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Lubricating grease

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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.

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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
Application	Class	Cone penetration number a)		Force (load)			Water contamination	
				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 mm²/s to 74.8 mm²/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 mm²/s to 242 mm²/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)		—	12 max.	10 max.	11
Oxidation stability (99 °C, 100 h)		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		430 max.	400 max.	375 max.	15
Water washout resistance (38 °C, 1 h)		—	10 max.	10 max.	16
Low temperature torque (-40 °C) mN · m		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.	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
Low temperature torque (-30 °C) mN · m	Starting torque	490 max.	590 max.	790 max.	18
	Revolving torque	250 max.	290 max.	390 max.	
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 (-10 °C, slip rate 10 s ⁻¹) Pa · s		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)		5 max.	5 max.	11
Oxidation stability (99 °C, 100 h)		70 max.	70 max.	12
Foreign matter particles particles/cm ³	10 µm min.	5 000 max.	5 000 max.	13
	25 µm min.	3 000 max.	3 000 max.	
	75 µm min.	500 max.	500 max.	
	125 µm min.	0	0	
Worked stability		375 max.	375 max.	15
Water washout resistance (79 °C, 1 h)		10 max.	10 max.	16
Leakage tendency (104 °C, 6 h)		10 max.	10 max.	17
Low temperature torque (-20 °C) mN · m	Starting torque	790 max.	990 max.	18
	Revolving torque	390 max.	490 max.	
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 (−10 °C, slip rate 10 s ^{−1}) Pa · s	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)		—	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)		—	20 max.	10 max.	16
Mass fraction (%)					
Apparent viscosity (−10 °C, slip rate 10 s ^{−1}) Pa · s		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 (−10 °C, slip rate 10 s ^{−1}) Pa · s	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.	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)		—	20 max.	10 max.	16
Mass fraction (%)					
Apparent viscosity (−10 °C, slip rate 10 s ^{−1}) Pa · s		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.

- 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.
- The worked penetration is determined immediately after working the sample for 60 strokes in the specified grease worker.
- The prolonged worked penetration is determined on the sample worked more than 60 strokes.
- 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).

- 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.

