SAE International™

INDUSTRIAL LUBRICANTS STANDARD

SAE MS1008

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Lubricants, Industrial Oils and Related Products Type M (Metal Removal Fluids)—Specification

Foreword—The Society of Automotive Engineers (SAE) Industrial Lubricants Committee has developed a number of industrial, non-production lubricant performance specifications.

The purpose of these voluntary SAE specifications is to:

a. Define minimum performance requirements for industrial lubricants.
b. Provide lubricant suppliers with performance targets for a minimum number of key industrial lubricants.
c. Improve the availability of these lubricants to member companies.
d. Provide a plant oriented, user friendly, classification system using common test standards and properties.

ISO Standard 6743 - Lubricants, industrial oils and related products (class L) - Classification is the foundation for these documents.

a. Performance characteristics and test procedures are specified.
b. For information, equivalent ISO, DIN, CEN, BSI, ASTM, AFNOR, CETOP, and IP test methods are referenced.[1]

1. International Standards Organization (ISO)
Deutsches Institut fur Normung e. V. (DIN)
European Committee for Standardization (CEN)
American Society for Testing and Materials (ASTM)
Association of Francaise de Normalisation (AFNOR)
The Institute of Petroleum (IP) NOTE: Now combined wtih BSI
British Standards Institution (BSI), BS 2000: XXX where XXX is the corresponding IP number
European Committee on Hydraulic Oil and Pneumatics (CETOP)

TO PLACE A DOCUMENT ORDER:
Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

Industrial lubricant classifications targeted:

a. Lubricants, Industrial Oils and Related Products - Classification (SAE MS1000)
b. Hydraulic fluids (SAE MS1004)
c. Fire resistant hydraulic fluids (SAE MS1005)
d. Lubricating oils (various applications – SAE MS1001, SAE MS1002, SAE MS1003 SAE MS1006, SAE MS1007, SAE MS1009, SAE MS 1010)
e. Lubricating greases (SAE MS1011)
f. Metal Removal Fluids (SAE MS1008)

See SAE MS1000 - Index of lubricants and symbols.

NOTE—Environmental, Technical Reports, and/or health and safety regulations may present additional specifications to the supplier.

EXAMPLE—Factory Mutual Research Corporation, Spray Flammability of Hydraulic Fluids and Development of a Test Method

1. ***Scope—***See Tables 1A and 1B.

1.1 **Rationale—**The revision of SAE MS1008 was necessary to reflect changes to test limits, changes to test methods and additional standards that have been incorporated since SAE MS1008 was originally released.

TABLE 1A—SCOPE, TYPICAL APPLICATIONS AND SYMBOLS; STRAIGHT OILS

Particular Application	More Specific Application	Product Type and/or End Use Requirements	Symbol	Cutting	Abrasion	Petroleum Oil[1] or Other[2]	Extreme Pressure Properties, Chemically Active[3]	Extreme Pressure Properties, Chemically Inactive[4]	Remarks
Metal removal by cutting, abrasion or electrical discharge	Operations primarily needing lubrication, e.g., milling, drilling, tapping, grinding, hobbing, honing	Fluid having anti-corrosion properties	MHA	•		Petroleum Oil			These fluids which are used undiluted may be inhibited against oxidation or may contain fillers for particular operations
		Fluid having anti-corrosion properties and with extreme pressure (E.P.) properties, chemically active	MHB	•	•	Petroleum Oil	•		
		Fluid having anti-corrosion properties and with extreme pressure (E.P.) properties, chemically non-active	MHC	•	•	Petroleum Oil		•	
		Fluid having anti-corrosion properties	MHD	•		Other			
		Fluid having anti-corrosion properties and with extreme pressure (E.P.) properties, chemically non-active	MHE	•	•	Other	•		
		Fluid having anti-corrosion properties and with extreme pressure (E.P.) properties, chemically active	MHF	•	•	Other		•	

1. Petroleum oils include Group I, II, III, and IV oils; Group IV oils are those such as polyalphaolefins
2. Oils other than petroleum would include non-petroleum derived, such as natural fats or vegetable oils
3. Corrosive to copper
4. Not corrosive to copper

TABLE 1B—SCOPE, TYPICAL APPLICATIONS AND SYMBOLS; AQUEOUS FLUIDS

Particular Application	More Specific Application	Product Type and/or End Use Requirements	Symbol	Cutting	Abrasion	Emulsion	Micro-Emulsion	Solution	Extreme Pressure Properties	Remarks (Typical Description)
Metal removal by cutting or abrasion	Operations primarily needing cooling	Concentrates typically containing >30% petroleum[1] or other[2] (vegetable, PAO, ester, etc.) oil, when blended with water, giving macro-emulsions	MAA	•	•	•				Soluble Oil
		Concentrates typically containing >30% petroleum or other (vegetable, PAO, ester, etc.) oil, when blended with water, giving macro-emulsions, plus extreme pressure (EP) additives	MAA-EP	•		•			•	Soluble Oil
		Concentrates containing <50% petroleum or other (vegetable, PAO, ester, etc.) oil, when blended with water, giving micro-emulsions	MAC	•	•		•			Semi-synthetic
		Concentrates containing <50% petroleum or other (vegetable, PAO, ester, etc.) oil, when blended with water, giving micro-emulsions, plus EP	MAC-EP	•			•		•	Semi-synthetic
		Concentrates containing no oil, when blended with water, giving true solutions	MAE	•	•			•		Synthetic
		Concentrates containing no oil, when blended with water, giving true solutions, plus EP	MAE-EP	•				•	•	Synthetic

