Asphalt

Asphalt is a versatile "family of materials" rather than a single product, lending itself to many engineering and industrial uses. It is denned by the American Society for Testing Materials as "a dark brown to black cementitious material, solid or semisolid in consistency, in which the predominating constituents are bitumens which occur in nature as such or are obtained as residua in refining petroleum." Asphalt is naturally present in most crude petroleum, from which it can be separated by various refinery processes which also yield gasoline, kerosine, lubricating oils, and other petroleum products.

Asphalts also occur naturally in pits or lakes. These asphalts are residues from crude oils that have seeped up through fissures in the ground and from which the lighter fractions evaporated over many thousands of years.

TYPES OF PETROLEUM ASPHALT

The removal of light petroleum distillates and a substantial portion of the heavier, oily distillates provides asphaltic products of semisolid to solid consistency, depending on the amount of oily distillate remaining. These semisolid to solid asphaltic products are termed "asphalt cements." By permitting a greater proportion of the oily fraction to remain or by blending oily distillates with an asphalt cement, a group of products normally termed "road oils" can be obtained.

Blending asphalt cements with lighter petroleum distillates, such as naphtha, gasoline, or kerosene, produces a group of materials known as "cutback asphalts." The emulsification of asphalt cements with chemically treated water provides " emulsified asphalts." Road oils, cutback asphalts, and emulsified asphalts are classified as "liquid asphalts."

Asphaltic residuals, such as road oils, can be subjected to a "blowing" process to provide various materials for use in many special or industrial pplications.

Some asphalt cements for paving purposes are also produced by partial blowing of softer grades of asphalt cement. In some instances, blowing is accomplished in the presence of catalysts, such as phosphorus pentoxide or ferric chloride, to provide materials with special characteristics.

ASPHALT CEMENT

Asphalt cement is a thermoplastic material varying in consistency from "firm" to "hard" at normal temperature. For application or for mixing with other materials,

however, it must be heated to a fluid consistency. Several standard grades of asphalt cement are commercially available, which are normally classified into different grades by a penetration test.

Penetration Test.

The penetration test is a measure of the consistency or relative hardness of the asphaltic material. Its general features are illustrated in Fig. 13-1.

A sample of the asphalt cement is placed in a suitable container and brought to a standard test temperature (normally 770°F) in a temperature-controlled water bath.

A weighted needle is then brought to bear on the surface of the asphalt cement for a given period. The load on the needle is 100 g, and the time interval is 5 sec. For special purposes, however, other temperatures, loadings, and time intervals may be employed. The penetration of the needle into the asphalt cement, in units of 1/10 mm, is termed the "penetration" of the asphalt cement.

For a given set of conditions, the needle will penetrate farther into a soft asphalt than a harder grade. Thus, soft asphalt cements are indicated by the higher penetration numbers, and the harder grades by the lower penetration numbers. Standard grades are normally identified on the basis of a penetration range. For example, one of the standard grades is the 85 to 100 penetration grade. The penetration-test procedure is prescribed in the ASTM test method designated as D5.

In addition to the classification of asphalt cements on the basis of penetration ranges, specifications for these products also include several other test requirements to prescribe more completely the characteristics desired by users of the material.

Flash Point. The flash point of an asphalt cement is of interest primarily to the user, since the material must be heated for application or mixing. It tells the user how much the material can be safely heated without danger of instantaneous flash in the presence of an open flame. This temperature, however, is usually well below that at which the material will burn. The temperature at which the material will burn is called the "fire point." It is seldom included in specifications on asphalt cements.

The flash point of an asphalt cement is measured by the Cleveland open-cup flash point test under standard test conditions prescribed in ASTM D 92.2 A schematic illustration of the test is shown in Fig. 13-2. A brass cup is partially filled with asphalt cement and heated at a prescribed rate. At intervals a small flame is played over the surface of the sample. The temperature at which sufficient vapors are released to produce an instantaneous flash is designated as the flash point of the sample under test.

Loss on Heating.

In most applications, the user specifies the properties of an asphalt cement which he wishes to have in the finished product. Since the material must be heated for application or mixing, its properties should not change appreciably when it is heated to the specified application or mixing temperatures. Such temperatures may vary, but they usually do not exceed 325°F. The loss-on-heating test was devised to prevent the inclusion of excessive amounts of volatile materials, the loss of which might cause appreciable changes in some of the properties of the asphalt cement. Results of this test should be considered only as a general indication of what can be expected under service conditions.

