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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Grease Institute (JGI)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently, **JIS K 2220**:2003 is replaced with this Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, applications for a patent after opening to the public or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, applications for a patent after opening to the public or utility model rights.

Lubricating grease

Introduction

This Japanese Industrial Standard has been prepared based on the third edition of **ISO 2137** published in 2007, the second edition of **ISO 2176** published in 1995, the second edition of **ISO 6743-9** published in 2003, the first edition of **ISO 11009** published in 2000 and the first edition of **ISO 12924** published in 2010 with some modifications of the technical contents to meet the actual situation in Japan.

The portions with continuous sidelines or dotted underlines are the matters in which the contents of the corresponding International Standards have been modified. A list of modifications with the explanations is given in Annex JE.

1 Scope

This Standard specifies the lubricating greases (including gear compounds) to be mainly used as the lubricants for various types of machine parts.

WARNING Persons carrying out tests based on this Standard should be familiar with normal laboratory practice. This Standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this Standard to establish appropriate safety and health practices.

NOTE : The International Standards corresponding to this Standard and the symbol of degree of correspondence are as follows:

ISO 2137:2007 *Petroleum products and lubricants—Determination of cone penetration of lubricating greases and petrolatum*

ISO 2176:1995 *Petroleum products—Lubricating grease—Determination of dropping point*

ISO 6743-9:2003 *Lubricants, industrial oils and related products (class L)—Classification—part 9: Family X (Greases)*

ISO 11009:2000 *Petroleum products and lubricants—Determination of water washout characteristics of lubricating greases*

ISO 12924:2010 *Lubricants, industrial oils and related products (Class L)—Family X (Greases)—Specification* (Overall evaluation: MOD)

The symbols which denote the degree of correspondence in the contents between the relevant International Standards and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 1521 *Rolling bearings—Deep groove ball bearings*

JIS B 7410 *Liquid-in-glass thermometers for testing of petroleum product*

JIS B 7505-1 *Aneroid pressure gauges—Part 1: Bourdon tube pressure gauges*

JIS G 3459 *Stainless steel pipes*

JIS G 4051 *Carbon steels for machine structural use*

JIS G 4053 *Low-alloyed steels for machine structural use*

JIS G 4303 *Stainless steel bars*

JIS G 4305 *Cold-rolled stainless steel plate, sheet and strip*

JIS H 3100 *Copper and copper alloy sheets, plates and strips*

JIS H 3250 *Copper and copper alloy rods and bars*

JIS K 0557 *Water used for industrial water and wastewater analysis*

JIS K 1101 *Oxygen*

JIS K 2238 *Machine oils*

JIS K 2246 *Rust preventive oils*

JIS K 2251 *Crude petroleum and petroleum products—Sampling*

JIS K 2265-4 *Determination of flash points—Part 4: Cleveland open cup method*

JIS K 2275 *Crude oil and petroleum products—Determination of water content*

JIS K 2283 *Crude petroleum and petroleum products—Determination of kinematic viscosity and calculation of viscosity index from kinematic viscosity*

JIS K 2519 *Lubricating oil—Testing methods for load carrying capacity*

JIS K 6323 *Classical V-belts for power transmission*

JIS K 8034 *Acetone (Reagent)*

JIS K 8102 *Ethanol (95) (Reagent)*

JIS K 8594 *Petroleum benzine (Reagent)*

JIS R 6111 *Artificial abrasives*

JIS R 6251 *Abrasive cloths*

JIS R 6252 *Abrasive papers*

JIS T 3201 *Glass syringes*

JIS Z 8401 *Guide to the rounding of numbers*

JIS Z 8402-6 *Accuracy (trueness and precision) of measurement methods and results—Part 6: Use in practice of accuracy values*

JIS Z 8801-1 *Test sieves—Part 1: Test sieves of metal wire cloth*

ISO 8681 *Petroleum products and lubricants—Method of classification—Definition of classes*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply.

3.1 grease

a semisolid or solid matter produced by dispersing a thickener in base oil

It may contain other components to give special properties.

3.2 gear compound

a matter produced by dissolving/dispersing a viscous substance such as asphalt in mineral oil

It is principally used for a lubricant for open gear and may contain other components to give special properties.

3.3 base oil

a lubricating oil to be the raw material for grease in which refined mineral oil, synthetic lubricating oil and their mixed oil are mainly included

3.4 thickener

a substance to make a base oil a semisolid or solid state by being dispersed in base oil in colloidal state

Thickeners are mainly classified into the metallic soap type and the non-soap type. The former is represented by metallic soaps of lithium, calcium, sodium and others, and the latter by inorganic compounds such as bentonite and silica gel, and organic compounds such as urea derivatives and phthalocyanine. The performance of grease greatly depends upon the type of thickener to be used.

3.5 water resistance

the performance of resistance without any adverse influence on the performance of grease when a grease is contaminated with moisture or water

3.6 mechanical stability

the performance of resistance against the change in hardness when subjected to a mechanical shearing force on grease

It is also called shearing stability.

3.7 pressure feeding property

the fluidity performance of grease when it is fed under pressure through piping, nozzle and accessories of a lubricating system

3.8 load carrying capacity

the maximum force (load) or pressure under which lubrication is sustainable without causing defects such as seizure or fusion on the bearing or the sliding surface when a grease is used under the conditions in which breakage of oil film easily occurs

3.9 cone penetration

the distance that a standardized cone of **7.2 b**) **1**) and an option cone penetrates into a sample under standardized conditions of force (load), time and temperature

It is expressed by the value in unit of 0.1 mm multiplied by 10.

3.10 working

the operation in which the sharing action of a grease worker is given to a grease

3.11 worked penetration

the cone penetration of a sample which has been worked for a defined number of strokes by a grease worker

3.12 unworked penetration

the cone penetration of a sample that has received the minimum disturbance only in transfer from the sample container to the pot of the grease worker

3.13 prolonged worked penetration

the cone penetration of a sample which has been worked for more than the defined number of strokes in worked penetration

3.14 block penetration

the cone penetration determined on a sample which is sufficiently hard to keep its shape without a container

3.15 one-quarter scale and one-half scale penetrations

the cone penetration measured by using the specified cone which is the standardized cone of **7.2 b**) **1**) or the option cone being reduced by 1/4 and 1/2

3.16 cone penetration number

number classified according to the worked penetration range of grease as shown in table 1

Table 1 Cone penetration number

Cone penetration number	Worked penetration range
No. 000	445 to 475
No. 00	400 to 430
No. 0	355 to 385
No. 1	310 to 340
No. 2	265 to 295
No. 3	220 to 250
No. 4	175 to 205
No. 5	130 to 160
No. 6	85 to 115

3.17 dropping point

the temperature at which a drop of lubricating grease is extruded from the bottom of a specified grease cup under the test conditions of this Standard

For certain greases [see **8.4 g**)], the temperature recorded is that when the first portion of extruded grease touches the bottom of the test tube holding the grease cup.

3.18 worked stability

the cone penetration of a sample measured immediately after working by 60 strokes, which has been worked by one hundred thousand strokes in the specified worker and held at 25 °C

3.19 low temperature torque

the force required to restrain the turning of the outer ring of the specified open type ball bearing, in which the sample is packed and of which the inner ring is turned at the specified rate of revolution (one revolution per minute) at the specified temperature

It is expressed by the following two torques.

a) **Starting torque** the maximum torque obtained at the start of revolution

b) **Revolving torque** the averaged torque obtained after revolutions for the specified time

3.20 apparent viscosity

the ratio of the slip stress (shear stress) to the slip rate (shear rate) calculated from Poiseuille's formula

Since a grease is non-Newtonian fluid, the ratio will vary with the slip rate.

3.21 slip rate (shear rate)

the rate of a series of adjacent layers of grease to move each other

4 Classification of grease

Greases shall be classified into seven types as the following **a**) to **g**) according to the application. Furthermore, it shall be subdivided as shown in table 2 according to the class (component and performance) and the cone penetration number (worked penetration range or kinetic viscosity range).

The classification of greases according to **ISO** is shown in Annex A.

a) **Grease for general purpose**

1) **Class 1** That principally consists of base oil and calcium soap as thickener, and has sufficient water resistance.

2) **Class 2** That principally consists of base oil and sodium soap as thickener, and has sufficient heat resistance.

b) **Grease for rolling bearing**

1) **Class 1** That principally consists of base oil and thickener, and has sufficient mechanical stability, water resistance and rust preventive property.

2) **Class 2** That principally consists of base oil and thickener, and has sufficient low temperature property, water resistance, mechanical stability and rust preventive property.

3) **Class 3** That principally consists of base oil and thickener, and has sufficient low temperature property, heat resistance, mechanical stability, water resistance and rust preventive property.

c) **Chassis grease for automobile Class 1** That principally consists of base oil and calcium soap as thickener, and has sufficient load carrying capacity and pressure feeding property.

d) **Grease for wheel bearing for automobile Class 1** That principally consists of base oil and thickener, and sufficient heat resistance, water resistance, mechanical stability and anti-leakage property.

e) **Grease for central lubricating system**

1) **Class 1** That principally consists of base oil and calcium soap as thickener, and has sufficient property of pressure feeding property.

2) **Class 2** That principally consists of base oil and thickener, and has sufficient pressure feeding property, heat resistance and mechanical stability.

3) **Class 3** That principally consists of base oil, calcium soap as thickener and extreme pressure additives, and has sufficient pressure feeding property and load carrying capacity.

4) **Class 4** That principally consists of base oil, thickener and extreme pressure additives, and has sufficient pressure feeding property, load carrying capacity and mechanical stability.

f) **Grease for heavy load Class 1** That principally consists of base oil, thickener and solid lubricants such as molybdenum disulfide, and has sufficient load carrying capacity, mechanical stability and heat resistance.

g) **Gear compound Class 1** That principally consists of base oil and asphalt.

Table 2 Classification of grease

Classification			Applicable temperature range °C	Applicability to usage condition				Example of application
				Force (load)			Water contamination	
Application	Class	Cone penetration number [a)]		Light	Heavy	Impact		
Grease for general purpose	Class 1	No. 1, No. 2, No. 3, No. 4	−10 to 60	Applicable	Inapplicable	Inapplicable	Applicable	For general light load
	Class 2	No. 2, No. 3	−10 to 100	Applicable	Inapplicable	Inapplicable	Inapplicable	For general medium load
Grease for rolling bearing	Class 1	No. 1, No. 2, No. 3	−20 to 100	Applicable	Inapplicable	Inapplicable	Applicable	For general purpose
	Class 2	No. 0, No. 1, No. 2	−40 to 80	Applicable	Inapplicable	Inapplicable	Applicable	For low temperature
	Class 3	No. 1, No. 2, No. 3	−30 to 130	Applicable	Inapplicable	Inapplicable	Applicable	For wide temperature range
Chassis grease for automobile	Class 1	No. 00, No. 0, No. 1, No. 2	−10 to 60	Applicable	Applicable	Applicable	Applicable	For chassis grease for automobile
Grease for wheel bearing for automobile	Class 1	No. 2, No. 3	−20 to 120	Applicable	Inapplicable	Inapplicable	Applicable	For wheel bearing of automobile

Table 2 (concluded)

Classification			Applicable temperature range °C	Applicability to usage condition				Example of application
Application	Class	Cone penetration number [a]		Force (load)			Water contamination	
				Light	Heavy	Impact		
Grease for central lubricating system	Class 1	No. 00, No. 0, No. 1	−10 to 60	Applicable	Inapplicable	Inapplicable	Applicable	For medium load of central lubricating system
	Class 2	No. 0, No. 1, No. 2	−10 to 100	Applicable	Inapplicable	Inapplicable	Applicable	
	Class 3	No. 0, No. 1, No. 2	−10 to 60	Applicable	Applicable	Applicable	Applicable	For heavy load of central lubricating system
	Class 4	No. 0, No. 1, No. 2	−10 to 100	Applicable	Applicable	Applicable	Applicable	
Grease for heavy load	Class 1	No. 0, No. 1, No. 2, No. 3	−10 to 100	Applicable	Applicable	Applicable	Applicable	For impact heavy load
Gear compound [b]	Class 1	No. 1, No. 2, No. 3	−10 to 100	Applicable	Applicable	Applicable	Applicable	For open gear and wire rope

Notes [a] For the greases of the cone penetration number No, 000, No. 5 and No. 6, they are not classified because the application is unusual; however, the quality performance and the test method shall be specified upon the agreement between the parties concerned with delivery.

[b] For the gear compound, it is classified according to the kinematic viscosity.

5 Quality and performance

5.1 Grease for general purpose

5.1.1 Grease for general purpose Class 1

Grease for general purpose Class 1, when tested according to clause **7** to clause **9**, clause **14**, clause **16** and clause **22**, shall conform to the requirements specified in table 3. The base oil shall be 6.12 mm^2/s to 74.8 mm^2/s in kinematic viscosity (40 °C). As occasion demands, the kinematic viscosity of basic oil shall be additionally stated in the test report.

Table 3 Grease for general purpose Class 1

Test items	Cone penetration number				Applicable number
	No. 1	No. 2	No. 3	No. 4	
Worked penetration	310 to 340	265 to 295	220 to 250	175 to 205	**7.5**
Dropping point °C	80 min.	85 min.	85 min.	90 min.	**8**
Copper plate corrosion (room temperature, 24 h)	No change to green or black colour on copper plate.				**9** (Method A)
Ash content Mass fraction (%)	3.0 max.	3.5 max.	4.0 max.	4.5 max.	**14**
Water washout resistance (38 °C, 1 h) Mass fraction (%)	20 max.	20 max.	20 max.	20 max.	**16**
Water content Mass fraction (%)	2.0 max.	2.5 max.	2.5 max.	3.0 max.	**22**

5.1.2 Grease for general purpose Class 2

Grease for general purpose Class 2, when tested according to clause **7** to clause **10** and clause **15** shall conform to the requirements specified in table 4. The base oil shall be 41.4 mm^2/s to 242 mm^2/s in kinematic viscosity (40 °C). As occasion demands, the kinematic viscosity of basic oil shall be additionally stated in the test report.

Table 4 Grease for general purpose Class 2

Test items	Cone penetration number		Applicable number
	No. 2	No. 3	
Worked penetration	265 to 295	220 to 250	**7.5**
Dropping point °C	170 min.	170 min.	**8**
Copper plate corrosion (room temperature, 24 h)	No change to green or black colour on copper plate.		**9** (Method A)
Evaporation loss (99 °C, 22 h) Mass fraction (%)	2.0 max.	2.0 max.	**10**
Worked stability	375 max.	375 max.	**15**

5.2 Grease for rolling bearing

5.2.1 Grease for rolling bearing Class 1

Grease for rolling bearing Class 1, when tested according to clause **7** to clause **13**, clause **15**, clause **16**, clause **18** and clause **21**, shall conform to the requirements specified in table 5. As occasion demands, the kinematic viscosity of basic oil and the type of thickener shall be additionally stated in the test report.

Table 5 Grease for rolling bearing Class 1

Test items		Cone penetration number			Applicable number
		No. 1	No. 2	No. 3	
Worked penetration		310 to 340	265 to 295	220 to 250	**7.5**
Dropping point °C		170 min.	175 min.	175 min.	**8**
Copper plate corrosion (100 °C, 24 h)		No change to green or black colour on copper plate.			**9** (Method B)
Evaporation loss (99 °C, 22 h) Mass fraction (%)		2.0 max.	2.0 max.	2.0 max.	**10**
Oil separation percentage (100 °C, 24 h) Mass fraction (%)		10 max.	5 max.	5 max.	**11**
Oxidation stability (99 °C, 100 h) kPa		70 max.	70 max.	70 max.	**12**
Foreign matter particles particles/cm^3	10 μm min.	5 000 max.	5 000 max.	5 000 max.	**13**
	25 μm min.	3 000 max.	3 000 max.	3 000 max.	
	75 μm min.	500 max.	500 max.	500 max.	
	125 μm min.	0	0	0	
Worked stability		400 max.	375 max.	350 max.	**15**
Water washout resistance (38 °C, 1 h) Mass fraction (%)		10 max.	10 max.	10 max.	**16**

Table 5 (concluded)

Test items		Cone penetration number			Applicable number
		No. 1	No. 2	No. 3	
Low temperature torque (–20 °C) mN・m	Starting torque Revolving torque	490 max. 250 max.	590 max. 290 max.	790 max. 390 max.	**18**
Humidity cabinet (14 days)		Class A	Class A	Class A	**21**

5.2.2 Grease for rolling bearing Class 2

Grease for rolling bearing Class 2, when tested according to clause **7** to clause **13**, clause **15**, clause **16**, clause **18** and clause **21**, shall conform to the requirements specified in table 6. As occasion demands, the kinematic viscosity of basic oil and the type of thickener shall be additionally stated in the test report.

Table 6 Grease for rolling bearing Class 2

Test items		Cone penetration number			Applicable number
		No. 0	No. 1	No. 2	
Worked penetration		355 to 385	310 to 340	265 to 295	**7.5**
Dropping point °C		145 min.	150 min.	150 min.	**8**
Copper plate corrosion (100 °C, 24 h)		No change to green or black colour on copper plate.			**9** (Method B)
Evaporation loss (99 °C, 22 h) Mass fraction (%)		10.0 max.	10.0 max.	10.0 max.	**10**
Oil separation percentage (100 °C, 24 h) Mass fraction (%)		—	12 max.	10 max.	**11**
Oxidation stability (99 °C, 100 h) kPa		70 max.	70 max.	70 max.	**12**
Foreign matter particles particles/cm^3	10 μm min. 25 μm min. 75 μm min. 125 μm min.	5 000 max. 3 000 max. 500 max. 0	5 000 max. 3 000 max. 500 max. 0	5 000 max. 3 000 max. 500 max. 0	**13**
Worked stability		430 max.	400 max.	375 max.	**15**
Water washout resistance (38 °C, 1 h) Mass fraction (%)		—	10 max.	10 max.	**16**
Low temperature torque (–40 °C) mN・m	Starting torque Revolving torque	390 max. 200 max.	490 max. 250 max.	590 max. 290 max.	**18**
Humidity cabinet (14 days)		Class A	Class A	Class A	**21**

5.2.3 Grease for rolling bearing Class 3

Grease for rolling bearing Class 3, when tested according to clause **7** to clause **13**, clause **15**, clause **16**, clause **18** and clause **21**, shall conform to the requirements specified in table 7. As occasion demands, the kinematic viscosity of basic oil and the type of thickener shall be additionally stated in the test report.

Table 7 Grease for rolling bearing Class 3

Test items		Cone penetration number			Applicable number
		No. 1	No. 2	No. 3	
Worked penetration		310 to 340	265 to 295	220 to 250	**7.5**
Dropping point °C		180 min.	185 min.	185 min.	**8**
Copper plate corrosion (100 °C, 24 h)		No change to green or black colour on copper plate.			**9** (Method B)
Evaporation loss Mass fraction (%)	99 °C, 22 h	1.5 max.	1.5 max.	1.5 max.	**10**
	130 °C, 22 h	5.0 max.	5.0 max.	5.0 max.	
Oil separation percentage Mass fraction (%)	100 °C, 24 h	10 max.	5 max.	5 max.	**11**
	130 °C, 24 h	12 max.	8 max.	8 max.	
Oxidation stability (99 °C, 100 h) kPa		50 max.	50 max.	50 max.	**12**
Foreign matter particles particles/cm^3	10 μm min. 25 μm min. 75 μm min. 125 μm min.	5 000 max. 3 000 max. 500 max. 0	5 000 max. 3 000 max. 500 max. 0	5 000 max. 3 000 max. 500 max. 0	**13**
Worked stability		400 max.	375 max.	350 max.	**15**
Water washout resistance (38 °C, 1 h) Mass fraction (%)		10 max.	10 max.	10 max.	**16**
Low temperature torque (−30 °C) mN • m	Starting torque Revolving torque	490 max. 250 max.	590 max. 290 max.	790 max. 390 max.	**18**
Humidity cabinet (14 days)		Class A	Class A	Class A	**21**

5.3 Chassis grease for automobile

Chassis grease for automobile Class 1, when tested according to clause **7** to clause **9**, clause **16** and clause **19** to clause **22** shall conform to the requirements specified in table 8. As occasion demands, the kinematic viscosity of basic oil shall be additionally stated in the test report.

Table 8 Chassis grease for automobile Class 1

Test items	Cone penetration number				Applicable number
	No. 00	No. 0	No. 1	No. 2	
Worked penetration	400 to 430	355 to 385	310 to 340	265 to 295	**7.5**
Dropping point °C	80 min.	85 min.	90 min.	90 min.	**8**
Copper plate corrosion (room temperature, 24 h)	No change to green or black colour on copper plate.				**9** (Method A)
Water washout resistance (38 °C, 1 h) Mass fraction (%)	—	—	20 max.	10 max.	**16**
Apparent viscosity Pa • s (−10 °C, slip rate 10 s^{-1})	100 max.	200 max.	—	—	**19**
Load carrying capacity by Timken machine OK value kg	4.08 min.	4.08 min.	4.08 min.	4.08 min.	**20**

Table 8 (concluded)

Test items	Cone penetration number				Applicable number
	No. 00	No. 0	No. 1	No. 2	
Humidity cabinet (14 days)	—	—	Class A	Class A	**21**
Water content Mass fraction (%)	2.0 max.	2.0 max.	2.0 max.	2.0 max.	**22**

5.4 Grease for wheel bearing for automobile

Grease for wheel bearing for automobile Class 1, when tested according to clause **7** to clause **13**, clause **15** to clause **18** and clause **21** shall conform to the requirements specified in table 9. As occasion demands, the kinematic viscosity of basic oil and the type of thickener shall be additionally stated in the test report.

Table 9 Grease for wheel bearing for automobile Class 1

Test items		Cone penetration number		Applicable number
		No. 2	No. 3	
Worked penetration		265 to 295	220 to 250	**7.5**
Dropping point °C		175 min.	175 min.	**8**
Copper plate corrosion (100 °C, 24 h)		No change to green or black colour on copper plate.		**9** (Method B)
Evaporation loss (99 °C, 22 h) Mass fraction (%)		2.0 max.	2.0 max.	**10**
Oil separation percentage (100 °C, 24 h) Mass fraction (%)		5 max.	5 max.	**11**
Oxidation stability (99 °C, 100 h) kPa		70 max.	70 max.	**12**
Foreign matter particles particles/cm^3	10 μm min. 25 μm min. 75 μm min. 125 μm min.	5 000 max. 3 000 max. 500 max. 0	5 000 max. 3 000 max. 500 max. 0	**13**
Worked stability		375 max.	375 max.	**15**
Water washout resistance (79 °C, 1 h) Mass fraction (%)		10 max.	10 max.	**16**
Leakage tendency (104 °C, 6 h) g		10 max.	10 max.	**17**
Low temperature torque (−20 °C) mN · m	Starting torque Revolving torque	790 max. 390 max.	990 max. 490 max.	**18**
Humidity cabinet (14 days)		Class A	Class A	**21**

5.5 Grease for central lubricating system

5.5.1 Grease for central lubricating system Class 1

Grease for central lubricating system Class 1, when tested according to clause **7** to clause **9**, clause **19**, clause **20** and clause **22** shall conform to the requirements specified in table 10. As occasion demands, the kinematic viscosity of basic oil shall be additionally stated in the test report.

Table 10 Grease for central lubricating system Class 1

Test items	Cone penetration number			Applicable number
	No. 00	No. 0	No. 1	
Worked penetration	400 to 430	355 to 385	310 to 340	**7.5**
Dropping point °C	80 min.	85 min.	90 min.	**8**
Copper plate corrosion (room temperature, 24 h)	No change to green or black colour on copper plate.			**9** (Method A)
Apparent viscosity Pa・s (–10 °C, slip rate 10 s^{-1})	150 max.	200 max.	400 max.	**19**
Load carrying capacity by Timken machine OK value kg	2.72 min.	2.72 min.	2.72 min.	**20**
Water content Mass fraction (%)	2.0 max.	2.0 max.	2.0 max.	**22**

5.5.2 Grease for central lubricating system Class 2

Grease for central lubricating system Class 2, when tested according to clause **7** to clause **11**, clause **13**, clause **15**, clause **16** and clause **19** to clause **21**, shall conform to the requirements specified in table 11. As occasion demands, the kinematic viscosity of basic oil and the type of thickener shall be additionally stated in the test report.

Table 11 Grease central lubricating system Class 2

Test items		Cone penetration number			Applicable number
		No. 0	No. 1	No. 2	
Worked penetration		355 to 385	310 to 340	265 to 295	**7.5**
Dropping point °C		170 min.	170 min.	170 min.	**8**
Copper plate corrosion (100 °C, 24 h)		No change to green or black colour on copper plate.			**9** (Method B)
Evaporation loss (99 °C, 22 h) Mass fraction (%)		2.0 max.	2.0 max.	2.0 max.	**10**
Oil separation percentage (100 °C, 24 h) Mass fraction (%)		—	10 max.	5 max.	**11**
Foreign matter particles particles/cm^3	25 μm min.	3 000 max.	3 000 max.	3 000 max.	**13**
	75 μm min.	500 max.	500 max.	500 max.	
	125 μm min.	0	0	0	
Worked stability		430 max.	400 max.	375 max.	**15**
Water washout resistance (38 °C, 1 h) Mass fraction (%)		—	20 max.	10 max.	**16**
Apparent viscosity Pa・s (–10 °C, slip rate 10 s^{-1})		150 max.	250 max.	500 max.	**19**
Load carrying capacity by Timken machine OK value kg		2.72 min.	2.72 min.	2.72 min.	**20**
Humidity cabinet (14 days)		Class A	Class A	Class A	**21**

5.5.3 Grease for central lubricating system Class 3

Grease for central lubricating system Class 3, when tested according to clause **7** to clause **9**, clause **19**, clause **20** and clause **22** shall conform to the requirements specified in table 12. As occasion demands, the kinematic viscosity of basic oil shall be additionally stated in the test report.

Table 12 Grease for central lubricating system Class 3

Test items	Cone penetration number			Applicable number
	No. 0	No. 1	No. 2	
Worked penetration	355 to 385	310 to 340	265 to 295	**7.5**
Dropping point °C	80 min.	85 min.	90 min.	**8**
Copper plate corrosion (room temperature, 24 h)	No change to green or black colour on copper plate.			**9** (Method A)
Apparent viscosity Pa・s (−10 °C, slip rate 10 s^{-1})	200 max.	400 max.	700 max.	**19**
Load carrying capacity by Timken machine OK value kg	9.53 min.	9.53 min.	9.53 min.	**20**
Water content Mass fraction (%)	2.0 max.	2.0 max.	2.0 max.	**22**

5.5.4 Grease for central lubricating system Class 4

Grease for central lubricating system Class 4, when tested according to clause **7** to clause **11**, clause **13**, clause **15**, clause **16** and clause **19** to clause **21**, shall conform to the requirements specified in table 13. As occasion demands, the kinematic viscosity of basic oil and the type of thickener shall be additionally stated in the test report.

Table 13 Grease central lubricating system Class 4

Test items		Cone penetration number			Applicable number
		No. 0	No. 1	No. 2	
Worked penetration		355 to 385	310 to 340	265 to 295	**7.5**
Dropping point °C		170 min.	170 min.	170 min.	**8**
Copper plate corrosion (100 °C, 24 h)		No change to green or black colour on copper plate.			**9** (Method B)
Evaporation loss (99 °C, 22 h) Mass fraction (%)		2.0 max.	2.0 max.	2.0 max.	**10**
Oil separation percentage (100 °C, 24 h) Mass fraction (%)		—	10 max.	5 max.	**11**
Foreign matter particles particles/cm^3	25 μm min. 75 μm min. 125 μm min.	3 000 max. 500 max. 0	3 000 max. 500 max. 0	3 000 max. 500 max. 0	**13**
Worked stability		430 max.	400 max.	375 max.	**15**
Water washout resistance (38 °C, 1 h) Mass fraction (%)		—	20 max.	10 max.	**16**
Apparent viscosity Pa・s (−10 °C, slip rate 10 s^{-1})		150 max.	250 max.	500 max.	**19**

Table 13 (concluded)

Test items	Cone penetration number			Applicable number
	No. 0	No. 1	No. 2	
Load carrying capacity by Timken machine OK value kg	10.9 min.	10.9 min.	10.9 min.	**20**
Humidity cabinet (14 days)	Class A	Class A	Class A	**21**

5.6 Grease for heavy load

Grease for heavy load Class 1, when tested according to clause **7** to clause **11**, clause **15**, clause **16** clause **21** to clause **26**, shall conform to the requirements specified in table 14. As occasion demands, the kinematic viscosity of basic oil and the type of thickener shall be additionally stated in the test report.

Table 14 Grease for heavy load Class 1

Test items	Cone penetration number				Applicable number
	No. 0	No. 1	No. 2	No. 3	
Worked penetration	355 to 385	310 to 340	265 to 295	220 to 250	**7.5**
Dropping point °C	170 min.	170 min.	170 min.	175 min.	**8**
Copper plate corrosion (100 °C, 24 h)	No change to green or black colour on copper plate.				**9** (Method B)
Evaporation loss (99 °C, 22 h) Mass fraction (%)	2.0 max.	2.0 max.	2.0 max.	2.0 max.	**10**
Oil separation percentage (100 °C, 24 h) Mass fraction (%)	—	10 max.	5 max.	5 max.	**11**
Worked stability	430 max.	400 max.	375 max.	350 max.	**15**
Water washout resistance (38 °C, 1 h) Mass fraction (%)	—	20 max.	10 max.	10 max.	**16**
Humidity cabinet (14 days)	Class A	Class A	Class A	Class A	**21**
Test of ability to lubricate under high load (Shell-type four-ball test method), fusion force (load) N	2 452 min.	2 452 min.	2 452 min.	2 452 min.	**26**

5.7 Gear compound

Gear compound Class 1, when tested according to clause **9**, clause **14**, and clause **23** to clause **25** shall conform to the requirements specified in table 15.

Table 15 Gear compound Class 1

Test items		Cone penetration number			Applicable number
		No. 1	No. 2	No. 3	
Copper plate corrosion (100 °C, 24 h)		No change to green or black colour on copper plate.			**9** (Method B)
Ash content	Mass fraction (%)	4.0 max.	4.0 max.	4.0 max.	**14**
Kinematic viscosity (100 °C)	mm^2/s	50 to 120	121 to 360	361 to 720	**23**
Flash point (COC type)	°C	150 min.	150 min.	150 min.	**24**
Load carrying capacity (Soda-type four-ball test method)	MPa	0.2 min.	0.2 min.	—	**25**
NOTE : The cone penetration number is classified according to the range of kinematic viscosity.					

6 Classification of test methods

The classification of test methods shall be as shown in table 16.

Table 16 Classification of test methods

Designation of test method	Applicable clause number	Corresponding International Standard
Test method for cone penetration	**7**	**ISO 2137**
Test method for dropping point	**8**	**ISO 2176**
Test method for copper plate corrosion	**9**	—
Test method for evaporation loss	**10**	—
Test method for oil separation	**11**	—
Test method for oxidation stability	**12**	—
Test method for foreign matter	**13**	—
Test method for ash content	**14**	—
Test method for worked stability	**15**	—
Test method for water washout resistance	**16**	**ISO 11009**
Test method for leakage tendency of grease	**17**	—
Test method for low temperature torque	**18**	—
Test method for apparent viscosity	**19**	—
Test method for load carrying capacity by Timken machine	**20**	—
Test method for humidity cabinet	**21**	—
Test method for water content	**22**	—
Test method for kinematic viscosity	**23**	—
Test method for flash point	**24**	—
Test method for load carrying capacity (Soda-type four-ball test method)	**25**	—
Test method for ability to lubricate under high load (Shell-type four-ball test method)	**26**	**4.4** in **ISO 12924**

Table 16 (concluded)

Designation of test method	Applicable clause number	Corresponding International Standard
Test method for undisturbed penetration	Annex JA (informative)	—
Test method for determination of free acid, free alkali and insoluble carbonate	Annex JB (informative)	—
Test method for open-type evaporation loss	Annex JC (informative)	—
Test method for sulfated ash content	Annex JD (informative)	—

7 Test method for cone penetration

7.1 Principle of test

The cone penetration of grease is determined at 25 °C by releasing the cone from the penetrometer and allowing the cone to drop for 5 s, and measuring the extent of the penetration.

This test method, when the standard cone is used, is applicable to the cone penetration up to 620 units. The test method for cone penetration by using one-half scale cone and one-quarter scale cone is applicable to the sample of 175 units to 385 units in cone penetration when the standard cone cannot be used and the quantity of sample is small. The test method for cone penetration by using one half-scale cone and one-quarter scale cone does not intend to be used in place of the test method by using the standard cone.

a) The unworked penetration is determined on the sample transferred with a minimum of disturbance to a container suitable for the test. The unworked penetration does not indicate the hardness of grease in use so effectively as the worked penetration. For the inspection of grease, generally, the worked penetration is more suitable.

b) The worked penetration is determined immediately after working the sample for 60 strokes in the specified grease worker.

c) The prolonged worked penetration is determined on the sample worked more than 60 strokes.

d) The block penetration is determined on a freshly prepared surface of a cube cut from a block of grease with the specified cutter.

NOTE : The cone penetration of solid grease having the hardness to hold the shape sufficiently is usually under 85 units.

