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Construction Engineering Research Laboratory

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Membrane and Flashing Condition Indexes for Modified Bitumen Roofs

Inspection and Distress Manual

David M. Bailey

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David M. Bailey

Construction Engineering Research Laboratory
U.S. Army Engineer Research and Development Center
2902 Newmark Drive
Champaign, IL 61822

Final report

Prepared for The Assistant Chief of Staff for Installation Management (ACSIM)
Arlington, VA 22202

Under Reimbursable Customer Order MIPR8H0DFG7068, “Implementation Guidance to Installations for Sustainment Management Systems Compliance”

Abstract: The U.S. Army is currently responsible for maintaining millions of square feet of modified bitumen roofing on its facilities. Modified bitumen roofing systems share a number of characteristics with other common systems, but they also employ certain unique materials and therefore have their own specialized distress and degradation mechanisms. Dedicated inspection guidance and condition index calculation methods are required to quantify the condition of an installation's modified bitumen roofing assets in order to make the best use of Army maintenance and repair resources. This document was developed to provide roof inspectors with a standard reference for performing inspections, and calculating a flashing condition index (FCI) and membrane condition index (MCI) for use in facility maintenance management activities. It represents a new implementation of the widely used ROOFER Sustainment Management System for roofing asset management.

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Preface

This study was conducted for U.S. Army Assistant Chief of Staff for Installation Management (ACSIM), under Reimbursable Customer Order MIPR8H0DFG7068, "Implementation Guidance to Installations for Sustainment Management Systems Compliance," dated 30 June 2008. The technical monitor was Phil Columbus, Assistant Chief of Staff for Installation Management, Facilities Policy Directorate (DAIM-ODF).

The work was performed by the Materials and Structures Branch (CF-M) of the Facilities Division (CF), U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Vicki L. Van Blaricum was Chief, CEERD-CF-M; L. Michael Golish was Chief, CEERD-CF; and Martin J. Savoie was the Technical Director for Installations. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti, and the Director was Dr. Ilker Adiguzel.

Many of the procedures, figures, and methods presented in this manual were previously developed in ROOFER implementations for bituminous built-up roofs, single-ply roofs, and asphalt shingle steep roofs. This inspection and distress manual incorporates applicable technology from established ROOFER implementations as well as adaptations and new methodologies specifically for modified bitumen roofing systems.

The following individuals are acknowledged for their technical review and comment on draft versions of this manual:

- William "Andy" Anderson, Architect, Engineering Services, Department of Public Works, Fort Riley, KS
- Dane Bradford, President, Bradford Roof Management, Inc., Billings MT
- Tim Benzie, INSPEC, Minneapolis, MN.

COL Gary E. Johnston was the Commander and Executive Director of ERDC, and Dr. James R. Houston was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
feet	0.3048	meters
inches	0.0254	meters
mils	0.0254	millimeters
square feet	0.09290304	square meters

1 Introduction

Background

In order to help effectively track the condition and maintenance requirements of the most widely used roofing systems installed on facilities managed by the U.S. military services, the U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL) and other agencies developed a Sustainment Management System* called ROOFER. Previous implementations of ROOFER have been developed for bituminous built-up roofs (Bailey et al. 1989; Bailey, Brotherson, and Tobiasson 1989), single ply roofs (Bailey et al. 1993), and asphalt shingle steep roofs (Bailey 1999).

The U.S. Army is currently responsible for maintaining millions of square feet of modified bitumen roofing on its facilities. Modified bitumen roofing systems share a number of characteristics with other common systems, but they also employ certain unique materials and therefore have their own specialized distress and degradation mechanisms. Dedicated inspection guidance and condition index calculation methods are required to quantify the condition of an installation's modified bitumen roofing assets in order to make the best use of Army maintenance and repair resources. This document was developed to provide roof inspectors with a standard reference for performing inspections, and calculating a flashing condition index (FCI) and membrane condition index (MCI) for use in facility maintenance management activities.

Objective

The objective of this work was to develop ROOFER inspection procedures specifically for modified bitumen roofing systems based on visual inspection of the flashing and membrane components.

* Sustainment Management Systems were originally referred to as Engineered Management Systems, or EMS.

Approach

The concepts and theory behind the ROOFER condition indexing methodology, and the process used to develop and field-validate the distress definitions and deduct value curves, were documented in Shahin, Bailey, and Brotherson (1987a). The procedures for determining membrane and flashing condition indexes for built-up and single-ply roofs (Shahin, Bailey, and Brotherson 1987b; Bailey et al. 1993) provide a basis for the current work. An initial inspection and distress manual for modified bitumen roofing systems was developed by identifying similar applicable distresses from the established built-up and single-ply procedures, then making necessary modifications to more accurately assess modified bitumen roof condition. The modified bitumen procedures were finalized through iterations of field testing and revision to refine the distress definitions.

How to use this manual

Chapter 2 describes inspection and condition evaluation procedures for modified bitumen roofs using the established ROOFER methodology. Descriptions and illustrations of distresses for flashings and the membrane are presented in Chapters 3 and 4, respectively. Those chapters provide detail about the distresses, severity levels, defect definitions, measurement criteria, and photographs of applicable defects. Inspectors should study this manual and carry a copy for reference during inspections.

Results of the roof inspections are to be used in conjunction with the calculation procedures described in Chapter 2 to determine the FCI and MCI and the corresponding condition ratings. The computed indexes are also used to determine a roof condition index (RCI) that provides an overall measure of the roof condition. For reference, Appendix A contains the deduct value curves for every modified bitumen roof system component and distress. Appendix B includes a blank specimen of both the ROOFER roof inspection worksheet and the roof section rating form, which may be photocopied for use by inspectors.

Mode of technology transfer

Information about the ROOFER SMS, computer software, support, training, and implementation costs are available at the U.S. Army Engineer Research and Development Center online fact sheet navigation page:

http://www.erdc.usace.army.mil/pls/erdcpub/WWW_WELCOME.NAVIGATION_PAGE?tmp_next_page=42507

Inquiries about ROOFER may be directed to Chief, Materials and Structures Branch (CEERD-CF-M), U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL), P.O. Box 9005, Champaign, IL 61826-9005, 217-352-6511.

2 Procedures for Roof Inspection and Calculation of Indexes

Introduction

Determining the condition indexes for modified bitumen roofing requires measurement of all current roof flashing and membrane distresses. A thorough roof inspection must be made to determine the types, severity, specific defects, and amounts (density) of each distress present. This inspection must be carefully organized and planned in order to provide the necessary information for determining the flashing and membrane conditions.

For the purposes of this document, a modified bitumen roofing system is defined as a membrane system that can be used for low-slope roof applications. The membrane consists of at least two plies comprising a base layer and a surface layer. One or both layers consist of a rolled sheet material having a bitumen and polymer blend that provides waterproofing. The polymer modifiers, which can be elastomeric or thermoplastic, provide enhanced mechanical and physical properties. The surface layer will typically be a factory-applied mineral surface, a smooth surface with an added coating, a metal foil surface, or a layer of aggregate embedded in bitumen.

This chapter presents the procedures for visually inspecting bituminous modified bitumen roofs and computing the flashing and membrane condition indexes.

Roof sections

Dividing a building's roof into sections and rating each separately provides a more accurate indication of maintenance and repair requirements because (1) a roof section that is in poor condition does not detract from the condition index of a good roof section on the same building and (2) a condition index indicating that replacement of the section is necessary does mean that the entire roof needs to be replaced. The division of a roof into sections, therefore, helps to avoid unnecessary asset management costs by excluding intact portions of the roof that require no repair and focusing on sections that have advanced degradation or may fail soon.

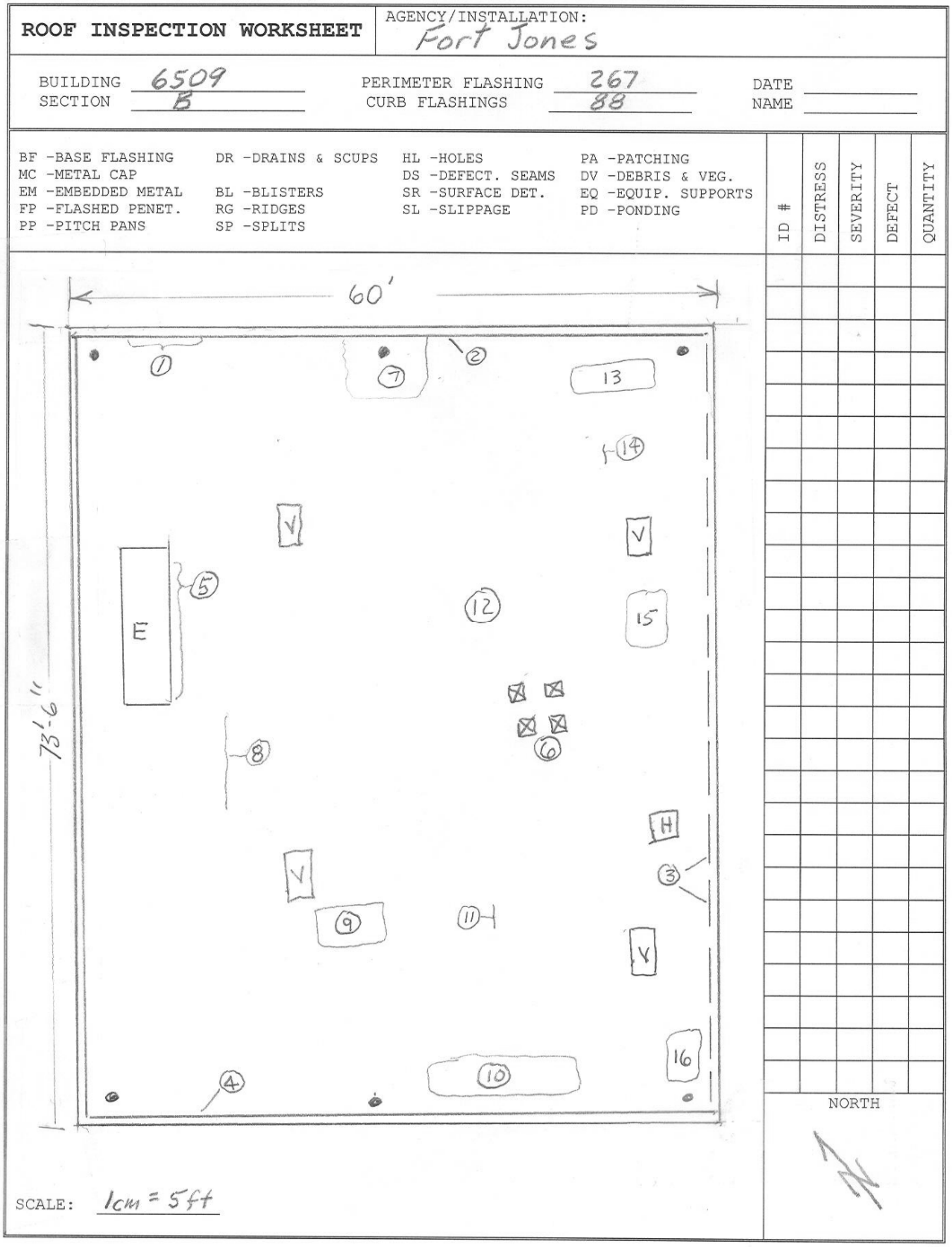
A roof section is generally delineated by at least one of the following boundaries or distinctions:

- expansion joints or area dividers
- different roof elevations
- areas of major repair or replacement
- areas that were built at different times
- areas having different roof systems, different amounts of rooftop traffic, rooftop equipment, or radically different occupancies below the roof
- areas having particularly sensitive occupancies below, such as computer centers, operating rooms or command centers

Some judgment is necessary in cases where the roof is segmented into very small areas or if there are no identifiable delineations on large roofs. Small sections may be combined where practical. However, areas with clearly different characteristics, such as different roofing systems, supporting structural systems, or environments below the roof structure (e.g., canopies, freezers, unheated warehouses) should be treated as individual sections. Large areas without delineations can be divided into sections with areas of 25,000 to 40,000 sq ft.

Roof plans

Each roof section should have a roof plan drawn to a scale (approximately 1 in. = 30 ft) that fits on the roof inspection worksheet (Figure 1). The plan should show all physical roof features, including perimeter conditions (roof edge, expansion joint, penthouse, etc.), rooftop equipment, projections through the roof, roof drains, walkways, sign supports, piping, etc. Standard symbols, such as those shown in Figure 2, should be used to identify these items whenever possible.



ROOF INSPECTION WORKSHEET
AGENCY/INSTALLATION: Fort Jones

BUILDING 6509
SECTION B
PERIMETER FLASHING 267
CURB FLASHINGS 88
DATE
NAME

BF -BASE FLASHING
MC -METAL CAP
EM -EMBEDDED METAL
FP -FLASHED PENET.
PP -PITCH PANS
DR -DRAINS & SCUPS
BL -BLISTERS
RG -RIDGES
SP -SPLITS
HL -HOLES
DS -DEFECT. SEAMS
SR -SURFACE DET.
SL -SLIPPAGE
PA -PATCHING
DV -DEBRIS & VEG.
EQ -EQUIP. SUPPORTS
PD -PONDING

ID #	DISTRESS	SEVERITY	DEFECT	QUANTITY

SCALE: 1cm = 5ft

Figure 1. Roof inspection worksheet showing roof section plan.

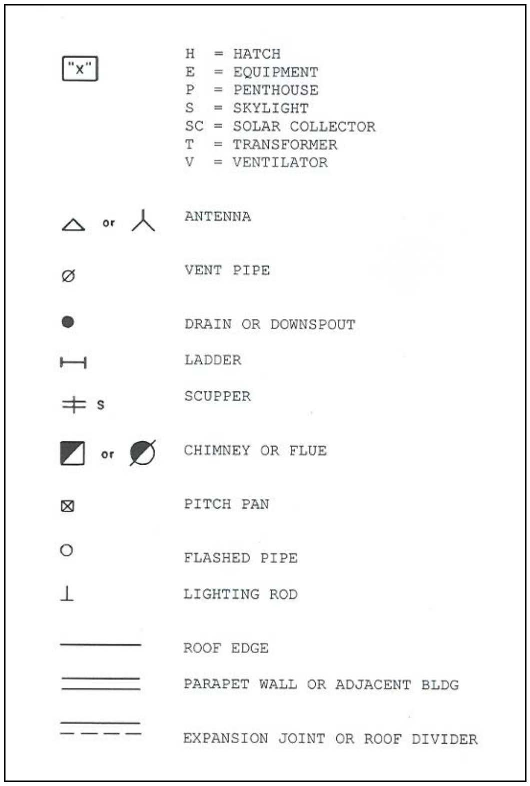


Figure 2. Legend showing standard symbols to be used on roof section plans.

Inspection procedure

Survey team

The roof inspection should be performed by a team of at least two people: an inspector and a recorder. The inspector surveys the roof, identifying distresses and determining severity levels, specific defects, and quantities. The recorder fills in the information on the roof inspection worksheet and assists in measuring distress quantities when required. The recorder must also serve as the safety observer for the team.

Supplies

The following supplies are required for performing the inspection:

- this inspection and distress manual
- pencil and clipboard
- roof inspection worksheets
- small 3 in. pointing trowel (to scrape granules, dirt, and debris)
- can of spray paint
- lumber crayon

- stiff bristle whisk broom
- pocket knife
- 12 ft and 100 ft measuring tapes
- large plastic bag (to collect rooftop debris)
- satchel (for carrying tools and materials).