Solubility.

Pure asphalt cement is completely soluble in carbon disulfide and, except for carbenes, completely soluble in carbon tetrachloride. As mineral matter and other foreign products are insoluble in these solvents, they can, therefore, be used to detect the presence of such matter. For reasons of safety and convenience, carbon tetrachloride is the preferred solvent.

However, if asphalt cements do not meet the specification requirements for solubility when using carbon tetrachloride, the test should also be run with carbon disulfide as the solvent. When differences in solubility are encountered by use of the two solvents, the presence of carbenes may be indicated. If this difference is greater than about 0.5 per cent, it may mean that the asphalt cement has been overheated or "cracked" in the process of manufacture. On the other hand, cracked products do not always show the presence of carbenes.

The determination of solubility is simply a process of dissolving the asphalt cement in the solvent and separating out the insoluble matter. The procedure is prescribed in ASTM D 4.1.

LIQUID ASPHALTS

It is often desirable to use asphaltic materials of a more liquid consistency than that of asphalt cements. Many standard types and grades of liquid asphalts are produced to meet numerous requirements in a variety of applications. In some instances,

petroleum distillates are blended with the asphalt cement to provide the desired fluidity, or oily distillates are permitted to remain during the refining process. In other instances, asphalt cements are emulsified in chemically treated water to provide various types and grades of emulsified asphalts.

Cutback Asphalts and Road Oils

The liquid asphaltic materials that are a blend of asphalt cement and volatile petroleum distillates, or diluents, are of three standard types: (1) slow curing, (2) medium curing, and (3) rapid curing. The slow-curing products, often called "road oils," are usually a residual material produced from the fractional distillation of certain crude petroleum. Lighter fractions of the crude stock (naphtha, gasoline, kerosene, certain oils, etc.) are first vaporized in the distillation tower and then drawn off for further separation. A residue of asphalt and oil remains, the consistency of which depends principally upon the amount and character of the oil. Slow-curing liquid asphaltic materials can also be prepared by blending an asphalt cement with an oily petroleum fraction.

Medium-curing and rapid-curing liquid-asphaltic materials, known as " cutback asphalts," are a blend of asphalt cement with naphtha, gasoline, or kerosine. Rapid curing products are prepared with a light, rapidly evaporating diluent such as a naphtha or gasoline, while medium-curing products are prepared with a less volatile diluent such as kerosine.

Emulsified Asphalts

Emulsified asphalts consist of minute globules of asphalt suspended in chemically treated water. The asphalt globules are generally in the colloidal-size range. Asphalt water emulsions are usually prepared in a high-speed mixing apparatus, which emulsifies the asphalt into the water. The chemical used in treating the water is usually some type of caustic soap, clay, or other such agent, which assists in promoting the emulsification process and which also controls some of the properties of the emulsion.

When the emulsion is deposited upon the surfaces of soil or stone, the asphalt particles coalesce through chemical action on the surface of the stone or by evaporation of the water. In the jargon of the trade, the emulsion "breaks" and in so doing leaves a thin film of asphalt on the aggregate.

BLOWN ASPHALTS

Another type of asphalt is known as "blown" asphalt, sometimes referred to as "oxidized" asphalt. This is produced by blowing air through residual oil at temperatures usually in the range of 400 to 6000F. In the blowing process, air reacts with the resinous fraction, increasing its molecular weight and converting it into asphaltenes.

Depending upon the characteristics of the residual oil and the length of blowing time, blown asphalts of varying characteristics are produced.

USES OF PETROLEUM ASPHALT

Asphalt is one of man's oldest construction materials. Some of the earliest recordings of history tell of its use as a preservative of the dead, as a waterproofing material, as a mortar for stone-built structures, and as a cement for roads. The asphalts used by ancient peoples were the "natural" asphalts found in pits and lakes.

The development of the petroleum industry,- beginning in the latter part of the nineteenth century, afforded the means of refining and producing asphaltic materials

Uses in Highway Construction.