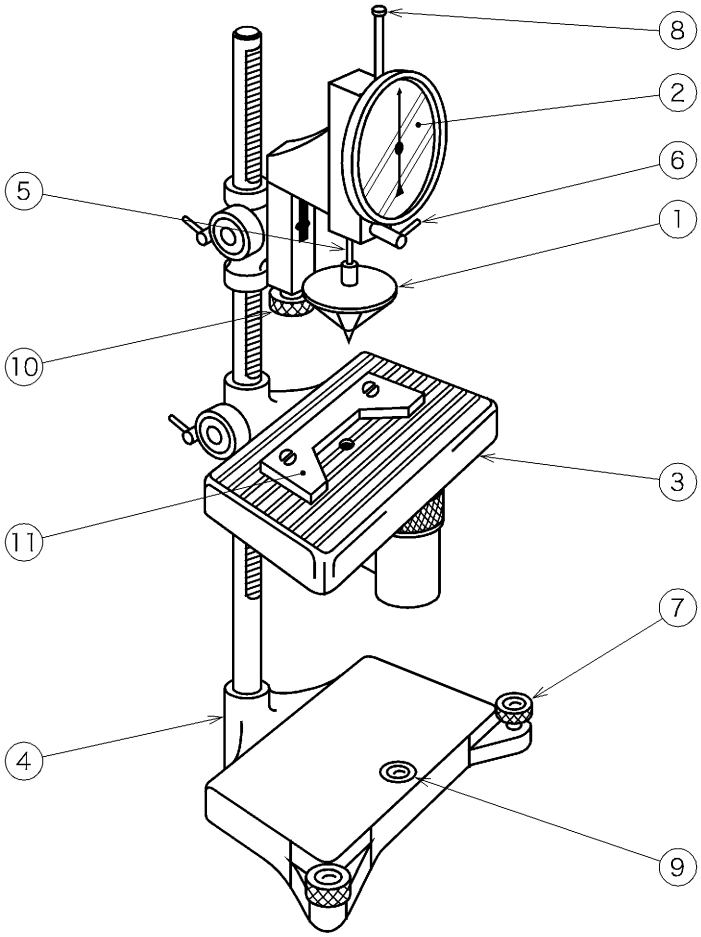
7.2 Test apparatus

The test apparatus for cone penetration consists of the following items **a**) to **i**).

a) **Penetrometer** An example of penetrometer is shown in figure 1. The penetrometer shall be designed to measure, in tenths of a millimetre, the penetration of a cone in a sample. The cone assembly or the sample table of the penetrometer shall be adjustable to enable accurate placement of the tip of the cone on the level surface of the sample while maintaining a “zero” reading on the dial gauge.

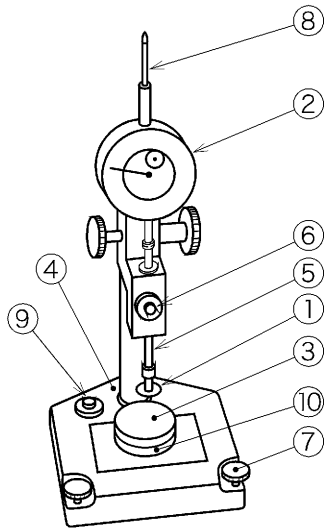
The cone shall fall, when released from the state to be fixed to the penetrometer, without appreciable friction for at least 62 mm, and the tip of the cone shall not hit the bottom of the sample container. The penetrometer shall be provided with levelling screws and a spirit level to maintain the cone shaft in a vertical position.

An example of one-half scale or one-quarter scale penetrometer is shown in figure 2. The one-half scale cone and the one-quarter scale cone shall fall without appreciable friction for 20 mm or over.



① Cone
② Dial gauge
③ Sample table
④ Supporting table
⑤ Holder
⑥ Retainer
⑦ Levelling screw
⑧ Rack for measurement
⑨ Level
⑩ Knob for fine adjustment
⑪ Centring device

Figure 1 Example of penetrometer



① Cone
② Dial gauge
③ Sample table
④ Supporting table
⑤ Holder
⑥ Retainer
⑦ Levelling screw
⑧ Rack for measurement
⑨ Level
⑩ Knob for fine adjustment

Figure 2 Example of one-half or one-quarter penetrometer

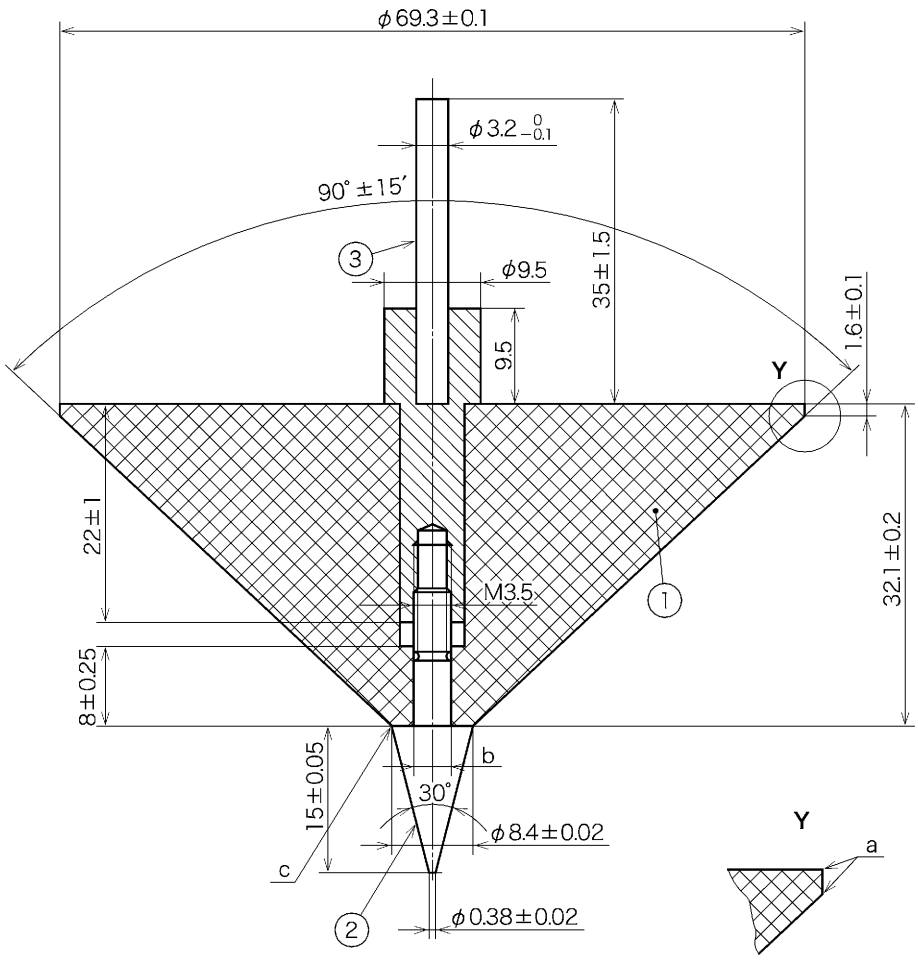
b) **Cone**

1) **Standard cone** Consisting of a conical body of magnesium or other suitable metal with a detachable hardened steel tip. Dimensions and tolerance shall be as shown in figure 3. The total mass of the cone shall be 102.5 g ± 0.05 g and the mass of the holder of cone shall be 47.5 g ± 0.05 g. The holder has a stop at its upper end and a suitable means at its lower end for engaging the cone. The interior construction may be modified to achieve the specified mass, provided that the general contour and mass distribution are not altered. The outer surface shall be polished to a very smooth finish. For samples whose cone penetration is up to 400, the optional cone (figure 4) may be used.

2) **One-half scale cone and holder** Of steel, stainless steel or brass with a hardened steel tip of 45 to 50 in Rockwell C hardness and so constructed to conform to the dimensions and tolerances shown in figure 5. The holder may be made of stainless steel. The total mass of the cone and the holder shall be 37.5 g ± 0.05 g. The mass of the cone shall be 22.5 g ± 0.025 g, and the mass of the holder shall be 15 g ± 0.025 g.

3) **One-quarter scale cone and holder** Consisting of a conical body of plastics or other low density material with a hardened steel tip of 45 to 50 in Rockwell C hardness, and constructed to conform to the dimensions and tolerances shown in figure 6. The holder may be constructed of magnesium alloy. The total mass of the cone and the holder shall be 9.38 g ± 0.025 g. The total mass of the cone and the holder may be adjusted by adding small shot to the cavity of the shaft.

Unit: mm

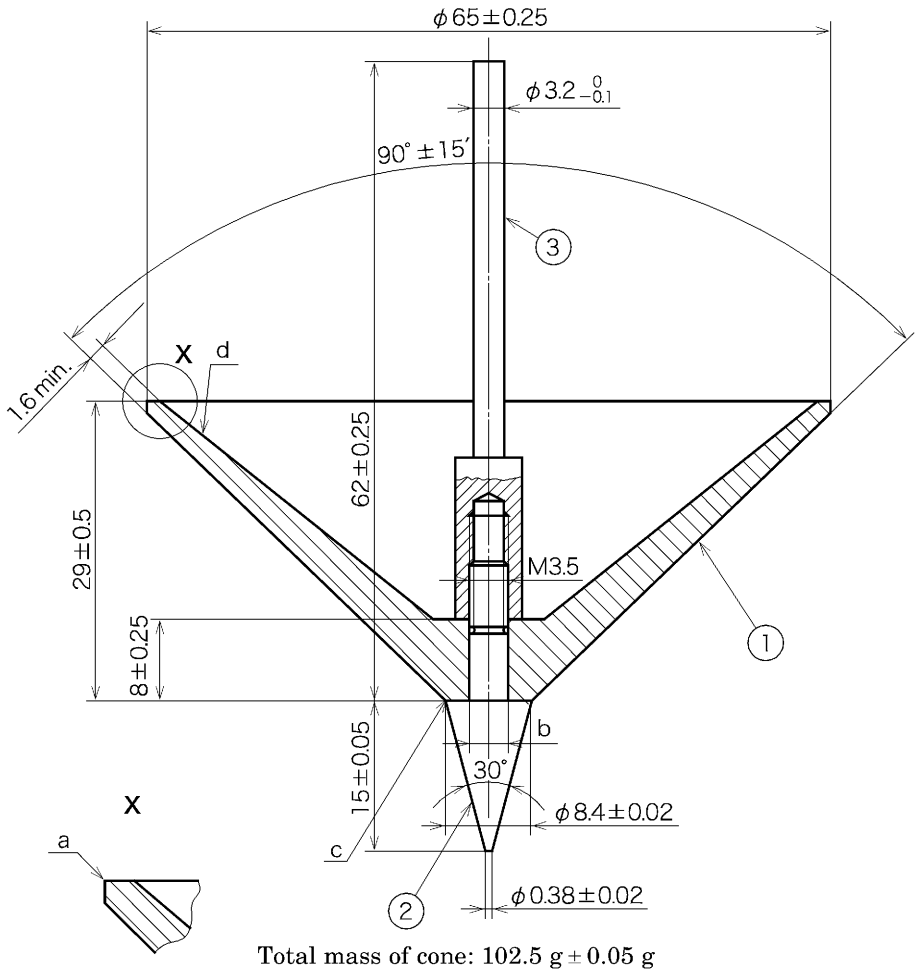


① Cone (made of magnesium or other appropriate metal whose surface is polished smoothly)
② Hardened steel tip
③ Shaft (stainless steel)
a Do not round edges.
b ϕ4 max., tight fit.
c No shoulder.

Total mass of cone: 102.5 g ± 0.05 g
Total mass of holder of cone: 47.5 g ± 0.05 g

Figure 3 Standard cone

Unit: mm

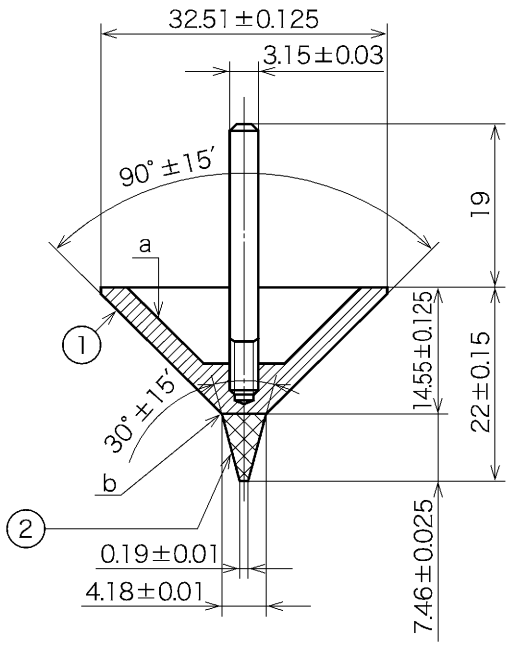


① Cone (made of brass or corrosion resistant steel whose surface is polished smoothly)
② Hardened steel tip
③ Shaft (stainless steel)
a Round all sharp edges.
b ϕ4 max, tight fit.
c No shoulder.
d Machining to the required mass.

Total mass of cone: 102.5 g ± 0.05 g
Total mass of holder of cone: 47.5 g ± 0.05 g

Figure 4 Optional cone

Unit: mm

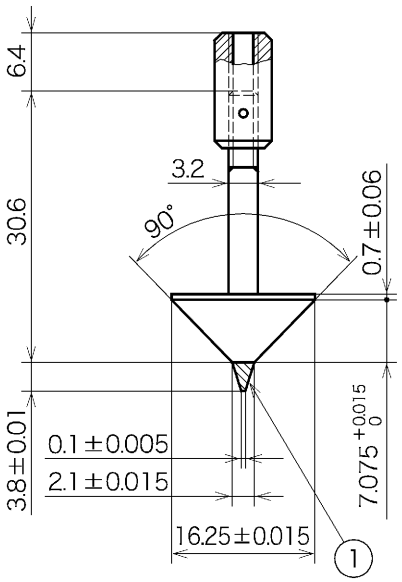


① Cone (whose surface is polished smoothly)
② Hardened steel tip
a Machine this surface to give specified mass.
b Sharp corner.

Total mass of cone:
22.5 g ± 0.025 g
Total mass of holder of cone:
15 g ± 0.025 g
Total mass of cone and holder of cone:
37.5 g ± 0.050 g

Figure 5 One-half scale cone

Unit: mm



① Hardened steel tip

Total mass of cone and holder of cone:
9.38 g ± 0.025 g

Figure 6 One-quarter scale cone

c) **Grease workers**

1) **1/1 grease worker** That conforming to the dimensions shown in figure 7. The sizes of non-dimensioned parts are not critical and may be varied according to individual requirements, and other methods of fastening the lid and securing the grease worker may be used. The grease working may be either manually or by mechanical operation. The design shall be such that a rate of 60 strokes ± 10 strokes per minute, with a length of 67 mm to 71 mm, can be maintained. A suitable thermometer, standardized at 25 °C, shall be provided for insertion through the vent valve. An example of motor-driven worker is shown in figure 8.

2) **One-half scale worker** That conforming to the dimensions shown in figure 9. Other methods of fastening the lid and securing the worker may be used. The grease working may be either manually or by mechanical operation. The design shall be such that a rate of 60 strokes ± 10 strokes per minute, with a maximum length of 35 mm, can be maintained.

3) **One-quarter scale worker** That conforming to the dimensions shown in figure 10. Other methods of fastening the lid and securing the worker may be used. The grease working may be either manually or by mechanical operation. The design shall be such that a rate of 60 strokes ± 10 strokes per minute, with a maximum length of 14 mm, can be maintained.

d) **Overflow ring (optional)** That conforming in principle to the illustration shown in figure 7. This is useful aid for returning displaced grease to the pot of 1/1 grease worker. The overflow ring shall be positioned at least 13 mm below the rim of the pot while making a penetration measurement.

e) **Grease cutter** Having a sharp, bevelled and rigidly mounted blade as shown in figure 11. It is necessary that the blade be straight and sharpened as shown. An example of the part of blade top is shown in figure 11.

f) **Thermostatic water bath** Capable of being maintained at 25 °C ± 0.5 °C and holding the assembled grease worker. If the bath is to be used for samples for unworked penetrations, a means shall be provided for protecting the grease surface from water. A cover shall also be provided to maintain the air temperature above the sample at 25 °C.

An air bath, maintained at 25 °C ± 0.5 °C, is required for determining block penetration. If the thermostatic water bath is used, a tightly sealed container containing the sample shall be immersed in the water bath. A constant temperature test room or an air bath may be used instead of a thermostatic water bath.

g) **Thermometer** Calibrated at 25 °C for the thermostatic water bath or air bath.

h) **Spatula** Corrosion-resistant, square-ended, having a stiff blade about 32 mm wide and at least 150 mm long; for the tests with one-half scale cone and one-quarter scale cone, the width of blade should be about 13 mm.

i) **Stop watch** That capable of indicating tenth of a second.

Unit: mm

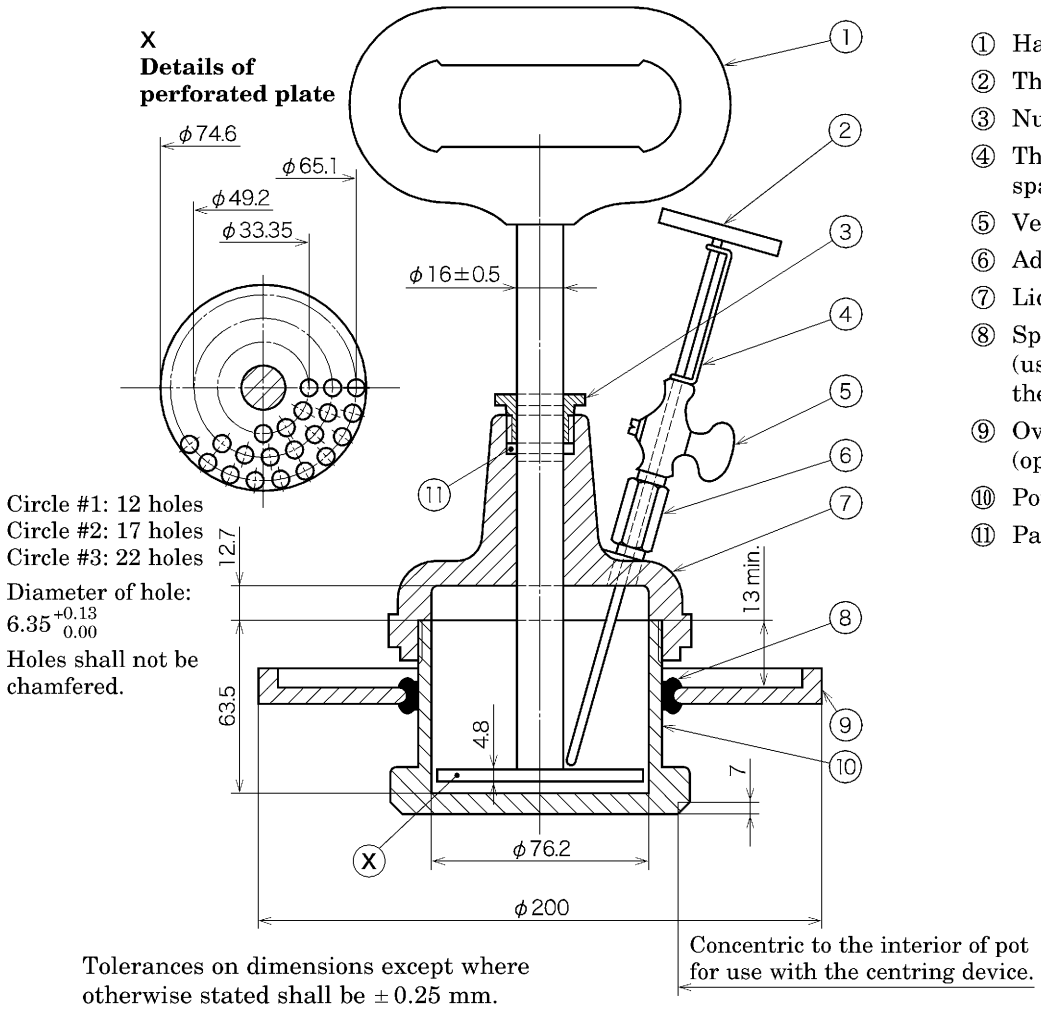
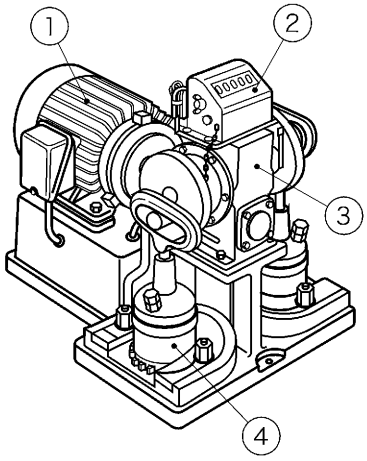


Figure 7 Example of grease worker and overflow ring

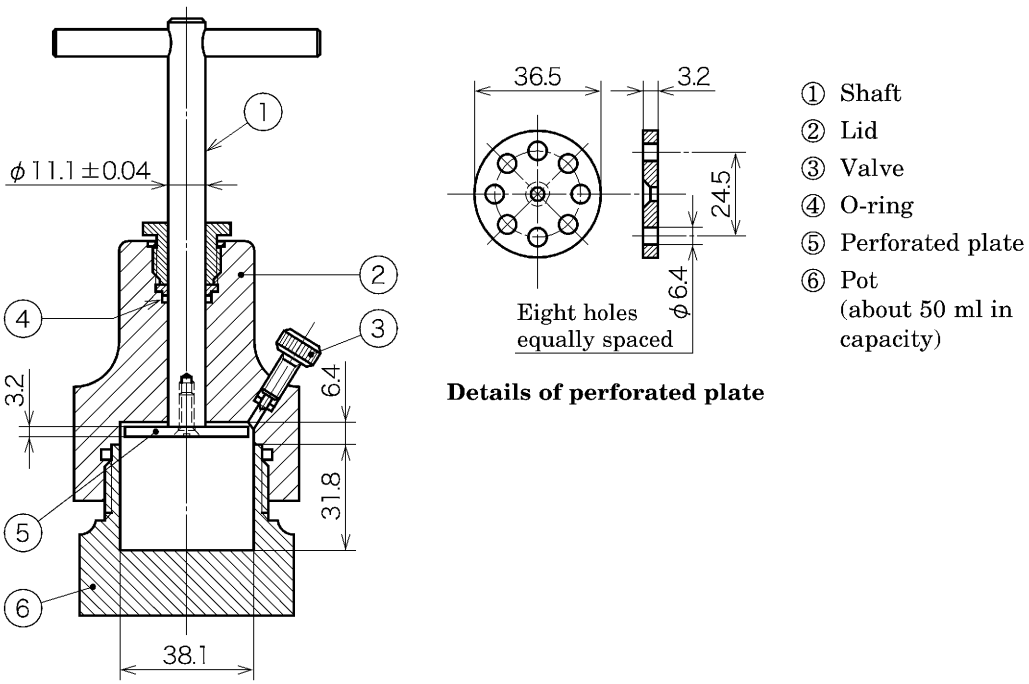


① Motor
② Integrating counter
③ Reduction gear
④ Grease worker

NOTE : This diagram is prepared based on Fig.A1.5 of **ASTM D 217**-97.

Figure 8 Example of motor driven grease working apparatus

Unit: mm

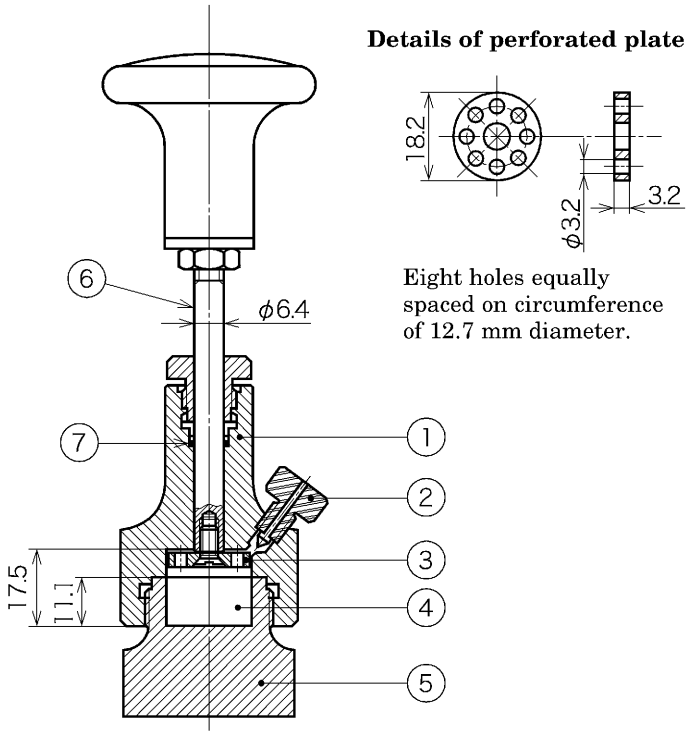


Material: stainless steel

Tolerances on dimensions except where otherwise stated shall be ±0.25 mm.

Figure 9 Example of one-half scale grease worker

Unit: mm



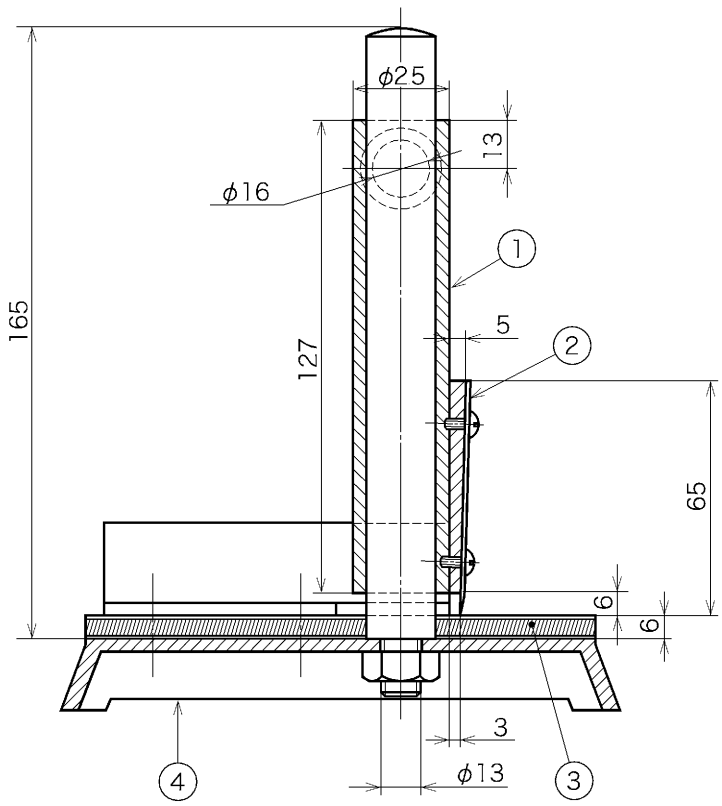
① Lid
② Valve
③ Perforated plate
④ Chamber of 19.0 mm in diameter × 17.5 mm in length
⑤ Pot (about 4 ml in capacity with perforated plate)
⑥ Shaft
⑦ O-ring

Material: stainless steel

Tolerances on dimensions except where otherwise stated shall be ± 0.25 mm.

Figure 10 Example of one-quarter scale grease worker

Unit: mm



① Pipe
② Blade of 65 × 185 (hardened steel) Grind both surfaces to 1.2 mm in thickness, grind lower edge and attach it.
③ Plywood (Grain of top surface is perpendicular to blade.)
④ Base

Figure 11 Example of grease cutter

7.3 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

7.4 Test procedure for unworked penetration test by using standard cone

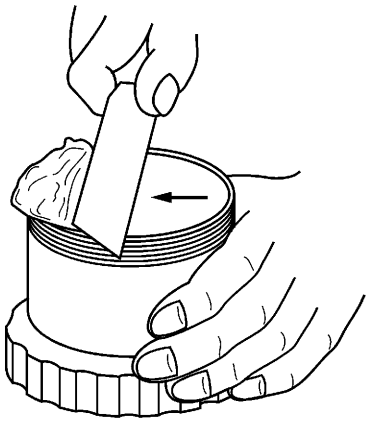
a) **Preparation of sample**

1) Take sufficient sample (at least 0.5 kg) to overfill the pot of 1/1 grease worker.

If the cone penetration is above 200 units, at least three times (1.5 kg) the amount needed to fill the pot will be required.

2) Place the empty assembled 1/1 grease worker, or metal container of equal inside dimensions, and an appropriate amount of the sample in a metal container in a thermostatic water bath maintained at 25 °C for sufficient time to bring the temperature of the sample to 25 °C ± 0.5 °C. Transfer from the container a sample, preferably in one lump to overfill the pot to the 1/1 grease worker, or metal container of equal inside dimensions. Make this transfer in such a manner that the grease will be worked as little as possible. Jar the container to drive out trapped air by striking it on an appropriate table, and pack the grease with the spatula, with as little manipulation as possible, to obtain a cupful sample without air pockets. Scrape off the excess grease extending above the rim by moving the blade of the spatula, held inclined toward the direction of motion at an angle of about 45° across the rim of the pot, and flatten the surface of the sample. An example of moving way of spatula is shown in figure 12. Do not perform any further levelling or smoothing of the surface by touching with a spatula before and throughout the determination, and carry out the measurement immediately. If the temperature of sample is 17 °C or under or 33 °C or over, or if an alternative method of adjusting the sample to 25 °C is used, allow the sufficient time to ensure that the sample is at 25 °C ± 0.5 °C before processing. Also, if the sample is larger than 0.5 kg, allow sufficient additional time to ensure that the sample is at 25 °C ± 0.5 °C. Testing may proceed if the sample is at a uniform temperature of 25 °C ± 0.5 °C.

b) **Cleaning of standard cone and holder** Clean the standard cone carefully before each test. Bending of the holder can be avoided by holding it securely in its raised position while cleaning. Remove all grease or oil on the holder as they can cause drag on the shaft assembly. Do not rotate the cone as this may cause wear on the release mechanism. For the cone penetration up to 400 units, the optional cone (figure 4) may be used.



NOTE : This diagram is prepared based on Fig.2 of **ASTM D 217**-97.

Figure 12 Example of moving way of spatula

c) **Cone penetration measurement**

1) Place the pot on the sample table of penetrator adjusted to a horizontal position making certain that it cannot rock. Set the mechanism to hold the cone in the "zero" position, and adjust the apparatus carefully so that the tip of the cone just touches the surface of the sample at the point specified in **2**) or **3**) by moving either the cone part or the sample table up and down. Watching the shadow of the cone tip is an aid to accurate setting. For greases with cone penetration over 400 units, centre the pot to within 0.3 mm of the tip of the cone. One way to centre the pot accurately is to use a centring device as shown in figure 1. Next, release the holder rapidly by pushing retainer, allow it to drop for 5 s ± 0.1 s, and reclamp it in this position. The release mechanism shall not drag on the shaft assembly, but move smoothly. Gently depress the indicator shaft until it is stopped by the cone shaft and read the indicator scale in integer.

2) If the sample has a cone penetration of over 200 units, centre the cone carefully in the container. This sample can be used for only one test.

3) If the sample has a cone penetration of 200 units or less, perform three tests in a single container, spacing three radii about 120° apart, and midway between the centre and the side of the container. An example of measuring position of penetration is shown figure 13. According to above, the cone will neither strike the side of the pot or container nor impinge on the disturbed area made in a previous test.

4) Make a total of three determinations on the sample in three pots or containers or in one pot or container, and record the values obtained.

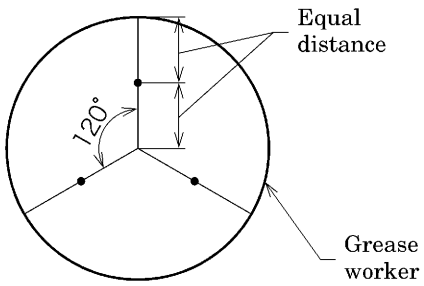


Figure 13 Example of measuring position of cone penetration (mark ●)

7.5 Test procedure for worked penetration by using standard cone

a) **Preparation of sample**

1) Take sufficient sample (at least 0.5 kg or at least 1.5 kg) to overfill the pot of the 1/1 grease worker.

2) Transfer a sufficient quantity of sample to the clean 1/1 grease worker to overfill it (mounded up about 13 mm at the centre), avoiding the trap of air by packing with the spatula. Jar the pot (strike it on an appropriate table) from time to time as it is being packed to remove trapped air. Assemble the 1/1 grease worker with the perforated plate raised and, with the vent valve open, depress the perforated plate to the bottom. Insert a thermometer through the vent valve so that its tip is in the centre of the sample. Place the assembled 1/1 grease worker in the thermostat water bath maintained at 25 °C until the indication of the thermometer inserted into the sample becomes 25 °C ± 0.5 °C.

   If it is desired to immerse the part of the grease worker above its closure, take care that the lid is watertight in order to prevent the entrance of water to the grease worker.

3) Then, remove the grease worker from the thermostat water bath and wipe off excess water adhering to its surfaces. Remove the thermometer and close the vent cock. Subject the grease to 60 strokes of the perforated plate, completed in about 1 min, and return the perforated plate to its top position. Open the vent valve, remove the top and perforated plate, and return to the pot as much of the grease clinging to the perforated plate as can readily be removed.