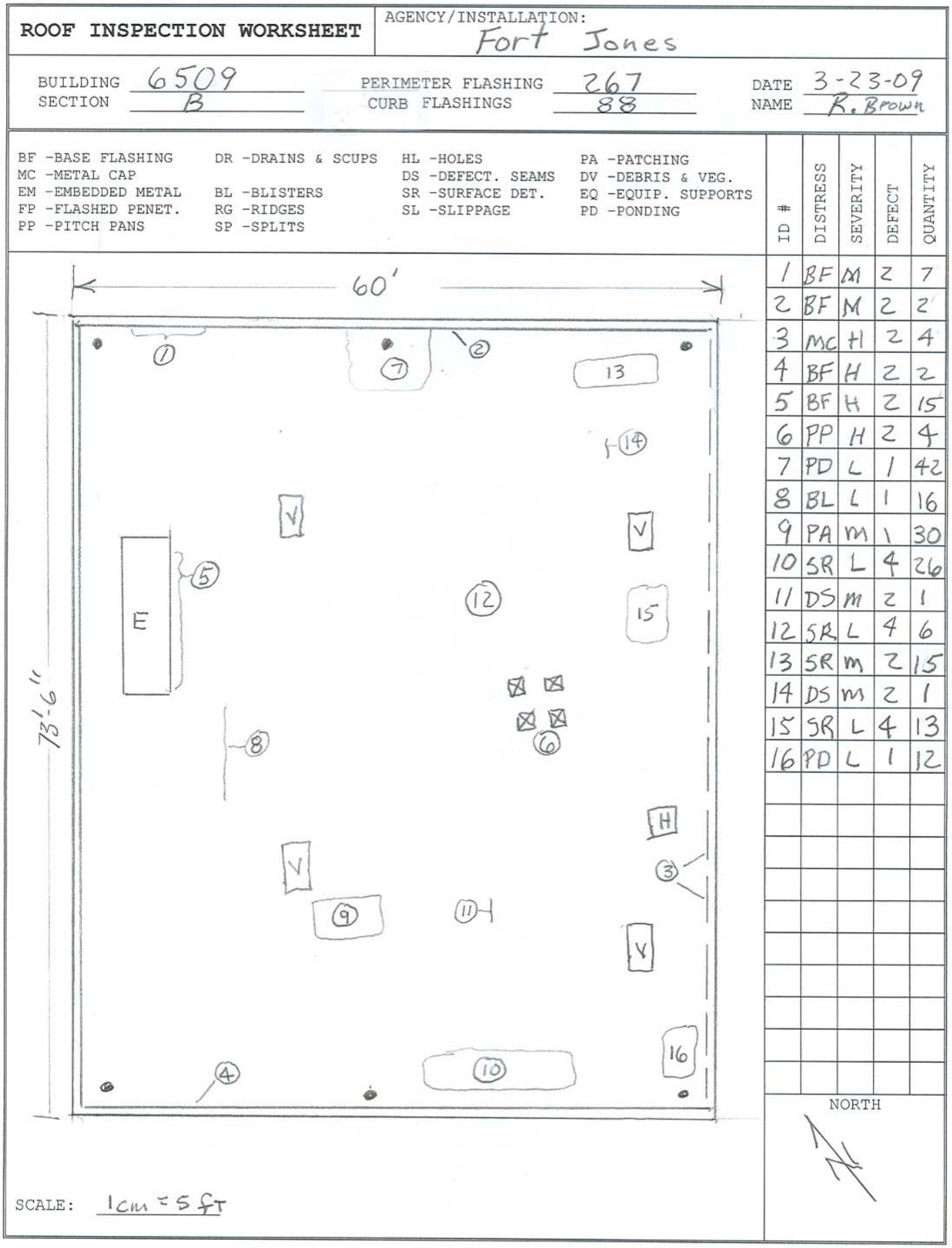
Survey preparation

Before beginning the inspection, the roof section plan should be developed (or verified, if a plan already exists). Check plan dimensions against actual field dimensions. Locate all penetrations, projections, rooftop equipment, and perimeter conditions on the plan. Measure and record dimensions on the roof plan. Measure and record the total length of perimeter flashing, which is the flashing at the perimeter of the roof section (i.e., roof edge, expansion joint, area divider, parapet wall, etc.) in the appropriate space on the heading of the roof inspection worksheet. Also determine and record on the worksheet the length of curb flashing around rooftop penetrations (i.e., equipment curbs). These flashing quantities are important because they are used to determine the relative amounts of flashing defects as compared with the total amount of flashing component that exists on the roof section.

Distress survey

Perform the distress survey using the following sequence:

1. Inspect the perimeter flashing. Establish a starting point at one corner of the roof section. Walk the entire perimeter, examining the base flashing, embedded edge metal flashing, and metal cap flashing.
2. Identify all distresses and specific defects according to the distress manual. Mark each medium- and high-severity distress with spray paint or a lumber crayon. Enter each identified distress by type, severity level, specific defect (specific defects are listed numerically for each distress [see Chapters 3 and 4]), and quantity on the Roof Inspection Worksheet. Note the location of each distress on the roof plan using an identification number, as shown in Figure 3. Determine the distress quantities using the measurement criteria provided for the particular distress.
3. After inspecting the perimeter, work across the roof area inspecting all other flashings: curbed penetrations, flashed penetrations, pitch pans, drains, etc. Record the data on the Roof Inspection Worksheet.


ROOF INSPECTION WORKSHEET

AGENCY/INSTALLATION: Fort Jones

BUILDING 6509 SECTION B

PERIMETER FLASHING 267 CURB FLASHINGS 88

DATE 3-23-09 NAME R. Brown

BF -BASE FLASHING
MC -METAL CAP
EM -EMBEDDED METAL
FP -FLASHED PENET.
PP -PITCH PANS
DR -DRAINS & SCUPS
BL -BLISTERS
RG -RIDGES
SP -SPLITS
HL -HOLES
DS -DEFECT. SEAMS
SR -SURFACE DET.
SL -SLIPPAGE
PA -PATCHING
DV -DEBRIS & VEG.
EQ -EQUIP. SUPPORTS
PD -PONDING

ID #	DISTRESS	SEVERITY	DEFECT	QUANTITY
1	BF	M	2	7
2	BF	M	2	2
3	MC	H	2	4
4	BF	H	2	2
5	BF	H	2	15
6	PP	H	2	4
7	PD	L	1	42
8	BL	L	1	16
9	PA	m	1	30
10	SR	L	4	26
11	DS	m	2	1
12	SR	L	4	6
13	SR	m	2	15
14	DS	m	2	1
15	SR	L	4	13
16	PD	L	1	12

SCALE: 1cm = 5 ft

Figure 3. Example of completed roof inspection worksheet.

4. Inspect the roof membrane. Establish a starting point at one corner of the roof section. Survey that section by inspecting strips 10 – 15 ft wide, proceeding back and forth until the entire membrane has been inspected. Record the data.
5. Complete the “Remarks” section on the back of the roof inspection worksheet.

Note: It is imperative to use the distress definitions listed in this manual (Chapters 3 and 4) when performing roof inspections. If these definitions are not followed, accurate indexes cannot be developed. Use a second roof inspection worksheet if the first one becomes filled.

Inspection guidelines

The guidelines below should be followed when performing the visual inspection and distress survey.

Base flashing

Measure the height of top termination of base flashing above the roof surface. To establish the height, run fingers up behind the counterflashing. If the base flashing height cannot be determined, assume it is adequate.

Metal cap flashing

Check for looseness of metal cap flashing by attempting to lift it by hand at several locations.

Embedded edge metal

Check that the embedded edge metal flashing is secure by attempting to lift the outside edge. For roof surfaces where defects above the joints in the underlying course of edge metal are not readily apparent (i.e., embedded aggregate surfacing), use the following sampling technique. Determine the total number of joints by dividing the total length of embedded edge metal flashing by the stock length of the edge metal sections (typically 10 ft). Inspect every fourth joint for splits in the stripping plies, removing any loose granules, gravel or dirt from the joint using the small whisk broom and pointing trowel. Determine the number of inspected joints that are high severity (i.e., have splits in the stripping plies) and multiply by 4 to get the total number of high-severity joints (one joint equals 1 ft). All other joints are considered medium-severity. Multiply the number of inspected joints not counted as high-severity by 4 to obtain the total number of medium-severity joints.

Flashed penetrations

Check the height of the flashing sleeve above the roof surface. Use a whisk broom and trowel to examine stripping plies.

Interior drains and roof-level scuppers

Check all drains and scuppers and remove debris whenever possible. When inspecting drains, make sure the clamping ring is tight. Stripping plies around scuppers should be inspected for holes at corners.

Membrane

Membrane inspection requires surveying the entire roof area. However, when large areas of a particular distress and severity level are present, the representative sampling technique can be used. Select a portion of the roof (approximately 1,000 sq ft) that appears to be typical of the entire roof area. Measure the quantity of distress in the sample area and, by extrapolation, calculate the quantity for the entire roof area. An area that differs greatly from the majority of the roof should be surveyed separately.

General

The following is a list of general guidelines for the roof inspection:

- Be careful not to damage the roof. Do not step on blisters, kick base flashing, or step on edge flashing.
- Note existing problems that are not included in the lists of flashing and membrane distresses in the "remarks" section on the back of the worksheet. Walk the building perimeter at ground level and look for water stains, efflorescence, missing mortar, spalled brick, and gutter and drainage problems.
- Walk the interior of the building and examine the ceiling below the roof deck for water marks. Note rusting or other signs of water penetration or leaks in the "remarks" section on the back of the worksheet.
- If there is snow or a large area of ponding on the roof, postpone the inspection until the roof is clear.
- Wherever possible, use a measuring tape to determine roofing distress quantities. Estimating is acceptable when necessary, but the rating ac-

curacy will be only as good as the estimating accuracy. Pacing to find lengths, or some other quantifying estimating method, is preferable to an "eyeball" estimate.

- If more than one severity level of a distress exists in a localized area, assign the highest severity level to the entire area.

FCI and MCI calculations

The FCI and MCI of a roof section are determined from the information recorded on the roof inspection worksheet. The condition indexes can be calculated by entering the distress information into the ROOFER software program. The indexes can also be determined manually using the roof section rating form (Figure 4) with the following procedure. A blank copy of the form is provided in Appendix B. With the initial step being the visual inspection, the other steps for manual determination are described below and illustrated in Figure 5.

Determine deduct values

Use information from the roof inspection worksheet to complete the heading section of the roof section rating form. Transfer the quantities for each combination of distress type and severity level to the roof section rating form, as illustrated in Figure 4. Flashing distresses are tabulated on the left side of the page and membrane distresses on the right. Total the quantities for each severity of each distress, calculate each density using the distress-specific equations given in Chapters 3 and 4, and determine deduct values (DV) using the distress-specific deduct value curves in Appendix A.

ROOF SECTION RATING FORM

BUILDING 6509	SECTION B	DATE 3-23-09	CALC. BY S.T
PER. FLASHING 267 FT CURB FLASHING 88 FT	FLASHING TOTAL 355 FT	AREA 4410 SQ FT	CHKD. BY R.B

FLASHING

DISTRESS TYPES

BF -BASE FLASHING
MC -METAL CAP
EM -EMBEDDED METAL
FP -FLASHED PENET.
PP -PITCH PANS
DR -DRAINS & SCUPS

DIS	SEV	QUANTITIES	TOT	DEN	DV
BF	m	7+2	9	2.5	9
mC	H	4	4	1.1	11
BF	H	2+15	17	4.8	20
PP	H	4	4	1.1	10

CORRECTED DEDUCT VALUE (CDV) 24

FCI = 100 - CDV = 76

FLASHING RATING Very Good

MEMBRANE

DISTRESS TYPES

BL -BLISTERS
RG -RIDGES
SP -SPLITS
HL -HOLES
DS -DEFECT. SEAMS
SR -SURFACE DET.
SL -SLIPPAGE
PA -PATCHING
DV -DEBRIS & VEG.
EQ -EQUIP. SUPPORTS
PD -PONDING

DIS	SEV	QUANTITIES	TOT	DEN	DV
PD	L	42+12	54	1.22	4
BL	L	16	16	0.36	5
PA	m	30	30	0.68	10
SR	L	26+6+13	45	1.02	5
DS	m	1+1	2	0.05	5
SR	m	15	15	0.34	8

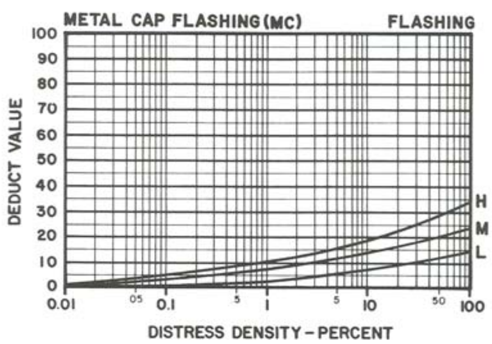
CORRECTED DEDUCT VALUE (CDV) 16

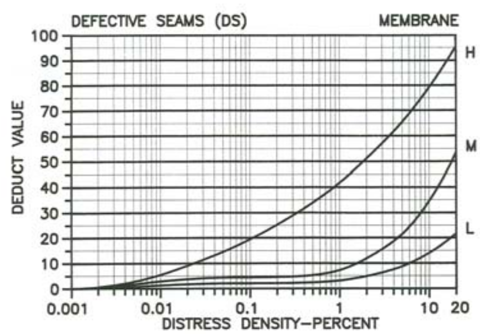
MCI = 100 - CDV = 84

MEMBRANE RATING Very Good

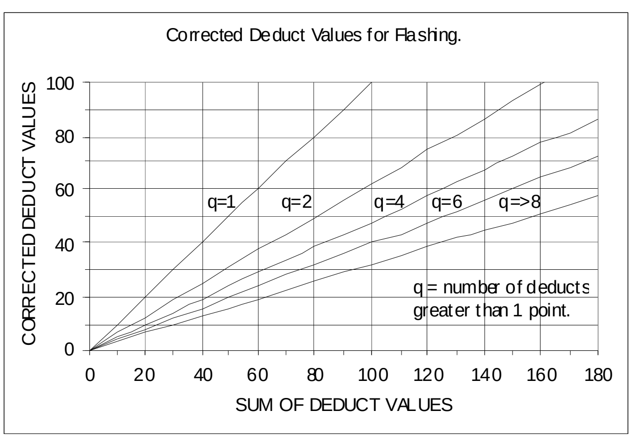
Figure 4. Example of completed roof section rating form.

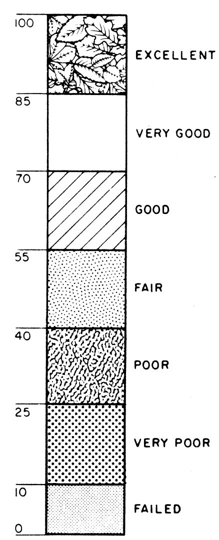
Step 1. Inspect roof. Determine distress types, severity levels and defects. Determine quantities and calculate densities.





Step 2. Determine deduct values.





Step 3. Compute corrected deduct value. Step 4. Compute cond. index

Figure 5. Steps for determining condition indexes and ratings.

Determine corrected deduct values

Tabulate flashing deduct values in descending order using the data obtained from the roof section rating form. Table 1 illustrates how the flashing component deduct value would be determined manually using the example data shown in Figure 4. Calculate the sum of the flashing deduct values (∑DV) and the sum of the number of distresses with deduct values greater than 1 (DV <1 = q), then use those two values and the component-specific deduct graph in Appendix A to determine corrected deduct values (CDV) for the flashing distresses. Select the maximum value of CDV, as shown in bold in Table 1. In this case the Max. $CDV_{flashing}$ is 24.

Table 1. Determination of corrected flashing deduct value using data from Figure 5.

DV	**∑DV**	**q**	**$CDV_{flashing}$**
20	20	1	20
11	31	2	20
10	41	3	23
9	50	4	**24**

Use the same process in conjunction with the distress-specific graph in Appendix A to determine the maximum corrected deduct value for the membrane. In this case, using the example data from Figure 4, the Max. $CDV_{membrane}$ is 16 (shown in bold type in Table 2).

Table 2. Determination of corrected membrane deduct value using data from Figure 5.

DV	**∑DV**	**q**	**$CDV_{membrane}$**
10	10	1	10
8	18	2	13
5	23	3	14
5	28	4	15
5	33	5	**16**
4	37	6	16

Compute FCI and MCI

Calculate flashing and membrane condition indexes using the following equations:

$$FCI = 100 - \text{Max. } CDV_{flashing}$$
$$MCI = 100 - \text{Max. } CDV_{membrane}$$

Determine the corresponding descriptive condition ratings from Figure 6 for both indexes. For these data, FCI = 76 and MCI = 84, meaning that both the flashings and membrane are rated “very good.”

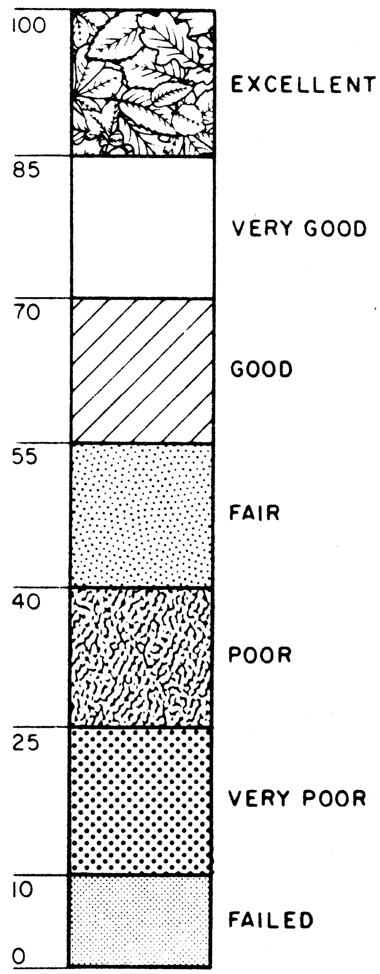


Figure 6. Flashing and membrane condition indexes (FCI and MCI) and ratings.

