Preface

In the contemporary landscape, standards have emerged as indispensable tools for facilitating trade, fostering economic growth, and serving as catalysts for achieving the ambitious Sustainable Development Goals set forth by the United Nations. In a globalized economy, where goods and services traverse international borders with increasing frequency, adherence to common standards ensures interoperability, reliability, and safety, thereby facilitating seamless transactions and enhancing consumer confidence.

Recognizing their paramount importance, especially in the realm of engineering education, it becomes imperative for students, particularly those from esteemed institutes of national importance, to delve deeper into the realm of standards. These students are the future architects of technological innovation and industrial progress, and their understanding of standards not only enriches their academic journey but also equips them with the requisite knowledge and skills to navigate the complexities of the modern industrial landscape. Standards can serve as stronger linkages between academia and the industry because they are formulated with industry needs in mind, incorporating relevant theories. Additionally, the stakeholders involved in formulating standards typically represent both academia and industry.

Acknowledging this need, the Bureau of Indian Standards (BIS), the national standards body of India, has taken proactive measures by forging Memorandums of Understanding (MoUs) with various institutes of national importance, including the prestigious Indian Institutes of Technology (IITs) and National Institutes of Technology (NITs). This collaboration has resulted in the establishment of chairs of standardization within these institutions, aimed at promoting research and development activities in standardization and integrating standards into the academic curriculum.

However, despite these efforts, the curriculum for undergraduate and postgraduate students in many of these institutions often lacks comprehensive coverage of Indian Standards, with notable exceptions in disciplines such as Civil Engineering, where students study IS codes for materials like cement, TMT bars, and the National Building Code. While international standards, particularly those from organizations like ASTM, find some mention in fields like metallurgy and materials science, a significant gap persists in exposing students to national standards across various engineering disciplines.

To address this gap and instill a deeper understanding of standards among students and educators in the Chemical/Petroleum Engineering discipline, this handbook is the first of its kind—an attempt to link standards with the curriculum for topics related to petroleum products in petroleum engineering/chemical engineering of eminent engineering institutes.This handbook has been meticulously structured to foster a stronger connection between standards and the petroleum products curricula. It commences by familiarizing readers with the processes, manufacturing techniques, and inherent characteristics of various petroleum products. Commencing with crude oil—the fundamental raw material—the handbook progresses through each refining stage, encompassing the evolution into diverse products like natural gas, naphtha, gasoline, diesel, and beyond. Throughout this educational journey, readers seamlessly encounter a diverse array of Indian Standards relevant to each product, ensuring a thorough understanding of their applications and significance. Additionally, a dedicated chapter explores various subjects and topics within Chemical/Petroleum Engineering curricula from esteemed institutions like IIT Kharagpur, IIT Bombay, and IIT ISM Dhanbad. Here, Indian Standards are identified and discussed for their potential utility in elucidating these subjects, thereby enriching the learning experience.

During the preparation of this book, only standards related to petroleum products and their testing methods have been explored. However, in the overall Chemical Engineering/Petroleum Engineering curricula, standards related to other technical departments such as Mechanical Engineering Department (MED) of BIS for products like shell and tube heat exchangers, valves, etc., can also be considered for learning purposes.

The primary objective of this handbook is to sow seeds of curiosity regarding available standards among students, empowering them to comprehend the intricacies of standard development processes. By fostering this awareness, it is hoped that students will not only be equipped to contribute meaningfully to the field of standardization but also extend their expertise to other domains, thereby advancing innovation and progress on a broader scale. Ultimately, by nurturing a generation of standards-savvy engineers, this handbook aims to catalyse positive change and drive sustainable development in the petroleum sectors, both in India and beyond.

First of all, I acknowledge the contributions of the dedicated members of the various technical committees of PCD (Petroleum, Coal and Related Products Department) of the Bureau of Indian Standards (BIS), whose tireless efforts and invaluable expertise have been instrumental in the formulation of different Indian Standards. Without these standards, this handbook would not have been possible.

Acknowledgement

Furthermore, I would like to express my appreciation to the authors and contributors of the numerous textbooks on petroleum engineering, whose comprehensive knowledge and insights have served as the foundation for my understanding of this complex field. Their scholarly works have been invaluable resources in shaping the content and scope of this handbook.

I would also like to extend my heartfelt gratitude to Shri Pramod Kumar Tiwari, IAS and Director General, BIS, who reignited my academic rigour and provided me the opportunity to utilize my academic experience in the petroleum sector and undertake the exercise of writing this handbook on a unique subject.

Special recognition is also due to my colleague Shri Ashutosh Shukla, Scientist C. His continued support in the search for latest developments on this specialised subject as also in enlisting all the related Indian Standards and establishing their relevance to theories has been indispensable throughout the development of this handbook.

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PETROLEUM PRODUCTS LIFE CYCLE

Petroleum, often referred to as 'black gold,' stands as one of the most significant discoveries in human civilization. Its history spans millennia, with its earliest extraction dating back to the 4th century AD in China. Utilizing rudimentary tools such as bamboo poles, the Chinese drilled wells to extract the dark, viscous substance primarily for fuel and medicinal purposes. Over time, oil was discovered across Asia and Europe, eventually leading to the birth of the modern oil industry in the mid-19th century.

The modern oil industry was catalyzed by Colonel Edwin Drake's groundbreaking discovery on August 27, 1859, near Titusville, Pennsylvania, USA. Drake's successful drilling yielded the first underground oil reservoir, marking the birth of the modern oil industry. This discovery paved the way for the mass production of petroleum products, with kerosene emerging as one of the earliest products followed by gasoline and diesel, catering to the rising demand propelled by the advent of automobiles.

The significance of petroleum products extends beyond fueling transportation; it permeates every aspect of modern life. From the food we eat to the clothes we wear and the electronics we use, petroleum products play an indispensable role. Indeed, without oil, the standard of living that we enjoy today would be unattainable. Petroleum products serve as raw materials for an array of goods, including plastics, medicines, cleaning products, and cosmetics, shaping the fabric of modern society.

Crude oil, the primary source of petroleum products, undergoes a refining process to yield marketable products. Crude oil refining involves the separation of crude oil into fractions, which are then treated to produce a diverse range of products such as gasoline, diesel fuel, lubricating oil, wax, and petrochemicals. The refining process has evolved over time, driven by the demand for hydrocarbon products, changes in crude oil quality, environmental regulations, and technological advancements. Today, the petroleum industry continues to evolve, with advancements in extraction techniques unlocking previously inaccessible sources such as tar sands, shale oil, and methane hydrates. These unconventional sources, coupled with increasing global demand, present both opportunities and challenges for sustainable resource management.

The need for standardization arose with the advent of large-scale petroleum product production by refineries. The primary objective was to enhance efficiency in exploration, drilling, and refining and ensure safety throughout these operations. Subsequently, product standardization became imperative due to factors like refined product quality, health considerations, and environmental concerns. For instance, in the 1960s, the addition of lead to gasoline was mandated to enhance automobile engine efficiency by reducing friction. However, due to health concerns, lead was later phased out from gasoline.

In the following chapters, we will discuss the manufacturing of various petroleum products from crude oil through the refining process and explore the standards formulated by the Bureau of Indian Standards (BIS) that are relevant to this topic.

CHAPTER II

NATURAL GAS AND CRUDE OIL

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2.1 Natural Gas

Natural gas is often found alongside crude oil either as a gas cap (associated natural gas) or independently in its own gas reservoir (unassociated natural gas). Nonetheless, crude oil is categorized as a non-renewable asset, incapable of replenishing naturally at the pace of consumption. Consequently, it stands as a finite resource, with an estimated lifespan currently around 50 years.

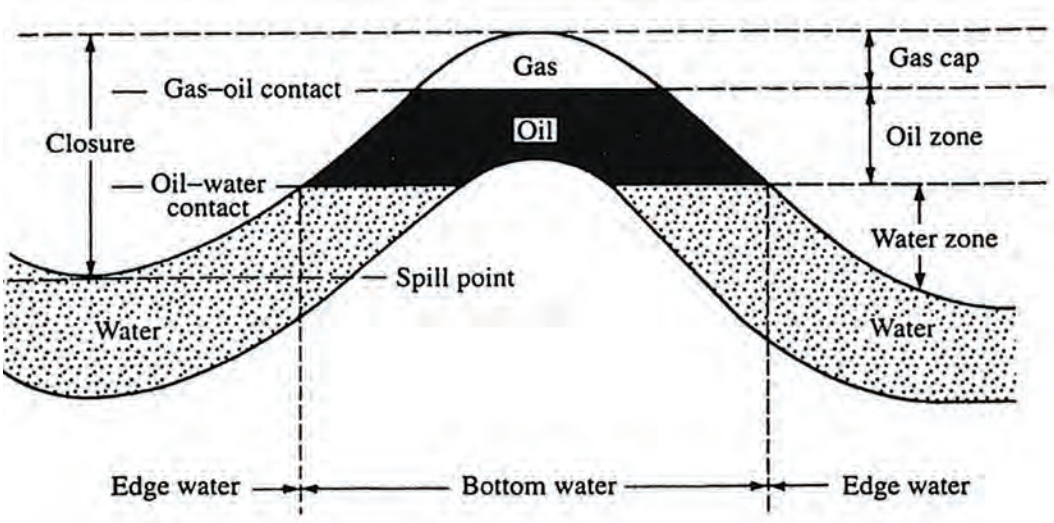

Figure 2.1: Schematic illustration of a syncline-anticline petroleum reservoir.

A gaseous fuel obtained from underground sources and consisting of a complex mixture of hydrocarbons, primarily methane, but generally also including ethane, propane and higher hydrocarbons in much smaller amounts. It generally also includes some inert gases, such as nitrogen and carbon dioxide, plus minor amounts of trace constituents. It is produced by processing raw gas or from liquefied natural gas and, if required, blended to give a gas suitable for direct use. The principal constituent of natural gas is methane (CH4). Other constituents are paraffinic hydrocarbon derivatives such as ethane (CH_3CH_3), propane ($CH_3CH_2CH_3$), and the butanes [$CH_3CH_2CH_2CH_3$and/or$(CH_3)_3CH$]. Many natural gases contain nitrogen (N_2) as well as carbon dioxide (CO_2) and hydrogen sulfide (H_2S). Trace quantities of argon, hydrogen, and helium may also be present. Generally, the hydrocarbon derivatives having a higher molecular weight than methane, carbon dioxide, and hydrogen sulfide are removed from natural gas prior to its use as a fuel. Gases produced in a refinery contain methane, ethane, ethylene, propylene, hydrogen, carbon monoxide, carbon dioxide, and nitrogen, with low concentrations of water vapor, oxygen, and other gases. Unless produced specifically as a product (e.g., liquefied petroleum gas), the gaseous products of refinery operations are mixtures of various gases. Each gas is a byproduct of a refining process. Thus, the compositions of natural, manufactured, and mixed gases can vary so widely, no single set of specifications could cover all situations.

BIS has formulated various standards for Natural Gas. Some of them are as follows:

1. IS 14504 : 2021 ISO 6976 : 2016 NATURAL GAS — CALCULATION OF CALORIFIC VALUES, DENSITY, RELATIVE DENSITY AND WOBBE INDICES FROM

   COMPOSITION: Both international and intra-national custody transfer of natural gas usually require precise determination of both the quantity and the quality of the gas to be traded. This standard specifies methods for the calculation of key properties that describe gas quality, namely gross and net calorific value, density, relative density, and gross and net Wobbe index. The methods provide the means of calculating these properties and their uncertainties for any natural gas, natural gas substitute or similar combustible gaseous fuel of known composition at commonly used reference conditions.

2. IS IS 15126 : 2002 ISO 13443 Natural gas - Standard reference conditions : specifies the standard reference conditions of temperature, pressure and humidity to be used for measurements and calculations carried out on natural gases, natural-gas substitutes and similar fluids. The primary application is expected to be in international custody transfer, where the reduction to a common basis of those physical attributes of a gas which describe both its quality and quantity will simplify the practice of world trade and commerce. The physical properties to which these standard reference conditions apply include volume, density, relative density, compression factor, superior calorific value, inferior calorific value and Wobbe index.

3. IS 15127 : 2002 ISO 13686 Natural gas - Quality designation: specifies the parameters required to describe finally processed and, where required, blended natural gas. The main text of this standard contains a list of these parameters, their units and references to measurement standards.

4. IS IS 15958: 2023 Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) for Automotive Purposes — Specification: The standards prescribes the requirements of Wobbe index, Water content, Hydrocarbons (Methane, Ethane, C_3 and Higher HC, C_6 and Higher HC, Total unsaturated HC), Corrosive components i.e. total sulphur, oxygen; Carbon dioxide and Nitrogen, Methane Number, Gas GVC, Hydrogen, Carbon monoxide, methane number and the methods of sampling and test for natural gas (NG) at the point of use for automotive purposes.

5. IS 15125:2002 NATURAL GAS — SAMPLING GUIDELINES: It provides guidelines for the collection, conditioning and handling of representative samples of processed natural gas streams in custody transfer measurement systems or allocation measurement systems. It considers spot, composite (incremental) and continuous sampling systems. It also explains the technical considerations for sampling such as Flow characteristics, Condensation and revapourisation, absorption and desorption etc.

6. IS 15128 : 2020 ISO 10723 : 2012: NATURAL GAS — PERFORMANCE EVALUATION FOR ANALYTICAL SYSTEMS: The standard outlines a method to assess if a natural gas analysis system is suitable for its intended use. It can be used in two ways: a) To identify the range of gas compositions the method can handle by using a specific calibration gas. This ensures that the analysis meets predefined criteria for maximum errors and uncertainties. b) To examine the potential errors and uncertainties in analyzing gases within a defined composition range

using a specified calibration gas. This helps gauge the accuracy of the analysis results. This Standard is applicable to analytical systems which measure individual component amount fractions. For an application such as calorific value determination, the method will be typically gas chromatography, set up, as a minimum, for the measurement of nitrogen, carbon dioxide, individual hydrocarbons from C_1 to C_5 and a composite measurement representing all higher hydrocarbons of carbon number 6 and above. This allows for the calculation of calorific value and similar properties with acceptable accuracy. In addition, components such as H_2S can be measured individually by specific measurement methods to which this evaluation approach can also be applied.

7. IS 15130 (Part 1) :2002 ISO 6974-1 :2000 NATURAL GAS — DETERMINATION OF COMPOSITION WITH DEFINED UNCERTAINTY BY GAS CHROMATOGRAPHY

   PART 1 GUIDELINES FOR TAILORED ANALYSIS: gives guidelines for the quantitative analysis of natural-gas-containing constituents (Hydrogen, Helium, Oxygen, Nitrogen, Carbon dioxide, Methane, Ethane, Propane, Butanes, Pentanes Hexanes and heavier constituents) within the application ranges as prescribed in the standard.

8. IS 15130 (Part 2) : 2021 ISO 6974-2 : 2012 NATURAL GAS — DETERMINATION OF COMPOSITION AND ASSOCIATED UNCERTAINTY BY GAS CHROMATOGRAPHY PART 2 UNCERTAINTY CALCULATIONS: describes the process required to determine the uncertainty associated with the mole fraction for each component from a natural gas analysis in accordance with IS 15130 (Part 1) :2002 ISO 6974-1 :2000

9. IS 18247 : 2023 ISO 23306 : 2020 Liquefied Natural Gas as a Fuel for Marine Applications — Specification:

   Due to numerous economic and environmental factors, the use of liquefied natural gas (LNG) as fuel for marine applications has increased. The 0.10 % sulfur limit, in the sulfur emission controlled areas in Europe and the US, which entered into force on 1 January 2015 has been one of the major driving forces for using LNG as fuel for marine applications. The decision for the 0.50 % global sulfur limit from 1 January 2020 by the International Maritime Organization (IMO) might further increase the interest in LNG. The International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) was a response to the need of guidance in this emerging market. Since LNG-fueled vessels are likely to bunker LNG in different parts of the world, a common specification is needed for ship owners, ship operators and LNG suppliers. It would help engine manufacturers and ship designers and it is beneficial for the development of this new alternative marine fuel market. In 2018, IMO adopted an initial strategy on reduction of greenhouse gas (GHG) emissions from ships. The strategy includes the objective to peak GHG emissions from international shipping as soon as possible, whilst pursuing efforts towards decarbonizing the sector as soon as possible in this century. It also includes the objectives to reduce the CO2 emissions per transport work and total annual GHG emissions from international shipping by 2050, with an interim target in 2030. Thus, LNG produced from renewable sources as biomethane that can reduce CO2 emissions when used as marine fuel is also addressed in this document.

The standards are crucial not only for assessing the quality of natural gas in terms of usage and performance but also for ensuring safety during transportation, storage, and end usage. For example, the Wobbe index, calculated as per IS 14504:2021, is a measure of the interchangeability of fuel gases and their energy output. This is an important factor for ensuring that burners and appliances can operate safely with different natural gas sources without needing modifications, thereby preventing incomplete combustion and associated risks. It also helps in maintaining consistent energy output from burners, avoiding fluctuations that can lead to unsafe operating conditions. Similarly, density determines the storage requirements, including the volume and pressure needed to store a specific amount of gas safely. It also affects the design of pipelines and containers, ensuring these can withstand the pressure and prevent leaks.

2.2 Crude Oil

Crude oil, by definition, is a naturally sourced, unprocessed fluid consisting primarily of hydrocarbon compounds alongside other organic elements containing heteroatoms like nitrogen, oxygen, sulfur, and metals such as iron, copper, nickel, and vanadium. It may exist in gaseous, liquid, or solid forms. Typically, refining crude oil yields various useful products including gasoline, diesel fuel, fuel oils, lubricants, wax, and diverse petrochemicals. The hydrocarbon compounds are ensnared by impermeable layers of underlying and overlying rock formations. IS 4639 (Part

1): 2000 ISO 1998-1:1998 PETROLEUM INDUSTRY —TERMINOLOGY PART 1 RAW MATERIALS AND PRODUCTS defines crude oil as “naturally occurring form of petroleum, mainly occurring in a porous underground formation such as sandstone.”

Crude oil is a naturally found blend of hydrocarbon derivatives, predominantly in liquid form, which may also contain compounds of sulfur, nitrogen, oxygen, metals, and assorted elements. Consequently, the conventional usage of the term “crude oil” includes all forms of gaseous, liquid, and solid hydrocarbon derivatives. Within the reservoir, the distribution of constituents in the gaseous, liquid, and solid phases depends upon subsurface temperature and pressure. However, upon reaching the surface (at the wellhead), under prevailing temperature and pressure conditions, lighter hydrocarbon derivatives (such as methane, ethane, propane, and butane) rise from the crude oil as gases, while pentane and higher boiling hydrocarbon derivatives remain in liquid form. Heavier molecular weight hydrocarbon derivatives can even solidify (such as wax derivatives) and persist as solids dissolved within the liquid phase. Present-day crude oils exhibit relatively higher viscosity due to elevated proportions of non-volatile (asphaltic) constituents compared to earlier refinery feedstocks.

Indeed, alterations in feedstock composition, such as the tendency toward heavier (higher boiling) materials (heavy oils), necessitate adaptations in refinery processes to handle these denser crude oils, mitigating coke formation during processing and ensuring a harmonious product spectrum. IS 4639 (Part 1) :2000 ISO 1998-1:1998 PETROLEUM INDUSTRY —TERMINOLOGY PART 1 RAW MATERIALS AND PRODUCTS defines different types of crude oil depending on their properties:

1. Paraffinic crude: crude oil consisting essentially of paraffinic hydrocarbons and aromatic and naphthenic ring compounds with paraffinic side chains. Such crude may contain a high proportion of solid, waxy material at ambient temperature.

2. Asphaltic crude: heavy crude oil containing a high proportion of asphaltenes, aromatics, and naphthenes, and which yields a residue suitable for the manufacture of bitumens.

3. Naphthenic base crude crude oil containing a substantial proportion of naphthenes (cycloparaffins) in some or all of the distillation fractions and residues.

4. aromatic crude crude oil with a higher content of aromatic hydrocarbons than is generally found.

5. mixed crude or intermediate crude crude oil whose atmospheric distillates contain a higher than normal proportion of aromatic compounds.

6. sour crude crude oil containing a significant amount of corrosive sulfur compounds.

7. non-corrosive crude or sweet crude crude oil having compounds such as mercaptans.

8. reduced crude product obtained after removal, by atmospheric distillation, of the light components of crude oil

9. topped crude long residue crude oil which has been freed of gases, gasoline, kerosine and gas oil.

10. synthetic crude liquid hydrocarbons suitable for use as feedstock to primary refinery processing units as a substitute for crude oil, which may include, or be totally composed of, liquids from non-petroleum origin.

2.2.1 Composition and Properties of Crude Oil

The petroleum products derived from crude oil are primarily comprised of alkane derivatives, cycloalkane derivatives, and an array of aromatic hydrocarbon derivatives. Additionally, other organic compounds present include nitrogen, oxygen, sulfur, and trace amounts of metallic derivatives like iron, copper, nickel, and vanadium. The exact molecular composition of crude oil varies widely from formation to formation, but the proportion of chemical elements tends to vary only over fairly narrow limits. Thus, the percentage of weight to weight ratio is given below:

- Carbon: 83%-85% w/w
- Hydrogen: 10%-14% w/w
- Nitrogen: 0.1%-2% w/w
- Oxygen: 0.05%-1.5% w/w
- Sulfur: 0.05%- 6% w/w
- Metals: 100 to 5000 ppm w/w

Thus, the term crude oil covers a wide assortment of materials consisting of mixtures of hydrocarbon derivatives and other compounds containing variable amounts of sulfur, nitrogen, and oxygen, which may vary widely in properties. Metal-containing constituents, notably those compounds that contain vanadium and nickel, usually occur in the more viscous crude oils in amounts up to several thousand parts per million and can have serious consequences during the processing of these feedstock. Because

crude oil is a mixture of widely varying constituents and proportions, its physical properties also vary widely and the color varies from near colorless to black.

2.2.2 Properties of Crude Oil & Indian Standards to determine the same

The properties of crude oil play a pivotal role in determining various aspects of its production, refining, transportation, and waste disposal. Crude oil varies widely in its composition, including its density, viscosity, sulfur content, and presence of impurities such as heavy metals and organic compounds. These properties influence the choice of refining methods employed to process crude oil into valuable products like gasoline, diesel, jet fuel, and various petrochemicals. For instance, crude oils with higher sulfur content require more extensive refining processes, such as hydrodesulfurization, to meet environmental regulations and produce cleaner fuels. Additionally, the density and viscosity of crude oil affect the efficiency of transportation methods, with lighter, less viscous oils being easier and cheaper to transport via pipelines compared to heavier, more viscous oils, which may require specialized tankers or dilution with lighter oils. Moreover, understanding the properties of crude oil is crucial for managing the waste generated during its production and refining processes. Waste streams from oil extraction and refining can contain hazardous materials such as heavy metals, organic compounds, and sulfur compounds, which must be handled and disposed of properly to mitigate environmental risks. Overall, a comprehensive understanding of crude oil properties is essential for optimizing refining processes, maximizing yield, ensuring safe transportation, and effectively managing waste disposal in the oil industry.

Salt Content

Salt present in crude oil recovered from reservoir have an adverse effect in downstream processes[1]due to corrosion and catalyst deactivation. Pre-treatment operations are applied to the crude oil prior to transportation. Any crude oil to be shipped by pipeline, or by any other form of transportation, must meet strict regulations in regard to salt content. Thus, it is essential to measure the salt content in the crude oil. BIS has formulated IS 1448 (Part 115) : 2023 Petroleum and Its Products — Methods of Test Part 115 Determination of Salt Content in Crude Oil. This standard prescribes three test methods for determination of salt content in crude oil: conductometric method, extraction method and ion chromatography method.

Method A covers the determination of the chloride (salts) concentration in crude oil. The range of concentration covered is 3.5 mg/kg to 500 mg/kg as chloride concentration/ volume of crude oil. This method measures conductivity in the crude due to the presence of common chlorides, such as sodium, calcium, and magnesium. Other conductive materials present in the crude oil may also contribute to the conductivity. Test method B is intended for the determination of total halide concentration of 0.002 percent to 0.02 percent, weight in crude petroleum, topped crude, residual cracking stock, and fuel oil. It may also be applied to the estimation of seawater contamination of used turbine oil and marine diesel fuel. Test method C for salt content in crude oil using extraction by hot water with mechanical stirring and detection by ION chromatography technique. The method covers the concentration of salt measurement starting from 0.1 PTB (pounds per thousand barrel) and above.

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[1] The Downstream sector is the part of the oil industry involved with purifying crude oil and refining it into different products. It also involves the transportation and marketing of crude oil and its products. While Upstream activities include exploratory work, such as the search for underground (or underwater) oil and gas reservoirs, and the initial drilling, followed by the production phase, which is the actual extraction of oil from the ground.

Sodium, Nickel and Vanadium Content

When fuels are combusted, metals present in the fuels can form low-melting compounds that are corrosive to metal parts. Metals present at trace levels in petroleum can deactivate catalysts during processing. For determination of these, BIS has formulated IS 1448 (Part 145): 2022 Methods of Test for Petroleum and its Products Part 145 Determination of Sodium, Nickel, and Vanadium in Fuel Oils and Crude Oils by Atomic Absorption Spectroscopy. Two methods are prescribed in the standard.

Method A: This method is intended for the determination of sodium and nickel at levels above

1 mg/kg and vanadium at levels above 10 mg/kg in crude oils and residual fuel oils by Atomic Absorption Spectrometry (AAS).

Method B: Difficulty may be experienced in sodium determination with some samples due to the particulate nature of the sodium compounds present in them. It is recommended that an ashing technique should be used for such samples.

Density

Density of the crude oil determines the selection of refining process and the yield after the refining. Less dense (lighter) crude oils generally have more light hydrocarbons. Refineries can produce high-value products such as gasoline, diesel fuel, and jet fuel from light crude oil with simple distillation. When refineries use simple distillation on denser (heavier) crude oils they produce low-value products. Heavy crude oils require additional, more expensive processing to produce high-value products. BIS has formulated two standards for determining the density of crude oil:

IS 1448 [P : 16] : 2014 ISO 3675 : 1998 Methods of Test for Petroleum and Its Products [P : 16] Crude Petroleum and Liquid Petroleum Products — Laboratory Determination of Density — Hydrometer Method for determination of density of crude oil: The Standard specifies a method for the laboratory determination, using a glass hydrometer, of the density at 15 °C of crude petroleum, liquid petroleum products, and mixtures of petroleum and nonpetroleum products normally handled as liquids and having a Reid vapour pressure (RVP) of 100 kPa or less. This Standard is suitable for determining the density of mobile transparent liquids. It can also be used for viscous liquids by carrying out the determinations at temperatures above ambient using a suitable liquid bath for temperature control. It can also be used for opaque liquids by reading the hydrometer scale where the top of the meniscus meets the stem of the hydrometer and applying a correction from a table given in the standard.

IS 1448 [P : 32] : 2019 ISO 3838 : 2004 Methods of Test for Petroleum and its Products [P :32] Crude Petroleum and Liquid or Solid Petroleum Products — Determination of Density or Relative Density — Capillary Stoppered Pyknometer and Graduated Bicapillary Pyknometer Methods: The capillary-stoppered pyknometer method is not suitable for the determination of the density or relative density of highly volatile liquids having Reid vapour pressures greater than 50 kPa according to ISO 3007 or having an initial boiling point below 40 °C. The graduated bicapillary pyknometer method is recommended for the accurate determination of the density or relative density of all except the more viscous products, and is particularly useful when only small amounts of samples are available. The method is restricted to liquids having Reid vapour pressures of 130 kPa

or less according to ISO 3007 and having kinematic viscosities less than 50 mm2/s [50 centistokes (cSt)] at the test temperature.

Asphaltenes (Heptane Insolubles) Content

Crude oil is usually characterized into SARA (Saturates, Aromatics, Resins, and Asphaltenes) fractions. Among the SARA fractions, asphaltene is regarded as the heaviest and most polar component of crude oil. The presence of asphaltene causes a marked increase in crude oil viscosity, making it difficult to transport and process. Because of their high resistance to cracking, asphaltene molecules are usually held responsible for decreasing the yield of petroleum distillates. Also, owing to the presence of heavy metal components, asphaltenes are very difficult to biodegrade, making them the most undesired compound from a petroleum waste management perspective. BIS has formulated

IS 1448 [P : 22] : 2019 Methods of Test for Petroleum and its Products [P : 22] Determination of Asphaltenes (Heptane Insolubles) in Crude Petroleum and Petroleum Products. A test sample is mixed with heptane and is heated under reflux. The precipitated asphaltenes, waxy substances and inorganic material are gathered on a filter paper. The waxy substances are expelled in an extractor by washing with hot heptane. After removal of the waxy substances, the asphaltenes are isolated from the inorganic material by dissolution in hot toluene. The extraction solvent is evaporated, and the asphaltenes are weighed. The precision is applicable to values between 0.5 and 30.0 percent m/m. The values outside this range may still be valid, but may not give the same precision values. Presence of additives in the oils may lead to imprecise results.

Water and Sediment contents

The water and sediment content of crude oil is significant because it can cause corrosion of equipment and problems in processing. A determination of water and sediment content is required to accurately measure net volumes of actual oil in sales, taxation, exchanges, and custody transfers. BIS has formulated following standards for the same:

IS 1448 [P : 30] : 2013 ISO 3735 : 1999 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 30] CRUDE PETROLEUM AND FUEL OILS — DETERMINATION OF SEDIMENT — EXTRACTION METHOD: The standard specifies a method for the determination of sediment in crude petroleum and fuel oils by extraction with toluene. The precision applies to a range of sediment levels from 0.01 % (m/m) to 0.40 % (m/m), although higher levels may be determined. The principle behind this method is that a test portion in a refractory thimble is extracted with hot toluene until the residue reaches constant mass.

IS 1448 [P : 41] : 2019 ISO 9030 : 1990 Methods of Test for Petroleum and its Products [P : 41] Crude Petroleum — Determination of Water and Sediment — Centrifuge Method: This standard determines sand and water content of crude oil by means of centrifugal procedure. The precision data have only been determined for water content upto 1% (V/v). Equal volumes of Crude oil and water saturated toluene are placed in a cone-shaped centrifuge tube. After configuration, the volume of higher density water and sediment layer at the bottom of tube is read.

IS 1448 [P : 135] : 2013 ISO 9029 : 1990 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 135] CRUDE PETROLEUM — DETERMINATION OF WATER —

DISTILLATION METHOD: This Standard specifies a method for determining water in crude oil by distillation. The precision data have only been determined for water contents up to I % (V/v). A test portion is heated under reflux conditions with a water-immiscible solvent which co-distills with the water in the sample. Condensed solvent and water are continuously separated in a trap. The water settles in the graduated section of the trap, and the solvent returns to the distillation flask.

2.2.3 Crude oil refining

IS 4639 (Part 4) :2000 ISO 1998-4:1998 PETROLEUM 1NDUSTRY —TERMINOLOGY

PART 4 REFINING defines refining as processes such as distillation, cracking, etc. where crude oil and other hydrocarbon feedstocks are converted into marketable commodities. Therefore, Crude oil refining is the separation of recovered crude oil into fractions and the subsequent treating of these fractions to yield marketable products (Table 2.1). In fact, refining is the means by which hydrocarbon derivatives including petroleum products are separated or produced from crude oil. A refinery is essentially a group of manufacturing plants which vary in number with the variety of products produced. As the basic elements of crude oil, hydrogen and carbon form the main input into a refinery, combining into thousands of individual constituents and the economic recovery of these constituents varies with the individual crude oil according to its particular individual qualities, and the processing facilities of a particular refinery. In general, crude oil, once refined, yields three basic groupings of products that are produced when it is broken down into cuts or fractions .The complexity of crude oil is emphasized insofar as the actual proportions of low-boiling, medium-boiling, and high-boiling fractions vary significantly from one crude oil to another.

Naphtha, a precursor to gasoline and solvents, is extracted from both the low-boiling and middle range of distillate cuts and is also used as a feedstock for the petrochemical industry. The middle distillates refer to hydrocarbon products from the middle boiling range of crude oil and include kerosene, diesel fuel, distillate fuel oil, and low-boiling gas oil. Waxy distillate and lower boiling lubricating oils are sometimes included in the middle distillates. The remainder of the crude oil includes the higher boiling lubricating oil fractions, gas oil, and residuum (the non-volatile fraction of the crude oil). The residuum can also produce high-boiling lubricating oils and waxes but is more often used for asphalt production.

Refinery process for crude oil are generally divided into three categories: (i) separation processes, of which distillation is the prime example, (ii) conversion processes, of which coking and catalytic cracking are prime examples, and (iii) finishing processes, of which hydrotreating to remove sulfur is a prime example. The simplest refinery configuration is the topping refinery, which is designed to prepare feedstocks for petrochemical manufacture or for production of industrial fuels in remote oil-production areas. The topping refinery consists of tankage, a distillation unit, recovery facilities for gases and low- boiling hydrocarbon derivatives, and the necessary utility systems (steam, power, and water-treatment plants). Topping refineries produce large quantities of unfinished oils and are highly dependent on local markets, but the addition of hydrotreating and reforming units to this basic configuration results in a more flexible hydroskimming refinery, which can also produce desulfurized distillate fuels and high-octane petrol. These refineries may produce up to half of their output as residual fuel oil, and they face

increasing market loss as the demand for low-sulfur (even no-sulfur) and high-sulfur fuel oil increases. The most versatile refinery configuration today is known as the conversion refinery, which incorporates all the basic units found in both the topping and hydroskimming refineries, but it also features gas oil conversion plants such as catalytic cracking and hydrocracking units, olefin conversion plants such as alkylation or polymerization units, and, frequently, coking units for sharply reducing or eliminating the production of residual fuels. Modern conversion refineries may produce two-thirds of their output as unleaded gasoline, with the balance distributed between liquefied crude oil gas, jet fuel, diesel fuel, and a small quantity of coke. Many such refineries also incorporate solvent extraction processes for manufacturing lubricants and petrochemical units with which to recover propylene, benzene, toluene, and xylenes for further processing into polymers. Finally, the yields and quality of refined crude oil products produced

Fraction	**Boiling Range**	
	^{O}C	^{O}F
Low Boiling Naphtha	-1-150	30-300
Gasoline	-1-180	30-355
Heavy Naphtha	150-205	300-400
Kerosene	205-260	400-500
Low-boiling Gas Oil	260-315	400-600
Heavy Gas Oil	315-425	600-800
Lubricating Oil	>400	>750
Vacuum Gas Oil	425-600	800-1100
Residuum	>510	>950

Table 2.1: Fraction obtained from crude petroleum by distillation

by the configuration of refineries may vary from refinery to refinery. Some refineries may be more oriented toward the production of gasoline (large reforming and/ or catalytic cracking) whereas the configuration of other refineries may be more oriented toward the production of middle distillates such as jet fuel and gas oil. The gas and gasoline fractions form the lower boiling products and are usually more valuable than the higher boiling fractions and provide hydro- carbon gas (liquefied petroleum gas, LPG) and hydrocarbon fractions such as naphtha, kerosene, aviation fuel, fuel oil, and feedstocks for the petrochemical industry.