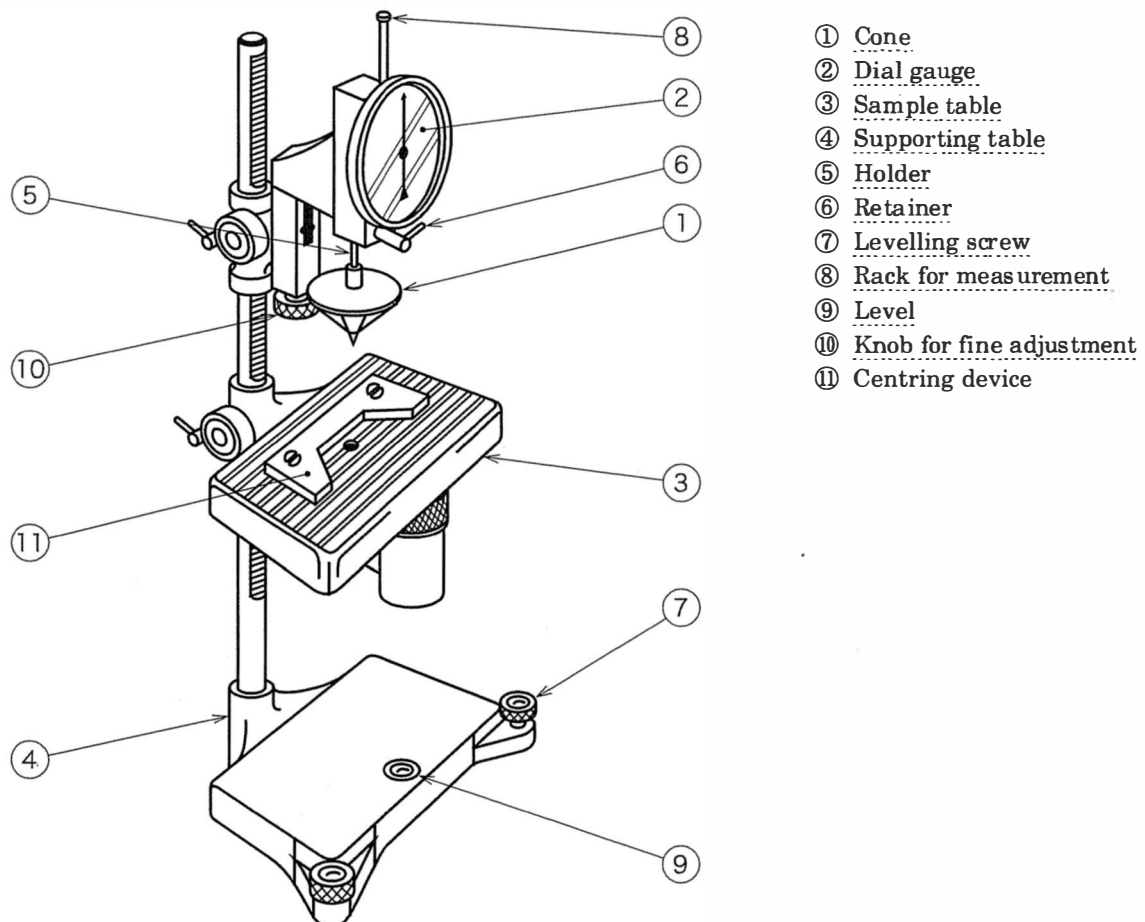


Figure 1 Example of penetrometer

