Valve material and valve standards- detailed version.

What material is WCB/LCB/LCC/WC6/WC in the valve?

W, wrought casting; C, Carbon steel; A, B, C indicate the strength value of steel grades from low to high.

WCA, WCA, WCC represent carbon steel, ABC represents the strength level, and WCB is commonly used. The corresponding pipe material of WCB should be A106B, and the corresponding forging material should be A105.
WC6 is an alloy steel casting, the corresponding pipe material is about A355 P11, and the forging is A182 F11; there is also WC9, high temperature resistant alloy steel, the corresponding pipe material is about A355 P22, and the corresponding forging is A182 F22.
WC: weldable casting
LCB/LCC (ASTM A352) low temperature carbon steel
ITCS is carbon steel with impact toughness; impact test C=carbon S=steel (A350)
Split body split type, side entry side mounted (referring to the actuator), corresponding to TOP entry top mounted type

Commonly used valve casting and forging carbon steel material table:

material	country	standard	material grade name		
Casting	China	GB/T 12229	WCA	WCB	WCC
			ZG205-415	ZG250-485	ZG275-485
	USA	ASTM A216/A216M	WCA	WCB	WCC
			UNS J02502	UNS J03002	UNS J02503
Forged	China	GB/T 12228 GB/T 699	25 25Mn 35 40 A105		
	USA	ASTM A105/A105M	A105		

Low temperature casting parts material name and temperature range

C	C	C-Mn	C-Mo	2.5Ni	Ni-Cr-Mo	3.5Ni	4.5Ni	9Ni	Cr-Ni-Mo
LCA	LCB	LCC	LC1	LC2	LC2-1	LC3	LC4	LC9	CA6NM
J02504	J03303	J02505	J12522	J22500	j42215	j31550	j41500	j31300	j91540
-32	-46	-46	-59	-73	-73	-101	-115	-115	-73

Commonly used valve ASTM Casting and Forged material sheet (ASME B16.5)

ASTM Casting	ASTM Forged	China name	Temp ° C	suitable medium
Carbon steel				
A216 WCB	A105	20	-29/427	water, steam, air, petroleum products
Low temp Carbon steel				
A352 LCB	A350 LF2	16Mn	-46/343	

A352 LCC	A350 LF2	16Mn	-46/343	
High temp alloy				
A217 WC1	A182 F1	20MnMo	-29/454	High temp, High pressure medium
A217 WC6	A182 F11	15CrMo	-29/552	High temp, High pressure medium
A217 WC9	A182 F22	10Cr2Mo1	-29/593	High temp, High pressure medium
A217 C5	A182 F5	1Cr5Mo	-29/650	Corrosive high temperature medium
A217 C12	A182 F9	Cr9Mo1	-29/593	High sulfur oxidizing medium
Martensitic stainless steel				
A217 CA15	A182 F6a	Cr9Mo1	-29/593	High sulfur oxidizing medium
Austenitic stainless steel (C≤0.08)				
A351 CF8	A182 F304	0Cr18Ni9	-196/537	corrosive medium
A351 CF3	A182 F304L		-196/425	corrosive medium
A351 CF8M	A182 F316	0Cr18Ni12Mo2Ti	-196/537	corrosive medium
A351 CF3M	A182 F316L		-196/425	corrosive medium
low carbon Austenitic stainless steel (C≤0.03)				
A351 CF3	A182 F304L	00Cr18Ni10	-0.459016393	corrosive medium
A351 CF3M	A182 F316L	00Cr18Ni14Mo2	-196/454	corrosive medium
Special alloy				
A351 CN7M	B462Gr.N08020 (ALLOY20)		-29/149	Oxidizing medium and various concentrations of sulfuric acid
A494 M-30C (Monel alloy)	B4564 Gr.N04400		-29/482	Hydrofluoric acid, Sea water
Hastelloy H.B H.C				Strong corrosive medium such as dilute sulfuric acid

Notes:

1. Forged valve body material is dense, not easy to have defects, the structure size is not limited by the mold, and the pressure bearing performance is reliable. It is mostly used for high pressure, oxygen working conditions, small diameter or other small batch valve manufacturing, generally at high temperature, Choose forgings under high pressure or low temperature or special medium; castings are generally only suitable for medium and low pressure, and are mostly used for mass production of standardized molded valves.

2. The difference between material A351 CF3M and A182 F316L: the materials corresponding to the two standards are 316 stainless steel. CF3M stands for castings and is often used as valve material. The corresponding forging steel code is A182 F316L. ASTM A216 WCB is a casting, and its forging is A105; the casting of SS304 is A351-CF8, and the forging is A182-F304.

Selection of valve material:

There are many materials for manufacturing valve parts, including various types of ferrous and non-ferrous metals and their alloys, and various non-metallic materials. The materials for manufacturing valve parts are selected according to the following factors:

1. The pressure, temperature and characteristics of the working medium.
2. The force of the part and its function in the valve structure.
3. Have better manufacturability.
4. If the above conditions are met, there must be a lower cost.

Section one: the material of the valve body, bonnet and valve plate

1. Gray cast iron: Gray cast iron is suitable for water, steam, air, gas, oil and other media with a nominal pressure of PN≤1.0MPa and a temperature of -10°C–200°C. The commonly used grades of gray cast iron are: HT200, HT250, HT300, HT500.

2.. Malleable cast iron: suitable for water, steam, air and oil media with a nominal pressure of PN≤2.5Mpa and a temperature of -30-300°C. Commonly used grades are: KTH300-06, KTH330-08, KTH350-10.

3. Nodular cast iron: suitable for water, steam, air and oil with PN≤4.0Mpa and temperature of -30-350°C. Commonly used grades are: QT400-15, QT450-10, QT500-7.

4. Carbon steel (WCA, WCB, WCC): Suitable for nominal pressure PN≤32MPa, suitable for medium and high pressure valves with operating temperature between -29°C and +425°C. Among them, 16Mn and 30Mn work at -29-595°C, and are often used to replace ASTM A105. Commonly used grades are WC1, WCB, ZG25 and high-quality steel 20, 25, 30 and low-alloy structural steel 16Mn.

