

Preparing Activity: NAVFAC

Superseding
UFGS-13 31 33 (February 2023)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2026

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SECTION 13 31 34

FRAME SUPPORTED MEMBRANE STRUCTURES FOR AIRCRAFT HANGARS OR PROTECTION OF
AIRCRAFT
02/26

NOTE: This guide specification covers the requirements for frame supported membrane structures for use on airfields for either an aircraft hangar or for protection of aircraft (weather, sunshade, environmental shelter).

These types of structures have had numerous and significant failures. The intent of this guide specification is to help eliminate and mitigate known issues and causes of these failures. Because these types of structures are often procured as equipment versus real property, normal designer of record responsibilities, technical review and technical coordination may be inadvertently avoided, overlooked or not performed due to the process. This guide specification, including notes to the specifier, should be followed regardless of the procurement process being used to help direct proper responsibilities and coordination.

Causes of failures have included frame corrosion, excessive frame deflection, inadequate wind-load design, inadequate fabric strength, fabric deterioration, inadequate foundation design, lack of foundation design, lack of maintenance, and more.

There is a history of foundation failures due to improper or inadequate foundations and anchorage being relied upon by the manufacturer without a licensed professional engineer being involved. The foundation and anchorage design must be sealed and signed by a licensed professional engineer and provided to the frame supported membrane structure manufacturer for coordination and compatibility. It is imperative that there is a plan in place for the procurement for both foundation design by a licensed professional engineer, the frame supported membrane

structure and the installation.

Adhere to [UFC 1-300-02 Unified Facilities Guide Specifications \(UFGS\) Format Standard](#) when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a [Criteria Change Request \(CCR\)](#).

NOTE: It is beyond the intent of this specification to include items such as Doors, Windows, Electrical, Communications, Heating, Fire Protection, or other such building systems which are more covered in other specifications and are governed by UFC 4-211-01 AIRCRAFT MAINTENANCE HANGARS.

NOTE: Foundations are not included in this specification and must be designed by a Professional Engineer in accordance with UFC 3-301-01 STRUCTURAL ENGINEERING and the support conditions (layout, configuration, reactions, anchorage, and other design elements) provided by the frame supported membrane structure manufacturer. Pay special attention to uplift forces and attachment to the foundations. If this is an equipment procurement, validate who is responsible to design and coordinate the foundation.

NOTE: Aircraft rated pavements are not included in this specification and must be designed by a Professional Engineer in accordance with UFC 3-260-02 PAVEMENT DESIGN FOR AIRFIELDS. Provide aircraft tie-down/anchorage and grounding as required.

NOTE: Accessory items, if required, are not specified in this specification. Examples of accessory items are included below in the list of items to show in Drawings. If these accessory items are required by the project specifier, please refer to potential reference sources such as UFC 3-260-02

PAVEMENT DESIGN FOR AIRFIELDS or UFC 4-211-01
AIRCRAFT MAINTENANCE HANGARS for guidance on design
standards.

For these designs, utilize a Professional Engineer
to perform the design including system detailing
suitable for the environment and project need.
While accessory items are not required to be
provided by the manufacturer, they are required to
be supported by the manufacturer, by this
specification. Carefully consider any accessories
as some DoD policy may consider these as real
property versus equipment, depending on utility
services.

NOTE: On the design drawings, show:

1. Location and quantity of the frame supported
membrane structures. Locate in accordance with
Chapter 2-1 of UFC 4-211-01 AIRCRAFT MAINTENANCE
HANGARS, specifically considering Airport Operations
Area (AOA) safety, clearances, and security as well
as Construction Phasing for ongoing airfield
operations.

2. Appropriate design loads for Live, Snow, Wind,
Rain, Ice and Earthquake (Seismic) Loads, including
resistance to Hail Impact. Show design wind
pressures based on the design wind velocity,
including component and cladding loads by
contributory area.

3. Size and arrangement of frame supported membrane
structures, including, but not limited to,
permissible column locations, permissible x-bracing
locations (if any), and roof configuration with
slope(s) or radii. In the case of more than one
sunshade, also note whether each sunshade is stand
alone or shares bracing frames.