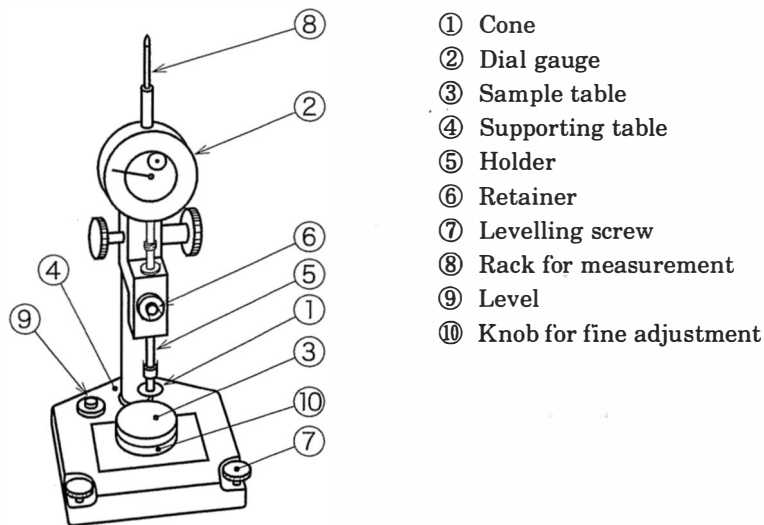
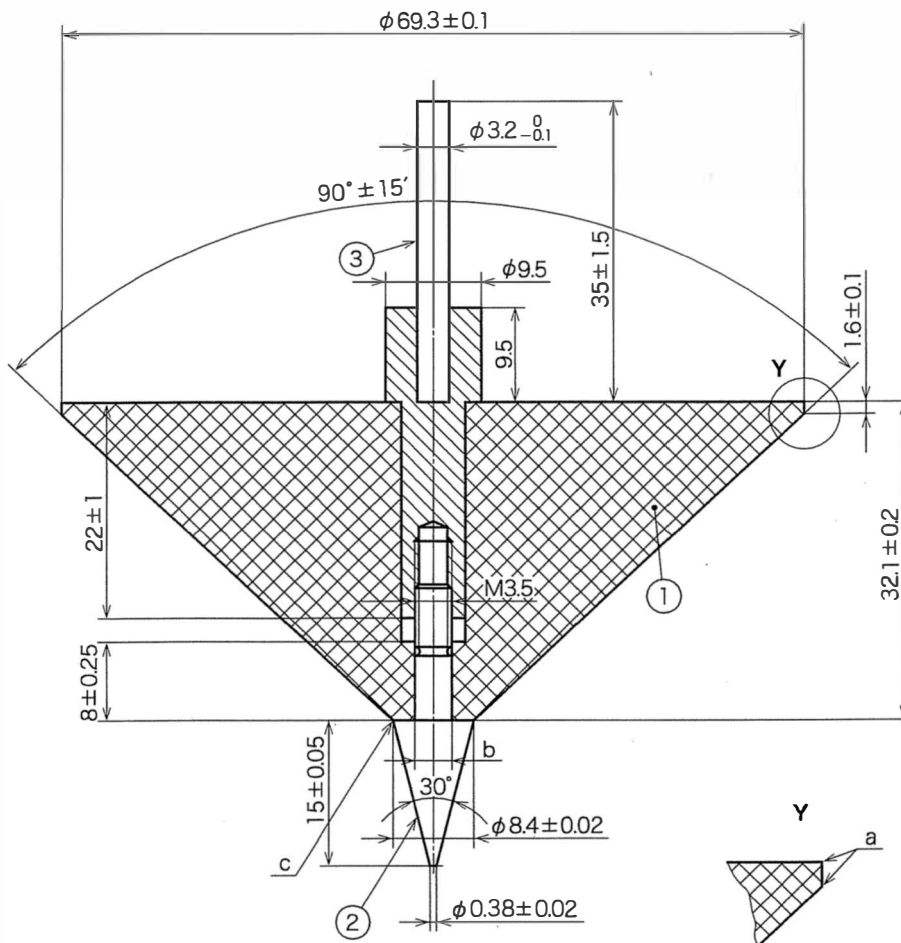