   As the worked penetration may change significantly when the sample is left as it is, proceed without delay according to **b**) and **c**).

b) **Preparation of sample**

1) Prepare the worked sample in the pot for testing so that a uniform and reproducible structure of grease will be obtained.

2) Jar the pot sharply on the bench, the floor, etc. and pack the sample down with the spatula to fill the holes left by the perforated plate and to remove trapped air. The jarring should be vigorous as is required to remove the trapped air without splashing the sample from the pot. In performing these operations, a minimum manipulation shall be used, as continued agitation of the grease may have the effect of increasing the working beyond the specified strokes.

3) Scrape off the excess sample extending above the rim of the pot by moving the blade of the spatula, held inclined toward the direction of motion at an angle of about 45° across the rim of the pot, retaining the sample removed. Particularly, when testing soft greases, retain the sample removed for subsequent test after scraping the pot to full. Keep the outside of the rim of the pot clean so that the sample forced by the penetrometer cone to overflow the pot can be returned to the pot for the next test.

c) **Cone penetration measurement**

1) Determine the cone penetration of the sample according to **7.4 b**) and **7.4 c**).

2) Immediately make two more determinations in succession on the same sample. First return the sample previously removed to the pot with the spatula and prepare the sample according to **7.5 b**). Then, repeat the operation specified in **7.4 b**) and **7.4 c**). Record the three values obtained.

7.6 Test procedure for prolonged worked penetration by using standard cone

a) **Preparation of test apparatus and sample**

1) Maintain the temperature of the room used for the test within the range of 15 °C to 30 °C. No further control of the grease worker temperature is necessary, but before starting the test, the sample shall be left in the room for sufficient time to bring its temperature within the range of 15 °C to 30 °C.

2) Fill the sample and assemble the grease worker. Subject the sample to the prescribed or agreed number of strokes. In order to minimize leakage during working, special attention shall be paid to the gland on the grease worker lid.

b) **Cone penetration measurement** Immediately after the working is completed, place the grease worker in a thermostatic water bath or an air bath to bring the sample temperature to 25 °C ± 0.5 °C within 15 h. Remove the worker from the bath and subject the sample to a further 60 strokes. Prepare the sample according to **7.5 a**) and **7.5 b**), and measure the cone penetration according to **7.5 c**).

7.7 Test procedure for block penetration by using standard cone

a) **Preparation of sample**

1) Take sufficient sample hard enough to hold its shape to permit cutting from it a cube of about 50 mm or over as a sample.

2) By means of the grease cutter, cut a cube of about 50 mm on the edge as a sample from the above at the room temperature, and slice off a layer about 1.5 mm in thickness from each of the three faces adjacent to a single corner to make the measured surface, which may be truncated for identification. Take care not to touch the newly exposed face to be used for testing or to the sample table or guide of the cutter. Bring the temperature of the prepared sample to 25 °C ± 0.5 °C by placing it in a constant temperature air bath maintained at 25 °C for at least 1 h. An example of sample for the measurement of block penetration is shown in figure 14. The testing of three faces is intended to equalize in the final value due to the effect of the fibre orientation in the test of fibrous greases. Smooth-textured

and non-fibrous greases may be tested on one face only upon the agreement between the parties concerned with delivery.

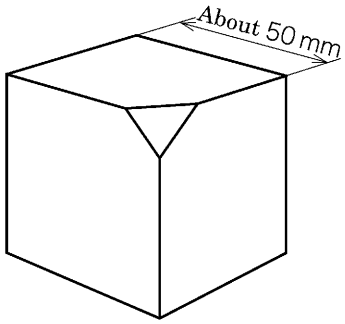


Figure 14 Example of sample for measurement of block penetration

b) **Cone penetration measurement** Place the sample on the sample table of the penetrometer adjusted to a horizontal position with one of the prepared face upward, and press it down lightly to make it rest level and firmly on the table so that it cannot rock during the test. Set the mechanism to hold the cone in the "zero" position on dial gauge, and adjust the apparatus carefully so that the tip of the cone just touches the surface at the centre of the sample by moving either the cone part or the sample table up and down. Determine the cone penetration according to the procedures of **7.4 b**) and **7.4 c**). Make a total three tests on the same measured surface of the sample, locating the tests at least 6 mm from the edge and as far apart as possible without impinging on any touched portion, air hole, or other apparent flaw in the surface. If the result of any of these tests differs from the others by more than 3 units, make additional tests until three values agreeing within 3 units are obtained. Average these three values for the same face being tested.

c) Repeat the procedure described in **b**) on each of the other two prepared faces of the sample and record the average values obtained.

7.8 Test procedure for unworked penetration by using one-half scale or one-quarter scale cone

a) **Preparation of sample** Take sufficient sample to overfill the pot of one-half scale or one-quarter scale grease worker. If the cone penetration by using the one-quarter scale cone is over 47 units or by using the one-half scale cone over 97 units, at least three times the amount needed to fill the pot shall be taken. Hereafter, follow the procedure of **7.4 a**) **2**).

b) **Cleaning of cone and holder** Clean the penetrometer cone carefully before each test. Bending of the cone shaft can be avoided by holding it securely in its raised position while cleaning. Remove all grease or oil from the penetrometer shaft, as they can cause drag on the shaft assembly. Do not rotate the cone, as this may cause wear of the release mechanism.

c) **Cone penetration measurement**

1) Carry out a preliminary determination of cone penetration as specified below with the cone at the centre of the sample surface. If the approximate value of cone penetration is already known, the preliminary determination may be omitted.

2) If the sample has a cone penetration over 47 units by using the one-quarter scale cone or over 97 units by using the one-half scale cone, centre the cone carefully in the container. Accordingly, this sample can be used for only one test.

3) If the sample has a cone penetration of 47 units or less by using the one-quarter scale cone or 97 units or less by using the one-half scale cone, perform three tests in a single container, spacing these tests on three radii about 120° apart, and the midway between the centre and side of the container so that the cone will neither strike the side of the container nor impinge on the measured area made in a previous test.

4) Carry out the measurements according to **7.4 c**) **1**) and **7.4 c**) **4**).

7.9 Test procedure for worked penetration by using one-half scale or one-quarter scale cone

a) **Preparation of sample**

1) Take sufficient sample to overfill the pot of the one-half scale or one-quarter scale grease worker.

2) Proceed according to **2**) and **3**) of **7.5 a**), but mounding up to about 6 mm, and without using a thermometer in the grease worker.

b) **Preparation of sample** Proceed according to **7.5 b**).

c) **Cone penetration measurement**

1) Immediately determine the penetration of the sample according to **7.4 c**) **1**).

2) Immediately, make two more determinations in succession on the same portion. First, return to the pot the portion of grease previously removed with the spatula. Then, determine the penetration according to **7.5 c**) and **7.4 c**) **1**), and record the three values obtained.

7.10 Calculation method and precision

a) **Calculation method** The mean value of cone penetrations which are determined according to any of the test methods for penetration and recorded shall be calculated respectively and rounded with the rounding interval of 1 according to **JIS Z 8401**.

b) **Conversion of cone penetration by using one-half scale and one-quarter scale cones** The penetration obtained by using one-half scale and one-quarter scale cones can be converted to the penetration by using the standard cone or an optional cone according to the following formula.

1) In the case of conversion from the cone penetration by using one-quarter scale cone

$$P = 3.75p + 24$$

where, P : cone penetration to be obtained

p : cone penetration obtained by using one-quarter scale cone

2) In the case of conversion from the cone penetration by using one-half scale cone

$$P = 2r + 5$$

where, P : cone penetration to be obtained

r : cone penetration obtained by using half-quarter scale cone

c) **Precision** The tolerance (probability 0.95) in test results obtained according to this test method shall be as follows.

1) **Repeatability** When the same sample is tested twice in the same laboratory by the same person by using the same test apparatus within a short time successively, the tolerance in test results shall be as shown in table 17 and table 18.

2) **Reproducibility** When the same sample is tested once in different laboratories by different persons by using different test apparatus respectively, the tolerance of difference in two test results shall be as shown in table 17 and table 18.

Table 17 In the case of using standard cone

Cone penetration	Penetration range [a)]	Repeatability	Reproducibility
Unworked penetration	85 to 475	6	18
Worked penetration	130 to 475	5	14
Prolonged worked penetration	130 to 475	7 [b)]	23 [b)]
Block penetration	85 max.	3	7
Notes [a)] The precision for over 475 units penetration has not be determined. [b)] Determined at 60 000 strokes within 21 °C to 29 °C ambient temperature range.			

Table 18 In the case of using one-half scale and one-quarter scale cone

Cone penetration	Scale	Repeatability	Reproducibility
Unworked penetration	1/2	5 (10) [a)]	13 (26) [a)]
Worked penetration	1/2	3 (6) [a)]	10 (20) [a)]
Unworked penetration	1/4	3 (11) [a)]	10 (38) [a)]
Worked penetration	1/4	3 (11) [a)]	7 (26) [a)]
Note [a)] The values in parentheses are converted values using the standard cone.			

7.11 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **7.10**

d) Date of test

e) Specially mentioned matters

8 Test method for dropping point

8.1 Principle of test

The grease cup filled with the sample is put in a test tube, and a thermometer is inserted. These are placed in an oil bath to heat under the specified condition, and the dropping point is obtained from the indication of the thermometer when the sample drops from the orifice of bottom part of the grease cup. The results of the dropping point test may be used as an indication of the maximum temperature to which a grease can be exposed without excessive oil separation or complete liquefaction. Also, it is used for the indicator of the classification of grease and for the establishment of manufacturing control or quality control. However, the results should not be considered as having any direct correlation between the dropping point and the actual performance unless such correlation has been established.

NOTE : In general, the dropping point of grease means the temperature at which the grease changes from semisolid to liquid state under the specified condition of test. This change in state, as a thickener, is typical of greases containing soaps of conventional types. Greases containing materials other than conventional soaps as a thickener may exhibit oil separation without change in state.

8.2 Test apparatus

The apparatus for dropping point test shall be composed of the following **a**) to **m**). An example of configuration is shown in figure 15. The automatic test apparatus according to this Standard may be used. If a doubt arises on the test results obtained by the automatic test apparatus, the results obtained by this test method shall be used.

a) **Grease cup** That of chromium-plated brass conforming to the shape/dimensions shown in figure 16.

b) **Test tube** That of heat-resistant borosilicate glass with rim conforming to the shape/dimensions shown in figure 17. The tube shall have three indentations on the circumference to support the grease cup at about the point shown in figure 17.

c) **Thermometer** That of DP-38 in thermometry number specified in **JIS B 7410** including a test tube use and an oil bath use.

d) **Oil bath** That consisting of a beaker of 400 ml or over filled with a suitable amount of oil to such a level to permit the test tube to be suspended to the correct depth but allowing for expansion of the fluid at the upper limit of the fluid's operation. An example of oil bath is shown in figure 18.

e) **Test tube holder** That capable of holding test tubes in oil bath. An example is shown in ③ of figure 15.

f) **Cup plug gauge** That conforming to the shape/dimensions shown in figure 19.

g) **Rod gauge** That conforming a metal rod of 2.78 mm and 2.82 mm in diameter, and used for confirming the diameter of the orifice of bottom part of the grease cup.

h) **Thermometer depth gauge** That conforming to the shape/dimensions shown in figure 20.

i) **Clamp for thermometer** That capable of holding the thermometer for oil bath.

j) **Cork** Stopper to hold a thermometer for test tube at the upper part in test tube and a guide ring to hold it at the lower part (as shown in figure 17).

k) **Metal rod** That of 1.2 mm to 1.6 mm in diameter and about 150 mm in length, which is finished by polishing.

l) **Electric heater** That capable of being regulated by voltage control.

m) **Stirrer** That capable of maintaining appropriately the rate of revolution.

8.3 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

8.4 Test procedure

The test procedure shall be as follows.

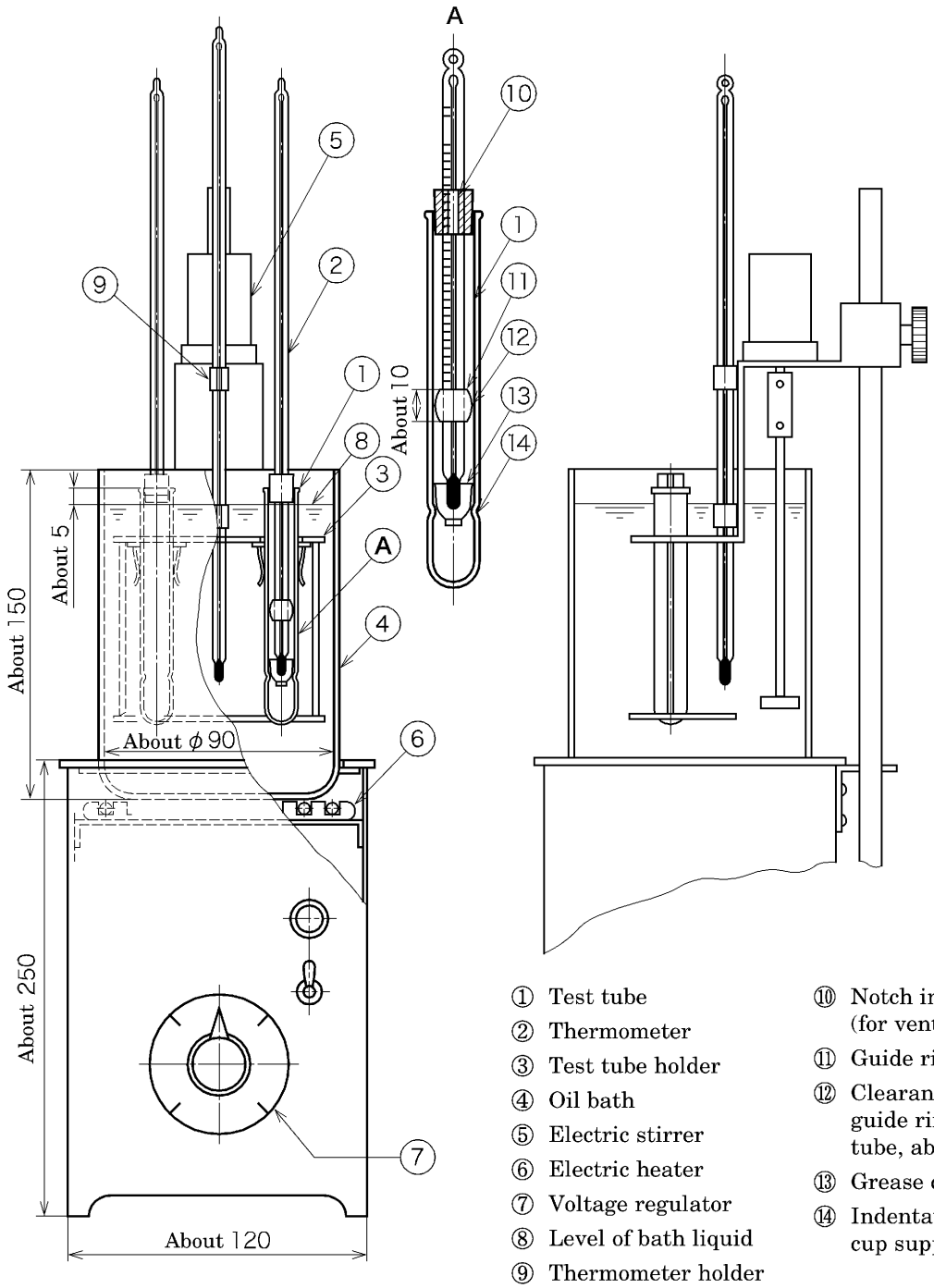
a) Use the cup plug gauge (figure 19) to select a grease cup conforming to the dimensions of the rounded end of the gauge. Check the diameter of the orifice of bottom part of the grease cup by using a 2.78 mm diameter rod gauge and a 2.82 mm diameter rod gauge. The orifice shall allow the 2.78 mm rod gauge to pass easily, but not the 2.82 mm rod gauge. If the orifice is undersized, it shall be reamed to the correct dimensions or the grease cup shall be discarded. If the orifice is too large, the grease cup shall be discarded.

b) Fill the grease cup with a sample by pressing from the larger opening of the grease cup. Remove the excess sample with a spatula. Insert the metal rod from the orifice of bottom part of the grease cup and protrude it about 25 mm. Press the metal rod against the grease cup in such a manner that the rod makes contact at both the upper and the lower peripheries of the grease cup. Maintain this contact, rotating the grease cup on the rod along the index finger to give a spiral-like motion down the metal rod to remove a conical section of the sample. As the grease cup approaches the end of the metal rod, carefully slip the metal rod out of the grease cup. The sample remained inside the grease cup shall be such that there is no air bubbles and the surface thereof is smooth with a definite thickness.

c) Place the cork as shown in figure 17. With the thermometer depth gauge as shown in figure 20 in position in the test tube, adjust the position of the upper cork so that the thermometer bulb touches the bottom of the depth gauge. Observe the position of the top edge of the upper cork relative to thermometer stem as well as the position of the top edge of the test tube relative to the cork. Ensure that the thermometer is inserted to the same depth when the apparatus is reassembled with the grease cup in position.

d) Replace the thermometer depth gauge with the grease cup containing the sample so that the thermometer is inserted to the previously gauged depth set in **c**). When properly inserted, the bulb of the thermometer shall not touch either the sample or the grease cup.

Unit: mm



① Test tube
② Thermometer
③ Test tube holder
④ Oil bath
⑤ Electric stirrer
⑥ Electric heater
⑦ Voltage regulator
⑧ Level of bath liquid
⑨ Thermometer holder
⑩ Notch in cork stopper (for vent)
⑪ Guide ring
⑫ Clearance between guide ring and test tube, about 1.5 mm
⑬ Grease cup
⑭ Indentation for grease cup support

Figure 15 Example of configuration of dropping point tester (double mounting)

Unit: mm

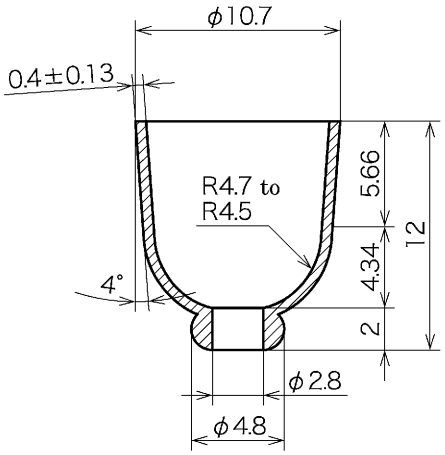


Figure 16 Grease cup

Unit: mm

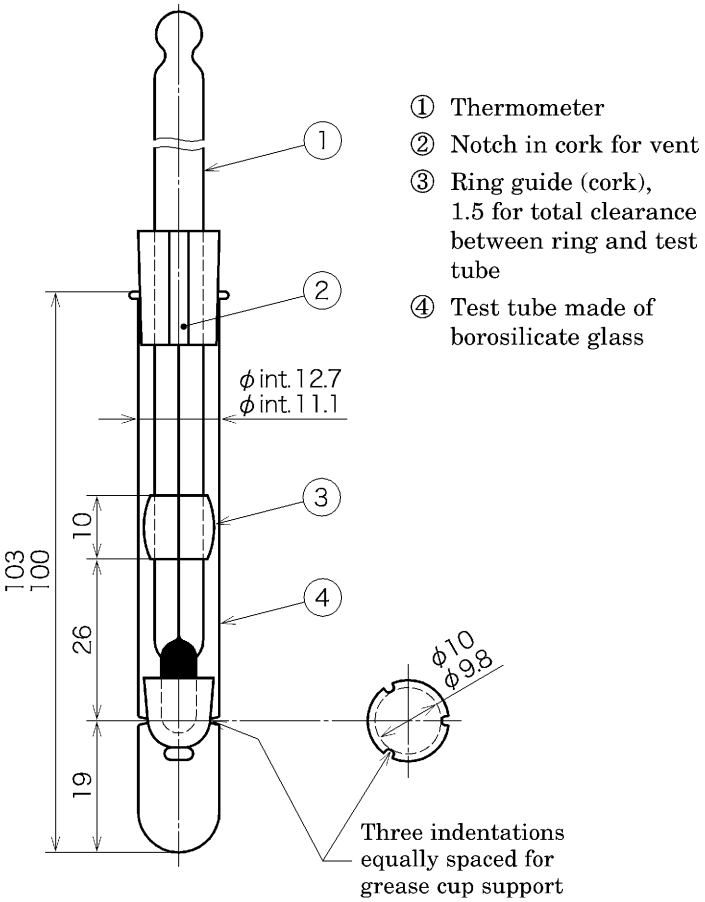


Figure 17 Test tube assembled

Unit: mm

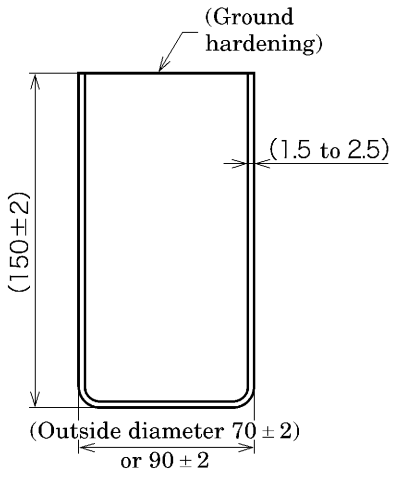


Figure 18 Example of oil bath

Unit: mm

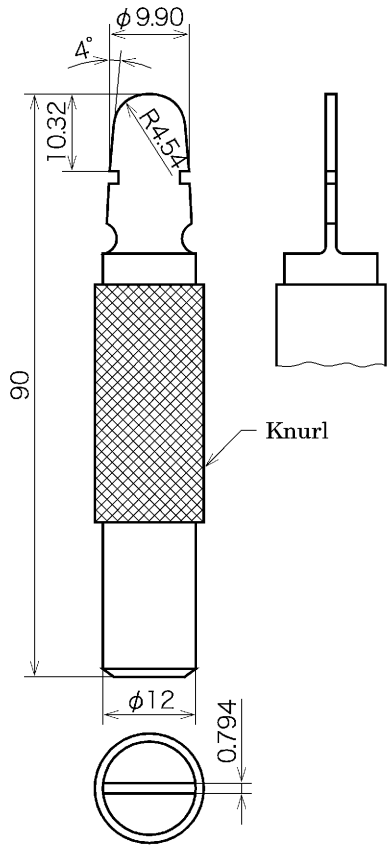


Figure 19 Cup plug gauge

Unit: mm

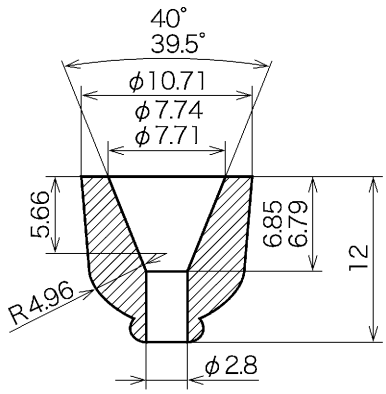


Figure 20 Thermometer depth gauge

e) Attach the test tube to the oil bath. The attaching depth shall be the depth corresponding to the immersion mark of 76 mm on the thermometer. At this time, the upper end of test tube shall be made to be at least about 6 mm above the liquid level.

f) Attach the thermometer to the oil bath so that its bulb is located at about the same height to the bulb of the test tube thermometer.

g) Start to heat as stirring the oil bath and heat at the rate of 4 °C/min to 7 °C/min until the temperature of oil bath reaches a temperature about 17 °C below that of the expected dropping point of the sample. When it reaches this temperature, reduce the rate of heating so that the temperature difference between the test tube and the oil bath becomes 2 °C. Then, raise the temperature of oil bath at the rate between 1.0 °C/min and 1.5 °C/min. Read and record, in integer, the indication of the thermometer of oil bath and the thermometer of test tube when the sample drops from the orifice of the grease cup. The dropping part of some greases, especially the dropping point of grease containing a simple aluminium soap, will decrease upon ageing. It is known that this change largely exceeds the permissible deviation among the results obtained at different test laboratories. Consequently, when the comparative test between the different test laboratories are to be carried out, it is required to be carried out within six days. A certain grease, when melted, becomes a tailing thread form which may break off or hold until the thread form reaches the bottom of the test tube. In any case, the temperature when the sample

reaches the bottom of test tube shall be taken as the dropping point. For the grease whose dropping point is almost the same, the multiple samples can be simultaneously measured in the same oil bath.

8.5 Calculation method and precision

a) **Calculation method** The mean value of the indication on the thermometer of oil bath and the indication on the thermometer of test tube recorded in **8.4 g**) shall be rounded with the rounding interval of 1 according to **JIS Z 8401**.

b) **Precision** The tolerance (probability: 0.95) of the test results obtained according to this test method shall be as follows.

In the case where the test result is deviated from the tolerance, treat according to **JIS Z 8402-6**.

1) **Repeatability** When the same sample is tested twice in the same laboratory by the same person by using the same test apparatus within a short time successively, the tolerance on the difference between the test results shall be as follows.

Tolerance: 7 °C

2) **Reproducibility** When the same sample is tested once in different laboratories by different persons by using different test apparatus respectively, the tolerance on the difference between the test results shall be as follows.

Tolerance: 13 °C

8.6 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **8.5**

d) Date of test

e) Specially mentioned matters

9 Test method for copper corrosion

9.1 Principle of test

A polished copper plate is immersed in the sample, and the presence of discoloration on the copper plate after keeping for 24 h at the room temperature (Method A) or at 100 °C (Method B) shall be examined.

9.2 Reagents

The reagents shall be as follows.

a) **Solvent for cleaning** Acetone specified in **JIS K 8034**.

b) **Water** That of A3 specified in **JIS K 0557**.

9.3 Test apparatus

The test apparatus for copper corrosion shall be composed of the following **a**) to **d**).

a) **Test container** A test tube specified in figure 21 or a beaker made of borosilicate glass.

b) **Thermostatic air bath** An electric heating thermostatic air bath capable of keeping the temperature at 100 °C ± 1 °C equipped with a suitable holder which is capable of holding the test tube vertically. When a test tube is used, a liquid bath or an aluminium block may be used. A liquid bath shall be so constructed that the test tube can be immersed vertically in the liquid bath about 100 mm and the direct sunlight on the sample is avoided. An aluminium block shall be equipped with a hole in which a test tube can be vertically inserted about 100 mm.

c) **Holder for polishing** An example of holder for polishing is shown in figure 22, which is to be used to fix the test piece when polished (see **JIS K 2513**).

d) **Thermometer** No. 42 thermometer (thermometer for specific gravity floating method) specified in **JIS B 7410**.

Unit: mm

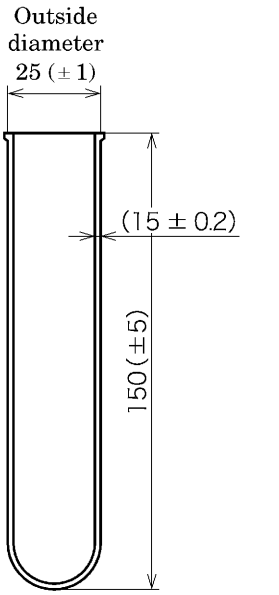


Figure 21 Test tube

Unit: mm

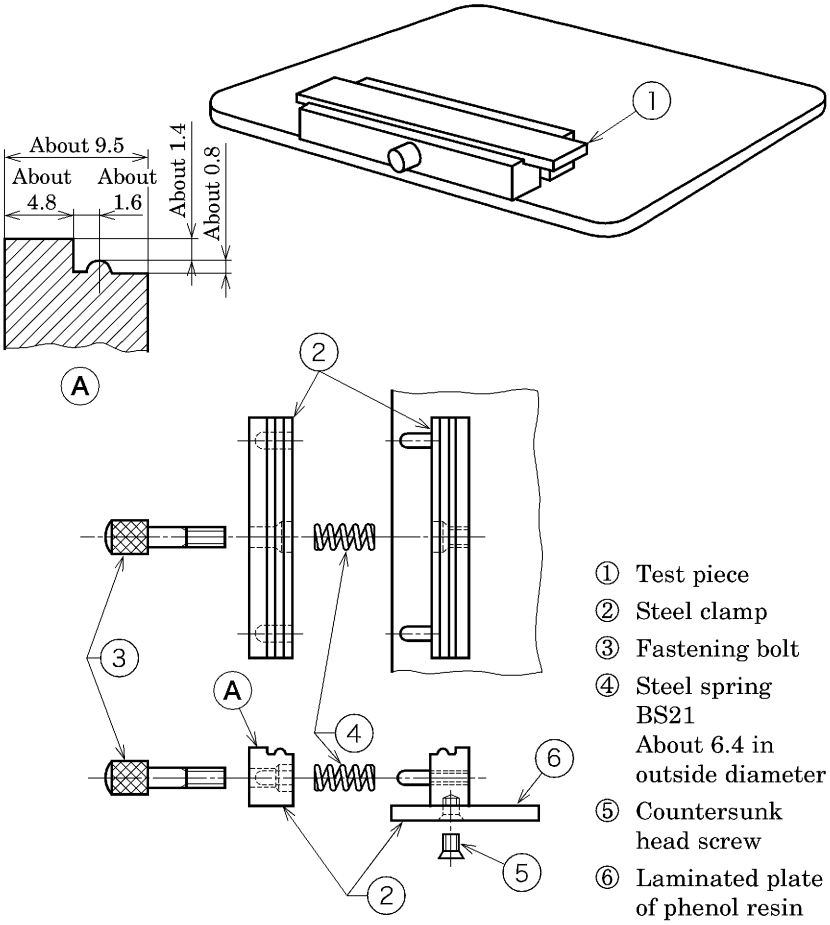


Figure 22 Holder for polishing

9.4 Test piece and others

The test piece and others shall be as follows.

a) **Test piece** That made of C1100P, C1201P or C1220P specified in **JIS H 3100** with length of about 75 mm, width of about 12.5 mm and thickness of 1.5 mm to 3.0 mm. The test piece may be repeatedly used; however, the test piece with a deep flaw which cannot be removed or with a deformed surface shall not be used.

b) **Preliminary abrasives** Any of the following shall be used.

1) Abrasive cloths of silicon carbide or fused alumina and P240 in grain size specified in **JIS R 6251**

2) Abrasive papers of silicon carbide or fused alumina and P240 in grain size specified in **JIS R 6252**

c) **Finishing abrasives**

Artificial abrasives of silicon carbide (C or GC) and F150 in grain size specified **JIS R 6111** and Pharmacopoeia absorbent cotton

9.5 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

9.6 Preparation of test

The preparation of test shall be as follows.

a) **Preliminary polishing of test piece** Use abrasive paper or abrasive cloth of appropriate grain size. Place abrasive paper or abrasive cloth on a flat plate, wet it with the solvent for cleaning, put the test piece on it, press the test piece with an ashless filter paper, and polish the test piece by circular movement to remove the flaws on whole surface of test piece. Then, polish with abrasive paper or abrasive cloth of FP240, clean the test piece by immersing in solvent for cleaning, and immediately proceed to the finish polishing. When the finish polishing is unable to be made in succession, the test piece shall be immersed still in the solvent for cleaning.

b) **Finish polishing of test piece** Take the test piece out from the solvent for cleaning, put it between ashless filter papers and hold with hand, first polish both end surfaces with absorbent cotton slightly wetted with solvent for cleaning and putting silicon carbide grains of F150 on it, then polish the both side surfaces. Further rub strongly with fresh absorbent cotton alone. Hereafter, handle the test piece with a stainless steel tweezers with care not to allow finger to touch the test piece directly. Fix the test piece to the holder for polishing, polish the both principal surfaces of test piece in its longitudinal direction by the use of absorbent cotton putting silicon carbide grains of F150 on it. The polishing shall be made uniformly from one end to another of the test piece with care not to round the edges. Finally rub strongly with absorbent cotton alone until no stain is found on fresh absorbent cotton. Within 1 min, put the test piece in the sample.

c) **Cleaning of test tube** Wash to clean the test tube by immersing in the specified solvent for cleaning, wash with city water until the solvent for cleaning is gone out, then rinse with water specified in **9.2 b**), and dry.

9.7 Test procedure

The test procedure shall be as follows.

a) Put a sample in a test container to about 90 mm depth and insert the test piece until the upper edge is immersed in the sample with care not to involve air bubbles [1].

Note [1] It should be preferable to coat the same sample previously on the whole surface of the test piece.

b) In the case of Method A, leave the test container at the room temperature for 24 h. In the case of Method B, hold the test container vertically, and place it in thermostatic air bath kept at 100 °C ± 1 °C for 24 h. Take it out and leave it for cooling to the room temperature.

c) Pull out the test piece from the test container with a stainless steel tweezers, and clean it with the solvent for cleaning.

9.8 Test results

The test results shall be as follows.

The copper plate shall be observed and the presence of change in colour to green or black shall be reported.

9.9 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **9.8**

d) Date of test

e) Specially mentioned matters

10 Test method for evaporation loss

10.1 Principle of test

The sample is weighed out in a test container, fixed to an evaporator and put in a thermostatic bath maintained at the specified temperature. The specified flow rate of clean heated air is made flow on the surface of sample for 22 h, then the evaporation loss is calculated from the loss in mass of the sample.