4. Clearances for frame supported membrane
structure and any accessory items to the parked
aircraft, aircraft operations, equipment, and
aircraft ingress and egress. If applicable to the
operation, clearances must include consideration for
heat associated with Engines and Auxiliary Power
Units (APU) as well as thrust from engines (jet
blast).

5. Fabric membrane color and specular gloss.
Surfaces must not produce glare to aircraft in
flight or to the control tower. Provide roofs and
other external surfaces with a specular reflectance
compatible with the location of structure on the
airfield. If located such that glare is an
operational hazard, provide surfaces of the
structure with a light reflectance of not more than

10, measured at an angle of 85 degrees in accordance with American Society of Testing and Materials (ASTM) D523 (Specular Gloss) at critical surfaces of the structure.

6. Foundation design, including layout of the columns and their attachment to the foundation. Configuration, type, size, spacing, minimum embedment and minimum projection of anchor bolts, or anchoring system, to the foundation must be provided to resist the column reactions with special attention to uplift forces. This design must be provided by a licensed professional engineer experienced in the design of foundation and anchoring systems.

7. Aircraft maintenance bay slab on ground, including thickness, joint locations/detailing, aircraft tie-down/anchorage and grounding as required. Include SECTION 03 30 00 CAST-IN-PLACE CONCRETE, at a minimum, in order to properly specify aircraft rated pavements interior to hangars.

8. Accessory items, if required. Examples of accessory to be shown elsewhere in the Contract documents for coordination with this product include Aviation Obstruction Lighting, Apron Lighting, Understructure Security/Task Lighting, Utilities (such as power, communications/data, compressed air, water), Ventilation/De-stratification, Eyewashes, Lightning Protection, Fall Protection, and any other applicable items. Include system detailing suitable for the environment. Accessory items are not required to be provided by the manufacturer but are required to be supported and braced by the manufacturer if shown in the Contract Documents.

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project

specification when you choose to reconcile
references in the publish print process.

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.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

- AISC 325 (2017) Steel Construction Manual
- AISC 360 (2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

- ASCE 55 (2016) Tensile Membrane Structures

AMERICAN WELDING SOCIETY (AWS)

- AWS D1.1/D1.1M (2025) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

- ASTM A36/A36M (2019) Standard Specification for Carbon Structural Steel
- ASTM A53/A53M (2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- ASTM A123/A123M (2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A153/A153M (2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A500/A500M (2023) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- ASTM A572/A572M (2025) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- ASTM A780/A780M (2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- ASTM A992/A992M (2022) Standard Specification for Structural Steel Shapes
- ASTM D751 (2019) Standard Test Methods for Coated Fabrics

- ASTM D2136 (2019; E 2021) Coated Fabrics - Low-Temperature Bend Test
- ASTM E84 (2025) Standard Test Method for Surface Burning Characteristics of Building Materials
- ASTM F3125/F3125M (2019) Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 409 (2026) Standard on Aircraft Hangars
- NFPA 701 (2023; ERTA 1 2023) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

U.S. DEPARTMENT OF DEFENSE (DOD)

- MIL-STD-889 (2021; Rev D) Galvanic Compatibility of Electrically Conductive Materials
- UFC 1-200-01 (2022; with Change 4, 2024) DoD Building Code
- UFC 3-301-01 (2023; with Change 6, 2026) Structural Engineering

1.2 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification with a code of up to three characters 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 and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Manufacturer's Qualifications; G, [_____]

Installer's Qualifications; G, [_____]

SD-02 Shop Drawings

NOTE: Sealed by the frame supported membrane structure's Registered Professional Engineer.

Frame Supported Membrane Structure; G, [_____]

Erection Plan; G, [_____]

SD-03 Product Data

Fabric (Membrane); G, [_____]

Product Data

SD-04 Samples

Fabric (Membrane); G, [_____]

SD-05 Design Data

NOTE: Sealed by the frame supported membrane structure's Registered Professional Engineer.

