**SPECIFICATION FORM COVER SHEET**

**SECTION 13 3110**

**INSULATED TENSIONED MEMBRANE STRUCTURES**

**Revision – July 2021**

**ALL TEXT IN RED WITHIN THE FOLLOWING PAGES TO BE REMOVED AFTER EDITING FOR A SPECIFIC PROJECT**

This specification section is written in general conformance with the Construction Specifications Institute’s (CSI) MasterFormat™ guidelines. It must be carefully reviewed and edited by the Project Architect and/or Engineer to ensure compliance with project requirements and the applicable building code, including coordinating this section with other specification sections and the construction drawings.

SECTION 13 3110 – INSULATED TENSILE MEMBRANE STRUCTURES

# PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 specification sections, apply to the Work of this Section.

1.2 SUMMARY

A. This Section includes an architectural insulated tensile membrane structure system.

B. The insulated tensile membrane structure contractor (hereafter referred to as “Subcontractor”) shall be responsible for the detailing, fabrication, supply, and installation of the work specified herein, some or all of which may be subcontracted by Subcontractor to others meeting the qualification requirements of Section 1.5. The intent of this specification is to establish in the first instance an undivided, single-source responsibility of the Subcontractor for all of the foregoing functions.

C. Subcontractor’s Work shall include, but not necessarily be limited to, the supply, fabrication, shipment, and erection of the following principal items [Edit scope as necessary.]:

1. The insulated architectural membrane system as indicated on the drawings and in these specifications.

2. Cables and end fittings.

3. Perimeter, catenary, and sectionalized aluminum clamping system.

4. Structural steel, including masts, trusses, struts, beams, and/or weldments, as indicated on the drawings.

5. Fasteners and gasketing.

D. The insulated architectural membrane system used in these structures shall be a composite system consisting of PTFE (polytetrafluoroethylene, such as Teflon®) coated woven fiberglass exterior, aerogel insulating blanket, PTFE coated woven fiberglass interior. All references to "insulated membrane" in this Section, without exception, and whether singular, plural, or capitalized or not, are to such architectural membrane.

E. Related Sections: The following Construction Specification Institute (CSI) MasterFormat™ divisions contain requirements relating to this section [Edit divisions as necessary.]:

1. Division 1: General Requirements.

2. Division 3: Concrete, for cast-in-place foundations.

3. Division 5: Metals, for structural metal framing, metal fabrications, expansion control systems, and shop-applied metal coatings.

4. Division 8: Doors and Windows, for skylights, clerestories, and/or glazed curtain wall systems.

5. Division 9: Finishes, for paints and coatings.

6. Division 11: Roof Hatch

1.3 REFERENCES

A. General: Except as otherwise shown or noted, all Work shall comply with the requirements of the following codes and standards:

1. Building Code of [Identify State or Prevailing Code.], [Insert year.] edition.

2. American Architectural Manufacturers Association (AAMA).

3. American Institute of Steel Construction (AISC).

a. AISC/ANSI 360-05 Specifications for Structural Steel Buildings

b. AISC 303-05 Code of Standard Practice for Steel Buildings and Bridges

c. AISC/ANSI 341-05 Seismic Provisions for Structural Steel Buildings

4. American Society of Civil Engineers (ASCE).

a. ASCE 19: Structural Applications of Steel Cables for Buildings

5. American Society for Testing and Materials (ASTM) International.

a. ASTM A586: Standard Specification for Zinc-Coated Steel Structural Strand

b. ASTM A603: Standard Specification for Zinc-Coated Steel Structural Wire Rope

c. ASTM C423: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

d. ASTM C518: Standard Test Method for steady-state heat flux measurements and thermal transmission properties by means of the heat flow meter apparatus

e. ASTM C1363: Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus

f. ASTM D4851: Standard Test Methods for Coated and Laminated Fabrics for Architectural Use

g. ASTM E84: Standard Test Method for Surface Burning Characteristics of Building Materials

h. ASTM E90: Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

i. ASTM E96: Standard Test Methods for Water Vapor Transmission of Materials (dry cup method)

j. ASTM E108: Standard Test Methods for Fire Tests of Roof Coverings

k. ASTM E424: Standard Test Method for Solar Energy Transmittance

l. ASTM G21 Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

6. American Welding Society (AWS).

a. AWS D1.1: Structural Welding Code

b. AWS 2.4: Symbols for Welding and Nondestructive Testing

7. Aluminum Association.

a. Specifications for Aluminum Structures

8. National Fire Protection Association (NFPA).

a. NFPA 701: Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

9. Society for Protective Coatings (SSPC).

a. Steel Structures Painting Manual, Volumes 1 and 2

1.4 SYSTEM REQUIREMENTS

A. General: Provide an insulated tensile membrane structure system that complies with requirements specified herein by testing the Subcontractor’s corresponding membrane system in accordance with the indicated test methods.

B. Building Code Criteria: The tensile membrane structure shall comply with the State of [Identify State or Prevailing Code.] Building Code, [Insert year.] edition. [Controlling code and design criteria insertions below to be provided and verified by the Project Engineer.]