1. Petroleum oils include API Group I, II and III oils.
2. Oils other than petroleum include API Group IV oils, such as polyalphaolefins, and non-petroleum oils, such as esters or vegetable oils.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE MS1000—Lubricants, Industrial Oils and Related Products—Classification
SAE MS1001—Lubricants, Industrial Oils and Related Products Type A Lubricant for General Purposes and Total Loss Systems—Specification
SAE MS1002—Lubricants, Industrial Oils and Related Products Type C Gears—Specification
SAE MS1003—Lubricants, Industrial Oils and Related Products Type D Compressor Oils—Specification
SAE MS1004—Lubricants, Industrial Oils and Related Products Type H (Hydraulic Fluids)—Specification
SAE MS1005—Lubricants, Industrial Oils and Related Products Type HF (Fire-Resistant Hydraulic Fluids)—Specification
SAE MS1006—Lubricants, Industrial Oils and Related Products Type F Lubricant for Spindle Bearings and Associated Clutches—Specification
SAE MS1007—Lubricants, Industrial Oils and Related Products Type G Slideway Lubricants—Specification
SAE MS1008—Lubricants, Industrial Oils and Related Products Type M Metal Removal Fluids—Specification
SAE MS1009—Lubricants, Industrial Oils and Related Products Type P Pneumatic Tools—Specification
SAE MS1010—Lubricants, Industrial Oils and Related Products Type T Turbine Oils—Specification
SAE MS1011—Lubricants, Industrial Oils and Related Products Type X (Greases)—Specification

2.1.2 AFNOR PUBLICATIONS—Referenced, AFNOR, ASTM, BS, CEN, DIN, IP, ISO, and VDMA Standard hardcopies are available from the ILI Website (http://www.ili-info.com) or by contacting ILI at:

Europe
ILI, Index House, Ascot, Berkshire, SL5 7EU, UK
Tel: +44 (0)1344 636400 Fax: +44 (0)1344 291194
Email: databases@ili.co.uk

USA
ILI, 610 Winters Avenue, Paramus, NJ 07652, USA
Tel: 201-986-1131 Fax: 201-986-7886
Email: sales@ili-info.com

AFNOR NFT60-187—Liquides D'usinage Aqueux—Aptitude A La Mise En Emulsion Ou En Solution Et Stabilite Au Repos (Test method for Emulsion Stability)

2.1.3 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D 92—Test Method for Flash and Fire Points by Cleveland Open Cup
ASTM D 94—Test Methods for Saponification Number of Petroleum Products
ASTM D 97—Test Methods for Pour Point Of Petroleum Products
ASTM D 128—Test Methods for Analysis of Lubricating Grease
ASTM D 129—Test Method for Sulfur in Petroleum Products (General Bomb Method)
ASTM D 130—Method for Detection of Copper Corrosion from Petroleum Products by Copper Strip Tarnish Test

ASTM D 445—Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
ASTM D 471—Test Method for Rubber Property—Effect of Liquids
ASTM D 664—Test Method for Neutralization Number of Petroleum Products by Potentiometric Titration
ASTM D 665A—Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water
ASTM D 808—Test Method for Chlorine in New and Used Petroleum Products (Bomb Method)
ASTM D 892—Test Method for Foaming Characteristics of Lubricating Oils
ASTM D 974—Test Method for Acid and Base Number by Color-Indicator Titration
ASTM D 1126—Test Method for Water Hardness
ASTM D 1298—Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
ASTM D 1401—Test Method for Water Separability of Petroleum Oils and Synthetic Fluids
ASTM D 1500—Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
ASTM D 1662—Test Method for Active Sulfur in Cutting Oils
ASTM D 1833—Test Method for Odor of Petroleum Wax
ASTM D 2068—Test Method for Filter Blocking Tendency of Distillate Fuel Oils
ASTM D 2070—Standard Test Method for Thermal Stability of Hydraulic oils
ASTM D 2270—Practice For Calculating Viscosity Index from Kinematic Viscosity at 40 °C and 100 °C
ASTM D 2422—Classification of Industrial Fluid Lubricants by Viscosity System
ASTM D 2622—Test Method for Sulfur in Petroleum Products by X-Ray Spectrometry
ASTM D 2711—Test Method for Demulsibility Characteristics of Lubricating Oils
ASTM D 2783—Method for Measurement of Extreme-Pressure Properties of Lubricating Fluids (Four-Ball Method)
ASTM D 2893—Test Method for Oxidation Characteristics of Extreme Pressure Lubrication Oils
ASTM D 2896—Test Method for Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration
ASTM D 3238—Method for Calculation of Carbon Distribution and Structural Group Analysis of Petroleum Oils by the N-D-M Method
ASTM D 3519—Test Method for Foam in Aqueous Media (Blender Test)
ASTM D 3946—Test Method for Evaluating the Bacteria Resistance of Water-Dilutable Metalworking Fluids
ASTM D 4052—Test Method for Density and Relative Density of Liquids by Digital Density Meter
ASTM D 4294—Test Method for Sulfur in Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectrometry
ASTM D 4627—Test Method for Iron Chip Corrosion Test for Water-Dilutable Metalworking Fluids
ASTM D 4927—Test Method for Elemental Analysis of Lubricant and Additive Components—Barium, Calcium, Phosphorus, Sulfur and Zinc by Wavelength-Dispersive X-Ray Fluorescence Spectroscopy
ASTM D 4951—Test Method for the Determination of Additive Elements in Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry
ASTM D 5185—Standard Test Method for Determination of Additive Elements, Wear Metals and Contaminants in Used Lubricating Oils and Determination of Selected Elements in Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)
ASTM D 5619—Test Method for Comparing Metal Removal Fluids Using the Tapping Torque Test Machine
ASTM E 70—Test Method for pH of Aqueous Solutions with the Glass Electrode
ASTM E 618—Standard Test Method for Evaluating Machining Performance of Ferrous Metals Using an Automatic Screw-Bar Machine
ASTM E 1131—Test Method for Compositional Analysis by Thermogravimetry
ASTM E 1687—Standard Test Method for Determining Carcinogenic Potential of Virgin Base Oils in Metalworking Fluids
ASTM F 1110—Test Method for Sandwich Corrosion Test (Corrosive Effect on Aluminum)

