 1B)
Combination Ⅲ : 2) and 3)

Where,

1A) : Sealing piping of "U" type must be provided on feed-water heater and drain water will exhausted by gravity.

1B) : Automatic drain exhausting system must be provided separately with adequate capacity on feed-water heaters.

2) : Automatic shut-off valves must be provided on extraction steam piping between turbine casing and feed-water heaters and drain piping connected cascade to feed-water heaters.

3) : Automatic shut-off valves must be provided on feed-water piping to feed-water heaters. Normally, automatic by-pass piping is necessary on relevant feed-water heaters.

Reference: 11.4.2 of JIS 8101-2003 "General specification for steam turbines"

【Reference Standard】			
1.	ASME PTC20.2	1965	Over-speed Trip Systems of Steam Turbine-Generator Units
2.	ASME PTC20.1	1977	Speed and Load-Governing Systems for Steam Turbine-Generator Units
3.	ASME PTC6A	2000	Appendix-A to Test Code for Steam Turbines

Article 33-2-4. Main Valves

1. The main stop valve and reheat stop valve is basically protective equipments. They are ON/OFF valves which are kept fully opened while in normal operation and which isolate steam immediately in case of emergency. However, the valve body and actuator are developed depending on the function to inject from all around which reduce excessive heat stress due to high pressure and high temperature occurred on turbine when controlling speed with nozzle close and added special function, etc. to prevent over-speed. The sub-valve which is provided in the main stop valve controls the amount of inflow steam into turbine when applying injection from all around. The main stop valve and reheat stop valve have the mechanism to test full or half open action regularly during operation in order to prevent sticking in the hot steam. It is also the first part of the steam coming from boiler; the strainer is provided in front of main stop valve to prevent contamination. Fig-55 and Photo-33 is the sample of main stop valve. Fig-57 and Photo-34 is the integrated with the stem governing valve.

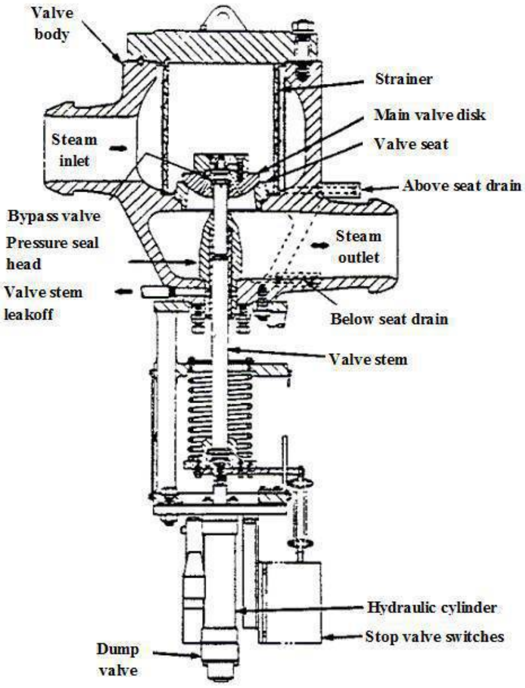


Fig- 55: Main stop valve

http://www.kntc.re.kr/openlec/nuc/NPRT/module2/module2_5/module2_5_2/images/fig12-19.gif

Photo- 33: 600MW class main stop valve

http://www.goodwinsteelcastings.com/steam_turbines.html

The governor valve is the valve to control steam inflow to turbine, and it works in conjunction with the governor system. It will be built into the upper half and lower half of HP casing for relatively small turbine. Generally, the steam room which is installed separately from the high pressure turbine (construction which has common with multiple governor valves) is applied to the turbine exceed 350MW, and the oil servomotor is installed on each valve. It has become difficult to meet the change of glowing valve diameter even the construction which has common with multiple governor valves. The combination of a main steam valve and a governor valve which the governor valve is separated in each valve is applied for the 700~1,000MW class steam turbine.

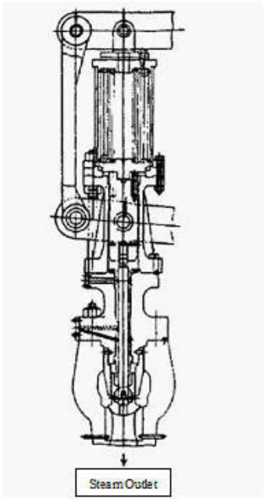


Fig- 56: Governor valve

Reference: P-79 of Journal (No.574: Jul/2004):

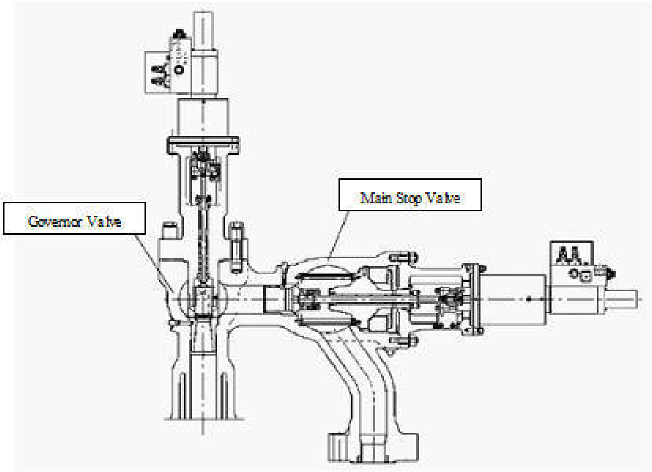


Fig- 57: Main Stop valve (integrated structure)

Reference: P-79 of Journal (No.574: Jul/2004): TENPES

Fig-56 is a sample of the governor valve, and it is called the balanced steam valve. The sub-valve opens first with few mm stroke to reduce imbalance force in order to open main valve easily before opening the main valve. There is the possibility that the remaining steam in the reheat steam pipe accelerate the rotor speed due to the expansion in the downward of IP stage, even if closing the steam governor valve because of immediate blocking of load and working of the governor.

The intercept valve has the function to prevent the inflow of excess steam by starting to close from 101% and closing fully at 105% when the rotation speed rise from rated speed. Photo-35 is an example of the intercept valve which has been incorporated into the steam room of the reheat stop valve.

Photo- 34: 1000MW class MSV-GV

http://www.goodwinsteelcastings.com/steam_turbines.html

Photo- 35: 600MW class RSV-IV

http://www.goodwinsteelcastings.com/steam_turbines.html

Article 34. Pressure Relief Device for Steam Turbine, etc.

Article 34-1-1. Over-pressure

1. The "**over-pressure**" stipulated in Article 34-1 of design technical regulation must mean the pressure exceed maximum operation pressure at usual situation.

Article 34-1-2. Appropriate Pressure Relief Device

1. The "**appropriate pressure relief device**" stipulated in Article-34-1 of design technical regulation must mean the emergency rupture disc (atmosphere relief diaphragm) or pressure relief valve which has sufficient capacity to prevent pressure rise of exhaust steam of steam turbine. The Article 24-1 and 24-2 of technical guideline of safety valve for boiler must be applied to the safety valve of auxiliary facility of steam turbine. Generally, it is the structure which release over-pressure by means of the rupture of the lead sheet as shown in Fig-58, 59 and Photo-36.

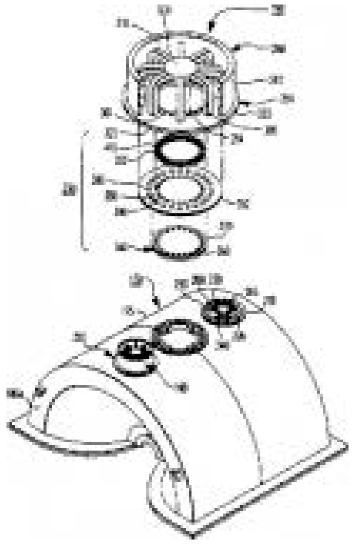


Fig- 58: Atmosphere relief diaphragm

http://static.patsnap.com/patent/image/small/US5222862&w=120

Photo- 36: Atmosphere relief diaphragm

http://nolstuijt.wordpress.com/2011/03/15/duvha-powerstation-turbine-blowup-sa/

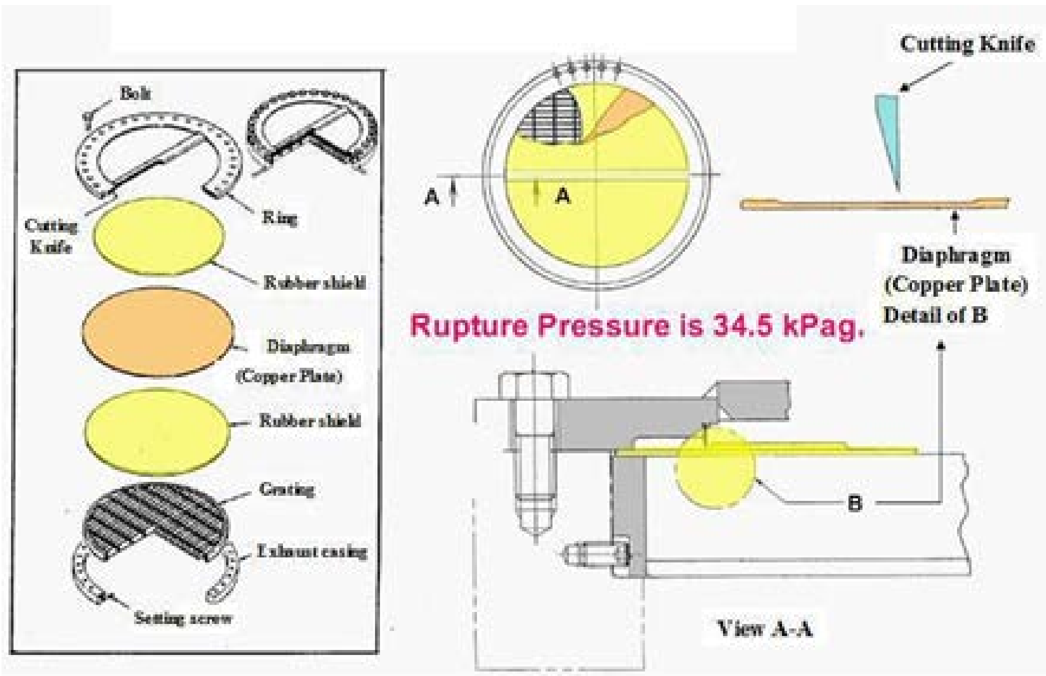


Fig- 59: Atmospheric relief diaphragm

http://www.scribd.com/doc/46789244/Steam-Turbine (PPT of Toshiba "Steam turbine and auxiliaries")

【Reference Standard】			
1.	JIS B8101	2003	General Specification of Steam Turbine-Pressure Relief Valve
2.	JIS B8210	2009	Safety devices for protection against excessive pressure -Direct spring loaded safety valves for steam and gas service
3.	ASME Sec. I	2007	Boiler applications
4.	ANSI/ASME PTC 25.3	1994	Safety and Relief Valves - performance test codes
5.	API RP 520	2000	Sizing selection and installation of pressure relieving devices in refineries, Part 1 Design, Part 2 Installation
6.	API RP 521	1997	Guide for pressure relieving and depressurizing systems
7.	API STD 526	2002	Flanged steel pressure relief valves
8.	API STD 527	2007	Seat tightness of pressure relief valves
9.	EN ISO 4126-1	2004	Safety devices for protection against excessive pressure Part1-Safety valves
10.	ISO 4126	2004	Safety valves - general requirements
11.	AFNOR NFE-E -29-411 to 416		Safety and relief valves
12.	AFNORNFE-E -29-421		Safety and relief valves
13.	BS 6759	1999	Part 1 specification for safety valves for steam and hot water Part 2 specification for safety valves for compressed air and inert gas Part 3 specification for safety valves for process fluids
14.	A. D. Merkblatt A2	2000	Pressure Vessel Equipment safety devices against excess pressure - safety valves
15.	TRD 421	1982	Technical Equipment for Steam Boilers Safeguards against excessive pressure - safety valves for boilers of groups I, III & IV
16.	TRD 721		Technical Equipment for Steam Boilers Safeguards against excessive pressure-safety valves for steam boilers group II

Article 35. Instrument Equipment for Steam Turbine, etc.

Article 35-1-1. Instrument Device to Monitor the Operation Status

1. The "**instrument device to monitor the operation status**" stipulated in Article 35-1 of design technical regulation means the devices to measure following items. However, the item-(7) may not apply for steam turbine with rated output equal and less 10,000kW but the automatic recorder, records including electric media, shall be applied to steam turbine exceed rated output 400MW.

(1) Pressure gauge

1) Pressure at the up-stream of main stop valve or steam strainer
2) Pressure at the up-stream of reheat stop valve or steam strainer
3) Extraction steam pressure (in case of extraction turbine)
4) Extraction steam pressure to feed-water heater
5) Outlet steam pressure of each casing
6) Exhaust pressure of turbine
7) Lubrication oil pressure at bearing inlet
8) Control oil pressure

(2) Thermometer

1) Main steam temperature
2) Reheat steam temperature
3) Outlet steam temperature of HP and IP casing
4) Exhaust temperature
5) Extraction steam temperature for heat exchanger
6) Outlet oil temperature from oil cooler
7) Oil outlet temperature from bearing or metal temperature of bearing

(3) Level gauge

1) Level of main oil tank
2) Level of control oil tank

(4) Turbine speed indicator
(5) Power meter
(6) Differential expansion indicator and shell expansion indicator

1) To measure relative axial transfer of rotor against casing or pedestal of bearing at far end from thrust bearing
2) To measure relative axial transfer of bearing pedestal against turbine foundation

(7) Shaft position indicator to measure relative axial position with thrust collar
(8) Vibration indicator
(9) Thermometer for casing
(10) Governor valve position indicator

(11) Typical supplement instruments for large scale turbine

1) Cooling water temperature for condenser
2) Pressure and level of various tanks
3) Steam and feed –water pressure and temperature of feed-water heat exchanger and other heat exchanger
4) Suction and delivery pressure of feed –water pump
5) Flow of condensate-water, feed-water and main steam
6) Pressure of downstream of 1st stage

To effectively manage the health and performance of steam turbines, there are a number of turbine parameters which should be measured, monitored and/or displayed on a continuous basis. How much information is monitored is a function of the steam turbine design and application, but with today's modern steam turbines, the following parameters should be monitored:

1) Speed (RPM) and load (kW/MW, or shaft horsepower (SHP))
2) Steam turbine inlet pressure and temperature
3) Steam turbine 1st stage pressure and temperature (these are the conditions downstream of the first/large impulse stage before remaining HP section blading, as applicable)
4) HP turbine outlet (or cold reheat), IP turbine inlet (or hot reheat), and IP turbine outlet/LP turbine inlet (or crossover) pressures and temperatures for reheat and multiple shell turbines only
5) Steam turbine rotor/shell differential expansions (as applicable for large turbines)
6) Steam turbine shell and steam chest temperatures/differentials (lower and upper half thermocouples installed in HP and IP turbine sections for large turbines)
7) Admission and extraction pressures and temperatures (as applicable)
8) Extraction line thermocouples to detect water induction (as applicable)
9) Water and steam purity at the main steam inlet and condensate pump discharge
10) Sealing steam and exhauster pressures (as applicable)
11) Steam turbine exhaust pressure and temperature
12) Lube oil and hydraulic fluid supply pressures and temperatures
13) Cooling water supply pressures and temperatures for the lube oil and hydraulic fluid systems
14) Journal bearing and thrust bearing metal temperatures (or drain temperatures, if applicable) for the turbine and gearbox (as applicable)
15) Bearing vibration – seismic, shaft rider, or shaft x-and-y proximity probes measurements for all turbine and gearbox (pinion) bearing locations (as applicable)

Monitoring of these and other parameters is typically done in conjunction with today's modern turbine digital controls and plant control room systems. These systems will also handle the starting sequence, synchronizing, loading, speed governing, alarms, and trip logic for the turbine, gearbox (if present), generator, and any supporting systems. These systems also provide the electronic portion of the protection (i.e., turbine over-speed) for critical turbine and generator parameters. For older units there may be an analog control system which provides limited protection along with mechanical/electrical devices on the unit. There usually is a limited display of monitoring parameters. For even older units, all operation will be manual with only a gage panel to monitor a few turbine parameters. Vibration monitoring is done periodically using hand-held instrumentation. These older units are dependent solely on the knowledge of the operating staff, the presence and use of written operating procedures, and the mechanical/electrical devices on the unit for protection. All of these issues are important for every unit but the consequence is higher with older, outdated units. Because the amount of equipment monitoring may depend on the complexity of the steam turbine, the ***minimum acceptable*** turbine parameters that should be monitored by turbine type/size are indicated in Table-27.

Table- 27: Recommended steam turbine monitoring parameters by turbine size/type

Steam turbine parameters to be monitored continuously	Small single stage units 0.5~2MW	Medium size multi-stage units 1.5~10MW	Admission/ extraction and non-reheat units < 100MW	Combined cycle reheat units	Large reheat sub-critical and super-critical units
Speed (RPM)	X	X	X	X	X
Power (MW or SHP)	X	X	X	X	X
Steam turbine inlet pressure	X	X	X	X	X
Steam turbine inlet temperature	X	X	X	X	X
Steam turbine 1^{st} stage pressure	—	X	X	X	X
HP turbine outlet, IP turbine inlet, IP turbine outlet/LP turbine inlet pressure and temperature	—	—	—	X	X
Admission steam inlet pressure and temperature (as applicable)	—	—	X	X	—
Extraction steam outlet pressure and temperature (as applicable)	—	—	X	—	—
Turbine exhaust steam pressure	X	X	X	X	X
Turbine exhaust steam temperature			X	X	X
Sealing steam pressure	X	X	X	X	X
Sealing seal exhauster vacuum	—	X	X	X	X
Hp and IP turbine shell/steam chest temperature/differentials	—	—	X	X	X
Rotor/shell differential expansions	—	—	X	X	X

Steam turbine parameters to be monitored continuously	Small single stage units 0.5~2MW	Medium size multi-stage units 1.5~10MW	Admission/ extraction and non-reheat units < 100MW	Combined cycle reheat units	Large reheat sub-critical and super-critical units
Rotor eccentricity	—	—	**X**	**X**	**X**
HP and IP stress	—	—	—	—	**X**
Extraction line and drain line thermocouples	—	—	**X**	**X**	**X**
Lube oil supply pressure	**X**	**X**	**X**	**X**	**X**
Lube oil supply temperature	—	**X**	**X**	**X**	**X**
Lube oil sump pump level	—	—	**X**	**X**	**X**
Bearing vibration (seismic, shaft rider, or proximity measurements)	—	**X**	**X**	**X**	**X**
Thrust bearing wear/temperatures	—	**X**	**X**	**X**	**X**
Hydraulic fluid pressure and temperatures	—	**X**	**X**	**X**	**X**
Cooling water supply pressures and temperatures for lube oil and hydraulic fluid heat exchangers	**X**	**X**	**X**	**X**	**X**
Water and steam purity monitoring	—	**X**	**X**	**X**	**X**
Control valve position indication (%)	—	**X**	**X**	**X**	**X**
Admission and extraction valve position indication (%)	—	—	**X**	**X**	—

Reference: P-21 of "Maintenance and Overhaul of Steam Turbines" IMIA-WGP 42-2005

Article 35-1-2. Turbine Supervisory Instrument

1. The supervisory device which monitors the location of casing and rotor and vibration, etc. is especially important as a protective device. It is necessary to provide combined supervisory devices in consideration with the construction of devices in order to monitor in real time. The typical construction of them is as shown in Fig-60 and Table-28 below.

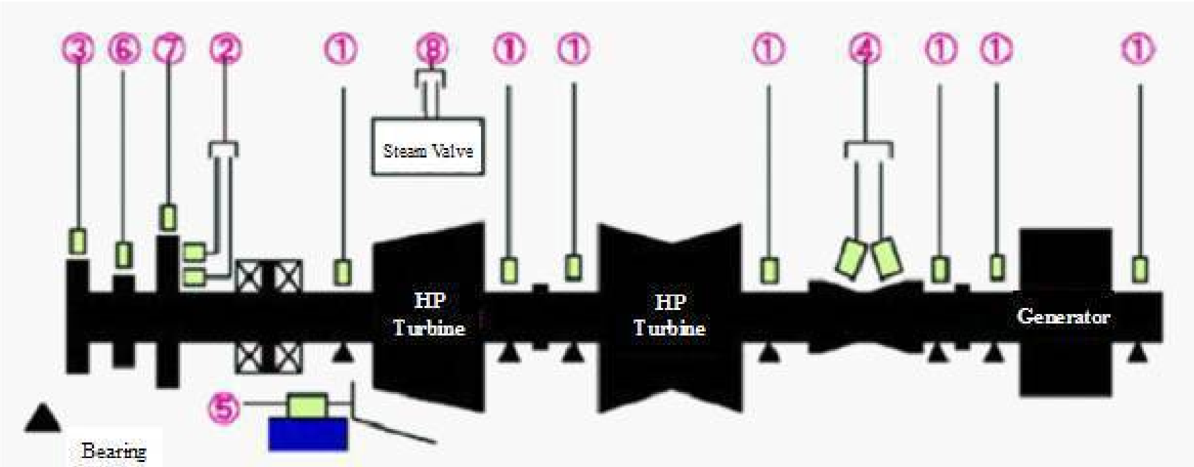


Fig- 60: Monitoring system for steam turbine and generator

Table- 28: Monitoring parameter of turbine rotor

No.	Monitoring Parameter	No.	Monitoring Parameter
1	Shaft Vibration	5	Casing Expansion
2	Axial Position	6	Rotating/Zero Speed
3	Eccentricity P-P	7	Phase Marker
4	Differential Expansion	8	Valve Position

http://www.forbesmarshall.com/fm_micro/IndustryAppAndProducts.aspx?Id=shinkawa&AppId=1

【Reference Standard】			
1.	JIS B8101	2003	General Specification of Steam Turbine-Turbine Instrument
2.	IEC 60045-1	1991	Steam turbines Part1: Specification
3.	IEC 60962	1991	Maintenance and use guide for petroleum lubrication oil for steam turbine
4.	DIN EN45510-5-1	1998	Guide for procurement of power station equipment Part5.

Chapter-3. Reference International Technical Standards

The reference international standards for designing steam turbine are organized in Table-29.

Table- 29: Reference international standards

Number	Rev.	Title	Content
ASME/ANSI PTC-PM	1993	Performance Monitoring Guidelines for Steam Power Plants	Performance information of the operating unit will be displayed on the fossil and nuclear generating power stations, and the following items are pursued as the guidelines in order to utilize optimized operation effectively: summarizes of data, analyzes, procedure or method of retrofitting and optimization in future, diagnosis of prevention and prediction, etc.
ASME/ANSI PTC-46	1996	Performance Test Code on Overall Plant Performance	This stipulates the procedures and guidelines of thermal acceptance tests for the verifications of output and/or thermal efficiency of combined cycle power plants in case of power generating and cogeneration plants of various capacity. Heat recovery steam generator may be involved.
ASME/ANSI PTC-6	1995	Performance Test Code on Steam Turbines	This stipulates the procedures of most accurate thermal acceptance tests of steam turbine with minimum uncertainty of measurements in the fossil and superheated steam power plants and nuclear saturated steam plants. The following items are involved in this document: necessary items of preparations, method of instruction and measurements, calculation method of the results.etc.
ASME/ANSI PTC-6A	1982	Test Code for Steam Turbines on Appendix to PTC-6	Some example of numerical calculations is shown including corrections to specified conditions according to "PTC-6". Examples: considering type, reheat regenerative type, nuclear plants, controlled extraction and back pressure type, etc.
ASME/ANSI PTC-6A Report	1985	Performance Test Code on Guidance for Evaluation of Measurement Uncertainty in Performance	This specifies the procedures of most accurate thermal acceptance tests of steam turbines with minimum uncertainty of measurement. On the contrary, this standard shall specify the guideline for evaluation of level of measuring uncertainty in case that the test was carried out by other method than of "PTC-6".
ASME/ANSI PTC-6S Report	1988	Procedures for Routine Performance Tests of Steam Turbine	This standard can offer chapter and simple method of performance test for operating turbine units of various type and capacity compared with "PTC-6" with high accuracy and high cost. And also, this specifies the guideline of verification for level of measuring uncertainty in case of applying other method than of "PTC-6".
ASME/ANSI PTC20.1	1982	Speed and Load Governing Systems for Steam Turbine Generator Units	This stipulates performance testing of steam turbine and generator speed response governor of ASME
ASME/ANSI PTC20.2	1986	Over-speed Trip Systems for Steam Turbine Generator Units	This stipulates performance testing of steam turbine and generator trip

Number	Rev.	Title	Content
ASME/ANSI PTC20.3	1986	Pressure Control System on Steam Turbine Generator Units	This stipulates performance testing of steam turbine and generator pressure control system
ANSI/API 611	1992	General-Purpose Steam Turbine for Refinery Service	This stipulates design and operation of relatively small steam turbine and its auxiliary facility for driving use of pump and auxiliary machine
ANSI/API 612	1996	Special-Purpose Steam Turbines for Refinery Service	This stipulates relatively large steam turbine for driving use of centrifugal compressor, etc.
ANSI/API 614	1992	Lubrication Shaft-Sealing and Control-oil Systems for Special Purpose Application	This stipulates American National Standard for required specification of oil feed equipment, oil seal equipment and control oil equipment for special turbine
ASME/NEMA SM23	1994	Steam Turbine for Mechanical Drive Service	This stipulates American National Standard which is applied to the steam turbine for pump, fan, compressor and generator
NEMA SM24	1991	Land Based Steam Turbine Generator Sets 0 to 33,000MW	This stipulates American standard of National Electrical Manufacturers Association which covers single- and multi-stage steam turbines and expansion turbine, reduction gears, air-cooled electric generators, switchgear and auxiliary systems. Does not apply to other equipment in the steam cycle or electrical distribution systems
BS EN60045-1	1993	Guide to Steam Turbine Procurement	This stipulates English standard of general specifications of the steam turbine, identical to IEC60045-1
VDI 2059-1	1972	Shaft Vibration of turbo sets; Part-1: measurement and evaluation	This stipulates German standard for basic measurement method and evaluation method of steam turbine shaft vibration
IEC 60034-3	2007	Rotating electrical machines-Part3: Specific requirements for synchronous generators driven by steam turbine s or combustion gas turbines	This applies to three-phase synchronous generators, having rated outputs of 10 MVA and above driven by steam turbines or combustion gas turbines. Provides common requirements as well as specific requirements for air, hydrogen or liquid cooled synchronous generators and supplements the basic requirements given in IEC 60034-1. Gives also the precautions to be taken when using hydrogen cooled generators. The scope of this new edition has been limited with respect to the previous edition.
IEC 60045-1	1991	Steam turbines Part1: Specification	This applies to steam turbines driving generators for electrical power services. Includes provisions relevant to turbines for other applications. Enables a prospective purchaser to be aware of the available options and alternatives and to explain his technical requirements to suppliers. Replaces IEC 60045 (1970).
IEC 60651	1979	Standard for Sound Level Meters	This deals with sound level meters of four degrees of precision, designated Types 0, 1, 2 and 3. Specifies the following characteristics: directional characteristics, frequency weighting characteristics, time-weighting, detector and indicator characteristics, sensitivity to various environments. Establishes electrical and acoustical tests to verify compliance with characteristics specified and describes the method for absolute sensitivity calibration. This standard supersedes IEC 60123 and IEC 60179.

Number	Rev.	Title	Content
IEC 60804	2000	Standard for Integrating Sound Level Meters	This describes instruments for the measurement of frequency weighted and time averaged sound-pressure levels. Ensures specified accuracy and stability of an integrating sound level meter and reduces to the practical minimum any differences in equivalent measurements taken with instruments of various makes and models which satisfy the requirements of this standard. Specifies the following characteristics and test methods for integrating sound-level meters: a) integrating and averaging characteristics; b) indicator characteristics; c) overload sensing and indicating characteristics.
IEC 60953-1	1990	Rules for steam turbine thermal acceptance tests-Part1 Method A : High accuracy for large condensing steam turbines	This specifies procedures and guideline of thermal acceptance tests for verifications of output and/or thermal performance on generating steam turbines. "Part-1" intends to pursue procedure with higher accuracy according to "ASME PTC-6".
IEC 60953-2	1990	Rules for steam turbine thermal acceptance tests-Part2 Method B : Wide range of accuracy for various types and sizes of turbine	This specifies procedures and guideline of thermal acceptance tests for verifications of output and/or thermal performance on generating steam turbines. "Part-2" intends to apply procedure of wide range accuracy on the units of various type and capacity according to "BS" and "DIN".
IEC 60953-3	2001	Rules for steam turbine thermal acceptance tests Part3 : Thermal performance verification tests of retrofitted steam turbines	This specifies procedures and guideline of thermal acceptance tests for verifications of output and/or thermal efficiency in case that steam turbine is retrofitted partially or totally on thermal and nuclear generating power plants. Other than the original manufacturer can also offer retrofitting plan by adoption of absolute or relative guaranty. And, suitable evaluation method of influences due to the non-retrofitting equipments will be given.
IEC 60962	1991	Maintenance and use guide for petroleum lubricating oils for steam turbines	This guide applies to petroleum oils used as lubricating and control fluids with steam turbine systems in power generating stations. It may also be applied to petroleum oils used in gas or hydraulic turbines and in other auxiliary power plant equipment where appropriate.
IEC 61063	1991	Acoustics – Measurement of airborne noise emitted by steam turbines and driven machinery	This describes a method for the measurement of noise emitted by steam turbines including driven machinery operating under steady state conditions. The results are expressed in sound power levels and in sound pressure levels. Applies to steam turbines of all sizes without limitation of output.
IEC 61064	1991	Acceptance tests for steam turbine speed control systems	This contains recommendations for the conduct of tests of speed control systems of steam turbines. Applies primarily to constant speed steam turbines but may be applied where appropriate for other types of turbines. The purpose of the tests described in this publication is to verify the criteria guaranteed by the manufacturer and to check compliance with IEC 60045-1.

Number	Rev.	Title	Content
IEC/TS 61370	2002	Steam turbines-Steam purity	This describes the importance of the chemical characteristics of steam supplied to steam turbines and the need to prevent corrosion and deposition in steam space, in order to minimize the risk of turbine corrosion failures or loss of efficiency or output. Is applicable to turbines of all electrical output rating and any exhaust condition, i.e. condensing or back pressure. It is designed for new plant, but may be adapted for use on existing plant. The limits described in this specification are specifically designed to protect the steam turbine. This specification is applicable to steam turbines driven from any source, except geothermal plants in which the turbine is fed direct from the geothermal sources.
ISO 1925	2001	Mechanical vibration—Balancing--Vocabulary	—
ISO 1940-1	2003	Mechanical vibration -- Balance quality requirements for rotors in a constant (rigid) state -- Part 1: Specification and verification of balance tolerances	This gives specifications for rotors in a constant (rigid) state. It specifies balance tolerances, the necessary number of correction planes, and methods for verifying the residual unbalance. Recommendations are also given concerning the balance quality requirements for rotors in a constant (rigid) state, according to their machinery type and maximum service speed. These recommendations are based on worldwide experience. This is also intended to facilitate the relationship between the manufacturer and user of rotating machines, by stating acceptance criteria for the verification of residual unbalances.
ISO 1940-2	1997	Mechanical Vibration – Balance quality requirements of rigid rotors – Part-2: Balance errors	This detailed consideration of errors associated with balancing and verification of residual unbalance are given in ISO 1940-2.
ISO 2954	1975	Mechanical vibration of rotating and reciprocating machinery -- Requirements for instruments for measuring vibration severity	This states the requirements for measuring devices if inaccuracies of measurement are not to exceed a specified value. Devices covered give direct indication or recording of root-mean-square vibration velocity.
ISO 5348	1998	Mechanical vibration and shock-Mechanical mounting of accelerometers	—
ISO 11342	1998	Mechanical vibration -- Methods and criteria for the mechanical balancing of flexible rotors	—
ISO 7919-1	1996	Mechanical vibration of non-reciprocating machines—Measurements on rotating shafts and evaluation criteria—Part1:General guideline	—
ISO 7919-2	2001	Mechanical vibration Evaluation of machine vibration by measurements on rotating shafts Part 2: Land--based steam turbines and generators in excess of 50 MW with normal operating speeds of 1 500 r/min, 1 800 r/min, 3 000 r/min and 3 600 r/min	This establishes provisions for applying evaluation criteria for the severity of *in-situ*, broad-band shaft vibration measured radial (i.e. transverse) to the shaft axis at, or close to, the main bearings. These are in terms of: - vibration under normal steady-state operating conditions; - vibration during other (non-steady-state) conditions when transient changes are taking

Number	Rev.	Title	Content
			place, including run up or run down, initial loading and load changes; - changes in vibration which can occur during normal steady-state operation. This is applicable to land-based steam turbines and generators with power outputs greater than 50 MW and a normal operating speed of 1 500 r/min, 1800 r/min, 3 000 r/min or 3 600 r/min.
ISO 7919-3	2009	Mechanical vibration -- Evaluation of machine vibration by measurements on rotating shafts -- Part 3: Coupled industrial machines	This gives guidelines for applying evaluation criteria of shaft vibration under normal operating conditions, measured at or close to the bearings of coupled industrial machines.
ISO 2371	1974	Field balancing equipment-Description and evaluation	—
ISO 10436	1993	Petroleum natural gas industries – General purpose steam turbine for refinery service	It is not applicable to general-purpose steam turbines, which are covered in ISO 10436.
ISO 10437	2003	Petroleum, petrochemical and natural gas industries –Steam turbines– Special purpose applications	This specifies requirements and gives recommendations for the design, materials, fabrication, inspection, testing and preparation for shipment of special-purpose steam turbines. It also covers the related lube-oil systems, instrumentation, control systems and auxiliary equipment. It is not applicable to general-purpose steam turbines, which are covered in ISO 10436.
ISO 10816-1	2009	Mechanical vibration – Evaluation of machine vibration by measurement on non-rotating parts Part-1:General guidelines	This establishes the general conditions and procedures for the measurement and evaluation of vibration, using measurements made on the non-rotating parts of machines. The general evaluation criteria relate to both operational monitoring and acceptance testing and have been established primarily with regard to securing reliable long-term operation of the machine. Replaces ISO 2372 and ISO 3945, which have been technically revised.
ISO 10816-2	2009	Mechanical vibration – Evaluation of machine vibration by measurement on non-rotating parts Part-2:Large land-based steam turbine generator sets in excess of 50MW	This establishes provisions for evaluating the severity of *in-situ*, broad-band vibration measured radial (i.e. transverse) to the shaft axis on all main bearing housings or pedestals and in the axial direction on thrust bearings. These are in terms of: - vibration under normal steady-state operating conditions; - vibration during other (non-steady-state) conditions when transient changes are taking place, including run up or run down, initial loading and load changes; - changes in vibration which can occur during normal steady-state operation. This is applicable to land-based steam turbines and generators with power outputs greater than 50 MW and a normal operating speed of 1 500 r/min, 1 800 r/min, 3 000 r/min or 3 600 r/min.
DIN 4304	1989	Steam-turbines: terms, classification	Terms and classification of steam turbine
DIN 4305-1	1968	Steam-turbines: terms of assemblies and parts of the turbine	Terms and classification of steam turbine
DIN 4305-2	1968	Steam-turbines: terms of assemblies	Terms and classification of steam turbine

Number	Rev.	Title	Content
		and parts of the condenser system	
DIN 4312	1983	Industry-type turbines: steam turbines and gas expansion turbines; construction principles for industrial-type turbines	Construction principle of steam turbine
DIN EN 45510-5-1	1998	Guide for procurement of power station equipment-Part5-q:Steam turbine; German version EN45510-5-1:1998	German version of guidance when purchasing power plant facility(steam turbine) EN 45510-5-1-1998
DIN EN 10816-2	2010	Mechanical vibration Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts - Part 2: Land-based steam turbines and generators in excess of 50 MW with normal operating speeds of 1500 r/min, 1800 r/min, 3000 r/min and 3600 r/min (ISO 10816-2:2009)	Mechanical vibration
DIN EN 10816-3	1998	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 3: Industrial machines with nominal power above 15 kW and nominal operating speeds between 120 r/min and 15000 r/min when measured in situ (ISO 10816-3:1998)	Mechanical vibration
DIN ISO7919-2	2001	Mechanical vibration -- Evaluation of machine vibration by measurements on rotating shafts -- Part 2: Land-based steam turbines and generators in excess of 50 MW with normal operating speeds of 1500 r/min, 1800 r/min, 3000 r/min and 3600 r/min	Mechanical vibration

Chapter-4. Reference Japanese Technical Standards

The reference Japanese technical standards for designing steam turbine are organized in Table-30.