Frame Supported Membrane Structure; G, [_____]

Sealed and Signed Calculations

Sealed and Signed Shop Drawings

SD-07 Certificates

Welding Procedures and Qualifications; G, [_____]

SD-10 Operation and Maintenance Data

Frame Supported Membrane Structure O&M, Data Package 1; G, [_____]

SD-11 Closeout Submittals

Final Completion Certification; G, [_____]

Manufacturer's Warranty; G, [_____]

1.3 DESIGN REQUIREMENTS

The frame supported membrane structure depicted in the Construction Documents is representative of a permanent, custom designed, prefabricated, commercially available system. Design and fabricate the structure and fabric membrane in accordance with ASCE 55 and NFPA 409, to fit within the space allocated, including support and bracing for accessory items, and in accordance with the criteria specified herein, including all aircraft clearances and permissible bracing locations, if permitted. The structure's fabric membrane cladding cannot be utilized to brace or support any structural member such that, should any damage of the fabric membrane occur, the integrity of the structural framework is not adversely affected. Contractor will [utilize the sealed and signed foundation and anchorage design included in the Construction Documents] [include a sealed and signed foundation and anchorage design]. Submit complete sealed and signed calculations for the frame supported membrane structure prepared by the manufacturer's registered professional engineer, including bracing locations, column reactions and attachment to the foundation for verification of compatibility with the foundation design, including column uplift. Provide calculations in a logical and orderly manner for independent review. Submit complete sealed and signed shop drawings for the frame supported membrane structure prepared by the manufacturer's registered professional engineer.

1.3.1 Loads

Design the frame supported membrane structure to support all dead loads, including weights of accessory items, combined with Live, Snow, Wind, Rain, Ice, Earthquake (Seismic) and Temperature Loads as required by the Contract Documents, UFC 1-200-01 and UFC 3-301-01. Provide separate reactions for each load combination used in the design of the structure in accordance with ASCE 55.

NOTE: Delete the following subsections if Loads are specified elsewhere in the Contract Documents, such as in the Structural Drawings Sheets.

In the paragraphs below, use the appropriate Risk Category as determined from UFC 4-211-01.

[1.3.1.1 Live Load

Design the structure and fabric membrane to support a [non-reducible] uniform live load of [575 Pa] [12 psf] [_____][plus a point load of 1.33 KN 300 pounds acting over any 1 square foot area].

1.3.1.2 Snow Load

Design the structure and fabric membrane to support a uniform snow load of [_____] Pa psf. Include unbalanced snow loads and loads due to snow drifts as required by the geometry of the roof including adjacent roofs.

1.3.1.3 Wind Loads

Design the structure and fabric membrane for a wind speed of [_____] kmh mph, Risk Category [III][_____] , and Exposure Category [_____] . Utilize the appropriate wind pressures for Main Frame, and Components and Cladding, based upon the appropriate tributary area. Design all components to withstand both the highest positive and negative pressures including a minimum jet blast pressure of [960 Pa] [20 psf] [_____] . Design and provide support and bracing for accessories.

1.3.1.4 Rain

The structure must be capable of withstanding the effects of rainfall up to [_____] cm inches per hour for a minimum of [2][_____] hours.

1.3.1.5 Ice

Design all exposed elements, including the fabric membrane, to support a uniform ice accumulation of [_____] mm inches on all sides of all surfaces. Provide system to resist damage from hail.

1.3.1.6 Earthquake (Seismic)

Design the structure using a Short Period Acceleration [_____]g, Long Period Acceleration [_____]g, Soil Site Class [_____] , Risk Category [III][_____] , along with codified factors, coefficients and methods consistent with the type of seismic force resisting system(s) being designed and provided. Design and provide support and bracing for accessory items.

1.3.1.7 Temperature

Design all structural elements, including the fabric membrane to be capable of being assembled, utilized and dismantled in all ambient temperatures between [_____] C and [_____] C [_____] degrees F and [_____] degrees F. Provide a fabric membrane designed to withstand a temperature of [_____] C degrees F.

1.3.2 Deflections

Deflection due to the imposed loading of any truss panel point or joint where a purlin or column connects to one of the main structural frames must be less than the clear width (span width) of the structure divided by 180 (span width/180). In addition, coordinate with the hangar door and bridge crane manufacturer to not exceed their deflection limitations and provide details accommodating differential deflections in both the downward and upward direction.