10.2 Test apparatus

The test apparatus for evaporation loss shall be composed of the following **a**) to **f**), and an example of construction diagram is shown in figure 23.

a) **Evaporator** The outer cylinder, lid, exhaust tube and outlet shall be the stainless steel pipes of SUS304 specified in **JIS G 3459**, and the air preheating tube shall be that made of tin plated copper.

b) **Sample container and cover** An example of the sample container and cover is shown in figure 24. The material quality of those shall be stainless steel and the mass of the sample container shall be 200 g or under. For easy detaching of the sample container in weighing-out the sample, all of the container, cover, and exhaust tube shall be of threaded type.

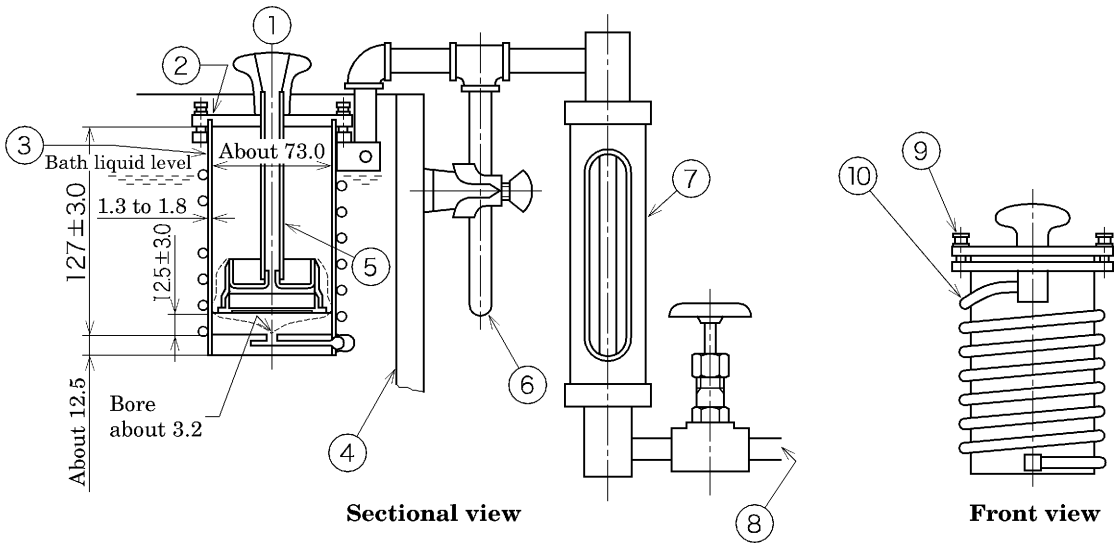
c) **Air supplying apparatus** That capable of supplying air at the specified flow rate to the evaporator through a filter device. The filter device shall be a tube of about 25 mm in diameter and about 400 mm in length which is stuffed with glass wool, or that having the equivalent performance to this.

d) **Thermostatic oil bath** That deep enough capable of immersing the air preheating tube of evaporator sufficiently, and shall be equipped with such a regulator as is capable of controlling at the specified temperature ± 0.5 °C with a maximum variation throughout the bath within 0.5 °C. The oil having sufficient thermal stability such as silicone oil shall be used.

e) **Thermometer** No. 6 thermometer specified in **JIS B 7410**. When the test is carried out at over 99 °C, the appropriate thermometer other than this shall be used.

f) **Flow meter** That shall be the flow metre (such as rotor metre) capable of measuring the passing quantity of 2.58 g/min ± 0.02 g/min (2 L/min) between 15 °C and 29 °C equipped with an air regulating valve.

Unit: mm

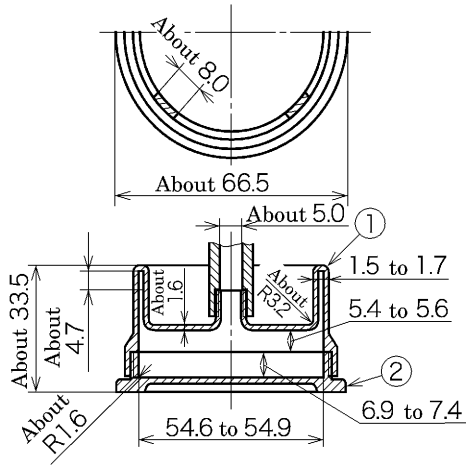


① Outlet
② Inserting lid
③ Outer cylinder
④ Bath wall
⑤ Exhaust tube
⑥ Supporting rod
⑦ Flow meter
⑧ Air inlet
⑨ Screw for air tightening
⑩ Air preheating tube
Steel pipe of about 6.3 in outside diameter and 1 830 or over in length (about 7 turns)

NOTE : This diagram is prepared based on Fig.1 and Fig.1a of **ASTM D 972**-97.

Figure 23 Example of construction of evaporator

Unit: mm



① Cover
② Sample container

NOTE : This diagram is prepared based on Fig.2 of **ASTM D 972**-97.

Figure 24 Example of construction of sample container and cover

10.3 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

10.4 Test procedure

The test procedure shall be as follows.

a) Weigh out a clean sample container together with a cover to the nearest 1 mg, and pack the sample with care not to allow air to enter. Flatten the surface along a rim of the test container with a straight blade of a spatula. Remove the sample adhering onto the rim and the screw with clean cloth. Screw the cover onto the container with care not to give flaws to the flattened surface. Weigh this and obtain the mass of the sample to the nearest 1 mg.

b) Regulate the thermostatic oil bath containing the evaporator at the test temperature ± 0.5 °C, and leave it at least for 30 min as it is while sending clean air to the evaporator at the rate of 2.58 g/min ± 0.02 g/min (2 L/min). Then, detach the lid, attach the sample container weighed and the cover weighed to the exhaust tube and put the lid again, clamp strongly several fasteners so as not to allow air to leak from under the lid. Send air into the evaporator for 22 h ± 5 min.

c) After 22 h, take out the container as the cover is attached, and leave it cool in a desiccator with no desiccant contained down to the room temperature as it is. Weigh out it and obtain the mass of the sample to the nearest 1 mg and calculate the loss in mass.

10.5 Calculation method and precision

a) **Calculation method** The calculation shall be according to the following formula, and the mean value of two measurement results obtained in **10.4** shall be rounded with the rounding interval of 0.01 according to **JIS Z 8401**, and this shall be taken as the test result.

$$W_1 = \frac{W_s - W}{W_s} \times 100$$

where, W_1 : evaporation loss (mass fraction %)

W_s : mass of sample before test (g)

W : mass of sample after test (g)

b) **Precision** The tolerance (probability: 0.95) of the test results obtained according to this test method shall be as follows.

In the case where the test result deviates from the tolerance, treat according to **JIS Z 8402-6**.

1) **Repeatability** When the same sample is tested twice in the same laboratory by the same person by using the same test apparatus within a short time successively, the tolerance of test results shall be as follows.

Tolerance: 10 % of the mean value

2) **Reproducibility** When the same sample is tested once in different laboratories by different persons by using different test apparatus respectively, the tolerance of two test results shall be as follows.

Tolerance: 35 % of the mean value

10.6 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **10.5**

d) Date of test

e) Specially mentioned matters

11 Test method for oil separation

11.1 Principle of test

The sample is weighed out in the conical wire gauge filter, kept in a thermostatic air bath at the specified temperature for the specified time, then the mass of oil separated from the sample is weighed and the oil separation percentage is calculated,

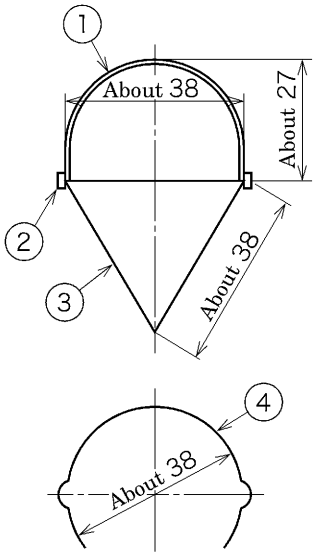
11.2 Test apparatus

The test apparatus shall be composed of the following **a**) to **e**).

a) **Conical wire gauze filter** (hereafter referred to as "filter") That of which the shape and dimensions shall be as shown in figure 25 and figure 26, and the conical part shall be made of stainless wire gauze of 250 μm in opening (160 μm in wire diameter) specified in **JIS Z 8801-1**. Nickel wire of about 0.8 mm in diameter shall be brazed to the circumference of the upper rim, and a hanger of nickel wire of the same diameter shall be attached to it.

b) **Beaker** That made of borosilicate glass. An example is shown in figure 27.

Unit: mm

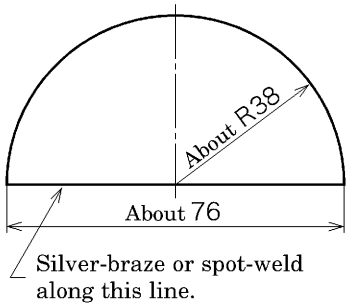


① Hanger
② Socket for hanger
③ Stainless wire gauge
④ Brazed nickel wire of about 0.8 in diameter

NOTE : This diagram is prepared based on Fig.1 of **ASTM D 6184**-98.

Figure 25 Example of conical wire gauze filter

Unit: mm



NOTE : This diagram is prepared based on Fig.1 of **ASTM D 6184**-98.

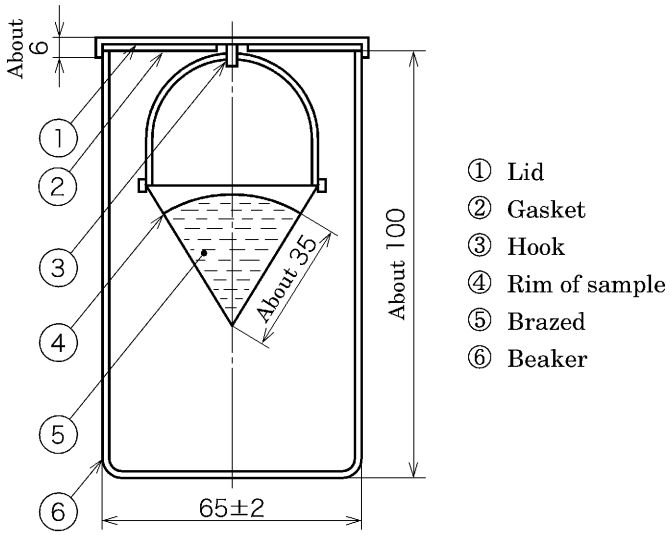
Figure 26 Example of development diagram of conical wire gauze filter

c) **Lid** That of shape/dimensions as shown in figure 27, made of copper or brass of about 1 mm in thickness, and a hook of copper or brass of about 1.5 mm in diameter shall be brazed near the centre of the inside surface.

d) **Gasket** That having the same diameter as the inside diameter of the lid, and shall be made of nitrile rubber of 1.5 mm in thickness or the synthetic rubber having equivalent oil resistance and heat resistance to this. It is used by opening a hole of about 20 mm at the central part.

e) **Thermostatic air bath** An electric heating type capable of maintaining at the specified temperature ± 0.5 °C.

Unit: mm



NOTE: This diagram is prepared based on Fig.1 of **ASTM D 6184**-98.

Figure 27 Example of assembly of oil separation tester

11.3 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

11.4 Test procedure

The test procedure shall be as follows.

a) Depress the sample uniformly to the inside of the wire gauze with a spatula from the top end of the clean filter of known mass to the position of about 35 mm length so as to allow the sample to be extruded out of the wire gauze, then stuff the sample slowly with care not to allow air bubbles to enter. Then mound up the sample surface so as not to accumulate separated oil on the surface, and smoothen it with a spatula. Remove the sample extruded from the net of the filter by finger, and after adjusting the whole mass of the sample to be about 10 g, weigh the mass to the nearest 0.01 g.

b) Suspend the filter containing the sample with the hook of the lid, put in a clean beaker of known mass, and place in the thermostatic air bath kept at the specified temperature ± 0.5 °C for the specified hours. Then take out the beaker from the thermostatic air bath, leave it still in a desiccator without desiccant to cool down to the room temperature. By applying the end of the filter slightly to the inside edge of the beaker, transfer the oil adhering on the tip of the cone to the beaker. Weigh the mass of the separated oil to the nearest 0.01 g and obtain the mass of separated oil.

11.5 Calculation method and precision

a) **Calculation method** The calculation shall be according to the following formula, and the mean value of two measurement results obtained in **11.4** shall be rounded

with the rounding interval of 0.1 according to **JIS Z 8401**, and this shall be taken as the test result.

$$A = \frac{C}{B} \times 100$$

where, A : oil separation percentage (mass fraction %)

B : mass of sample (g)

C : mass of separated oil (g)

b) **Precision** The precision is not specified.

11.6 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **11.5**

d) Date of test

e) Specially mentioned matters

12 Test method for oxidation stability

12.1 Principle of test

The sample is heated at 99 °C in a cylinder under 755 kPa of oxygen pressure, the drop of oxygen pressure is recorded at every interval of definite time and the decrease of oxygen pressure is measured after 100 h.

12.2 Reagents and materials

The reagents and materials shall be as follows.

a) **Water** That of A3 specified in **JIS K 0557**.

b) **Petroleum benzine** That specified in **JIS K 8594**.

c) **Oxygen** That specified in **JIS K 1101**.

12.3 Test apparatus

The test apparatus for oxidation stability shall be composed of the following **a**) to **h**). An example of the construction of the test apparatus for oxidation stability is shown in figure 28.

a) **Cylinder** An example of the cylinder is shown in figure 29. The cylinder shall be made of anti-corrosive metal with pressure-proof and airtightness, and be composed of the cylinder body, needle valve, the lid with pipe for attaching pressure gauge, and nuts and gaskets for fastening the cylinder. The material quality of those shall be according to table 19 or equivalent thereto, shall withstand the hydraulic test of 3 920 kPa, and a pressure drop shall not be observed when placed still in thermostatic bath of 99 °C ± 0.5 °C for 100 h or over at the oxygen pressure of 755 kPa.

The inner surface of cylinder body, lid and pipe for attaching pressure gauge shall be finished so as to facilitate washing and cleaning, and the capacity excluding the sample container and its holder shall be 185 ml ± 6 ml to the contact surface of the gasket of socket for pressure gauge. The assembly is shown in figure 28.

b) **Pressure gauge** That (marked as "oil-prohibited") specified in **JIS B 7505-1** of Class 0.6, size 150 mm, screw joint PF3/8, pressure range 0 kPa to 1 000 kPa and minimum graduation 10 kPa, otherwise, an instrument of indicating or recording type with the same precision may be used. For the inspection of pressure gauge, oils and fats shall not be used.

c) **Test container holder** That having the shape/dimensions shown in figure 30, and the material quality of rod part shall be SUS304 of **JIS G 4303** and that of plate part shall be SUS304 of **JIS G 4305**.

d) **Test container** That having the shape/dimensions shown in figure 30, and the material quality shall be borosilicate glass.

e) **Fastening tool for cylinder** A wrench to fasten the nut for cylinder fastening and a block for fixing the cylinder, and an example thereof is shown in figure 31.

f) **Oxygen introducing tube** A flexible tube of metal or other appropriate material to connect the cylinder and the oxygen vessel for introducing oxygen to the cylinder, and shall have metal fittings at both ends to connect the cylinder and the oxygen vessel.

g) **Thermostatic oil bath** An example of the thermostatic oil bath is shown in figure 28. It shall be equipped with a motor driven stirrer, an electric heater and a temperature regulator, and shall be capable of keeping the bath temperature in the range of 99 °C to 150 °C within ± 0.5 °C.

The lid of the bath shall be provided with cylinder inserting holes and a thermometer holder. The cylinder inserting hole shall be equipped with a guide for the cylinder supporting plate, and when the cylinder is inserted, the distance between the upper surface of the cylinder and the level of the bath liquid shall be about 50 mm or over. For the thermostatic bath liquid, heat resistant silicone oil or the like having good thermal stability should be used.

NOTE : A safety device for overheating should preferably be attached to the thermostatic oil bath.

h) **Thermometer** That of No. 6 specified in **JIS B 7410**. In the case of testing at over 99 °C, other appropriate thermometer shall be used.

Unit: mm

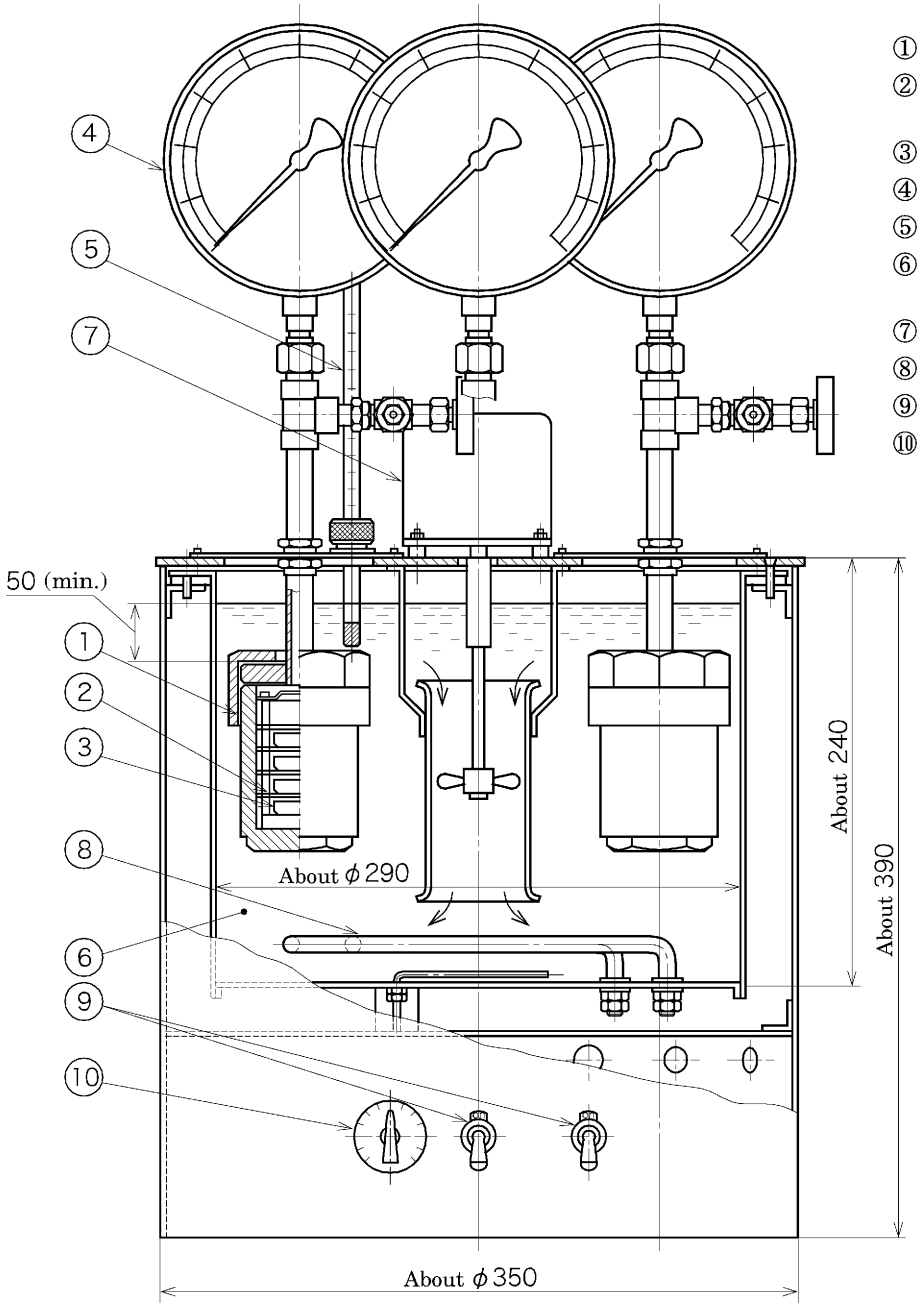
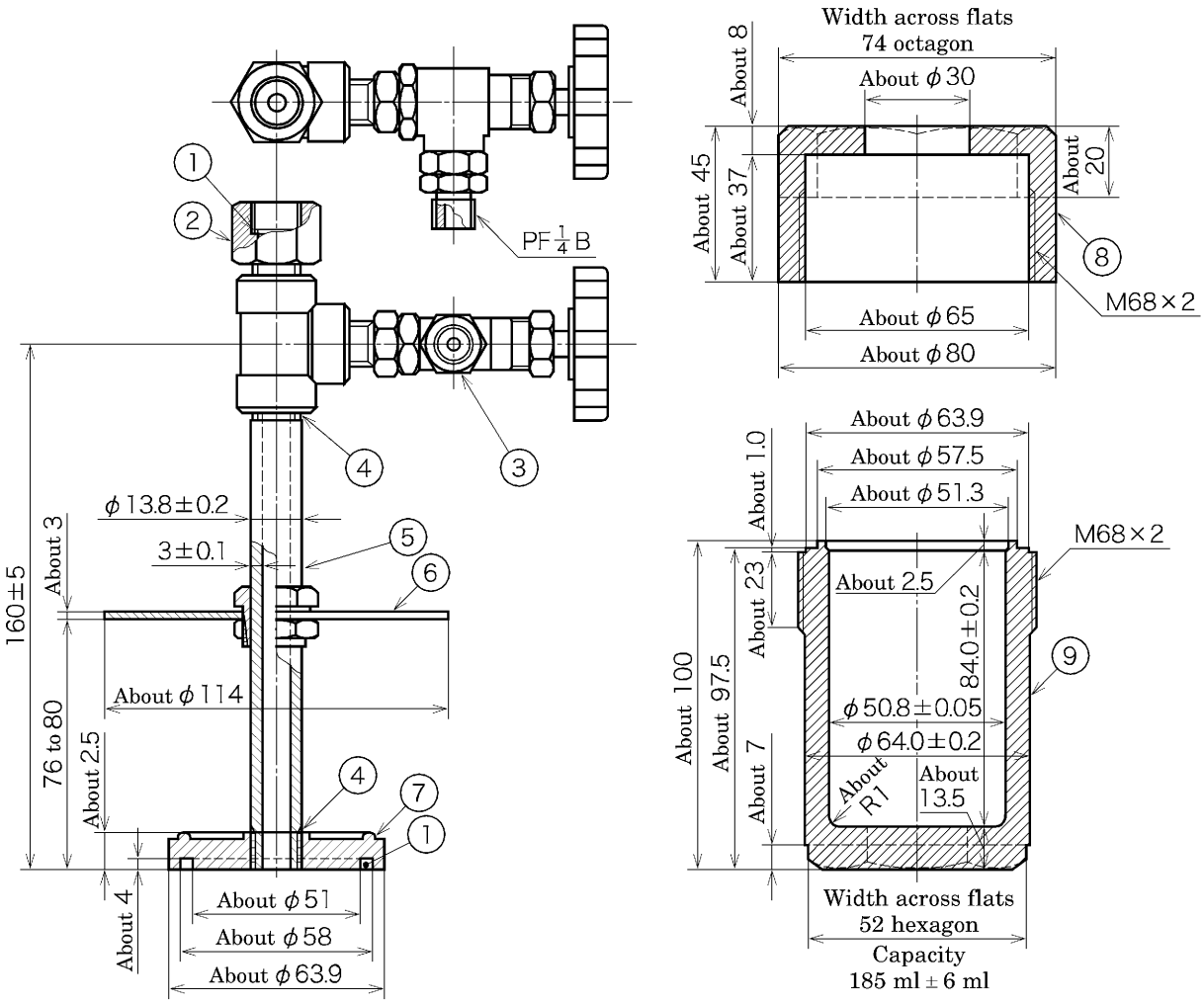


Figure 28 Example of test apparatus for oxidation stability

Table 19 Material quality of cylinder

Name of component	Material quality
Cylinder body	SUS304 of **JIS G 4303**
Fastening nut	C3602 of **JIS H 3250**
Socket for pressure gauge	C3602 of **JIS H 3250**
Needle valve	SUS304 of **JIS G 4303**
Attaching pipe for pressure gauge	SUS304TP nominal diameter 1/4B5 and nominal thickness schedule 80 of **JIS G 3459**
Cylinder supporting plate	C2600P of **JIS H 3100**
Gasket	Nitrile rubber, or synthetic rubber having oil resistance and heat resistance at least equal thereto

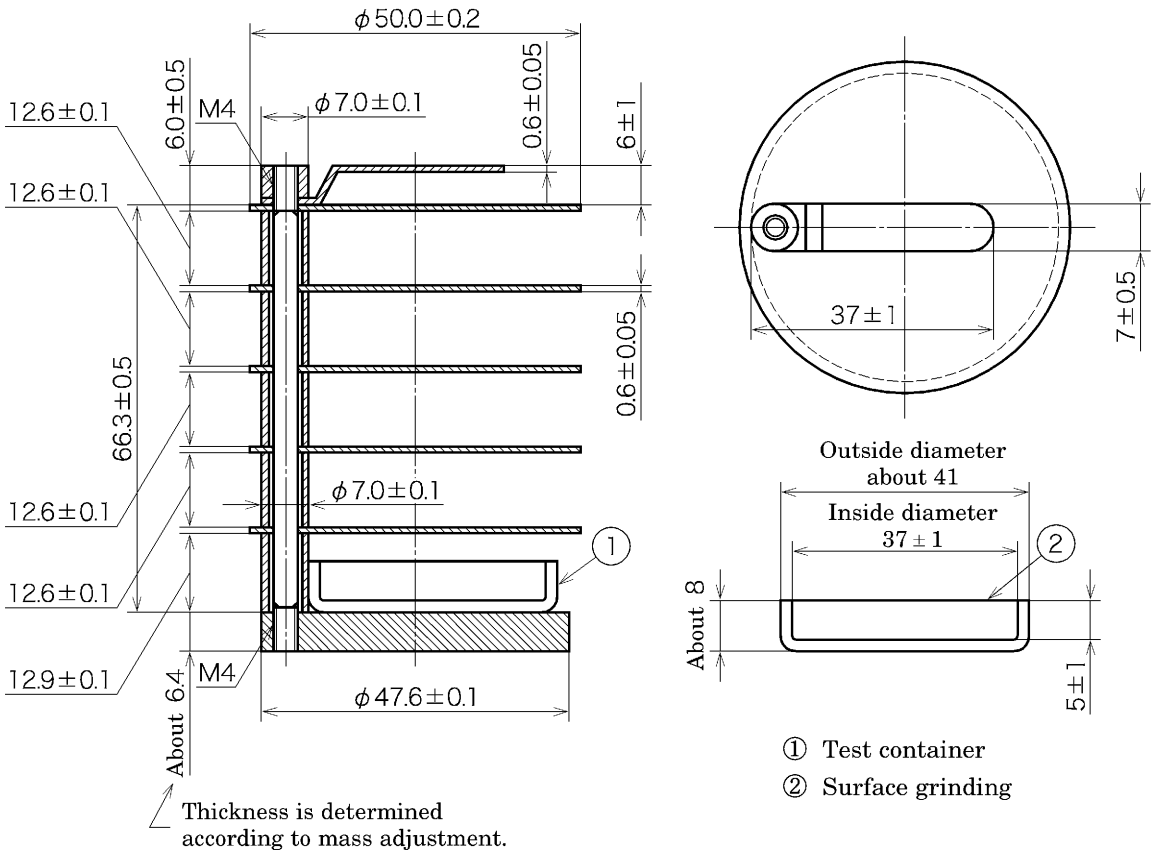
Unit: mm



① Gasket
② Socket for pressure gauge
③ Needle valve
④ Brazed
⑤ Attaching pipe for pressure gauge
⑥ Cylinder supporting plate
⑦ Lid
⑧ Fastening nut
⑨ Cylinder body

Figure 29 Example of cylinder

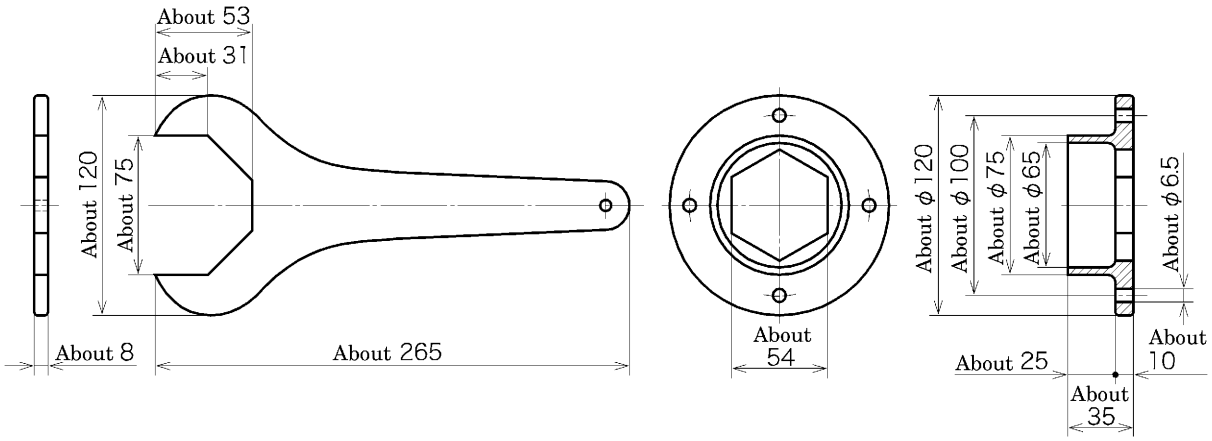
Unit: mm



NOTE : This diagram is prepared based on Fig.1 of **ASTM D 6184**-98.

Figure 30 Test container holder and test container

Unit: mm



a) Wrench **b) Block for fixing**

Figure 31 Example of fastening tool for cylinder

12.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

12.5 Preparation of test

The preparation of test shall be as follows.

a) Wash and clean the test container with a suitable solvent, wash with warm soap water, then rinse with city water and with water well in this order, and dry in a dryer. Thereafter, the test container shall not be touched with hand directly.

b) Wash sufficiently the inner surface of the cylinder, the test container holder, the lid and the inner surface of the attaching pipe for pressure gauge with petroleum benzine, then dry thoroughly.

12.6 Test procedure

The test procedure shall be as follows.

a) Weigh out 4.00 g ± 0.01 g of the sample each and transfer it into five test containers so as not to enter air bubbles, make the surface of each sample smooth, and place on the shelves of the test container holder. When assembling the cylinder, loosely stuff rounded glass wool in the bottom of the attaching pipe for pressure gauge.

b) Put the test container holders in the cylinder and close with the lid and the fastening nuts. Introduce slowly the oxygen specified in **JIS K 1101** into the cylinder up to the oxygen pressure of 685 kPa, then release slowly. Repeat this procedure four times. When the pressure reaches 685 kPa at the fifth charging of oxygen, close the needle valve tightly, and check for the presence of gas leakage either by leaving quietly for several hours as it is or immersing in water.

c) After confirming no leakage of the gas, put the cylinder in the thermostatic oil bath kept at 99 °C ± 0.5 °C. Since the pressure of cylinder rises at the beginning of the immersion in the bath, continue the operation of releasing oxygen from time to time for about 2 h so that the pressure stabilizes at 755 kPa ± 5.0 kPa.

d) Read out the decrease of oxygen pressure in the unit of 5 kPa after a lapse of 100 h from the time of immersing the cylinder in thermostatic oil bath. Record the pressure every 24 h during the testing period.

12.7 Calculation method and precision

a) **Calculation method** The mean value of two measured results (pressure drop kPa) obtained in **12.6** on the same sample is taken as the oxidation stability, which is expressed by integral times of 5 kPa according to the specifications in **JIS Z 8401** and taken as the test result.

b) **Precision** The tolerance (probability: 0.95) of test result obtained according to this test method shall be as follows. This precision shall be applicable only to the sample for which oxygen is absorbed at a rate approximately in proportion to time. It shall not be applied to the sample for which the rate of oxygen absorption accelerates rapidly from the middle. If the test result is out of the tolerance, the result shall be treated according to the specifications of **JIS Z 8402-6**.

1) **Repeatability** When the same sample is tested twice in the same laboratory by the same person by using the same test apparatus within a short time successively, the tolerance in test results shall be as shown in table 20.

Table 20 Repeatability

Pressure drop kPa	Tolerance kPa
Under 35	15
35 or over to and excl. 70	30
70 or over to and excl. 135	40
135 or over to and excl. 380	70

2) **Reproducibility** When the same sample is tested once in different laboratories by different persons by using different test apparatus respectively, the tolerance of difference in two test results shall be as shown in table 21.

Table 21 Reproducibility

Pressure drop kPa	Tolerance kPa
Under 35	40
35 or over to and excl. 70	55
70 or over to and excl. 135	85
135 or over to and excl. 380	135

12.8 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **12.7**

d) Date of test

e) Specially mentioned matters

13 Test method for foreign matters

13.1 Principle of test

The notch of the specified template is filled with the sample in a clean environment, and the number of foreign matters contained in the sample shall be counted according to the size by using a microscope.

13.2 Test apparatus

The test apparatus for foreign matters shall be composed of the following **a**) to **d**).

a) **Microscope** That of about 100 magnifications provided with an ocular micrometre and a mechanical stage.

b) **Template** That of metallic plate with 0.1 mm ± 0.01 mm in thickness of the shape/dimensions as shown in figure 32, which shall have a notch of about 10 mm in width and about 20 mm in length.

c) **Desiccator** That having a size enough to contain slide glasses for microscope, and shall be capable of obtaining reduced pressure by the aid of a vacuum pump.

d) **Vacuum pump** That capable of exhausting rapidly the pressure of air in the desiccator to 1.33 kPa or under.