Figure 2 Example of one-half or one-quarter penetrometer

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 $102.5 \text{ g} \pm 0.05 \text{ g}$ and the mass of the holder of cone shall be $47.5 \text{ g} \pm 0.05 \text{ g}$. 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 $37.5 \text{ g} \pm 0.05 \text{ g}$. The mass of the cone shall be $22.5 \text{ g} \pm 0.025 \text{ g}$, and the mass of the holder shall be $15 \text{ g} \pm 0.025 \text{ g}$.
- 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 $9.38 \text{ g} \pm 0.025 \text{ g}$. 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 $\phi 4$ max., tight fit.
- c No shoulder.

Total mass of cone: $102.5 \text{ g} \pm 0.05 \text{ g}$

Total mass of holder of cone: $47.5 \text{ g} \pm 0.05 \text{ g}$

Figure 3 Standard cone

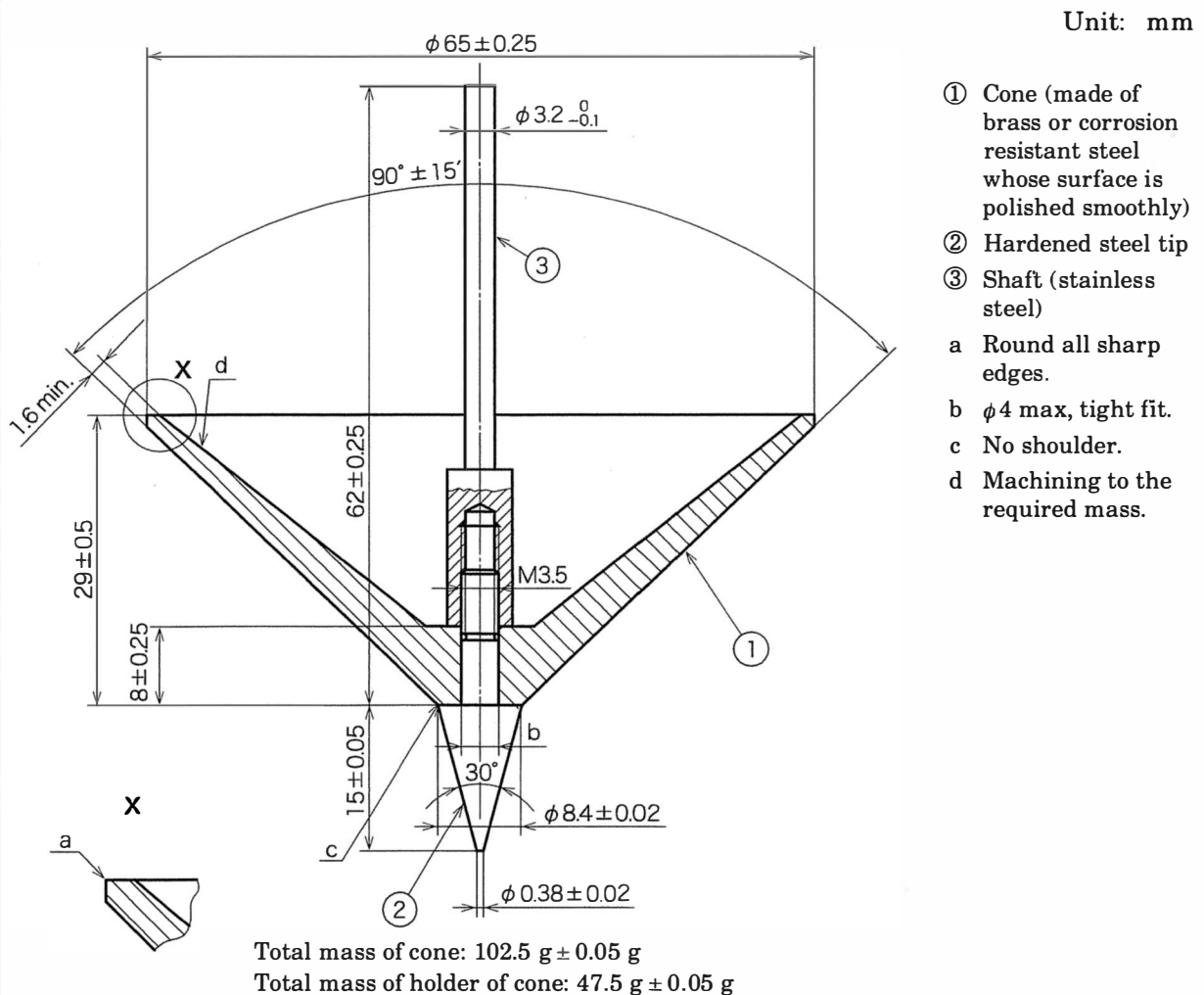


Figure 4 Optional cone

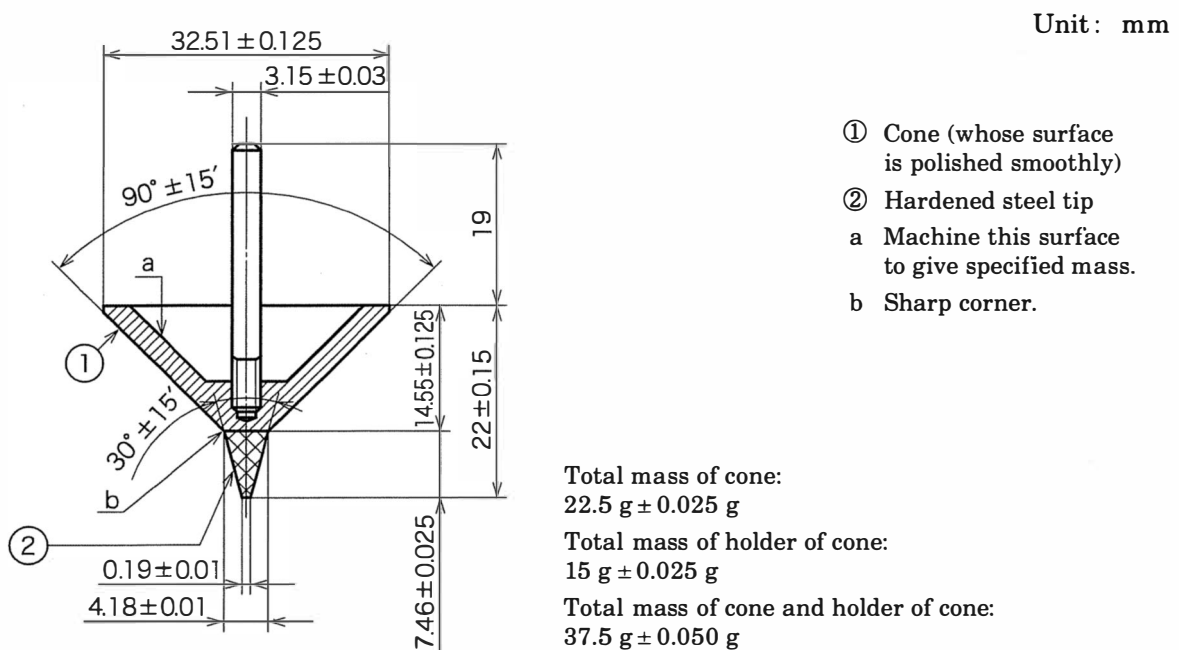
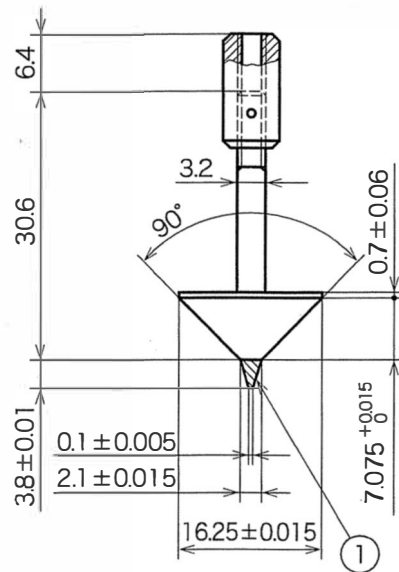