2.1.4 BS PUBLICATIONS—Available from ILI as referenced in 2.1.2.

BS 188—Determination of the Viscosity of Liquids
BS 903: PTA 35—Physical Testing of Rubber—Temperatures, Humidities and Times for Conditioning and Testing of Test Pieces
BS 4231—Classification for Viscosity Grades of Industrial Liquid Lubricants
BS 4385—Methods for Determination of Water in Crude Petroleum, Petroleum Products and Bituminous Materials by Distillation (Superseded by ISO 9029)
BS 4450—Determination of Ash from Petroleum Products (Superseded by ISO 6245)
BS 4459—Petroleum Products—Calculation of Viscosity Index from Kinematic Viscosity
BS 4832—Determination of the Behavior of Rubber and Elastomers when Exposed to Liquids, Vapors and Gases (Superseded by ISO 6072)

2.1.5 CETOP PUBLICATIONS—Hard copies of referenced Standards are not in the ILI database but may be special ordered by contacting ILI as referenced in 2.1.2 or by contacting the European Oil Hydraulic and Pneumatics Committee (Website: http://www.cetop.org) at:

British Fluid Power Association, Cheriton House, Cromwell Business Park, Banbury Road, Chipping Norton, GB-Oxfordshire OX7 5SR, Tel: +44 (1608) 647900, Fax: +44 (1608) 647919, E-Mail: enquiries@BFPA.co.uk, http://www.BFPA.co.uk.

CETOP RP110H—Hydraulic Fluids for Hydraulic Transmission—Fire Resistant Fluids—Group HFA—Specifications

2.1.6 DIN PUBLICATIONS—Available from ILI as referenced in 2.1.2.

DIN 38 405/9—German Standard Methods for the Examination of Water, Sewage and Sludge; Anions (Group D), Determination of Nitrate Ions (D9)
DIN 38 406/3—German Standard Methods for the Examination of Water, Sewage and Sludge; Cations (Group E), Determination of Calcium and Magnesium (E3)
DIN 38 409/7—German Standard Methods for the Examination of Water, Sewage and Sludge; Summary of Indices of Actions and Substances (Group H), Determination of Acid and Base Capacity (H7)
DIN 51 360/2—Testing of Cooling Lubricants; Determination of Corrosion Preventing Characteristics of Cooling Lubricants Mixed with Water; Chip/Filter Paper Method
DIN 51 369—Testing of Cooling Lubricants; Determination of the pH Value of Water-Mixed Cooling Lubricants
DIN 51 519—Lubricants; ISO Viscosity Classification for Industrial Liquid Lubricants
DIN 51 558/1—Testing of Mineral Oils; Determination of the Neutralization Number, Colour Indicator Titration
DIN 51 561—Testing of Mineral Oils, Liquid Fuels and Related Liquids; Measurement of Viscosity Using the Vogel-Ossag Viscometer; Temperature Range: Approximately 10 to 150-Deg C (CANCELLED)
DIN 51 562/1—Viscometry - Determination of Kinematic Viscosity Using the Ubbelohde Viscometer—Part 1: Apparatus and Measurement Procedure
DIN 51 566—Testing of Lubricants; Determination of Foaming Characteristics (CANCELLED)
DIN 51 569—Determination of Viscosity of Mineral Oils, Liquid Fuels and Related Liquids at Temperatures from –55 °C To Approximately 10 °C Using the Vogel-Ossag Viscometer
DIN 51 585—Testing of Lubricants; Testing of Corrosion Protection Properties of Steam Turbine Oils and Hydraulic Oils Containing Additives
DIN 51 757—Testing of Mineral Oils and Related Materials; Determination of Density
DIN 51 759/1—Testing of Liquid Mineral Oil Products; Method of Test for Copper Corrosion; Copper Strip Test (SUPERSEDED BY ISO 2160)
DIN 53 505—Testing of Rubber, Elastomers, and Plastics; Shore Hardness Testing A and D

DIN 53 521—Determination of the Behaviour of Rubber and Elastomers when Exposed to Fluids and Vapours
DIN 53 538/1—Standard Reference Elastomers; Acrylonitrile-Butadiene Rubber (NBR); Peroxide-Cured, for Characterizing Service Fluids with Respect to their Action on NBR

2.1.7 EPA PUBLICATIONS—Standard test methods of the U. S. Environmental Protection Agency. SW-846 Methods are available on-line (Website: http://www.epa.gov/epaoswer/hazwaste/test/8xxx.htm).

Method 24 available in the Code of Federal Regulations in 40 CFR, Part 60, Appendix A
EPA SW 846, Method 8082—Polychlorinated Biphenyls (PCB's) by Gas Chromatography
EPA SW 846, Method 9253—Chlorinated Hydrocarbons by Gas Chromatography: Capillary Column Technique
EPA SW 846, Method 8270C—Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry
EPA Method 351.3—Total Kjeldahl Nitrogen
EPA Method 405.1—Biochemical Oxygen Demand
EPA Method 410.1—Chemical Oxygen Demand

2.1.8 INSTITUTE FOR ADVANCED MANUFACTURING SERVICES PUBLICATION—Available from TechSolve, 6705 Steger, Cincinnati, OH 45237, Tel: 800-345-4482, www.techsolve.org.

