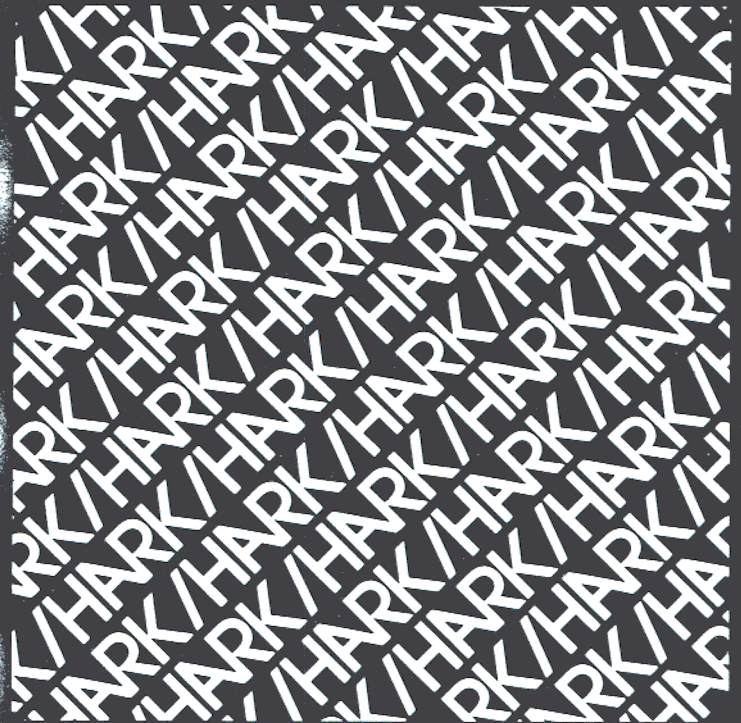


National Roofing  
Contractors Association

HANDBOOK OF  
ACCEPTED  
ROOFING  
KNOWLEDGE



# HANDBOOK OF ACCEPTED ROOFING KNOWLEDGE



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**Chicago, Illinois 60631**  
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## **FOREWORD**

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This Handbook of Accepted Roofing Knowledge is designed to provide designers, specifiers, owners, consultants, and roofing contractors with information pertinent to the design and installation of quality roof systems.

The practices herein contained represent a consensus of opinion of roofing contractors throughout the country. Application techniques may vary according to climatic conditions, and each geographical area may employ "area practices" that are sound and time proven. We do not mean to imply by any exclusion that proven area practices are unsatisfactory.

Roofing technology is currently experiencing revolutionary changes. Recent problems have stimulated technical research and investigations that are expanding our knowledge of roof systems. In the interest of brevity, some minor technical points have been excluded from this text. If questions arise, designers are encouraged to contact the National Roofing Contractors Association (NRCA) members in their geographical area for specific advice.

The Built-Up Roofing Committee of the Asphalt Roofing Manufacturers Association congratulates NRCA for the preparation and publication of this Handbook of Accepted Roofing Knowledge, an important contribution to the built-up roofing industry.

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## **I. PRE-ROOFING CONFERENCE**

A pre-roofing conference attended by the owner, architect, general contractor, deck contractor, mechanical contractor and the roofing contractor should be scheduled well in advance of ordering materials and beginning work. If a roof bond is required, a representative from the roofing materials manufacturer should be present. A written record should be made of the proceedings and should become a part of the job record. If the roofing contractor discovers roof problems in his inspection of the roof, a second pre-work inspection should be held.

The architect's specifications, roof plans and all roof and flashing details should be reviewed at the pre-roofing conference. Any discrepancies between the architect's and the manufacturer's specifications should be reviewed and resolved. In the event that certain discrepancies arise, the manufacturer's representative should be consulted to resolve the issue. If FM or UL requirements are included in the specifications, these requirements should be carefully reviewed. Building code or architectural directives that are in conflict with these insurance requirements should be resolved.

The directives listed below should be followed to assure a successful pre-roofing conference:

- Establish trade related job schedules, including the installation of mechanical equipment.
- Establish roof schedules and work methods that will prevent roof damage.
- Require that all penetrations and walls be in place prior to installing the roof.
- Establish those areas on the job site that will be designated as work and storage areas.
- Establish weather and working temperature conditions to which all parties must agree.
- Establish the conditions for which a temporary roof would be used and who will pay for its cost.
- Establish provisions for on-site monitoring after the completion of work.

If changes in these conditions are desired, the party requesting the change should:

- Give written notice regarding the desired changes to all parties.
- Secure written agreement to the changes from all parties.

## **II. STORAGE & HANDLING**

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1. All roof system materials should be properly stored in a dry location prior to application.
2. When materials are stored outside, they should be placed on platforms that are raised off the ground or roof deck, and they should be covered with waterproof coverings (some which may be shrink wrapped coverings) that have been properly secured. Coverings that are "breathable" (such as canvas) are preferred.
3. All roll materials should be stored on end to prevent their becoming deformed or damaged.
4. It is recommended that roofing materials be delivered to the job site just prior to roof installation when possible or stored in closed vans.
5. Roofing bitumens may be stored unprotected on the ground. However, moisture, dirt, snow or ice should be removed from roofing bitumens before they are heated.
6. Lids should be re-placed on cans of material stored on the job site.
7. Water based materials should be protected from freezing.
8. Insulation materials should be handled with care.
9. Some insulation materials are extremely light and must be weighted in storage to prevent wind damage.

### III. TEMPORARY ROOFS

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Frequently, construction pressures lead to the installation of roofing materials during unsuitable weather conditions or ahead of construction schedule. In addition, these pressures sometimes cause roofing materials to be installed prior to the installation of wood blocking, curbs and penetrations, and prior to the erection of walls, all of which may cause roof problems. As an effective means of dealing with the problems caused by construction pressures, the use of a temporary roof is recommended to allow the application of the specified roof membrane in suitable weather and/or to allow other trades to complete their work prior to the installation of the permanent roof.

The temporary roof specification (the type and number of plies) will depend on the watertight integrity required for the building and the length of time involved before the permanent roof will be installed. (After suitable repairs are made, a temporary roof may be used, if desired, as a vapor retarder in the permanent installation.) Generally, if roof insulation is used in the temporary roof, it should be removed prior to the installation of the permanent system since any moisture sustained from damage could be retained in this insulation, and damage to the permanent roof system could result.

If a temporary roof is to be used, the specifications should positively state the following:

- That a temporary roof will be required
- The type and specification of temporary roof to be used.

In addition, consideration should be given to having the cost of the temporary roof itemized in the quoted price.

If doubt exists as to the necessity for a temporary roof, it can be bid as an additional alternate on a per square foot basis. The decision to use a temporary roof, and over what areas it is to be used, can then be made during the construction period as weather and construction schedules dictate. The additional cost of a temporary roof is far preferable to shortened roof life or roof failure!

It should be noted that a temporary roof can increase the value received from the permanent roof because it allows the permanent roof to be constructed during suitable weather conditions. A temporary roof can also accelerate overall building construction by providing a shelter beneath which other trades may complete their work on schedule.

## IV. WEATHER CONSIDERATIONS

No other trade is more directly involved in work related weather considerations than roofing. Many impressions exist throughout the construction industry regarding suitable roofing weather. Some restrictions prohibit roofing under all but the most ideal conditions. The roofing contractor is vitally concerned with the limitations imposed on construction activity by the weather, but he must respond to "real world" conditions and construction demands. To satisfy construction demands and cope with the limitations imposed by weather, the roofing contractor should consider the following guidelines for the application of roofing materials during various weather conditions.

### 1. Cold Temperatures

Roofing materials should not be applied unless correct bitumen application temperatures can be maintained. The heating of asphalt bitumens should conform to the Equiviscous Temperature range concept (EVT). (See Section XX, **Bitumens**.) The roofing contractor may use insulated heating equipment, insulated pumping lines, insulated hot carriers, etc., to maintain proper bitumen application temperatures. If proper application temperatures cannot be maintained, however, roof application should cease. In cold temperatures, roofing materials must be embedded directly with haste. "Brooming" directly behind the felt embedment is advised to assist the bonding of the felt. Hot bitumen must not be allowed to cool substantially prior to placing felts and insulation in the bitumen.

### 2. Warm Temperatures

Warm temperatures also present problems in maintaining the proper application temperatures for bitumens. In hot weather the applied bitumen will cool more slowly, which can lead to sticking, making the membrane susceptible to physical damage from mechanical equipment and foot traffic.

### 3. Wind

Wind can affect the application of roofing materials in the following ways:

1. Hot materials may be blown about.

2. The handling of roll materials may become difficult.
3. "Wind chill" may affect the proper application temperatures of materials.
4. Sprays of cold mastics and coatings can become airborne and cause damage to surrounding property.

### 4. Precipitation

Roofing materials should not be installed if precipitation of any kind is occurring.

### 5. Moisture

Roofing materials should not be installed if moisture, snow or ice is present on the roof.

## V. DECK & STRUCTURAL DESIGN

Good roof systems depend upon the structural integrity of the roof deck. To ensure the construction of a quality roof deck, provisions for the following items should be included in the deck design:

- Live loads, such as moving installation equipment, wind, snow, ice, rain, etc.
- Dead loads, such as topside mechanical equipment and the deck itself
- Strength of the deck
- Deflections
- Drainage
- Placement of expansion joints and area dividers
- Curb details
- Attachment provisions for the deck
- Rolling construction loads of 300 lbs.

The following chart shows the typical allowable deck deflections for various spans under a concentrated load of 300 pounds. Deflections greater than those listed in the table may lead to roof problems.

Span	Deck Deflection
4 ft.	0.20 inches
5 ft.	0.25 inches
6 ft.	0.30 inches

Prior to the application of roofing materials, the roofing contractor should make a visual inspection of the deck **surface** to see that it is ready for the application of roofing materials. The deck must be clean, smooth, free of voids or depressions, must be rigid and must not deflect excessively under live loads.

If the roofing contractor discovers defects in the surface of the deck during his inspection, a second inspection should be made prior to roofing by the roofing contractor, the general contractor, the deck contractor and the owner's representative. All defects in the deck at the time of this inspection should be noted, and corrections should be made prior to the commencement of work. The trade contractor who is responsible for any defects or damage to the deck should be responsible for making repairs. Job specifications should clearly define this responsibility.

## VI. SLOPE & DRAINAGE

All roofs should be designed and built to ensure positive, thorough drainage. (See **Positive Drainage** in the Glossary.) Ponding water can be detrimental to roof membranes and can result in:

- Deterioration of the surface and membrane
- Debris accumulation and vegetation growth
- Deck deflections (sometimes resulting in structural problems)
- Tensile splitting of water weakened felts
- Difficulties in repair should leaks occur
- Ice formation and resultant membrane damage

Since every roof has its own specific set of drainage requirements, either the architect or the structural engineer is responsible for including proper drainage provisions in the roof design. The designer should not simply specify a standard  $\frac{1}{8}$  inch or  $\frac{1}{4}$  inch of slope per foot but should make provisions in his design for positive drainage. In order to achieve the necessary slope in his design, he must consider the structural framing of the roof, the deck type, the roof membrane specification, roof deflections, and the building layout. The necessity for brevity herein prevents a complete explanation of each of these considerations. The following brief examples, however, are typical slope and drainage computations.

### Deflection Slopes

Roof deflections are of critical importance in providing roof drainage. They should be limited to no more than  $\frac{1}{240}$  of the roof span in order to accommodate the stresses of either concentrated or uniform loading. Drains should be located at points of maximum deflection in the deck (i.e., midspan), if possible, and not at points of minimum deflection (i.e., columns or bearing walls). For example, in Figure 1 a deck span of 50 feet should deflect not more than  $2\frac{1}{2}$  inches ( $\frac{1}{240}$  of 50 feet) and should have drains located at midspan in order to provide drainage under maximum loading conditions.

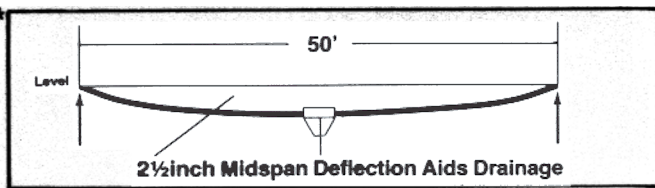


FIGURE 1

If drains are required to be placed at columns or bearing walls, the slope of the roof must be increased in order to compensate for the minimum deflections that exist at these locations. The allowable deflection will still be 2½ inches, but the designer must provide for 5 inches of additional slope at the column or bearing wall location in order to keep this deck level at midspan under maximum loading conditions. (See Figure 2.)

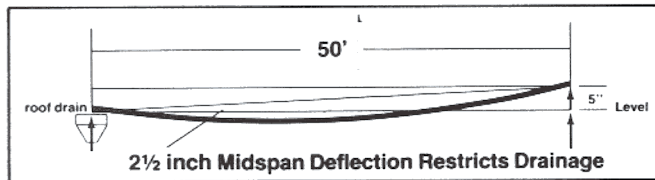


FIGURE 2

Maintaining a roughly level line between one support and a 2½ inch midspan deflection requires raising the other support 5 inches.

### Positive Slopes

After the drain locations have been selected and the deflection slopes have been computed, the designer must provide additional slope to ensure positive drainage. Since drainage must occur under both minimum and maximum loading conditions, an additional minimum slope of ⅛ inch per foot should be added to the deflection computation in order to attain a slope that will positively

\*NOTE: Figures 1, 2, and 3 have been exaggerated to help illustrate the respective drainage conditions more clearly.

drain the roof. Thus, to drain the 50 foot span in Figure 1 where the drain is placed at the point of maximum deflection, the designer should provide at least 3.125 inches of differential slope for positive drainage under all loading conditions. For Figure 2, where the drain is located at a point of minimum deflection, the positive slope required is 6.25 inches, which, when added to the 5 inches of deflection slope, yields a total required slope of 11.25 inches under all loading conditions.

