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ABSTRACT

This workbook on materials and equipment is one of a series of nine individual units of instruction for roofing apprenticeship classes in California. The workbook covers eight topics: production of bitumens and asphaltic roofing materials; built-up roofing materials and adhesives; asphaltic products and rigid roofing materials; elastomeric and plastic membranes; flashing materials; fasteners; handling of roofing materials; and operation and maintenance of small engines. For each topic, student learning objectives and information sheets with line illustrations are given. Multiple choice tests corresponding to the eight topics are provided for teacher use in evaluating student progress. (No answers are included.) A list of required instructional materials and a glossary are also included in the workbook. Appendixes contain general industry safety order on industrial truck operation, and Uniform Building Code roof covering application requirements. (KC)

Roofing

Workbook and Tests

Common Roofing and Waterproofing Materials and Equipment

Prepared under the direction of the

CALIFORNIA EDUCATIONAL ADVISORY COMMITTEE FOR THE ROOFING INDUSTRY
and the
BUREAU OF PUBLICATIONS, CALIFORNIA STATE DEPARTMENT OF EDUCATION

5.25

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The following titles in the roofing series, each containing workbook and tests in a single volume, were available at the time of publication of this document:

Cold-Applied Roofing	(1982)	$5.25
Common Roofing and Waterproofing Materials and Equipment	(1982)	$5.25
Entering the Roofing and Waterproofing Industry	(1980)	$4
Rigid Roofing	(1980)	$4
Built-up Roofing	(1981)	$4

Books on first-aid practices and shingling are currently in production.

A complete list of publications available from the Department of Education, including instructional materials for some 23 other trades, is available from the address given above.

Questions and comments about existing apprenticeship materials or the development of new materials should be directed to:

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Foreword

In the California apprenticeship programs, experience gained on the job is supplemented by classroom work that is closely related to the job. This balanced system of training enables the apprentice to learn the "why" as well as the "how" of the trade. Both types of training are required for advancement in today's competitive industries.

The job-related courses for the skilled trades are highly specialized, and adequate training materials are for the most part not available commercially. To meet this need, the Department of Education, in cooperation with labor and management, develops the required training materials and makes them available to you at cost. This workbook is an example. It was written to provide you with up-to-date information you must have to meet the growing technical demands of the roofing and waterproofing trade. Every effort has been made to make the workbook clear, comprehensive, and current.

I congratulate you on your choice of roofing and waterproofing as a career. The effort you put forth today to become a competent journey-level worker will bring you many rewards and satisfactions, and the benefits will extend also to your community. We need your skills and knowledge, and I wish you every success in your new venture.

Superintendent of Public Instruction

Preface

The California State Department of Education, through the Bureau of Publications, provides for the development of instructional materials for apprentices under provisions of the California Apprentice Labor Standards Act. These materials are developed through the cooperative efforts of the Department of Education and employer-employee groups representing apprenticeable trades.

This edition of *Common Roofing and Waterproofing Materials and Equipment* was planned and prepared under the direction of the California Educational Advisory Committee for the Roofing Industry, with the cooperation of the State Joint Roofing Industries Apprenticeship Committee. The members of this committee include representatives of the Roofing Contractors Association of California and representatives of local unions. Employer representatives serving on the Educational Advisory Committee are Herman Little, San Jose; Robert Culbertson, Sacramento; and Arthur Adams, San Carlos. Representing employees are Joe Guagliardo, Fresno; Oscar Padilla, Los Angeles; and William Penrose, San Jose. Special thanks and appreciation are extended to M. Duane Mongerson of Oakland, who served as Committee Adviser. Joy Westberg of San Mateo prepared the original copy for this publication. Bob Klingensmith, Publications Consultant, Apprenticeship, coordinated activities for the Bureau of Publications.

This publication is one of a series of nine individually bound units of instruction for roofing apprenticeship classes. These new books reflect the continuing cooperative effort of labor, management, local schools, and the Department of Education to provide the best instructional materials for California apprenticeship classes. They are dedicated to excellence in the training of roofing apprentices.

THEODORE R. SMITH
Editor in Chief
Bureau of Publications

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Acknowledgments

Gratitude is expressed to the following manufacturers and organizations within the construction industry who contributed valuable information, drawings, and photographs used in this workbook:

Asphalt Roofing Manufacturers Association
International Conference of Building Officials
National Roofing Contractors Association

Common Roofing and Waterproofing Materials and Equipment

TOPIC 1—THE PRODUCTION OF BITUMENS AND ASPHALTIC ROOFING MATERIALS

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Discuss the importance of materials selection.**
- **Describe common bituminous materials used in the manufacture of finished roofing materials.**
- **Discuss the steps involved in the manufacture of asphaltic roofing materials.**

The quality of every roofing, waterproofing, and dampproofing job is dependent to a large degree on the selection of appropriate materials for the job. In fact, only the skill of the roofer is more important than materials selection in achieving high-quality roofing work. For this reason the apprentice roofer should have a thorough knowledge of the most common materials employed in the industry.

In most cases materials are selected in accordance with what the customer wants or can afford. However, in selecting materials, both the roofer and the customer must consider several factors. the design of the structure, fire rating requirements, climate, snow loads, cost, the expected life of the roof, the design and cost of supporting members, and the pitch, or slope, of the roof.

Bitumens Used in Roofing

The term *bitumen* is a general name for solid or semisolid, naturally occurring hydrocarbons. The two bitumens used in the roofing industry are coal-tar pitch and asphalt.

Production of Coal-Tar Pitch

The production of coal-tar pitch involves two basic steps: (1) destructive distillation of coal to produce tar; and (2) partial evaporation, or distillation, of the tar to produce pitch.

Description of Asphalts

Asphalts are dark brown or black solids or semisolids that occur in nature or are produced by refining petroleum. Today, more than 95 percent of the asphaltic materials used in North America are derived from the refining of petroleum.

For 5,000 years asphalt has been used as a preservative and as a waterproofing and adhesive agent. It was used by the Babylonians to waterproof baths and to form pavements. The Egyptians used asphalt to preserve mummies. Throughout the Middle Ages asphalt was commonly used in Europe. One of the largest natural deposits of asphalt was discovered by Columbus on the island of Trinidad in the British West Indies during his third voyage, in 1498.

Properties of Bitumens

Bitumens have a number of properties that make them useful in the roofing industry. One is their tendency to adhere to solid surfaces. This adhesiveness will vary depending on the nature of the surface and the state of the bitumen. For an adhesive to adhere to a surface, it must be able to wet the surface. Bitumens have this wetting ability in the fluid state, but the presence of water, moisture, or foreign matter (such as dust or dirt) on the surface can prevent adhesion.

The water resistance of bitumens is also very important. Under certain conditions water may be absorbed by minute quantities of inorganic salts in the bitumen or by the bitumen's various fillers. The absorbent qualities of both coal-tar pitch and asphalt are very low.

Manufacture of Asphaltic Roofing Materials

Asphalt flux, the primary material used today in the manufacture of asphaltic roofing materials, is a product of the fractional distillation of crude oil. It is produced toward the end of the distillation process. Asphalt flux is sometimes refined by the oil refiner and delivered to the roofing manufacturer in conformance with the manufacturer's specifications. Some manufacturers, however, purchase the flux and do their own refining.

Asphalt flux is used to make certain roofing grades of asphalt known in the trade as *saturants* and *coatings* (products of secondary processing). It is in these forms that asphalt is combined with dry felt in the manufacture of asphaltic roofing materials. Figure 1-1 shows the primary raw materials and secondary processing products required in the production of asphaltic roofing products.

Dry Felts

In the production of dry felt, cellulose fibers, such as those from paper, wood pulp, and wood paste, are blended in varying proportions to produce roofing materials with the desired strength, absorptive capacity, and flexibility.

Manufacturing felt is both an art and a science. To know exactly the proportions of the various ingredients necessary to meet specifications requires much experience on the part of the mill operator. The felt must be manufactured in accordance with the specifications for weight, tensile strength (the greatest longitudinal strength a substance can withstand without tearing), and flexibility, which must be such that it can (1) withstand the strains placed on it during the manufacturing processes; and (2) absorb one and a half to two times its weight in asphaltic saturants. The various steps involved in the manufacture of felts are shown in Figure 1-2.

Roofing felts are made on machines very similar to those used in manufacturing paper. The fibers are prepared by various pulping methods, depending on the fiber source. For example, rag fibers are prepared in beaters after the rags have been cut and shredded.

The finished dry felt comes off the end of the machine in a continuous wide sheet, from which it is cut into specified widths and wound in rolls.

Glass-Fiber Mats

Glass-fiber mats are composed of inorganic fibers in both continuous and random chopped strands firmly bonded with plastic binders. These basic glass fibers may be reinforced with additional chopped

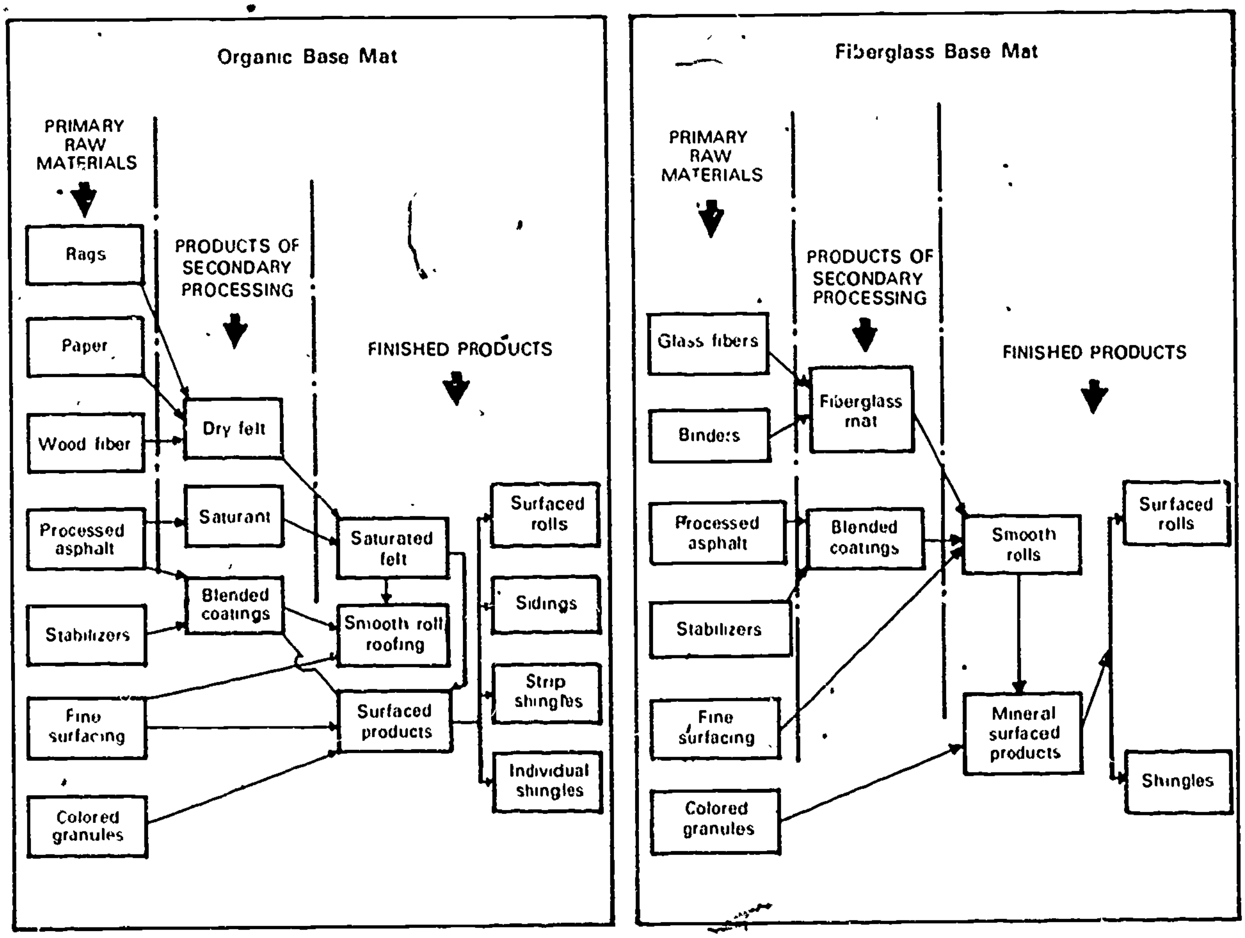


Fig. 1-1. Processing charts for asphaltic roofing products, from raw materials to finished products

strands or continuous random or parallel strands. The glass-fiber mat may be produced by any of several processes.

Saturants and Coatings

The preservative and water-resistant characteristics of asphalt are derived from several of its oily constituents. Saturants—oil-rich asphaltic bitumens—are used to saturate, or impregnate, felts and glass-fiber mats and make them highly absorbent. This saturant is later sealed with an application of harder, more viscous coating asphalt, which may also be protected by a covering of opaque mineral granules.

The asphalt used for saturants and coatings is prepared by processing the flux in such a way as to modify the temperature at which it will soften. The softening points of saturants vary from 100° to 160° F. (37.8° to 71.1° C), whereas those of the coatings run as high as 260° F. (126.7° C). This ability to "control" the softening point of flux is extremely important in producing materials that can withstand the high temperatures that may occur on roofs.

Mineral Stabilizers

Coating asphalts resist weathering more effectively and are more shatterproof and shockproof in cold weather if they contain a certain percentage of finely divided minerals called *stabilizers*. Materials that may be used as stabilizers include silica, slate dust, talc, mica materials, dolomite, and trap rock. A suitable stabilizer, when used in the proper amount, can greatly increase the life of the product.

Fine Mineral Surfacings

Finely ground minerals are dusted on the surfaces of smooth roll roofing, the backs of mineral-surfaced roll roofing, and the backs of asphaltic shingles. They aid in preventing the convolutions of the roll from sticking together after the material is wound and in preventing shingles from sticking together in the package. The materials most often used for this purpose are talc and mica. Mineral surfacings are not a permanent part of the finished product and will gradually disappear from exposed surfaces after the roofing is applied.

Coarse Mineral Surfacings

Mineral granules are used on certain roll roofing products and on shingles for the following reasons:

1. They protect the underlying coating of asphalt from light rays. Therefore, they should be opaque, dense, and properly graded for maximum coverage.
2. By virtue of their mineral origin, they increase the fire resistance of the product.
3. They provide for a wide range of colors and color blends for aesthetic appeal.

The materials most frequently used for mineral surfacing are (1) naturally colored slate; and (2) rock granules in natural form or colored by a ceramic process.

Typical Production Steps

Figure 1-3 shows the steps that may be involved in producing various asphaltic roofing products from a roll of dry felt. In sequence these steps are as follows:

1. A roll of dry felt is installed on the felt reel and fed onto the dry looper. The dry looper acts as a reservoir of felt that can be drawn upon as required. This reservoir makes it unnecessary to stop the machine when a new roll of dry felt must be added to the felt reel or when imperfections in the felt must be cut out.
2. From the dry looper the felt is moved to the saturation tank, where it is subjected to hot saturant to eliminate moisture and fill the felt fibers and intervening spaces as completely as possible with the asphaltic saturant.
3. At the completion of the saturation process, excess saturant usually remains on the surface of the felt sheet. The felt is moved to the wet looper, where it is held for cooling. During this cooling period the asphalt shrinks and is drawn down into the felt. This allows for a very high degree of saturation of the felt.
4. At the coater the coating asphalt is applied to both the top and bottom sides of the felt. The amount of coating to be applied is regulated by means of coating rolls. Bringing these rolls together reduces the amount of coating that is applied, separating them increases it. At this point in the process, the finished weight of the product is controlled by the machine operator. Long experience enables the operator to maintain uniform production through delicate adjustments of the control mechanism. Many machines are equipped with automatic scales that weigh the sheets during the operation and warn the operator when the weight of the material is over or under specifications.
5. If smooth roll roofing is being made, talc, mica, or other suitable minerals are applied to both sides by spreading them on the felt and passing the felt through a press roll. If mineral-surfaced products are being prepared, granules of specified color or color combinations are added from a hopper and spread thickly on the hot coating asphalt. The sheet is then run through a series of

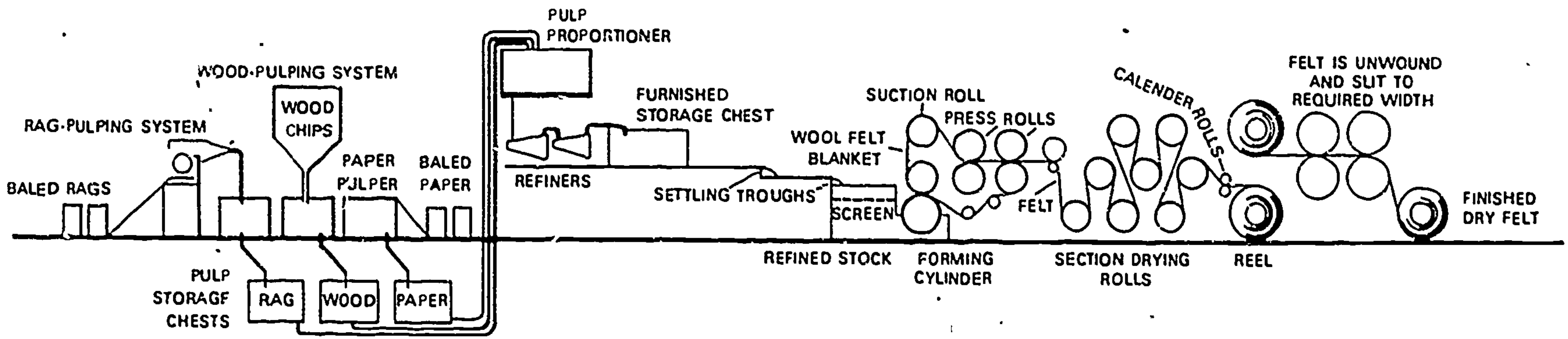


Fig. 1-2. Production sequence for finished dry felt

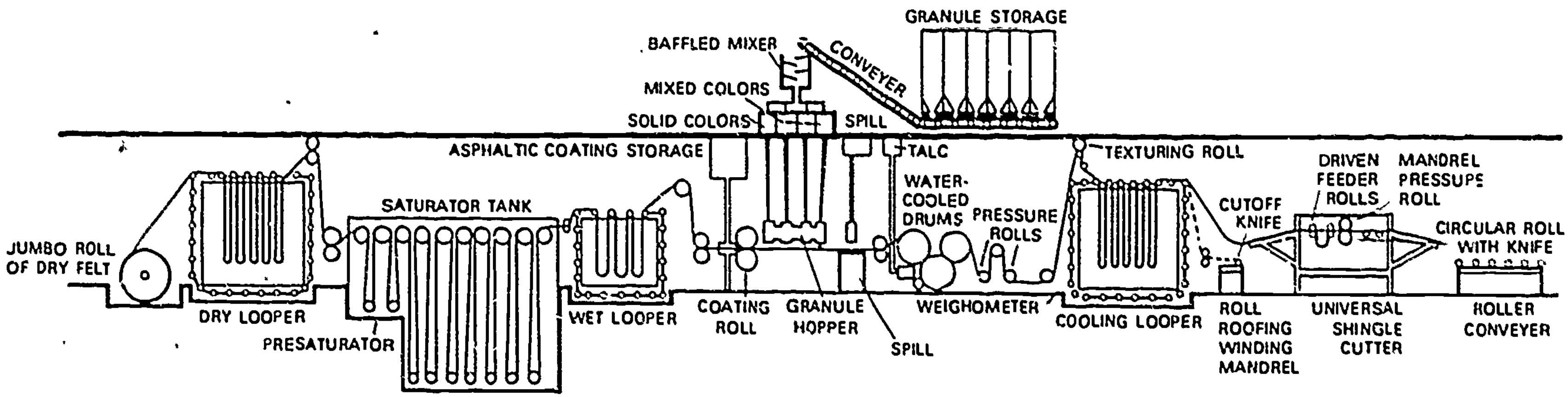


Fig. 1-3. Production sequence for finished asphaltic roofing materials from dry felt

pressing and cooling, rolls, or drums. Proper embedment of the granules is achieved by subjecting the sheet to controlled pressure, which forces the granules into the coating to the desired depth.