Pollution Prevention Guide to Using Metal Removal Fluids in Machining Operations

2.1.9 IP PUBLICATIONS—Available from ILI as referenced above in 2.1.2.

IP 15—Petroleum Products—Determination of Pour Point
IP 36—Determination of Open Flash and Fire Point—Cleveland Method
IP 61—Determination of Sulfur - Bomb Method
IP 71 (Sect. 1)—Petroleum Products—Transparent and Opaque Liquids—Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity
IP 135—Determination of Rust-Preventing Characteristics of Steam Turbine Oil In the Presence of Water
IP 136 (Sect. 1)—Petroleum Products—Determination of Saponification Number—Colour-Indicator Titration Method
IP 139—Petroleum Products and Lubricants—Determination of Acid or Base Number—Colour-Indicator Titration Method
IP 146—Determination of Foaming Characteristics of Lubricating Oils
IP 154—Petroleum Products—Corrosiveness to Copper - Copper Strip Test
IP 160—Determination of Density—Hydrometer Method
IP 177—Test Method for Acid Number by Potentiometric Titration
IP 185—Determination of Odour of Petroleum Wax
IP 196—Petroleum Products—Determination of Colour (ASTM Scale)
IP 226—Petroleum Products—Calculation of Viscosity Index from Kinematic Viscosity
IP 276—Petroleum Products—Determination of Base Number—Perchloric Acid Potentiometric Titration Method
IP 278—Determination of Seal Compatibility Index of Petroleum Oils
IP 284—Determination of Saponifiable and Unsaponifiable Matter in Oils, Fats and Waxes

2.1.10 ISO PUBLICATIONS—Available from ILI as referenced above in 2.1.2.

ISO 1817—Rubber vulcanized—Determination of the effect of liquids
ISO 2049—Petroleum products—Determination of colour (ASTM Scale)
ISO 2160—Petroleum products—Corrosiveness to copper - Copper strip test
ISO 2592—Petroleum products—Determination of flash and fire points—Cleveland open cup method
ISO 2909—Petroleum products—Calculation of viscosity index from kinematic viscosity
ISO 3016—Petroleum products—Determination of pour point
ISO 3104—Petroleum products—Transparent and opaque liquids—Determination of kinematic viscosity and calculation of dynamic viscosity
ISO 3448—Industrial liquid lubricants—ISO viscosity classification
ISO 3675—Crude petroleum and liquid petroleum products—Laboratory determination of density or relative density—Hydrometer method
ISO 3685—Tool-life testing with single-point turning tools
ISO 3696—Water for analytical laboratory use—Specification and test methods
ISO 3771—Petroleum products—Determination of base number—perchloric acid potentiometric titration method
ISO 6072—Hydraulic fluid power—Compatibility between elastomeric materials and fluids
ISO 6247—Petroleum products—Lubricating oils—Determination of foaming characteristics
ISO 6293/1&2—Petroleum products—Determination of saponification number—Colour-indicator titration method petroleum products—Determination of saponification number—Potentiometric titration method
ISO 6618—Petroleum products and lubricants—Determination of acid or base number—Colour-indicator titration method
ISO 6743/0—Lubricants, industrial oils and related products (Class L)—Classification—General
ISO 7120—Petroleum products and lubricants—Petroleum oils and other fluids—Determination of rust—Preventing characteristics In the presence of water
ISO 7619—Rubber—Determination of indentation hardness by means of pocket hardness meters
ISO 8688—Tool life testing in milling
ISO/DTR 12927—Guidelines for establishing specifications

2.1.11 NCMS PUBLICATION—Available from National Center for Manufacturing Sciences, 3025 Boardwalk, Ann Arbor, MI 48108-3230, Tel: 800-222-6267, www.ncms.org.

NCMS Report 0274RE95—Metalworking Fluids Optimization Guide

2.1.12 ORGANIZATION RESOURCE COUNSELORS, INC. PUBLICATION—Available from Organization Resource Counselors, Inc 1910 Sunderland Place, N.W., Washington, D.C. 20036, Tel: 202-293-2980, ORCSTAFF@ORC-DC.com.

Management of the Metal Removal Fluid Environment—A Guide to the Safe and Efficient Use of Metal Removal Fluids

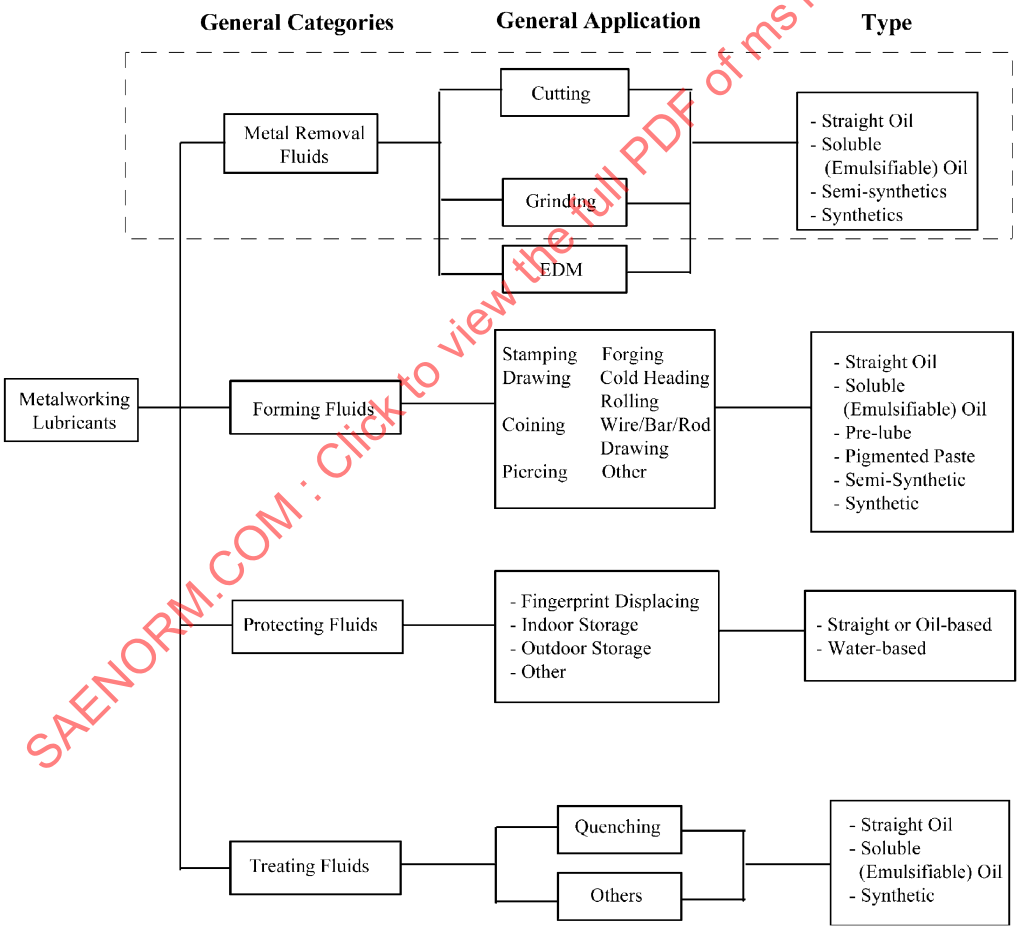
3. ***Concept***—The metalworking fluids defined by this specification are high quality products used for the purpose of metal removal (see Figure 1).