Table- 30: Reference Japanese standards

Number	Rev.	Title	Content
JIS B0127	2004	Glossary of terms for thermal power plant −Steam turbines and auxiliary equipment of thermal and geothermal power plant	This defines the terms of steam turbine for power plant.
JIS B0130	2006	Glossary of Terms for Thermal Power Plants--General	This stipulates the terms of respect for thermal generation, whole environment including main provisions relating to general terms for operation and maintenance.
JIS B2220	2004	Steel welding pipe flanges	This stipulates steel flanges to connect piping and valves for general piping, pressure piping, high temperature piping alloy piping and stainless piping for steam, air, gas, water and oil, etc.
JIS B8101	2003	Specifications for steam turbines	This stipulates the general specifications of steam turbine based on IEC60045-1.
JIS B8102	2002	Steam turbines--Acceptance test	This stipulates the method of acceptance test for steam turbine quoted from IEC60953-1, 2.
JIS B8105	2004	Steam turbines--Acceptance test-Thermal performance verification tests of retrofitted steam turbines	This stipulates the method of acceptance test for steam turbine several modifications made due to changes based on IEC60953-3.
JIS B8201	2005	Stationary steel boilers−Construction	This stipulates stationary steel steam boiler, hot water boiler, ancillary equipment and accessories quoted from ASME BPV for land use.
JIS F4201	1996	Shipbuilding-Shop test code for steam turbines for propelling use	This stipulates the method of land based test for marine steam turbine.
JIS B0905	1992	Rotating machines ― Balance quality requirements of rigid rotors	This defines the good balance applying the concept of good valance in the eccentricity of modified surface of the rigid rotor.
JIS B0911	2000	Mechanical vibration ― Susceptibility and sensitivity of machines to unbalance	This stipulates the method how to determine the sensitivity to mechanical vibrations against disproportionate.
JEAC 3701	2007	Rules for power boilers	This stipulates necessary matters for design, inspection, operation and maintenance incorporating the latest knowledge about power boiler and ancillary equipment installed in thermal power plant.
JEAC 3702	2007	Rules for Heat exchanger and pressure vessel regulations	This stipulates necessary matters for design, installation, inspection, operation and management as the matters to be observed in case of installation, operation maintenance of heat exchanger and pressure vessel.
JEAC 3703	1994	Rules for steam turbine for power generation	This stipulates material, design, construction, testing method, operation and maintenance of steam turbine and ancillary equipment for steam turbine.

Number	Rev.	Title	Content
JEAC 3706	2006	Rules for pressure piping and valves	This stipulates necessary detailed technical matters for design, manufacturing, assembling, thermal insulation and operation of piping, fittings, valves, supports accessories used for thermal power facility.
JEAC 3717	1991	Rrules concerning the vibration of steam turbine and generator for power generation	Private standard for vibration of steam turbine and generator for generation.
JEAC 3718	1991	Rules for fire protection for power generators and steam turbines	Private standard for fire safety measures for the steam turbine and generator for generation.
JEAC 3202	1986	Rules for non-destructive testing of steam turbine for power generation	Private standards for non-destructive testing of rotor material and how to evaluate for steam turbine for generation.
JESC T0003	2005	Rules for steam turbine for power generation	JESC(Japan Electrotechnical Standards and Codes Committee) enacted as JESC T0003-2000 which (Corporation) Japan Electric Association accomplished Electric Engineering Regulations "Steam Turbines for Power Generation" (JEAC3703) of the committee in 3/2000.
NISA -234a-07-6	2007	Interpretation of technical regulation for thermal power facility	This stipulates specific example to achieve the requirement of the technical regulation.

Chapter-5. Reference TCVN

The reference Vietnamese national standards for designing steam turbine are organized in Table-31.

Table- 31: Reference TCVN

Number	Rev.	Title	Content
QCVN 01 BLDTBXH	2008	National technical regulation on safety work of steam boiler and pressure part	Quy chuẩn này quy định về an toàn lao động trong thiết kế, chế tạo, xuất nhập khẩu, mua bán, lắp đặt, sửa chữa, sử dụng đối với các nồi hơi, bình chịu áp lực
TCVN 7704	2007	Boilers—Technical requirement of design, construction, manufacture, installation, operation, maintenance	Tiêu chuẩn này quy định các yêu cầu về thiết kế, chế tạo, lắp đặt sử dụng và sửa chữa các thiết bị nồi hơi có áp suất làm việc của hơi lớn hơn 0,07 MPa và các nồi đun nước nóng có nhiệt độ của nước lớn hơn 115 độ C.

Chapter-6. Referenced Literature and Materials

The referenced books, literatures, standards to establishing this guide line are organized as follows.

1. Interpretation of technical regulation for thermal power facility (10/Jul/2007): NISA (Nuclear and Industrial Safety Agency) of METI (Ministry of Economy, Trade and Industry)
2. Design and material for steam turbine (Journal No.553 Oct/2002) : TENPES (Thermal and Nuclear Engineering Society of Japan)
3. Construction of steam turbine—Steam turbine for utility (Journal No.574 Jul/2004): TENPES (Thermal and Nuclear Engineering Society of Japan)
4. Example of applicable materials for turbine hot parts—Handbook for thermal and nuclear power engineering: TENPES (Thermal and Nuclear Engineering Society of Japan)
5. PPT of Toshiba “Steam turbine and auxiliaries” (http://www.scribd.com/doc/46789244/Steam-Turbine)
6. Maintenance and overhaul of steam turbines— (International association of engineering insurers 38th annual conference- Moscow 2005 : John Latcovich and others)

Chapter-7. Appendix

Table- 32: Appendix

Appendix-1	: Allowable Tensile Stress of Ferrous Materials at Each Temperature	Part-1.
	: Notes for Part-1.	
	: ASME Sec. II Part-D Standard Material	Part-2-1
	: ASME B31.1 Standard Material	Part-2-2
Appendix-2	: Allowable Tensile Stress of Non-Ferrous Materials at Each Temperature	Part-1.
	: Notes for Part-1.	
	: ASME Sec. II Part-D Standard Material	Part-2-1
	: Remarks for Part-2-1	
Appendix-3	: Allowable stress of Major Material of Support and Foundation for Tank and Gas Holder	
	: Remarks for Appendix-3.	
Appendix-4	: Longitude Joint Efficiency of Piping belong to Liquefied Gas Facility	

Appendix-1. Allowable Tensile Stress of Ferrous Materials at Each Temperature Part-1. (JIS Standard, API Standard, ASTM Standard, Interpretation of Japanese Technical Regulation for Thermal Power, Others)

