
USACE / NAVFAC / AFCEA UFGS-07515 (August 2004)

Preparing Activity: USACE Superseding
UFGS-07515A (January 2002)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 22 December 2004

Latest change indicated by CHG tags

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SECTION 07515

PROTECTED MEMBRANE ROOFING (PMR) 08/04

NOTE: This guide specification covers the requirements for protected membrane roof system.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

This guide specification includes tailoring options for paver ballast, and aggregate ballast. Selection or deselection of a tailoring option will include or exclude that option in the section, but editing the resulting section to fit the project is still required.

PART 1 GENERAL

NOTE: This specification covers a roofing system in which the membrane is protected by an overlay of extruded polystyrene insulation, a filter fabric, and a layer of ballast on top. The surface of overhangs must be sealed to prevent leakage of air and, therefore, uplift. For additional guidance on PMR, the designer should consult the National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual.

Roof must be constructed with a minimum slope of 1 to 48, and a maximum slope of 1 to 6. Drainage is critical as the insulation will float if submerged and not adequately ballasted. Where internal drains are not used, ice dams may occur at eaves and scuppers. For guidance on flashings and drainage details, the designers should consult the SMACNA "Architectural Sheet Metal Manual."

Undersides of the deck, including overhangs, should be sealed when using loose-laid protected membrane to prevent wind from pressurizing the underside of the membrane.

Bituminous membranes should be flood-coated and not surfaced with aggregate. Polystyrene should not be placed in contact with asphalt.

Except where exposed drain baskets pose a safety hazard, there must be an opening in the insulation, filter fabric, and ballast above each drain basket. Pavers above hidden drains will be marked so that the drains can be inspected periodically.

Designer should require materials, products, and innovative construction methods and techniques which are environmentally sensitive, take advantage of recycling and conserve natural resources.

1.1 REFERENCES

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 1177/C 1177M	(2001) Glass Mat Gypsum Substrate for Use as Sheathing
ASTM C 29/C 29M	(1997; R 2003) Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C 36/C 36M	(2001) Gypsum Wallboard
ASTM C 578	(2003a) Rigid, Cellular Polystyrene Thermal Insulation

ASTM C 726	(2000a) Mineral Fiber Roof Insulation Board
ASTM D 448	(2003) Sizes of Aggregate for Road and Bridge Construction
ASTM D 4751	(1999a) Determining Apparent Opening Size of a Geotextile
ASTM D 5034	(1995; R 2001) Breaking Strength and Elongation of Textile Fabrics (Grab Test)
ASTM D 751	(2000) Coated Fabrics

FM GLOBAL (FM)

FM P7825a	(2003) Approval Guide Fire Protection
FM P9513	(2002) Specialist Data Book Set for Roofing Contractors; contains 1-22 (2001), 1-28 (2002), 1-29 (2002), 1-28R/1-29R (1998), 1-30 (2000), 1-31 (2000), 1-32 (2000), 1-33 (2000), 1-34 (2001), 1-49 (2000), 1-52 (2000), 1-54 (2001)

SPRI (SPRI)

SPRI RP-4	(2002) Wind Design Standard for Ballasted Single-Ply Roofing Systems
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UNDERWRITERS LABORATORIES (UL)

UL 580	(1994; Rev thru Feb 1998) Tests for Uplift Resistance of Roof Assemblies
UL 790	(2004) Test Methods for Fire Tests of Roof Coverings

1.2 SUBMITTALS

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority.

Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Roof Assembly

Drawings required for the membrane shall be modified to include the complete PMR assembly.

SD-07 Certificates

Material and Equipment

The material supplier's or equipment manufacturer's statement that the supplied insulation, filter fabric and membrane materials meet specified requirements. Each certificate shall be signed by an official authorized to certify on behalf of material supplier or product manufacturer and shall identify quantity and date or dates of shipment or delivery to which the certificates apply.

Qualifications

Documentation verifying that the Contractor has a minimum of 2 years experience with PMR systems and has been certified by the PMR manufacturer as an approved Installer for the specified PMR system.

1.3 STORAGE OF MATERIALS

Insulation shall be stored away from areas where welding is being performed or where contact with open flames is possible. Insulation shall be shielded from extended exposure to sunlight. Materials damaged by moisture shall be removed from the site. Ballast shall not be stored on the roof.

1.4 FIRE RESISTANCE

The completed roof system shall be rated Class A as determined by UL 790 or Class I as determined by FM P7825a. Compliance of each component of the roofing system shall be evidenced by the label or written certification

from the manufacturer.

1.5 WIND UPLIFT REQUIREMENTS

NOTE: Design should be in accordance with SPRI
RP-4. Fully adhered protected membranes have
performed well in hurricane areas when ballasted as
specified in SPRI RP-4. Roof deck must be adequate
to support weight of ballast as dead load.

Wind uplift resistance of the complete roof assembly shall be rated Class
I-[60] [90] in accordance with UL 580. Wind resistance of loose-laid
ballasted system shall be in accordance with [FM P9513] [SPRI RP-4].