Certain decks, such as precast concrete decks or long span prestressed concrete decks, incorporate camber in anticipation of future loading conditions. The camber must be considered in the design of the drainage slope system. Depending upon the structural design of the roof and the placement of drains, the camber may assist or restrict drainage. (See Figure 3.)

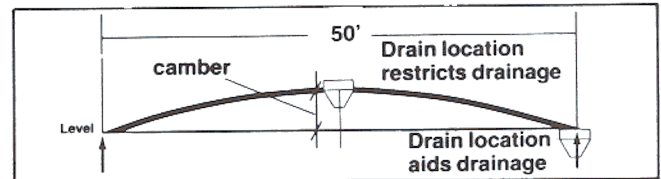


FIGURE 3

These examples illustrate that the computations for roof slope should be determined by the deflections expected in **each particular roof deck** and that the commonly specified ⅛ inch or ¼ inch of slope per foot is inadequate as an absolute specification to attain proper drainage on all roofs.

In providing for drainage, the designer must carefully consider all areas of the roof. **Good practice dictates that there be no ponding water.** For information pertinent to deck design for ponding water conditions, designers may consult the American Institute of Timber Construction [AITC], the Steel Joist Institute [SJI], or the American Institute of Steel Construction [AISC]. Drainage crickets should be provided between drains and on the high side of mechanical curbs to drain these areas. (See NRCA Detail "P" in the Appendix.)

To ensure the proper draining of water in the heaviest rains, the design of drain sizes and drain placement should be based on either:

- The requirements of the American National Standards Institute (ANSI)—Standard A 112.21.2, or
- Building code requirements, or
- Maximum rainfall information of the geographical area.

Drains should be recessed (sumped) below the roof surface, and sufficient insulation must remain around the drains to prevent condensation from occurring. This is accomplished by setting the drain head below the level of the insulation and tapering the insulation down to the drain. (See NRCA Detail "W-2" in the Appendix.) Regular maintenance should be performed to prevent clogging of drains. To avoid the dangers of water buildup from clogged drains, the use of auxiliary drains or throughwall scuppers is recommended and, in many cases, is a part of building code requirements.

## VII. EXPANSION JOINTS & AREA DIVIDERS

### Expansion Joints

Roof expansion joints are used to minimize the effect of the stresses and movements of a building's components and to prevent these stresses from splitting or ridging the roof membrane. Joints in the roof assembly (the term **roof assembly** includes the roof deck) must be placed in the same location as the building's structural expansion joints (although they may also be required in other locations as discussed in this section). Each of a building's components has varying coefficients of expansion and contraction, and each of them is subjected to varying temperature changes. Therefore, in the design and placement of expansion joints, the designer should consider:

- The thermal movement characteristics of the building
- The structural roof deck
- The roof membrane selected
- The climatic conditions to be encountered.

Expansion joints must extend across the entire width of the roof; they must never terminate short of the roof edge or perimeter. They should be designed to accommodate contraction as well as expansion. The expansion joint should be detailed and constructed to a raised (nominal) height of 8 inches above the roof line. (See NRCA Detail "C-1" in the Appendix.) Water drainage should NEVER be attempted through or over an expansion joint.

Expansion joints are required and **should always be provided** at the following locations:

- Wherever expansion or contraction joints are provided in the structural system
- Where steel framing, structural steel, or decking change direction
- Where separate wings of "L," "U," "T," or similar configurations exist
- Where the type of decking changes; for example, where a precast concrete deck and a steel deck abut

- Whenever additions are connected to existing buildings
- At junctions where interior heating conditions change, such as a heated office abutting an unheated warehouse, canopies, etc.
- Where movement between vertical walls and the roof deck may occur.

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### Area Dividers

Where expansion joints are not provided, area dividers help control the thermal stresses in a roof system (the term **roof system** does NOT include the roof deck). They minimize the transmission of stress from one area of the roof to another by dividing the entire roof area into smaller roof sections. These sections should be of rectangular shape and uniform spacing where possible. The designer should determine the respective location and the type of area divider to be used.

An area divider is designed simply as a raised, double-wood member attached to a properly flashed wood base plate that is anchored to the roof deck. (See NRCA Detail "D-1" in the Appendix.) Depending upon climatic conditions and area practices, area dividers for attached membrane systems are generally required at 150-200 foot intervals. They should be located between structural roof expansion joints. **They should not restrict the flow of water.**

The use of elastic, preformed "control" joints that are designed to be installed in the flat plane of the roof is not recommended because roof system movement may result when these units are used. The use of raised curb area dividers is consistent with good roofing practice.

## VIII. MECHANICAL CURBS & PENETRATIONS

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To avoid deflections that are damaging to the roof, the structural design of the roof should always allow for the concentrated loading of mechanical equipment. Vibrations from roof-mounted or joist-mounted mechanical equipment should be isolated from the membrane and flashing. Some equipment may allow moisture to enter the building either from the exterior or from condensation within. Therefore, it is imperative that mechanical equipment housings be watertight. Water discharge from mechanical equipment should not be allowed upon the roof surface.

When large mechanical units are used, drainage crickets should be provided around the units to allow adequate drainage of these areas. Mechanical units should not restrict the flow of water. Adequate space should be provided between mechanical units, penetrations and walls so that roofing materials can be installed correctly. (See NRCA Detail "V" in the Appendix.)

Units using curbs that have built in metal base flashing flanges are difficult to seal and, therefore, are not recommended for use. Composition base flashing should extend a minimum of (a nominal) 8 inches above the roof line. Wood or fiber cants must be provided at any 90° angle created by rectangular curbs or projections. Wood nailers should be provided on all prefabricated curbs. The composition flashing (base flashing) should be fastened either with 1 inch, solid cap-head nails or with nails driven through tin discs. The nails should be spaced approximately 8 inches apart. (See NRCA Detail "R" in the Appendix.)

On mechanical units, two piece metal counterflashing should be installed over the base flashing. On units that will be frequently serviced, the counterflashing should extend down over the cant to the roof line so that no base flashing is exposed.

Penetrations around short pipe projections may be flashed into the membrane by using soft metal or lead flashing with integral flashing flanges stripped into the

membrane. (See NRCA Detail "M" in the Appendix for major pipe penetrations.) **Good practice dictates that curbs be placed around all penetrations; the use of so-called "pitch boxes" or "pitch pockets" around penetrations should be avoided because they pose a constant maintenance problem.** Projections should not be located in valleys or drain areas. Adequate space should be provided between pipes, curbs and walls to allow for the installation of roofing materials. (See NRCA Detail "V" in the Appendix.)

All curbs, penetrations, roof drains and plumbing pipes must be in place before installing the roof. Openings for curbs cut through the roof membrane after the roof has been completed can present a serious bitumen drippage problem when the membrane is constructed of low softening point bitumen. All curbs should be firmly fastened to the building structure or to the roof deck prior to the application of roofing materials. Roof drains, vent pipes, etc., should all be in place prior to roofing and restrained to prevent damage to the flashings or membrane that may occur if mechanical devices are installed over the completed membrane.

Mechanical units mounted on pipe standards beneath which roofing materials will extend must be mounted to a height sufficiently above the roof to allow room to install the roof system and to make repairs beneath the unit. (See NRCA Detail "N-1" in the Appendix.) Heavy loads, such as large mechanical units, should not be rolled over the completed membrane as they may cause damage to the roof. A failure in horizontal shear between the membrane, insulation or deck from these loads may result in future splitting of the roof. NRCA recommends that mechanical equipment be installed on fully enclosed curbs (not on support stands) to eliminate the need for reroofing under these units when reroofing becomes necessary in the future.

As a final consideration, it should be noted that helicopter placement of mechanical equipment can cause damage to the roof system if the helicopter is operated too close to the roof surface.

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NRCA, in cooperation with certain manufacturers, has developed the following criteria for pre-manufactured roof curbs.

#### **The NRCA Roof Curb Criteria**

1. The curb should be furnished with adequate supports on all sides.
2. The curb and mechanical equipment should be structurally capable of supporting intended loads and should be so designed that no penetration for drains, power lines, etc., will occur through the curb flashing. The curb should extend around the entire perimeter of the mechanical unit.
3. The curb should be furnished by the manufacturer with insulation and a wood nailer, which provides 2 inches of nailing surface, mounted at the top of the curb to permit mechanical attachment of the flashing material.
4. The metal frame should be of heavy construction; either 16 gauge minimum, 18 gauge with structural bracing to reinforce the metal frame, or equivalent construction.
5. Pre-manufactured curbs should be (a nominal) 14 inches in height (effective as of January 1, 1981) and should provide a minimum clearance of approximately 8 inches between the top of the finished roof surface and the top of the wood nailer. **This height is needed to accommodate the varying insulation thicknesses commonly used in tapering "slope to drain" insulation.** (See NRCA Detail "R" in the Appendix.)
6. The design of the curb should be such that it will accommodate the installation of a metal counterflashing receiver (supplied by the curb manufacturer) and the counterflashing (supplied by the sheet metal contractor). On units requiring a great deal of servicing, this metal counterflashing should extend down over the base flashing so that no composition material is exposed, thereby eliminating the danger of foot abuse. (See NRCA Detail "R" in the Appendix.)
7. Installation instructions should require the installer of the rooftop mechanical unit to provide a weather-tight seal between the mechanical unit and the top of the curb.

8. A detailed illustration of the curb in the **NRCA Construction Details** clearly indicates who is responsible for furnishing each element of the curb and flashing system. (See NRCA Detail "R" in the Appendix.)
9. Detail "R" requires a 45° cant strip at the base of the curb to permit the proper application of composition flashing. The use of uninsulated, integral, metal cant strips is not acceptable to NRCA.
10. Where drawings call for support of part or all of a mechanical unit on legs or piers instead of on a curb, which requires that part of the roof membrane extend beneath the mechanical unit, the height of the unit above the finished roof should meet the requirements of NRCA Detail "N-1". The flashing of the unit supports should meet the requirements of NRCA Details "N-2" and "N-3".
11. Installation instructions for flashing pipes and electrical conduits extending through the roof should conform to NRCA Detail "M". All piping and plumbing should be flashed with a sleeve and roof flange and should extend a minimum of 8 inches above the roof surface. It is suggested that electrical and gas lines for rooftop units be serviced externally.
12. The installation instructions for mechanical equipment should call attention to the desirability of installing roof walkways where they are needed for servicing rooftop equipment.

**Note:** Check with roof curb manufacturers to see that their materials meet the standards set forth in the **NRCA Roof Curb Criteria**.

## IX. PREFORMED ROOF INSULATION

Roof insulation provides both the insulation for the building and a substrate to which the built-up roofing materials are applied. Therefore, it must be compatible with, and should provide support for, the roof membrane.

An **ideal** roof insulation would have the following theoretical properties:

- It would be able to withstand the bitumen application temperatures required for installation of the roof membrane.
- It would have good physical strength, rigidity, and impact resistance.
- It would be incombustible and would be acceptable for insurance and building code requirements.
- It would be constructed of materials that will resist deterioration.
- It would be moisture resistant.
- It would have a low "k" value (thermal conductivity) so that the highest possible "R" values (thermal resistance) can be obtained in the thinnest possible piece of a particular insulation.
- The "k" value would remain constant and would not "drift" higher with age.
- Its surfaces would accommodate secure attachment.
- It would have dimensional stability under varying temperature and moisture conditions.
- It would be manufactured so as to be compatible with the roof membrane.

The qualifications listed above would be present in an **ideal** insulation. In practice, however, **NO** single commercial product contains all of the ideal properties. Thus, the designer should choose materials whose properties are best suited to the specific project.

Roof insulations, when used for the control of heat flow, should be installed in two layers when thickness permits with all joints offset between the upper and lower layers. The joints of the insulation should be installed in such a way as to provide moderate contact at the joints. The

upper layer should be installed with the long dimension of the insulation boards placed in a continuous line and the end joints staggered.

Over steel decks, mechanical fasteners should be used to attach the first layer of insulation. Where possible the first layer of insulation should have an insulation value equal to or lower than that of the second layer. The second layer of insulation should be laid in moppings of hot asphalt and, normally, should have the greater insulation value.

All roof insulation should be protected from the elements before, during and after installation. During and after installation, this protection is provided by the immediate installation of the roof membrane. On low-sloped roofs, proper membrane application dictates that roofing felts be laid perpendicular to the flow of water, beginning at low points (or drain points) in the deck. All roof membrane plies should be installed in an unbroken time period; phased construction is NOT recommended. The long dimension of the insulation boards should be laid perpendicular to the flow of water.

Roof membranes should NOT be installed directly to the top side of any felt-skinned, foam-type insulation, including polystyrene and polyurethane because of the potential for blister formations.

When composite board roof insulation, polyisocyanurate foam board roof insulation or polyurethane foam board roof insulation is used as the insulation substrate, one of the two procedures listed below should be followed:

- Over the top surface of the insulation, a thin layer of wood fiberboard insulation, perlite board insulation, or glass fiber board insulation should be installed. The roof membrane should then be applied as specified by the designer
- Over the top surface of the insulation, a venting type base ply should be installed in such a way as to allow for venting. The balance of the roof membrane should then be applied as specified by the designer.

Performance-type specifications should be avoided when specifying any insulation since manufacturers' data may vary considerably. Instead of listing performance-type specifications, the designer should list the ASTM Specification, the thickness requirement and the "C" value for any insulation board to be used in the roof construction.

## X. VAPOR RETARDERS

The term “**vapor retarder**” refers to a broad range of roofing materials which are used to control the flow of water vapor from the interior of the building into the roof system. Moisture in the form of water vapor generally comes from the following sources:

- **Construction processes**, which include interior concrete and masonry, cementitious roof fills, plaster finishes, and fuel burning heaters
- **Occupancy-generated sources**, which include such areas as swimming pools, textile, food and paper plants, and other wet-process industrial plants.