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm^2)	Production Method	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																										
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Rolled steels for general structure: JIS G3101-2010	SS330	–	300	–	–	-10	82	82	82	82	82	82	82	82	82	82	82	82	82	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SS400	–	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steel and molybdenum alloy steel plates for boilers and pressure vessels: JIS G3103-2007	SB410	–	410	–	(1)(42)	-10	103	103	103	103	103	103	103	103	103	103	103	103	102	98	89	75	62	46	32	22	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SB450	–	450	–	(1)(42)	-10	112	112	112	112	112	112	112	112	112	112	112	112	111	105	95	80	63	46	32	22	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SB480	–	480	–	(1)(42)	-10	121	121	121	121	121	121	121	121	121	121	121	121	119	113	101	84	67	51	34	22	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SB450M	0.5Mo	450	–	(2)(42)	-10	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	109	106	97	70	44	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SB480M	0.5Mo	480	–	(2)(42)	-10	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	120	118	101	70	44	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rolled steels for welded structure: JIS G3106-2008	SM400A	–	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM400B	–	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM400C	–	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM490A	–	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM490B	–	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM490C	–	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM490YA	–	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM490YB	–	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM520B	–	520	–	–	-10	130	130	130	130	130	130	130	130	130	130	130	130	130	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM520C	–	520	–	–	-10	130	130	130	130	130	130	130	130	130	130	130	130	130	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SM570	–	570	–	–	-10	142	142	142	142	142	142	142	142	142	142	142	142	142	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hot-rolled atmospheric corrosion resisting steels for welded structure: JIS G3114-2008	SMA400AW	0.6Cr-0.4Cu-Ni	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA400AP	0.4Cr-0.3Cu	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA400BW	0.6Cr-0.4Cu-Ni	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA400BP	0.4Cr-0.3Cu	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA400CW	0.6Cr-0.4Cu-Ni	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA400CP	0.4Cr-0.3Cu	400	–	–	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA490AW	0.6Cr-0.4Cu-Ni	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA490AP	0.4Cr-0.3Cu	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA490BW	0.6Cr-0.4Cu-Ni	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA490BP	0.4Cr-0.3Cu	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA490CW	0.6Cr-0.4Cu-Ni	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA490CP	0.4Cr-0.3Cu	490	–	–	-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA570W	0.6Cr-0.4Cu-Ni	570	–	–	-10	142	142	142	142	142	142	142	142	142	142	142	142	142	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMA570P	0.4Cr-0.3Cu	570	–	–	-10	142	142	142	142	142	142	142	142	142	142	142	142	142	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Steel plates for pressure vessels for intermediate temperature service: JISG3115-2010	SPV235	–	400			-10	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SPV315	–	490	–		-10	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)(44)	-30	142	142	132	130	127	127	126	126	126	126	126	126	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SPV355	–	520	–		-10	130	130	130	130	130	130	130	130	130	130	130	130	130	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)(44)	-30	160	155	151	147	143	143	143	143	143	143	143	143	143	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SPV410	–	550	–		-10	138	138	138	138	138	138	138	138	138	138	138	138	138	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SPV450	–	570	–		-10	142	142	142	142	142	142	142	142	142	142	142	142	142	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)(44)	-30	182	177	173	169	163	163	163	163	163	163	163	163	163	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SPV490	–	610	–		-10	152	152	152	152	152	152	152	152	152	152	152	152	152	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)(44)	-30	195	189	185	179	175	175	175	175	175	175	175	175	175	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Steel sheet, plates and strip for gas cylinders: JIS G3116-2010	SG255	–	400	–	–	40	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SG295	–	400	–	–	40	110	110	110	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SG325	–	490	–	–	40	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SG365	–	540	–	–	40	135	135	135	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steel plates for pressure vessels for intermediate and moderate temperature services: JIS G3118-2010	SGV410	–	410	–	–	0	103	103	103	103	103	103	103	103	103	103	103	103	102	98	89	75	62	46	36	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SGV450	–	450	–	–	0	112	112	112	112	112	112	112	112	112	112	112	112	111	105	95	80	63	46	32	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SGV480	–	480	–	–	0	121	121	121	121	121	121	121	121	121	121	121	121	119	113	101	84	67	51	34	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Manganese-molybdenum and manganese-molybdenum-nickel alloy steel plates for boilers and pressure vessels: JIS G3119-2007	SBV1A	Mn-0.5Mo	520	–	–	0	130	130	130	130	130	130	130	130	130	130	130	130	130	129	126	122	117	100	70	44	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SBV1B	Mn-0.5Mo	550	–	(42)	0	138	138	138	138	138	138	138	138	138	138	138	138	138	138	135	130	124	102	70	44	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SBV2	Mn-0.5Mo-0.5Ni	550	–	(42)	0	138	138	138	138	138	138	138	138	138	138	138	138	138	138	135	130	124	102	70	44	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SBV3	Mn-0.5Mo-0.5Ni	550	–	(42)	0	138	138	138	138	138	138	138	138	138	138	138	138	138	138	135	130	124	102	70	44	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Manganese-molybdenum and manganese-molybdenum-nickel alloy steel plates quenched and tempered for pressure vessels: JIS G3120-2009	SQV1A	Mn-0.5Mo	550	–	(42)	-10	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	132	118	98	77	55	43	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SQV1B	Mn-0.5Mo	620	–		-10	155	155	155	155	155	155	155	155	155	155	155	155	155	155	151	146	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)	-10	198	192	187	182	178	178	178	178	178	178	178	178	178	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SQV2A	Mn-0.5Mo-0.5Ni	550	–		-10	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	132	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SQV2B	Mn-0.5Mo-0.5Ni	620	–		-10	155	155	155	155	155	155	155	155	155	155	155	155	155	155	151	146	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)	-10	198	192	187	182	178	178	178	178	178	178	178	178	178	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SQV3A	Mn-0.5Mo-0.75Ni	550	–		-10	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	132	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SQV3B	Mn-0.5Mo-0.75Ni	620	–		-10	155	155	155	155	155	155	155	155	155	155	155	155	155	155	151	146	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)	-10	198	192	187	182	178	178	178	178	178	178	178	178	178	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steel plates for pressure vessels for low temperature service: JIS G3126-2009	SLA235A	–	400	–	–	-30	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SLA235B	–	400			-45	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SLA325A	–	440	–		-45	110	110	110	110	110	110	110	110	110	110	110	110	110	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)	-45	140	136	133	129	126	126	126	126	126	126	126	126	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SLA325B	–	440	–		-60	110	110	110	110	110	110	110	110	110	110	110	110	110	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)	-60	140	136	133	129	126	126	126	126	126	126	126	126	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SLA365	–	490	–		-60	122	122	122	122	122	122	122	122	122	122	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)	-60	156	156	151	148	144	140	140	140	140	140	140	140	140	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SLA410	–	520	–		-60	130	130	130	130	130	130	130	130	130	130	130	130	130	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm²)	Production Method	Remarks	Minimum Operation Temperature (°C)	Allowable Tensile Stress at each Temperature (N/mm²)																																									
							-40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Nickel steel plates for pressure vessels for low temperature services: JIS G3127-2005	SL2N255	2.25Ni	450	–	(K1)	-70	112	112	112	112	112	112	112	112	112	112	112	112	111	105	95	80	65	49	36	24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)(K1)	-70	115	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SL3N255	3.5Ni	450	–	(K1)	-100	112	112	112	112	112	112	112	112	112	112	112	112	111	105	95	80	65	49	36	24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)(K1)	-100	115	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SL3N275	3.5Ni	480	–	(K1)	-100	121	121	121	121	121	121	121	121	121	121	121	121	119	113	101	84	67	50	36	24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)(K1)	-100	124	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SL3N440	3.5Ni	540	–		-110	135	135	135	135	135	135	135	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)	-110	173	169	164	160	155	155	155	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SL5N590	5Ni	690	–	(3)	-130	172	172	172	172	172	172	172	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SL9N520	9Ni	690	–	(3)	-196	164	161	153	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(4)	-196	172	169	160	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)(45)	-196	220	213	208	202	197	197	197	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SL9N590	9Ni	690	–	(3)	-196	163	160	152	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(4)	-196	172	169	160	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(43)(45)	-196	220	213	208	202	197	197	197	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hot-rolled mild steel plates, sheet and strip: JIS G3131-2010	SPHC	–	270	–	–	-10	68	68	68	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SPHD	–	270	–	–	-10	68	68	68	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SPHE	–	270	–	–	-10	68	68	68	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon Steel Forgings for General Use JIS G3201-2008	SF340A	–	340	–	(24)	-10	85	85	85	85	85	85	85	85	85	85	85	85	85	79	75	64	51	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SF390A	–	390	–		-10	98	98	98	98	98	98	98	98	98	98	98	98	98	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(1)(24)(42)	-10	98	98	98	98	98	98	98	98	98	98	98	98	98	93	84	73	56	49	36	24	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SF440A	–	440	–		-10	110	110	110	110	110	110	110	110	110	110	110	110	110	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(1)(24)(42)	-10	110	110	110	110	110	110	110	110	110	110	110	110	110	104	94	81	57	49	36	24	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SF490A	–	490	–		-10	121	121	121	121	121	121	121	121	121	121	121	121	119	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(1)(24)(42)	-10	121	121	121	121	121	121	121	121	121	121	121	121	119	113	101	84	69	51	34	22	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon Steel Forgings for Pressure Vessels JIS G3202-2008	SFVC1	–	410	–	(1)	-10	103	103	103	103	103	103	103	103	103	103	103	103	102	98	89	75	62	46	32	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVC2A	–	490	–	(1)	-10	121	121	121	121	121	121	121	121	121	121	121	121	119	113	101	84	67	51	34	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVC2B	–	490	–	(1)	-10	121	121	121	121	121	121	121	121	121	121	121	121	119	113	101	84	67	51	34	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alloy Steel Forgings for Pressure Vessels for High-Temperature Service JIS G3203-2008	SFVAF1	0.5Mo	480	–	–	-10	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	118	101	70	44	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF2	0.5Cr-0.5Mo	480	–	–	-10	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	118	83	51	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF12	1Cr-0.5Mo	480	–	–	-10	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	118	114	91	63	41	27	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF11A	1.25Cr-0.5Mo-0.75Si	480	–	–	-10	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	118	101	75	53	37	26	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF11B	1.25Cr-0.5Mo-0.75Si	520	–	–	-10	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	127	114	88	61	40	27	19	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF22A	2.25Cr-1Mo	410	–	–	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	100	95	81	64	48	35	24	16	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF22B	2.25Cr-1Mo	520	–	–	-10	130	130	129	128	126	125	124	124	124	123	123	122	122	120	119	117	114	110	90	65	46	31	20	13	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF21A	3Cr-1Mo	410	–	–	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	102	100	96	92	85	69	55	44	34	25	17	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF21B	3Cr-1Mo	520	–	–	-10	130	130	129	128	126	125	124	124	124	123	123	122	122	120	119	117	114	96	74	55	41	30	21	15	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF5A	5Cr-0.5Mo	410	–	(34)	-10	103	103	103	101	100	100	99	99	99	99	98	97	96	94	91	88	84	77	62	47	35	26	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF5B	5Cr-0.5Mo	480	–	(34)	-10	121	121	120	119	117	117	116	116	116	115	114	113	112	110	106	103	98	80	62	47	35	26	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF5C	5Cr-0.5Mo	550	–	(34)	-10	138	138	137	136	134	133	132	132	132	132	131	130	128	125	121	117	102	81	62	47	35	26	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF5D	5Cr-0.5Mo	620	–	(34)	-10	155	155	154	152	150	150	149	149	149	148	147	146	143	141	136	132	104	81	62	47	35	26	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVAF9	9Cr-1Mo	590	–	–	-10	147	146	146	144	142	141	141	141	141	140	139	138	135	133	129	125	119	113	89	62	44	30	21	14	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Quenched and Tempered Alloy Steel Forgings for Pressure Vessels JIS G3204-2008	SFVQ1A	0.5Ni-0.5Mo-V	550	–	–	0	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	132	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVQ1B	0.5Ni-0.5Mo-V	620	–	–	0	155	155	155	155	155	155	155	155	155	155	155	155	155	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVQ2A	0.75Ni-0.3Cr--0.5Mo-V	550	–	–	0	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	132	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVQ2B	0.75Ni-0.3Cr--0.5Mo-V	620	–	–	0	155	155	155	155	155	155	155	155	155	155	155	155	155	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVQ3	3.5Ni-1.75Cr-0.5Mo-V	620	–	–	0	155	155	155	155	155	154	154	153	153	152	151	150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon and Alloy Steel Forgings for Pressure Vessels for Low-Temperature Service JIS G3205-2008	SFL1	–	440	–	(K1)	-30	110	110	110	110	110	110	110	110	110	110	110	110	108	98	89	76	57	39	25	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFL2	–	490	–	(K1)	-45	121	121	121	121	121	121	121	121	121	121	121	121	119	113	101	84	67	51	34	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFL3	3.5Ni	490	–	–	-100	121	121	121	121	121	121	121	121	121	121	121	121	121	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
High Strength Chromium-molybdenum Ally Steel Forgings for Pressure Vessels under High-Temperature Service JIS G3206-1993	SFVCMF22B	2.25Cr-1Mo	580	–	–	40	147	147	147	147	147	147	146	145	144	143	142	141	139	136	128	126	123	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVCMF22V	2.25Cr-1Mo-0.3V	580	–	–	40	147	147	147	147	147	147	147	147	147	146	144	142	139	137	134	131	127	123	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SFVCMF3V	3Cr-1Mo-0.25V	580	–	–	40	147	147	146	143	141	139	137	135	134	133	132	131	130	129	127	126	124	121	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stainless Steel Forgings for Pressure Vessels JIS G3214-2009	SUSF304	18Cr-8Ni	520	–	(7)(8)	-196	129	120	114	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	114	113	112	111	110	110	110	110	110	109	107	105	103	102	100	98	92	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
			480	–	(7)(8)(25)	-196	120	117	113	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(25)	-196	120	117	114	110	107	106	104	103	102	102	102	102	102	102	101	101	100	98	97	95	91	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF304H	18Cr-8Ni	520	–		-30	129	120	114	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-30	129	125	122	118	114	113	112	111	110	110	110	110	110	109	107	105	103	102	100	98	92	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
			480	–	(25)	-30	120	117	113	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(25)	-30	120	117	114	110	107	106	104	103	102	102	102	102	102	102	101	101	100	98	97	95	91	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF304L	18Cr-8Ni very low carbon	480	–		-196	114	104	97	93	88	85	81	79	76	74	72	71	69	69	68	67	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	115	114	113	109	105	104	102	101	100	99	97	96	94	93	92	90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			450	–	(25)	-196	112	103	97	93	88	85	81	79	76	74	72	71	69	69	68	67	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(25)	-196	112	108	105	101	98	96	94	93	93	92	91	91	90	90	90	89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF304N	18Cr-8Ni-N	550	–	(7)(8)	-196	138	134	130	122	115	110	104	101	97	95	94	91	89	87	86	85	84	82	80	78	77	73	64	52	42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	138	138	137	134	131	129	127	125	123	122	120	120	119	118	116	115	113	110	108	105	96	79	64	52	42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF310	25Cr-20Ni	520	–	(7)(8)	-196	129	124	120	115	111	108	105	102	100	97	96	94	93	92	90	89	88	87	85	76	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	128	126	124	121	121	120	120	120	120	120	120	120	120	119	117	115	113	111	87	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF316	16Cr-12Ni-2Mo	520	–	(7)(8)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
			480	–	(7)(8)(25)	-196	121	121	119	113	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(25)	-196	121	121	120	119	118	117	116	116	116	116	116	116	114	112	111	110	108	108	107	105	101	94	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm²)	Production Method	Remarks	Minimum Operation Temperature (°C)	Allowable Tensile Stress at each Temperature (N/mm²)																																										
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Stainless Steel Forgings for Pressure Vessels JIS G3214-2009	SUSF316H	16Cr-12Ni-2Mo	520	–		-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
			480	–	(25)	-196	121	121	119	113	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(25)	-196	121	121	120	119	118	117	116	116	116	116	116	116	114	112	111	110	108	108	107	105	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF316L	16Cr-12Ni-2Mo	480	–		-196	114	103	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)	-196	115	115	115	112	110	109	108	106	103	101	98	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			450	–	(25)	-196	112	102	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(25)	-196	112	110	108	105	102	101	100	99	99	98	97	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF316N	16Cr-12Ni-2Mo-N	550	–	(7)(8)	-196	138	138	137	134	131	126	122	119	115	112	109	107	104	102	100	98	96	95	94	92	90	88	81	65	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	138	138	137	135	132	131	130	129	128	128	128	128	128	128	128	127	126	125	123	121	115	101	81	65	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF317	18Cr-13Ni-3-Mo	520	–	(7)(8)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF317L	18Cr-13Ni-3Mo	480	–		-196	114	103	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	115	115	115	112	110	109	108	106	103	101	98	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			450	–	(25)	-196	112	102	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(25)	-196	112	110	108	105	102	101	100	99	99	98	97	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF321	18Cr-10Ni-Ti	520	–	(7)(8)	-196	129	125	122	118	114	110	106	103	100	97	95	93	91	89	88	86	86	85	84	83	75	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	115	114	113	113	113	113	113	113	113	113	113	113	113	113	113	107	87	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
			480	–	(7)(8)(25)	-196	120	117	114	111	108	107	106	103	100	97	95	93	91	89	88	86	86	85	84	83	75	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(25)	-196	120	117	114	111	108	107	106	105	105	105	105	105	105	105	105	105	105	105	105	104	87	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF321H	18Cr-10Ni-Ti	520	–		-30	129	125	122	118	114	110	106	103	100	97	95	93	91	89	88	86	86	85	84	83	82	75	59	46	37	29	23	18	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-30	129	125	122	118	115	114	113	113	113	113	113	113	113	113	113	113	113	113	113	111	99	77	59	46	37	29	23	18	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
			480	–	(25)	-30	120	117	114	111	108	107	106	103	100	97	95	93	91	89	88	86	86	85	84	77	71	67	58	46	37	29	23	18	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(25)	-30	120	117	114	111	108	107	106	105	105	105	105	105	105	105	105	105	105	105	105	104	93	75	59	46	37	29	23	18	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF347	18Cr-10Ni-Nb	520	–	(7)(8)	-196	129	125	122	118	113	110	107	106	104	102	100	98	97	95	94	94	93	93	93	92	88	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	113	110	107	106	104	103	103	102	102	101	101	101	101	101	101	100	92	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
			480	–	(7)(8)(25)	-196	120	117	114	110	106	103	100	99	97	96	96	96	95	94	94	94	93	93	93	92	89	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(25)	-196	120	117	114	110	106	103	100	99	97	96	96	96	95	94	94	94	94	94	94	93	89	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF347H	18Cr-10Ni-Nb	520	–		-30	129	125	122	118	113	110	107	106	104	102	100	98	97	95	94	94	93	93	93	92	92	91	87	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-30	129	125	122	118	113	110	107	106	104	103	103	102	102	101	101	101	101	101	101	100	98	96	88	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
			480	–	(25)	-30	120	117	114	110	106	103	100	99	97	96	96	96	95	94	94	94	93	93	93	92	92	90	85	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(25)	-30	120	117	114	110	106	103	100	99	97	96	96	96	95	94	94	94	94	94	94	93	92	90	85	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUSF410	13Cr	590	–	–	-10	147	142	139	137	135	133	131	129	126	124	123	121	119	117	114	109	101	89	69	52	38	27	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			480			-10	120	117	114	112	111	109	107	106	104	102	101	100	98	97	94	89	84	78	68	53	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steel pipes for ordinary piping: JIS G3452-2010	SGP	–	290	E	(5)(56)(57)	-10	62	62	62	62	62	62	62	62	62	62	62	62	62	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				B	(5)(56)(57)	-10	47	47	47	47	47	47	47	47	47	47	47	47	47	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steel pipes for pressure service: JIS G3454-2007	STPG370	–	370	S		-10	92	92	92	92	92	92	92	92	92	92	92	92	92	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E		-10	78	78	78	78	78	78	78	78	78	78	78	78	78	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPG410	–	410	S		-10	103	103	103	103	103	103	103	103	103	103	103	103	102	98	89	75	62	46	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E		-10	88	88	88	88	88	88	88	88	88	88	88	88	87	83	75	64	53	39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steel pipes for high pressure service: JIS G3455-2005	STS370	–	370	S	–	-10	92	92	92	92	92	92	92	92	92	92	92	92	92	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STS410	–	410	S	–	-10	103	103	103	103	103	103	103	103	103	103	103	103	102	98	89	75	62	46	32	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STS480	–	480	S	–	-10	121	121	121	121	121	121	121	121	121	121	121	121	119	113	101	84	67	51	34	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steel pipes for high temperature service: JIS G3456-2010	STPT370	–	370	S	(1)	-10	92	92	92	92	92	92	92	92	92	92	92	92	92	89	80	70	56	47	36	24	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(1)	-10	78	78	78	78	78	78	78	78	78	78	78	78	78	76	68	60	48	40	31	20	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPT410	–	410	S	(1)(42)	-10	103	103	103	103	103	103	103	103	103	103	103	103	102	98	89	75	62	46	32	22	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(1)(42)	-10	88	88	88	88	88	88	88	88	88	88	88	88	87	83	75	64	53	39	27	19	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPT480	–	480	S	(1)	-10	121	121	121	121	121	121	121	121	121	121	121	121	119	113	101	84	67	51	34	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Arc welded carbon steel pipes: JIS G3457-2005	STPY400	–	400	A	(6)	-10	70	70	70	70	70	70	70	70	70	70	70	70	70	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(55)	-10	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alloy steel pipes: JIS G3458-2005	STPA12	0.5Mo	380	S	(2)(42)	-10	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	93	91	88	68	44	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPA20	0.5Cr-0.5Mo	410	S	(42)	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	103	102	99	97	95	75	51	43	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPA22	1Cr-0.5Mo	410	S	–	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	101	98	85	63	41	27	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPA23	1.25Cr-0.5Mo-0.75Si	410	S	–	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	103	102	99	97	94	75	53	37	26	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPA24	2.25Cr-1Mo	410	S	–	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	100	95	81	64	48	35	24	16	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPA25	5Cr-0.5Mo	410	S	–	-10	103	103	103	101	100	100	99	99	99	99	98	97	96	94	91	88	84	77	62	47	35	26	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPA26	9Cr-1Mo	410	S	–	-10	103	103	103	101	100	100	99	99	99	99	98	97	96	94	91	88	84	80	75	61	44	30	21	14	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stainless steel pipes: JIS G3459-2004	SUS304TP	18Cr-8Ni	520	S	(7)(8)	-196	129	120	114	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	114	113	112	111	110	110	110	110	110	109	107	105	103	102	100	98	92	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)(10)	-196	110	102	97	92	88	85	81	79	77	75	72	71	70	69	67	66	65	64	63	61	60	59	54	44	36	28	23	18	14	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(10)	-196	110	106	103	100	97	96	95	94	93	93	93	93	93	93	91	89	88	87	85	83	78	67	54	44	36	28	23	18	14	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUS304HTP	18Cr-8Ni	520	S		-30	129	120	114	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-30	129	125	122	118	114	113	112	111	110	110	110	110	110	109	107	105	103	102	100	98	92	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(10)	-30	110	102	97	92	88	85	82	79	77	74	72	71	70	69	67	65	65	64	63	61	60	59	54	44	36	28	23	18	14	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(10)	-30	110	106	104	100	97	96	95	94	94	94	94	94	94	93	91	89	88	87	85	83	78	67	54	44	36	28	23	18	14	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUS304LTP	18Cr-8Ni	480	S		-196	114	104	97	93	88	85	81	79	76	74	72	71	69	69	68	67	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)	-196	115	114	113	109	105	104	102	101	100	99	97	96	94	93	92	90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W	(10)	-196	97	88	82	79	75	72	69	67	65	63	61	60	59	59	58	57	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(10)	-196	98	97	96	93	89	88	87	86	85	84	82	82	80	79	78	77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS309TP	23Cr-12Ni	520	S	(7)(8)	-196	129	124	120	115	111	108	105	102	98	97	96	95	94	93	92	90	89	88	87	77	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	130	129	129	128	126	125	124	123	121	120	119	118	116	114	111	108	105	85	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)(10)	-196	110	106	102	98	94	92	89	86	84	82	82	81	80	79	78	77	76	75	74	65	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(10)	-196	110	110	110	110	110	109	108	107	105	104	103	102	101	100	99	97	95	92	89	72	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm^2)	Production Method	Remarks	Minimum Operation Temperature (^{0}C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																										
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Stainless steel pipes: JIS G3459-2004	SUS309STP	23Cr-12Ni	520	S	(7)(8)	-196	129	124	120	115	111	108	105	102	98	97	96	95	94	93	92	90	89	88	87	77	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	130	129	129	128	126	125	124	123	121	120	119	118	116	114	111	108	105	85	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)(10)	-196	110	106	102	98	94	92	89	86	84	82	82	81	80	79	78	77	76	75	74	65	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(10)	-196	110	110	110	110	110	109	108	107	105	104	103	102	101	100	99	97	95	92	89	72	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS310TP	25Cr-20Ni	520	S	(7)(8)	-196	129	124	120	115	111	108	105	102	100	97	96	94	93	92	90	89	88	87	85	76	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	128	126	124	121	121	120	120	120	120	120	120	120	120	119	117	115	113	111	87	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)(10)	-196	106	105	102	98	94	92	89	87	85	83	81	80	79	78	77	76	75	73	73	65	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(10)	-196	110	109	107	105	103	103	102	102	102	102	102	102	102	102	101	100	98	96	94	74	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS310STP	25Cr-20Ni	520	S	(7)(8)	-196	129	124	120	115	111	108	105	102	100	97	96	94	93	92	90	89	88	87	85	76	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	128	126	124	121	121	120	120	120	120	120	120	120	120	119	117	115	113	111	87	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)(10)	-196	110	106	102	98	94	92	89	87	85	83	81	80	79	78	77	76	75	73	73	65	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(10)	-196	110	108	107	105	103	103	102	102	102	102	102	102	102	102	101	100	98	96	94	74	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316TP	16Cr-12Ni-2Mo	520	S	(7)(8)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)(10)	-196	110	106	102	97	92	88	85	82	79	77	75	73	72	71	70	68	68	68	67	67	66	65	63	55	43	33	25	20	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(10)	-196	110	110	110	109	108	107	106	106	106	104	102	99	97	96	94	93	93	91	91	90	89	83	69	55	43	33	25	20	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316HTP	16Cr-12Ni-2Mo	520	S		-30	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-30	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(10)	-30	110	106	102	97	91	88	84	82	79	77	75	73	71	71	70	69	68	67	67	66	66	65	63	55	43	33	26	20	16	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(10)	-30	110	110	110	109	108	107	106	106	105	104	101	99	97	95	94	94	92	91	91	90	89	83	69	55	43	33	26	20	16	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316LTP	16Cr-12Ni-2Mo very low carbon	480	S		-196	114	103	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	115	115	115	112	110	109	108	106	103	101	98	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W	(10)	-196	97	88	82	78	74	72	69	67	65	63	62	60	60	58	57	57	55	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(10)	-196	98	98	97	96	94	93	92	90	88	86	83	82	80	79	77	77	75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS317TP	18Cr-12Ni-3.5Mo	520	S	(7)(8)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)(10)	-196	110	106	102	97	92	88	85	82	79	77	75	73	72	71	70	68	68	68	67	67	66	65	63	55	43	33	25	20	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(10)	-196	110	110	110	109	108	107	106	106	106	104	102	99	97	96	94	93	93	91	91	90	89	83	69	55	43	33	25	20	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUS317LTP	18Cr-12Ni-3.5Mo very low carbon	480	S		-196	114	103	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	115	115	115	112	110	109	108	106	103	101	98	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W	(10)	-196	97	88	82	78	74	71	69	67	65	63	62	60	60	59	58	56	55	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(10)	-196	98	98	98	95	94	93	92	90	88	86	83	82	81	79	77	77	75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS321TP	18Cr-10Ni-Ti	520	S	(7)(8)	-196	129	125	122	118	114	110	106	103	100	97	95	93	91	89	88	86	86	85	84	83	75	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	115	114	113	113	113	113	113	113	113	113	113	113	113	113	113	103	82	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)(10)	-196	110	106	103	100	96	93	90	88	85	83	81	79	77	76	75	73	73	72	71	71	64	51	38	28	21	16	11	8	6	4	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(10)	-196	110	106	103	101	98	97	96	96	96	96	96	96	96	96	96	96	96	96	96	94	77	51	38	28	21	16	11	8	6	4	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS321HTP	18Cr-10Ni-Ti	520	S		-30	129	125	122	118	114	110	106	103	100	97	95	93	91	89	88	86	86	85	84	83	82	75	59	46	37	29	23	18	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-30	129	125	122	118	115	114	113	113	113	113	113	113	113	113	113	113	113	113	113	111	99	77	59	46	37	29	23	18	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
				W	(10)	-30	110	106	104	100	97	94	90	88	85	82	81	79	77	76	75	73	73	72	71	71	68	61	50	39	31	25	20	15	13	10	8	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(10)	-30	110	106	104	100	98	97	96	96	96	96	96	96	96	96	96	96	96	96	95	94	64	54	50	39	31	25	20	15	13	10	8	–	–	–	–	–	–	–	–	–	–	–	–
	SUS347TP	18Cr-10Ni-Nb	520	S	(7)(8)	-196	129	125	122	118	113	110	107	106	104	102	100	98	97	95	94	94	93	93	93	92	88	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	113	110	107	106	104	103	103	102	102	101	101	101	101	101	101	100	92	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)(10)	-196	110	107	104	100	96	94	91	90	89	87	85	84	82	81	80	80	79	79	79	79	75	65	49	35	26	20	14	10	8	6	5	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(10)	-196	110	107	104	100	96	94	91	90	89	88	88	87	87	86	86	86	86	86	86	85	79	65	49	35	26	20	14	10	8	6	5	–	–	–	–	–	–	–	–	–	–	–	–
	SUS347HTP	18Cr-10Ni-Nb	520	S		-30	129	125	122	118	113	110	107	106	104	102	100	98	97	95	94	94	93	93	93	92	92	91	87	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-30	129	125	122	118	113	110	107	106	104	103	103	102	102	101	101	101	101	101	101	100	98	96	88	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(10)	-30	110	106	104	100	96	94	91	90	88	87	85	83	82	81	80	80	79	79	79	78	78	77	74	60	46	36	27	20	16	13	10	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(10)	-30	110	106	104	100	96	94	91	90	88	88	88	87	87	86	86	86	86	86	86	85	84	82	75	60	46	36	27	20	16	13	10	–	–	–	–	–	–	–	–	–	–	–	–
	SUS329J1TP	25Cr-4Ni-2Mo	590	S	–	-10	148	148	142	140	137	135	132	131	130	129	127	127	127	126	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W		-10	126	126	121	119	116	115	112	111	110	110	108	107	104	102	99	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS836LTP	21Cr-24Ni-6Mo	520	S	–	-196	129	114	104	97	77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W		-196	110	97	89	83	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS890LTP	21Cr-25Ni-Mo	490	S	–	-196	122	118	114	109	104	100	96	92	89	86	84	82	80	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W		-196	104	100	97	92	88	85	81	78	76	73	71	70	68	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Steel pipes for low temperature service: JIS G3460-2006	STPL380	–	380	S	–	-45	95	95	95	95	95	95	95	95	95	95	95	95	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E		-45	81	81	81	81	81	81	81	81	81	81	81	81	81	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPL450	3.5Ni	450	S		-100	112	112	112	112	112	112	112	112	112	112	112	112	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E		-100	95	95	95	95	95	95	95	95	95	95	95	95	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STPL690	9Ni	690	S, E	(4)	-196	172	169	160	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			655	E	(3)	-196	163	159	153	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steel boiler and heat exchanger tubes: JIS G3461-2005	STB340	–	340	S, E	(1)(31)(42)	-10	85	85	85	85	85	85	85	85	85	85	85	85	85	82	76	66	53	49	36	24	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(1)(42)(58)	-10	72	72	72	72	72	72	72	72	72	72	72	72	72	70	65	56	45	42	31	20	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STB410	–	410	S, E	(1)(31)(42)	-10	103	103	103	103	103	103	103	103	103	103	103	103	102	98	89	75	62	46	32	22	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(1)(42)(58)	-10	88	88	88	88	88	88	88	88	88	88	88	88	87	83	76	64	53	39	27	19	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STB510	–	510	S, E	(31)	-10	128	128	128	128	128	128	128	128	128	128	128	128	128	128	115	98	69	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(58)	-10	109	109	109	109	109	109	109	109	109	109	109	109	109	109	98	83	59	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alloy steel tubes for boiler and heat exchanger: JIS G3462-2009	STBA12	0.5Mo	380	S, E	(2)(31)(42)	-10	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	93	91	88	68	44	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(2)(42)(58)	-10	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	79	78	75	58	37	28	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STBA13	0.5Mo	410	S, E	(2)(31)(42)	-10	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	100	95	88	69	44	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(2)(42)(58)	-10	87	87	87	87	87	87	87	87	87	87	87	87	87	87	87	85	81	75	59	37	28	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STBA20	0.5Cr-0.5Mo	410	S, E	(31)(42)	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	103	102	99	97	95	75	51	41	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(42)(58)	-10	88	88	88	88	88	88	88	88	88	88	88	88	88	88	87	84	82	81	64	43	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STBA22	1Cr-0.5Mo	410	S, E	(31)	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	101	98	85	63	41	27	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(58)	-10	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	86	83	72	54	34	23	15	10	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STBA23	1.25Cr-0.5Mo-0.75Si	410	S, E	(31)	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	103	102	99	99	94	75	53	37	26	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(58)(K6)		88	88	88	88	88	88	88	88	88	88	88	88	88	88	87	84	83	81	64	45	32	22	15	11	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STBA24	2.25Cr-1Mo	410	S, E	(31)	-10	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	100	95	81	64	48	35	24	16	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E	(58)(K6)		88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	85	81	69	55	41	29	20	13	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STBA25	5Cr-0.5Mo	410	S	–	-10	103	103	103	101	100	100	99	99	99	99	98	97	96	94	91	88	84	77	62	47	35	26	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm^2)	Production Method	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																										
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Alloy steel tubes for boiler and heat exchanger: JIS G3462-2009	STBA26	9Cr-1Mo	410	S	–	-10	103	103	103	101	100	100	99	99	99	99	98	97	96	94	91	88	84	80	75	61	44	30	21	14	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stainless steel boiler and heat exchanger tubes: JIS G3463-2006	SUS304TB	18Cr-8Ni	520	S	(7)(8)	-196	129	120	114	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	114	113	112	111	110	110	110	110	110	109	107	105	103	102	100	98	92	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	98	91	87	83	79	76	74	72	70	68	67	66	65	63	62	61	60	59	58	57	54	54	44	36	28	23	18	15	12	10	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	106	103	100	97	96	95	94	93	93	93	93	93	93	91	89	88	87	85	83	78	67	54	44	36	28	23	18	15	12	10	–	–	–	–	–	–	–	–	–	–	–	–
	SUS304HTB	18Cr-8Ni	520	S	(7)(8)	-30	129	120	114	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-30	129	125	122	118	114	113	112	111	110	110	110	110	110	109	107	105	103	102	100	98	92	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-30	110	102	97	92	88	85	82	79	77	77	72	71	70	69	67	65	65	64	63	61	60	59	54	44	36	28	23	18	14	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-30	110	106	104	100	97	96	95	94	94	94	94	94	94	93	91	89	88	87	85	83	78	67	54	44	36	28	23	18	14	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUS304LTB	18Cr-8Ni very low carbon	480	S	(7)(8)	-196	114	104	97	93	88	85	81	79	76	74	72	71	69	69	68	67	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	115	114	113	109	105	104	102	101	100	99	97	96	94	93	92	90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	97	89	83	79	75	72	69	67	65	63	61	60	59	58	57	57	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	98	97	96	93	90	88	86	86	85	84	83	82	80	79	78	77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS309TB	23Cr-12Ni	520	S	(7)(8)	-196	129	124	120	115	111	108	105	102	98	97	96	95	94	93	92	90	89	88	87	77	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	130	129	129	128	126	125	124	122	121	120	119	118	116	114	111	108	105	85	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	105	102	98	94	92	89	87	83	82	82	81	80	79	78	77	76	75	74	65	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	110	110	110	110	109	108	107	105	104	103	102	101	100	99	97	95	92	89	72	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS309STB	23Cr-12Ni	520	S	(7)(8)	-196	129	124	120	115	111	108	105	102	98	97	96	95	94	93	92	90	89	88	87	77	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	128	126	124	121	121	120	120	120	120	120	120	120	120	119	117	115	113	111	87	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	106	102	98	94	92	89	87	85	83	81	80	79	78	77	76	75	73	73	65	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	110	110	110	110	109	107	106	105	104	103	102	101	100	99	97	94	92	89	72	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS310TB	25Cr-20Ni	520	S	(7)(8)	-196	129	124	120	115	111	108	105	102	100	97	96	94	93	92	90	89	88	87	85	76	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	128	126	124	121	121	120	120	120	120	120	120	120	120	119	117	115	113	111	87	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	106	102	98	94	92	89	87	85	83	81	80	79	78	77	76	75	73	73	65	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	108	107	105	103	103	102	102	102	102	102	102	102	102	101	100	98	96	94	74	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS310STB	25Cr-20Ni	520	S	(7)(8)	-196	129	124	120	115	111	108	105	102	100	97	96	94	93	92	90	89	88	87	85	76	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	128	126	124	121	121	120	120	120	120	120	120	120	120	119	117	115	113	111	87	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	106	102	98	94	92	89	87	85	83	81	80	79	78	77	76	75	73	73	65	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	108	107	105	103	103	102	102	102	102	102	102	102	102	101	100	98	96	94	74	51	37	28	20	14	9	5	3	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316TB	16Cr-12Ni-2Mo	520	S	(7)(8)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	106	102	97	92	88	85	82	79	77	75	73	72	71	70	68	68	68	67	67	66	65	63	55	43	33	25	20	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	110	110	109	108	107	106	106	106	104	102	99	97	96	94	93	93	91	91	90	89	83	69	55	43	33	25	20	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316HTB	16Cr-12Ni-2Mo	520	S	(7)(8)	-30	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-30	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-30	110	106	102	97	92	88	85	82	79	77	75	73	72	71	70	69	68	68	67	67	66	65	63	55	43	33	25	20	16	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-30	110	110	110	109	108	107	106	106	106	104	102	99	97	96	94	93	93	91	91	90	89	83	69	55	43	33	25	20	16	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316LTB	16Cr-12Ni-2Mo very low carbon	480	S	(7)(8)	-196	114	103	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	115	115	115	112	110	109	108	106	103	101	98	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	97	88	82	78	74	72	69	67	65	63	62	60	60	58	57	57	55	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	98	98	97	96	94	93	92	90	88	86	83	82	80	79	77	77	75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS317TB	18Cr-12Ni-3.5Mo	520	S	(7)(8)	-196	130	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	106	102	97	92	88	85	82	79	77	75	73	72	71	70	68	68	68	67	67	66	65	63	55	43	33	25	20	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	110	110	109	108	107	106	106	106	104	102	99	97	96	94	93	93	91	91	90	89	83	69	55	43	33	25	20	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
	SUS317LTB	18Cr-12Ni-3.5Mo very low carbon	480	S	(7)(8)	-196	114	103	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	115	115	115	112	110	109	108	106	103	101	98	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	97	88	82	78	74	71	69	67	65	63	62	60	60	59	58	56	55	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	98	98	98	95	94	93	92	90	88	86	83	82	81	79	77	77	75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS321TB	18Cr-10Ni-Ti	520	S	(7)(8)	-196	129	125	122	118	114	110	106	103	100	97	95	93	91	89	88	86	86	85	84	83	75	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	115	114	113	113	113	113	113	113	113	113	113	113	113	113	113	107	87	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	106	103	100	96	93	90	88	85	83	81	79	77	76	74	73	73	72	71	71	64	51	38	28	21	16	11	8	6	4	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	106	103	101	98	97	96	96	96	96	96	96	96	96	96	96	96	96	95	94	77	51	38	28	21	16	11	8	6	4	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS321HTB	18Cr-10Ni-Ti	520	S	(7)(8)	-30	129	125	122	118	114	110	106	103	100	97	95	93	91	89	88	86	86	85	84	83	82	75	59	46	37	29	23	18	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-30	129	125	122	118	115	114	113	113	113	113	113	113	113	113	113	113	113	113	113	111	99	77	59	46	37	29	23	18	15	12	9	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-30	110	106	104	100	97	94	90	88	85	82	81	79	77	76	75	73	73	72	71	71	68	61	50	39	31	25	20	15	13	10	8	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-30	110	106	104	100	98	97	96	96	96	96	96	96	96	96	96	96	96	96	95	94	84	65	50	39	31	25	20	15	13	10	8	–	–	–	–	–	–	–	–	–	–	–	–
	SUS347TB	18Cr-10Ni0Nb	520	S	(7)(8)	-196	129	125	122	118	113	110	107	106	104	102	100	98	97	95	94	94	93	93	93	92	92	91	87	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	113	110	107	106	104	103	103	102	102	101	101	101	101	101	101	100	98	96	88	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	106	104	100	96	94	91	90	88	87	85	83	82	81	80	80	79	79	79	78	78	77	74	60	46	36	27	20	16	13	10	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	106	104	100	96	94	91	90	88	88	88	87	87	86	86	86	86	86	86	85	84	82	75	60	46	36	27	20	16	13	10	–	–	–	–	–	–	–	–	–	–	–	–
	SUS347HTB	18Cr-10Ni0Nb	520	S	(7)(8)	-196	129	125	122	118	113	110	107	106	104	102	110	98	97	95	94	94	93	93	93	92	92	91	87	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	113	110	107	106	104	103	103	102	102	101	101	101	101	101	101	100	98	96	88	70	54	42	32	24	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
				W	(7)(8)	-196	110	106	104	100	96	94	91	90	88	87	85	83	82	81	80	80	79	79	79	78	78	77	74	60	46	36	27	20	16	13	10	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	110	106	104	100	96	94	91	90	88	88	88	87	87	86	86	86	86	86	86	85	84	82	75	60	46	36	27	20	16	13	10	–	–	–	–	–	–	–	–	–	–	–	–
	SUS329J1TB	25Cr-4Ni-Mo	590	S	(7)(8)	-10	148	148	142	140	137	135	132	131	130	129	127	127	127	126	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-10	126	126	121	119	116	115	112	111	110	110	108	107	104	102	99	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS329J4LTB	25Cr-6.5Ni-3Mo	620	S	(7)(8)	-10	155	155	154	152	150	147	145	143	141	140	140	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)																																												
	SUS405TB	12Cr-Al	410	W	–	-30	103	100	98	97	95	94	92	91	89	88	86	85	84	83	81	77	72	68	61	42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
						-30	88	85	84	83	81	80	78	77	76	75	74	73	72	71	68	65	61	58	52	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS410TB	13Cr	410	S	–	-30	103	100	98	97	95	94	92	91	89	88	86	85	84	83	81	77	72	68	61	50	38	27	18	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W		-30	88	85	84	82	81	79	78	77	76	75	73	72	71	71	69	65	61	58	53	43	32	22	15	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS430TB	17Cr	410	S	(11)	-30	103	100	98	97	95	94	92	91	89	88	86	85	84	83	81	77	72	68	62	51	39	28	21	16	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W	(11)	-30	88	85	84	83	81	80	78	77	76	75	74	73	72	71	68	65	61	58	52	43	33	24	17	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS444TB	18Cr-2Mo	410	S	(K6)	-30	103	100	98	97	95	94	92	90	89	88	87	85	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm^2)	Production Method	Remarks	Minimum Operation Temperature (°C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																									
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Stainless steel boiler and heat exchanger tubes: JIS G3463-2006	SUS836LTB	21Cr-24Ni-6Mo	520	S	–	-196	129	114	104	98	77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W		-196	110	99	89	83	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS890LTB	21Cr-25Ni-Mo	490	S	–	-196	122	118	144	109	104	100	96	92	89	86	84	82	80	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				W		-196	104	100	97	92	88	85	81	78	76	73	71	70	68	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Steel heat exchanger tubes for low temperature service: JIS G3464-2006	STBL380	–	380	S, E	(31)	-45	95	95	95	95	95	95	95	95	95	95	95	95	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E		-45	81	81	81	81	81	81	81	81	81	81	81	81	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STBL450	3.5Ni	450	S	–	-100	112	112	112	112	112	112	112	112	112	112	112	112	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STBL690	9Ni	690	S, E	(4)	-196	172	169	160	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			655	E	(3)	-196	163	159	153	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Steel tubes for fired heater: JIS G3467-2006	STF410	–	410	S	–	325	–	–	–	–	–	–	–	–	–	–	–	102	102	102	102	93	74	57	42	30	25	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STFA12	0.5Mo	380	S	–	325	–	–	–	–	–	–	–	–	–	–	–	95	95	95	95	95	95	95	86	53	32	20	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STFA24	2.25Cr-1Mo	410	S	–	325	–	–	–	–	–	–	–	–	–	–	–	102	102	102	102	102	102	102	96	71	53	39	29	21	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STFA25	5Cr-0.5Mo	410	S	–	325	–	–	–	–	–	–	–	–	–	–	–	102	102	102	102	102	102	100	75	56	42	31	24	18	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	STFA26	9Cr-1Mo	410	S	–	325	–	–	–	–	–	–	–	–	–	–	–	102	102	102	102	102	101	96	91	76	53	37	26	19	13	9	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS304TF	18Cr-8Ni	520	S	(7)(K8)	325	–	–	–	–	–	–	–	–	–	–	–	114	112	110	108	106	104	102	100	98	96	95	80	64	52	41	33	27	22	18	14	12	–	–	–	–	–	–	–	–	–	–	–
	SUS304HTF	18Cr-8Ni	520	S	–	325	–	–	–	–	–	–	–	–	–	–	–	114	112	110	108	106	104	102	100	98	96	95	80	64	52	41	33	27	22	18	14	12	–	–	–	–	–	–	–	–	–	–	–
	SUS316TF	16Cr-12Ni-2Mo	520	S	(7)(K8)	325	–	–	–	–	–	–	–	–	–	–	–	117	115	113	111	110	108	107	106	105	104	103	102	83	64	49	37	28	22	17	13	11	–	–	–	–	–	–	–	–	–	–	–
	SUS316HTF	16Cr-12Ni-2Mo	520	S	–	325	–	–	–	–	–	–	–	–	–	–	–	117	115	113	111	110	108	107	106	105	104	103	102	83	64	49	37	28	22	17	13	11	–	–	–	–	–	–	–	–	–	–	–
	SUS321TF	18Cr-10Ni-Ti	520	S	(7)(K8)	325	–	–	–	–	–	–	–	–	–	–	–	112	110	108	107	106	105	105	105	104	98	74	55	41	31	24	18	13	10	7	6	5	–	–	–	–	–	–	–	–	–	–	–
	SUS321HTF	18Cr-10Ni-Ti	520	S	–	325	–	–	–	–	–	–	–	–	–	–	–	112	110	108	107	106	105	105	105	105	104	92	73	57	45	36	28	23	18	14	11	10	–	–	–	–	–	–	–	–	–	–	–
	SUS347TF	18Cr-10Ni-Nb	520	S	(7)(K8)	325	–	–	–	–	–	–	–	–	–	–	–	128	128	127	127	126	126	126	126	126	126	126	114	87	67	52	39	30	24	18	14	12	–	–	–	–	–	–	–	–	–	–	–
	SUS347HTF	18Cr-10Ni-Nb	520	S	–	325	–	–	–	–	–	–	–	–	–	–	–	128	128	127	127	126	126	126	126	126	126	126	114	87	67	52	39	30	24	18	14	12	–	–	–	–	–	–	–	–	–	–	–
	NCF800HTF	21Cr-32Ni	450	S	–	325	–	–	–	–	–	–	–	–	–	–	–	128	128	128	128	127	127	126	125	123	120	108	84	65	61	50	41	33	27	23	19	17	15	12	10	8	7	6	5		4	–	–
Large diameter welded stainless steel pipes: JIS G3468-2004	SUS304TPY	18Cr-8Ni	520	W	(7)(8)(30)	-196	90	80	75	71	68	65	62	61	59	57	56	55	54	53	52	51	50	50	48	48	47	45	41	36	29	23	19	15	12	10	8	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(30)	-196	90	87	84	82	80	78	78	77	76	76	76	76	76	76	75	73	72	71	70	68	64	55	44	36	29	23	19	15	12	10	8	–	–	–	–	–	–	–	–	–	–	–	–
	SUS304LTPY	18Cr-8Ni	480	W	(30)	-196	80	73	68	65	62	59	57	55	53	52	51	49	48	48	47	47	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)(30)	-196	80	80	79	76	74	72	71	71	70	69	68	67	66	65	64	63	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS309STPY	23Cr-12Ni	520	W	(7)(8)(30)	-196	90	87	84	80	77	75	73	71	69	67	67	66	66	65	64	63	62	62	61	53	42	30	23	16	11	7	4	2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(30)	-196	90	90	90	90	90	89	88	87	86	85	84	84	83	82	81	80	78	75	73	59	42	30	23	16	11	7	4	2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS310STPY	25Cr-20Ni	520	W	(7)(8)(30)	-196	90	87	84	80	77	75	73	71	70	68	66	66	65	64	63	62	62	60	60	53	42	30	23	16	11	7	4	2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(30)	-196	90	89	88	86	84	84	84	84	84	84	84	84	84	84	83	82	80	79	79	77	42	30	23	16	11	7	4	2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316TPY	16Cr-12Ni-2Mo	520	W	(7)(8)(30)	-196	90	87	84	80	75	72	70	67	65	63	62	60	59	58	57	56	56	56	55	55	54	53	52	45	35	27	21	16	12	10	8	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(30)	-196	90	90	90	89	89	88	87	87	87	85	84	81	80	79	77	76	76	75	75	74	73	68	57	45	35	27	21	16	12	10	7	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316LTPY	16Cr-12Ni-2Mo	480	W	(30)	-196	80	72	67	64	61	59	57	55	53	52	51	49	49	48	48	47	44	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)(30)	-196	80	80	80	79	77	76	75	74	72	71	68	67	66	65	63	63	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS317TPY	18Cr-13Ni-3Mo	520	W	(7)(8)(30)	-196	91	87	84	80	76	72	70	68	65	63	62	60	59	58	58	56	56	56	55	55	54	54	52	45	35	27	21	16	12	10	7	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(30)	-196	91	91	91	90	89	88	87	87	87	86	84	82	80	79	77	77	77	75	75	74	73	68	57	45	35	27	21	16	12	10	7	–	–	–	–	–	–	–	–	–	–	–	–
	SUS321TPY	18Cr-10Ni-Ti	520	W	(7)(8)(30)	-196	90	87	84	82	79	76	74	72	70	68	66	65	63	62	61	60	60	59	58	58	52	42	31	23	17	13	9	7	5	3	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(30)	-196	90	87	84	83	80	79	79	79	79	79	79	79	79	79	79	79	79	79	78	77	63	42	31	23	17	13	9	7	5	3	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS347TPY	18Cr-10Ni-Nb	520	W	(7)(8)(30)	-196	90	88	85	82	79	77	75	74	73	71	70	69	67	66	66	66	65	65	65	65	62	53	40	29	21	16	11	8	7	5	4	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(30)	-196	90	88	85	82	79	78	75	74	73	72	72	71	71	71	71	71	71	71	71	70	65	53	40	29	21	16	11	8	7	5	4	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steels for machine structural use: JIS G4051-2009	S10C	–	310	–	(12)	-10	78	78	78	78	78	78	78	78	78	78	78	78	78	76	71	61	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	S12C, S15C	–	370	–	(12)	-10	92	92	92	92	92	92	92	92	92	92	92	92	92	89	80	70	56	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			310		(12)	-10	78	78	78	78	78	78	78	78	78	78	78	78	78	76	71	61	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	S17C, S20C	–	400	–	(12)	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	95	86	75	57	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			370		(12)	-10	92	92	92	92	92	92	92	92	92	92	92	92	92	89	80	70	56	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	S22C, S25C	–	440	–	(12)	-10	110	110	110	110	110	110	110	110	110	110	110	110	110	104	94	79	57	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			400		(12)	-10	100	100	100	100	100	100	100	100	100	100	100	100	100	96	86	75	57	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	S28C, S30C	–	470	–	(12)	-10	118	118	118	118	118	118	118	118	118	118	118	118	118	110	99	82	58	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			440		(12)	-10	110	110	110	110	110	110	110	110	110	110	110	110	110	101	91	79	57	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	S33C, S35C	–	510	–	(12)(45)	-10	128	128	128	128	128	128	128	128	128	128	128	128	128	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			470		(12)(45)	-10	118	118	118	118	118	118	118	118	118	118	118	118	118	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steels for machine structural use: JIS G4053-2008	SMn420	1.35Mn	690	–	(12)	40	172	172	172	172	172	172	172	172	172	172	172	172	172	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMn433	1.35Mn	690		(12)	40	172	172	172	172	172	172	172	172	172	172	172	172	172	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMn438	1.50Mn	740		(12)	40	185	185	185	185	185	185	185	185	185	185	185	185	185	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMn443	1.50Mn	780		(12)	40	195	195	195	195	195	195	195	195	195	195	195	195	195	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMnC420	Mn-0.5Cr	830		(12)	40	208	208	208	208	208	208	208	208	208	208	208	208	208	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SMnC443	Mn-0.5Cr	930		(12)	40	232	232	232	232	232	232	232	232	232	232	232	232	232	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCr430	0.3C-1Cr	780	–	(12)	-30	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCr435	0.35C-1Cr	880		(12)	-30	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Scr440	0.4C-1Cr	930		(12)	-30	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCr445	0.45C-1Cr	980		(12)	-30	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCM430	1,1Cr-0.23Mo	830	–	(12)	-30	208	208	208	208	208	208	208	208	208	208	208	208	208	208	208	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCM432	1.25Cr-0.23Mo	880		(12)	-30	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCM435	1.1Cr-0.23Mo	930		(12)	-30	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCM440	1.1Cr-0.23Mo	980		(12)	-30	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCM445	1.1Cr-0.23Mo	1030		(12)	-30	258	258	258	258	258	258	258	258	258	258	258	258	258	258	258	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SNC236	1.25Ni-0.7Cr	740	–	(12)	-30	185	185	185	185	185	185	185	185	185	185	185	185	185	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SNC631	2.75Ni-0.8Cr	830		(12)	-30	208	208	208	208	208	208	208	208	208	208	208	208	208	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SNC836	3.25Ni-0.8Cr	930		(12)	-30	232	232	232	232	232	232	232	232	232	232	232	232	232	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SNCM240	0.55Ni-0.5Cr-0.23Mo	880	–	(12)	-30	220	220	220	220	220	220	220	220	220	220	220	220	220	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SNCM431	1.8Ni-0.8Cr-0.23Mo	830	–	(12)	-30	208	208	208	208	208	208	208	208	208	208	208	208	208	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SNCM439	1.8Ni-0.8Cr-0.23Mo	980	–	(12)	-30	245	245	245	245	245	245	245	245	245	245	245	245	245	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SNCM447	1.8Ni-0.8Cr-0.23Mo	1030	–	(12)	-30	258	258	258	258	258	258	258	258	258	258	258	258	258	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SNCM625	3.25Ni-1.25Cr-0.23Mo	930	–	(12)	-30	232	232	232	232	232	232	232	232	232	232	232	232	232	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SNCM630	3.0Ni-3Cr-0.5Mo	1080	–	(12)	-30	270	270	270	270	270	270	270	270	270	270	270	270	270	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm^2)	Production Method	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																										
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Chromium-molybdenum alloy steel plates for boilers and pressure vessels: JIS G4109-2008	SCMV1	0.5Cr-0.5Mo	380		(14)(42)	-5	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	93	89	72	51	41	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			480		(14)(42)	-5	121	121	121	121	121	121	121	121	121	121	121	121	120	120	120	120	120	118	83	51	41	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMV2	1Cr-0.5Mo	380		(13)	-5	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	93	90	82	63	41	27	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			450		(14)	-5	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	109	106	88	63	41	27	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMV3	1.25Cr-0.5Mo-0.75Si	410		(13)	-5	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	101	96	75	53	37	26	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			520		(14)	-5	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	127	103	75	53	37	26	18	12	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMV4	2.25Cr-1Mo	410		(13)	-5	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	100	95	81	64	48	35	24	16	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			520		(14)	-5	130	130	129	128	126	125	124	124	124	123	123	122	122	120	119	117	114	110	90	65	46	31	20	13	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMV5	3Cr-1Mo	410		(13)	-5	103	103	103	103	103	103	103	103	103	103	103	103	103	102	100	96	92	85	69	55	44	34	25	17	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			520		(14)	-5	130	130	129	128	126	125	124	124	124	123	123	122	122	120	119	117	114	96	74	55	41	30	21	15	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMV6	5Cr-0.5Mo	410		(13)	-5	103	103	103	101	100	100	99	99	99	99	98	97	96	94	91	88	84	77	62	47	35	26	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			520		(14)	-5	130	129	129	127	125	125	124	124	124	124	123	121	119	117	114	111	105	83	62	47	35	26	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
High strength chromium-molybdenum and chromium-molybdenum-vanadium alloy steel plates for pressure vessels under high-temperature service: JIS G4110-2008	SCMQ4E	2.25Cr-1Mo	580			40	147	147	147	147	147	147	146	145	144	143	142	141	139	136	128	126	123	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMQ4V	2.25Cr-1Mo	580			40	147	147	147	147	147	147	147	147	147	146	144	142	139	137	134	131	127	123	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMQ5V	3Cr-1Mo	580			40	147	147	146	143	141	139	137	135	134	133	132	131	130	129	127	126	124	121	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
アルミニウム クロムモリブデン鋼鋼材 JIS G4202-1979	廃止																																																
Stainless steel bars: JIS G4303-2005 Hot-rolled stainless steel plate, sheet and strip: JIS G4304-2010 Cold-rolled stainless steel plate, sheet and strip: JIS G4305-2010	SUS302	18Cr-8Ni	520	–		-30	129	120	114	108	103	100	96	93	90	87	85	83	82	81	79	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)		129	125	122	118	114	113	112	111	110	110	110	110	110	109	107	105	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS304	18Cr-8Ni	520	–	(7)(8)	-196	129	120	114	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	114	113	112	111	110	110	110	110	110	109	107	105	103	102	100	98	92	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUS304L	18Cr-8Ni	480	–		-196	114	104	97	93	88	85	81	79	76	74	72	71	69	69	68	67	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)	-196	115	114	113	109	105	104	102	101	100	99	97	96	94	93	92	90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS309S	23Cr-12Ni	520	–	(7)(8)	-196	129	124	120	115	111	108	105	102	98	97	96	95	94	93	92	90	89	88	87	77	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	130	129	129	128	126	125	124	123	121	120	119	118	116	114	111	108	105	85	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS310S	25Cr-20Ni	520	–	(7)(8)	-196	129	124	120	115	111	108	105	102	100	97	96	94	93	92	90	89	88	87	85	76	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	128	126	124	121	121	120	120	120	120	120	120	120	120	119	117	115	113	111	87	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316	16Cr-12Ni-2Mo	520	–	(7)(8)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316L	16Cr-12Ni-2Mo	480	–		-196	114	103	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)	-196	115	115	115	112	110	109	108	106	103	101	98	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316J1	16Cr-12Ni-2Mo-2Cu	520	–	(7)(8)	-196	130	125	120	114	109	103	99	96	93	90	88	86	84	83	82	81	80	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316J1L	16Cr-12Ni-2Mo-2Cu	480	–		-196	117	103	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)	-196	117	115	115	112	110	109	108	106	103	100	98	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316Ti	16Cr-12Ni-2Mo-Ti	520	–	(7)(8)(52)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(52)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUS317	18Cr-13Ni-3Mo	520	–	(7)(8)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUS317L	18Cr-13Ni-3Mo	480	–		-196	114	103	96	92	87	84	81	79	76	74	73	71	70	69	68	66	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)	-196	115	115	115	112	110	109	108	106	103	101	98	96	95	93	91	90	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS321	18Cr-10Ni-Ti	520	–	(7)(8)	-196	129	125	122	118	114	110	106	103	100	97	95	93	91	89	88	86	86	85	84	83	75	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	115	114	113	113	113	113	113	113	113	113	113	113	113	113	113	111	91	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
	SUS347	18Cr-10Ni-Nb	520	–	(7)(8)	-196	129	125	122	118	113	110	107	106	104	102	100	98	97	95	94	94	93	93	93	92	88	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	113	110	107	106	104	103	103	102	102	101	101	101	101	101	101	100	92	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
	SUS329J1	25Cr-4Ni-2Mo	590	–	–	-10	148	148	142	140	137	135	132	131	130	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS329J3L	23Cr-5.5Ni-3Mo-N	620	–	–	-10	155	155	154	152	150	147	145	143	141	140	140	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon																																																
	SUS329J4L	25Cr-6.5Ni-3Mo-W-Cu-N	620	–	–	-10	155	155	154	152	150	147	145	143	141	140	140	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon																																																
	SUS405	12Cr-Al	410	–	(11)	-10	103	100	98	97	95	94	92	91	89	88	86	85	84	83	81	77	72	68	61	42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS410	13Cr	440	–	–	-10	110	109	106	105	103	101	100	98	96	95	94	93	91	90	87	83	79	74	65	52	38	27	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS410S	13Cr	410	–	(52)	-10	103	100	98	97	95	94	92	91	89	88	86	85	84	83	81	77	72	68	61	50	38	27	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS429	15Cr	450	–	(11)(52)	-10	112	109	106	105	103	101	100	98	96	95	94	93	91	90	87	83	79	74	67	53	39	28	21	16	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS430	17Cr	450	–	(11)	-10	112	109	106	105	103	101	100	98	96	95	94	93	91	90	87	83	79	74	67	53	39	28	21	16	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS434	17Cr-1Mo	450	–	–	-10	112	109	106	105	103	101	100	98	96	95	93	92	91	90	87	83	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS630	17Cr-4Ni-4Cu	930	–	(51)(59)(60)(61)	40	232	232	232	232	232	229	227	224	222	220	219	217	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS836L	21Cr-24Ni-6Mo	520	–	(51)	-196	129	114	104	97	77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS890L	21Cr-25Ni-Mo	490	–	(51)	-196	122	118	114	109	104	100	96	92	89	86	84	82	80	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Heat-resisting Steel Bars JIS G4311-2007 Heat-resisting Steel Plates and Sheets JIS G4312-1991	SUH21	18Cr-3Al	440	–	(53)	-10	110	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUH309	23Cr-12Ni	560	–	(53)	-10	140	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUH310	25Cr-20Ni	590	–	(53)	-10	148	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUH330	16Cr-35Ni	560	–	(53)	-10	140	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUH409	11Cr-Ti	360	–	(53)	-10	90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUH446	27Cr	510	–	(53)	-10	128	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUH661	21Ni-18Co-22Cr-30Fe-3Mo-3W	690	–	(62)	-196	172	172	171	165	159	153	148	144	142	137	135	132	130	129	127	126	124	123	122	120	119	118	117	113	93	76	63	52	43	34	28	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(62)	-196	172	172	172	170	169	166	164	162	160	159	158	157	156	155	154	154	153	152	151	149	148	146	137	113	93	76	63	52	43	34	28	–	–	–	–	–	–	–	–	–	–	–	–
	SUS304	18Cr-8Ni	520	–	(7)(8)	-196	129	120	114	108	103	100	96	93	90	87	85	83	82	81	79	77	76	75	74	72	71	69	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	114	113	112	111	110	110	110	110	110	109	107	105	103	102	100	98	92	79	64	52	42	33	27	21	17	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUS309S	23Cr-12Ni	520	–	(7)(8)	-196	129	124	120	115	111	108	105	102	98	97	96	95	94	93	92	90	89	88	87	77	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	130	129	129	128	126	125	124	123	121	120	119	118	116	114	111	108	105	85	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
	SUS310S	25Cr-20Ni	520	–	(7)(8)	-196	129	124	120	115	111	108	105	102	100	97	96	94	93	92	90	89	88	87	85	76	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	128	126	124	121	121	120	120	120	120	120	120	120	120	119	117	115	113	111	87	60	44	32	24	17	11	6	4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm^2)	Production Method	Remarks	Minimum Operation Temperature (°C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																																	
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Heat-resisting Steel Bars JIS G4311-2007	SUS316	16Cr-12Ni-2Mo	520	–	(7)(8)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUS316Ti	16Cr-12Ni-2Mo-Ti	520	–	(7)(8)(53)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)(53)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
Heat-resisting Steel Plates and Sheets JIS G4312-1991	SUS317	18Cr-13Ni-3Mo	520	–	(7)(8)	-196	129	125	120	114	107	103	99	96	93	90	88	86	84	83	82	81	80	79	79	78	78	77	74	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	130	130	129	128	127	126	125	125	124	122	119	117	114	112	111	110	108	108	107	106	105	98	81	65	50	39	30	23	18	14	11	–	–	–	–	–	–	–	–	–	–	–	–
	SUS321	18Cr-10Ni-Ti	520	–	(7)(8)	-196	129	125	122	118	114	110	106	103	100	97	95	93	91	89	88	86	86	85	84	83	75	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	115	114	113	113	113	113	113	113	113	113	113	113	113	113	113	111	91	60	44	33	25	18	13	9	6	4	3	–	–	–	–	–	–	–	–	–	–	–	–
	SUS347	18Cr-10Ni-Nb	520	–	(7)(8)	-196	129	125	122	118	113	110	107	106	104	102	100	98	97	95	94	94	93	93	93	92	88	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(8)(9)	-196	129	125	122	118	113	110	107	106	104	103	103	102	102	101	101	101	101	101	101	100	92	76	58	40	30	23	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
	SUS403	12Cr	440	–	(53)	-10	103	100	98	97	95	94	92	91	89	88	86	85	84	83	81	77	72	68	61	50	38	27	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS405	12Cr-Al	410	–	(11)	-10	103	100	98	97	95	94	92	91	89	88	86	85	84	83	81	77	72	68	61	42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS410	13Cr	440	–	(53)	-10	110	109	106	105	103	101	100	98	96	95	94	93	91	90	87	83	79	74	65	52	38	27	18	12	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS430	17Cr	450	–	(11)(51)	-10	112	109	106	105	103	101	100	98	96	95	94	93	91	90	87	83	79	74	67	53	39	28	21	16	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SUS630	17Cr-4Ni-4Cu	930	–	(51)(59)(60)(61)	40	232	232	232	232	232	229	227	224	222	220	219	217	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Corrosion-resisting and Heat-resisting Superalloy Bars JIS G4901-2008	NCF600B	72Ni-15Cr-8Fe	550	–		-196	138	138	138	138	138	138	138	138	138	138	138	137	136	135	134	132	129	115	86	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	117	86	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF625B	60Ni-22Cr-9Mo-3.5Nb	760	–	–	-196	190	190	190	190	190	187	185	183	181	179	176	175	173	172	171	170	168	166	165	164	163	162	157	137	89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			830			-196	190	190	190	190	190	187	185	183	181	179	176	175	173	172	171	170	168	166	165	164	163	162	157	137	89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF690B	58Ni-29Cr-9Fe	590	–		-196	147	146	144	141	137	135	132	130	128	127	127	127	127	127	127	127	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	147	147	147	146	145	143	142	141	140	139	138	138	138	137	137	137	136	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF750B	70Ni-15Cr-7Fe-2.5Ti-0.7Al-1Nb	960	–	(16)	-196	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			1170		(17)	-196	292	292	292	292	292	292	292	292	292	292	292	292	292	292	292	292	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF800B	33Ni-21Cr-42Fe	520	–	(32)	-196	129	129	128	126	123	121	119	117	116	114	113	112	111	109	108	107	106	104	103	102	101	96	84	64	45	30	16	12	9	7	6		–	–	–	–	–	–	–	–	–	–	–
					(9)(32)	-196	129	129	129	129	129	129	129	129	129	129	129	129	128	128	128	128	126	126	124	122	120	108	84	64	45	30	16	12	9	7	6		–	–	–	–	–	–	–	–	–	–	–
	NCF800HB	33Ni-21Cr-42Fe	450	–		-196	111	108	105	103	100	97	94	92	90	88	85	83	82	80	79	77	75	74	73	72	70	69	68	62	51	41	34	28	23	18	15		12	10	9	8	–	–	–	–	–	–	–
					(9)	-196	112	112	112	112	112	112	112	111	111	110	110	110	110	108	106	106	104	103	101	100	97	90	76	62	51	41	34	28	23	18	15		12	10	9	8	–	–	–	–	–	–	–
	NCF825B	42Ni-22Cr-3Mo-2.5Cu-1Ti	580	–		-196	146	146	146	143	140	137	133	130	127	125	124	122	121	119	119	118	117	116	115	115	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	146	146	146	146	146	146	146	146	146	146	146	146	145	145	144	143	142	142	140	137	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Corrosion -resisting and Heat-resisting Superalloy Plates and Sheets JIS G4902-1991	NCF600P	72Ni-15Cr-8Fe	550	–		-196	138	138	138	138	138	138	138	138	138	138	138	137	136	135	134	132	129	115	86	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	117	86	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF625P	60Ni-22Cr-9Mo-3.5Nb	760	–	–	-196	190	190	190	190	190	187	185	183	181	179	176	175	173	172	171	170	168	166	165	164	163	162	157	137	89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			830			-196	190	190	190	190	190	187	185	183	181	179	176	175	173	172	171	170	168	166	165	164	163	162	157	137	89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF690P	58Ni-29Cr-9Fe	590	–		-196	147	146	144	141	137	135	132	130	128	127	127	127	127	127	127	127	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	147	147	147	146	145	143	142	141	140	139	138	138	138	137	137	137	136	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF750P	70Ni-15Cr-7Fe-2.5Ti-0.7Al-1Nb	960	–	(16)	-196	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			1170		(17)	-196	292	292	292	292	292	292	292	292	292	292	292	292	292	292	292	292	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF800P	33Ni-21Cr-42Fe	520	–	(32)	-196	129	129	128	126	123	121	119	117	116	114	113	112	111	109	108	107	106	104	103	102	101	96	84	64	45	30	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(32)	-196	129	129	129	129	129	129	129	129	129	129	129	129	128	128	128	128	126	126	124	122	120	108	84	64	45	30	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
	NCF800HP	33Ni-21Cr-42Fe	450	–		-196	111	108	105	103	100	97	94	92	90	88	85	83	82	80	79	77	75	74	73	72	70	69	68	62	51	41	34	28	23	18	15		12	10	9	8	–	–	–	–	–	–	–
					(9)	-196	112	112	112	112	112	112	112	111	111	110	110	110	110	108	106	106	104	103	101	100	97	90	76	62	51	41	34	28	23	18	15		12	10	9	8	–	–	–	–	–	–	–
	NCF825P	42Ni-22Cr-3Mo-2.5Cu-Ti	580	–		-196	146	146	146	143	140	137	133	130	127	125	124	122	121	119	119	118	117	116	115	115	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	146	146	146	146	146	146	146	146	146	146	146	146	145	145	144	143	142	142	140	137	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stainless Nickel-chromium-iron Alloy Pipes JIS G4903-2008	NCF600TP	72Ni-15Cr-8Fe	550	S	(19)	-196	138	134	131	128	125	123	121	119	117	115	113	111	110	107	107	106	104	103	84	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(18)	-196	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	136	117	86	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			520	S	(19)	-196	115	109	105	102	100	98	97	95	94	93	91	90	90	90	89	88	85	82	76	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(18)	-196	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	114	111	111	77	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			550	S	(20)	-196	138	138	138	138	138	138	138	138	138	138	138	137	136	135	134	132	129	115	86	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(20)	-196	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	117	86	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				S	(21)	-196	138	134	131	128	125	123	121	119	117	115	113	111	110	107	107	106	104	103	84	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(21)	-196	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	117	86	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF625TP	60Ni-22Cr-9Mo-3.5Nb	820	S	(9)(22)	-196	207	207	207	207	207	201	195	191	188	185	183	181	180	179	179	179	179	179	179	179	179	179	171	138	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
						-196																																												
	NCF690TP	58Ni-29Cr-9Fe	590	S	(9)	-196	147	146	144	141	137	135	132	130	128	127	127	127	127	127	127	127	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(20)	-196	147	147	147	146	145	143	142	141	140	139	138	138	138	137	137	137	136	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF800TP	33Ni-21Cr-42Fe	450	S	(33)	-196	111	108	105	103	100	97	94	92	90	88	85	83	82	80	79	77	75	74	73	72	70	69	68	62	51	41	34	28	23	18	15	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(33)	-196	112	112	112	112	112	112	112	111	111	110	110	110	110	108	106	106	104	103	101	100	97	90	76	62	51	41	34	28	23	18	15	–	–	–	–	–	–	–	–	–	–	–	–
			520	S	(22)	-196	129	129	128	126	123	121	119	117	116	114	113	112	111	109	108	107	106	104	103	102	101	96	84	64	45	30	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(22)	-196	129	129	129	129	129	129	129	129	129	129	129	129	128	128	128	128	126	126	124	122	120	108	84	64	45	30	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
	NCF800HTP	33Ni-21Cr-42Fe	450	S	(33)	-196	111	108	105	103	100	97	94	92	90	88	85	83	82	80	79	77	75	74	73	72	70	69	68	62	51	41	34	28	23	18	15		12	10	9	8	–	–	–	–	–	–	–
					(9)(33)	-196	112	112	112	112	112	112	112	111	111	110	110	110	110	108	106	106	104	103	101	100	97	90	76	62	51	41	34	28	23	18	15		12	10	9	8	–	–	–	–	–	–	–
	NCF825TP	42Ni-27Fe-22Cr-3Mo-2.5Cu-1Ti	580	S		-196	146	146	146	143	140	137	133	130	127	125	124	122	121	119	119	118	117	116	115	115	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	146	146	146	146	146	146	146	146	146	146	146	146	145	145	144	143	142	142	140	137	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Seamless Nickel-chromium-iron Alloy Heat Exchanger Tubes JIS G4904-2008	NCF600TB	72Ni-15Cr-8Fe	550	S		-196	138	138	138	138	138	138	138	138	138	138	138	137	136	135	134	132	129	115	86	60	40	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	117	86	60	41	28	19	15	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF625TB	60Ni-22Cr-9Mo-3.5Nb	820	S		-196	207	207	207	207	207	201	195	191	188	185	183	181	180	179	179	179	179	179	179	179	179	179	171	138	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)																																													
	NCF690TB	58Ni-22Cr-9Fe	590	S		-196	147	146	144	141	137	135	132	130	128	127	127	127	127	127	127	127	126	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	147	147	147	146	145	143	142	141	140	139	138	138	138	138	138	138	136	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	NCF800TB	33Ni-21Cr-42Fe	520	S	(32)	-196	129	129	128	126	123	121	119	117	116	114	113	112	111	109	108	107	106	104	103	102	101	96	84	64	45	30	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
					(9)(32)	-196	129	129	129	129	129	129	129	129	129	129	129	129	128	128	128	128	126	126	124	122	120	108	84	64	45	30	16	12	9	7	6	–	–	–	–	–	–	–	–	–	–	–	–
	NCF800HTB	33Ni-21Cr-42Fe	450	S	(15)	-196	111	108	105	103	100	97	94	92	90	88	85	83	82	80	79	77	75	74	73	72	70	69	68	62	51	41	34	28	23	18	15		12	10	9	8	–	–	–	–	–	–	–
					(9)(32)	-196	112	112	112	112	112	112	112	111	111	110	110	110	110	108	106	106	104	103	101	100	97	90	76	62	51	41	34	28	23	18	15		12	10	9	8	–	–	–	–	–	–	–
	NCF825TB	42Ni-27Fe-22Cr-3Mo-2.5Cu-1Ti	580	S		-196	146	146	146	143	140	137	133	130	127	125	124	122	121	119	119	118	117	116	115	115	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(9)	-196	146	146	146	146	146	146	146	146	146	146	146	146	145	145	144	143	142	142	140	137	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon steel castings: JIS G5101-1991	SC360	–	360	–	(26)	-10	60	60	60	60	60	60	60	60	60	60	60	60	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(27)(28)(K7)(K8)	-10	72	72	72	72	72	72	72	72	72	72	72	72	72	66	61	53	42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SC410	–	410	–	(26)	-10	69	69	69	69	69	69	69	69	69	69	69	69	68	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(1)(27)(28)(42)	-10	82	82	82	82	82	82	82	82	82	82	82	82	82	78	71	60	50	37	26	18	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm^2)	Production Method	Remarks	Minimum Operation Temperature (^oC)	Allowable Tensile Stress at each Temperature (N/mm^2)																																										
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
					(K7)(K8)																																												
Carbon steel castings: JIS G5101-1991	SC450	–	450	–	(26)	-10	75	75	75	75	75	75	75	75	75	75	75	75	75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(1)(27)(28)(42)	-10	90	90	90	90	90	90	90	90	90	90	90	90	90	84	76	65	46	39	29	19	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(K7)(K8)																																										
	SC480	–	480	–	(26)	-10	81	81	81	81	81	81	81	81	81	81	81	81	80									–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(1)(27)(28)(42)	-10	97	97	97	97	97	97	97	97	97	97	97	97	95	90	81	67	54	41	27	18	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(K7)(K8)																																										
Steel castings for welded structure: JIS G5102-1991	SCW410	–	410	–	(26)	40	69	69	69	69	69	69	69	69	69	69	69	69	69	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(28)	40	82	82	82	82	82	82	82	82	82	82	82	82	82	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCW450	–	450	–	(26)	40	75	75	75	75	75	75	75	75	75	75	75	75	75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(28)	40	90	90	90	90	90	90	90	90	90	90	90	90	90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCW480	–	480	–	(26)	40	81	81	81	81	81	81	81	81	81	81	81	81	80	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(28)	40	97	97	97	97	97	97	97	97	97	97	97	97	95	90	81	67	54	41	27	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCW550	–	550	–	(26)	40	92	92	92	92	92	92	92	92	92	92	92	92	92	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(28)	40	110	110	110	110	110	110	110	110	110	110	110	110	110	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCW620	–	620	–	(26)	40	104	104	104	104	104	104	104	104	104	104	104	104	104	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(28)	40	124	124	124	124	124	124	124	124	124	124	124	124	124	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
High tensile strength carbon steel castings and low alloy steel castings for structural purposes: JIS G5111-1991	SCC3A	–	520	–	(28)	40	104	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCC5A	–	620	–	(28)	40	124	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMn1A	–	540	–	(28)	40	108	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMn2A	–	590	–	(28)	40	118	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMn3A	–	640	–	(28)	40	128	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMn5A	–	690	–	(28)	40	138	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCSiMn2A	0.65Si-Mn	590	–	(28)	40	118	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMnCr2A	Mn-0.6Cr	590	–	(28)	40	118	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMnCr3A	Mn-0.6Cr	640	–	(28)	40	128	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMnCr4A	Mn-0.6Cr	690	–	(28)	40	138	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Corrosion-resistant cast steels for general applications: JIS G5121-2003	SCS1-T1	13Cr	540	–	–	-10	108	108	108	108	108	108	108	108	107	105	104	102	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCS1-T2	13Cr	620	–	(11)(28)	-10	124	121	118	116	114	112	110	109	107	106	104	102	101	99	97	92	84	66	49	34	23	16	11	8	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCS13	18Cr-8Ni	440	–	(28)	-196	88	88	84	80	76	73	69	66	64	62	61	59	58	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCS13A	18Cr-8Ni	480	–	(7)(28)	-196	97	93	90	86	82	80	77	74	72	70	68	66	66	65	63	62	61	60	59	58	55	49	39	32	26	22	18	16	14	12	10	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(9)(28)	-196	96	93	90	87	83	83	83	82	82	82	82	82	82	82	81	81	80	78	78	72	61	49	39	32	26	22	18	16	14	12	10	–	–	–	–	–	–	–	–	–	–	–	–
	SCS14	16Cr-12Ni-2Mo	440	–	(28)	-196	88	88	86	82	78	76	75	74	73	73	73	72	71	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCS14A	16Cr-12Ni-2Mo	480	–	(7)(28)	-196	97	97	95	90	86	82	79	77	74	72	70	69	69	66	66	65	64	63	63	62	62	58	46	37	30	24	19	16	14	12	10	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(9)(28)	-196	97	97	96	95	94	94	93	93	93	93	93	92	91	90	88	87	86	86	85	83	84	58	46	37	30	24	19	16	14	12	10	–	–	–	–	–	–	–	–	–	–	–	–
	SCS16	16Cr-12Ni-2Mo	390	–	(28)	-196	78	78	78	78	78	76	75	74	73	73	73	72	71	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon																																															
	SCS16A	16Cr-12Ni-2Mo	480	–	(28)	-196	97	97	95	90	86	82	79	77	74	72	70	69	67	66	66	65	64	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)(28)	-196	97	97	96	95	94	94	93	93	93	93	93	92	91	90	88	87	86	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCS17	25Cr-12Mi	480	–	(7)(28)	-196	96	91	88	86	84	83	82	80	78	77	75	74	72	70	69	67	66	65	62	58	52	43	34	26	21	16	14	10	8	6	5	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(9)(28)	-196	96	91	88	86	84	83	82	81	80	80	79	79	78	78	77	77	76	74	70	63	53	43	34	26	21	16	14	10	8	6	5	–	–	–	–	–	–	–	–	–	–	–	–
	SCS18	25Cr-20Ni	450	–	(7)(28)	-196	90	85	82	80	78	78	76	75	74	72	70	68	67	66	65	63	62	61	59	58	55	52	46	39	33	27	21	15	10	7	6	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(9)(28)	-196	90	85	82	80	78	78	76	75	74	74	74	73	73	72	72	72	70	70	67	63	58	52	46	39	33	27	21	15	10	7	6	–	–	–	–	–	–	–	–	–	–	–	–
	SCS19	18Cr-8Ni	390	–	(28)	-196	78	78	78	77	76	73	69	66	64	62	61	59	58	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon																																															
	SCS19A	18Cr-8Ni	480	–	(28)	-196	96	94	90	86	82	80	77	74	72	70	68	66	66	65	63	62	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		very low carbon			(9)(28)	-196	96	94	91	88	86	85	83	82	82	82	82	82	82	82	81	81	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCS21	18Cr-10Ni-Nb	480	–	(7)(28)	-196	96	94	91	88	85	82	80	79	78	77	77	77	76	75	75	75	74	74	74	74	70	61	46	32	24	18	13	10	7	6	5	–	–	–	–	–	–	–	–	–	–	–	–
					(7)(9)(28)	-196	96	94	91	88	85	82	80	79	78	77	77	77	76	75	75	75	75	75	75	74	71	61	46	32	24	18	13	10	7	6	5	–	–	–	–	–	–	–	–	–	–	–	–
Heat-resistant cast steels and alloys for general applications: JIS G5122-2003	SCH12	21Cr-20Ni	490	–	–	40	98	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCH13	26Cr-13Ni	490	–	–	40	98	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCH16	15Cr-35Ni	440	–	–	40	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCH17	28Cr-10Ni	540	–	–	40	108	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCH18	28Cr-16Ni	490	–	–	40	98	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCH21	25Cr-20Ni	440	–	–	40	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCH22	25Cr-20Ni	440	–	(46)	40	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	37	31	26	–	21	17	14	11	9	7	6	5	–	4	4
	SCH22CF	25Cr-20Ni	440	–	–	750	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	37	31	26	–	21	17	14	11	9	7	6	5	–	4	4
	SCH23	30Cr-20Ni	450	–	–	40	90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCH24	26Cr-35Ni	450	–	–	40	90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
High manganese steel castings: JIS G5131-2008	SCMnH1	12Mn	740	–	–	40	148	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCMnH2	12Mn-Si	740	–	–	40	148	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Steel castings for high temperature and high pressure service: JIS G5151-1991	SCPH1	–	410	–	(1)(28)(42)	-10	82	82	82	82	82	82	82	82	82	82	82	82	82	78	71	60	50	37	26	18	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(K7)(K8)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCPH2	–	480	–	(1)(28)(42)	-10	97	97	97	97	97	97	97	97	97	97	97	97	95	90	81	67	54	41	27	18	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(K7)(K8)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCPH11	0.5Mn	450	–	(2)(28)(42)	-10	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	87	85	78	56	35	26	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(K7)(K8)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCPH21	1Cr-1Mo	480	–	(28)(K7)(K8)	-10	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	94	81	60	42	30	21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCPH32	2.5Cr-1Mo	480	–	(28)(K7)(K8)	-10	97	97	96	96	95	94	94	93	93	93	93	93	91	91	89	86	83	79	69	52	37	25	16	10	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCPH61	5Cr-0.5Mo	620	–	(28)(K7)(K8)	-10	124	124	123	122	120	120	119	119	119	118	118	117	114	113	109	106	83	66	50	38	28	21	14	10	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Steel castings for low temperature and high pressure service: JIS G5152-1991	SCPL1	–	450	–	(28)	-45	90	90	90	90	90	90	90	90	90	90	90	90	89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCPL11	0.5Mo	450	–	(28)	-60	90	90	90	90	90	90	90	90	90	90	90	90	90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCPL21	2.5Ni	480	–	(28)	-60	97	97	97	97	97	97	97	97	97	97	97	97	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	SCPL31	3.5Ni	480	–	(28)	-100	97	97	97	97	97	97	97	97	97	97	97	97	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm^2)	Production Method	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																									
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Centrifugally cast steel pipes for welded structure: JIS G5201-1991	SCW480-CF	–	480	–	(1)	40	97	97	97	97	97	97	97	97	97	97	97	97	95	90	81	67	54	41	27	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Centrifugally cast steel pipes for high temperature and high pressure service: JIS G5202-1991	SCPH2-CF	–	480	–	(1)	40	97	97	97	97	97	97	97	97	97	97	97	97	95	90	81	67	54	41	27	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Spheroidal Graphite Iron Castings JIS G5502-2007	FCD400-18	–	400	–	–	-10	50	50	50	50	50	50	50	50	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	FCD400-18L	–	400	–	–	-10	50	50	50	50	50	50	50	50	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	FCD400-15	–	400	–	–	-10	50	50	50	50	50	50	50	50	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	FCD450-10	–	450	–	–	-10	56	56	56	56	56	56	56	56	56	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	FCD500-7	–	500	–	–	-10	63	63	63	63	63	63	63	63	63	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	FCD600-3	–	600	–	–	-10	75	75	75	75	75	75	75	75	75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ductile iron pipes: JIS G5526-1998	D1	–	420	–	–	40	49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	D2	–	420	–	–	40	49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	D3	–	420	–	–	40	49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ductile iron fittings: JIS G5527-1998	DF	–	420	–	–	40	49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–		–	–
Steel Pipe for Pipeline API 5L-1995	X42	–	413	–	(63)	-10	103	103	103	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(64)	-10	130	120	117	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	X46	–	434	–	(63)	-10	108	108	108	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(64)	-10	139	134	131	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	X52	–	455	–	(63)	-10	114	114	114	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(64)	-10	146	142	139	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	X56	–	489	–	(63)	-10	122	122	122	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(64)	-10	157	152	148	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	X60	–	517	–	(63)	-10	129	129	129	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(64)	-10	165	161	155	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	X65	–	530	–	(63)	-10	132	132	132	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
					(64)	-10	170	165	160	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
ASTM A694-1995	F42	–	415	–	(K3)	-10	130	121	118	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	F46	–	415	–	(K3)	-10	132	128	125	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	F52	–	455	–	(K3)	-10	146	142	139	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	F56	–	470	–	(K3)	-10	150	146	143	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	F60	–	515	–	(K3)	-10	165	161	155	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	F65	–	530	–	(K3)	-10	169	165	160	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Molybdenum Alloy Plates for Pressure Vessel for Power Generation (Remarks-15)	®SB520M	0.5Mo	520	–	–	-10	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	129	127	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon Plates for Low-Temperature Pressure Vessel for Power Generation (Remarks-16)	®SLA325B	–	440	–	–	-60	110	110	110	110	110	110	110	110	110	110	110	110	110	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alloy Steel Forgings for Power Generation (Remarks-17)	®SFVAF22AJ1	2.25Cr-1.6W	510	–	–	-10	128	128	128	128	128	127	127	126	123	123	123	123	123	123	122	120	116	113	110	101	84	70	54	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	®SFVAF27	9Cr-2Mo	510	–	–	-10	128	128	128	125	122	121	119	117	115	115	114	112	110	110	110	108	105	102	99	93	84	61	41	27	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	®SFVAF28	9Cr-1Mo-Nb-V	590	–	(K4)	-10	148	148	148	148	146	146	146	146	145	145	144	142	140	137	133	128	124	117	110	102	94	81	63	45	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			590	–	(K5)	-10	148	148	148	148	146	146	146	146	145	145	144	142	140	137	133	128	124	117	110	102	94	81	62	45	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	®SFVAF29	9Cr-1.8W	620	–	–	-10	155	155	155	155	153	151	148	146	145	143	141	139	137	134	132	129	126	122	118	113	107	101	78	56	30	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nickel Steel Forgings for Low-Temperature Pressure Vessel for Power Generation (Remarks-18)	®SFL9N690	9Ni	690	–	(4)	-196	172	160	152	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stainless Steel Forgings for Power Generation (Remarks-19)	®SUSF410J3	11Cr-2W-0.4Mo-1Cu-Nb-V	620	–	–	-10	155	155	155	155	153	150	147	146	144	142	140	138	136	134	132	129	125	122	118	112	106	100	68	46	27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbon Steel Pipes for Power Generation (Remarks-20)	®STPT380J2	0.3Cu-0.1Sb	380	S	–	-10	95	95	95	95	95	95	95	95	95	95	95	95	91	88	85	78	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
				E		-10	81	81	81	81	81	81	81	81	81	81	81	81	78	75	72	67	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alloy Steel Pipe for Power Generation (Remarks-21)	®STPA21	1Cr-0.3Mo	410	S	–	-10	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	98	92	74	51	28	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	®STPA24J1	2.25Cr-1.6W	510	S	–	-10	128	128	128	128	128	127	127	126	123	123	123	123	123	123	122	120	116	113	110	101	84	70	54	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	®STPA27	9Cr-2Mo	510	S	–	-10	128	128	125	124	122	121	119	117	115	115	114	112	110	110	110	108	105	102	99	93	84	61	41	27	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	®STPA28	9Cr-1Mo-Nb-V	590	S		-10	148	148	148	148	146	146	146	146	145	145	144	142	140	137	133	128	124	117	110	102	94	81	63	45	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			590	S	(K5)	-10	148	148	148	148	146	146	146	146	145	145	144	142	140	137	133	128	124	117	110	102	94	81	62	45	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	®STPA29	9Cr-1.8W	620	S	–	-10	155	155	155	155	153	151	148	146	145	143	141	139	137	134	132	129	126	122	118	113	107	101	78	56	30	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stainless Steel Pipe for Power Generation (Remarks-22)	®SUS410J3TP	11Cr-2W-0.4Mo-1Cu-Nb-V	620	S	–	-10	155	155	155	155	153	150	147	146	144	142	140	138	136	134	132	129	125	122	118	112	106	100	68	46	27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Material Name & Standard Number	Symbol	Standard Property (%)	Minimum Tensile Strength (N/mm^2)	Production Method	Remarks	Minimum Operation Temperature (^0C)	~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400
Carbon Steel Tubes for boiler for Power Generation (Remarks-23)	®STB380J2	0.3Cu-0.1Sb	380	S, E	(31)	-10	95	95	95	95	95	95	95	95	95	95	95	95	91	88	85
				E	(58)	-10	81	81	81	81	81	81	81	81	81	81	81	81	78	75	72
	®STB480		480	S	–	-10	120	120	120	120	120	120	120	120	120	120	120	120	120	113	101
Alloy Steel tubes for Boiler for Power Generation (Remarks-24)	®STBA10	1.25Cr-0.3Cu	410	S	–	-10	102	102	102	102	102	102	102	102	102	102	102	102	102	97	88
	®STBA21	1Cr-0.3Mo	410	S	–	-10	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
	®STBA24J1	2.25Cr-1.6W	510	S	–	-10	128	128	128	128	128	128	128	128	127	127	126	126	125	124	122
	®STBA27	9Cr-2Mo	510	S	–	-10	128	128	128	125	122	121	119	117	115	115	114	112	110	110	110
	®STBA28	9Cr-1Mo-Nb-V	590	S	–	-10	148	148	148	148	146	146	146	146	145	145	144	142	140	137	133
	®STBA29	9Cr-1.8W	620	S	–	-10	155	155	155	155	153	151	148	146	145	143	141	139	137	134	132
Stainless Steel Tubes for Boiler for Power Generation (Remarks-25)	®SUS304J1HTB	18Cr-9Ni-3Cu-Nb-N	590	S		-30	148	136	128	124	121	118	114	111	109	106	103	102	101	100	99
					(9)	-30	148	147	147	145	142	140	137	137	137	137	137	137	136	136	136
	®SUS309J1TB	24Cr-15Ni-1Mo-N	690	S	(9)	-196	128	121	115	112	109	108	107	106	105	104	104	104	104	104	104
	®SUS309J2TB	22Cr-14Ni-1.5Mo-N	590	S		-196	148	136	124	118	111	104	98	95	92	90	87	87	87	86	86
					(9)	-196	148	147	146	142	138	134	131	129	127	126	124	123	122	122	121
	®SUS309J3LTB	25Cr-14Ni-0.8Mo-N-0.2Si	690	S		-196	172	159	149	145	141	137	133	130	128	126	123	122	121	120	119
					(9)	-196	172	159	149	146	142	139	136	134	132	131	129	128	128	127	126
	®SUS309J4HTB	22Cr-15Ni-Nb	590	S		-30	148	145	137	135	132	129	126	123	120	117	114	111	108	105	101
					(9)	-30	148	145	142	138	135	131	128	127	126	126	125	125	125	125	125
	®SUS310J1TB	25Cr-20Ni-Nb-V	660	S		-30	165	159	152	148	145	136	128	127	125	123	121	121	121	118	116
					(9)	-30	165	164	162	159	156	154	149	148	146	144	144	144	144	144	144
	®SUS310J2TB	20Cr-25Ni-1.5Mo	640	S	(K2)	-30	160	156	149	144	140	137	135	133	131	130	128	126	124	122	120
					(9)(K2)	-30	160	160	160	159	156	154	152	151	150	149	149	149	149	149	149
	®SUS310J3TB	22.5Cr-18.5Ni-1.8W-3Cu-0.45Nb-0.2N	650	S		-30	163	163	163	159	153	148	143	139	135	132	129	127	125	123	122
					(9)	-30	163	163	163	161	158	156	154	152	151	150	149	148	148	147	146
	®SUS321J1HTB	18Cr-10Ni-Ti-Nb	520	S		-30	128	122	117	112	108	103	98	97	97	96	95	93	91	90	88
					(9)	-30	128	124	121	119	116	114	111	111	111	110	110	110	110	109	108
	®SUS321J2HTB	18Cr-10Ni-3Cu-Ti-Nb	500	S	(9)	-30	125	125	125	125	124	123	122	121	121	120	120	120	119	119	118
	®SUSTP347HTB	18Cr-10Ni-Nb	520	S		-30	128	123	119	115	111	108	104	101	98	96	94	92	90	88	88
					(9)	-30	128	126	123	118	113	110	107	105	104	102	102	101	101	101	101
	®SUS347J1TB	18Cr-9Ni-W-Nb-V	650	S	(9)	-196	163	158	152	147	144	141	139	138	137	136	135	135	134	133	132
	®SUS410J2TB	12Cr-1Mo-W-V-Nb	590	S	–	-30	148	148	148	147	146	146	145	143	141	139	137	136	134	132	131
	®SUS410J3TB	11Cr-2W-0.4Mo-1Cu-Nb-V	620	S	–	-30	155	155	155	153	151	148	146	144	143	141	140	138	136	134	132
	®SUS410J3DTB	12Cr-2W-0.4Mo-1Cu-Nb-V	620	S	–	-30	155	155	155	153	151	148	146	144	143	141	140	138	136	134	132
Chromium-molybdenum Alloy Steel Plates for Pressure Vessel for Power Generation (Remarks-26)	®SCMV28	9Cr-1Mo-Nb-V	590	–	(K4)	-5	148	148	148	148	146	146	146	146	145	145	144	142	140	137	133
			590		(K5)	-5	148	148	148	148	146	146	146	146	145	145	144	142	140	137	133
	®SCMV4J1	2.25Cr-1.6W	510	–	–	-5	128	128	128	128	128	127	127	126	123	123	123	123	123	123	122
Stainless Steel Plates for Power Generation (Remarks-27)	®SUS410J3	11Cr-2W-0.4Mo-1Cu-Nb-V	620	–	–	-10	155	155	155	155	153	150	147	146	144	142	140	138	136	134	132
Alloy Steel Forgings for Power Generation (Remarks-28)	®SCPH91	9Cr-1Mo-Nb-V	590	–	–	0	148	147	146	146	146	146	146	146	146	146	145	144	142	140	133
Manganese-molybdenum-nickel Steel Plates for Boilers and Pressure Vessels (Remarks-29)	®SBV2J1	Mn-0.5Mo-0.5Ni-V	610	–	–	0	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152
Mangananese-molybdenumbden-nickel Forgings for Boilers and pressure vessels (Remarks-30)	®SFBV2J1	Mn-0.5Mo-0.5Ni-V	610	–	–	0	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152
36%Ni Alloy Plates (Remarks-31)	S36N240	36Ni	440	–	–	-196	110	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Allowable Tensile Stress at each Temperature (N/mm^2) (continued)