RCI calculation

Each individual index (FCI, MCI) reflects the component’s ability to provide its intended service and indicates repair/replacement needs. As is typical with other low-slope membrane roofing systems, modified bitumen roofs normally will have one or more layers of insulation board placed between the membrane and roof deck. For those roofs having underlying insulation, these two condition indexes are combined with an insulation condition index (ICI). The ICI is determined using roof moisture survey techniques and gravimetric analyses of core cuts extracted from areas of wet insulation.

Since the components must interact to function as a roof system, they are dependent on each other. The indexes, in total, provide an assessment of the condition of the roof section. By combining these indexes, a roof condition index (RCI) can be calculated. This single index is useful for evaluating the overall condition of a roof section and for comparing conditions between roof sections. The RCI allows the user to rank individual roof sections in accordance with their ability to perform.

For insulated roofing systems, the following equation is used to determine the RCI:

RCI = (0.7 x lowest condition index) + (0.15 x sum of the remaining condition indexes).

For non-insulated roofs, which will not have an ICI, use the following equation.

RCI = (0.7 x lowest condition index) + (0.3 x remaining condition index)

The above equations gives the greatest weight to the component with the lowest condition index and then modifies it by adding “value” from the remaining index(es).

The following example illustrates how this relationship works for the inspection results presented here and assuming that the ICI has been determined to be 100:

Example: FCI = 76; MCI = 84; ICI = 100

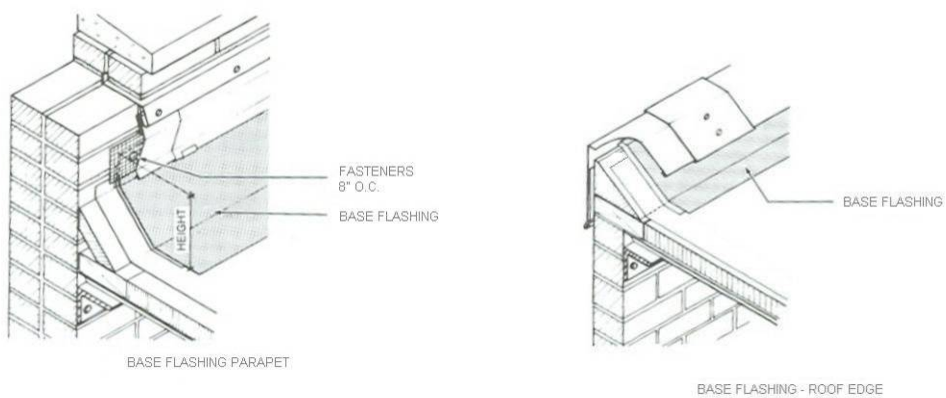
RCI = (0.7 x 76) + (0.15 x 184)

= 81

3 Flashing Distresses

Base Flashing (BF)

Description: Base flashing is one or more plies of material that extend from the roof surface up onto a vertical or inclined surface providing a water-tight termination of the membrane. The base flashing surface ply may be mineral surfaced, smooth coated, uncoated, or metal foil surfaced.



Base flashing details.

Distress severity levels:

Low: Any of the following defects:

1. Loss of granules or coating or delamination of foil surfacing and poor appearance (including patching) but no visible deterioration of base flashing.
2. Top of base flashing is less than 6 in. above the roof surface.
3. Flashing has permanent repairs.

Medium: Any of the following defects:

1. Slippage, wrinkling, blistering, or pulling of base flashing material.
2. Loss of granules or coating or delamination of foil surfacing and some visible deterioration of base flashing; but no holes, splits, or tears.
3. Grease, solvent, or oil drippings on the base flashing but no visible deterioration of base flashing.

4. Flashing has temporary repairs.

High: Any of the following defects:

1. Holes, splits, or tears in flashing caused by deterioration or physical damage.
2. Exposed gaps at the top of the base flashing which are not covered by counterflashing or open side laps in the flashing which allow water to channel behind them.
3. Grease, solvent, or oil drippings on the base flashing with deterioration through the base flashing.
4. No base flashing exists.

Measurement: Measure lineal feet of base flashing having the above defects. Holes, open side laps, and seams count as 1 ft each. If an area of the base flashing is at medium severity and holes are closer than 6 in., count that entire length of distressed base flashing as high severity.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = length of base flashing defects (ft)
B = total length of flashed perimeter of roof section being rated (including flashings for penthouses, courtyards, and curbed projections)

Note: The problem density is calculated for each existing severity level.

Causes:

- Flashing splits or tears can result from mechanical damage, material shrinkage, unattached membrane pulling the flashing, or differential movement between the wall and the deck.
- Delamination and sliding result from weak or no attachment between the flashing plies or between the flashing and the substrate. This can result from any of the following conditions:
  - When first installed, the flashing plies were not firmly pressed into the bitumen to form a solid, continuous laminate.
  - No primer was used on the wall.

- The wrong flashing adhesive was used to attach the flashing plies to the wall.
- The flashing adhesive was improper, incompatible, incorrectly applied or of poor quality.
- The hot-mopped bitumen was allowed to cool before the flashing plies were applied.
- Fasteners were improper type or too few to hold flashing to substrate.
- Inadequate heat-applied to back of torched materials.
- Loss of surfacing on mineral surfaced materials can result from ambient temperatures being too high.

Reference photographs

BF-L-2: Top of base flashing is less than 6 in. above the roof surface.

BF-L-3: Flashing has permanent repairs.

BF-M-1: Slippage, wrinkling, blistering, or pulling of base flashing material.

BF-M-4: Flashing has temporary repairs.

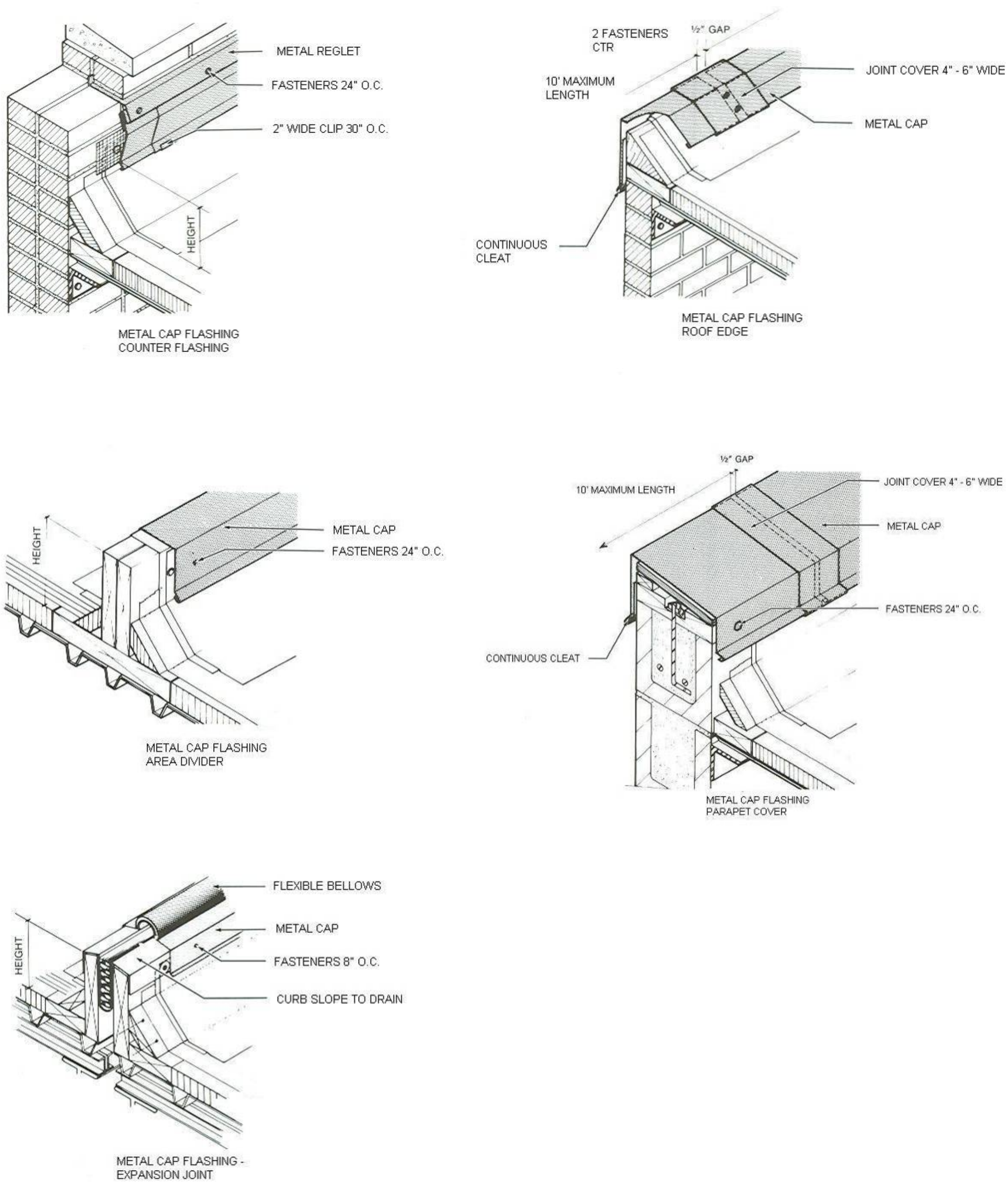
BF-H-1: Holes, splits, or tears in flashing caused by deterioration or physical damage.

BF-H-2: Exposed gaps at the top of the base flashing that are not covered by counterflashing or open side laps in the flashing.

BF-H-4: No base flashing is present.

Metal Cap Flashing (MC)

Description: Metal cap flashing includes counterflashing and any sheet metal coping cap which serves as part of the counterflashing or the cover over a detail such as a roof area divider, equipment curb, raised roof edge, or an expansion joint (including the rubber bellows of an expansion joint).



Metal cap flashing details.

Counterflashing is the material, usually sheet metal, which protects the top termination of base flashing and sheds water away from it. Counterflashing should be free to expand and contract.

Distress severity levels:

Low: Any of the following defects:

1. Loss of paint or protective coating or start of metal corrosion.
2. Metal coping cap is deformed and allows water to pond on the top.
3. Counterflashing is deformed but still performing its function.
4. Counterflashing has been sealed to the base flashing.

Medium: Any of the following defects:

1. Corrosion holes have occurred through the metal on a vertical surface.
2. Metal coping cap has loose fasteners, failure of soldered or sealed joints, open joints, or loss of attachment.
3. Sealant at reglet or top of counterflashing is missing or no longer functioning, allowing water to channel behind counterflashing.
4. Counterflashing is loose at the top, allowing water to channel behind it.
5. Counterflashing does not extend over top of base flashing.

High: Any of the following defects:

1. Metal coping cap or counterflashing is missing or displaced from its original position.
2. Corrosion holes have occurred through the metal on a horizontal surface or rubber bellows of an expansion joint cover.
3. Metal coping cap has missing joint covers where joint covers were originally installed.

Measurement: Measure lineal feet of metal cap flashing having the above defects. Individual defects (i.e., joints, holes) count as one foot minimum.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = length of metal cap flashing defects (ft)

B = total length of flashed perimeter of roof section being rated (including flashings for penthouses, courtyards, and curbed projections)

Note: The problem density is calculated for each existing severity level.

Reference photographs

MC-L-2: Metal coping cap is deformed and allows water to pond on the top.

MC-M-2: Metal coping cap has loose fasteners, failure of soldered or sealed joints, open joints, or loss of attachment.

MC-M-3: Sealant at reglet or top of counterflashing is missing or no longer functioning, allowing water to channel behind.

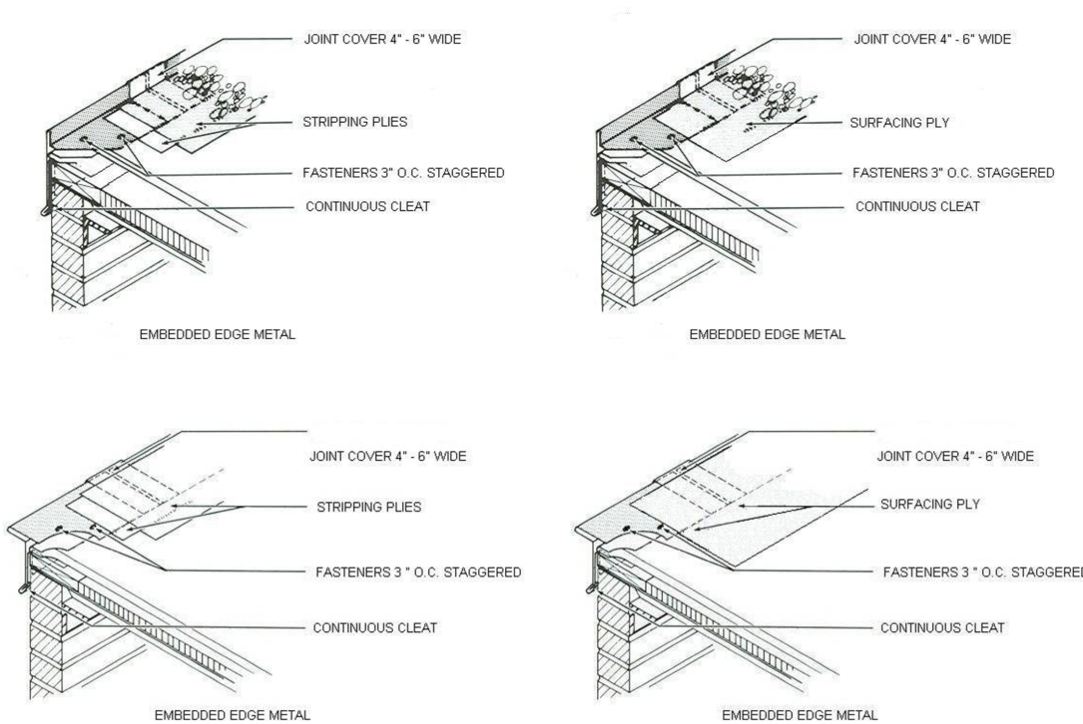
MC-H-1 : Metal coping cap or counterflashing is missing or displaced from its original position.

MC-H-2: Corrosion holes penetrating metal on horizontal surface or rubber bellows of an expansion joint cover.

MC-H-3: Metal coping cap has missing joint covers where joint covers were originally installed.

Embedded Edge Metal (EM)

Description: Formed strip of metal at the roof edge which continues down the vertical part of the wall to form a fascia or drip. The roof flange of the metal flashing may be covered by the surfacing ply or separate stripping plies. This flashing provides a finished termination for the roofing membrane. A formed vertical projection (gravel stop) may be incorporated to prevent loose aggregate from rolling or washing off the roof. Exterior and interior gutters, which are embedded into the membrane, are considered as embedded edge metal. (An interior gutter is a built-in trough of metal or other material which collects water from the roof and carries it to a downspout.)



Embedded edge metal details.

Note: A raised roof edge which is not stripped in, is rated as metal cap flashing and not as embedded edge metal.

Distress severity levels:

Low:

1. The entire length of embedded edge metal flashings is rated low severity as a minimum due to the maintenance problems associated with it.

Medium: Any of the following defects:

1. The joints in embedded edge metal flashings are rated medium severity as a minimum due to the maintenance problems associated with them.
2. Loss of granules or coating or delamination of foil surfacing and some deterioration of surfacing plies; but no holes, splits, or tears.
3. Nails attaching the metal to the nailer are backing out or are exposed.
4. Corrosion of the metal.
5. Loose or lifted metal flange without deterioration of the surfacing plies.
6. The entire length of interior gutter is rated medium severity as a minimum due to the maintenance problems and high potential for leak damage associated with its presence.

High: Any of the following defects:

1. Surfacing plies are loose or missing, leaving metal flange exposed.
2. Splits in the surfacing plies above the metal joints.
3. Holes, splits, or tears in surfacing plies caused by deterioration or physical damage.
4. Holes have occurred through the metal.
5. Loose or lifted metal flange with deterioration of the surfacing plies.
6. Holes or joint movement are present in the interior gutter.