In the generally temperate climate of the United States, during the winter months, water vapor flows upward through the roof system from a heated, more humid interior toward a colder, drier exterior. Vapor retarders are more commonly required in northern climates than in southern regions, where downward vapor pressure may be expected, and the roof membrane itself becomes the vapor retarder.

As a general guide, vapor retarders should be considered for use when both of two conditions are anticipated:

1. The outside, mean, average January temperature is below 40°F.
2. The expected winter, interior, relative humidity is 45% or greater.

Vapor retarders should be installed at a location where they will be warmer than the winter design dew-point temperature. The dew-point should fall within the insulation. It is recommended that moisture relief vents, preferably one-way vents, be incorporated into the roof system at the minimum quantity of one vent per one thousand square feet of roof area (10 roof squares) or less.

Roof system vapor retarders generally fall into two classifications:

1. **Bituminous membranes**, in which a continuous film of bitumen serves as the vapor resistant element. A typical two-ply installation using three moppings of steep asphalt can provide a vapor retarder which is rated less than .005 perms.
2. **Non-bituminous sheet systems**, in which the sheet serves as the vapor retarder, and adhesive is used to seal the laps. These include PVC films, kraft paper and aluminum foil combinations, which may provide vapor retarders having permeability ratings ranging from 0.10 to 0.50 perms. PVC films and associated cold-applied adhesives are not recommended by NRCA because of their susceptibility to damage from other components in the system, such as the melting of vinyls by hot asphalt.

Wherever vapor retarders are used, they should be constructed of materials which are compatible with other roof system components. It is recommended that the designer pay particular attention to flashing details at edge seals and at all penetrations through the vapor retarder in order to ensure the moisture-tight integrity of the vapor retarder. Vapor retarders can be easily punctured and damaged by foot traffic and mechanical equipment. These punctures must be carefully repaired prior to the installation of insulation, using a patch that is at least 12 inches larger in each direction than the puncture. In order to properly install and help prevent damage to a vapor retarder system, the laps must be made on solid bearing. For more specific information on vapor retarders, see VAPOR RETARDERS in the DECK section of the **NRCA Roofing Manual**.

## XI. LIGHTWEIGHT INSULATING CONCRETE DECKS

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Lightweight insulating concrete is used for the construction of composite structural decks and as a fill material over some structural decks. (It is not recommended for use, however, directly over **poured-in-place or precast concrete decks.**) The installation of lightweight insulating concrete requires the use of large quantities of water, and some moisture will remain in the concrete even after the surface is dry. Thus, venting must be provided to allow additional drying of the concrete and to prevent the buildup of water vapor pressure. Either topside venting or underside venting is advised on all lightweight insulating concrete decks. (Topside, one-way venting in the field is preferable.)

Lightweight insulating concrete decks must have the following physical properties:

- A minimum thickness of 2 inches of lightweight concrete
- A minimum dry density of 22 lbs. per cubic foot (pcf), or a dry density capable of providing a fastener withdrawal resistance of 40 lbs. per fastener
- A minimum compressive strength of 125 lbs. per square inch (psi).

Lightweight insulating concrete decks should be installed according to the lightweight insulating concrete manufacturer's specifications.

The roof membrane should be attached to the lightweight insulating concrete deck in accordance with the deck material manufacturer's recommendations. If no recommendations are provided, a coated base ply or a vented base ply should be used as the first ply of the membrane and should be attached to the lightweight insulating concrete deck with approved mechanical fasteners. **In no case should the base ply of the membrane be attached to these decks in moppings of hot asphalt or by the use of adhesives.**

Additional roof insulation should NOT be installed directly over lightweight insulating concrete decks as it will inhibit the drying of the concrete. However, when above-deck insulation is specified, the insulation should be protected from moisture by a low perm-rated vapor retarder placed between the lightweight insulating concrete and the insulation. (See Section X, **Vapor Retarders.**) The insulation must be vented. Smooth surfaced roof membrane systems are generally not recommended for use over lightweight insulating concrete decks.

NRCA recommends that specifiers consult with the membrane manufacturer for specific recommendations regarding their requirements for roofing over lightweight insulating concrete decks.

## XII. POURED GYPSUM CONCRETE DECKS

Poured gypsum concrete is used in various combinations with other building products as a structural deck. The roof membrane should be attached to the poured gypsum concrete deck in accordance with the deck material manufacturer's recommendations. If no recommendations are provided, a coated base ply or a vented base ply should be used as the first ply of the membrane and should be attached to the poured gypsum concrete deck with approved mechanical fasteners. Venting to the interior should be provided and is generally accomplished through the use of a vapor permeable formboard. If this type of formboard is not employed, topside venting should be designed and installed.

The gypsum fill should be reinforced with wire mesh. It should have a minimum thickness of 2 inches, not including the formboard, and should cover the top of bulb tees a minimum of ¼ inch. A coated base ply or a vented base ply is generally used as the first ply of the membrane and is attached to the gypsum concrete deck with mechanical fasteners. **The membrane should NEVER be installed to gypsum concrete decks in moppings of hot asphalt or by the use of adhesives.**

Roof insulation should NOT be installed directly over newly poured gypsum concrete decks as it will inhibit the drying of the concrete. However, when above-deck insulation is specified, the insulation should be protected from moisture by a low perm-rated vapor retarder placed between the poured gypsum concrete and the insulation. (See Section X, **Vapor Retarders**.) The insulation must be vented.

Smooth surfaced roof membrane systems are not recommended for use over poured gypsum concrete decks. Roofing materials may be installed as soon as the deck is set and is surface dry (approximately 1 hour). After the roof is installed, the general contractor should provide sufficient ventilation on the underside of the deck and within the building to allow continued drying of the deck.

## XIII. PRECAST PLANK DECKS

Precast plank decks are constructed of metal bound gypsum, structural lightweight insulating concrete or cementitious wood fiber and are used either as structural decking or in combination with sub-purlins. Voids and joints over sub-purlins must be grouted with materials supplied or recommended by the deck manufacturer and should provide approximately ⅛ inch of slope per foot. Particular attention must be given to the storage and handling instructions for these materials. The designer must carefully consider the concentrated live loads of roof application equipment in the selection of these decks. All slabs should be securely fastened to resist uplift and horizontal movements.

Precast plank decks should be roofed promptly after installation. The planks may be fragile and should be treated with care. Planks should be installed during weather conditions that are suitable for the installation of roofing materials, or temporary protection should be provided.

Membrane application to these decks should follow the deck manufacturer's recommendations. Generally, attachment of the base ply with approved mechanical fasteners is recommended. If insulation is used, a nailable base ply is required as the attachment layer. Insulation should then be solidly adhered to the base ply with hot asphalt only. Adequate ventilation of the underside of the deck during the construction process is mandatory. **In no case should the first ply of the roof membrane be mopped directly to precast planks.**

## XIV. PRECAST/PRESTRESSED CONCRETE DECKS

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Precast concrete units are used as structural roof decks. The manufacturing process of precast concrete units may produce units which vary in joint elevation when set in place. If variations in the elevations of adjacent units exceed  $\frac{1}{4}$  inch, the deck should be levelled with a fibrous, cementitious grout that has been feathered to a slope of  $\frac{1}{8}$  inch per foot prior to roofing. Venting for this fill should be provided. A vapor retarder may be required, depending upon the fill material used. (See Section X, **Vapor Retarders**.) The joints between adjacent units should be filled with a compressible material to prevent drippage of the cementitious fill that is used to level the units.

Recommendations of the Precast Concrete Institute for deck installation should be followed. Weld plates should be provided between other structural components and the deck units and between the deck units themselves. The top surface is sometimes neglected in the casting of precast units. A smooth surface, free of voids and depressions, should be provided for proper adhesion of the roof system. In order to provide adequate drainage, the designer must consider the "bowing" (or vertical camber) of precast units that occurs in the manufacturing process of the units. Depending on structural design and drain placement, the camber may assist or restrict drainage. (See **Figures 1, 2, & 3**, pages 10 and 11.)

The designer should carefully detail all wood blocking provisions at roof edges and penetrations to ensure proper attachment of the membrane and sheet metal. In no case should the roof membrane be attached directly to precast/prestressed concrete decks. Preformed roof insulation (preferably in 2 layers) should be installed on top of the deck prior to the application of roof membrane materials.

When precast walls are used, the designer should carefully consider the flashing provisions required to properly secure the roof to the precast wall units. Cast-in reglets, which are frequently used for this purpose, are difficult to align properly. When they are not properly aligned, they can hinder the proper installation of counterflashing. For

this reason the use of cast-in reglets is not recommended. A flashing detail similar to Detail "H" should be incorporated to properly secure the roof to the precast wall units. (See Detail "H" in the Appendix.) In all such flashing situations, consideration should be given to camber and creep.

When precast walls are used, it is recommended that provisions be made for low parapet walls. The base flashing should be fastened to a vertical wood upright whose horizontal base is attached to the deck only. After the base flashing has been attached to the wood upright, the metal wall cap flashing may be installed. Then the counterflashing may be attached to the wall cap, extending down over the top of the base flashing. This method allows lateral movement of the wall without damage to the base flashing.

## XV. REINFORCED CONCRETE DECKS

Reinforced concrete is used as a structural deck. The pouring process requires large quantities of water, and some moisture will remain in concrete decks even after the surface is dry. Prior to the application of roofing materials, the concrete surface must be smooth, level and free of moisture. The deck contractor is responsible for removing sharp ridges or other irregularities in the deck surface. Wood blocking nailers should be designed and provided at all roof perimeters and penetrations for fastening the flashings and sheet metal. Concrete curing compounds which are used to finish the deck surface must be compatible with the bitumen being used (either asphalt or coal tar bitumen).

Reinforced concrete should be primed, and the primer must be allowed to dry prior to the application of roofing materials. If roof insulation is to be installed over reinforced concrete, the insulation and membrane must be protected from the effects of latent moisture in the concrete. In northern climates, this is generally accomplished by using a vapor retarder or a venting sheet. (See Section X, **Vapor Retarders**.) In southern climates, however, vapor retarders are often omitted, and venting of the insulation alone has proved to be adequate. In cold weather poured concrete is usually protected by insulative batts or blankets. When these batts or blankets are removed, the concrete may be cured at the surface, but some moisture will remain inside the concrete deck. In these situations, if subsequent insulation is to be installed, the use of a vapor retarder is recommended to prevent moisture damage to the insulation.

## XVI. STEEL DECKS

Steel decks should be designed according to the steel deck manufacturer's specifications and installed according to the application procedures recommended by the Steel Deck Institute in order to obtain optimum performance of the steel deck. Decks should be 22 gauge or heavier. Maximum span recommendations for typical 1½ inch steel decks with 6 inch rib spacing are published by Factory Mutual (FM) in Bulletin 1-28. FM field offices and steel system deck manufacturers should be consulted for advice on the maximum span recommendations for steel decks.

Insulation commonly applied to steel decks prior to the application of the roof membrane should be applied in two separate layers where insulation thicknesses permit. The first layer should be capable of spanning the flute width of the metal deck in accordance with the insulation manufacturer's specifications. The first layer of insulation should be attached with mechanical fasteners in accordance with Factory Mutual Data Sheet 1-28. The second layer should be laid with joints offset from the first layer and in moppings of hot asphalt.

When specifications call for only one layer of insulation, the insulation should be attached with mechanical fasteners in accordance with Factory Mutual Data Sheet 1-28.

Certain FM or UL requirements for the deck surface and for the attachment of the insulation may be applicable. The most current FM and UL publications should be consulted for specific deck surface and insulation attachment requirements. Generally, these requirements place limitations on the concavity ("cupping") of contact flanges and stiffening ribs. They also require that side lap fasteners be used to secure steel deck panels to adjacent panels. Provisions should be made to have the top flanges of the steel deck units installed perpendicular to the roof slope. This will allow for the long dimension of the insulation boards to be laid parallel to the steel deck as FM requires and will help to avoid phased construction of the roof membrane.

Adequate side lap bearing is necessary to support rigid insulation boards. To help achieve the proper bearing, the steel deck units should be installed with a maximum horizontal-alignment tolerance of ¼ inch for every 100 feet of deck length (i.e., after installation, the deck units should vary in horizontal alignment by no more than ¼ inch).

Mechanical fastening of steel deck units to the structural steel provides the most positive means of attachment. When steel deck units are spot welded, the weld material will frequently "pop" loose due to improper welding techniques or minor flaws in welding. When it is desired that steel decks be welded, it is recommended that "puddle welds" of ½ inch or larger, welded into washers and spaced a maximum of 12 inches on center at every support, be used.

## **XVII. THERMO-SETTING INSULATING FILLS**

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Thermo-setting insulating materials are used as insulative fills over structural decks. They should be installed according to the manufacturer's specifications. These materials require compaction by weighted rollers, and the structural designer must consider the concentrated live loads of these rollers in the design. When thermo-setting insulating fill is placed over a metal deck, the deck must be rigid enough to prevent flexing during the compaction process. The compacted density of the fill should range between 18 and 22 lbs. per cubic foot. This density is generally attained by compacting the thermo-setting insulating fill in one layer or, if the total thickness is greater than 6 inches, in two layers. A spray of water is usually used to cover the surface prior to compaction. The quantity of water in this spray should be kept to a minimum.

Thermo-setting insulative fills should be protected from moisture. Roofing materials should be applied each day, or temporary protection should be provided. The base ply over these fills should be applied in a solid mopping of steep asphalt, and provisions for roof venting should be incorporated into the fill by the designer to release moisture vapor. If roof insulation is installed over these fills, a protective, base ply vapor retarder should be mopped to the fill to protect the insulation from substrate moisture and to allow time to install the insulation and roof membrane. Wood nailers must be provided at all perimeters and projections through the roof. It is preferred that aggregate surfaced roofs be applied over these fills.

