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Cutting fluid

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Cutting fluid

1 Scope This Japanese Industrial Standard specifies cutting fluids to be used for cutting and grinding mainly of metals.

Remarks 1 The normative references to this Standard are listed in Attached Table 1.

2 The units in { } in this Standard are traditional units, and are appended for informative reference.

2 Definitions The definitions of the terms mainly used in this Standard are as follows:

- (1) **water-insoluble cutting fluids** Cutting fluids applicable without being diluted with water.
- (2) **water-soluble cutting fluids** Cutting fluids applicable after being diluted with water.
- (3) **fatty-oil content** Content percentage of animal and vegetable oil and ester contained in cutting fluids.
- (4) **extreme pressure agents** Additives added in base oil in order to keep from seizing resulted from local friction and to improve its cuttability when making cutting. Mainly, compounds of chlorine base or sulfur base are used.
- (5) **surfactant** A group of synthesized materials with such functions as emulsifying water-insoluble liquid, dispersing powder or solid in water, eliminating soils on the surface of fibers or metals or the like.
- (6) **chlorine content** Content percentage of chlorine contained in fluid.
- (7) **total sulfur content** Content percentage of all sulfur contained in the fluids, obtained by totaling that in base oil and additives.
- (8) **copper-plate corrosion** Immerse copper plate in sample, keep it for the specified condition, compare its discoloration with the reference plate for copper corrosion, and judge the corrosiveness of the sample.
- (9) **load carrying capacity** When the fluid is tested under the specified friction condition using a specified tester, the maximum load until which the fluid can withstand without occurring seizing on the surface contacting with sliding friction nor any other damage.
- (10) **emulsification stability** When water-soluble cutting fluid Class W1 is diluted with water, stability of emulsification under the specified condition.
- (11) **non-volatile matter** Percentage residue after removing such content as water, which can evaporate at lower than 100 °C, by means of holding the sample for the specified duration in the thermostat kept at the specified temperature.
- (12) **bubbling** Amount of bubbles (ml) appeared on fluid surface after agitating water-diluted water-soluble cutting fluid under the specified condition and standing for the specified time.

- (13) **metal corrosion** The existence of corrosion on metal after immersing various kinds of metals in water-diluted water-soluble cutting fluid and standing for the specified time.

3 Types Cutting fluids shall be classified into two types of water-insoluble and water-soluble cutting fluid.

The water-insoluble cutting fluid consisting of mineral oil and animal and vegetable oil, or mineral oil and ester shall be made Class 1, and above-mentioned fluid with addition of extreme pressure agent be made Class 2. Class 1 is subclassified into 6 types, that is No. 1 to No. 6 according to kinematic viscosity and fatty-oil content; and Class 2 is subclassified into 13 types, that is, from No. 1 to No. 6 and from No. 11 to No. 17 according to kinematic viscosity, fatty-oil content, chlorine content, and copper-plate corrosion.

The water-soluble cutting fluid (diluted solution becomes any of whitey turbid, semitransparent, or transparent depending on the mixing rate of mineral oil with surfactant) shall be classified into Class W1 when it gives white turbidity, and Class W2 when it becomes semitransparent or transparent; and subclassified into 3 types, respectively, that is, from No. 1 to No. 3 according to pH value, chlorine content, and metal corrosion.

4 Quality and performance Cutting fluids, giving no deterioration during storage, free from harmful ingredients, shall have effective performance for diminishing the abrasion of tools or grinding wheel and for improving finished accuracy, and shall conform to the requirements shown in Table 1 and Table 2 when being tested according to the testing methods in 5 and 6.

Table 1 Type and properties of water-insoluble cutting fluids

Type		Kinematic viscosity mm ² /s{cSt} (40 °C)	Fatty oil content mass%	Chlorine content mass%	Total sulfur content mass%	Copper-plate corrosion		Flash point °C	Pour point °C	Load carrying capacity MPa (kgf/cm ²)			
Class 1		Under 10	3 to 8 excl. 8 to 15 excl. 15 and over	—	—	—	1 max.	70 min.	-5 max.	0.10 {1.0} min.			
No. 1	No. 2	No. 3	100 °C 1 h					150 °C 1 h					
No. 4	No. 5	No. 6	130 min.										
10 and over													
No. 1	No. 2	No. 3						5 max.			2 max.	(1) 2 min.	70 min.
No. 4	No. 5	No. 6											
10 to 50 excl.													
No. 11	No. 12	No. 13		(1) 3 min.	—	70 min.							
No. 14	No. 15	No. 16	130 min.										
50 and over													
No. 17	—						150 min.	—					

Water-insoluble cutting fluids

Note (1) Applicable to cutting fluids added with sulfur series extreme pressure agents.