1.3.3 Structural Frame System

Provide a steel structure, including all connections and attachments. Design the structure in accordance with the requirements of the Contract

Documents, UFC 1-200-01 and UFC 3-301-01. Design all structural members in accordance with the specified loads and the requirements of AISC 325, AISC 360. Thin-walled steel, less than 5 mm3/16 inches structural material thickness, or cold-formed steel are prohibited. Design connections for structural elements and fabric membrane to transfer all forces present in each joint, including required factors of safety. Connection eccentricities, where lines of force do not align with nodal points, are not permitted unless accounted for and modeled in the calculations. Where sleeve joints are used, the material must be appropriately sized and reinforced to avoid shear failure of the material.

1.3.3.1 Wall and Roof Structure

Provide a steel structure of the shape indicated in the Contract Documents. Surfaces must be planar, sloped or radiused as indicated. Structure must also be square and plumb. Provide the interior of the structure clear of any structural members or obstructions. Provide purlin and girt spacing to ensure structural stability, to minimize unsupported areas of fabric membrane in the walls and roof. Provide for installation and support of accessory items. Laterally brace the main structural frames with purlins and girts at intervals no greater than [2 m] [6.5 feet] [_____].

1.3.3.2 Lateral Force Resisting System(s)

NOTE: Based upon historical failures, the second paragraph below prohibits use of cable x-bracing. Based upon the size of the structure, the second paragraph below should be edited to not permit tension only bracing or to allow tension only rod bracing, depending upon applicable seismic limitations.

Provide a complete lateral and diagonal bracing system to properly stabilize the structural frame elements in all directions, to fit within the space allocated, including all aircraft clearances and permissible braced bay locations, if permitted. Provide moment frames where braced bays are not permitted as determined by anticipated movement of people and equipment around the aircraft parking position(s). Coordinate the lateral force resisting system with the foundation, including anchorage to the foundation. The fabric membrane is not permitted to serve as a diaphragm in the lateral force resisting system.

[Tension only bracing is not permitted.][Tension only rod assemblies are permitted to serve as bracing. The minimum permitted rod diameter for bracing is [10 mm] [3/8 inch] [_____]. Design rod connections to the structural frame using attachment clips, or lugs, not less than [10 mm] [3/8 inch] [_____] thick steel and detail and install in a manner to prevent slacking or loosening over time. The use of cables is not permitted.]

[1.3.3.3 Accessory Items

Provide framing and points of attachment to support and brace all accessory items. Accessory items are indicated in the Contract Documents and include[Building Systems,][Aviation Obstruction Lighting,][Apron Lighting,][Understructure Security/Task Lighting,][Utilities

(communications/data, compressed air, water),][Eyewashes,][Lightning Protection,] [_____].

1.3.4 Fabric Membrane System

Design to form a continuous, uninterrupted cover over the framework. Cover the[entire wall and] roof area of the structure with the[insulated] fabric membrane in accordance with the design drawings included with this specification.

1.3.4.1 Fabric Membrane Joints and Seams

Provide adjacent cladding sections with a mechanical tensioning system which allows the fabric membrane to be fully tensioned around the structure. Maintain proper gaps between sections to allow sufficient distance to enable full tensioning of the material resulting in the fabric membrane securing tightly and neatly over the structural frame with a remaining range of adjustment. Overlap seams such that the fabric membrane panels are supplied with overlapping joints to allow adjacent panels to be field heat-sealed together.[Seal around all required penetrations for accessory items, such as vents.]

Provide fabric pretensioning in frame-supported fabric membrane structures to prevent the fabric membrane from making contact with structural framing members during buffeting or flutter and include a factor of safety to account for the loss of tensioning likely to occur over the service life of the fabric.

1.3.4.2 Design Factor of Safety

Design the fabric membrane, using the load combinations and strength reduction factors as required by [ASCE 55](#). Utilize minimum net factors of safety as indicated in Table 4-2 of [ASCE 55](#) compared to the tensile strength of the fabric membrane while accounting for degradation due to UV and temperature effects.