Some variation in the shade of asphaltic shingle roofs is unavoidable. Shading is usually caused by slight variations in the texture of the surface of the shingles; these variations occur during normal manufacturing operations. The resulting variable absorptive capacity and ability to reflect light cause variations in appearance but do not affect the durability of the roofing. Shading is especially noticeable on black or dark-colored roofs viewed from certain angles or under certain light conditions. Although shading is less apparent on white or light-colored roofs, any variation in shade can be made less noticeable by the use of blends of granules of a variety of colors.

At this point in the process, some products are textured by being pressed by an embossing roll, which forms a pattern in the surface of the sheet.

6. The felt sheet is now ready to go into the cooling looper. In the cooling, or finish, looper, the sheet is cooled to a temperature at which it can be cut and packed without danger to the material.
7. If shingles are being made, the material is next fed into the shingle cutter. The sheet is cut by a cutting cylinder against which pressure is exerted by an anvil roll as the sheet passes between the two components. The cylinder cuts the sheets from the back, or smooth, side. After the shingles have been cut, they are separated into units that accumulate in stacks of the proper number for packaging. The stacks are moved to manually operated or automatic packaging equipment, where the bundles are prepared for warehousing or shipment.
8. If roll roofing is being made, the sheet is drawn from the cooling looper to the roll roofing winder. Here, it is wound on a mandrel that measures the length of the material as it turns. When sufficient footage has accumulated, the sheet is cut off, removed from the mandrel, and passed on for wrapping. After packaging, the rolls are assembled for warehousing or shipment.

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 2—BUILT-UP ROOFING MATERIALS AND ADHESIVES

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Distinguish among the various materials used in built-up roofing.**
- **Recognize that some built-up roofing materials are multipurpose and may be used for other roofing processes.**
- **Identify rosin-sized dry sheeting and its uses.**
- **List some common saturated felts.**
- **Discuss cap sheets and their uses.**
- **Describe the basic principles for use of decking materials.**
- **Identify the five general kinds of roofing insulation.**
- **Describe commonly used hot and cold adhesives.**

Built-up roofing materials, as the term implies, are used to form the various layers (or plies) and coverings (cap sheets) that comprise built-up roofs. These materials are also used as underlayments on rigid roofs. During the application process the layers are bonded together with hot bitumen or cold-application adhesives or are nailed, spot-mopped, or sprinkle-mopped to decks as underlayments. Many of the materials described in this topic have multiple uses. A majority of the asbestos, asphalt-based, and glass felts, for example, can be used in cold-applied processes, as well as hot-applied applications. A good knowledge of these materials and their uses will increase the apprentice roofer's value to the employer.

Rosin-Sized Dry Sheets

The contraction and expansion of the roofing material and the deck upon which it is laid could cause new roofing to buckle, split, or crack. One method of preventing this problem is the use of rosin-sized dry sheets between the deck and roofing material to keep the new roofing material from being attached to the roof deck or previous roof covering. These dry sheets also prevent the asphalt or tar from causing damage inside the building that is being roofed by keeping these materials from reaching the sheathing and bleeding through it.

Dry sheets are seldom used over plywood decks. Various base sheets, which can also function as dry sheets, can be nailed or sprinkle-mopped to plywood or other deck structures. Dry sheeting, like other roofing materials, is generally identified by numeric designations (for example, number 20 roll).

The most common types of dry sheets now in use are the following:

- Number 20 roll Number 20 roll weighs approximately 4 pounds (1.8 kilograms) per square (100 square feet, or 9.3 square metres).
- Number 30 roll Number 30 roll weighs approximately 6 pounds (2.7 kilograms) per square.
- Number 35 roll Number 35 roll weighs approximately 7 pounds (3.2 kilograms) per square.

Rolls of each of the three dry sheets listed above are 36 inches (91.4 centimetres) wide, contain 180 lineal feet (54.9 metres), and will cover five squares.

Base Sheets

The base sheet is the first saturated or coated sheet to be installed in a multiple ply, built-up roofing system. The base sheet and successive ply sheets are held together by coats of asphalt or coal-tar pitch. These coats are applied by mopping them on while the material is hot and then rolling the felt on before the hotstuff sets. The cover sheet is applied on this base by using hotstuff as the cohesive agent. (See Fig. 2-1.) However, roofing membranes should never be mopped solid to nailable-type decks or to existing (old roof) membranes. Because the old roof membrane or nailable deck often expands and contracts at a rate different from that of the new membrane, buckling and cracking of the new membrane could result. In cold-process jobs cold-process adhesives bond the felts together. The felts commonly used in roofing today are discussed in the following sections.

Asphalt-Saturated Felts

Felts that have been completely saturated with asphalt, either perforated or unperforated felts, are packaged as follows:

- Number 15 felt is available in 4-square rolls (rolls that will cover 4 squares), which weigh approximately 60 pounds (27.2 kilograms per roll). Each roll is 36 inches (91.4 centimetres) wide and contains 144 lineal feet (43.9 metres) or 432 square feet (40.1 square metres). It is also available in

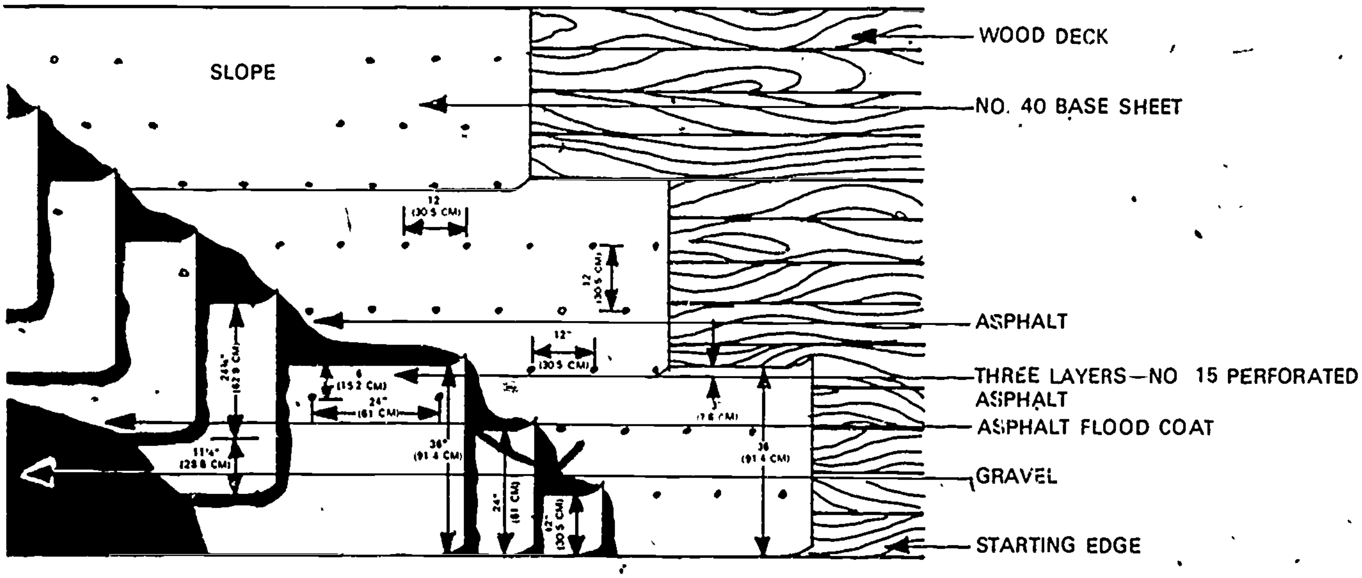


Fig. 2-1. A one-ply base sheet and three-ply finish felt with gravel on a wood deck

3-square rolls, which weigh approximately 45 pounds (20.4 kilograms) each. The rolls are 36 inches (91.4 centimetres) wide and contain 108 lineal feet (32.9 metres) or 324 square feet (30.1 square metres). Unperforated number 15 felt is used as underlayment with shingles and other rigid roofing materials. Perforated number 15 felt is used for asphaltic adhesion in built-up waterproofing and dampproofing systems and as a dampproofing membrane.

- Number 30 felt (unperforated) is available in 2-square rolls, which weigh approximately 60 pounds (27.2 kilograms) per roll. Rolls are 36 inches (91.4 centimetres) wide and contain 72 lineal feet (21.9 metres) or 216 square feet (20.1 square metres). Number 30 felt is used as a base sheet in built-up roofing systems and as an underlayment for tile and asphalt and asbestos shingles. Half-rolls of this product are used for interlacing between shakes.
- Number 40 felt (unperforated) is available in 2-square rolls, which weigh approximately 80 pounds (36.3 kilograms) per roll. Rolls are 36 inches (91.4 centimetres) wide and contain 72 lineal feet (21.9 metres) or 216 square feet (20.1 square metres). This heavy rag felt is thoroughly saturated with asphalt and coated on both sides with a sand or mica finish. It is used primarily as a base sheet. However, it can also be used in many of the same areas as the number 30 felt.
- Number 50 and number 75 felts are examples of heavy asphalt-saturated rag felt sheets. They are coated on both sides and dusted with talc, mica, or sand. They are used mainly as base sheets and are available in 1-square rolls that are 36 inches (91.4 centimetres) wide.
- Asphalt-saturated cotton fabric is available in rolls 4 inches (10.2 centimetres), 6 inches (15.2 centimetres), 9 inches (22.9 centimetres), and 36 inches (91.4 centimetres) wide. The 36-inch-wide (91.4-centimetre-wide) rolls contain 450 square feet (41.8 square metres). This material is most frequently used for flashings and waterproofing.

Venting Base Sheet

Venting base sheet is an asphalt-saturated material and is recommended for use on all nailable, lightweight, poured-in-place decks as a substitute for regular base sheet. It is applied with the perforation dimples down. Its advantage over regular base sheet is its superior ability to disperse moisture-laden air, which can cause blisters, cracks, and premature failure of the roofing assembly. It is available in 1-square rolls that weigh approximately 65 to 70 pounds (29.5 to 31.8 kilograms) per roll. Venting base sheet can be used with or without insulation.

Coal-Tar Pitch Felts

Coal-tar pitch felts are similar in appearance to asphaltic felts but are saturated with coal-tar pitch rather than asphalt. They *must* be applied with coal-tar pitch. Asphalt cannot be used, because it is not compatible with pitch. Coal-tar pitch felts are available in rolls of various weights and sizes. Three-square rolls, which weigh approximately 45 pounds (20.4 kilograms), are 36 inches (91.4 centimetres) wide and contain 108 lineal feet (32.9 metres) or 324 square feet (30.1 square metres). Four-square rolls weigh approximately 60 pounds (27.2 kilograms) per roll, are 36 inches (91.4 centimetres) wide, and contain 144 lineal feet (43.9 metres) or 432 square feet (40.1 square metres).

Asbestos Felts

Asbestos felts are made of inorganic asbestos, which makes possible a greater life span than materials made of rag or wood fibers. However, they are manufactured by similar processes. Asbestos felts may be used as either base sheets or finish roofing. In either case they are applied with the perforation dimples up so that gases or air trapped during the application will be released during the contraction of the felt. Brief descriptions of the most commonly used asbestos felts follow:

- Number 15 perforated asphalt-impregnated felt rolls weigh approximately 45 pounds (20.4 kilograms) per roll. Three-square rolls are 36 inches (91.4 centimetres) wide and include 108 lineal feet (32.9 metres) or 324 square feet (30.1 square metres). Four-square rolls are 36 inches (91.4 centimetres) wide and include 144 lineal feet (43.9 metres) or 432 square feet (40.1 square metres). This material is used for constructing built-up roofs of asbestos and roofs of combination rag and asbestos. The perforations allow air to escape from underneath the felt at the time of application, which provides for better adhesion and prevents buckling and blistering of the felt.
- Number 45 asbestos-based felt is a heavy asbestos roofing material that is thoroughly saturated and coated on both sides with asphalt and sand. It is manufactured in 1-square rolls, which weigh approximately 45 pounds (20.4 kilograms) per roll. The rolls are 36 inches (91.4 centimetres) wide, and they contain 36 lineal feet (11 metres) or 108 square feet (10 square metres).

Fiberglass Sheets

In addition to the felts described above, an additional group of coverings is made of glass fibers. These are not felts but are ply sheets in the strict sense of the word. The most often used fiberglass materials are the following:

- Fiberglass base sheet is a fibrous glass mat reinforced with glass yarns that are bonded together with a resinous binder and completely impregnated with asphalt. Fiberglass sheets are available in 3-square rolls, which weigh approximately 25 pounds (11.3 kilograms) per square. The rolls are 36 inches (91.4 centimetres) wide. A perforated fiberglass base sheet is now available for application over urethane insulation to prevent the blistering that occurs when regular (unperforated) base sheet is applied over urethane. The perforated sheet is available in the same size rolls as the unperforated fiberglass base sheet described above.
- Fiberglass ply sheets are porous sheets of strong fiberglass mat, reinforced with continuous glass yarns, bonded with resin, and saturated with weathering-grade asphalt. They are usually available in 5-square rolls. Each roll is 36 inches (91.4 centimetres) wide and contains 180 lineal feet (54.9 metres) or 540 square feet (50.2 square metres). Weights of approximately 8 to 11 pounds (3.6 to 5 kilograms) per square are available. An 11-pound (5-kilogram) heavy-duty "combined-strand" fiberglass sheet has been developed for increased weather resistance. This fiberglass material features approximately 15 percent more continuous strands of greater thickness than the regular 11-pound (5-kilogram) fiberglass ply sheet.
- Glass fabric is a lightweight cloth woven from glass strands. The fabric is available in widths of 4 inches (10.2 centimetres), 6 inches (15.2 centimetres), 12 inches (30.5 centimetres), 18 inches (45.7 centimetres), and 36 inches (91.4 centimetres) by 150 feet (45.7 metres) long. It is used for flashing, waterproofing, and cold-applied applications.
- Glass roof tape is a strong mat of continuous strand fibers bonded together with a resinous binder. The tape is available in rolls that are 6 inches (15.2 centimetres) wide and that contain 300 lineal feet (91.4 metres). Glass roof tape, when used with glass roof insulation, reinforces the insulation joints and also prevents bitumen loss at insulation joints and possible asphalt voids.

Cap Sheets

Cap sheets are finish-saturated felts that are made in different weights and that have a variety of surfaces. The following surfaces and weights are commonly used:

- Number 90 mineral-surfaced cap sheet is an asphalt-saturated rag felt that is coated on both sides but more heavily on the side into which colored mineral granules are embedded. This cap sheet is used for covering built-up roof assemblies and single-ply nail-on roll roofing assemblies. It is also used as a flashing material. Number 90 cap sheet is available in 1-square rolls, which weigh approximately 90 pounds

(40.8 kilograms) per square. The rolls are 36 inches (91.4 centimetres) wide, contain 36 lineal feet (11 metres) or 108 square feet (10 square metres), and include a 2-inch (5.1-centimetre) selvage. In some areas 77-pound (34.9-kilogram) rolls that contain 96 square feet (8.9 square metres) are used.

- Number 105 mineral-surfaced cap sheet is similar to the number 90 mineral-surfaced cap sheet, but it offers a heavier felt and a 3-inch (7.6-centimetre) selvage. It is most commonly furnished in 3/4-square rolls weighing approximately 80 pounds (36.2 kilograms) each. The rolls are 36 inches (91.4 centimetres) wide and contain 75 square feet (7 square metres).
- Number 80 mineral-surfaced asbestos cap sheet is a heavy asphalt-impregnated asbestos felt and is surfaced on one side with mineral granules. Inorganic asbestos fibers are used in place of rag or wood fibers to increase the life span of the material. It is available in 1-square rolls that weigh approximately 80 pounds (36.2 kilograms) per square and have a 2-inch (5.1-centimetre) selvage.
- Split sheet, or S.I.S., is a heavy asphalt-saturated rag felt that is manufactured in 36-inch-wide (91.4-centimetre-wide) rolls. The rolls include a 19-inch (48.3-centimetre) selvage and 17 inches (43.2 centimetres) of exposed surface. The exposed surface is covered with colored mineral granules embedded in asphalt. Split sheet is used over built-up roofs where color is desired or where the pitch of the roof is too steep for gravel to be used. It is manufactured in 1/2-square rolls that weigh approximately 58 pounds (26.3 kilograms) and contain 108 square feet (10 square metres).
- Fiberglass mineral-surfaced cap sheet is used over ply sheets. The sheet is an extra thick mat of glass fibers reinforced with glass yarns and bonded together with a resinous binder. It is impregnated and coated with asphalt and covered with colored granules on one side. It is available in 1-square rolls that weigh from 72 to 78 pounds (32.7 to 35.4 kilograms). The rolls are 36 inches (91.4 centimetres) wide and contain 36 lineal feet (11 metres).