5. Low temperature carbon steel (LCB): suitable for ethylene, propylene, liquid natural gas, liquid nitrogen and other media with nominal pressure PN≤6.4MPa and temperature ≥-196°C. Commonly used grades are ZG1Cr18Ni9, 0Cr18Ni9, 1Cr18Ni9Ti, ZG0Cr18Ni9.

6. Alloy steel (WC6, WC9), suitable for high temperature and high pressure valves with non-corrosive medium working temperature between -29-595°C;

WC5, WC9 are suitable for working temperature between -29-659°C High temperature and high pressure valves for corrosive media.

7. Austenitic stainless steel, suitable for valves with corrosive media with working temperature between -196-600°C.
Eight. Monel alloy: mainly suitable for valves with hydrofluoric medium.
nine. Cast copper alloy: Mainly suitable for valves for oxygen pipelines whose operating temperature is between -29 and 595°C

Fig.1-1 Commonly used valve body material:

valve body material	standard	temp	PN/Mpa	medium
Grey cast Iron		-15/200	≤1.6	water,gas
Black Heart Malleable Cast Iron		-15/300	≤2.5	water, seawater, gas, Ammonia
ductile cast iron		-30/350	≤4.0	water,seawater,gas,air,steam
carbon steel (WCA,WCB,WCC)	ASTM A216	-29/425	≤32	non-corrosive water, oil, gas
Low temp carbon steel (LCB,LCC)	ASTM A352	-46/345	≤32	low temp application
Alloy (WC6, WC9, C5, C12)	ASTM A217	-29/595 -29/650	High pressure	non-corrosive corrosive medium
Austenitic stainless steel	ASTM A351	-196/600		corrosive medium
Monel alloy	ASTM A494	400		Hydrofluoric acid medium
Hastelloy	ASTM A494	649		Strong corrosive medium such as dilute sulfuric acid
Titanium alloy				Various strong corrosive media
Cast copper alloy		-273/200		Oxygen, sea water
Plastic, Ceramic		-60	≤1.6	corrosive medium

Name	material	standard	temp range ° C	application
WCB	carbon steel	ASTM A216	-29/425	non-corrosive water, oil and gas
LCB	low temp carbon steel	ASTM A352	-46/345	low temp applicaion
LC3	3.5% nickel steel	ASTM A352	-101/340	low temp applicaion
WC6	1.25% chromium, 0.5% molybdenum	ASTM A217	-30/593	non-corrosive water, oil and gas
WC9	2.25% chromium			
C5	5% chromium,0.5% molybdenum	ASTM A217	-30/649	light or non-corrosive application
C12	9% chromium 1% molybdenum			

CA15(4)	12% chromium	ASTM A217	704	corrosive application
CA6NM(4)	12% chromium	ASTM A487	-30/482	corrosive application
CF8M	stainless steel 316	ASTM A351	-268/649 when <425, need C=0.04% info	corrosive,ultra low/high temp with no corrosive application
CF8C	stainless steel 347	ASTM A351	-268/649 when <425, need C=0.04% info	high temp, corrosive application
CF8	stainless steel 304	ASTM A351	-268/649 when <425, need C=0.04% info	corrosive,ultra low/high temp with no corrosive application
CF3	stainless steel 304L	ASTM A351	425	corrosive or non-corrosive
CF3M	stainless steel 316L	ASTM A351	454	corrosive or non-corrosive
CN7M	alloy	ASTM A351	425	Good resistance to hot sulfuric acid corrosion
M35-1	monel	ASTM A494	400	Weldable grade, good resistance to common organic acid and salt water corrosion, resistance to most alkaline solutions
N7M	Hastelloy B	ASTM A494	649	Suitable for treating various concentrations and temperatures of hydrofluoric acid, with good resistance to corrosion by sulfuric acid and phosphoric acid
CW6M	Hastelloy C	ASTM A494	649	Very good resistance to strong oxidation, resistance to phosphoric acid, sulfurous acid and sulfuric acid at high temperatures
CY40	Inconel alloy	ASTM A494		Resistant to strong corrosive fluids at high temperatures

Section 2: Sealing surface material

The sealing surface is the most critical working surface of the valve. The quality of the sealing surface is related to the service life of the valve. Generally, the sealing surface material considers factors such as corrosion

resistance, scratch resistance, erosion resistance, and oxidation resistance. Generally, sealing surface materials are divided into two categories:
1. Soft materials

- 1. Rubber (including nitrile rubber, ethylene propylene rubber, fluorine rubber, etc.)
- 2. Plastics (polytetrafluoroethylene, nylon, etc.)

2. Hard sealing material

- 1. Copper alloy (for low pressure valve)
- 2. Chrome stainless steel (used for ordinary high and medium pressure valves)
- 3. Stellite alloy (used for high temperature and high pressure valves and strong corrosion valves)
- 4. Nickel-based alloy (used for corrosive media)

Section 3: Valve Stem Material
During the opening and closing of the valve, the valve stem bears tensile, compressive and torsional forces, and is in direct contact with the medium. At the same time, there is relative frictional movement with the packing. Therefore, the valve stem material must ensure sufficient strength at the specified temperature And impact toughness, a certain degree of corrosion resistance and abrasion resistance, and good manufacturability. Commonly used valve stem materials are as follows:
1. Carbon steel: For water with low temperature and medium temperature not exceeding 300°C, when steam medium, A5 ordinary carbon steel is generally selected (now Q275, A3 is Q235)
2. Alloy steel: For medium pressure and high pressure, when the medium temperature does not exceed 450°C, 40Cr (chromium steel) is generally used when the medium temperature does not exceed 450°C. Water, the medium temperature does not exceed 540°C For steam and other media, 38CrMoAlA nitriding steel can be selected; for high-pressure steam media with a medium temperature not exceeding 570°C, 25Cr2MoVA chromium molybdenum vanadium steel is generally selected.
3. Stainless and acid-resistant steel: used for medium and high pressure, non-corrosive and weakly corrosive media with a medium temperature not exceeding 450°C. 1Cr13, 2Cr13, 3Cr13 chromium stainless steel can be selected; when used in corrosive media, it can be used Use Cr17Ni2, 1Cr18Ni9Ti, Cr18Ni12Mo2Ti, Cr18Ni12Mo3Ti and other stainless acid-resistant steels and PH15-7Mo precipitation hardening steels.
4. Heat-resistant steel: 4Cr10Si2Mo martensitic heat-resistant steel and

4Cr14Ni14W2Mo austenitic heat-resistant steel can be used for high-temperature valves whose medium temperature does not exceed 600°C.