Symbol	Remarks	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
®STB380J2	(31)	78	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	(58)	67	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®STB480	–	84	58	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®STBA10	–	76	57	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®STBA21	–	102	98	92	74	51	28	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®STBA24J1	–	120	117	114	111	104	87	71	53	34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®STBA27	–	108	105	102	99	93	84	61	41	27	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®STBA28	–	128	124	117	110	102	94	83	62	44	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®STBA29	–	129	126	122	118	113	107	101	76	55	30	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUS304J1HTB		97	96	94	92	91	90	89	89	88	80	63	47	33	23	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	(9)	134	132	130	128	126	123	119	115	101	80	63	47	33	23	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUS309J1TB	(9)	104	104	103	102	101	97	87	68	51	38	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUS309J2TB		84	82	80	78	76	75	74	73	73	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	(9)	120	118	116	113	111	108	106	95	73	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUS309J3LTB		117	115	113	111	108	106	96	86	65	42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	(9)	124	121	118	116	113	110	98	86	65	42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUS309J4HTB		100	98	97	96	96	96	93	93	85	67	54	44	34	27	21	17	–	–	–	–	–	–	–	–	–	–	–	–
	(9)	124	122	121	120	116	113	109	106	85	67	54	44	34	27	21	17	–	–	–	–	–	–	–	–	–	–	–	–
®SUS310J1TB		112	109	109	109	106	103	103	102	99	76	59	44	33	25	21	17	–	–	–	–	–	–	–	–	–	–	–	–
	(9)	144	143	142	140	137	134	131	124	99	76	59	44	33	25	21	17	–	–	–	–	–	–	–	–	–	–	–	–
®SUS310J2TB	(K2)	118	116	114	112	110	109	108	107	102	83	69	57	48	40	32	26		21	17	–	–	–	–	–	–	–	–	–
	(9)(K2)	149	148	148	146	145	143	140	127	102	83	69	57	48	40	32	26		21	17	–	–	–	–	–	–	–	–	–
®SUS310J3TB		121	120	119	118	118	117	117	116	112	92	74	60	48	37	30	23	–	–	–	–	–	–	–	–	–	–	–	–
	(9)	145	144	143	142	140	138	135	132	112	92	74	60	48	37	30	23	–	–	–	–	–	–	–	–	–	–	–	–
®SUS321J1HTB		86	84	83	81	80	80	79	79	78	62	49	39	29	23	17	13	–	–	–	–	–	–	–	–	–	–	–	–
	(9)	107	105	104	103	100	98	95	93	78	62	49	39	29	23	17	13	–	–	–	–	–	–	–	–	–	–	–	–
®SUS321J2HTB	(9)	118	117	116	114	112	110	108	105	100	81	66	51	42	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUSTP347HTB		87	87	87	87	87	86	85	80	70	54	41	32	25	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
	(9)	101	101	101	101	100	98	95	85	70	54	41	32	25	19	15	11	–	–	–	–	–	–	–	–	–	–	–	–
®SUS347J1TB	(9)	131	130	128	127	125	123	120	118	102	81	65	52	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUS410J2TB	–	128	125	119	113	106	99	73	50	35	24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUS410J3TB	–	129	126	123	120	115	111	102	66	46	27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUS410J3DTB	–	129	126	123	120	115	111	94	52	25	16	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SCMV28	(K4)	128	124	117	110	102	94	81	63	45	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	(K5)	128	124	117	110	102	94	81	63	45	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SCMV4J1	–	120	116	113	110	101	84	70	54	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SUS410J3	–	129	125	122	118	112	106	100	68	46	27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SCPH91	–	128	124	117	110	103	94	83	72	48	30	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SBV2J1	–	148	142	123	77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
®SFBV2J1	–	148	142	123	77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S36N240	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note-1 : ®marked materials are stipulated by Interpretation of Japanese Technical Regulation for Thermal Power are other than JIS Standard Material, API Standard Material, and stipulated in this table as the recommended remarked material for thermal power plant.