The “MH’ code indicates straight (non-aqueous) fluid types MHA, MHB, MHC, MHD, MHE, MHF. Types MHG and MHH are not addressed in this document.

The “MA” code indicates a concentrate to be mixed with water by the end user in the form of aqueous fluids MAA, MAC and MAE. Types MAB, MAD, MAF, MAG, MAH and MAI are not addressed in this document.

Aqueous fluid identification characteristics are related to the concentrate. In some cases, the presence of water or volatile products does not permit the use of the conventional method intended for the characterization of petroleum products. Among the methods likely to raise problems, the following may be mentioned for example: viscosity, flash point, pour point, demulsibility. Performance characteristics are evaluated on the fluid after dilution either in standardized water or in the end user water at precise strengths compatible with those required by the applications. The choice of the water to be used as agreed upon by the user and supplier. The standardized water represents a severe water condition and provides a common basis for comparison of results.

Metalworking fluids for forming, protecting, treating, and electric discharge machining (EDM) are not addressed in this document. This document is not meant to be all inclusive. There are a number of characteristics to be considered in the selection and use of metalworking fluids, as listed in Table 2. This document addresses those characteristics where test methods and operational parameters have been established. The document does not address maintenance issues. Not all key parameters relating to performance, compatibility, health and safety, and environment are addressed, as standard test methods may not be readily available.



NOTE: This document only addresses applications contained in the dotted box above. Other applications may be the subject of future specifications.

FIGURE 1—METALWORKING FLUIDS

TABLE 2—ATTRIBUTES INFLUENCED BY METAL REMOVAL FLUID CHARACTERISTICS

Fluid Types: Straight Oil (MHA-MHF), Soluble Oils (MAA), Semi-synthetic (MAC), Synthetic (MAE)

	Health/ Safety	Environmental	Compatibility Fluid System	Compatibility Machine	Compatibility Part/Tool	Performance	Maintenance
Physical Tests							
Viscosity / Viscosity Index			X	X		X	
Pour Point			X				
Flash Point	X	X					
Density / API Gravity			X				
VOC	X	X					X
Color			X				
Odor	X	X					
Residue	X	X	X	X	X		X
Emulsifiability/Stability	X		X	X	X	X	X
Chemical Tests							
Ester Content	X	X	X	X		X	
Acidity	X			X	X	X	X
Alkalinity	X			X	X		X
Chlorine	X	X		X	X	X	
Sulfur	X	X			X	X	
Phosphorus	X	X			X	X	
Mineral Oil, % and Type	X	X	X	X		X	
pH	X	X		X	X	X	X
Performance Tests							
Corrosion							
Copper				X	X	X	X
Steel				X	X	X	X
Lubrication							
EP-Four Ball						X	
Lubrication-Friction Reduction							
Four Ball Wear Test				X	X	X	
Filterability			X				X
Misting Tendency	X	X					X
Foam		X	X	X		X	X
Seal Compatibility			X	X			
Hardness Range		X	X	X		X	X

Original table courtesy Independent Lubricant Manufacturer's Association.

4. Requirements and Testing—See A1A through A1D.

Type M metal removal fluids shall be compatible with all materials (elastomer seals, coatings, metallic and non-metallic components, etc.) normally encountered in the recommended applications as defined by the user. Known incompatibility of the fluid with standard materials shall be brought to the attention of the user.

This document contains information from ISO/DTR 12927 - Guidelines for establishing specifications:

Appendix A - Definitions
Appendix B - Properties of standardized reagent water.
Appendix C - A method not yet standardized to evaluate some properties of metalworking fluids.

5. Notes

5.1 Marginal Indicia—The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE INDUSTRIAL LUBRICANTS COMMITTEE

APPENDIX A

DEFINITIONS

A.1 ***Fluid—***A liquid substance containing lubricants and other chemical additives of petroleum, animal, vegetable or synthetic origin. These fluids may be used as received or dispersed in water, as appropriate, for given metal removal operations.

A.2 ***Concentrate—***A blend of suitable emulsifying agents and additives, such as anti-rust, anti-microbial and others, with refined mineral oils in the case of aqueous emulsions, or suitable chemical products in the case of aqueous solutions, which are later diluted with water for use.