Section 4: Valve Stem Nut Material

The stem nut directly bears the axial force of the stem during the opening and closing of the valve, so it must have a certain strength. At the same time, it and the valve stem are threaded transmission, which requires a small coefficient of friction, no rust and avoid seizure. The main materials are as follows:

1. Copper alloy: Copper alloy has a small friction coefficient and does not rust. It is one of the commonly used materials. For low pressure valves with Pg<1.6Mpa, ZHMn58-2-2 cast brass can be used.

2. Steel: When the working conditions do not allow the use of copper alloys, high-quality carbon steels such as 35, 40, 2Cr13, 1Cr18Ni9, Cr17Ni2 and other stainless and acid-resistant steels can be selected. The working conditions do not allow the following:

For electric valves, stem nuts with gua-shaped clutches require heat treatment to obtain high hardness or surface hardness.

When the working medium or the surrounding environment is not suitable for copper alloys, such as ammonia medium that is corrosive to copper.

When selecting steel stem nuts, pay special attention to thread seizure.

Fastener materials: Fasteners mainly include bolts, studs and nuts. The fastener directly bears the pressure on the valve, which plays a key role in preventing the outflow of the medium. Therefore, the selected material must ensure sufficient strength and impact toughness at the operating temperature.

When selecting fastener materials according to medium pressure and temperature, the following table can be selected:

<table>
<tr><td rowspan="2">Name</td><td rowspan="2">Pn(Mpa)</td><td colspan="6">medium temp /° C</td></tr>
<tr><td>300</td><td>350</td><td>400</td><td>425</td><td>450</td><td>530</td></tr>
<tr><td rowspan="3">bolt
Stud bolt</td><td>1.6-2.5</td><td>Q235(A3)</td><td colspan="2">35</td><td>30CrMoA</td><td>-</td></tr>
<tr><td>4.0-10.0</td><td colspan="3">35</td><td>35CrMoA</td><td>25Cr2MoVA</td></tr>
<tr><td>16.0-20.0</td><td colspan="2">30CrMoA</td><td colspan="2">35CrMoA</td><td>25Cr2MoVA</td></tr>
<tr><td rowspan="3">nut</td><td>1.6-2.5</td><td>Q235(A3)</td><td colspan="2">30</td><td>35</td><td></td></tr>
<tr><td>4.0-10.0</td><td colspan="3">30</td><td>35</td><td>35CrMoA</td></tr>
<tr><td>16.0-20.0</td><td colspan="4">35</td><td>35CrMoA</td></tr>
</table>

Heat treatment must be carried out when selecting alloy steel materials. When there are special corrosion resistance requirements for fasteners, stainless acid-resistant steels such as Cr17Ni2, 2Cr13, 1Cr18Ni9 can be selected.

Packing /Filler material:

On the valve, the packing is used to fill the space of the valve cover packing chamber to prevent the medium from leaking through the valve stem and the bonnet packing chamber.

ductile iron, DI, butterfly valve, manufacturer, center line, TH valve

Requirements for packing.

- 1. Good corrosion resistance, the filler must be able to withstand the corrosion of the medium in contact with the medium.
- 2. Good airtightness, the packing will not leak under the action of the medium and working temperature.
- 3. The friction coefficient is small to reduce the friction torque between the valve stem and the packing.

Types of filler:

1. Soft filler: it is a string woven from plant matter, that is hemp, flax, cotton, jute, etc., or mineral, that is, asbestos fiber, or asbestos fiber with metal wire inside and graphite powder coated on the outside. Pressed molding fillers, and flexible graphite filler materials developed in recent years.
Vegetable packing is often used for low pressure valves below 100°C; mineral packing can be used for valves with 450-500°C. In recent years, the temperature of structural media using rubber O-rings as fillers is generally limited to below 60°C.
The packing on the high temperature and high pressure valve is also made of pure asbestos and flake graphite powder.

2. Hard filler: that is, filler made of metal or metal mixed with asbestos and graphite and filler formed by pressing and sintering of PTFE, metal filler is used less.

Selection of filling material:
The choice of packing should be based on the medium, temperature and pressure. The commonly used materials are as follows:

- 1. Oil-impregnated asbestos rope, can be selected according to Table 5-2
- 2. Rubber asbestos rope, can be selected according to 5-3
- 3. Graphite asbestos rope: The asbestos rope is coated with graphite powder, the usable temperature is above 450°C, and the pressure can

reach 16MPA, which is generally suitable for high-pressure steam. Lately, it gradually adopts the compressed herringbone type packing, which is placed in a single circle and has good sealing performance.

- 4. Polytetrafluoroethylene: This is a kind of filler that is currently widely used. Especially suitable for corrosive media, but the temperature should not exceed 200°C. Generally, it is made by pressing or rod car.

Fig.5-2:

Material	Grade name	shape	size(dia or square)	Max Pressure kgf/cm2	max temp/ ° C	application
Oil-impregnated asbestos rope	YS450	F	3, 4, 5, 6, 8, 10, 13, 16, 19, 22, 25	60	450	water, steam, air, petroleum products
		Y	5, 6, 8, 10, 13, 16, 19, 22, 25			
		N	3, 5, 6, 8, 10, 13, 16, 19, 22, 25			
	YS350	F, Y, N	3, 5, 6, 8, 10, 13, 16, 19, 22, 25	45	350	
	YS250	F, Y, N	3, 5, 6, 8, 10, 13, 16, 19, 22, 25	45	250	

Note: The shape code F means square, through the heart or one or more layers of weaving; Y means round, with a twisted core in the middle and one or more layers of weaving on the outside; N means twisted.