Crude oil products i.e. Petroleum Products (in contrast to petrochemicals) are those hydrocarbon fractions that are derived from crude oil and have commercial value as a bulk product (Table 3.1). A major group of hydrocarbon products from crude oil (petrochemicals) are the basis of a major industry. The gross fractions of crude oil (such as gasoline, naphtha, kerosene, and gas oil), which are usually obtained by distillation and/or refining, are classed as crude oil products (petroleum products); asphalt and other solid products (e.g. wax) are also included in this division. This type of classification separates this group of products from those obtained as crude oil chemicals (petrochemicals), for which the emphasis is on the separation and purification of single chemical compounds, which are, in fact, starting materials for a host of other chemical products.

CHAPTER III

PETROLEUM PRODUCTS FROM REGINING AND THEIR STANDARDS

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3.1 Gaseous products

The principal types of gaseous hydrocarbon derivatives are crude oil (distillation) gas, reformed natural gas, and reformed propane or liquefied petroleum gas (LPG). Thus, the gaseous hydrocarbons that are produced from crude oil comprise mixtures that are predominantly natural gas and liquefied petroleum gas. The constituents of each type of gas may be similar but the variations of the amounts

Product	**Lower Carbon Number**	**Upper Carbon Number**	**lower b.p. (°C)**	**upper b.p. (°C)**
Liquefied Petroleum Gas	C3	C4	-42	-1
Naphtha	C5	C17	36	302
Kerosene	C8	C18	126	258
Low-boiling gasoil	C12	>C20	216	421
High-boiling gasoil	>C20		>345	
Residuum	>C20		>345	

Table 3.1: Various distillation fractions of crude oil

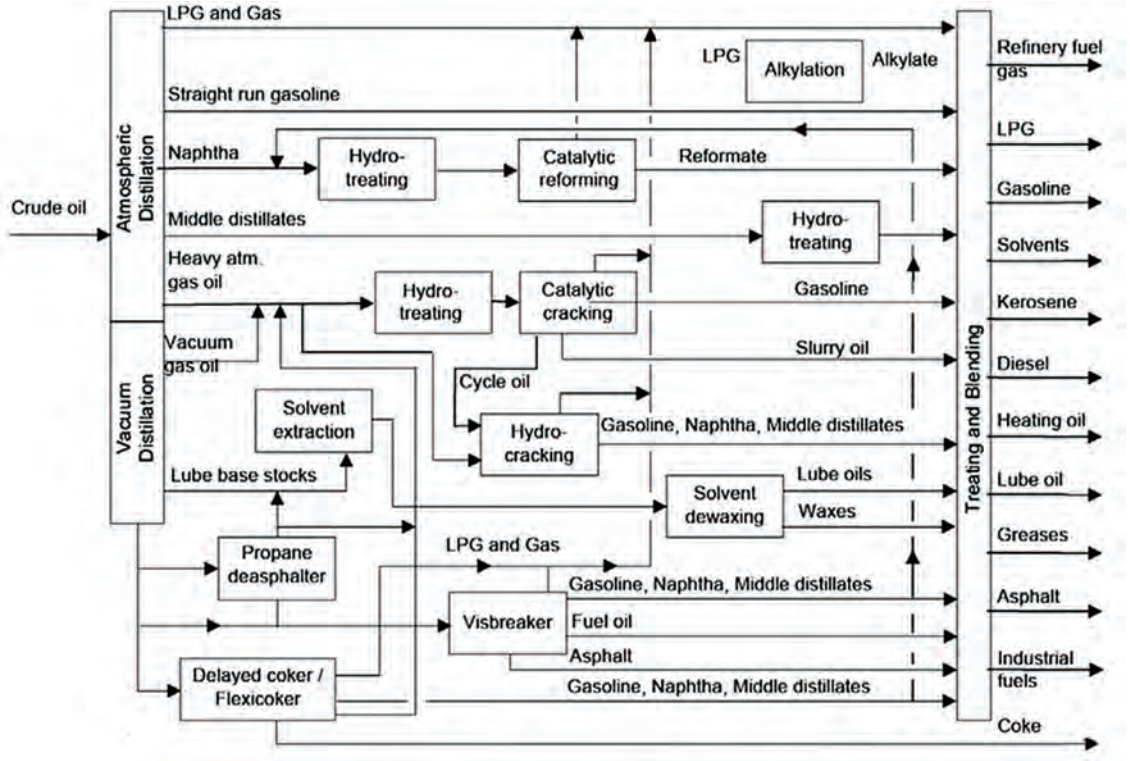


Figure 3.1: Schematic presentation of a modern refinery illustrating the various hydrocarbon product streams from fuel gas to grease.

of these constituents can cover wide ranges. Each type of gas may be analyzed by similar methods although the presence of high boiling hydrocarbons and nonhydrocarbon species such as carbon dioxide and hydrogen sulfide may require slight modifications to the analytical test methods.

3.1.1 LPG

Liquefied petroleum gas (LPG) is the term applied to certain specific hydrocarbons and their mixtures, which exist in the gaseous state under atmospheric ambient conditions but can be converted to the liquid state under conditions of moderate pressure at ambient temperature. Typically, fuel gas with four or less carbon atoms in the hydrogen-carbon combination have boiling points that are lower than room temperature and these fuels are gases at ambient temperature and pressure. Liquefied petroleum gas is a hydrocarbon mixture containing propane ($CH_3CH_2CH_3$, boiling point: -42°C/-44°F), butane ($CH_3CH_2CH_2CH_3$, boiling point: 0°C/32°F), and iso-butane ($CH_3CH(CH_3)CH_3$, boiling point: -11.7°C/10.9°F). The most common commercial fuel consists of propane and butane. In addition, liquefied petroleum gas is usually available in different grades (usually specified as: Commercial Propane, Commercial Butane, Commercial Propane-Butane

(P-B) Mixtures, and Special Duty Propane). During the use of liquefied petroleum gas, the gas must vaporize completely and burn satisfactorily in the appliance without causing any corrosion or producing any deposits in the system. BIS has formulated following standards related to LPG :

1. IS 1448 [P: 1511:2004 ISO 7941 :1988 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P: 151] COMMERCIAL PROPANE AND BUTANE — ANALYSIS BY GAS CHROMATOGRAPHY: It specifies a gas chromatographic method for the quantitative determination of hydrocarbons in liquefied petroleum gas (LPG), excluding components whose concentrations are below 0,1 % [m/m). It is applicable to the analysis of propane, butane and their commercial mixtures, which may include saturated and unsaturated C_2,$C_3$$C_4andC_5$ hydrocarbons. It does not apply to “on-line” chromatography. It is based on the following principle: Physical separation by gas chromatography. Identification of the components by passing a standard reference mixture or pure hydrocarbons through the column, or by comparison with relative retention volumes of typical chromatograms. Calculation of concentrations of components by measuring peak areas and applying correction factors.

2. IS 1448 (Part 74) : 2022 ISO 13758 : 1996 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS PART 74 LIQUEFIED PETROLEUM GASES — ASSESSMENT OF THE DRYNESS OF PROPANE — VALVE FREEZE METHOD: It describes a procedure for the assessment of whether liquefied petroleum gas (LPG) hydrocarbons consisting predominantly of propane and/or propene are sufficiently dry to avoid malfunctions in pressure-reducing systems installed in domestic, industrial and automotive LPG applications. The test is normally used as a functional pass/fail test in which the behaviour of the product is assessed in a specially designed and calibrated regulator valve. It is based on the following principle : A liquid-phase aliquot of the sample to be tested is allowed to flow

through the wide-open test valve under its own vapour pressure, in order to cool the valve body by vaporization After cooling, the test valve is partially closed to a small pre-set orifice and the time required for the valve to freeze, and thus interrupt the normal flow, is recorded. The average time measured for a number of successive observations is recorded as the valve freeze time.

3. IS 14861:2000 LIQUEFIED PERTOLEUM GASES (LPG) FOR AUTOMOTIVE

PURPOSES – SPECIFICATION: With the increased stress on reduction of pollution caused by vehicle emissions due to increased population of automobiles, liquefied petroleum gases (LPG) is being used as an alternate fuel abroad. The need is also being felt in India to use LPF as an alternate fuel. This standard stipulates the requirements for a mixture of propane (C_3)andbutane(C_4) for automotive use. It has laid down the requirements Vapour pressure at 4O°C, C_5 Hydrocarbons and heavier, Dienes (as 1:3 Butadiene). Total volatile sulphur (After stenching), Copper strip corrosion at 4O °C for 1 hour. Hydrogen sulphide Evaporation residue, Free water content Motor octane number (MON) and Odour. It has also mentioned the relevant standards related to the test methods of determining these requirements. The presence of water in liquefied petroleum gas (or in natural gas) is undesirable since it can produce hydrates that will cause, for example, line blockage due to the formation of hydrates under conditions where the water dew point is attained. If the amount of water is above acceptable levels, the addition of a small methanol will counteract any such effect.

4. IS 1448 [P :71] :2004 ISO 4256:1996 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P: 71] LIQUEFIED PETROLEUM GASES — DETERMINATION OF GAUGE VAPOUR PRESSURE — LPG METHOD: This standard describes a method for the determination of gauge vapour pressures of liquefied petroleum gas products at temperatures within the approximate range of 35 °C to 70 °C. Information on the vapour pressure of liquefied petroleum gases is required for the selection of properly designed storage vessels, shipping containers and customer utilization equipment, to ensure the safe handling of these products, and to ensure that maximum operating design pressures are not exceeded under the foreseen ambient operating conditions. The vapour pressure of liquefied petroleum gases is an indirect measure of the lowest temperature at which initial the vaporisation can be expected to occur. It may also be considered to be an indirect indication of the most volatile constituent present in the product. The test apparatus, equipped with a pressure gauge, is purged and then filled completely with an aliquot of the test sample. A given volume of the liquid content of the apparatus is withdrawn, and the apparatus immersed in a water bath maintained at the test temperature. The observed gauge pressure at equilibrium, corrected for gauge error and ambient barometric pressure, is recorded.

5. IS : 1448 [P : 111] - 1983 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P:lll] ANALYSIS OF LIQUEFIED PETROLEUM GASES (LPG) AND PROPYLENE CONCENTRATES BY GAS CHROMATOGRAPHY: This method covers the determination of the composition of liquefied petroleum gases (LPG). It is applicable to analysis of propane, propylene and butane in all concentration ranges 0.1 percent and above. The component distribution of liquefied petroleum gases and propylene concentrates is often required as a specification analysis

for end-use sale of this material. Its wide use as chemical feedstocks or as fuel, require precise compositional data to ensure uniform quality of the desired reaction products. The component distribution data of liquefied petroleum gases and propylene concentrates can be used to calculate physical properties such as specific gravity, vapour pressure, average molecular weight, calorific (heating) value, combustion requirements, and products of combustion. Precision and accuracy of compositional data are extremely important when these data are used to calculate various properties of these

petroleum products. Components in a sample of LP gas are physically separated by gas chromatography and compared to corresponding components separated under identical operating conditions from a reference standard mixture of known composition or from use of pure hydrocarbons. The chromatogram of the sample is interpreted by comparing peak heights or areas with those obtained on the reference standard mixture of pure hydrocarbons.

Water has a detrimental effect on the various uses of liquefied petroleum gas (LPG), causing operational problems in customer equipment and downstream processes. It causes corrosion and creates safety hazards during the storage, distribution, and use of LPG and pressurized low molecular weight hydrocarbons and their mixtures. Therefore, the standard IS 1448 (Part 74): 2022 ISO 13758:

1996 ensures safety by determining the water content in LPG.

3.1.2 Ethane

Ethane is present as a constituent of natural gas and it is also produced in refineries through cracking processes. Ethane is mainly used to produce ethylene, which is then used by the petrochemical industry to produce a variety of intermediate products, most of which are converted into polymers like polyethylene, mono ethylene glycol (MEG), etc. Ethane is highly flammable and safety issues are relevant. Ethane should be kept away from heat, hot surfaces, sparks, open flames and other ignition sources. It may also displace oxygen and cause suffocation. BIS has formulated following standard related to ethane:

1. IS 18465 : 2023 ETHANE FOR USE AS FEEDSTOCK FOR PETROCHEMICAL —SPECIFICATION: This standard prescribes the requirements inter-alia Composition, total sulphur content, Dew point, Hydrogen Sulphide etc.and the methods of sampling and test for ethane used in petrochemical industries.

3.2 Liquid Products

During the refining of crude oil, a diverse range of liquid petroleum products is extracted, each serving critical roles in various industries and everyday life. Among these essential products are naphtha, gasoline, diesel fuel, and kerosene. Naphtha, a light liquid hydrocarbon, finds application as a feedstock for petrochemical processes, including the production of plastics and chemicals. Gasoline, a highly volatile liquid mixture of hydrocarbons, powers the majority of vehicles worldwide, providing essential mobility for both personal and commercial transportation. Diesel fuel, with its higher energy density compared to gasoline, drives heavy-duty vehicles, trucks, and machinery, serving as the backbone of logistics and industrial operations. Kerosene, prized for its relatively

low cost and clean-burning properties, fuels heating systems, lamps, and stoves in homes and businesses around the globe.

3.2.1 Naphtha

Naphtha (petroleum naphtha) is a generic term applied to refined, partly refined, or unrefined crude oil fuels and liquid fuels of natural gas which distill below 240°C (465°F) and is the volatile fraction of the crude oil, which is used as a solvent or as a precursor to gasoline and is produced by a variety of processes. In fact, not less than 10% v/v of material should distil below 75°C (167°F); not less than 95% v/v of the material should distil below 240°C (465°F) under standard distillation conditions, although there are different grades of naphtha within this extensive boiling range that have different boiling ranges. Naphtha (often referred to as naft in the older literature) is actually a generic term applied to refined, partly refined, or unrefined crude oil products. In the strictest sense of the term, not less than 10% of the material should distill below 175C (345F); not less than 95% of the material should distill below 240°C (465°F) under standardized distillation conditions.

Naphtha has been available since the early days of the crude oil industry. Indeed, the infamous Greek fire documented as being used in warfare during the last three millennia is a crude oil derivative. It was produced either by distillation of crude oil isolated from a surface seepage or (more likely) by destructive distillation of the bituminous material obtained from bitumen seepages (of which there are/were many known during the heyday of the civilizations of the Fertile Crescent. The bitumen obtained from the area of Hit (Tuttul) in Iraq (Mesopotamia) is an example of such an occurrence. Other crude oil products boiling within the naphtha boiling range include (i) industrial spirit and white spirit. Industrial spirit comprises liquids distilling between 30C and 200°C (1°F - 390°F), with a temperature difference between 5% volume and 90% volume distillation points, including losses, of not more than 60°C (140°F). There are several (up to eight) grades of industrial spirit, depending on the position of the cut in the distillation range defined above. On the other hand, white spirit is an industrial spirit with a flash point above 30°C (99°F) and has a distillation range from 135°C to 200°C (275°F-390°F).

Petroleum naphtha, generally known as naphtha, is a light distillate petroleum fraction derived out of various processes in the refinery or a light liquid fraction recovered in the production of crude oil and natural gas. The refinery sources of naphtha are crude distillation unit, fluid catalytic cracking (FCC) unit, coker, hydrotreaters, hydrocrackers, naphtha splitters etc. Crude oil or gas wells and oil refineries are the main sources of naphtha. It is used by refineries in blending of petroleum products, isomerization, reforming, feed for hydrogen plants and in the production of value added products. Petrochemical crackers use naphtha as a feedstock; for producing ethylene and propylene which are polymerized to produce polymers such as polyethylene (HDPE, LDPE, LLDPE and PET), polypropylene, PVC etc. The heavier fractions of naphtha are used in production of benzene, toluene, xylene and hexane. Naphtha is also used as a source of hydrogen in producing ammonia and urea in fertilizer manufacturing plants and as fuel in power plants. This usage of naphtha as fuel is diminishing and is being replaced with natural gas, due to its low cost and lesser emissions. Naphtha is available in market in three grades, such as light naphtha, heavy naphtha and full range naphtha.BIS has formulated following standard related to Naphtha:

1. IS 17794 : 2022 PERTOLEUM NAPHTHA — SPECIFICATION: Naphtha is imported or exported or traded between the refineries within the country. Therefore, in order to cater the requirements of revenue authorities, in classifying the product and to help in monitoring the quality of the product imported, this standard is being prepared. It prescribes the requirements and test methods of naphtha used as a feedstock in petrochemical plants, steam cracking, fuel, as a gasoline blend stock and various other applications in the refineries

3.2.2 Gasoline

Gasoline, also called petrol (India) or gas (United States and Canada), or benzine (Europe) is a mixture of volatile, flammable liquid hydrocarbon derivatives derived from crude oil and used as fuel for internal-combustion engines. It is also used as a solvent for oils and fats. Originally a byproduct of the crude oil industry (kerosene being the principal product), gasoline became the preferred automobile fuel because of its high energy of combustion and capacity to mix readily with air in a carburetor. There is no single process in a refinery that produces gasoline. In fact, gasoline is a mixture of hydrocarbon derivatives that usually boil below 180°C (355°F) or, at most, below 200°C (390°F). The hydrocarbon constituents in this boiling range are those that have 4 to 12 carbon atoms in their molecular structure and fall into three general types: paraffins (including the cycloparaffins and branched materials), olefins, and aromatics.

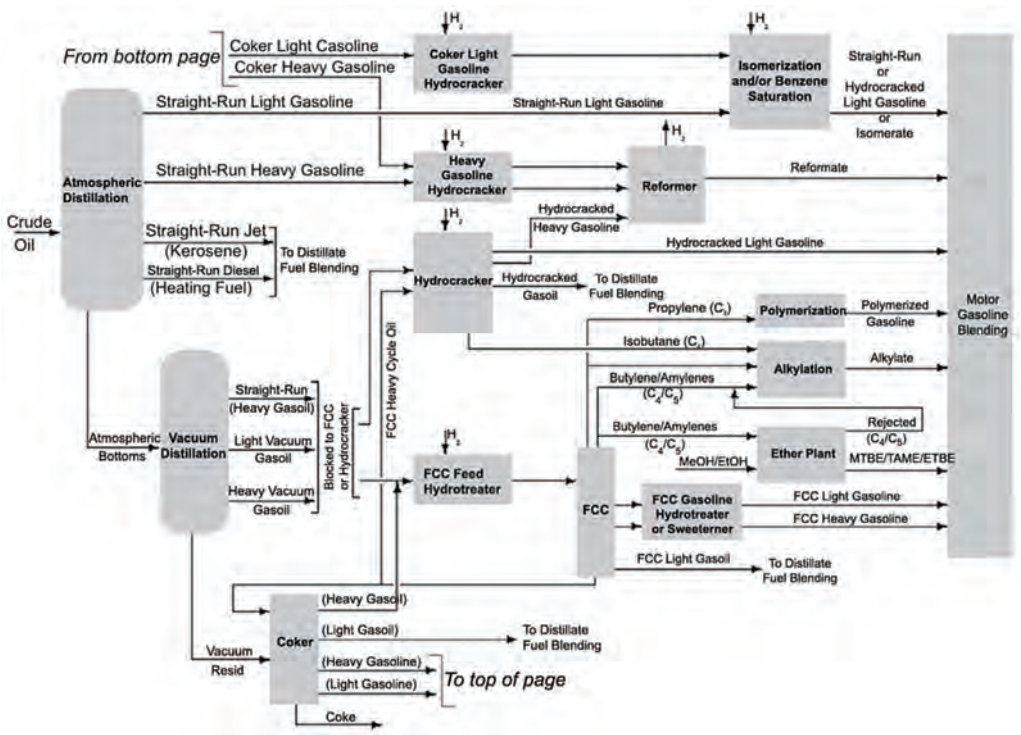


Figure 3.2: Refinery streams that are blended to produce gasoline.

Gasoline was at first produced from crude oil by distillation, simply separating the volatile, more valuable fractions of crude oil and was actually equivalent to the distillate now referred to as naphtha. Up to and during the first decade of the present century, the gasoline produced was that originally present in crude oil or that could be condensed from natural gas. However, it was soon discovered that if the higher-boiling portions of

crude oil (such as the fraction that boiled higher than kerosene, e.g., gas oil) were heated to more severe temperatures, thermal degradation (or cracking) occurred to produce smaller molecules within the range suitable for gasoline. Therefore, gasoline that was not originally in the unrefined crude oil could be manufactured. Later processes, designed to raise the yield of gasoline from crude oil, decomposed higher molecular weight constituents into lower molecular weight products by processes known as cracking. And like typical gasoline, several processes produce the blending stocks for gasoline manufacture. Thermal cracking, employing heat and high pressures, was introduced in 1913 but was accompanied in refineries after 1937 by catalytic cracking, the application of catalysts that facilitates chemical reactions producing more gasoline. Thermal cracking processes for converting the high boiling fraction of crude oil to lower-boiling products still play an important role in the modern refinery through upgradation of heavy residue and improving the economics of the refinery through the production of lower boiling distillates and other valuable products such as hydrocarbon gases and petroleum coke.

The predominant reactions of thermal cracking are: (i) cracking of side chains aromatic nuclei, (ii) dehydrogenation of naphthene derivatives to form aromatic derivatives, (iii) condensation of aliphatic derivatives to form aromatic products, (iv) condensation of aromatic derivatives to form higher molecular weight aromatic derivatives, and (v) dimerization or oligomerization. Other methods used to improve the quality of gasoline and increase its supply include polymerization, alkylation, isomerization, and reforming. Gasoline is manufactured to meet specifications and regulations and not to achieve a specific distribution of hydrocarbon derivatives by class and size. However, chemical composition often defines properties. Gasoline is manufactured to meet specifications and regulations and not to achieve a specific distribution of hydrocarbon derivatives by class and size. However, chemical composition often defines properties. For example, volatility is defined by the individual hydrocarbon constituents, and the lowest boiling constituent(s) defines the volatility as determined by certain test methods.

A Automotive gasoline typically contains approximately almost 200 (if not several hundred) hydrocarbon compounds. The relative concentrations of the compounds vary considerably depending on the source of crude oil, refinery process, and product specifications. Typical hydrocarbon chain lengths range from C_4 through C_{12} with a general hydrocarbon distribution consisting of alkanes (4%-8%), alkenes (2%-5%), iso-alkanes 25%-40%, cycloalkanes (3%-7%), cycloalkenes (l%-4%), and aromatics (20%-50%). However, these proportions vary greatly.

B Aviation gasoline is form of motor gasoline that has been especially prepared for use for aviation piston engines. It has an octane number suited to the engine, a freezing point of 60°C (76°F), and a distillation range usually within the limits of 30°C-180°C (86°F-356°F) compared to 1°C to 200°C (30°F-390°F) for automobile gasoline. The narrower boiling range ensures better distribution of the vaporized fuel through the more complicated induction systems of aircraft engines. Aircraft operate at altitudes at which the prevailing pressure is less than the pressure at the surface of the Earth (pressure at 17,500 feet is 7.5 psi compared to 14.7 psi at the surface of the Earth). Thus, the vapor pressure of aviation gasoline must be limited to reduce boiling in the tanks, fuel lines, and carburetors. Thus, the aviation gasoline does not usually contain the gaseous hydrocarbon derivatives (butanes) that give automobile gasoline the higher vapor pressures.

Aviation gasoline is strictly limited regarding hydrocarbon composition. The important properties of the hydrocarbon derivatives are the highest octane numbers economically possible, boiling points in the limited temperature range of aviation gasoline, maximum heat contents per pound (high proportion of combined hydrogen), and high chemical stability to withstand storage. Aviation gasoline are composed of paraffins and iso-paraffins (50%-60%), moderate amounts of naphthenes (20%-30%), small amounts of aromatics (10%), and usually no olefins, whereas motor gasoline may contain up to 30% olefins and up to 40% aromatics.

BIS has formulated following standards related to gasoline:

1. IS 1448 [P : 28] :2008 ISO 7536: 1994 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 28] PETROLEUM PRODUCTS — DETERMINATION OF OXIDATION STABILITY OF GASOLINE — INDUCTION PERIOD METHOD:

   This standard specifies a method for the determination of the stability of aviation and motor gasolines in their finished form only, under accelerated oxidation conditions, by measuring the induction period to breakpoint in a pressure bomb apparatus.

   The method is not intended for the determination of the stability of gasoline components individually, particularly those with a high percentage of low-boiling unsaturated compounds, as they may cause explosive conditions within the apparatus. However, because of the unknown nature of certain samples, the specified bomb assembly includes a safety burst-disc in order to safeguard the operator.

   The induction period may be used as an indication of the tendency of gasoline to form gum in storage. It should be recognized, however, that this correlation may vary markedly under different storage conditions and with different gasolines.

   The sample is oxidized in a pressure bomb (figure 3.3) initially filled at 15 °C to 25 °C with oxygen at 690 kPa and heated at a temperature between 98°C and 102°C. The pressure is. read at stated intervals or recorded continuously until the breakpoint is reached. The time required for the sample to reach this point is the ob served induction period at the temperate of test, from which the induction period at 100°C may be calculated.

2. IS 1448 (P:82):2008 Method of Test for Petroleum and its products (P:82)Petroleum Products – Determination of Lead content of Gasoline-Iodine monocloride Method:The reduction of the lead content of gasoline and the introduction of reformulated gasoline have been very successful in reducing automobile emissions. This standard specifies a method for the determination of total lead content in gasoline containing lead alkyls at concentrations between 0.026g and 1300 g lead/liter.

   A known volume of the test sample is diluted with heavy distillate and sahaken with aqueous iodine monochloride reagent. Any tetraalkyl lead compounds present react with the iodine monochloride and are extracted into the aqueous phase as the dialkyl lead compounds. The aqueous extract

is separated from the gasoline and evaporated to low bulk to decompose free iodine monochloride. Any organic matter present is removed by oxidation with nitric acid which also serves to convert the dialkyl lead compound into inorganic lead compounds. The residue is dissolved in water and buffered to pH 5 with sodium acetate/acetic acid buffer. The lead content of the buffered solution in determined by titration with Na_2EDTA using xylenon orange as indicator.

3. IS:1448[P:104]-1981 METHOD OF TEST FOR PETROLEUM AND ITS PRODUCTS [P:104] AROMATICS IN LIGHT NAPHTHAS AND AVIATION GASOLINES BY GAS

CHROMATOGRAPHY: This method covers the determination of benzene, toluene, C_8 and heavier aromatics, and total aromatics in the concentration range from 1.0 to 30 percent of the individual aromatic compounds listed above in the following products: (i) aviation gasolines, (ii) reformer products having a final boiling point below 175°C, and (iii) reformer feed and other petroleum products having a final boiling point below 150 æ%*C*.

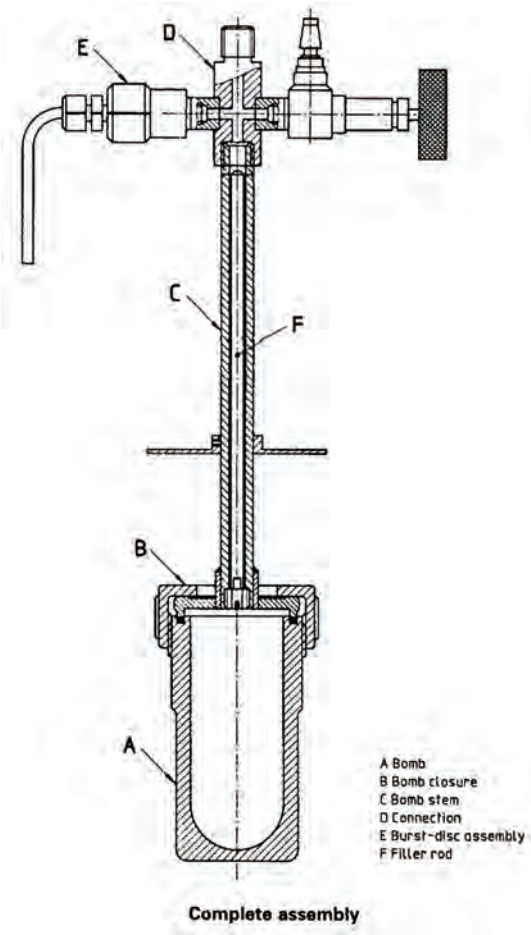


Figure 3.3: Oxidation bomb and burst disc assembly The sample is introduced into a gas chromatographic column containing a strongly polar liquid phase. The polar phase has very little affinity for saturated and olefinic hydrocarbons while exhibiting a pronounced selectivity for aromatics. This selectivity results in the elution of all saturated and olefinic hydrocarbons in the products described above prior to the elution of benzene. Either a thermal conductivity or flame ionization detector may be used. Calibration is performed by using synthetic blends of the aromatic compounds charged at the same constant volume as is used to analyze the sample. n-undecane or n-dodecane is used as an internal standard.

4. IS : 1448 [P : 112]- 1983 METHODS OF TEST FOR .I PETROLEUM AND ITS PRODUCTS [P : 112] DETERMINATION OF LEAD IN GASOLINE BY ATOMIC

ABSORPTION SPECTROMETRY This method covers the determination of the total lead content of gasoline within the concentration range of 2.5 to 25 mg of lead/litre. The method compensates for variations in, gasoline composition and is independent of lead alkyl type. The gasoline sample is diluted with methyl isobutyl ketone and the alkyl lead compounds are stabilized by reaction with iodine and a quarternary ammonium salt. The lead content of the sample is determined by atomic absorption flame spectrometry at 2 833 A, using standards prepared from reagent grade lead chloride. By the use of this treatment, all alkyl lead compounds give identical response.

5. IS 1448 [P : 147] : 1998 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 147] DETERMINATION OF POTENTIAL GUM IN MOTOR

GASOLINES It describes determination of potential gum in motor gasolines. Gum is a non-volatile, polymeric, and resinous material with a high molar mass that forms when some gasoline hydrocarbons react with each other and absorbed atmospheric oxygen during storage. Gum formation in gasoline can be attributed to Aliphatic diolefins, Cyclic diolefins, Monoor diolefins attached to a benzene ring, High concentrations of certain mono-olefins, Alkylation of unsaturated, the presence of sulfur, Oxidation & polymerization of unsaturates, Higher aromatic content. Gum is primarily the result of oxidation, which is apparently of the autocatalytic type. Once a gasoline has started to form gum, it usually continues as long as air or oxygen is present. To increase the fuel stability, stabilizing agents, such as oxidation inhibitors, are added. The sample is oxidised in a bomb in the presence of oxygen for four hours under prescribed test conditions. The oxidised gasoline is evaporated and n-heptane insoluble portion of evaporation residue is reported as potential gum

6. IS 1448 [P : 163] : 2018 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 163] DETERMINATION OF GASOLINE DILUENT IN USED GASOLINE ENGINE OILS BY GAS CHROMATOGRAPHY prescribes gas chromatographic techniques equipped with flame ionization detector and programmable oven to determine fuel dilution of used gasoline fuel engine oils. A sample containing a known percentage of n-tetra decane as primary standard is used to determine the weight percent of gasoline fuel in the sample boiling below the boiling point of the primary standard. This test method measures and indicate the fuel dilution of the engine oil during normal operation. Fuel dilution of the crankcase oil retards the performance of the engine oil however in normal performance some fuel dilution may take place.

7. IS 1448 [P : 173] : 2020 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 173] DETERMINATION OF LEAD CONTENT IN MOTOR GASOLINE — ENERGY DISPERSIVE X-RAY FLUORESCENCE SPECTROMETRY

METHOD specifies the test procedure for the determination of the lead content of motor gasoline, where the lead is present as lead alkyl. The method is applicable for the lead concentration from 0.002 g Pb/l to 0.50 g Pb/l (low range from 0.002 g Pb/l to 0.020 g Pb/l and high range from 0.01 g Pb/l to 0.50 g Pb/l). A test portion is exposed to an X-ray beam, and the intensity of specified excited lines of lead is measured and compared with the calibration curve of intensity versus lead content. For the high-range analysis, the intensity of the lead L line is measured, whereas for the low-range analysis, the low-power X-ray tube instrument measures a region of the spectrum centered on the L*á* line together with one set to the high energy backscatter to calculate a net intensity. Oxygenated components of gasoline, such as alcohols or ethers, may interfere with the results of this method. Differences in density and sulfur content between the product under analysis and the diluent mixture used for the preparation of calibration solutions can lead to errors in the result of the test.

8. IS 1448 (Part 181):2020 ISO 22854:2016 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS PART 181 LIQUID PETROLEUM PRODUCTS — DETERMINATION OF HYDROCARBON TYPES AND OXYGENATES IN

AUTOMOTIVE MOTOR GASOLINE AND IN ETHANOL (E85) AUTOMOTIVE FUEL — MULTIDIMENSIONAL GAS CHROMATOGRAPHY METHOD: specifies the gas chromatographic (GC) method for the determination of saturated, olefinic and aromatic hydrocarbons in automotive motor gasoline and ethanol (E85) automotive fuel. Additionally, the benzene content, oxygenate compounds and the total oxygen content can be determined. Olefins are a key component of gasoline, and can increase fuel reactivity and improve octane number. For example, increasing olefin volume from 10% to 25% can shorten combustion duration and reduce hydrocarbon emissions by about 15%. Aromatic hydrocarbons make up about 20–40% of gasoline by volume. The combustion behavior of these fuels is significantly impacted by aromatic combustion chemistry. For example, increasing aromatics from 35% to 45% can increase engine-out nitrogen oxides (NOx) emissions by 4%.

This standard defines two procedures, A and B:

Procedure A is applicable to automotive motor gasoline with total aromatics of up to 50 % (V/V); total olefins from about 1.5 % (V/V) up to 30 % (V/V); oxygenates from 0.8 % (V/V) up to 15 % (V/V); total oxygen from about 1.5 % (m/m) to about 3.7 % (m/m); and benzene of up to 2 % (V/V). The system can be used for ethers with 5 or more C atoms up to 22 % (V/V) but the precision has not been established up to this level. Although this test method can be used to determine higher-olefin contents of up to 50 % (V/V), the precision for olefins was tested only in the range from about 1.5 % (V/V) to about 30 % (V/V). Although specifically developed for the analysis of automotive motor gasoline that contains oxygenates, this test method can also be applied to other hydrocarbon streams having similar

boiling ranges, such as naphthas and reformates.

Procedure B describes the procedure for the analysis of oxygenated groups (ethanol, methanol, ethers, C_3 to C_5 alcohols) in ethanol (E85) automotive fuel containing ethanol between 50 % (V/V) and 85 % (V/V). The gasoline is diluted with an oxygenate-free component to lower the ethanol content to a value below 20 % (V/V) before the analysis by

GC. If the ethanol content is unknown, it is advisable to use a dilution of 4:1 when analysing the sample.

