CHAPTER 4

BUILT-UP ROOFING

Section I. DESCRIPTION AND GENERAL DISCUSSION

4.1.1 General

Built-up roofing is exactly what the name implies, a membrane built-up on the job from alternate layers of bituminous-saturated or saturated and coated felt or fabric and bitumen. Since each roof is custom-made, the importance of good workmanship cannot be overemphasized. Figure 8 illustrates extremely poor workmanship on both roof membrane and flashings.

4.1.2 Slope

Built-up roofs are adapted particularly to relatively flat slopes (2 inches and less per foot) because they furnish a continuous membrane. They may be applied on slopes steeper than 2 inches per foot when proper precautions are taken. While many built-up roofs have been installed over dead level decks, the better practice is to have a minimum slope of ¼ inch per foot or more to completely drain the roof within 48 hours.

4.1.3 Bitumen

The bitumen used to saturate the felt and as a plying cement and coating for the saturated felts may be asphalt or coal-tar pitch. These can usually be distinguished by their odors. Asphalt has an oily odor and coal-tar pitch a somewhat pungent, phenolic odor. These odors can be determined best with freshly broken specimens or from the fumes of specimens that have been ignited and freshly extinguished. Asphalt can also be distinguished from coal-tar pitch if a small specimen of bitumen is placed in a glass jar filled with varsol, the jar is shaken to dissolve some of the bitumen, and the color of the resultant solution is observed. The varsol solution will turn black if the bitumen is asphalt since the asphalt being a by-product of petroleum, is soluble in varsol. The coal-tar pitch is only partially soluble in varsol. If a positive identification cannot be made by these methods, a sample should be sent to a qualified laboratory for examination.

4.1.3.1 Coal-Tar Pitch. Coal-tar pitch is particularly adaptable for use in the construction of the flat built-up roofs on which water collects and stands. Coal-tar pitch is more susceptible than asphalt to changes in temperature, that is, roofing grade coal-tar pitch is more fluid at high temperatures and more brittle at low temperatures than comparable roofing grade asphalts. Consequently, asphalt is better suited than coal-tar pitch for built-up roofing on slopes exceeding ½ inch per foot. Coal-tar pitch, because of its self-healing properties and ability to resist water, is better suited for low slopes on which water collects and stands. Coal-tar pitch conforming to ASTM Specification D-450, Type A is suitable for use with roofing. Coal-tar pitch built-up roofs are always hot-applied. The pitch is melted to a heavy liquid consistency and, except when the felts are laid mechanically (fig. 9), it is mopped when used as a plying cement and poured when used as a surface coating. Because of the susceptibility of coal-tar pitch to changes in temperature, coal-tar pitch roofs should always be surfaced with slag, gravel, crushed stone or other suitable surfacing.

4.1.3.2 Asphalt. Asphalt for use with built-up roofing should conform to ASTM Specification D-312, type as appropriate for the slope of roof on which the asphalt is to be applied and climatic (temperature) conditions. Generally, asphalt built-up roofs are not recommended on roof slopes over 3 inches per foot. Asphalt built-up roofs may be either hot-or-cold applied and may be either surfaced or unsurfaced. Hot-applied asphalt and coal-tar pitch roofs are applied similarly. Hot-applied asphalt roofs use uncoated, saturated felts (except for base sheets and cap sheets); cold-applied roofs use saturated and coated felts and cut-back cements containing a volatile solvent.

4.1.4 Felts

The layers of felts in a built-up roof function primarily to hold the layers of bitumen in place. Generally felts do not materially contribute to the

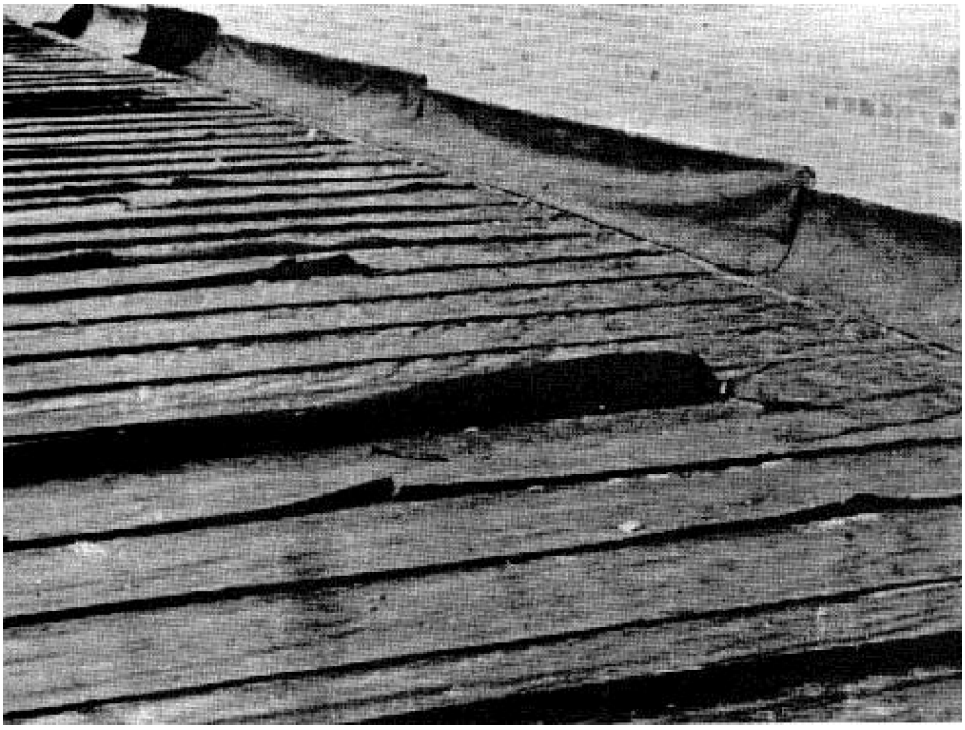

Figure 8. Results of poor workmanship in applying built-up roof.

waterproofness of the roof and are not suitable for exposure to the weather. Built-up roofs are always designated by the number of plies of felt they contain; for example, 3-ply and 5-ply roofs contain 3 and 5 plies of felt respectively. Felts may be: organic-fiber (wool, paper, rag), asphalt-saturated; organic-fiber (wool, paper, rag) coal-tar saturated; glass fiber, asphalt-saturated; asbestos, asphalt-saturated. Asphalt saturated and coated felts are manufactured for use as a vapor barrier. For built-up roofs utilizing glass-fiber felts, a combination base sheet consisting of glass-fiber felt with kraft paper backing is available. Coated felts surfaced with mineral granules are sometimes used for the wearing surface (cap sheets) on built-up roofs. Glass fiber felts should not be used in extremely cold weather (arctic) locations.

4.1.5 Aggregate-Surfaced Roofs

Aggregate surfacing for built-up roofs serve these important functions. They permit the use of thick surface coatings of bitumen, protect the bitumen from sunlight and heat, and increase the wind and fire resistance of the roofing. Surfacing materials may be gravel, slag, marble, and other suitable materials. Marble or other light colored aggregates may be used to reflect the heat or for aesthetic purposes. Light weight aggregates such as scoria are useful in reducing the load on the roof structure, for example, on roof decks supported by wood trusses. When crushed stone is used for surfacing, the stone should not have sharp edges. ASTM specification D 1863 covers the quality and grading of crushed stone, crushed slag, and waterworn gravel suitable for use as aggregate surfacing. Other materials should conform to the grading requirements of ASTM specification D 1863 and be opaque to ultraviolet light, hard, and free of dirt or foreign material. Built-up roofs, except those surfaced with promenade tile or similar surfacing are not intended to carry much foot traffic. On roof areas that are subjected to regular traffic, tile surfacing, concrete, wood, or asphalt plank walkways must be provided. Aggregate surfacing must not be used on any built-up roofs near a flight line, as the aggregate can be blown off the roofs and sucked into the aircraft jet engines.