Aggregates

Aggregates (gravel) are often used in place of cap sheets as a finish material on built-up roofs. Like the granules in cap sheets, gravel helps prevent the evaporation of oils from the asphalt and felts. It is also decorative on roofs and reflects heat and ultraviolet rays, which are the biggest contributors to roof deterioration. Therefore, the light-colored rocks are often preferred. The maximum roof pitch for practical application is 3/12 where asphalt is used and 1/2/12 where coal-tar pitch is used.

Unlike asphalt, coal-tar pitch does not contain oil. Thus, the molecules of coal-tar pitch, if protected by gravel or slag, will tend to heal themselves when exposed to the sun. The gravel used on coal-tar pitch roofs should be hard and opaque and not less than 3/8 inch (1 centimetre) in diameter. The slag used should be graded from 1/4 inch (0.6 centimetre) to 5/8 inch (1.6 centimetres) in diameter.

While the term *gravel* is used to describe this material, the material may have a number of different origins, often depending on the resources of the particular area. The rock may be brought from the quarry and only crushed and screened for size before delivery, or it may also be treated with a glaze and fired in a furnace before delivery. Among the quarried materials used are marble, gravel, and dolomite.

In addition, a number of other materials are used on rock roofs. These include crushed china, crushed brick, and iron ore slag. The aggregate materials are usually available in bulk or bags and should be free of dust and moisture. The more angular the pieces, the better they will embed themselves in the asphalt or coal-tar pitch.

Insulating Materials

Many different kinds and sizes of insulating materials are used to prevent the loss of heat from a structure or the penetration of heat or cold into the structure. They are made of either organic materials, such as fiberboard, wood fibers, or bark, or of inorganic materials, such as plastic foam, fiberglass, or spun rock. In form these insulations include loose-fill, blankets, batts, rigid insulation board, slab or block insulation, reflective insulation, sprayed-on insulation, foamed-in-place insulation, and corrugated insulation. Of these perhaps the one most commonly used by the roofer is the rigid insulation board. The boards, in addition to insulating the deck, also serve to strengthen it. Some are impregnated with asphaltic products to resist water. Many have vapor barriers such as kraft paper or metal foil, laminated to one or both sides. Some are tapered in thickness to provide a sloping deck for water drainage. Rigid insulation board is usually manufactured from one or a combination of insulating materials.

Perlite

A fire-resistant volcanic glass, perlite (cellular glass insulation) is classified as a nonmetallic mineral. Perlite ore is mined, crushed, screened, graded, and then heated to temperatures above 1,700° F. (926.7° C).

During the heating process the ore expands to as much as 20 times its original size. Each separate expanded particle contains many nonconductive cells that make the material lightweight and resistant to thermal conductivity. The expanded perlite is combined with binders and waterproofing agents to produce rigid insulation board.

Plastics

Urethane and polystyrene are two plastics commonly used for rigid insulation purposes. They usually feature cores of rigid urethane or polystyrene foam that are bonded with asphalt-saturated felt skins. The foam is extruded into slabs of various sizes and in thicknesses ranging from 1 to 3 inches (2.5 to 7.6 centimetres). A special urethane insulation with foil-skin surfacing on both sides is used as underlayment insulation for tile, shakes, wood shingles, and composition shingles. Foil-skin urethane insulation can also be used under built-up roofing systems.

Fiberglass

Fiberglass insulation board is made of inorganic glass fiber and is surfaced with an impact-resistant asphalt and paper mopping surface. It is used mainly on flat roof decks of any standard type, however, it is occasionally applied on roofs with steeper slopes.

Fiberboard

Fiberboard is manufactured from wood that has been pulped and treated with waterproofing chemicals. The fibers are then formed into sheets of various thicknesses and cut into standard lengths. Some are impregnated with asphalt during the manufacturing process, and others are left plain. Cane and cork are other organic fibers used in the manufacture of fiberboard.

Composite Board

Because standard perlite insulation is not normally applied to metal decks, composite board was developed for metal deck applications. Composite board consists of a layer of perlite that is chemically bonded to a layer of urethane foam. (See Fig. 2-2.)

Ideal Preformed Insulation

In *Handbook of Accepted Roofing Knowledge*, the National Roofing Contractors Association (NRCA) describes the properties of an ideal preformed roof insulation.[1] These properties are the following:

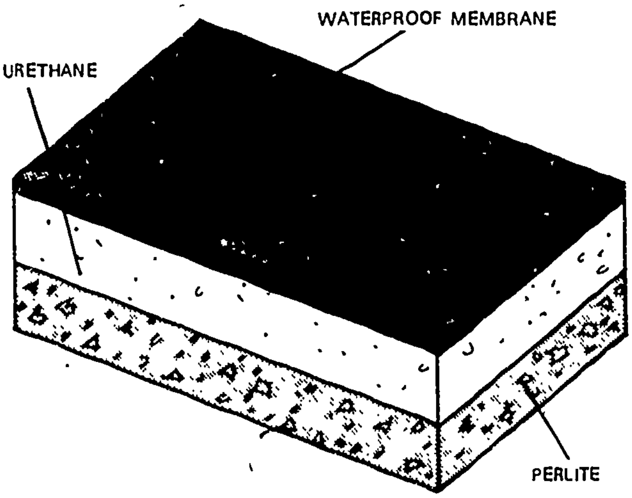


Fig. 2-2. Composite board cross section

1. Have ability to withstand the bitumen application temperatures required for insulation of the roof membrane.
2. Have good physical strength, rigidity, and impact resistance.
3. Be incombustible and acceptable for insurance and building code requirements.
4. Be constructed of materials that resist deterioration.
5. Be moisture resistant.
6. Have low "k" value (thermal conductivity), so that the highest possible "R" values (thermal resistance) can be obtained with the thinnest possible layer.
7. Have constant "k" value.
8. Have surfaces that accommodate secure attachment.
9. Have dimensional stability under varying temperature and moisture conditions.
10. Be manufactured so as to be compatible with the roof membrane.

However, according to the NRCA, no single commercial product contains all these properties. Therefore, the best insulation for a particular job is often a trade-off and depends on the specific requirements of the structure.

Adhesives

The remainder of this topic is devoted to a discussion of common types of cold adhesives and hot-applied bitumens.

Cold Adhesives

Cold adhesives are cold-applied cements that are used to bond plies together. Many of the same coated sheets used in the hot-application process can be used

[1] *Handbook of Accepted Roofing Knowledge*. Oak Park, Ill. National Roofing Contractors Association, 1980, p. 19

with cold adhesives. Some commonly used cold adhesives include the following:

- *Cold-application cement*—Cold-application cement is a heavy asphalt-based cement that is used between plies of felt on a cold-process built-up roof. It can be applied with a brush, roller, or spray gun.
- *Asphalt-based fibrated or nonfibrated plastic cement*—Asphalt-based plastic cement is an all-purpose weatherproofing cement applied with a trowel. It is used to repair roofs, flashings, gutters, valleys, skylight glass and frames, ventilators, collars, and so forth.
- *Coal-tar roof cement*—Coal-tar roof cement is, as its name indicates, a coal-tar pitch product. This cement is used with coal-tar pitch roofs just as an asphalt-plastic cement is used with asphalt roofs. It is applied with a trowel and is used only with coal-tar roofing systems.
- *Wetpatch*—Wetpatch is a thick, black, gummy plastic used for making temporary repairs to wet or damp roof surfaces.
- *Asphaltic emulsions*—Asphaltic emulsions are made in two types, fibrated and nonfibrated. A fibrated emulsion is one in which a certain amount of fiber has been added for extra strength. Since this compound is emulsified (mixed with water under pressure and subjected to violent agitation), it hardens after application as the water evaporates, and the emulsion is no longer soluble in water. The emulsion can be applied with a brush, spray gun, or roller. Under normal conditions it is imperative to allow asphaltic emulsions a minimum of 24 hours to harden. They must be allowed to dry thoroughly before being exposed to rain, to prevent dilution runoff.
- *Aluminum roof coatings*—Aluminum roof coating is an asbestos-fiber, asphalt-aluminum coating of heavy consistency for use on a finished smooth roof. The coating comes in various colors and can be applied with a brush, roller, or spray gun.
- *Concrete primer*—Concrete primer is an asphalt-based primer designed to provide better adhesion for bonding asphalt to masonry, metal surfaces, or any other surface where proper adhesion normally cannot be obtained.
- *Mortar*—Mortar is used as a method of securing tile chips, ridges, copings, rakes, and so forth. It is sometimes used to achieve special architectural effects or to prevent damage to roofs that are subject to high winds or excessive foot traffic. The mortar mix consists of three parts fine washed sand to one part cement, with just enough water added to make it easily workable. The mortar is sometimes colored with oxides to match the tile. Fireclay can also be added to increase bonding.

Hot-Applied Bitumens

Hot-applied bitumens, like cold adhesives, do not simply "glue" roofing felts together. Rather, the process is a bonding or fusion. The heated bitumens saturate the felts to bond the plies. Hot bitumens are of two basic kinds: asphalt and coal-tar pitch. Asphalts are sold in 100-pound (45.4-kilogram) cardboard containers, in drums delivered on pallets, and in bulk liquid form delivered in a tanker. They are available in four different grades or types for field application:

- Type I, dead-level asphalt, has a maximum heating temperature of 475° F. (246.1° C) and a melting point between 135° and 150° F. (57.2° and 65.6° C).
- Type II, flat-grade asphalt, has a maximum heating temperature of 500° F. (260° C) and a melting point between 150° and 170° F. (65.6° and 76.7° C).
- Type III, steep-grade asphalt, has a maximum heating temperature of 525° F. (273.9° C) and a melting point between 180° and 200° F. (82.2° and 93.3° C).
- Type IV, special steep-grade asphalt, has a maximum heating point of 525° F. (273.9° C) and a melting point between 200° and 220° F. (93.3° C and 104.4° C).

To ensure that a mopping of asphalt is not too light (causing incomplete coverage) or too heavy (causing poor adhesion, high expansion properties, and low tensile strength that can lead to roof splits), an optimum temperature range during the asphalt application process is extremely important. This optimum temperature range is described as the "equiviscous temperature" (EVT). The temperatures listed above are general guidelines only. The manufacturer's specific EVT recommendations should be checked and followed in preparing and using the asphaltic material.

Overheating of asphalt was discussed in *Entering the Roofing and Waterproofing Industry*, Topic 11, and should be reviewed for greater familiarity with the dangers involved in overheating asphalt or coal-tar pitch. As a rule of thumb, a roofer must never keep a roofing asphalt within 25° F. (13.9° C) of its flash point for any extended period. However, a roofer must never regard the flash point as the magic safety number, since an asphalt with a flash point of 575° F. (301.7° C) can flash anywhere between 540° and 610° F. (282° and 321.1° C). Also, in cold weather (45° F. [7.2° C] and below, including wind-chill factor), asphalt can lose up to 50° F. (27.7° C) from the kettle to its actual application. (See Fig. 2-3.) The kettle should not be overheated to compensate for expected rapid cooling, but instead insulated pipes and carrying containers should be used to help prevent the loss of temperature.

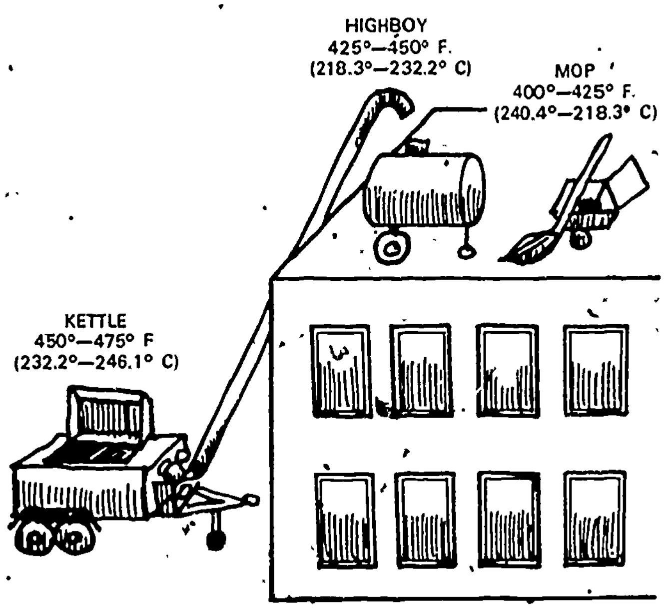


Fig. 2-3. Effect of cold weather on hot asphalt during movement from kettle to point of application

Effect of high temperatures on low-melt asphalt. In areas where high temperatures prevail, low-melt asphalt is affected by temperature changes and will flow when applied on a roof other than a dead-level roof. In such areas special attention must also be given to the types of pipe sleeves and collars, gravel guards, outlets, and decks that are used, to avoid seepage of this material. Also, care must be taken to store cartons of low-melt asphalt only one tier high when they are left uncovered outdoors. In the final analysis the type of asphalt used will depend on two main factors: (1) slope of the roof; and (2) geographic area.

Fluidity of coal-tar pitch. Coal-tar pitch is a dead-level roofing product. It has a softening point of 130° to 140° F. (54.4° to 60° C), which will allow it to flow easily. Because of this fluidity coal-tar pitch will remain liquid to seal cracks in felt for many years. As with low-melt asphalt, special attention must be given to the pipe sleeves, collars, gravel guards, outlets, and decks to avoid seepage.

Dangers of overheating coal-tar pitch. Coal-tar pitch should never be heated over 400° F. (204.4° C). Above this temperature chemicals are dissipated through vapors. Orange-colored smoke is an indication of overheating and severe vapors that can leave a burning sensation on the hands, face, neck, and any other unprotected areas of the body. A protective cream and a respirator should be used at all times when working with coal-tar pitch. Overheating of pitch does not make mopping any easier than it is at lower temperatures, because of the material's built-in flow quality. Coal-tar pitch is generally available in 55-gallon (208.2-litre) drums. Full drums weigh approximately 550 pounds (249.5 kilograms). These drums have no tops and must remain upright to prevent this low-melt product from spilling and running out of the drum on warm days. The standard axe can be used to split open the drums and chop the pieces of pitch.

TOPIC 3—ASPHALTIC PRODUCTS AND RIGID ROOFING MATERIALS

This topic and the related instruction classes are designed to enable the apprentice to do the following:

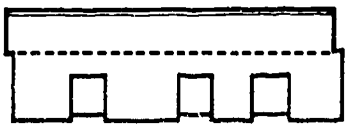
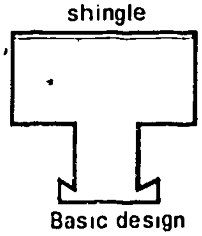
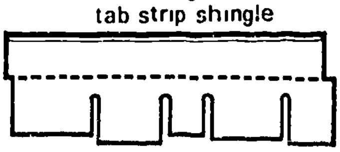
- **Describe asphalt shingles.**
- **Identify the basic types of roofing tile.**
- **Discuss the manufacture of rigid asbestos shingles.**
- **Describe the appearance of slate shingles, including the various shapes, thicknesses, and colorings.**
- **Discuss the kinds of metal shingles.**
- **Differentiate wood shingles from wood shakes.**

Most residential structures and some commercial buildings require a different type of roofing material from the roll or sheet types. This may be because of decorative considerations, climate, the shape of the roof, or the slope of the roof. Usually, however, the slope will determine whether flexible or rigid roofing should be used.

Asphaltic Shingles

Asphaltic shingles, often called *composition shingles*, are made from inorganic glass felts or organic felts that are saturated with asphalt and coated with high-melting-point flexibile asphalt. Ceramic-coated mineral granules are pressed into the asphalt coating on the exposed face to provide a fire-resistant surface. The three basic types of asphaltic shingles strip, individual, and interlocking are available in a selection of styles, weights, and colors. Figure 3-1 includes illustrations and specifications for these and other types of asphaltic shingles.