1. Ground Snow Load: [Insert] psf

2. Snow Load Importance Factor: [Insert]

3. Roof Live Load: [Insert] psf

4. Basic Wind Speed: [Insert] mph

5. Wind Load Importance Factor: [Insert]

6. Wind Exposure Category: [Insert]

7. Design Mean Roof Height(s): [Insert] feet

C. Life Safety: All insulated tensile membrane structures shall be detailed so that no life safety issue is created in the event of a loss of a part of the membrane. The insulated tensile membrane structure shall not rely on the membrane for structural stability.

D. Fire Performance:

1. Range of characteristics required of membranes:

a. Burning Characteristics (ASTM E84):

i. Flame Spread 5 max.

ii. Smoke Generation (Tunnel Test) 20 max.

b. Fire Resistance of Roof Coverings (ASTM E108):

i.. Burning Brand Class A

c. Flame Resistance (NFPA 701 Small Scale, UL 94).

i. Flame Out 1 second after

ii. Char Length 0.25-inch max.

2. Range of characteristics required of composite assembly, tested at a composite thickness of 16mm minimum:

a. Burning Characteristics (ASTM E84):

i. Flame Spread 15 max.

ii. Smoke Generation (Tunnel Test) 55 max.

b. Fire Resistance of Roof Coverings (ASTM E108):

i. Burning Brand Class A

ii. Intermittent Flame Class A

iii. Spread of Flame Class A

1.5 QUALITY ASSURANCE

A. Subcontractor Qualifications: Fabrication and erection of the insulated tensile membrane structure is limited to firms with proven experience in fabrication and construction of complex insulated tensile membrane structures. Such firms, through their own experience and/or that of their qualified subcontractors, shall meet the following minimum requirements:

1. The Subcontractor shall have at least fifteen (15) years’ experience in the successful fabrication and erection of permanent, custom tensile membrane structures. The Subcontractor shall have at least three (3) years’ experience in the successful fabrication and erection of permanent, custom aerogel-insulated composite tensile membrane structures.

2. The Subcontractor shall have fabricated and erected at least fifty (50) PTFE-coated woven fiberglass tensile membrane structures, with at least three (3) aerogel blanket insulated composite tensile membrane structures of similar size and complexity as this project.

3. The Subcontractor shall design, procure, fabricate and erect PTFE-coated woven fiberglass tensile membrane and aerogel insulation as an insulated tensile membrane composite structure.

4. The Subcontractor shall demonstrate it owns and operates a fabrication facility of adequate capacity and will maintain a staff experienced in the fabrication of PTFE-coated woven fiberglass tensile membrane and aerogel insulation structures that will undertake the fabrication of this project.

5. The Subcontractor shall maintain an in-house Warranty and Service department to assist in repair and service calls.

6. The Subcontractor shall submit a Corporate Quality Control Manual describing the company’s complete quality assurance program.

B. Qualified Subcontractor.

1. **Birdair, Inc.**

6461 Main Street, Amherst, New York 14221 USA

Phone (716) 633-9500 Fax (716) 633-9850

Sales@Birdair.com Web Site [www.birdair.com](http://www.birdair.com)

1.6 SUBMITTALS

A. General: Notwithstanding any provisions of these specifications that may appear to be to the contrary, any and all submittals by the Subcontractor shall be subject to review, approval, and adoption by the Project Engineer as part of the overall project design and engineering, and shall not create a contractual or other professional design relationship between the Subcontractor and either the Project Engineer or the Owner.

B. Product Data: Include manufacturer’s specifications for materials, fabrication, installation, and recommendations for maintenance. Include test reports showing compliance with project requirements where test method is indicated.

1. Samples: Submit selection and verification samples.

C. Submittals With Bid: The General Contractor shall submit with its bid the following materials from the Subcontractor:

1. Schedule indicating key milestone dates during the project.

2. Pre-qualification package including:

 a. Company background and years of experience

 b. Organizational chart and staff C.V.

c. List of past project references pursuant to Section 1.5.A.1 and 1.5.A.2

d. Client recommendations

e. Fabrication facility documentation pursuant to Section 1.5.A.4:

i) Background, including proof of ownership and years of operation

ii) Physical address

D. Shop Drawings: Subcontractor shall submit insulated tensile membrane structure drawings defining the completed structure, anchorage and connection details, interfaces with building construction, and general membrane seam arrangements.

 E. Quality Assurance Submittals.

1. Test Reports: Provide test reports from a qualified testing laboratory that show compliance of the Subcontractor’s PTFE-coated woven fiberglass tensile membrane aerogel system with specification requirements, as follows:

a. Physical test data of the actual fabric roll goods to be used in the project confirming conformance with specifications for the membrane.

b. Product data for aerogel insulation blanket confirming conformance with specifications of the insulation.

2. Certificates: Product certificates signed by the Subcontractor certifying materials comply with specified characteristics, criteria, and physical requirements.

F. Closeout Submittals.

1. Warranty: Project Warranty documents as described herein.

2. Record Documents: Project record documents for installed materials in accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.