9. IS 15464 : 2022 Anhydrous Ethanol for Use as Blending Component in Motor Gasoline — Specification: Ethyl alcohol (ethanol) is considered as an alternative fuel source that possesses environment friendly characteristics associated with its use. The term anhydrous ethanol is applied to ethyl alcohol after the first addition of a denaturant. Ethanol is denatured to make it undrinkable and unsuitable for human consumption. Denatured ethanol is ethanol that has been mixed with toxic additives, such as methanol and isopropanol. These additives make the ethanol poisonous, bad-tasting, foul-smelling, or nauseating.

Ethanol till recently was being produced only through molasses. In order to increase usage of alternate fuels in the country, National Biofuel Policy 2018 included various routes for producing ethanol. Bioethanol [1st Generation (1G) Ethanol] is produced from biological sources, such as sugar containing materials like sugar cane, sugar beet, sweet sorghum etc.; starch containing materials, such as corn, cassava, rotten potatoes, etc.; as well, and from damaged food grains like wheat, broken rice etc. which are unfit for human consumption. Food grains during surplus phase and algal feedstock and cultivation of sea weeds were identified as potential feedstock for ethanol production from 1G technology.

Ethanol produced through cellulosic materials, such as bagasse, wood waste, agricultural and forestry residues or other renewable resources like industrial waste, and 'Advanced biofuels' that are produced from lignocellulosic feedstocks (that is, agricultural and forestry residues, for example, rice and wheat straw/corn cobs and stover, bagasse, woody biomass), non-food crops (that is, grasses, algae), or industrial waste and residue streams and having low CO2 emission or high GHG reduction and do not compete with food crops for land use are categorized as second generation (2G) ethanol. The large volume of waste gas produced at industrial facilities, such as refineries cannot be stored or transported; rather it must be combusted to make power locally and emitted as carbon dioxide (CO_2). These refinery off-gases formed often contain components, such as olefins, hydrogen, CO_2, CO, hydrocarbons, H_2S, etc. Ethanol production through fermentation of gas mixtures containing CO, CO_2 and H_2 has just started operating at commercial scale and process is known as Off Gas Fermentation (OGF). Instead of sugars and yeast, the fermentation process uses a biological catalysts to ferment waste gas emissions to ethanol.

Properties like purity, methanol content, higher alcohols content, contaminants like chloride, moisture are important to define the quality of ethanol produced through various technologies and raw materials mentioned in National Biofuel Policy, 2018 and hence included. This standard specifies requirements, methods of sampling and test methods for anhydrous ethanol to be used as blending component with gasoline for automotive fuel in positive ignition engine vehicles.

10. IS 1604 : 2012 AVIATION GASOLINE — SPECIFICATION It prescribes requirements and methods of sampling and test for two grades of aviation gasoline i.e. Grade 80 and Grade 100LL, intended for use in aircraft reciprocating engines.

11. IS 16634 : 2023 E85 FUEL — ADMIXTURE OF ANHYDROUS ETHANOL AND MOTOR GASOLINE FOR FLEX FUEL POSITIVE IGNITION ENGINE POWERED

VEHICLES — SPECIFICATION: Ethanol is an alternative fuel source that offers environment friendly characteristics associated with its use. Anhydrous ethanol meeting specifications prescribed under IS 15464 is used as blending component in motor gasoline to manufacture E10 fuel (10 percent ± 1 percent volume blend in motor gasoline) and used in existing positive ignition engines of automotive vehicles.

As per the report on 'Roadmap for ethanol blending in India 2020 to 2025' released in 2021 by Government of India, the bio-fuel usage in automotive vehicles need to be increased in order to reduce emissions; achieve better environment friendly performance; encourage make in India products; and reduce the import bill. The report recommends this can be achieved by higher percentage of ethanol blending in gasoline (above E10) for automotive vehicles usage. Accordingly, IS 17021 'E20 fuel — Admixture of anhydrous ethanol and gasoline — As fuel for spark ignited engine powered vehicles — Specification' is already published, and its implementation is planned from 2023. New vehicles, materials, engine calibration are being considered by original equipment manufacturers (OEMs) to use E20 fuel when implemented.

Compatibility study of existing engines and vehicles to use E20 fuel is also in progress jointly between OEMs, oil manufacturing companies (OMCs) and testing agencies. However, the existing gasoline vehicles or E20 compatible vehicles are not suitable using higher ethanol blends (above E20). Potential issues like reduced fuel efficiency, performance, driveability, failure of fuel system material and components over a period of usage may occur leading to leakages and other failures. To overcome such problems, flexible fuel vehicles (FFVs) need to be developed which are specially designed to operate on higher blends of ethanol, safely and effectively. The FFVs are versatile to operate on ethanol blended gasoline ranging from 20 percent up to 85 percent without adverse effects on fuel system material, emissions, on-board diagnostic (OBD) systems or drivability. Further, higher ethanol containing fuels have lower calorific value. Hence, FFVs will be fortified with ethanol and/or oxygen sensors,

other electronic engine control units which adjusts air fuel ratio of engine and provide fuelling related to the oxygen content. These are required to maintain the proper stoichiometric ratio under the various engine operating loads and condition thereby to optimize emission, recover performance deterioration owing to lower energy content of ethanol. The vaporization characteristics of ethanol require modified engine fuelling strategies under engine cold start and warm up conditions as well. Global references of countries using ethanol blended gasoline varying from 10 percent to 85 percent in FFV are also available.

This standard prescribes requirements, methods of sampling and test for E85 fuel, an admixture of 80 percent to 85 percent anhydrous ethanol conforming to IS 15464 with ethanol free motor gasoline conforming to IS 2796. This E85 fuel can be used in specially designed positive ignition flex fuel vehicles directly or as a mixture with gasoline conforming to IS 2796 or as a mixture with E20 fuel conforming to IS 17021.

12. IS 16634:2017 E85 fuel (Blend Of Anhydrous Ethanol And Gasoline) – Specification

13. IS 17021 : 2018 E 20 FUEL — ADMIXTURE OF ANHYDROUS ETHANOL AND GASOLINE — AS FUEL FOR SPARK IGNITED ENGINE POWERED VEHICLES — SPECIFICATION

14. IS 17021 : 2018 E 20 FUEL — ADMIXTURE OF ANHYDROUS ETHANOL AND GASOLINE — AS FUEL FOR SPARK IGNITED ENGINE POWERED VEHICLES — SPECIFICATION: The term E20 fuel pertains to an admixture of anhydrous ethanol meeting IS 15464 at 20 percent by volume and ethanol free Motor Gasoline meeting IS 2796 at 80 percent by volume. Its properties of E20 and observed that properties like Reid Vapour Pressure (RVP), Vapor Lock Index (VLI), Research Octane number and Motor Octane number are important. Since Anhydrous ethanol has higher octane rating, the E20 fuel shall give user the benefit of improved octane, by about 4-5 units over base Motor Gasoline. It prescribes requirements, methods of sampling and test methods for two octane grades of E20 fuel, an admixture of anhydrous ethanol meeting IS 15464 at 20 percent by volume and ethanol free Motor Gasoline meeting IS 2796 at 80 percent volume, under each of BS IV and BS VI categories suitable for use as a fuel in the automobile spark-ignition internal combustion engines of vehicles complying with BS IV and BS VI emission norms respectively.

15. IS 17076 : 2019 M15 FUEL — ADMIXTURE OF ANHYDROUS METHANOL AND MOTOR GASOLINE AS FUEL FOR SPARK IGNITED ENGINES —

SPECIFICATION: Methanol is considered as an alternative fuel source that offers environmental friendly characteristics associated with its use. ASTM D 1152 and IMPCA (International Methanol Producers and Consumers Association) provides specification of Methyl alcohol for wider application and not limited to Automotive. The blends may be produced by admixture of this anhydrous methanol with automobile fuel such as motor gasoline (IS 2796). However, it is observed that use of methanol blend in

existing motor gasoline engines will require modification in engine, fuel system components and engine calibration, to match the performance and emissions of the vehicle. The term M15 fuel pertains to an admixture of anhydrous methanol (IS 17075 : 2018), at 15 percent by volume and methanol free motor gasoline (IS 2796) at 85 percent volume which can be used as fuel in the vehicles with spark ignition engine or industrial engines which may require modifications as mentioned above.

Due to hygroscopic characteristics of methanol, special care should be taken to keep storage and handling system as dry as possible. Further, direct contact of this fuel through hand or mouth may be potentially lethal. Its properties like Reid Vapor Pressure (RVP), Vapor Lock Index (VLI), research octane number and motor octane number are important. Since, anhydrous methanol has higher octane rating, the M15 fuel shall give user the benefit of improved octane, by about 4-5 units over base motor gasoline.

This standard prescribes requirements, methods of sampling and test for M15 fuel, an admixture of anhydrous methanol meeting IS 17075 at 15 percent by volume and methanol free motor gasoline meeting IS 2796 at 85 percent volume, for use in vehicles equipped with spark ignition engines, stationary and industrial engines specially designed for using such fuel.

16. IS 17586 : 2021 E12 AND E15 FUEL — ADMIXTURE OF ANHYDROUS ETHANOL AND MOTOR GASOLINE — FOR POSITIVE IGNITION ENGINE POWERED VEHICLES — SPECIFICATION: The term E12 fuel pertains to an admixture of anhydrous ethanol meeting IS 15464 at 12 percent by volume and ethanol free motor gasoline meeting IS 2796 at 88 percent by volume. Similarly, the term E15 fuel pertains to an admixture of anhydrous ethanol meeting IS 15464 at 15 percent by volume and ethanol free motor gasoline meeting IS 2796 at 85 percent by volume. This standard prescribes requirements, methods of sampling and test methods for E12 fuel, an admixture of anhydrous ethanol meeting IS 15464 at 12 percent by volume and ethanol free motor gasoline meeting IS 2796 at 88 percent volume and E15 fuel, an admixture of anhydrous ethanol meeting IS 15464 at 15 percent by volume and ethanol free motor gasoline meeting IS 2796 at 85 percent volume, for use as a fuel in the automobile positive-ignition internal combustion engines of vehicles complying with BS VI emission norms.

17. IS 17943 : 2022 E20 REFERENCE FUEL — ADMIXTURE OF ANHYDROUS ETHANOL AND MOTOR GASOLINE — SPECIFICATION: As per the Central Motor Vehicle Rules (CMVR) requirement (rule No. 115), for new vehicles type approval and conformity of production tests, test agencies and OEMs shall use reference fuel. The reference fuel specification parameters have closer tolerance limits, essential for the above-mentioned regulatory tests consistency and has additional parameters which are not part of the IS 17021 : 2018. This standard prescribes requirements, methods of sampling and test methods for E20 reference fuel, an admixture of anhydrous ethanol at 20 percent by volume and ethanol free motor gasoline at 80 percent volume, for use in Positive-Ignition Engines Type Approval (TA) and

Conformity of Production (COP) tests by authorized test agencies and OEMs.

18. IS 2796 : 2017 MOTOR GASOLINE — SPECIFICATION:It prescribes the requirements and methods of sampling and test methods for two octane grades each of Motor Gasoline (earlier also known as Motor Spirit) and up to 10 percent ethanol blended motor gasoline (E10) under each of BS IV and BS VI categories suitable for use as a fuel in the automobile spark-ignition internal combustion engines of vehicles complying with BS IV and BS VI emission norms respectively. It also applies to blends of motor gasoline with organic oxygenates such as alcohols and ethers. The following grades of gasoline are defined in the standard: two octane grades each (RON 91 and 95) of BS IV and BS VI categories under motor gasoline and 10 percent ethanol blended motor gasoline (E10), as given below.

    (a) Motor Gasoline (Without or With 5 Percent Ethanol Blended Motor Gasoline) a) BS IV Regular (RON 91), b) BS IV Premium (RON 95), c) BS VI Regular (RON 91), and d) BS VI Premium (RON 95).

    (b) 10 Percent Ethanol Blended Motor Gasoline (EBMG) a) 10 percent EBMGBS IV Regular (RON 91), b) 10 percent EBMG BS IV Premium (RON 95), c) 10 percent EBMGBS VI Regular (RON 91), and d) 10 percent EBMG BS VI Premium (RON 95).

The standard IS 1448 [P: 147]: 1998 for the determination of gum content in gasoline is important for preventing fire hazards. Gums can potentially increase the risk of fires by creating deposits that may ignite under certain conditions. Ensuring low gum content helps maintain the reliability and safety of storage facilities, transportation systems, and end-user applications, reducing the likelihood of accidents or equipment failure. Similarly, the standard IS 1448 [P: 112]-1983 ensures that the lead content in gasoline is within safe limits to prevent adverse effects on human health, as lead laden smoke from motor vehicles can be a significant health hazard.

3.2.3 Kerosene and related fuels

Kerosene, also called liquid paraffin or paraffin oil, is a flammable pale-yellow or colorless oily liquid with a characteristic odor. It is obtained from crude oil and used for burning in lamps and domestic heaters or furnaces, as a fuel or fuel component for jet engines, and as a solvent for greases and insecticides. Kerosene is intermediate in volatility between naphtha and gas/diesel oil. It is a medium oil distilling between 150°C and 300°C (300°F 570°F). Kerosene has a flash point of approximately 25°C (77°F) and is suitable for use as an illuminant when burned in a wide lamp.

The term kerosene is also too often incorrectly applied to various fuel oils, but a fuel oil is actually any liquid or liquid crude oil product that produces heat when burned in a suitable container or that produces power when burned in an engine. Kerosene was first manufactured in the 1850s from coal tar, hence the name coal oil is often applied to kerosene, but crude oil became the major source after 1859. From that time, the kerosene fraction is and has remained a distillation fraction of crude oil. However, the quantity and quality vary with the type of crude oil, and although some crude oils yield excellent kerosene quite simply, others produce kerosene that requires substantial refining. In the modern refinery, kerosene is largely produced by cracking the less

volatile portion of crude oil at atmospheric pressure and elevated temperatures. In the early days, the poorer quality kerosene was treated with large quantities of sulfuric acid to convert them to marketable products. However, this treatment resulted in high acid and kerosene losses, but the later development of the Edeleanu process overcame these problems.

Kerosene is a very stable product, and additives are not required to improve the quality. Apart from the removal of excessive quantities of aromatics by the Edeleanu process, kerosene fractions may need only a lye wash or a doctor treatment if hydrogen sulfide is present to remove mercaptans. Chemically, kerosene is a mixture of hydrocarbons; the chemical composition depends on its source, but it usually consists of approximately 10 different hydrocarbons, each containing from 10 to 16 carbon atoms per molecule; the constituents include n-dodecane (n-$C_{12}H_{26}$), alkyl benzenes, and naphthalene and its derivatives. Kerosene is less volatile than naphtha; it boils between approximately 140°C (285°F) and 320°C (610°F). Kerosene, because of its use as burning oil, must be free of aromatic and unsaturated hydrocarbons, as well as free of the more obnoxious sulfur compounds. The desirable constituents of kerosene are saturated hydrocarbons, and it is for this reason that kerosene is manufactured as a straight-run fraction, not by a cracking process.

Although the kerosene constituents are predominantly saturated materials, there is evidence for the presence of substituted tetrahydronaphthalene. Dicycloparaffin derivatives also occur in substantial amounts in kerosene. Other hydrocarbons with both aromatic and cycloparaffin rings in the same molecule, such as substituted indan, also occur in kerosene. The predominant structure of the dinuclear aromatics appears to be that in which the aromatic rings are condensed, such as naphthalene whereas the isolated two-ring compounds, such as biphenyl, are only present in traces, if at all.

The essential properties of kerosene are flash point, fire point, distillation range, burning, sulfur content, color, and cloud point. In the case of the flash, the minimum flash temperature is generally placed above the prevailing ambient temperature; the fire point determines the fire hazard associated with its handling and use. The boiling range is of less importance for kerosene than for naphtha, but it can be taken as an indication of the viscosity of the product, for which there is no requirement for kerosene. The ability of kerosene to burn steadily and cleanly over an extended period is an important property and gives some indication of the purity or composition of the product. The significance of the total sulfur content of a fuel oil varies greatly with the type of oil and the use to which it is put. Sulfur content is of great importance when the oil to be burned produces sulfur oxides that contaminate the surroundings. The color of kerosene is of little significance, but a product darker than usual may have resulted from contamination or aging. Finally, the cloud point of gives an indication of the temperature at which the wick may become coated with wax particles, thus lowering the burning qualities of the oil.

Kerosene was the major refinery product before the onset of the automobile age, but now kerosene can be termed one of several secondary crude oil products after the primary refinery product naphtha. Kerosene originated as a straight-run crude oil fraction that boiled between approximately 205°C and 260°C (400°F - 500°F) Jet fuel comprises both gasoline-type and kerosene-type jet fuels meeting specifications for use in aviation turbine power units and is often referred to as gasoline-type jet fuel

and kerosene-type jet fuel. Kerosene type jet fuel is a medium distillate product that is used for aviation turbine power units. It has the same distillation characteristics and flash point as kerosene (between 150°C and 300°C, 300°F and 570°F, but not generally above 250°C, 480°F). In addition, it has particular specifications (such as freezing point) which are established by the International Air Transport Association (IATA). Following are the Indian Standards related to Kerosene:

1. IS 1459 : 2018 KEROSENE — SPECIFICATION prescribes requirements and methods of sampling and test of kerosene intended for use as an illuminant and as a fuel. There are two grades of kerosene as specified in the standard: a) Grade A — Low sulphur kerosene; and b) Grade B — Kerosene.

2. IS 17081 : 2019 AVIATION TURBINE FUELS (KEROSENE TYPE, JET A-1), CONTAINING SYNTHESIZED HYDROCARBONS — SPECIFICATION Aviation turbine fuel, kerosene type, Jet A-1 fuel (IS 1571) consists predominantly refined hydrocarbons derived from conventional sources including crude oil, natural gas liquid condensates, heavy oil, oil shale and oil sands. Use of synthesized fuel components from alternate renewable sources is envisaged to decrease net lifecycle carbon emissions. Hence, the formulation of this standard was taken up to cover the manufacture of aviation turbine fuel that consists of conventional and synthetic blending components.

   Research and development work is being carried out all over the world in the area of synthetic components derived from renewable sources. Indigenously, the Indian Institute of Petroleum (IIP) of the Council of Scientific & Industrial Research (CSIR) has developed a technology for synthesizing hydrocarbons from esters and fatty acids using hydroprocessing technology (Refer CSIR-IIP report HA/CCD/2018/Bio-ATF-157). The research work is available in the technical project report reference number ICRD08-054, titled "Applications of Biofuels for Aviation," a joint project between ISTP Canada — Pratt & Whitney Canada (P&WC), GITA, and Infotech enterprises. CSIR-IIP's process control document no.: HA/CCD/2018/Bio-ATF-157 discusses the process, and the test results of the bio-jet fuel produced from the hydroprocessing of esters and fatty acids for the production of hydrocarbons. A test flight with Bombardier Q400 Aircraft of SpiceJet Ltd., powered with a blend of 25 percent of this Bio-Jet fuel in the right engine, was carried out.

   The need for International Coordination among recognized standards of other countries on the subject is particularly significant for a product of this type since refueling of aircraft in different countries is often involved. Hence this standard is aligned with British Ministry of Defence specification DEF STAN 91-091 (Issue 9, 03 October 2016) and ASTM specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons D7566 – 18 and shall be revised whenever needed, to align with the international specifications and practices. Assistance has also been derived from ASTM D 1655-18, Aviation Fuel Quality Requirements for Jointly Operated System (AFQRJOS-Issue 29 – Oct 2016).

This standard prescribes requirements and the methods of sampling and test for synthetic blending components as well as aviation turbine fuel, kerosene type, Jet A-1 containing synthesized hydrocarbons for use in aircraft gas turbine engines designed to operate on such fuel. This specification covers the manufacture of aviation turbine fuels that consists of conventional and synthetic blending components in the specified ratio.

3. IS 17793 : 2022 KEROSENE INTERMEDIATE — SPECIFICATION Kerosene intermediate is a middle distillate petroleum fraction derived out of various processes in the refinery or a liquid fraction recovered in the production of crude oil and natural gas. The refinery sources of kerosene intermediate are crude distillation units, coker units, hydrotreaters and hydrocrackers. Kerosene Intermediate is used as a feedstock in Linear Alkyl Benzene (LAB) plant for extracting n-paraffins; which are then used to produce Linear Alkyl Benzene (LAB). The return kerosene coming back from LAB plants is also considered as intermediate kerosene stream. The kerosene intermediate stream requires further treatment in the form of hydro treating and/or merox processing to make the finished product; namely Kerosene or Aviation Turbine Fuel (ATF) in the refineries. Kerosene intermediate is produced and traded by oil/gas producers and oil refineries. It is used by refineries in preparing various petroleum products.

3.2.4 Diesel fuel

Diesel fuel oil is essentially the same as furnace fuel oil, but the proportion of cracked gas oil is usually less since the high aromatic content of the cracked gas oil reduces the cetane value of the diesel fuel. Diesel fuel derived from crude oil (also called petrodiesel or fossil diesel) is the most common type of diesel fuel and is produced from the fractional distillation of crude oil between 200°C and 350°C (390°F and 660°F) at atmospheric pressure, resulting in a mixture of hydrocarbon derivatives that typically contain between 9 and 25 carbon atoms per molecule. Under the broad definition of diesel fuel, many possible combinations of characteristics (such as volatility, ignition quality, viscosity, gravity, stability, and other properties) exist. The diesel fuel produced in a modern refinery is (like gasoline) a blend of all the appropriate available streams, such as: (i) a straight-run product, (ii) the light cycle oil from a fluid catalytic cracking unit, and (iii) hydrocracked gas oil.

The straight-run diesel may be acceptable as is, or may need minor upgrading for use in diesel fuel prepared for off-road use. The refiner must blend the available streams to meet all performance, regulatory, economic, and inventory requirements. Typically, the refiner really has limited control over the detailed composition of the final diesel blend which is determined primarily by the composition of the crude oil feedstock. While the chemical reactions that occur in the conversion processes involve compositional changes, they are not specific enough to allow for much tailoring of the products.

On the other hand, synthetic diesel fuel can be produced from any carbonaceous material, including biomass, biogas, natural gas, coal, and many others. The raw material is gasified into synthesis (a mixture of carbon monoxide and hydrogen), which after purification is converted by the FischerTropsch process to a series of synthetic hydrocarbon derivatives This type of diesel fuel is typically paraffinic in nature and has

a zero sulfur content of and very low content of aromatic derivatives thereby reducing the emissions of environmentally unfriendly hydrocarbons, sulfur oxides, and particulate matter (PM). Diesel fuel is a member of the class of crude oil products known as middle distillates. As the name implies, these fuels are higher boiling than gasoline but lower boiling than gas oil. Middle distillates cover the boiling range from approximately 175°C to 375°C (350°F - 700°F) and the carbon number range from about C_8toC_{24}. Diesel fuel derived from crude oil is composed of approximately saturated hydrocarbon derivatives (75% v/v, primarily paraffin hydrocarbons including n-paraffins, iso-paraffins, and cycloparaffins), and aromatic hydrocarbon derivatives (25% v/v, including alkyl benzenes and naphthalene derivatives). Diesel fuels predominantly contain a mixture of C_{10}toC_{19}.

The principal measure of diesel fuel quality is the cetane number which is a measure of the delay of ignition of a diesel fuel and is based upon the ignition characteristics of two hydrocarbons n-hexadecane (cetane) and 2,3,4,5,6,7,8- heptamethylnonane. Cetane has a short delay period during ignition and is assigned a cetane number of 100; heptamethylnonane has a long delay period and has been assigned a cetane number of 15. Just as the octane number is meaningful for automobile fuels, the cetane number is a means of determining the ignition quality of diesel fuels and is equivalent to the percentage by volume of cetane in the blend with heptamethylnonane, which matches the ignition quality of the test fuel.

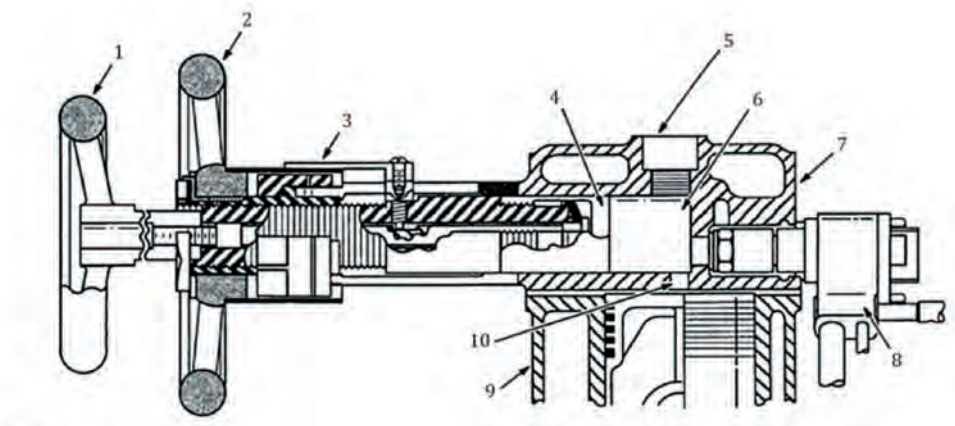
Cetane Number = % v/v n-cetane + 0.15% v/v heptamethylnonane.

One of the most widely used methods is based on the calculated Cetane Index formula. This formula represents a method for estimating the cetane number of distillate fuels from API gravity and mid-boiling point. The index value as computed from the formula is designated as a calculated cetane index. A high cetane number indicates that the fuel ignites more readily when sprayed into hot compressed air. BIS has formulated following standards related to Diesel Fuel:

1. IS 1460 : 2017 AUTOMOTIVE DIESEL FUEL — SPECIFICATION: The automotive diesel fuel continues to be the main fuel in India for both public as well as commercial transport and this trend is expected to continue for a long time to come because of favourable economic benefits associated with its use. The fuel demand pattern in our country is, therefore, heavily tilted towards automotive diesel fuel and there is an imperative need to maximize its production to meet the requirements of consumers. Accordingly, the requirements of automotive diesel fuel for vehicles meeting Bharat Stage IV and Bharat Stage VI Norms are furnished in the standard. Automotive diesel fuel is a complex mixture of hydrocarbons that varies depending on crude source and manufacturing process. Consequently, it is impossible to define the exact composition of automotive diesel fuel. This specification has therefore evolved primarily as a performance specification rather than a compositional specification. It is acknowledged that this standard largely relies on accumulated experience; therefore, the specification limits automotive fuels to those made from conventional sources. It prescribes the requirements, sampling procedure and test methods for automotive diesel fuel (earlier also known as High Speed Diesel Fuel, HSD). It is applicable to automotive diesel fuel for use in diesel engine vehicles and stationary diesel engines, designed to run

on automotive diesel fuel.

2. IS 1448 (Part 9) : 2023 ISO 5165 : 2020 Petroleum and its Products - Methods of Test PART 9 DETERMINATION OF THE IGNITION QUALITY OF DIESEL FUELS - CETANE ENGINE METHOD: The standard establishes the rating of diesel fuel oil in terms of an arbitrary scale of cetane numbers (CNs)[2] using a standard single cylinder, four-stroke cycle, variable compression ratio, indirect injected diesel engine. The CN provides a measure of the ignition characteristics of diesel fuel oil in compression ignition engines. The CN is determined at constant speed in a pre-combustion chamber-type compression ignition test engine. However, the relationship of test engine performance to full scale, variable speed and variable load engines is not completely understood.



Key

1	VCP locking wheel	6	precombustion chamber
2	VCP handwheel	7	cylinder head
3	VCP micrometer	8	injector nozzle assembly
4	VCP	9	cylinder
5	combustion pickup hole	10	turbulence passage

Figure 3.4: Test engine assembly — Engine cylinder head and handwheel assembly

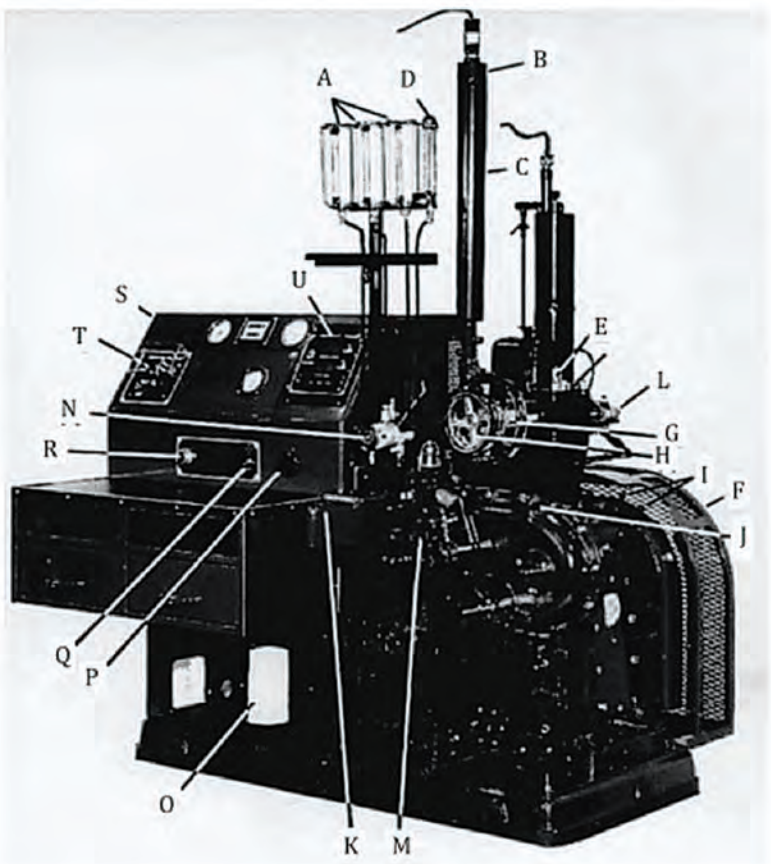
This document is applicable for the entire scale range from 0 CN to 100 CN but typical testing is in the range of 30 CN to 65 CN. An interlaboratory study executed by CEN in 2013 (10 samples in the range 52.4 CN to 73.8 CN)[3] confirmed that paraffinic diesel from synthesis or hydrotreatment, containing up to a volume fraction of 7 % fatty acid methyl ester (FAME), can be tested by this test method and that the precision is comparable to conventional fuels. Samples with fluid properties that interfere with the gravity flow of fuel to the fuel pump or delivery through the injector nozzle are not suitable for rating by this method.

3. IS 1448 (Part 149) : 2020 ISO 12156-1 : 2018 Methods of Test for Petroleum and its Products Part 149 Diesel Fuel — Assessment of Lubricity Using the High-Frequency Reciprocating Rig (HFRR) — Test Method:

   All diesel fuel injection equipment has some reliance on diesel fuel as a lubricant. Wear due to excessive friction resulting in shortened life of engine components, such as diesel fuel injection pumps and injectors, has sometimes been ascribed to lack of lubricity in the fuel. The relationship of

test results to diesel injection equipment component distress due to wear has been demonstrated for some fuel/hardware combinations where boundary lubrication is a factor in the operation of the component. Test results from fuels tested to this procedure have been found to correlate with many fuel/hardware combinations and provide an adequate prediction of the lubricating quality of the fuel. The correlation of biodiesel blends has been validated through 15 years of field experience and anecdotal data.

This standard specifies a test method using the high-frequency reciprocating rig (HFRR), for assessing the lubricating property of diesel fuels, including those fuels which could contain



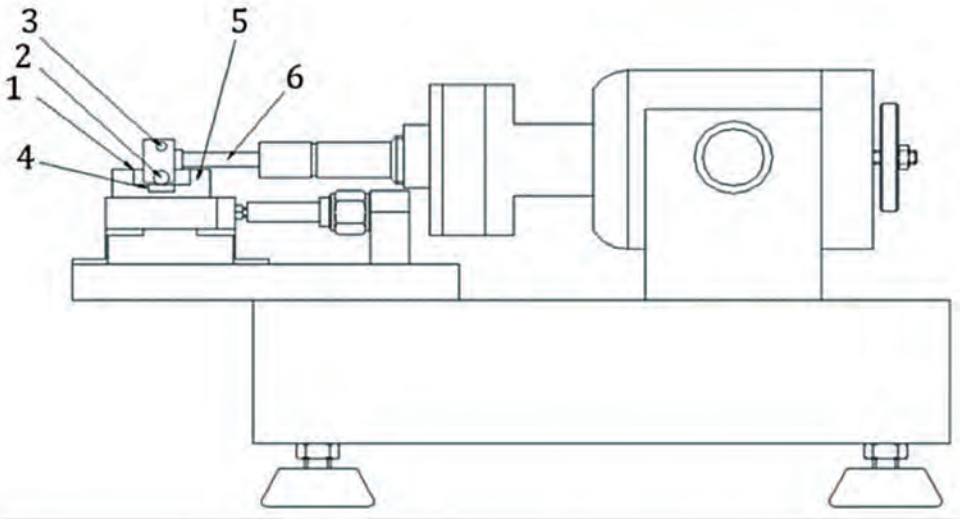
Key

A	fuel tanks	L	injector assembly
B	air heater housing	M	fuel injection pump
C	air intake silencer	N	fuel selector valve
D	fuel flow-rate burette	O	oil filter
E	combustion pickup	P	crankcase oil heater control
F	safety guard	Q	air heater switch
G	variable compression plug (VCP) handwheel	R	engine start-stop panel
H	VCP locking handwheel	S	instrument panel
I	flywheel pickups	T	intake air temperature controller
J	oil filter cap	U	dual digital cetane meter
K	injection pump safety shutoff solenoid		

Figure 3.5: Cetane method Test Engine assembly a lubricity-enhancing additive. It defines two methods for measurement of the wear scar;

Method “A” — Digital camera, and Method “B” — Visual observation. (Fig 3.7)

A sample of the fluid under test is placed in a test reservoir which is maintained at the specified test temperature. A fixed steel ball is held in a vertically mounted chuck and forced against a horizontally mounted stationary steel plate with an applied load. The test ball is oscillated at a fixed frequency and stroke length while the interface with the plate is fully immersed in the fluid. The metallurgies of the ball and plate, test fluid temperature, load, frequency, stroke length, and the ambient air conditions of temperature and humidity during the test are specified. The wear scar generated on the test ball is taken as a measure of the fluid lubricity.



Key

1	fluid reservoir	4	test plate
2	test ball	5	heating bath
3	test mass	6	oscillating motion

Figure 3.6: Schematic of the high-frequency reciprocating rig

4. IS 15770: 2008 LIGHT DIESEL OIL – SPECIFICATION LDO is used in medium and slow-speed diesel engines employed in earth-moving equipment, pump sets, power generation, marine engines, industrial applications, heating purposes, etc. Considering the fact that diesel engines are used in these applications, the requirements of LDO have been specified in this standard.