Shingle weights can vary from 150 pounds (68 kilograms) for light shingles to 390 pounds (176.9 kilo-

		Per square			Size			
Type of shingle	Configuration	Approximate shipping weight	Number of shingles	Bundles	Width	Length	Exposure	Underwriters Laboratory listing
Self-sealing random-tab strip shingle  Multi-thickness	Various edge, surface texture, and application treatments	285—390 lb (129.3—176.9 kg)	66—90	4 or 5	11½"—14" (29 2—25 6 cm)	36"—40" (91 4—101 6 cm)	4"—6" (10 2—15 2 cm)	A or C, many wind resistant
Individual interlocking shingle  Basic design	Several design variations	180—250 lb (81 6—113 4 kg)	72—120	3 or 4	18"—22¼" (45 7—56 5 cm)	20"—22½" (50 8—57 2 cm)	—	C, many wind resistant
Self-sealing random-tab strip shingle  Single thickness	Various edge, surface texture, and application treatments	250—300 lb (113 4—136 1 kg)	66—80	3 or 4	12"—13¼" (30.5—33 7 cm)	36"—40" (91 4—101 6 cm)	5"—5⅝" (12 7—14 3 cm)	A or C, many wind resistant

(continued)

Fig. 3-1. Selected asphaltic shingles and specifications

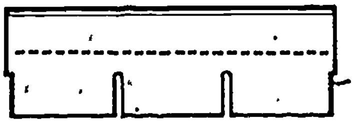
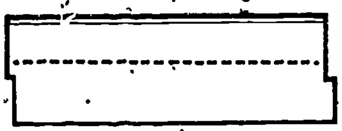
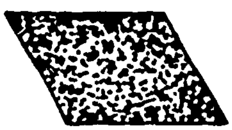
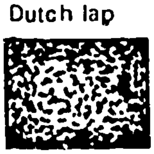
Type of shingle	Configuration	Per square: Approximate shipping weight	Number of shingles	Bundles	Size: Width	Length	Exposure	Underwriters Laboratory listing
Self-sealing square-tab strip shingle  Three tab	Two tab or four tab	215—325 lb (97.5—159 7 kg)	66—80	3 or 4	12"—13¼" (30.5—33.7 cm)	36"—40" (91.4—101 6 cm)	5"—5⅝" (12 7—14.3 cm)	A or C, all wind resistant
	Three tab	215—300 lb. (97.5—136 1 kg)	66—80	3 or 4	12"—13¼" (30 5—33 7 cm)	36"—40" (91 4—101 6 cm)	5"—5⅝" (12 7—14 3 cm)	
Self-sealing square-tab strip shingle  No cutout	Various edge, surface texture, and application treatments	215—290 lb (97 5—131 5 kg)	66—81	3 or 4	12"—13¼" (30 5—33 7 cm)	36"—40" (91 4—101 6 cm)	5"—5⅝" (12 7—14 3 cm)	A or C, all wind resistant
Three-tab hexagon 	Three tab	195 lb. (88 5 kg)	86	2	11⅓" (28 7 cm)	36" (91 4 cm)	4⅔" (11 9 cm)	C
Angolap 	Rectangular	150—175 lb (68 0—79 4 kg)	96	2 or 3	12" (30 5 cm)	18" (45 7 cm)	10" (25 4 cm)	C
Dutch lap 	Rectangular	150—175 lb (68 0—79 4 kg)		2 or 3	12" (30 5 cm)	16" (40 6 cm)	10" (25 4 cm)	C

Fig. 3-1 (concluded)

grams) for heavy ones. The term *weight* as used here refers to the weight of the number of shingles required to cover one square.

Weights are varied by the following methods: altering the thickness of the felt, altering the amount of asphalt absorbed by the felt, changing the thickness of the asphalt coating, and altering the amount of mineral used on the surface.

Rigid Asbestos Shingles

The rigid asbestos shingle, as its name indicates, is a combination of cement and asbestos joined under pressure and finished in a grain pattern or smooth pattern. Typical rigid asbestos shingles and specifications are illustrated in Figure 3-2.

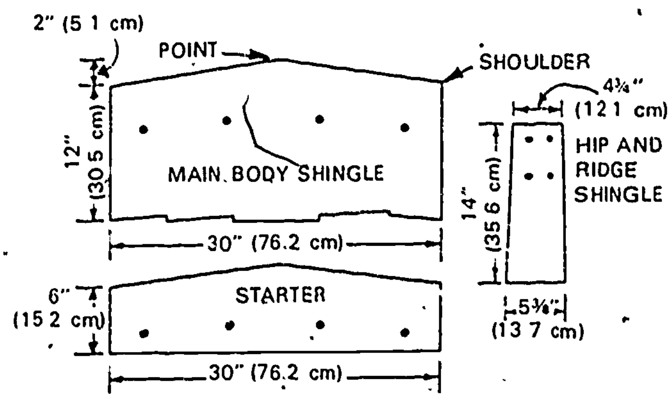


Fig. 3-2. Typical rigid asbestos shingles and specifications

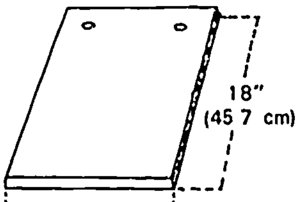
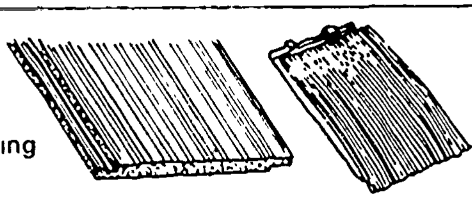
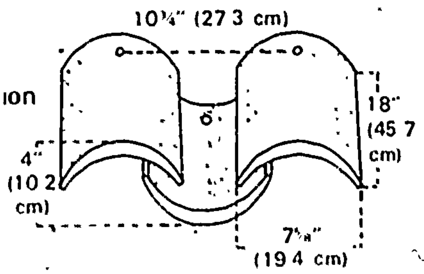
Roll Roofing

Although roll roofing materials are not shingles or rigid-type materials, they are often made to simulate the appearance of asphaltic shingles. Manufactured from heavy felt saturated with asphalt, roll roofing is available in mineral-surfaced smooth rolls (usually weighing 90 pounds [40.8 kilograms] per square) and pattern-edge rolls (105 pounds [47.6 kilograms] per square). (See "Cap Sheets" in Topic 2.) Diamond point and Gothic point are two pattern-edge designs currently available. Although pattern-edge roofing looks like asphalt shingles, it has the advantage of lower cost, since it is applied in long strips rather than short units. However, it has a shorter life span than asphalt shingles.

Tile

Tile, either a clay tile or lightweight concrete product, is designed to be applied to a roof in a manner similar to that used with shingles. Because of their great weight, however (up to 1,500 pounds [680.4 kilograms] per square), a strong, well-braced roof deck is necessary to support the tile.

Tile is manufactured in a variety of forms, such as flat, flat interlocking, sculptured interlocking, and roll styles. Roll tiles include one-piece mission, or S, tiles, Spanish and oriental tiles, and two-piece mission barrel and Roman tiles. Some tile is glazed to enhance its beauty and to increase its waterproofing ability. Figure 3-3 includes illustrations and specifications for selected types of tile.

Type of tile	Length exposed to weather (regular laying method)	Center-to-center specification	No. of pieces required per square	Average weight per square
Flat shingle 	12" (30.5-cm) widths			
	14" (35.6 cm)	12" (30.5 cm)	86	980 lb. (444.9 kg)
	Random widths			
	13½" to 15" (34.3 cm to 38.1 cm)	Varies	4"(10.2 cm):12 6"(15.2 cm):26 8"(20.3 cm):26 12"(30.5 cm):52	985 lb. (447.2 kg)
Flat interlocking 	11" (27.9 cm)	9" (22.9 cm)	150	950 lb. (431.3 kg)
Sculptured interlocking 	13¼" (33.7 cm)	8⅛" (20.6 cm)	90	900 lb. (408.6 kg)
Two-piece straight mission barrel 	14" (35.6 cm)	10¾" (27.3 cm)	190	1,030 lb. (467.6 kg)

(continued)

Fig. 3-3. Selected types of tile and specifications

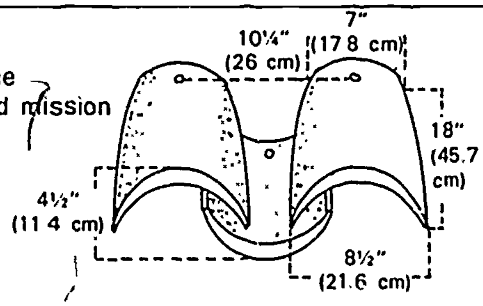
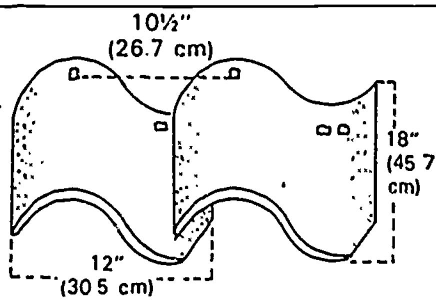
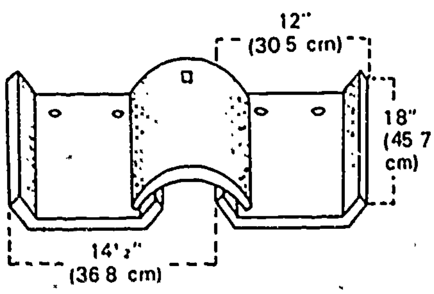
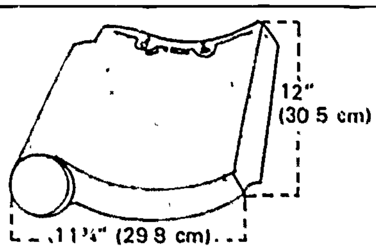
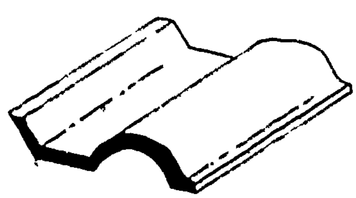
Type of tile		Length exposed to weather (regular laying method)	Center-to-center specification	No. of pieces required per square	Average weight per square
Two-piece tapered mission barrel		14" (35.6 cm)	10¾" (27.3 cm)	190	1,150 lb. (522.1 kg)
One-piece mission, or S, tile		15" (38.1 cm)	10½" (26 7 cm)	88	990 lb. (449.5 kg)
Shingle (pan and cover shingle)		Regular laying method			
		14" (35.6 cm)	14½" (36.8 cm)	144	1,100 lb. (499.4 kg)
		Alternate laying method			
		14" (35.6 cm)	18½" (47 cm)	120	1,200 lb. (544.8 kg)
Oriental interlocking shingle		9" (22 9 cm)	10¼" (26 cm)	152	950 lb. (431 3 kg)
Spanish		10¼" (26 cm)	8¼" (21 cm)	90	900 lb. (408 6 kg)

Fig. 3-3 (concluded)

Slate

Slate shingles are manufactured from dense, fine-grained rock that is quarried and slit into the desired shape and thickness and finished in either a smooth or rough texture. Slate roofing varies in thickness from ⅜ inch to 2 inches (1 centimetre to 5.1 centimetres) and in length from 9 inches to 26 inches (22.9 centimetres to 66 centimetres). The widths vary in proportion.

Slate shingles come in a variety of natural colors, such as black, gray, brown, purple, green, red, blue-black, mottled purple, and green-and-purple variegated. Typical slate shingles and specifications are illustrated in Figure 3-4.

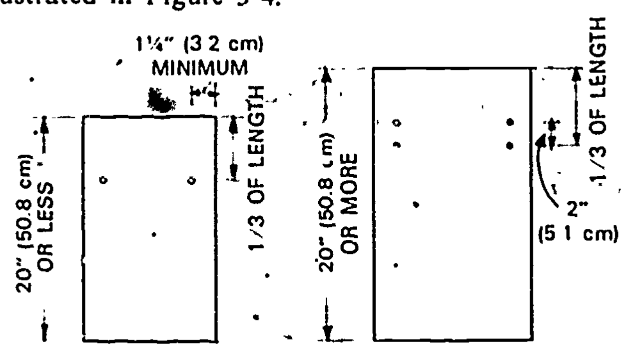


Fig. 3-4. Typical slate-shingles and specifications

Aluminum Shakes

Aluminum shakes and steel tile provide roofing systems that will not warp, rot, or burn. Aluminum shakes are made from sheet aluminum approximately 0.02 inch (0.5 millimetre) thick and may be 9 inches (22.9 centimetres) square or 12 inches by 36 inches (30.5 centimetres by 91.4 centimetres). They are folded on all edges with reversed folds so that the adjacent shakes will interlock. Starting strips are laid around the perimeter to lock the shakes in place, or, if laid individually, the strips are cut to form a straight line at the eave. This type of shake is usually applied on roofs with at least a 3, 12 pitch. Aluminum shakes are manufactured with a plain surface, with an anodized finish, or with a baked-on vinyl-enamel finish in a variety of colors.

Steel Tile

Steel tiles used for roofing are coated with zinc, tin, lead, or combinations of two of these. Steel coated with zinc is commonly known as *galvanized steel;* when coated with tin, it is called *bright plate;* and when coated with a mixture of 75 percent lead and 25 percent tin, it is known as *terneplate*. Typical steel tile and specifications are illustrated in Figure 3-5.

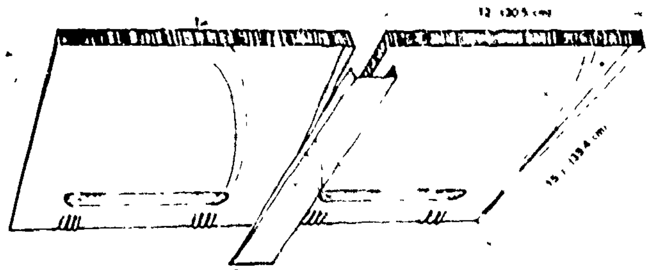


Fig. 3-5. Typical steel tile and specifications

Wood Shingles and Shakes

Wood shingles and shakes are made of cypress, redwood, or cedar. Shingles are similar to shakes except that the shingles are sawn rather than split.

Cedar shingles vary according to grades, sizes, textures, and cuts. Quality is graded by numbers ranging from 1 to 4. Number 1 shingles, which are made from near-vertical-grain heartwood, are the best. Number 2 is a good grade shingle that allows minimal flat grain and sapwood. Number 3 is a utility grade, and number 4 is for use in under-coursing and on interior walls. Common lengths are 16, 18, and 24 inches (40.6, 45.7, and 61 centimetres); they vary in width from 3 to 14 inches (7.6 to 35.6 centimetres). Shingles of one width, called *dimension shingles,* may be obtained, but they are more expensive than shingles of random width.

Wood shakes are like large, thick, hand-split shingles. They come in three variations. hand-split and resawn, taper-split, and straight-split shakes. The hand-split and resawn shakes are thin at one end, thick at the other end, rough on the face, and smooth on the backside. Taper-split shakes are also thick at one end and thin at the other, but because they are not resawn, both faces are rough. Straight-split shakes have a regular thickness and are rough on both sides. All shakes are number 1 grade, with thicknesses of ⅜ inch (1 centimetre) and up and lengths of 15, 18, 24, and 32 inches (38.1, 45.7, 61, and 81.3 centimetres). Widths are random, and not all types of shakes are available in all sizes. Typical wood shakes are shown in Figure 3-6.

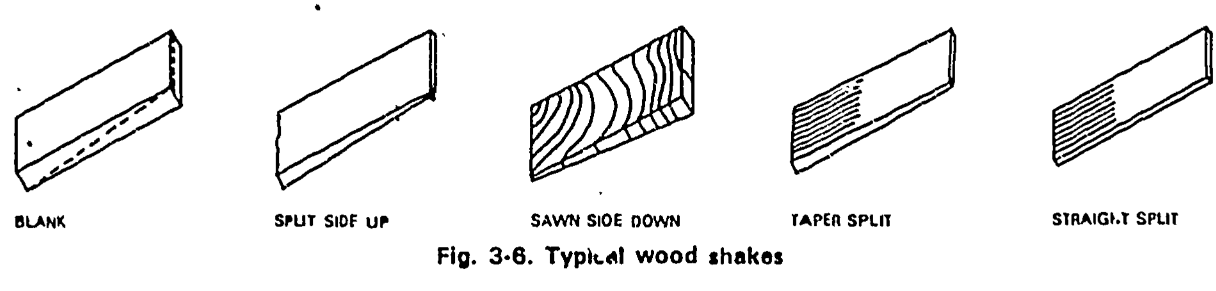


Fig. 3-6. Typical wood shakes

TOPIC 4—ELASTOMERIC AND PLASTIC MEMBRANES

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Define the term *elastomer*.**
- **Distinguish between elastomeric membranes and plastic membranes.**
- **Explain the meaning of the term *preformed membrane*.**
- **Identify several common fluid-applied products.**

A relatively recent development in the roofing and waterproofing industry is the use of cold-applied, monolithic membranes. They can be brushed, rolled, or sprayed on to form a seamless system that covers either horizontal or vertical surfaces, including many unusually shaped roofs. These membranes can be applied over a base of roofing felts or directly onto roof decks. The materials for the membranes are available in two basic forms. (1) preformed sheets or rolls, installed with adhesives or mechanical fasteners, and (2) liquids applied with a spray gun, brush, or roller.

Many of these membranes are manufactured from synthetic rubber components called *elastomers*. Elastomers, or elastomeric substances, behave like rubber in that they can be compressed or stretched and will still return to near their original shapes.

In addition to elastomeric materials, cold-applied membranes are manufactured from newly developed vinyl, plastic, and asphalt combinations. These new products also contain elastomers to make them more elastic.

The basic concept of elastomeric and plastic waterproofing is to utilize the rubberlike properties to maintain a waterproof membrane even though the structure to which the membrane is applied may undergo movement.

The relatively thin films used in this type of roofing must be of a very high quality. They must resist chemicals, abrasion from foot traffic, and the ravages of the weather Elastomeric materials are usually tightly bonded to the structural deck. This bond strength depends on the particular coating or adhesive used and is influenced by several factors.

One such factor is adhesive bond, which is simply the ability of the coating to stick to another material. Surface roughness or texture and the composition of both the elastomer and the deck influence the adhesive bond. Additives are sometimes used to promote or increase the adhesive strength to particular decks. In many instances primers must be used to gain maximum adhesion to surfaces. The manufacturer's primer recommendations, particularly for metals, painted surfaces, and flashing or trim areas, should be adhered to.

Another factor is cohesive strength, or the resistance of the coating to tear apart within itself. In general, cohesive adhesion is proportional to the tensile strength of the elastomeric materials. The stronger the material, the greater its resistance to being pulled apart.

Elastomers consist of a generic polymer (the base elastomer) compounded with extenders, pigments, chemical curing agents, and other ingredients that provide specific performance properties. Extenders are used to lower cost, improve adhesion, and achieve high-quality performance under special environmental conditions, such as constant soaking with water. Pigments give color and reinforcement to the elastomer and provide protection from the effects of sunlight. Curing agents supply the chemical mechanism by which elastomers cure. Some special ingredients may be used to enhance fire retardance, resistance to oxidation, and other damaging conditions.