For particular applications, these concentrates may be applied undiluted.

A.3 ***Copper corrosive lubricant—***A fluid that is corrosive to copper and its alloys, as opposed to "chemically non-active lubricants" which are not.

A.4 ***Containing a filler—***Containing additives in a solid form, such as solid lubricants (graphite, molybdenum disulfide), metallic salts, metallic soaps, metallic oxides, etc., to enhance lubricating properties when contact pressures are high (hot operations in particular).

A.5 ***Metalworking Fluid (MWF)—***Any liquid product used for the purpose of metal removal, forming, or both. MWF's are typically classified by the general chemical composition as soluble oils, semi-synthetic oils, straight oils or synthetic fluids.

A.6 ***Metal Forming Fluid (MFF)—***Any fluid in the subclass of metalworking fluids used for the purpose of drawing, rolling stamping or other metal shaping process.

A.7 ***Metal Removal Fluid (MRF)—***Any fluid in the subclass of metalworking fluids used to either cut or otherwise remove material from a part or piece of metal stock. Metal removal processes include broaching, cutting, grinding, gun drilling, honing, machining, sawing, tapping and reaming.

A.8 ***Soluble Oil—***A metal removal fluid typically composed of a stable milky emulsion of water, oil (mineral, vegetable, PAO, etc.), emulsifiers and other additives. Commonly used where cooling is of primary importance.

A.9 ***Semi-synthetic—***A metal removal fluid typically composed of a translucent micro-emulsion of water, chemicals and a small percentage of oil (mineral, vegetable, PAO, etc.).

A.10 ***Straight Oil—***A metal removal fluid typically composed of mineral or vegetable oil or esters and functional additives. Commonly used where lubricity is of primary importance.

A.11 ***Synthetic Fluid—***A metal removal fluid that contains no oil and forms a true solution (no micelles) when mixed with water.

TABLE A1A—TYPE M METAL REMOVAL—STRAIGHT OILS

Property / Type of Product	Requirements or Report MHA Petroleum	Requirements or Report MHB Pet. + CAEP	Requirements or Report MHC Pet. + IEP	Requirements or Report MHD Non-Petroleum	Requirements or Report MHE N.P. + CAEP	Requirements or Report MHF N.P. + IEP	Testing as Specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards IP/BS*/Other
Base Oil Specifications:										
Paraffinic, Napththenic, Aromatic Content	Report	Report	Report	If these fluids contain any mineral oil components, fluids must meet base oil specifications for MHA, MHB and MHC					D 3238	
Total PNA, ppm	1000 max	1000 max	1000 max							EPA SW-846 TN 8270C[1]
Total PCB, ppm	Not Detectable at 1 ppm	Not Detectable at 1 ppm	Not Detectable at 1 ppm							EPA SW-846 TN 8082[1]
Total Organic Halogens, ppm	5 max	5 max	5 max							EPA SW-846[1] TN 9253
Modified Ames: Fold Increase / Mutagenicity Index / Mutag, Potency Index	Report / 1 max / Report	Report / 1 max / Report	Report / 1 max / Report						E 1687	
Metals	Report	Report	Report						D 4927 D 4951	
Corrosive effect on steel	Not exceeding degree of corrosion ISO 7120-0-A	Not exceeding degree of corrosion ISO 7120-0-A	Not exceeding degree of corrosion ISO 7120-0-A	Not exceeding degree of corrosion ISO 7120-0-A	Not exceeding degree of corrosion ISO 7120-0-A	Not exceeding degree of corrosion ISO 7120-0-A	7120	51 585	D 665; Proc. A	IP 135
Corrosive effect on copper, 3 hours at 100 °C	1B Max	Report	1B Max	1B Max	Report	1B Max	2160	51 759	D 130	IP 154
Four Ball EP Load Wear Index, Kg Weld Load, Kg	NA	45 Min 200 Min (This test is for EP Classification purposes and does not necessarily reflect machining performance)	45 Min 200 Min (This test is for EP Classification purposes and does not necessarily reflect machining performance)	NA	45 Min 200 Min (This test is for EP Classification purposes and does not necessarily reflect machining performance)	45 Min 200 Min (This test is for EP Classification purposes and does not necessarily reflect machining performance)			D 2783	
Behavior towards the SRE-NBR 1 sealant[2] (DIN 53 538), relative change in % volume, after 7 days	Report	Report	Report	Report	Report	Report	1817 6072	53 521	D 471	
Change in Shore A hardness * Or other seal material as agreed upon	–7 to +10	–7 to +10	–7 to +10	–7 to +10	–7 to +10	–7 to +10	1817 with 7619	53 521 with 53 505	D 471	IP 278, BS 4832
Pour Point, °C (relates to storage)	≤+5	≤+5	≤+5	≤+5	≤+5	≤+5	3016	DIN ISO 3016	D 97	IP 15
Flash Point, °C (A fluid with a viscosity between ISO grades must meet the flash point requirement of the lower viscosity grade.)	ISO VG 2 > 110 ISO VG 3-7 > 120 ISO VG 10 > 140 ISO VG 22 > 150 ISO VG 32-46 > 160 ISO VG 68 > 170 ISO VG 100 > 200	ISO VG 2 > 110 ISO VG 3-7 > 120 ISO VG 10 > 140 ISO VG 22 > 150 ISO VG 32-46 > 160 ISO VG 68 > 170 ISO VG 100 > 200	ISO VG 2 > 110 ISO VG 3-7 > 120 ISO VG 10 > 140 ISO VG 22 > 150 ISO VG 32-46 > 160 ISO VG 68 > 170 ISO VG 100 > 200	ISO VG 2 > 110 ISO VG 3-7 > 120 ISO VG 10 > 140 ISO VG 22 > 150 ISO VG 32-46 > 160 ISO VG 68 > 170 ISO VG 100 > 200	ISO VG 2 > 110 ISO VG 3-7 > 120 ISO VG 10 > 140 ISO VG 22 > 150 ISO VG 32-46 > 160 ISO VG 68 > 170 ISO VG 100 > 200	ISO VG 2 > 110 ISO VG 3-7 > 120 ISO VG 10 > 140 ISO VG 22 > 150 ISO VG 32-46 > 160 ISO VG 68 > 170 ISO VG 100 > 200	2592	DIN ISO 2592	D 92	IP 36
Foam volume, in ml. Seq. I	As agreed upon by user and supplier	As agreed upon by user and supplier	As agreed upon by user and supplier	As agreed upon by user and supplier	As agreed upon by user and supplier	As agreed upon by user and supplier	6247	51 566	D 892	IP 146
Misting Tendency	As agreed upon by user and supplier	As agreed upon by user and supplier	As agreed upon by user and supplier	As agreed upon by user and supplier	As agreed upon by user and supplier	As agreed upon by user and supplier				
Machining Properties	Tapping Torque Test, Microtap Test or as agreed upon by user and supplier	Tapping Torque Test, Microtap Test or as agreed upon by user and supplier	Tapping Torque Test, Microtap Test or as agreed upon by user and supplier	Tapping Torque Test, Microtap Test or as agreed upon by user and supplier	Tapping Torque Test, Microtap Test or as agreed upon by user and supplier	Tapping Torque Test, Microtap Test or as agreed upon by user and supplier	ISO 3685 ISO 8688		D 5619 E 618	ANSI/ASME B94.55M