5. IS 16861: 2018 High Flash High-Speed Diesel Fuel — Specification It prescribes the requirements, sampling procedure, and test methods for High Flash High-Speed Diesel (HFHSD). It is mainly applicable for marine use, including use by the Indian Navy, Merchant Ships, fishing vessels, etc., where a high flash point diesel is required and also for use in

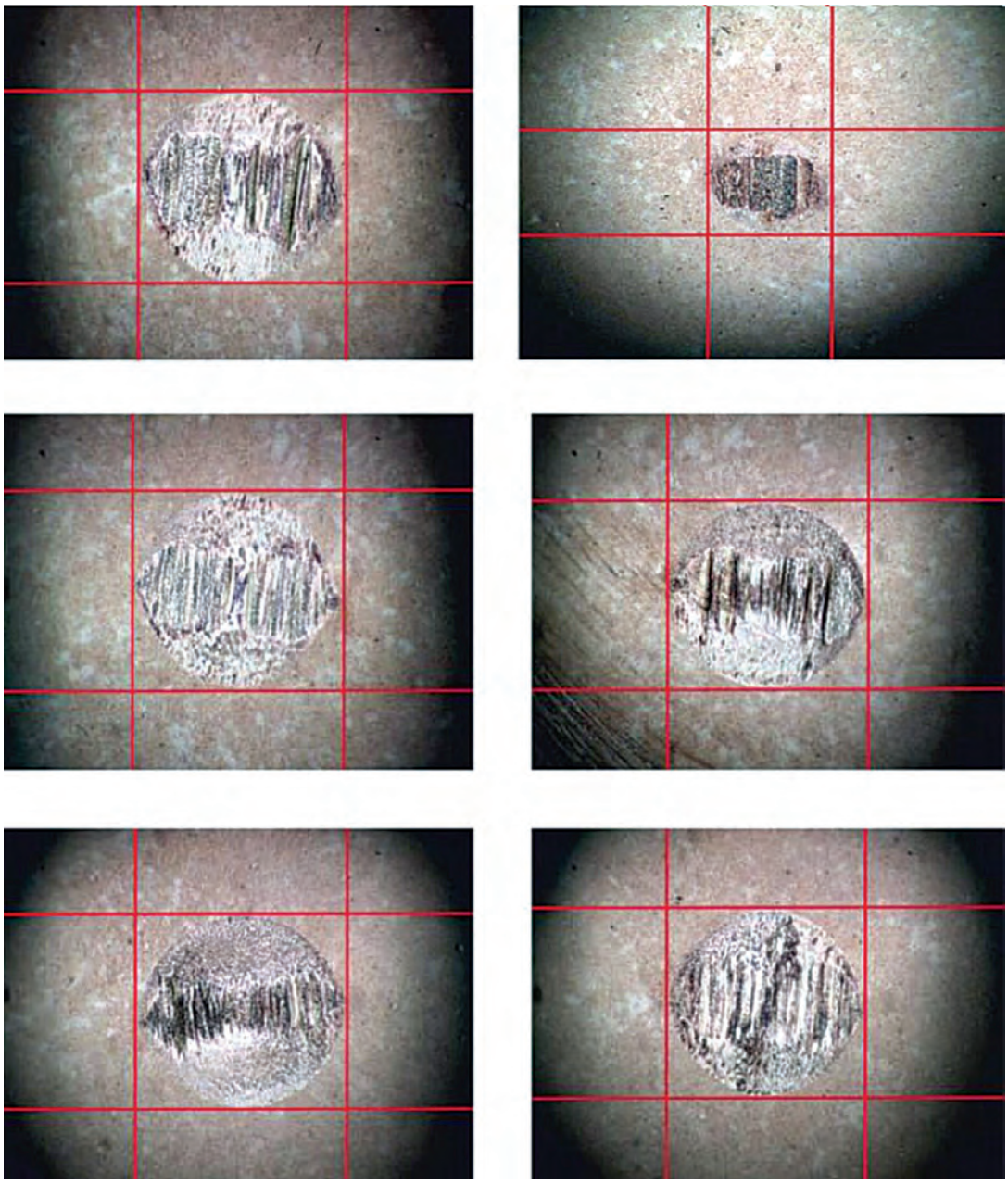


Figure 3.7: Examples of wear scars in HFRR test non-automotive purposes and in other compression ignition engines as well as stationary engines designed to run on this type of diesel fuel.

3.2.5 Gas oil and fuel oil

Gas oil is a distillate fraction that is intermediate in boiling range and viscosity between kerosene and lubricating oil, which is used as a fuel oil. More specifically, light gas oil (low-boiling gas oil) is typically the last fraction distilled from crude oil at atmospheric pressure (without thermal decomposition) while heavy gas oil (high-boiling gas oil) is the first fraction distilled from the atmospheric residuum of crude oil under reduced pressure (without thermal decomposition) (table 3.1 earlier).

Fuel oil is classified in several ways but generally may be divided into two main types: distillate fuel oil and residual fuel oil. Distillate fuel oil is vaporized and condensed during a distillation process and thus has a definite boiling range and does not contain high-boiling constituents. A fuel oil that contains any amount of residue from crude

distillation of thermal cracking is a residual fuel oil. The terms distillate fuel oil and residual fuel oil are losing their significance since fuel oil is now made for specific uses and may be either distillates or residuals, or mixtures of the two. The terms domestic fuel oil, diesel fuel oil, and heavy fuel oil are more indicative of the uses of fuel oils. Domestic fuel oil is fuel oil that is used primarily in the home. This category of fuel oil includes kerosene, stove oil, and furnace fuel oil; they are distillate fuel oils. It is also used as a carrier for pesticides, as a weed killer, as a mold release agent in the ceramic and pottery industry, and in the cleaning industry. It is found in asphalt coatings, enamels, paints, thinners, and varnishes.

The manufacture of fuel oil at one time largely involved using what was left after removing desired products from crude oil. Now fuel oil manufacture is a complex matter of selecting and blending various crude oil fractions to meet definite specifications, and the production of a homogeneous, stable fuel oil requires experience backed by laboratory control.

Heavy fuel oil comprises all residual fuel oils and the constituents range from distillable constituents to residual (nondistillable) constituents that must be heated to 260°C (500°F) or more before they can be used. The kinematic viscosity is above 10 cSt at 80°C (176°F). The flash point is always above 50°C (122°F) and the density is always higher than 0.900. In general, heavy fuel oil usually contains cracked residua, reduced crude, or cracking coil heavy product which is mixed (cut back) to a specified viscosity with cracked gas oils and fractionator bottoms. For some industrial purposes in which flames or flue gases contact the product (ceramics, glass, heat treating, and open hearth furnaces), fuel oils must be blended to contain minimum sulfur contents, and hence low-sulfur residues are preferable for these fuels. Stove oil, like kerosene, is always a straight-run fraction from suitable crude oils, whereas other fuel oils are usually a blend of two or more fractions, one of which is usually cracked gas oil. The straight-run fractions available for blending into fuel oils are heavy naphtha, light and heavy gas oils, reduced crude, and pitch. Cracked fractions such as light and heavy gas oils from catalytic cracking, cracking coil tar, and fractionator bottoms from catalytic cracking, may also be used as blends to meet the specifications of the different fuel oils. Since the boiling ranges, sulfur contents, and other properties of even the same fraction vary from crude oil to crude oil and with the way the crude oil is processed, it is difficult to specify which fractions are blended to produce specific fuel oils. In general, however, furnace fuel oil is a blend of straight-run gas oil and cracked gas oil to produce a product boiling in the 175°C to 345°C range.

All fuel oils consist of complex mixtures of aliphatic and aromatic hydrocarbons, the relative amounts depending on the source and grade of the fuel oil. The aliphatic alkanes (paraffins) and cycloalkane constituents (naphthene constituents) are hydrogen saturated and compose as much as 90% w/w of the fuel oil. Aromatic constituents (e.g., benzene) and olefin constituents compose up to 20% v/v and 1% v/v, respectively, of the fuel oils. Indian Standards related to fuel Oil and Gas oil are as follows:

1. IS 1593 : 2018 FUEL OILS — SPECIFICATION prescribes the requirements and the methods of sampling and test for fuel oils, essentially residual in character, for industrial uses. These fuel oils are primarily intended for oil fired furnaces. The low viscosity grade oil is suitable for use as diluents for creosote. four grades of the fuel oil have been defined : a) Grade LV :

Low viscosity b) Grade MV1 : Medium viscosity c) Grade MV2 : Medium viscosity and d) Grade HV : High viscosity

2. IS 15217:2002 FUEL OIL FOR DIESEL GENERATING SETS — SPECIFICATION It prescribes the requirements and methods of sampling and test for fuel oil for use in diesel generating set engines. 1.2 This specification provides guidance for interested parties, such as diesel generating set designers, suppliers and purchasers of DG set fuels. two grades depending on kinematic viscosity: a) FO DG Grade 1, and b) FO DG Grade 2 have been defined in this standard.

3. IS 17789 : 2022 GAS OIL — SPECIFICATION Gas oil is a middle distillate petroleum fraction derived out of crude/vacuum distillation unit (CDU/VDU), fluid catalytic cracking units (FCCU), coker or hydrocracker units in the refinery. It is also a liquid fraction recovered in the production of crude oil and natural gas. Gas oil is used as a blend component for diesel, steam cracking and for blending in heating oil, fuel oil and marine fuels. In some countries diesel oil is called as gas oil. This gas oil is a refinery intermediate with high sulphur quantity and need further refining for preparing diesel fuel, heating fuel, fuel oil or marine fuels. It is used as a diesel blend stock, feed for steam crackers and as a blend component in heating oil, fuel oil and marine fuels in the refineries.

4. IS 17792 : 2022 VACUUM GAS OIL (V G O) — SPECIFICATION Vacuum gas oil (VGO) is an output of vacuum distillation tower of petroleum distillation. It is a refinery intermediate product produced from various sources such as crude distillation, coker and hydrocracker. VGO is generally used by the refineries as a feedstock for 'fluid catalytic cracking units' (FCCU), as a product blend stock in 'residual fuel oil', 'marine fuel oils' and as a cutter stock in Bitumen. It can also be used as a petrochemical feedstock by steam crackers. VGO is also a precursor for the production of motor gasoline and diesel. It is also used in steam cracking. If a refinery lacks enough cracking to upgrade the VGO it generates, it will sell this as an intermediate to another refinery.

3.2.6 Lubricating Oil

After kerosene the early crude oil refiners wanted paraffin wax for the manufacture of candles, and lubricating oil was, at first, byproduct of wax manufacture. The preferred lubricants in the 1860s were lard oil, sperm oil, and tallow. The demand that existed for kerosene did not develop for crude oilederived lubricating oils. In fact, oils were used to supplement the animal and vegetable oils used as lubricants. However, as the trend to heavier industry increased, the demand for mineral lubricating oils increased, and after the 1890s crude oil displaced animal and vegetable oils as the source of lubricants for most purposes.

Mineral oils are often used as lubricating oils but also have medicinal and food uses. A major type of hydraulic fluid is the mineral oil class of hydraulic fluids. The mineral-based oils are produced from the high-boiling crude oil distillates. Hydrocarbon numbers ranging from C_{15} to C_{50} occur in the various types of mineral oils, with the higher-boiling distillates having higher percentages of the higher carbon number compounds.

Crankcase oil (motor oil) may be either mineral-based or synthetic. The mineral-based oils are more widely used than the synthetic oils and may be used in automotive engines, railroad and truck diesel engines, marine equipment, jet and other aircraft engines, and most small 2- and 4-stroke engines. The mineral-based oils contain hundreds to thousands of hydrocarbon compounds, including a substantial fraction of nitrogenand sulfurcontaining compounds. The hydrocarbons are mainly mixtures of straight and branched chain hydrocarbons (alkanes), cycloalkanes, and aromatic hydrocarbons. Polynuclear aromatic hydrocarbons (and the alkyl derivatives) and metal-containing constituents are components of motor oils and crankcase oils, with the used oils typically having higher concentrations than the new unused oils. Typical carbon number chain lengths range from C_{15} to C_{50}.

The production of lubricating oils is well established and consists of four basic processes: (i) distillation to remove the lower boiling and lower molecular weight constituents of the feedstock, (ii) solvent refining, such as deasphalting, and/or hydrogen treatment to remove the nonhydrocarbon constituents and to improve the feedstock quality, (iii) dewaxing to remove the wax constituents and improve the low-temperature properties, (iv) and clay treatment or hydrogen treatment to prevent instability of the product. Chemical, solvent, and hydrogen refining processes have been developed and are used to remove aromatics and other undesirable constituents, and to improve the viscosity index and quality of lube base stocks. Traditional chemical processes that use sulfuric acid and clay refining have been replaced by solvent extraction/refining and hydrotreating which are more effective, cost efficient, and generally more environmentally acceptable. Chemical refining is used most often for the reclamation of used lubricating oils or in combination with solvent or hydrogen refining processes for the manufacture of specialty lubricating oils and byproducts.

Lubricating oil is distinguished from other fractions of crude oil by their usually high (>400°C, >750°F) boiling point, as well as their high viscosity. Materials suitable for the production of lubricating oils are comprised principally of hydrocarbons containing from 25 to 35 or even 40 carbon atoms per molecule, whereas residual stocks may contain hydrocarbons with 50 or more (up to 80 or so) carbon atoms per molecule. The composition of lubricating oil may be substantially different from the lubricant fraction from which it was derived, since wax (normal paraffins) is removed by distillation or refining by solvent extraction and adsorption preferentially removes nonhydrocarbon constituents as well as polynuclear aromatic compounds and the multiring cycloparaffins.

Lubricating oil may be divided into many categories according to the types of service they are intended to perform. However, there are two main groups: (i) oils used in intermittent service, such as motor and aviation oils, and (ii) oils designed for continuous service, such as turbine oils. Lubricating oil is distinguished from other fractions of crude oil by a high (>400°C, >750°F) boiling point, as well as a high viscosity and, in fact, lubricating oil is identified by viscosity.

Oils used in intermittent service must show the least possible change in viscosity with temperature; that is, their viscosity indices must be high. These oils must be changed at frequent intervals to remove the foreign matter collected during service. The stability of such oils is therefore of less importance than the stability of oils used in continuous service for prolonged periods without renewal. Oils used in continuous service must be extremely stable, but their viscosity indices may be low because the engines operate

at fairly constant temperature without frequent shutdown. Following are the Indian Standards related to Lubricating Oil:

1. IS 1012:2002 TURBINE LUBRICATING SPECIFICATION It prescribes the requirements and methods of sampling and testing for lubricating oils intended for use as lubricants and control fluids in steam, gas and hydroturbine systems at ambient temperatures of 0°C and above. The lubricating oil shall falling one of the following four grades as defined in IS 9466: a) VG32, b) VG46, C) VG 68, and d) VG 100. The lubricants are defined as of the following two performance types: a) b) Turbine Oil, Rust and Oxidation (R&O) Type — lt is intended to be used in turbine lubricating system where the machinery does not require lubricants with enhanced load carrying capacity. Turbine Oil, EP Type — It is intended to be used in turbine lubricating systems where the machinery requires lubricants with enhanced load carrying capacity. Each of these two types is further sub-divided into two categories, namely 'Normal' and 'Superclean' depending upon the cleanliness level.

2. IS 1448 [P : 65] : 2018 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 65] OXIDATION TEST FOR LUBRICATING OILS covers the test method for the determination of tendency of lubricating oil to deteriorate on oxidation under specified conditions. A measure of the deterioration is obtained by comparison of the viscosity and carbon residue before and after oxidation. The test is not suitable for additive-type oils (other than those containing ashless additives) or those which form solid products or lose more than 10 percent by evaporation during the test. The method defined is based on gravimetric analysis.(Figure 3.8 and Figure 3.9)

3. IS 1448 [P: 67]: 2020 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P: 67] PETROLEUM PRODUCTS DETERMINATION OF FOAMING CHARACTERISTICS OF LUBRICATING OILS Foaming in lubricating oil can reduce lubrication, cause oxidation, and damage cavitation. It can also cause the oil to age, which can lead to polar product formation, increased viscosity, and loss of anti-foaming properties. The standard describes a method for the determination of foaming characteristics of lubricating oils at specified moderate temperatures. It is applicable to lubricants which may or may not contain additives to modify or suppress the tendency to form stable foams. The ratings used to describe the foaming tendency and/ or stability are empirical. The test portion, maintained at 24 ± 0.5°C, is blown with air at a constant rate for 5 min, then allowed to settle for 10 min. The volume of foam is measured at the end of each period. The test is repeated on a second test portion at 93.5°C, and then, after collapsing the foam, at 24 ± 0.5°C.

4. IS 1448 [P : 95] : 2019 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 95] DETERMINATION OF DEMULSIBILITY CHARACTERISTICS OF LUBRICATING OILS When a petroleum oil is mixed with water, it usually separates upon standing. The presence of minute contaminating materials decreases the rate of separation and may cause

formation of stable emulsions. For liquids, an emulsion is the suspension of small globules of one in the other. For some special purposes, it is desirable that an oil form a relatively stable emulsion with water. However, for most other purposes, it is important that the oil separates rapidly and completely from the water. This usually happens when steam or water

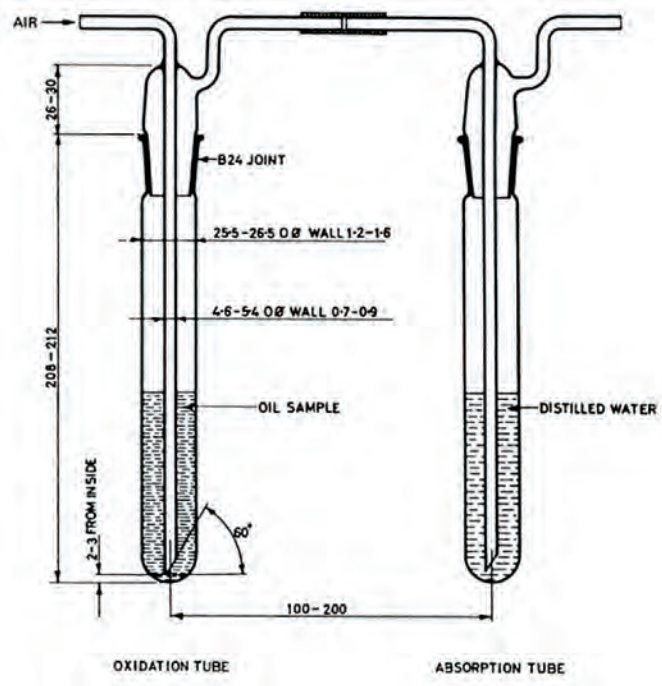


Figure 3.8: Oxidation and absorption tubes used in the test

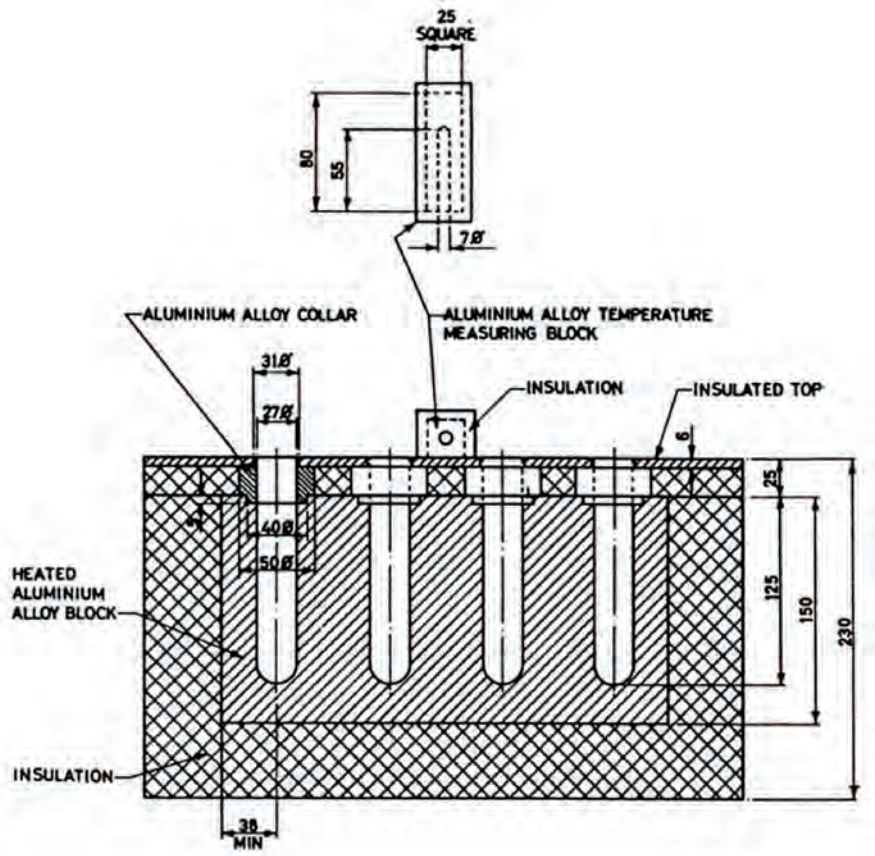


Figure 3.9: Typical Metal Heating bath used for oxidation test

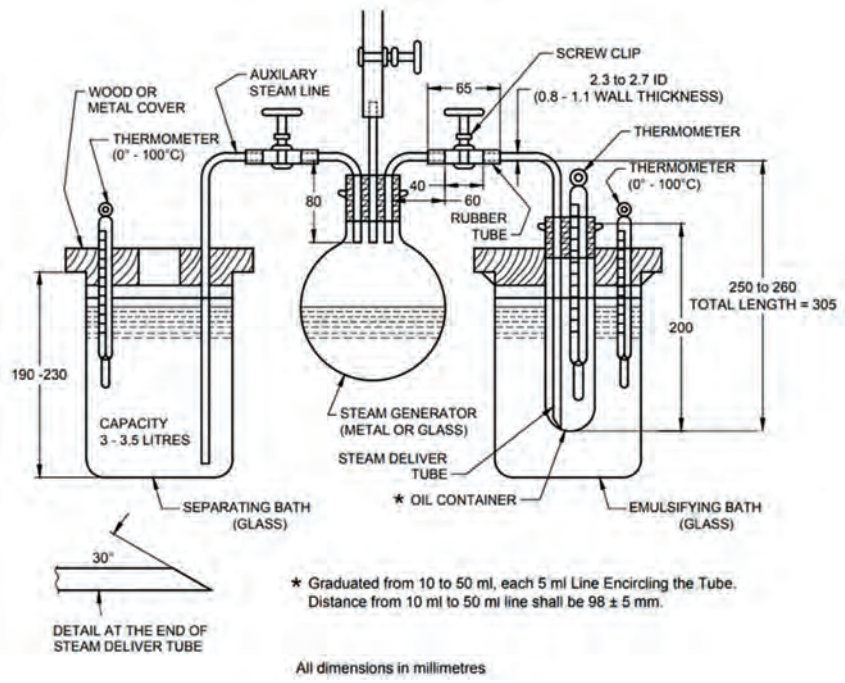


Figure 3.10: Apparatus For Determination of Emulsification number

leaks into the oil system. Various standards are available for testing the quality of oils in the respect. One such standard is the "Demulsification Number" which is also known as the "Steam Emulsion Number" and the unit of measurement is 'sec'. In this method, steam is passed into the sample under definitely prescribed conditions. The time in seconds that is, required for complete separation of the oil and condensed steam is the steam emulsion number of the sample. The test is sensitive to certain foreign materials but cannot be used to determine cleanliness because there materials have widely variable effects on the Steam Emulsion Number.

The test for steam emulsion is important for turbine oils because they frequently come in contact with water or steam as the oil flows through the circulation system. If the oil and water form a permanent emulsion, it will reduce the effectiveness of lubrication and contribute to the formation of water and sludge. Such emulsions may be due to impurities dissolved in the oil, or to the condition of the system into which the oil is introduced or to contamination such as fly ash from the air. When a new oil is put into an installation, it is important that the circulating system be clean, free of residual rust preventives, sludge, or other coatings from previous services. Steam emulsion numbers determined on turbine oils inhibited against oxidation and rust formation are unreliable as shown by correlation with results obtained in service. The method for steam emulsion number is used only occasionally for other oils. Its value depends upon the type of oil and, at best, its correlation with service is no better than for turbine oils.

5. IS 1448 (Part 101) : 1980 Methods of test for petroleum and its products (P 101) colorimetric determination of phosphorus in lubricating oils: The method in the standard is used for determination of low concentrations of phosphorous in lubricating oils. Metallic elements such as iron, lead, magnesium and barium in amounts commonly encountered in lubricating oils do not interfere. Organic matter in the sample is destroyed by ignition

in presence of zinc oxide. The residue is dissolved in sulfuric acid and a proportion of the solution is reacted with ammonium molybdate and hydrazine sulphate. The intensity of the resultant colour is proportional to the amount of phosphorous present and is measured with photoelectric colorometer.

6. IS : 1448 [P : 103]- 1981 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P:103] BARIUM, CALCIUM, PHOSPHORUS AND ZINC IN LUBRICATING OILS BY DIRECT READING EMISSION SPECTROGRAPHIC METHOD the method intended for the routine determination of barium calcium, phosphorus, and zinc in unused lubricating oils and is suitable for the concentration range 0.01 to 0.5 percent m/m of the elements, provided that the nature of all the additives present is known. The sample is sparked between graphite electrodes, the upper electrode being a rod having a conical end, while the lower electrode is a rotating disc, the lower edge of which dips into the oil and feeds a continuous film into the spark gap. A direct reading spectrograph is used to measure the emission of selected radiations, and the measurements are converted to element concentrations by reference to appropriate calibration curves.

7. IS 1448[P:107]-1982 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P: 107) PRECIPITATION NUMBER OF LUBRICATING OILS: Precipitation number is the number of millilitres of precipitate formed when 10 ml of lubricating oil is mixed with 90 ml of precipitation naphtha, and centrifuged under prescribed conditions.

   Fully refined petroleum oils normally contain no naphtha insoluble material. Semi-refined or black oils frequently contain some naphtha insoluble material (sometimes referred to as asphalts). This test measures the amount of naphtha insoluble material in the oil. This quantity is reported as the precipitation number.

8. IS 1448 [P : 129] : 2018 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 129] DETERMINATION OF POLYMERIC CONTENT IN LUBRICATING OILS BASE STOCK Polymeric additives are used in modern lubricants, especially motor oils, to modify viscosity characteristics. These additives can include acrylic acid, methacrylic acid, acrylic acid esters, acrylonitrile, acrylamide, cyanoacrylates, and copolymers of these compounds. The sample is taken in a suitable rubber membraneand is dialyzed/extracted with hothexane for 16 h period. After this period, the residue is collected in a 250 ml beaker followed by evaporation of solvent on water bath and finally in vacuum oven. The amount of residue obtained is reported as the percent of polymer present in the oil.

9. IS 1448 [P : 136 1 : 1991 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P:136] DETERMINATION OF EVAPORATION LOSS OF LUBRICATING OILS (NOACKS METHOD) The evaporation loss is of particular importance in motor and cylinder lubrication. With high temperatures encountered a high evaporation loss may tantamount to an increased oil consumption and may lead to a change in the properties of the oil. It is defined as the reduction in mass of the oil in percent occuring under standard condition.

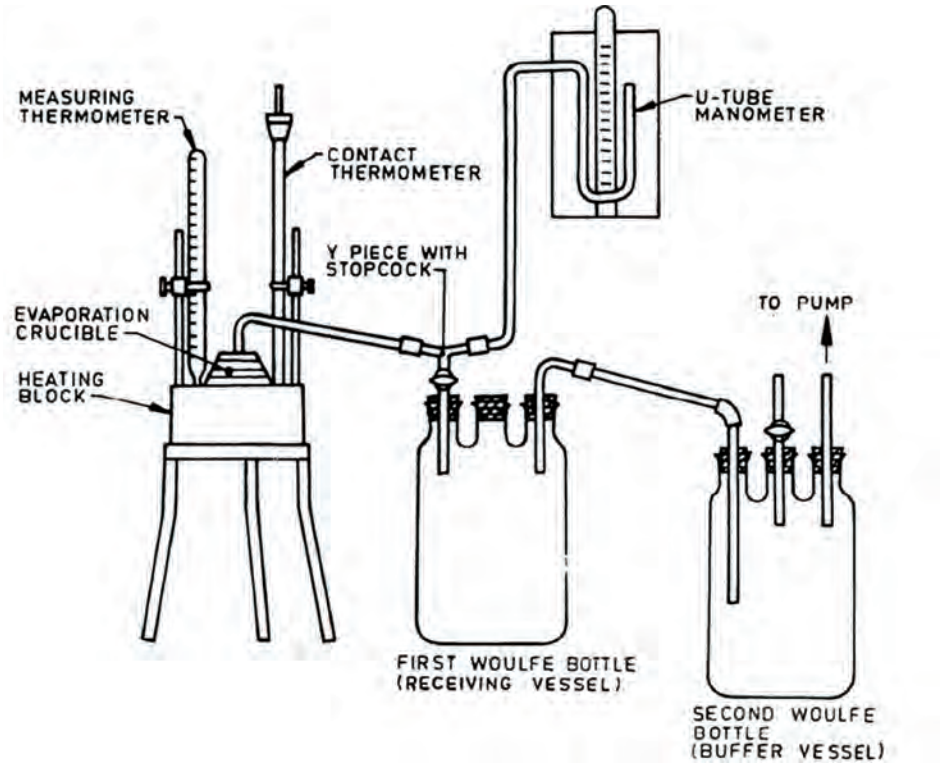


Figure 3.11: TESTING APPARATUS FOR DETERMINING THE EVAPORATION LOSS OF LUBRICATING OILS

10. IS 1448 (Part 187) : 2021 ISO 3987 : 2010 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS PART 187 PETROLEUM PRODUCTS — DETERMINATION OF SULFATED ASH IN LUBRICATING OILS AND ADDITIVES The sulfated ash may be used to indicate the concentration of known metal-containing additives in new lubricating oils. When phosphorus is absent, barium, calcium, magnesium, sodium and potassium are converted to their sulfates, and tin (IV) and zinc to their oxides. Sulfur and chlorine do not interfere, but when phosphorus is present with metals, it remains partially or wholly in the sulfated ash as metal phosphates.

Application of this procedure to sulfated ash levels below 0.02 % (m/m) is restricted to oils containing ashless additives. The lower limit of applicability of the procedure is 0.005 % (m/m) sulfated ash.The sample of unused lubricating oil is ignited and burned until only ash and carbon remain. After cooling, the residue is treated with sulfuric acid and heated at 775°C until oxidation of carbon is complete. The ash is then cooled, retreated with sulfuric acid, and heated at 775 °C to constant mass. The mass percentage of sulfated ash obtained is then calculated.

11. IS 17382 : 2021 SYN GAS/AMMONIA TURBO COMPRESSOR LUBRICATING OILS — SPECIFICATION Ammonia is produced by combining nitrogen and hydrogen at high pressures and temperatures. At the heart of an ammonia plant is the turbo-machinery, that is, compressors to raise the pressure of the process media – process air, synthesis gas and ammonia – together with the compressor drivers, which are normally steam turbines. In the compressor lubrication systems, the oils are used to lubricate bearings

and couplings of the hydraulic control systems and sealing systems for compressors.The production of high grade ammonia requires elimination of contaminants including lubricants. Turbo compressor oil is high performance rust and oxidation inhibited lubricant specially designed for the lubrication of turbo compressors in ammonia compression systems. These oils are formulated with a special non-acidic rust inhibitor designed to help resist harmful ammonia soap formation in high speed gearboxes and couplings.

Keeping in view the limited compatibility of ammonia with mineral oils, there is a tendency for sludge formation under certain operating conditions in turbo-compressors. Hence a need is felt to frame a specification to address this issue by incorporating modified thermo-oxidation stability test in the presence of ammonia to ascertain suitability of mineral oil based lubricant, for ammonia turbo-compressor application, mainly in fertilizer/chemical plants.

12. IS 4578 : -1997 LUBRICANTS - LUBRICATING OIL FOR REFRIGERATION MACHINERY – SPECIFICATION The primary function of a refrigeration oil is to lubricate, either through splash or forced feed, the pistons or rotors and the bearings of the refrigeration compressor and to serve as a sealing medium. It also serves as an additional cooling medium to dissipate heat of motor windings in case of hermetically sealed compressor units. Unavoidably the oil comes in contact with the refrigerant and is thus exposed to cold as well as relatively hot discharge temperature in the refrigeration system. There are various kinds of refrigerants used in the present-day refrigerating machinery. Thus, the refrigeration oil should not only be a suitable lubricant for compressor mechanism, but it should also not react with the refrigerant in any way.

The oils should have satisfactory low temperature as well as relative high temperature characteristics, so that these will not tend to reduce heat transfer or produce clogging by congealing, oil-logging or forming waxy deposits in the capillary tube restrictor or expansion valve and other passages of the refrigeration system. They should not decompose, chemically react with component parts, motor winding insulations or, flash and fire at relatively higher temperatures normally occurring in the system. Thus, resistance to formation of wax haze at low temperatures, pour point and foaming are some of the important characteristics of refrigeration oils. The exclusion of moisture from these oils is important to prevent corrosion, refrigerant decomposition and any ice formation in the system.

3.3 Other Products

3.3.1 Wax

Crude oil-derived wax (paraffin wax or petroleum wax) is a soft colourless solid, derived from crude oil which consists of a mixture of hydrocarbon derivative molecules containing between 20 and 40 carbon atoms. The wax is solid at room temperature and begins to melt above approximately 37°C (99°F) with a boiling point of > 370°C (700°F). The crude oil-derived wax is of two general types: (i) paraffin wax in crude oil distillates and (ii)

microcrystalline wax in crude oil residua. The melting point of wax is not directly related to the boiling point because waxes contain hydrocarbon derivatives of different chemical nature. Nevertheless, waxes are graded according to their melting point and oil content.The feedstock for paraffin is slack wax which is a mixture of oil and wax, a byproduct from the refining of lubricating oil. The first step in making paraffin wax is to remove the

3.3 Other Products

Oil (deoiling or dewaxing) from the slack wax which is wax from a solvent dewaxing operation and the processes employed for the production of waxes are aimed at deoiling the slack wax (petroleum wax concentrate)

The oil is separated by crystallization. Most commonly, the slack wax is heated, mixed with one or more solvents such as a ketone derivative, and then cooled. As it cools, wax crystallizes out of the solution, leaving only oil. This mixture is filtered into two streams: solid (wax plus some solvent) and liquid (oil and solvent). After the solvent is recovered by distillation, the resulting products are called “product wax” (or “press wax”) and “foots oil.” The lower the percentage of oil in the wax, the more refined it is considered (semirefined vs. fully refined). The product wax may be further processed to remove colors and odors. The wax may finally be blended together to give certain desired properties such as melt point and penetration. Paraffin wax is sold in either liquid or solid form.

Paraffin wax is a solid crystalline mixture of straight-chain (normal) hydrocarbons ranging from C_{20}toC_{30} and possibly higher, that is, $CH_3(CH_2)nCH_3$ where *n*e” 18. It is distinguished by its solid state at ordinary temperatures (25°C, 77°F) and low viscosity (35-45 SUS at 99°C, 210°F) when melted. However, in contrast to petroleum wax, petrolatum (petroleum jelly), although solid at ordinary temperatures, does, in fact, contain both solid and liquid hydrocarbons. It is essentially a low-melting, ductile, microcrystalline wax.