Table 2 Type and properties of water-soluble cutting fluids

Type	Surface tension	Emulsification stability ml (room temperature, 24 h)			Non-volatile matter	pH	Chlorine content	Total sulfur content	Bubbling test	Metal corrosion
		Water		Hard water						
		Oil layer	Cream layer	Oil layer						
Class W1	—	Trace	2.5 max.	2.5 max.	2.5 max.	8.5 to 10.5 excl.	—	5 max.	1 max.	No discoloration (steel plate)
					1 to 15 incl.					
		No. 3				8.0 to 10.5 excl.	—	No discoloration (aluminium plate and copper plate)		
Class W2	Under 40	—			30 min.	8.5 to 10.5 excl.	—			No discoloration (steel plate)
							1 to 15 incl.			
		No. 3				8.0 to 10.5 excl.	—	No discoloration (aluminium plate and copper plate)		

Remarks: Non-volatile matter, chlorine content, and total sulfur content are determined when they are in stock solution, and other properties are determined at 20 °C to 30 °C room temperature when they are in standard dilution 10 times by water in case of Class W1 and in 30 times dilution in case of Class W2.

The method for dilution shall be as specified in 6.2.

5 Testing method for water-insoluble cutting fluids

5.1 Matters in common The matters commonly applied to chemical analysis shall follow **JIS K 0050**, **JIS Z 8402**, and **JIS Z 8103**.

5.2 Sampling method In case of water-insoluble cutting fluids, take up the primary sample according to the method specified in **JIS K 2251**, and employ it as the secondary sample as it is.

5.3 Testing method of kinematic viscosity The testing method of kinematic viscosity shall follow **JIS K 2283**.

5.4 Testing method of fatty-oil content The testing method of fatty-oil content shall be as follows:

- (1) **Summary of testing method** Saponify the sample, and separate unsaponified part from saponified part. Decompose the saponified substance with acid, analyze quantitatively fatty-acid content, and convert it to the content of fatty oil.
- (2) **Reagents**
 - (a) **Diethyl ether** Specified in **JIS K 8103**.
 - (b) **1 mol/l alcoholic potassium hydroxide solution** Follow the preparation, standardization, and storing of the solution, specified in **JIS K 8001**.
 - (c) **Acetone** Specified in **JIS K 8034**.
 - (d) **Ethanol** Specified in **JIS K 8102**.
 - (e) **Petroleum ether** Specified in **JIS K 8593**.
 - (f) **Indicator of titration phenolphthalein solution and indicator of titration methyl orange solution** Follow the preparation method of indicator solution for titration, specified in **JIS K 8001**.
 - (g) **Hydrochloric acid** Follow 1 mol/l hydrochloric acid specified in **JIS K 8001**.
 - (h) **Sodium sulfate** Specified in **JIS K 8987**.
- (3) **Procedures of test** (refer to Table 3)
 - (a) Weigh about 10 g of sample into a first 300 ml flask to the nearest 0.1 g, add 50 ml of 1 mol/l alcoholic potassium hydroxide solution and a little amount of boiling stone, attach a reflux condenser, heat it on a water bath, and boil it for about one hour. During this operation, shake the flask gently at intervals.
 - (b) Transfer the contents, whose saponification has finished, into a first 500 ml separatory funnel, wash twice the first flask with about 40 ml of warm water, and pour these washings into the first separatory funnel, followed by cooling it to room temperature.
 - (c) After cooling, wash twice the first flask, which was used for saponification, with about 50 ml of petroleum ether. Pour this petroleum ether into the first separatory funnel while washing is being carried.