Measurement: Measure lineal feet of embedded edge metal flashing having the above defects. Each split above a joint is counted as one foot. As a method of sampling the joints, determine the total number of joints by dividing the total length of embedded edge metal flashing by the length of edge metal sections (normally 10 ft). Every fourth joint should be inspected for splits in the surfacing plies. Count the number of inspected joints that are high severity and multiply by 4 to determine the total lineal feet of high-severity joints. All other joints are rated medium severity. Multiply the number of inspected joints not rated high severity by 4 to determine the total lineal feet of medium-severity joints.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = length of embedded edge metal flashing defects (ft)
B = total length of flashed perimeter of roof section being rated (including flashings for penthouses, courtyards and curbed projections)

Note: The problem density is calculated for each existing severity level.

Causes:

- Splits in the surfacing plies and loose surfacing plies are caused by:
  - Insufficient or improper nailing of the metal flange allowing it to move.
  - Insufficient or no priming of the metal flange (top and bottom) before installation. This prevents bonding of the bitumen to the metal.
  - The widely different expansion coefficients of the metal and bituminous components.
  - Inadequate adhesive or inadequate heat for the application of torch applied materials.
- Exposed metal flanges can result from surfacing ply deterioration or the flange may never have been stripped-in.
- Loose or lifted metal edge is caused by insufficient fastening, rotting, or lack of a wood perimeter nailer.

Reference photographs

EM-L-1: The entire length of embedded edge metal flashings is rated low severity at minimum due to the maintenance problems.

EM-M-3: Nails attaching the metal to the nailer are backing out or exposed.

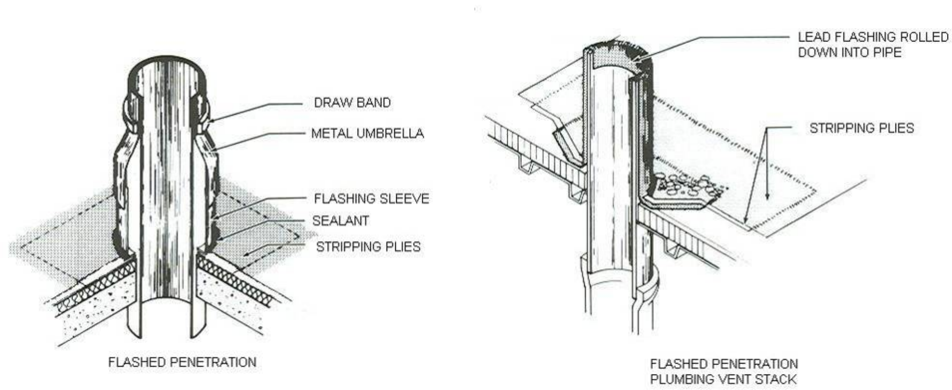
EM-M-6: Entire length of interior gutter is rated medium severity at minimum due to the maintenance problems.

EM-H-1: Surfacing plies are missing or loose.

EM-H-2: Splits in the surfacing plies above the metal joints.

Flashed Penetrations (FP)

Description: Open pipes, plumbing vent stacks, flues, ducts, continuous pipes, guy wires, drain sumps, and other penetrations through the roof membrane (excluding pitch pans but including metal curbing for hatches and ventilators), where the flange is stripped into the membrane.



Flashed penetration details.

Distress severity levels:

Low: Any of the following defects:

1. Flashing sleeve is deformed.
2. Opening in the penetration or flashing is less than 6 in. above the roof surface.
3. Loss of granules or coating or delamination of foil surfacing and poor appearance (including patching) but no visible deterioration of stripping ply.

Medium: Any of the following defects:

1. Loss of granules or coating or delamination of foil surfacing and some deterioration of stripping ply; but no holes, splits, or tears.
2. Top of flashing sleeve is not sealed or has not been rolled down into an existing plumbing vent stack.
3. The sleeve or umbrella is open or no umbrella is present (where required).
4. Metal is corroded.

High: Any of the following defects:

1. Flashing sleeve or metal curb has been installed with no stripping plies.
2. Flashing sleeve or metal curb is cracked, broken, or corroded through.
3. No flashing sleeve is present.
4. Penetration is not sealed at the membrane level.
5. Holes, splits, or tears in stripping ply caused by deterioration or physical damage.

Measurement: Count each distressed flashed penetration as one linear ft at the highest severity level which exists. For metal curbs and ducts with greater than 1 ft of perimeter, count the actual length (in feet) of distressed perimeter.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = lineal feet of distressed flashed penetrations
B = total length of flashed perimeter of roof section being rated (including flashings for penthouses, courtyards and curbed projections)

Note: The problem density is calculated for each existing severity level.

Reference photographs

FP-L-1: Flashing sleeve is deformed.

FP-L-2: Opening in the penetration or flashing is less than 6 in. above the roof surface.

FP-M-2: Top of flashing sleeve is not sealed or has not been rolled down into an existing plumbing vent stack.

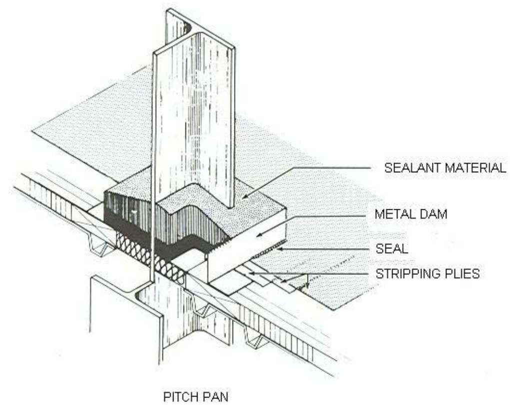
FP-M-3: The sleeve or umbrella is open or no umbrella is present (where required).

FP-H-1: Flashing sleeve or metal curb has been installed with no stripping plies.

FP-H-3: No flashing sleeve is present.

Pitch Pans (PP)

Description: A pitch pan is a flanged metal sleeve placed around a roof-penetrating element and filled with a sealer.



Pitch pan details.

Distress severity levels:

Low:

1. Pitch pans are rated low severity as a minimum due to the maintenance problems associated with them.

Medium:

1. Loss of granules or coating or delamination of foil surfacing and some deterioration of the stripping ply; but no holes, splits, or tears.

High: Any of the following defects:

1. Metal corrosion.
2. Sealing material is below metal rim.
3. Holes, splits, or tears in stripping ply caused by deterioration or physical damage.
4. Sealing material has cracked or separated from pan or penetration.

Measurement: Each distressed pitch pan should be counted once at the highest severity level that exists.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = number of distressed pitch pans
B = total length of flashed perimeter of roof section being rated (including flashings for penthouses, courtyards, and curbed projections)

Note: The problem density is calculated for each existing severity level.

Reference photographs

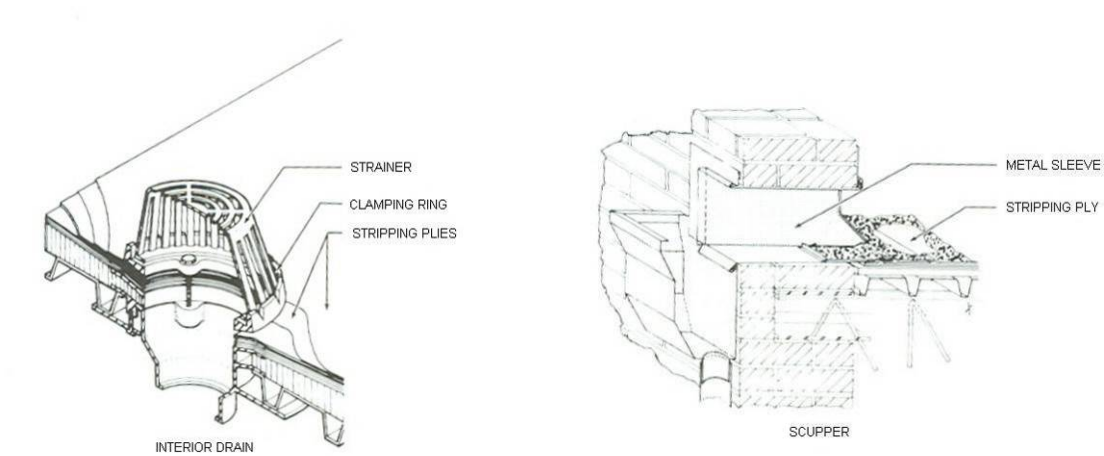
PP-L-1: Pitch pans are rated low severity as a minimum due to the maintenance problems associated with them.

PP-H-2: Sealing material does not fill pitch pan to top of metal rim.

PP-H-4 : Sealing material has cracked or separated from pan or penetration.

Interior Drains and Roof-Level Scuppers (DR)

Description: A drain is a penetration at the roof membrane which allows water to flow from the roof surface into a piped drainage system. The drain fixture at the roof has a flange and/or clamping arrangement to which the roofing membrane is attached. The lead flashing may be covered by the surfacing ply or separate stripping plies. A roof-level scupper is a channel through a parapet or raised roof edge which is designed for peripheral drainage of the roof.



Details for interior drain (left) and roof-level scupper (right).

Note: Stripping plies around scuppers should be carefully inspected for holes at corners.

Distress severity levels:

Low: Either of the following defects:

1. Bitumen has flowed into the drain leader but the drain is not clogged.
2. Loss of granules or coating or delamination of foil surfacing and poor appearance (including patching) but no visible deterioration of surfacing/stripping ply.

Medium: Any of the following defects:

1. Loss of granules or coating or delamination of foil surfacing and some deterioration of surfacing/stripping ply; but no holes, splits, or tears.
2. Strainer is broken or missing.

3. Scupper shows loss of paint or protective coating or start of metal corrosion.
4. Field seam exists under clamping ring.

High: Any of the following defects:

1. Holes, splits, or tears in stripping ply caused by deterioration or physical damage.
2. Clamping ring is loose or missing from drain body or bolts are missing.
3. Drain is clogged.
4. Scupper metal is broken or holes have occurred through the metal.

Measurement: Each distressed drain and scupper should be counted once at the highest severity level which exists.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = number of distressed interior drains and roof-level scuppers
B = total length of flashed perimeter of roof section being rated (including flashings for penthouses, courtyards and curbed projections)

Note: The problem density is calculated for each existing severity level.

Reference photographs

DR-L-1: Bitumen has flowed into the drain leader but the drain is not clogged. (Strainer was removed for photograph.)

DR-M-1: Loss of granules or coating or delamination of foil surfacing and some deterioration of surfacing/stripping ply.

DR-M-4: Field seam exists under clamping ring.

DR-H-1: Holes, splits, or tears in stripping ply caused by deterioration or physical damage.

DR-H-3: Drain is clogged.

4 Membrane Distresses

Blisters (BL)

Description: Blisters are round or elongated raised areas of the membrane which are filled with air.

Note: Blisters and ridges are difficult to differentiate at the low and medium severity levels. The rating error will be insignificant because of the similarity in the deduct curves. At high severity, however, it is important to distinguish between the two distresses due to their different leak potentials.

Blister severity levels:

Low:

1. The raised areas are noticeable by vision or feel. The surfacing is still in place and there is no membrane deterioration.

Medium: Either of the following defects:

1. The raised areas have a loss of surfacing (on mineral-surfaced membrane) and some deterioration of the membrane; but no holes, splits or tears.
2. Blister is beneath a seam, which has exposed unsurfaced membrane along the seam.

High: Either of the following defects:

1. The blisters are broken; there are holes, splits or tears.
2. Blister is beneath a seam, that has separated the surfacing plies at the lap and seam is open through its entire depth allowing water to penetrate.

Measurement:

- Measure the length and width of the blister in lineal feet and calculate the area (length times width). If the distance between individual blisters is less than 5 ft, measure the entire affected area in sq ft.
- When large quantities of this problem are present (especially on large roofs), the representative sampling technique can be used.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = total area of membrane blisters (sq ft)
B = total area of roof section being rated (sq ft)

Note: The problem density is calculated for each existing severity level.

Causes: Blisters are caused by voids or lack of attachment within the membrane. Moisture and gasses within the void greatly increases the potential for growth.

Blister photographs

BL-L-1: The raised areas are noticeable by vision or touch. The surfacing is still in place and there is no membrane deterioration.

BL-L-1: The raised areas are noticeable by vision or feel. The surfacing is still in place and there is no membrane deterioration.

BL-M-2: Blister is beneath a seam, which has exposed unsurfaced membrane along the seam.

BL-H-1: The blisters are broken; there are holes, splits or tears.

BL-H-1: The blisters are broken; there are holes, splits or tears.

Ridges (RG)

Description: Ridges are long, narrow (usually less than 3 in. wide), raised portions of the roof membrane. Their maximum height is about 2 in. Usually ridges occur directly above the insulation board joints and run perpendicular or parallel to the felts. They typically include all the plies and therefore are generally stiffer than blisters.

Note: Blisters and ridges are difficult to differentiate at the low and medium severity. The rating error will be insignificant because of the similarity in the deduct curves. However at the high severity, it is important to distinguish between the two distresses due to their different leak potentials.

Distress severity levels:

Low:

1. The ridges are noticeable but the surfacing is still in place and there is no membrane deterioration.

Medium: Either of the following defects:

1. The ridges are raised and clearly visible. The raised areas have loss of granules or coating or delamination of foil surfacing and some deterioration; but no holes, splits, or tears.
2. The ridge runs across seams, which have exposed unsurfaced membrane along the seams but do not allow water to penetrate through.

High: Either of the following defects:

1. Open breaks have developed in the ridge.
2. The ridge runs across seams, which have separated surfacing plies and the seams are open through their entire depth.

Measurement: Measure lineal feet of ridges running in all directions.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = total length of membrane ridges (ft)
B = total area of roof section being rated (sq ft)

Note: The problem density is calculated for each existing severity level.

Causes: Ridging can be the result of internally generated moisture vapor collecting at insulation joints and affecting the membrane or of movement of the substrate.

Ridge photographs

RG-L-1: The ridges are noticeable but the surfacing is still in place and there is no membrane deterioration.

Splits (SP)

Description: Splits are tears that extend through the top surface ply. They vary in length from a few feet to the length of the roof, and in width from a hairline crack to more than an inch. Splits generally occur directly above the joints between the long sides of insulation boards and run in the direction the felts were installed.

Distress severity levels:

High:

1. An unrepaired split or a repaired split which has started to re-open.

Measurement: Measure lineal feet of split.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

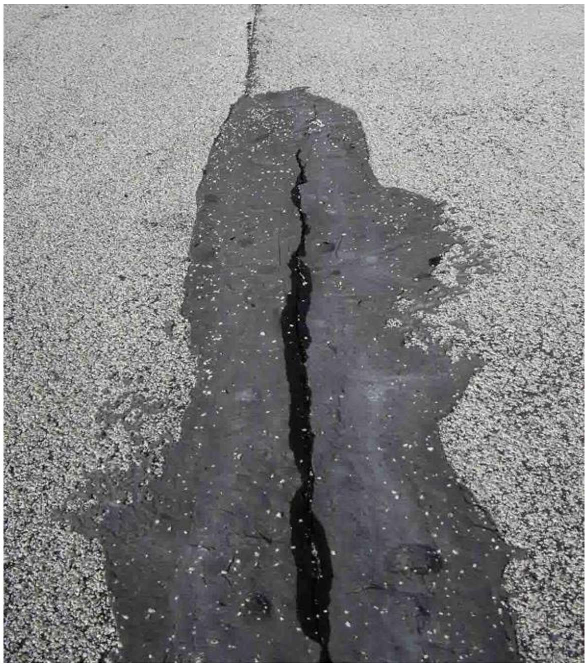
A = total length of membrane splits (ft)

B = total area of roof section being rated (sq ft)

Causes:

- There is little or no attachment between any of the following: membrane, insulation, vapor retarder (if any), and deck.
- Differential movement at deck joints.
- Structural movement within the roof system.
- Stress concentration due to shrinkage cracking of a poured deck.
- The membrane is too weak.

Reference photograph



SP-H-1: An unrepaired split or a repaired split which has started to reopen.

Holes (HL)

Description: A membrane hole is any visible opening that penetrates through the top surfacing ply. Holes can be of various sizes and shapes, and can be located anywhere on the roof surface.

Distress severity levels:

High:

1. All holes are considered high severity due to their high leak potential.

Measurement: Count the total number of holes in the membrane. If the distance between two holes is less than 1 ft, count them as one hole.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = number of membrane holes
B = total area of roof section being rated (sq ft)

Hole photographs

HL-H-1: All holes are considered high severity due to their high leak potential.