Although many natural waxes contain esters, paraffin waxes are hydrocarbon derivatives, mixtures of alkane derivatives usually in a homologous series of chain lengths. These materials represent a significant fraction of crude oil and are refined by vacuum distillation. Paraffin waxes are mixtures of saturated n- and iso-alkanes, naphthenes, and alkyl-substituted and naphthene-substituted aromatic compounds. A typical alkane paraffin wax’s chemical composition comprises hydrocarbons with the general formula CnH2nþ2. The degree of branching has an important influence on the properties. Petroleum waxes (and petrolatum) find many uses in pharmaceuticals, cosmetics, paper manufacturing, candle making, electrical goods, rubber compounding, textiles, and many others. BIS has formulated following standards on wax:

1. IS 13833 : 2019 MICROCRYSTALLINE WAX DERIVED FROM PETROLEUM — SPECIFICATION microcrystalline wax are used for pharmaceuticals, cosmetics, packaging and various other industrial and general-purpose uses.

2. IS 1448 [P : 114] : 2019 ISO 2207 : 1980 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 114] PETROLEUM WAXES — DETERMINATION OF CONGEALING POINT Congealing point is the

temperature at which molten petroleum wax ceases to flow. At this temperature the wax may be at or close to the solid phase, or it may be semi-solid and quiet unctuous. In this test a test portion of wax is melted and droplet is made to adhare to the bulb of thermometer. Using a pre-warmed flask as an air-jacket, the droplet on the bulb is allowed to cool at fixed rate until it congeals. The congealing point is the temperature at which the droplet ceases to flow as the thermometer is turned.

3. IS 4654 : 2019 PARAFFIN WAX — SPECIFICATION paraffin wax are used for waxing paper, making candles, impregnating match sticks and for other general uses.

CHAPTER IV

LINKING CURRICULU WITH STANDARDS

CHAPTER IV

LINKING CURRICULU WITH STANDARDS

In this chapter, we will discuss various theories and test methods mentioned in the undergraduate and postgraduate Chemical/Petroleum Engineering curricula of various Technical Institutes, utilizing available Indian Standards related to petroleum products. These topics are taught in both classes and lab sessions. We will cover properties of gaseous and liquid fuels, such as Reid Vapor Pressure, Gum Content, Smoke Point, Flash Point, Aniline Point, Ramsbottom Carbon Residue, and Orsat

Analysis of gaseous contents. Additionally, we will explore the subject of DISTILLATION OF PETROLEUM PRODUCTS, which is taught in Mass Transfer subject at various institutes. We will also examine standards pertaining to Calorimeter properties. Furthermore, we will discuss other topics including different types of storage systems, the types and features of storage tanks, as well as fixed roof and floating roof tanks. In the annexures of this book, we have incorporated the properties of various fuels such as natural gas, gasoline, LPG, and diesel fuels.

4.1 Fuel Laboratory

The Fuel Laboratory session involves the examination of various properties and test methods applicable to a wide range of fuels. Typically, the following practical lab sessions are conducted covering the following topics: Liquid fuels: ASTM distillation, Reid vapour pressure (RVP), Gum content (existent), Smoke point, Aniline point, Flash point, Moisture content by Dean and Stark method, Kinematic viscosity by Redwood viscometer, Pour point, Conradson/Ramsbottom Carbon residue. Gaseous fuels: Orsat analysis, Calorific Value by Junkers calorimeter. There are various Indian standards available for most of these subjects, which can be integrated into these lab sessions to further enhance the learning experience.

4.1.1 ASTM Distillation

IS 1448 (Part 18) : 2020 METHOD OF TEST FOR PETROLEUM AND ITS PRODUCTS Part 18 DISTILLATION OF PETROLEUM PRODUCTS: The boiling range gives information on the composition, the properties, and the behaviour of the fuel during storage and use. Thus the distillation that is, volatility characteristics of hydrocarbon have an important effect on their safety and performance. Volatility is the major determinant of the tendency of a hydrocarbon mixture to produce potentially explosive vapours.

The distillation characteristics are critically important for both automotive and aviation gasolines, affecting starting, warm-up, and tendency to vapour lock at high operating temperature or at high altitude, or both. The presence of high boiling point components in these and other fuels can significantly affect the degree of formation of solid combustion deposits. Volatility, as it affects rate of evaporation, is an important factor in the application of many solvents, particularly those used in paints.

This method of test covers the distillation of motor gasoline, ethanol fuel blends with greater than 10 percent volume ethanol, diesel fuels, biodiesel blends upto 20 percent biodiesel, aviation gasoline, aviation turbine fuels, special boiling point spirits, napthas, white spirit, kerosene, gas oils, distillate fuel oils and similar petroleum products.

This method of test covers a laboratory test method for the atmospheric distillation, utilizing either manual or automated equipment, to determine the boiling range of light and middle distillates derived from petroleum and having initial boiling points (IBP) above 0°C and end points below approximately 400°C, automotive spark ignition engine fuels with or without oxygenates, burner fuels and marine fuels that have no appreciable quantities of residue.

The sample is placed in one of the four groups, based on its composition, vapour pressure, expected initial boiling point (IBP) or expected final boiling point (FBP). The apparatus arrangement, condenser temperature and other operational variables are defined by the group in which the sample falls. A 100 ml test portion is distilled under the specified conditions appropriate to the group into which the sample falls, and systematic observations of thermometer readings and volumes of condensate recovered are made. The volume of the residue in the flask is measured, and the loss on distillation recorded. The thermometer readings are corrected for barometric pressure and from the data, the results of the test are calculated and reported as per specification requirement. Test results are commonly expressed as percent evaporated or percent recovered versus corresponding temperature, either in a table or graphically, as a plot of the distillation curve.

4.1.2 Reid vapour pressure (RVP)

IS 1448 [P : 39] : 2012 ISO 3007 : 1999 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 39] DETERMINATION OF VAPOUR PRESSURE — REID METHOD

Reid vapour pressure is absolute vapour pressure exerted by a liquid under the specific conditions of test temperature, vapour:liquid ratio, and air and water saturation described in this Standard.

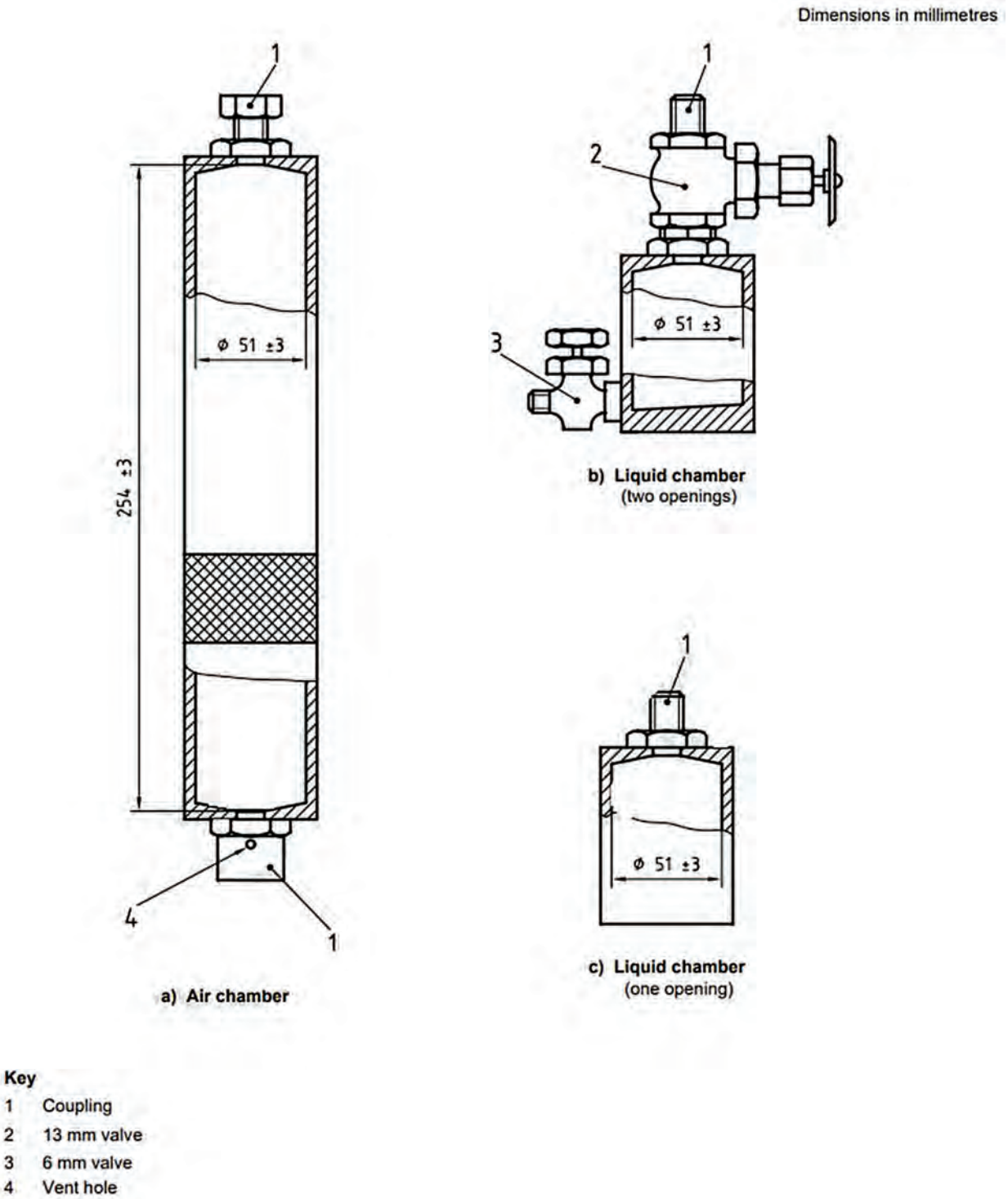
Vapour pressure is an important physical property of volatile liquids, and has critical performance implications for automotive and aviation gasolines. Vapour pressure is also one of the properties affecting atmospheric evaporation, and is therefore increasingly used in regulations relating to emissions and air quality control. Vapour pressure is also a critical property limiting the performance and safety of operation of equipment during transfer operations.

The liquid chamber of the Reid vapour-pressure apparatus is filled with the chilled sample and connected to the vapour chamber that has been preheated to 37.8 °C. The assembled apparatus is immersed in a bath at 37.8 °C until constant pressure is observed. The pressure reading, corrected if necessary, is the Reid vapour pressure.

4.1.3 Gum content

IS 1448 (Part 29) : 2021 ISO 6246 : 2017 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS PART 29 PETROLEUM PRODUCTS — GUM CONTENT OF

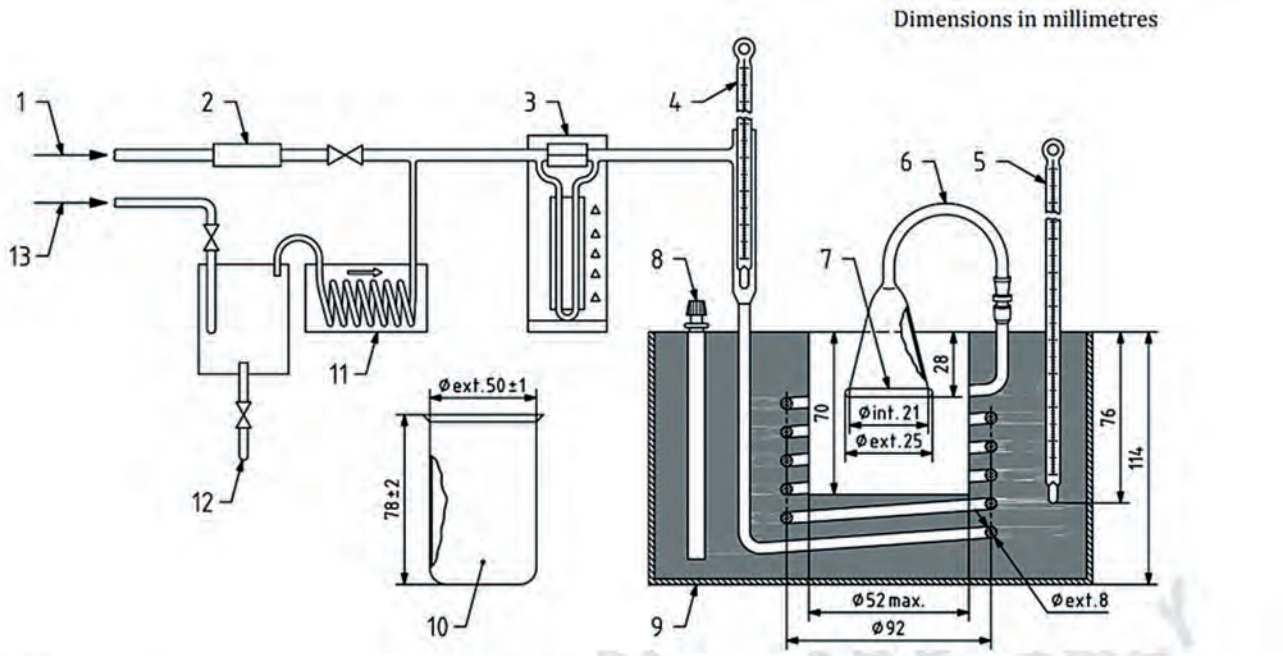
FUELS — JET EVAPORATION METHOD It has been proven that high gum content can cause induction-system deposits and sticking of intake valves, and in most cases, it can be assumed that



Key

1 Coupling
2 13 mm valve
3 6 mm valve
4 Vent hole

Figure 4.1: Reid vapour-pressure apparatus low gum content will ensure absence of induction-system difficulties. The primary purpose of the test, as applied to motor gasoline, is the measurement of the oxidation products formed in the sample prior to or during the comparatively mild conditions of the test procedure. Since many kinds of motor gasoline are purposely blended with non-volatile oils or additives, the heptane extraction step is necessary to remove these from the evaporation residue so that the deleterious material, gum, can be determined. With respect to aviation turbine fuels, large quantities of gum are indicative of contamination of fuel by higher boiling oils or particulate matter and generally reflect poor handling practices in distribution downstream of the refinery.



Key

1	air supply	8	thermo-regulator
2	cotton or glass wool filter	9	metal, black bath
3	flow indicator	10	beaker
4	thermometer and thermometer well (optional)	11	super heater
5	thermometer	12	steam trap
6	removable adaptor	13	steam supply
7	copper or stainless steel screen, (500 - 600) µm		

Figure 4.2: Apparatus for determining gum content by jet evaporation

A measured test portion of fuel is evaporated under controlled conditions of temperature and flow of air or steam. The resulting residue is weighed and may be subject to further treatment by solvent washing and further weighing.

4.1.4 Smoke Point

IS 1448 (Part 31) : 2017 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 31] DETERMINATION OF SMOKE POINT: Smoke Point is The maximum height, in millimetres, of a smokeless flame of fuel burned in a wick-fed lamp of specified design.

The sample is burned in an enclosed wick-fed lamp that is calibrated daily against pure hydrocarbon blends of known smoke point. The maximum height of flame that can be achieved with the test fuel without smoking is determined to the nearest 0.5 mm. It is quantitatively related to the potential radiant heat transfer from the combustion products of the fuel.

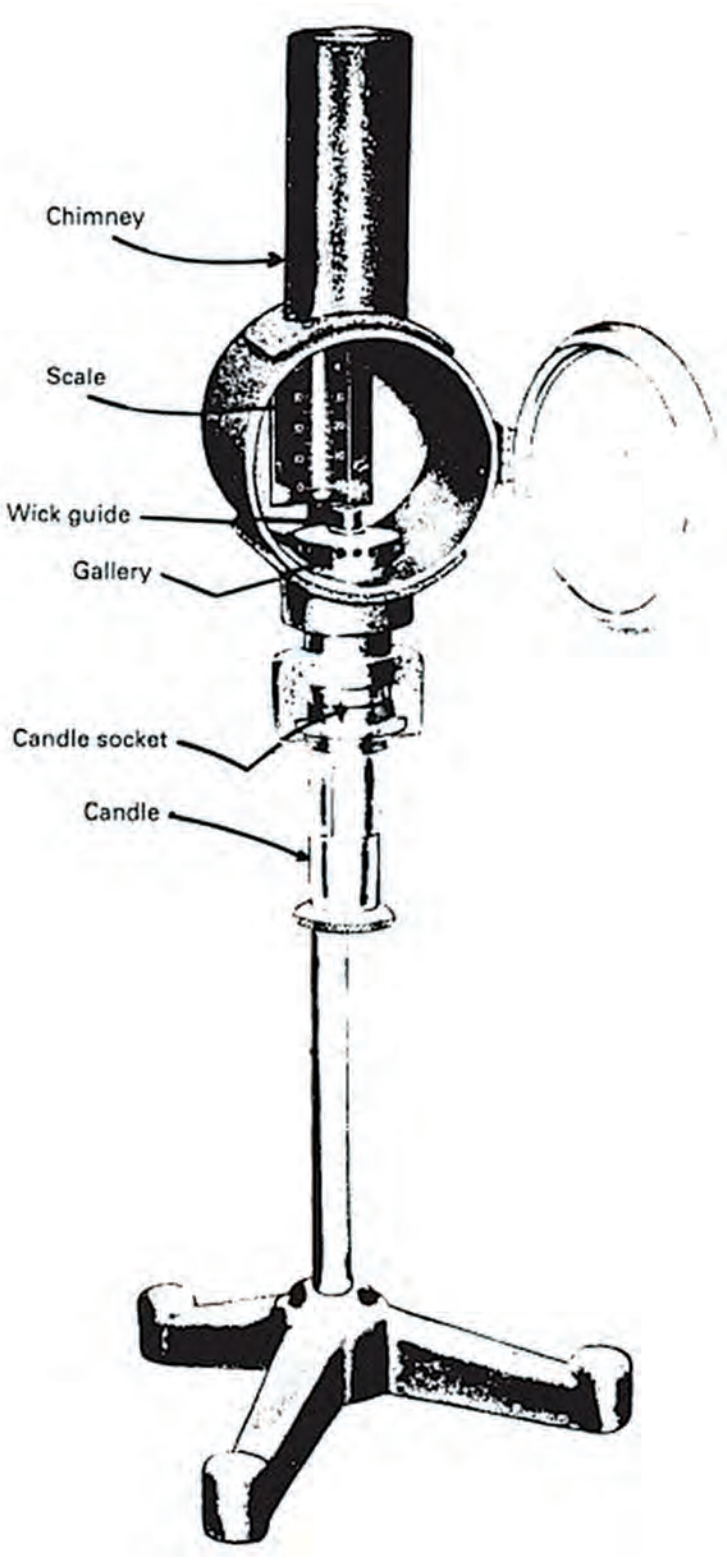


Figure 4.3: Smoke point Lamp

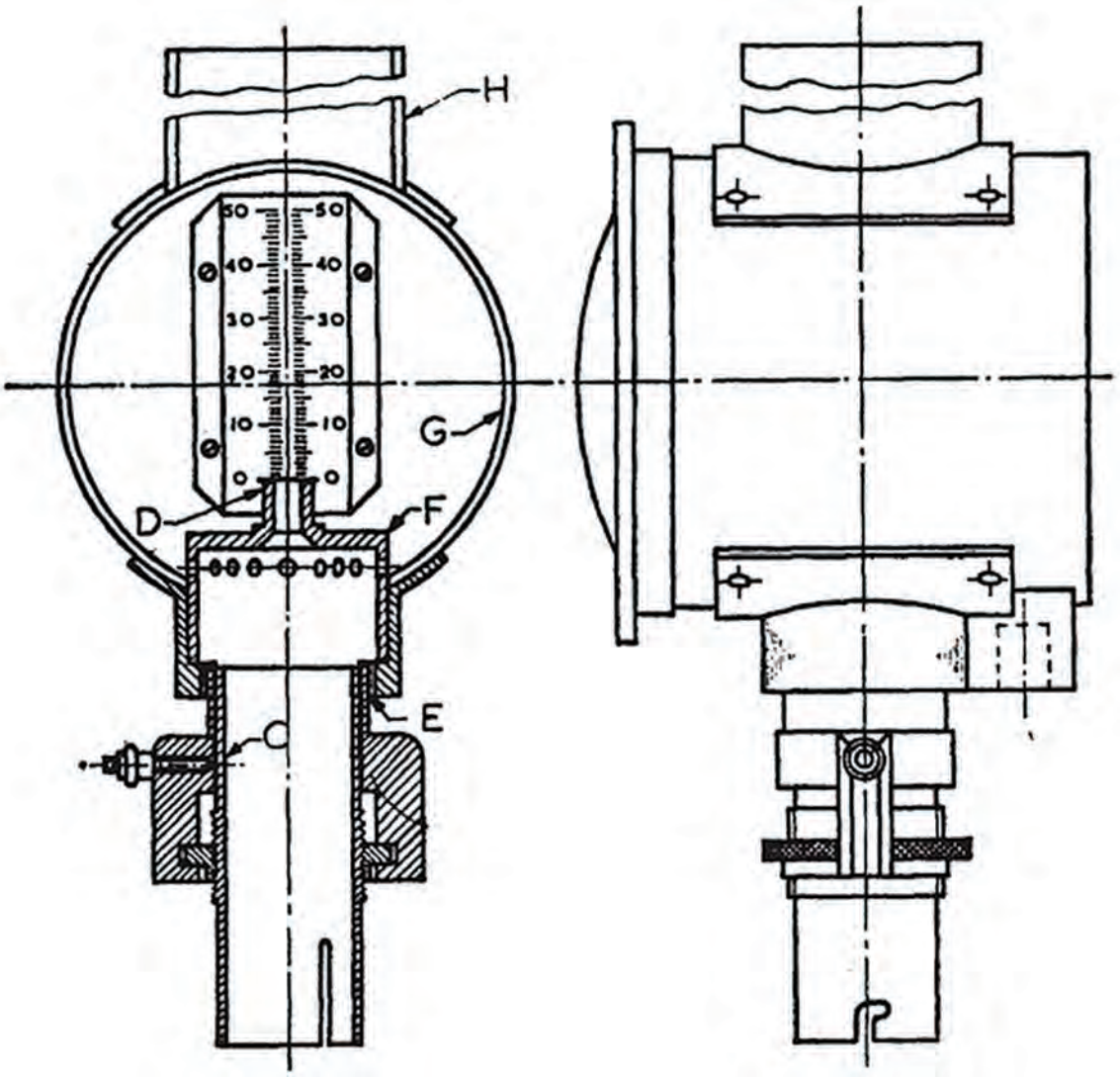


Figure 4.4: Lamp

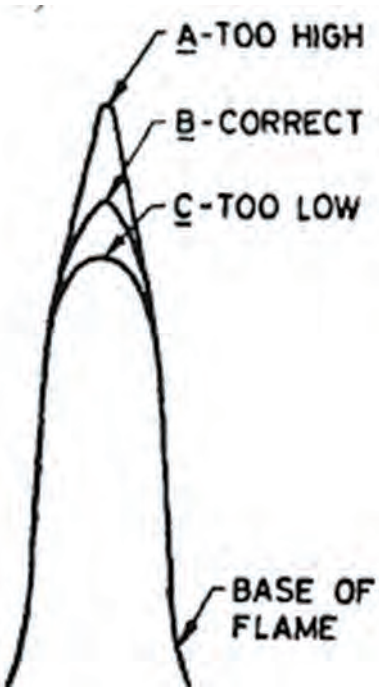


Figure 4.5: TYPICAL FLAME APPEARANCE

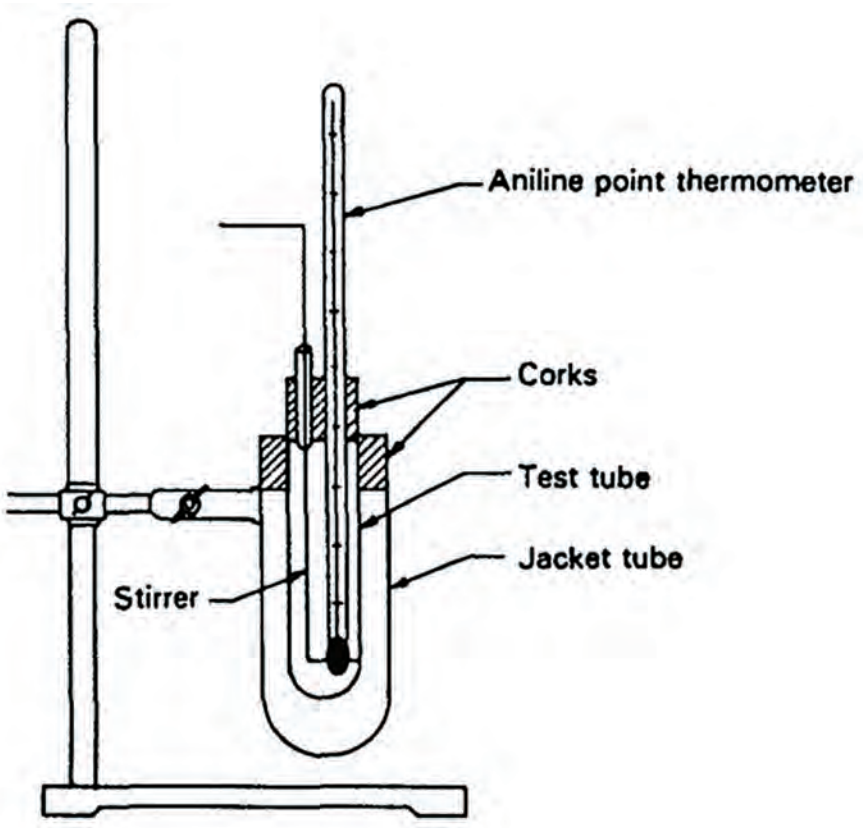


Figure 4.6: Apparatus for method 1 of Aniline Point Determination

4.1.5 Aniline Point

IS 1448[P:3] :2007 ISO 2977:1997 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P:3] PETROLEUM PRODUCTS AND HYDROCARBON SOLVENTS — DETERMINATION OF ANILINE POINT AND MIXED ANILINE POINT Aniline point is

The minimum equilibrium solution temperature, in degrees Celsius, of a mixture of equal volumes of aniline and the product under test 5 methods are prescribed in the standards.

1. Method 1 applicable to clear, light-coloured samples and to samples not darker than 6.5 by ISO2049, having initial boiling points well above the expected aniline point.(Figure 4.6)

2. Method 2 is applicable to Iight-coloured samples, to moderately dark samples, and to very darksamples.(Figure 4.7)

3. Method 3 is applicable to clear samples and to samples not darker than 6.5 by ISO 2049, havinginitial boiling points sufficiently low to give incorrect aniline point readings by method 1.(Figure 4.8)

4. Method 4 is a small-scale method, applicable to the same type of sample as method 3, and isapplied when only limited quantities of sample are available.

5. Method 5 is applicable when using automated or automatic apparatus.

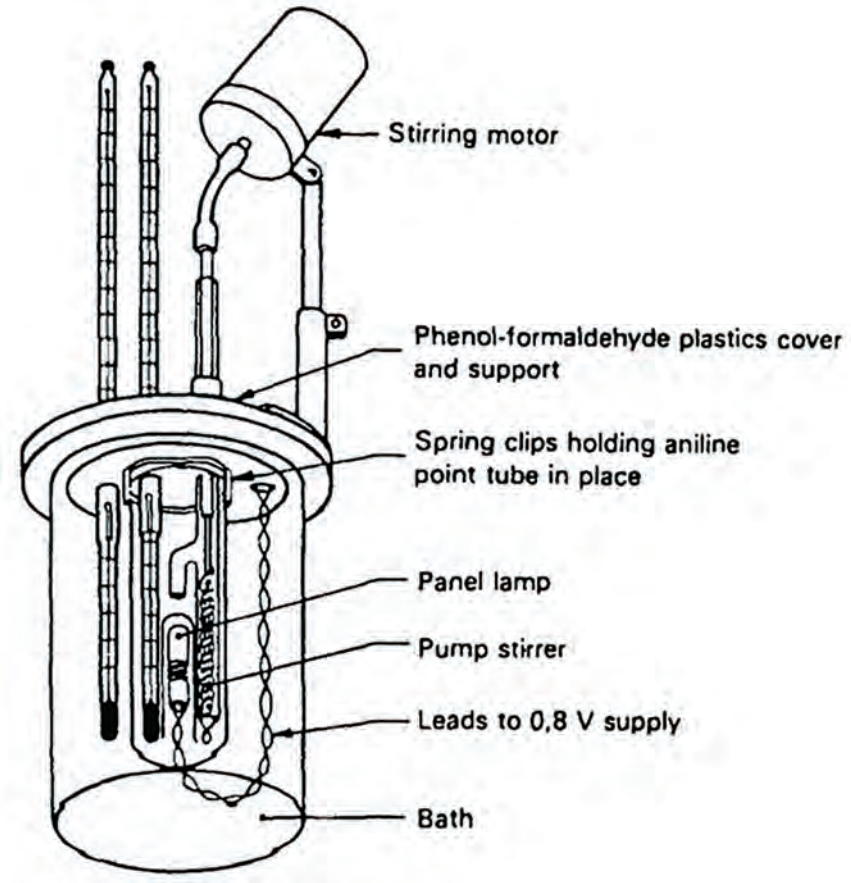


Figure 4.7: Assembly of thin-film Apparatus for method 2 of aniline point determination

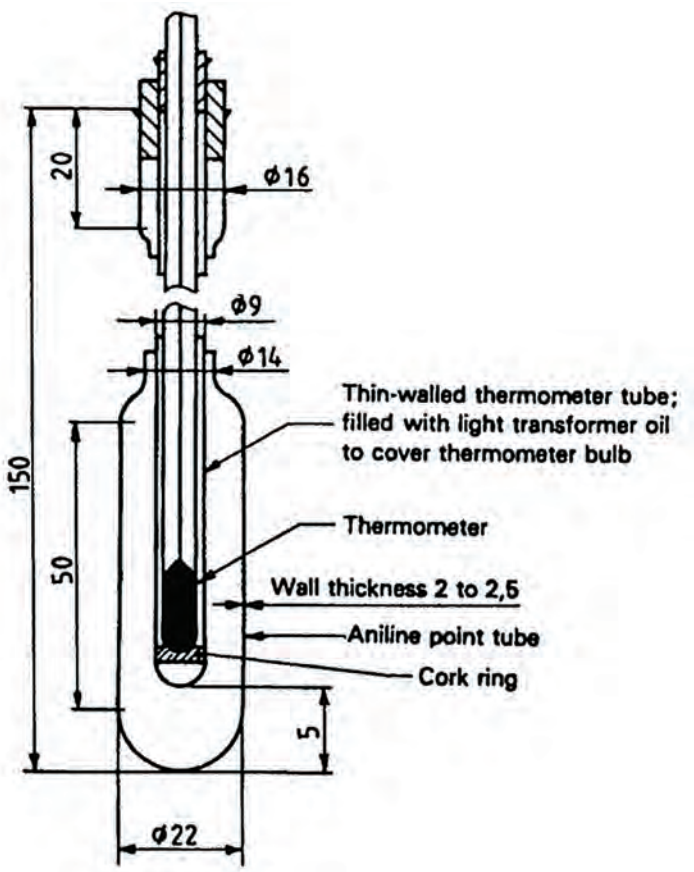


Figure 4.8: Aniline point apparatus for volatile samples Method 3

4.1.6 Flash Point

1. IS 1448 [P : 20] : 2019 ISO 13736 : 2013 METHODS OF TEST FOR PETROLEUM ANDITS PRODUCTS [P : 20] DETERMINATION OF FLASH POINT — ABEL CLOSED-CUP METHOD A flash point value can indicate the presence of highly volatile material(s) in a relatively non-volatile or non-flammable material, and flash point testing can be a preliminary step to other investigations into the composition of unknown materials. Flash point determinations are not appropriate for potentially unstable, decomposable, or explosive materials, unless previously established that heating the specified quantity of such materials in contact with the metallic components of the flash point apparatus, within the temperature range required for the method, does not induce decomposition, explosion or other adverse effects. Flash point values are not a constant physical-chemical property of materials tested. They are a function of the apparatus design, the condition of the apparatus used, and the operational procedure carried out. Flash point can therefore be defined only in terms of a standard test method, and no general valid correlation can be guaranteed between results obtained by different test methods or with test apparatus different from that specified.

   In this method the test portion is placed in the test cup of an Abel apparatus and heated to give a constant temperature increase with continuous stirring. An ignition source is directed through an opening in the test cup cover at regular temperature intervals with simultaneous interruption of stirring. The lowest temperature at which application of the ignition source causes the vapours of the test portion to ignite and propagate over the surface of the liquid is recorded as the flash point at the ambient barometric pressure. The temperature is corrected to standard atmospheric pressure using an equation.

2. IS 1448 [P : 21] : 2019 ISO 2719 : 2016METHODS OF TEST FOR PETROLEUM ANDITS PRODUCTS [P : 21] DETERMINATION OF FLASH POINT — PENSKY-MARTENS CLOSED CUP METHOD Describes three procedures, A, B and C, using the Pensky-Martens closed cup tester, for determining the flash point of combustible liquids, liquids with suspended solids, liquids that tend to form a surface film under the test conditions, biodiesel and other liquids in the temperature range of 40 °C to 370 °C.

   Procedure A is applicable to distillate fuels (diesel, biodiesel blends, heating oil and turbine fuels), new and in-use lubricating oils, paints and varnishes, and other homogeneous liquids not included in the scope of Procedures B or C.

   Procedure B is applicable to residual fuel oils, cutback residua, used lubricating oils, mixtures of liquids with solids, liquids that tend to form a surface film under test conditions or are of such kinematic viscosity that they are not uniformly heated under the stirring and heating conditions of Procedure A.

   Procedure C is applicable to fatty acid methyl esters (FAME) as specified in specifications such as EN 14214 or ASTM D6751.

The test portion is placed into the test cup of a Pensky-Martens apparatus and heated to give a constant temperature increase with continuous stirring. An ignition source is directed through an opening in the test cup lid at regular temperature intervals with simultaneous interruption of stirring. The lowest temperature at which the application of the ignition source causes the vapour of the test portion to ignite and a flame propagate over the surface of the liquid is recorded as the flash point at the absolute barometric pressure. This temperature is corrected to standard atmospheric pressure using a specified formula.