4.1.6 Smooth-Surfaced Roofs

A smooth surface treatment may be employed in lieu of aggregate surfacing to provide a weathering surface on asphalt built-up roofs where it is necessary to hold roof loads to a minimum, where there is a possibility of surfacing aggregates being blown off and damaging sensitive or critical material and equipment, where required by roof configuration, or other reasons. Smooth-surface treatments include mineral-surfaced cap sheets (roll

Figure 9. Laying felts mechanically and brooming-in after felt is rolled into hot bitumen.

roofing) and mopped-on, brushed-on, or sprayed-on asphalt coatings. Clay type asphalt-base emulsions (ASTM D-1227, Type I) may be used as a protective coating for smooth-surfaced asphalt roofs having inclines of not less than ½ inch to the foot. Emulsions are sometimes reinforced with glass fibers. Aluminum pigmented, solvent type, asphalt coatings (ASTM D-2824) may be used to provide a reflective protective coating on asphalt or metal roofing. Both the emulsion and the solvent type coatings must be renewed periodically, i.e., every 3 to 6 years.

4.1.7 Insulation

Generally, because of economic and other practical considerations, roof insulation is applied above the roof deck. The various types of insulation are described in current guide specifications for new construction. Most commonly used are the rigid, board-type insulations and the poured-in-place insulating concrete fills. The insulation must have sufficient compressive strength to avoid the possibility of puncturing of the roofing membranes by foot traffic. The thickness of insulation is determined from the heat transmission or V-valve which is required. Steel decks must be provided with a layer of underlayment (board-type insulation or lightweight insulating fill) to bridge between deck ribs and support the roofing membrane. The insulation must have good adherence or fastening to the substrate. Likewise the roofing membrane must be firmly adhered or fastened to the insulation. Roof assemblies utilizing cellular plastic insulations must be carefully checked for compliance to fire protection requirements. While the provision of above deck insulation offers many advantages, it can result in considerable maintenance problems. For example, moisture from condensation or leaks can damage the insulation, result in a loss of thermal insulation value, and cause blisters or other problems in the roof membrane. In arctic areas (-20° F and colder temperature zones) it is preferable to place the insulation beneath the roof deck. A comprehensive discussion of insulation and vapor control can be found in the publication entitled "Manual of Built-Up Roof Systems," written for the American Institute of Architects by C. W. Griffin, Jr., P.E., and available from the McGraw-Hill Book Company.

4.1.8 Vapor Barrier

The purpose of a vapor barrier is to retard the passage of water vapor into the insulation from the interior (warm side) thereby preventing condensation within the insulation. Such would be the case where very high humidity conditions prevail as in a bakery or laundry. A vapor barrier must be continuous to be effective. Suitable vapor barriers include: two layers of 15 pound saturated felt mopped solidly between the layers with bitumen or one layer of double coated felt, polyvinyl sheet or laminate consisting of polyvinyl sheet between plies of reinforced kraft paper, each with all laps sealed. A danger in using a vapor barrier is that it may impede the escape of moisture which may inadvertently get into the insulation during initial construction or through leaks in the roofing membrane or flashing. Because of this the use of a vapor barrier must be carefully considered. The modern theory regarding a vapor barrier states "when in doubt, leave it out."

4.1.9 Venting

Whenever insulation is sandwiched between a vapor barrier and a roofing membrane there is a possibility of a build-up of a vapor pressure within the sandwich relative to the ambient atmospheric pressure which can cause blisters to form in the membrane. Venting should be provided to relieve this build-up of vapor pressure. Venting can be accomplished by means of stack vents or edge vents consisting of a series of slotted openings cut in treated wood nailers at roof edges, parapets or other walls, and at roof expansion joints. Venting is required along the complete perimeter of roof decks or common roof areas.

4.1.10 Fastenings

Sufficient anchorage of roofing membrane, insulation, and underlayment must be provided, by adhesive bond, mechanical fastening, or both, to preclude ply slippage and/or blow-off. Types of fasteners and anchorage requirements are given in guide specifications and design manuals. Uplift (suction) forces due to wind are generally greatest at edge of the roof. Hence, blow-off of roofing usually commences at the roof edge, the roofing membrane and sometimes the insulation then being peeled back towards the center of the roof. This points up the need for adequate fastening of the gravel stop, and roofing membrane and insulation near the edges of the roof. This also points up the need for a wood nailing strip securely fastened to the deck structure at the roof edge. For wood or other decks with cracks or openings, consideration must be taken of the up-lift of the membrane due to wind pressure from below. For arch type roofs with steep slopes, the use of the up-and-over, "vertical" application can be used advantageously to preclude ply slippage. Nailing is not generally required for asphalt built-up roofs on concrete decks with inclines of less than 1 inch per foot or for coal-tar built-up roofs on concrete decks with inclines of less than ½ inch per foot.

4.1.11 Roof Drainage

Roof decks for built-up roofing should be sloped for drainage at least ¼ inch to the foot. An adequate number of drains of sufficient size must be provided and must be located at low points of roof to preclude ponding. Drains, gutters, leaders, and storm drains must be sized for storm-design conditions. Structures with continuous parapet walls must include scuppers or overflow drains.

4.1.12 Designation

Built-up roofs suffer by being designated as 10-, 15-, or 20-year roofs. Too often these designations are interpreted to mean that the roof will require no maintenance for the stated period. Roofs that are not maintained will, in all probability, require replacement at or before the end of the stated period, while those that are maintained properly can be expected to serve well beyond the period.

Section II. ROOF DECKS FOR BUILT-UP ROOFS

4.2.1 Wood Decks

(1) Wood decks should be low moisture content tongued and grooved lumber or may be plywood with exterior glue of thickness and nailing appropriate for rafter spacing and total roof load. Best results will be obtained with plywood ½ inch and thicker.

(2) Deck should be dry when roofing is applied.

(3) At least two nails should be driven flush per 6 inches width of board at each rafter. Annular ringed or spirally grooved nails can be used to reduce troublesome "nail popping."

(4) Roof deck must be smooth with no irregularities. Existing decks which do not present a smooth surface may be overlaid with ¼ inch thick exterior grade plywood.

(5) Knot holes and cracks wider than ¼ inch

between boards should be covered with sheet metal.

(6) A dry, red rosin, separation sheet should be provided between wood deck and roofing membrane.

4.2.2 Poured Concrete and Gypsum Decks

(1) Deck must be aged, dry, smooth, free from frost or freezing effects, properly graded to drains, and free from loose material.

(2) If deck is uneven, high spots must be removed or low spots filled with portland cement or gypsum mortar.

(3) Nailing strips in concrete, when required, must be treated to resist rot, properly keyed into the concrete, and flush with the surface.

(4) Concrete decks must be primed prior to application of asphalt.

4.2.3 Precast Concrete Units

(1) Deck must be dry, smooth, free from frost or freezing effects.

(2) Deck units must be aligned to eliminate humps or ridges between adjacent units.

(3) Use cement mortar to level inequalities and fill cracks in the deck.

4.2.4 Precast Gypsum Units

(1) Protect units stored on the job from rain or snow. Store metal-edge gypsum plank on edge, not more than three tiers high, with ample ventilation.

(2) Gypsum decking applied each day must be covered with roofing that day or otherwise protected.

(3) Use only gypsum mortar to fill cracks and level inequalities in the roof deck.

(4) Examine old decks from beneath prior to reroofing. Such decks in contact with water deteriorate rapidly. Replace deteriorated areas.

4.2.5 Steel Decks

(1) Deck must be dry, firm, tight, free from rust, grease, or any loose material.

(2) All steel decks should be shop coated or painted.

(3) Lightweight fill or board-type insulation must be provided over steel decks to form a firm, plane surface.

(4) Fasteners for suspended items should not be hung from the steel roof deck.

(5) Steel decks must be sufficiently rigid to insure that flexing under the weight of men or equipment does not result in breaking the bond between the steel deck and the vapor barrier and/or insulation.