HL-H-1: All holes are considered high severity due to their high leak potential.

Defective Seams (DS)

Description: Defective seams include incomplete, damaged, or weak seams that join two adjacent surfacing plies.

Distress severity levels:

Low: Either of the following defects:

1. Seam is open less than ½ inch.
2. Fishmouths, wrinkling, blistering or ridging at seam that is watertight.

Medium: Any of the following defects:

1. Seam is open ½ inch or more, but does not allow water to penetrate the membrane.
2. Pinch wrinkle at seam.
3. Lap seam has exposed unsurfaced membrane (selvage edge) but does not allow water to penetrate the membrane.

High: Either of the following defects:

1. Seam is open through its entire depth, allowing water to penetrate.
2. Fishmouths, wrinkling, blistering or ridging at the seams that allow water to penetrate.

Measurement: Measure lineal feet of defective seams.

Density:

$$\text{Problem Density } = \frac{A}{B} \times 100$$

A = total length of defective seams (ft)

B = total area of roof section being rated (sq ft)

Note: The problem density is calculated for each existing severity level.

Causes:

- Seams improperly made.
- Seams damaged in use.
- Misalignment of surface plies during application.

Defective seam photographs

DS-L-1: Seam is open less than ½ inch.

DS-L-1: Seam is open less than ½ inch.

DS-M-1: Seam is open ½ inch or more, but does not allow water to penetrate the membrane.

DS-H-1: Seam is open through its entire depth, allowing water to penetrate.

DS-H-2: Fishmouths, wrinkling, blistering or ridging at the seams that allow water to penetrate.

Surface Deterioration (SR)

Description: A modified bitumen membrane will generally have one of the following types of surfacing: mineral surface-cap, smooth liquid applied, metal foil or aggregate or may be unsurfaced.

Note: Walkways are treated as part of the membrane surfacing.

Distress severity levels:

Low: Any of the following defects:

1. On aggregate surfacing, the aggregate is not embedded or is poorly embedded but the underlying ply remains covered with aggregate.
2. On smooth liquid applied surfacing, there is loss of coating but no visible deterioration of surfacing ply.
3. On smooth liquid applied surfacing, there is evidence of crazing of top surface with hairline cracks (alligatoring).
4. On mineral surfaced capsheet surfacing, there is loss of granules and poor appearance but no visible deterioration of surfacing ply.
5. On metal foil surfacing, there is delamination of foil surfacing and poor appearance but no visible deterioration of surfacing ply.
6. Walkway shows loss of surfacing, loss of adhesion, cracks, blistering or cracked coating.

Medium: Any of the following defects:

1. On aggregate surfacing, the aggregate is displaced and the top coat of bitumen is exposed.
2. On mineral surfaced capsheet surfacing, there is loss of granules, exposing the surfacing ply.
3. On smooth liquid applied surfacing, there is a loss of surface coating and reinforcement is exposed.
4. On smooth liquid applied surfacing, alligator cracks extend down through the coating to the surfacing ply.
5. On metal foil surfacing, the foil is torn, peeled or missing; exposing the underlying bitumen.
6. On unsurfaced membranes, there is alligatoring or loss of material exposing the reinforcement, but no deterioration of the membrane.

High: Any of the following defects:

1. On aggregate surfaced roofs, the aggregate cover has been displaced and the underlying surfacing ply is deteriorated.
2. On mineral surfaced-cap sheet roofs, there is loss of granules, exposing the modified bitumen and membrane is deteriorated.
3. On smooth liquid applied surfacing, there is loss of surfacing, modified bitumen is exposed and membrane is deteriorated.
4. On smooth liquid applied surfacing, alligator cracks extend down to the reinforcement and the membrane is deteriorated.
5. On metal foil surfacing, the foil is torn, peeled or missing; exposing the reinforcement and the membrane is deteriorated.
6. Shrinking of the walkway has torn the membrane below it.

Measurement:

- Measure square feet of each affected area and rate at highest severity level which exists.
- When large quantities of this problem are present (especially on large roofs), the representative sampling technique can be used.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = total area of surface deterioration (sq ft)

B = total area of roof section being rated (sq ft)

Note: The problem density is calculated for each existing severity level.

Causes:

- Poor granule embedment in bitumen during manufacturing.
- Wind erosion such as occurs at roof corners and water erosion such as occurs when downspouts empty directly onto the membrane.
- Alligatoring results from over-application of bitumen or aging bitumen, combined with weathering and temperature cycling. The bitumen

gradually loses the ability to flow back together and alligatoring is enhanced.
- For metal foil surfacing, excessive heat applied to back of sheet during application.
- Inadequate top pour coat during aggregate application.
- Use of bitumen on a slope that is greater than proper for that bitumen. The bitumen and gravel run off, leaving the underlying ply exposed. This can affect localized areas or the entire roof.
- Inadequate embedment of aggregate during application.

Surface deterioration photographs

SR-L-2: On smooth liquid applied surfacing, there is loss of coating but no visible deterioration of surfacing ply.

SR-L-3: On smooth liquid applied surfacing, there is evidence of crazing of top surface with hairline cracks (alligatoring).

SR-M-2: On mineral surfaced capsheet surfacing, there is loss of granules, exposing the surfacing ply.

SR-M-2: On mineral surfaced capsheet surfacing, there is loss of granules, exposing the surfacing ply.

SR-M-4: On smooth liquid-applied surfacing, alligator cracks extend down through coating to the surfacing ply.

Slippage (SL)

Description: Slippage is a downslope lateral movement of membrane plies. Slippage usually occurs on roofs with slopes greater than 1/4 in./ft.

Distress severity levels:

Low:

1. Less than 2 in. of slippage has occurred, evidenced by the presence of narrow bare strips perpendicular to the slope.

High:

1. More than 2 in. of slippage has occurred or the exposed bitumen has shown deterioration. There may be evidence of humping and wrinkling.

Measurement: Measure square feet of affected roof area. The affected area extends from the high point on the slope where bare felts are noticeable, down to the low point of the slope or the area where humping and wrinkling are noticeable.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = total affected area of roof (sq ft)

B = total area of roof section being rated (sq ft)

Note: The problem density is calculated for each existing severity level.

Causes:

- Inadequate fastening of membrane plies for the amount of roof slope present.
- Use of improper bitumen.
- Thickness of bitumen interply moppings is too great, reducing horizontal shear resistance between plies.

Slippage photographs

SL-H-1: More than 2 in. of slippage has occurred or the exposed bitumen has shown deterioration. There may be evidence of humping and wrinkling.

SL-H-1: More than 2 in. of slippage has occurred or the exposed bitumen has shown deterioration. There may be evidence of humping and wrinkling.

Patching (PA)

Description: A localized repair of the membrane done with cold-applied adhesive with fabric or felt embedded in it, with hot bitumen and felts, or modified bitumen materials. It should be obvious that the work is not part of the original roof construction.

Distress severity levels:

Low:

1. All patches are rated low severity as a minimum.

Medium:

1. The materials and workmanship of the patch are not equal to or better than the existing membrane.

High:

1. Ruptures or other membrane distresses of at least medium severity are present within the patched area (count as patching distress only).

Measurement:

- Measure square feet of each patch having the above defects.
- When large quantities of this problem are present (especially on large roofs), the representative sampling technique can be used.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = total area of patching (sq ft)

B = total area of roof section being rated (sq ft)

Note: The problem density is calculated for each existing severity level.

Patching photographs

PA-M-1: The materials and workmanship of the patch are not equal to or better than the existing membrane.

PA-M-1: The materials and workmanship of the patch are not equal to or better than the existing membrane.

PA-H-1: Ruptures or other membrane distresses of at least medium severity are present within the patched area.

Debris and Vegetation (DV)

Description:

- Foreign objects on the roof which could damage or puncture the membrane.
- The growth of vegetation on the roof.
- Accumulation of grease, solvent, or oil drippings on the roof.

Distress severity levels:

Medium: Any of the following defects:

1. The collection of foreign objects which are not removed from the roof during the inspection.
2. Grease, solvent, or oil drippings on the roof that show no degradation of the roof membrane.
3. Evidence of vegetation, but not penetrating the membrane.

High: Either of the following defects:

1. Grease, solvent, or oil drippings on the roof that is causing degradation to the roofing system.
2. Vegetation roots that have penetrated the membrane.

Measurement: Measure square feet of affected area. Each isolated case of debris and vegetation of less than 1 sq ft in area should be counted as 1 sq ft.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = total area of debris and vegetation (sq ft)
B = total area of roof section being rated (sq ft)

Note: The problem density is calculated for each existing severity level.

Debris and vegetation photographs

DV-M-1: The collection of foreign objects which are not removed from the roof during the inspection.

DV-M-2: Grease, solvent, or oil drippings on the roof which show no degradation of the roof membrane.

Improper Equipment Supports (EQ)

Description: Pipe, conduit, and mechanical equipment supports (wood sleepers, channels, etc.) which are placed directly on the roof surface with no protective pad or placed at insufficient height to allow for maintaining the membrane below the equipment. Repairing this distress may require replacing the surrounding insulation and membrane.

Note: Terminations for guy wires are to be rated as flashed penetrations.

Distress severity levels:

Low:

1. All improper equipment supports are rated low severity as a minimum due to the maintenance problems associated with them.

Medium: Either of the following defects:

1. Movement of the support has caused displacement of the roof surfacing but has not damaged the membrane.
2. The equipment is bolted through the membrane but the bolts appear to be sealed.

High: Either of the following defects:

1. The support has caused damage to the roof membrane.
2. The equipment is bolted through the membrane and the bolts appear not to be sealed.

Measurement: Measure square feet of each improper equipment support. The minimum dimension for length and width of a support shall be 1 ft.

Density:

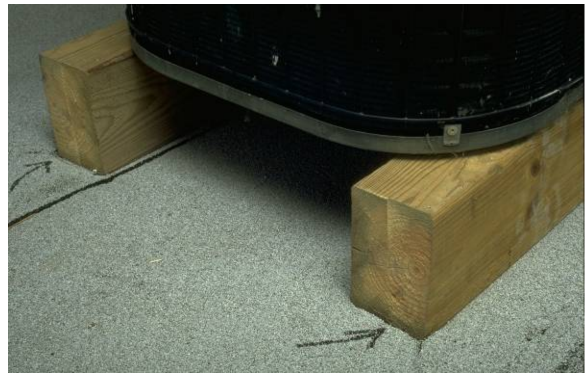
$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = total area of improper equipment supports (sq ft)
B = total area of roof section being rated (sq ft)

Note: The problem density is calculated for each existing severity level

Improper equipment support photographs

EQ-L-1: All improper equipment supports are rated low severity as a minimum due to the maintenance problems.



EQ-L-1: All improper equipment supports are rated low severity as a minimum due to the maintenance problems.

EQ-M-2: The equipment is bolted through the membrane but the bolts appear to be sealed.

EQ-H-2: The equipment is bolted through the membrane and the bolts appear not to be sealed.

Ponding (PD)

Description: Standing water is present or there is evidence of ponding by the presence of staining. Water that remains for more than 48 hours after rainfall is considered ponded water.

Distress severity levels:

Low:

1. Ponding is rated low severity due to the maintenance problems associated with correcting it.

Measurement: Measure square feet of affected area.

Density:

$$\text{Problem Density} = \frac{A}{B} \times 100$$

A = total area of ponding (sq ft)
B = total area of roof section being rated (sq ft)

Causes:

- Improper design of roof drainage system.
- Irregularities of membrane surface.
- Clogged roof drains and scuppers or obstructions.

Ponding

PD-L-1: Ponding is rated low severity due to the maintenance problems associated with it.

PD-L-1: Ponding is rated low severity due to the maintenance problems associated with it.

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Shahin, M.Y., D. Bailey, and D. Brotherson, *Membrane and Flashing Condition Indexes for Built-Up Roofs Volume I: Development of the Procedure*, Technical Report M-87/13/ADA190367 (CERL, September 1987a).