1.3.5 Bird Nesting/Roosting Mitigation

Design a mitigation system, using bird netting, to prevent bird access, roosting and nesting within the structure and accessory items. Coordinate the design and installation of the bird netting with all accessory items and their function.[Alternatives to bird netting which function to eliminate nesting surfaces under the roof and inside the covered areas of the sunshade may be accepted as alternatives to bird netting.]

1.4 QUALITY ASSURANCE

1.4.1 [Manufacturer's Qualifications](#)

Provide a complete system from a manufacturer who has regularly engaged in the design, fabrication, erection, and service of frame supported membrane structures of the type and size required for this project. The manufacturer must have at least 5 years of similar design experience in membrane clad, steel framed structures. The manufacturer's Professional Engineer in Responsible Charge must have at least 5 years of similar design experience, including height and clear span, in membrane clad, steel framed structures. Perform all aspects of design, fabrication, erection, and service of these frame supported membrane structures in accordance with a comprehensive quality system, such as ISO 9000

certification or other comparable and proven quality program.

Contractor must submit written evidence of each of the above requirements for similar past designs, fabrications and installations and include a list of the names, locations, contact information of owners, installation dates, overall sizes, features, and other relevant information for experience, qualifications and quality evaluation. Only manufacturers who can submit this evidence of actual installations where the products have proven practicable, durable, and require a minimum of maintenance, will be qualified under this specification.

1.4.2 **Installer's Qualifications**

Installation of the frame supported membrane structures must be supervised by a manufacturer's representative, performed by an authorized representative of the manufacturer and in accordance with approved shop drawings and manufacturers written instructions, including coordination with the foundation and anchorage design. Installers must be skilled and experienced in the erection of similar membrane clad, steel framed structures of the type specified herein, including height and clear span.

Installers must submit written evidence of each of the above requirements for similar past designs, fabrications and installations and include a list of the names, locations, contact information of owners, installation dates, overall sizes, features, and other relevant information for experience, qualifications, and quality evaluation. Only installers who can submit this evidence of actual installations will be qualified under this specification.

1.5 **SHIPPING, HANDLING AND STORAGE**

Provide shipping documents with lists showing the description, quantity and piece marks of the various parts, components, and elements. Clearly mark all individual parts or bundles and packages of identical parts for identification or otherwise identify by clear installation procedures. Package bolts and fasteners according to type, size, and length. Package loose nuts and washers according to size and type. Deliver materials in original rolls, packages, containers, boxes, or crates bearing the manufacturer's name, brand, and project reference numbers.

Handle carefully to prevent damage. At no time must materials be dropped, thrown, or dragged over the transport equipment or the ground. Store materials and equipment in dry locations with adequate ventilation, free from dust and water, and to permit access for inspection and handling. Remove damaged items that cannot be restored to like-new condition and provide new items.

1.6 **WARRANTY**

NOTE: Intention of this specification is to obtain a steel structure, designed to meet minimum loading conditions with sufficient corrosion protection and have it perform similarly to a permanent structure. For the fabric membrane component, the below warranty is reasonable for many environments with current materials. Specifier should consult with manufacturers when in harsh environments regarding warranty and coordinate with Government/User

**expectations regarding establishment of reasonable
fabric membrane replacement intervals.**

For the fabric membrane, provide a warranty for all materials and workmanship for a period of [15][_____] years beginning from the date of final acceptance. Include full repair or replacement coverage, including labor and materials. Include in the warranty for fabric membrane, failure due to deterioration, breakdown, mildew, heat, cold, fading, discoloration, or other failure under design conditions. Include in the contractor's warranty, a copy of the fabric manufacturer's warranty which indicates a minimum of 70 percent strength is maintained for the full duration of the warranty.

PART 2 PRODUCTS

2.1 FRAME SUPPORTED MEMBRANE STRUCTURE

Provide new materials without defects and free of repairs. Provide materials of the quality and requirements specified herein.

Submit frame supported membrane structure drawings showing details of construction and installation, including column/bracing orientation and proving attachment to the foundation meets the requirements for the foundation design as provided by the Government. Demonstrate aircraft clearances have been met and show size, shape, and thickness of materials; hardware; joints; connections; reinforcing; devices; support/bracing for accessory items; and design and detail data for the work of other trades.