## XVIII. WOOD PLANK OR PLYWOOD DECKS

### Wood Plank Decks

Planks for wood plank decks should be (a nominal) 1 inch or thicker and of tongue and groove construction. Cracks or knot holes larger than 1/2 inch in diameter must be covered with sheet metal if roof insulation is not used. End joints of the wood deck units should be staggered. Since wood can be adversely affected by moisture, wood decks should be constructed of air dried or kiln dried lumber and should be protected from moisture.

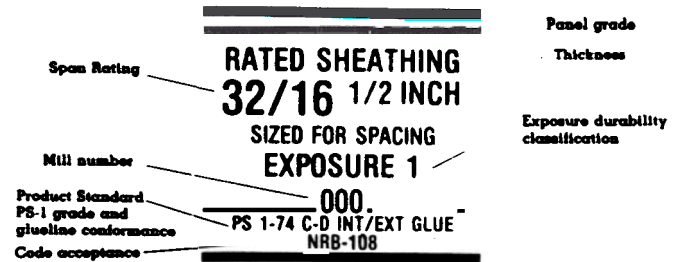
Bitumens or adhesives are not generally used to attach the membrane to a wood deck. The use of mechanical fasteners is recommended for the attachment of the membrane directly to a wood deck.

A separator sheet of rosin-sized sheathing paper is recommended for use over wood plank decks.

**Note:** Caution should be exercised when wood decks are constructed of wood that has been treated with an oil borne preservative. When such treated wood is used in the deck, a barrier of rosin paper or similar material should be placed between the roof membrane and the deck.

### Plywood Decks

Most building codes require a label on plywood panels, assuring that the plywood complies with the standards set forth in Department of Commerce Standard PS 1-74. This is a voluntary standard, and producers do not have to meet these standards in order to sell their product. NRCA recommends that plywood decks be designed and applied in accordance with the recommendations of the American Plywood Association. Plywood should be interior type (with exterior glue), bear the APA, PTL, or TECO trademark, be graded C-D or better, and be secured to structural joists either by annular threaded nails, ring-shank nails or by staples. (See the sample on the following page.)



A label similar to this one and containing the same categories of information should be found on each panel of plywood. The Span Rating (32/16 in this label) is of particular significance. The left-hand number of the Span Rating (32 in this label) indicates the maximum recommended center-to-center spacing of supports in inches when the panel is used for roof decking with the long dimension of the panel running across the supports. The right-hand number of the Span Rating (16 in this label) indicates the maximum recommended spacing of supports in inches when the panel is used for subflooring in double-layer construction with the long dimension of the panel running across the supports. Therefore the Span Rating of 32/16 in this sample label means that this particular plywood panel may be used either for roof decking over supports that are spaced 32 inches on center or for subflooring over supports that are spaced 16 inches on center. In all cases panels are assumed continuous over two or more spans.

**Note:** Though the industry terminology refers to plywood sheathing with exterior glue as C-DX, the "X" (which refers to Exterior Glue) is not used in the label. The words EXTERIOR GLUE or EXT GLUE appear on the bottom of the label to denote this requirement.

End joints of the plywood panels should be staggered and supported by framing members, and deck support clips should be installed on the unsupported sides of plywood sheets. Temporary protection should be provided by the installer to prevent the delamination of plywood boards. (See Section III, *Temporary Roofs*.)

A slip sheet of dry sheathing paper is recommended for use over wood plank decks but is not needed over plywood decks. It is good practice, however, to nail a minimum layer of insulation over plywood decks. On plywood decks not covered with insulation, a base ply should be mechanically fastened over the plywood deck (preferably with annular threaded nails) to serve as the base ply of the roof membrane.

## XIX. ROOF MEMBRANES

Each built-up roof system is designed to satisfy a specific set of conditions for substrate, life span, roof slope, and climate. The designer should relate these conditions to field conditions in order to determine the proper specifications. The geographical location and climatic conditions to be encountered frequently determine the type of membrane to be installed. A roof membrane in Arizona, with little rainfall and extreme sunlight, may require a different roof system than one in Montana with its extreme temperature changes.

In the past designers have lacked sufficient engineering data for existing and proposed membranes. Studies, however, have provided much needed technical information for use in selecting roof membranes. In 1967, the National Bureau of Standards issued Building Science Series #9, "Thermal Shock Resistance for Built-Up Membranes." This study proposed the development of a "strength" factor for membranes, rating their resistance to thermally induced loads. In 1974, Building Science Series #55, Preliminary Performance Criteria for Bituminous Membrane Roofing, proposed performance criteria for built-up membranes and selected the following performance attributes desirable in a good roof membrane:

- Tensile Strength
- Thermal Expansion
- Flexural Strength
- Tensile Fatigue Strength
- Flexural Fatigue Strength
- Shear Strength (punching)
- Impact Resistance
- Notch Tensile Strength
- Moisture Effects on Strength
- Creep
- Ply Adhesion
- Abrasion Resistance
- Tear Resistance
- Pliability
- Permeability
- Moisture Expansion
- Weather Resistance

- Uplift Resistance
- Fire Resistance
- Fungus Attack Resistance

While some disagreement exists as to the priority and acceptability of these attributes, the designer is urged to study the above mentioned National Bureau of Standards documents to better understand their relationship to the membrane selection process.

Roofing felts should be laid in bitumen whose temperature falls within the correct application EVT temperature range. (See Section XX, *Bitumens*.) The rates of interply bitumen application will vary according to:

- A particular mopping asphalt's EVT temperature range (and its corresponding viscosity range)
- The weights of the rolls
- The ambient temperature and wind chill factors
- The type of felt material to be used
- The rate of speed at which the bitumen is applied (when mechanical application procedures are used).

The application of interply bitumens at excessive rates is discouraged. (See Section XXIV, *Sampling & Test Cuts*.) Bitumen is used as an adhesive as well as a waterproofing layer, and a thin, complete layer of bitumen is required for the installation of felts. All plies should be immediately broomed after application to aid the fusion process. When possible, all plies should be installed in shingle fashion. Any irregularities, such as fishmouths or blisters, should be repaired prior to the application of surfacing. Membranes should be laid as continuously as possible; therefore, it is important that edge nailers, curbs and penetrations be in place prior to roofing. On low-sloped roofs, the roof membrane should be applied perpendicular to the flow of water, beginning at low points in the deck. On slopes over 2 inches per foot, consideration may be given to laying the felts parallel to the slope.

For asphalt roofs, treated wood nailers are required on inclines exceeding 2 inches per foot to help secure insulation and roof membranes to non-nailable decks or to

decks with insulation. These nailers should be the same thickness as the insulation and should be installed perpendicular to the slope (on 20 foot centers for slopes up to 3 inches per foot and on 4 foot centers for slopes greater than 3 inches per foot). This method dictates that roofing felts be installed parallel to the slope and backnailed into the wood nailers. (See **Backnailing** in the Glossary.) Spacing of the wood nailers should not exceed the recommendations of the roof insulation manufacturer or the roof membrane manufacturer.

After the built-up roof membrane has been applied, the roofing contractor should advise the **general contractor** or **owner** to provide surveillance and protection of the roof during the remainder of the construction period. Damage to the roof membrane by other trades during this period is a major cause of roof problems. On gravel surfaced roofs, damage is most difficult to discover and can remain undetected for years.

The roofing contractor should make a final inspection of the roof, and, if he finds evidence of so-called "work-bench" abuse, he should prepare a written report to the general contractor and/or owner of any visible damage found in the roof system. **Where damage can be expected, the use of a temporary roof should be considered.** (See Section III, **Temporary Roofs.**)

## XX. BITUMENS

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Asphalt and coal tar are the bitumens used for roofing purposes. They are versatile waterproofing materials whose properties are desirable for use in built-up roofing practice. They are thermoplastic, becoming more fluid with heat and reverting to a more solid material as they cool.

An erroneous impression exists that roofing bitumens are the "glue" with which roofing felts are cemented together. Actually, the process is more of a "welding" or "fusion" process than a glueing process. The heated mopping bitumen melts and fuses with the saturant bitumen in the roofing felts, creating a "welding" together of the plies. Correct application temperatures are thus vital to the creation of a quality roof membrane system, and a high bitumen temperature must be maintained to create the welding process.

The properties of bitumen are such that heating it at **extreme temperatures for extremely long periods of time** may reduce the softening point of asphalt and raise the softening point of coal tar pitch. This property of bitumen has produced the erroneous impression that the temperatures ordinarily employed in bituminous heating are damaging to the material. In the past this impression has led to restrictive heating criteria. These restrictions have substantially contributed to poor roof installations.

The key words above are "extreme temperatures" and "extremely long periods of time." **Bitumens can be heated at high temperatures for short periods of time without damage.** In fact, they must be heated to high temperatures in order to achieve complete fusion and strong bonding of the plies.

Temperature affects the viscosity, or flow, of the bitumen and, thus, the mopping weight. Temperatures that are **too high** (bitumen that has low viscosity and high flow) can lead to light moppings, incomplete film coverage, voids and a potential lack of waterproofing qualities. Temperatures that are **too low** (bitumen that has high viscosity and insufficient flow) can lead to heavy moppings, which result in poor adhesion, potential slippage

problems, high expansion properties and low tensile strengths, which can contribute to roof splits. Obviously, an optimum viscosity range and, therefore, an optimum temperature range **at the point of application**, exists for achieving complete fusion, optimum wetting and mopping properties, and which results in the desirable interply bitumen weight.

In 1975, this optimum application condition was defined as the "Equiviscous Temperature" (EVT). **The EVT is the temperature at which asphalt will attain a target viscosity of 125 centistokes.** This is the practical and optimum temperature for wetting and fusion at the point of application. A tolerance range is added for practical application in the field to accommodate the effects of wind chill, sunshine, or ambient temperature. This range is expressed as a temperature, plus or minus 25°F. Good practice indicates the use of this EVT range as the temperature range at which hot bitumen should be applied. Asphalt bitumen should be sufficiently heated in the kettle/tanker to achieve this optimum viscosity/temperature range (EVT) **at the point of application.**

Bitumen heating is subject to two restraints:

1. It should NOT be heated to or above the actual COC Flash Point. (ANSI/ASTM Method D 92, Test for Flash & Fire Points by Cleveland Open Cup.)
2. It should NOT be heated and held above the Finished Blowing Temperature (FBT) for more than 4 hours.

This concept emphasizes that the temperature of bitumen **at the point of application** is the main consideration and that kettle/tanker heating should, therefore, be based on reaching the desired **application** temperature.

The Roofing Systems Technical Committee, a joint committee of the Asphalt Roofing Manufacturers Association and the National Roofing Contractors Association, endorses and recommends the following identification system for mopping grade asphalts. This information should be printed on all asphalt packages or bills of lading covering bulk asphalt:

- **The Softening Point (SP) Range.** The temperature ranges of the asphalt determined in accordance with ASTM D-312 and D-36.
- **The Flash Point (FP).** The flash point of the asphalt as determined by ASTM Method D-92.
- **The Equiviscous Temperature (EVT) Range.** The temperature range at which a viscosity of 125 centistokes is attained, plus or minus 25°F.
- **The Finished Blowing Temperature (FBT).** The temperature at which the blowing of the asphalt has been completed.

In the event EVT information is not furnished by the manufacturer, the following maximum heating temperatures should be used as guidelines. The same two restraints for bitumen heating previously listed (i.e., Flash Point and Finished Blowing Temperature) pertain to these temperatures.

Type No.	Kind of Asphalt	Maximum Heating Temperature
Type I	Dead Level Asphalt	475°F
Type II	Flat Asphalt	500°F
Type III	Steep Asphalt	525°F
Type IV	Special Steep Asphalt	525°F

Coal tar roofing bitumens are produced by a limited number of manufacturers and have fewer material variations than asphalt. Although EVT has not been applied to coal tar bitumens for this reason, the same concept is applicable. Heating and application temperatures for coal tar are slightly lower than asphalt bitumens. Most manufacturers recommend a kettle temperature of 425°F, with application temperatures ranging from 325°F to 400°F. As with asphalt, higher heating temperatures may be necessary to attain the proper **application** temperature, but higher heating temperatures should be maintained only for short periods of time.

## **XXI. WATER CUTOFFS & WEATHER PROTECTION**

Water cutoffs are temporary felt courses that are installed to prevent moisture from entering the insulation and membrane during construction. They should be applied at the end of each day's work and whenever work is halted for an indefinite period to protect the membrane from precipitation. They must be removed prior to installing additional insulation.

Temporary flashings should be installed as weather protection if permanent flashings are not in place. All openings in the membrane should be sealed to prevent any moisture from entering the roof system prior to the completion of membrane application.

Specifications requiring gravel installation each day are unrealistic and sometimes detrimental to the quality of the completed roof. Where working conditions permit, roofing felts should be "glazed" and sealed at the end of each day's work if final surfacing is not installed.

## **XXII. FLASHING & CANTS**

The most vulnerable part of any roof system is that point at which the horizontal roof deck and a vertical surface join. Most roof leaks occur at these flashing locations. The designer should carefully consider the design of flashing details at these locations. (See NRCA Construction details for FLASHING in the *NRCA Roofing and Waterproofing Manual*.)

The term "flashing" can be divided into two groups:

### **Composition Flashing (Base Flashing)**

The bending radius of present composition roofing materials is generally limited to 45°. To allow for this bending radius, all vertical surfaces must have cant strips installed between the roof and the vertical surface. The height of the base flashing should be not less than (a nominal) 8 inches and not higher than (a nominal) 14 inches above the finished roof surface. Walls requiring flashings higher than 14 inches should receive special moisture-proofing. A wood nailer strip or suitable detail allowing mechanical fastening of the base flashing at the top must be provided. Masonry surfaces should be primed with asphalt concrete primer.