Note-2 : The allowable tensile stress of the materials shown in JISB8265-2010 "construction pressure vessel-General" is stipulated in JIS.

Note-3 : This table is referred to The Interpretation of Japanese Technical Regulation for Thermal Power dated 3/Sept/2007.

Part-2-1: ASME Sec. II Part-D Standard Material

Material Symbol	ASME Sec II Page	ASME Sec II Line	Considerations for Application	Equivalent Material to JIS in No.	Equivalent Material to JIS in Symbol
SA 36	6	26		JIS G3106-2008	SM400A
SA 53 S-B	10	26	–	JIS G3454-2007	STPG410
SA 53 Type E-A	2	24, 25	(7)		
SA 53 Type E-B	10	24, 25	(7)	–	–
SA 53 Type S-A	2	28	(7)		
SA 53 Type F	2	27	(7)		
SA 105	18	6		JIS G3201-2008	SF490A
SA 106 A	2	30	–	–	–
SA 106 B	10	29		JIS G3456-2010	STPT410
SA 106 C	18	28		JIS G3456-2010	STPT480
SA 135 A	2	33			
SA 135 B	10	32	–	JIS G3454-2007	STPG410
SA 178 A	2	11,12		JIS G3461-2005	STB340
SA 178 C	14	12,14		JIS G3461-2005	STB410
SA 178 D	18	30,31			
SA 179	2	14	–	–	–
SA 181 cl. 60	6	32			
SA 181 cl. 70	18	8		JIS G3201-2008	SF490A
SA 182 F1	30	11		JIS G3203-2008	SFVAF1
SA 182 F11 cl.1	34	35			
SA 182 F11 cl.2	38	9		JIS G3203-2008	SFVAF11A
SA 182 F12 cl.1	34	13			
SA 182 F12 cl.2	34	27	–	JIS G3203-2008	SFVAF12
SA 182 F2	30	34		JIS G3203-2008	SFVAF2
SA 182 F21	42	10			
SA 182 F22 cl.1	38	20		JIS G3203-2008	SFVAF22A
SA 182 F22 cl.3	38	32	–	JIS G3203-2008	SFVAF22B
SA 182 F304	98	1		JIS G3214-2009	SUSF304
SA 182 F304	94	22		JIS G3214-2009	SUSF304
SA 182 F304H	94	24		JIS G3214-2009	SUSF304H
SA 182 F304H	98	4	–	JIS G3214-2009	SUSF304H
SA 182 F304L	90	27		JIS G3214-2009	SUSF304L
SA 182 F310	158	6		JIS G3214-2009	SUSF310
SA 182 F316	74	36		JIS G3214-2009	SUSF316
SA 182 F316	78	8	–	JIS G3214-2009	SUSF316
SA 182 F316H	78	2		JIS G3214-2009	SUSF316H
SA 182 F316H	82	2	–	JIS G3214-2009	SUSF316H
SA 182 F316L	70	35		JIS G3214-2009	SUSF316L
SA 182 F321	126	26	–	JIS G3214-2009	SUSF321
SA 182 F321	130	7		JIS G3214-2009	SUSF321
SA 182 F321H	126	35		JIS G3214-2009	SUSF321H
SA 182 F321H	134	8		JIS G3214-2009	SUSF321H
SA 182 F347	114	1, 25		JIS G3214-2009	SUSF347
SA 182 F347H	114	8		JIS G3214-2009	SUSF347H
SA 182 F347H	118	14		JIS G3214-2009	SUSF347H
SA 182 F3V	42	13			
SA 182 F5	42	28		JIS G3203-2008	SFVAF5B
SA182 F5a	42	36			

Part-2-1: ASME Sec. II Part-D Standard Material

Material Symbol	ASME Sec II Page	ASME Sec II Line	Considerations for Application	Equivalent Material to JIS in No.	Equivalent Material to JIS in Symbol
SA 182 F9	46	6		JIS G3203-2008	SFVAF9
SA 182 FR	62	27	–	–	–
SA 192	2	15			
SA 199 T11	34	34	–	JIS G3462-2009	STBA23
SA 199 T21	38	38			
SA 199 T22	38	19		JIS G3462-2009	STBA24
SA 199 T5	42	19		JIS G3462-2009	STBA25
SA 199 T9	46	1	–	JIS G3462-2009	STBA26
SA 203 A	66	5		JIS G3127-2005	SL2N255
SA 203 B	66	8			
SA 203 D	66	27		JIS G3127-2005	SL3N255
SA 203 E	66	32	–	JIS G3127-2005	SL3N275
SA 203 F	66	37	(3)	JIS G3127-2005	SL3N440
SA 204 A	30	6		JIS G3103-2007	SB450M
SA 204 B	30	12		JIS G3103-2007	SB480M
SA 204 C	30	17	–	–	⊗SB520M
SA 209 T1	26	27		JIS G3462-2009	STBA12
SA 209 T1a	26	39		JIS G3462-2009	STBA13
SA 209 T1b	26	23			
SA 210 A1	14	19		JIS G3461-2005	STB410
SA 210 C	18	32			⊗STB480
SA 213 T11	34	36		JIS G3462-2009	STBA23
SA 213 T12	34	15	–	JIS G3462-2009	STBA22
SA 213 T2	30	32		JIS G3462-2009	STBA20
SA 213 T21	38	39			
SA 213 T22	38	21		JIS G3462-2009	STBA24
SA 213 T5	42	20	–	JIS G3462-2009	STBA25
SA 213 T5b	42	38			
SA 213 T5c	42	40			
SA 213 T9	46	2		JIS G3462-2009	STBA26
SA 213 TP304	98	7, 8	–	JIS G3463-2006	SUS304TB
SA 213 TP304H	98	10, 11		JIS G3463-2006	SUS304HTB
SA 213 TP304L	90	31, 32		JIS G3463-2006	SUS304LTB
SA 213 TP310H	162	22, 23			
SA 213 TP316	78	9, 10	–	JIS G3463-2006	SUS316TB
SA 213 TP316H	82	3, 4		JIS G3463-2006	SUS316HTB
SA 213 TP316L	70	41	–	JIS G3463-2006	SUS316LTB
SA 213 TP321	130	9, 10		JIS G3463-2006	SUS321TB
SA 213 TP321H	134	9, 10	–	JIS G3463-2006	SUS321HTB
SA 213 TP347	114	26, 27		JIS G3463-2006	SUS347TB
SA 213 TP347H	118	15, 16		JIS G3463-2006	SUS347HTB
SA 213 TP347H	118	15, 16			⊗SUS TP347HTB
SA 216 WCA	6	35			
SA 216 WCB	18	10			
SA 216 WCC	18	34			
SA 217 C5	42	33		JIS G5151-1991	SCPH61
SA 217 C12	46	9			
SA 217 WC1	30	1		JIS G5151-1991	SCPH11

Part-2-1: ASME Sec. II Part-D Standard Material

Material Symbol	ASME Sec.II		Considerations for Application	Equivalent Material to JIS in No.	Equivalent Material to JIS in Symbol
	Page	Line			
SA 217 WC4	62	20			
SA 217 WC5	62	19	-	-	-
SA 217 WC6	34	30		JIS G5151-1991	SCPH21
SA 217 WC9	38	30	-	JIS G5151-1991	SCPH32
SA 226	2	18 to 20			
SA 234 WPl	26	29			
SA 234 WPl1 cl.1	34	38			
SA 234 WPl2 cl.1	34	17	-	-	-
SA 234 WC22 cl.1	38	22			
SA 234 WP91	46	15, 16			
SA 234 WPB	10	35			
SA 234 WPC	18	35	-	-	-
SA 240 Type 304	98	15		JIS G4304-2010	SUS304
SA 240 Type 304	98	15	-	JIS G4305-2010	SUS304
SA 240 Type 304L	90	33		JIS G4304-2010	SUS304L
SA 240 Type 304L	90	33		JIS G4305-2010	SUS304L
SA 240 Type 309S	150	44		JIS G4304-2010	SUS309S
SA 240 Type 309S	150	44		JIS G4305-2010	SUS309S
SA 240 Type 310S	158	26		JIS G4304-2010	SUS310S
SA 240 Type 310S	158	26		JIS G4305-2010	SUS310S
SA 240 Type 316	78	12		JIS G4304-2010	SUS316
SA 240 Type 316	78	12		JIS G4305-2010	SUS316
SA 240 Type 316L	74	2	-	JIS G4304-2010	SUS316L
SA 240 Type 316L	74	2		JIS G4305-2010	SUS316L
SA 240 Type 317	138	8	-	JIS G4304-2010	SUS317
SA 240 Type 317	138	8		JIS G4305-2010	SUS317
SA 240 Type 317L	138	10		JIS G4304-2010	SUS317L
SA 240 Type 317L	138	10		JIS G4305-2010	SUS317L
SA 240 Type 321	130	13	-	JIS G4304-2010	SUS321
SA 240 Type 321	130	13		JIS G4305-2010	SUS321
SA 240 Type 347	114	29		JIS G4304-2010	SUS347
SA 240 Type 347	114	29		JIS G4305-2010	SUS347
SA 249 TP304	98	20 to 23	-	JIS G3463-2010	SUS304TB
SA 249 TP304L	90	37		JIS G3463-2010	SUS304LTB
SA 249 TP316	78	13 to 16	-	JIS G3463-2010	SUS316TB
SA 249 TP316L	74	5		JIS G3463-2010	SUS316LTB
SA 249 TP321	130	15 to 18	-	JIS G3463-2010	SUS321TB
SA 249 TP347	114	30 to 33		JIS G3463-2010	SUS347TB
SA 250 T1	26	32, 33	-	JIS G3462-2009	STBA12
SA 250 T1a	26	40, 41		JIS G3462-2009	STBA13
SA 250 T1b	26	25, 26			
SA 266 1	6	38			
SA 266 2	18	11			
SA 266 3	22	20			
SA 268 TP410	50	3, 5		JIS G3463-2006	SUS410TB
SA 268 TP430	50	26, 27		JIS G3463-2006	SUS430TB
SA 283 B	6	2		JIS G3101-2010	SS330
SA 283 C	6	10	(8)	-	-

Part-2-1: ASME Sec. II Part-D Standard Material

Material Symbol	ASME Sec II Page	ASME Sec II Line	Considerations for Application	Equivalent Material to JIS in No.	Equivalent Material to JIS in Symbol
SA 283 D	10	22		JIS G3101-2010	SS400
SA 285 C	6	12	(8)(9)		
SA 299	22	25			
SA 302 A	58	13	–	JIS G3119-2007	SBV1A
SA 302 B	58	16		JIS G3119-2007	SBV1B
SA 302 C	58	23		JIS G3119-2007	SBV2
SA 302 D	58	31		JIS G3119-2007	SBV3
SA 312 TP310H	162	31 to 34	–	–	–
SA 312 TP316H	82	11, 12	(6)	JIS G3459-2004	SUS316HTP
SA 312 TP316L	74	7, 10	–	JIS G3459-2004	SUS316LTP
SA 312 TP321	130	21, 22	(2)	JIS G3459-2004	SUS321TP
SA 312 TP321	130	24 to 27	–	JIS G3459-2004	SUS321TP
SA 312 TP321H	134	17, 18	(2)(6)	JIS G3459-2004	SUS321HTP
SA 312 TP304	98	33, 34	–	JIS G3459-2004	SUS304TP
SA 312 TP304	98	36 to 39		JIS G3459-2004	SUS304TP
SA 312 TP304H	102	1,2		JIS G3459-2004	SUS304HTP
SA 312 TP304L	94	2,4		JIS G3459-2004	SUS304LTP
SA 312 TP316	78	18 to 23		JIS G3459-2004	SUS316TP
SA 312 TP347	114	35 to 40		JIS G3459-2004	SUS347TP
SA 312 TP347H	118	24, 25		JIS G3459-1997	SUS347HTP
SA 333 1	6	13		JIS G3460-2006	STPL380
SA 333 3	66	22, 23		JIS G3460-2006	STPL450
SA 333 8	70	13 to 15		JIS G3460-2006	STPL690
SA 334 1	6	14, 15		JIS G3464-2006	STBL380
SA 334 3	66	24, 25	–	JIS G3464-2006	STBL450
SA 334 8	70	18 to 20		JIS G3464-2006	STBL690
SA 335 P1	26	35		JIS G3458-2005	STPA12
SA 335 P11	38	1		JIS G3458-2005	STPA23
SA 335 P12	34	21	–	JIS G3458-2005	STPA22
SA 335 P2	30	26		JIS G3458-2005	STPA20
SA 335 P21	42	1			
SA 335 P22	38	24		JIS G3458-2005	STPA24
SA 335 P5	42	23	–	JIS G3458-2005	STPA25
SA 335 P9	46	4		JIS G3458-2005	STPA26
SA 336 F1	30	13	–	JIS G3203-2008	SFVAF1
SA 336 F11 cl.1	38	3			
SA 336 F11 cl.2	38	10		JIS G3203-2008	SFVAF11A
SA 336 F11 cl.3	38	11			
SA 336 F12	34	28	–	JIS G3203-2008	SFVAF12
SA 336 F21 cl.1	42	3			
SA 336 F21 cl.3	42	11			
SA 336 F22 cl.1	38	25		JIS G3203-2008	SFVAF22A
SA 336 F22 cl.3	38	33		JIS G3203-2008	SFVAF22B
SA 336 F304	94	26		JIS G3214-2009	SUSF304
SA 336 F304H	94	28		JIS G3214-2009	SUSF304H
SA 336 F304L	90	28		JIS G3214-2009	SUSF304L
SA 336 F310	158	11		JIS G3214-2009	SUSF310
SA 336 F316	74	37		JIS G3214-2009	SUSF316

Part-2-1: ASME Sec. II Part-D Standard Material

Material Symbol	ASME Sec II Page	ASME Sec II Line	Considerations for Application	Equivalent Material to JIS in No.	Equivalent Material to JIS in Symbol
SA 336 F316H	78	4		JIS G3214-2009	SUSF316H
SA 336 F316L	70	37	–	JIS G3214-2009	SUSF316L
SA 336 F321	126	29		JIS G3214-2009	SUSF321
SA 336 F321H	130	2		JIS G3214-2009	SUSF321H
SA 336 F347	114	4		JIS G3214-2009	SUSF347
SA 336 F347H	114	11	–	JIS G3214-2009	SUSF347H
SA 336 F3V	42	14			
SA 336 F5A	42	31, 32	–	–	–
SA 336 F5	42	27			
SA 336 F9	46	8	–	JIS G3203-2008	SFVAF9
SA 336 F91	46	19, 20			
SA 350 LF2	18	13		JIS G3205-2008	SFL2
SA 350 LF3	66	30		JIS G3205-2008	SFL3
SA 351 CF8C	110	36	(5)	JIS G5121-2003	SCS21
SA 351 CH20	154	37, 38		JIS G5121-2003	SCS17
SA 351 CK20	154	41, 42	–	JIS G5121-2003	SCS18
SA 352 LC1	30	3		JIS G5152-2003	SCPL11
SA 352 LC2	66	10		JIS G5152-2003	SCPL21
SA 352 LC3	66	35		JIS G5152-2003	SCPL31
SA 352 LCB	14	25		JIS G5152-2003	SCPL11
SA 353	70	21, 22		JIS G3127-2005	SL9N520
SA 376 TP304	102	14, 16		JIS G3459-2004	SUS304TP
SA 376 TP304H	102	17, 19	–	JIS G3459-2004	SUS304HTP
SA 376 TP316	78	25, 26		JIS G3459-2004	SUS316TP
SA 376 TP316H	82	18, 19	–	JIS G3459-2004	SUS316HTP
SA 376 TP321	130	31, 32	(2)	JIS G3459-2004	SUS321TP
SA 376 TP321H	134	24, 25	(2)	JIS G3459-2004	SUS321HTP
SA 376 TP347	118	2, 3		JIS G3459-2004	SUS347TP
SA 376 TP347H	118	30, 31		JIS G3459-2004	SUS347HTP
SA 387 11 cl.1	38	6		JIS G4109-2008	SCMV3 (Strength Class-1)
SA 387 11 cl.2	38	12	–	JIS G4109-2008	SCMV3 (Strength Class-2)
SA 387 12 cl.1	34	11		JIS G4109-2008	SCMV2 (Strength Class-1)
SA 387 12 cl.2	34	25	–	JIS G4109-2008	SCMV2 (Strength Class-2)
SA 387 2 cl.1	30	28		JIS G4109-2008	SCMV1 (Strength Class-1)
SA 387 2 cl.2	30	35		JIS G4109-2008	SCMV1 (Strength Class-2)
SA 387 21 cl.1	42	7		JIS G4109-2008	SCMV5 (Strength Class-1)
SA 387 21 cl.2	42	12	–	JIS G4109-2008	SCMV5 (Strength Class-2)
SA 387 22 cl.1	38	27		JIS G4109-2008	SCMV4 (Strength Class-1)
SA 387 22 cl.2	38	34	–	JIS G4109-2008	SCMV4 (Strength Class-2)
SA 387 5 cl.1	42	25		JIS G4109-2008	SCMV6 (Strength Class-1)
SA 387 5 cl.2	42	30		JIS G4109-2008	SCMV6 (Strength Class-2)
SA 403 WP304	102	22, 24, 25			
SA 403 WP304H	102	28, 30, 31			
SA 403 WP304L	94	9, 11, 12			
SA 403 WP316	78	29, 31, 32			
SA 403 WP316H	82	22, 24			
SA 403 WP316L	74	14,15, 17,18			
SA 479 304	102	38	–	JIS G4304-2010	SUS304

Part-2-1: ASME Sec. II Part-D Standard Material

Material Symbol	ASME Sec II		Considerations for Application	Equivalent Material to JIS in No.	Equivalent Material to JIS in Symbol
	Page	Line			
SA 479 304	102	38		JIS G4305-2010	SUS304
SA 479 304	102	38	–	JIS G4303-2005	SUS304
SA 479 304L	94	15		JIS G4303-2005	SUS304L
SA 479 309S	150	19		JIS G4304-2010	SUS309S
SA 479 309S	150	19		JIS G4305-2010	SUS309S
SA 479 309S	150	19	–	JIS G4303-2005	SUS309S
SA 479 310S	162	9		JIS G4304-2010	SUS310S
SA 479 310S	162	9	–	JIS G4305-2010	SUS310S
SA 479 310S	162	9		JIS G4303-2005	SUS310S
SA 479 316	78	35	–	JIS G4304-2010	SUS316
SA 479 316	78	35		JIS G4305-2010	SUS316
SA 479 316	78	35		JIS G4303-2005	SUS316
SA 479 316L	74	21		JIS G4304-2010	SUS316L
SA 479 316L	74	21	–	JIS G4305-2010	SUS316L
SA 479 321	134	3		JIS G4303-2005	SUS321
SA 479 347	118	11	–	JIS G4304-2010	SUS347
SA 479 347	118	11		JIS G4305-2010	SUS347
SA 479 347	118	11		JIS G4303-2005	SUS347
SA 515 60	10	11		JIS G3103-2007	SB410
SA 515 65	14	27		JIS G3103-2007	SB450
SA 515 70	18	21	(1)	JIS G3103-2007	SB480
SA 515 60	10	14		JIS G3118-2010	SGV410
SA 515 65	14	32	–	JIS G3118-2010	SGV450
SA 515 70	18	23		JIS G3118-2010	SGV480
SA 522 Type I	70	26, 27	–	–	@SFL9N690
SA 533 Type A cl.1	58	17		JIS G3120-2009	SQV1A
SA 533 Type A cl.2	58	18		JIS G3120-2009	SQV1B
SA 533 Type B cl.1	58	24		JIS G3120-2009	SQV2A
SA 533 Type B cl.2	58	27		JIS G3120-2009	SQV2B
SA 533 Type C cl.1	58	32		JIS G3120-2009	SQV3A
SA 533 Type C cl.2	58	33	–	JIS G3120-2009	SQV3B
SA 537 cl.1	14	40			
SA 537 cl.1	22	12	–	–	–
SA 537 cl.2	26	3	(4)	JIS G3115-2010	SPV450
SA 553 Type I	70	28, 29		JIS G3127-2005	SL9N590
SA 556 C2	22	2			@STB480
SA 612	26	9, 10	–	–	–
SA 662 A	6	29	(3)	JIS G3115-2010	SPV235
SA 662 C	22	8	–	–	–
SB 163 N06600	230	1, 2		JIS G4904-2008	NCF600TB
SB 163 N08800	245.1	1, 2		JIS G4904-2008	NCF800TB
SB 167 N06600 CWA	230	12, 13		JIS G4903-2008	NCF600TP
SB 167 N06600 CWA	229.1	15, 16		JIS G4903-2008	NCF600TP
SB 167 N06600 HW/HWA	229.1	17, 18		JIS G4903-2008	NCF600TP
SB 167 N06600 CWA	229.1	8, 9		JIS G4903-2008	NCF600TP
SB 407 N08800 CWA	245.1	7, 8		JIS G4903-2008	NCF800TP
CC 2115 (SA 213 TP310HCbN)	226				@SUS310J1TB

Part-2-1: ASME Sec. II Part-D Standard Material

Material Symbol	ASME Sec.II		Considerations for Application	Equivalent Material to JIS in No.	Equivalent Material to JIS in Symbol
	Page	Line			
CC 2159 (SA 213 TP347HFG)	310		–	–	–
CC 2192	368		–	–	–

Part-2-2: ASME B31.1 Standard Material

Material Symbol	ASME B31.1(A79)		Considerations for Application	Equivalent Material to SA	Equivalent Material to JIS	
	Page	Line			Standard No.	Symbol
A 36	114	17		SA-36	JIS G3106-2008	SM400A
A35 B S	102	2		SA-53 Type S-B		®SFL9N690
A 105	114	9	–	SA-105	JIS G3201-2008	SF490A
A 135 B	102	21		SA-135B	JIS G3454-2007	STPG480
A 178 A	104	1	–	SA-178 A	JIS G3461-2005	STB340
A 178 C	104	2		SA-178 C	JIS G3461-2005	STB410
A 181 70	114	11	–	SA-181 cl 70	JIS G3201-2009	SF490A
A 182 F22 Class-3	128	10		SA-182 F22 cl.3	JIS G3203-2008	SFVA F22B
A 182 F316L	158	9	–	SA-182 F316L	JIS G3214-2009	SUSF316L
A 182 F321	158	13, 15		SA-182 F321	JIS G3214-2009	SUSF321
A 199 T11	120	3		SA-199 T11	JIS G3462-2009	STBA23
A 199 T22	120	5		SA-199 T22	JIS G3462-2009	STBA24
A 199 T5	120	1		SA-199 T5	JIS G3462-2009	STBA25
A 199 T9	120	2		SA-199 T9	JIS G3462-2009	STBA26
A 210 A1	102	8		SA-210 A1	JIS G3461-2005	STB410
A 213 TP316	136	13, 14		SA-213 TP316	JIS G3463-2006	SUS316TB
A 213 TP316L	136	17		SA-213 TP316L	JIS G3463-2006	SUS316LTB
A 213 TP321	136	21, 22		SA-213 TP321	JIS G3463-2006	SUS321TB
A 213 TP321H	136	23, 24		SA-213 TP321H	JIS G3463-2006	SUS321HTB
A 240 304 L	154	12	–	SA-240 Type304L	JIS G4304,5-2010	SUS304L
A 240 316 L	154	27		SA-240 Type316L	JIS G4304,5-2010	SUS316L
A 240 321	154	36		SA-240 Type321	JIS G4304,5-2010	SUS321
A 249 TP304	144	21, 22		SA-249 TP304	JIS G3463-2006	SUS304TB
A 249 TP304L	144	23	–	SA-249 TP304L	JIS G3463-2006	SUS304LTB
A 249 TP316	146	3, 4		SA-249 TP316	JIS G3463-2006	SUS316TB
A 249 TP316L	146	7		SA-249 TP316L	JIS G3463-2006	SUS316LTB
A 249 TP321	146	13, 14		SA-249 TP321	JIS G3463-2006	SUS321TB
A 249 TP347	146	17, 18	–	SA-249 TP347	JIS G3463-2006	SUS347TB
A 312 TP304L	138	5		SA-312 TP304L	JIS G3459-2004	SUS304LTP
A 312 TP304L	148	5	–	SA-312 TP304L	JIS G3459-2004	SUS304LTP
A 312 TP316H	138	19, 20	(6)	SA-312 TP316H	JIS G3459-2004	SUS316HTP
A 312 TP316L	138	21		SA-312 TP316L	JIS G3459-2004	SUS316LTP
A 312 TP316L	148	17		SA-312 TP316L	JIS G3459-2004	SUS316LTP
A 312 TP321	140	3, 4	(2)	SA-312 TP321	JIS G3459-2004	SUS321TP
A 312 TP321	150	3, 4	(2)	SA-312 TP321	JIS G3459-2004	SUS321TP
A 312 TP321H	140	5, 6	(2)(6)	SA-312 TP321H	JIS G3459-2004	SUS321HTP
A 333 1	102, 104	10, 5		SA-333 1	JIS G3460-2006	STPL380
A 350 LF3	128	11		SA-350 LF cl.2	JIS G3205-2008	SFL3
A 351 CF8C	164	3	(5)	SA-351 CF8C	JIS G5121-2003	SCS21
A 376 TP304	140	20, 21		SA-376 TP304	JIS G3459-2004	SUS304TP
A 376 TP304H	140	22, 23	–	SA-376 TP304H	JIS G3459-2004	SUS304HTP
A 376 TP316	140	26, 27		SA-376 TP316	JIS G3459-2004	SUS316TP
A 376 TP316H	140	28, 29		SA-376 TP316H	JIS G3459-2004	SUS316HTP
A 376 TP321	140	32, 33	(2)	SA-376 TP321	JIS G3459-2004	SUS321TP
A 376 TP321H	140	34, 35	(2)	SA-376 TP321H	JIS G3459-2004	SUS321HTP
A 376 TP347	142	1, 2		SA-376 TP347	JIS G3459-2004	SUS347TP
A 376 TP347H	142	3, 4		SA-376 TP347H	JIS G3459-2004	SUS347HTP

Part-2-2: ASME B31.1 Standard Material

Material Symbol	ASME B31.1(A79)		Considerations for Application	Equivalent Material to SA	Equivalent Material to JIS	
	Page	Line			Standard No.	Symbol
A 387 11 1	126	1	–	Sa-387 11 cl.1	JIS G4109-2008	SCMV3(Strength Class-1)
A 387 11 2	126	2	–	Sa-387 11 cl.2	JIS G4109-2008	SCMV3(Strength Class-2)
A 479 TP316L	168	12		SA-479 316L	JIS G4304,5-2010	SUS316L
A 479 TP321	168	16		SA-479 321	JIS G4303-2005	SUS321
A 515 70	114	4	(1)	SA-515 70	JIS G3103-2007	SB480

Appendix-2. Allowable Tensile Stress of Non-ferrous Material at Each Temperature Part-1. (JIS Standard, Interpretation of Japanese Technical Regulation for Thermal Power, Others)

Material Name & Standard Number	classification		Symbol	Minimum Tensile Strength (N/mm^2)	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																												
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Copper and copper alloy sheets, plates and strips JIS H3100-2000	1020	O	C1020 P-O	195 (30mm≥thickness≥0.3m	—	-196	46	39	37	36	35	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1020 R-O	195 (3mm≥thickness≥0.3mm)																																															
	1100	O	C1100 P-O	195 (30mm≥thickness≥0.3mm)	—	-196	46	39	37	36	35	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1100 R-O	195 (30mm≥thickness≥0.3mm)																																															
	1201	O	C1201 P-O	195 (30mm≥thickness≥0.3mm)	—	-196	46	39	38	36	35	27	21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1201 R-O	195 (3mm≥thickness≥0.3mm)																																															
	1220	O	C1220 P-O	195 (30mm≥thickness≥0.3mm)	—	-196	46	39	37	36	35	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1220 R-O	195 (3mm≥thickness≥0.3mm)																																															
	4621	F	C4621 P-F	375 (20mm≥thickness≥0.8mm)	—	-196	86	86	86	86	86	43	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				345 (40mm≥thickness≥20mm)		-196	86	86	86	86	86	43	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				345 (125mm≥thickness≥40mm)		-196	79	79	79	79	79	43	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4640	F	C4640 P-F	375 (20mm≥thickness≥0.8mm)	—	-196	86	86	86	86	86	43	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				345 (40mm≥thickness≥20mm)		-196	86	86	86	86	86	46	21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				345 (125mm≥thickness≥40mm)		-196	79	79	79	79	79	43	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6140	O	C6140 P-O	480 (50mm≥thickness≥4mm)	—	-196	120	120	120	120	120	120	118	115	112	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				450 (125mm≥thickness≥50mm)		-196	113	113	113	113	113	113	110	107	103	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6161	O	C6161 P-O	490 (50mm≥thickness≥0.8mm)	—	-196	121	121	121	121	121	121	121	117	114	110	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				450 (125mm≥thickness≥50mm)		-196	112	112	112	112	112	112	112	109	105	101	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6280	F	C6280 P-F	620 (50mm≥thickness≥0.8mm)	—	-196	138	135	134	127	119	110	101	93	84	76	67	58	50	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				590 (90mm≥thickness≥50mm)																																															
				550 (125mm≥thickness≥90mm)																																															
	6301	F	C6301 P-F	635 (50mm≥thickness≥0.8mm)	—	-196	159	155	155	155	155	155	155	153	149	127	99	76	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				590 (125mm≥thickness≥50mm)		-196	148	148	148	148	145	143	140	138	136	122	99	76	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7060	F	C7060 P-F	275 (50mm≥thickness≥0.5mm)	—	-196	69	67	66	64	62	60	59	57	56	51	45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7150	F	C7150 P-F	345 (50mm≥thickness≥0.5mm)	—	-196	86	84	82	80	78	76	75	73	72	71	70	69	67	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Copper and copper alloy rods and bars JIS H3250-2000	1020	F	C1020 BE-F	195 (diameter≥6mm)	—	-196	46	39	37	36	35	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1100		C1100 BE-F																																															
	1201		C1201 BE-F																																															
	1220		C1220 BE-F																																															
	1221		C1221 BE-F																																															
		O	C1020 BD-O	195 (75mm≥diameter≥6mm)	—	-196	46	39	37	36	35	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1100 BD-O																																															
			C1201 BD-O																																															
			C1220 BD-O																																															
			C1221 BD-O																																															
	2600	F	C2600 BE-F	275	—	-196	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	C2600 BD-O	275	—	-196	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2700	F	C2700 BE-F	295	—	-196	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	C2700 BD-O	295	—	-196	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2800	F	C2800 BE-F	315	—	-196	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	C2800 BD-O	315	—	-196	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3601	O	C3601 BD-O	295 (75mm≥diameter≥6mm)	—	-196	74	74	69	68	68	37	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3602	F	C3602 BE-F	315 (75mm≥diameter≥6mm)	—	-196	79	79	79	71	68	37	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C3602 BD-F																																															
	3603	O	C3603 BD-O	315 (75mm≥diameter≥6mm)	—	-196	79	79	79	71	68	37	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3604	F	C3604 BE-F	335 (75mm≥diameter≥6mm)	—	-196	84	84	84	71	68	37	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C3604 BD-F																																															
	3712	F	C3712 BE-F	315 (diameter≥6mm)	—	-196	79	79	79	73	73	42	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C3712 BD-F																																															
	3771	F	C3771 BE-F	315 (diameter≥6mm)	—	-196	79	79	79	73	73	42	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C3771 BD-F																																															
Copper and copper alloy seamless pipes and tubes JIS H3300-1997	1020	O	C1020 T-O	205 (100mm≥outside diameter≥4mm	—	-196	41	34	33	33	32	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1020 TS-O	30mm≥thickness≥0.3mm)																																															
	1100	O	C1100 T-O	205 (250mm≥outside diameter≥5mm	—	-196	41	34	33	33	32	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1100 TS-O	30mm≥thickness≥0.5mm)																																															
	1201	O	C1201 T-O	205 (250mm≥outside diameter≥5mm	—	-196	41	34	33	33	32	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1201 TS-O	30mm≥thickness≥0.5mm)																																															
	1220	O	C1220 T-O	205 (250mm≥outside diameter≥5mm	—	-196	41	34	33	33	32	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1220 TS-O	30mm≥thickness≥0.5mm)																																															
	1020	O	C1020 T-O	245 (100mm≥outside diameter≥4mm	—	-196	41	34	33	33	32	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1020 TS-O	30mm≥thickness≥0.3mm)																																															
	1201	OL	C1201 T-OL	205 (250mm≥outside diameter≥5mm	—	-196	41	34	33	33	32	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1201 TS-OL	30mm≥thickness≥0.5mm)																																															
	1220	OL	C1220 T-OL	205 (250mm≥outside diameter≥5mm	—	-196	41	34	33	33	32	28	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1220 TS-OL	30mm≥thickness≥0.5mm)																																															
	1020	1/2H	C1020 T-1/2H	245 (100mm≥outside diameter≥4mm	(1)	-196	62	62	62	62	60	58	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1020 TS-OL	30mm≥thickness≥0.3mm)																																															
	1100	1/2H	C1100 T-1/2H	245 (250mm≥outside diameter≥5mm	(1)	-196	62	62	62	61	60	58	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1100 TS-1/2H	30mm≥thickness≥0.5mm)																																															
	1201	1/2H	C1201 T-1/2H	245 (100mm≥outside diameter≥4mm	(1)	-196	61	61	61	61	60	59	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1201 TS-1/2H	:30mm≥thickness≥0.3mm)																																															
	1220	1/2H	C1220 T-1/2H	245 (100mm≥outside diameter≥4mm	(1)	-196	62	62	62	62	60	58	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1220 S-1/2H	30mm≥thickness≥0.3mm)																																															
	1020	H	C1020 T-H	315 (100mm≥outside diameter≥25mm	(1)	-196	78	78	78	78	76	71	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1020 TS-H	6mm≥thickness≥0.3mm)																																															
	1100	H	C1100 T-H	265 (100mm≥outside diameter≥5mm	(1)	-196	64	64	59	57	55	34	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			C1100 TS-H	10mm≥thickness≥0.5mm)																																															
	1201	H	C1201 T-H	315 (25mm≥outsidediameter	(1)	-196	78	78	78	78	76	71	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1220		C1201 TS-H	: 3mm≥thickness≥0.3mm																																															