Fig.5-3:

Material	Grade name	size(dia or square)	Max Pressure kgf/cm2	max temp/ ° C	application
Rubber, asbestos, packing	XS450	3, 4, 5, 6, 8, 10, 13, 16, 19, 22, 25, 28	60	450	steam, petroleum products
	XS350		45	350	
	XS250		45	250	

Valve Gasket material:

The gasket is used to fill all the unevenness between the two joint surfaces (such as the sealing surface between the valve body and the bonnet) to prevent the medium from leaking between the joint surfaces.

1. Requirements for gaskets: The gasket material has a certain degree of elasticity, plasticity and sufficient strength at working temperature to ensure sealing. At the same time, it must have good corrosion resistance.

2. Types and selection of gasket materials: gaskets are divided into two types: soft and hard. The soft is generally non-metallic materials, such as cardboard,

rubber, asbestos rubber sheet, and PTFE. Hardness is generally metal material or metal-coated asbestos, metal and asbestos entangled, etc.

There are many forms of gaskets, including flat, round, oval, tooth-shaped, lens-shaped and other special shapes.
Metal gaskets are generally made of 08, 10, 20 high-quality carbon steel and 1Cr13, 1Cr18Ni9 stainless steel, which require high machining accuracy and surface finish, and are suitable for high temperature and high pressure valves.
Non-metallic gasket materials generally have good plasticity and can be sealed with less pressure, which is suitable for low temperature and low pressure valves.
The gasket material can be selected according to Table 5-4.

Table 5-4:

Gasket material	medium	Pressure/Mpa	Temp/° C
cardboard	water, oil	≤10	40
Oil-impregnated cardboard	water, oil	≤10	40
rubber board	water,air	≤6	50
asbestos board	steam, gas	≤6	450
PTFE	corrosive	≤25	200
rubber asbestos board XB-450	water steam, air, gas	≤60	450
XB-350	water steam, air, gas	≤40	350
XB-250	water steam, air, gas	≤15	200
Oil-resistant rubber asbestos sheet	oil	160	30
08 steel and XB-450 filling	steam	100	450
08 steel and XB-350 filling	steam	40	350
1Cr13,0Cr13 and asbestos filling	steam	100	600
08 steel and oil-resistant rubber and asbestos filling	oil	100	350
copper	water steam,air	100	250
aluminium	water steam,air	64	350
10steel, 20steel	water steam, oil	2--	450
1Cr13	steam	200	550
1Cr3Ni9	steam	200	600

Attached Table 1-2 Common Materials for Valve Trim:

internal parts material	suitable temp/° C	internal parts material	suitable temp/° C
304	-268/316	SS440 60RC	-29/427

316	-268/316	17-4PH	-40/427
bronze	-273/232	6 alloy(Co-Cr)	-273/816
inconel alloy	-240/649	Electroless Nickel	-268/427
K monel alloy	-240/482	chrome	-273/316
monel alloy	-240/482	NBR	-40/93
hastelloy B	-198/371	Viton	-23/204
hastelloy C	-198/538	PTFE	200
Titanium alloy	-29/316	Nylon	-73/93
Nickel alloy	-198/316	Polyethylene	-73/93
20 alloy	-46/316	Neoprene	-40/82
SS416 40RC	-29/427		

Attached Table 1-3 Common materials and operating temperature of valve sealing surface:

Sealing surface material	temp range / ° C	hardness	suitable medium
bronze	-273/232		water, seawater, air, oxygen, saturated vapor
316L	-268/316	14HRC	Slightly corrosive and non-impact media like steam, water, oil, gas, liquid gas
17-4PH	-40/400	40-50HRC	slightly corrosive and impact medium
Cr13	-101/400	37-42HRC	slightly corrosive and impact medium
Stellite alloy	-268/650	40-45HRC (normal temp); 38HRC (650° C)	impact and corrosive medium
Monel alloy KS	-240/482	27-35HRC, 30-38HRC	Air-free acid solution like alkali, salt, food
Hastelloy CB	371, 538	14HRC, 23HRC	Corrosive mineral acid, sulfuric acid, phosphoric acid, wet hydrochloric acid gas, chlorine-free acid solution, strong oxidizing medium
20 alloy	-45.6/316	36-61HRC	Oxidizing medium and various concentrations of sulfuric acid

Material table of stem, sealing surface, gasket, packing and fastener of cast iron valve:

name	standard	material name	remarks
Vlave stem	ASTM A182	F6a	
	ASTM A276	410, 420	
	GB/T 1220	1Cr13, 2Cr13	
sealing	GB/T 1176	ZCuZn25A15Fe3Mn3	Cast aluminum

surface			brass
		ZCuZn38Mn2Pb2	Cast manganese brass
		ZCuS19Mn2, ZCuA110Fe3	cast aluminum bronze
	GB/T 1220	1Cr13, 2Cr13, 1Cr18Ni9, 1Cr18Ni9Ti	
		PTFE	
		rubber	
gasket	GB/T 3985	XB350, XB450	rubber asbesto sheet
		1Cr13/XB450	Spiral wound gasket
	GB/T 3985	1Cr18Ni9/XB450	
filler		PTFE	
	JB/T 6617	flexible graphite ring	
fastener	GB/T 699	bolt 35/nut25	
	GB/T 3077, GB/T 699	bolt 30CrMo, 35CrMo/nut 35, 45	

Monel alloy for corrosion resistant valve

1. Introduction/overview of Monel alloy:

Monel alloy, cast nickel alloy, Hastelloy alloy, etc. are all materials for making special purpose valves. Monel alloy is a Ni-Cu alloy in nickel-based corrosion-resistant alloys. It was first developed by the US Nickel Company. Its typical composition is 70% Ni and 30% Cu. It is the most widely used nickel-based corrosion-resistant alloy.