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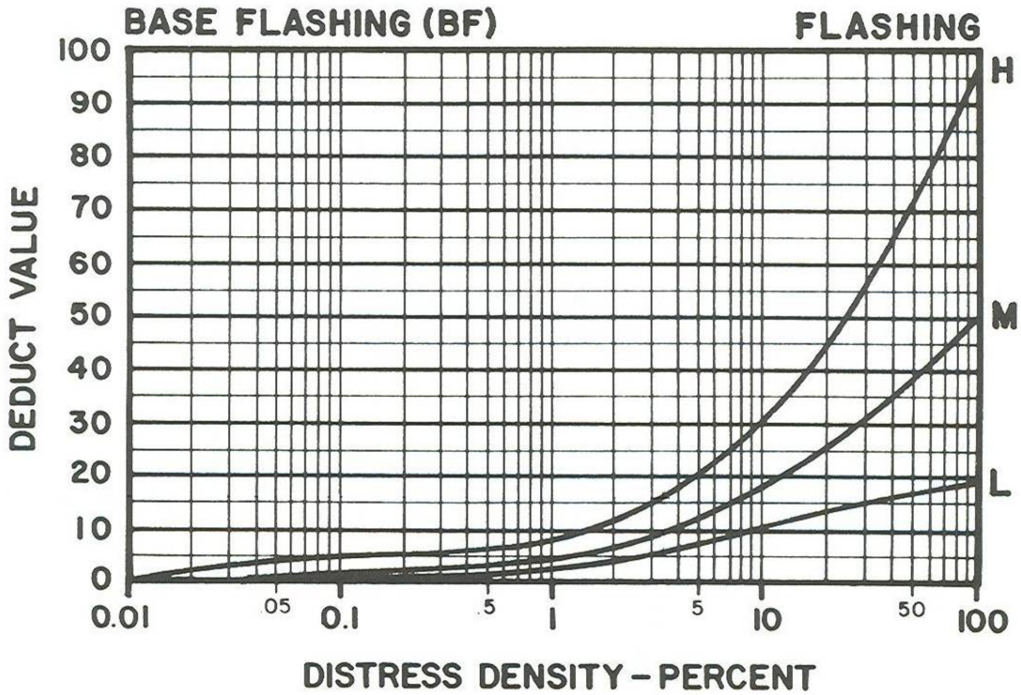
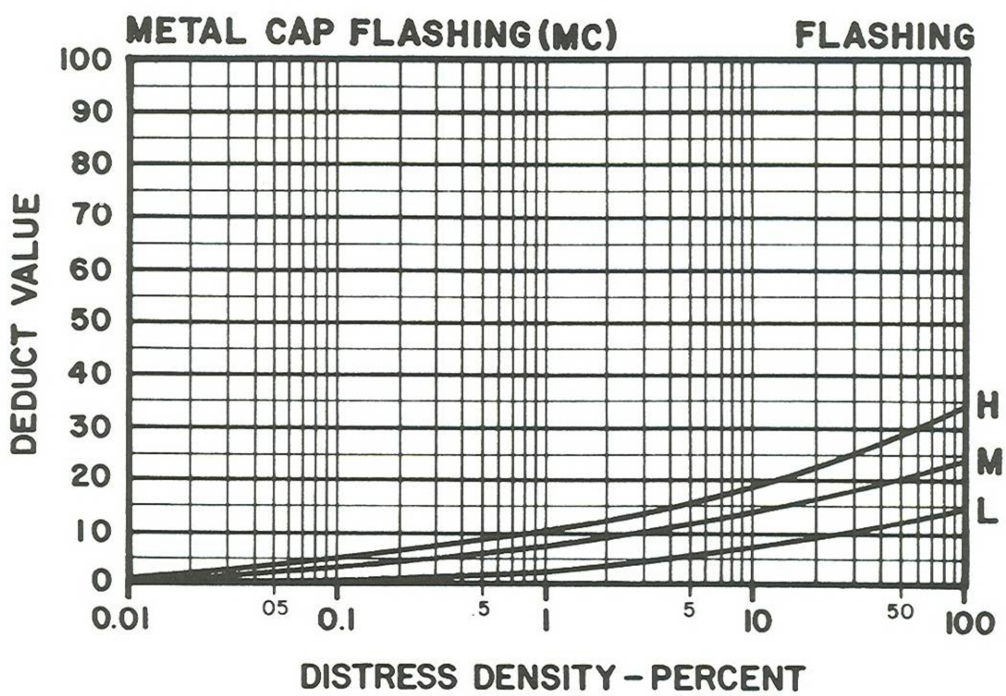
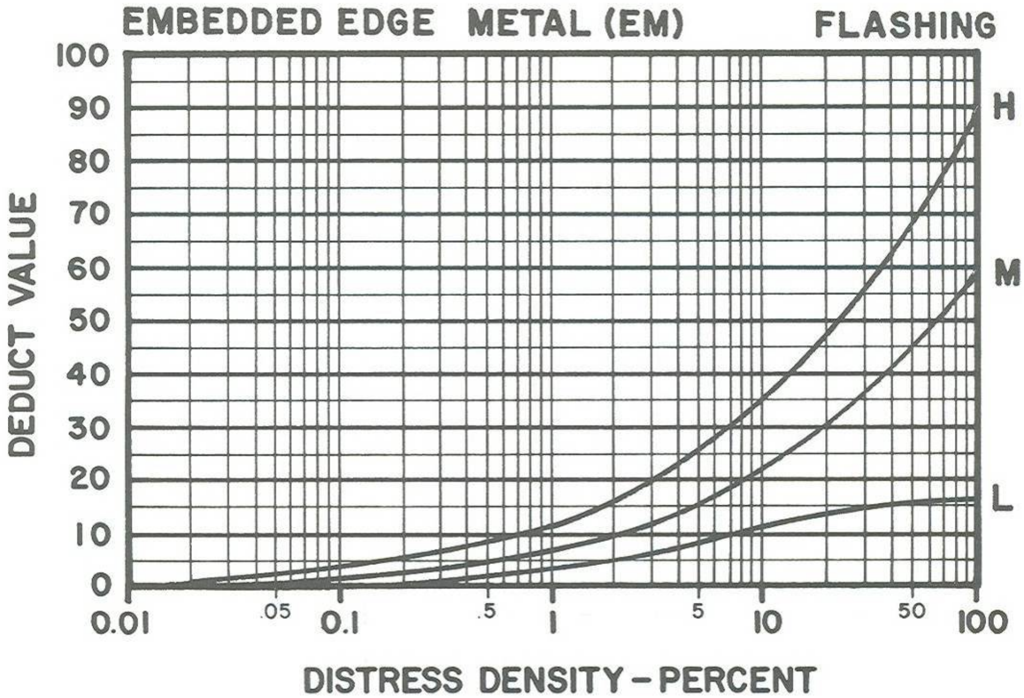
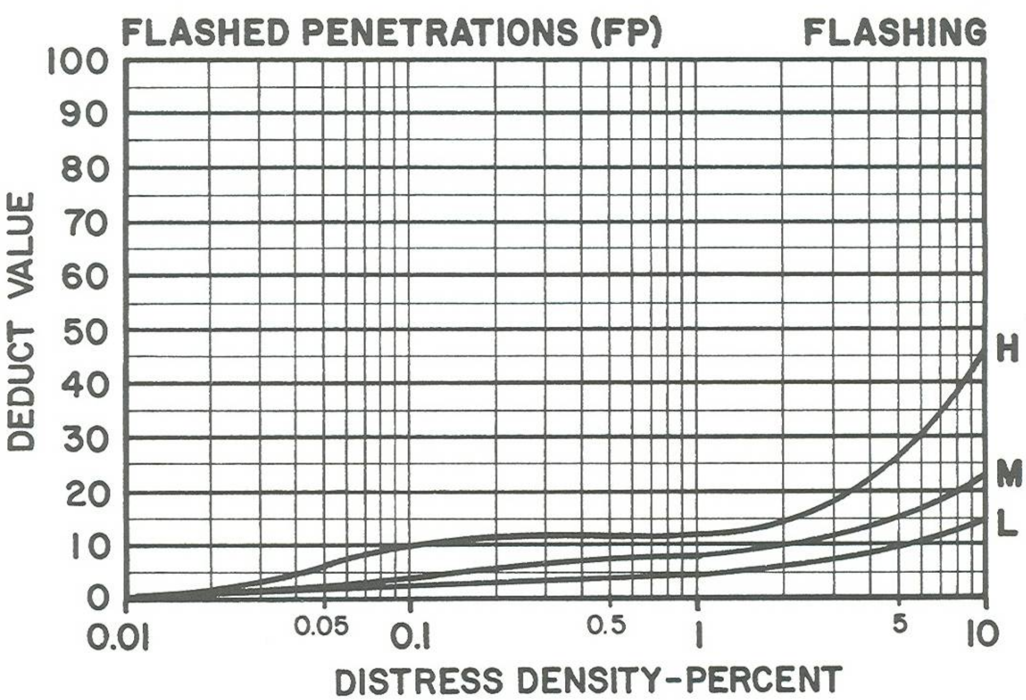
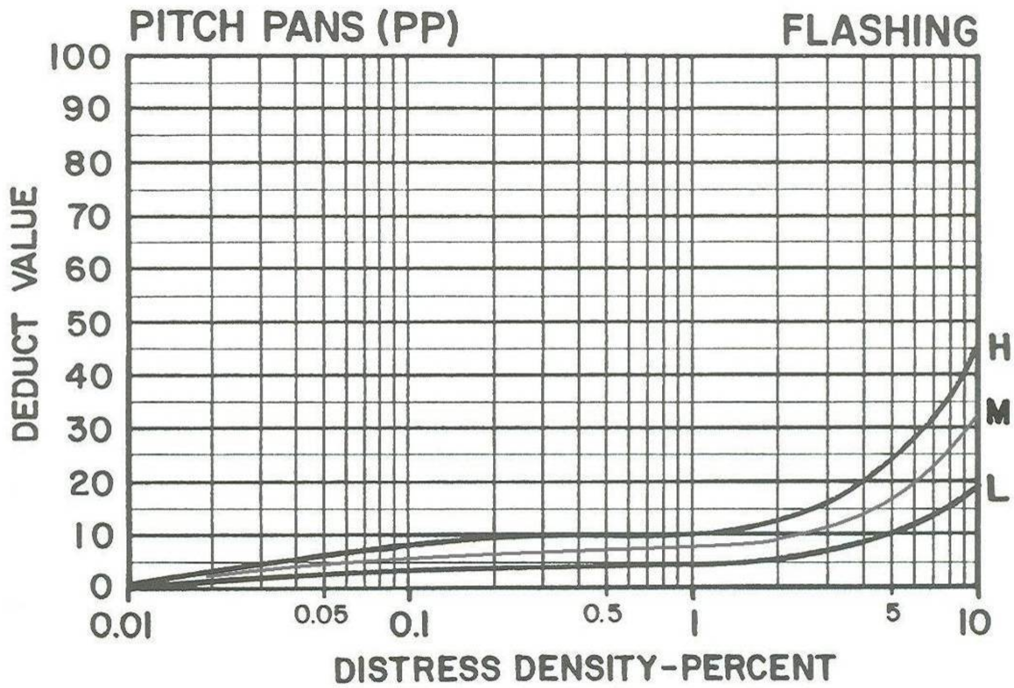
Appendix A: Deduct Value Curves

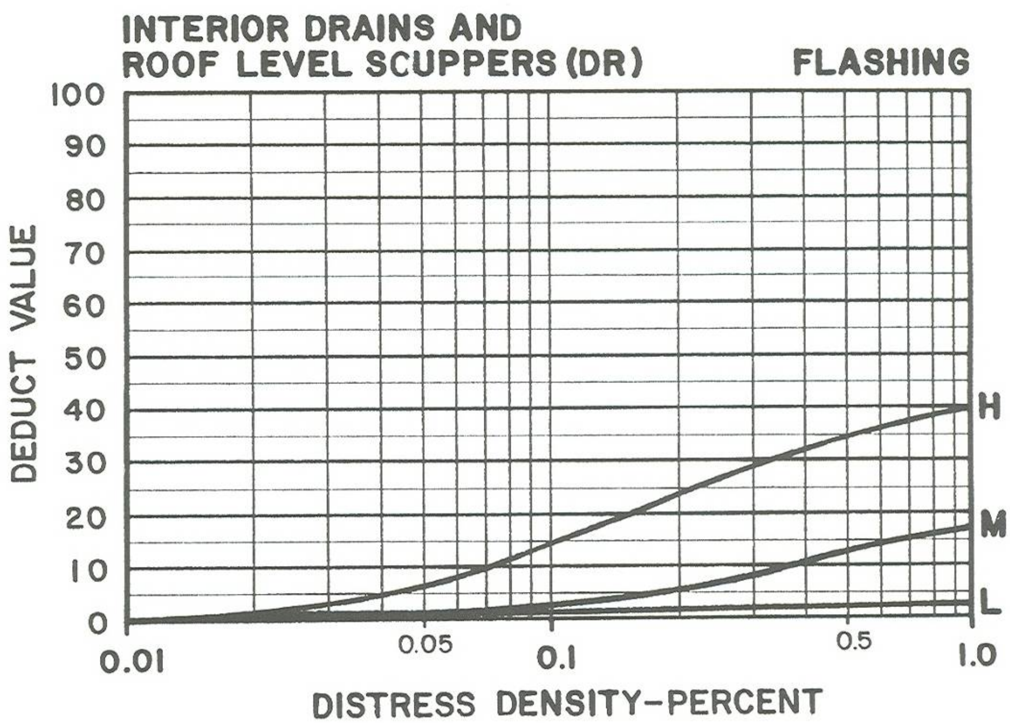


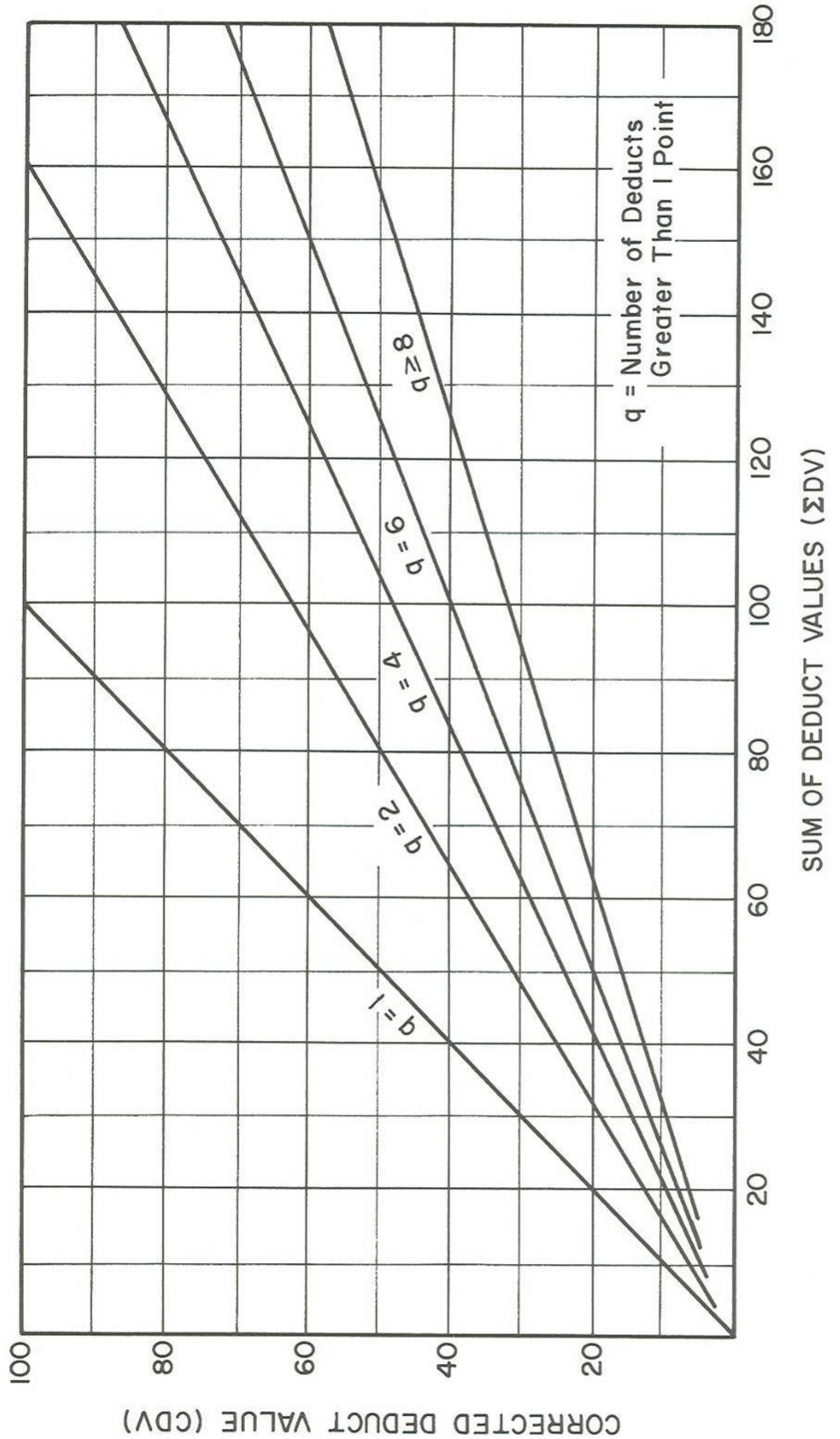



EMBEDDED EDGE METAL (EM)
FLASHING
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
M
L
0.01
.05
0.1
.5
1
5
10
50
100
DISTRESS DENSITY - PERCENT

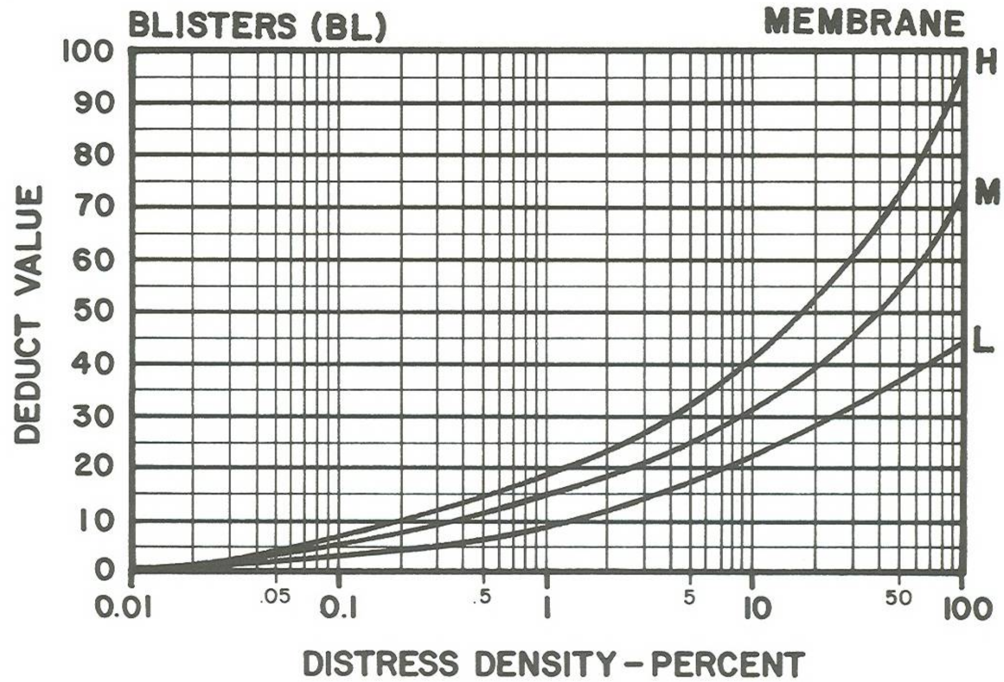

FLASHED PENETRATIONS (FP)
FLASHING
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
M
L
0.01
0.05
0.1
0.5
1
5
10
DISTRESS DENSITY-PERCENT