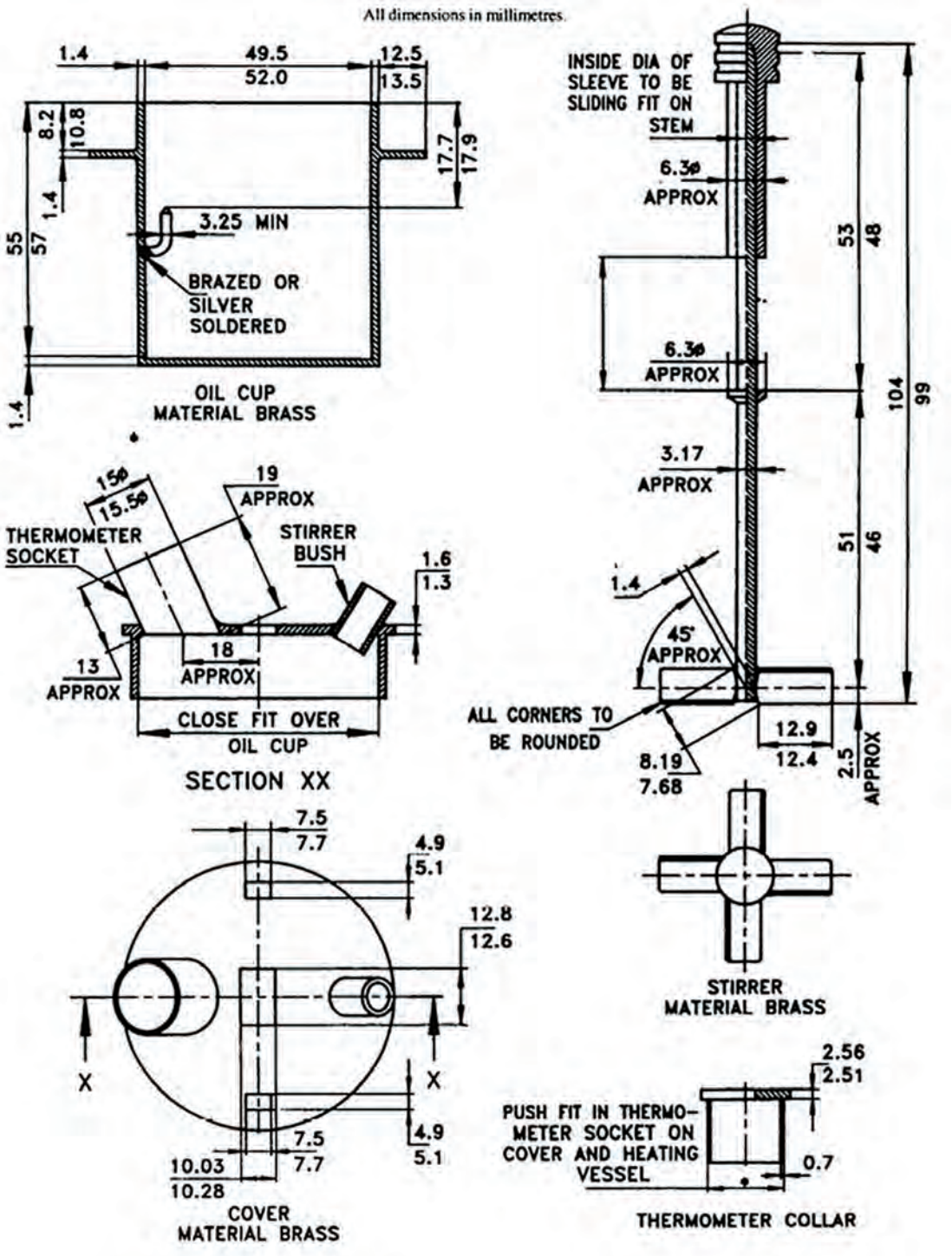


Figure 4.9: Abel flash point apparatus

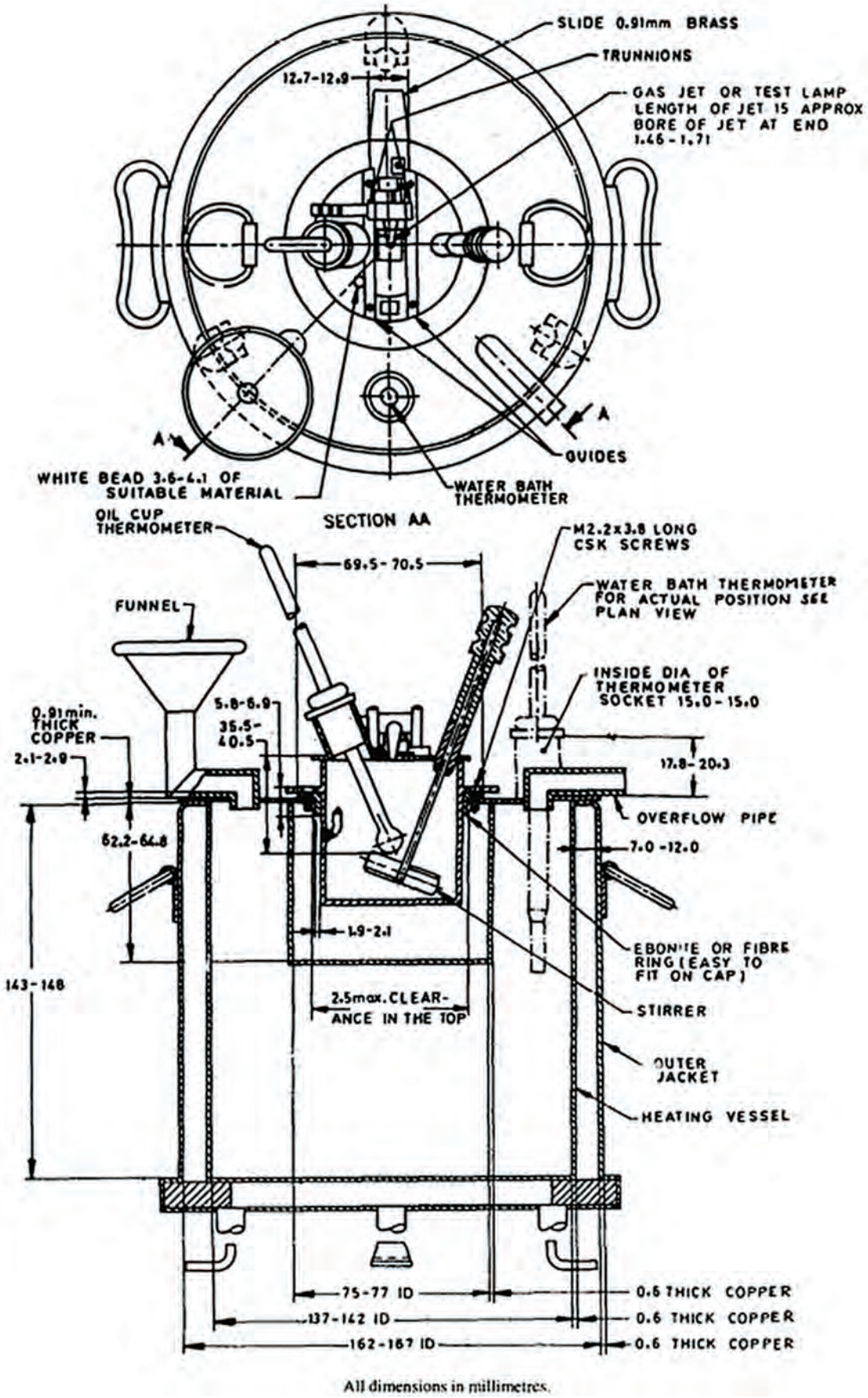
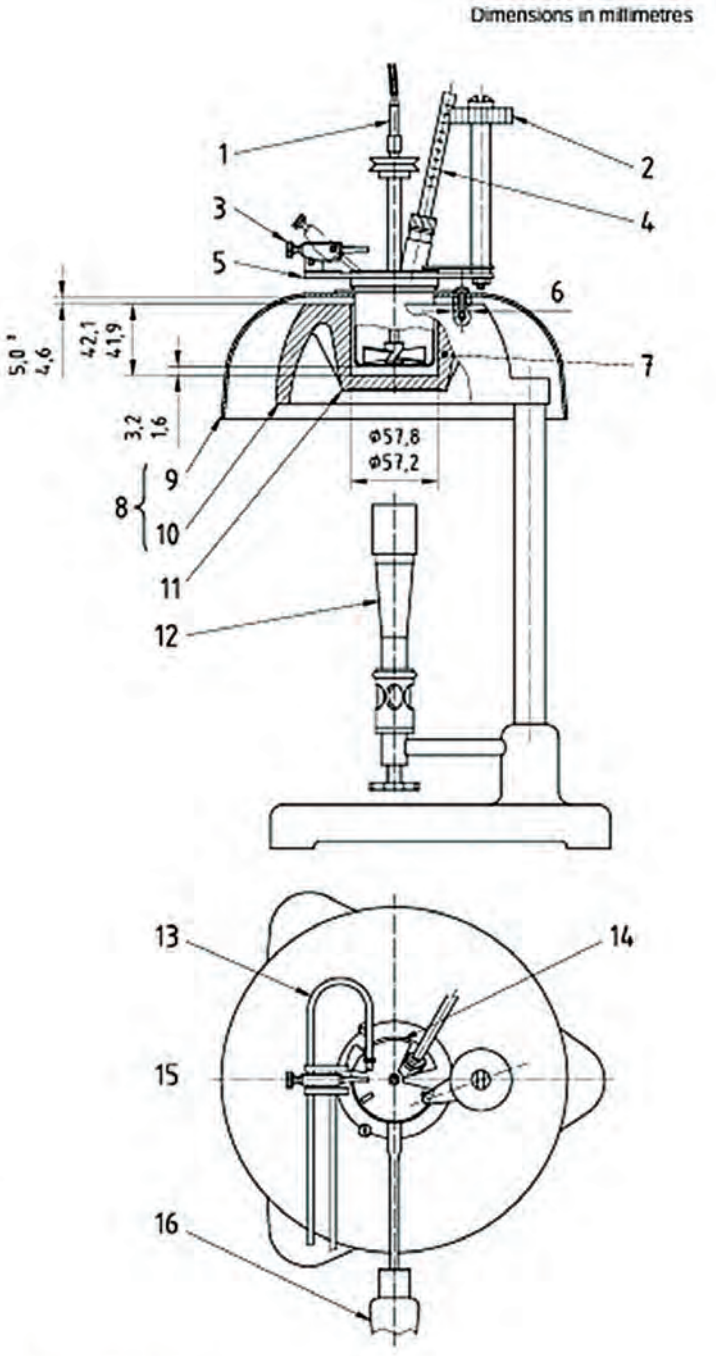


Figure 4.10: Abel flash point apparatus



Key

1	Flexible shaft
2	Shutter-operating knob
3	Flame-exposure device
4	Thermometer
5	Lid
6	Distance piece ∅ 9,5 max.
7	Test cup
8	Heating chamber
9	Top plate
10	Air bath
11	6,5 min. thickness over cup area, i.e. metal surrounding the cup
12	Heater, flame-type or electric-resistance type (flame-type shown)
13	Pilot
14	Shutter
15	Front
16	Handle (optional)

NOTE The lid assembly may be positioned either right- or left-handed.

Figure 4.11: Pensky-Martens closed cup apparatus

4.1.7 Moisture Content

IS 1211 : 2022 METHODS FOR TESTING TAR AND BITUMINOUS MATERIALS — DETERMINATION OF WATER CONTENT — DEAN AND STARK METHOD This Standard covers the method for the determination of water content of asphalt bitumen and fluxed native asphalt, crude coal tar, road tar, cutback bitumen, Digboi type cutback bitumen and creosote and anthracene oil. The apparatus is shown in (Figure 4.15)

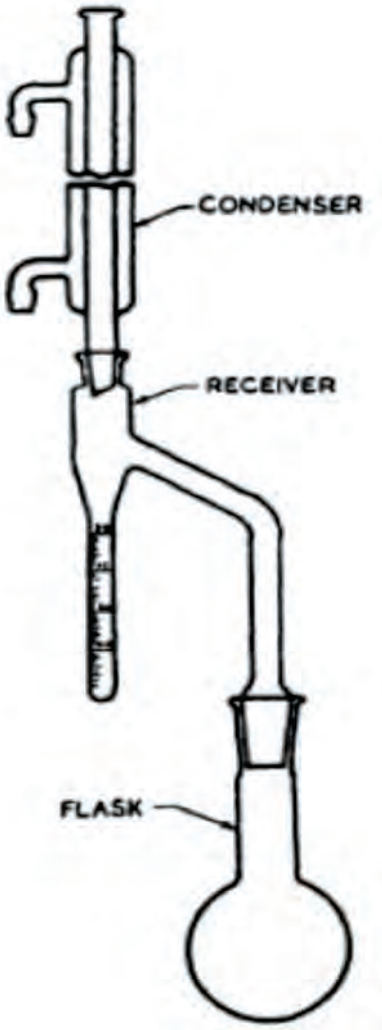
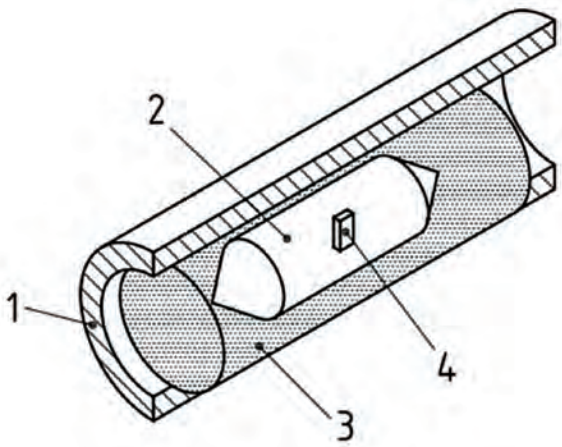


Figure 4.12: Dean and Stark Assembly



Key

1	outer rotor (constant speed)	3	sample fluid
2	inner rotor (measured speed)	4	magnet

Figure 4.13: Viscosity cell

4.1.8 Kinematic viscosity

IS 1448 (Part 186) : 2021 ISO 23581 : 2020 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS PART 186 PETROLEUM PRODUCTS AND RELATED PRODUCTS — DETERMINATION OF KINEMATIC VISCOSITY - METHOD BY STABINGER TYPE VISCOMETER

It specifies a procedure for the determination of kinematic viscosity at 40 °C in the range from 2 mm2/s to 6 mm2/s by calculation from dynamic viscosity and density of middle distillate fuels, fatty acid methyl ester fuels (FAME) and mixtures of these using the Stabinger type viscometer. A test portion of a sample is introduced into the measuring cells, which are at closely controlled and known temperature. The measuring cells consist of a pair of rotating concentric cylinders and an oscillating U-tube. The dynamic viscosity is determined from the equilibrium rotational speed of the inner cylinder under the influence of the shear stress of the test specimen and an eddy current brake in conjunction with adjustment data. The density is determined by the oscillation frequency of the U-tube in conjunction with adjustment data. The kinematic viscosity is calculated by dividing the dynamic viscosity by the density

4.1.9 Pour Point

IS 1448 (Part 10/Sec 2) : 2021 ISO 3016 : 2019 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS PART 10 PETROLEUM AND RELATED PRODUCTS FROM NATURAL OR SYNTHETIC SOURCES Section 2 Determination of pour point

Pour point is the lowest temperature at which a sample of petroleum product will continue to flow when it is cooled under specified standard conditions.

After preliminary heating, the sample is cooled at a specified rate and examined at intervals of 3 °C for flow characteristics. The lowest temperature at which movement (’pour’ or ’flow’) of the sample is observed is recorded as the pour point.

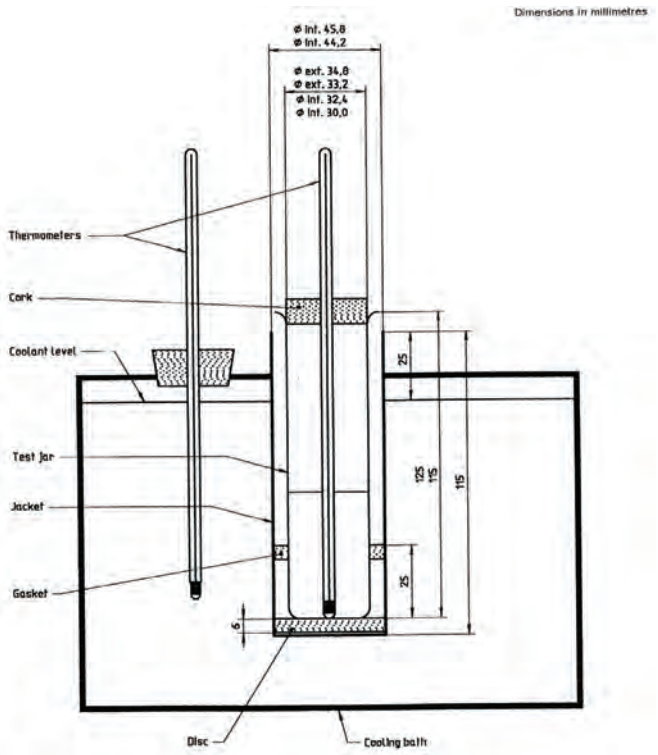


Figure 4.14: Apparatus for pour point test

4.1.10 Ramsbottom Carbon residue

IS 1448 [P : 8] : 2012 ISO 4262 : 1993 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 8] DETERMINATION OF CARBON RESIDUE – RAMSBOTTOM

METHOD This standard specifies a method for determining the amount of carbon residue, in the range of 0.01 % (m/m) to 30.0 % (m/m), left after evaporation and pyrolysis of an Oil, and is intended to provide some indication of relative Coke-forming tendency. The method is generally applicable to relatively non-volatile Petroleum products which partially decompose on distillation at atmospheric pressure.

The test Portion is weighed into a glass coking bulb having a capillary opening, and is placed

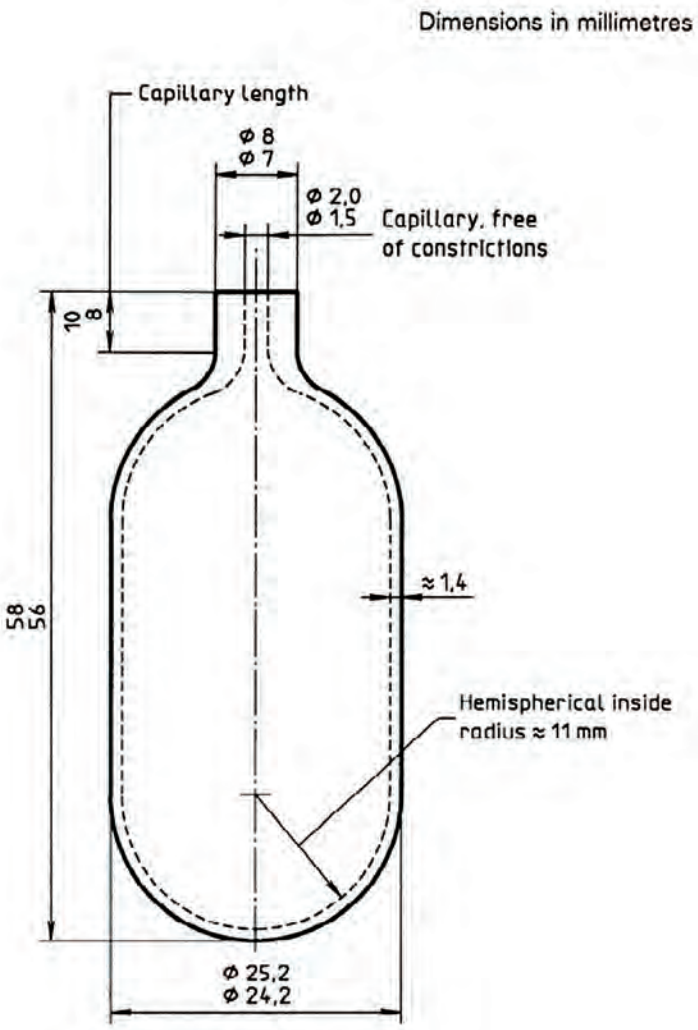


Figure 4.15: Glass coking bulb

in a metal furnace maintained at a temperature of approximately 550 “C. The test Portion is thus quickly heated to the Point at which all volatile matter is evaporated out of the bulb with or without decomposition, while the heavier residue remaining in the bulb undergoes cracking and coking reactions. In the later stages of the heating period, the coke or carbon residue is subject to further slow. decomposition or slight Oxidation due to the possibility of air being drawn into the bulb. After a specified heating period, the bulb is removed from the furnace, cooled in a desiccator, and again weighed. The residue remaining is calculated as a mass percentage of the test Portion.

4.1.11 Conradson Carbon Residue

IS 1448 [P : 122] : 2013 ISO 6615 : 1993 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS [P : 122] DETERMINATION OF CARBON RESIDUE — CONRADSON METHOD It is a method for determining the amount of carbon residue, in the range of 0.01 % (m/m) to 30.0 % (m/m), left after evaporation and pyrolysis of an Oil, and is intended to provide

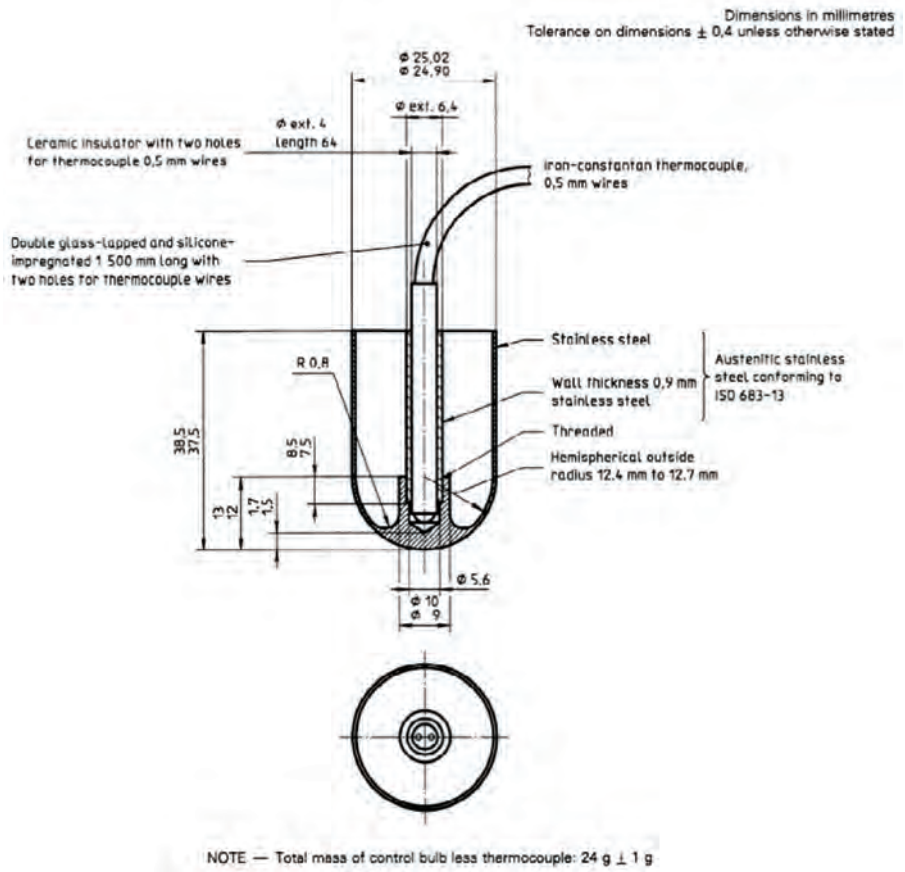
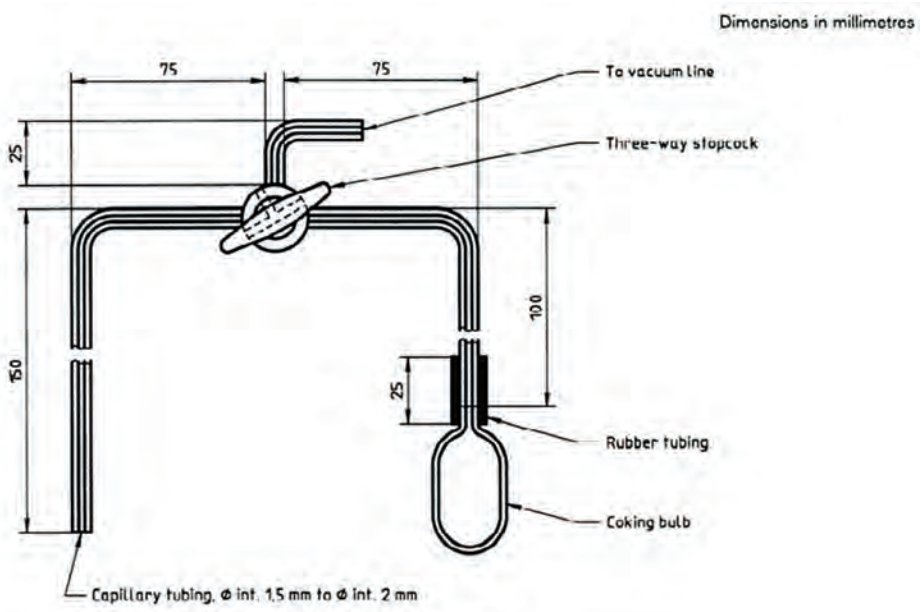


Figure 4.16: Control bulb used in Ramsbottom Method



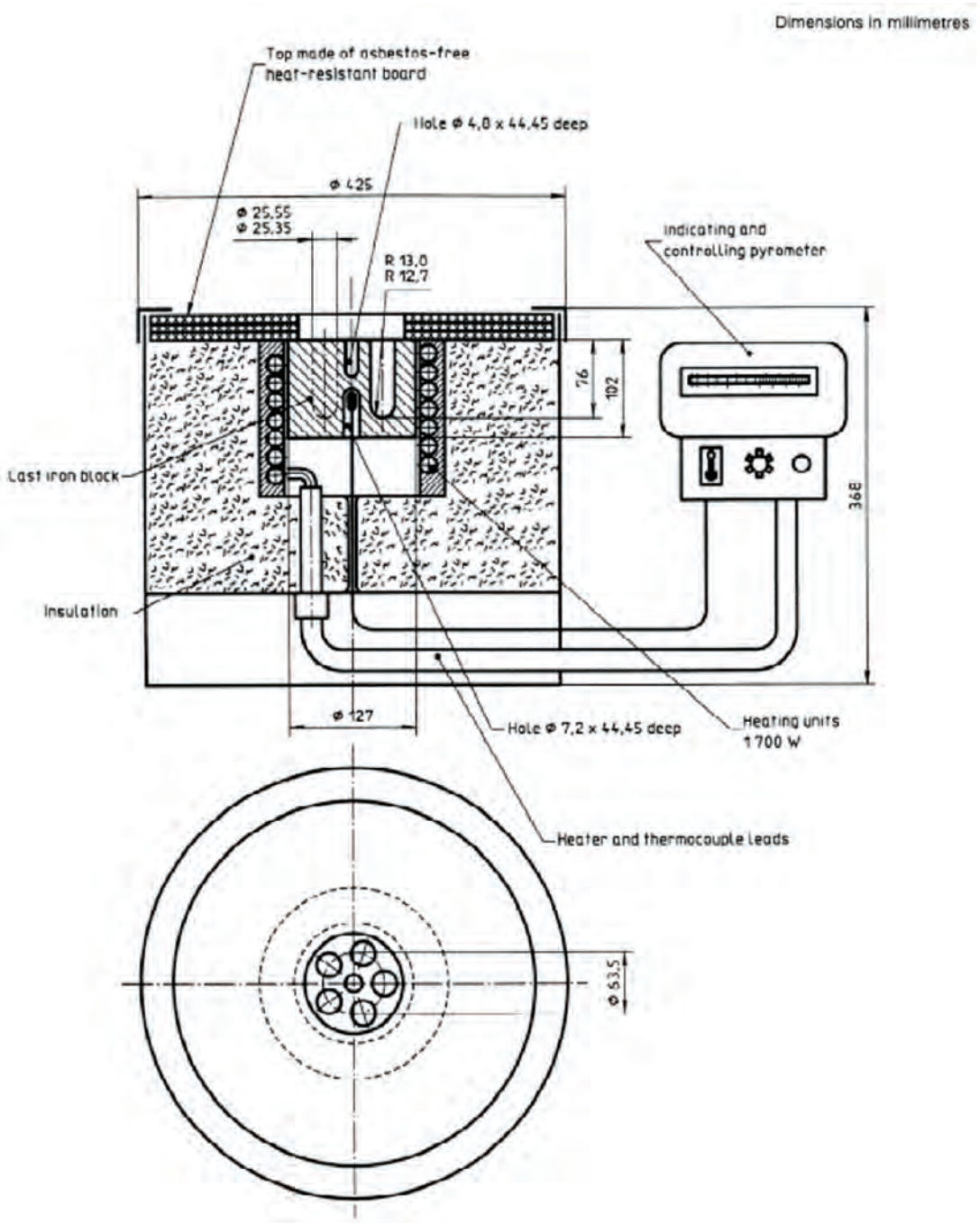


Figure 4.17: Sampling device for Ramsbottom method Figure 4.18: Solid metal furnace used in DETERMINATION OF CARBON RESIDUE –RAMSBOTTOM METHOD some indication of relative Coke-forming tendency. The method is generally applicable to relatively non-volatile Petroleum products which partially decompose on distillation at atmospheric pressure.

A weighed test Portion is placed in a crucible and subjected to destructive distillation. The residue undergoes cracking and coking reactions during a fixed period of severe heating. At the end of the specified heating period, the test crucible containing the carbonaceous residue is cooled in a desiccator and weighed. The residue remaining is calculated as a mass percentage of the original test Portion.

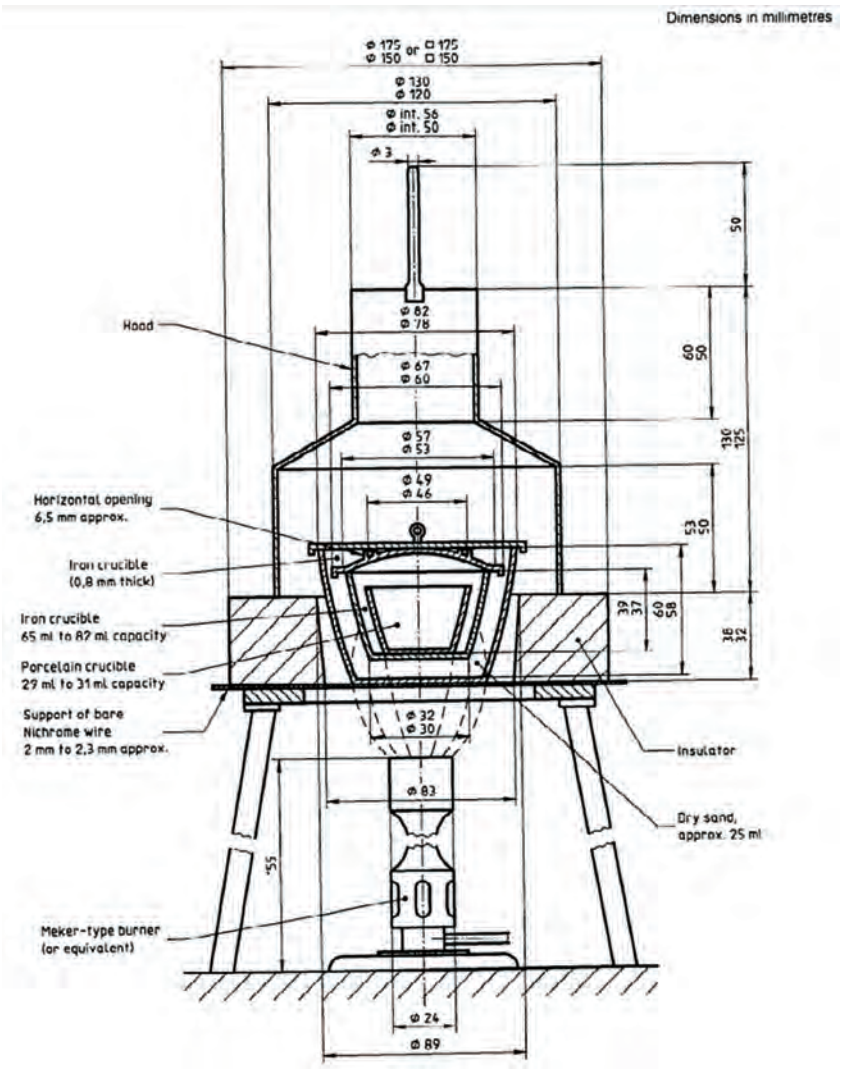


Figure 4.19: Apparatus for determining Conradson carbon residue

4.1.12 Cloud Point

IS 1448 (Part 10/Sec 1) : 2021 ISO 3015 : 2019 Methods of Test for Petroleum and its Products Part 10 Petroleum and Related Products from Natural or Synthetic Sources Section 1 Determination of cloud point The standardspecifies a method for the determination of the cloud point of petroleum products which are transparent in layers 40 mm in thickness and have a cloud point below 49 °C, amongst which are diesel fuels with up to 30 % (V/V) of fatty acid methyl ester (FAME), paraffinic diesel fuels with up to 7 % (V/V) FAME, 100 % FAME and lubricants. Cloud point is the temperature at which a cloud of wax crystals first appears in a liquid when it is cooled under specified conditions. A sample is cooled at a specified rate and examined periodically. The temperature at which a cloud is first observed at the bottom of the test jar is recorded as the cloud point

4.1.13 Orsat Analysis

IS 13270 : 1992 TEST FOR GASES BY ORSAT AND CHROMATOGRAPHIC METHODS

This standard prescribes the following two methods for determination of various gases like oxygen, carbon monoxide, carbon dioxide, nitrogen, hydrocarbon, etc, present in gaseous mixtures: a) Orsat analysis, and b) Gas chromatographic analysis.

Orsat analysis and chromatographic gas analysis are commonly used. Each one has some advantages and disadvantages. These are listed below:

Orsat Analysis	**Chromatographic Analysis**	
Advantages	Gasometric (volumetric procedures)	Gas chromatographic analysis
	1. The equipment required is relatively simple.	1. It has a great advantage of speed.
	2. It does not require any calibration.	2. A gas analysis can be completed in a few minutes.
	3. When the analysis is done on an infrequent basis, it is very useful.	3. It can be used for low range.
	4. Simple to operate.	4. The method is suitable for continuous analysis, as the instrument needs calibration before use.
Disadvantages		
	1. Errors may be due to collection storage and handling of samples.	1. Instrument must have been previously calibrated for each gas of interest.
	2. Unless special care is taken in the collection of samples, contamination by air occurs.	2. The oven must have reached a constant temperature and the detector must be giving stable response.
	3. Mercury is an ideal confining liquid/fluid because of the solubility of all gases in it. But practically, it cannot be used due to great density and cost. Hence, saturated salt/water is used for ordinary purposes.	3. It is very difficult to carry instruments to the site. If the sample is collected in gas holder or any other equipment, collection, storage or handling becomes a problem.
	4. It cannot measure concentrations of gases below 0 2 percent.	4. It requires an inert gas cylinder.