- (d) After the first separatory funnel was closely stoppered, shake violently it for about 1 min, and allow it to stand until it gets clear 2 layers.
- (e) After complete separation into 2 layers, transfer lower layer into a second 300 ml separatory funnel, add 50 ml of petroleum ether into it, and similarly to (d) shake and stand it still. When it separates to 2 layers, transfer lower layer into a third 300 ml separatory funnel, carry out similar testing procedures, and transfer the last lower layer into a first 500 ml distilling flask.
- (f) Put all petroleum ether solutions together, and transfer it into the first 500 ml separatory funnel. Wash the second and the third separatory funnels with a small amount of petroleum ether and water, place them into the first 500 ml separatory funnel, add 30 ml of water, shake it, allow it to stand, separate it to 2 layers, and add the lower layer into the first 500 ml distilling flask.
- (g) Add another 30 ml of water into the petroleum ether solution kept in the first separatory funnel, and shake them to wash it. Repeat this procedure until red color of the washings, which was caused by adding of indicator phenolphthalein solution, will disappear. These washings are added into the first 500 ml distilling flask.
- (h) Add indicator methyl orange solution into the first 500 ml distilling flask, and add hydrochloric acid until the solution gives red color. Place a little amount of boiling stone in it, attach a reflux condenser, and heat it on a water bath for about 1 h. Fatty acid will float on the upper layer due to acid decomposition.
- (i) After acid decomposition, transfer the contents into a fourth 500 ml separatory funnel. Wash twice the first 500 ml distilling flask with about 40 ml of warm water, transfer these warm washings into the fourth 500 ml separatory funnel, and allow it to cool down room temperature.
- (j) When the first 500 ml distilling flask gets room temperature, wash twice it with 50 ml of diethyl ether, and pour it into the fourth 500 ml separatory funnel.
- (k) Stopper closely the fourth 500 ml separatory funnel, shake it violently for about 1 min, and allow it to stand until it gives clear two layers.
- (l) After separating to 2 layers, transfer lower layer into a fifth 300 ml separatory funnel, add 50 ml of diethyl ether, and similarly to (k) shake and stand it still. After separating to 2 layers, transfer the lower layer into a sixth 300 ml separatory funnel, and carry out the similar testing procedures.
- (m) Put the diethyl ether solutions together, and place it into the fourth 500 ml separatory funnel. Wash twice the fifth and sixth separatory funnels with about 10 ml diethyl ether, and place them into the fourth 500 ml separatory funnel.
- (n) Add 30 ml of water into the diethyl ether solution, shake them to wash, and repeat this procedure until indicator methyl orange solution gives no red color.

- (o) Dehydrate the diethyl ether solution with adding about 20 g of sodium sulfate (anhydrous), filtrate it through dried filter paper and transfer it into the second 500 ml distilling flask. Wash three times the fourth separatory funnel and the filter paper with about 10 ml of diethyl ether, and transfer them into the second 500 ml distilling flask.
 - (p) Heat the diethyl ether solution on a water bath using a distilling apparatus, and concentrate it.
 - (q) When its volume becomes about 30 ml, allow it to cool, and transfer it into a 100 ml round-bottom flask whose mass has been known. Wash twice the second 500 ml distilling flask with about 10 ml of diethyl ether, and put it into the 100 ml round-bottom flask. Carry out distillation similarly to the distilling procedures in (p).
 - (r) Then, add 3 ml of acetone, and distill it. Place on a water bath, and remove remained solvent and water while applying slight vacuum, and keep it in a vacuum desiccator until it gets constant weight. When the mass discrepancy for 30 min interval becomes 0.1 % or less of the sample, regard the weight to be constant, and make it the residual quantity.
- (4) **Calculation and result** Calculate fatty-oil content, as oleic acid glyceride, according to the following formula to second decimal place, and round it off to one decimal place according to **JIS Z 8401**.

$$A = \frac{B}{m} \times 1.048 \times 100$$

where, *A* : content of fatty oil (mass%)

B : mass of residual obtained at (r) (g)

m : taken amount of sample (g)

1.048 : factor for conversion of fatty acid to fatty oil (oleic acid glyceride)

- (5) **Precision** Precision shall be as follows:

- (a) **Repeatability** The discrepancy between duplicate test results, which are carried out in the same laboratory by the same person using the same tester within successively considerably short period with the same sample, shall not be more than 5 % (relative) of the average in case of fatty oil with less than 10 % content, and 3 % (relative) of the average in case of fatty oil with 10 % or more content.
- (b) **Reproducibility** The discrepancy between two test results, which are respectively carried out in different laboratories by different persons using different testers with the same sample, shall not be more than 8 % (relative) of the average in case of fatty oil with less than 10 % content, and 5 % (relative) of the average in case of fatty oil with 10 % or more content.