An expansion joint type flashing (one allowing expansion and contraction) should be constructed as detailed in NRCA Construction Detail "H" (in the Appendix). It should be attached to the wood curbing. The wood curbing should be placed against the wall and secured only to the deck. The designer is cautioned to consider that building components are subjected to thermal movements at different rates and in different directions from the roof membrane. If the roof is to be "tied into" these components, special consideration should be given to the design of that juncture.

## 2. Metal Flashing (Counterflashing and Cap Flashing)

Since metals have a high coefficient of expansion, metal flashing must be isolated from the roof membrane wherever possible to prevent metal movements from splitting the membrane. Flashing details that require metal flanges to be sandwiched into the roof membrane should be avoided if possible.

For all walls and projections that receive composition base flashing, metal counterflashing should be installed in the wall above the base flashing. The design of this detail should be two piece, allowing installation of the counterflashing after the base flashing. Single piece installations cannot be flashed properly nor can reroofing and roofing maintenance be performed without deforming the metal. Sheet metal should NEVER be used as a base flashing.

Metal wall cap flashing is often used to cover the top of a wall in lieu of masonry copings. In most cases the metal counterflashing is attached to the inside face of the metal wall cap flashing with sheet metal screws.

Gravel stops should be raised above the waterline by using tapered cants and wood blocking. When this is not possible, the metal flanges for low profile gravel stops should be set in mastic on top of the completed roof membrane and nailed at close intervals to the wood nailer. (See NRCA Detail "O" in the Appendix.) The metal flange should then be primed with asphalt primer and felt flashing strips applied. Interior drainage is recommended, and edges should be raised whenever possible. A metal edging should NEVER be used as a water dam or waterstop. **The practice of connecting sheet metal to the roof membrane should be avoided whenever possible.** Pipe projections through the membrane require metal flashing or the insertion of roof jacks into the membrane. Metal flanges should be set in mastic over the completed membrane, primed and stripped in with flashing strips.

## XXIII. SURFACING & AGGREGATE

Most roof membranes, if not presurfaced, require some type of wearing surface. This surfacing should be applied as soon as is practical after the membrane is installed. Gravel, slag, marble chips, etc., are the aggregates used for aggregate surfaced roofs. Asphalt and liquid surface coatings are used on some smooth surfaced roofs.

Gravel or aggregate surfacing should be set in hot bitumen, either by a bitumen dispenser or by hand pouring. Gravel placed by machine will result in somewhat lighter surface bitumen poundages in some locations since the gravel, as it flows from the gravelling machine, tends to create a "wave" effect in the hot bitumen as it is placed. Hand pouring produces heavier poundages but less uniform coverage, and neither method is preferable to the other. Gravel or other aggregate should be fairly rounded in shape and should contain a minimum of flat, sharp or elongated particles. At the time of application, the aggregate should be hard, durable, opaque, surface dry and free of clay, loam, sand or other foreign substances. Storage piles of aggregate should be placed on coated or gravelled portions of the membrane and not on bare felt. Occasionally, on well applied roofs, small black globules known as "raspberries" or "blueberries" will form in the roof surface. These are not detrimental to the roof and simply indicate that large quantities of bitumen flood coat were applied and have bubbled up around the aggregate. To avoid excessive aggregate loss, aggregate surfacing should not be applied to roofs whose slope is greater than 3 inches per foot.

Generally, smooth surfaced coatings should be applied as soon as possible after the membrane is installed. Some coatings, however, must be applied over a previously applied thin coating of hot asphalt. The manufacturer's instructions should be consulted to determine if this thin coating is required. If it is, that asphalt should be allowed to "age" (or oxidize) for a period of two to four weeks, depending upon the amount of sunlight, before final surfacing is applied. Emulsions must be protected from freezing and must not be applied in freezing temperatures or when precipitation is occurring or expected. Frozen materials must be discarded.

Foot traffic can be highly detrimental in extremely cold or warm temperatures and should be controlled. Walkways, if required, should be constructed of 2 inch × 4 inch redwood materials, and fasteners for these walkways should not extend through the roof membrane. All sharp edges should be eliminated from these walkways.

Some pad-type composition walkways have exhibited extreme degradation in a short period of time. When these walkpads are used, a flood coat and aggregate surfacing should be applied first, and the walkpad area then swept clear of loose aggregate. Good practice dictates that one piece of the walkpad be spaced no closer than 6 inches from an adjacent piece. The walkpad can then be set in hot bitumen on top of the surfacing aggregate and, thereby, raised above the plane of the roof.

## **XXIV. QUALITY ASSURANCE & TEST CUTS**

NRCA believes the most effective method of verifying correct roof application is visual inspection during the application process by persons experienced and knowledgeable in roofing. To help obtain a quality roof application, the following items should be verified.

### **1. Deck Surface**

The surface of the deck should be clean, firm, smooth, visibly dry and properly secured against movement.

### **2. Materials**

Roofing materials used on the job should comply with material specifications for the job. All materials should be clean, visibly dry and free from damage.

### **3. Storage of Materials**

Roofing materials should be stored and protected.

### **4. Attachment**

The roof membrane and/or insulation should be secured with the specified number and types of fasteners, nails or bitumen.

### **5. Bitumen**

The type of bitumen should be checked to insure that it is the proper type for the specification, roof slope and climatic conditions. Proper heating temperatures should be maintained in the kettle or tanker to insure that the bitumen will be the E.V.T. at the point of application on the roof.

### **6. Bitumen Application**

Bitumen applicators should be well versed in the specified bitumen application rates. In addition, applicators should be thoroughly knowledgeable of the volume capacity of the equipment being used and the length of runs required to achieve the specified bitumen application rates.

### **7. Plys of Felt**

The specified number of plys of felt should be applied in accordance with specification procedures. The

lapping sequence of the felt plys should satisfy specification requirements to achieve complete coverage.

#### 8. **Phased Application**

The installation of all plys should be completed in the same day, and the plys should be surfaced either with a glaze coat or complete surfacing on all organic roof membranes. The final surfacing can be delayed on glass fiber roof membranes.

#### 9. **Flashings**

Composition base flashings should be completed on a daily basis. Any metal or masonry surfaces where bitumen materials are to be attached must be primed and allowed to dry. Composition and metal materials must be properly secured with appropriate mechanical fasteners using the spacing required (sheet metal 3" on center; masonry 6" on center; wood 9" on center). Walls, projections, wood nailers and other termination points should be completed before roof membrane and flashings are commenced. All sheet metal flashings, such as pipe collars, drains, gravel stops, etc., should be on site before roofing is required to be commenced. No condition should be allowed that would permit moisture entering behind, around, or under roof or flashing membrane. Flashing installations should be monitored for lap openings and voids.

#### 10. **Gravel Adhesion**

The gravel which makes initial contact with the hot bitumen flood coat should become embedded in the bitumen, leaving the balance of the gravel to serve as ballast and protection for the roof membrane system.

#### 11. **Roof Cuts**

Roof cuts are sometimes used to determine the average weight of the interply bitumen quantities. When the job documents call for test cuts, a reliable scale should be maintained on the job site and cuts should be taken during application, evaluated, and replaced before the application of the surfacing. In no instance does the NRCA recommend a test cut

solely to determine membrane weight after the gravel or final surfacing has been applied. When test cuts are required, the NRCA recommends procedures as called for in ASTM D3617. This procedure is an acceptable quality control method. If gravel surfacing has been applied, a test cut should be taken only where significant evidence of roof deficiencies exists.

It should be noted that the layer of bitumen between plys of the membrane reinforcement should not be excessive. Maximum bond strength is achieved with the thinnest practical continuous application of bitumen between the plys. There should be sufficient bitumen to penetrate the membrane reinforcing, in addition to that required to provide waterproofing properties.

The important criterion is to apply a sufficient quantity of bitumen to provide a full and continuous course of bitumen for the embedment of each subsequent ply of roofing reinforcement. The bitumen should be applied in a manner that will not allow contact between layers of reinforcements. The quantities to achieve this may vary from as low as 15 lbs. per 100 square feet to possibly 35 lbs. per 100 square feet for application of bitumen between membrane plys. For open type fiber-glass reinforcement plys, the variances are narrower.

Difference in application rates may result from atmospheric conditions, methods of application, temperature at actual time of placement, and the type of equipment locally available to the applicators. Bitumen flows less readily at lower application temperatures and the interply layer of bitumen tends to be heavier in weight. The quantity may also vary between the machine application and mop application. These quantity variations are recognized as normal and acceptable, as many factors affect the application of hot bitumen. Bitumen is used as an adhesive as well as a waterproofing layer, and a thin, continuous layer of bitumen is required for the installation of felts.

## XXV. REROOFING

Each reroof or recover project has its own specific problems that require individual assessment. The designer can obtain much of the information needed to prepare for reroofing by a thorough study of the existing roof system and the reasons for its deterioration.

The existing roof deck must be sound and undamaged. A sample of the existing membrane should always be removed down to the deck. The insulation should be carefully examined, and wet or damaged insulation, in most every case, should be replaced. It may be possible to salvage existing roof insulation if it is undamaged or if it is dry. Some insulation products cannot be salvaged since removing the membrane causes delamination of the insulation boards. If doubt exists as to the adequacy of the attachment of the first layer of insulation, this layer should be mechanically attached prior to the attachment of the second layer. Where removing the membrane may cause **minor** surface damage to the existing insulation, a single minimum layer, or recover board, should be considered for installation over the existing insulation to provide a suitable surface for the new membrane. In addition, the designer should carefully calculate the dew-point location and make provisions for it in his reroofing plans. The practice of installing a new roof membrane directly to the existing roof is discouraged.

Building owners may wish to consider the use of additional insulation in order to anticipate future energy requirements. In selecting a new membrane specification, the designer should consider the performance of the old roof specifications. Changes in the wood blocking heights and additional expansion provisions may be required at the time of reroofing. The existing drainage provisions should be examined and revised as needed.

Sample evaluation cuts are used to investigate existing roofs. In the hands of skilled investigators, they may help to identify the nature of the existing roof system. It must be stressed that their usefulness in this area is in direct proportion to the experience and expertise of the investigator.

## XXVI. INSPECTION & MAINTENANCE

**All roofs require periodic maintenance to achieve maximum roof life.** While complex repairs and some maintenance should be performed by qualified roofers, the owner can help maintain the roof by seeing that regular clean up procedures are performed. The designer and roofing contractor should make the owner aware of these procedures after the roof is completed.

### Owner Inspection and Maintenance Recommendations

1. Inspect the roof at least twice yearly, in the spring and fall, and inspect all roofs after any severe storm. Make frequent inspections on buildings that house manufacturing facilities that evacuate exhaust debris onto the roof. Clean roof drains of debris. Remove leaves, twigs, cans, balls, etc., which could plug roof drains. Bag and remove all debris from the roof since debris on the roof surface will be quickly swept into drains by heavy rains, and drainage problems may occur.
2. Notify the roofing contractor immediately after a roof leak occurs. If possible, note conditions resulting in leakage. Heavy or light rain, wind direction, temperature and the time of year that the leak occurs are all important clues to tracing roof leaks. Note whether the leaks stop shortly after each rain or continue to drip until the roof is dry. If the owner is prepared with facts, the diagnosis and repair of roof problems can proceed more rapidly.
3. File all job records, plans and specifications for future reference. Set up a maintenance schedule. Record maintenance procedures as they occur. Log all access times and parties working on the roof in case damage should occur.
4. Do not allow foot traffic on the roof in very cold or very hot temperatures as damage can result. Do not allow the installation of television and radio antennas or mechanical equipment without notifying the roofing contractor and consulting with him about the methods and details for these installations. One of the keys to avoiding roof damage is the key to the padlock on the roof hatch! Allow only

- authorized personnel on the roof.
5. In emergency situations, patch leaks to minimize property loss.
  6. Except for emergency situations, do not attempt owner-performed roof repairs. The puncturing of a blister or the spreading of a coating or mastic only covers up evidence the roofing contractor needs to ascertain the problem. Do not consider using maintenance coatings, "resaturants," sprays or "miracle" products without consulting a qualified roofing contractor.

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### **Roofing Contractor Maintenance Recommendations**

After completion, each roof is subjected to various weathering conditions. Roofs do not wear uniformly since certain areas may be affected more severely than others. Equalizing wear by upgrading worn areas is the secret to prolonged roof life. To equalize wear the maintenance and repair of these areas should be done by a qualified roofing contractor. Maintenance may be as simple as regravelling a windswept corner, or more complex, such as correcting a water ponding problem, but maintenance is a necessary part of good roofing practice.

## **XXVII. FACTORY MUTUAL (FM) & UNDERWRITERS LABORATORIES (UL)**

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Insurance bureaus rely on FM and UL requirements for insurance rating purposes. These requirements have had a strong impact on the construction of quality roof systems. They were established to reduce physical damage to roofing materials and the ensuing financial losses. The requirements, however, are aimed at preventing material waste and financial loss and do not necessarily guarantee the construction of quality roof systems. Roof components are tested for loss prevention but are NOT tested for the overall performance of the roof system that is desired. In summary, the use of FM & UL classified materials or methods will not necessarily result in quality roof systems.

Since some FM and UL requirements change every year, it is good practice to consult current issues of FM & UL bulletins for the latest information on installation methods and approved materials that pertain to a specific building project. This document will exclude specific FM & UL information. For further information see the FM & UL section of the ***NRCA Roofing and Waterproofing Manual***.