4.2 Analytical Instrumentation: Calorimeters

Sample gas is contacted successively by a series of chemically reactive solutions. Each solution removes a specific constituent of the sample gas mixture with the corresponding decrease in gas volume at each step representative of the volume of the specific gas removed. A levelling bulb is used to adjust all gas volume measurements to atmospheric pressure. Ordinarily, the analysis is applied in the field using the portable, orsat apparatus to determine the volume composition of carbon monoxide, carbon dioxide, - oxygen and unsaturated hydrocarbons in the gaseous emission from combustion processes. Results are usually expressed in volume percent of each component gas. Methane and ethane shall be determined by fractional combustion and nitrogen is calculated by difference.

4.2 Analytical Instrumentation: Calorimeters

IS:1448[P:8]-1984 METHODS OF TEST FOR PETROLEUM AND ITS PRODUCTS

(P:8] HEAT OF Combustion OF LIQUID HYDROCARBON FUELS BY BOMB Calorimeter

METHOD A weighed quantity of the sample is burned in oxygen in a bomb calorimeter under controlled conditions. The heat of combustion is calculated from the mass of the sample and the rise in temperature, with proper allowance for heat transfer and for the formation of nitric and sulphuric acids in the bomb, no account being taken of other minor products formed. The value so obtained is the gross heat of combustion at constant Volume.

4.3 Different types of storage systems, Types & features of storage tanks, fixed roof and floating roof tanks

IS 17141 (Part 4) : 2019 ISO 4266-4 : 2002 PETROLEUM AND LIQUID PETROLEUM PRODUCTS — MEASUREMENT OF LEVEL AND TEMPERATURE IN STORAGE TANKS BY AUTOMATIC METHODS PART 4 MEASUREMENT OF TEMPERATURE IN ATMOSPHERIC TANKS

This standard gives guidance on the selection, accuracy, installation, commissioning, calibration and verification of automatic tank thermometers (ATTs) in fiscal/custody transfer applications in which the ATT is used for measuring the temperature of petroleum and liquid petroleum products having a Reid vapour pressure less than , stored in atmospheric storage tanks.

IS 17141 (Part 2) : 2019 ISO 4266-2 : 2002 PETROLEUM AND LIQUID PETROLEUM PRODUCTS — MEASUREMENT OF LEVEL AND TEMPERATURE IN STORAGE TANKS BY AUTOMATIC METHODS PART 2 MEASUREMENT OF LEVEL IN MARINE

VESSELS It gives guidance on the accuracy, installation, calibration and verification of automatic level gauges (ALGs), both intrusive and non-intrusive, for measuring the level of petroleum and liquid petroleum products having a Reid vapour pressure less than , transported aboard marine vessels (i.e. tankers and barges).

IS 4639 (Part 5) : 2000 IS0 1998-5 : 1998 PETROLEUM INDUSTRY -TERMINOLOGY PART 5 TRANSPORT, STORAGE, DISTRIBUTION This standard consists of a list of equivalent English terms, in use in the petroleum industry in the area of transport, storage and distribution, together with the corresponding definitions in the two languages.

IS : 9964 (Part II) – 1981 RECOMMENDATIONS FOR MAINTENANCE AND OPERATION OF PETROLEUM STORAGE TANKS PART II INSPECTION Storage tanks in marketing installations of refineries are used to store crude oil, intermediates and refined products, gas, chemicals and water. These tanks are of different types and sizes, depending on their intended use. In this standard, provisions regarding inspection and inspection procedures for the maintenance of petroleum storage tanks have been covered.

IS 9964:Part 1: 1981 RECOMMENDATIONS FOR MAINTENANCE AND OPERATlON OF PETROLEUM STORAGE TANKS PART I PREPARATION O-F TANK FOR SAFE

ENTRY AND WORK In this standard, provision regarding hazards encountered in the cleaning of petroleum tanks for the safe entry and methods and procedures for cleaning these tanks have been dealt with. The practices being followed in the country, in the maintenance of these tanks, have been kept in view while formulating this standard. In this standard type of different storage tanks as well as different types of atmospheric tanks have been defined.

CHAPTER V

REGULATORY REQUIREMENTS IN PETROLEUM SECTOR

CHAPTER V

REGULATORY REQUIREMENTS IN PETROLEUM SECTOR

Important regulatory bodies in India and regulatory requirements in Petroleum Sector made by them have been mentioned in the following sections.

5.1 The Petroleum and Natural Gas Regulatory Board (PNGRB)

It was constituted under The Petroleum and Natural Gas Regulatory Board Act, 2006 (NO. 19 OF 2006) notified via Gazette Notification dated 31st March, 2006. The Act provide for the establishment of Petroleum and Natural Gas Regulatory Board to protect the interests of consumers and entities engaged in specified activities relating to petroleum, petroleum products and natural gas and to promote competitive markets and for matters connected therewith or incidental thereto. Further as enshrined in the act, the board has also been mandated to regulate the refining, processing, storage, transportation, distribution, marketing and sale of petroleum, petroleum products and natural gas excluding production of crude oil and natural gas so as and to ensure uninterrupted and adequate supply of petroleum, petroleum products and natural gas in all parts of the country. The following are the regulatory requirements laid by PNGRB:

1. Petroleum and Natural Gas Regulatory Board (Authorizing Entities to Lay, Build, Operate or Expand Natural Gas Pipelines) Regulations, 2008
2. Petroleum and Natural Gas Regulatory Board (Affiliate Code of Conduct for Entities Engaged in Marketing of Natural Gas and Laying, Building, Operating, or Expanding Natural Gas Pipeline)Regulations, 2008
3. Petroleum and Natural Gas Regulatory Board (Access Code for Common Carrier or Contract Carrier Natural Gas Pipelines) Regulations, 2008
4. Petroleum and Natural Gas Regulatory Board (Determination of Natural Gas Pipeline Tariff) Regulations, 2008
5. Petroleum and Natural Gas Regulatory Board (Guiding Principles for Declaring or Authorizing Natural Gas Pipeline as Common Carrier or Contract Carrier) Regulations, 2009
6. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Natural Gas Pipelines) Regulations, 2009
7. Petroleum and Natural Gas Regulatory Board (Determining Capacity of Petroleum, Petroleum Products and Natural Gas Pipeline) Regulations, 2010
8. Petroleum and Natural Gas Regulatory Board (Integrity Management System for Natural Gas Pipelines) Regulations, 2012
9. Petroleum and Natural Gas Regulatory Board (Imbalance Management Services) Regulations, 2014
10. Petroleum and Natural Gas Regulatory Board (Authorizing Entities to Lay, Build,

Operate or Expand Petroleum and Petroleum Products Pipelines) Regulations, 2010

11. Petroleum and Natural Gas Regulatory Board (Determination of Petroleum and Petroleum Products Pipeline Transportation Tariff) Regulations, 2010

12. Petroleum and Natural Gas Regulatory Board (Guiding Principles for Declaring or Authorizing Petroleum and Petroleum Products Pipelines as Common Carrier or Contract Carrier) Regulations, 2012

13. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Petroleum and Petroleum Products Pipelines) Regulations, 2016

14. Petroleum and Natural Gas Regulatory Board (Access Code for Common Carrier or Contract Carrier Petroleum and Petroleum Products Pipelines) Regulations, 2016

15. Petroleum and Natural Gas Regulatory Board (Integrity Management System for Petroleum and Petroleum Products Pipelines) Regulations, 2021.

16. Petroleum and Natural Gas Regulatory Board (Procedure for Development of Technical Standards and Specifications including Safety Standards) Regulations, 2009

17. Petroleum and Natural Gas Regulatory Board (Codes of Practices for Emergency Response and Disaster Management Plan

18. Petroleum and Natural Gas Regulatory Board (Third Party Conformity Assessment) Regulations, 2015

19. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Liquefied Natural Gas Facilities) Regulations, 2018

20. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Retail Outlets dispensing Petroleum, Auto LPG and CNG) Regulations

21. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety, Safety Standards for LPG Storage, Handling and Bottling Facilities) Regulations, 2019

22. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Petroleum Installations) Regulations, 2020

23. petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Petroleum Refineries and Gas Processing Plants) Regulations, 2023.

24. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for City or Local Natural Gas Distribution Networks)

25. Petroleum and Natural Gas Regulatory Board (Integrity Management System for City or Local Natural Gas Distribution Networks) Regulations, 2013

26. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Natural Gas Pipelines) Regulations, 2009

27. Petroleum and Natural Gas Regulatory Board (Integrity Management System for Natural Gas Pipelines) Regulations, 2012

28. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for Petroleum and Petroleum Products Pipelines) Regulations, 2016

29. Petroleum and Natural Gas Regulatory Board (Integrity Management System for Petroleum and Petroleum Products Pipelines) Regulations, 2021.

30. Petroleum and Natural Gas Regulatory Board (Authorizing Entities to Lay, Build, Operate or Expand City or Local Natural Gas Distribution Networks) Regulations, 2008

31. Petroleum and Natural Gas Regulatory Board (Determination of Transportation Rate for CGD and Transportation Rate for CNG) Regulations

32. Petroleum and Natural Gas Regulatory Board (Exclusivity for City or Local Natural Gas Distribution Network) Regulations, 2008 (

33. Petroleum and Natural Gas Regulatory Board (Technical Standards and Specifications including Safety Standards for City or Local Natural Gas Distribution Networks)

34. Petroleum and Natural Gas Regulatory Board (Code of Practice for Quality of Service for City or Local Natural Gas Distribution Networks) Regulations, 2010

35. Petroleum and Natural Gas Regulatory Board (Access Code for City or Local Natural Gas Distribution Networks) Regulations, 2020

36. Petroleum and Natural Gas Regulatory Board (Integrity Management System for City or Local Natural Gas Distribution Networks) Regulations, 2013

37. Petroleum and Natural Gas Regulatory Board (Determining Capacity of City or Local Natural Gas Distribution Network) Regulation, 2015

38. Petroleum and Natural Gas Regulatory Board (Guiding Principles for Declaring City or Local Natural Gas Distribution Networks as Common Carrier or Contract Carrier) Regulation, 2020

5.2 Petroleum and Explosives Safety Organization (PESO)

The Petroleum and Explosives Safety Organization (PESO), formerly known as the Department of Explosives, since its inception on 05/09/1898, has been serving the nation as a nodal agency for regulating the safety of hazardous substances such as explosives, compressed gas, and petroleum.

The following are Acts/Rules related to petroleum products regulated by PESO

a. Explosives Act 1884
b. Petroleum Act 1934
c. Gas Cylinder Rules 2016
d. SMPV Rules 2016
e. Inflammable Substance Act 1952

ANNEXURES

A. SPECIFICATIONS FOR IMPORTANT PETROLEUM PRODUCTS

A.1 Specification for Liquefied Petroleum Gas

Table A.1: Specification for Liquefied Petroleum Gas (Commercial Butane-Propane Mixture) IS 4576:2021

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
1	Density@ 15°C,kg/ m3	IP 432	-	Report
2	Vapour pressure at 40°C,kPa	IP 432	Min-Max	520-1050
3	Composition (Liquid Volume Percentage) (a) C2 Hydrocarbons (b) C3 Hydrocarbons (a) C4 Hydrocarbons (a) C5 Hydrocarbons & Heavier OR	ASTMD 2163	- Max	 Report Report Report 2.5
4	Volatility: Evaporation temperature in °C for 95 percent by volume at 760 mm Hg pressure, °C	IS 1448 P:72	Max	2.2
5	Volatility: Evaporation temperature in °C for 95 percent by volume at 760 mm Hg pressure, °C	IS 1448 P:72	Max	2.2

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Table A.1: Specification for Liquefied Petroleum Gas (Commercial Butane-Propane Mixture) IS 4576:2021 (Continued)

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
5	Total Volatile Sulphur, mg/kg	ASTMD 6667	Max	140
6	Copper Strip Corrosion @ 40°C, for 1 hour.	IS 1448P: 152	-	Not worse than No. 1
7	Hydrogen Sulfide	IS 1448 P:73	-	Pass
8	Free water Content	IS 4576: 2021 Note:9	-	None
9	Caustic Test	IS 4576: 2021 Note: 11	-	Pass

A.2 Specification for Motor Gasoline (Regular) BS VI (MG 91)

Table A.2: Specification for Motor Gasoline (Regular) Bharat Stage VI (MG 91) IS2796:2017

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
1	Appearance	Visual	-	Clear and bright, Free from un-dissolved water, foreign matter, and other visible impurities.
2	Color	Visual	-	Orange
3	Density at 15°,kg/m3	ASTMD 4052	Min-Max	720-775
4	Distillation (a) Percent evaporated at 70°C (E70°C), percent v/v		Min-Max	10.0-45.0
	(b) Percent evaporated at 100°C (E100°C), percent v/v	IS 1448 P:18	Min-Max	40.0-70.0
	(c) Percent evaporated at 150°C (E150°C), percent v/v		Min	75.0
	(d) Final Boiling Point, °C		Max	210.0
	(e) Residue, percent volume		Max	2.0

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A.2 Specification for Motor Gasoline (Regular) BS VI (MG 91)

Table A.2: Specification for Motor Gasoline (Regular) Bharat Stage VI (MG 91) IS2796:2017 (Continued)

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
5	Research octane number(RON)	IS 1448 P:27	Min	91.0
6	Motor octane number MON)	IS 1448 P:26	Min	81.0
7	Gum content (Solvent washed), g/m3	IS 1448 P:29	Max	40.0
8	Total Sulphur, mg/kg	ASTMD 5453	Max	10.0
9	Reid Vapour Pressure (RVP) at 37.8°C, kPa	IS 1448 P:39	Max	60.0
10	Vapour Lock Index (VLI = 10*RVP+7*E 70°C)	Calculation	Max	750 Summer 950 Other months
11	Benzene content percent by volume	ASTMD 3606	Max	1.0

12	Copper strip corrosion for 3 hrs. at 50°C	IS 1448 P:15	-	Not worse than No.1
13	Oxidation stability, Minutes	IS 1448 P:28	Min	360.0
14	Olefin content, percent by volume	IS 1448 P:23	Max	21.0
15	Aromatics content, percent by volume	IS 1448 P:23	Max	35.0
16	Oxygen content, percent by mass	ASTMD 6839	Max	4.2
17	Ethanol content, percent by volume	ASTMD 4815	Max	5.0
18	Oxygenates percent by volume a) Ethers containing 5 or more 'C' atoms per molecule such as MTBE, ETBE, or TAME b) Any other oxygenates	ASTMD 4815	Max	15.0 Not Permitted
19	Lead content (as Pb), g/l	IS1448P: 112	Max	0.005

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Table A.2: Specification for Motor Gasoline (Regular) Bharat Stage VI (MG 91) IS2796:2017 (Continued)

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
20	Water tolerance of motor gasoline-alcohol blends, temperature for phase separation, °C	IS2796: 2017 Annex- B	Max	0 for Winter 10 for Other months
21	Engine intake system cleanliness, mg/kg	-	-	Report MFA used

A.3 Specification for Aviation Turbine Fuel (Kerosene Type - JET A-1)

Table A.3: Specification for Aviation Turbine Fuel (Kerosene Type - JET A-1) IS 1571:2018

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
1 (a)	Appearance Visual Appearance	Visual	-	Clear, bright, and free from solid matter and un-dissolved water at ambient fuel temperature.

(b)	Color	ASTMD 6045	-	Report
(c)	Particulate Contamination at point of manufacture. (mg/l)	ASTMD 5452	Max	1.0
	Particulate channel count 1. Particulate, at point of manufacture, cumulative channel particle counts			1. Channel count/ISO Code
	2. ≥ 4 μm(c)			2.Report/Max 19
	3. ≥ 6 μm(c)			3. Report/Max 17
	4. ≥ 14 μm(c)	IP 577	-	4.Report/Max 14
	5. ≥ 21 μm(c)			5. Report/Report
	6. ≥ 25 μm(c)			6. Report/Report
	7. ≥ 30 μm(c)			7. Report/Max 13
2	Composition			
(a)	Total acidity, mg KOH/g	IS 1448P: 113	Max	0.015
(b)	Aromatics, percent by volume	IS 1448 P:23	Max	25.0 (22.0 Defence Max)

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A.3 Specification for Aviation Turbine Fuel (Kerosene Type - JET A-1)

Table A.3: Specification for Aviation Turbine Fuel (Kerosene Type - JET A-1) IS 1571:2018 (Continued)

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
	OR Total Aromatics percent by volume	ASTMD 6379	Max	26.5
(c)	Total Sulphur, percent by mass	ASTMD 4294	Max	0.30 (0.25 Defence Max)
(d)	Sulphur mercaptan, percent(m/m) OR	IS 1448 P:109	Max	0.0030 (0.0020 Defence Max)
	Doctor Test	IS 1448 P:19	-	Negative
(f)	Refining components at the point of manufacture			
	1) Non-hydro processed components, percent (v/v)		-	Report
	2) Severely hydro-processed components, percent (v/v)		-	Report

	3) Synthetic components, percent (v/v)		-	Report as per IS 17081
3	Volatility			
(a)	Distillation			
	1) Initial boiling point, ^{O}C		-	Report
	2) 10 percent recovery (v/v) ^{O}C		Max	
	3) 50 percent recovery (v/v) ^{O}C		-	
	4) 90 percent recovery (v/v) ^{O}C	IS 1448 P:18	-	
	5) Final boiling point, ^{O}C			Max
	6) Residue, percent(v/v)			Max
	7) Loss, percent (v/v)			Max
(b)	Flash point (Abel), ^{O}C	IS 1448 P:20	Min	38.0
(c)	Density at 15°C,kg/m3	ASTMD 4052	Min-Max	775.0-840.0
4	Fluidity			
(a)	Freezing point, ^{O}C	ASTMD 7153	Max	Minus 47

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Table A.3: Specification for Aviation Turbine Fuel (Kerosene Type - JET A-1) IS 1571:2018 (Continued)

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
(b)	Kinematic viscosity at minus 20°C, mm2/s ASTM D7042Max 8.000			
5	Combustion			
(a)	Specific energy, MJ/kg	ASTM	D3338	Min 42.80
(b)	Smoke point, mm or	IP 598	Min	25.0
	1) Smoke point, mm	IP 598	Min	18.0
	2) Naphthalenes, percent (v/v)	IS 1448 P:118	Max	3.00
6	Corrosion			
(a)	Copper strip corrosion for 2 hrs at 100°C	IS 1448 P:15	-	Not worse than No.1
(b)	Silver strip corrosion Classification for 4 h at 50°C	IS1571: 2018, Annex B	-	Max 1

7	Thermal stability at control Temperature of 260°C.JFTOT			
(a)	1) Filter pressure differential, mm Hg		Max	25.0
	2) Tube Deposit rating, visual(VTR) OR	ASTMD 3241		Less than 3, No Peacock (P) or Abnormal (A)
(b)	2) Tube rating by ITR or ETR, Average over area of 2.5 mm2 in nm		Max	85
8	Contaminants			
(a)	Existent gum, mg/100ml	IS 1448 P:29	-	7.0
9	Water Separation Characteristic:			
(a)	Water reaction: Interface rating	IS 1448 P:42	Max	1b
(b)	Micro-separometer rating at the point of manufacture:			

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A.3 Specification for Aviation Turbine Fuel (Kerosene Type - JET A-1)

Table A.3: Specification for Aviation Turbine Fuel (Kerosene Type - JET A-1) IS 1571:2018 (Continued)

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
	1) MSEP without SDA	IS 1448 P:142	Min	85.0
	2) MSEP with SDA		Min	70
10	Conductivity		Min	50
	Electrical conductivity, pS/m	ISO 6297	Max	600
11	Lubricity			
	Wear scar diameter, mm	ASTM D 5001	Max	0.85 (0.65 Defence Max)
12	Additives			
a)	1)Static dissipater additive (SDA) Qualification ref no: RDE/A/621), mg/l	Max	3.00	

b)	1) Antioxidant (for Hydro processed Qty), Qualification ref no: RDE/A/607,mg/l		-	17-24

A.4 Specification for Kerosene Grade A - Low Sulphur Kerosene

Table A.4: Specification for Kerosene Grade A - Low Sulphur Kerosene as per IS 1459:2018

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
1	Acidity, inorganic, mgKOH/g	ASTM D 974	-	Nil
2	Appearance	Visual	-	Clear and Bright, free from un-dissolved water, foreign matter and other visible impurities
3	Burning Quality			
	(a) Char value, mg /kg of oil consumed.	IS 1448 P:5	Max	20.0
	(b) Bloom on glass chimney		-	Not worse than No.1
4	Color(a) Saybolt (in case of undyed kerosene).	ASTM D 156	Min	10.0
5	Copper strip corrosion for 3 hrs. at 50 ^{O}C	IS 1448 P:15	-	Not worse than No.1
6	Density at 15 ^{O}C, g/ml	ASTMD 4052	-	Not limited, but to be reported
7	Distillation(a) Percent recovered below200 ^{O}C , percent (b) Final boiling point, ^{O}C	IS 1448 P:18	Min Max	20.0 300
8	Flash point (Abel), ^{O}C	IS 1448 P:20	Min	35.0
9	Smoke point, mm	IP 598	Min	18.0
10	Total Sulphur Content,	ASTMD 4294	Max	0.100

A.5 Specification for Automotive Diesel Fuel (BS VI)

Table A.5: Specification for Automotive Diesel Fuel (Bharat Stage VI) IS 1460:2017

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
1	Appearance	Visual	-	Clear, bright and free from sediments, suspended matter and undissolved water at normal ambient fuel temperature
2	Acidity Inorganic, mgKOH/g	ASTM D 974	-	Nil
3	Acidity (Total), mg KOH/g	ASTM D 974	-	Nil
4	Ash, percent by mass	IS 1448 P:4	Max	0.01
5	Carbon residue (Micro) on 10 percent residue, percent by mass	ISO 10370	Max	0.30
6	Cetane number	IS 1448 P:9	Min	51
7	Cetane index	ASTMD 4737	Min	46
8	Pour point, ^{O}C	ASTMD 5950	Max	3^{O}C Winter 15^{O}C Summer
9	Copper strip corrosion for 3 hrs. at 50^{O}C	IS 1448 P:15	-	Not worse than No.1
10	Distillation, 95 percent v/v recovery, ^{O}C	IS 1448 P:18	Max	360
11	Flash Point,^{O}C	IS 1448 P:20/P:21	Min	35
12	Kinematic viscosity, cSt, at 40^{O}C	IS 1448 P:25, Section 1	Min-Max	2.0 to 4.5
13	Total contamination, mg/kg	IP 440	Max	24
14	Density at 15 ^{O}C, kg/m3	ASTMD 4052	Min-Max	810.0-845.0
15	Total sulphur, mg/kg	ASTMD 7220	Max	10
16	Water content, mg/kg	ISO 12937	Max	200
17	Cold Filter Plugging Point (CFPP), ^{O}C	ASTMD 6371	Max	6^{O}C Winter 18^{O}C Summer

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Table A.5: Specification for Automotive Diesel Fuel (Bharat Stage VI) IS 1460:2017 (Continued)

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
18	Oxidation stability, g/m3	IS 1448 P:154	Max	25
19	Lubricity corrected wear scar diameter (wsd 1.4) at 60°C, microns	IS	1448P:149	Max 460
20	Polycyclic Aromatic Hydrocarbon (PAH), percent by wt	IP 391	Max	8.0
21	FAME content, percent v/v	ASTMD 7371	Max	7.0

A.6 Specification for High Flash High-speed Diesel

Table A.6: Specification for High Flash High-speed Diesel IS 16861-2018

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
1	Appearance	Visual	-	Clear, bright and free from sediments, suspended matter and undissolved water at normal ambient fuel temperature
2	Acid Number, mg of KOH/g	ASTM D 974	Max	0.5
3	Ash, percent by mass	IS 1448 P:4	Max	0.01
4	Carbon residue on 10 percent volume distillation residue, %	ISO 10370	Max	0.3
5	Cetane index	ASTMD 4737	Min	45
6	Pour point	IS 1448 P:10	Max	3 °C Winter 15 °C Summer
7	Copper strip Corrosion for 3 h at 100°C	IS 1448 P:15	-	Not worse than No.1
8	Distillation, percent (v/v), recovereda) at 350°C b) at 370°C	IS 1448 P:18	Min Min	85 95

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A.7 Specification for Furnace Oil MV2 Grade

Table A.6: Specification for High Flash High-speed Diesel IS 16861-2018 (Continued)

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
9	Flash point Pensky Martens Closed cup ^{O}C	IS 1448 P:21	Min	66
10	Kinematic viscosity, cSt, at 40^{O}C	IS 1448 P:25 SECTION 1	Min-Max	2.0 to 5.0
11	Density at 15^{O}, kg/m3	ASTMD 4052	Max	860
12	Total sulphur, % by mass	ASTMD 4294	Max	0.20
13	Water content, ppm	ISO 12937	Max	500
14	Cold Filter Plugging Point (CFPP), ^{O}C	ASTMD 6371	-	To report
15	Oxidation stability, g/m3	IS	1448P:154	Max 25
16	Lubricity corrected WSD at 60^{O}C, microns	ISO 12156-1	Max	520

A.7 Specification for Furnace Oil MV2 Grade

Table A.7: Specification for Furnace Oil MV2 Grade IS 1593-2018

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
1	Acidity, Inorganic	ASTM D974	-	Nil
2	Ash, percent by mass	IS 1448, P:4	Max	0.1
3	Carbon residue, mass percent	ISO 10370	Max	18.0
4	Gross Calorific Value	IS 1448 P:7	-	Report
5	Density at 15°C, kg/m3	IS 1448 P:16	-	Report
6	Flash Point (Pensky Martens Closed),°C	IS 1448 P:21	Min	66.0
7	Kinematic Viscosity in centistokes at 50 °C	IS 1448 P:25	Min-Max	125- 180
8	Sediment, percent by mass	IS 1448 P:30	Max	0.25

9	Sulphur total, percent by mass	ISO 8754	Max	4.0

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Table A.7: Specification for Furnace Oil MV2 Grade IS 1593-2018 (Continued)

S.N.	CHARACTERISTIC	TEST METHOD	LIMIT	REQUIREMENT
10	Water content, percent by mass	IS 1448 P:40	Max	1.0

ANNEXURES

B. LIST OF INDIAN STANDARDS

All the Indian Standards related to petroleum products and their test methods are listed below.

These Standards are available free of cost at BIS website www.bis.gov.in under "Know Your Standard" tab and can be easily downloaded from there.

B.1 Petroleum and Related Products

Petroleum and their Related Products of Synthesis or Biological Origin sectional committee,

PCD 3 is one of the 15 sectional committees working under PCDC with the scope "To formulate Indian Standards for terminology; petroleum, petroleum products, biofuels (liquid and gas), fuels produced through synthesis route, specification for natural gas and codes of practice for storage, handling, transport and application.". This committee has formulated a total of 69 standards. A complete list of standards formulated by this committee has been placed below.

Table B.1: Standards of Petroleum Products

S.N.	IS No.	Description
1.	IS 534 : 2021	Benzene
2.	IS 537 : 2011	Toluene - Specification (Second Revision)
3.	IS 1459 : 2018	Kerosene - Specification (Fourth Revision)
4.	IS 1460 : 2017	Automotive diesel fuel - Specification (Sixth Revision)
5.	IS 1571 : 2018	Aviation turbine fuels, kerosine type, jet - A - 1 - Specification (TenthRevision)
6.	IS 1587 : 2017	Aviation turbine fuel, high flash point type - Specification (FourthRevision)
7.	IS 1593 : 2018	Fuel oils - Specification (Third Revision)
8.	IS 1604 : 2022	Aviation gasoline - Specification (fifth revision)
9.	IS 1745 : 2018	Petroleum hydrocarbon solvents - Specification (Third Revision)
10.	IS 2796 : 2017	Motor gasoline - Specification (Sixth Revision)
11.	IS 3470 : 2017	Hexane, food grade - Specification (Second Revision)
12.	IS 4576 : 2021	Liquefied Petroleum Gases-Specification
13.	IS 4639 (Part 1) : 2000/ ISO1998-1	Petroleum industry - Terminology: Part 1 raw materials and products(First Revision)
14.	IS 4639 (Part 2) : 2000/ ISO1998-2	Petroleum industry - Terminology: Part 2 properties and tests (FirstRevision)
15.	IS 4639 (Part 3) : 2000/ ISO1998-3	Petroleum industry - Terminology: Part 3 exploration and production(First Revision)
16.	IS 4639 (Part 4) : 2000/ ISO1998-4	Petroleum industry - Terminology: Part 4 refining (First Revision)
17.	IS 4639 (Part 5) : 2000/ ISO1998-5	Petroleum industry - Terminology: Part 5 transport, storage, distribution(First Revision)

18.	IS 4639 (Part 6) : 2002/ ISO1998-6	Petroleum industry - Terminology: Part 6 measurement (First Revision)
19.	IS 4639 (Part 7) : 2000/ ISO1998-7	Petroleum industry - Terminology: Part 7 miscellaneous terms (FirstRevision)
20.	IS 4639 (Part 99) : 2002/ ISO 1998-99	Petroleum industry - Terminology: Part 99 general and index (FirstRevision)
21.	IS 4654 : 2019	Paraffin Wax — Specification (Third Revision)
22.	IS/ISO 8216-1 : 2010/ ISO8216-1	Petroleum products - Fuels (Class F) classification: Part 1 categories of marine fuels
23.	IS 8502 : 2018	Petroleum coke - Specification (Second Revision)
24.	IS 11254 : 2009	Code of practice for dispensation of aviation fuel and allied products(First Revision)
25.	IS 11489 : 1985	Specification for heavy petroleum stock (HPS)
26.	IS 13833 : 2019	Microcrystalline Wax Derived From Petroleum — Specification (FirstRevision)
27.	IS 14861 : 2000	Liquefied petroleum gases (LPG) for automotive purposes - Specification
28.	IS 15126 : 2002/ ISO 13443	Natural gas - Standard reference conditions
29.	IS 15127 : 2002/ ISO 13686	Natural gas - Quality designation
30.	IS 15217 : 2002	Fuel oil for diesel generating sets - Specification
31.	IS 15320 (Part 1) : 2012/ ISO 15403-1 : 2006	Natural gas - Natural gas for use as a compressed fuel for vehicles: Part1 designation of the quality (First Revision)
32.	IS 15464 : 2022	Anhydrous ethanol for use as blending component in motor gasoline specification (First Revision)
33.	IS 15607 : 2022	Biodiesel B-100 - Fatty Acid Methyl Esters FAME Specification SecondRevision
34.	IS 15770 : 2008	Light diesel oil - Specification
35.	IS 15770 : 2021	Heating Oil (LDO) - Specification
36.	IS 15958 : 2023	Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) forAutomotive Purposes — Specification (First Revision)
37.	IS 16061 (Part 1/Sub-Sec2013): 2021/ ISO14687:2019	Hydrogen Fuel Quality Product Specification

Cont'd on following page

B.1 Petroleum and Related Products

Table B.1, cont'd.

S.N.	IS No.	Description
38.	IS 16087 : 2016	Biogas (Biomethane) - Specification (First Revision)
39.	IS 16531 : 2022	Biodiesel Diesel Fuel Blend B8 to B20 Specification First Revision ofIS 16531
40.	IS 16629 : 2017	Hydrous ethanol for use in ed 95 automotive fuel - Specification
41.	IS 16634 : 2023	E85 Fuel Admixture Of Anhydrous Ethanol And Motor Gasoline ForFlex Fuel Positive Ignition Engine Powered Vehicles Specification
42.	IS 16704 : 2018/ ISO 16861	Petroleum products - Fuels (Class F) - Specifications of dimethyl ether(DME)
43.	IS 16731 : 2019/ ISO 8217 :2017	Petroleum products - Fuels (Class F) - Specifications of marine fuels
44.	IS 16737 : 2018/ ISO 8216-2: 1986	Petroleum Products- Fuels (Class F) - Classification Part 2 Categories ofGas Turbine Fuels for Industrial and Marine Applications
45.	IS 16737 (Part 3) : 2018/ ISO 8216-3 : 1987	Petroleum products - Fuels (Class F) - Classification: Part 3 family l(Liquefied Petroleum Gases)
46.	IS 16737 (Part 99) : 2017/ ISO 8216-99 : 2002	Petroleum products - Fuels (Class F) - Classification: Part 99 general
47.	IS 16861 : 2018	High flash high speed diesel fuel - Specification
48.	IS 17021 : 2018	E 20 fuel - Admixture of anhydrous ethanol and gasoline - As fuel for spark ignited engine powered vehicles - Specification
49.	IS 17042 (Part 1) : 2020/ ISO 22241-1:2019	Diesel Engines — NOx Reduction Agent AUS 32 Part 1 QualityRequirements (First Revision)
50.	IS 17042 (Part 2) : 2020/ ISO 22241-2:2019	Diesel Engines — NOx Reduction Agent Aus 32 Part 2 Test Methods (First Revision)
51.	IS 17042 (Part 3) : 2018/ ISO 22241-3	Diesel Engines - NOX Reduction Agent AUS 32 Part 3 Handling,Transportation and Storage
52.	IS 17049 : 2018	Petroleum coke for anode making in aluminium industry - Specification
53.	IS 17075 : 2019	Anhydrous methanol for use as a blending component in fuels -Specification
54.	IS 17076 : 2019	M15 fuel - Admixture of anhydrous methanol and motor gasoline as fuel for spark ignited engines - Specification
55.	IS 17081 : 2019	Aviation turbine fuel (Kerosene Type, Jet A - 1) containing synthesized hydrocarbons - Specification
56.	IS 17314 : 2019	Hydrogen Enriched Compressed Natural Gas (HCNG) for AutomotivePurposes Specification

57.	IS 17586 : 2021	E12 and E15 Fuel - Admixture of Anhydrous Ethanol and MotorGasoline - For Positive Ignition Engine Powered Vehicles - Specification
58.	IS 17661 (Part 1) : 2022/ ISO 18611-1:2014	Ships and marine technology Marine NOX Reduction Agent AUS 40Part 1: Quality Requirements
59.	IS 17661 (Part 2) : 2022/ ISO 18611-2:2014	Ships and marine technology Marine NOX Reduction Agent AUS 40Part 2: Test Methods
60.	IS 17661 (Part 3) : 2022/ ISO 18611-3:2014	Ships and marine technology Marine NOX Reduction Agent AUS 40Part 3: Handling transportation and storage
61.	IS 17789 : 2022	Gas oil - Specification
62.	IS 17792 : 2022	Vacuum gas oil VGO - Specification
63.	IS 17793 : 2022	Kerosene Intermediate - Specification
64.	IS 17794 : 2022	Petroleum naphtha - Specification
65.	IS 17821 : 2022	Ethanol as a fuel for use in positive ignition engine powered vehicles specification
66.	IS 17943 : 2022	E20 Reference Fuel Admixture of Anhydrous Ethanol and MotorGasoline Specification
67.	IS 18247 : 2023/23306: 2020 ISO	Liquefied natural gas as a fuel for marine applications - Specification
68.	IS 18465 : 2023	Ethane for use as feedstock for petrochemical - Specification
69.	IS/ISO/PAS 22263 : 2019 ISO/PAS 23263	Petroleum Products Fuels (class F) Considerations for Fuel Suppliers and Users Regarding Marine Fuel Quality in View of the Implementation of Maximum 0.50% Sulfur in 2020

B.2 Standards Related to Test Methods

Methods of Sampling and Test for Petroleum and Related Products of Natural or Synthetic Origin (excluding bitumen) sectional committee, PCD 1 is one of the 15 sectional committees working under PCDC with the scope "To formulate Indian Standards for Methods for Sampling and test for Petroleum and related products of natural or synthetic origin including lubricants, greases, speciality products, additives and gaseous fuels (excluding bitumen) b) To organize correlation schemes for evaluating the accuracy and the performance of fuel and lubricant testing engines". This committee has formulated total 198 standards. Complete list of standards formulated by this committee has been placed below.