Unit: mm

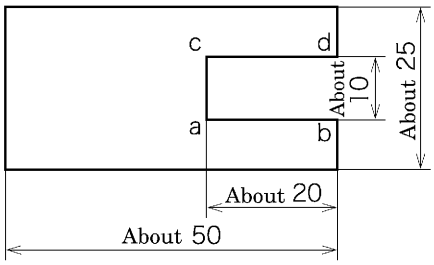


Figure 32 Example of template

13.3 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

13.4 Test procedure

The test procedure shall be as follows.

a) Remove the surface of the sample with a spatula, place the template on the slide glass, and fill the notch with the sample slightly over the upper surface of the template while pressing the end without notch by hand.

If necessary, air shall be removed by pretreatment.

b) When air bubbles are contained in the grease existing in the notch of the template, put the sample together with slide glass in the desiccator to subject to the pressure reduction treatment, which is made by keeping pressure 1.33 kPa or under for 10 min to 15 min. Slide the cover glass while pressing it to the template so that the excess sample be scraped off from the edge of the notched side of the template.

c) Place the slide glass on the stage of the microscope, and adjust the ocular lens and stage so that the graduation of the micrometre comes to the line a-b of the notch.

d) Move the stage along the line a-c of the notch while focussing on the foreign matters, record the number of foreign matters crossing the graduation of the ocular micrometre while classifying into four classes of 10 μm or over to and excluding 25 μm, 25 μm or over to and excluding 75 μm, 75 μm or over to and excluding 125 μm, and 125 μm or over, continue the measurement until the graduation arrives at the line c-d of the notch of the template, and take this classification as the first section.

In this case, for a fibrous matter measurement shall be made for the width, not for the length. Particles smaller than 10 μm shall not be counted.

e) Shift the stage along the line c-d of the notch adjacent to the first section by equal distance of the graduation length of micrometre, and count and record the number of particles by the method specified in **d**) until the stage reaches the line a-b of the notch. Repeat the procedure to about 10 mm on the line a-b or the c-d of the notch.

13.5 Calculation method and precision

a) **Calculation method** The number of particles per cubic centimetre of sample by every size shall be calculated according to the following formula, and the mean value of three measurement results obtained in **13.4** shall be rounded with the rounding interval of 1 according to **JIS Z 8401**.

$$A' = \frac{1\,000(A+B+C+D)}{T \times S \times N}$$

$$B' = \frac{1\,000(B+C+D)}{T \times S \times N}$$

$$C' = \frac{1\,000(C+D)}{T \times S \times N}$$

$$D' = \frac{1\,000D}{T \times S \times N}$$

where, A' : number of particles of 10 μm or over in maximum dimension per 1 cm^3 of sample (pieces/cm^3)

B' : number of particles of 25 μm or over in maximum dimension per 1 cm^3 of sample (pieces/cm^3)

C' : number of particles of 75 μm or over in maximum dimension per 1 cm^3 of sample (pieces/cm^3)

D' : number of particles of 125 μm or over in maximum dimension per 1 cm^3 of sample (pieces/cm^3)

A : total number of particles of 10 μm or over to and excl. 25 μm (pieces)

B : total number of particles of 25 μm or over to and excl. 75 μm (pieces)

C : total number of particles of 75 μm or over to and excl. 125 μm (pieces)

D : total number of particles of 125 μm or over (pieces)

T : sectional area of notch of template (mm^2) [2)]

S : length of graduation of ocular micrometre (mm)

N : number of measuring sections

Note [2)] Measure the thickness of template and the width of the notch to calculate the sectional area (mm^2).

b) **Precision** The precision is not specified.

13.6 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **13.5**

d) Date of test

e) Specially mentioned matters

14 Test method for ash content

14.1 Principle of test

The sample is weighed out and transferred into a crucible, burnt until the sample becomes ash and carbide matter, then put in an electric furnace and heated at 600 °C. After the carbonaceous matter has completely become ash, it is left to cool in a desiccator as it is and the mass is weighed to obtain ash content.

14.2 Reagent

The reagent shall be as follows.

a) **Ethanol** That specified in **JIS K 8102**.

14.3 Test apparatus

The test apparatus for ash content shall be according to the following **a**) to **d**).

a) **Crucible** That of 15 ml [3)] in capacity, and made of porcelain, quartz or platinum. When a sample contains lead, zinc and other substances which react with platinum at high temperature, platinum crucible shall not be used.

Note [3)] A crucible with different capacity may be used as the result of considering the expected amount of ash content of the sample and the thermal expansion of the sample when burnt.

b) **Electric furnace** That capable of regulating the temperature of furnace inside at 600 °C ± 25 °C.

c) **Desiccator** That having an appropriate size, which shall be used without desiccant.

d) **Balance** That capable of weighing the total mass of crucible and sample to the nearest 0.01 g.

14.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

14.5 Test procedure

The test procedure shall be as follows.

a) Place the crucible in the electric furnace maintained at 600 °C ± 25 °C, heat it, leave it cool as it is in a desiccator, and weigh the mass to the nearest 0.01 g.

b) Weigh out 2 g to 5 g of the sample in this crucible and read out the mass to the nearest 0.01 g.

c) Heat the crucible containing the sample weighed out with gas burner, and burn the sample gradually. When the sample foams and scatters during burning, add 1 ml to 2 ml of ethanol before heating.

d) When the sample starts to burn, regulate the heating so as to continue to burn at a constant state thereafter.

NOTE : An electric heater such as hot plate may be used.

e) After the burning of the sample has finished and the content in the crucible has become the carbonaceous substance, place the crucible in the electric furnace maintained at 600 °C ± 25 °C and heat it until the carbonaceous substance cannot be completely observed.

f) Take out the crucible from the electric furnace, leave it cool as it is in a desiccator to the room temperature, and weigh the mass to the nearest 0.01 g.

14.6 Calculation method and precision

a) **Calculation method** The calculation shall be according to the following formula, and the mean value of two measurement results obtained in **14.5** shall be rounded with the rounding interval of 0.1 according to **JIS Z 8401**, and this shall be taken as the test result.

$$A = \frac{W_r}{W_s} \times 100$$

where, A : ash content (mass fraction %)

W_r : mass of ash (g)

W_s : mass of sample (g)

b) **Precision** The precision is not specified.

14.7 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **14.6**

d) Date of test

e) Specially mentioned matters

15 Test method for worked stability

15.1 Principle of test

After the sample is worked one hundred thousand times in the specified worker, it is kept at 25 °C for the specified time, further worked 60 times, and the penetration is measured.

15.2 Test apparatus

The test apparatus shall be composed of the following **a**) to **f**).

a) **Worker for worked stability** An example of the worker for worked stability is shown in figure 33. The worker shall be capable of moving up and down strokes of the perforated plate attached to the top of the sliding rod. The gland of the sliding rod and the jointing part of the pot and the cover or the like shall be so constructed that the sample in the pot should leak extremely little for one hundred thousand up and down strokes.

b) **Motor driven working apparatus** The apparatus shall be similar to the motor-driven working apparatus shown in figure 8 in construction and shall be capable of moving up and down perforated plate of the worker for worked stability at a rate of 60 strokes ± 10 strokes per minute for 67 mm to 71 mm travel. The mechanism of up and down movement shall be capable of withstanding the test for worked stability, and it is preferable that the motor to be used is of 0.75 kW.

c) **Penetrometer** That specified in **7.2 a**).

d) **Cone** That specified in **7.2 b**) **1**).

e) **Spatula** That specified in **7.2 h**).

f) **Thermostatic water bath** That specified in **7.2 f**).

Unit: mm

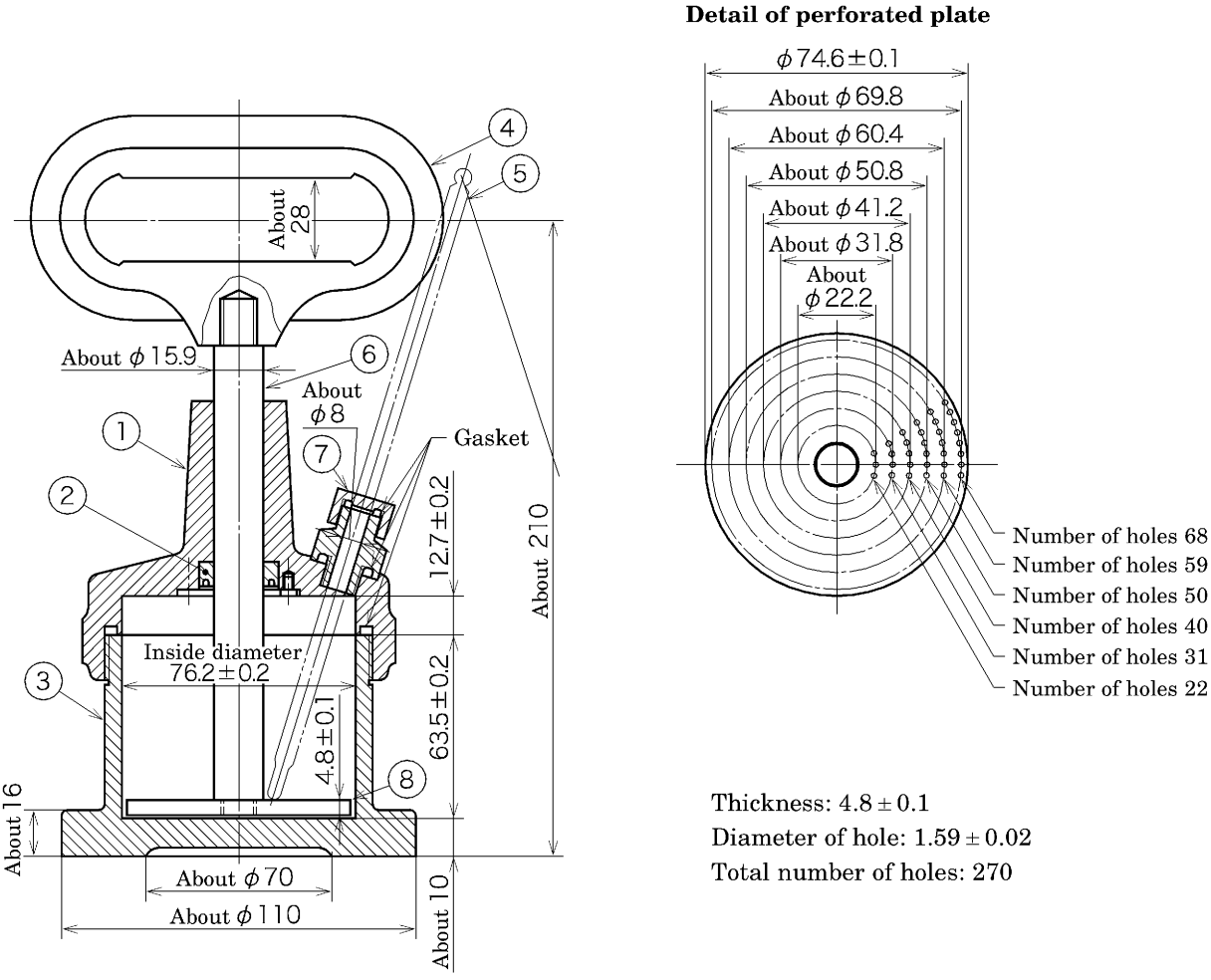


Figure 33 Example of worker for worked stability

15.3 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

15.4 Test procedure

The test procedure shall be as follows.

a) Prepare the sample of amount (0.5 kg or over) enough to overfill the pot of the worker, and leave it as it is until the temperature of sample reaches the room temperature in the testing place. The temperature of the testing place should preferably be kept within the range 15 °C and 30 °C.

b) After leaving the sample as it is for enough time in the testing place, pack the pot of clean grease worker with sample with a spatula with care not to allow air to enter the pot, and mound it to a mountain shape so that the central part will be about 10 mm or higher than the rim, open the cock on the cover of the grease worker, and assemble the grease worker. Then depress the perforated plate to the bottom of the pot, close the cock, fit the worker to the motor driven working apparatus, and work the sample until it reaches one hundred thousand times continuously (about 28 h).

c) Immediately after working, remove the grease worker from the motor driven working apparatus, leave it as it is in the thermostatic water bath kept at 25 °C ± 0.5 °C for 2 h, and prepare the sample by the method specified in **7.5 a**) **3**). In this case, the perforated plate specified in **15.2** shall be used.

d) Measure the penetration of the sample according to the method according to **7.5 b**) and **7.5 c**).

15.5 Calculation method and precision

a) **Calculation method** The mean value of three measurement results obtained in **15.4** shall be rounded with the rounding interval of 1 according to **JIS Z 8401**, and this test result shall be taken as the worked stability.

b) **Precision** The precision is not specified.

15.6 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **15.5**

d) Date of test

e) Specially mentioned matters

16 Test method for water washout resistance

16.1 Principle of test

The grease is packed in a ball bearing. The bearing is then inserted in a housing with specified clearances, and rotated at 63 rad/s ± 3 rad/s. Water, controlled at 38 °C or 79 °C, impinges on the bearing housing at a rate of 5 ml/s ± 0.5 ml/s for 60 min. The amount of sample washed out in 60 min is taken as a measure of the resistance of the sample (grease) to water washout.

16.2 Reagents

The reagents shall be as follows.

a) **Water** That of A3 specified in **JIS K 0557**.

b) **Solvent** That of petroleum benzine specified in **JIS K 8594**.

16.3 Test apparatus

The test apparatus for water washout resistance shall be composed of the following **a**) to **i**). An example of the construction of the test apparatus for water washout resistance is shown in figure 34.

a) **Rotation mechanism of ball bearing for test** That to rotate the ball bearing for test in the housing as shown in figure 35 at 63 rad/s ± 3 rad/s being composed of a housing, a ball bearing for test and an appropriate driving mechanism.

1) **Ball bearing for test** That of open type 6204, Class 0, clearance C3 specified in **JIS B 1521**.

2) **Housing and shaft** That of shape and dimensions as shown in figure 35, made of brass or stainless steel (SUS304), and being attachable or detachable easily to the thermostatic water tank.

b) **Thermostatic water tank** That of shape and dimensions as shown in figure 34 equipped with electric heater, temperature regulator, appropriate cover and base, capable of maintaining water tank at 38 °C ± 1.7 °C or 79 °C ± 1.7 °C, and which shall be easily attached with the housing and jet nozzle at the position shown in figure 34.

c) **Water jet mechanism** That consisting of the jet nozzle, bypass valve, flow-rate regulating valve, pump, motor and others and capable of circulating and jetting the warm water in the water tank to the housing at a rate of 5 ml/s ± 0.5 ml/s. The flow rate of jet shall be obtained in such a way that a rubber tube is joined to the top end of jet nozzle, the other end of rubber tube is received in a measuring cylinder and the flow rate for 10 s is measured.

1) **Jet nozzle** That of 1.0 mm ± 0.1 mm in inside diameter. When it is attached to the thermostatic water tank, the water stream shall be capable of impinging on the extension of the centreline of capillary (jet target of the outer ring retainer) specified in figure 35 without spreading.

2) **Pump** That capable of jetting the warm water from the jet nozzle without pulsations at the specified flow rate.

d) **Thermometer** That of a glass thermometer capable of reading 38 °C and 79 °C with scale interval of 1 °C or under, or a thermocouple equivalent to this in quality.

e) **Thermostatic air bath** That of electric heating type capable of maintaining the temperature at specified temperature ± 3 °C by natural convection.

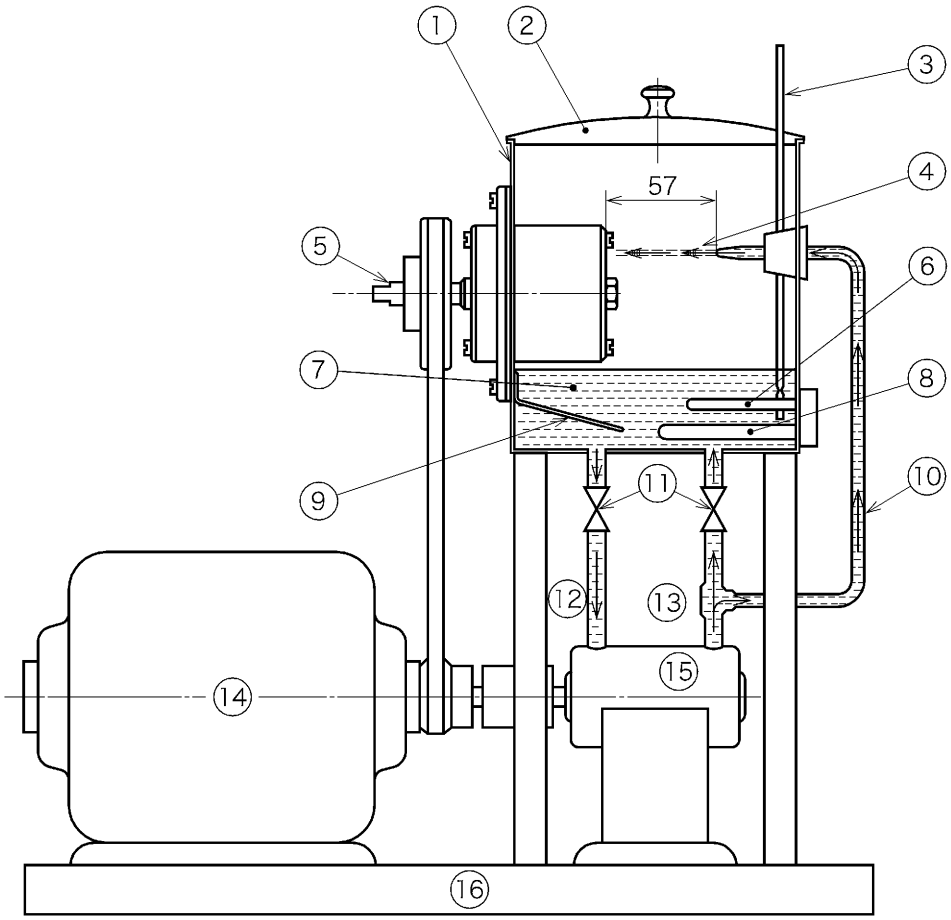
f) **Stop watch** That capable of indicating tenths of a second.

g) **Watch glass** That of sufficient size to accommodate a ball bearing for test, outer ring holder, outer ring retainer and inner ring retainer.

h) **Measuring cylinder** That of 100 ml in nominal capacity.

i) **Balance** That capable of weighing to 1 mg.

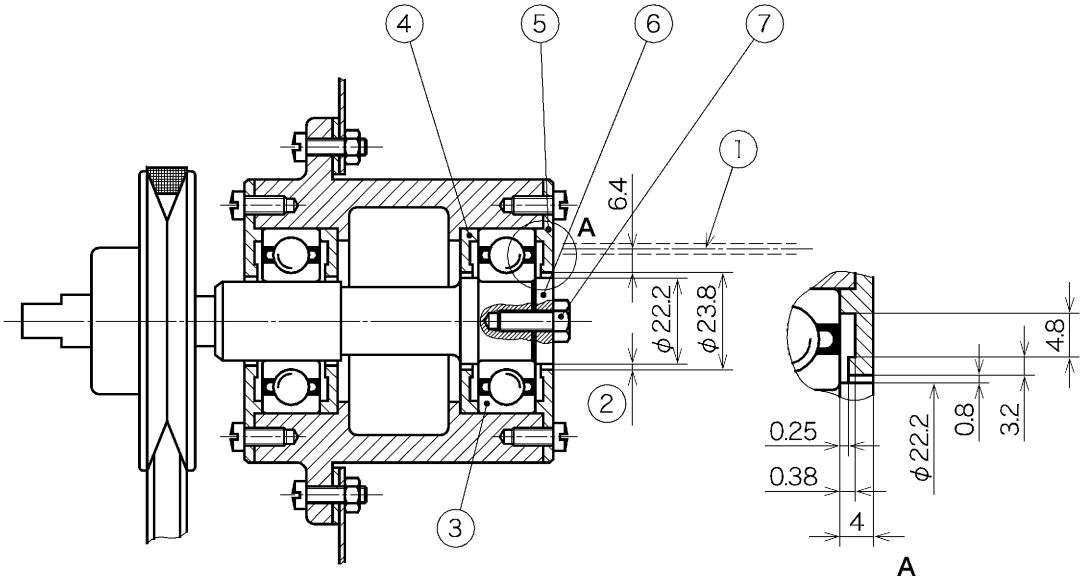
Unit: mm



① Thermostatic water tank
(size: about 150 mm × about 150 mm × about 150 mm)
② Cover
③ Thermometer
④ Jet nozzle (capillary of 1 mm diameter)
(flow rate: 5 ml/s ± 0.5 ml/s)
⑤ Ball bearing (rotation speed: 63 rad/s ± 3 rad/s)
⑥ Temperature regulator (thermostat, etc.)
⑦ Water in thermostatic water tank
(minimum amount: 750 ml)
⑧ Electric heater
⑨ Baffle
⑩ Water supply pipe
⑪ Flow-rate regulating valve and bypass valve
⑫ Return pipe
⑬ Bypass
⑭ Motor
⑮ Fluid pump
⑯ Base

Figure 34 Example of construction of test apparatus for water washout resistance

Unit: mm



① Centreline of capillary of 1 mm in diameter
② Annular opening of 0.8 mm in width
③ Ball bearing for test
(Class 6204 of C3 in clearance)
④ Outer ring holder of ball bearing for test
⑤ Outer ring retainer of ball bearing for test
⑥ Inner ring retainer of ball bearing for test
⑦ Fastening bolt for inner ring retainer of ball bearing for test

Figure 35 Example of construction of housing

16.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

16.5 Preparation of test

The preparation of test shall be as follows.

a) Each test will require a quantity of grease sufficient to fill two test ball bearings for test (about 4 g each). A minimum of 15 g of sample shall be supplied. The sample shall be examined for any indication of non-homogeneity such as oil separation, phase changes or gross contamination. If any abnormal conditions are found, a new sample shall be prepared.

b) The thermostatic water tank and the water circulating passages shall be cleaned with water, and any oil scum deposited on the inner surface of thermostatic water tank shall be wiped off.

c) The ball bearing for test shall be cleaned with petroleum benzine then dried.

d) It is ensured that the water flow rate can be maintained within the specified limits for the test run of 1 h.

16.6 Test procedure

The test procedure shall be as follows.

a) Carry out the test in duplicate. Record the mass of ball bearing for test and outer ring retainer of ball bearing for test (figure 35 ⑤), outer ring holder of ball bearing for test (figure 35 ④) and inner ring retainer of ball bearing for test (figure 35 ⑥) to the nearest 0.01 g. Pack the ball bearing for test with 4.00 g ± 0.05 g of sample. Record the mass of ball bearing for test packed with the sample and outer ring retainer of ball bearing for test, outer ring holder of ball bearing for test and inner ring retainer of ball bearing for test to the nearest 0.01 g. Insert this bearing, outer ring retainer, outer ring holder and inner ring retainer into the housing as shown in figure 35.

b) Add a minimum of 750 ml of preheated water in the thermostatic water tank and start the motor. At this time, introduce water through a rubber tube connected to the end of jet pipe so that the housing is not splashed with water directly, and regulate the water temperature at 38 °C ± 1.7 °C or 79 °C ± 1.7 °C. The water level shall be below the lower end of the housing.

c) When the water reaches the specified temperature, adjust the flow rate to 5 ml/s ± 0.5 ml/s based on the flow rate measured from the volume of water flowing into the cylinder for a period of 10 s as measured with the stop watch by putting the end of rubber tube into the measuring cylinder.

d) Detach the rubber tube from the jet pipe, and adjust the water jet so that it impinges on the jet target 6.4 mm ± 0.05 mm above the upper end of the clearance between the outer ring retainer and the inner ring retainer, and start the test and continue for 60 min ± 5 min from the moment when the rotation speed of the bearing reaches 63 rad/s ± 3 rad/s.

e) Shut out the motor and the electric heater, detach the ball bearing for test, outer ring holder, outer ring retainer and inner ring retainer from the housing, place them on a watch glass whose mass is known and dry them in the thermostatic air bath maintained at 77 °C ± 6 °C for 15 h. In such a case, separate the outer ring holder, outer ring retainer and inner ring retainer from the ball bearing for test and place them on the watch glass with inner side upward. Some mass loss can be experienced for greases containing low-viscosity oils because of oil evaporation during drying. The drying temperature should be increased to 93 °C ± 3 °C for greases containing high-viscosity oils to facilitate removal of water during the time period specified.

f) After drying, leave them cool as they are in a desiccator to room temperature, weigh the mass of the ball bearing for test, outer ring holder, outer ring retainer, inner ring retainer and watch glass to the nearest 0.01 g, and obtain the loss of the sample [4].

Note [4] The sample remaining on the outer ring holder, outer ring retainer, inner ring retainer and watch glass, and any leakage occurring during drying period, shall not be considered as the loss.

16.7 Calculation method and precision

a) **Calculation method** For the water washout resistance, each test result shall be calculated according to the following formulae, and the mean value of two test results shall be rounded off with the rounding interval of 1 according to **JIS Z 8401**.

Also, the temperature of drying the ball bearing for test, outer ring holder, outer ring retainer, and inner ring retainer and the sample shall be clearly mentioned.

$$\Delta m_e = m_2 - m_1$$

$$\Delta m_a = m_3 - m_1$$

$$w = \frac{\Delta m_e - \Delta m_a}{\Delta m_e} \times 100$$

where, w : water washout resistance (mass fraction %)

m_1 : mass of ball bearing for test, outer ring holder, outer ring retainer and inner ring retainer (g)

m_2 : mass of sample before test, ball bearing for test, outer ring holder, outer ring retainer and inner ring retainer (g)

m_3 : mass of sample after test, ball bearing for test, outer ring holder, outer ring retainer and inner ring retainer (g)

b) **Precision** The tolerance (probability: 0.95) of the test results obtained according to this test method shall be as follows.

In the case where the test result is deviated from the tolerance, treat according to **JIS Z 8402-6**.

1) **Repeatability** When the same sample is tested twice in the same laboratory by the same person by using the same test apparatus within a short time successively, the tolerance on the difference between the test results shall be as follows.

At 38 °C $r = 0.8\ (X + 2)$

At 79 °C $r = 0.6\ (X + 4.6)$

r : repeatability X = mean value of two test results

2) **Reproducibility** When the same sample is tested once in different laboratories by different persons by using different test apparatus respectively, the tolerance on the difference between the test results shall be as follows.

At 38 °C $R = 1.4\ (X + 2)$

At 79 °C $R = 1.1\ (X + 4.6)$

R : reproducibility X = mean value of two test results

16.8 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **16.7**

d) Date of test

e) Specially mentioned matters

17 Test method for leakage tendency

17.1 Principle of test

The wheel-hub and the bearing are filled with the specified quantity of sample respectively, and rotated under the specified conditions. The total mass of grease and oil leaked is obtained.

17.2 Reagent

The reagent shall be as follows.

a) **Solvent** Petroleum benzine specified in **JIS K 8594**.

17.3 Test apparatus

The test apparatus for leakage tendency shall be composed of the following **a**) to **g**). An example of the construction of the test apparatus for leakage tendency is shown in figure 36.

a) **Thermostatic air bath** The air bath shall be as shown in figure 36 in shape and dimensions, equipped with a heater capable of maintaining the bath temperature at 113 °C ± 2 °C, a temperature regulator and a fan. The heater shall be capable of raising the bath temperature to 113 °C within 15 min ± 5 min. The bath contains the rotating mechanism of wheel bearing specified in **b**) below.

b) **Rotating mechanism of wheel bearing** The mechanism to rotate the wheel hub at a rate of 660 rpm ± 30 rpm, which shall consist of the spindle, wheel hub, bearing, hub pulley, transmission pulley, V-belt, motor and the like as shown in figure 36.

1) **Spindle and wheel hub** The spindle and wheel hub shall be as shown in figure 37 and figure 38 in shapes and dimensions, and the material thereof shall be as follows.

Spindle: chromium molybdenum steel specified in **JIS G 4053**

Wheel hub: that specified in **JIS G 4051**

2) **Bearing** Two types of tapered roller bearing shown in table 22 shall be used.

Table 22 Tapered roller bearing

Unit: mm

	Bearing inside diameter	Bearing outside diameter	Assembled bearing width	Inner ring width	Outer ring width
Large bearing	30.213	63.500	20.638	20.638	15.875
Small bearing	19.050	49.225	23.020	21.539	17.463
NOTE 1 The large bearing corresponds to 15118/15250X in Timken nominal number. NOTE 2 The small bearing corresponds to 09074/09196 in Timken nominal number.					

3) **Hub pulley and transmission pulley** The hub pulley shall be as shown in figure 39 in shape and dimensions, made of steel, and fixed to the wheel hub by bolts, rivets or others. The transmission pulley shall be a metallic pulley capable of rotating the hub pulley at a rate of 660 rpm ± 30 rpm.

4) **Motor and belt** The motor shall be to drive the wheel hub and the fan in thermostatic air bath, and should preferably be about 0.2 kW in capacity. The belt shall be Type A specified in **JIS K 6323**.

5) **Fan** The fan shall be as shown in figure 40 in shape and dimensions, made of light alloy, and shall be jointed directly to the motor shaft, to be driven to the direction against the heater.

c) **Hub cap** The hub cap shall be made of metal into the shape and dimensions shown in figure 41.

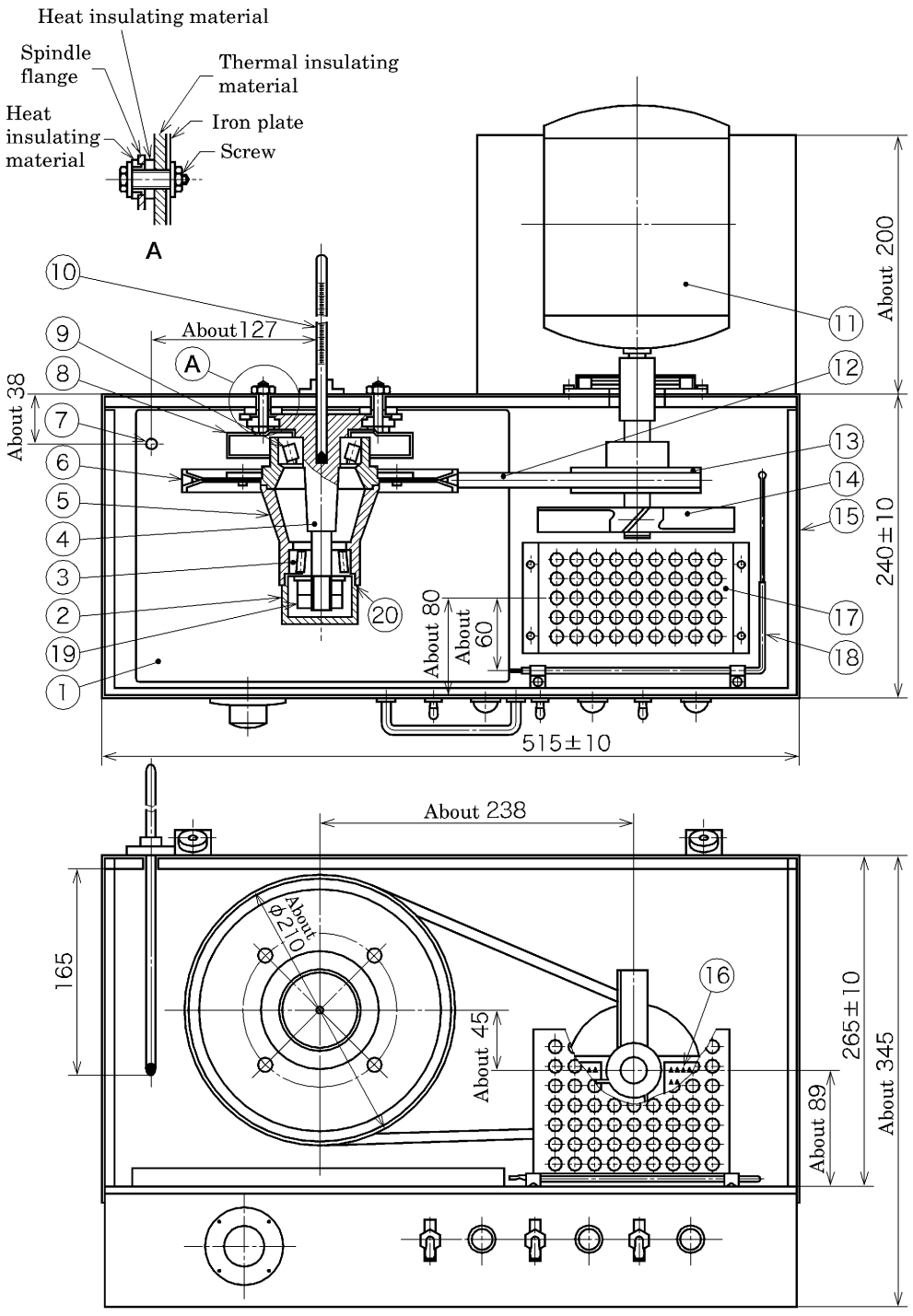
d) **Leakage collector** The collector shall be made of light alloy into the shape and dimensions shown in figure 42.

e) **Receiving pan** The pan shall be a rectangular pan made of stainless steel and the dimensions of about 220 mm in length, about 280 mm in breadth and about 13 mm in depth may be suitable.

f) **Torque wrench** The wrench shall be capable of fastening the spindle nut shown in figure 36 with a torque of 6.8 N·m ± 0.2 N·m.

g) **Thermometer** That of No. 34 specified in **JIS B 7410**.