Elastomeric and plastic materials and their application procedures are discussed in detail in *Cold-Applied Roofing Systems and Waterproofing and Dampproofing*. However, because of the large number of manufacturers and varieties of formulations, no instructional guide can be all inclusive with regard to the installation and safety procedures to be used with such materials. It is therefore necessary, when installing a specific elastomeric or plastic system, to read the instructional data provided by the product manufacturer and carefully review the label for specific application and safety procedures. For example, if the system includes a solvent, it is probably flammable and will ignite during application if safety procedures are not followed. Many materials are highly toxic and can be harmful to the health of workers without a respirator in an enclosed area. *NOTE.* In some cases the manufacturer's instructions will conflict with the architect's specifications. These differences should be resolved before the work proceeds.

Fluid application of elastomeric roof membranes is usually accomplished by using a hand- or power-operated paint roller. Some membranes may be applied by spraying, except for neoprene, which will not atomize into droplets. Trim and edge work is usually done by brushing.

The usual recommended thickness of elastomeric membranes ranges from 20 to 60 mils (0.5 millimetre to 1.5 millimetres), and sometimes more, depending on the material type and the specifications. Most membranes require two to six individual coats to achieve the recommended thickness. The time between application of coats is sometimes important to ensure maximum adhesion of each coat, but as a matter of good practice, it is always best to complete an entire roofing membrane without long delays. This practice helps to avoid accumulation of dirt and other atmospheric fallout that will impair adhesion.

Preformed Elastomeric and Plastic Membranes

Roofers should be familiar with the following eight basic types of preformed elastomeric sheeting. (1) polyvinyl chloride (PVC sheet), (2) glass-fiber-reinforced PVC sheet, (3) nylon-reinforced PVC sheet, (4) chlorosulfonated polyethylene (Hypalon, a DuPont tradename); (5) polychloroprene (neoprene); (6) Hypalon-coated neoprene sheet, (7) polyethylene sheet, and (8) polyethylene.

The PVC sheets are examples of plastics that have elastomeric properties. Neoprene sheet is an elastomer that employs a contact adhesive to join its sheets together. Neoprene and Hypalon are compatible, with Hypalon normally used as the top coating because of its weathering characteristics. It is manufactured in various colors and is lightweight and flame resistant.

Fluid-Applied Membranes

While most fluid-applied coatings are elastomeric (rubberlike) compounds, some asphaltic and plastic-based coatings are also available in fluid form. However, both elastomers and plastic, asphalt coatings form seamless waterproof membranes. Hypalon, neoprene, and PVC are available in liquid form. One asphalt-based system incorporates glass reinforcement into the finished monolithic film membrane. The basic tool for application is a spray gun that cuts continuous glass filament into predetermined lengths and sprays them together with liquid emulsion compounds to form the membrane.

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 5—FLASHING MATERIALS

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Define the term *flashing*.**
- **Describe the importance of using the proper flashing material in a specific location.**
- **List some important factors to consider in choosing a flashing material.**
- **Identify some common flashing materials.**

Flashing is used to seal off a roof at termination points where the roof meets various structural parts of a building (usually, vertical structures) and to prevent the intrusion of moisture at all such points. The proper selection, cutting, and application of flashing materials are among the main skills a roofer must learn. Incorrect flashing accounts for most roof leaks today, and selection of the proper flashing for a job can help to ensure the greatest economy for both the client and the contractor.

Flashing material should always be suited for the conditions found in the area where it is to be used. Corrosive metals should not be used near the ocean or in factory areas where destructive fumes are present. Flashing that cannot withstand extreme heat (such as that around hot stacks) should be avoided where such heat is apt to be common.

Although the type of flashing material to be used on new work is generally specified by the architect, in actual practice the roofer is often called on to suggest substitutions or modifications to the specifications. In addition, flashing on recover work is almost always the total responsibility of the roofer, from the selection of the type of flashing to be used to the method of installation.

Factors in the Selection of Flashing Material

Certain factors must be considered in the selection of flashing material:

- Geographic location
- Type of work done in the building being roofed
- Whether or not insulation is used
- Whether the roof is subject to alternate condensation and drying
- Whether the roof is subject to extreme temperature variants
- Amount of water expected on the roof
- Thickness required for the metal used in flashing
- Degree of galvanizing required
- Amount of flashing area located at the drip point of wood shingles
- Correct treating and painting of the flashing
- Method of assembling the job
- Quantity of organic matter expected to fall on the roof

Types of Flashing

Flashing is manufactured in finished forms, or it may be fabricated on the roof. Among the many types of materials used for flashing are the following:

- Galvanized iron
- Aluminum
- Copper
- Lead
- Asphaltic felts and cap sheets
- Asbestos felts and cap sheets
- Irish flax
- Flexible vinyl
- Flexible neoprene
- Plastic (fiberglass impregnated with polyester or epoxy resin)
- Stainless steel (chrome and steel alloy)
- Self-adhesive, aluminum-faced sealing strip
- Monel metal (copper and nickel alloy)
- Terneplate (lead-coated sheet iron)
- Tile (clay and glazed)
- Asphalt-based fibrated and nonfibrated plastic cement (mastic)
- Coal-tar-based fibrated and nonfibrated plastic cement (mastic)
- Glass fabric or cotton fabric (webbing)

Descriptions of several of these materials are provided below.

Galvanized Iron

Galvanized iron is made in sheets of various thicknesses, the thickness of a sheet is indicated by a gage number. The smaller numbers indicate thicker metals and vice versa. The U.S. standard gage for sheet metal for plate ranges from number 0000000 (equal to ½ inch [1.3 centimetres]) to number 38 (equal to 1/160 inch [0.2 millimetres]).

Galvanizing is accomplished by pickling (cleaning) and dipping hot sheet steel into an alloy of zinc and tin. Galvanized iron is made in various qualities and thicknesses to meet different flashing specifications. It is generally used only on competitive work where the best quality is not required. When working with this material, the roofer must be careful not to bend it any more than necessary, because bends cause slight fractures to occur in the coating, allowing the steel to rust under normal moisture conditions. The quality of galvanized iron is difficult to determine by appearance alone, it can, however, be indicated by the following factors:

- Good quality galvanized iron will not flake or crack readily when it is bent.
- No holidays (voids) or blisters will be observable on the surface.

Terneplate

Terneplate, a flashing material similar to galvanized iron, is produced by coating steel with a mixture of 75 percent lead and 25 percent tin.

Copper

Flashing made from copper is durable, provided that it is not installed on, or close to, another dissimilar metal that will allow electrolytic action (deterioration caused by chemical change) to occur. Copper flashing is frequently called for by architects because of its weathering qualities.

Lead Flashing

Lead flashing is used extensively in high-quality roofing work. This flashing may be purchased in standard sizes and forms, but much of it is custom-welded for the specific job. Lead has long been used for flashing because of its malleability, that is, it can be stretched and molded into the desired shape by pounding with a mallet. Lead is especially advantageous for use on tile and slate roofs not only because of its plasticity but also because of its lasting qualities, since both tile and slate are costly to remove and replace.

Aluminum

Aluminum has been used as a flashing material in increasing quantities during recent times. It has the advantage of low cost and easy handling, but its disadvantages are many. It is subject to rapid deterioration by electrolysis, is adversely affected by alkali and salt air, and has a high expansion coefficient, causing it to break its seals.

Irish Flax

Irish flax is a felted, flaxine flashing material available in rolls 32 inches (81.3 centimetres) wide and approximately 80 feet (24.4 metres) long. Most Irish flax, as the name implies, is imported from Ireland.

Flexible Flashings

Neoprene, vinyl, butyl, and other rubberlike substances are used for flashing where the expansion and contraction characteristics of metal may cause a problem. Self-adhesive, aluminum-faced sealing tape, for example, is a flexible flashing that is available from several manufacturers. The aluminum is backed by a rubberized (butyl) adhesive designed to resist cracking and softening in a variety of temperature ranges. The roofer should always study the application instructions thoroughly before attempting to apply any of the many flexible flashings available.

Glass fabric, cotton fabric, and roofing cement are also flexible flashings. Information on these materials can be found in Topic 2.

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 6—FASTENERS

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Describe the "do's" and "don'ts" of the nailing process.**
- **Distinguish among several common roofing nails and their uses.**
- **Identify some factors involved in selecting the appropriate roofing nail for a specific job.**

Fasteners used in securing roofing materials to the deck include various types of nails and other fastening devices. Several of these are shown in Figure 6-1. The type used depends on the kind of roof being applied, the type of deck, and the local climatic conditions. Wind action, for example, may require special fastening methods. The focus of this topic is on nails and nailing techniques.

Nailing Techniques

Nailing is one of the first jobs assigned to apprentice roofers. Apprentices soon find that their work is judged by not only the speed with which they nail but also the skill and precision with which they drive nails. Nails that are improperly driven can cause roof failures, especially if they punch unnecessary holes in the material nailed or if the heads stick up and fracture the material laid over them.

Roofers use a shingler's hatchet or a straight claw hammer for driving nails. In all instances nailing tools of high quality should be used.

Driving nails properly requires much practice. Sharp taps (not heavy blows) should be used. The head of the hatchet or hammer should strike the nailhead squarely to avoid bending the nail or damaging the surface of the roofing. An important rule in nailing is to "save the last lick," which means to withhold the final tap that would drive the nail to the point where the head rests flush with the surface of the roofing.

On some jobs nailing machines may be used. These machines can drive nails at a faster rate than any human being nailing manually, but they cannot be used to advantage on all roofs, and they cannot always be used to do all the nailing required on a roofing job. Nailing machines can, for example, be used efficiently on many flat, open areas but not on very small areas.

Staplers represent another fastening innovation in the roofing trade. Staples are now generally approved for use in the application of some kinds of roofing. Before staples are used, however, the local building code and the roofing material manufacturer's specifications should be checked. The stapler used, whether the manual or pneumatic type, must be handled only by roofers who are skilled in the operation of these tools.

Roofing Nails

It is important that any nail to be used in roofing be designed specifically for roofing. Using nails designed for any other purpose is wasteful because such a practice can result in a job that has to be done over or a roof that is easily damaged and therefore frequently requires repairs.

The holding power of a nail driven into wood results from the resistance between the wood fibers and the nail shank. For this reason rough-shank nails or ring-shank nails are generally used.

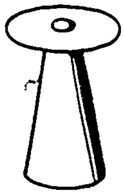
Roofing nails are made of different metals, and various types are available for use with different kinds of roofing materials or to meet specific requirements. For example, galvanized steel or copper nails are generally used to fasten tile or slate. The type of nail to be used may be designated in the job specifications or the requirements of the local building code. If no specifications are available, the contractor may use the kind of nail the contractor believes to be most satisfactory—as long as it meets code requirements. Roofers are rarely called on to select the nails to be used, but they should know why nails made of a given metal are selected for use on a specific job.

A bright steel nail—called a slick—will rust out rapidly if exposed to the weather, while galvanized steel nails will last many years, even if exposed. Copper, brass, and aluminum nails will last almost indefinitely under the same conditions. Although these are important considerations, it should be remembered that most nails used in roofing are never directly exposed to the elements. In hot-applied roofing all nails used are covered with asphalt or felt; and in shingling, most nails are covered by the succeeding layers of shingles. Even so, the nails are subjected to a certain amount of moisture, and for this reason the rust-resistant qualities of the different kinds of nails should be considered in selecting the right nail for the job.

Another important consideration in the choice of nails is the type of material with which the nails will come in contact (flashing material, for example). Contact between dissimilar metals will result in electrolytic action. deterioration of the most electropositive metal.

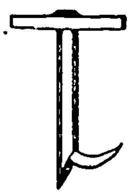
Size of the Nailhead

Next in importance to the metal selected for roofing nails is the size of the nailhead. The larger the head, the more holding power it will have on the surface—provided the nail has been driven properly. The most commonly used head size for asphaltic shingle roofing



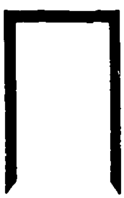
HOLLOW CONE SHANK FASTENER

Electro-zinc, galvanized tapered cone shank



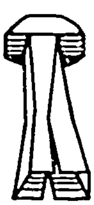
TWO-PIECE TUBE NAIL

Cap diameter 1" (2 5 cm) When nail is driven, tip spreads out to provide back-out resistance



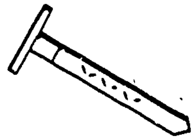
ROOFING STAPLE

Used only for power-driven application over tape or through discs



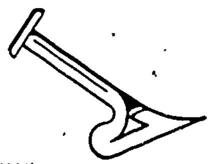
SPLIT-SHANK FASTENER

When fastener is driven, electro-zinc, galvanized shank spreads out to provide back-out resistance



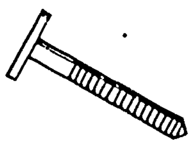
STANDARD ROOFING NAIL

Head $\frac{3}{8}$" to $\frac{7}{16}$" (1 cm to 1 1 cm) in diameter Barbed shank, 11 or 12 gage



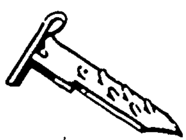
WEDGE NAIL

When nail is driven, shank bends to provide back-out resistance (as shown)



THREADED ROOFING NAIL

Head ⅜" (1 cm) in diameter Annular ring or spiral threaded; 11 gage

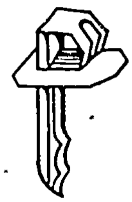


SPRING STEEL BARBED CLIP

Driven through tin disc

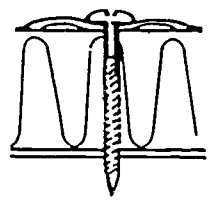
HARDENED SPLIT-SHANK NAIL

When nail is driven, shank spreads out to provide back-out resistance



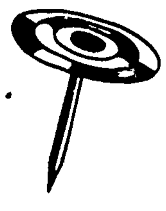
SELF-LOCKING FASTENER

Cap 1" (2 5 cm) in diameter When nail is driven, shank spreads out to provide back-out resistance



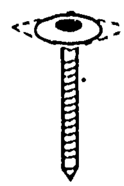
THREADED SELF-TAPPING SCREW

Driven through a minimum 3" (7.6-cm) diameter disc



HARDENED-STEEL SERRATED NAIL

Head 1" (2 5 cm) in diameter Milled and coated to provide back-out resistance



CAPPED-HEAD NAIL

Round or square cap 1" (2 5 cm) in diameter Annular threaded or spiral threaded

Fig. 6-1. Fasteners commonly used in the roofing industry is ⅜ inch (1 centimetre) in diameter. Properly spaced (a typical nailing schedule is shown in Fig. 2-1), nails with heads of this size will afford adequate holding power for such a roof.

When holding power greater than that of the ⅜-inch (1-centimetre) nailheads is required for built-up roofing base sheets, either capped nails or regular nails driven through the center of tin disks are used. These disks are usually 1 inch to 1½ inches (2.5 to 3.8 centimetres) in diameter.

Length of the Nail

Another important consideration is the length of the nail used. A nail that is too short will not hold properly and may pull out; one that is too long will project through the sheathing.

Among the factors to be taken into consideration in determining nail length is whether or not the underside of the deck will be exposed, as the ceiling or cover of a porch or patio might be. If so, the nails must not protrude through the deck where they can be seen from the underside. In all cases, however, it is best to use a nail short enough to avoid penetrating the deck on the underside.

The nails selected for a job must be long enough to penetrate the roof deck sufficiently to ensure adequate holding power. In wood this is usually considered to be ¾ inch (1.9 centimetres) or through the sheathing (whichever is less). In reroofing, a special problem is faced in selecting the length of nails because the nails must be long enough to go through both the new and old roofs and still penetrate the deck by the recommended ¾-inch (1.9-centimetre) distance.

To determine the thickness of old roofing, the roofer can either find a raw (exposed) edge that shows the depth of the old roof or cut a patch to determine the depth.

Concrete or Clay Tile Fasteners

Fastening tiles requires special fastening devices. For such purposes tile wire or strips or special tile "nails" are used. Tile fasteners are manufactured from galvanized, brass, copper, or stainless steel wire. More detailed information on tile fasteners can be found in *Rigid Roofing*.

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 7—HANDLING OF ROOFING MATERIALS

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Identify the steps involved in checking out the truck that will be used to deliver roofing materials to the jobsite.**
- **Describe truck and forklift safety precautions.**
- **Discuss the proper loading procedures for built-up roofing materials, composition shingles, and other roofing materials.**
- **Identify the major considerations involved in loading materials on the roof.**
- **Describe the types of rope commonly used by roofers.**

Several important tasks must be attended to before work can begin on a roofing job. The truck to be used to transport materials to the jobsite must be checked and loaded, materials must be unloaded at the jobsite, lifting and hoisting equipment must be checked, materials must be loaded on the roof, and so forth. Information on such tasks is provided in this topic.

Checking the Truck

The first task in preparing to begin any roofing job is to ensure that the truck to be used to move materials to the jobsite is in good working order: A completely loaded truck that is not in operating condition can be very costly in terms of both time and money.

Before any equipment or materials are placed on the truck, the vehicle's oil and fuel supplies, lights, windshield wipers, tires, and the like should be checked. If a forklift is to be towed behind the truck, it should be checked in a similar manner. This check should include an examination of the hydraulic system, the locking brake, the towing hitch, and the safety chain. Before the vehicle is towed, the forks should be placed in the down position, and the safety brake should be released.

In California every truck must be equipped with an ABC powder-type fire extinguisher and a first-aid kit. Both should be checked regularly to be sure they are ready for use.

Operating Trucks and Forklifts Safely

Most regulations pertaining to the operation of forklifts, industrial trucks, and industrial tow tractors deal with the operator and safe operation of these vehicles. However, the roofer apprentice, as well as the journey-level roofer, should be aware that many injuries occur to persons just walking or working near forklifts and industrial trucks and tow tractors.

Sections 3657 and 3664 of the *General Industry Safety Orders* include rules for operating these vehicles. Both sections are reproduced in Appendix A of this workbook. The apprentice is strongly encouraged to read these sections carefully and to become thoroughly familiar with their content.

Loading Materials on the Truck

A truck that is to be used to transport materials and equipment to the jobsite should be loaded with the particular job in mind; that is, the materials and equipment should be loaded in such a manner that they can be taken off the truck in the order in which they will be needed. Items needed first should be loaded last and vice versa (see Fig. 7-1).