Miscellaneous uses of asphalts, for industrial and specialty purposes, are quite extensive. To mention only a few, asphalts are used in battery cases, automobile undercoating, tire manufacture, a wide variety of waterproofing and dampproofing applications, as a base for paints and lacquers, and for printing inks, and in the manufacture of floor coverings and building insulations. Even a summary discussion of the many uses of asphaltic materials in special and industrial applications is beyond the scope of this text. For information of this nature, the reader can consult Asphalts and Allied Substances6 and other reference books on asphaltic materials.

Questions

Section 1: General Definition & Origin

1. How does the American Society for Testing Materials (ASTM) define asphalt?
2. Besides petroleum refining, where else does asphalt occur naturally?
3. How are natural asphalts formed over long periods?

Section 2: Types of Petroleum Asphalt

4. What are “asphalt cements”?
5. How are “road oils” produced?
6. What are “cutback asphalts,” and what are they made from?
7. What are “emulsified asphalts,” and how are they produced?
8. What does the “blowing” process produce, and at what temperature range is it typically conducted?

Section 3: Asphalt Cement & Penetration Test

9. Why must asphalt cement be heated before application or mixing?
10. In the penetration test, what is the standard load on the needle, and for how long is it applied?
11. How is penetration measured (units)?
12. What do higher penetration numbers indicate about the asphalt cement?

Section 4: Flash Point & Solubility

13. Why is the flash point of asphalt cement important to the user?
14. What is the difference between flash point and fire point?
15. Which test method (ASTM) measures flash point of asphalt cement?
16. What does the loss-on-heating test help prevent?
17. What is the preferred solvent for solubility testing, and why?
18. If solubility differs between carbon tetrachloride and carbon disulfide, what does that indicate?

Section 5: Liquid Asphalts

19. Name the three standard types of cutback asphalts and road oils.
20. What diluents are used for rapid-curing cutback asphalts?
21. What diluent is typically used for medium-curing cutback asphalts?
22. How do emulsified asphalts “break” after application?

Section 6: Uses of Asphalt

23. List three historical uses of natural asphalt by ancient peoples.
24. Give four miscellaneous industrial or specialty uses of asphalt mentioned in the document.

Answers

Section 1: General Definition & Origin

1.
"A dark brown to black cementitious material, solid or semisolid in consistency, in which the predominating constituents are bitumens which occur in nature as such or are obtained as residua in refining petroleum."

2.
In pits or lakes.

3.
They are residues from crude oils that seeped up through ground fissures, from which lighter fractions evaporated over thousands of years.

Section 2: Types of Petroleum Asphalt

4.
Semisolid to solid asphaltic products obtained after removal of light petroleum distillates and a substantial portion of heavier, oily distillates.

5.
By permitting a greater proportion of the oily fraction to remain, or by blending oily distillates with an asphalt cement.

6.
Cutback asphalts are materials made by blending asphalt cements with lighter petroleum distillates such as naphtha, gasoline, or kerosene.

7.
Emulsified asphalts are minute globules of asphalt suspended in chemically treated water (usually with caustic soap, clay, or similar agents).

8.
Blown asphalts (or oxidized asphalts). Temperature range: **400 to 600°F**.

Section 3: Asphalt Cement & Penetration Test

9.
To bring it to a fluid consistency for application or mixing.

10.
Load: **100 g**. Time: **5 seconds**.

11.
In units of **1/10 mm**.

12.
Higher penetration numbers indicate **softer** asphalt cement.

Section 4: Flash Point & Solubility

13.
It tells the user how much the material can be safely heated without danger of instantaneous flash in the presence of an open flame.

14.
Flash point: temperature at which vapors produce an instantaneous flash. Fire point: temperature at which the material will actually burn.

15.
ASTM D 92.

16.
It prevents inclusion of excessive volatile materials, whose loss might cause appreciable changes in asphalt cement properties.

17.
Carbon tetrachloride — for reasons of **safety and convenience**.

18.
The presence of **carbenes** (may indicate the asphalt cement has been overheated or "cracked" during manufacture).

Section 5: Liquid Asphalts

19.
(1) Slow curing, (2) medium curing, (3) rapid curing.

20.
Naphtha or gasoline (light, rapidly evaporating diluent).

21.
Kerosene (less volatile diluent).

22.
Through chemical action on the surface of stone or by evaporation of water, leaving a thin film of asphalt on the aggregate.

Section 6: Uses of Asphalt

23.