Material Name & Standard Number	classification		Symbol	Minimum Tensile Strength (N/mm^2)	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																									
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Copper and copper alloy seamless pipes and tubes JIS H3300-1997			C1220 T-H C1220 TS-H	: 50mm≥outsidediameter≥25mm : 4mm≥thickness≥0.9mm : 100mm≥outsudediameter≥50mm : 6mm≥thickness≥1.5mm)																																													
	2300	O	C2300 T-O C2300 TS-O	275 : 150mm≥outside diameter≥10mm : 15mm≥thickness≥0.5mm	—	-196	55	55	55	55	55	49	39	19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		OL	C2300 T-OL C2300 TS-OL																																														
	2800	O	C2800 T-O C2800 TS-O	315 : 250mm≥outside diameter≥10mm : 15mm≥thickness≥1mm	—	-196	79	79	79	79	79	75	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4430	O	C4430 T-O C4430 TS-O	315 : 250mm≥outside diameter≥5mm : 10mm≥thickness≥0.8mm	—	-196	69	69	69	69	69	68	31	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6870	O	C6870 T-O C6870 TS-O	375 : 250mm≥outside diameter≥5mm : 10mm≥thickness≥0.8mm	—	-196	82	82	81	80	80	47	25	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6871	O	C6871 T-O C6871 TS-O	375 : 250mm≥outside diameter≥5mm : 10mm≥thickness≥0.8mm	—	-196	82	82	81	80	80	47	25	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6872	O	C6872 T-O C6872 TS-O	375 : 250mm≥outside diameter≥5mm : 10mm≥thickness≥0.8mm	—	-196	82	82	81	80	80	47	25	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7060	O	C7060 T-O C7060 TS-O	275 : 5mm≥outside diameter≥0.8mm : 10mm≥thickness≥0.8mm	—	-196	69	66	65	64	62	60	59	58	56	51	45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7100	O	C7100 T-O C7100 TS-O	315 : 50mm≥outside diameter≥5mm : 5mm≥thickness≥0.8mm	—	-196	74	73	72	72	71	70	68	67	65	63	60	56	52	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7150	O	C7150 T-O C7150 TS-O	365 : 50mm≥outside diameter≥5mm : 5mm≥thickness≥0.8mm	—	-196	83	79	77	76	74	73	71	70	69	68	67	66	65	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Copper and copper alloy welded pipes and tubes JIS H3320-1992	1220	O	C1220TW-O C1220TWS-O	205 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	—	-196	35	29	28	28	27	24	19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		OL	C1220TW-OL C1220TWS-OL																																														
		1/2H	C1220TW-1/2H C1220TWS-1/2H	245 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	(1)	-196	53	53	53	53	51	49	48	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H	C1220TW-H C1220TWS-H	315 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	(1)	-196	66	66	66	66	65	60	31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2600	O	C2600TW-O C2600TWS-O	275 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	—	-196	59	59	59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		OL	C2600TW-OL C2600TWS-OL																																														
		1/2H	C2600TW-1/2H C2600TWS-1/2H	375 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	(1)	-196	79	79	79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H	C2600TW-H C2600TWS-H	450 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	(1)	-196	96	96	96	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2680	O	C2680TW-O C2680TWS-O	295 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	—	-196	63	63	63	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		OL	C2680TW-OL C2680TWS-OL																																														
		1/2H	C2680TW-1/2H C2680TWS-1/2H	375 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	(1)	-196	79	79	79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H	C2680TW-H C2680TWS-H	450 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	(1)	-196	96	96	96	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4430	O	C4430TW-O C4430TWS-O	315 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	—	-196	59	59	59	59	59	58	26	14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7060	O	C7060TW-O C7060TWS-O	275 : 76.2mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	—	-196	59	56	55	54	53	51	50	49	48	43	38	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7150	O	C7150TW-O C7150TWS-O	365 : 50mm≥outside diameter≥4mm : 3mm≥thickness≥0.3mm	—	-196	70	67	65	65	63	62	60	60	59	58	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Copper and copper alloy castings JIS H5120-1997	—	—	CAC201(TBsC1)	145	—	-196	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC202(YBsC2)	195	—	-196	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC203(YBsC3)	245	—	-196	49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC301(HBsC1)	430	—	-196	86	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC302(HBsC2)	490	—	-196	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC303(HBsC3)	635	—	-196	79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC304(HBsC4)	755	—	-196	84	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC402(BC2)	245	—	-196	49	49	47	47	45	44	44	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC403(BC3)	245	—	-196	49	49	47	47	45	44	44	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC406(BC6)	195	—	-196	42	42	42	41	40	39	38	37	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC407(BC7)	215	—	-196	43	43	43	43	43	40	37	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC502A(PBC2)	195	—	-196	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC502B(PBC2B)	295	—	-196	59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC701(AlBC1)	440	—	-196	87	85	82	80	78	78	78	78	78	71	54	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC702(AlBC2)	490	—	-196	98	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC703(AlBC3)	590	—	-196	118	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC704(AlBC4)	590	—	-196	118	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Copper alloy continuous castings JIS H5121-1997	—	—	CAC301C(HBSC1C)	470	—	-196	59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC502C(PBC2C)	295	—	-196	59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC503C(PBC3C)	295	—	-196	59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			CAC702C(AlBC2C)	540	—	-196	108	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Material Name & Standard Number	classification		Symbol	Minimum Tensile Strength (N/mm^2)	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																									
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Aluminum and aluminum alloy sheets and plates, strips and coiled sheets JIS H4000-1999	1080 1070	O	A1080P-O A1070P-O	55	(1)	-196	10	10	9	8	7	6	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H12 H22	A1080P-H12, -H22 A1070P-H12, -H22	70	(1)	-196	18	18	16	15	13	12	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14 H24	A1080P-H14, -H24 A1070P-H14, -H24	85	(1)	-196	21	21	21	21	18	13	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H-12	A1080P-H112 A1070P-H112	75 : 6.5mm≥thickness≥4mm	(1)	-196	19	17	15	13	11	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				70 : 13mm≥thickness>6.5mm	(1)	-196	18	16	15	13	11	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				60 : 25mm≥thickness>13mm	(1)	-196	15	14	13	11	10	8	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				55 : 50mm≥thickness>25mm	(1)	-196	13	12	11	9	7	6	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				55 : 75mm≥thickness>50mm	—	-196	10	10	9	8	7	6	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1050	O	A1050P-O	60	—	-196	13	13	12	11	10	8	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H12 H22	A1050P-H12, -H22	80	(1)	-196	20	19	18	16	15	13	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14 H24	A1050P-H14, -H24	95	(1)	-196	24	24	22	21	18	13	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H112	A1050P-H112	85 : 6.5mm≥thickness≥4mm	(1)	-196	21	19	17	14	13	11	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				80 : 13mm≥thickness>6.5mm	(1)	-196	20	18	16	14	13	11	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				70 : 25mm≥thickness>13mm	(1)	-196	18	17	15	13	12	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				65 : 50mm≥thickness>25mm	(1)	-196	16	14	13	12	10	8	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				65 : 75mm≥thickness>50mm	—	-196	13	13	12	11	10	8	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1100 1200	O	A1100P-O A1200P-O	75	—	-196	16	16	16	16	12	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H12 H22	A1100P-H12, -H22 A1200P-H12, -H22	95	(1)	-196	24	24	24	22	20	14	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14 H24	A1100P-H14, -H24 A1200P-H14, -H24	120	(1)	-196	28	28	27	25	19	14	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H112	A1100P-H112 A1200P-H112	95 : 6.5mm≥thickness>4mm	(1)	-196	24	23	21	19	17	12	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				90 : 13mm≥thickness>6.5mm	(1)	-196	23	22	20	18	16	12	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				85 : 50mm≥thickness>13mm	(1)	-196	21	20	19	17	15	12	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				80 : 75mm≥thickness>50mm	(1)	-196	19	19	18	16	12	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3003 3203	O	A3003P-O A3203P-O	95	—	-196	23	23	23	20	16	13	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H12 H22	A3003P-H12, -H22 A3203P-H12, -H22	120	(1)	-196	30	30	29	27	25	21	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14 H24	A3003P-H14, -H24 A3203P-H14, -H24	135	(1)	-196	34	34	34	33	29	23	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H112	A1100P-H112 A1200P-H112	120 : 13mm≥thickness>4mm	(1)	-196	30	30	29	27	25	21	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				110 : 50mm≥thickness>13mm	(1)	-196	26	26	25	21	16	13	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				100 : 75mm≥thickness>50mm	(1)	-196	25	25	24	21	16	13	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3400	O	A3004P-O	155	—	-196	38	38	38	37	34	27	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H12	A3004P-H12	195	(1)(K1)	-196	48	48	48	47	39	27	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14	A3004P-H14	225	(1)(K1)	-196	55	55	55	53	39	27	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H32	A3004P-H32	195	(1)	-196	48	48	48	47	40	27	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H34	A3004P-H34	225	(1)	-196	55	55	55	53	40	27	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5052 5652	O	A5052P-O A5652P-O	175	—	-196	43	43	43	43	38	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H12 H22 H32	A5052P-H12, -H22, -H32 A5652P-H12, -H22, -H32	215	(1)	-196	54	54	53	50	42	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14 H24 H34	A5052P-H14, -H24, -H34 A5652P-H14, -H24, -H34	235	(1)	-196	59	59	59	56	42	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H112	A5052P-H112	195 : 13mm≥thickness≥4mm	(1)	-196	48	48	48	47	42	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A5652P-H112	175 : 75mm≥thickness>13mm	(1)	-196	43	43	43	43	41	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5154 5254	O	A5154P-O A5254P-O		(2)	-196	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H12 H22 H32	A5154P-H12, -H22, -H32 A5254P-H12, -H22, -H32		(1)(2)	-196	62	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14 H24 H34	A5154P-H14, -H24, -H34 A5254P-H14, -H24, -H34		(1)(2)	-196	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H112	A5154P-H112 A5254P-H112	235 : 6.5mm≥thickness≥4mm	(1)(2)	-196	59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				235 : 13mm≥thickness>6.5mm	(1)(2)	-196	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				205 : 75mm≥thickness>13mm	(2)	-196	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5454	O	A5454P-O	215	—	-196	54	54	53	49	38	29	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5083	O	A5083P-O	275 : 80mm≥thickness>0.8mm	(2)	-196	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				265 : 100mm≥thickness>80mm	(2)	-196	66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H32	A5083P-H32	315 : 2.9mm≥thickness>0.8mm	(1)(2)	-196	79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				305 : 12mm≥thickness>2.9mm	(1)(2)	-196	76	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H321	A5080P-H321	305 : 40mm≥thickness>4mm	(1)(2)	-196	76	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				285 : 80mm≥thickness>40mm	(1)(2)	-196	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H112	A5080P-H112	285 : 6.5mm≥thickness>4mm	(1)(2)	-196	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				275 : 75mm≥thickness>6.5mm	(2)	-196	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A5083PS-O	275	(2)	-196	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Material Name & Standard Number	classification		Symbol	Minimum Tensile Strength (N/mm^2)	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																								
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Aluminum and aluminum alloy sheets and plates, strips and coiled sheets JIS H4000-1999	5086	O	A5086P-O	245	(2)	-196	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H32	A5086P-H32	275	(1)(2)	-196	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H34	A5086P-H34	305	(1)(2)	-196	76	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H112	A5086P-H112	255 : 6.5mm≥thickness>4mm	(1)(2)	-196	62	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				245 : 50mm≥thickness>6.5mm	(2)	-196	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				235 : 75mm≥thickness>50mm	(2)	-196	59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6061	T4	A6061P-T4	205	(3)	-196	52	52	52	51	47	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T451	A6061P-T451	205	(3)	-196	52	52	52	51	47	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A6061P-T6	295	(3)	-196	72	72	71	67	57	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T651	A6061P-T651	295	(3)	-196	72	72	71	67	57	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T4W) (T451W) (T6W) (T651W)	A6061P-T4W, -T451W A6061P-T6W, -T651W	165	—	-196	41	41	41	40	38	32	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7N01	T4	A7N01P-T4	315	(2)(3)	-196	79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	AN701P-T6	335	(2)(3)	-196	84	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T4W) (T6W)	A7N01P-T4W AN701P-T6W	280	(2)	-196	70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aluminum and aluminum alloy rod, bars and wires JIS H4040-1999	1070	H12	A1070BE-H112 A1070BES-H112	55	—	-196	10	10	9	8	7	6	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A1070BD-O A1070BDS-O	55	—	-196	10	10	9	8	7	6	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1050	H112	A1050BE-H112 A1050BES-H112	65	—	-196	13	13	12	11	10	8	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1100 1200	H112	A1100BE-H112 A1100BES-H112 A1200BE-H112 A1200BES-H112	75	—	-196	14	14	14	14	12	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A1100BD-O A1100BDS-O A1200BD-O A1200BDS-O	75	—	-196	14	14	14	14	12	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2024	T4	A2024BE-T4 A2024BES-T4	390 (6mm≥diameter or minimum distance between opposite side)	(3)	-196	99	97	96	84	65	43	31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				410 (19mm≥diameter or minimum distance between opposite side>6mm)	(3)	-196	103	103	100	88	68	45	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				450 (38mm≥diameter or minimum distance between opposite side>19mm)	(3)	-196	112	112	109	95	73	49	35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				470 (diameter or minimum distance between between opposite side>38mm, 200cm2≥cross section area)	(3)	-196	117	117	114	100	77	51	37	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A2024BD-T4 A2024BDS-T4	430	(3)	-196	107	107	104	91	71	47	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3003	H12	A3003BE-H112 A3003BES-H112	95	—	-196	23	23	23	20	16	13	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A3003BD-O A3003BDS-O	95	—	-196	23	23	23	20	16	13	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5052	H112 O	A5052BE-H112, O A5052BES-H112, O	175	—	-196	43	43	43	43	38	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A5052BD-O A5052BDS-O	175	—	-196	43	43	43	43	38	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5056	H12	A5056BE-H112 A5056BES-H112	245 (300cm2≥cross section area)	(2)	-196	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5083	H12 O	A5083BE-H112, O A5083BES-H112, O	275	(2)	-196	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A5083BD-O A5083BDS-O	275	(2)	-196	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6061	T4	A6061BE-T4 A6061BES-T4	175	(3)	-196	45	45	45	44	41	40	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A6061BE-T6 A6061BES-T6	265	(3)	-196	66	66	65	62	54	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T4W) (T6W)	A6061BE-TW A6061BES-TW A6061BE-T6W A6061BES-T6W	165	—	-196	41	41	41	40	38	31	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A6061BD-T6 A6061BDS-T6	295	(3)	-196	72	72	72	67	57	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6W	A6061BD-T6W A6061BDS-T6W	165	—	-196	41	41	41	40	38	32	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6063	T1	A6063BE-T1 A6063BES-T1	120 (12mm≥diameter or minimum distance between opposite side)	(3)	-196	30	30	30	29	29	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				110 (25mm≥diameter or minimum distance between opposite side>12mm)	(3)	-196	28	28	28	28	27	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T5	A6063BE-T5 A6063BES-T5	155 (12mm≥diameter or minimum distance between opposite side)	(3)	-196	38	38	37	35	31	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				145 (25mm≥diameter or minimum distance between opposite side>12mm)	(3)	-196	36	36	35	33	29	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A6063BE-T6 A6063BES-T6	205	(3)	-196	51	51	50	45	34	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Material Name & Standard Number	classification		Symbol	Minimum Tensile Strength (N/mm^2)	Remarks	Minimum Operation Temperature (^{0}C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																								
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Aluminum and aluminum alloy rod, bars and wires JIS H4040-1999		(T5W) (T6W)	A6063BE-T5W, -T6W A6063BES-T5W, -T6W	120	—	-196	30	30	30	29	27	21	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7003	T5	A7003BE-T5 A7003BES-T5	285 (12mm≧diameter or minimum distance between opposite side)	(2)(3)	-196	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				275 (25mm≧diameter or minimum distance between opposite side>12mm)	(2)(3)	-196	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T5W	A7003BE-T5W A7003BES-T5W	265	(2)	-196	66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7N01	T4	A7N01BE-T4 A7N01BES-T4	315	(2)(3)	-196	79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A7N01BE-T6 A7N01BES-T6	335	(2)(3)	-196	84	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T4W) (T6W)	A7N01BE-T4W, -T6W A7N01BES-T4W, -T6W	285	(2)	-196	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aluminum and aluminum alloy extruded tubes and cold-drawn tubes JIS H4080-1999	1070	H12	A1070TE-H112 A1070TES-H112	55	—	-196	10	10	9	8	7	6	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A1070TD-O A1070TD-O	55	—	-196	10	10	9	8	7	6	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14	A1070TD-H14 A1070TDS-H14	85	(1)	-196	21	21	21	21	18	13	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1050	H12	A1050TE-H112 A1050TES-H112	65	—	-196	13	13	12	11	10	8	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A1050TD-O A1050TD-O	60	—	-196	13	13	12	11	10	8	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14	A1050TD-H14 A1050TDS-H14	95	(1)	-196	24	24	22	21	18	13	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1100 1200	H112	A1100TE-H112 A1100TES-H112 A1200TE-H112 A1200TES-H112	75	—	-196	14	14	14	14	12	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A1100TD-O A1100TDS-O A1200TD-O A1200TDS-O	75	—	-196	14	14	14	14	12	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14	A1100TD-H14 A1100TDS-H14 A1200TD-H14 A1200TDS-H14	110	(1)	-196	28	27	27	25	19	14	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3003 3203	H112	A3003TE-H112 A3003TES-H112 A3203TE-H112 A3203TES-H112	95	—	-196	23	23	23	20	16	13	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A3003TD-O A3003TDS-O A3203TD-O A3203TDS-O	95	—	-196	23	23	23	20	16	13	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14	A3003TD-H14 A3003TDS-H14 A3203TD-H14 A3203TDS-H14	135	(1)	-196	34	34	34	33	29	23	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H18	A3003TD-H18 A3003TDS-H18 A3203TD-H18 A3203TDS-H18	185	(1)	-196	46	46	46	43	37	25	19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5052	H112 O	A5052TE-H112, -O A5052TES-H112, -O	175	—	-196	43	43	43	43	38	30	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A5052TD-O A5052TDS-O	175	—	-196	43	43	43	43	38	30	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H34	A5052TD-H34 A5052TDS-H34	235	(1)	-196	59	59	58	56	42	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5154	H112 O	A5154TE-H112, -O A5154TES-H112, -O	205	—	-196	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A5154TD-O A5154TDS-O	205	—	-196	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5454	H112 O	A5454TE-H112, -O A5454TES-H112, -O	215	—	-196	54	54	53	49	38	29	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5056	H112 O	A5056TE-H112, -O A5056TES-H112, -O	245 (300cm2≧cross section area)	(2)	-196	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5083	H112 O	A5083TE-H112, -O A5083TES-H112, -O	275	(2)	-196	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		O	A5083TD-O A5083TDS-O	275	(2)	-196	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6061	T4	A6061TE-T4 A6061TES-T4	175	(3)	-196	44	44	44	44	41	40	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A6061TE-T6 A6061TES-T6	265	(3)	-196	66	66	65	62	54	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T4W)	A6061TE-T4W A6061TES-T4W	165	—	-196	41	41	41	40	38	32	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T6W)	A6061TE-T6W																																														

Material Name & Standard Number	classification		Symbol	Minimum Tensile Strength (N/mm^2)	Remarks	Minimum Operation Temperature (^{0}C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																											
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Aluminum and aluminum alloy extruded tubes and cold-drawn tubes JIS H4080-1999			A6061TES-T6W																																														
		T4	A6061TD-T4 A6061TDS-T4	205	(3)	-196	51	51	51	51	47	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A6061TD-T6 A6061TDS-T6	295	(3)	-196	72	72	71	67	57	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T4W)	A6061TD-T4W A6061TDS-T4W	165	—	-196	41	41	41	40	38	32	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T6W)	A6061TD-T6W A6061TDS-T6W																																														
	6063	T1	A6063TE-T1	120 (12mm≥thickness)	(3)	-196	30	30	30	29	29	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A6063TES-T1	110 (25mmmm≥thickness>12mm)			28	28	28	28	27	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T5	A6063TE-T5 A6063TES-T5	155 (12mm≥thickness)	(3)	-196	30	30	30	29	29	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A6063TE-T6 A6063TES-T6	205	(3)	-196	28	28	28	28	27	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T5W) (T6W)	A6063TE-T5W,-T6W A6063TES-T5W, -T6W	120	—	-196	38	38	37	35	31	24	15																																				
		T6	A6063TD-T6 A6063TDS-T6	225	(3)	-196	51	51	50	45	34	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T6W)	A6063TD-T6W A6063TDS-T6W	120	—	-196	30	30	30	29	27	21	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7003	T1	A7003TE-T5	285 (12mm≥thickness)	(2)(3)	-196	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A7003TES-T5	275 (25mmmm≥thickness>12mm)	(2)(3)		69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T5W)	A7003TE-T5W A7003TES-T5W	265	(3)	-196	66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7003	T5	A7003TE-T5	285 (12mm≥thickness)	(2)(3)	-196	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A7003TES-T5	275 (25mmmm≥thickness>12mm)	(2)(3)		69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T5W)	A7003TE-T5W A7003TES-T5W	265	(3)	-196	66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7N01	T4	A7N01TE-T4 A7N01TES-T4	315	(2)(3)	-196	79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A7N01TE-T6	325 (6mm≥thickness≥1.6)	(2)(3)	-196	81	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A7N01TES-T6	335 (12mmmm≥thickness>6mm)	(2)(3)	-196	84	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T4W) (T6W)	A7N01TE-T4W,-T6W A7N01TES-T4W, -T6W	285	—	-196	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aluminum and aluminum alloy welded pipes and tubes JIS H4090-1990	1050	O	A1050TW-O A1050TWS-O	60	—	-196	11	11	10	9	8	7	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14	A1050TW-H14 A1050TWS-H14	95	(1)	-196	20	20	19	18	15	11	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1100 1200	O	A1100TW-O A1100TWS-O A1200TW-O A1200TWS-O	75	—	-196	12	12	12	12	10	9	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14	A1100TW-H14 A1100TWS-H14 A1200TW-H14 A1200TWS-H14	120	(1)	-196	24	24	23	20	16	12	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3003 3203	O	A3003TW-O A3003TWS-O A3203TW-O A3203TWS-O	95	—	-196	20	20	20	17	14	11	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14	A3003TW-H14 A3003TWS-H14 A3203TW-H14 A3203TWS-H14	135	(1)	-196	29	29	29	28	25	20	14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H18	A3003TW-H14 A3003TWS-H14 A3203TW-H14 A3203TWS-H14	185	(1)	-196	40	40	39	36	31	21	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5052	O	A5052TW-O A5052TWS-O	175	—	-196	37	37	37	36	32	25	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		H14 H34	A5052TW-H14, -H34 A5052TWS-H14, -H34	235	(1)	-196	50	50	49	48	36	25	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aluminum and aluminum alloy extruded shape JIS H4100-1999	1100 1200	H112	A1100S-H112 A1100SS-H112 A1200S-H112 A1200SS-H112	75	—	-196	14	14	14	14	12	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2024	T4	A2024S-T4	390 (6mm≥thickness at test point)	(3)	-196	97	97	96	84	65	43	31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A2024SS-T4	410 (19mmmm≥thickness at test point>6mm)	(3)	-196	103	103	100	88	68	43	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				450 (38mmmm≥thickness at test point>19mm)	(3)	-196	112	112	109	95	73	49	35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				470 (thickness at test point>38mm 200cm2≥cross section area)	(3)	-196	117	117	114	100	77	51	37	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3003 3203	H112	A3003S-H112 A3003SS-H112 A3203S-H112 A3203SS-H112	95	—	-196	23	23	23	20	16	13	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5052	H112,O	A5052S-H112, -O A5052SS-H112, -O	175	—	-196	43	43	43	43	38	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Material Name & Standard Number	classification		Symbol	Minimum Tensile Strength (N/mm^2)	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																								
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Aluminum and aluminum alloy extruded shape JIS H4100-1999	5454	H112,O	A5454S-H112, -O A5454SS-H112, -O	215 (130mm≥thickness at test point 200cm2≥cross section area)	—	-196	54	54	53	49	37	29	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5083	H112,O	A5083S-H112, -O A5083SS-H112, -O	275 (130mm≥thickness at test point 200cm2≥cross section area)	(2)	-196	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5086	H112,O	A5086S-H112, -O A5083SS-H112, -O	240 (130mm≥thickness at test point 200cm2≥cross section area)	(2)	-196	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6061	T4	A6061S-T4 A6061SS-T4	175	(3)	-196	44	44	44	44	41	40	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A6061S-T6 A6061SS-T6	265	(3)	-196	66	66	65	62	54	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T4W) (T6W)	A6061S-T4W A6061SS-T4W A6061S-T6W A6061SS-T6W	165	(3)	-196	41	41	41	40	38	32	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6063	T1	A6063S-T1	120 (12mm≥thickness)	(3)	-196	30	30	30	29	29	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A6063SS-T1	110 (25mmmm≥thickness>12mm)			28	28	28	28	27	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T5	A6063S-T5	155 (12mm≥thickness)	(3)	-196	38	38	37	35	31	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A6063SS-T5	145 (25mmmm≥thickness>12mm)			36	36	35	33	29	24	15																																		
		T6	A6063S-T6 A6063SS-T6	205	(3)	-196	51	51	50	45	34	24	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T5W) (T6W)	A6063S-T5W,-T6W A6063SS-T5W, -T6W	120	—	-196	30	30	30	29	27	21	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7003	T5	A7003S-T5	285 (12mm≥thickness)	(2)(3)	-196	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A7003SS-T5	275 (25mmmm≥thickness>12mm)	(2)(3)		69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T5W)	A7003S-T5W A7003SS-T5W	265	(2)	-196	66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7N01	T4	A7N01S-T4 A7N01SS-T4	315	(2)(3)	-196	79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T5	A7N01S-T5 A7N01SS-T5	325	(2)(3)	-196	81	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A7N01S-T6 A7N01SS-T6	335	(2)(3)	-196	84	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T4W) (T5W) (T6W)	A7N01S-T4W, -T5W, -T6W A7N01SS-T4W, -T5W, -T6W	285	(2)	-196	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aluminum and aluminum alloy forgings JIS H4140-1988	1100 1200	H112	A1100FD-H112 A1200FD-H112	75 (100mm≥maximum thickness at heat treatment)	—	-196	16	16	16	15	12	10	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2014	T4	A2014FD-T4	380 (100mm≥maximum thickness at heat treatment)	(3)	-196	95	94	90	85	78	49	31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A2014FD-T4	440 (75mm≥maximum thickness at heat treatment)	(3)	-196	110	110	108	99	78	49	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				430 (100mm≥maximum thickness at heat treatment>75mm)	(3)	-196	108	108	107	99	78	49	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5052	O	A5052FH-O	175 (200mm≥maximum thickness at heat treatment)	—	-196	43	43	43	42	38	29	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5056	H112	A5056FD-H112	245 (100mm≥maximum thickness at heat treatment)	(2)	-196	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5083	H112,O	A5083FD-H112, -O	275 (100mm≥maximum thickness at heat treatment)	(2)	-196	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			A5083FH-H112, -O	275 (200mm≥maximum thickness at heat treatment)	(2)	-196	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6061	T6	A6061FD-T6	265 (100mm≥maximum thickness at heat treatment)	(3)	-196	66	66	65	62	54	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T6W)	A6061FD-T6W	165	—	-196	41	41	41	40	38	32	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		T6	A6061FH-T6	265 (255: in case specimen taken in the direction ST) (100mm≥maximum thickness at heat treatment)	(3)	-196	66	66	65	62	54	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				255 (245: in case specimen taken in the direction ST) (200mm≥maximum thickness at heat treatment>100mm)	(3)	-196	64	64	63	60	53	44	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T6W)	A6061FH-T6W	165	—	-196	41	41	41	40	38	32	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aluminum alloy castings JIS H5202-1999	class-4C	T6	AC4C-T6	220 (Die casting)	(3)	-196	46	43	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				200 (Shell casting or sand mold)	(3)	-196	41	41	41	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		(T6W)	A6061FH-T6W	125	—	-196	25	25	25	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-7A	F	AC7A-F	210 (Die casting)	(2)	-196	42	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				140 (Shell casting or sand mold)	(2)	-196	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aluminum alloy die castings JIS H5302-2000	class-1	—	ADC 1	—	—	-196	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-3	—	ADC 3	—	—	-196	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-5	—	ADC 5	—	—	-196	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-6	—	ADC 6	—	—	-196	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-10	—	ADC 10	—	—	-196	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-12	—	ADC 12	—	—	-196	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lead sheets and plates and hard lead sheets and plates JIS H4301-1993	—	—	PbP-1 PbP-2	—	—	-196	3	3	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-4	—	HPbP4	—	—	-196	9	7	5	4	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-6	—	HPbP6	—	—	-196	11	8	6	4	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Material Name & Standard Number	classification		Symbol	Minimum Tensile Strength (N/mm^2)	Remarks	Minimum Operation Temperature (^{0}C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																									
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Lead and lead alloy tubes for common industries JIS H4311-1993	class-1		PbT1	—	—	-196	3	3	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-2		PbT2	—	—	-196	3	3	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-4		HPbT4	—	—	-196	9	7	5	4	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-6		HPbT6	—	—	-196	11	8	6	4	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nickel and nickel alloy plate, sheet and strip JIS H4551-2000	NiCu30	A	NW4400	480	—	-196	120	116	112	109	106	104	102	102	101	101	101	101	101	101	101	98	79	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Ni99.0	A	NW2200	380	—	-196	69	69	69	69	69	69	69	69	69	69	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Ni99.0-LC	A	NW2201	345	—	-196	54	54	53	52	52	52	52	52	52	52	52	52	52	51	50	42	40	33	28	23	19	16	13	10	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiMo30Fe5	A	NW0001	790 (4mm≥thickness)	—	-196	199	199	199	199	198	196	193	188	183	180	178	176	174	172	170	169	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	199	199	199	199	199	199	199	199	199	199	199	199	199	199	199	198	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				690 (thickness>4mm)	—	-196	172	172	172	172	172	171	170	167	164	162	160	159	157	155	154	152	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	172	172	172	172	172	171	170	169	168	167	167	167	166	165	165	164	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiMo28	A	NW0665	750	—	-196	190	190	190	190	190	190	190	190	190	189	188	187	184	183	180	177	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	190	190	190	190	190	190	190	190	190	189	188	188	187	187	185	185	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiMo16Cr15Fe6W4	A	NW0276	690	—	-196	172	172	171	165	158	153	147	142	139	136	132	128	125	122	120	118	117	115	114	114	114	110	99	82	67	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	172	172	172	172	172	170	168	167	165	164	163	162	160	159	158	157	156	154	153	151	140	119	99	82	67	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiCr22Fe20Mo6Cu2Nb	A	NW6007	620 (4mm≥thickness)	—	-196	155	148	143	139	134	130	126	123	121	119	117	115	114	113	112	111	110	110	110	109	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	155	155	155	154	154	152	151	150	149	147	146	145	144	143	142	141	140	138	136	133	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				580 (thickness>4mm)	—	-196	138	137	134	124	114	111	108	106	104	102	100	99	98	96	96	95	95	94	94	93	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	138	138	138	138	138	138	138	138	138	137	135	133	132	131	130	128	128	127	126	126	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiCr21Fe18Mo9	A	NW6002	660 (4mm≥thickness)	—	-196	160	149	143	137	132	128	124	119	115	112	109	107	105	103	103	101	101	100	100	99	98	98	98	95	79	65	55	45	38	31	24		19	15	11	8	—	—	—	—	—	—	—
					(14)	-196	161	161	161	161	161	159	158	156	155	151	148	145	142	140	139	137	136	135	135	134	133	129	115	95	79	65	55	45	38	31	24		19	15	11	8	—	—	—	—	—	—	—
Nickel and nickel alloy seamless piped and tubes JIS H4552-2000	NiCu30	A	NW4400	480 (125mm≥outside diameter)	—	-196	120	116	112	109	106	104	102	102	101	101	101	101	101	101	101	98	79	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		SR	NW4400	590	—	-196	146	146	146	146	146	146	145	145	145	145	145	144	141	137	123	90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Ni99.0	A	NW2200	380 (125mm≥outside diameter)	—	-196	69	69	69	69	69	69	69	69	69	69	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		SR	NW2200	450	—	-196	112	112	112	112	112	112	112	112	112	112	112	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Ni99.0-LC	A	NW2201	345 (125mm≥outside diameter)	—	-196	55	54	53	52	52	52	52	52	52	52	52	52	52	51	50	42	40	33	28	23	19	16	13	10	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		SR	NW2201	410	—	-196	103	103	103	103	103	103	102	102	101	100	99	98	96	92	88	84	81	78	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiMo16Cr15Fe6W4	A	NW0276	690	—	-196	172	172	171	165	158	153	147	142	139	136	132	128	125	122	120	118	117	115	114	114	114	110	99	82	67	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	172	172	172	172	172	170	168	167	165	164	163	162	160	159	158	157	156	154	153	151	140	119	99	82	67	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiCr21Fe18Mo9	A	NW6002	690	—	-196	160	149	143	137	132	128	124	119	115	112	109	107	105	103	103	101	101	100	100	99	98	98	98	95	79	65	55	45	38	31	24		19	15	11	8	—	—	—	—	—	—	—
					(14)	-196	161	161	161	161	161	159	158	156	155	151	148	145	142	140	139	137	136	135	135	134	133	129	115	95	79	65	55	45	38	31	24		19	15	11	8	—	—	—	—	—	—	—
Nickel and nickel alloy bars JIS H4553-1999	Ni99.0	A	NW2200	380	—	-196	69	69	69	69	69	69	69	69	69	69	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Ni99.0-LC	A	NW2201	340	—	-196	46	45	44	44	43	43	43	43	43	43	43	43	43	43	41	41	40	33	28	23	19	16	13	10	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiCu30	A	NW4400	480	—	-196	114	105	100	96	94	92	91	91	90	90	90	90	90	90	90	88	78	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiMo30Fe5	S	NW0001	790 (40mm≥outside diameter≥6mm)	—	-196	198	197	195	191	187	183	178	174	171	168	165	162	160	158	157	155	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	199	199	199	199	199	199	199	199	199	199	199	199	199	199	199	198	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				690 (90mm≥outside diameter>40mm)	—	-196	172	172	172	172	172	171	170	169	168	166	165	162	160	158	157	155	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	172	172	172	172	172	171	170	169	168	167	167	167	166	165	165	164	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiMo28	S	NW0665	760 (90mm≥outside diameter≥6mm)	—	-196	190	190	190	190	190	190	190	190	190	189	188	187	184	183	180	177	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	190	190	190	190	190	190	190	190	190	189	188	188	187	187	185	185	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiMo16Cr15Fe6W4	S	NW0276	690 (90mm≥outside diameter≥6mm)	—	-196	172	172	171	165	158	153	147	142	139	136	132	128	125	122	120	118	117	115	114	114	114	110	99	82	67	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	172	172	172	172	172	170	168	167	165	164	163	162	160	159	158	157	156	154	153	151	140	119	99	82	67	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiCr22Fe20Mo6Cu2Nb	A	NW6007	625 (20mm≥outside diameter≥6mm)	—	-196	155	148	143	139	134	130	126	123	121	119	117	115	114	113	112	111	110	110	110	109	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	155	155	155	154	154	152	151	150	149	147	146	145	144	143	142	141	140	138	136	133	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				590 (90mm≥outside diameter>20mm)	—	-196	138	137	134	124	114	111	108	106	104	102	100	99	98	96	96	95	95	94	94	93	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
					(14)	-196	138	138	138	138	138	138	138	138	138	137	135	133	132	131	130	128	128	127	126	126	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NiCr21Fe18Mo9	S	NW6002	660 (90mm≥outside diameter)	—	-196	160	149	143	137	132	128	124	119	115	112	109	107	105	103	103	101	101	100	100	98	98	98	98	95	79	65	55	45	38	31	24		19	15	11	8	—	—	—	—	—	—	—
					(14)	-196	161	161	161	161	161	159	158	156	155	151	148	145	142	140	139	137	136	135	135	134	133	129	115	95	79	65	55	45	38	31	24		19	15	11	8	—	—	—	—	—	—	—
Titanium and titanium alloy sheets, plates and strips JIS H4600-2001	class-1	—	TP270H TR270H TP270C TP270C	270 (15mm≥thickness≥0.2mm)	—	-196	68	55	50	45	40	37	33	31	28	27	25	24	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-2	—	TP340H TR340H TP340C TP340C	340 (15mm≥thickness≥0.2mm)	—	-196	85	80	74	68	62	58	54	51	47	44	41	30	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-3	—	TP480H TR480H TP480C TP480C	480 (15mm≥thickness≥0.2mm)	—	-196	120	118	111	104	98	92	87	83	79	77	76	46	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-12	—	TP340PdH TR340PdH TP340PdC TP340PdC	340 (15mm≥thickness≥0.2mm)	—	-196	85	80	74	68	62	58	54	51	47	44	41	30	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-13	—	TP480PdH TR480PdH TP480PdC TP480PdC	480 (15mm≥thickness≥0.2mm)	—	-196	120	118	111	104	98	92	87	83	79	77	76	46	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Titanium and titanium alloy seamless pipes JIS H4630-2001	class-1	—	TP270H TP270C	270 (80mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(11)	-196	68	55	50	45	40	37	33	31	28	27	25	24	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-2	—	TP340H TP340C	340 (80mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(11)	-196	85	80	74	68	62	58	54	51	47	44	41	30	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-3	—	TP480H TP480C	480 (80mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(11)	-196	120	118	111	104	98	92	87	83	79	77	76	46	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-12	—	TP340PdH TP340PdC	340 (80mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(11)	-196	85	80	74	68	62	57	54	51	47	44	41	30	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-13	—	TP480PdH TP480PdC	480 (80mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(11)	-196	120	118	111	104	98	92	87	83	79	77	76	46	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Material Name & Standard Number	classification		Symbol	Minimum Tensile Strength (N/mm^2)	Remarks	Minimum Operation Temperature (^0C)	Allowable Tensile Stress at each Temperature (N/mm^2)																																									
							~40	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	815	825	850	875	900	925	950	975	980	985	1000	1010
Titanium and titanium alloy tubes for heat exchangers JIS H4631-2001	class-1	—	TTH270C	270 (60mm≥outside diameter≥10mm) 5mm≥thickness≥1mm)	(11)	-196	64	55	50	45	40	37	33	31	28	27	25	24	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			TTH270W TTH270WC	270 (60mm≥outside diameter≥10mm) 3mm≥thickness≥0.3mm)	(12)	-196	54	47	42	38	34	31	28	26	25	24	22	21	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-2	—	TTH340C	340 (60mm≥outside diameter≥10mm) 5mm≥thickness≥1mm)	(11)	-196	85	80	74	68	62	58	54	51	47	44	41	30	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	TTH340W TTH340WC	340 (60mm≥outside diameter≥10mm) 3mm≥thickness≥0.3mm)	(12)	-196	72	69	63	58	53	49	46	43	40	37	35	25	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-3	—	TTH480C	480 (60mm≥outside diameter≥10mm) 5mm≥thickness≥1mm)	(11)	-196	120	118	111	104	98	92	87	83	79	77	76	46	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	TTH480W TTH480WC	480 (60mm≥outside diameter≥10mm) 3mm≥thickness≥0.3mm)	(12)	-196	102	100	94	88	83	78	75	71	68	66	64	39	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-12	—	TTH340PdC	340 (60mm≥outside diameter≥10mm) 5mm≥thickness≥1mm)	(11)	-196	85	80	74	68	62	58	54	51	47	44	41	30	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	TTH340PdW TTH340PdWC	340 (60mm≥outside diameter≥10mm) 3mm≥thickness≥0.3mm)	(12)	-196	72	69	63	58	53	49	46	43	40	37	35	26	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-13	—	TTH480PdC	480 (60mm≥outside diameter≥10mm) 5mm≥thickness≥1mm)	(11)	-196	120	118	111	104	98	92	87	83	79	77	76	46	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	TTH480PdW TTH480PdWC	480 (60mm≥outside diameter≥10mm) 3mm≥thickness≥0.3mm)	(12)	-196	102	100	94	88	83	78	75	71	68	66	64	39	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Titanium and titanium alloy welded pipes JIS H4635-2001	class-1	—	TTP270W TTP270WC	270 (50mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(12)	-196	58	47	42	38	34	31	28	26	25	24	22	21	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-2	—	TTP340W TTP340WC	340 (50mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(12)	-196	72	69	63	58	53	49	46	43	40	37	35	25	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-3	—	TTP480W TTP480WC	480 (50mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(12)	-196	102	100	94	88	83	78	75	71	68	66	64	39	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-12	—	TTP340PdW TTP340PdWC	340 (50mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(12)	-196	72	69	63	58	53	49	46	43	40	37	35	26	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-13	—	TTP480PdW TTP480PdWC	480 (50mm≥outside diameter≥10mm) 10mm≥thickness≥1mm)	(12)	-196	102	100	94	88	83	78	75	71	68	66	64	39	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Titanium and titanium alloys rods and bars JIS H4650-2001	class-1	—	TB270H TB270C	270 (100mm≥outside diameter≥8mm)	—	-196	64	55	50	45	40	37	33	31	28	27	25	24	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-2	—	TB340H TB340C	340 (100mm≥outside diameter≥8mm)	—	-196	85	80	74	68	62	58	54	51	47	44	41	30	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-3	—	TB480H TB480C	480 (100mm≥outside diameter≥8mm)	—	-196	120	118	111	104	98	92	87	83	79	77	76	46	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-12	—	TB340PdH TB340PdC	340 (100mm≥outside diameter≥8mm)	—	-196	85	80	74	68	62	58	54	51	47	44	41	30	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	class-13	—	TB480PdH TB480PdC	480 (100mm≥outside diameter≥8mm)	—	-196	120	118	111	104	98	92	87	83	79	77	76	46	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Appendix-3. Allowable stress of main material used for support and foundation of storage tank and gasholder