Monel alloy not only has high strength and toughness, but also has excellent resistance to corrosion by reducing acid and strong alkali media and sea water, so it is usually used to manufacture and transport hydrofluoric acid (HF), salt water, neutral media, and alkali salts. And reducing acid medium equipment. Monel alloy is also suitable for dry chlorine, hydrogen chloride, high temperature chlorine (425°C) and high temperature hydrogen chloride and other media, but it is not resistant to corrosion by sulfur-containing media and oxidizing media (such as nitric acid, media with high oxygen content), and it is nickel It reacts violently with sulfur and oxygen and easily forms Ni3S2 and NiO.

2. Performance of Monel alloy:

Monel alloy is a Ni-Cu solid solution, where Cu is used as a non-oxidizing resist added to Ni, which improves the corrosion resistance of nickel alloys and acts as a strengthening alloy. The addition of C can improve the casting performance of the alloy, but only 0.15% of C can be dissolved in the alloy at room temperature, and the excess C will be precipitated as a graphite phase.

Adding 1.5%-3.5% Fe can also improve the casting performance of the alloy. Adding Mn and Si can improve the mechanical properties of the alloy, especially the content of Si has an important influence on the mechanical and physical properties of the Monel alloy.

3. Classification of Monel alloy:
Monel alloys are classified into casting alloys and deformed alloys.
3.1 Deformation alloy: There are more than 10 types of deformed Monel alloys in the United States, such as Monel400, MonelC, Monel403, Monel404, Monel R2405, Monel406, Monel411, MonelK500, MonelK501 and Monel502. Because Monel has its own representation methods in different American standard systems, SAE and ASTM jointly developed ASTM2SAE unified digital system (unified numbt system2 UNS) in order to facilitate the use and unified management of calculations. In the United States' UNS, nickel alloys have 5 grades of deformed Monel alloys, including solid solution hardened No5500 (Monel400), No4404 (Monel404) and No4405 (MonelR2405), and precipitation hardened NO5500 (MonelK500) and NO5502 (Monel502).) Etc. (refer to Table 1). Among them, the deformed Monel alloy commonly used in the manufacture of corrosion-resistant valves is Monel400 and MonelK500.
Table 1. Chemical composition of deformed Monel alloy in United States UNS

Table 1. Chemical composition of deformed Monel alloy in United States UNS

Grade name	chemical composition/ %						
	C	Si	Mn	S	Ni	Fe	others
N04400(Monel400)	≤0.3	≤0.5	2	≤0.024	63-70	≤2.5	Cu base
No4404(Monel404)	≤0.15	≤0.1	≤0.1	≤0.024	52-57	≤0.5	Cu base, Al≤0.05
No4405(MonelR2405)	≤0.3	≤0.5	≤2.0	0.025-0.06	63-70	≤2.5	Cu base
No5500(MonelK500)	≤0.25	≤0.5	≤1.5	≤0.01	63-70	≤2	Cu base, Al213-3115, Ti0135-0185
N05502(Monel502)	≤0.10	≤0.5	≤1.5	≤0.01	63-70	≤2	Cu base, Al215-315

3.2 Casting alloy: The American cast Monel alloy has five grades of M35-1, M35-2, M-30H, M-25S and M-30C in ASTM A494 (Table 2), which is in the US Federal Standard QQ-N2-88 There are also 5 cast Monel alloys (Table 3).
Table 2. Cast Monel alloy in ASTM A494:

grade name	chemical composition /%								mechanical properties			
	C	Mn	Si	P.S	Cu	Fe	Ni	Nb	Compressive strength/Mpa	Tensile strength/Mpa	Elongation rate/%	HB
M35-1(a)	≤0.35	≤1.5	≤1.25	≤0.03	26-33	≤3.5	Ba		≥450	≥170	≥25	
M35-2	≤0.35	≤1.5	≤2.00	≤0.03	26-33	≤3.5	Ba		≥450	≥205	≥25	
M-30H	≤0.30	≤1.5	2.7-3.7	≤0.03	27-33	≤3.5	Ba		≥690	≥415	≥10	

M-25S	≤0.25	≤1.5	3.5-4.5	≤0.03	27-33	≤3.5	Ba					243-294(b)
M-30C(a)	≤0.30	≤1.5	1.0-2.0	≤0.03	26-33	≤3.5	Ba	1-3	≥450	≥225	≥25	125-130(b)

Notes:
1.Ba=balance, means the balance is all Ni content.
2. To remove the weldability, it should be M3521 or M230C
3. This table is a data parameter
4. HB minimum is 300
Table 3 QQ2N2288 cast Monel alloy:

QQ-N-288	chemical composition /%							mechanical properties			
	C	Si	Mn	Cu	Fe	Ni	Nb	Compressive strength /Mpa	Tensile strength/ Mpa	Elongation rate/%	HB
A	≤0.35	≤2.0	≤1.5	26-33	≤2.5	62-68		≥448	≥224	≥25	125-150
B	≤0.30	2.7-3.7	≤1.5	27-33	≤2.5	61-68		≥689	≥455	≥10	240-290
C	≤0.20	3.3-4.5	≤1.5	27-31	≤2.5	≥60		≥825	≥550	≥10	250-300
D	≤0.25	3.5-4.5	≤1.5	27-31	≤2.5	≥60					≥300
E	≤0.30	1.0-2.0	≤1.5	26-33	≤2.5	≥60	1-3	≥448	≥221	≥25	125-150