Section III. STORAGE, HANDLING, AND APPLICATION OF MATERIALS

4.3.1 Weather Conditions

Except in emergencies, roofing work should be accomplished only during dry weather. Preferably it should be accomplished in other than the winter months. The inspector or foreman should insure that built-up roofing work is not started until the ambient temperature is above 40° F. and that the surfaces on which roofing is to be applied are free of ice, frost, or moisture. During cold weather roofing felts should be stored inside at a temperature above 50° F. prior to use.

4.3.2 Asphalt and Coal-Tar Pitch

Drums of asphalt and coal-tar pitch should be stood on end and protected from the weather during storage. Asphalt and pitch should be cleaned of extraneous matter and broken up in pieces before placing in the kettle. For safety, pieces should be slipped rather than dropped into melted bitumen. Asphalt-base emulsions contain water and must be stored at temperatures above plus 40° F.

4.3.2.1 Temperature of Bitumen. The inspector should insist that the temperature of the melted bitumen be controlled. The properties of both asphalt and coal-tar pitch may be changed adversely by overheating. Consequently, in some cases overheating the bitumen may result in a reduction in the useful life of a built-up roof while in others may be a major factor in roof slippages. Modern heating kettles are usually equipped with a thermometer, but these are frequently broken or so covered with bitumen as to be illegible. The inspector should be provided with a thermometer. Asphalt should not be heated above 450° F. and should normally be not lower than 350° F. when poured or mopped on a roof. If asphalt with a softening point of 150° F. or lower is used, the maximum kettle temperature is 375° F. and the minimum temperature for application is 300° F. Coal-tar pitch should not be heated above 400° F. and should not be poured or mopped at temperatures under 350° F. Dense yellow fumes from the heating kettle is proof that the coal-tar pitch is too hot. Once the bitumen has been overheated it must be discarded and not used.

4.3.2.2 Application of Bitumen. The final coating of asphalt or coal-tar pitch on aggregate-surfaced built-up roofs should always be poured rather than mopped to insure sufficient (60 to 80

Figure 10. Surface coating of hot bitumen should be poured, not mopped.

pounds per square) bitumen for embedding the aggregate surfacing (fig. 10). To determine whether aggregate surfacing is embedded properly, the inspector should include a broom as part of his regular equipment (fig. 11). Emulsions or aluminum pigmented coatings may be applied by brush, mop, or spray.

4.3.3 Felts

4.3.3.1 Storage. Felts stored on the job must be protected from the weather. It must be realized that these felts, although they are described as "saturated" with asphalt or coal-tar pitch, will still absorb considerable moisture if exposed to it. Felts that contain moisture are certain to result in blistered built-up roofs. Felt rolls should be stood on end, not in contact with the ground.

4.3.3.2 Application of Felts. When felts are applied, they should preferably be rolled into the hot asphalt or coal-tar pitch that has been applied with a mop not more than three feet ahead of the roll. Sufficient asphalt or pitch (20 to 25 pounds per square) should be present between the plies of felt to insure that, in no case, is felt touching felt. Immediately after the felt is rolled into the hot bitumen, it should be "broomed in" with a stiff bristle broom (fig. 9). Any small blisters or buckles remaining should be slit with a knife and smoothed out with the broom. If blisters or buckles longer than 8 inches in any dimension are present, the felt should be removed and relaid. The plies of felt should be laid shingle fashion. Generally, the layers of felt should be applied at right angles to the slope of the deck. Cant strips should be provided where the roof intersects vertical surfaces such as parapet walls. Felts should extend to the top of the cant strip. The objective of the cant strip is to keep the metal flashing above the highest water line wherever possible. Generally, felts should not be mopped directly to precast gypsum, cast-in-place gypsum, or insulating-concrete surfaces. The first ply should be nailed only to prevent shrinkage or structural cracks which may develop in the substrate from damaging the roofing membrane. On nonnailable decks with inclines that require the nailing of felts, treated wood nailing strips must be provided. At eaves and rakes, the bottom layer of felt should be turned back over the remaining plies to form an envelope which will prevent bitumen from dripping down the outside of the building. Separate layers of roofing felt may be used to provide the bitumen stop or a metal bitumen stop can be used.

4.3.4 Surfacing

Surfacing aggregates for built-up roofs should be dry and free from dust since wet or dusty surfacing

Figure 11. Insufficient bitumen to embed aggregate surfacing.

materials will not bond well with the bitumen. If wet they should be dried by piling over a heated metal drum with open ends. If roofing work must be done in cold weather, this method may be used to heat the surfacing material to secure proper embedment. If, in reroofing work, surfacing materials are to be reused, they must be screened to remove fines, dirt or other foreign material. The embedment of light weight aggregates may be improved by rolling with a light roller.

4.3.5 Insulation and Underlayment

4.3.5.1 Storage. Insulation should be stored under cover and be kept dry at all times. No more insulation should be installed in a single day than can be covered with roofing on that day. At the end of each day's work the exposed edges of insulation or underlayment should be provided with temporary cutoffs of mopped-on felts. The cutoffs are removed when work is resumed.

4.3.5.2 Application. Since the application of insulation and/or underlayment varies with the different kinds of decks, the kinds of insulation or underlayment, and the use of the structure, general instructions only will be given here. For detailed instructions, reference should be made to current guide specifications for new construction, design manuals, and to instructions furnished by the manufacturers. Units of insulation or underlayment should be laid in parallel courses with horizontal joints broken, in moderate contact with adjoining units without forcing, and cut to fit neatly against adjoining surfaces. Tests indicate that felts are stronger in the "in the machine" direction than in the "across machine" direction. Therefore, it is preferable to lay the insulation with the continuous joint parallel to the short dimension (slope) of the roof and to lay the felt parallel to the long (eave) dimension of the roof. Continuous joints between underlayment units should not occur over the fluted openings in steel decks. Insulation or underlayment may be applied in solid or spot moppings of bitumen, with special adhesives, by nailing, or with special fasteners, as appropriate. If light-weight fills are used as insulating materials, provision must be

made to allow dissipation of mixing water. Thermosetting light-weight insulation fills are available which do not require water for mixing and can be reroofed over immediately. It is important that these fills be dry before roofing is applied. On decks of limited expanse, light-weight fills may sometimes be used advantageously to provide additional roof slope. All decks over which insulation is to be applied must be provided with wood edge strips at least 6 inches wide and of the same thickness as the insulation at all open edges and elsewhere where metal flashing must be fastened to the roof.

4.3.6 Vapor Barriers

For detailed instructions on the application of vapor barriers, reference should be made to the latest guide specifications for new construction and to manufacturers' literature. The vapor barrier must be continuous and unbroken. The vapor barrier must not be turned over edges of insulation board adjoining vented gravel stops or other vented edges. Felt vapor barrier plies should be extended at edges of the roof and folded back to form an envelope to prevent dripping of bitumen. Adhesive for use with polyvinyl-sheet vapor barriers should be nonflammable and compatible with contact surfaces. Insulation applied to polyvinyl sheets shall be layed in nonflammable adhesive.

Section IV. DETERMINING TREATMENT FOR BUILT-UP ROOFS

An analysis of the data furnished in the historical records and that listed on the inspection forms will assist in determining what treatment, if any, the roof is to receive. If necessary, cutouts of roofing and insulation will be examined to verify the condition of the roofing assembly. Walls, parapets and the underside of the roof deck should be examined. As-built drawings and specifications provide essential information. In addition to the above, consideration must be given to such factors as the kind of structure, whether permanent or temporary, its occupancy; the kind of roof, its age, and the frequency at which leaks occur. A roof on a structure designated for temporary retention should be given only the minimum treatment necessary to keep it leakproof during the period of retention. A roof on a structure for permanent retention should be considered in the light of the prolonged use of the structure and should be given the best maintenance, repair, or reroofing possible.