2.1.1 Structural Steel

NOTE: Use of pre-galvanized/in-line galvanized (ASTM G-60, G-90, or similar method) steel or painted steel is not deemed to be of sufficient corrosion resistance to meet the design intent and must not be utilized for structural steel components. Post fabrication hot-dip galvanizing to ASTM A123/123M provides a substantially thicker, more durable and long lasting surface protection than pre-galvanized and single coat paint systems and it is typically more cost effective than higher quality multi-coat epoxy or powder coat systems which do not provide the cathodic/sacrificial protection offered by zinc coated steel. Post fabrication hot-dip galvanizing of welded steel fabrications also provides protection for concealed surfaces as compared to pre-galvanized and painted systems where the heat of the welding process leaves concealed surfaces unprotected and subject to corroding from the inside out.

Pre-galvanized tubular fabrications, especially thin wall systems, have demonstrated full failure due to rusting from the inside out in less than ten years from installation (with significantly compromised structural capacity in less than 10 years) and therefore do not meet the design requirement for a thirty-year useful life. Similarly cold-formed

steel is not permitted for this same reason.

Provide all members of the structure in accordance with [AISC 325](#) and [AISC 360](#) using [ASTM A500/A500M](#), [Grade B][Grade C] tubular steel, [ASTM A992/A992M](#) W-shapes, or [ASTM A53/A53M](#) Grade B pipes and then hot-dip galvanize all members in accordance with [ASTM A123/A123M](#). Provide connections using [ASTM A36/A36M](#) or [ASTM A572/A572M](#) for miscellaneous shapes such as angles, plates, and flat bars.[Fabricate tension only members, if utilized, from [ASTM A36/A36M](#) rods and design and install to prevent clapping, slacking or loss of tension. In all locations where rods may be encountered by people or equipment moving around the structure, provide rods with high visibility, reflective protection sleeves.]

Utilize welding only where specified in the manufacturer's design and approved shop drawings or where approved in writing by the manufacturer. Perform welding in accordance with [AWS D1.1/D1.1M](#) utilizing welders tested and qualified to perform the required type of weld. Submit [welding procedures and qualifications](#) for all welds and welders performing work either in the shop or in the field. Inspect all welded joints for proper size, placement, thorough penetration, and good fusion, free from scabs, blisters, abnormal pocket marks, cracks, voids, scab inclusion, and other defects. Welded steel work must be hot dip galvanized to [ASTM A123/A123M](#) after manufacture to provide corrosion protection.

2.1.2 Fabric Membrane

NOTE: Technically acceptable membrane suppliers include: Seaman, Ferrari, HeyTex/Bondcoat, Protan, and Mehler; however, editor should consult the Contracting Officer for procurement compliance requirements regarding the FAR and the Berry Amendment. Other PVC coated manufacturers and materials may be considered; however, the membrane manufacturer must demonstrate experience with PVC coated polyester cladding in use on structures of the type contemplated in this specification in addition to demonstrating minimum field performance consistent with the required warranty. PVC degrades with UV exposure. Coatings are available that can extend fabric life.

When in harsh environments, specifier should consult with experienced, reputable manufacturers regarding fabric membrane materials and warranty and then coordinate with Government/User for requirements and expectations regarding acceptable fabric membrane replacement intervals.

Translucent fabric is not recommended in all geographies (i.e., extremely high UV index areas, such as the Middle East). Additionally, very high fabric tension forces may require heavier fabric (i.e., 800 plus gram/square meter) which limits its intended purpose. Prior to including any of the below options for translucent panels, consult with a manufacturer.