Type of material	Symbol	Allowable stress (N/mm^2)								
		Tensile	Compression	Bend	Shear	Lateral pressure	Buckling		Adhesion	
							λ ≤ A	A < λ	Top reinforcement	Other
Rolled steels for general structures: JIS G3101-2010	SS400	157	157	157	88	294	—	—	—	—
	SS490: 4mm ≤ t< 40mm	186	186	186	108	343	$f_c\left\{\frac{1-0.4(\lambda/\Lambda)^2}{1+4/9(\lambda/\Lambda)^2}\right\}$	$f_c\frac{0.46}{\left(\frac{\lambda}{\Lambda}\right)^2}$		
	SS490: 40mm ≤ t	167	167	167	98	323				
Rolled steels for welded structures: JIS G3106-2008		157	157	157	88	294	—	—	—	—
	SM490: 4mm ≤ t< 40mm	216	216	216	127	412	$f_c\left\{\frac{1-0.4(\lambda/\Lambda)^2}{1+4/9(\lambda/\Lambda)^2}\right\}$	$f_c\frac{0.46}{\left(\frac{\lambda}{\Lambda}\right)^2}$		
	SM490: 40mm ≤ t	196	196	196	118	372				
Carbon steel casting: JIS G5101-2011	SC480	157	157	157	88	294	—	—	—	—
Gray cast iron products: JIS G5501-2010	FC100 FC150 FC200 FC250 FC300 EC350	—	98	—	—	—	—	—	—	—
Steel bars for rivets: JIS G3104-2009	SV400	157	—	—	118	—	—	—	—	—
Hexagon head bolts and hexagon head screws: JIS B1180-2008	SS400 SM400	118	—	—	88	—	—	—	—	—
Sets of high strength hexgon bolt, hexagon nut and plain washers for friction grip joints JIS B1186-2007	F8T	245	—	—	118	—	—	—	—	—
	F10T	304	—	—	147					
	F11	323	—	—	157					
Welded part — Butt	SS400 SM400	137	137	137	78	—	—	—	—	—
	SM490	196	196	196	118	—				
Welded part — Fillet	SS400 SM400	78	78	78	78	—	—	—	—	—
	SM490	118	118	118	118	—				
Reinforced concrete — Steel bar for concrete reinforcement: JIS G3112-1987	SS400 SR235: 4mm ≤ t< 40mm	157	—	—	—	—	—	—	*either smaller $4F_c/100$ or 0.88*	*either smaller $6F_c/100$ or 1.32*
	SS490 SR295: 40mm ≤ t	157	—	—	—	—				
	SD295	196	—	—	—	—	—	—	*either smaller Fc/15 or $(0.88+2F_c/7.5)$*	*either smaller Fc/10 or $(1.32+F_c/2.5)$*
	SD345: less than 28mm diameter	216	—	—	—	—				
	SD345: 28mm diameter and more	196	—	—	—	—				
Reinforced concrete — Concrete	—	—	*either Fc/50 or (0.49+Fc/100)*	—	—	—	—	—	—	—

Remarks:

1. f_c must be the allowable compressive stress of steel (as units of N/mm2)

2. λ is the effective slenderness ratio and is the value which calculated according to the following equation, however, the slenderness ratio of compression menber must be 250 or less and 200 or less in the piller material.

$$\lambda = \frac{lk}{i}$$

ℓk is the length of steal beam when the state of support it is both end pin type, 0.7 times the length of the steel when one side pin and the other is fixed, 0.5 times the length of steel when both ends are fixed, 2 times the length of the steel when one snd is free and the other is fixed (as units mm).

i must be the secondary cross-sectional radius (as units of mm)

3. Λ is the critical slenderness ratio which is calculated by following formula.

$$\Lambda = \frac{1500}{\sqrt{fc}}$$

4. Fc is the compressive strength of 4 weeks (as units of N/mm2).

5. The value in parenthness will be applied when using for shear reinforcement.

Appendix-4: Longitude joint efficiency of piping belonging to liquefied gas facility

Type of joint	When full length is tested by radiographic test and confirmed no defects	When 20% of full length is tested by radiographic test and confirmed no defects	Other cases
Butt welding on both sides or butt welding on one side equivalent to this (limited to those which the backing strip were removed, in case of using a backing strip)	1	0.95	0.7
One side butt welding using a backlng strip without removinh	0.90	0.85	0.65
One side butt welding other than above	—	—	0.60
Full fillet lap welding on both sides	—	—	0.55
Full fillet lap welding on one side	—	—	0.50
Full filet welding on one side	—	—	0.45

Chapter-8. Recommended Materials for Thermal Power Facility

The following remarks show the materials standard for thermal power facility and the limitation of application of each material. However, it is difficult to describe all limitation condition under all operation circumstances, because the operation condition is over the range of circumstances. It is recommended to refer and apply materials in the Appendix in this guideline under the responsibility of the user with consideration to the operation condition.

1. The notes (1) to (64) and (K1) to (K8) stipulated in “Allowable Tensile Stress of Ferrous Material at each Temperature Part-1.” are due as listed below. Remarks (1) to (64) and (63) to (64) are respectively same as the content of the remarks of table 2.1.1 and table 2.1.2 stipulated in JIS B8265-2000 “construction of pressure vessel – General”.

   (1) The material which is served in the long time at temperature more than 450°C shall be noted graphitization.
   (2) The material which is served in the long time at temperature more than 475°C shall be noted graphitization.
   (3) This shall be applied to when the tensile strength by joint tensile test according to JIS B8285 is above 655 N/mm^2 and below 690 N/mm^2
   (4) This shall be applied to the case without welding or when the tensile strength by joint tensile test according to JIS B8285 is above 690 N/mm^2.
   (5) This may apply up to 200°C for compressed air, steam and water, up to 350°C for the fluid of pressure below 0.2MPa when applying to exceed 100°C.
   (6) The value of allowable tensile stress shall be produced by submerged arc butt welding in the inside and outside welded joint and its welded joint efficiency is a value obtained by multiplying 0.7.
   (7) The value above 550°C in this column shall be applied to the material of its carbon content above 0.04%.
   (8) The value more than 525°C in this column shall be applied to the material which carried out solution treatment to rapid cool down from above 1040°C.
   (9) The value in this column may be applied to the case when some deformation is tolerable.
   (10) The greater value more than 350°C shall be applied to the material which is produced by automatic arc welding without using filler metal and is carried out best solution treatment to obtain complete corrosion resistance.
   (11) This kind of steel shall not be used unless sufficient reason above 425°C, because of the greater brittle at room temperature after using more than 425°C.
   (12) When applying this value, the specified minimum tensile strength shall be confirmed according to JIS G0303. However, the upper value excluding S10C in JIS G4501 shall be applied to those which the diameter, the width across flats and thickness of main part is 100mm or less, and the lower value shall be applied to those which the diameter, the width across flats and thickness of main part is more than 100mm and 200mm or less.
   (13) The value in this column shall be applied to the material of strength crass-1.
   (14) The value in this column shall be applied to the material of strength crass-2.

(15) The value in this column shall be applied to the material which is carried out solution treatment.

(16) The value in this column shall be applied to the material which is carried out H1 aging treatment after solution treatment.

(17) The value in this column shall be applied to the material which is carried out H2 aging treatment after solution treatment.

(18) The value in this column shall be applied to the piping of its outside diameter 127mm or less which is annealed after hot finish.

(19) The value in this column shall be applied to the piping of its outside diameter more than 127mm which is annealed after hot finish.

(20) The value in this column shall be applied to the piping of its outside diameter 127mm or less which is annealed after cold finish.

(21) The value in this column shall be applied to the piping of its outside diameter more than 127mm which is annealed after cold finish.

(22) The value in this column shall be applied to the piping which is annealed after cold finish.

(23) The value in this column shall be applied to the piping which is carried out solution treatment after hot finish or cold finish.

(24) The value in this column shall be applied to those which carbon content is 0.35% or less.

(25) The value in this column shall be applied to forgings which have above 130mm diameter or thickness.

(26) The value in this column shall be determined by the coefficient standard casting set allowable tensile stress value is multiplied by 0.67.

(27) When applying the value in this column, the chemical composition shall be satisfied in the following table.

Symbol of Type	chemical composition (%)				
	C	Mn	P	S	Si
SC360 SC410	0.25% or less	0.70% or less	0.04% or less	0.04% or less	0.60% or less
SC450 SC480	0.35% or less	0.70% or less	0.04% or less	0.04% or less	0.60% or less

Remarks-1. The Mn content may be increased 0.04 more than maximum value stipulated in above table according to the 0.01% reduction of C content from maximum value stipulated in the above table. However, The Mn content shall not exceed 1.10%. Moreover, each content of Ni, Cr, Cu as an impurity shall be 0.5% or less, and sum of them shall be limited to 1.0% or less.

(28) The value in this column shall be determined by the coefficient standard casting set allowable tensile stress value is multiplied by 0.8. When tested on the following table, the quality factor of castings can be selected 1.0 or 0.9.

examination	quality factor of castings
according to Remarks-2. of (28)	0.9
according to Remarks-4. of (28)	0.9
according to Remarks-1. and 3. of (28)	0.9
according to Remarks-2. and 4. of (28)	1.0

Remarks-1. The sampling products shall be examined according to the remarks5. of note (28) by JIS G0581: Radiographic test and they shall pass at least 3 level or higher for the each kind of defects stipulated in that standard.

Remarks-2. The all products (including one case) shall be examined according to the remarks5. of note (28) by JIS G0581: Radiographic test and they shall pass at least 3 level or higher for the each kind of defects stipulated in that standard.

Remarks-3. The sampling products shall be examined according to the remarks5. of note (28) by magnaflax test or penetrant test, and shall pass.

Remarks-4. The all products shall be examined by magnaflax test or penetrant test, and shall pass.

Remarks-5. The sampling test shall be executed to at least three pieces of first five produced by new design wooden block, a sample of later 5 or fraction products shall be examined to the part where the defect is easy to appear.

(29) The value more than 425°C in this column shall be applied to the material of its carbon content above 0.04%.

(30) The value in this column shall be multiplied welding joint efficiency 0.7 stipulated in the table 6.2 “welding joint efficiency according to the type of joint (B-1)” of JIS B8265. When the product is produced according to the same type joint and examined by radiographic test, the value shall be multiplied allowable tensile stress of same JIS G4304 with appropriate welding joint factor.

(31) The piping produced by E-method shall be examined by ultrasonic test according to JIS G0582. In this case, the classification of sensitivity shall be “UC”.

(32) The value in this column shall be applied to the annealed material.

(33) This value in this column shall be applied to the annealed material after hot finish.

(34) If cleave performance is required in this column, a nickel content as impurities shall be 0.5% or less.

(35) ～(41) These shall be missing number in this table.

(42) 550°C shall be red to 538°C.

(43) This value of allowable tensile stress is based on the yield point or proof stress. The all welding parts shall be examined according to the radiographic test and magnaflux test stipulated in JIS B8265-2003 “construction of pressure vessel – General”.

(44) This shall be applied to the thickness 50mm or less.

(45) This shall be normalized at temperature above 840°C and 890°C or below.

(46) The allowable stress between 750°C and 1010°C shall not be applied to except the reforming tube, the end plate of reforming tube, the tube plate of cover plate and flat plate of reforming tube.

(47)～(50) These shall be missing number in this table.

(51) This shall be applied to steel bar.

(52) This shall be applied to steel strip.

(53) This shall be applied to steel plate.

(54) These shall be missing number in this table.

(55) The allowable tensile stress in this column shall be applied to the piping which is produced by automatic submerged arc butt welding in the inside and outside except in wall thickness less than 6mm and passed the ultrasonic examination.

(56) This shall not be applied to those as listed below.

1) The piping for steam that pressure is 1MPa or less.
2) The feed-water piping listed as below.

1. The feed-water piping which is from boiler to check valve and maximum operation temperature is 0.7MPa or less.
2. The feed-water piping which is other than stipulated in a) and maximum operation temperature is 1MPa or less.

1) The blow-down piping listed as below.

a) The blow-down piping which is from boiler to blow-down valve (if there are more than two, it shall be a farthest one) and maximum operation temperature is 0.7MPa or less.
b) The blow-down piping which is other than stipulated in a) and maximum operation temperature is 1MPa or less.

2) The piping for air, gas and oil that maximum pressure is 1MPa or less.

(57) This shall not be applied to the piping which the liquefied gas passing through or the maximum operation pressure is not less than 1.0MPa.

(58) The value in upper column shall be applied to electric resistant welded piping which is annealed and passed the examination by JIS G0582-2004 “method of ultrasonic test of steel piping”, and served for the water tube of boiler casing or inside of brick wall, super-heater tube, re-heater tube or economizer tube.

(59) The value in this column shall be applied to the material which is carried out H1150 precipitation hardening after solution heat treatment.

(60) This type of steel decrease in toughness at room temperature after heating in about 500h at 320^{o}C and heating in a short time at 340^{o}C.

(61) This type of steel will be greater brittle after using intermediate temperature. This type of steel decrease ductility significantly due to the generation of ά-phase after a relatively short time heating between 590^{o}C and 930^{o}C.

(62) The value in this column shall be applied to the material which is carried out solution heat treatment.

(63) The value in the upper column is the allowable tensile stress value which is relative to the minimum tensile strength.

(64) The value in the lower column is the allowable tensile stress value which is relative to the o.5% of proof stress. It shall be applied to those which are passed ultrasonic test and radiographic test of

general longitudinal joint (all welding lines).

(K1) This type of steel may be reduced the toughness at temperature not less than 400°C depending on the chemical composition, etc.

(K2) The value more than 700°C in this column shall be applied to the material contained titanium not less than 0.02%.

(K3) The allowable stress in this table is with respect to 0.2% proof stress.

(K4) The value in this column shall be applied to thickness 76mm or less.

(K5) The value in this column shall be applied to thickness more than 76mm.

(K6) This kind of steel is not stipulated in JIS B8265-2003.

(K7) When this casting steel is applied to pipe fittings, etc. and the one which is met to following condition is butt-welded, the quality factor of the cylinder edge can be treated 1.0.

1) Inner and outer surface of the welding edge shall be finished by machine and free from defects.
2) Groove surface of the welding edge shall be free from defects.

(K8) The criterion of magnaflax test and penetrant test shall be as follows, when the quality factor is 0.9 or 1.0.

method of examination	criterion
Magnaflux test stipulated in the Appendix-27 and penetrant test stipulated in the Appendix-28 of "Article 127, Part-10: Welding" of interpretation for Japanese Electric Technical Regulation.	Magnaflux test stipulated in the Appendix-27 and penetrant test stipulated in the Appendix-28 of "Article 127, Part-10: Welding" of interpretation for Japanese Electric Technical Regulation.

2. In this table, the value of allowable tensile stress at each temperature shall be calculated by linear interpolation. And in case of the lowest temperature is less than 40 °C, the value of allowable tensile stress between lowest temperature and 40 °C shall be the value stipulated in the column of "~ 40 °C".

3. The symbol S, E, B, A and W in the column "production method" show the S; seamless piping, E; electric resistance welding piping, B; butt-welded piping, A; submerge arc welding piping and automatic arc welding or electric resistance welding piping. The $\sigma a \eta$ which is used for calculation of inner pressure shall be applied selected from this table, because the welded joint efficiency is contained in allowable tensile.
4. The rimmed steel shall not be used in a temperature more than 350 °C.

5. The "rolled steels for general structure" stipulated in JIS G3101-2010 shall not be used for other than the pressure part of air, gas , oil and water with its temperature less than 100 °C. However, when SS330 and SS400 stipulated in JIS G3101-2010 are applied the pressure part where maximum operation pressure is less 1MPa or below (excluding boiler, independent super-heater, independent economizer and steam accumulator, and which have longitude welding joint) instead of the "carbon steel and molybdenum alloy steel plates for boilers and pressure vessels" stipulated in JIS G3103-2007, this is not applied to. In this case, when the allowable tensile strength is more than 96N/mm^2, it shall be red 96N/mm^2.

6. The “Rolled steels for welded structure” stipulated in JIS G3101-2010 and the SM400A, SM490A and AM490YA stipulated in JIS G3106-2008; “Rolled steels for welded structure” and SMA400AW, SMA400AP, SMA stipulated in JIS G3114-2008; “Hot-rolled atmospheric corrosion resisting steels for welded structure” and the JIS G3457-2005; “Arc welded carbon piping” shall not be applied to the body, pane and other similar part where the design pressure is exceeding 3MPa.

    1. The body, pane and other similar part where the design pressure is more than 1.6MPa.
    2. The body, pane and part of pressure vessel where the pressure is more than 1MPa, and which has welding joint on the pane.
    3. The body, pane and other similar part where the thickness of welding base metal is more 16mm.
    4. One is intended to reserve lethal substances, toxic materials or liquefied gas which design pressure is more than 0.2MPa

7. The “rolled steels for welded structure” stipulated in JIS G3106-2008 (excluding SM400A, SM490A and SM490YA) and “Hot-rolled atmospheric corrosion resisting steels for welded structure” (excluding SMA400AW, SMA400AP, SMA490AW and SMA490AP) shall not be applied to the body, pane and other similar part where the design pressure is more than 3MPa.

8. The “carbon steel pipes for ordinary piping” stipulated in JIG G3452-2010 shall not be applied to the part of pressure vessel listed below.

    1) The design pressure of it is more than 1MPa.
    2) The design temperature of it is less than 0 ^{o}C or more than 100 ^{o}C. However, it can be used for compressed air, steam and water up to 200 ^{o}C and fluid up to 350 ^{o}C with design pressure less than 0.2MPa.
    3) One is intended to reserve lethal substances, toxic materials or liquefied gas which design pressure is more than 0.2MPa.

9. The “Arc welded carbon steel pipes” stipulated in JIG G3457-1988 shall not be applied to the piping which the maximum operation pressure is more than 1.6MPa.

10. The “Rolled steels for general structure” stipulated in JIS G3101-2010 shall not be used for other than the pressure part of air, gas , oil and water with its temperature less than 100 ^{o}C. However, when SS330 and SS400 stipulated in JIS G3101-2010 are applied the pressure part where maximum operation pressure is 1MPa or below (excluding boiler, independent super-heater, independent economizer and steam accumulator, and which have longitude welding joint) instead of the “Carbon steel and molybdenum alloy steel plates for boilers and pressure vessels” stipulated in JIS G3103-2007, this is not applied to. In this case, when the allowable tensile strength is more than 96N/mm^2, it shall be red 96N/mm^2.

11. The “Carbon steel boiler and heat exchanger tubes” STB340 and STB410 stipulated in JIS G3461-2005 shall contain 0.1~0.35% Si when applying the part temperature more than 350 ^{o}C.

12. The “Carbon steels for machine structure use” stipulated in JIS G4051-2009, limited to S10C to S35C, shall be normalized at the temperature range shown in right each columns depending on the kind of steel in the left column.

kind of steel	
S10C	900^0C to 950^0C
S12C and S15C	880^0C to 930^0C
S17C and S20C	870^0C to 920^0C
S22C and S25C	860^0C to 910^0C
S28C and S30C	850^0C to 900^0C
S33C and S35C	840^0C to 890^0C

13. When applying it to liquefied facility or gasification furnace facility under the operation temperature -30^{o}C or below, the stainless steel other than austenitic stainless steel which carbon content is less than 0.10% shall pass pursuant to the following impact test.

1) The number of specimen, sampling location, and testing method shall conform to the part of specimen, sampling location and testing method of JIS G3126-2009 “Carbon steel plates for pressure vessels for low-temperature service” when the kind of material is rolled steel, JIS G3460-1988 “Steel pipes for low-temperature service” when the kind of material is tubes, JIS G3205-2006 “Carbon and alloy steel forgings for pressure vessels for low-temperature service” when the kind of material is for forgings, JIS G5152-1991 “Steel castings for low temperature and high pressure service” when the kind of material is casting.
2) The shape and dimensions of the specimens shall be No4. specimen stipulated in JIS Z2202-1998 “Metals impact specimen.
3) The absorbed energy shall be in the range of stipulated in the right-hand column of following table depending on the classification of specimen stipulated in left-hand column when executing impact test at the temperature below minimum operation temperature.

dimension of test piece (mm)	absorbed energy (J)	
	mean value of a pair and two each values of a pair	value of an individual
10×10	not less than 21	not less than 14
10×7.5	not less than 17	not less than 12
10×5	not less than 14	not less than 10
10×2.5	not less than 7	not less than 5

4) If it is not succeeded to 3), the test result shall conform to all above provisions by providing the number of sets of specimens twice as many specimen pairs as prescribed in 1).

14. The molybdenum alloy plates for pressure vessel of power generation shall conform to the following

standard. (®SB 520M)

1) The surface shall be finished in good and free from harmful defects to use.
2) The percentages of chemical composition shall be in the range of value listed in the table below.

symbol	chemical composition (%)					
	C	Si	Mn	P	S	Mo
®SB520M	0.23 or less : 25mm or less in thickness 0.26 or less : more than 25mm and less than 50mm in thickness 0.28 or less : more than 50mm in thickness	0.15 to 0.30	0.90 or less	0.035 or less	0.040 or less	0.45 to 0.60

3) The steel plate 38mm thick or below shall be kept rolled situation. However, it is capable to be baking or stress-relief annealing, if required.
4) The steel plate with above 38mm thick shall be normalized.
5) The tensile strength, yield point, growth and bending shall be in the range of each value listed in the table below. However, the crack shall not occur on the outer surface of bended piece when bend 180 decree.

symbol	tensile test				bending test
	tensile strength (N/mm^2)	yield point (N/mm^2)	growth (%)		inside radius
			specimen No.1A	specimen No.10	
®SB520M	not less than 520	not less than 295	not less than 16	not less than 20	25mm or less in thickness : 1.00times of thickness not less than 50mm and more than 25mm in thickness : 1.25 times of thickness more than 50mm in thickness: 1.50 times of thickness

6) The analysis test, mechanical test, inspection and indication shall conform to the stipulation "9.1: Analysis test" " 9.2: Mechanical test" " 10: Inspection" " 12: Indication" of JIS G3103-2007 "Carbon steel plates and molybdenum steel plates for boilers and pressure vessels".

15. The carbon plates for low-temperature pressure vessel of power generation shall conform to the following standard. (®SLA 325 B)

1) It shall be produced from aluminum fine processing killed steel and be above 32mm thick.
2) These forgings shall be tempered after quenching.
3) The chemical composition and mechanical nature shall conform to a part of SLA325A stipulating "4: Chemical composition", "6: Mechanical nature" of JIS G3126-2009 "Carbon steel plates for pressure vessels for low temperature service". However, the temperature for impact test shall be -60°C or below.
4) The numbers of specimens for tensile testing, bend testing and impact testing, the position of the collection, specimen shapes, dimensions and test method shall conform to the provision "10.2: Mechanical test" of JIS G3126-2009 "Carbon steel plates for pressure vessel temperature".
5) The inspection and re-inspection shall conform to "11: Inspection" and "11.2: Re-inspection" off JIS G3126-2009 "Carbon steel plates for pressure vessels for low temperature service".

16. The alloy steel forgings for power generation shall conform to the following standard.

1) It shall be produced forgings and rolling.
2) The percentages of chemical composition shall be in the range of value listed in the right column in table below depending on the kind of forgings in the left column.

symbol	chemical composition (%)													
	C	Si	Mn	P	S	Ni	Cr	Mo	V	Nb	Al(*)	N	W	B
®SFVAF22AJ1	0.04 to 0.10	0.50 or less	0.10 to 0.60	0.030 or less	0.010 or less	–	1.90 to 2.60	0.05 to 0.30	0.20 to 0.30	0.02 to 0.08	0.030 or less	0.030 or less	1.45 to 1.75	0.0005 to 0.006
®SFVAF27	0.08 or less	0.50 or less	0.30 to 0.70	0.030 or less	0.030 or less	–	8.00 to 10.00	1.80 to 2.20	–	–	–	–	–	–
®SFVAF28	0.08 to 0.12	0.20 to 0.50	0.30 to 0.60	0.020 or less	0.010 or less	0.40 or less	8.00 to 9.50	0.85 to 1.05	0.18 to 0.25	0.06 to 0.10	0.04 or less	0.030 to 0.070	–	–
®SFVAF29	0.07 to 0.13	0.50 or less	0.30 to 0.60	0.020 or less	0.010 or less	0.40 or less	8.50 to 9.50	0.30 to 0.60	0.15 to 0.25	0.04 to 0.09	0.04 or less	0.030 to 0.070	1.50 to 2.00	0.001 to 0.006
(*) : soluile to acid														

3) Forgings shall be executed following heat treatment. The tensile strength, yield point, proof stress, growth and reduction area shall be in the range of value listed in the right column in the table below depending on the kind of steel forgings in the left column.

symbol	heat treatment	tensile test			
		tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%) specimen No.14	reduction of area (%)
®SFVAF22AJ1	tempering after normalizing	not less than 510	not less than 400	not less than 20	not less than 40
®SFVAF27	tempering in not less than 700^0C after normalizing in not less than 900^0C	not less than 510	not less than 295	not less than 18	not less than 40
®SFVAF28	tempering in not less than 730^0C after normalizing in not less than 1040^0C	not less than 590	not less than 410	not less than 20	not less than 40
®SFVAF29	tempering in not less than 730^0C after normalizing in not less than 1040^0C	not less than 629	not less than 440	not less than 20	not less than 40

Remarks 1. It is capable to cool down ®SFVAF22AJ1, SFVAF28, ®SFVAF29 rapidly after normalization by liquid cooling (including splay cooling).

4) The analysis test, mechanical test, inspection and indication shall conform to a part of "9.2: Analysis test", "9.3: Mechanical test", "11: Inspection", "12: Indication" of JIS G3203-2008 "Alloy steel forgings for pressure vessels for high-temperature service". However, JIS G1216-1997 "Iron and steel-Method for determination of nickel content", JIS G1220-1994 "Iron and steel-Method for determination of tungsten contest", JIS G1221-1998 "Iron and steel-Method for determination of vanadium contents", JIS G1224-2001 "Iron and steel-Method for determination of aluminum contents", JIS G1227-1999 "Iron and steel-Method for determination of boron contest", JIS G1228-2006 "Iron and steel-Method for determination of nitrogen contents" and JIS G1237-1997

“Iron and steel-Method for determination of niobium contents” shall conform to analysis test simultaneously in analysis test.