Figure 5 One-half scale cone

Unit: mm



① Hardened steel tip

Total mass of cone and holder of cone:
 $9.38 \text{ g} \pm 0.025 \text{ g}$

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 $60 \text{ strokes} \pm 10 \text{ strokes per minute}$, 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 $60 \text{ strokes} \pm 10 \text{ strokes per minute}$, 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 $60 \text{ strokes} \pm 10 \text{ strokes per minute}$, 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 $25\text{ }^{\circ}\text{C} \pm 0.5\text{ }^{\circ}\text{C}$ 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 $25\text{ }^{\circ}\text{C}$.

An air bath, maintained at $25^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$, 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.

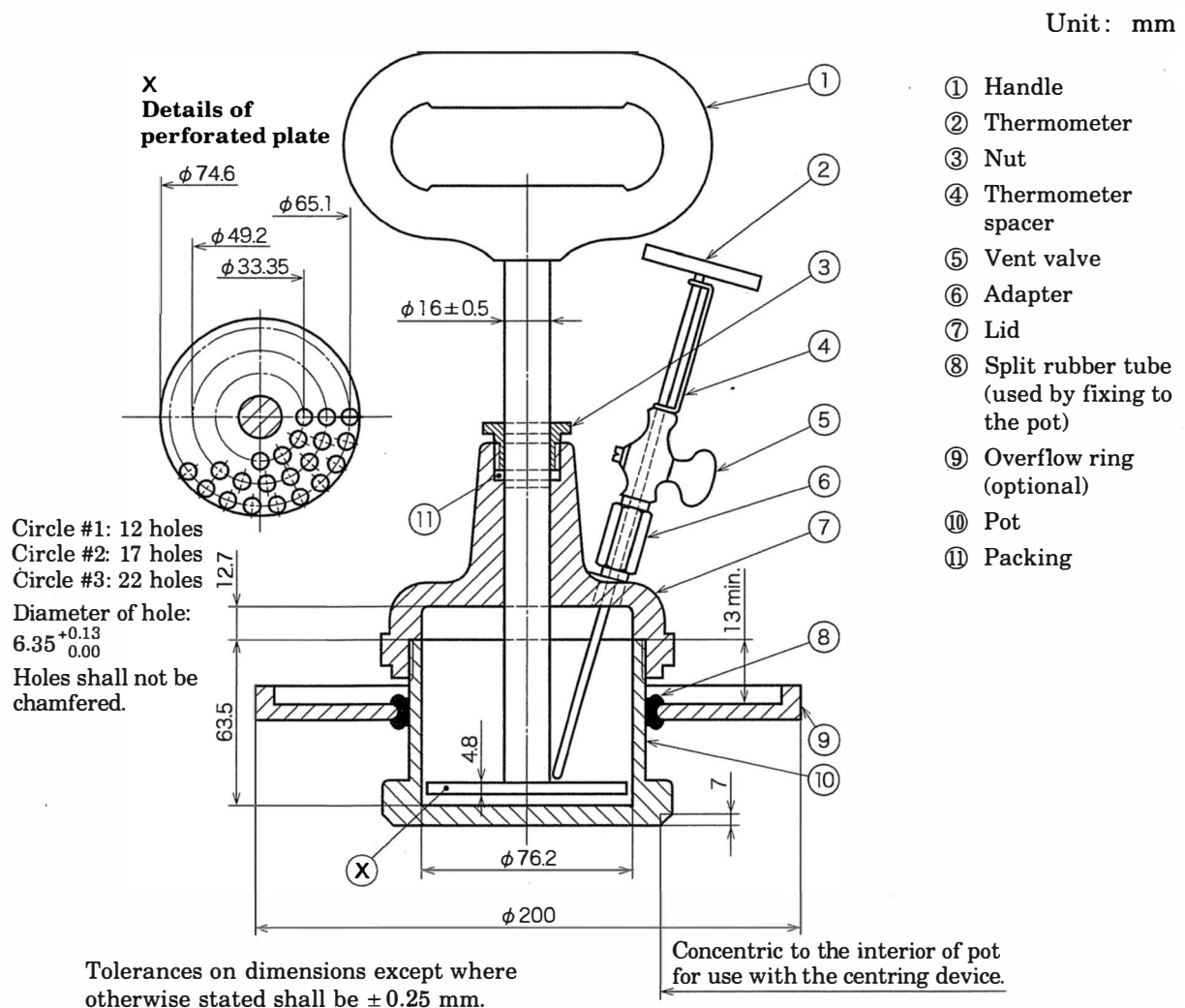
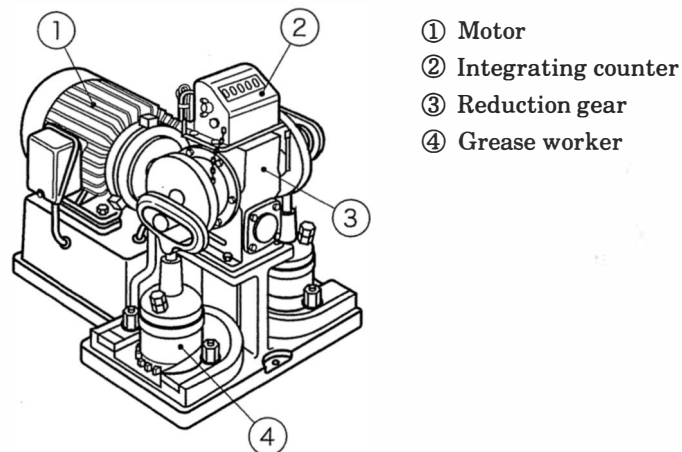