Section V. MAINTENANCE METHODS FOR BUILT-UP ROOFS (TREATMENT PRIOR TO FAILURE)

4.5.1 General

Asphalt products should always be used in the maintenance of asphalt built-up roofs, and coal-tar pitch products in the maintenance of coal-tar pitch built-up roofs. Asphalt and coal-tar pitch are not compatible so that contact between the two should be avoided whenever possible. In the text that follows, the terms "bitumen" and "bituminous" are used to indicate asphalt when asphalt roof maintenance is discussed and coal-tar pitch when coal-tar pitch roofs are discussed. *Exception:* While asphalt and coal-tar pitch should not be mixed in heated form, they may be used together under certain conditions. These conditions are where asphalt coated base sheets and plastic base flashings composed of asphalt-saturated felts and mineral surfaced roll roofing embedded in asphalt-base bituminous cement are used in constructing coal-tar built-up roofing.

4.5.2 Maintenance of Aggregate-Surfaced Built-Up Roofs (Treatment Prior to Failure)

4.5.2.1 Bare Areas (Small Areas).

4.5.2.1.1 Bituminous Coating Exposed. When the bituminous coating is exposed (fig. 12), scrape the gravel or slag from the bare area and broom clean. While it is sometimes possible to apply hot asphalt directly to the old asphalt and attain satisfactory adhesion, it is generally better to apply a thin coat of asphalt primer conforming to ASTM Specification D41. This will insure that a satisfactory bond is attained. Use a thin coat of primer only and allow to dry. A primer is not required over coal-tar pitch. Cover the bare area with hot bitumen poured on at a rate of 60 pounds per square for asphalt and 75 pounds per square for coal-tar pitch, and while hot embed clean gravel or slag. Do not attempt to apply hot bitumen over slag or gravel surfacing since bitumen will not adhere

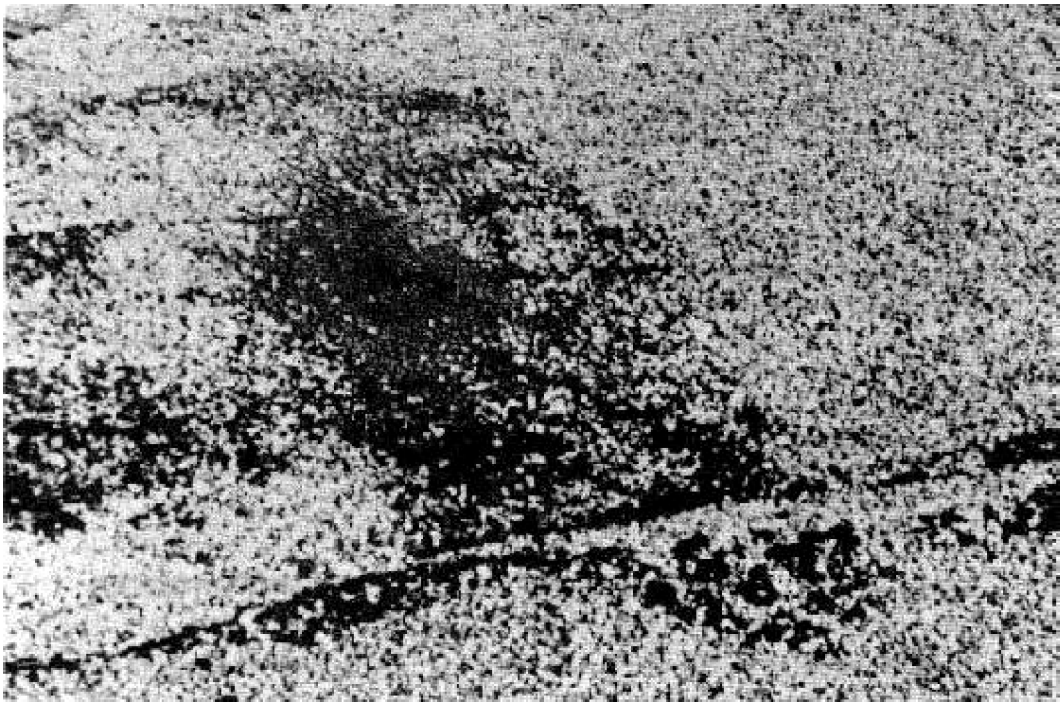

Figure 12. Bituminous coating exposed due to loss of aggregate.

(fig. 13) and water will penetrate under the bitumen.

4.5.2.1.2 Felts Exposed. If the bituminous coating has weathered to the extent that the top ply of felt is exposed (fig. 14) but is still in good condition (not disintegrated), brush dust and dirt from the exposed area and, in the case of asphalt roofs, apply a thin coat of asphalt primer and allow to dry. Apply a flood coat of bitumen and aggregate surfacing as described in preceding paragraph. Coal-tar pitch roofs are treated similarly except that the primer is omitted.

4.5.2.2 Small Blisters and Buckles. If bare, treat small blisters and buckles as bare areas; otherwise disregard them (fig. 15).

4.5.2.3 Bituminous Coating Weathered Severely Over Entire Roof Area. When bituminous coating is weathered severely over the entire roof area, remove as much of the bituminous coating and aggregate surfacing as possible. Removal is best accomplished in cool weather. When large roof areas are involved, the use of mechanical equipment to remove the bituminous coating and surfacing material is easier and more economical than removal by hand methods. Replace disintegrated felts and repair damaged areas, blisters and buckles as described hereinafter under paragraph 4.6, "Repair Methods-Built-Up Roofs Treatment Following at Least Partial Failure." Sweep off loose material. In the case of asphalt, weathered surfaces should be primed. Recoat with hot bitumen poured on at a rate of 60 pounds per square for asphalt and 75 pounds per square for coal-tar pitch. Into the hot bitumen embed 400 pounds of gravel or 300 pounds of slag per square.

4.5.3 Maintenance of Smooth-Surfaced Roofs (Treatment Prior to Failure)

4.5.3.1 Felts Exposed(Small Areas). Same as for aggregate-surfaced, built-up roofs, except that 20 to 25 pounds of asphalt should be mopped per square and the aggregate surfacing omitted.

4.5.3.2 Small Blisters and Buckles. If felts are exposed, treat as described for exposed felts, aggregate surfaced, built-up roofing, applying 25 pounds of asphalt per square and omitting aggregate surfacing. If felts are not exposed, disregard small blisters and buckles.

4.5.3.3 Asphalt Coating Weathered Severely Over Entire Roof Area.

4.5.3.3.1 General Discussion. Smooth surfaced, asphalt built-up roofs, in which the surface topping is relatively thin and is exposed directly to the weather, usually show definite alligatoring of the surface coating within 3 to 5 years. Alligatoring is always most severe where the asphalt coating is thickest. If "alligatoring" is allowed to proceed, it will develop into cracking (fig. 16). Once the surfacing coating is cracked, water enters the membrane, leaks may appear and the roofing deteriorates at a rapid rate. Consequently, maintenance before cracks appear is necessary.