Unit: mm

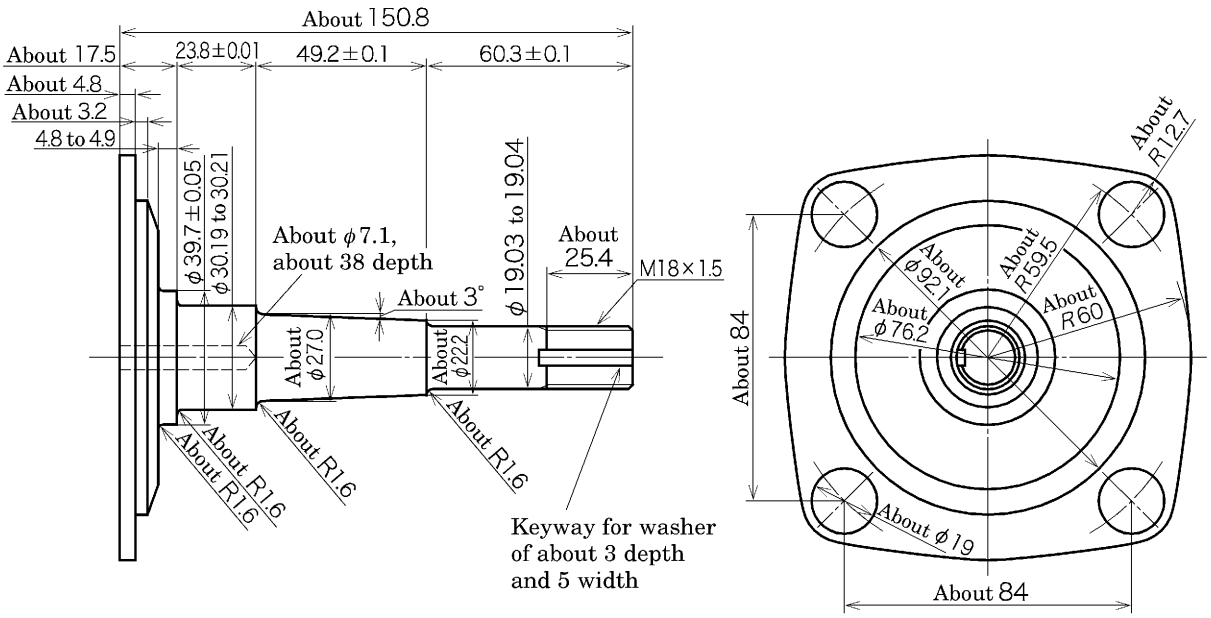


① Receiving pan
② Hub cap
③ Small bearing
④ Spindle
⑤ Wheel hub
⑥ Hub pulley
⑦ Thermometer (for air bath)
⑧ Leakage collector
⑨ Large bearing
⑩ Thermometer (for spindle)
⑪ Motor
⑫ V-belt
⑬ Transmission pulley
⑭ Fan
⑮ Cover of air bath
⑯ Heater
⑰ Cover of heater
⑱ Automatic temperature regulator
⑲ Spindle nut
⑳ Washer

NOTE : This diagram is prepared based on Fig.2 of **ASTM D 1263**-94.

Figure 36 Example of construction of test apparatus for leakage tendency

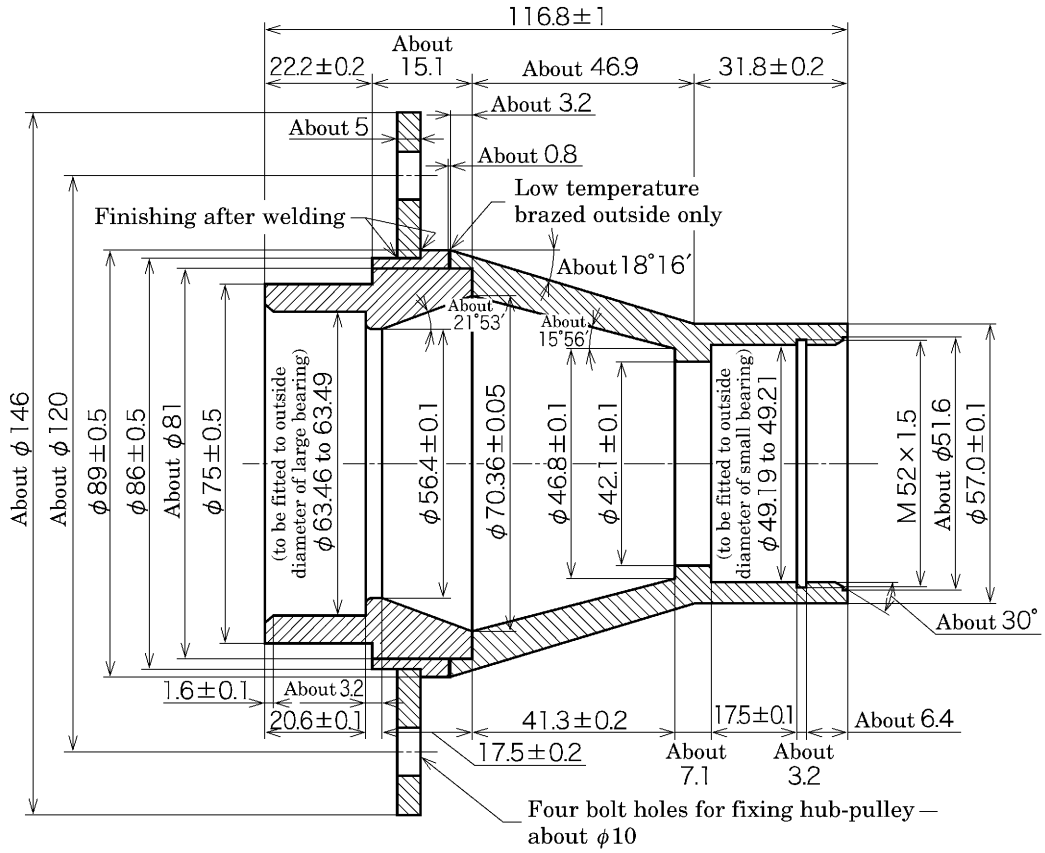
Unit: mm



NOTE : This diagram is prepared based on Fig.A1.1 of **ASTM D 1263**-94.

Figure 37 Example of spindle

Unit: mm



NOTE : This diagram is prepared based on Fig.A1.2 of **ASTM D 1263**-94.

Figure 38 Example of wheel hub

Unit: mm

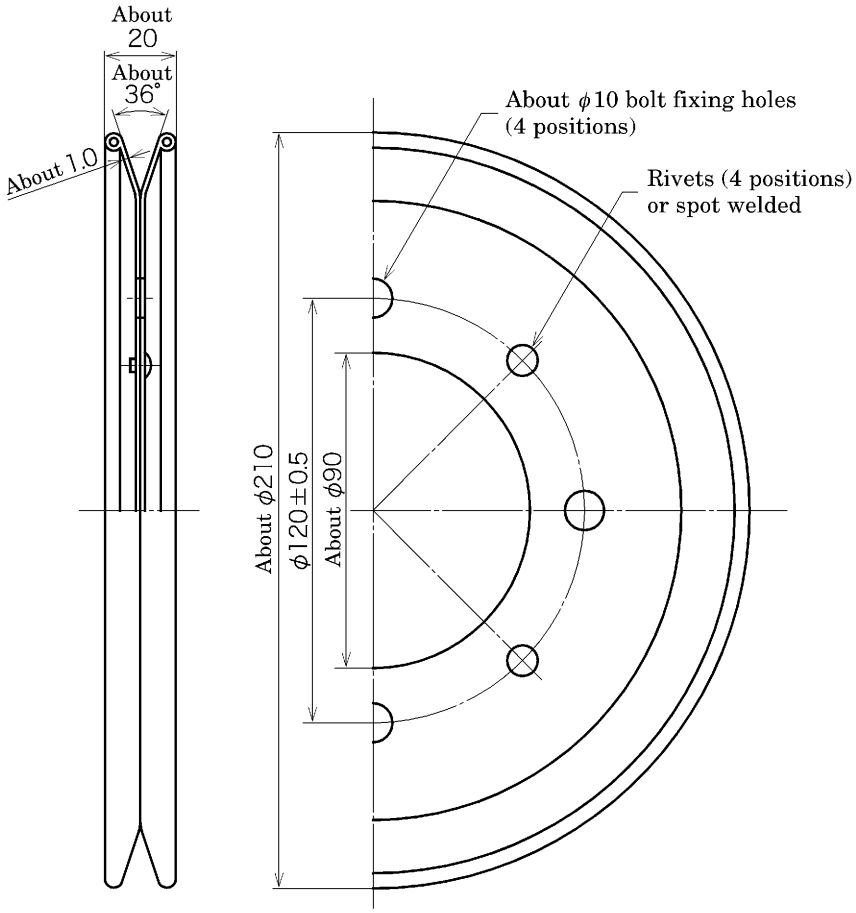
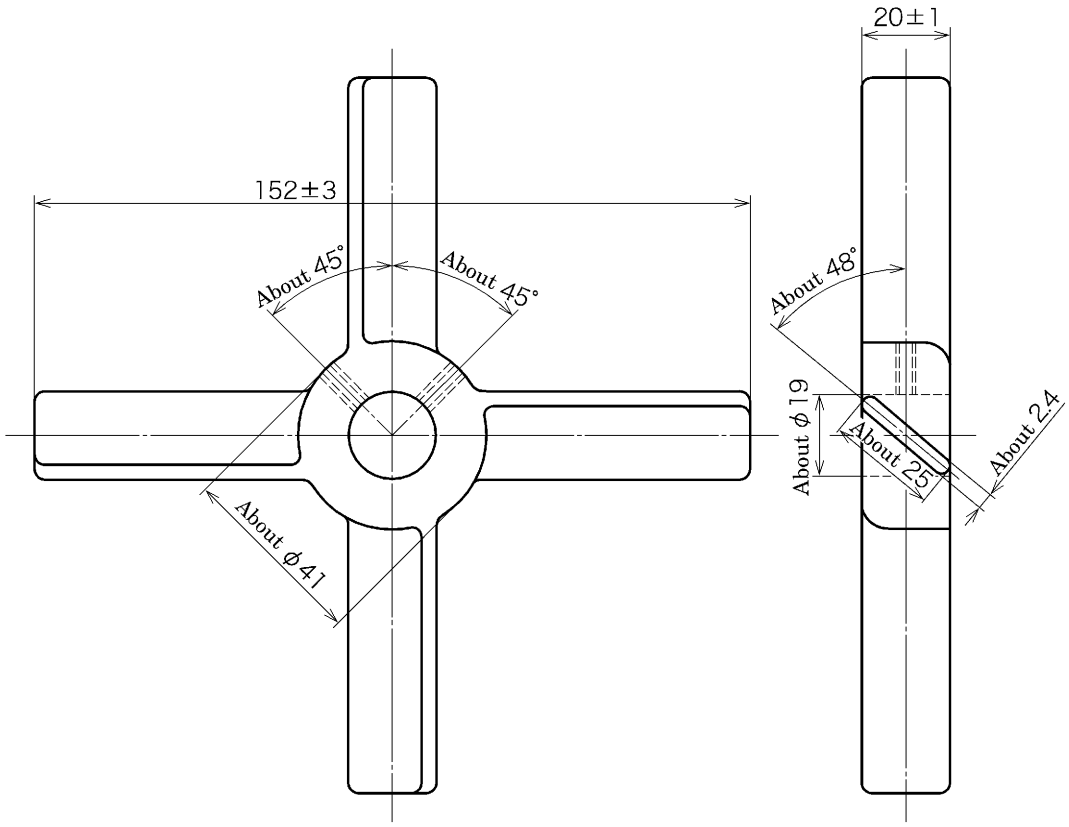


Figure 39 Example of hub pulley

Unit: mm



NOTE : This diagram is prepared based on Fig.A1.4 of **ASTM D 1263**-94.

Figure 40 Example of fan

Unit: mm

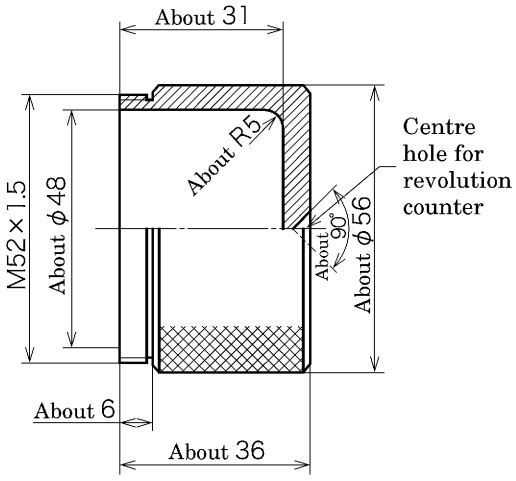
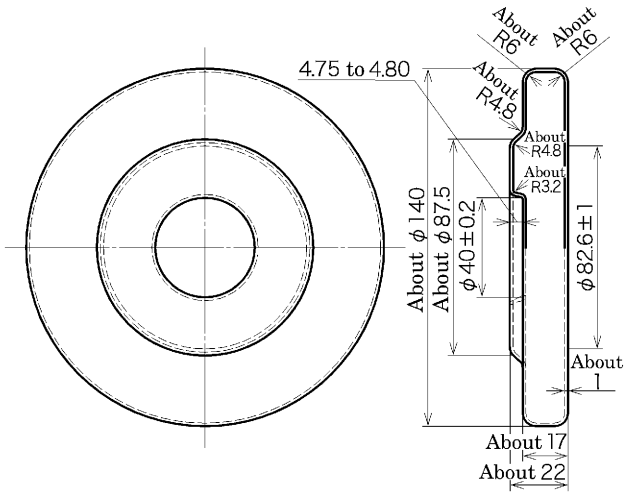


Figure 41 Example of hub cap

Unit: mm



NOTE : This diagram is prepared based on Fig.A1.3 of **ASTM D 1263**-94.

Figure 42 Example of leakage collector

17.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

17.5 Preparation of test

The preparation of test shall be as follows.

a) By using a narrow wedge-shape spatula, fill the small bearing with the sample 2.0 g ± 0.1 g, the large bearing with 3.0 g ± 0.1 g, and the inside of the wheel hub with the remaining sample 85 g ± 1 g so as to be a uniform layer. Next, apply the sample in a thin layer over the outer ring raceway surfaces of the large bearing and the small bearing. When packing the remaining sample in the wheel hub, pack it so that the surfaces of the sample come to the same height as those of the outer ring raceway of the large bearing and the small bearing of wheel hub by using a suitable spatula. In the case where further excess sample remains, pack this sample like a mound in the centre of the wheel hub.

In place of a spatula, a glass syringe of 10 ml or 20 ml specified in **JIS T 3201** may be used.

b) Weigh the leakage collector, the hub cap and the receiving pan each to the nearest 0.1 g, fit the leakage collector to the fixed position of the spindle, mount the large bearing to the spindle, then mount the wheel hub and the small bearing with care not to allow the filled sample to contact the spindle. Next, put a washer at the top of the small bearing, fit the first hexagon nut, fasten with a force of 6.8 N·m ± 0.2 N·m with a torque wrench, return the nut by an angle of 60° ± 5°, and fix the first hexagon nut by fastening the second hexagon nut.

The bearings, the wheel hub and the spindle shall be examined thoroughly at every test, and it shall be ascertained that they have no abrasion and other defects. The use of bearings shall not exceed 250 test times.

c) After fixing the hexagon nut to the spindle, mount the hub cap to the wheel hub, put the V-belt around the pulley so that they are aligned in a straight line, place the receiving pan at the fixed place and close the cover of air bath.

17.6 Test procedure

The test procedure shall be as follows.

a) After the completion of the preparation of test according to **17.5**, switch on the motor and the heater to rotate the wheel hub at a rate of 660 rpm ± 30 rpm, and start the test. Raise the temperature of the air bath to 113 °C ± 3 °C within 15 min ± 5 min. Make the temperature of the spindle reach at 104 °C ± 1.5 °C within 60 min ± 10 min, and maintain the spindle temperature until the completion of the test.

b) Immediately after a lapse of 6 h, switch off the motor and the heater, open the cover of air bath, detach hub cap, large bearing and small bearing, wheel hub and leakage collector from the spindle respectively, leave the leakage collector and the hub cap still to cool down to room temperature, and measure the mass to the nearest 0.1 g respectively.

c) Immerse the large bearing and the small bearing detached from the spindle in **b**) in a beaker containing petroleum benzine at room temperature for 2 min to remove the sample adhering onto the bearings, and examine the presence of varnish, gum or lacquer-like deposits on the surfaces thereof.

17.7 Calculation and precision

a) **Calculation method** For the leakage tendency, the total mass (g) of the sample leaked in both leakage collector and hub cap shall be obtained, and rounded off with the rounding interval of 0.1 according to **JIS Z 8401**. When the sample deposits in the receiving pan, the mass shall be added to the leakage tendency above. In this case, whether or not varnish, gum or lacquer-like deposits present on the surface of the bearings shall be appended to the test report.

b) **Precision** The precision is not specified.

17.8 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **17.7**

d) Date of test

e) Specially mentioned matters

18 Test method for low temperature torque

18.1 Principle of test

The bearing is packed with the sample, and mounted in the low temperature air bath maintained previously at the specified temperature. The bearing is maintained for 2 h from the time when the temperature of low temperature air bath has reached again to the specified temperature. Then, the inner ring of bearing is rotated at the rate of 1 rpm, and the restraining force (torque) of outer ring is measured.

18.2 Reagent

The reagent shall be as follows.

a) **Solvent** Petroleum benzine specified in **JIS K 8594**.

18.3 Test apparatus

The test apparatus for low temperature torque shall be composed of the following **a**) to **f**), and an example of the construction of the test apparatus for low temperature torque is shown in figure 43.

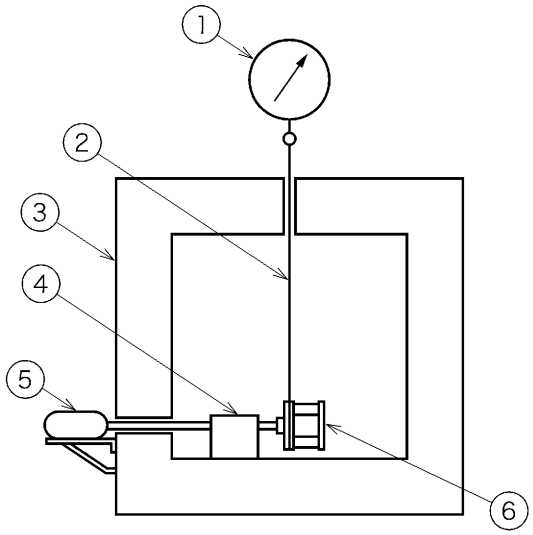
a) **Low temperature air bath** A bath of 0.03 m^3 or over in inner capacity capable of controlling the temperature in the bath at the specified temperature ± 1 °C. The driving mechanism may be mounted externally or directly in the bath. A partition wall shall be interposed to avoid the direct radiation from the test bearing to the

cooling medium bath. When the driving mechanism is provided outside, the temperature on the surface of the driving shaft between the test bearing and the inner wall of the low temperature air bath shall not be 1 °C or higher than the specified temperature.

b) **Bearing** The ball bearing for the test shall be the open type 6204 ball bearing specified in **JIS B 1521**, of which tolerance Class is 0, and radial internal clearance is ordinary, and the holder shall be made of punched steel plate.

c) **Driving device** An example of the driving device is shown in figure 44, and shall consist of the motor, the reduction gear, the driving shaft and others. It shall be capable of rotating the driving shaft at a rate of 1 rpm ± 0.05 rpm by fixing the spindle of the test jig to it.

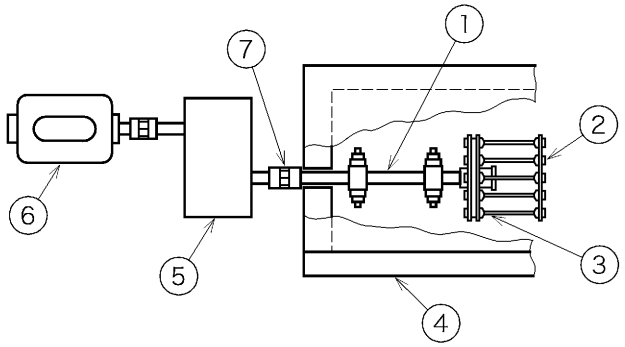
d) **Test jig** The test jig shall be of shape and dimensions shown in figure 45 and figure 46, and made of stainless steel SUS304 or brass.



① Needle pointer type spring balance (0 mN to 39 000 mN)
② String
③ Low temperature air bath
④ Reduction gear
⑤ Motor
⑥ Test jig

NOTE : This diagram is prepared based on Fig.1 of **ASTM D 1478**-91.

Figure 43 Example of construction of test apparatus for low temperature torque (one sample mounting)



① Driving shaft
② Load disk
③ Test bearing housing
④ Low temperature air bath
⑤ Reduction gear
⑥ Motor
⑦ Heat insulating shaft joint

NOTE : This diagram is prepared based on Fig.2 of **ASTM D 1478**-91.

Figure 44 Example of driving device

e) **Torque measuring device** That capable of measuring the load of 0 mN to 39 000 mN. (There are a needle pointer type spring balance, an electronic balance and others.)

f) **Grease cup** That of shape and dimensions shown in figure 47, and made of brass.

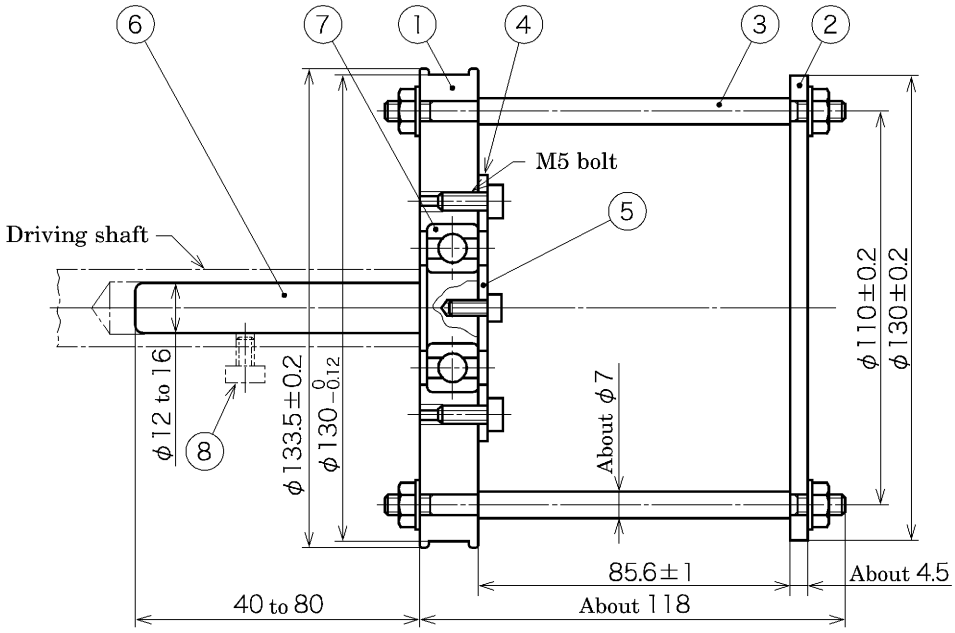
18.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

18.5 Preparation of test

After washing and drying the bearing according to **18.6 a**), the bearing shall rotate smoothly when it is made rotate in radial and thrust directions with fingers applying slight loads respectively. Then, apply several drops of **ISO** VG 460 specified in **JIS K 2238** or of a lubricating oil with a viscosity equivalent thereto to the bearing, and carry out the rotating torque test at room temperature according to **18.6 i**) to measure the average torque and the maximum torque. The average torque shall be less than 1.96 mN・m and the maximum torque be less than 2.45 mN・m. When the measured values of torque are not more than these numerical values, the bearing may be used for the test.

Unit: mm



① Bearing housing
② Load disk
③ Connecting rod
④ Outer ring retainer of bearing
⑤ Inner ring retainer of bearing
⑥ Spindle
⑦ NP 6204 bearing
⑧ Fixing bolt of spindle

NOTE : This diagram is prepared based on Fig.3 of **ASTM D 1478**-91.

Figure 45 Example of construction of test jig

18.6 Test procedure

The test procedure shall be as follows.

a) Clean the test bearing with petroleum benzine, and dry it at a temperature not exceeding 100 °C. Use it after cooling down to room temperature.

b) Mount the dried clean bearing on the spindle [figure 46 f)], and retain the inner ring of the bearing by means of the inner ring retainer and the screw. Pack the sample in the grease cup to about 3/4 volume thereof using a clean steel spatula.

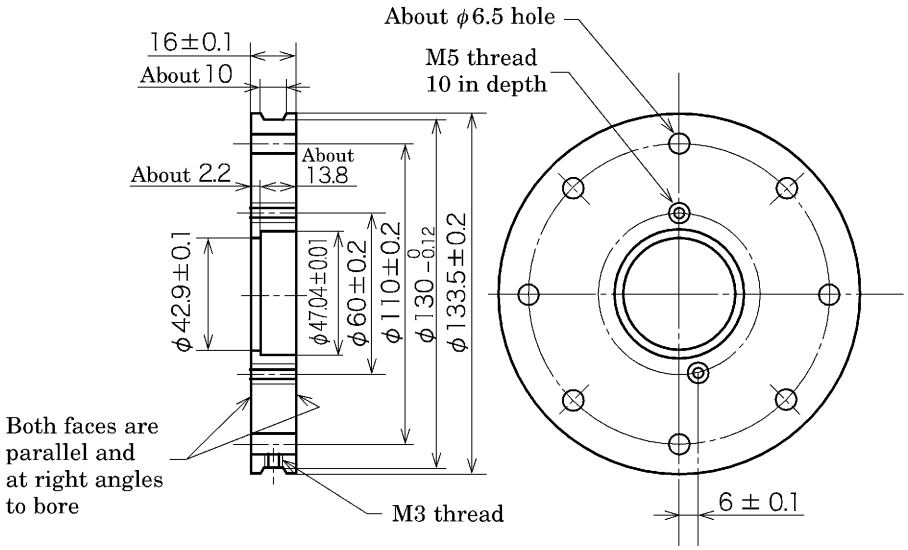
c) In order to pack the whole bearing with the sample, push the bearing down into the grease while rotating the inner ring and the spindle first in one direction, then in the counter direction slowly. When the bearing reaches the bottom of the grease cup, take it out, and remove it from the spindle. Turn out the bearing, and refasten it on the spindle. Repack the grease into the grease cup. Again push the bearing into the grease cup until it reaches the bottom. Remove the spindle and bearing as a unit from the grease cup, crape off the excess grease extending on both sides of bearing, and fill holes or clearances left, if any. Take care not to rotate the bearing at any time after packed with the sample prior to the measurement of starting torque according to **i**).

d) Mount the bearing packed with sample into the housing, and fasten the outer ring retainer [figure 46 d)] not to let the bearing rotate. Construct the test jig as in figure 45.

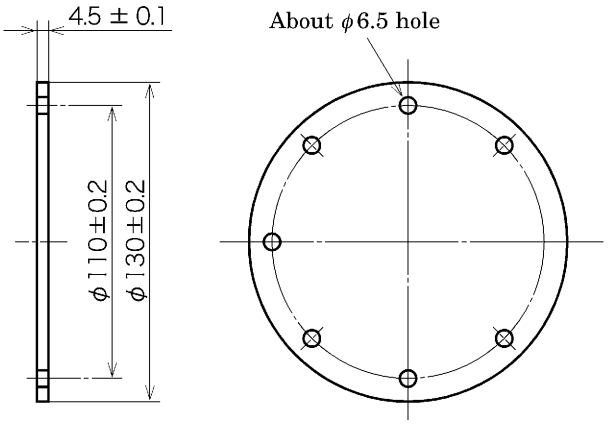
e) Open the low temperature air bath maintained previously at the specified temperature, and slide the spindle of the test jig to the end of the driving shaft.

f) Fix the string with screw to the periphery of housing. Connect the string to the apparatus for measurement of torque and rotate the spindle until the slack of string is almost removed, then fix the spindle at that position on the driving shaft by means of the fixing bolt. At this time, operate so as not to rotate the bearing. The position of the screw on the periphery of housing shall be at least 90° to the vertical. Coat the string with silicone oil to prevent the string from stiffening due to moisture in the air bath at low temperature.

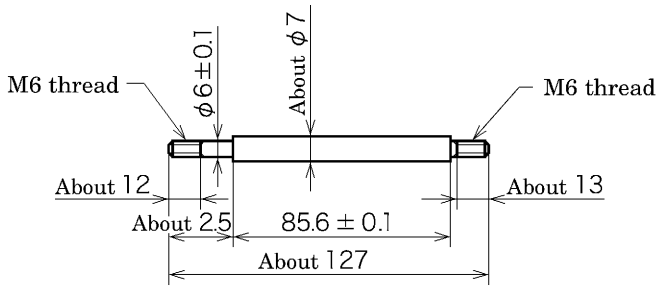
Unit: mm



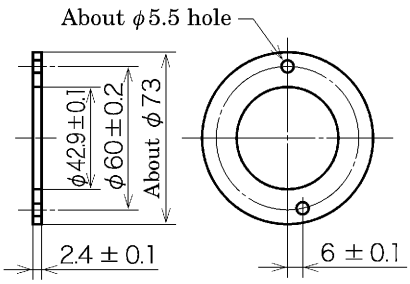
a) Bearing housing



b) Load disk



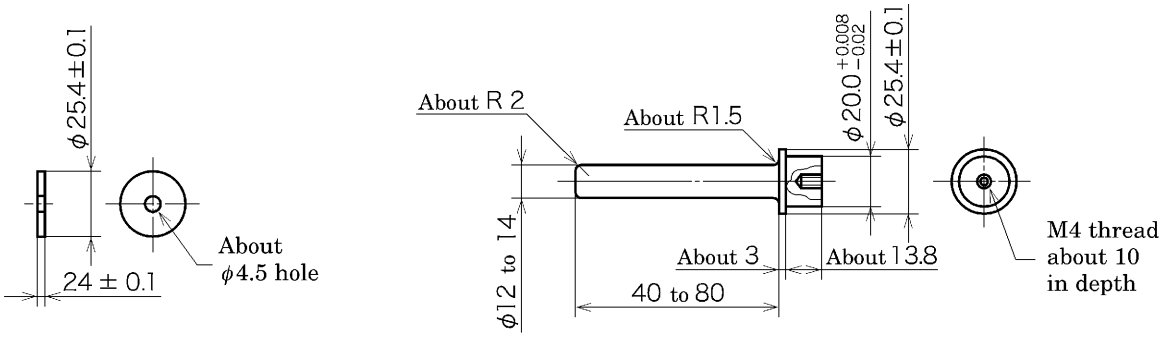
c) Connecting rod



d) Outer ring retainer of bearing

Figure 46 Example of parts consisting test jig

Unit: mm

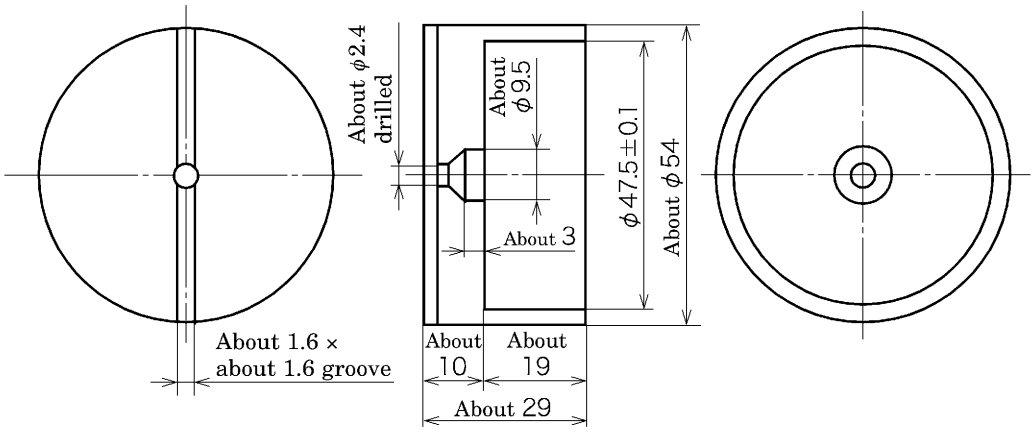


e) Inner ring retainer of bearing **f) Spindle**

NOTE : This diagram is prepared based on Fig.3 and Fig.4 of **ASTM D 1478**-91.

Figure 46 (concluded)

Unit: mm



NOTE : This diagram is prepared based on Fig.5 of **ASTM D 1478**-91.