## XXVIII. TO THE OWNER AND DESIGNER

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The successful performance of a built-up roof requires:

- 1. Proper Design**  
Compatible materials and systems that will withstand the environmental conditions of the area where the building is constructed should be carefully selected. The roof system components, as they relate to each other, should be carefully detailed. While primary responsibility for proper design is placed with the designer, the roofing contractor and the material manufacturer may be consulted for input helpful to the design.
- 2. Quality Materials**  
The selection of materials should be based on the quality of the roof system rather than on economic considerations.
- 3. Quality Workmanship**  
Only skilled, trained workmen familiar with the products to be used should perform the work. Interference from other parties involved in the construction process should be avoided.
- 4. Weather Considerations**  
The permanent roof system should be constructed under reasonable weather conditions.
- 5. Timely Maintenance**  
Damage to the roof by other trades or by owner personnel should be prevented. The roof should be maintained in top condition by equalizing wear and by reducing degradation factors with periodic inspections and repairs. A good maintenance program is the owner's greatest assurance of value.
- 6. Qualified Roofing Contractors**  
Work with qualified roofing contractors! Consult them before issuing plans and specifications. Be sure that all contractors are bidding on exactly the same application procedures and materials.

## GLOSSARY

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### **Aggregate:**

(1) crushed stone, crushed slag, or water-worn gravel used for surfacing a built-up roof; (2) any granular mineral material.

### **Alligatoring:**

the cracking of the surfacing bitumen on a built-up roof, producing a pattern of cracks similar to an alligator's hide; the cracks may or may not extend through the surfacing bitumen.

### **Application Rate:**

the quantity (mass, volume or thickness) of material applied per unit area.

### **Area Divider:**

a raised, double wood member attached to a properly flashed wood base plate that is anchored to the roof deck. It is used to relieve thermal stresses in a roof system where no expansion joints have been provided. (See NRCA Construction Detail "D-1".)

### **Asbestos:**

a group of natural fibrous impure silicate materials.

### **Asphalt:**

a dark brown to black cementitious material in which the predominating constituents are bitumens which occur in nature or are obtained in petroleum processing.

### **Asphalt, Air Blown:**

an asphalt produced by blowing air through molten asphalt at an elevated temperature to raise its softening point and modify other properties.

### **Asphalt Felt:**

an asphalt-saturated felt or an asphalt-coated felt.

### **Asphalt Mastic:**

a mixture of asphaltic material and graded mineral aggregate that can be poured when heated but requires mechanical manipulation to apply when cool.

**Asphalt, Steam Blown:**

an asphalt produced by blowing steam through molten asphalt to modify its properties, normally used for high-way bitumen.

**Backnailing:**

the practice of blind nailing (in addition to hot-mopping) all the plies of a substrate to prevent slippage. (See BLIND NAILING.)

**Base Flashing:**

see FLASHING.

**Base Ply:**

the base ply is the first ply when it is a separate ply and not part of a shingled system.

**Base Sheet:**

a saturated or coated felt placed as the first ply in some multi-ply, built-up roof membranes.

**Bitumen:**

the generic term for an amorphous, semi-solid mixture of complex hydrocarbons derived from any organic source. Asphalt and coal tar are the two bitumens used in the roofing industry.

**Bituminous:**

containing or treated with bitumen. Examples: bituminous concrete, bituminous felts and fabrics, bituminous pavement.

**Bituminous Emulsion:**

(1) a suspension of minute globules of bituminous material in water or in an aqueous solution; (2) a suspension of minute globules of water or of an aqueous solution in a liquid bituminous material (invert emulsion).

**Bituminous Grout:**

a mixture of bituminous material and fine sand that will flow into place without mechanical manipulation when heated.

**Blind Nailing:**

the practice of nailing the back portion of a roofing ply.

**Blister:**

a spongy raised portion of a roof membrane, ranging in area from 1 inch in diameter and of barely detectable height upwards. Blisters result from the pressure buildup of gases entrapped in the membrane system. These gases most commonly are air and/or water vapor. Blisters usually involve delamination of the underlying membrane plies.

**Bond:**

the adhesive and cohesive forces holding two roofing components in intimate contact.

**Brooming:**

embedding a ply by using a broom to smooth out the ply and ensure contact with the adhesive under the ply.

**BTU:**

(British Thermal Unit)—the heat energy required to raise the temperature of 1 lb. of water 1 degree Fahrenheit.

**Built-Up Roof Membrane:**

a continuous, semi-flexible membrane assembly consisting of plies of saturated felts, coated felts, fabrics or mats with alternate layers of bitumen, generally surfaced with mineral aggregate, bituminous materials, or a granule surfaced sheet. (Abbreviation: BUR.)

**Cant Strip:**

a bevelled shaped strip of wood or wood fiber that fits into the angle formed by the intersection of a horizontal surface and a vertical surface. The 45 degree slope of the exposed surface of the cant strip provides gradual angular transition from the horizontal surface to the vertical surface.

**Cap Flashing:**

see FLASHING.

**Capillarity:**

the action by which the surface of a liquid (where it is in contact with a solid) is elevated or depressed, depending upon the relative attraction of the molecules of the liquid for each other and for those of the solid.

**Cap Sheet:**

a granule-surfaced coated sheet used as the top ply of a built-up roof membrane or flashing.

**Caulking:**

a composition of vehicle and pigment, used at ambient temperatures for filling joints, that remains plastic for an extended time after application.

**Coal Tar Bitumen:**

a dark brown to black, semi-solid hydrocarbon formed as a residue from the partial evaporation or distillation of coal tar. It is used as the waterproofing agent in dead-level or low-slope built-up roofs. It differs from COAL TAR PITCH in having a lower front-end volatility. (For specification properties, see ASTM Standard D450, Type III.)

**Coal Tar Felt:**

See TARRED FELT

**Coal Tar Pitch:**

a dark brown to black, semi-solid hydrocarbon formed as a residue from the partial evaporation or distillation of coal tar. It is used as the waterproofing agent in dead-level or low-slope built-up roofs. (For specification properties, see ASTM D450, Types I and II.)

**Coated Base Sheet (or Felt):**

a felt that has been impregnated and saturated with asphalt and then coated on both sides with harder, more viscous asphalt to increase its impermeability to moisture; a parting agent is incorporated to prevent the material from sticking in the roll.

**Cold-Process Roofing:**

a continuous, semi-flexible membrane consisting of plies of felts, mats, or fabrics that are laminated on a roof with alternate layers of cold-applied roof cement and surfaced with a cold-applied coating.

**Condensation:**

the conversion of water vapor or other gas to liquid as the temperature drops or the atmospheric pressure rises. (See DEW-POINT.)

**Coping:**

the covering piece placed on top of a wall that is exposed to the weather. It is usually sloped to shed water.

**Counterflashing:**

formed metal or elastomeric sheeting secured on or into a wall, curb, pipe, rooftop unit or other surface to cover and protect the upper edge of a base flashing and its associated fasteners.

**Course:**

(1) the term used for each application of material that forms the waterproofing system or the flashing; (2) one layer of a series of materials applied to a surface (i.e., a five course wall flashing is composed of three applications of mastic with one ply of felt sandwiched between each layer of mastic).

**Coverage:**

the surface area (in square feet) to be continuously coated by a specific roofing material, with allowance made for a specific lap.

**Crack:**

a separation or fracture occurring in a roof membrane or in a roof deck, generally caused by thermally induced stress or substrate movement.

**Creep:**

the permanent deformation of a roofing material or roof system caused by the movement of the roof membrane that results from continuous thermal stress or loading.

**Cricket:**

a superimposed construction placed in a roof area to assist drainage. (See NRCA Construction Detail "P".)

**Cutback:**

any roofing bituminous material that has been solvent thinned. Cutbacks are used in cold-process roofing adhesives, flashing cements, and roof coatings.

**Cutoff:**

a material seal that is designed to prevent lateral water movement into the edge of a roof system where the

membrane terminates at the end of a day's work or used to isolate sections of the roof system. Cutoffs are usually removed before the continuation of work.

**Dampproofing:**

treatment of a surface or structure to resist the passage of water in the absence of hydrostatic pressure.

**Dead Level:**

the term used to describe an absolutely horizontal roof. Zero slope. (See SLOPE.)

**Dead Level Asphalt:**

a roofing asphalt that has a softening point of 140°F (60°C) and that conforms to the requirements of ASTM Specification D 312, Type I.

**Dead Loads:**

non-moving rooftop loads, such as mechanical equipment, air conditioning units, and the roof deck itself.

**Deck:**

the structural surface to which the roofing or waterproofing system (including insulation) is applied.

**Delamination:**

separation of the plies in a membrane system or separation of laminated insulation layers.

**Dew-Point:**

the temperature at which water vapor starts to condense in cooling air at the existing atmospheric pressure and vapor content.

**Drain:**

a device that allows for the flow of water from a roof area. (See NRCA Construction Detail "W-2".)

**Dropback:**

a reduction in the softening point of bitumen that occurs when bitumen is heated in the absence of air. (See SOFTENING POINT DRIFT.)

**Edge Sheets:**

felt strips that are cut to widths narrower than the standard full felt roll width. They are used to start the felt-shingling pattern at a roof edge.

**Edge Stripping:**

application of felt strips cut to narrower widths than the normal felt-roll width to cover a joint.

**Edge Venting:**

the practice of providing regularly spaced protected openings along a roof perimeter to relieve moisture vapor pressure.

**Elastomer:**

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

**Elastomeric:**

the term used to describe the elastic, rubber-like properties of a material.

**Embedment:**

(1) the process of pressing a felt, aggregate, fabric, mat, or panel uniformly and completely into hot bitumen or adhesive; (2) the process of placing a material into another material so that it becomes an integral part of the whole material.

**Emulsion:**

the intimate dispersion of an organic material and water achieved by using a chemical or clay emulsifying agent.

**Envelope:**

a continuous felt fold formed by wrapping and securing a portion of a base felt back up and over the felt plies above it. Envelopes help prevent the seepage of bitumen.

**Equilibrium Moisture Content:**

(1) the moisture content of a material stabilized at a given temperature and relative humidity, expressed as percent moisture by weight; (2) the typical moisture content of a material in any given geographical area.

**Equiviscous Temperature (EVT) Range:**

the optimum application temperature of asphalt. It is the temperature range at which a viscosity of 125 centistokes is attained, plus or minus 25°F.

**Expansion Joint:**

a structural separation between two building elements designed to minimize the effect of the stresses and movements of a building's components and to prevent these stresses from splitting or ridging the roof membrane. (See NRCA Construction Detail "C-1".)

**Exposure:**

(1) the transverse dimension of a roofing element not overlapped by an adjacent element in any roof system. The exposure of any ply in a membrane may be computed by dividing the felt width minus 2 inches by the number of shingled plies; thus, the exposure of a 36 inch wide felt in a shingled, four-ply membrane should be 8½ inches; (2) the time during which a portion of a roofing element is exposed to the weather.

**Fabric:**

a woven cloth of organic or inorganic filaments, threads, or yarns.

**Factory Mutual (FM):**

an organization which classifies roof assemblies for their fire characteristics and wind-uplift resistance for insurance companies in the United States.

**Factory Square:**

108 square feet (10 square meters) of roofing material.

**Felt:**

a fabric manufactured from vegetable fibers (organic felts), asbestos fibers (asbestos felts), or glass fibers (glass-fiber felts). The manufacturing process involves mechanically interlocking the fibers of the particular felt material in the presence of moisture and heat.

**Felt Mill Ream:**

the mass in pounds of 480 square feet of dry, unsaturated felt; also termed "point weight."

**Fine Mineral Surfacing:**

a water-insoluble, inorganic material, more than 50% of which passes through the No. 35 sieve, that may be used on the surface of roofing material.

**Fishmouth:**

(1) a half-cylindrical or half-conical opening formed by an edge wrinkle; (2) in shingles, a half-conical opening formed at a cut edge.

**Flashing:**

the system used to seal the edges of a membrane at walls, expansion joints, drains, gravel stops, and other areas where the membrane is interrupted or terminated. **Base flashing** covers the edges of the membrane. **Cap flashing** or **counterflashing** shield the upper edges of the base flashing.

**Flashing Cement:**

a trowelable mixture of cutback bitumen and mineral stabilizers, including asbestos or other inorganic fibers.

**Flat Asphalt:**

a roofing asphalt that has a softening point of approximately 170°F (77°C) and that conforms to the requirements of ASTM Specification D 312, Type II.

**Flood Coat:**

the top layer of bitumen into which the aggregate is embedded on an aggregate-surfaced, built-up roof.

**Fluid Applied Elastomer:**

an elastomeric material, which is fluid at ambient temperature, that dries or cures after application to form a continuous membrane.

**Glass Felt:**

a felt sheet in which glass fibers are bonded into the felt sheet with resin. They are suitable for impregnation and coating. They are used in the manufacture and coating of bituminous waterproofing materials, roof membranes, and shingles.

**Glass Mat:**

a thin mat of glass fibers with or without a binder.

**Glaze Coat:**

(1) the top layer of asphalt in a smooth-surfaced built-up roof assembly; (2) a thin protective coating of bitumen applied to the lower plies or top ply of a built-up membrane when application of additional felts or the flood coat and aggregate surfacing are delayed.

**Grain:**

the weight unit equal to 1/7000 lb.; used in measuring atmospheric moisture content.

**Gravel:**

coarse, granular aggregate, containing pieces approximately 5/8 inch to 1/2 inch in size and suitable for use in aggregate surfacing on built-up roofs.

**Gravel Stop:**

a flanged device, frequently metallic, designed to provide a continuous finished edge for roofing materials and to prevent loose aggregate from washing off of the roof.

**Headlap:**

the minimum distance, measured at 90° degrees to the eave along the face of a shingle or felt as applied to a roof, from the upper edge of the shingle or felt, to the nearest exposed surface.

**Holiday:**

an area where a liquid-applied material is missing.

**“Hot Stuff” or “Hot”:**

the roofer's term for hot bitumen.