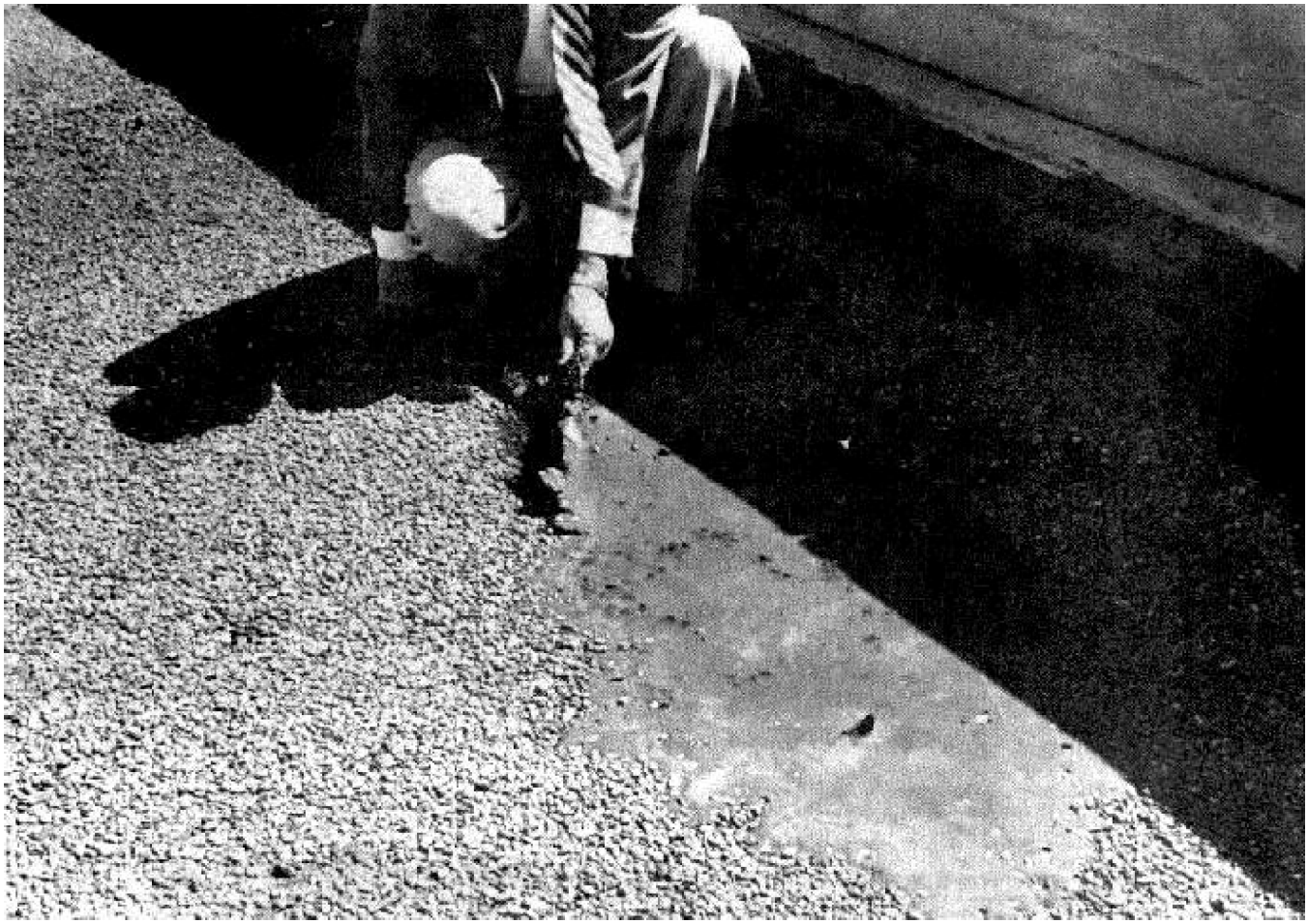

Figure 13. Hot bitumen poured on unprepared surface — note lack of adhesion.

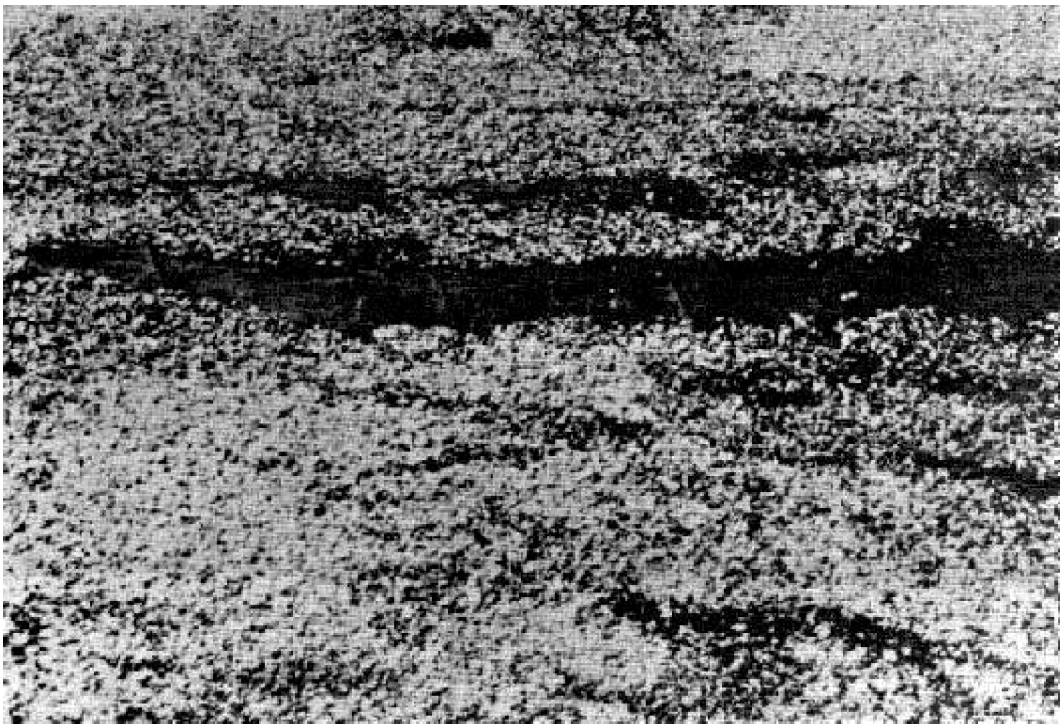

Figure 14. Felts exposed and weathered due to loss of aggregate and bituminous coating.

Figure 15. Small blisters or buckles — when bare should be treated as bare areas (para 4.5.2.1).

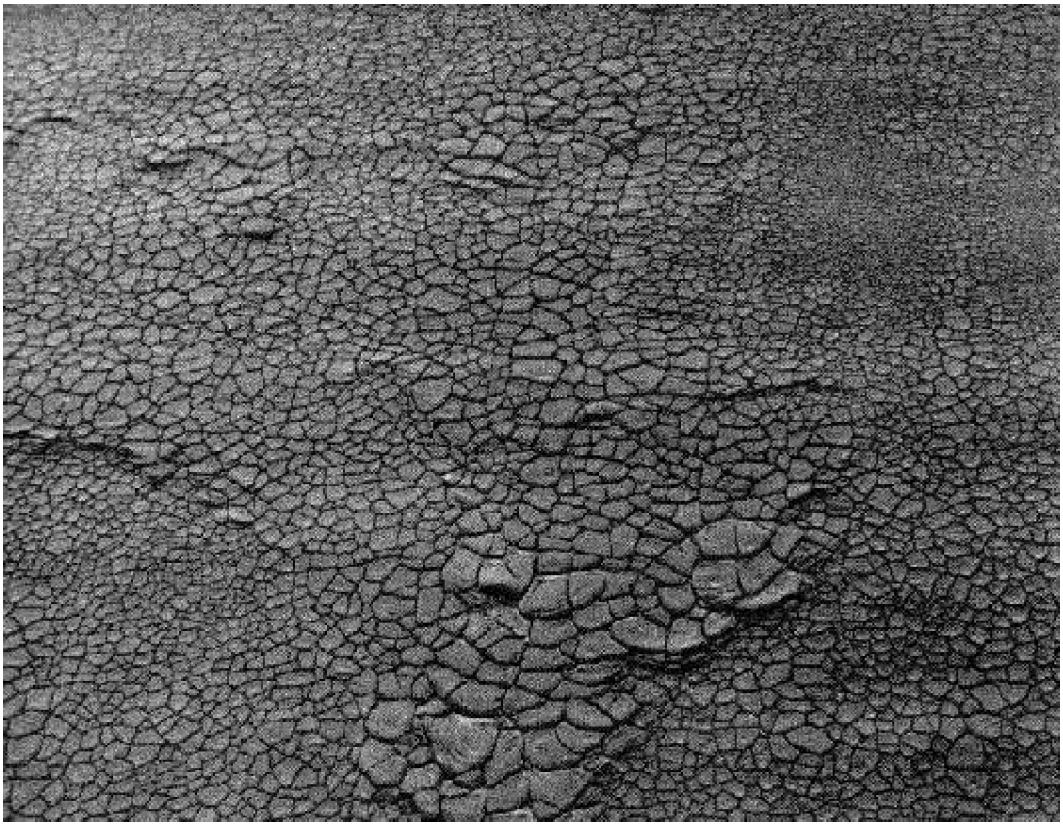

Figure 16. Severe alligatoring on thick coating of asphalt.