PART 2 PRODUCTS

NOTE: Insulation to be placed beneath the membrane
is described in Section 07220 ROOF AND DECK
INSULATION.

2.1 UNDERLAYMENT

NOTE: Loose-laid membrane will not be placed
directly on concrete or other hard, potentially
rough deck.

Underlayment may be [concrete] [any insulation which is suitable for the
particular membrane] [mineral fiberboard per ASTM C 726] [or] [gypsum board
per ASTM C 36/C 36M, 16 mm 5/8 inch thick or glass mat gypsum roof board
per ASTM C 1177/C 1177M and ASTM C 36/C 36M, [6.35 mm 1/4 inch] [12.7 mm 1/2
inch] [15.87 mm 5/8 inch]].

2.2 ROOF MEMBRANE

NOTE: Specify built-up roof, EPDM, modified bitumen
roofing, or PVC roof membrane, or allow Contractor
to choose from these options. Delete each
inapplicable roof membrane. When editing these
paragraphs, delete aggregate surfacing, walkways,
and types of insulation not used. Specify Section
07510 BUILT-UP ROOFING when membrane is applied
directly to concrete deck, and require two final
bitumen flood coats, each coat providing 1.5 kg of
bitumen per square meter (30 pounds per square).

Roof membrane shall be in accordance with Section [07511 BUILT-UP ASPHALT
ROOFING] [07530 ELASTOMERIC ROOFING (EPDM)] [07548 POLYVINYL CHLORIDE (PVC)
ROOFING] [or] [07550 MODIFIED BITUMEN ROOFING].

2.3 INSULATION ABOVE THE MEMBRANE

NOTE: Determine the required R-value and show the R-value at the appropriate detail on the drawings. The required R-value will never be less than that used in the Energy Budget Analysis.

Specify a vapor retarder only when required by calculations made as specified in ASTM Manual 18 "Moisture Control in Buildings" or in the CRREL-EC report "Vapor Retarders for Membrane Roofing Systems."

Insulation placed above the membrane shall be extruded polystyrene, or extruded polystyrene with a mortar face. Insulation shall be a standard product of the manufacturer, and shall be factory marked with the manufacturer's name or trade mark, the material specification number, the R-value at 24 degrees C, 75 degrees F, and the thickness. Boards shall be marked individually. The thermal resistance of the insulation shall be not less than the R-value shown on the drawings. Insulation shall conform to ASTM C 578, Type V, VI or VII and shall be intended by the manufacturer for use above a protected roof membrane. Bottom layer of insulation shall provide drainage paths, mostly parallel to the slope, between insulation and membrane. Top surface of mortar-faced insulation shall be 10 mm 3/8 inch thick portland cement latex mortar having minimum properties as follows: specific gravity: 2.0, compressive strength: 20.7 MPa (3000 psi) 3000 psi and bond strength to insulation: 69 kPa (10 psi). 10 psi. Top layer of insulation may have ribbed top surfaces when flat-bottom pavers are used as ballast. The Contractor shall comply with EPA requirements in accordance with Section 01670 RECYCLED / RECOVERED MATERIALS.

2.4 FILTER FABRIC

Filter fabric shall be either woven or non-woven pervious sheet of long chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride, formed into a pattern with distinct and measurable openings. The filter fabric shall provide an ASTM D 4751 Apparent Opening Size (AOS) no finer than the 0.125 mm No. 120 sieve and no coarser than the 0.212 mm No. 70 sieve. Edges of fabric shall be selvaged or otherwise finished to prevent raveling. Fabric shall have minimum weight of 102 gms/sq. m (3 oz/sq. yard) 3 oz/sq. yard and shall conform to the following table:

Property	Test Procedure	Result
Tensile strength	ASTM D 5034 Grab test method using 25 mm square jaws and a travel rate of 5 mm per sec (12 inches per minute) direction	29 kg/25 mm (65 lbs/in) minimum in any principal
Puncture strength	ASTM D 751 - Tension testing machine with ring clamp; steel ball replaced with a 8 mm (5/16 inch) diameter solid steel	18 kg (40 lbs) minimum load

Property	Test Procedure	Result
	cylinder with a hemispherical tip centered within the ring clamp	
Property	Test Procedure	Result
Tensile strength	ASTM D 5034 Grab test method using 1 inch square jaws and a travel rate of 12 inches per minute	65 lbs/in minimum in any principal direction
Puncture strength	ASTM D 751 - Tension testing machine with ring clamp; steel ball replaced with a 5/16 inch diameter solid steel cylinder with a hemispherical tip centered within the ring clamp	40 lbs minimum load

2.5 BALLAST

NOTE: Pavers are preferred over aggregate ballast, and a combination of pavers and ballast is preferred over aggregate only.

Determine ballast and/or paver size and quantity using SPRI RP-4 and modify paragraph BALLAST INSTALLATION accordingly. SPRI RP-4 allows crushed stone over protected membrane. Use light-colored aggregate when locally available. Small aggregate will not be used in vicinity of aircraft operations; however, rock or paver ballast may be used in such areas. Where ambient temperatures drop below freezing, avoid use of ballast or pavers that will break during freeze-thaw cycles.