**Hygroscopic:**

the term used to describe a material which attracts, absorbs and retains atmospheric moisture.

**Incline:**

the slope of a roof expressed either in percent or in the number of vertical units of rise per horizontal unit of run.

**Inorganic:**

being or composed of matter other than hydrocarbons and their derivatives, or matter that is not of plant or animal origin.

**Insulation:**

a material applied to reduce the flow of heat.

**Knot:**

an imperfection or non-homogeneity in materials used in fabric construction, the presence of which causes surface irregularities.

**Live Loads:**

moving roof installation equipment, wind, snow, ice or rain.

**Manufacturer's Bond:**

a security company's guarantee that it will stand behind a manufacturer's liability to finance membrane repairs occasioned by ordinary wear within a period generally limited to 5, 10, 15, or 20 years.

**Mastic:**

see FLASHING CEMENT or ASPHALT MASTIC.

**Membrane:**

a flexible or semi-flexible roof covering or waterproofing, whose primary function is the exclusion of water.

**Mesh:**

the square or circular opening of a sieve.

**Metal Flashing:**

see FLASHING; frequently used as through-wall flashing, cap flashing, counterflashing or gravel stops.

**Mineral Fiber Felt:**

a felt with mineral wool as its principle component.

**Mineral Granules:**

opaque, natural, or synthetically colored aggregate commonly used to surface cap sheets, granule-surfaced sheets, and roofing shingles.

**Mineral Stabilizer:**

a fine, water-insoluble, inorganic material used in a mixture with solid or semi-solid bituminous materials.

**Mineral-Surfaced Roofing:**

built-up roofing materials whose top ply consists of a granule-surfaced sheet.

**Mineral-Surfaced Sheet:**

a felt that is coated on one or both sides with asphalt and surfaced with mineral granules.

**Mole Run:**

a meandering ridge in a membrane not associated with insulation or deck joints.

**Mop-And-Flop:**

an application procedure in which roofing elements (insulation boards, felt plies, cap sheets, etc.) are initially placed upside down adjacent to their ultimate locations, are coated with adhesive, and are then turned over and applied to the substrate.

**Mopping:**

an application of hot bitumen applied to the substrate or to the felts of a built-up roof membrane with a mop or mechanical applicator.

**Solid Mopping:**

a continuous mopping of a surface, leaving no unmopped areas.

**Spot Mopping:**

a mopping pattern in which hot bitumen is applied in roughly circular areas, leaving a grid of unmopped, perpendicular bands on the roof.

**Sprinkle Mopping:**

a random mopping pattern wherein heated bitumen beads are strewn onto the substrate with a brush or mop.

**Strip Mopping:**

a mopping pattern in which hot bitumen is applied in parallel bands.

**Nailing:**

(1) in the **exposed-nailing method**, nail heads are exposed to the weather; (2) in the **concealed-nailing method**, nail heads are concealed from the weather. (See also BLIND NAILING.)

**Neoprene:**

a synthetic rubber (polychloroprene) used in liquid-applied and sheet-applied elastomeric roof membranes or flashing.

**Nineteen-Inch Selvage:**

a prepared roofing sheet with a 17 inch granule-surfaced exposure and a nongranule-surfaced 19 inch selvage edge. This material is sometimes referred to as SIS or as **Wide-Selvage Asphalt Roll Roofing Surfaced with Mineral Granules**.

**Organic:**

being or composed of hydrocarbons or their derivatives, or matter of plant or animal origin.

**Perlite:**

an aggregate used in lightweight insulating concrete and in preformed perlitic insulating boards, formed by heating and expanding siliceous volcanic glass.

**Perm:**

a unit of water vapor transmission defined as 1 grain of water vapor per square foot per hour per inch of mercury pressure difference (1 inch of mercury = 0.491 psi). The formula for perm is: **P = GRAINS OF WATER VAPOR/ SQUARE FOOT•HOUR•INCH MERCURY**.

**Permeance:**

an index of a material's resistance to water-vapor transmission. (See PERM.)

**Phased Application:**

the installation of a roof system or waterproofing system during two or more separate time intervals.

**Picture Framing:**

a rectangular pattern of ridges in a membrane over insulation or deck joints.

**Pitch Pocket:**

a flanged, open bottomed metal container placed around columns or other roof penetrations that is filled with hot bitumen and/or flashing cement to seal the joint. The use of pitch pockets is not recommended by NRCA.

**Plastic Cement:**

see FLASHING CEMENT.

**Ply:**

a layer of felt in a built-up roof membrane system. A four-ply membrane system has four plies of felt. The dimension of the exposed surface (the "exposure") of any ply may be computed by dividing the felt width (minus 2 inches) by the number of plies; thus, the exposed surface of a 36 inch wide felt in a four-ply membrane should be 8½ inches. (See EXPOSURE.)

**Point Weight:**

see FELT MILL REAM.

**Pond:**

a roof surface which is incompletely drained.

**Positive Drainage:**

the drainage condition in which consideration has been made for all loading deflections of the deck, and additional roof slope has been provided to ensure complete drainage of the roof area within 24 hours of rainfall precipitation.

**Primer:**

a thin, liquid bitumen applied to a surface to improve the adhesion of subsequent applications of bitumen.

**Rake:**

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

**Re-entrant Corner:**

an inside corner of a surface, producing stress concentrations in the roofing or waterproofing membrane.

**Reglet:**

a groove in a wall or other surface adjoining a roof surface for use in the attachment of counterflashing.

**Reinforced Membrane:**

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

**Relative Humidity:**

the ratio of the weight of moisture in a given volume of air-vapor mixture to the saturated (maximum) weight of water vapor at the same temperature, expressed as a percentage. For example, if the weight of the moist air is 1 lb. and if the air could hold 2 lbs. of water vapor at a given temperature, the relative humidity (RH) is 50%.

**Reroofing:**

the practice of applying new roofing materials over existing roofing materials.

**Ridging:**

an upward, "tenting" displacement of a membrane, frequently occurring over insulation joints, deck joints and base sheet edges.

**Roll Roofing:**

the term applied to smooth-surfaced or mineral-surfaced coated felts.

**Roof Assembly:**

an assembly of interacting roof components (including the roof deck) designed to weatherproof and, normally, to insulate a building's top surface.

**Roofer:**

the trade name for the workman who applies roofing materials.

**Roof System:**

a system of interacting roof components (**NOT** including the roof deck) designed to weatherproof and, normally, to insulate a building's top surface.

**Saturated Felt:**

a felt that has been partially saturated with low softening-point bitumen.

**Screen:**  
an apparatus with apertures for separating sizes of material.

**Seal:**  
(1) a narrow closure strip made of bituminous materials;  
(2) to secure a roof from the entry of moisture.

**Sealant:**  
a mixture of polymers, fillers, and pigments used to fill and seal joints where moderate movement is expected; it cures to a resilient solid.

**Selvage:**  
an edge or edging which differs from the main part of (1) a fabric, or (2) granule-surfaced roll roofing material.

**Selvage Joint:**  
a lapped joint designed for mineral-surfaced cap sheets. The mineral surfacing is omitted over a small portion of the longitudinal edge of the sheet below in order to obtain better adhesion of the lapped cap sheet surface with the bituminous adhesive.

**Shark Fin:**  
an upward-curved felt sidelap or endlap.

**Shingle:**  
(1) a small unit of prepared roofing material designed to be installed with similar units in overlapping rows on inclines normally exceeding 25°; (2) to cover with shingles; (3) to apply any sheet material in overlapping rows like shingles.

**Shingling:**  
(1) the procedure of laying parallel felts so that one longitudinal edge of each felt **overlaps**, and the other longitudinal edge **underlaps**, an adjacent felt. (See PLY.) Normally, felts are shingled on a slope so that the water flows over rather than against each lap; (2) the application of shingles to a sloped roof.

**Sieve:**  
an apparatus with apertures for separating sizes of material.

**Slag:**  
a hard, air cooled aggregate that is left as a residue from blast furnaces. It is used as a surfacing aggregate and should be surface dry and free of sand, clay, or other foreign substances at the time of application.

**Slippage:**  
the relative lateral movement of adjacent components of a built-up membrane. It occurs mainly in roof membranes on a slope, sometimes exposing the lower plies to the weather.

**Slope:**  
the tangent of the angle between the roof surface and the horizontal. It is measured in inches per foot. The Asphalt Roofing Manufacturers Association (ARMA) ranks slope as follows:

Level Slope	..... up to ½ inch per foot.
Low Slope	..... ½ inch per foot to 1½ inches per foot.
Steep Slope	..... over 1½ inches per foot.

**Smooth-Surfaced Roof:**  
a built-up roof membrane surfaced with a layer of hot-mopped asphalt, cold-applied asphalt-clay emulsion, cold-applied asphalt cutback, or sometimes with an unmopped inorganic felt.

**Softening Point:**  
the temperature at which bitumen becomes soft enough to flow. Asphalt softening point is measured by the "ring-and-ball" test (ASTM D2398). Coal-tar pitch softening point is measured by the "cube-in-water" test (ASTM D61).

**Softening Point Drift:**  
a change in the softening point of bitumen during storage or application. (See DROPBACK.)

**Solid Mopping:**  
see MOPPING.

**Special Steep Asphalt:**

a roofing asphalt that has a softening point of approximately 220°F (104°C) and that conforms to the requirements of ASTM Specification D 312, Type IV.

**Split:**

a separation in roofing material resulting from movement of the substrate. (See CRACK.)

**Split Sheet:**

see NINETEEN-INCH SELVAGE.

**Spot Mopping:**

see MOPPING.

**Sprinkle Mopping:**

see MOPPING.

**Square:**

the term used to describe 100 square feet of roof area.

**Stack Vent:**

a vertical outlet in a built-up roof system designed to relieve any pressure exerted by moisture vapor between the roof membrane and the vapor retarder or deck.

**Steep Asphalt:**

a roofing asphalt that has a softening point of approximately 190°F (88°C) and that conforms to the requirements of ASTM Specification D 312, Type III.

**Strawberry:**

a small bubble or blister in the flood coating of a gravel-surfaced membrane.

**Strip Mopping:**

see MOPPING.

**Stripping:**

strip flashing: (1) the technique of sealing a joint between metal and the built-up membrane with one or two plies of felt and hot-applied or cold-applied bitumen; (2) the technique of taping joints between insulation boards on deck panels.

**Substrate:**

the surface upon which the roofing or waterproofing membrane is placed (i.e., the structural deck or insulation).

**Superimposed Loads:**

loads that are added to existing loads. For example, a large stack of insulation boards placed on top of a structural steel deck.

**Tapered Edge Strip:**

a tapered insulation strip used to (1) elevate the roof at the perimeter and at curbs that extend through the roof; (2) provide a gradual transition from one layer of insulation to another.

**Taping:**

see STRIPPING.

**Tar:**

a brown or black bituminous material, liquid or semi-solid in consistency, in which the predominating constituents are bitumens obtained as condensates in the processing of coal, petroleum, oil-shale, wood, or other organic materials.

**Tarred Felt:**

a felt that has been saturated with refined coal tar.

**Test Cut:**

a sample of the roof membrane, usually 4 inches × 40 inches in size, that is cut from a roof membrane to:

1. Determine the weight of the average interply bitumen poundages
2. Diagnose the condition of the existing membrane (e.g., to detect leaks or blisters).

NRCA recommends that the test cut procedure **NOT** be used as a means of determining the quality of a roof system.

**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 one square foot of one inch thick homogeneous material in one hour when there is a difference of 1 degree Fahrenheit perpendicularly across the two surfaces of the material. The formula for thermal conductivity is:  $k = \text{BTU/SQUARE FOOT/INCH/HOUR/DEGREE FARENHEIT.}$

**Thermal Insulation:**

a material applied to reduce the flow of heat.

**Thermal Resistance (R):**

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

$$R = \frac{1}{C} \text{ or } R = \frac{1}{k} \text{ or } R = \frac{\text{thickness in inches}}{k}$$

**Thermal Shock:**

the stress-producing phenomenon resulting from sudden temperature changes in a roof membrane. (For example, when a rain shower follows brilliant sunshine.)

**Through-Wall Flashing:**

a water-resistant membrane or material assembly extending through a wall and its cavities, positioned to direct any water entering the top of the wall to the exterior.

**Underwriters Laboratories (UL):**

an organization which classifies roof assemblies for their fire characteristics and wind-uplift resistance for insurance companies in the United States.

**Vapor Migration:**

the movement of water vapor from a region of high vapor pressure to a region of lower vapor pressure.

**Vapor-Pressure Gradient:**

a graph, analogous to a temperature gradient, indicating the changes in water vapor pressure at various cross-sectional planes through a roof or wall system.

**Vapor Retarder:**

a material designed to restrict the passage of water vapor through a wall or roof. In the roofing industry, a vapor retarder should have a perm rating of 0.5 or less.

**Vent:**

an opening designed to convey water vapor or other gas from inside a building or a building component to the atmosphere, thereby relieving vapor pressure.

**Vermiculite:**

an aggregate used in lightweight insulating concrete, formed by the heating and consequent expansion of a micaceous mineral.

**Water Cutoff:**

see CUTOFFS.