TABLE A1A—TYPE M METAL REMOVAL—STRAIGHT OILS (CONTINUED)

Property Type of Product	Requirements or Report MHA Petroleum	Requirements or Report MHB Pet. + CAEP	Requirements or Report MHC Pet. + IEP	Requirements or Report MHD Non-Petroleum	Requirements or Report MHE N.P. + CAEP	Requirements or Report MHF N.P. + IEP	Testing as Specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards IP/BS*/Other
ISO viscosity classification	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls.	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls.	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls.	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls.	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls.	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls.	3448	51 519	D 2422	BS 4231
Kinematic viscosity in mm^2/s at 40 °C	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	3104	51 561, 51 562 part 1 or 51 569	D 445	IP 71:Sec. 1 BS 188
Viscosity Index	Report	Report	Report	Report	Report	Report	2909	DIN ISO 2909	D 2270	IP 226 BS 4459
Density	Report	Report	Report	Report	Report	Report	3675	51 757	D 4052 D 1298	IP 160
Saponification number	Report	Report	Report	Report	Report	Report	6293		D 94	IP 136: Sec. 1
% Volatile Organics, by TGA or oven method	Report	Report	Report	Report	Report	Report			E 1131	EPA 24
Chlorine, %	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)			D 808	
Total Sulfur, %	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)			D 129 D 4294 D 4951 D 5185	IP 61
Active Sulfur, %	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)			D 1662	
Phosphorus, %	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)			D 4927 D 4951 D 5185	
Total Acid Number and Base Number	Report	Report	Report	Report	Report	Report	6618	51 558 Part 1	D 664	IP 177 IP 139
Fatty Acid, % (by analysis or % added)	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)	Report(1)			by FTIR	IP 284
Esters, % (by analysis or % added)	Report (Includes fats, fatty acids, and esters)(1)	Report (Includes fats, fatty acids, and esters)(1)	Report (Includes fats, fatty acids, and esters)(1)	Report (Includes fats, fatty acids, and esters)(1)	Report (Includes fats, fatty acids, and esters)(1)	Report (Includes fats, fatty acids, and esters)(1)			by FTIR Method as agreed upon	IP 284
Color	Report	Report	Report	Report	Report	Report	2049		D 1500	IP 196
Odor – method modified as appropriate	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier			D 1833	IP 185
Oxidation stability (EP oils)									D 2893	
Viscosity increase at 100 °C Precipitation number Comparative IR scan	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier				
Thermal stability									D 2070 (except 75 ml oil in 100 ml beaker, 101 °C, 72 h)	Cincinnati Milacron Procedure B
Comparative IR Scan Acid Number Change Viscosity Change Sludge, mg/100 ml	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier				
Copper rod color (Cinn. Mil.) Copper weight loss, mg Steel rod color (Cinn. Mil.)	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier				
Demulsibility									D 2711	
Water in oil after 5 h Emulsion after centrifuge Total free water	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier				

TABLE A1A—TYPE M METAL REMOVAL—STRAIGHT OILS (CONTINUED)

Property Type of Product	Requirements or Report MHA Petroleum	Requirements or Report MHB Pet. + CAEP	Requirements or Report MHC Pet. + IEP	Requirements or Report MHD Non-Petroleum	Requirements or Report MHE N.P. + CAEP	Requirements or Report MHF N.P. + IEP	Testing as Specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards IP/BS*/Other
Filterability - paper size as agreed upon recirculate sample for 24 h	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier	As agreed upon between user and supplier			D 2068	
Waste Treatability	As agreed between supplier and user	As agreed between supplier and user	As agreed between supplier and user	As agreed between supplier and user	As agreed between supplier and user	As agreed between supplier and user				
Cleanability (for possible later operations)	As agreed upon between supplier and user	As agreed upon between supplier and user	As agreed upon between supplier and user	As agreed upon between supplier and user	As agreed upon between supplier and user	As agreed upon between supplier and user				
Corrosive Effect on Aluminum	1 Max	1 Max	1 Max	1 Max	1 Max	1 Max			Modified F1110[3]	

1. Equivalent methods may be used as agreed upon between user and supplier.
2. SRE-NBR 1 sealant must be used as specified in DIN 53 538, specified reference sealant is available from Bundesantalt fur, Berlin Materialforschung und-prufung (BAM) Unter den Eichen 87, D-12205 Berlin, Germany Telephone ++49 30 8104-0 or TEI. Many standard common elastomers (polyacrylate, nitrile, fluoroelastomer, NBR1 and LRCCP) are available from Test Engineering, Inc. in San Antonio (www.tei-net.com).
3. Run using Al 319, 356, 380, 383, 390.