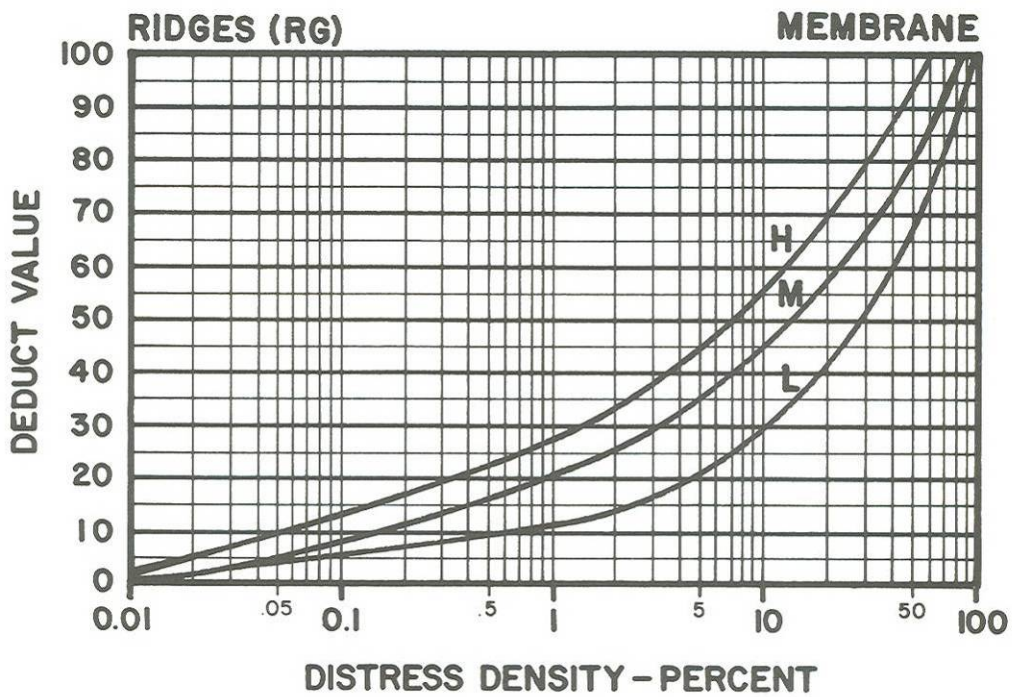

PITCH PANS (PP)
FLASHING
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
M
L
0.01
0.05
0.1
0.5
1
5
10
DISTRESS DENSITY-PERCENT

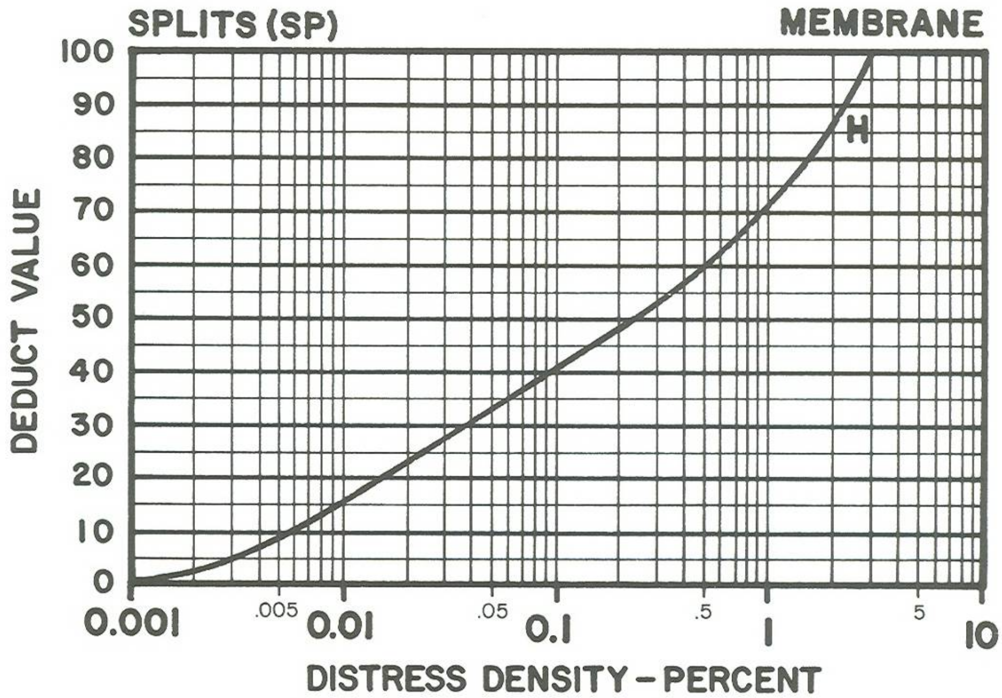

INTERIOR DRAINS AND
ROOF LEVEL SCUPPERS (DR)
FLASHING
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
M
L
0.01
0.05
0.1
0.5
1.0
DISTRESS DENSITY-PERCENT

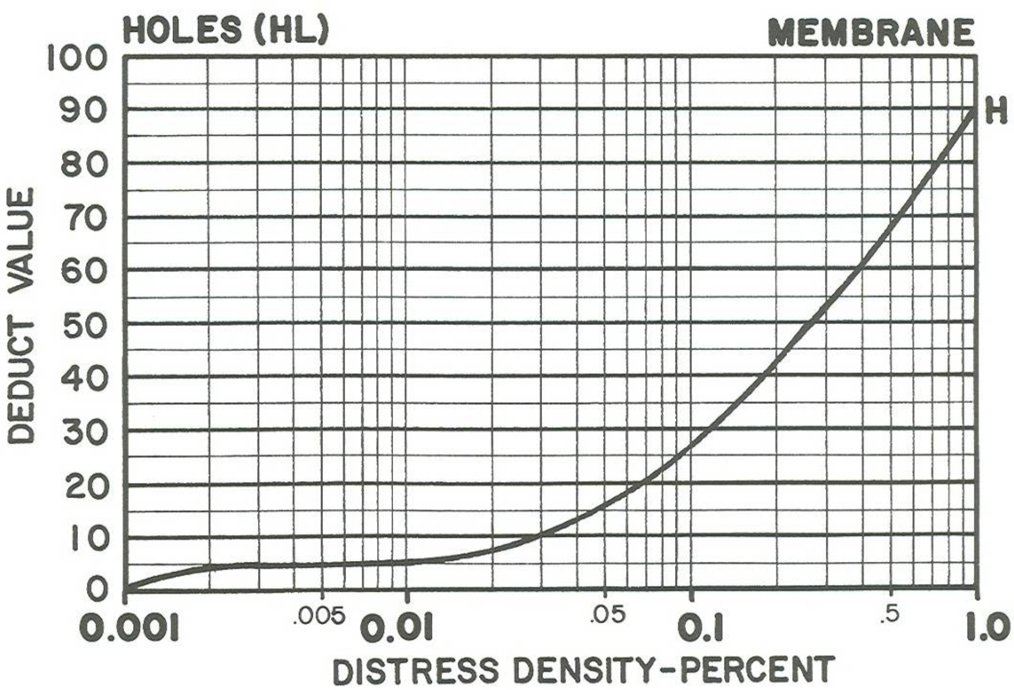


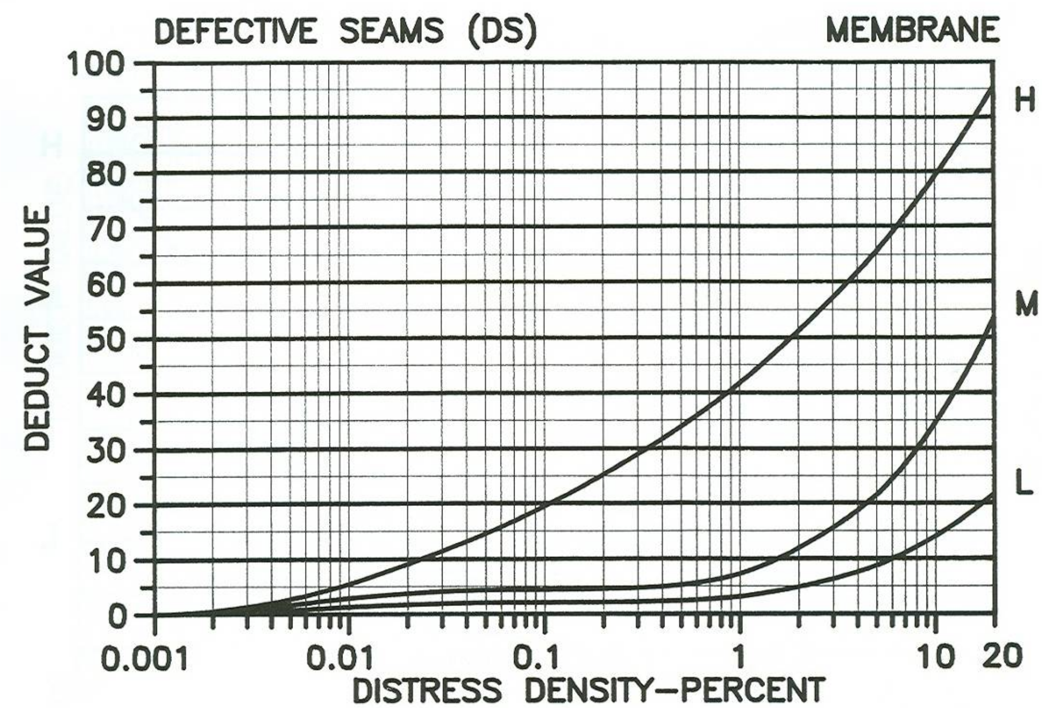
Corrected deduct values for flashing.


BLISTERS (BL)
MEMBRANE
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
M
L
0.01
.05
0.1
.5
1
5
10
50
100
DISTRESS DENSITY - PERCENT


RIDGES (RG)
MEMBRANE
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
M
L
0.01
.05
0.1
.5
1
5
10
50
100
DISTRESS DENSITY - PERCENT


SPLITS (SP)
MEMBRANE
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
0.001
.005
0.01
.05
0.1
.5
1
5
10
DISTRESS DENSITY - PERCENT


HOLES (HL)
MEMBRANE
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
0.001
.005
0.01
.05
0.1
.5
1.0
DISTRESS DENSITY-PERCENT


DEFECTIVE SEAMS (DS)
MEMBRANE
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
M
L
0.001
0.01
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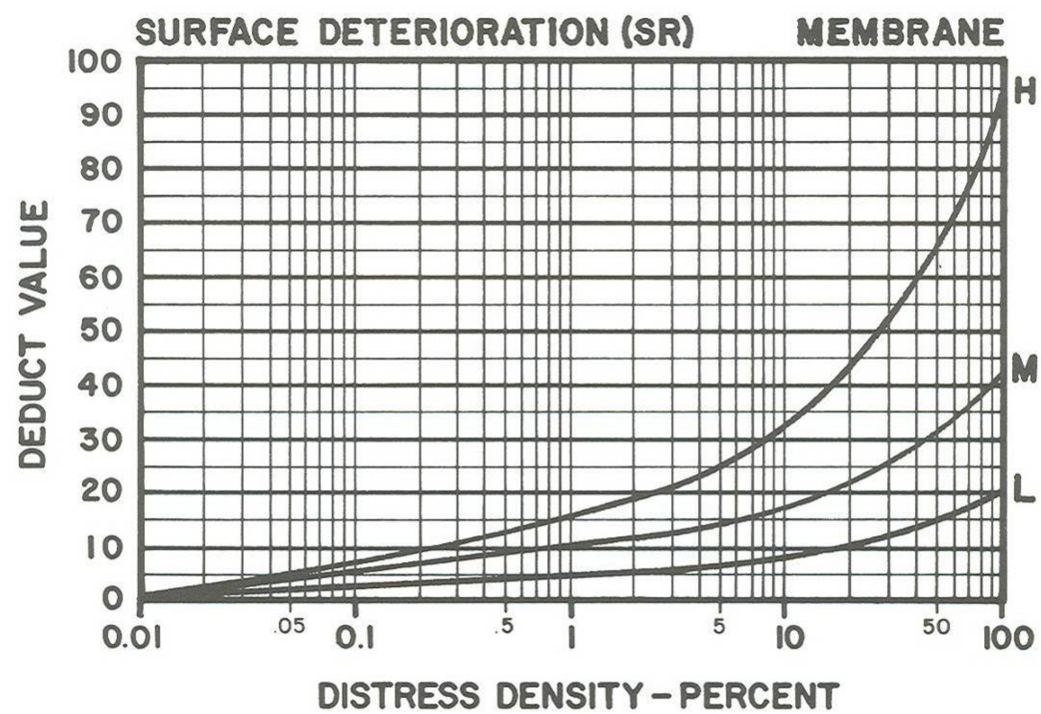
1
10
20
DISTRESS DENSITY–PERCENT


SURFACE DETERIORATION (SR)
MEMBRANE
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
M
L
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.05
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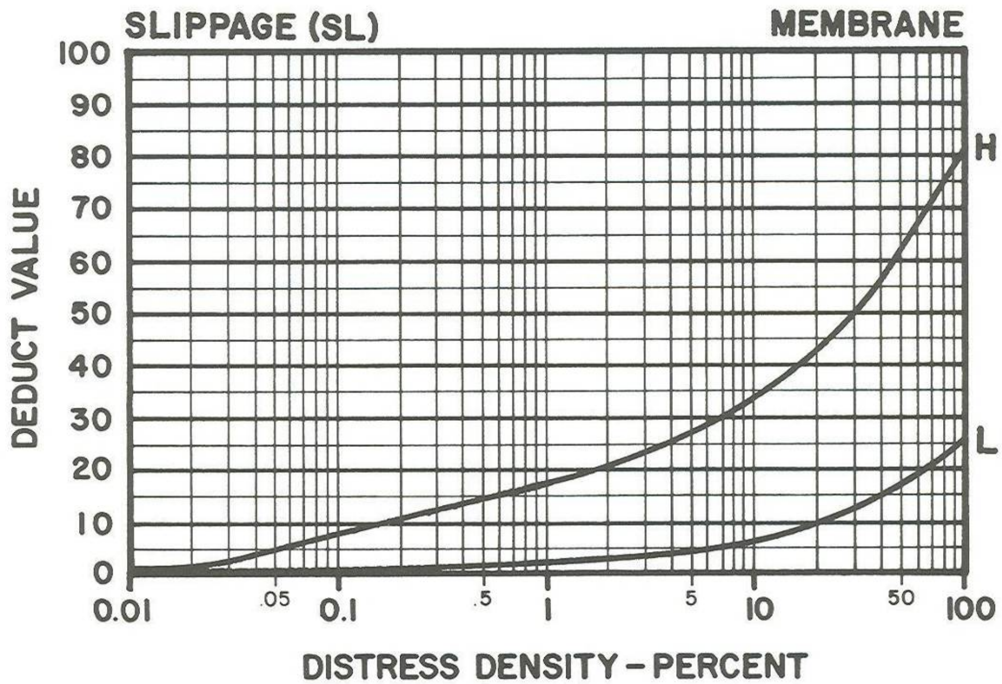
.5
1
5
10
50
100
DISTRESS DENSITY – PERCENT


SLIPPAGE (SL)
MEMBRANE
DEDUCT VALUE
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90
80
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60
50
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30
20
10
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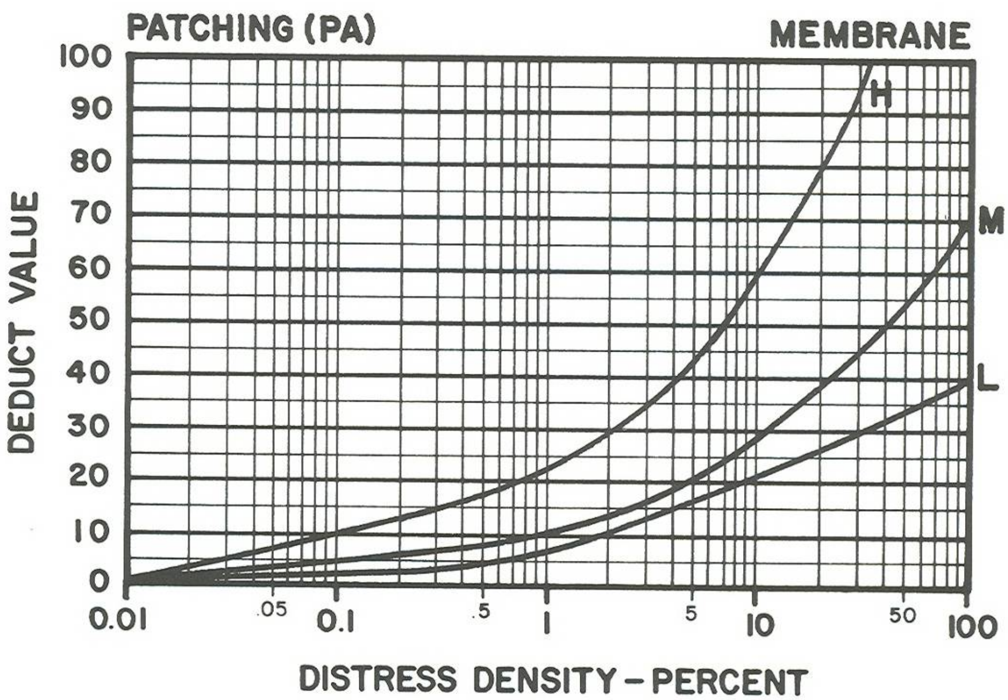
100
DISTRESS DENSITY - PERCENT