Supply the fabric membrane from a manufacturer with a demonstrated experience supplying PVC coated polyester cladding on structures of the type required by this specification. Provide a heavy-duty, PVC coated polyester fabric membrane with a demonstrated minimum field performance consistent with this structure's use, environment and required warranty for a minimum service life of 15 years. Minimum fabric membrane weight is 950 grams/square meter 28 ounces per square yard and laminated with a polyester with a minimum base fabric weight of 250 grams/square meter 7.5 ounces per square yard. Minimum permitted tensile strength is 4160/3940 N/50mm 475/450 lb/in according to Strip Tensile ASTM D751 Procedure B. A minimum of 70 percent strength is to be maintained for the full duration of the warranty period. Provide a fabric membrane that is free from defects, fully waterproof, ultraviolet (UV) stabilized, self-extinguishing (0-75 flame spread), flame retardant in accordance with NFPA 701 Test Method 2, and suitable to withstand temperatures between 71 C to minus 34 C 160 degrees F to minus 31 degrees F in compliance with ASTM D2136. Test the fabric to meet the criteria of ASTM E84 (flame spread - Class A interior wall and ceiling finish), ASTM D2136 (cold cracking, brittleness and temperature), and ASTM D751 (tensile and tear strength). Submit product data demonstrating compliance with strength, durability and stated standards.

Provide continuous, uninterrupted cover. Provide fabric that is impervious and resistant to solvents, fuel, lubricants, and other similar fluids commonly found around aircraft. The fabric membrane must cover the entire structure as indicated. Depending on the size of the structure, the membrane may be fabricated in one large section or can be fabricated in smaller sections connected and sealed together as specified in this specification to provide a continuous, uninterrupted, cover over the indicated framework. [The fabric membrane will be selected from the manufacturer's standard colors.] [The fabric membrane will match the existing, adjacent sunshades.] [The fabric membrane will be translucent white.] [Fabric will be opaque with reflective white coating on the underside to increase visibility for maintainers.] [Fabric will be the exterior and interior colors, reflectivity, and opacity as specified in the Contract Documents; note additional framing may be required to support changes in fabric as shown.] Submit fabric (membrane) samples for weight, strength, color approval. Submit fabric (membrane) product data, including all certificates and test report data to demonstrate compliance with strength, durability and referenced standards. Laminated PVC materials, Polyethylene/Polypropylene fabrics and other "poly tarp" materials are not acceptable materials.

2.1.1.3 Hardware

Hot-dip galvanize all hardware in accordance with ASTM A153/A153M.

2.1.1.3.1 Structural Bolts

Provide minimum [13 mm] [1/2 inch] [_____] diameter structural bolts that conform to ASTM F3125/F3125M. Provide a minimum of two bolts per connection and provide all bolts with lock washers or locking nuts. Install and tighten all bolts in accordance with AISC 325 and AISC 360.

2.1.1.3.2 Tensioning Hardware

Provide tensioning hardware which permits full and free rotation at the connections to avoid fatigue failure of threaded assemblies. Hot-dip

galvanize load rated hardware utilized to tension the fabric membrane to prevent corrosion.

2.1.3.3 Non-Structural Fasteners

Provide standard non-structural fasteners, such as tek screws, hot dip galvanized and of standard commercial quality.

2.1.3.4 Exterior Trim

Battens or washers used for final seal of the PVC fabric membrane are permitted to be stainless steel or aluminum, in lieu of hot-dip galvanizing, to resist corrosion.

2.2 LIGHTING

NOTE: Task/Security Lighting "Accessory" Coordination. In the Contract documents, specify LED fixtures/luminaires and power/disconnects suitable for wet locations and include desired color temperature, uniform illumination levels and locate fixtures/luminaires to physically avoid aircraft clearance envelope, including exhaust, blast shields and areas which produce undesirable shadows.

Coordinate the frame supported membrane structure with the light fixtures in accordance with [Drawings and] [Section 26 51 00 INTERIOR LIGHTING] [_____].

2.3 LIGHTNING PROTECTION SYSTEM

NOTE: Lightning Protection "Accessory" Coordination. In the Contract documents, specify the complete Lightning Protection System including counterpoise loop, ground rods and aircraft grounding locations. Specify interconnection of all ground rods with copper bonding conductors. Specify interconnection of all air terminals with copper bonding conductors and provide copper down conductors to connect to the counterpoise loop (and ground rods).

Coordinate frame supported membrane structure with the Lightning Protection System in accordance with [Drawings and] [Section 26 41 00 LIGHTNING PROTECTION SYSTEM] [_____], including air terminals and copper conductors. Do not utilize the frame supported membrane structure for the lightning protection (electrical) load path. Design the frame supported membrane structure to facilitate replacement of fabric to minimize, as much as possible, the removal and reinstallation of air terminals.