4.5.3.3.2 Treatment. Remove all loose dust and dirt by sweeping, vacuuming or air blast. Apply one coat of asphalt primer conforming to ASTM Specification D 41. A thin coat only is desired, applied preferably by brushing, to avoid excess primer. After primer is dry, apply one of the following:

(1) Clay type asphalt emulsion conforming to

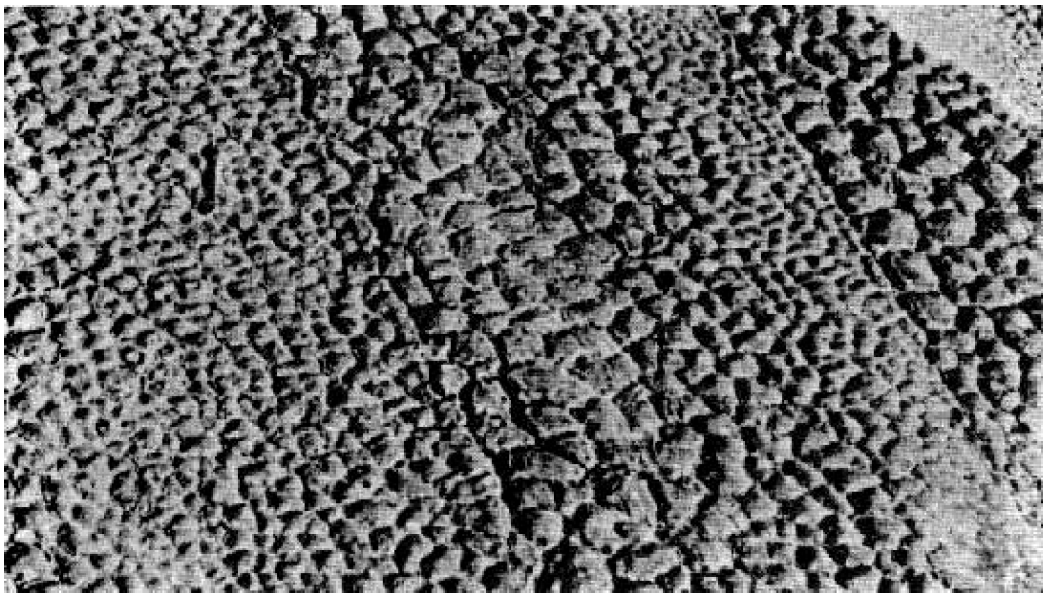

Figure 17. Alligatoring and cracking of a cold coating over alligatored asphalt surface after 1 year exposure.

Military Specification MIL-R-3472, "Roof Coating; Asphalt-Base Emulsion" by brush or spray at a rate of 3 gallons per square (ASTM D-1227, Asphalt-Base Emulsions for Use as Protective Coatings for Built-up Roofs, Type I). Chemical type should not be used. The clay type is available with a reinforcing of chopped glass fibers.

(2) Asphalt-base roof coating meeting Federal Specification SS-A-694 "Asphalt, Petroleum (Coating, Brushing and Spraying Consistency)," by brush or spray at a rate of 3 gallons per square (ASTM D-2823, Asphalt Roofing Coatings). If a reflective coating is desired, an asphalt-based aluminum roof coating conforming to ASTM Specification D-2824 may be applied by brush or spray.

(3) Hot-mopping asphalt conforming to ASTM Specification D-312, "Asphalt for Use in Constructing Built-up Roof Coverings," of type suited for the slope of the roof, at a rate of 20 to 25 pounds per square.

Note. If an emulsion coating is to be applied to such surfaces, dust and dirt may be washed off with a stream of water from a hose. The emulsion may be applied to a damp, but not a wet surface. Coatings applied over alligatored and cracked surfaces also tend to alligator and crack (fig. 17). This tendency increases as the coating thickness is built-up; when recoating, therefore, coating thicknesses should be properly controlled. Since the asbestos felts are constructed mainly of inorganic materials, exposure to the weather is much less serious than with organic felts. Manufacturers of asbestos felts generally do not recommend recoating asbestos felt roofs at any time.

Section II. REPAIR METHODS FOR BUILT-UP ROOFS (TREATMENT FOLLOWING AT LEAST PARTIAL FAILURE)

4.6.1 Aggregate Surfaced, Built-Up Roofs

See paragraph 4.5.1 regarding compatibility of asphalt and coal-tar pitch.

4.6.1.1 Felts Exposed and Partially Disintegrated-Small Areas (fig. 18). Scrape off all surfacing material to a distance at least 21/2 feet beyond the area of disintegrated felts. Remove disintegrated felt layers and replace them with new 15-pound bituminous-saturated felts of approximately the same size and mopped in place with hot bitumen. Apply at least two additional layers of 15-pound saturated felt. Extend the edges of the first ply 9 inches beyond the area of disintegrated felts, and the second ply 18 inches, mopped on with hot bitumen. Apply a pouring of hot bitumen to the repaired area at a rate of 60 pounds per square for asphalt and 75 pounds per square for coal-tar pitch and into it, while hot, embed clean gravel or slag.

4.6.1.2 Roof Membrane Cracked (Split). Treat as described for disintegrated felts, except that it is usually only necessary to mop on at least two plies of 15-pound saturated felt, followed by the heavy pouring of bitumen, with slag or gravel surfacing. If splitting is extensive or occurs in a pattern the cause should be ascertained and corrective action

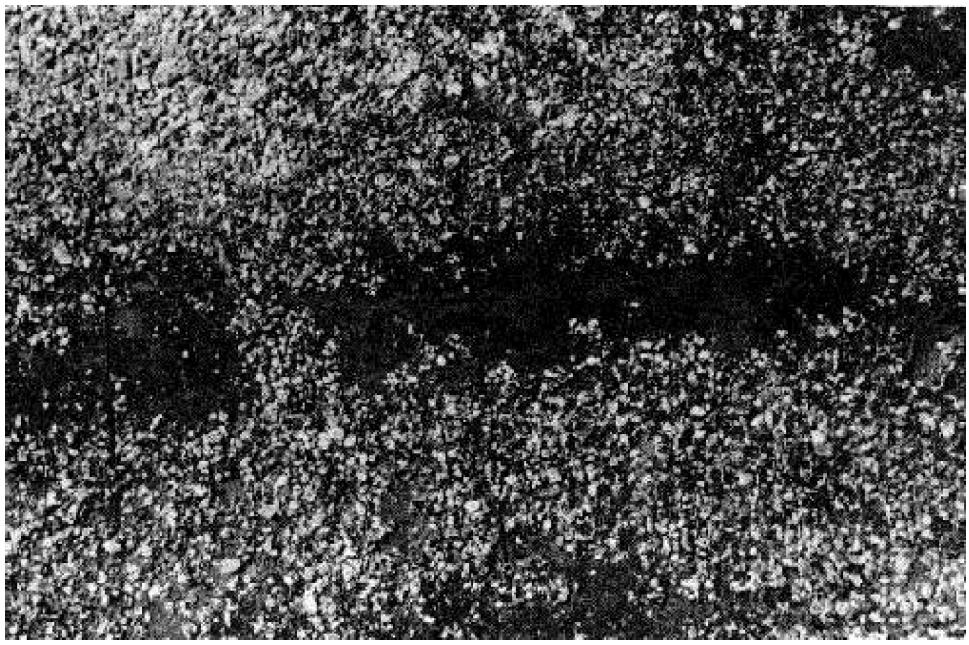

Figure 18. Coating weathered off small areas — felt exposed ad partially disintegrated..