TABLE A1B—TYPE M (METAL REMOVAL - AQUEOUS FLUIDS)
THESE TESTS TO BE RUN ON BASE OIL PORTION OF UNDILUTED CONCENTRATE

Property Type of Product	Requirements or Report MAA Soluble	Requirements or Report MAA-EP Soluble + EP	Requirements or Report MAC Semi Synth.	Requirements or Report MAC-EP Semi + EP	Requirements or Report MAE Synthetic	Requirements or Report MAE-EP Syn. + EP	Testing as Specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards IP/BS/Other
Base Oil Specifications: (not required for fluids containing no mineral oils)										
Paraffinic, Naphthenic, Aromatic Content	Report(1)	Report	Report	Report	NA	NA			D 3238	
Total PNA, ppm	1000 max	1000 max	1000 max	1000 max	NA	NA				EPA SW-846 TN 8270C(1)
Total PCB, ppm	Not detectable at 1 ppm	Not detectable at 1 ppm	Not detectable at 1 ppm	Not detectable at 1 ppm	NA	NA				EPA SW-846 TN 8082(1)
Total Organic Halogens, ppm	5 max	5 max	5 max	5 max	NA	NA				EPA SW-846 TN 9253(1)
Modified Ames					NA	NA			E 1687	
Fold Increase	Report	Report	Report	Report						
Mutagenicity Index	1 max	1 max	1 max	1 max						
Mutag. Potency Index	Report	Report	Report	Report						
Metals	Report	Report	Report	Report	Report	Report			D 4927 D 4951	

1. Equivalent methods may be used as agreed upon between user and supplier.

TABLE A1C—TYPE M (METAL REMOVAL - AQUEOUS FLUIDS), (CONTINUED)
THESE TESTS TO BE RUN ON THE UNDILUTED CONCENTRATE.

Property Type of Product	Require-ments or Report MAA Soluble	Require-ments or Report MAA-EP Soluble + EP	Require-ments or Report MAC Semi Synth.	Require-ments or Report MAC-EP Semi + EP	Require-ments or Report MAE Synthetic	Require-ments or Report MAE-EP Syn. + EP	Testing as Specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards IP/BS[1] Other
Four Ball EP Load Wear Index, Kg Weld Load, Kg (For EP classification purposes only)	NA	45 Min 200 Min	NA	45 Min 200 Min	NA	45 Min 200 Min			D 2783	
Emulsion Stability	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	NA	NA				AFNOR NF T 60-187
ISO viscosity classification	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls)	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls)	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls)	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls)	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls)	Report (For a fluid with a viscosity between ISO grades, state the grades between which it falls)	3448	51 519	D 2422	BS 4231
Kinematic viscosity in mm^2/s at 40 °C	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	3104	51 561, 51 562 Part 1 or 51 569	D 445	IP 71:Sec.1 BS 188
Pour Point, °C (relates to storage)	To be specified by the user	To be specified by the user	To be specified by the user	To be specified by the user	NA	NA	3016	Din Iso 3016	D 97	Ip 15
Flash Point, °C	Report	Report	Report	Report	Report	Report	2592	DIN ISO 2592	D 92	IP 36
Density, kg/m	Report	Report	Report	Report	Report	Report	3675	51 757	D 4052 D 1298	IP 160
Color	Report	Report	Report	Report	Report	Report	2049		D 1500[2]	IP 196
Mineral or Other Base Oil Content, % Mass	Report	Report	Report	Report	NA	NA				
Chlorine, %	Report	Report	Report	Report	Report	Report			D 808	
Total Sulfur, %	Report[3]	Report[3]	Report[3]	Report[3]	Report[3]	Report[3]			D 129 D 2622 D 4294 D 4951 D 5185	IP 61
Active Sulfur, %	Report[3]	Report[3]	Report[3]	Report[3]	Report[3]	Report[3]			D 1662	
Fatty Acid, % (Method as agreed upon)	Report[3]	Report[3]	Report[3]	Report[3]	Report[3]	Report[3]				IP 284
Esters, % (Method as agreed upon)	Report (Includes fats, fatty acids, and esters)[3]	Report (Includes fats, fatty acids, and esters)[3]	Report (Includes fats, fatty acids, and esters)[3]	Report (Includes fats, fatty acids, and esters)[3]	Report (Includes fats, fatty acids, and esters)[3]	Report (Includes fats, fatty acids, and esters)[3]				IP 284
Recommended hardness range of water	As agreed between user and supplier	As agreed between user and supplier	As agreed between user and supplier	As agreed between user and supplier	As agreed between user and supplier	As agreed between user and supplier			D 1126	
Base Number, mg/kg KOH	Report	Report	Report	Report	Report	Report	3771		D 2896	IP 276
Odor	As agreed upon	As agreed upon	As agreed upon	As agreed upon	As agreed upon	As agreed upon				

1. All IP XXX standards are now BS 2000 : Part XXX
2. If dyed, report color qualitatively.
3. Equivalent methods may be used as agreed upon between user and supplier. OK to report based on amount added.