Installations where this roofing system is used should be monitored; any problems or noteworthy benefits encountered in the use of this system should be brought to the attention of HQUSACE (CEMP-ET) WASH DC 20314-1000 for information and possible dissemination.

Ballast shall be screened gravel, screened crushed stone, precast concrete pavers, or extruded polystyrene insulation with integral mortar topping. Size and placement shall be as indicated.

2.5.1 Pavers

Concrete pavers shall be air-entrained concrete, minimum 38 mm 1-1/2 inches thick, having 21 MPa (3000 psi) 3000 psi minimum compressive strength. Pavers shall be ribbed on the bottom for use over smooth topped insulation and flat on the bottom for use over insulation with ribbed top.

2.5.2 Aggregate Ballast

Gravel and crushed stone shall conform to ASTM D 448, Size 4 and 2, with less than 2 percent that passes through a 10 mm 3/8 inch screen. Ballast shall have minimum unit mass of 960 kg/cubic meter 60 pounds/cubic foot as determined by ASTM C 29/C 29M.

PART 3 EXECUTION

3.1 ROOF MEMBRANE AND FLASHING

Roof membrane and flashing shall be installed in accordance with Sections [07511 BUILT-UP ASPHALT ROOFING] [07530 ELASTOMERIC ROOFING (EPDM)] [07548 POLYVINYL CHLORIDE (PVC) ROOFING] [or] [07550 MODIFIED BITUMEN ROOFING].

3.2 FLOOD TEST

After the membrane and its flashings are installed, and before the insulation is placed above the membrane, the drains shall be plugged and the roof shall be flooded with water for 24 hours. Leaks shall be remedied before insulation is installed.

3.3 INSULATION

NOTE: Specify or indicate a 0.13 mm (4 mil)
polyethylene sheet below the insulation when surface
is flood coat bitumen.

Insulation shall be loose laid on the membrane after the membrane is completed and flood coat (if any) is cool. When required by the manufacturer of the insulation, a slip sheet shall be installed over the membrane. Drainage paths shall be provided between the lower surface of the insulation and the membrane. Most of the drainage paths shall be parallel to the slope of the roof. Unless otherwise specified by the manufacturer, end joints shall be staggered. Joints between boards shall not exceed 6 mm. 1/4 inch. Insulation shall be installed to within 19 mm 3/4 inch of projections and cant strips.

3.4 FILTER FABRIC INSTALLATION

Filter fabric shall be laid loose over insulation, smooth and free of tension and stress. Edges and ends shall be lapped a minimum of 300 mm 1 foot and extended above the ballast 50 to 75 mm 2 to 3 inches at the perimeter and penetrations. Joints parallel to perimeter will not be permitted within 1.8 meters 6 feet of the perimeter.

3.5 BALLAST INSTALLATION

Ballast shall be placed to provide a weight of 479 Pa 10 psf on the roof area, except that the weight shall be 957 Pa 20 psf within 1.2 meters 4 feet of the roof perimeter. At approved intervals, the placed ballast shall be weighed and corrected to be within plus or minus 10 percent of specified weight. Pavers shall be installed where indicated. Pavers above hidden drains shall be marked so that drains may be inspected. Interior roof drains shall be surrounded with gravel or stone graded between 25 and 38 mm 1 and 1-1/2 inches to the level of ballast over insulation or to mid-height

of drain bonnet, whichever is lower. During placement of aggregate ballast, drains and other openings shall be covered to prevent inadvertent entry of ballast. Ballast buggy wheels shall not be allowed on the membrane.

3.6 INSPECTION

NOTE: Where justified by the amount or criticality of the insulation and roofing involved, and similar requirements are not established for the Contractor Quality Control Organization specified elsewhere, the following INSULATION TECHNICIAN and inspection requirements may be added:

"INSULATION TECHNICIAN

A roof insulation technician responsible directly to the Contractor and experienced in the installation of roof insulation and related work shall perform the inspection functions and shall be on the site whenever roof insulation operations are in progress."

The Contractor shall establish and maintain an inspection procedure to ensure compliance of the installed roof with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Inspection shall include, but not be limited to, the following:

- a. Observation of environmental conditions; number and skill level of roofing workers; start and end time of various tasks; condition of substrate.
- b. Verification of compliance of materials before, during, and after installation, proper storage and handling of insulation.
- c. Inspection of mechanical fasteners; type, number, length, and spacing.
- d. Coordination with other materials, cants, nailers, flashings, and penetrations.
- e. Inspection of proper placement of insulation, joint orientation and laps between layers, joint widths and bearing of edges of underlayment on deck.
- f. Inspection of proper placement of pavers and amount and leveling of ballast.

Procedures shall be submitted for approval prior to start of roofing work and shall include a checklist of points to be observed. The actual inspections shall be documented and a copy of the documentation furnished to the Contracting Officer at the end of each day.

-- End of Section --