PATCHING (PA)
MEMBRANE
DEDUCT VALUE
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80
70
60
50
40
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20
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0
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M
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10
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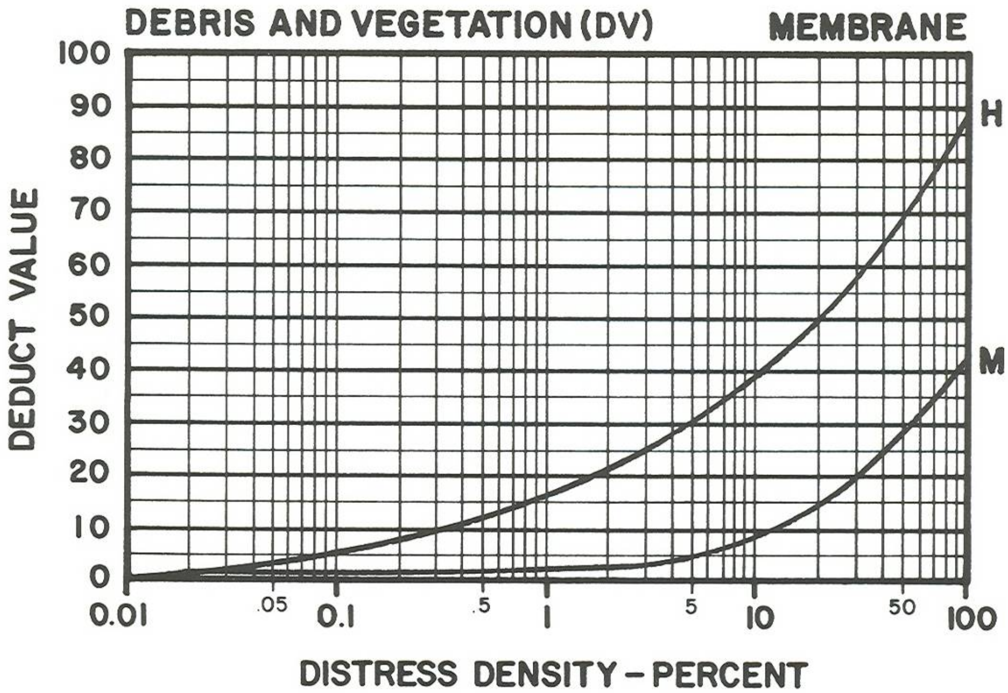
100
DISTRESS DENSITY - PERCENT


DEBRIS AND VEGETATION (DV)
MEMBRANE
DEDUCT VALUE
100
90
80
70
60
50
40
30
20
10
0
H
M
0.01
.05
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1
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10
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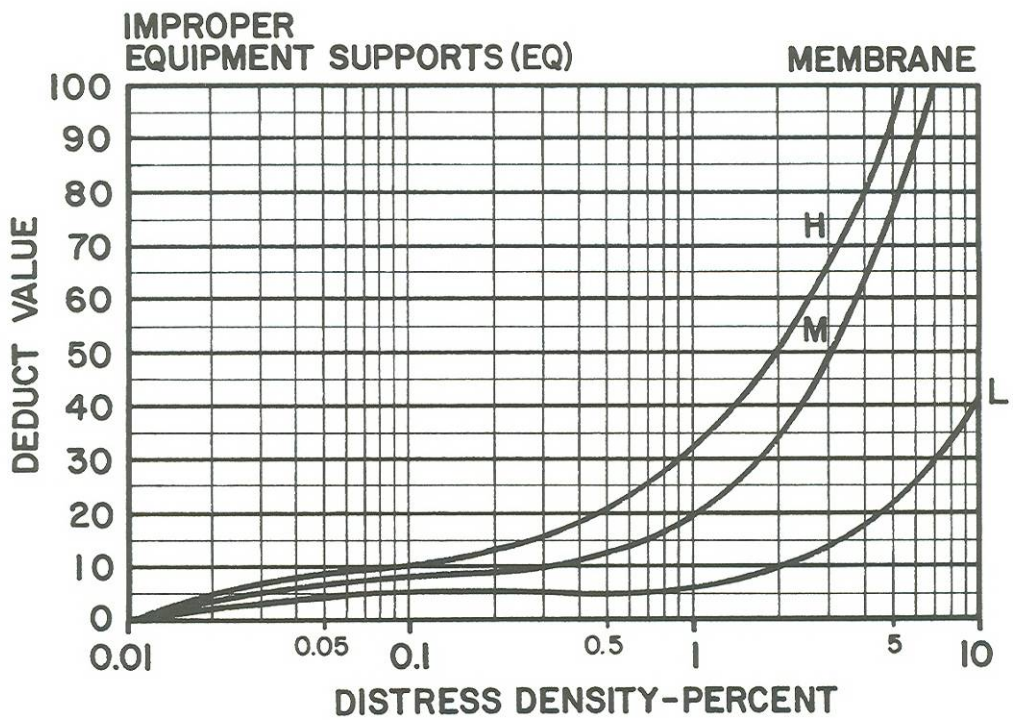
100
DISTRESS DENSITY - PERCENT


IMPROPER
EQUIPMENT SUPPORTS (EQ)
MEMBRANE
DEDUCT VALUE
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90
80
70
60
50
40
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20
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0
H
M
L
0.01
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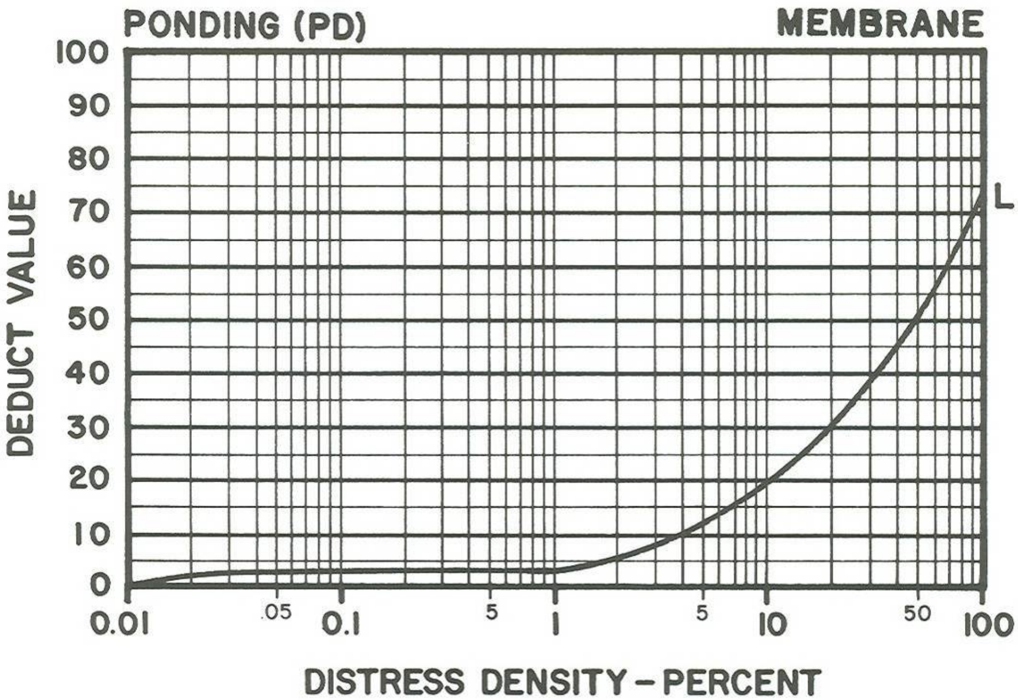
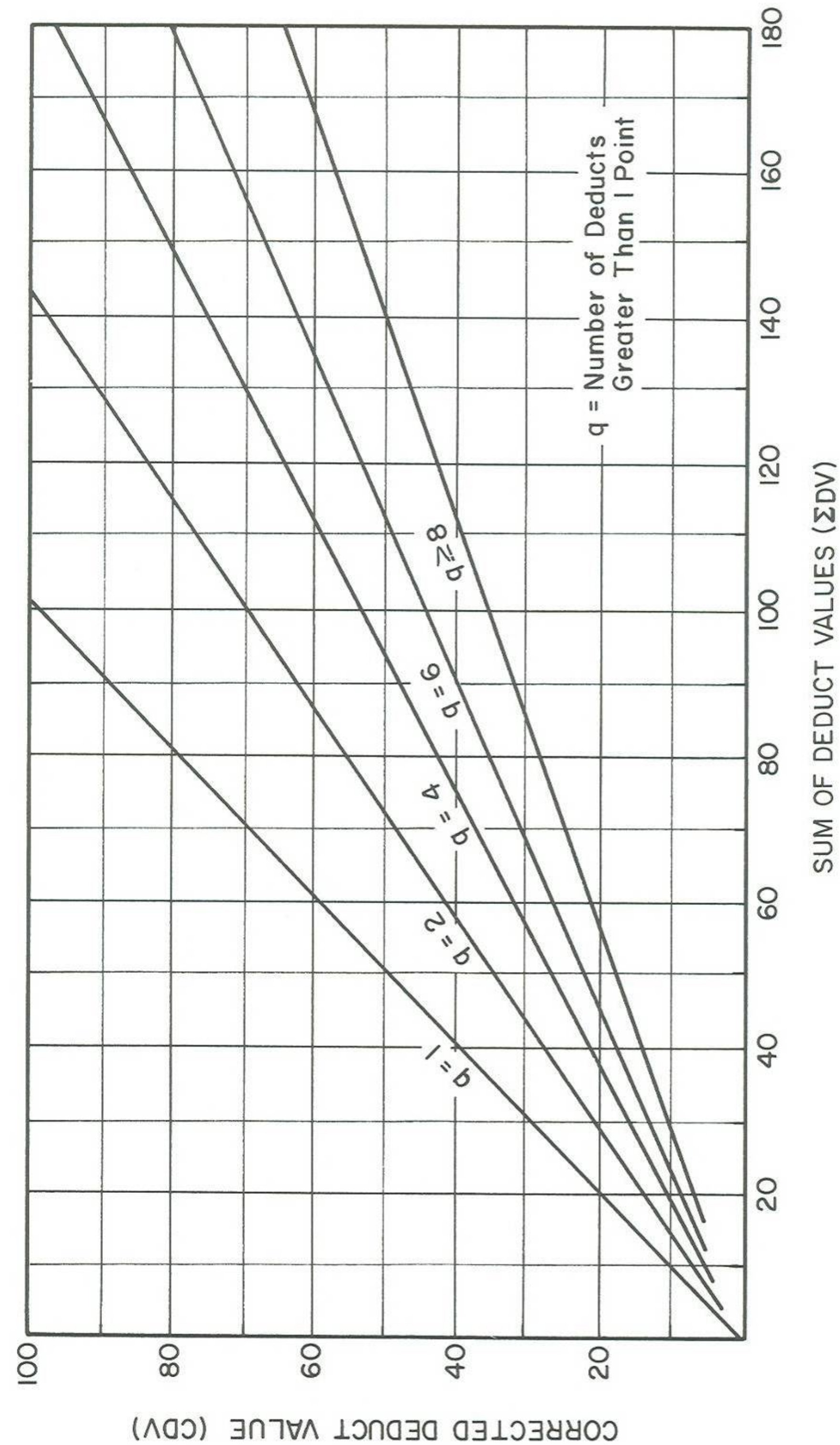
10
DISTRESS DENSITY-PERCENT


PONDING (PD)
MEMBRANE
100
90
80
70
60
50
40
30
20
10
0
DEDUCT VALUE
L
0.01
.05
0.1
5
1
5
10
50
100
DISTRESS DENSITY - PERCENT



Corrected deduct values for membrane.

Appendix B: Inspection and Rating Forms

On the following pages are a roof inspection worksheet (front and back) and a roof section rating form that may be photocopied for use.

ROOF INSPECTION WORKSHEET

AGENCY/INSTALLATION:

BUILDING ________________ PERIMETER FLASHING ______________ DATE ___________
SECTION ________________ CURB FLASHINGS ______________ NAME ___________

BF -BASE FLASHING
MC -METAL CAP
EM -EMBEDDED METAL
FP -FLASHED PENET.
PP -PITCH PANS
DR -DRAINS & SCUPS
BL -BLISTERS
RG -RIDGES
SP -SPLITS
HL -HOLES
DS -DEFECT. SEAMS
SR -SURFACE DET.
SL -SLIPPAGE
PA -PATCHING
DV -DEBRIS & VEG.
EQ -EQUIP. SUPPORTS
PD -PONDING

ID #	DISTRESS	SEVERITY	DEFECT	QUANTITY

NORTH

SCALE: ___________

ROOF INSPECTION WORKSHEET - COMMENTS

INSTRUCTIONS: Circle response, i.e., Y = yes, N = no or U = unknown or not observed. If Y (yes), circle the type of problem.

A. EVALUATION OF INTERIOR CONDITIONS

1. Does the roof leak? Describe:______________________ Y N U
____
____

2. Are there water stains on: Y N U
   a. walls c. deck e. structural elements
   b. ceilings d. floor f. other:_______________

3. Do structural elements show any of the following: Y N U
   a. cracks d. alteration g. physical damage
   b. splits e. rotting h. insect damage
   c. spalling f. settlement i. other:_______________

4. Does the underside of the deck show any of the following: Y N U
   a. rusting c. spalling e. sagging
   b. rotting d. cracks f. other_______________

B. EVALUATION OF EXTERIOR CONDITIONS

1. Do the exterior walls show any of the follwoing: Y N
   a. cracks c. spalling e. water stains
   b. rusting d. movement f. other:_______________

2. Does the fascia or soffit show any of the following: Y N
   a. cracks c. spalling e. water stains
   b. rusting d. peeling f. other:_______________

3. Do the gutters or downspouts show any of the following: Y N
   a. loose c. missing e. clogged
   b. damaged d. disconnected f. other:_______________

C. EVALUATION OF ROOFTOP CONDITIONS

1. Is there any unauthorized, unnecessary, or improperly installed equipment on the roof? Y N
   a. equipment c. antennas e. cables
   b. signs d. platforms f. other:_______________

2. Do adjacent parapet walls show any of the following: Y N
   a. cracks c. cap cracked e. sealant flaws
   b. spalling d. cap missing f. other:_______________

D. REMARKS:____
____
____
____
____

ROOF SECTION RATING FORM

BUILDING ________	SECTION ________	DATE ________	CALC. BY
PER. FLASHING ________ FT CURB FLASHING ________ FT	FLASHING TOTAL ________ FT	AREA ________ SQ FT	CHKD. BY

FLASHING

DISTRESS TYPES

BF -BASE FLASHING
MC -METAL CAP
EM -EMBEDDED METAL
FP -FLASHED PENET.
PP -PITCH PANS
DR -DRAINS & SCUPS

DIS	SEV	QUANTITIES	TOT	DEN	DV

CORRECTED DEDUCT VALUE (CDV)

FCI = 100 - CDV = ________

FLASHING RATING ________

MEMBRANE

DISTRESS TYPES

BL -BLISTERS
RG -RIDGES
SP -SPLITS
HL -HOLES
DS -DEFECT. SEAMS
SR -SURFACE DET.
SL -SLIPPAGE
PA -PATCHING
DV -DEBRIS & VEG.
EQ -EQUIP. SUPPORTS
PD -PONDING

DIS	SEV	QUANTITIES	TOT	DEN	DV

CORRECTED DEDUCT VALUE (CDV)

MCI = 100 - CDV = ________

MEMBRANE RATING ________

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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March 2010	Final	

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Membrane and Flashing Condition Indexes for Modified Bitumen Roofs: Inspection and Distress Manual

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
David M. Bailey

5d. PROJECT NUMBER

5e. TASK NUMBER
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ACSIM

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

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13. SUPPLEMENTARY NOTES

14. ABSTRACT
The U.S. Army is currently responsible for maintaining hundreds of millions of square feet of modified bitumen roofing on its facilities. Modified bitumen roofing systems share a number of characteristics with other common systems, but they also employ certain unique materials and therefore have their own specialized distress and degradation mechanisms. Dedicated inspection guidance and condition index calculation methods are required to quantify the condition of an installation's modified bitumen roofing assets in order to make the best use of Army maintenance and repair resources. This document was developed to provide roof inspectors with a standard reference for performing inspections, and calculating a flashing condition index (FCI) and membrane condition index (MCI) for use in facility maintenance management activities. It represents a new implementation of the widely used ROOFER Sustainment Management System for roofing asset maintenance management.

15. SUBJECT TERMS
ROOFER, roofing inspection, engineered management systems, sustainment management systems, modified bitumen roofs, asset management

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
Unclassified	Unclassified	Unclassified		90	

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