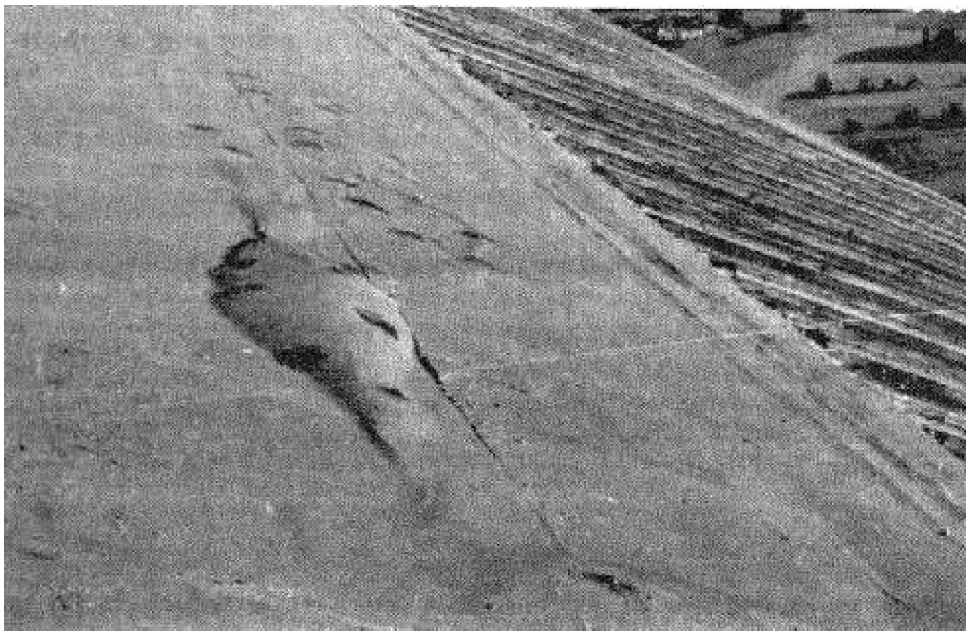

Figure 19. Large blister on smooth-surface roof.

taken to prevent recurrence especially if reroofing is required. Some causes of splitting are: lack of provision for expansion and contraction, ply slippage, extension of cracks in substrate up through roofing membrane.

4.6.1.3 Large blisters or Buckles that have Cracked to Allow Water to Penetrate. Blisters or buckles(fig. 19), though large, if intact, will not leak. Only if the felts disintegrate or are cracked should they be repaired. Scrape off all surfacing material to a dry felt surface at least 2½ feet beyond the edge of the blister or buckle. Make two cuts at right angles to each other extending 12 inches beyond the edge of the blister or buckle. Fold back the four corners of the membrane and allow to stand until thoroughly dry. When dry, apply a liberal mopping of bitumen (hot is preferred but cold cement may be used), fold down the four corners of the membrane and press them firmly into the hot bitumen. Apply at least two additional layers of 15-pound saturated felt mopped on with hot bitumen and extending at least 9 inches and 18 inches respectively beyond the ends of the cuts. Apply a pouring of hot bitumen at a rate of 60

Figure 20. Felts disintegrated and disbonded — reroofing is mandatory.

pounds per square for asphalt and 75 pounds per square for coal-tar pitch, and while hot, embed gravel or slag.

4.6.1.4 Fishmouths. Scrape off all surfacing material to a distance at least 12 inches beyond the affected area. Cut the fishmouth and cement down the loose felts with hot bitumen or cold plastic cement. Apply at least two layers of 15-pound saturated felt mopped on with hot bitumen. Extend the first ply at least 6 inches beyond the end of the cut felt and 6 inches below the lap edge. Extend the second ply 6 inches beyond the first ply. Apply a heavy pouring of hot bitumen and into it, while hot, embed gravel or slag.

4.6.1.5 Felts Exposed and Disintegrated in Numerous Areas (fig. 20). Under this category no definite criteria can be established to determine whether the existing membrane should be repaired by adding plies of felt or whether the old membrane should be removed entirely and a new one applied. The condition of the membrane (determined from cut-outs) should largely govern, but the historical record of the roof will be of definite assistance in making a decision.

4.6.1.5.1 Cases Where Repairs Are Indicated.

(1) Roof has not reached its expected life; that is, roughly, for a 5-ply roof, 20 to 25 years; a 4-ply roof, 15 to 20 years; and a 3-ply roof, 10 to 15 years.

(2) Base felts are in sound condition and are not waterlogged.

(3) Insulation, if present, is sound and dry.

(4) Leaks that have developed are few in number and are not serious.

4.6.1.5.2 Cases Where Reroofing is Mandatory.

(1) Roof has exceeded its expected life with little or no maintenance.

(2) Felts have disintegrated and/or are disbonded; entire membrane is in poor condition.

(3) Insulation, is wet and/or disintegrated.

(4) Numerous leaks of a serious nature have developed in the membrane.

4.6.1.5.3 Repairing by Applying Additional Plies of Felt. In applying additional plies of felt to an existing built-up roof, the best practice is not to mop the additional felts solidly to the existing membrane. It is better to isolate the repair