Procedures for loading different types of roofing materials are discussed below. Regardless of the materials being loaded, however, those loading the truck must be careful to distribute the load as evenly as possible over the wheels of the vehicle.

Loading Built-up Roofing Materials

The list of materials for a typical built-up roofing job might include the following: 14 rolls of number 15 felt, ten cartons of asphalt, and 20 rolls of number 90 cap sheet. These materials should be loaded as follows:

1. Cap sheet Because the cap sheet will be used last, it should be loaded first. The rolls should be stacked on ends, in rows, against the cab from one side of the truck to the other. Cap sheet should never be laid flat, because this will press the rolls together and flatten the material.
2. Felt Felt rolls should be stacked on ends. If the truck is not specially equipped to hold such tools and equipment as mops, brooms, and shovels, these should be placed upright in or between the felt rolls.
3. Asphalt This is the first material to be used, and so it should be the last item placed on the truck. The aslphalt should be positioned against the felt and equipment, from side to side of the truck.

In most cases the weight of the asphalt will hold the rest of the load in place. But if the load is very large, it should be secured with ropes. If ladder racks are not provided, ladders can be placed on top of the load, but they must be tied down to prevent their falling off.

If a kettle is to be towed to the jobsite, the last step in the loading process is hooking it up to the truck. This connection is usually made with a ball trailer hitch or pin. The safety chain should be connected every time the kettle is hooked up to the truck, and the kettle leg must be raised before the kettle is moved. The burner should never be in operation while the kettle is in transit, and nothing should be hung on the kettle. If a brake light connection is available, it should be used.

Loading Asphalt Shingles

When a truck is loaded for an asphaltic shingle roofing job, care must be taken not to concentrate the shingles at the back of the truck. This could cause excessive strain on the axle and result in a broken spring if the truck were to strike a bump. It is recommended that the load be distributed equally from side to side and from back to front. To prevent stacks of asphaltic shingles from sliding or toppling, those loading them should alternate the bundles in layers of three—the first layer facing in one direction, the second layer crisscrossed on top of the first, and so forth.

Loading Clay Tile

Clay tile should be stacked on ends, if loaded loose, and as straight as possible to prevent breaking or cracking. Most manufacturers deliver tiles to the shop or jobsite already stacked on pallets and secured with metal bands to keep them from slipping. *NOTE:* Before cutting the metal bands on stacks of tile, the roofer should make sure that the tile is not leaning to one side. If the tile is leaning, it will fall when the pressure from the band is released.

Loading Rigid Asbestos, Slate, and Rigid Plastic Tile

Rigid asbestos, slate, and rigid plastic tiles should be loaded flat on the truck. They should not be stacked so high that the weight of the stacks breaks the bottom rows. They must never be stacked on edge, because the edges may be damaged to a degree that would render the tiles useless. If they are stacked in tiers, the tiers should be crisscrossed in the manner described for clay tile in the preceding section.

Loading Metal Roofing

Metal roofing is normally very rugged, and the shipping package will usually be sufficient protection against bending or mashing. However, when aluminum shakes are loaded, care must be taken not to mash the exposed ends, because such damage makes the shakes useless.

Loading Materials on the Roof

Proper loading of roofs requires skill and a knowledge of the roof structure. Unless careful consideration is given to loading properly and safely, damage to the roof and to the interior finish may result. When materials are loaded on a roof, consideration must be given to the strength of the roof deck, condition of sheathing boards, weight distribution, accessibility of the materials for application, and the order in which the materials will be needed. Proper distribution of materials on a built-up roofing job is shown in Figure 7-2.

Reloading Materials on the Truck

When the job has been completed and the truck is being reloaded for the return to the yard, trash should

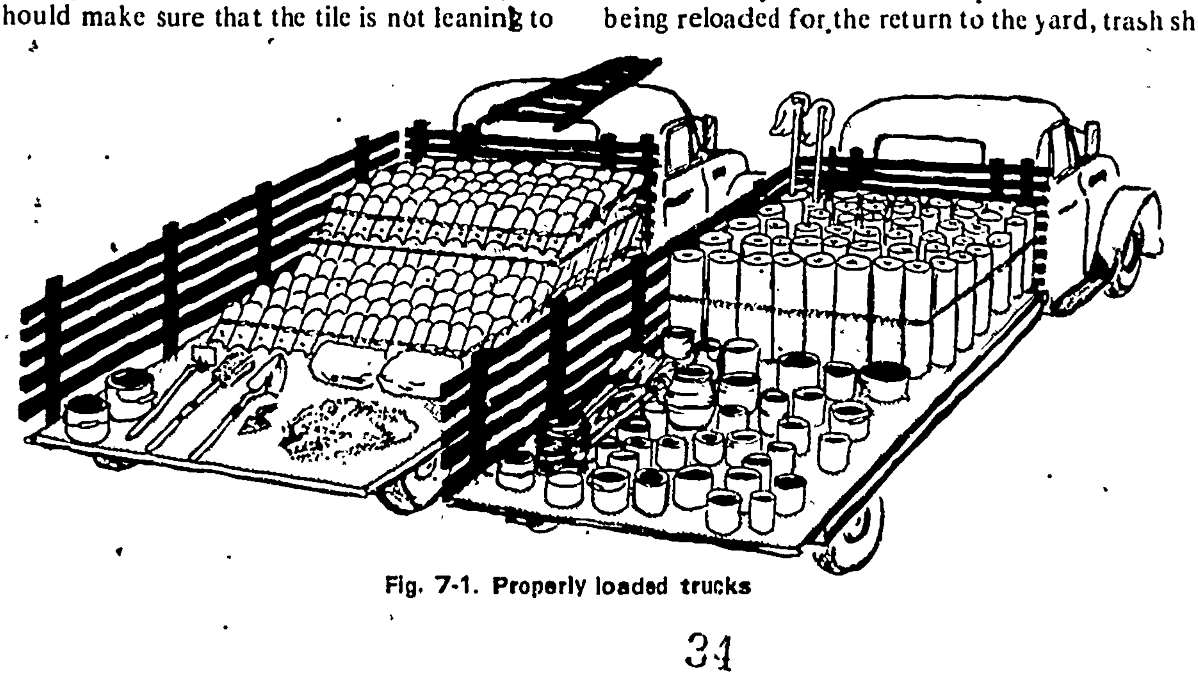


Fig. 7-1. Properly loaded trucks

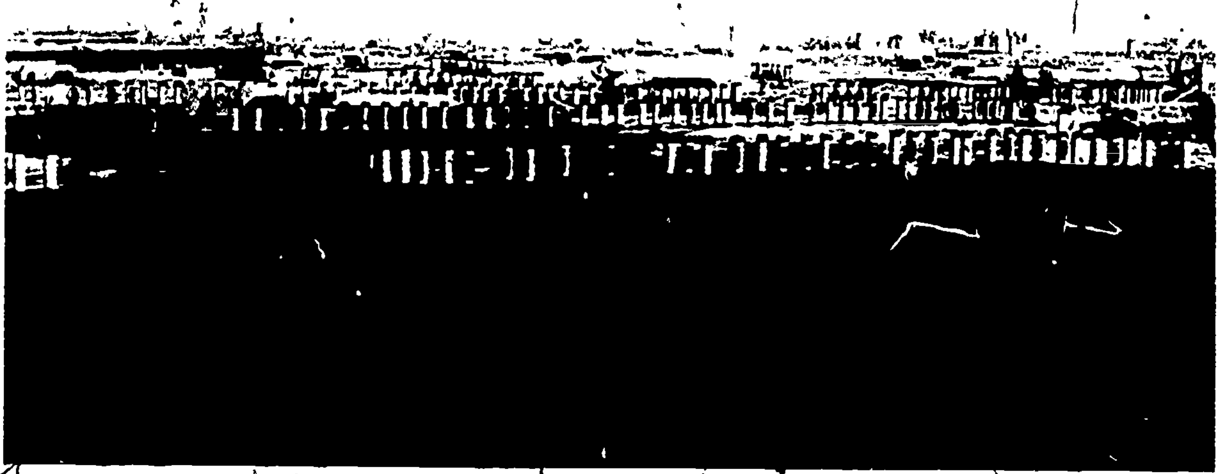


Fig. 7-2. Distribution of materials on a built-up roofing job

be separated from leftover materials. If trash is stacked on top of the leftover material and equipment, good materials or equipment may be thrown out with the trash. A common practice is to place trash at the rear of the truck and tools, equipment, and leftover materials against the cab. If the materials were delivered on pallets, the pallets can be placed on the trash to prevent it from blowing or falling off the truck. Particular care should be taken to load hot mops so that they do not come into contact with flammable materials. When the truck is returned to the yard, the mops should be removed, the kettle should be disconnected, and both should be put in a safe place at once.

Selecting Ropes for Rigging

Three types of ropes are used in rigging for roofing jobs—manila, nylon, and wire. Each has its own specific requirements and should only be used for the job it was designed to do.

Manila Rope

Manila rope is usually a ¾-inch-diameter (1.9-centimetre-diameter) rope that is designed for hoisting by hand. It can also be used for securing a roofing jack system (scaffold) and as a handhold when a crawling board (chicken ladder) is being used on a steep roof. On a gallows-type frame hoist, when no counterbalancing material is available, a ¾-inch (1.9-centimetre) rope that is tied securely to the tailpiece, stretched tight, and laced to an object on the roof will provide secure anchorage to hold the frame in place when loaded. *NOTE:* The hoisting devices described above are intended for single-line, hand use only. Any attachment of a power system, winch, hoist, or blocks and falls can be dangerous unless the system complies with Article 15, Section 1613, of the *Construction Safety Orders.*

Nylon Rope

Nylon rope, compared to manila rope of equal size, is stronger and can be used with greater loads. However, nylon rope is very difficult to work with in cold or wet weather. It is often used to secure material on a loaded truck.

Wire Rope

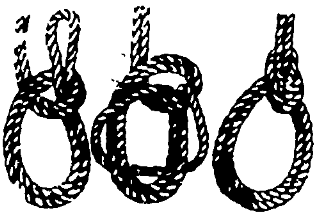
Wire rope is composed of wire strands formed in a spiral around a core, which may be either fiber or a separate wire rope. It is used on almost all motorized hoisting equipment because it can withstand heavy loads and is very durable. Care must be taken, however, to prevent overloading this rope. Wire rope should be inspected daily for wear, broken strands of wire, signs of unusual impacts, kinks, and any marked decrease in rope diameter. Wire rope, like any metal, is subject to rust, and so it should be lubricated to protect it from rust and corrosion, stored in a dry place, and kept as clean as possible.

Whenever it is necessary to make a loop or attach wire rope to an object for pulling or lifting, it is recommended that wire rope clips that are made of a good grade steel be used. They should be properly applied with a thimble to provide a safe end fitting. At least three clips should be used. For larger ropes at least one clip for each ¼ inch (0.6 centimetre) of rope diameter is appropriate.

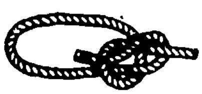
Knots

Being able to tie the proper knots is vitally important for the roofer in hoisting material from the ground to the roof level. The knots shown in Figure 7-3 are those commonly used by roofers.

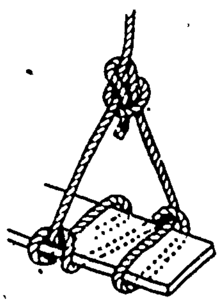
EYE SPLICE—Used to hold needle beams.



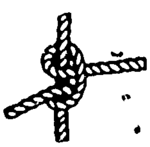
BOWLINE ON THE BIGHT—Used in emergencies to lift an injured worker off a building or out of a hole. Also, used to tie bowline in middle of the line.



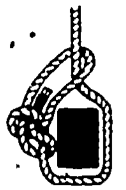
BOWLINE—Used wherever a hitch is required that will not slip, jam, or fall.



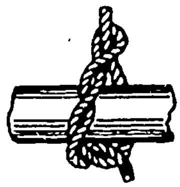
SCAFFOLD HITCH—Used to fasten single-scaffold planks to hang level.



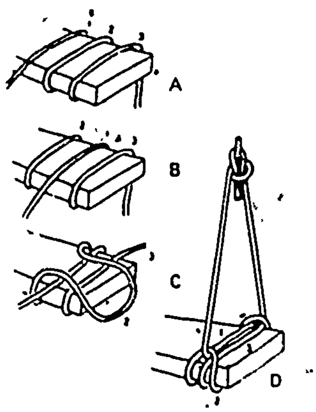
CLOVE HITCH OR BUILDER'S HITCH—Used to fasten rope to upright posts on staging to act as a rail or safety line.



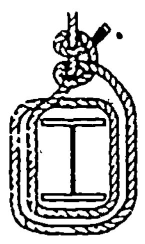
RUNNING BOWLINE—Used to hold needle beams.



TIMBER HITCH—Used to hoist planks, timbers, and pipe. A half-hitch can be added to keep a plank or length of pipe on end while lifting.

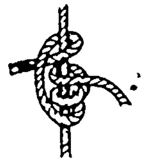


SELF-CENTERING BOWLINE—Used to fasten single-scaffold planks.



ROUND TURN AND TWO HALF-HITCHES—Used to fasten a scaffold line to a supporting beam

ROUND TURN AND TWO HALF-HITCHES—Used to hold needle beams

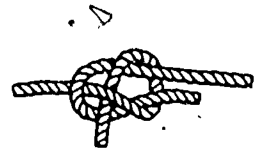


ROLLING OR TAUT LINE HITCH—Used to hold tension in a line

SQUARE KNOT—Used to join two ropes or lines of the same size.

FIGURE 8—Used in the end of a rope to prevent the strands from unlaying and to prevent the end of a rope from slipping through a block or an eye.

TWO HALF-HITCHES—Used to secure rope to columns or posts.



SHEET BEND—Used to join two lines of different or same size

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Fig. 7-3. Knots commonly used in the roofing industry

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 8—OPERATION AND MAINTENANCE OF SMALL ENGINES

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Discuss the proper procedures for starting small engines used in the roofing industry.**
- **Identify the steps to follow in performing basic maintenance work on small engines.**

Small engines (see Fig. 8-1) are used for various tasks on roofing jobs to save time and physical exertion by the roofers. These engines vary in size from 1 to 12 horsepower (0.7 watt to 9 watts) and are used to power kettle pumps, hoists, cutters, sweepers, spudding machines, gravel machines, compressors, tile saws, and material carriers.

Some engines run on gasoline, and others require propane. Regardless of their types these engines must receive proper care to provide trouble-free operation. Some maintenance procedures and starting practices are standard for both types of engines, and no worker should attempt to perform maintenance operations or make adjustments on any small engine unless fully qualified to do so.

Starting Procedures

Before an attempt is made to start any engine, the fuel and oil supplies should be checked, and the shut-off needle valve should be turned on.

Some engines are equipped with a battery and electric starter, while others must be started by winding a knotted rope around the engine sheave and pulling. Regardless of the starting method, the following steps should be followed in starting all small engines.

1. Disengage the clutch if the engine is so equipped.
2. Set the throttle control to approximately half open.
3. Close the choke on the carburetor.
4. Attempt to start the engine.
5. If the engine does not start, open the choke halfway, and try again to start it.
6. Once the engine starts, open the choke completely, and let the engine warm up for a few minutes before "applying" the load. This warm-up period will allow a proper film of oil to be distributed inside the engine. *NOTE:* If they are available, always follow the manufacturer's starting instructions.

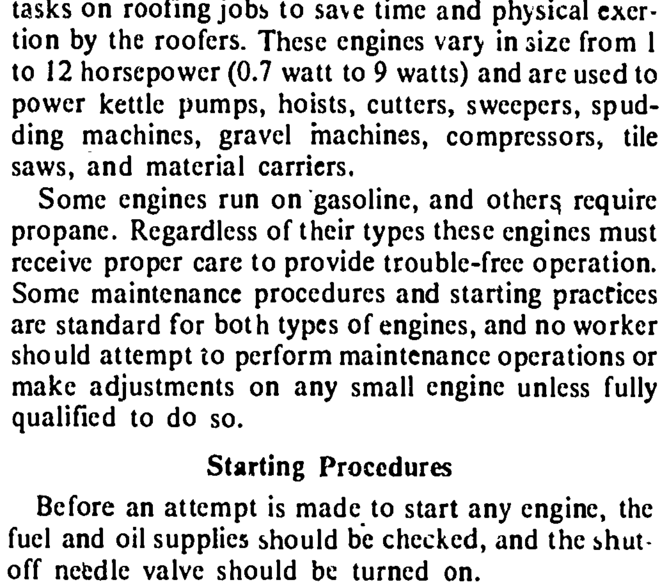

Fig. 8-1. A typical small engine

Most small engines are turned off by means of a ground switch. The types vary, but all work on the same principle. Moving the switch to the off position causes the ignition circuit to be shorted out, thereby stopping the engine. The choke should not be used to stop the engine, because this floods the carburetor and makes immediate restarting difficult.

Basic Maintenance Work

Basic maintenance of small engines includes periodic performance of the seven tasks described in the remainder of this topic. In addition to cleaning and other types of maintenance, parts should be replaced in accordance with the manufacturer's recommendations.

Cleaning the Air Filter

Air filters prevent dirt and dust from entering the engine valves and cylinders and abrading the interior finishes. Three basic types of air filters are used on small engines, and each must be serviced periodically to remove excess dirt and dust and keep the engine running properly. Each type is described below.

Oil foam filter. Oil foam filters should be cleaned in the following manner:

1. Wash the filter in kerosene or a solution of water and liquid detergent. If kerosene is used, rubber gloves should be worn to prevent absorption of the kerosene through the skin.
2. After cleaning, wrap the filter in a clean, dry cloth, and squeeze it dry.
3. Saturate the dry filter in clean engine oil, and reinstall it on the engine.

Dry-element filter. As its name implies, the dry-element filter does not use oil. This type of filter should be cleaned in the following manner:

1. Remove the wing nut and cover, and remove the filter from the engine.
2. Tap the filter lightly on a flat surface, or wash it with water and nonsudsing detergent. If the filter is washed, flush it from the inside out with water until the flushing water turns clear.
3. Air-dry the cleaned filter thoroughly before reinstalling it.