[2.4 FALL PROTECTION

NOTE: Fall Protection "Accessory" Coordination. In the Contract documents specify type, extent/coverage

**and number of people to be supported by the fall
protection system.**

Coordinate frame supported membrane structure with the fall protection system in accordance with [Drawings and] [_____].

]2.5 FABRICATION

Provide bolted or welded construction. When required, prepare splices to facilitate field assembly in accordance with standard practice. Provide structural members which are true to dimensions and square in all directions. Fabrication tolerances for steel components must conform to the requirements in the AISC Steel Construction Manual. For clarity in final and future structural inspections, it is not permitted to leave any connections, including base plates, with open bolt or anchor holes.

2.6 SIGNAGE

Provide permanent signage in an obvious and visible location on the structure which lists the manufacturer's name, manufacturer's phone number, manufacturer's project specific identification number, month and year of installation and the SERVICE level wind speed (in km/hr mph) which corresponds to the factored/ultimate wind speed used in the design of the facility. Service Level Wind Speed may be calculated using IBC Equation 16-33.

PART 3 EXECUTION

3.1 EXAMINATION

Examine the foundation and anchor bolts for completeness of installation and compatibility with the column attachment of the frame supported membrane structure. Do not begin to erect the structure until the foundation and anchor bolts are correct, or until revised attachment of the columns has been engineered by the manufacturer and the revised submittal is approved.

3.2 INSTALLATION

Submit sealed and signed erection plan for the frame supported membrane structure. Upon confirming compatibility with the foundations and attachment/anchorage as sealed and signed by a licensed professional engineer, install and erect the structure and install the fabric membrane in accordance with the approved shop drawings, manufacturer's written instructions and approved erection plan.

3.3 CLEANING

After installation, clean all surfaces thoroughly of all mill scale, rust, oil, grease and other foreign substances. Touch-up finishes of ferrous materials immediately after cleaning.

3.4 TOUCH-UP FINISHES

After installation of the structure, prep and coat all areas of missing or damaged galvanized finishes on ferrous materials, including welds. Apply a zinc cold galvanizing compound for corrosion protection conforming to ASTM A780/A780M. Provide cold galvanizing compound that contains a

minimum of 95 percent zinc dust in the dried film in accordance with the coating manufacturer's written instructions. Provide final finishes in accordance with the contract documents.

3.5 METAL PROTECTION

Provide in accordance with Chapter 4 of [UFC 1-200-01](#) when structure is in a corrosion prone location or where structural components use dissimilar metals. If dissimilar metals are used, also provide in accordance with [MIL-STD-889](#). Provide added corrosion protection to the design such as, but not limited to, the following. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape recommended by manufacturer for this purpose. Where aluminum will contact masonry or concrete, protect against corrosion by painting contact surfaces with bituminous coating.

3.6 FIELD QUALITY CONTROL

Provide a qualified and authorized representative of the manufacturer familiar with the design and approved shop drawings to supervise installation of the frame supported membrane structure on site. The authorized representative is responsible for providing quality control inspections, including all connections. When the installation of the structure is complete, provide a [final completion certification](#) signed by a representative of the Manufacturer, a representative of the Installer, and onsite Authorized Representative of the manufacturer performing field quality control.

3.7 EXTRA MATERIALS

Provide a patch kit with color matched fabric membrane and associated repair materials and tools. Supply approximately [4.2 square meters](#)⁴⁵ [square feet](#) of fabric for each frame supported membrane structure.

3.8 OPERATION AND MAINTENANCE DATA

Provide routine inspection, maintenance, cleaning and repair instructions for the frame supported membrane structure, including intervals. Include detailed instructions for re-tensioning, if required. Include inspection recommendations for assessing signs of fabric degradation, fabric connection issues, tightness of x-bracing or other lateral force resisting system, and any additional manufacturer items deemed critical to the performance of the structure.

Submit [Frame Supported Membrane Structure O&M](#) in accordance with Section [01 78 23](#) OPERATION AND MAINTENANCE DATA.

-- End of Section --