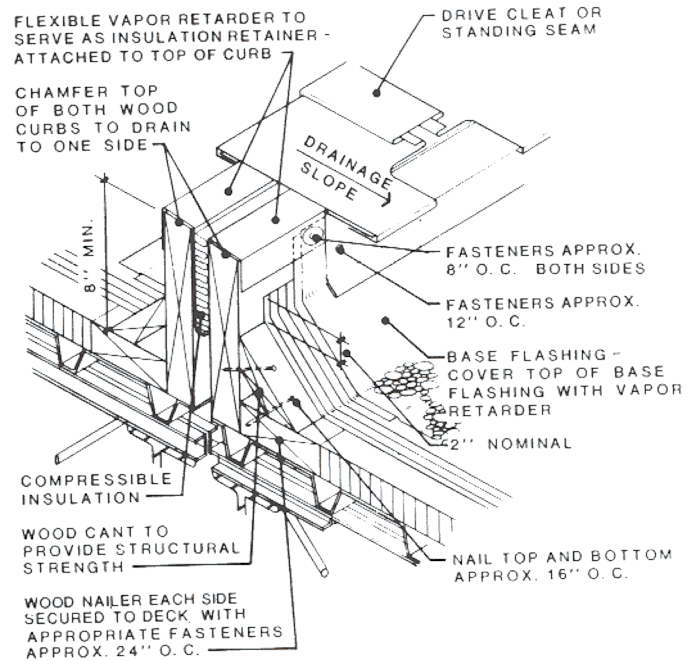
**Waterproofing:**

treatment of a surface or structure to prevent the passage of water under hydrostatic pressure.

## APPENDIX

The illustrations contained herein pertain to the NRCA Details referred to in this document. The complete set of NRCA Construction Details is included in the **NRCA Roofing and Waterproofing Manual**.

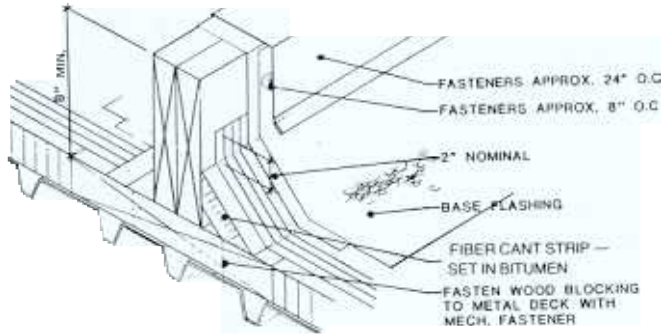
## EXPANSION JOINT



**NOTE:**  
This detail allows for building movement in both directions. It has proven successful with many contractors for many years.



## AREA DIVIDER

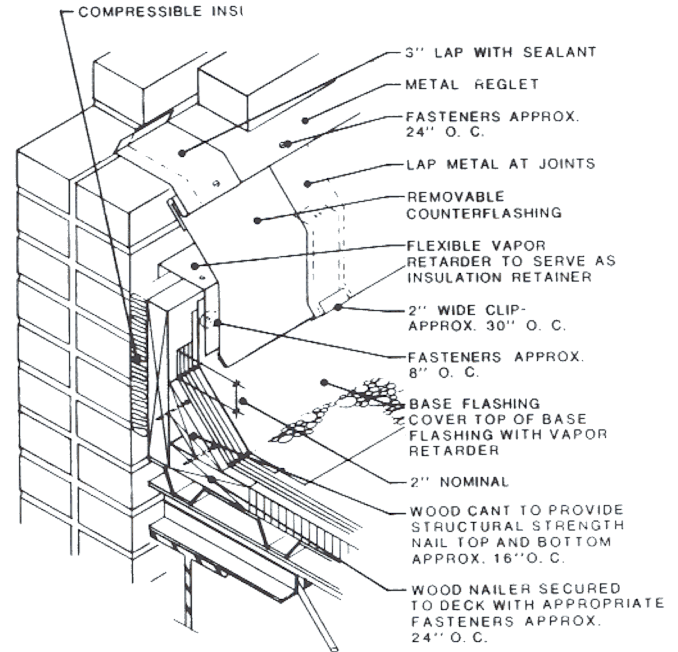


### NOTE:

An area divider is designed simply as a raised double-wood member attached to a properly flashed wood base plate that is anchored to the roof deck. Area dividers should be located between the roof's expansion joints at 100-200 foot intervals, depending upon climatic conditions and area practices. They should never restrict the flow of water.



## BASE FLASHING FOR NON-WALL SUPPORTED DECK



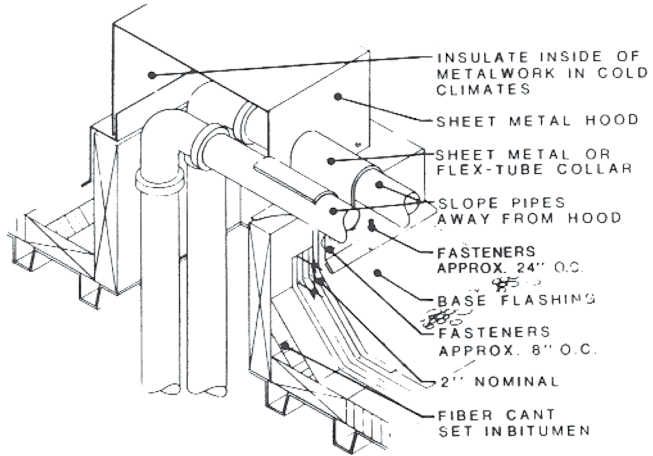
### NOTES:

This detail allows wall and deck to move independently.

This detail should be used where there is any possibility that differential movement will occur between the deck and a vertical surface, such as at a penthouse wall. The vertical wood member should be fastened to the deck only. This is one satisfactory method of joining the two piece flashing system. Other methods may be used.



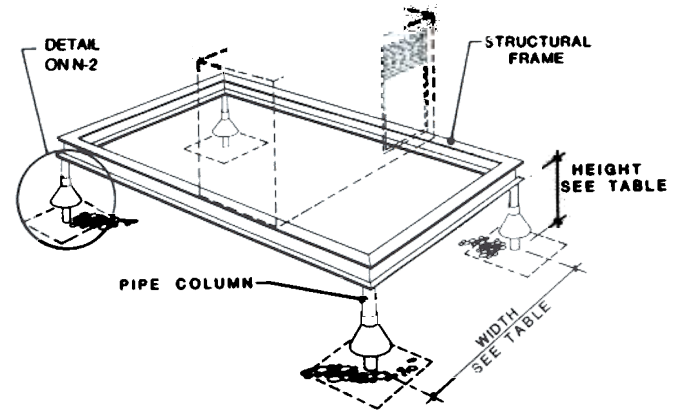
## PIPING THROUGH ROOF DECK



**NOTE:**  
This detail illustrates another method of eliminating pitch pockets and a satisfactory method of grouping piping that must come up above the roof surface.



## MECHANICAL EQUIPMENT STAND



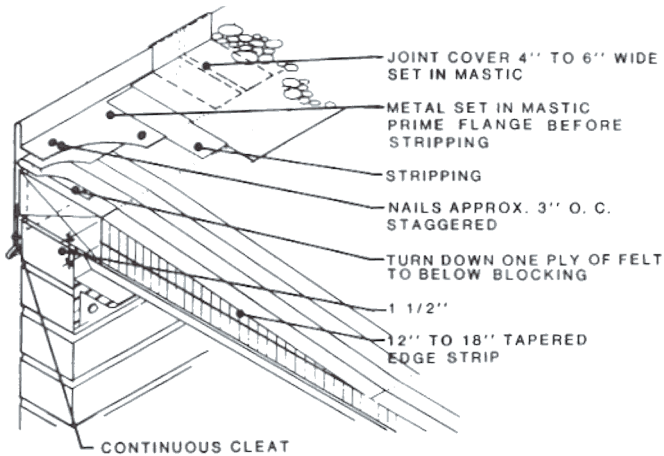
WIDTH OF EQUIPMENT	HEIGHT OF LEGS
UP TO 24"	14"
25" TO 36"	18"
37" TO 48"	24"
49" TO 60"	30"
61" AND WIDER	48"

**NOTE:**  
This detail is preferable when the concentrated load can be located directly over columns or heavy girders in the structure of the building. This detail can be adapted for other uses such as sign supports.





## LIGHT METAL ROOF EDGE DETAIL



### NOTES:

Envelope shown for coal tar pitch and low slope asphalt.

Attach nailer to masonry wall. Refer to Factory Mutual Data Sheet 1-49.

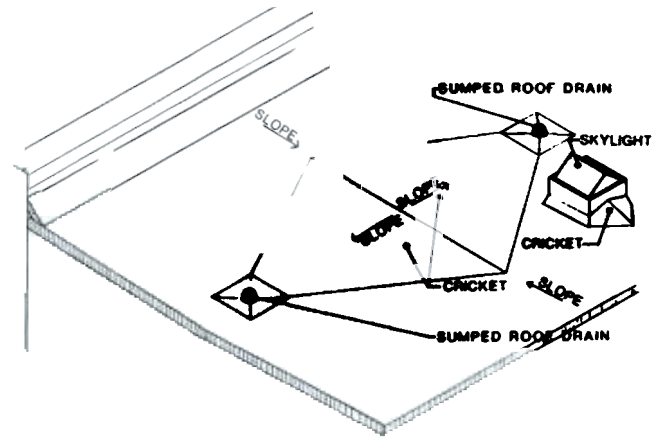
This detail should be used only where deck is supported by the outside wall.

This detail should be used with light gauge metals, such as 16 oz. copper, 24 gauge galvanized metal, or 0.040" aluminum. A tapered edge strip is used to raise the gravel stop. Frequent nailing is necessary to control thermal movement.

Wood blocking may be slotted for venting where required.



## CRICKET DETAIL

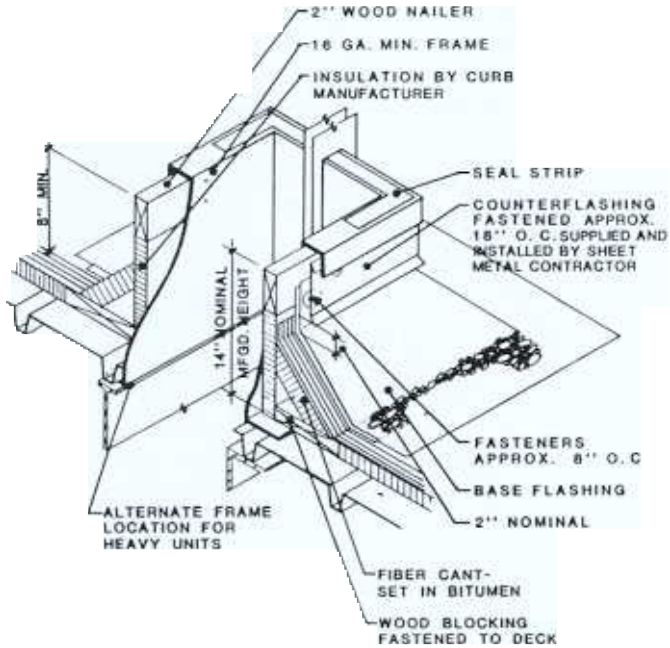


### NOTE:

Crickets should be located in low valleys between roof drains and on the high side of all curbs.



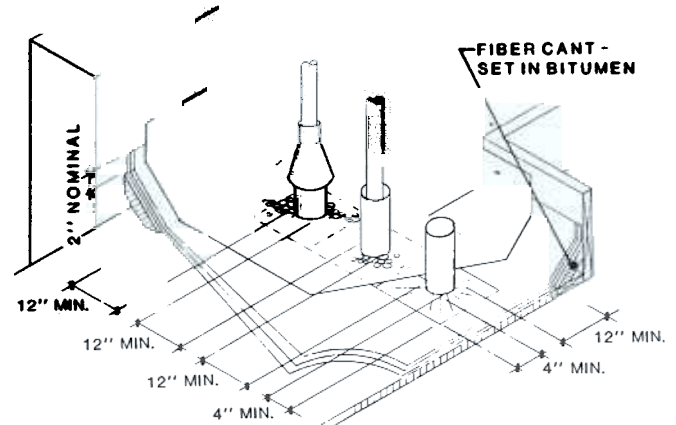
## CURB DETAIL FOR ROOFTOP AIR HANDLING UNITS



**NOTE:**  
The curb, wood nailer, insulation and seal strip are to be supplied by the curb manufacturer. The nominal 14 inch curb height is effective as of January 1, 1981.

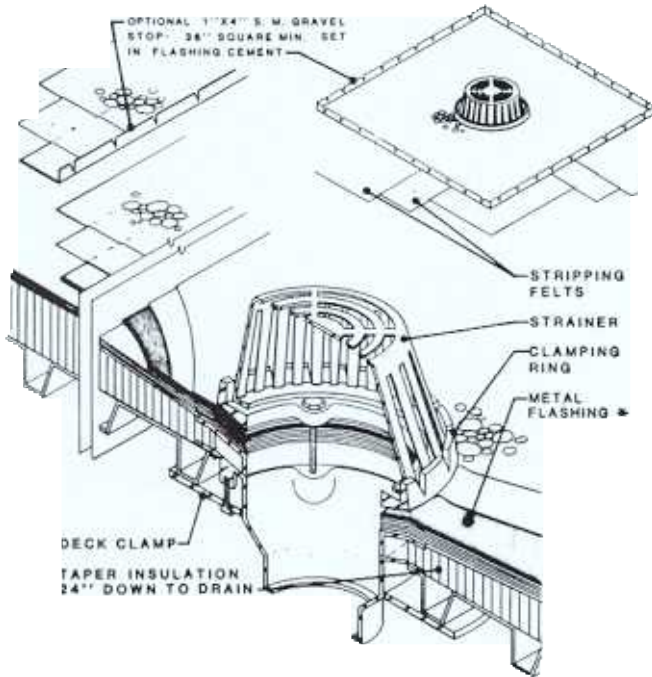


## CLEARANCES FOR MULTIPLE PIPES BETWEEN PIPES AND FROM WALLS AND CURBS



# ROOF DRAIN

# NOTES



## NOTES:

\*Min. 30" square 2½# to 4# lead or 16 oz. soft copper flashing set on finished roof felts in mastic—prime top surface before stripping.

Membrane plies, metal flashing, and flash-in plies extend under clamping ring.

Stripping felts— extend 4" and 6" beyond edge of flashing sheet.