Dual-element filter. The following steps should be followed in cleaning a dual-element filter:

1. Remove the upper screw and cover.
2. Remove the foam element by sliding it up off the paper cartridge.
3. Wash the foam element in water and liquid detergent.
4. Wrap the foam element in a clean, dry cloth, and squeeze dry.
5. Apply clean engine oil to the foam element, and squeeze out the excess oil.
6. Clean the paper cartridge by tapping it gently on a flat surface.
7. Install the foam element over the paper cartridge, reassemble the cover, and screw the cover down tight.

Because of the dusty conditions present on most jobsites, special care should be taken to inspect the air filter regularly. The dirt and grit generated by power brooms, spudding machines, and roof cutters can destroy an engine if they reach the interior moving parts.

Cleaning the Fuel System

Dusty conditions on the jobsite can also affect the operation of the fuel system. Cleaning the fuel filter bowl to ensure a steady supply of clean fuel involves the following steps:

1. Shut off the fuel supply needle valve.
2. Loosen the yoke by means of the thumbscrew on the bottom of the yoke.
3. Remove and clean the filter screen.
4. Check the condition of the gasket to ensure against leaks.
5. Clean the bowl with a clean rag, and replace the components.

Changing the Engine Oil

As was mentioned earlier, the engine oil level should be checked *before* the engine is started. Since most small engines have only a 1-quart (0.9-litre) capacity, the oil supply can be used up very quickly. If the oil level drops too low, the heat generated by the motor will quickly "seize" the moving parts (cause them to stick together) and destroy the engine. The oil should be changed after 35 to 40 hours of operation. This is about once a week for engines that are being used all day, but the oil may be changed more often if the job conditions are extremely dirty or dusty. (*NOTE:* Pump engines on kettles are extremely susceptible to rapid burnout from low or dirty oil. The oil on these engines should be checked, and changed if necessary, before start-up.) The following steps should be followed in changing engine oil:

1. Remove the oil drain plug with an adjustable wrench.
2. Drain the old oil into a bucket or other receptacle.
3. Select the proper oil for the jobsite temperature.
4. Insert a funnel into the oil drain housing, and fill with oil in accordance with the engine manufacturer's specifications; or fill to the "full" mark on the dipstick.
5. Replace the drain plug, and tighten it securely.
6. Start the engine, and let it run for one minute.
7. Stop the engine, allow it to cool for one minute, and then recheck the dipstick. Add more oil if necessary.
8. Pour the old oil into a bucket. Cover the bucket of old oil, and save it for lubricating wheels on machines.

Servicing the Cooling System

When the cooling fins become clogged with asphalt, pitch, slag, or other material, air cannot circulate and relieve the heat buildup. Cooling fins should be cleaned daily, or more often if necessary. This can be done easily with the sharp point of a stick. Heavy tools should not be used to clean the fins, because the weight of the tools could cause the fins to break.

Cleaning and Adjusting Spark Plugs

Spark plugs should be checked periodically for excessive wear. Excessive carbon buildup on the firing point or the gap wire indicates that a plug needs to be cleaned. If carbon buildup is apparent, the following procedures should be followed to clean the plug:

1. Remove the plug with an adjustable wrench.
2. Wash the plug in solvent.
3. Brush the plug clean with a wire brush.
4. Dry the plug with a wiping cloth.

5. Insert a spark-gap gage, and reset the spark gap in accordance with the engine manufacturer's specifications (usually 0.02 or 0.03 inch [0.5 or 0.8 millimetre]).
6. Replace the spark plug, and tighten it securely.
7. Replace the electrical lead on the plug.
8. Start the engine to check plug performance.

Cleaning and Adjusting Contact Points

Adjusting the contact points involves the following steps:

1. Remove the breaker box.
2. Clean the points with a Carborundum contact point stone or emery cloth. Insert a piece of absorbent paper between the points, and open and close the points so that the paper can absorb any dirt or filings left on the points.
3. Rotate the crankshaft until the points are open to the widest gap.
4. Loosen the locknut with a screwdriver until the locknut is just snug.
5. Insert the spark-gap gage, and rotate the breaker point screw to obtain the gap recommended by the engine manufacturer (usually 0.02 or 0.03 inch [0.5 or 0.8 millimetre]).
6. Tighten the locknut, and replace the breaker box cover.
7. Start the engine to check the performance of the contact point.

Adjusting the Carburetor

The following procedure should be followed in adjusting the carburetor:

1. Turn the needle valve clockwise until it is closed.
2. Turn the needle valve counterclockwise one and one-half turns.
3. Turn the idle valve clockwise until it is closed.
4. Turn the idle valve counterclockwise one-half to three-quarters of a turn.
5. Start the engine, and turn the needle valve clockwise until the engine misses. This will indicate that the fuel mixture is too lean.
6. Turn the needle valve counterclockwise to the point where the engine runs smoothly.
7. Turn the needle valve counterclockwise past the smooth operating point until the engine runs unevenly. This will indicate a fuel mixture that is too rich.
8. Turn the needle valve midway between the rich and lean adjustment points until the engine runs smoothly. The engine should run smoothly for at least two minutes with the needle valve in this position.

Instructional Materials

Materials Required for Each Apprentice

CAL/OSHA, State of California Construction Safety Orders (Current edition). Los Angeles: Building News, Inc..(Orders to: Building News, Inc., 3055 Overland Avenue, Los Angeles, CA 90034.)

Uniform Building Code (Current edition). Whittier, Calif.: International Conference of Building Officials. (Orders to: International Conference of Building Officials, 5360 S. Workman Mill Road, Whittier, CA 90601.)

Glossary

The definitions in this glossary are those pertinent to the roofing trade and are not necessarily those found in standard dictionaries. Some of the terms included are colloquial in nature and are used with the meanings applicable only to the roofing trade.

Aggregate. Crushed stone, crushed slag, or water-worn gravel used for surfacing a built-up roof, also, any granular mineral material.

Asphalt. A brownish-black, natural petroleum residue used in applying roofing.

Base sheet. The first layer of roofing applied on the deck; also, a dry or slip sheet.

Bitumen. Coal-tar pitch or asphalt.

Bond. To cause to stick together.

BTU (British Thermal Unit). The heat energy required to raise the temperature of 1 pound (0.5 kilogram) of water 1° F. (0.6° C).

Built-up roof membrane. A continuous, semiflexible membrane consisting of plies of saturated felts, coated felts, fabrics, or mats with alternate layers of bitumen, generally surfaced with mineral aggregates, bituminous materials, or a granule-surfaced sheet.

Cap sheet. A finish roofing material used as a covering for a roof.

Coal-tar bitumen. A dark brown to black, semisolid hydrocarbon formed as a residue from the partial evaporation or distillation of coal tar.

Coated base sheet. A felt that has been impregnated with asphalt and then coated on both sides with harder, more viscous asphalt to increase its permeability to moisture.

Cold process roofing. A continuous, semiflexible membrane consisting of plies of felts, mats, or fabrics that are laminated on a roof with alternate layers of cold-applied roofing cement and surfaced with a cold-applied coating.

Cutback. Any bituminous roofing material that has been solvent thinned (such as asphalt dissolved into liquid form).

Dead level. The term used to describe an absolutely horizontal roof.

Dead-level asphalt. A roofing asphalt that has a softening point of 130° to 140° F. (54.4° to 60° C).

Elastomer. A rubberlike material that returns rapidly to its approximate initial dimensions and shape after substantial deformation by a stress and the subsequent release of that stress.

Emulsion. A mixture of two liquids or a liquid and a semisolid (such as water and softened asphalt) that are not soluble in each other. Emulsions are aided by emulsifying agents.

Felt. A roofing material manufactured from cellulose fibers of rags, paper, wood, asbestos, or glass.

Fireclay. Clay capable of withstanding extremely high temperatures.

Flashing. Sheets of metal or other suitable materials used to make watertight joints in roofs.

Fluid-applied elastomer. An elastomeric material that is fluid at ambient temperature and that dries or cures after application to form a continuous membrane.

Inorganic. Being or composed of matter other than hydrocarbons and their derivatives.

Membrane. A flexible or semiflexible roof covering or waterproofing whose primary function is the exclusion of water.

Neoprene. A synthetic rubber used in liquid-applied elastomeric roof membranes or flashing.

Organic. Being or composed of hydrocarbons and their derivatives.

Parapet. A low wall above roof level.

Perlite. An aggregate used in lightweight insulating concrete and in preformed perlitic insulating boards; formed by heating and expanding volcanic glass.

Rake. The sloped edge of a roof at the first or last rafter.

Reinforced membrane. A roofing or waterproofing membrane reinforced with felts, mats, fabrics, or chopped fibers.

Softening point. The temperature at which bitumen becomes soft enough to flow.

Thermal conductance (C). A unit of heat flow that is used for specific thicknesses of material or for materials of combination construction, such as laminated insulation. The formula for thermal conductance is:

$$C = \frac{k}{\text{thickness in inches}}$$

Thermal conductivity (k). The heat energy that will be transmitted by conduction through 1 square foot (0.1 square metre) of 1-inch-thick (2.5-centimetre-thick) homogeneous material in one hour when there is a difference of 1° F. (0.6° C) perpendicularly across the two surfaces of the material. The formula for thermal conductivity is k = BTU/square foot/inch/hour/degree Fahrenheit.

Thermal resistance (R). An index of a material's resistance to heat flow; the reciprocal of thermal conductivity (k) or thermal conductance (C). The formula for thermal resistance is.

$$R = \frac{1}{c} \quad \text{or } R = \frac{1}{k}$$

$$\text{or } R = \frac{\text{thickness in inches}}{k}$$

Appendix A

General Industry Safety Orders on Industrial Truck Operation

3657. **Elevating Employees With Lift Trucks.**

(a) Whenever a truck is used to elevate employees for work positioning, a safe work platform having sufficient space to accommodate the employees and material being elevated, but having not less than 24 inches by 24 inches [61 centimetres by 61 centimetres] working space, shall be securely attached to the forks or mast in such manner as will prevent tipping, slipping, or falling from the supports. The platform shall be equipped with standard guardrails with midrails on all open or exposed sides, and toeboards shall be installed if work is performed above places where employees normally work or pass. The platform floor shall have no spaces between floor sections, or holes, greater than one inch [2.5 centimetres] in size and shall have a slip-resistant surface.

(b) Where a clearance restriction or the nature of the work prohibits the use of guardrails, a safety belt, or harness, with lanyard shall be used as described in Section 3656(e).

(c) Wherever the truck is operated under conditions which expose the operator to danger from falling objects, the truck shall be equipped with overhead protection.

(d) There shall be an operator in the control position on the truck while employees are on the elevated platform.

(e) Whenever a truck is equipped with vertical only, or vertical and horizontal controls elevatable with the lifting carriage or forks, means shall be provided whereby personnel on the platform can shut off the motive power of the truck.

(f) Means shall be provided to render inoperative all operating controls other than those on the elevatable platform when the controls on the elevatable platform have been selected for use. Only one location of controls shall be capable of being operated at one time.

(g) All bridge cranes or other moving or motorized equipment normally guarded by location which could now overrun or otherwise injure the elevated worker shall be shut down or locked out.

(h) Operating Rules Whenever Elevating Personnel.

(1) Use a securely attached safety platform.

(2) Make sure the lifting mechanism is operating smoothly.

(3) Before elevating personnel, make sure that the mast is vertical. The mast shall not be tilted forward or rearward while persons are elevated.

(4) Place truck in neutral and set parking brake.

(5) Lift and lower smoothly and with caution.

(6) Watch for overhead obstructions.

(7) Keep hands and feet clear of controls other than those in use.

(8) Never travel with personnel on the work platform other than to make minor movements for final positioning of the platform.

3664. **Operating Rules.** (a) Every employer using industrial trucks or industrial tow tractors, shall post and enforce a set of operating rules including the appropriate rules listed below:

(1) Only drivers authorized by the employer and trained in the safe operations of industrial trucks or industrial tow tractors shall be permitted to operate such vehicles. Methods shall be devised to train operators in safe operation of powered industrial trucks.

(2) Stunt driving and horseplay are prohibited.

(3) No riders shall be permitted on vehicles unless provided with adequate riding facilities.

(4) Employees shall not ride on the forks of lift trucks.

(5) Employees shall not place any part of their bodies outside the running lines of an industrial truck or between mast uprights or other parts of the truck where shear or crushing hazards exist.

(6) Employees shall not be allowed to stand, pass, or work under the elevated portion of any industrial truck, loaded or empty, unless it is effectively blocked to prevent it from falling.

(7) Drivers shall check the vehicle at least once per shift, and if it is found to be unsafe, the matter shall be reported immediately to a foreman or mechanic, and the vehicle shall not be put in service again until it has been made safe. Attention shall be given to the proper functioning of tires, horn, lights, battery, controller, brakes, steering mechanism, and the lift system of fork lifts (forks, chains, cable, and limit switches).

(8) No truck shall be operated with a leak in the fuel system.

(9) Vehicles shall not exceed the authorized or safe speed, always maintaining a safe distance from other vehicles, keeping the truck under positive control at all times and all established traffic regulations shall be observed. For trucks traveling in the same direction, a safe distance may be considered to be approximately 3 truck lengths or preferably a time lapse 3 seconds passing the same point.

(10) Other trucks traveling in the same direction shall not be passed at intersections, blind spots, or dangerous locations.

(11) The driver shall slow down and sound the horn at cross aisles and other locations where vision is obstructed. If the load being carried obstructs forward view, the driver shall be required to travel with the load trailing.

(12) Operators shall look in the direction of travel and shall not move a vehicle until certain that all persons are in the clear.

(13) Trucks shall not be driven up to anyone standing in front of a bench or other fixed object of such size that the person could be caught between the truck and object.

(14) Grades shall be ascended or descended slowly.

(A) When ascending or descending grades in excess of 10 percent, loaded trucks shall be driven with the load upgrade.

(B) On all grades the load and load-engaging means shall be tilted back if applicable, and raised only as far as necessary to clear the road surface.

(C) Motorized hand and hand, rider trucks shall be operated on all grades with the load-engaging means downgrade.

(15) The forks shall always be carried as low as possible, consistent with safe operations.

(16) When leaving a vehicle unattended, either.

(A) The power shall be shut off, brakes set, the mast brought to the vertical position, and forks left in the down position. When left on an incline, the wheels shall be blocked; or

(B) The power may remain on provided the brakes are set, the mast is brought to the vertical position, forks are left in the down position, and the wheels shall be blocked, front and rear.

(17) When the operator of an industrial truck is dismounted and within 25 feet [7.6 metres] of the truck still in his view, the load-engaging means shall be fully lowered, controls neutralized, and the brakes set to prevent movement.

(18) Vehicles shall not be run onto any elevator unless the driver is specifically authorized to do so. Before entering an elevator, the driver shall make sure that the capacity of the elevator will not be exceeded. Once on an elevator, the power shall be shut off and the brakes set.

(19) Motorized hand trucks shall enter elevators or other confined areas with the load end forward.

(20) Vehicles shall not be operated on floors, sidewalk doors, or platforms that will not safely support the loaded vehicle.

(21) Prior to driving onto trucks, trailers, and railroad cars, their flooring shall be checked for breaks and other structural weaknesses.

(22) Vehicles shall not be driven in and out of highway trucks and trailers at unloading docks until such trucks are securely blocked and brakes set.

(23) The width of one tire on the powered industrial truck shall be the minimum distance maintained from the edge by the truck while it is on any elevated dock, platform, freight car, or truck.

(24) Railroad tracks shall be crossed diagonally, wherever possible. Parking closer than 8½ feet [2.6 metres] from the centerline of railroad tracks is prohibited.

(25) Trucks shall not be loaded in excess of their rated capacity.

(26) A loaded vehicle shall not be moved until the load is safe and secure.

(27) Extreme care shall be taken when tilting loads. Tilting forward with the load-engaging means elevated shall be prohibited except when picking up a load. Elevated loads shall not be tilted forward except when the load is being deposited onto a storage rack or equivalent. When stacking or tiering, backward tilt shall be limited to that necessary to stabilize the load.

(28) The load-engaging device shall be placed in such a manner that the load will be securely held or supported.

(29) Special precautions shall be taken in the securing and handling of loads by trucks equipped with attachments and, during the operation of these trucks, after the loads have been removed.

(30) When powered industrial trucks are used to open and close doors, the following provisions shall be complied with:

(A) A device specifically designed for opening or closing doors shall be attached to the truck.

(B) The force applied by the device to the door shall be applied parallel to the direction of travel of the door.

(C) The entire door opening operation shall be in full view of the operator.

(D) The truck operator and other employees shall be clear of the area where the door might fall while being opened.

(b) Every employee who operates an agricultural or industrial tractor shall be informed of the following operating instructions and of any other practices dictated by the work environment. Such information shall be provided at the time of initial assignment and at least annually thereafter. Copies of these instructions, printed in a language understood by the majority of the employees, shall be conspicuously posted at a place frequented by the drivers.

EMPLOYEE OPERATING INSTRUCTIONS

1. Securely fasten your seat belt if the tractor has an ROPS.
2. Where possible, avoid operating the tractor near ditches, embankments, and holes.
3. Reduce speed when turning, crossing slopes, and on rough, slick, or muddy surfaces.
4. Stay off slopes too steep for safe operation.
5. Watch where you are going, especially at row ends, on roads, and around trees.
6. Do not permit others to ride.
7. Operate the tractor smoothly no jerky turns, starts, or stops.
8. Hitch only to the drawbar and hitch points recommended by tractor manufacturers.
9. When tractor is stopped, set brakes securely and use park lock if available.

(c) Every employee who operates an agricultural or industrial tractor shall be required to check the tractor prior to operation each day and if it is unsafe report the matter immediately to a foreman or mechanic and shall not use the tractor again until it has been made safe.

(d) Employees shall be prohibited from stunt driving or horseplay while operating an agricultural or industrial tractor.