Figure 47 Example of grease cup

g) Close the low temperature air bath, lower the bath temperature to the specified temperature, and maintain this temperature for 2 h. During this cooling time, do not move the bearing. If it is moved, the test shall be invalidated.

NOTE : Since high humidity in the air bath has a possibility to cause condensation of moisture on the bath walls, it is preferable to spread some desiccant such as activated alumina on a suitable shallow tray and place it on the bottom of the low temperature air bath prior to the test.

h) Check the string to be sure it is free of ice, and not stuck to the bath wall prior to test. Closing the hole with a split rubber stopper or cotton during the chilling is preferable for keeping the string and its passage free from ice. Remove the stopper at the time of the measurement of torque.

i) Start the motor as observing the torque measuring apparatus. Record the maximum reading reached [5]. Continue the rotation for 10 min, and record the average value of the readings of torque measuring apparatus during the last 15 s. The

temperature of the low temperature air bath shall be maintained at the specified temperature ± 1 °C during the rotation test.

Note [5] The maximum value will occur within a few seconds after starting the rotation.

j) When the same sample is repeatedly tested, clean the bearing according to **a**) every time and pack with a fresh charge of grease according to **b**) and **c**).

18.7 Calculation method and precision

a) **Calculation method** The starting torque (mN · m) and the running torque (mN · m) shall be calculated according to the following formula, and rounded off to two significant figures.

$$S = A \times r$$

$$R = B \times r$$

where, S : starting torque

R : running torque

A : maximum value in readings of torque measuring apparatus immediately after start (mN)

B : average of readings of torque measuring apparatus during last 15 s for rotation of 10 min (mN)

r : torque radius of housing (0.065 m)

b) **Precision** The precision is not specified.

18.8 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **18.7**

d) Date of test

e) Specially mentioned matters

19 Test method for apparent viscosity

19.1 Principal of test

The grease in the cylinder is extruded through a capillary by oil hydraulic pressure, and the pressure generated in the system at that time is measured. The apparent viscosity is calculated from the predetermined flow rate, the radius and length of the capillary and the measured pressure by using Poiseuille's formula specified in **19.6**. This test method is applicable to the measurement in the temperature range from –55 °C to 40 °C and in the apparent viscosity range from 2.5 Pa · s to 10 000 Pa · s at a slip rate (shear rate) 0.1 s^{-1} and that of 0.1 Pa · s to 10 Pa · s at 15 000 s^{-1}.

19.2 Test apparatus

The test apparatus for apparent viscosity shall be composed of the following **a**) to **e**), and an example is shown in figure 48.

When the test is carried out at other temperature than room temperature, a thermostatic liquid bath or air bath capable of maintaining the temperature of the grease system [figure 48 b)] at the test temperature ± 0.5 °C shall be used.

a) **Power system** The power system shall consist of an induction motor of about 200 W, a suitable reduction gear and a flow rate changing gear. For the flow rate changing gear, two interchangeable gears, 40 teeth and 64 teeth respectively, shall be used. However, any number of teeth is applicable if the flow rate of **b**) **1**) is satisfied.

b) **Oil hydraulic system (a)** The oil hydraulic system (a) shall consist of a gear pump, a driving gear of 42 teeth and oil hydraulic system piping (a). However, any number of teeth is applicable if the flow rate of **b**) 1) is satisfied.

1) **Gear pump** That corresponding to the discharge volume of 0.584 ml/rpm or 1.168 ml/rpm whose hydraulic oil having about 2 000 mm^2/s in kinetic viscosity at the temperature of test room shall be used. The pump shall be a constant volume gear pump with small variation of delivery volume and without pulsations against the fluctuation of discharge pressure, and the flow rate shall be interchangeable to about 4.8 ml/min and about 7.6 ml/min.

2) **Oil hydraulic system piping (a)** The piping to apply the hydraulic pressure from the oil hydraulic apparatus to the grease cylinder by passing the oil hydraulic system piping (b) through the hydraulic oil changing cylinder, which is equipped with a return valve. The piping of oil hydraulic system shall allow no leakage to a oil pressure of 27.5 MPa, and shall be arranged so as not to allow air bubbles to stay in the system.

c) **Oil hydraulic system (b)** Consisting of the oil hydraulic system piping (b) and the branch pipe for pressure gauges.

1) **Oil hydraulic system piping (b)** That to apply the hydraulic pressure to the grease cylinder by receiving the pressure from the oil hydraulic system piping (a) through the hydraulic oil changing cylinder. The oil hydraulic system piping (b) shall allow no leakage to a oil pressure of 27.5 MPa, and shall be arranged so as not to allow air bubbles to stay in the system.

The hydraulic oil having 2 000 mm^2/s or under in kinetic viscosity at test temperature shall be used.

2) **Branch pipe for pressure gauge** Either the type so as to be attached at one position as shown in figure 48 a) or the type so as to be attached to manifold pipes as shown in figure 48 b) may be permitted. When the pressure gauges are fixed to manifold pipes, the switching valve shall be equipped respectively.

3) **Pressure gauge** That of Grade 1.6 or upward specified in **JIS B 7505-1**. For example, the gauges having the scale range of 0 MPa to 0.4 MPa, 0 MPa to 1 MPa, 0 MPa to 4 MPa and 0 MPa to 25 MPa are equipped.

The pressure gauge shall be used at two third or under of the maximum pressure indicated.

d) **Grease system** The grease system shall consist of the grease cylinder and the capillary tube.

1) **Grease cylinder** The grease cylinder is shown in figure 49 as an example, which withstands a dynamic pressure of 27.5 MPa. The piston shall be such that it generates no sensible friction when it moves in the cylinder. The end cap A [figure 48 b)] shall be capable of being connected to the oil hydraulic system piping and the end cap B [figure 48 b)] shall be capable of being fitted with the capillary and the temperature sensing element. However, the inside diameter of the cylinder and the outside diameter of the piston as shown in figure 49 indicate the standard dimensions, and other dimensions are to some extent allowed. The clearance between the inside diameter of cylinder and the outside diameter of piston shall be 0.012 mm to 0.063 mm. The cylinder shall be constructed by gasket-fastening without any leakage under oil hydraulic pressure during test by using a copper gasket or O-ring of synthetic rubber for the gasket. For the fastening, cap nut may be used.

2) **Capillary** An example of capillary is shown in figure 50. Eight capillaries having different inside diameters comprise a set. Diameter of each capillary shall be nearly same as that shown in figure 50. The length (B) shall be 40 times the actual diameter (A) $\pm$ 0.02 mm.

e) **Thermometer** That capable of measuring the sample temperature in the grease cylinder, and capable of fixing the temperature sensing element such as thermocouple or thermistor to the end cap B of grease cylinder.

19.3 Calibration

a) **Calibration of flow rate in oil hydraulic system** Fill the oil hydraulic system (a) [see figure 48 b)] with hydraulic oil of about 2 000 mm^2/s in kinetic viscosity at the temperature of the test room, then dismount the grease cylinder which has been mounted to oil hydraulic system (b) [see figure 48 b)], and fix the needle valve [figure 48 b) ⑱].

b) Fill the oil hydraulic system (b) with hydraulic oil having the kinetic viscosity about 2 000 mm^2/s or under at test temperature, and expel air bubbles. Maintain the oil hydraulic system (b) shown in figure 48 b) at test temperature, operate the pump under the pressure of 0 MPa, place quickly a receiving flask for correction of flow rate of oil hydraulic pump under the discharge port, and, at the same time, push the stopwatch. Measure the time required for flowing out of 60 ml of hydraulic oil, and calculate the flow rate (cm^3/s). Then, continue the measurement of the flow rate under the pressure of 2.9 MPa, 6.9 MPa, 9.8 MPa and 9.8 MPa or over by adjusting the needle valve. Prepare calibration curve as shown in figure 51. This curve is used for the calibration of flow rate when measuring that of sample. The calibration of oil hydraulic system may be carried out by measuring the flow rate of grease to be tested. Since the wear of the pump changes its flow rate, repeat the calibration at a definite interval of operation.

19.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

19.5 Test procedure

The test procedure shall be as follows [see figure 48 b)].

a) Fill the oil hydraulic system (a) and the oil hydraulic system (b) respectively with the hydraulic oil specified carefully so as not to allow air bubbles to enter.

b) Prepare the sample of 0.3 kg or over.

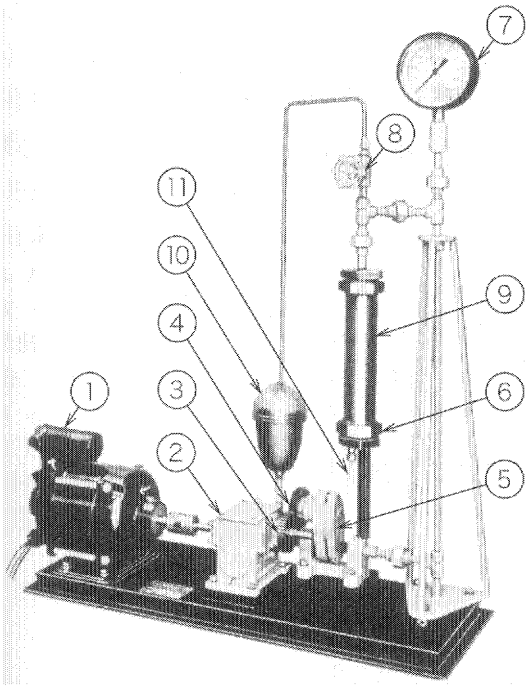
c) Pack the grease cylinder with the sample with care not to allow air bubbles to enter. Mount the piston into the end cap A side of the grease cylinder, and mount the end cap A, the end cap B and No. 1 capillary.

d) Connect the end cap A with the oil hydraulic system (b) while filling the connecting part with hydraulic oil.

e) Open the return valve, start the pump to circulate hydraulic oil, and expel air contained in the system. Thereafter, stop the pump and close the return valve.

f) Measure the temperature of the sample with the thermocouple, thermistor or the like inserted in the end cap B, and adjust the temperature at the test temperature ± 0.5 °C [6].

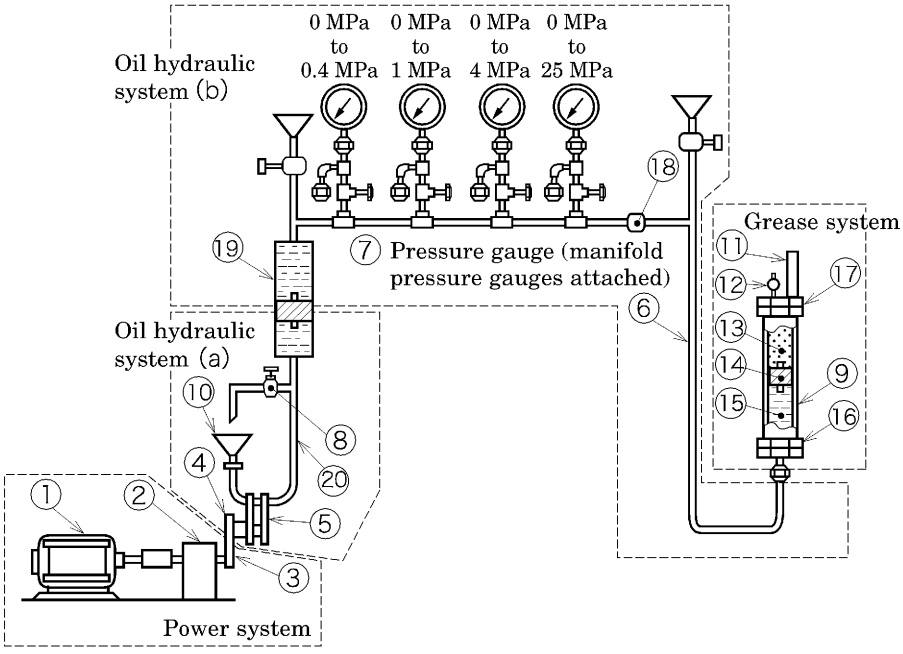
Note [6] The time required for the sample grease to reach the test temperature is, for example, about 2 h for liquid bath and about 8 h for air bath, in the case of the test temperature of –50 °C.



① Induction motor
② Reduction gear
③ Flow rate changing gear
④ Driving gear
⑤ Gear pump
⑥ Oil hydraulic system piping (b)
⑦ Pressure gauge
⑧ Return valve
⑨ Grease cylinder
⑩ Hydraulic oil receiver
⑪ Capillary
⑫ Temperature sensing element (thermocouple, thermistor, etc.)
⑬ Sample (grease)
⑭ Piston
⑮ Hydraulic oil
⑯ End cap A
⑰ End cap B
⑱ Setting position of needle valve
⑲ Hydraulic oil changing cylinder
⑳ Oil hydraulic system piping (a)

NOTE : This diagram is prepared based on Fig.2 of **ASTM D 1092**-99.

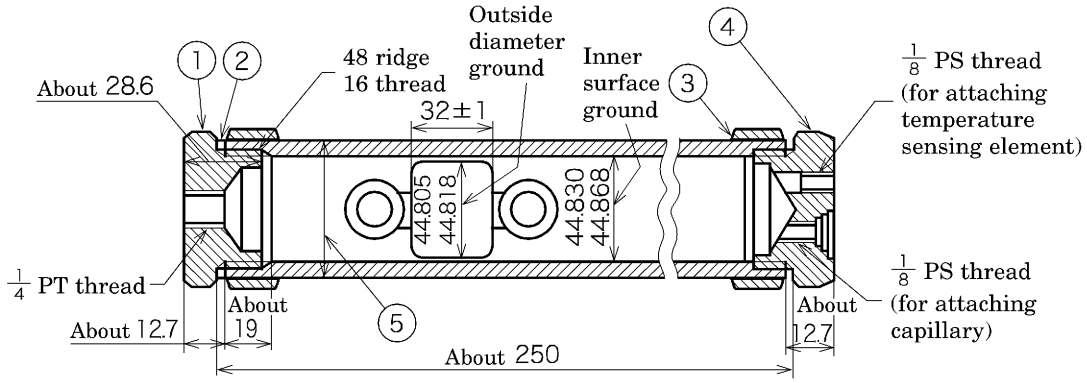
a) Construction of test apparatus for apparent viscosity



NOTE : This diagram is prepared based on Fig.1 of **ASTM D 1092**-99.

b) Grease system and oil hydraulic system of test apparatus for apparent viscosity

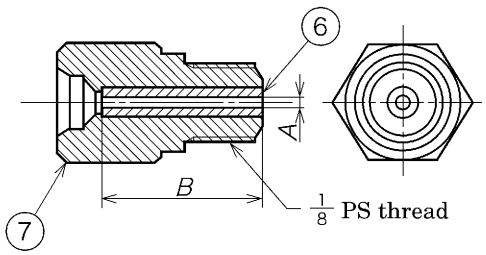
Figure 48 Example of test apparatus for apparent viscosity



① End cap A
② Copper gasket
③ Weld before machining
④ End cap B
⑤ Outside diameter about 54 seamless steel pipe

NOTE : This diagram is prepared based on Fig.A.1.1 of **ASTM D 1092**-99.

Figure 49 Example of grease cylinder

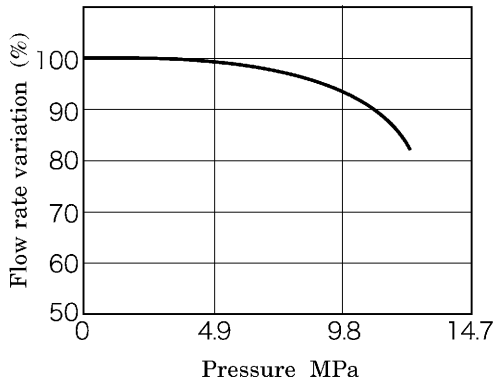


No. of capillary	Diameter (approx.) mm
1	3.8
2	2.4
3	1.85
4	1.5
5	1.2
6	1
7	0.65
8	0.45

⑥ Seamless stainless steel pipe
⑦ Hexagon nut

NOTE : This diagram is prepared based on Fig.A1.2 of **ASTM D 1092**-99.

Figure 50 Example of capillary



NOTE : This diagram is prepared based on Fig.3 of **ASTM D 1092**-99.

Figure 51 Example of calibration curve for pump flow rate

g) When the sample reaches the test temperature, connect the 40 teeth flow rate changing gear and operate the pump. When the equilibrium pressure is obtained, record the pressure at that time. Next, change the gear to 64 teeth gear, and again

obtain the equilibrium pressure. Record the pressure, open the return valve, and release the pressure from the system. Exchange No. 1 capillary for No. 2 capillary, and repeat the procedures above. Obtain two equilibrium pressures at two flow rates on each capillary, and record the pressures.

19.6 Calculation method and precision

a) **Calculation method** The apparent viscosity for grease shall be obtained according to the following formula, and rounded off to three significant figures. An example of the calculation is shown in table 23.

$$\eta = \frac{F}{S} = \frac{10^6 \pi R^4 P}{8Lv/t}$$

where, η : apparent viscosity (Pa·s)

F : slip stress (shear stress) (N/m^2)

S : slip rate (shear rate) (s^{-1})

P : reading of pressure gauge (MPa)

R : radius of capillary (cm)

L : length of capillary (cm)

v/t : corrected flow rate (cm^3/s)

Table 23 Example of calculation table for apparent viscosity

Capillary	Number of teeth of flow rate changing gear	Reading of pressure gauge P(MPa)	$K = \frac{10^6 \pi R^4}{8Lv/t}$	Apparent viscosity η(Pa·s) $= P \times K$	Slip rate [a] $S(s^{-1}) = \frac{4v/t}{\pi R^3}$	Slip stress $F(N/m^2) = \eta \times S$
1	40	0.175	410	71.8	15	1 080
2	40	0.263	102	26.8	61	1 630
3	40	0.335	52.5	17.6	120	2 110
4	40	0.431	27.8	12.0	230	2 760
5	40	0.657	13.1	8.61	480	4 130
6	40	0.853	8.50	7.25	755	5 470
7	40	1.96	2.03	3.98	3 140	12 500
8	40	3.73	0.679	2.53	9 320	23 600
1	64	0.206	253	52.1	24	1 250
2	64	0.314	62.1	19.5	98	1 910
3	64	0.412	32.9	13.6	195	2 650
4	64	0.569	17.2	9.79	370	3 620
5	64	0.892	8.12	7.24	770	5 570
6	64	1.13	5.31	6.00	1 220	7 320
7	64	2.65	1.26	3.34	5 020	16 800
8	64	4.90	0.426	2.09	14 900	31 100

NOTE : This table is prepared based on Table.1 of **ASTM D 1092**-99 (sample: grease A, test temperature 25 °C)

Note [a] The slip rate listed in this column have been calculated beforehand.

b) **Precision** The precision is not specified.

c) The slip rate shall be calculated according to the following formula.

$$S = \frac{4v/t}{\pi R^3}$$

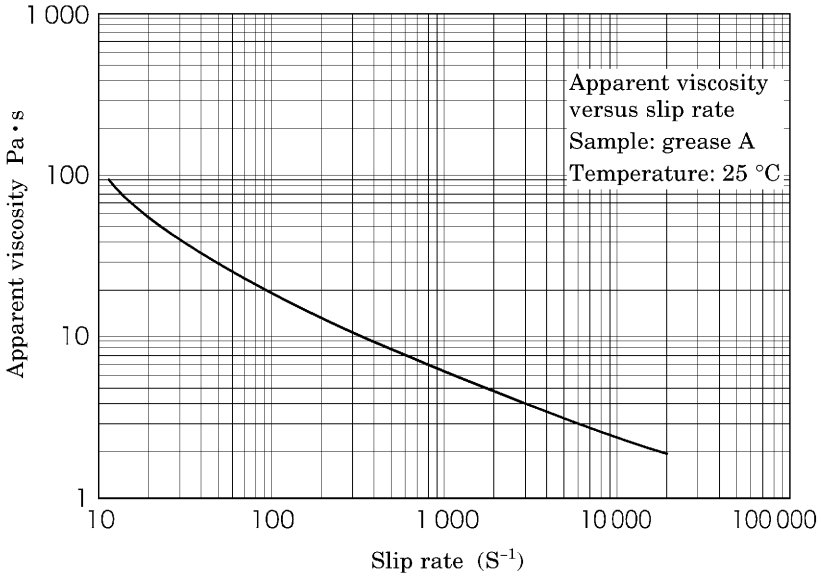
where, S : slip rate (shear rate) (s^{-1})

v/t : corrected flow rate (cm^3/s)

R : radius of capillary (cm)

NOTE : Sixteen values slip rate can be obtained by calculation using eight capillaries and two flow rates.

d) The curve of apparent viscosity versus slip rate on a logarithmic section paper as shown in figure 52 shall be prepared. From this chart, the apparent viscosity at a specified slip rate shall be obtained.



NOTE : This diagram is prepared based on Fig.4 of **ASTM D 1092**-99.

Figure 52 Example of correction curve of flow rate of pump

19.7 Measuring method for apparent viscosity at low slip rate

a) **Apparatus** The apparatus shall be according to **19.2**. However, the capillary of No. 0 (9.525 mm ± 0.025 mm in diameter and 381.000 mm ± 0.025 mm in length) shall be used. Since the pressure is low when measuring at the low slip rate, the error shall be minimized as possible by the complete verification of the apparatus and by ensuring the good operating conditions.

b) **Test procedure** The procedure shall be according to **19.5**. When measuring at the slip rate of 1 s^{-1} or less, it is preferable to use a variable flow rate pump.

c) **Calculation method and precision** According to **19.6**.

19.8 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **19.6**

d) Date of test

e) Specially mentioned matters

20 Test method for load carrying capacity by Timken method

20.1 Principle of test

The OK value and the score value are obtained from the condition of abrasion trace on the test block after the driving of the specified tester at the specified rotation rate for the specified time under fixed force (load) while supplying the sample between the test cup and the test block at a constant feeding rate.

NOTE : This test method specifies the items necessary for testing load carrying capacity of grease by the Timken method specified in clause **5** of **JIS K 2519**. For the definitions of terms, outlines of tester and the test procedure, **JIS K 2519** should be referred to.

20.2 Reagent

The reagent shall be according to **5.3** of **JIS K 2519**.

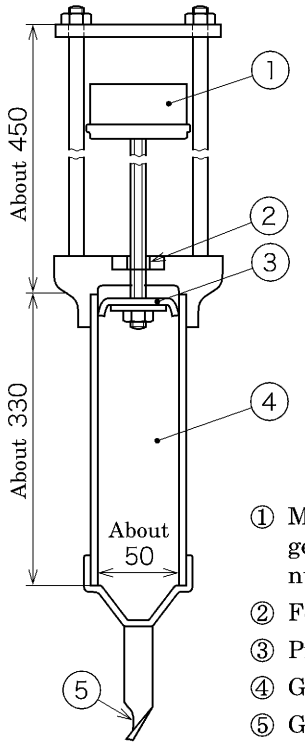
20.3 Test apparatus

For the test apparatus, Timken extreme pressure tester, automatic loading device, magnifying glass or microscope, and stopwatch specified in **5.2** of **JIS K 2519** shall be used. In addition, the grease feeding device, test cup and test block below shall be used.

The grease feeding device to be used shall be a container of a capacity enough to feed the sample for one-time test and shall be provided with a suitable piston mechanism capable of feeding the sample at a rate of 45 g/min ± 9 g/min. An example of grease feeding device is shown in figure 53. This feeding device shall be fixed to Timken extreme pressure tester, as shown in figure 54, from which the upper sample container has been detached previously.

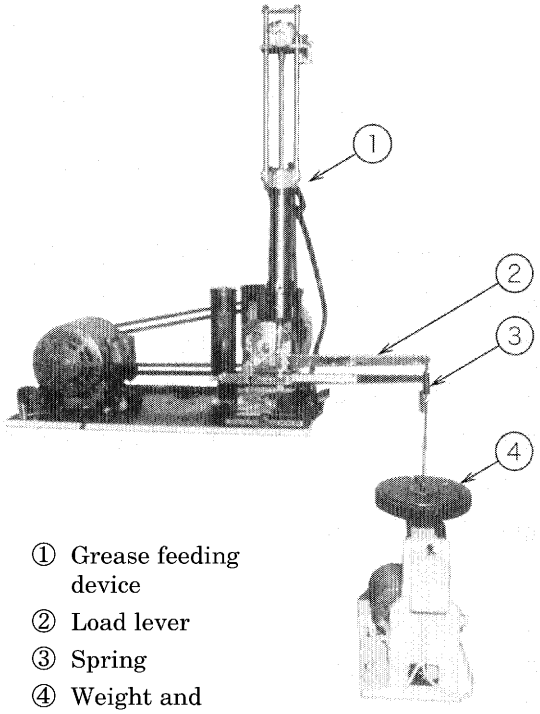
The test cup and the test block specified in **5.2** of **JIS K 2519** or those equivalent to these shall be used.

Unit: mm



① Motor (with reduction gear) of 12 min^{-1} in number of rotations
② Feed screw mechanism
③ Piston
④ Grease
⑤ Grease feeding port

Figure 53 Example of grease feeding device



① Grease feeding device
② Load lever
③ Spring
④ Weight and load pan

Figure 54 Example of assembly of grease feeding device

20.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

20.5 Preparation of test

The preparation of test shall be as follows.

a) Detach the upper sample container of Timken extreme pressure tester, and attach the grease feeding device to it. Since the pump is not used for the grease test, disconnect the joint of pump from the revolving shaft for prevention of abrasion due to idle running.

NOTE : In order to avoid the abrasion of pump, it is preferable to install previously a piping system having 3-way cock and a grease reservoir to a part of the grease circulating system of Timken extreme pressure tester.

b) Thereafter, follow the procedures specified in **5.5** of **JIS K 2519**.

20.6 Test procedure

The test procedure shall be as follows.

a) Use the sample maintained at 24 °C ± 6 °C. Fill the grease feeding device with the sample with care not allow air bubbles to enter. Apply a thin film of sample to the test cup and the test block.

b) Start the grease feeding device and feed the sample to the test surface at rate of 45 g/min ± 9 g/min. Then, drive the revolting shaft of the tester and run for about 30 s to break-in.

c) Thereafter, follow the procedures specified in **5.6.1** of **JIS K 2519** to obtain the OK value and the score value.

20.7 Result and precision

a) **Result** The OK value and the score value shall be obtained according to **5.7** of **JIS K 2519**. If necessary, the contact pressure between the test cup and the test block at the time when the OK value is obtained shall be calculated.

b) **Precision** The precision is not specified.

20.8 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **20.7**

d) Date of test

e) Specially mentioned matters

21 Method for humidity cabinet test

21.1 Principle of test

A steel plate coated with a sample is hung in a humidity cabinet, which is maintained at 49 °C in temperature and 95 % or over in relative humidity. After the specified time, the degree of rust gathering is measured.

21.2 Reagent

The reagent shall be as follows.

a) **Solvent** Petroleum benzine specified in **JIS K 8594**.

21.3 Test apparatus

The test apparatus shall consist of the following **a**) to **c**).

a) **Test piece** According to **6.3.1** of **JIS K 2246**.

b) **Humidity cabinet test apparatus** According to **6.34.2 b**) of **JIS K 2246**.

c) **Measuring plate for degree of rust gathering** According to **6.4.2** of **JIS K 2246**.

21.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

21.5 Preparation of test

The preparation of test shall be as follows.

a) **Preparation method of test piece** According to **6.3.1** and **6.3.2** of **JIS K 2246**.

b) **Preparation method of coated test piece** Apply the sample uniformly all over the surface of the test piece prepared in **a**) by a suitable method so that the applied amount on one surface shall be 0.30 g ± 0.05 g. The sample to be used shall be such that foams of which have been previously removed thoroughly. It is preferable that after putting an appropriate amount of the grease on one surface of the test piece, the grease is coated little by little like rubbing while being pressed strongly onto the test piece with a spatula.

21.6 Test procedure

The test procedure shall be as follows.

a) According to **6.34.4 b**) of **JIS K 2246**.

b) After the specified time has elapsed, take out the test piece, select the test surface facing to the rotating direction of the frame on which the test piece is mounted as the surface to be measured, remove the sample grease with a clean cloth, and wipe off the grease further with petroleum benzine.

21.7 Calculation and precision

a) **Calculation method** The degree (%) of rust gathering according to **6.4.3** of **JIS K 2246** is measured. The measured values on three test pieces from the same sample are averaged for the average degree of rust gathering, classified into five classes such as 0 %, 1 % to 10 %, 11 % to 25 %, 26 % to 50 % and 51 % to 100 %, and expressed by Class A, Class B, Class C, Class D and Class E (see table 11 of **JIS K 2246**).

b) **Precision** The precision is not specified.

21.8 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220**)

c) Results obtained according to **21.7**

d) Date of test

e) Specially mentioned matters

22 Test method for water content

According to clause **3** of **JIS K 2275**.

23 Test method for kinematic viscosity

According to **JIS K 2283**.

24 Test method for flash point

According to Cleveland open cup method of **JIS K 2265-4**.

25 Test method for load carrying capacity (Soda-type four-ball test method)

According to clause **4** of **JIS K 2519**.

26 Test method for ability to lubricate under high load (Shell-type four-ball test method)

According to **4.4 Symbol 4** of **ISO 12924**.

27 Designation of products

The designation of products shall be according to the classification (according to application, class and cone penetration number).

Example : Grease for general purpose, Class 1, No. 2

28 Marking

The following items shall be marked indelibly on a conspicuous place of the container.

a) Classification (according to application, class and cone penetration number)

Example : Grease for general purpose, Class 1 No. 2

b) Net mass

c) Name of manufacturer or its abbreviation

d) Date of manufacture or its abbreviation

e) Lot number

Annex A (normative)
Classification according to ISO

A.1 Overview

This Annex establishes the classification of family X (greases) which belongs to Class L (lubricants, industrial oils and related products).

This classification applies to categories of greases used for lubrication of equipment, components of machines, vehicles, etc.

The greases have been classified according to the operating conditions under which they are used, because the versatile nature of grease makes it impractical to classify them according to the end use. It will therefore be necessary to consult the supplier to be certain that the grease can be used in, for example, rolling bearings or pumped supply system, and also concerning the compatibility of products. Further, this classification cannot be utilized for indicating the aptitude of greases to the special use such as the contact with food, radiation, high vacuum. In such a case, it shall be designated as the requirements concerning special greases.

NOTE 1 In this classification, a grease cannot have more than one symbol. This symbol should correspond to the most severe conditions of temperature, water contamination and load in which the grease can be used.

NOTE 2 This Annex should be read in conjunction with **ISO 6743-99**.

A.2 Explanation of symbols used

A.2.1 The detailed classification of family X is based on the conditions of grease use.

A.2.2 In accordance with **ISO 8681**, the complete designation of the grease includes the following.

a) the initials **ISO**

b) the letter L for the class of lubricants, industrial oils and related products

c) the category of the grease constituted by a group of five letters where each letter and the order in which it is written has a particular significance

1) the letter X for the family of grease

2) the lower operating temperature (symbol 1)

3) the upper operating temperature (symbol 2)

4) the ability of the grease to provide satisfactory lubrication in water contamination conditions, and to provide the level of anti-rust protection specified in table A.3 (symbol 3)

5) the ability of the grease to lubricate in the presence of high loads or low loads (symbol 4)

d) the NLGI consistency number [1)] of the grease corresponding to the measured penetration level according to **ISO 2137**

Note [1)] For the definition of NLGI consistency number, see **ISO 6743-99**.

NLGI: National Lubricating Grease Institute

A.2.3 In this classification system, products are designated in a uniform manner, each letter having a significance of its own. It is therefore imperative that the order of writing in table A.1 be used. For instance, a grease for use under the following operating conditions will have the **ISO** designation: **ISO-L-XBEGB 00**.

a) **Lower operating temperature** : –20 °C

b) **Upper operating temperature** : +160 °C

c) **Water contamination** : environmental condition-water wash

d) **anti-rust** : none

e) **extreme pressure (EP)** : yes

f) **NLGI consistency number** : 00

A.2.4 Detailed classification

The detailed classification is as follows. The grease characteristics are determined according to the specifications detailed in **ISO 12924**. From the test results, the correct designation symbols can be determined.

The operating-temperature range of the grease is determined from table A.2, and comprises two symbols: the lowest operating temperature and the maximum continuous operating temperature.

Table A.1 Order of letters for designation of greases

ISO	L	X	Symbol 1	Symbol 2	Symbol 3	Symbol 4	NLGL number
ISO initials	Class of lubricants	Family of grease	Lower operating temperature	Upper operating temperature	Water contamination	Extreme pressure	Consistency
Example (see **A.2.3**)							
ISO	L	X	B	E	G	B	00

Table A.2 Operating temperature range

Symbol 1		Symbol 2	
Lower operating temperature		Upper operating temperature	
Temperature °C	Symbol 1	Temperature °C	Symbol 2
0	A	60	A
–20	B	90	B
–30	C	120	C
–40	D	140	D
< –40	E	160	E
		180	F
		> 180	G

The ability of the grease to provide satisfactory lubrication in conditions where water contamination is possible, and to provide the level of anti-rust protection is described in table A.3.

Table A.4 describes the requirements for symbol 4, according to the ability of the grease to lubricate in the presence of high loads.

The NLGI consistency makes up the final digits in the designation system (see table A.5).

The detailed classification of greases is shown in table A.6.