17. The nickel steel forgings for low-temperature pressure vessel of power generation shall conform to the following standard. (®SFL 9N 690)

1) It shall be forged from a killed steel block produced with pure oxygen furnace or electric furnace.
2) The chemical composition shall be in the range of value listed in the table below. In this case, the analysis of chemical composition shall be made of melted steel analysis.

symbol	chemical composition (%)					
	C	Si	Mn	P	S	Ni
®SFL9N690	0.13 or less	0.30 or less	0.90 or less	0.04 or less	0.04 or less	8.50 to 9.50

3) It shall be tempered after normalizing not less than 2 times, or be tempered after quenching
4) The tensile strength, yield point, proof stress, growth and reduction of area shall be in the range of each value listed in the following table.

symbol	tensile test			
	tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%)	reduction of area (%)
®SFL9N690	not less than 690	not less than 520	not less than 19	not less than 45

3) The absorbed energy shall be in the range of stipulated in the right-hand column of following table depending on the classification of specimen stipulated in left-hand column when executing impact test at the temperature below minimum operation temperature.

symbol	impact test		
	dimension of test piece (mm)	absorbed energy (J)	
		mean value of a pair and two each values of a pair	value of an individual
®SFL9N690	10×10	not less than 34	not less than 28
	10×7.5	not less than 25	not less than 22
	10×5	not less than 18	not less than 14

4) The analysis test, mechanical test, inspection and indication shall conform to a part of “9.2: Analysis test”, “9.3: Mechanical test”, “11: Inspection”, “12: Indication” of JIS G3205-2008 “Carbon and alloy steel forgings for pressure vessels for low-temperature service”.

18. The stainless steel forgings for power generation shall conform to the following standard. (®SUSF 410 J3)

1) It shall be produced forgings and rolling.
2) The percentages of chemical composition shall be in the range of value listed in the following table.

symbol	chemical composition (%)														
	C	Si	Mn	P	S	Ni	Cr	Mo	V	Nb	Al(*)	N	W	B	Cu
®SUSF410J3	0.07 to 0.14	0.50 or less	0.70 to 0.60	0.020 or less	0.010 or less	0.50 or less	10.00 to 11.50	0.25 to 0.60	0.15 to 0.30	0.04 to 0.10	0.040 or less	0.040 to 0.100	1.50 to 2.50	0.0005 to 0.006	0.30 to 1.70
(*) : soluile to acid															

3) This shall be tempered after normalizing. ®SUS 410 J3TP can be cool down rapidly when normalizing by liquid cooling include spray cooling.
4) The tensile strength, yield point, proof stress, growth and reduction area shall be in the range of value listed in the right column in table below depending on the kind of steel forgings in the left column.

symbol	tensile test			
	tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%) specimen No.14	reduction of area (%)
®SUSF410J3	not less than 620	not less than 400	not less than 20	not less than 40

5) The analysis test, mechanical test, inspection and indication shall conform to a part of "9.2: Analysis test", "9.3: Mechanical test", "11: Inspection", "12: Indication" of JIS G3214-2009 "Stainless steel forgings for pressure vessels". However, JIS G1220-1994 "Iron and steel-Method for determination of tungsten contest", JIS G1221-1998 "Iron and steel-Method for determination of vanadium contents", JIS G1224-2001 "Iron and steel-Method for determination of aluminum contents", and JIS G1227-1999 "Iron and steel-Method for determination of boron contest" shall conform to analysis test simultaneously in analysis test.

19. The carbon steel pipes for power generation shall conform to the following standard. (®STPT380J2)

1) It shall be produced without seam or produced by electric resistant welding.
2) The inner and outer surface shall be finished in good and free from harmful defects to use.
3) The percentages of chemical composition shall be in the range of value listed in the following table.

symbol	chemical composition (%)								
	C	Si	Mn	P	S	Mo	Cu	Sb	Ni
®STPT380J2	0.14 or less	0.55 or less	1.60 or less	0.025 or less	0.025 or less	0.20 or less	0.25 to 0.50	0.15 or less	0.50 or less

4) This shall be remaining as it was or low temperature annealing, normalizing, perfect annealing shall be done.

5) The tensile strength, yield point and proof stress and growth shall be in the range of each value listed in the following table.

symbol	tensile test					
	tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%)			
			specimen No.11 or No.2	specimen No.5	specimen No.4	
			vertical direction	lateral direction	vertical direction	lateral direction
®STPT380J2	not less than 380	not less than 230	not less than30	not less than 25	not less than 28	not less than 23

Remarks-1. When applying No.12 specimen or No.5 specimen for the tube which has thickness less than 8mm, the minimum value of growth shall be subtracting 1.5% from above table depending on per 1mm.

Remarks-2. The growth value in the above table shall not be applied to the tube which has outside diameter less than 40mm, however, the actual value shall be recorded.

Remarks-3.When collecting the specimen for tensile test from electric resistance welding, the specimen No.12 and No.5 shall be taken from the part except seam.

6) The analysis test, tensile test, flattening test, pressure test or non-destructive test, inspection, re-test and indication shall conform to a part of “10.1: Analysis test”, “10.2: Mechanical test”, “10.4: Pressure test or non-destructive test”, “11.1: Inspection”, “11.2: Re-test”, “12: Indication” of JIS G3456-2010 “Carbon steel pipes for high temperature service”. However, JIS G1216-1997 “Iron and steel-Method for determination of nickel content”, JIS G1218-1994 “Iron and steel-Method for determination of molybdenum content”, JIS G1218-1999 “Iron and steel-Method for determination of molybdenum content-supplement edition”, JIS G1219-1997 “Iron and steel-Method for determination of copper contents”, JIS G1235-1981 “Iron and steel-Method for determination of antimony content” shall conform to analysis test simultaneously in analysis test.

20. The alloy steel pipe for power generation shall conform to the following standard.

1) It shall be produced without seam.
2) The inner and outer surface shall be finished in good and free from harmful defects to use.
3) The percentages of chemical composition shall be in the range of value listed in the right column in table below depending on the kind of steel pipes in the left column.

symbol	chemical composition (%)													
	C	Si	Mn	P	S	Ni	Cr	Mo	V	Nb	Al(*)	N	W	B
®STPA21	0.10 to 0.20	0.50 or less	0.30 to 0.60	0.035 or less	0.035 or less	–	0.80 to 1.25	0.20 to 0.45	–	–	–	–	–	–
®STPA24J1	0.04 to 0.10	0.50 or less	0.10 to 0.60	0.030 or less	0.10 or less	–	1.90 to 2.60	0.05 to 0.30	0.20 to 0.30	0.02 to 0.08	0.30 or less	0.030 or less	1.45 to 1.75	0.0005 to 0.006
®STPA27	0.08 to 0.10	0.50 or less	030 to 0.70	0.030 or less	0.030 or less	–	8.00 to 10.00	1.80 to 2.20	–	–	–	–	–	–
®STPA28	0.08 to 0.12	0.20 to 0.50	0.30 to 0.60	0.020 or less	0.010 or less	0.40 or less	8.00 to 9.50	0.85 to 1.05	0.18 to 0.25	0.06 to 0.10	0.04 or less	0.030 to 0.070	–	–
®STPA29	0.07 to 0.13	0.50 or less	0.30 to 0.60	0.020 or less	0.010 or less	0.40 or less	8.50 to 9.50	0.30 to 0.60	0.15 to 0.25	0.04 to 0.09	0.04 or less	0.030 to 0.070	1.50 to 2.00	0.001 to 0.06
(*) : soluile to acid														

4) These pipes shall be executed heat treatment depending on the following table, and tensile strength, yield point, proof stress and growth shall be in the range of value listed in the right column in table below depending on the kind of steel pipes in the left column.

symbol	heat treatment	tensile test					
		tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%)			
				specimen No.11 or No.2	specimen No.5	specimen No.4	
				vertical direction	lateral direction	vertical direction	lateral direction
®STPA21	annealing or tempering after normalizing	not less than 410	not less than 205	not less than 30	not less than 25	not less than 24	not less than 19
®STPA24J1	tempering after normalizing	not less than 510	not less than 400	not less than 20	not less than 13	not less than 15	not less than 12
®STPA27	tempering in not less than 700^{0}C after normalizing in not less than 900^{0}C	not less than 510	not less than 295	not less than 25	not less than 18	not less than 20	not less than 15
®STPA28	tempering in not less than 730^{0}C after normalizing in not less than 1040^{0}C	not less than 590	not less than 410	not less than 20	not less than 13	not less than 15	not less than 12
®STPA29	tempering in not less than 730^{0}C after normalizing in not less than 1040^{0}C	not less than 620	not less than 440	not less than 20	not less than 13	not less than 15	not less than 12

Remarks 1. It is capable to cool down ®STPA21, ®STPA24J1, ®STPA27, ®STPA28 and ®STPA29 can be cooled down rapidly by liquid cooling, when normalizing by liquid cooling including splay cooling.

Remarks 2.When applying No.5 specimen or No.12 specimen for the tube which has thickness less than 8mm, the minimum value of growth shall be subtracting 1.5% from above table depending on per 1mm.

5) The analysis test, tensile test, flattening test, pressure test or non-destructive test, inspection, re-test and indication shall conform to a part of “9.1: Analysis test”, “9.2: Tensile test”, “9.3: Flattening test”, “9.4: Pressure test or non-destructive test”, “10.1: Inspection”, “10.2: Re-test”, “11: Indication” of JIS G3458-2005 “ Alloy steel pipes”. However, JIS G1220-1994 “Iron and steel-Method for determination of tungsten contest”, JIS G1221-1998 “Iron and steel-Method for determination of vanadium contents”, JIS G1224-2001 “Iron and steel-Method for determination of aluminum contents”, JIS G1227-1999 “Iron and steel-Method for determination of boron contest” , JIS G1228-2006 “Iron and steel-Method for determination of nitrogen contents” and JIS G1237-1997 “Iron and steel-Method for determination of niobium contents” shall conform to analysis test simultaneously in analysis test.

21. The stainless steel pipe for power generation shall conform to the following standard. (®SUS 410 J3TP)

1) It shall be produced without seam.
2) The inner and outer surface shall be finished in good and free from harmful defects to use.
3) The percentages of chemical composition shall be in the range of value listed in the following table.

symbol	chemical composition (%)														
	C	Si	Mn	P	S	Ni	Cr	Mo	V	Nb	Al(*)	N	W	B	Cu
®SUS410J3TP	0.07 to 0.14	0.50 or less	0.70 or less	0.020 or less	0.010 or less	0.50 or less	10.00 to 11.50	0.25 to 0.60	0.15 to 0.30	0.04 to 0.10	0.040 or less	0.040 to 0.100	1.50 to 2.50	0.0005 to 0.006	0.30 to 1.70
(*) : soluile to acid															

4) This shall be tempered after normalizing. ®SUS 410 J3TP can be cool down rapidly when

normalizing by liquid cooling include spray cooling.

5) The tensile strength, proof stress and growth shall be in the range of each value listed in the table below.

symbol	tensile test						
	tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%)				
			specimen No.11 or No.2	specimen No.5	specimen No.4	
			vertical direction	lateral direction	vertical direction	lateral direction
®SUS410J3TP	not less than 620	not less than 400	not less than 20	not less than 13	not less than 15	not less than 12

6) The analysis test, tensile test, flattening test, pressure test or non-destructive test, inspection, re-test and indication shall conform to a part of "13.1: Analysis test", "13.2: Tensile test", "13.3: Flattening test", "13.6: Pressure test or non-destructive test", "14.1: Inspection", "14.2: Re-test", "15: Indication" and "Appendix1: special quality provision-Z1 hardness" of JIS G3459-2004 "Stainless steel pipes". However, JIS G1220-1994 "Iron and steel-Method for determination of tungsten contest" JIS G1221-1998 "Iron and steel-Method for determination of vanadium contents", JIS G1227-1999 "Iron and steel-Method for determination of boron contest" shall conform to analysis test simultaneously in analysis test.

22. The carbon steel tubes for boiler of power generation shall conform to the following standard.

1) The ®STB380J2 shall be produced without seam or by electric resistant welding, or the ®STB480 shall be produced without seam.
2) The inner and outer surface shall be finished in good and free from harmful defects to use.
3) The percentages of chemical composition shall be in the range of value listed in the following table.

symbol	chemical composition (%)								
	C	Si	Mn	P	S	Mo	Cu	Sb	Ni
®STB380J2	0.14 or less	0.55 or less	1.60 or less	0.025 or less	0.025 or less	0.20 or less	0.25 to 0.50	0.15 or less	0.50 or less
®STB480	0.30 or less	0.10 or less	0.29 to 1.06	0.035 or less	0.035 or less	—	—	—	—

4) These pipes shall be executed heat treatment depending on the following table, and tensile strength, yield point, proof stress and growth shall be in the range of each value listed in the following table.

symbol	heat treatment	tensile test			hardness test
		tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%)	Rockwell hardness HRB
				specimen No.11 or No.2	
®STB380J2	without heat treatment, low-temperature annealing, normalizing or full annealing	not less than 380	not less than 230	not less than 35	—
®STB480	annealing or normalizing	not less than 480	not less than 275	not less than 30	not less than 89

Remarks 1.When the applying No.12 specimen for the tube which has thickness less than 8mm, the minimum value of growth shall be subtracting 1.5% from above table depending on per 1mm.

Remarks2.When collecting the specimen for tensile test from electric resistance welding, the specimen No.12 shall be taken from the part except seam.

5) The analysis test, tensile test, flattening test, flaring test, expansion test, pressure test or non-destructive test, inspection, re-test, indication and u-bend test shall conform to a part of "9.1: Analysis test", "9.2: Tensile test", "9.3: Flattening test", "9.4: Flaring test", "9.5: Expansion test", "9.6: Pressure test or non-destructive test", "10.1: Inspection", "10.2: Re-test", "11: Indication" , "Appendix1: special quality provision-Z1 hardness" and "Appendix2: U-bend piping" of JIS G3461-2005 "Carbon steel boiler and heat exchanger tubes". However, JIS G1216-1997 "Iron and steel-Method for determination of nickel content", JIS G1218-1994 "Iron and steel-Method for determination of molybdenum content" JIS G1218-1999 "Iron and steel-Method for determination of molybdenum content-supplement edition", JIS G1219-1997 "Iron and steel-Method for determination of copper contents", JIS G1235-1981 "Iron and steel-Method for determination of antimony contest" shall conformed to analysis test simultaneously in analysis test.

23. The alloy steel tubes for boiler of power generation shall conform to the following standard.

1) It shall be produced without seam.
2) The inner and outer surface shall be finished in good and free from harmful defects to use.
3) The percentages of chemical composition shall be in the range of value listed in the right column in table below depending on the kind of steel pipes in the left column.

symbol	chemical composition (%)														
	C	Si	Mn	P	S	Ni	Cr	Mo	V	Nb	Al(*)	N	W	B	Cu
®STBA10	0.10 or less	0.20 to 0.80	0.80 or less	0.025 or less	0.015 to 0.030	—	1.00 to 1.50	—	—	—	—	—	—	—	0.25 to 0.35
®STBA21	0.10 to 0.20	0.50 or less	0.30 to 0.60	0.035 or less	0.035 or less	—	0.80 to 1.25	0.20 to 0.45	—	—	—	—	—	—	—
®STBA24J1	0.04 to 0.10	0.50 or less	0.10 to 0.60	0.030 or less	0.010 or less	—	1.90 to 2.00	0.05 to 0.30	0.20 to 0.30	0.02 to 0.08	0.030 or less	0.030 or less	1.45 to 1.75	0.0005 to 0.006	—
®STBA27	0.08 or less	0.50 or less	0.30 to 0.70	0.030 or less	0.030 or less	—	8.00 to 10.00	1.80 to 2.20	—	—	—	—	—	—	—
®STBA28	0.08 to 0.12	0.20 to 0.50	0.30 to 0.60	0.020 or less	0.010 or less	0.40 or less	8.00 to 9.50	0.85 to 1.05	0.18 to 0.25	0.06 to 0.10	0.04 or less	0.030 to 0.070	—	—	—
®STBA29	0.07 to 0.13	0.50 or less	0.30 to 0.60	0.020 or less	00.10 or less	0.40 or less	8.50 to 9.50	0.30 to 0.60	0.15 to 0.25	0.04 to 0.09	0.04 or less	0.030 to 0.070	1.50 to 2.00	0.001 to 0.006	—
(*) : soluile to acid															

4) These pipes shall be executed heat treatment depending on the following table, and tensile strength, yield point, proof stress, growth and hardness shall be in the range of value listed in the right column in table below depending on the kind of steel pipes in the left column.

symbol	heat treatment	tensile test			hardness test
		tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%)	Rockwell hardness HRC
				specimen No.11 or No.2	
®SBA10	tempering	not less than 410	not less than 255	not less than 25	−
®STBA21	annealing or tempering after normalizing	not less than 410	not less than 205	not less than 30	−
®STBA24J1	tempering after normalizing	not less than 510	not less than 400	not less than 20	−
®STBA27	tempering in not less than 700^0C after normalizing in not less than 900^0C	not less than 510	not less than 295	not less than 25	−
®STBA28	tempering in no less than 730^0C after normalizing in not less than 1040^0C	not less than 590	not less than 410	not less than 20	25 or less
®STBA29	tempering in not less than 730^0C after normalizing in not less than 1040^0C	not less than 620	not less than 440	not less than 20	25 or less

Remarks 1.When the applying No.12 specimen for the tube which has thickness less than 8mm, the minimum value of growth shall be subtracting 1.5% from above table depending on per 1mm.

5) The analysis test, tensile test, flattening test, flaring test, pressure test or non-destructive test, inspection, re-test, indication and hardness test shall conform to a part of "10.1: Analysis test", "10.2: Mechanical test", "10.3: Pressure test or non-destructive test", "11.1: Inspection", "11.2: Re-test", "12: Indication" and "Appendix1: special quality provision-Z1 hardness" of JIS G3462-2009 "Alloy steel tubes for boiler and heat exchanger". However, JIS G1216-1997 "Iron and steel-Method for determination of nickel content", JIS G1220-1994 "Iron and steel-Method for determination of tungsten contest", JIS G1221-1998 "Iron and steel-determination method of vanadium contents", JIS G1224-2001 "Iron and steel-Method for determination of aluminum contents", JIS G1227-1999 "Iron and steel-Method for determination of boron contest", JIS G1228-2006 "Iron and steel-Method for determination of nitrogen contents" and JIS G1237-1997 "Iron and steel-Method for determination of niobium contents" shall conformed to analysis test simultaneously in analysis test.

24. The stainless steel tubes for boiler of power generation shall conform to the following standard.

1) It shall be produced without seam.
2) The inner and outer surface shall be finished in good and free from harmful defects to use.
3) The percentages of chemical composition shall be in the range of value listed in the right column in table below depending on the kind of steel pipes in the left column.

symbol	chemical composition (%)															
	C	Si	Mn	P	S	Ni	Cr	Mo	Ti	V	Nb	N	Cu	W	B	others
®SUS304J1HTB	0.07 to 0.13	0.30 or less	1.00 or less	0.040 or less	0.010 or less	7.50 to 10.50	17.00 to 19.00	–	–	–	0.30 to 0.60	0.05 to 0.12	2.50 to 3.50	–	–	–
®SUS309J1TB	0.06 or less	1.50 or less	2.00 or less	0.040 or less	0.030 or less	12.00 to 16.00	23.00 to 26.00	0.50 to 1.20	–	–	–	0.25 to 0.40	–	–	–	–
®SUS309J2TB	0.04 or less	1.00 or less	2.50 to 3.50	0.030 or less	0.030 or less	12.50 to 15.50	21.00 to 23.00	1.00 to 2.00	–	–	–	0.10 to 0.25	–	–	–	–
®SUS309J3LTB	0.025 or less	0.70 or less	2.00 or less	0.040 or less	0.030 or less	13.00 to 16.00	23.00 to 26.00	0.50 to 1.20	–	–	–	0.25 to 0.40	–	–	–	–
®SUS309J4HTB	0.03 to 0.10	1.00 or less	2.00 or less	0.040 or less	0.030 or less	14.50 to 16.50	21.00 to 23.00	–	–	–	0.50 to 0.80	0.10 to 0.20	–	–	0.005 or less	–
®SUS310J1TB	0.10 or less	1.50 or less	2.00 or less	0.030 or less	0.030 or less	17.00 to 23.00	23.00 to 27.00	–	–	–	0.20 to 0.60	0.15 to 0.35	–	–	–	–
®SUS310J2TB	0.10 or less	1.00 or less	1.50 or less	0.030 or less	0.010 or less	22.00 to 28.00	19.00 to 23.00	1.00 to 2.00	0.20 or less	–	0.10 to 0.40	0.10 to 0.25	–	–	0.002 to 0.010	–
®SUS310J3TB	0.05 to 0.12	1.50 or less	2.00 or less	0.030 or less	0.010 or less	15.00 to 22.00	21.00 to 24.00	–	–	–	0.30 to 0.60	0.15 to 0.30	2.00 to 4.00	0.80 to 2.80	–	–
®SUS321J1HTB	0.07 to 0.14	1.00 or less	2.00 or less	0.040 or less	0.030 or less	9.00 to 12.00	17.50 to 19.50	–	0.20 or less	–	0.40 or less	–	–	–	–	(*1)
®SUS321J2HTB	0.07 to 0.14	1.00 or less	2.00 or less	0.040 or less	0.010 or less	9.00 to 12.00	17.50 to 19.50	–	0.10 to 0.25	–	0.10 to 0.45	–	2.50 to 3.50	–	0.0010 to 0.0040	(*2)
®SUSTP347HTB	0.04 to 0.10	0.75 or less	2.00 or less	0.030 or less	0.030 or less	9.00 to 13.00	17.00 to 20.00	–	–	–	8×C% to 1.00	–	–	–	–	–
®SUS347J1TB	0.05 or less	1.00 or less	2.00 or less	0.040 or less	0.030 or less	8.00 to 11.00	17.00 to 20.00	–	–	0.20 to 0.50	0.25 to 0.50	0.10 to 0.25	–	1.50 to 2.60	–	–
®SUS410J2TB	0.14 or less	0.50 or less	0.30 to 0.70	0.030 or less	0.030 or less	–	11.00 to 13.00	0.80 to 1.20	–	0.20 to 0.30	0.20 or less	–	–	0.80 to 1.20	–	–
®SUS410J3TB	0.07 to 0.14	0.50 or less	0.70 or less	00.20 or less	0.010 or less	0.50 or less	10.00 to 11.50	0.25 to 0.60	–	0.15 to 0.30	0.04 to 0.10	0.040 to 0.100	0.30 to 1.70	1.50 to 2.50	0.0005 to 0.005	(*3)
®SUS410J3DTB	0.07 to 0.14	0.50 or less	0.70 or less	00.20 or less	0.010 or less	0.50 or less	11.51 to 12.50	0.25 to 0.60	–	0.15 to 0.30	0.04 to 0.10	0.040 to 0.100	0.30 to 1.70	1.50 to 2.50	0.0005 to 0.005	(*4)

(*1) : (Ti + Nb/2)/C = 0.6 to 2.5

(*2) : (Ti + Nb/2)/C = 2.0 to 4.0

(*3) : Al (soluile to acid) = 0.040 or less

(*4) : Al (soluile to acid) = 0.040 or less

4) These pipes shall be executed heat treatment depending on the following table, and tensile strength, yield point, proof stress, growth and hardness shall be in the range of value listed in the right column in table below depending on the kind of steel pipes in the left column.

symbol	heat treatment (^{0}C)		tensile test			hardness teat
	solution treatment	other heat treatment	tensile strength (N/mm^2)	proof stress (N/mm^2)	growth (%) specimen No.11 and 12	Rockwell hardness (HRB)
®SUS304J1HTB	rapid cooling from 1040^{0}C	–	not less than 590	not less than 235	not lesse than 35	–
®SUS309J1TB	rapid cooling from 1050^{0}C	–	not less than 690	not less than 345	not less than 40	–
®SUS309J2TB	rapid cooling from 1050^{0}C	–	not less than 590	not less than 245	not less than 35	–
®SUS309J3LTB	rapid cooling from 1050^{0}C	–	not less than 690	not less than 345	not less than 30	–
®SUS309J4HTB	rapid cooling from 1120^{0}C	–	not less than 590	not less than 235	not less than 35	–
®SUS310J1TB	rapid cooling from 1030^{0}C	–	not less than 660	not less than 295	not less than 30	–
®SUS310J2TB	rapid cooling from 1100^{0}C	–	not less than 640	not less than 270	not less than 30	–
®SUS310J3TB	rapid cooling from 1030^{0}C	–	not less than 650	not less than 295	not less than 30	–
®SUS321J1HTB	rapid cooling from 1100^{0}C	–	not less than 520	not less than 205	not less than 35	–
®SUS321J2HTB	rapid cooling from 1160^{0}C	–	not less than 500	not less than 205	not less than 35	90 or less
®SUSTP347HTB	rapid cooling from 1150^{0}C	–	not less than 520	not less than 205	not less than 35	90 or less
®SUS347J1TB	rapid cooling from 1100^{0}C	–	not less than 650	not less than 270	not less than 30	–
®SUS410J2TB	–	tempering after normalizing	not less than 590	not less than 390	not less than 20	–
®SUS410J3TB	–	tempering after normalizing	not less than 620	not less than 400	not less than 20	–
®SUS410J3DTB	–	tempering after normalizing	not less than 620	not less than 400	not less than 20	–

Remarks 1.When the applying No.12 specimen for the tube which has thickness less than 8mm, the minimum value of growth shall be subtracting 1.5% from above table depending on per 1mm.

5) The analysis test, tensile test, flattening test, flaring test, pressure test or non-destructive test, inspection, re-test, indication and hardness test shall conform to a part of "10.1: Analysis test", "10.2: Tensile test", "10.3: Flattening test", "10.4: Flaring test", "10.7: Pressure test or non-destructive test", "11.1: Inspection", "11.2: Re-test", "12: Indication" and "Appendix1: special quality provision-Z1 hardness" of JIS G3463-2006 "Stainless steel boiler and heat exchanger tubes". However, JIS G1220-1994 "Iron and steel-Method for determination of tungsten contest", JIS G1221-1998 "Iron and steel-Method for determination of vanadium contents" and JIS G1227-1999 "Iron and steel-Method for determination of boron contest" shall conform to analysis test simultaneously in analysis test.

25. The chromium-molybdenum steel plates for boilers and pressure vessels of power generation shall conform to the following standard. (®SCMV4J4, ®SCMV28)

1) This shall be the steel plate with thickness 150mm or less.
2) The surface shall be finished in good and free from harmful defects to use.
3) The percentages of chemical composition shall be in the range of value listed in the following table.

symbol	chemical composition (%)													
	C	Si	Mn	P	S	Ni	Cr	Mo	V	Nb	Al(*)	N	W	B
®SCMV4J1	0.04 to 0.10	0.50 or less	0.10 to 0.60	0.030 or less	0.010 or less	—	1.90 to 2.60	0.05 to 0.30	0.20 to 0.30	0.02 to 0.08	0.030 or less	0.030 or less	1.45 to 1.75	0.0005 to 0.006
®SCMV28	0.08 to 0.12	0.20 to 0.50	0.30 to 0.60	0.020 or less	0.010 or less	0.40 or less	8.00 to 9.50	0.85 to 1.05	0.18 to 0.25	0.06 to 0.10	0.04 or less	0.030 to 0.070	—	—

(*) : soluile to acid

4) The ®SCMV 4J1 shall be tempered after normalizing or be tempered after quenching. The ®SCMV 28 shall be tempered at temperature not less than 730°C after normalizing at temperature not less than 1040°C and less than 1095°C.
5) The tensile strength, yield point, proof stress and growth shall be in the range of each value listed in the following table.

symbol	tensile test		
	tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%) specimen No.10 or 1A
®SCMV4J1	not less than 510	not less than 400	not less than 18
®SCMV28	not less than 590	not less than 410	not less than 18

6) The analysis test, mechanical test, inspection and indication shall conform to a part of "10.1: Analysis test", "10.2: Mechanical test", "11: Inspection" and "13: Indication" of JIS G4109-2008 "Chromium-molybdenum alloy steel plates for boilers and pressure vessels". However, JIS G1216-1997 "Iron and steel-Method for determination of nickel content", JIS G1220-1994 "Iron and steel-Method for determination of tungsten contest" JIS G1221-1998 "Iron and steel-Method for determination of vanadium contents", JIS G1224-2001 "Iron and steel-Method for determination of aluminum contents", JIS G1227-1999 "Iron and steel-Method for determination of boron contest", JIS G1228-2006 "Iron and steel-Method for determination of nitrogen contents" and JIS G1237-1997 "Iron and steel-Method for determination of niobium contents" shall conformed to analysis test simultaneously in analysis test.

26. The stainless steel plates for power generation shall conform to the following standard. (®SUS 410J3)

1) This shall be produced by hot rolling.
2) The surface shall be finished in good and free from harmful defects to use.
3) The percentages of chemical composition shall be in the range of value listed in the following table.

symbol	chemical composition (%)														
	C	Si	Mn	P	S	Ni	Cr	Mo	V	Nb	Al(*)	N	W	B	Cu
®SUS410J3	0.07 to 0.14	0.50 or less	0.70 or less	0.020 or less	0.010 or less	0.50 or less	10.00 to 11.50	0.25 to 0.60	0.15 to 0.30	0.04 to 0.10	0.04 or less	0.040 to 0.100	1.50 to 2.50	0.0005 to 0.005	0.30 to 1.70

(*) : soluile to acid

4) This shall be tempered after normalizing, or be tempered after quenching.

5) The tensile strength, yield point, proof stress and growth shall be in the range of each value listed in the following table.

symbol	tensile test		
	tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%) specimen No.10 or 1A
®SUS410J3	not less than 620	not less than 400	not less than 18

6) The analysis test, mechanical test, inspection and indication shall conform to a part of “11.1: Analysis test”, “11.2: Mechanical test”, “12: Inspection” and “13: Indication” of JIS G4304-2010 “Hot-rolled stainless steel plate, sheet and strip”. However, JIS G1220-1994 “Iron and steel-Method for determination of tungsten contest”, JIS G1221-1998 “Iron and steel-Method for determination of vanadium contents” and JIS G1227-1999 “Iron and steel-Method for determination of boron contest” shall conform to analysis test simultaneously in analysis test.

27. The alloy steel castings for power generation shall conform to the following standard. (®SCPH91)

1) This shall be produced by casting.

2) The percentages of chemical composition shall be in the range of value listed in the following table.

symbol	chemical composition (%)											
	C	Si	Mn	P	S	Ni	Cr	Mo	V	Nb	Al(*)	N
®SCPH91	0.08 to 0.12	0.20 to 0.50	0.30 to 0.60	0.020 or less	0.010 or less	0.40 or less	8.00 to 9.50	0.85 to 1.05	0.18 to 0.25	0.06 to 0.10	0.04 or less	0.03 to 0.07

(*) : soluile to acid

3) This shall be tempered at temperature above 730 °C after normalizing at temperature above 1040 °C.

4) The tensile strength, yield point, proof stress, growth, reduction area and hardness shall be in the range of each value listed in the following table.

symbol	tensile test				
	tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%)	reduction of area (%)	Rockwell hardness (HRC)
®SCPH91	not less than 590	mnot less than 415	not less than 20	mnot less than 40	24 or less

5) The analysis test, mechanical test, pressure test or non-destructive test, inspection, re-test, indication and hardness test shall conform to a part of “6: Test and inspection” and “7: Indication” of JIS0307-1998 “General principle-production, test and inspection of forgings”.

28. The manganese-molybdenum-nickel steel plates for boilers and pressure vessels shall conform to the following standard. (®SBV2J1)

1) The surface shall be finished in good and free from harmful defects to use.
2) The percentages of chemical composition shall be in the range of value listed in the following table.

symbol	chemical composition (%)									
	C	Si	Mn	P	S	Ni	Cr	Mo	V	B
®SBV2J1	0.20 or less	0.15 to 0.30	1.15 to 1.50	0.020 or less	0.020 or less	0.40 to 0.70	0.30 or less	0.45 to 0.60	0.010 to 0.030	0.0005 to 0.0020

3) The executed normalizing plus stress relief annealing or normalizing plus stress relief annealing shall be done. However, it can be done rapid cooling and additional tempering for increasing mechanical property.
4) The tensile strength, yield point, proof stress and growth shall be in the range of each value listed in the following table.

symbol	tensile test		
	tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%)
			specimen No.10
®SBV2J1	not less than 610	not less than 440	not less than 20

5) The analysis test, tensile test and report shall conform to a part of "9.1: Analysis test", "9.2: Mechanical test" and "13: Reporting" of JIS G3119-2007 "Manganese-molybdenum and manganese-molybdenum-nickel alloy steel plates for boilers and pressure vessels". However, JIS G1227-1999 "Iron and steel- method for determination of boron contest" shall conform to analysis test simultaneously in analysis test.

29. The manganese-molybdenum-nickel forgings for boilers and pressure vessels shall conform to the following standard. (®SFBV2J1)

1) This shall be produced by forging and rolling.
2) The percentages of chemical composition shall be in the range of value listed in the following table.

symbol	chemical composition (%)									
	C	Si	Mn	P	S	Ni	Cr	Mo	V	B
®SFBV2J1	0.20 or less	0.15 to 0.30	1.15 to 1.50	0.020 or less	0.020 or less	0.40 to 0.70	0.30 or less	0.45 to 0.60	0.010 to 0.030	0.0005 to 0.0020

3) This forging shall be annealed after normalizing, or be tempered after quenching.

4) The tensile strength, proof stress and growth shall be in the range of each value listed in the following table.

symbol	tensile test		
	tensile strength (N/mm^2)	yield point or proof stress (N/mm^2)	growth (%)
			specimen No.10
®SFBV2J1	not less than 610	not less than 440	not less than 20

5) The analysis test, tensile test and report shall conform to a part of "9.2: Analysis test", "9.3: Mechanical test" and "13: Reporting" of JIS G3204 "Quenched and tempered alloy steel forgings for pressure vessels". However, JIS G1227-1999 "Iron and steel-methods for determination method of boron contest" shall conform to analysis test simultaneously in analysis test.

30. The 36% nickel alloy plate shall conform to the following standard. (S36N240)

1) It shall be executed heat treatment, pickling or equivalent after hot rolling.
2) The surface shall be finished in good and free from harmful defects to use.
3) The percentages of chemical composition shall be in the range of value listed in the following table. However, the other alloy elements can be added as needed.

symbol	chemical composition (%)							
	C	Si	Mn	P	S	Ni	Cr	Mo
S36N240	0.04 or less	0.30 or less	0.70 or less	0.025 or less	0.015 or less	35.00 to 37.00	0.15 or less	0.25 or less

4) The tensile strength, proof stress and growth shall be in the range of each value listed in the following table.

symbol	tensile test		
	tensile strength (N/mm^2)	proof stress (N/mm^2)	growth (%)
S36N240	not less than 440	not less than 240	not less than 30

5) The analysis test, tensile test and reports shall conform to a part of "11.1: Analysis test", "11.2: Mechanical test (limited to the part of tensile test)" and "14: Report" of JIS G4304-2010 "Hot-rolled stainless steel plate". However, JIS G1222-1999 "Iron and steel-methods for determination of cobalt" shall conform to analysis test simultaneously in analysis test.

31. The name of era of the standards which are listed in the column of name and standard number of JIS G3101, JIS G3106, JIS G3114, JIS G3126, JIS G3452, JIS G3456, JIS G3459 and JIS G3462 are different with era of JIS B8265-2003.