(e) No repairs shall be performed on any agricultural or industrial trucks or tractors until arrangements have been made to reduce the probability of injury to repairmen or others caused by sudden movement or operation of such equipment or its parts.

Appendix B

Uniform Building Code Roof Covering Application Requirements

BUILT-UP ROOFING [See Section 3203 (d) 2]			
	ROOF SLOPE		
ROOF COVERING MATERIAL	Minimum	Maximum	APPLICATION TO CLEAN SOLID DECK
1. Base Sheet	0:12	1:12[3]	Non-nailable deck cement per 3203 (d) 2 or nailable deck nail with at least one approved fastener for each 1⅓ square foot, Section 3203 (c) 4
2. Felts	0:12	1:12[3]	Cement each sheet with 20 lbs. per sq. asphalt or 30 lbs. per sq. pitch, Section 3203 (d) 2
3. Glass Fiber Felts	0:12	1:12[3]	Cement each sheet with 25 lbs. per sq. asphalt, Section 3202 (d) 2
4. Cap Sheets	1/2:12	2:12[3]	Cement with 20 lbs. per sq. asphalt, Section 3203 (d) 2
5. Gravel—400 lbs per sq.[2]	0:12	3:12	Embed in 60 lbs. per sq. of asphalt or 70 lbs. per sq. of pitch[2]
6. Slag—300 lbs. per sq.[2]	0:12	3:12	Embed in 60 lbs. per sq. of asphalt or 70 lbs. per sq. of pitch[2]

SHINGLES-SHAKES-TILE [See Section 3203 (d) 3 A for Ice Conditions]						
					NAILS	
ROOF MATERIAL	MINIMUM SLOPE	UNDERLAYMENT[1]	NUMBER OF FASTENERS	STAPLES	Minimum Gauge	Minimum Head
7. Asphalt Shingles	4:12[6]	One Type 15 felt applied per Section 3203 (d) 3 A	4 per 36 inch strip 2 per 18 inch shingle	•	12	3/8
8. Asbestos-Cement Shingles	5:12[6]	One Type 15 asbestos felt applied per Section 3203 (d) 3 A	4 per shingle[4]	NP	11	3/8
9. Metal Shingles	3:12	One Type 30 felt applied per Section 3203 (d) 3 A	•	•	•	•
10. Slate Shingles	4:12	Two Type 15 or One Type 30 felt applied per Section 3203 (d) 3 A	2 per shingle or wire tie	NP	11	•
11. Noninterlocking Tile—Flat or Curved	3:12		2 per tile or wire tie			•
12. Interlocking Tile—Flat or Curved			1 per tile or wire tie[5]			5/16
13. Wood Shingles	4:12[6]	NR	2 per shingle Section 3203 (d) 3 G	•	14 1/2	7/32
14. Wood Shakes	4:12[3]	One Type 30 felt interlayment Section 3203 (d) 3H	2 per shake	•	13	7/32

NP — Not Permitted NR — No Requirements

[1]See text of Chapter 32 for specific details and for construction, definitions, materials, re-roofing, drainage and roof insulation.

[2]See Section 3203 (f) 3 for ordinary roof covering.

[3]See Section 3203 (g) for exceptions.

[4]Approval of the building official required.

[5]Where the slope exceeds 7.12, two fasteners or positive engagement of anchor lugs over horizontal battens are required.

[6]See Table No. 32-A for exposures on lesser slopes.

Roofing

Common Roofing and Waterproofing Materials and Equipment

Tests

The following section contains objective tests for each topic of the workbook. The value of the tests depends to a great extent on the care taken by instructors and school supervisors in keeping them confidential.

Supervisors and instructors should feel free to modify the application of the workbook material and the tests to satisfy local needs. Also, the instructors will probably supplement the information in the workbook with other material that they themselves have developed, and they will need to augment the tests with questions based on any supplementary material they may use.

Instructors and supervisors should be aware that the test pages are perforated to facilitate removal of the tests, either individually or as a complete set, at the discretion of the instructor or supervisor.

Common Roofing and Waterproofing Materials and Equipment Tests

TOPIC 1—THE PRODUCTION OF BITUMENS AND ASPHALTIC ROOFING MATERIALS

Decide which of the four answers is correct, or most nearly correct, then write the corresponding number in the blank at the right.

1. The number of bitumens used in the roofing and waterproofing industry is: 1. ____

   1. Two
   2. Three
   3. Four
   4. Five

2. The primary material used today in the manufacture of asphaltic roofing materials is: 2. ____

   1. Coal-tar pitch
   2. Asphalt flux.
   3. Slag
   4. Irish flax

3. In the production of organic base mats, which of the following are considered products of secondary processing? 3. ____

   1. Rags
   2. Colored granules
   3. Wood fibers
   4. Saturants

4. The machines used to produce finished roofing felts are similar to those used to make: 4. ____

   1. Carpets
   2. Paper
   3. Blankets
   4. None of the above

5. The term *impregnate* means to: 5. ____

   1. Evaporate.
   2. Saturate.
   3. Distill.
   4. Preserve.

6. Which of the following materials may be used as stabilizers in coating asphalts? 6. ____

   1. Talc
   2. Slate dust
   3. Silica
   4. All of the above

7. The fire resistance of certain roll roofing products and shingles is increased through the addition of: 7. ____

   1. Coarse mineral surfacings
   2. Fine mineral surfacings
   3. Stabilizers
   4. Saturants

8. In the selection of roofing materials for a job, which of the following is *not* an important consideration? 8. ____

   1. Fire rating requirements
   2. The pitch of the roof
   3. The setback of the structure from the property lines
   4. The design of the supporting members

9. The presence of water, moisture, or foreign matter on a surface to which a bitumen is to be applied can: 9. ____

   1. Affect the bitumen's ability to spread when applied.
   2. Reduce the adhesive quality of the bitumen.
   3. Be overcome by using more bitumen than is called for.
   4. Can be disregarded because the hot bitumen will cause distillation of the water, moisture, or foreign matter.

10. Felt must be able to absorb from one and one-half to how many times its own weight in asphaltic saturants? 10. ____

    1. Two
    2. Three
    3. Four
    4. None of the above

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 2—BUILT-UP ROOFING MATERIALS AND ADHESIVES

Decide which of the four answers is correct, or most nearly correct; then write the corresponding number in the blank at the right.

1. Which of the following can be used to keep asphalt or tar from bleeding through sheathing? 1. ____

   1. Cap sheet
   2. Base sheet
   3. Rosin-sized dry sheet
   4. None of the above

2. A roll of roofing material that contains 324 square feet (30.1 square metres) is said to be a: 2. ____

   1. 2-square roll
   2. 3-square roll
   3. 4-square roll
   4. 5-square roll

3. Which of the following can be used in place of regular base sheet on a nailable, lightweight, poured-in-place deck? 3. ____

   1. Number 90 mineral-surfaced cap sheet
   2. Split sheet
   3. Number 15 perforated asphalt-impregnated felt
   4. Venting base sheet

4. The greatest cause of roof deterioration is: 4. ____

   1. Excessive snow
   2. Wind
   3. Heavy rains
   4. Ultraviolet rays from the sun

5. Generally, asphalt should not be kept within how many degrees of its flash point for an extended period of time? 5. ____

   1. 25° F. (-3.9° C)
   2. 30° F. (-1.1° C)
   3. 40° F. (4.4° C)
   4. 50° F. (10° C)

6. Coal-tar pitch is considered a: 6. ____

   1. Special steep-grade roofing product
   2. Dead-level roofing product
   3. Flat-grade roofing product
   4. Steep-grade roofing product

7. Fibers are added to asphaltic emulsions to: 7. ____

   1. Increase their strengths.
   2. Improve their looks.
   3. Cut costs.
   4. Eliminate the need for underlayment.

8. Temporary repairs to wet or damp roof surfaces are made with: 8. ____

   1. Mortar
   2. Wetpatch
   3. Concrete primer
   4. Asphaltic emulsions

9. If aggregate is used on a built-up roof with asphalt, the slope of the roof should not be greater than: 9. ____

   1. 1/12
   2. 3/12
   3. 4/12
   4. 6/12

10. Which of the following statements about asbestos felts is (are) true? 10. ____

   1. Inorganic felts have a greater life span than organic felts.
   2. Asbestos felts may be used as base sheets or finish roofing.
   3. If perforated, the asbestos felt should be applied with the perforation dimples up.
   4. All of the above.

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 3—ASPHALTIC PRODUCTS AND RIGID ROOFING MATERIALS

Decide which of the four answers is correct, or most nearly correct; then write the corresponding number in the blank at the right.

1. The factor that generally dictates whether flexible or rigid roofing will be used on a structure is the: 1. ____

   1. Cost
   2. Winter climate in the area
   3. Slope of the roof
   4. Amount of summer sunshine expected to fall on the roof

2. Steel tile may be coated with: 2. ____

   1. Zinc
   2. Lead
   3. Tin
   4. All of the above

3. The highest quality wood shingles are those with a rating of: 3. ____

   1. 4
   2. 3
   3. 2
   4. 1

4. The minimum thickness of wood shakes is: 4. ____

   1. 1/16 inch (0.2 centimetre)
   2. 1/8 inch (0.3 centimetre)
   3. 3/8 inch (1 centimetre)
   4. 1/2 inch (1.3 centimetres)

5. Steel coated with tin is called: 5. ____

   1. Bright plate
   2. Terneplate
   3. Galvanized steel
   4. None of the above

6. The three basic types of asphaltic shingles are strip, individual, and: 6. ____

   1. Roll
   2. Mission
   3. Interlocking
   4. Bright plate

7. Rigid asbestos shingles are made of a combination of asbestos and what other component joined under pressure? 7. ____

   1. Cement
   2. Glaze
   3. Mortar
   4. Viscous cold-process adhesive

8. Mission barrel tiles are how many inches long? 8. ____

   1. 16 (40.6 centimetres)
   2. 17 (43.2 centimetres)
   3. 18 (45.7 centimetres)
   4. 20 (50.8 centimetres)

9. Asphaltic shingles are often called: 9. ____

1. Sculptured interlocking shingles
2. Composition shingles
3. S shingles
4. Spanish shingles

10. Glazing tile increases its: 10. ____

1. Resistance to electrolytic action
2. Thickness
3. Waterproofing ability
4. Resistance to breaking under foot traffic

TOPIC 4—ELASTOMERIC AND PLASTIC MEMBRANES

Decide which of the four answers is correct, or most nearly correct, then write the corresponding number in the blank at the right.

1. Cold-applied membranes can be applied by: 1. ____

   1. Brush
   2. Roller
   3. Spray gun
   4. All of the above

2. The resistance of a coating to tearing apart is called its: 2. ____

   1. Bond strength
   2. Abrasive strength
   3. Additive strength
   4. Cohesive strength

3. In the application of elastomeric membranes, trim and edge work is usually done with a: 3. ____

   1. Brush
   2. Roller
   3. Spray gun
   4. None of the above

4. The maximum thickness usually recommended for elastomeric membranes is: 4. ____

   1. 30 mils (0.8 millimetre)
   2. 40 mils (1 millimetre)
   3. 50 mils (1.3 millimetres)
   4. 60 mils (1.5 millimetres)

5. Which of the following *cannot* be applied with a spray gun? 5. ____

   1. PVC
   2. Neoprene
   3. Polyethylene
   4. Polychloroprene

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 5—FLASHING MATERIALS

Decide which of the four answers is correct, or most nearly correct, then write the corresponding number in the blank at the right.

1. Most roof leaks are the result of: 1. ____

    1. Violent rainstorms
    2. Heavy accumulations of snow on the roof
    3. Incorrect flashing
    4. Clogged drains

2. Factors that must be considered in the selection of flashing materials include: 2. ____

    1. Geographic location of the structure
    2. Whether insulation is to be used
    3. Whether the roof will be subject to alternate condensation and drying
    4. All of the above

3. Sheet metal classified as 38-gage metal is: 3. ____

    1. Extremely thin
    2. Of medium thickness
    3. About ⅜ inch (1 centimetre) thick
    4. About ½ inch (1.3 centimetres) thick

4. A flashing material with a coating of 75 percent lead and 25 percent tin is: 4. ____

    1. Galvanized iron
    2. Terneplate
    3. Irish flax
    4. Stainless steel

5. Neoprene, vinyl, and butyl are advantageous for use as flashing: 5. ____

    1. On high-quality roofing work
    2. Where expansion and contraction of metal may cause problems
    3. Near the ocean
    4. All of the above

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COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 6—FASTENERS

Decide which of the four answers is correct, or most nearly correct, then write the corresponding number in the blank at the right.

1. In nailing work the roofer should: 1. ____

    1. Use sharp taps, not heavy blows.
    2. Use a shingler's hatchet or claw hammer.
    3. Strike the nailhead squarely.
    4. All of the above.

2. The holding power of a nail driven into wood is directly related to the: 2. ____

    1. Length of the nail shank
    2. Depth to which the nail is driven
    3. Resistance between the wood and the nail shank
    4. Strength of the worker who drives the nail

3. Generally, it is recommended that nails penetrate the roof deck by at least: 3. ____

    1. ½ inch (1.3 centimetres)
    2. ⅝ inch (1.6 centimetres)
    3. ¾ inch (1.9 centimetres)
    4. ⅞ inch (2.2 centimetres)

4. The majority of the nails used in the roofing industry have heads with diameters of: 4. ____

    1. ⅛ inch (0.3 centimetre)
    2. $^3/_{16}$ inch (0.5 centimetre)
    3. ¼ inch (0.6 centimetre)
    4. ⅜ inch (1 centimetre)

5. Which of the fasteners listed below has a shank that spreads or bends when the fastener is driven? 5. ____

    1. Self-locking fastener
    2. Split-shank fastener
    3. Wedge nail
    4. All of the above

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 7—HANDLING OF ROOFING MATERIALS

Decide which of the four answers is correct, or most nearly correct, then write the corresponding number in the blank at the right.

1. If a truck is to carry rolls of felt, cartons of asphalt, and rolls of cap sheet to a built-up roofing jobsite, which of these items should be loaded on the truck first? 1. ____

   1. Felt.
   2. Cap sheet.
   3. Cartons of asphalt.
   4. Any of the above may appropriately be loaded first.

2. Ideally, loads should be placed on a truck so that: 2. ____

   1. Most of the weight is over the front axle.
   2. Most of the weight is over the rear axle.
   3. Most of the weight is between the front and rear axles.
   4. The weight is distributed evenly

3. Most rope used for rigging in the roofing and waterproofing industry has a diameter of: 3. ____

   1. ¼ inch (0.6 centimetre)
   2. ½ inch (1.3 centimetres)
   3. ¾ inch (1.9 centimetres)
   4. ⅞ inch (2.2 centimetres)

4. The type of knot commonly used for safety lines is the: 4. ____

   1. Clove hitch
   2. Self-centering bowline
   3. Timber hitch
   4. Scaffold hitch

5. Before a forklift is towed, the forks should be: 5. ____

   1. Placed in the down position
   2. Placed in the up position
   3. Placed at a level even with the bed of the truck behind which it is to be towed
   4. Cleaned with a nonflammable cleaner

6. If ladders are to be carried on a truck: 6. ____

   1. They should be placed in ladder racks if the truck is so equipped.
   2. They can be laid loose on top of the load.
   3. They can be tied to a side gate.
   4. All of the above.

7. Stacks of asphaltic shingles loaded on a truck can be prevented from sliding or toppling by crisscrossing the bundles in layers of: 7. ____

   1. Two
   2. Three
   3. Four
   4. Five

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8. Which of the following is considered a bad practice? 8. ____

1. Transporting a lighted kettle
2. Transporting a kettle that has an object hanging from it
3. Transporting a kettle without the safety chain connected
4. All of the above

9. The illustration below shows which type of knot? 9. ____

1. Eye splice
2. Figure 8
3. Sheet bend
4. Square

10. When materials are reloaded on the truck for the return trip to the yard, materials that are to be thrown away should be: 10. ____

1. Loaded first
2. Placed inside the cab of the vehicle if possible
3. Placed at the rear of the truck
4. Placed on top of materials that are to be saved

COMMON ROOFING AND WATERPROOFING MATERIALS AND EQUIPMENT

TOPIC 8—OPERATION AND MAINTENANCE OF SMALL ENGINES

Decide which of the four answers is correct, or most nearly correct, then write the corresponding number in the blank at the right.

1. Small engines commonly used in the roofing and waterproofing industry range in horsepower from 1 (0.7 watt) to: 1. ____

   1. 10 (7.5 watts)
   2. 12 (9 watts)
   3. 14 (10.4 watts)
   4. 15 (11.2 watts)

2. Letting an engine run for a few minutes before using it for its intended purpose: 2. ____

   1. Is not recommended
   2. Is an unsafe practice
   3. Allows the necessary oil film to be distributed within the engine
   4. Is of little value

3. Which of the following is recommended for use in cleaning an oil foam filter? 3. ____

   1. Butane
   2. Propane
   3. Paint thinner
   4. Kerosene

4. The engine oil level should be checked: 4. ____

   1. Weekly
   2. Monthly
   3. Twice a week
   4. Before the engine is started each time

5. Under normal conditions engine oil should changed after how many hours of operation? 5. ____

   1. 24
   2. 40
   3. 55
   4. 60

6. Spark plug gaps should be set at approximately: 6. ____

   1. 0.02 inch (0.5 millimetre)
   2. 0.05 inch (1.3 millimetres)
   3. 0.04 inch (1 millimetre)
   4. None of the above

7. In the roofing and waterproofing industry, small engines are used to power: 7. ____

   1. Kettle pumps
   2. Tile saws
   3. Spudding machines
   4. All of the above

8. Any maintenance work done on a small engine should be performed: 8. ____

   1. By the crew supervisor
   2. In accordance with the manufacturer's specifications
   3. By the designated worker, regardless of his or her training and experience
   4. Only if permitted by CAL/OSHA

9. On the first attempt to start a small engine, the choke should be: 9. ____

1. Closed
2. About one-quarter open
3. Half open
4. Completely open

10. Engine oil should be changed more frequently than normal under what type of operating conditions? 10. ____

1. Dry
2. Cold
3. Humid
4. Dusty

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