4. Application of Monel alloy:
The A and E levels of M35-1, M35-2 and QQ-N2-88 are usually used to manufacture refined Monel alloy pumps,valves and accessories. The B-grade (3.5%Si) Monel alloy with the highest Si content is mainly used to manufacture shafts and wear-resistant rings that require good wear resistance due to its high strength, corrosion resistance and wear resistance. Class D (4.0% Si) Monel alloy is used to manufacture parts that require higher wear resistance and corrosion resistance.
Monel alloy valves have two types: integral and internal. The integral Monel alloy valve means that the valve shell and internal parts are all Monel, which is mainly used in the HF acid regeneration tower part of the alkylation unit of the refinery. Due to the high HF acid regeneration temperature (149°C) and high water content, an overall alloy valve is required. In addition, the overall Monel alloy valve is also used in the production of ashless additives for catalysts in refineries and high-concentration chlor-alkali systems in chlor-alkali plants. Situation.
The Monel alloy internal valve means that the valve housing is made of carbon steel or stainless steel, and the internal valve is made of Moenl alloy. The Monel alloy valve with carbon steel as the shell is mainly used in the low temperature area of the HF calculation system of the alkylation unit of the refinery. The use of carbon steel is good for low temperature (≤71°C)

anhydrous hydrofluoric acid (HF) However, carbon steel will form a film on its surface due to corrosion when used in this working condition for a long time. If carbon steel is used in the valve sealing part, the film formed after corrosion will affect the sealing performance of the valve. It should be pointed out that the commonly used Cr13 type sealing material for carbon steel valves cannot resist the corrosion of HF acid, and the internal material is much cheaper for Monel alloy valves. The Monel alloy valve with carbon steel as the shell can also be used in working conditions such as sea water. The valve housing is made of stainless steel Monel alloy internal valve, which is used in ethylene, propylene, liquid oxygen, pure oxygen, sea water and other working conditions. The monolithic Monel alloy valve and Monel alloy internal valve used in the alkylation unit require a pressure level of CL300 from a safety point of view. The pressure level of Monel alloy internal valve for other working conditions is CL150 and CL300. Or PN116-614Mpa etc.

5. Melting and casting of monel alloy:

The smelting and casting technology of Monel alloy is the key to determine whether the qualified Monel alloy castings can be produced. Because Moenl alloy has developed dendrites, shrinkage cavities and porosity, the tendency of gas absorption (hydrogen absorption, oxygen absorption) is great, and it will Sulfurizing chemical reaction occurs with molding materials. From a safety point of view, Monel alloy valves are required to undergo radiographic inspection in accordance with Class A pipeline valves in highly toxic and dangerous media such as hydrofluoric acid, chlorine and hydrogen chloride gas. . Although the American standard points out that casting M35-1 can be welded, in fact its weldability is extremely poor, and the quality of repaired castings is difficult to guarantee. The density of M35-1 alloy is 8163t/m3 (at 20°C), the solidification shrinkage rate is 21mm/m, and the alloy melting point is 1315-1345°C. The Class A and Class E of M35-1, M35-2 and QQ-N2-88 are delivered as cast. Although there are many grades of cast Monel alloy, when used to cast Monel alloy valve castings, M35-1 in ASTMA494 is mainly used.

Cast Monel alloy and deformed Monel alloy have little change in chemical composition (Table 4), but this change satisfies its better deformability for deformation and gold, while it provides better casting for cast alloys. performance. This is the reason why cast Monel alloy grades are used when casting, and deformed Monel alloy grades are used when selecting rolling materials.

Table 4. Commonly used cast and deformed Monel alloy chemical composition of valves (%)

Grade name	chemical composition /%								
	C	Mn	Si	P	S	Cu	Fe	Ni	others
M35-1	≤0.35	≤1.5	≤1.25	≤0.03	≤0.03	26-33	≤3.5	Ba	
Monel400	≤0.30	≤2.0	≤0.5		≤0.024	Ba	≤2.5	63-70	

MonelK500	≤0.25	≤1.5	≤0.5		≤0.01	Ba	≤2.0	63-70	Al2.5-3.5, Ti0.35-0.85

6. Conclusion

The current U.S. technical standards for Monel alloys include ASTM, SAE, AMS (American Aeronautical Standards Institute), MIL (U.S. Department of Defense Standards), ANSI, ASME and QQ (American Federal Standards). For the Monel alloy of the same grade, different technical specification systems are adopted, not only the representation method of the grade is different, but the number and content of the specification are not completely the same. Usually military products use MIL, QQ or AMS specifications, and civil products use ASTM and ASME specifications.

General valve material

The internal material combination specified by API600 for general valve material:

Stem material types	hardness	sealing surface		
		seal part no.,	material type	hardness
13Cr	200-275	1	13Cr	≥HB250
		4	13Cr	≥HB750
		5 or 5A	HF	≥HB350
		6	13Cr/NiCu	≥HB750/≥HB175
		7	13Cr/13Cr	≥HB250/≥HB750
		8-8A	13Cr/HF	≥HB250/≥HB350
18Cr-8Ni	no require	2	18Cr-8Ni	no require
25Cr-20Ni		3	25Cr-20Ni	
Nickel copper alloy		9	Nickel copper alloy	
		11 or 11A	Nickel copper alloy/HF	no require/≥HB350
18Cr-8Ni-Mo		10	18Cr-8Ni-Mo	no require
		12 or 12A	18Cr-8Ni-Mo/HF	no require/≥HB350
19Cr-29Ni		13	19Cr-29Ni/HF	no require
		14 or 14A	19Cr-29Ni/HF	no require/≥HB350

Commonly used valve trim material combination:

valve stem	sealing surface	valve stem	sealing surface
13Cr	13Cr/13Cr	321	321/321
13Cr	13Cr/STL	321	321/STL
13Cr	STL/STL	321	STL/STL
13Cr	13ZCr/Monel	1Cr18Ni9Ti	1Cr18Ni9Ti/1Cr18Ni9Ti
17-4PH	STL/STL	1Cr18Ni9Ti	1Cr18Ni9Ti/STL
17-4PH	17-4PH/17-4PH	1Cr18Ni9Ti	STL/STL

Monel	Monel/Monel	1Cr18Ni12Mo2Ti	1Cr18Ni12Mo2Ti/1Cr18Ni12Mo2Ti
304	304/304	1Cr18Ni12Mo2Ti	1Cr18Ni12Mo2Ti/STL
304	304/STL	1Cr18Ni12Mo2Ti	STL/STL
304	STL/STL	20 Alloy	20alloy/20alloy
316	316/316	Hastelloy B	Hastelloy B/Hastelloy B
316	316/STL	Hastelloy C	Hastelloy C/Hastelloy C
316	STL/STL	F51	F51/F51
304L	304L/304L	F51	F51/STL
304L	304L/STL	38CrMoALA	STL/STL
304L	STL/STL	25Cr2MoIV A	STL/STL
316L	316L/316L	4Cr10Si2Mo	STL/STL
316L	316L/STL	4Cr14Ni14W2Mo	STL/STL
316L	STL/STL	Inconel	Inconel/Inconel