- Preservative of the dead
- Waterproofing material
- Mortar for stone-built structures
- Cement for roads

24.
Any four of these:

- Battery cases
- Automobile undercoating
- Tire manufacture
- Waterproofing and dampproofing
- Base for paints and lacquers
- Printing inks
- Floor coverings
- Building insulations

Section 1: General Production & Raw Materials

1. What is the primary raw material for lube oil production?
2. How are different viscosity fractions of lube oil obtained from heavy oil?
3. What are the two main categories of lube oil fractions, and how do they differ?

Section 2: The “Old Three-Step” Process

4. Name the three steps in the traditional “old three-step” lube oil production process.
5. What is the purpose of solvent refining?
6. Why must the solvent have a higher density than the raw oil in solvent refining?
7. In the solvent extraction tower, where does the raw oil enter, and where does the solvent enter?
8. What are the two phases produced after solvent extraction, and what does each contain?
9. Why should a solvent have a low boiling point?

Section 3: Solvent Dewaxing

10. What is the main goal of solvent dewaxing?
11. What types of solvents are commonly used in solvent dewaxing?
12. Describe the basic principle of how solvent dewaxing works.

Section 4: Clay Refining

13. Why is clay refining (adsorption refining) needed after solvent refining and dewaxing?
14. What property of activated clay makes it effective for adsorption refining?
15. Name three impurities removed by clay refining.
16. What three improvements does clay refining bring to lube oil?

Section 5: Lubricant Oil Blending & Additives

17. What two main components determine the quality of lubricant oil?
18. Why are additives added to base oils?
19. Give four examples of common additive types mentioned in the document.
20. According to the document, name two specific additive chemicals and their functions.

Section 6: Quality Control, Packaging & Storage

21. List three types of quality control tests mentioned for lubricant samples.
22. What are three common packaging forms for finished lubricants?
23. Why must lubricants be stored in a controlled environment?
24. What two handling practices are emphasized to maximize lubricant effectiveness?

Answers

Section 1: General Production & Raw Materials

1.
Heavy oil extracted from crude oil.

2.
By vacuum distillation (heavy oil is distilled into various fractions and residues).

3.

- **Fractional lube oils** – obtained from different fractions
- **Residual lube oils** – obtained from residues
  They serve different applications due to their **varying viscosities**.

Section 2: The “Old Three-Step” Process

4.
(1) Solvent refining, (2) solvent dewaxing, (3) clay refining.

5.
To remove undesirable components such as polycyclic aromatic hydrocarbons, resins, and asphaltenes.

6.
The solvent is introduced from the top, and oil from the bottom; as they flow counter-currently, the denser solvent dissolves non-ideal components from the oil.

7.
Raw oil enters from the **bottom**; solvent enters from the **top**.

8.

- **Extract phase** – contains non-ideal components
- **Raffinate phase** – contains ideal lube oil components

9.
So that the solvent can be easily recovered by evaporation (its boiling point is lower than that of the lube oil).

Section 3: Solvent Dewaxing

10.
To lower the pour point of lubricant oil (and also yield valuable byproducts like paraffin wax).

11.
Ketone and benzene-based solvents.

12.
A solvent is mixed with oil to reduce viscosity; the mixture is cooled to induce wax crystallization; oil and wax are separated; solvent is recovered and reused.

Section 4: Clay Refining

13.
Because lube oil still contains impurities such as resins, asphaltenes, and residual solvents after the previous steps.

14.
It has a porous structure with a large surface area, giving it strong adsorption capabilities.

15.
Resins, asphaltenes, and residual solvents.

16.
(1) Enhancing oil color, (2) improving stability, (3) reducing remaining carbon.

Section 5: Lubricant Oil Blending & Additives

17.
(1) Quality of the base oil, (2) additives used.

18.
To enhance performance characteristics and meet specific requirements of various industrial applications.

19.
Any four of:

- Antioxidants
- Anti-wear agents
- Detergents
- Dispersants
- Viscosity index improvers
- Corrosion inhibitors

20.

- Disulfiram – an anti-oxidant
- Debitol – a rust inhibitor

Section 6: Quality Control, Packaging & Storage

21.

- Viscosity measurements
- Oxidation stability tests
- Performance evaluations

22.

- Bottles
- Drums
- Bulk tanks

23.
To maintain their quality and performance characteristics.

24.

- Avoiding contamination
- Ensuring correct application