Table A.3 Level of water resistance and protection against corrosion

Environmental condition [a)]	Anti-rust protection [b)]	Symbol 3
L	L	A
L	M	B
L	H	C
M	L	D
M	M	E
M	H	F
H	L	G
H	M	H
H	H	I

Notes [a)] L = dry, M = static, H = water wash

[b)] L = no protection, M = protect in the presence of water, H = protect in the presence of salt water

Table A.4 Ability to lubricate under high loads

Extreme pressure (EP) properties [a)]	Symbol 4
No	A
Yes	B
Note [a)] For the explanation of suitable test, see **4.4** of **ISO 12924**.	

Table A.5 NLGI consistency number

NLGI consistency number	Worked cone penetration range (60 strokes)
000	445 to 475
00	400 to 430
0	355 to 385
1	310 to 340
2	265 to 295
3	220 to 250
4	175 to 205
5	130 to 160
6	85 to 115

Table A.6 Classification of greases

General application	Application requirements									Designation **ISO**-L
	Range of operating temperature				Water contamination	Symbol 3	Load (EP)	Symbol 4	Consistency	
	Lower temperature °C [a]	Symbol 1	Upper temperature °C [b]	Symbol 2						
Lubrication requiring grease	0	A	60	A	Ability of grease to provide satisfactory lubrication in water-contamination conditions, and to provide the level of anti-rust protection described in table A.3.	A	Ability of grease to lubricate in the presence of high loads or low loads. Symbol A is used for requiring no EP grease and symbol B is used for requiring EP class grease, respectively. See table A.4.	A	Associate the appropriate NLGI consistency number, as shown in table A.5 with the other symbols.	The designation of grease is made by associating symbol X with other symbols 1, 2, 3 and 4 and with NLGI consistency number as illustrated in **A.2.3**.
			90	B		B		B		
			120	C		C				
			140	D		D				
			160	E		E				
			180	F		F				
			> 180	G		G				
	–20	B	60	A		H				
			90	B		I				
			120	C						
			140	D						
			160	E						
			180	F						
			> 180	G						
	–30	C	60	A						
			90	B						
			120	C						
			140	D						
			160	E						
			180	F						
			> 180	G						
	–40	D	60	A						
			90	B						
			120	C						
			140	D						
			160	E						
			180	F						
			> 180	G						
	< –40	E	60	A						
			90	B						
			120	C						
			140	D						
			160	E						
			180	F						
			> 180	G						

Notes [a] The lowest temperature experienced while starting or running, or while pumping the grease.

[b] The highest temperature of the lubricated component when in service.

Annex JA (informative)
Test method for undisturbed penetration

JA.1 Principle of test

A sufficient quantity of sample is taken in the pot of worker so as not to allow air bubbles to enter, and the surface of sample is flattened.

The sample is covered so that the surface is not touched, stored for the specified time, then the penetration of sample is measured.

JA.2 Test apparatus

The test apparatus shall be according to **7.2**.

JA.3 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

JA.4 Test procedure

The test procedure for undisturbed penetration by using the standard cone shall be as follows.

a) **Preparation of sample**

1) Prepare the sufficient sample (at least 0.5 kg) to overfill the pot of the 1/1 grease worker.

   If the penetration is above 200 units, at least three times (1.5 kg or over) the amount to fill the pot will be required.

2) Overfill the pot of 1/1 worker with the sample so as not to allow air bubbles to enter, then flatten the surface of the sample according to **7.4**. If the penetration is 200 units or under, prepare one sample, and if it exceeds 200 units, prepare three samples.

3) Cover the sample with an appropriate material so that the surface is not touched, and store it for the specified time as it is or place it quietly. The time and place for storage or placing quietly shall be subjected to the agreement between the parties concerned with delivery.

4) After the specified time has elapsed, immerse the pot containing the sample in the thermostatic water bath maintained at 25 °C so that the edge of pot is positioned at about 25 mm above the water level. Cover the thermostatic water bath and leave it for 2 h as it is as taking care so as not to allow water to enter in the sample.

5) Then, take out the pot from the thermostatic water bath, and wipe off water adhered on the outside of the pot.

b) **Measurement of cone penetration**

1) If the cone penetration of the sample exceeds 200 units, measure the cone penetration respectively on the prepared three samples according to the procedures of **7.4 b**) and **7.4 c**) **1**).

2) If the cone penetration is 200 units or under, measure the cone penetration according to the procedure of **7.4 c**) **3**).

JA.5 Calculation method and precision

a) **Calculation method** The measurement of **JA.4 b**) shall be carried out, and the mean value of the recorded values shall be calculated and rounded with the rounding interval of 1 according to **JIS Z 8401**.

b) **Precision** The precision is not specified.

JA.6 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220** Annex JA)

c) Results obtained according to **JA.5 a**)

d) Date of test

e) Specially mentioned matters

Annex JB (informative)
Test method for determination of free acid, free alkali and insoluble carbonate

JB.1 Principle of test

The sample is dispersed in solvent, ethanol is added and phenolphthalein solution (10 g/L) is dropped as an indicator. In the case of acidic indication, it is titrated with 0.5 mol/L alcoholic potassium hydroxide solution and the free acid is calculated. In the case of alkaline indication, a known mass of 0.5 mol/L hydrochloric acid is added and boiled, and the free alkali is neutralized. Then, the excess acid is back-titrated with alcoholic potassium hydroxide, and the free alkali is calculated.

In the case of the determination of free alkali, when insoluble carbonate is detected by effervescence, after adding the excess of 0.5 mol/L hydrochloric acid, it is back-titrated with 0.5 mol/L alcoholic potassium hydroxide solution and the insoluble carbonate is calculated. This test method is not applicable to the grease which contains weak basic soap such as lead, zinc, aluminium or the grease containing additives which react with potassium hydroxide or hydrochloric acid.

JB.2 Reagents

The reagents shall be as follows.

a) **Solvent** Petroleum benzine specified in **JIS K 8594**.

b) **Ethanol** That specified in **JIS K 8102**.

c) **Phenolphthalein solution** Prepared by dissolving 1.0 g of phenolphthalein specified in **JIS K 8799** in 50 ml of ethanol and adding 50 ml of water.

d) **0.5 mol/L alcoholic potassium hydroxide solution** [1)] Prepared by dissolving about 29 g of potassium hydroxide specified in **JIS K 8574** in 500 ml of ethanol and placing in a dark place. Then, the supernatant is filtered by an appropriate method, made to 1 000 ml in total volume by adding ethanol and standardized precisely.

Note [1)] 0.2 mol/L or 0.1 mol/L alcoholic potassium hydroxide solution may be used.

e) **0.5 mol/L hydrochloric acid** Prepared by diluting about 50 ml of hydrochloric acid specified in **JIS K 8180** with water to make 1 000 ml in total volume and standardizing with 0.5 mol/L alcoholic potassium hydroxide solution.

f) **Water** That of A3 specified in **JIS K 0557**.

JB.3 Test apparatus

The test apparatus shall be as follows.

a) **Burette** That specified in **JIS R 3505** having the nominal capacity of 50 ml (minimum graduation 0.1 ml) and the capacity of 10 ml (minimum graduation 0.05 ml) or that of motor-driven having the performance equivalent to this.

JB.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

JB.5 Test procedure

The test procedure shall be as follows.

a) **Preparation of sample** Weigh out about 10 g of sample precisely in a suitable beaker of 100 ml or over to the nearest 0.1 g, add 75 ml of solvent as dividing in several portions, and disperse the sample thoroughly in the solvent. Then, transfer it to a 250 ml Erlenmeyer flask, wash out the content of the beaker completely in the Erlenmeyer flask with 50 ml of ethanol, add about 1 ml of phenolphthalein solution, shake vigorously to mix for 10 min with an appropriate interval.

b) **Determination of free acid** When the alcoholic layer in **a**) does not colour, immediately titrate with 0.5 mol/L alcoholic potassium hydroxide solution until the faint pink colour continues for 1 min.

c) **Determination of free alkali** When the alcoholic layer in **a**) colours, add 50 ml or, when necessary, excess of 0.5 mol/L hydrochloric acid, and decompose thoroughly to make acidic [2)]. Attach a reflux condenser to the flask, put it on a hot plate, and boil the content for about 10 min to expel carbon dioxide. Then, detach the reflux condenser, and immediately titrate with 0.5 mol/L alcohol solution of potassium hydroxide according to **b**).

Note [2)] When the content includes carbonate, vigorous effervescence is caused by the addition of hydrochloric acid. In such a case, not **c**) but **d**) applies.

d) **Determination of insoluble carbide** When carbonate is observed, add 0.5 mol/L hydrochloric acid until the content shows slightly acidic, attach a reflux condenser to the Erlenmeyer flask, place it on the hot plate, and boil the content for about 10 min to expel carbon dioxide. Then, detach the condenser, and immediately titrate with 0.5 mol/L alcoholic solution of potassium hydroxide according to **b**).

e) **Blank test** Carry out the blank test for the procedures of **b**) and **c**), respectively. However, the blank test is not carried out for the procedure of **d**).

JB.6 Calculation method and precision

a) **Calculation method**

1) The free acid as oleic acid shall be calculated according to the following formula, and rounded with the rounding interval of 0.1 according to **JIS Z 8401**.

$$A = \frac{28.2 \times (v - v') \times n}{W}$$

where, A : free acid (%)

v : volume of 0.5 mol/L alcoholic solution of potassium hydroxide required for titration of sample (ml)

v' : volume of 0.5 mol/L alcoholic solution of potassium hydroxide required for titration of blank test (ml)

n : concentration of 0.5 mol/L alcoholic solution of potassium hydroxide (mol/L)

W : mass of sample (g)

2) The free alkali as hydroxide of principal metal composing a soap shall be calculated according to the following, and shall be rounded with the rounding interval of 0.01 according to **JIS Z 8401**.

$$B=\frac{E\times(v'-v)\times n}{10\times W}$$

where, B : free alkali (%)

E : equivalent mass of hydroxide of principal metal (g)

v : volume of 0.5 mol/L alcoholic solution of potassium hydroxide required for titration of sample (ml)

v' : volume of 0.5 mol/L alcoholic solution of potassium hydroxide required for titration of blank test (ml)

n : concentration of 0.5 mol/L alcoholic solution of potassium hydroxide (mol/L)

W : mass of sample (g)

3) The insoluble carbonate as calcium carbonate shall be calculated according to the following formula, and rounded with the rounding interval of 0.1 according to **JIS Z 8401**.

$$C=\frac{5\times(V\times N-v\times n)}{W}$$

where, C : insoluble carbonate (%)

V : volume of 0.5 mol/L hydrochloric acid added to sample (ml)

N : concentration of 0.5 mol/L hydrochloric acid (mol/L)

v : volume of 0.5 mol/L alcoholic solution of potassium hydroxide required for titration of sample (ml)

n : concentration of 0.5 mol/L alcoholic solution of potassium hydroxide (mol/L)

W : mass of sample (g)

b) **Precision** The precision is not specified.

JB.7 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220** Annex JB)

c) Results obtained according to **JB.6**

d) Date of test

e) Specially mentioned matters

Annex JC (informative)
Test method for open type evaporation loss

JC.1 Principle of test

The sample is heated in a thermostatic air bath maintained at 105 °C and equipped with a rotating disk which turns at a rate of 5 rpm to 6 rpm, for 8 h and the evaporation loss is calculated from the loss in mass of the sample.

NOTE : This is different from the test method for evaporation loss specified in clause **10**.

JC.2 Test apparatus

The test apparatus consists of the following **a**) to **d**).

a) **Test container** That having the shape and dimensions as shown in figure JC.1, and made of borosilicate of which quality is specified in **JIS R 3503**.

Unit: mm

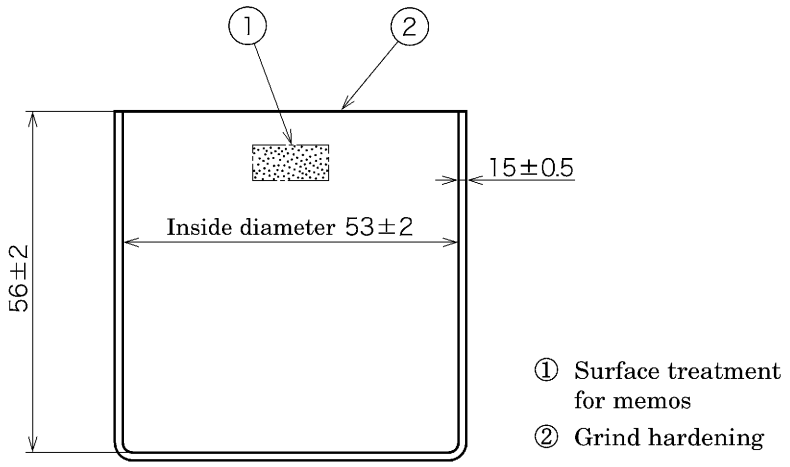


Figure JC.1 Test container

b) **Thermostatic air bath** An electric heating air bath as shown in figure JC.2 a) of double wall and square type having the following conditions of **1**) to **6**).

1) For the dimensions of inside excluding the heating part, the space of 290 mm or over in height and 300 mm or over in width/depth is necessary.

2) It shall be equipped with a swinging door, and a square double glass window of one side length approximately 100 mm to observe the temperature and the inner state on the wall.

3) It shall be equipped with one or more air inlet and at least one outlet for vapour to facilitate the suitable ventilation.

4) For circulating air around the heating coil, the air inlets shall be located at the bottom part or the lower part of side wall, and the total sectional area shall be 130 mm^2 or over. When two or more of them are equipped, they shall be located at the symmetrical positions.

5) The outlets for vapour shall be located at the top or the side wall in the vicinity of top, and the total sectional area shall be 130 mm^2 to 1 290 mm^2. When two or more of them are equipped, they shall be located at the symmetrical positions.

6) At the central part of the thermostatic air bath inside, an aluminium rotating disk made to the shape as shown in figure JC.2 b) capable of rotating at a rate of 5 rpm to 6 rpm by a motor shall be equipped.

c) **Thermometer for test** That of about 150 mm in total length, the graduation range of 100 °C to 110 °C, and the scale interval of 0.5 °C.

d) **Desiccator** That having an appropriate capacity and used without desiccant.

JC.3 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

JC.4 Test procedure

The test procedure shall be as follows.

a) Weigh the mass of clean test container and weigh out about 20 g of the sample in it to the nearest 0.01 g. Make the surface of the sample as flat as possible.

b) Maintain the thermostatic air bath at 105 °C ± 1 °C previously, fix the thermometer for test perpendicularly at the side arm attached to the shaft of the disk in a position about 20 mm inside the periphery of the disk, and the lower end of the mercury bulb is situated 6 mm above the top surface of the disk.

c) Place the test container containing the sample on the disk in the thermostatic air bath, then shut the door, rotate the disk at a rate of 5 rpm to 6 rpm, and leave it at 105 °C ± 1 °C for 8 h as it is. Then, take out the test container, leave it to cool down to room temperature in a desiccator, and weigh the mass to the nearest to 0.01 g.

JC.5 Calculation method and precision

a) **Calculation method** The results shall be calculated according to the following formula, and the mean value of two measured values shall be rounded with the rounding interval of 0.1 according to **JIS Z 8401**.

$$W_1 = \frac{W_s - W}{W_s} \times 100$$

where, W_1 : evaporation loss (mass %)

W_s : mass of sample before test (g)

W : mass of sample after test (g)

b) **Precision** The precision is not specified.

JC.6 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

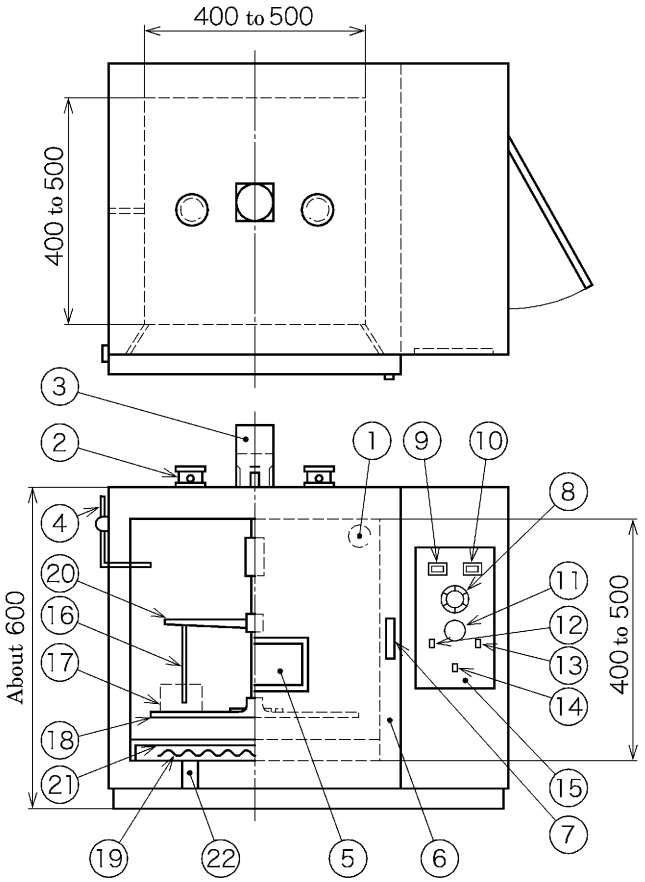
b) Designation of test method and the number of this Standard (**JIS K 2220** Annex JC)

c) Results obtained according to **JC.5 a**)

d) Date of test

e) Specially mentioned matters

Unit: mm



① Inside lamp of air bath
② Outlet hole for vapour
③ Motor driving apparatus for rotating disk
④ Thermometer for air bath
⑤ Double glass window
⑥ Door
⑦ Handle of door
⑧ Thermostat
⑨ Signal lamp for thermostat
⑩ Pilot lamp for power supply
⑪ Switch for heater
⑫ Driving switch for rotating disk
⑬ Switch for inside lamp of air bath
⑭ Switch for power supply
⑮ Switch board
⑯ Thermometer for test
⑰ Test container
⑱ Rotating disk
⑲ Electric heater
⑳ Side arm
㉑ Steel plate
㉒ Inlet hole for air

Figure JC.2 a) Example of thermostatic air bath

Unit: mm

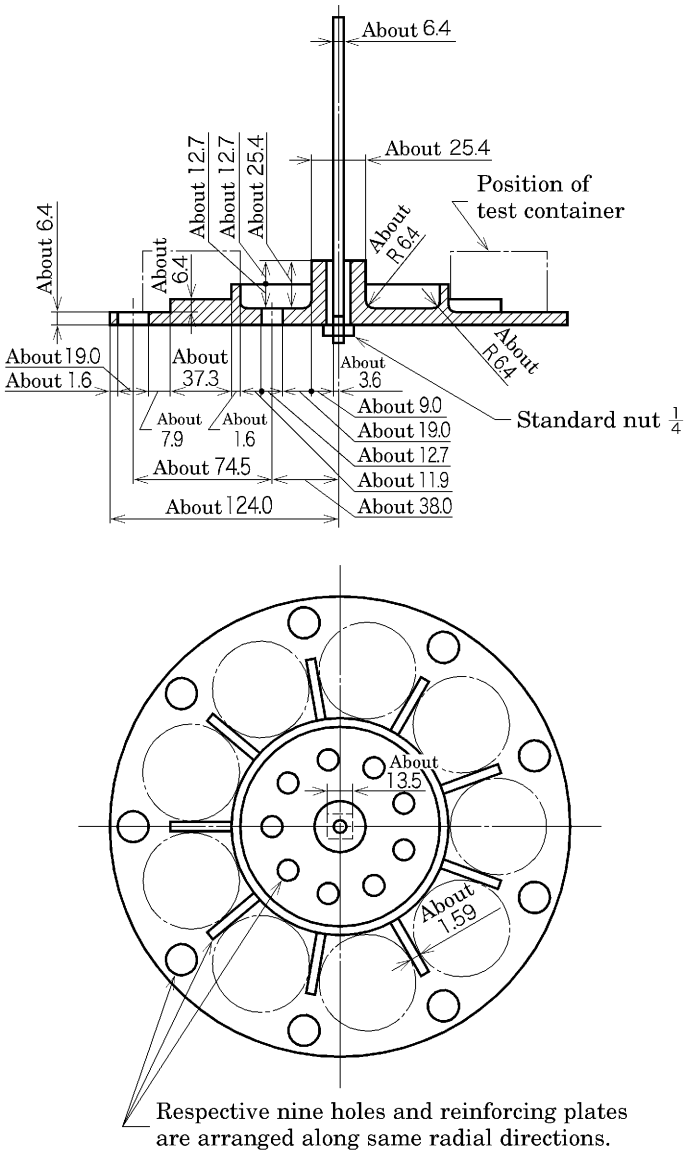


Figure JC.2 b) Example of rotating disk made of aluminium

Annex JD (informative)
Test method for sulfated ash content

JD.1 Principle of test

The sample is weighed out in a crucible, and burnt. This is added with sulfuric acid, ignited strongly, then the residue is weighed and calculated as sulfated ash content.

JD.2 Reagents

The reagents shall be as follows.

a) **Sulfuric acid** That of 10 % solution of guaranteed grade specified in **JIS K 8951**.

b) **Methyl orange indicator** That of 0.1 % aqueous solution specified in **JIS K 8893**.

c) **Ammonium carbonate** That specified in **JIS K 8613**.

d) **Ethanol** That specified in **JIS K 8102**.

e) **Water** That of A3 specified in **JIS K 0557**.

JD.3 Test apparatus

The test apparatus consists of the following **a**) to **d**).

a) **Crucible** That of 15 ml in capacity and made of porcelain, quartz or platinum.

When a substance such as lead, zinc, which reacts with platinum at high temperature, is contained in the sample, the crucible made of platinum shall not be used.

b) **Electric furnace** That capable of regulating the temperature of furnace inside at 600 °C ± 25 °C.

c) **Desiccator** That having an appropriate size and being used without desiccant.

d) **Balance** That capable of weighing the total mass of crucible and sample to the nearest 0.01 g.

JD.4 Sampling method and preparation method of sample

The sample shall be taken and prepared according to the sampling method of primary sample and the preparation method of secondary sample specified in **JIS K 2251** or the methods equivalent to these.

JD.5 Preparation of test

The preparation of test shall be as follows.

a) Heat a clean crucible in the electric furnace maintained at 600 °C ± 25 °C for 10 min or over, leave it to cool in the desiccator to room temperature as it is, then weigh the mass.

b) Weigh out 2 g to 5 g of the sample to the nearest 0.01 g in this crucible.

c) Heat the crucible containing the sample with a gas burner [1)], and burn the sample gradually [2)].

Notes [1)] An electric heater such as a hot plate may be used.

[2)] When the sample scatters by foaming, add 1 ml to 2 ml of ethanol before heating.

d) When the sample starts to burn, regulate the heating so as to continue to burn at a constant state as much as possible thereafter.

e) When the burning of the sample has been finished and the contents in the crucible has become ash and carbonaceous substance, transfer it to the electric furnace maintained at 600 °C ± 25 °C and further heat to burn until the carbonaceous substance is not observed.

f) Take out the crucible with contents from the electric furnace, cool it, then dissolve the soluble matter with a small amount of water, and put a cover on the crucible. Insert a pipette below the cover and add a little excess sulfuric acid with caution.

g) Warm the crucible added with sulfuric acid on a water bath until boiling ceases, and wash down the adhered substance on the cover into the crucible with water.

h) Drip methyl orange indicator to examine the presence of free acid.

i) Evaporate the contents to dryness in the crucible, and add a small amount of dry ammonium carbonate to expel the excess of sulfuric acid anhydride. Heat until the bottom of the crucible turns to faint pink colour.

j) Leave the crucible together with the contents to cool in a desiccator to room temperature as it is and weigh the mass to the nearest 0.01 g.

JD.6 Calculation method and precision

a) **Calculation method** The results shall be calculated according to the following formula, and the mean value of two measured values shall be rounded with the rounding interval of 0.1 according to **JIS Z 8401**.

$$A = \frac{W_r}{W_s} \times 100$$

where, A : sulfated ash content (mass fraction %)

W_r : mass of sulfated ash (g)

W_s : mass of sample (g)

b) **Precision** The precision is not specified.

JD.7 Report on test results

The following items shall be listed in the report.

a) Name of sample, place of sampling and date of sampling

b) Designation of test method and the number of this Standard (**JIS K 2220** Annex JD)

c) Results obtained according to **JD.6 a**)

d) Date of test

e) Specially mentioned matters

Bibliography

JIS K 2513 *Petroleum products—Corrosiveness to copper—Copper strip test*

JIS K 8180 *Hydrochloric acid (Reagent)*

JIS K 8574 *Potassium hydroxide (Reagent)*

JIS K 8613 *Ammonium carbonate (Reagent)*

JIS K 8799 *Phenolphthalein (Reagent)*

JIS K 8893 *Methyl orange (Reagent)*

JIS K 8951 *Sulfuric acid (Reagent)*

JIS R 3503 *Glass apparatus for chemical analysis*

JIS R 3505 *Volumetric glassware*

ISO 6743-99:2002 *Lubricants, industrial oils and related products (class L)—Classification—Part 99: General*

ASTM D 128-98 *Standard Test Methods for Analysis of Lubricating Grease*

ASTM D 217-97 *Standard Test Methods for Cone Penetration of Lubricating Grease*

ASTM D 942-90 *Standard Test Method for Oxidation Stability of Lubricating Greases by the Oxygen Bomb Method*

ASTM D 972-97 *Standard Test Method for Evaporation Loss of Lubricating Greases and Oils*

ASTM D 1092-99 *Standard Test Method for Measuring Apparent Viscosity of Lubricating Greases*

ASTM D 1263-94 *Standard Test Method for Leakage Tendencies of Automotive Wheel Bearing Greases*

ASTM D 1478-91 *Standard Test Method for Low-Temperature Torque of Ball Bearing Grease*

ASTM D 2509-93 *Standard Test Method for Measurement of Load-Carrying Capacity of Lubricating Grease (Timken Method)*

ASTM D 4048-97 *Standard Test Method for Detection of Copper Corrosion from Lubricating Grease*

ASTM D 6184-98 *Standard Test Method for Oil Separation from Lubricating Grease (Conical Sieve Method)*

Annex JE (informative)
Comparison table between JIS and corresponding International Standards

JIS K 2220:2013 *Lubricating grease*	**ISO 2137**:2007 *Petroleum products and lubricants—Determination of cone penetration of lubricating greases and petrolatum* **ISO 2176**:1995 *Petroleum products—Lubricating grease—Determination of dropping point* **ISO 6743-9**:2003 *Lubricants, industrial oils and related products (class L)—Classification—Part 9: Family X (Greases)* **ISO 11009**:2000 *Petroleum products and lubricants—Determination of water washout characteristics of lubricating greases* **ISO 12924**:2010 *Lubricants, industrial oils and related products (Class L)—Family X (Greases)—Specification*

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
1 Scope	Applicable to lubricating grease to be used as lubricants for various machine parts.		—	—	Addition	Not specified in **ISO**.	In **JIS**, the constitution unifying the product standard and the test method to meet the market trend in Japan is adopted, and the scope is specified.
2 Normative references							

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
3 Terms and definitions	Cone penetration, working, unworked penetration, worked penetration, prolonged worked penetration, block penetration and dropping point used in the corresponding **ISO** Standard, and further, the terms of water resistance, thickener, mechanical stability, worked stability, etc., necessary for **JIS** are defined.	**ISO 2137** **ISO 2176** **ISO 11009**	3 2	Cone penetration, working, unworked penetration, worked penetration, prolonged worked penetration, block penetration are defined. Dropping point is defined. In **ISO 11009**, the definitions are not specified.	Addition	The terms necessary for **JIS** are added.	The specification content is added to clarify terms.
4 Classification of grease	Greases are classified into seven types by application, and further sub-divided by class and cone penetration number.	**ISO 6743-9**		Greases are classified according to the operating conditions (operating temperature, water contamination, extreme pressure) at the usage of grease and the number of cone penetration.	Selection	In **JIS**, greases are classified into seven types, classes are specified by composition and performance, and also the cone penetration number is specified.	As rapid harmonization with **ISO** Standard has a possibility to cause the confusion in manufacturers and users, in this revision, the translation of **ISO** Standard is given as Annex A (normative).
5 Quality and performance	The test items and the required values to indicate the characteristics of greases classified into seven types are specified.			—	Addition	Not specified in **ISO**.	Product standards unique to **JIS** are added.

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
6 Classification of test methods	The classification of test methods constituting this Standard is given in table.			—	Addition	Not specified in **ISO**.	Added for the convenience of users of this Standard.
7 Test method for cone penetration	7.1 Principle of test	**ISO 2137**	4	Petrolatum is also specified in **ISO** Standard.	Deletion	In **JIS**, only greases are specified and the explanation part of grease is equivalent to that of **ISO** Standard.	The cone penetration of petrolatum is specified in **JIS K 2235**.
	7.2 Test apparatus	**ISO 2137**	5	Petrolatum is also specified in **ISO** Standard.	Deletion	In **JIS**, only greases are specified and the explanation part of grease is equivalent to that of **ISO** Standard.	The cone penetration of petrolatum is specified in **JIS K 2235**.
	7.3 Sampling method and preparation method of sample	**ISO 2137**	6	In **ISO**, the sampling procedure of grease is not specified in detail.	Addition	In **JIS**, the sampling procedure of grease is specified in detail.	The specification unique to **JIS** is added for the necessity of quality evaluation.
8 Test method for dropping point	8.1 Principle of test			—	Addition	Introduction, scope and note in scope of **ISO** Standard are included and given as the principle of test.	Requirements unique to **JIS** are added.
	8.2 Test apparatus	**ISO 2176**	3	Oil bath in **ISO** is specified to be 400 ml.	Alteration	Oil bath in **JIS** is specified to be 400 ml or over. Automated test apparatus is also permissible.	Double mounting of test tubes is considered in **JIS**. Automated test apparatus is widely used in Japan, therefore, added as unique to **JIS**.

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
	8.3 Sampling method and preparation method of sample			—	Addition	In **JIS**, the sampling procedure of grease is specified in detail.	The specification unique to **JIS** is added for the necessity of quality evaluation.
9 Test method for copper corrosion				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
10 Test method for evaporation loss				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
11 Test method for oil separation				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
12 Test method for oxidation stability				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
13 Test method for foreign matters				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
14 Test method for ash content				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
15 Test method for worked stability				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
16 Test method for water washout resistance	16.3 Test apparatus	**ISO 11009**	5	In **ISO**, the jet mechanism is specified in the explanatory sentence in figure 27.	Addition	In **JIS**, it also specified in the clause of test apparatus.	The specification unique to **JIS** is added.
	16.4 Sampling method and preparation method of sample	**ISO 11009**	6	In **ISO**, the quantity of sample required and the conditions of sample to be taken are specified.	Addition	In **JIS**, the sampling procedure of grease is specified in detail.	The specification unique to **JIS** is added for the necessity of quality evaluation.
17 Test method for leakage tendency				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
18 Test method for low temperature torque				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
19 Test method for apparent viscosity				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
20 Test method for load carrying capacity by Timken method				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
21 Method for humidity cabinet test				—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.
22 Test method for water content	**JIS K 2275** is quoted.			—	Addition	**JIS K 2275** is equivalent to **ISO 3733**.	The specification unique to **JIS** is added for the necessity of quality evaluation.
23 Test method for kinematic viscosity	**JIS K 2283** is quoted.			—	Addition	**JIS K 2283** is equivalent to **ISO 3104** and **ISO 3105**.	The specification unique to **JIS** is added for the necessity of quality evaluation.
24 Test method for flash point	**JIS K 2265-4** is quoted.			—	Addition	**JIS K 2265-4** is equivalent to **ISO 2592**.	The specification unique to **JIS** is added for the necessity of quality evaluation.
25 Test method for load carrying capacity (Soda-type four-ball test method)	**JIS K 2519** is quoted.			—	Addition	—	The specification unique to **JIS** is added for the necessity of quality evaluation.

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
27 Designation of products		**ISO 6743-9**	3	Greases are specified according to operation conditions (operation temperature, water contamination, extreme pressure) and consistency number.	Alteration	In **JIS**, greases are specified according to classification (application, class and cone penetration number).	As rapid harmonization with **ISO** Standard has a possibility to cause the confusion in manufacturers and users, the translation of **ISO 6749-9** in 2003 is given as Annex A (normative) without any change.
28 Marking				—	Addition	—	The specification unique to **JIS** is added because of the necessity in business custom.

Overall degree of correspondence between **JIS** and International Standards (**ISO 2137**:2007, **ISO 2176**:1995, **ISO 6743-9**:2003, **ISO 11009**:2000, **ISO 12924**:2010): MOD	
Related International Standard	**ASTM D 2699**-01a

NOTE 1 Symbols in sub-columns of classification by clause in the above table indicate as follows:

— Deletion: Deletes the specification item(s) or content(s) of International Standard.

— Addition: Adds the specification item(s) or content(s) which are not included in International Standard.

— Alteration: Alters the specification content(s) which are included in International Standard.

— Selection: Provides an alternative choice by adding the specification content(s) of equal status, which may be used in place of that given in the original International Standard.

NOTE 2 Symbol in column of overall degree of correspondence between **JIS** and International Standard in the above table indicates as follows:

— MOD: Modifies International Standards.

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