Commonly used fastener material:

Bolts	Nuts	Max temp ° C
35	25	425
35CrMo	35, 45	425
35CrMo	30CrMo	500
25Cr2MoVA	30CrMo	550
0Cr18Ni9	0Cr18Ni9	600
0Cr17Ni12Mo2	0Cr17Ni12Mo2	600
25Cr2Mo1VA	25Cr2Mo1VA	600
25Cr2MoVA	25Cr2MoVA	600

Matching materials of bolts and nuts for American standard valves:

Bolts		nuts		application temp
standard	grade name	standard	grade name	
ASTM A193	B7	ASTM A194	2H	-29/425° C
	B7M		2HM	-29/425° C NACE standard, anti-sulfer valve
	B16		7	-29/593° C
	B8		8	-196/700° C
	B8M		8M	
ASTM A320	L7		4	-46/101° C Cryogenic valve

Chemical composition and mechanical properties of commonly used bolts and nuts for American standard valves:

name	standard	grade name	chemical composition										mechanical properties					notes
			C	Mn	P≤	S≤	Si	Cr	Ni	Mo	V	Al	σ b ≥Mpa	σ s ≥Mpa	δ ≥	ψ ≥	hardness	≤M64
bolts	ASTM A193	B7	0.37-0.49	0.65-1.1	0.035	0.04	0.15-0.35	0.75-1.2		0.15-0.25			860	720	16	50	321HB/35HRC	≤M100
		B7M	0.37-0.49	0.65-1.1	0.035	0.04	0.15-0.35	0.75-1.2		0.15-0.25			690	550	16	50	235HB/99HRB	≤M64
		B16	0.36-0.47	0.45-0.7	0.035	0.04	0.15-0.35	0.8-1.15		0.5-0.65	0.25-0.35	0.015	860	725	18	50	321HB/35HRC	
		B8	≤0.08	≤2.0	0.04	0.03	≤1.0	18-20	8-11				515	205	30	50	223HB/	
		B8M	≤0.08	≤2.0	0.04	0.03	≤1.0	16-18	10-14	2-3			515	205	30	50	223HB/	≤M64
	ASTM A320	L7	0.38-0.48	0.75-1.0	0.035	0.04	0.15-0.35	0.8-1.1		0.15-0.25			860	725	16	50		≤M64
nuts	ASTM A194	2H	≥0.04	1.0	0.04												248-327HB	≤M64
		2HM	≥0.04	1.0	0.04												159-235HB	
		7	0.37-0.49	0.65-1.1	0.035	0.75-1.2		0.15-0.25									248-327HB	
		8	0.08	2.0	0.045	18-20	8-11										126-300HB	
		8M	0.08	2.0	0.045	16-20	10-14	2-3									126-300HB	
		4	0.4-0.5	0.7-0.9	0.035			0.2-0.3									248-327HB	

Conditions of use of metal gaskets

material	HB max	Pressure Mpa(lb)	suitable temp ° C
10/08	120	2.0-42(150-2500)	450
0Cr13	170	2.0-15(150-900)	540
0Cr18Ni9	160		600
0Cr17Ni12Mo2			

Spiral wound gasket service conditions:

metal belt material	Non-metallic belt material	Pressure grade Mpa (lb)	suitable temp ° C
0Cr18Ni9	flexible graphite	2.0-26(150-1500)	650
0Cr17Ni12Mo2	flexible graphite		
00Cr17Ni14Mo2	PTFE		200

Conditions for use of metal-clad gasket:

Cladding metal material	HB	filling material	pressure Mpa(lb)	suitable temp ° C
Al L3	40	asbestos	2.0-15(150-900)	200
Co T3	60			300
Galvanized steel sheet	90			400
Galvanized steel sheet 08F				

harry@tanghaivalve.com; cell:86-18910941489

0Cr18Ni9	187			500
00Cr19Ni10				
00Cr17Ni14Mo2				

Use conditions of flexible graphite composite gasket:

Core board and edging material	pressure grade Mpa (lb)	suitable temp ° C
low-carbon steel	2.0-11(150-600)	450
0Cr18Ni9	2.0-11(150-600)	650

Non-metallic gasket usage conditions:

material name	code name	pressure Mpa	suitable temperature ° C
natural rubber	NR	2.0	-50/90
Neoprene	CR	2.0	-40/100
NBR	NBR	2.0	-30/110
Ethylbenzene rubber	SBR	2.0	-30/110
EPDM rubber	EPDM	2.0	-40/130
fluororubber	Viton	2.0	-50/200
Asbestos Rubber Sheet	XB350	2.0 ≤300 P.T≤650 Mpa ° C	
Oil-resistant asbestos rubber sheet	XB450 NY400		
Modified or filled with PTFE		5.0	-196/260

Comparison table of common metal materials specified by Chinese, Japanese, German, British, American and international standards:

types	no.s	China	Japan	international standard	USA	UK	Germany
		GB1220 GB1221 GB12228 GB12229 GB12230	JIS	ISO683/13 ISO683/16	ANSI ASTM	BS970 BS1449	DIN17440 DIN17224
Cast carbon steel alloy steel	1	WCA	G5151 SCPH1		A216 WCA	161Cr-430F	GS-C25
	2	ZG230-450 WCB	G5151 SCPH2 SC410		A216 WCB		
	3	WCC			A216 WCC		
	4	ZG20CrMo			A217 WC5	3100 B2	
	5		G5151 SCPH21		A217 WC4	1504 621E	
	6	zg15CrMo V				3100 B3	
Cast stainless steel	7	ZG00Cr18Ni10	G5121 SCS19A		A351 CF3	1504 304C12E	
	8	ZG0Cr18Ni9Ti	G5121 SCS13A		A351 CF8	1504 304C15E	G-X6CrNiMo1810
	9	CF3M	G5121 SCS16A		A351 CF3M	1504 316C12E	
	10	ZG0Cr18Ni12Mo2Ti	G5121 SCS14A		A351 CF8M	1504 316C16E	
	11	CF8M	G5121 SCS14A		A744 CF-8M	3100 316C16	
	12	CF8C	G5121 SCS21		A351 CF8C	1504 347C17E	G-X7CrNiNb1189
	13	CF8	G5121 SCS13A G5121 SCS13		A744 CF-8	3100 304C15	G-X6CrNi189
	14	CF3M	G5121 SCS19A		A744 CF-3	3100 304C12	
Forged stainless steel	15	ZG0Cr17Ni4Cu4Nb	G5121 SCS24		17-4PH		
	16	1Cr18Ni9	SUS302	12	302, S30200	302S25	X12CrNi188
	17	0Cr18Ni9	SUS304	11	304, S3400	304S15	X5CrNi189
	18	00Cr18Ni10	SUS304L	10	304L, S30403	304S12	X2CrNi189
	19	0Cr25Ni20	SUS310S		310S, S31008		
	20	0Cr17Ni12Mo2	SUS316	20, 20	316, S31600	316S16	X5CrNiMo1810
	21	1Cr18Ni12Mo2Ti				320S17	X10CrNiMoTi1810
	22	0Cr18Ni12Mo2Ti				320S17	X10CrNiMoTi1810
	23	00Cr17Ni14Mo2	SUS316L	19, 19	316L, S31603	320S12	X2CrNiMo1810
	24	0Cr17Ni12Mo2N	SUS316N		316N, S31651		
	25	0Cr17Ni4Cu4Nb			17-4PH		X2CrNiMoN1812
	26	0Cr17Ni13Mo2N	SUS316LN				
	27	0Cr18Ni12Mo2Cu2	SUS316J1				X10CrNiTi189
	28	1Cr18Ni9Ti					X10CrNiTi189
	29	0Cr18Ni10Ti	SUS321	15	321, S32100	321S21, 321S20	
	30	1Cr13	SUS410	3	410, S41000	410S21	X10Cr13
	31	0Cr13	SUS410S	1	410S	403S17	X7Cr13
	32	2Cr13	SUS420J1	4	420S, S42000	420S37	X20Cr13
	33	3Cr13	SUS420J2	5	420S45		
	34	4Cr13	SUS420J2	5	431, S43100	431S29	X22CrNi17
	35	0Cr17Ni14Cu4Nb	SUS630B		630, S17400		X7CrNiAl177
	36	00Cr25Ni20Mn3Mo3N				U3	
	37	0Cr17Mn14Mo2N			A4		
	38	00Cr20Ni25Mo4Cu2		904L		UB6	
	39	00Cr15Ni60M16W4			Hastelloy C		
	40	0Cr20Ni30Mo2Cu3		20 ALLOY			
	41	0Ni70Cu30Mn		MONEL			

WC carbon steel +A/B/C --WCA,WCB,WCC

harry@tanghaivalve.com; cell:86-18910941489

TYPE	SPEC	GRADE	GENERAL APPLICATION	SERVICE CONDITIONS
carbon steel	ASTM ASME SA216	WCA	carbon steel castings, suitable for fusion welding and high	max. temp upto 454° C, non-corrosive and non-oxidation
		WCB WCC		max. temp upto 426° C, non-corrosive and non-oxidation
low alloy	ASTM ASME SA217	WC1	pressure-container parts, suitable for high-temp application	for temp upto 454° C, on flanged and weld end valves
		WC6		for temp upto 565° C, flanged and weld end valves
		WC9		for temp upto 593° C where good creep stength is required
		C-5		for temp upto 648° C with good corrosion and oxidation-resistant, plus high creep strength.
		C-12		for temp upto 648° C with good corrosion and oxidation resistance other than stainless grades
		C12A		for temp° C with excellent high-temp properties
	ASTM/ASME SA352	LCB LCC	ferritic steel castings, for pressure-container parts, low-temp application	for down to minus 45° C, must be quenching and tempered to obtain tensile and impact properties needed at a sub-zero temp
		LC1		for down to minus 59° C, a subsequent heat treat is given to obtain tensile and impact properties at sub-zero temp
		LC2		for down to minus 73° C, a subsequent heat treat is given to obtain tensile and impact properties at sub-zero temp
		LC3		for down to minus 101° C, a subsequent heat treat is given to obtain tensile and impact properties at sub-zero temp
stainless steel	ASTM/ASME SA351	CF3(304-L) CF8(304)	austenitic steel castings, for high-temp application	good creep strength, corrosion and oxidation resistance when exposed to temp above 426° C
		CF3M(316-L)		same as above except it is resistant to formulation of sigma phase.
		CN7M (A20)		good resistance to hot sulfuric acid. used extensively in manufacturing synthetic rubber, high octanc gasoline, solvent, explosives, plastics, heavy and organic chemicals, and food processing.
		CF8C (347)		resistant to intergranular corrosion above 426° C, excellent for weld end valves
	ASTM/ASME A487	CA6NM(12 Cr)	Martensitic SS, for high-temp appliation	good corrosion resistance, high tensile and impact properties, good pitting resistance. excellent weldability and castability, good for sourgas service
	ASTM A747	17-4 PH	precipitation hardening ss	with high tensile strength;wear resistance, higher corrosion resistance than high straight chrome alloy
	ASTM A564	Cr 630	bar (wrought=A705, Gr. 630)	
Nickel and Nickel alloy castings	ASTM A494	M35-1(Monel)	for corrosion resistant application	weldable grade. good corrosion resistance to all common organic acids and salt water. also highly resistance to most alkaline solutions
		N-12M(Hast-B)		suited for handling hydrochloric acid at all concentrations and temps. good resistance to sulfuric and phosphoric acids
		CW-12M(Hast-C)		good resistance to strong oxidation conditions. good properties at high temperature, high resistance to formic, phosphoric, sulfurous and sulfuric acids
		CY-40(incon		very good for high temp service, good resistance to strongly corrosive media and atmosphere
		CZ-100(Nick		same as Inconel except even higher corrosion resistance