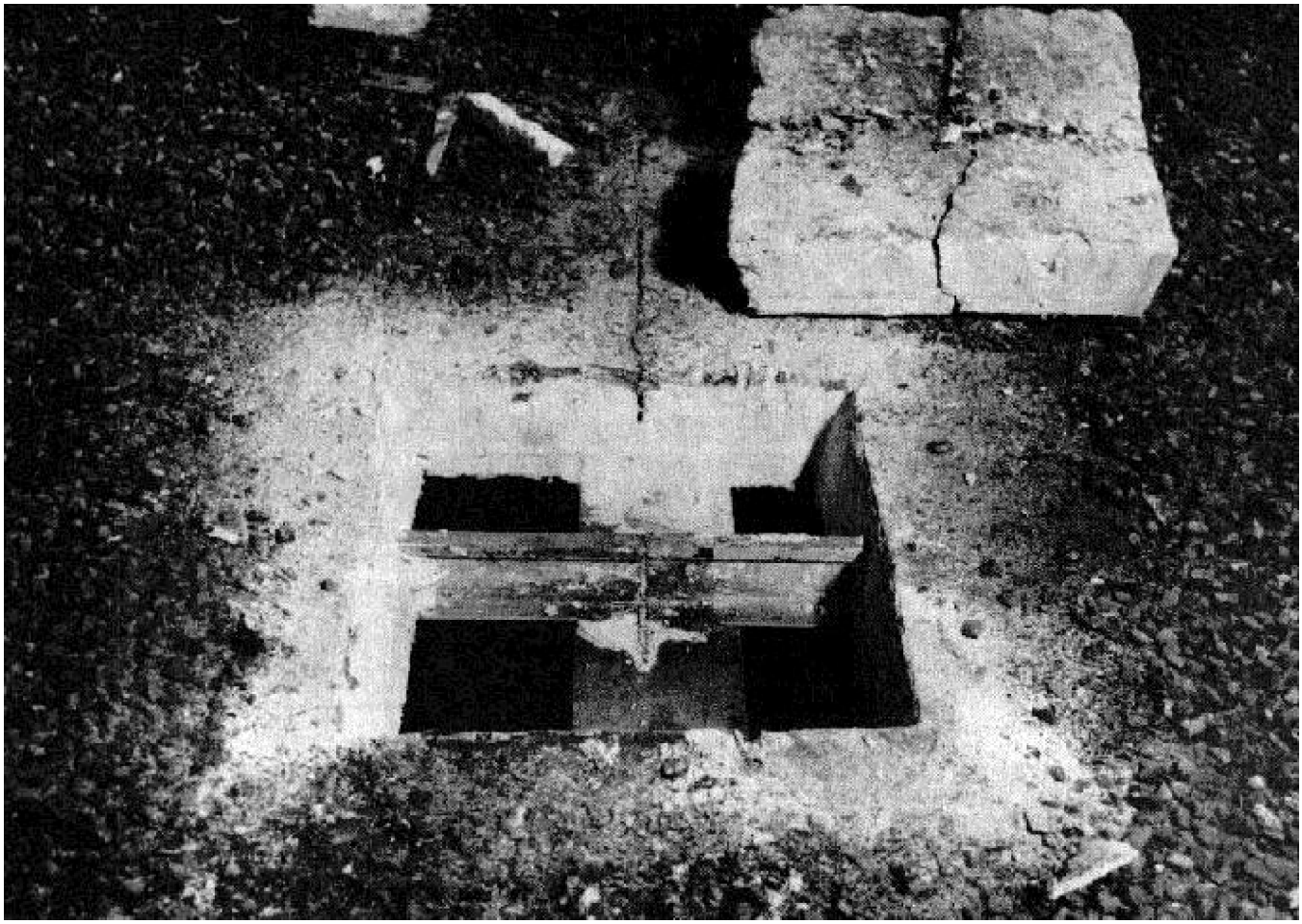

Figure 21. Test cut in gypsum deck — crack extends up through roofing membrane mopped directly to deck.

membrane from the old membrane with a "dry" felt layer, spot or strip mopped, or nailed, or preferably by ½ inch of roof insulation strip mopped, and if possible, nailed through the old membrane to the roof deck. If the slope of the roof is greater than 1 inch per foot, some provision must be made for fastening the felts and the insulation. The use of insulation is desirable because it effectively isolates the old membrane from the new one and provides a smooth surface free from irregularities for the new membrane. The new membrane should contain not less than 3 plies of felt. While the application of additional plies of felt is sometimes practical and advantageous, a word of caution about the danger of impounding moisture in old roofing and insulation is appropriate. If moisture is entrapped, blisters are likely to form and result in early failure of the additional plies of felt. It is imperative that the existing roofing and insulation be dry if additional plies of felt are to be applied. Other factors which also should be considered are: Cost; advantages of correcting roof deck, insulation, and flashing deficiencies when a membrane is replaced; desirability of keeping roof loads to a minimum; problem of maintaining a watertight roof while reroofing is being accomplished; dust problem on stored material when roofing is removed over wood sheathed decks; contemplated retention and use of structure.

4.6.1.5.4 Preparation of Existing Roofing to Receive New Membra ne--All Types of Decks. Remove aggregate surfacing, bituminous coating and all loose and disintegrated felts. Refer to paragraph 4.5.2 on "Maintenance of Aggregate Surfaced Built-Up Roofs; Treatment Prior to Failure." Repair blisters, buckles, cracks and fishmouths as indicated above, omitting final pouring of bitumen and aggregate surfacing material. Provide cant strips at intersection of roof with vertical surfaces where required.

4.6.1.5.5 Application of New Membrane Over Existing Membrane on Concrete Decks.

(1) *Saturated Organic or Glass Fiber Felt with Insulation.* Mop solidly with hot bitumen ½ inch of roof insulation to the existing membrane. Follow with at least 3 plies of 15-pound saturated

felt mopped solidly to the insulation and to each other with hot bitumen. Finish with a surface pouring of hot bitumen at a rate of 60 pounds per square for asphalt and 75 pounds per square for coal-tar pitch into which gravel or slag is embedded at a rate of 400 pounds of gravel or 300 pounds of slag per square. Use only organic base sheet and felts in localities with extremely cold temperatures; glass fiber felts contract more and tend to break, and therefore should not be used.

(2) *Saturated Organic or Glass Fiber Felt Without Insulation.* Spot or strip mop with hot bitumen one ply of saturated felt to the existing membrane. Follow with at least 2 plies of saturated felt mopped solidly and finished as described in the preceding paragraph.

(3) *Asphalt and Asphalt-Saturated Asbestos Felt — With and Without Insulation.* Proceed as described for organic or glass fiber felts using asphalt-saturated asbestos felts, except that the finish coat should consist of asphalt emulsion meeting Military Specification MIL-R-3472, applied at a rate of 3 gallons per square.

4.6.1.5.6 Application of New-Membrane Over Existing Membrane on Wood Decks. Proceed as described for concrete decks except that insulation and felt should always be nailed over wood decks in addition to the mopping recommended when applying a hew membrane over concrete. Spot or strip mopping may be omitted when the new membrane is applied directly to the old, the first ply being simply nailed.

4.6.1.5.7 Application of New Membrane to Existing Membrane on Gypsum Decks. Treat as described for wood decks. If the roof deck shows cracks on the under side, or if the existing roofing is cracked, the use of insulation under the new membrane is required to prevent extension of the cracks up through the new roofing (fig. 21).

4.6.1.5.8 Application of New Membrane over Existing Membrane on an Insulated Roof. First make certain that the old insulation is dry and not disintegrated. If the insulation is not thoroughly dry or if it shows any evidence of disintegration, the existing roofing and insulation should be removed down to the roof deck and a new roof applied. If satisfied that the insulation is in good condition, remove aggregate surfacing and apply an additional layer of ½ inch insulation, followed by 3 layers of 15-pound saturated felt, mopped on and finished as described for concrete decks.

4.6.2 Smooth-Surfaced Asphalt, Built-Up Roofs

Treatment of smooth-surfaced built-up roofs following partial failure is the same as for aggregate-surfaced built-up roofs except no removal of aggregate surfacing will be required, bitumen will always be asphalt, and the top coat should be as outlined in paragraph 4.5.3.3.2. The top coat for all built-up roofs of asbestos felts should be clay type asphalt emulsion conforming to Military Specification MIL-R-3472 applied at a rate of 3 gallons per square.

Section VII. REROOFING

4.7.1 General

A thorough analysis of the roof assembly should be made to determine the most feasible method of reroofing. If failure was premature, the cause should be determined and eliminated if possible. Selection of a specification for new roofing should be made mainly on the basis of the expected future use of a structure.

4.7.2 Specifications

Reroofing should, to the extent feasible, be accomplished in accordance with standard military guide specifications for new construction. Manufacturer's specifications provide helpful guidance in instances where military guide specifications are not applicable. It is reiterated that since guide specifications are essentially written for new construction they must be carefully adapted for each project to suit the conditions encountered.

4.7.3 Drawings

Complete contract drawings should be provided for built-up roofing projects. The drawings must clearly show what is to be left in place, what is to be removed, what, if anything, may be reused, and what is to be provided new. It is particularly important that each type of flashing installation (e.g. gravel stops, gutter and spouts, drains, base and cap flashings, expansion joints, curbs, copings, etc.) be individually designed and fully detailed on the drawings. Flashing or other details must not be left to the imagination or discretion of the contractor.

4.7.4 Preparation of Deck for Reroofing

Prepare the deck for reroofing as follows:

(1) Remove the old membrane entirely.

(2) Restore the deck to as nearly "new" condition as practicable.

(a) On wood decks remove all rotted boards, replace with sound boards and renail loose boards. If necessary to provide a smooth deck, an overlay of exterior grade plywood may be applied.

(b) On cracked gypsum or concrete decks, ½ inch of board type insulation may be applied if deemed necessary to prevent cracks in the deck from extending upward through the new membrane.

4.7.5 Corrective Measures

Replacement of built-up roofing need not be a replacement "in kind." It must include measures to eliminate design deficiencies that exist and trouble areas. Also, improved methods or techniques should be used where appropriate. Examples of such measures include: Provision of additional expansion joints; installation of fill to provide roof slope; installation of additional drains; provision of cant strips; overlayment of decks with plywood or insulation; installation of walkways.