Figure 7 Example of grease worker and overflow ring

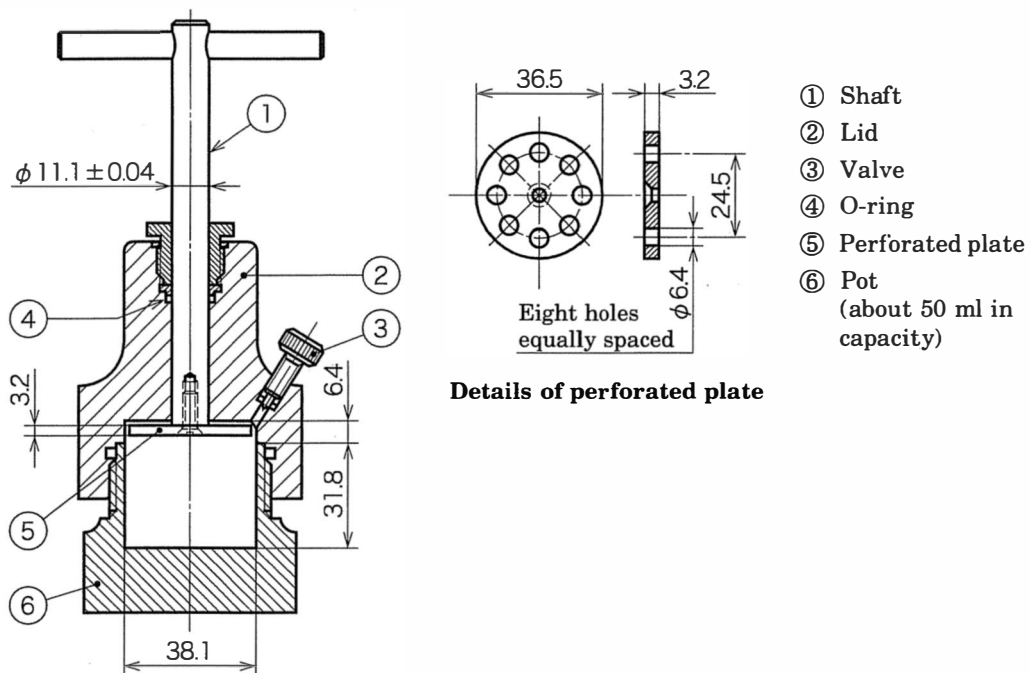


- ① Motor
- ② Integrating counter
- ③ Reduction gear
- ④ Grease worker

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



Details of perforated plate

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

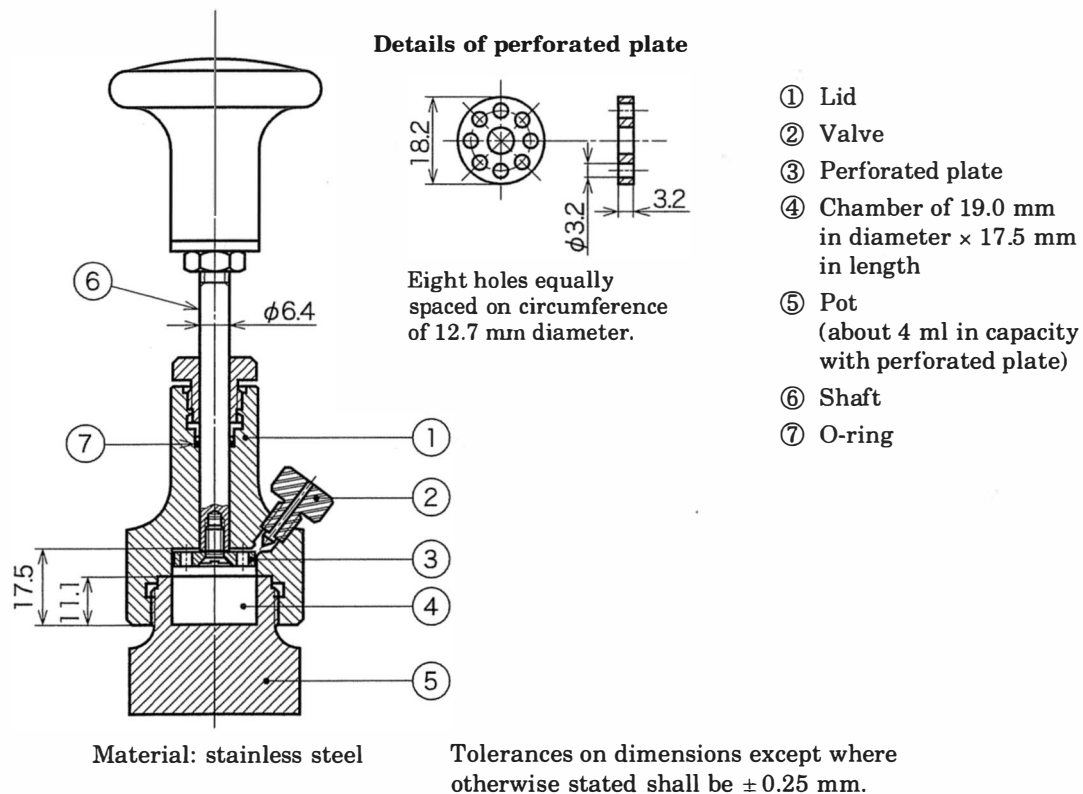


Figure 10 Example of one-quarter scale grease worker

Unit: mm

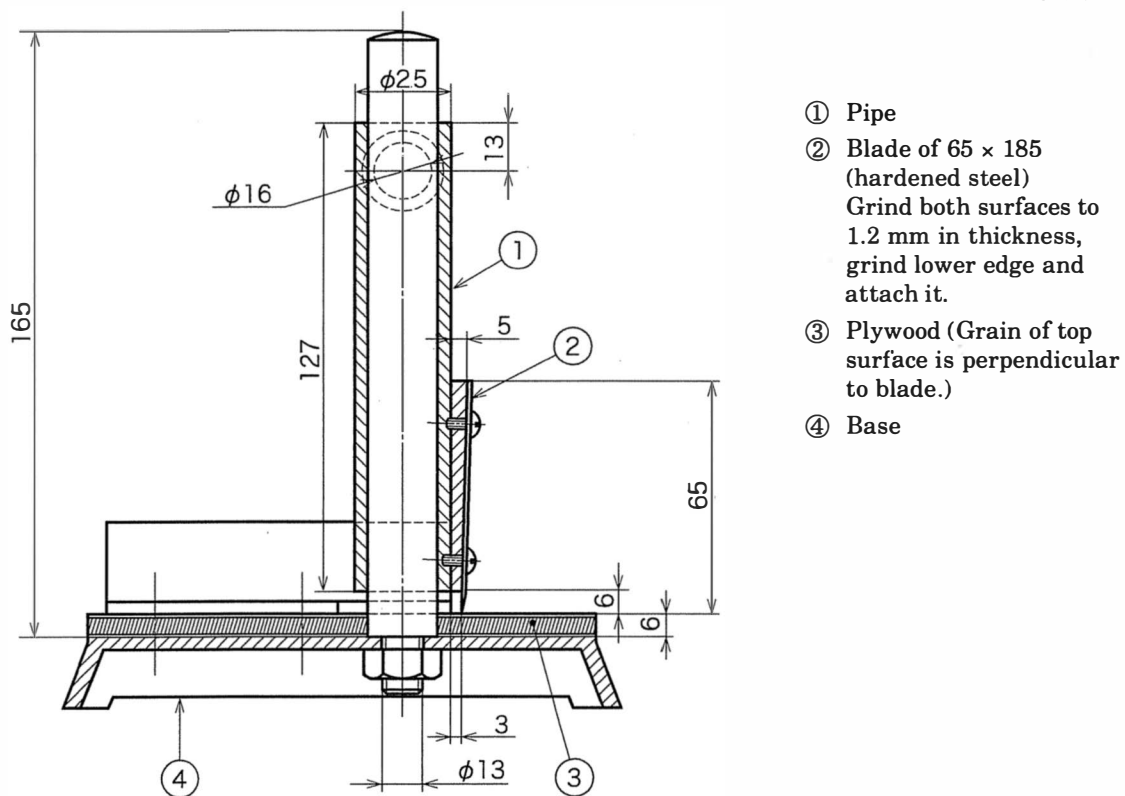


Figure 11 Example of grease cutter

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 $5 \text{ s} \pm 0.1 \text{ s}$, 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.

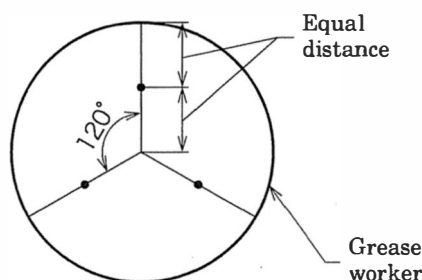


Figure 13 Example of measuring position of cone penetration (mark ●)

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 $25^\circ\text{C} \pm 0.5^\circ\text{C}$ 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 $25^\circ\text{C} \pm 0.5^\circ\text{C}$ 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.

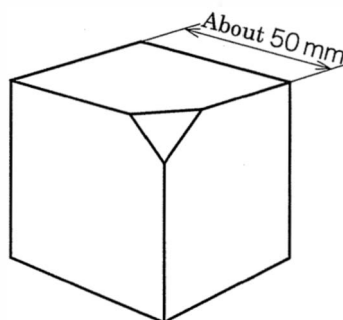


Figure 14 Example of sample for measurement of block penetration

- 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