Table B.2: Standards related to Testing of Petroleum Products

S.N.	IS No.	Description
1	IS 1447 (Part 1) : 2021	Methods of Sampling of Petroleum and its Products Part 1 ManualSampling (Second Revision)
2	IS 1447 (Part 2) : 2013/	Methods of sampling of petroleum and its products [p :
	ISO4257: 2001	2] liquefied petroleum gases - Method of sampling (Second Revision)

3	IS 1447 (Part 3) : 2021	Petroleum and its products methods of sampling: Part 3 method of sampling of semi - Solid and solid petroleum products First Revision
4	IS 1447 (Part 4): 1989	Petroleum and its products methods of sampling: Part 4 sampling of petroleum coke for laboratory analysis (First Revision)
5	IS 1447 (Part 5) : 2023/ ISO23572 : 2020	Methods of sampling of petroleum and its products Part Sampling of greases
6	IS 1448 (Part 1/Sec 2): 2002	Methods of test for petroleum and its products [p: 1/ section 2] determination of base number of petroleum products by potentiometric titration (Second Revision)
7	IS 1448 (Part 2): 2007/ ISO6619: 1988	Methods of test for petroleum and its products [p:2] petroleum products and lubricants - Neutralization number - Potentiometric titration method (Second Revision)
8	IS 1448 (Part 3): 2007/ ISO2977: 1997	Methods of test for petroleum and its products [p:3] petroleum products and hydrocarbon solvents - Determination of aniline point and mixed aniline point (Third Revision)
9	IS 1448 (Part 4/Sec 1) : 2021	Methods of test for petroleum and its products P : 4 Sec 1 Determination of ash
10	IS 1448 (Part 4/Sec 2) : 2021	Methods of test for petroleum and its products p : 4 section 2 ash from grease sulphated ash and water soluble ash Fourth Revision
11	IS 1448 (Part 5) : 1970	Methods of test for petroleum and its products: Part 5: burning quality(First Revision)
12	IS 1448 (Part 6) : 1984	Methods of test for petroleum and its products (P:6) heat of combustion of liquid hydrocarbon fuels by bomb calorimeter method (First Revision)
13	IS 1448 (Part 7) : 2004	Methods of Test for Petroleum and its Products - Part 7: Determination of Calorific Value by Calculation
14	IS 1448 (Part 8) : 2012 ISO4262 : 1993	Methods of test for petroleum and its products [p : 8] determination of carbon residue - Ramsbottom method (Second Revision)
15	IS 1448 (Part 9) : 2023/ ISO 5165 : 2020	Petroleum and its Products - Methods of Test Part 9 Determination of the Ignition Quality of Diesel Fuels - Cetane Engine Method
16	IS 1448 (Part 10/Sec 1) : 2021 ISO 3015	Methods of test for petroleum and its products Part 10 Petroleum and related products from natural or synthetic sources Section 1 Determination of cloud point
17	IS 1448 (Part 10/Sec 2) : 2021/ISO 3016	Methods of test for petroleum and its products Part 10 Petroleum and related products from natural or synthetic sources Section 2 Determination of pour point

18	IS 1448 (Part 11) : 2004/ ISO 3013: 1997	Methods of test for petroleum and its products [p:11] petroleum products- Determination of freezing point of aviation fuels (Fourth Revision)
19	IS 1448 (Part 12) : 2013/ ISO 2049 :1996	Methods of test for petroleum and its products [p : 12] determination of colour (Astm Scale) (Second Revision)
20	IS 1448 (Part 13) : 2023	Petroleum and its Products - Methods of Test Part 13 colour by lovibond tintometer
21	IS 1448 (Part 14) : 2019	Methods of test for petroleum and its products [p : 14] colour by saybolt chromometer (First Revision)
22	IS 1448 (Part 15) : 2004/ ISO 2160	Methods of Test for Petroleum and Its Products - Part 15: PetroleumProducts - Corrosiveness to Copper - Copper Strip Test
23	IS 1448 (Part 16) : 2014/ ISO 3675 : 1998	Methods of test for petroleum and its products [p : 16] crude petroleum and liquid petroleum products - Laboratory determination of density -Hydrometer method (Fourth Revision)
24	IS 1448 (Part 18) : 2020	Methods of Test for Petroleum and its Products Part 18 Distillation ofPetroleum Products (Third Revision)
25	IS 1448 (Part 19) : 2015/ ISO 5275 : 2003	Methods of test for petroleum and its products [p : 19] detection of thiols and other sulphur species - Doctor test (Second Revision)
26	IS 1448 (Part 20) : 2019/ ISO 13736:2013	Methods of test for petroleum and its products [p : 20] determination of flash point - Abel closed - Cup method (Third Revision)
27	IS 1448 (Part 21) : 2019/ ISO 2719	Methods of test for petroleum and its products [p : 21] determination of flash point - Pensky - Martens closed cup method (Fourth Revision)
28	IS 1448 (Part 22) : 2019	Methods of test for petroleum and its products [p : 22] determination of asphaltenes (Heptane Insolubles) in crude petroleum and petroleum products (Third Revision)
29	IS 1448 (Part 23) : 2004/ ISO 3837	Methods of Test for Petroleum and its Products - Part 23: Liquefied Petroleum Gases - Determination of Hydrocarbon Types - Fluorescent Indicator Adsorption Method
30	IS 1448 (Part 25/Sec 1) : 2018/ISO 3104	Methods of test for petroleum and its products [p : 25] transparent and opaque liquids section 1 determination of kinematic viscosity and calculation of dynamic viscosity (Second Revision)
31	IS 1448 (Part 26) : 2018/ ISO5163 :2014	Methods of test for petroleum and its products [p : 26] determination of knock characteristics of motor and aviation fuels - Motor method (Second Revision)
32	IS 1448 (Part 27) : 2018/ ISO 5164: 2014	Methods of test for petroleum and its products [p : 27] determination of knock characteristics of motor fuels - Research method (Second Revision)

33	IS 1448 (Part 28) : 2008/ ISO 7536	Methods of test for petroleum and its products [p : 28] petroleum products - Determination of oxidation stability of gasoline - Induction period method (Fourth Revision)
34	IS 1448 (Part 29) : 2021/ ISO 6246	Methods of test for petroleum and its products Part 29 Petroleum products Gum content of fuels Jet evaporation method
35	IS 1448 (Part 30) : 2013/ ISO 3735: 1999	Methods of test for petroleum and its products [p : 30] crude petroleum and fuel oils - Determination of sediment - Extraction method (Second Revision)
36	IS 1448 (Part 31) : 2017	Methods of test for petroleum and its products [p : 31] determination of smoke point (Second Revision)
37	IS 1448 (Part 32) : 2019/ ISO 3838	Methods of test for petroleum and its products [p : 32] crude petroleum and liquid or solid petroleum products - Determination of density or relative density - Capillary stoppered pyknometer and graduatedbicapillary pyknometer methods (Third Revision)
38	IS 1448 (Part 33) : 2021	Methods of test for petroleum and its products: Part 33 Sulphur by Bomb method
39	IS 1448 (Part 34) : 1979	Methods of test for petroleum and its products - Part 34 : determination of sulphur in petroleum products (Lamp Method) (Second Revision)
40	IS 1448 (Part 39) : 2012/ ISO 3007:1999	Methods of test for petroleum and its products [p : 39] determination of vapour pressure - Reid method (Second Revision)
41	IS 1448 (Part 40) : 2015/ ISO 3733 : 1999	Methods of test for petroleum and its products [p : 40] petroleum products and bituminous materials - Determination of water - Distillation method (Fourth Revision)
42	IS 1448 (Part 41) : 2019/ ISO 9030:1990	Methods of test for petroleum and its products [p : 41] crude petroleum- Determination of water and sediment - Centrifuge method (Fourth Revision)
43	IS 1448 (Part 42) : 2015/ISO 6250 : 1997	Methods of test for petroleum and its products [p : 42] determination of the water reaction of aviation fuels (Third Revision)
44	IS 1448 (Part 43) : 2018	Methods of test for petroleum and its products [p : 43] bromine number by colour indicator method (Third Revision)
45	IS 1448 (Part 44) : 2013/ ISO 3839: 1996	Methods of test for petroleum and its products [p : 44] determination of bromine number of distillates and aliphatic olefins - Electrometric method (Third Revision)
46	IS 1448 (Part 50) : 2021	Methods of test for petroleum and its products: Part 50 Chlorine in new and used lubricants (sodium alcoholate method)

47	IS 1448 (Part 51) : 2023	Methods of test for petroleum and its products Part 51 Copper strip corrosion test for lubricating greases
48	IS 1448 (Part 52) : 2017/ ISO 2176 : 1995	Methods of test for petroleum and its products [p : 52] drop point(Second Revision)
49	IS 1448 (Part 53) : 1979	Methods of test for petroleum and its products [p:53] determination of acidity and alkalinity of greases (First Revision)
50	IS 1448 (Part 54) : 2017	Methods of test for petroleum and its products [p : 54] determination of phosphorus content - Quinoline phosphomolybdate method (Third Revision)
51	IS 1448 (Part 55/Sec 1) : 2004	Methods of test for petroleum and its products [p:55/ section 1] determination of saponification value of petroleum products (First Revision)
52	IS 1448 (Part 55/Sec 2) : 2004	Methods of test for petroleum and its products [p : 55/ section 2] saponifiable and unsaponifiable matter in oil fat and waxes (First Revision)
53	IS 1448 (Part 56) : 2013/ ISO 2909: 2002	Methods of test for petroleum and its products [p : 56] calculation of viscosity index from kinematic viscosity (Third Revision)
54	IS 1448 (Part 57) : 1964	Consistency of greases at various temperatures (P : 57)
55	IS 1448 (Part 58) : 1991	Methods of test for petroleum and its products [p:58] determination of insolubles in greases (First Revision)
56	IS 1448 (Part 59) : 1991	Methods of test for petroleum and its products [p:59] determination of mineral oil content in greases (Second Revision)
57	IS 1448 (Part 60) : 2023/ ISO 2137 : 2020	Methods of test for petroleum and its products Part 60 Consistency of lubricating greases by cone penetrometer
58	IS 1448 (Part 61) : 2023	Methods of test for petroleum and its products Part 61 Determination of the leakage tendencies of automotive wheel bearing greases
59	IS 1448 (Part 62) : 2023	Petroleum and its Products - Methods of Test Part 62 heat stability of greases
60	IS 1448 (Part 64) : 2023	Petroleum and its Products - Methods of Test Part 64 Non-volatile Matter in Solvents (Second Revision)
61	IS 1448 (Part 65) : 2018	Methods of test for petroleum and its products [p : 65] oxidation test for lubricating oils (Third Revision)
62	IS 1448 (Part 66) : 2023	Methods of test for petroleum and its products [p:66] flash point (Open) and fire point by pensky martens apparatus
63	IS 1448 (Part 67) : 2020/ ISO 6247	Methods of Test for Petroleum and its Products [P:67] Determination of Foaming Characteristics of Lubricating Oils (Second Revision)

64	IS 1448 (Part 68) : 2023	Petroleum and its Products - Methods of Test for Part 68 Determination of Evaporation Loss of Lubricating Greases (22 hour drying) (First Revision)
65	IS 1448 (Part 69) : 2019/ ISO 2592 : 2017	Methods of Test for Petroleum and its Products [P:69] Determination of Flash and Fire Points - Cleveland Open Cup Method (Second Revision)
66	IS 1448 (Part 70) : 2018	Methods of test for petroleum and its products [p : 70] determination of residue in liquefied petroleum gases (First Revision)
67	IS 1448 (Part 71) : 2004/ ISO 4256	Methods of Test for Petroleum and its Products - Part 71: Liquefied Petroleum Gases - Determination of Gauge Vapour Pressure - LPG Method
68	IS 1448 (Part 72) : 2023	Methods of test for petroleum and its products Part 72 Method of volatility test of liquified petroleum gases
69	IS 1448 (Part 73) : 2004/ ISO 8819	Methods of test for petroleum and its products [p: 73] liquefied petroleum gases - Detection of hydrogen sulphide - Lead acetate method (First Revision)
70	IS 1448 (Part 74) : 2022/ ISO 13758 : 1996	Methods of test for petroleum and its products Part 74 Liquefied petroleum gases - Assessment of the dryness of propane - Valve freeze method
71	IS 1448 (Part 76) : 2019/ ISO 3993	Methods of Test for Petroleum and its Products [P:76] LiquifiedPetroleum Gases and Light Hydrocarbons - Determination of Density orRelative Density - Pressure Hydrometer Method (First Revision)
72	IS 1448 (Part 79) : 1992	Methods of test for petrolbum and its products [p:79] determination of trace element in petroleum products - Vanadium (First Revision)
73	IS 1448 (Part 82) : 2008/ ISO 3830 : 1993	Methods of test for petroleum and its products:: Part 82 determination of lead content in gasoline - Iodine monochloride method (First Revision)
74	IS 1448 (Part 84) : 2017	Methods of test for petroleum and its products [P : 84] determination of trace elements in petroleum products - Arsenic (First Revision)
75	IS 1448 (Part 85) : 2022	Methods of test for petroleum and its products P:85 oil seperation on storage of greases first revision
76	IS 1448 (Part 86) : 2023	Petroleum and its products - Methods of test part 86 determination of total base number by the potentiometrical perchloric acid titration method (first revision)
77	IS 1448 (Part 87) : 1979	Methods of test for petroleum and its products [p:87] autoignition temperature of liquid petroleum products
78	IS 1448 (Part 89) : 2023	Methods of test for petroleum and its products Part 89 Test for thermal stability of lubricating greases
79	IS 1448 (Part 90) : 2008/ ISO11009:2000	Methods of test for petroleum and its products [p : 90] petroleum products and lubricants - Determination of water washout characteristics of lubricating greases (First Revision)

80	IS 1448 (Part 91) : 2019/	Methods of test for petroleum and its products [p:91]
	ISO 6614 : 1994	determination of water separability of petroleum oils and synthetic fluids (First Revision)
81	IS 1448 (Part 93) : 2021	Methods of test for Petroleum and its products P: 93 Determination of needle penetration (First Revision)
82	IS 1448 (Part 94) : 2019	Methods of test for petroleum and its products [p : 94] test for oxidation stability of lubricating grease by oxygen pressure vessel method (First Revision)
83	IS 1448 (Part 95) : 2019	Methods of test for petroleum and its products [p : 95] determination of demulsibility characteristics of lubricating oils (First Revision)
84	IS 1448 (Part 96) : 2019/ ISO 7120: 1987	Methods of test for petroleum and its products [p : 96] petroleum products and lubricants - Petroleum oils and other fluids - Determination of rust - Preventing characteristics in the presence of water (First Revision)
85	IS 1448 (Part 97) : 2015/ ISO 6249 : 1999	Methods of test for petroleum and its products [p : 97] determination of thermal oxidation stability of gas turbine fuels - JFTOT method (First Revision)
86	IS 1448 (Part 98) : 1981	Methods of test for petroleum and its products:: Part 98 determination of emulsion stability of emulsifiable cutting oils
87	IS 1448 (Part 99) : 1981	Methods of test for petroleum and its products - Part 99 : determination of frothing characteristics of emulsifiable cutting oils
88	IS 1448 (Part 100) : 1980	Methods of test for petroleum and its products (P 100) Determination of thermal stability of emulsifiable cutting oils
89	IS 1448 (Part 101) : 1980	Methods of test for petroleum and its products (P 101) colorimetric determination of phosphorus in lubricating oils
90	IS 1448 (Part 102) : 2023	Methods of test for petroleum and its products Part 102 Determination of air release value
91	IS 1448 (Part 103) : 1981	Methods of test for petroleum and its products [p:103] barium, calcium, phosphorus and zinc in lubricating oils by direct reading emission spectrographic method
92	IS 1448 (Part 104) : 1981	Meteioinof test for petroleum and its products (P 104) aromatics in light naphthas and aviation gasolines by gas chromatography
93	IS 1448 (Part 105) : 1981	Methods of test for petroleum and its products [p:105] ultraviolet (UV) absorbance and absorptivity of petroleum products
94	IS 1448 (Part 106) : 1981	Methods of test for petroleum and its products [p:106] determination of oxidation characteristics of inhibited steam - Turbine oils

95	IS 1448 (Part 107) : 1982	Methods of test for petroleum and its products [p: 107) precipitation number of lubricating oils
96	IS 1448 (Part 109) : 2004/ ISO 3012 : 1999	Methods of test for petroleum and its products [p: 109] petroleum products - Determination of thiol (Mercaptan) sulphur in light and middle distillate fuels - Potentiometric method (First Revision)
97	IS 1448 (Part 110) : 2023	Methods of test for petroleum and its products [p : 110] cold filter plugging point of distillate fuels
98	IS 1448 (Part 111) : 1983	Methods of test for petroleum and its products [p:111] analysis of liquefied petroleum gases (LPG) and propylene concentrates by gas chromatography
99	IS 1448 (Part 112) : 1983	Methods of test for petroleum and its products [p : 112] determination of lead in gasoline by atomic absorption spectrometry
100	IS 1448 (Part 113) : 1983	Methods of test for petroleum and its products [p:113] Determination of total acidity in aviation turbine fuel
101	IS 1448 (Part 114) : 2019/ ISO 2207	Methods of test for petroleum and its products [p:114] petroleum waxes - Determination of congealing point (First Revision)
102	IS 1448 (Part 115) : 1984	Methods of test for petroleum and its products [p:115] determination of salt content in crude oil
103	IS 1448 (Part 116) : 2018	Methods of test for petroleum and its products [p : 116] determination of cone penetration of lubricating grease using one quarter and one half scale - Cone (Second Revision)
104	IS 1448 (Part 118) : 2019	Methods of test for petroleum and its products [p : 118] naphthalene hydrocarbons in aviation turbine fuel by ultraviolet spectrophotometry (First Revision)
105	IS 1448 (Part 119) : 1985	Methods of test for petroleum and its products (P : 119) aromatic traces in light saturated hydrocarbons by gas chromatography
106	IS 1448 (Part 120) : 2021	Methods of test for petroleum and its products: Part 120 Zinc in lubricating oil
107	IS 1448 (Part 121) : 2022	Methods of test for petroleum and its products Part 121 Barium lubricating oil additive concentrates
108	IS 1448 (Part 122) : 2013/ ISO 6615: 1993	Methods of test for petroleum and its products [p:122] determination of carbon residue - Conradson method (First Revision)
109	IS 1448 (Part 123) : 2013/ ISO 7624 : 1997	Methods of test for petroleum and its products [p:123] inhibited mineral turbine oils - Determination of oxidation stability (First Revision)
110	IS 1448 (Part 125) : 1987	Methods of test for petroleum and its products [p: 125] estimation of deleterious particles in lubricating grease

111	IS 1448 (Part 126) : 2023	Methods of test for petroleum and its products:: Part 126 determination of ash content in raw and calcined petroleum coke
112	IS 1448 (Part 127) : 2024	Petroleum and its Products - Methods of Test Part 127 Determination ofIron in Petroleum Coke
113	IS 1448 (Part 128) : 2018	Methods of test for petroleum and its products [p : 128] determination of nickel in calcined petroleum coke (First Revision)
114	IS 1448 (Part 129) : 2018	Methods of test for petroleum and its products [p : 129] determination of polymeric content in lubricating oils base stock (First Revision)
115	IS 1448 (Part 130) : 2019	Methods of test for petroleum and its products [p : 130] determination of vibrated bulk density of calcined petroleum coke (First Revision)
116	IS 1448 (Part 131) : 2024	Petroleum and its Products - Methods of Test Part 131 Determination ofSilicon in Petroleum Coke
117	IS 1448 (Part 132) : 2018	Methods of Test for Petroleum and its Products: Part 132 Determination of Moisture Content in Raw and Calcined Petroleum Coke
118	IS 1448 (Part 133) : 2018	Methods of test for petroleum and its products [p : 133] determination of real density of calcined petroleum coke (First Revision)
119	IS 1448 (Part 134) : 2018	Methods of test for petroleum and its products [p : 134] determination of volatile matter in raw and calcined petroleum coke (First Revision)
120	IS 1448 (Part 135) : 2013/ ISO 9029 : 1990	Methods of test for petroleum and its products [p :135] crude petroleum- Determination of water - Distillation method (First Revision)
121	IS 1448 (Part 136) : 1991	Methods of test for petroleum and its products [p:136] determination of evaporation loss of lubricating oils (Noacks Method)
122	IS 1448 (Part 137) : 1991	Methods of test for petroleum and its products [p:137] water separation characteristics of aviation turbine fuels
123	IS 1448 (Part 138) : 2023	Petroleum and its Products - Methods of Test Part 138 Determination ofSoap Content (Second Revision)
124	IS 1448 (Part 139) : 2018	Methods of test for petroleum and its products [p : 139] determination of real density of calcined petroleum coke using butanol or toluene (First Revision)
125	IS 1448 (Part 140) : 1992	Methods of test for petroleum and its products [p:140] determination of apparent density of petroleum coke by mercury pyknometer method
126	IS 1448 (Part 141) : 2018	Methods of test for petroleum and its products [p : 141] determination of apparent density of calcined petroleum coke by helium method (First Revision)

127	IS 1448 (Part 142) : 2021	Determination of water separation characteristics of aviation turbine fuels by portable separometer
128	IS 1448 (Part 143) : 2022	Methods of test for petroleum and its products Part 143 Evaluation of white mineral oils by ultraviolet absorption spectroscopy
129	IS 1448 (Part 144) : 1993	Methods of test for petroleum and its products [p:144] non - Condensable gases in c2 and lighter hydrocarbon products by gas chromatography
130	IS 1448 (Part 145) : 2022	Methods of test for petroleum and its products Part 145 Determination of sodium nickel and vanadium in fuel oils and crude oils by atomic absorption spectroscopy (first revision)
131	IS 1448 (Part 146) : 1998	Methods of test for petroleum and its products [p : 146] determination of yield stress and apparent viscosity of engine oils at low temperature
132	IS 1448 (Part 147) : 1998	Methods of test for petroleum and its products [p : 147] determination of potential gum in motor gasolines
133	IS 1448 (Part 148) : 2019/ ISO 6297	Methods of test for petroleum and its products [p :148] petroleum products - Aviation and distillate fuels - Determination of electrical conductivity (First Revision)
134	IS 1448 (Part 149) : 2020/ ISO 12156-1:2018	Methods of Test for Petroleum and its Products Part 149 Diesel Fuel Assessment of Lubricity Using the High - Frequency Reciprocating Rig (HFRR) - Test Method (Second Revision)
135	IS 1448 (Part 150) : 2004/ ISO 13757 : 1996	Methods of test for petroleum and its products [p:150] liquefied petroleum gases - Determination of oily residues - High - Temperature method
136	IS 1448 (Part 151) : 2004 ISO 7941	Methods of test for petroleum and its products [p: 151] commercial propane and butane - Analysis by gas chromatography
137	IS 1448 (Part 152) : 2004/ ISO 6251	Methods of test for petroleum and its products [p: 152] liquefied petroleum gases - Corrosiveness to copper - Copper strip test
138	IS 1448 (Part 153) : 2012/ ISO 20847 : 2004	Methods of test for petroleum and its products [p : 153] petroleum products - Determination of sulfur content of automotive fuels - Energy -Dispersive x - Ray fluorescence spectrometry
139	IS 1448 (Part 154) : 2012/ ISO 12205 : 1995	Methods of test for petroleum and its products [p : 154] determination of the oxidation stability of middle - Distillate fuels
140	IS 1448 (Part 155) : 2020	Methods of Test for Petroleum and its Products [P : 155] Determination of Trace Nitrogen in Liquid Petroleum Hydrocarbons by Oxidative Combustion with Chemiluminescence Detector

141	IS 1448 (Part 157) : 2018	Methods of test for petroleum and its products [p : 157] rust protections by metal preservatives in the humidity cabinet
142	IS 1448 (Part 158) : 2016/ ISO 5661	Methods of test for petroleum and its products [p : 158] hydrocarbon liquids - Determination of refractive index
143	IS 1448 (Part 159) : 2018/ ISO 20884	Methods of test for petroleum and its products [p : 159] determination of sulphur content of automotive fuels - Wavelength - Dispersive x - Ray fluorescence spectrometry
144	IS 1448 (Part 160) : 2017/ ISO 20846	Methods of test for petroleum and its products [p : 160] determination of sulphur content of automotive fuels - Ultraviolet fluorescence method
145	IS 1448 (Part 161) : 2017/ ISO 13032	Methods of test for petroleum and its products [p : 161] determination of low concentration of sulphur in automotive fuels - Energy - Dispersive x - Ray fluorescence spectrometric method
146	IS 1448 (Part 162) : 2018	Methods of Test for Petroleum and Its Products [P:162] Determination of insoluble Contamination of Hydraulic Fluids by Gravimetric Analysis
147	IS 1448 (Part 163) : 2018	Methods of test for petroleum and its products [p : 163] determination of gasoline diluent in used gasoline engine oils by gas chromatography
148	IS 1448 (Part 164) : 2018	Methods of test for petroleum and its products [p : 164] determination of the leakage tendencies of automotive wheel bearing grease under accelerated conditions
149	IS 1448 (Part 165) : 2018	Methods of test for petroleum and its products [p : 165] test method for roll stability of lubricating grease
150	IS 1448 (Part 167) : 2018/ ISO 12185	Methods of test for petroleum and its products [p : 167] determination of density - Oscillating u - Tube method
151	IS 1448 (Part 168) : 2018/ ISO 13758 : 1996	Methods of Test for Petroleum and its Products [P :168] Assessment of the Dryness of Propane - Valve Freeze Method
152	IS 1448 (Part 169) : 2018/ ISO 15597 : 2001	Methods of test for petroleum and its products [p : 169] determination of chlorine and bromine content - Wavelength - Dispersive x - Ray fluorescence spectrometry
153	IS 1448 (Part 170) : 2021/ ISO 20623	Methods of test for petroleum and its products Part 170 Petroleum and related products Determination of the extreme pressure and anti-wear properties of lubricants Four-ball method European conditions
154	IS 1448 (Part 171) : 2019/ ISO 10143 : 2014	Methods of test for petroleum and its products [p : 171] carbonaceous materials for the production of aluminum

		- Calcined coke for electrodes - Determination of the electrical resistivity of granules
155	IS 1448 (Part 172) : 2020	Methods of Test for Petroleum and its Products [P : 172] ICP-AESMethod for Determination of Trace Elements in Petroleum Products
156	IS 1448 (Part 173) : 2020	Methods of Test for Petroleum and its Products [P : 173] Determination of Lead Content in Motor Gasoline - Energy Dispersive X-Ray Fluorescence Spectrometry Method
157	IS 1448 (Part 174) : 2020/	Methods of Test for Petroleum and its Products Part
	ISO 4264 : 2018	174 Petroleum Products - Calculation of Cetane index of Middle-Distillate Fuels by the Four Variable Equation
158	IS 1448 (Part 175) : 2020/ ISO 6296 : 2000	Methods of Test for Petroleum and its Products Part 175 Petroleum Products - Determination of Water - Potentiometric Karl Fischer Titration Method
159	IS 1448 (Part 176): 2020/ ISO 7537: 1997	Methods of Test for Petroleum and its Products Part 176 PetroleumProducts - Determination of Acid Number - Semi-micro Colour-indicator Titration Method
160	IS 1448 (Part 177): 2020/ ISO 3648: 1994	Methods of Test for Petroleum and its Products Part 177 Aviation FuelsEstimation of Net Specific Energy
161	IS 1448 (Part 178): 2020/ ISO 6271: 2015	Methods of Test for Petroleum and its Products Part 178 Clear Liquids -Estimation of Colour by the platinum Cobalt Colour Scale
162	IS 1448 (Part 179): 2020/ ISO 14596: 2007	Methods of Test for Petroleum and its Products Part 179 PetroleumProducts - Determination of Sulfur Content - Wavelength-dispersive X-ray Fluorescence Spectrometry
163	IS 1448 (Part 180): 2020/ ISO 16591: 2010	Methods of Test for Petroleum and its Products Part 180 Petroleum Products - Determination of Sulphur Content - Oxidative Microcoulometry Method
164	IS 1448 (Part 181): 2020/ ISO 22854: 2016	Methods of Test for Petroleum and its Products Part 181 LiquidPetroleum Products - Determination of Hydrocarbon Types andOxygenates in Automotive Motor Gasoline and in Ethanol (E85)Automotive Fuel - Multidimensional Gas Chromatography Method
165	IS 1448 (Part 182): 2020/ ISO 12937: 2000	Methods of Test for Petroleum and its Products Part 182 Petroleum Products - Determination of Water - Coulometric Karl Fischer Titration Method
166	IS 1448 (Part 183): 2021/ ISO 14935	Methods of test for petroleum and its part 183 Petroleum and related Products -Determination of wick flame persistence of fire-resistant Fluids
167	IS 1448 (Part 184): 2021/ ISO 15029-2: 2018	Methods of Test for Petroleum and its Products Part 184 petroleum and related products - Determination of spray ignition characteristics of fire-resistant fluids spray test - Stabilised flame heat release method

168	IS 1448 (Part 185): 2021/ ISO 20823: 2003	Methods of Test for Petroleum and its products part 185 Petroleum and Related Products-Determination of the Flammability characteristics of fluids in Contact with Hot Surfaces-Manifold Ignition Test
169	IS 1448 (Part 186): 2021/ ISO 23581: 2020	Petroleum Products and Related Products Determination of KinematicViscosity Method by Stabinger Type Viscometer
170	IS 1448 (Part 187): 2021/ ISO 3987: 2010	Methods of test for Petroleum and its Products Part 187 PetroleumProducts-Determination of Sulfated Ash in Lubricating Oils and Additives
171	IS 1448 (Part 188): 2021/ ISO 6618: 1997	Petroleum products and lubricants determination of acid or base number colour-indicator titration method
172	IS 1448 (Part 189): 2021/ ISO 10370: 2014	Petroleum products - determination of carbon residue - micro method
173	IS 1448 (Part 190): 2021/ ISO 15167: 1999	Petroleum products determination of particulate content of middle distillate fuels laboratory filtration method
174	IS 1448 (Part 191): 2023/ ISO 13737: 2004	Methods of test for petroleum and its products Part Determination of low-temperature cone penetration of lubricating greases
175	IS 1448 (Part 192): 2023/ ISO 22285: 2018	Methods of test for petroleum and its products Part Determination of oil separation from grease Pressure filtration method
176	IS 1448 (Part 193): 2023/ ISO 22286: 2018	Methods of test for petroleum and its products Part Determination of the dropping point of grease with an automatic apparatus
177	IS 1448 (Part 194):2023/ ISO 11007-1: 2021	Petroleum and its Products - Methods of Test Part Determination of Rust - Prevention Characteristics of Lubricating Greases Dynamic Wet Conditions
178	IS 1448 (Part 195):2023/ ISO 10143: 2019	Petroleum and its Products-Methods of Test Part Determination ofResistivity of Petroleum Coke
179	IS 1488 (Part 157): 2018	Methods of test for petroleum and its products [p : 157] rust protections by metal preservatives in the humidity cabinet
180	IS 7895: 1975	Tests for fire - Resistant characteristics of hydraulic fluids used in mining machinery
181	14504:2021/ ISO 6976:2016	Natural Gas - Calculation of Calorific Values, Density, Relative Density and Wobbe Indices from Composition (First Revision)
182	IS 15125 : 2002/ ISO 10715	Natural gas - Sampling guidelines
183	IS 15128: 2020 / ISO10723:2012	Natural Gas - Performance Evaluation for Analytical Systems (FirstRevision)

184	IS 15129 : 2002/ ISO 14111	Natural gas - Guidelines to traceability in analysis
185	IS 15130 (Part 1): 2019/ ISO 6974-1	Natural Gas - Calculation of Compression Factor Part 1 Introduction andGuidelines (First Revision)
186	IS 15130 (Part 2) : 2021/ ISO 6974-2 : 2012	Natural Gas - Determination of Composition and Associated Uncertainty by Gas Chromatography Part 2 Uncertainty Calculations (First Revision)
187	IS 15130 (Part 3) : 2021/ ISO 6974-3:2018	Natural gas determination of composition and associated uncertainty by gas chromatography part 3: precision and bias
188	IS 15130 (Part 4) : 2002/ ISO 6974-4	Natural Gas - Determination of Composition with Defined Uncertainty by Gas Chromatography - Part 4 : Determination of Nitrogen, Carbon Dioxide and C1 to C5 and C6+ Hydrocarbons for a Laboratory andOn-line Measuring System Using Two Columns
189	IS 15130 (Part 5) : 2021/ ISO 6974-5	Natural Gas - Determination of Composition with Defined Uncertainty by Gas Chromatography - Part 5 : Determination of Nitrogen Carbon Dioxide and C1 to C5 and C6 Hydrocarbons for a Laboratory and On-lineProcess Application Using Three Columns
190	IS 15305 (Part 1) : 2019/ ISO 12213-1	Natural Gas - Calculation of Compression Factor Part 1 Introduction andGuidelines (First Revision)
191	IS 15305 (Part 2) : 2019/ ISO 12213-2:2006	Natural Gas - Calculation of Compression Factor Part 2 CalculationUsing Molar-Composition Analysis (First Revision)
192	IS 15305 (Part 3) : 2018/ ISO 12213-3	Natural gas - Calculation of compression factor: Part 3 calculation using physical properties (First Revision)
193	IS 15319 : 2020/ ISO 13734	Natural Gas - Organic Components Used as Odorants - Requirements and Test Methods (First Revision)
194	IS 15641 (Part 1) : 2006/ ISO 10101-1	Natural gas - Determination of water by the karl fischer method: Part 1Introduction
195	IS 15641 (Part 2) : 2006/ ISO 10101-2	Natural gas - Determination of water by the karl fischer method: Part 2 titration procedure
196	IS 15641 (Part 3) : 2007/ ISO 10101 -3	Natural gas - Determination of water by karl fischer method: Part 3 coulometric procedure
197	IS 17315 (Part 1) : 2019/ ISO 4259-1	Petroleum and Related Products - Precision of Measurement Methods and Results Part 1 Determination of Precision Data in Relation to Methods of Test
198	IS 17315 (Part 2) : 2019/ ISO 4259-2	Petroleum and Related Products - Precision of Measurement Methods and Results Part 2 Interpretation and Application of Precision Data in Relatio to Methods of Test