3. Maintenance Manual: Submit two (2) copies of a maintenance manual for the insulated tensile membrane structure to the Owner. The manual shall include a schedule for routine inspection, an inspection checklist, instructions for emergency repair and use of emergency repair materials, and warranty. During the system erection period, the Owner shall provide maintenance personnel to be trained in the use of the repair materials.

1.7 PRODUCT DELIVERY, HANDLING, AND STORAGE

A. General: Refer to the Conditions of the Contract for product handling provisions.

B. Materials shall be packed, loaded, shipped, unloaded, stored, and protected in a manner that will avoid abuse, damage, and defacement.

C. Durability: The Subcontractor shall demonstrate by test and experience the capacity of the insulation blanket to be fabricated within the composite membrane panel, shipped, installed and be exposed during its use to the specified design loadings without damage and without loss or dislocation of more than 1% of the total aerogel contained within the blanket. Refer to Section 2 Products for test procedures.

1.8 WARRANTY

A. General: Refer to the Conditions of the Contract for project warranty provisions.

B. After final payment, the Subcontractor shall furnish the Owner with a written Warranty, which warrants that the Tensotherm insulated membrane, its perimeter attachment system, and the structural support system as supplied by the Subcontractor have been installed in accordance with the project specifications and will be free from defects in materials and workmanship that will impair their normal use or service. The Warranty shall start from the date of Substantial Completion of the Tensotherm system insulated tensile membrane structure; which shall be the first date on which the entire insulated tensile membrane structure is subject to design prestress conditions, and continue for a period of [Number in Words] ([Number as digit]) years thereafter. [Verify Warranty period with Service Department prior to issuing specification.]

## PART 2 - MATERIALS

2.1 INSULATED ARCHITECTURAL MEMBRANE

1. General: The insulated membrane composite used in these structures shall be TensothermR utilizing a composite of PTFE fiberglass and Nanogel insulation, as manufactured by Birdair, Inc. of Amherst, NY.

B. The Tensotherm membrane shall meet the following performance requirements:

1. Thermal Performance: Thermal Resistance (R-value) of the insulated tensile membrane roof panels, average of X.XX [Insert]m2K/W (XX.X [Insert] ft2hr Fdeg/BTU) per ASTM C1363-05.

2. Light Transmittance: Mean Light transmittance of x.x[Insert]%, through the insulated tensile membrane roof panels per ASTM E424 Method B.

3. Acoustic Performance (insulated tensile membrane roof panel): Acoustic absorption of 0.x[Insert] Sabins per square foot average minimum as measured per ASTM C423-08. Acoustic sound transmission class (STC) of xx[Insert] minimum as measured per ASTM E90.

4. Vapor Barrier Performance: As determined by the Architect from available membrane products. Water vapor permeability to be between 0.26 and 4.8 perms maximum as measured per ASTM E96, Method A desiccant (dry cup).

2.2 COMPONENT MATERIALS

 A Architectural Membrane

1. General: The PTFE-coated fiberglass membrane used in these structures shall be based on building conditions (environment, interior moisture, ect.) Architectural Membranes as manufactured by one of the following:
	1. Saint-Gobain Performance Plastics Corp. of Merrimack, NH, USA.
	2. Chukoh Chemical Industries, Ltd., Tokyo, Japan
	3. Verseidag Indutex Gmbh, Krefeld, Germany

2. The membrane shall meet the following general requirements:

a. Source Quality Control: The primary materials shall be obtained from a single manufacturer. Secondary materials shall be those recommended by the primary manufacturer.

b. Physical Characteristics: The following indicates a range of physical properties typical of PTFE Architectural Membranes. The determination of specific characteristics and selection of a membrane shall be derived from project engineering by the Project Engineer. [Edit specific characteristics below per engineering requirements.]

 Outer Membrane:

i. Coated Fabric Weight (oz./sq. yd.): 24 to 45.5 nom. (ASTM 4851)

ii. Thickness (mils): 18 to 36 nom. (ASTM 4851)

iii. Strip Tensile (lbs./in., avg.):

a) Dry, Warp 520 min. to 975 min. avg. (ASTM 4851)

b) Dry, Fill 380 min. to 900 min. avg. (ASTM 4851)

iv. Strip Tensile, After Crease Fold (lbs./in., avg.):

a) Dry, Warp 375 min. to 760 min. avg. (ASTM 4851)

b) Dry, Fill 350 min. to 735 min. avg. (ASTM 4851)

v. Trapezoidal Tear (lbs./in., avg.):

a) Warp 35 min. to 95 min. avg. (ASTM 4851)

b) Fill 35 min. to 120 min. avg. (ASTM 4851)

vi. Solar Transmission Fabric Membrane(%): 7 to 22 nom.

(ASTM E424)

vii. Solar Reflectance (%): 70 to 73 nom. (ASTM E424)

Liner Membrane:

i. Coated Fabric Weight (oz./sq. yd.): 8.5 to 45.5 nom. (ASTM 4851)

ii. Thickness (mils): 9 to 36 nom. (ASTM 4851)

iii. Strip Tensile (lbs./in., avg.):

a) Dry, Warp 210 min. to 975 min. avg. (ASTM 4851)

b) Dry, Fill 180 min. to 900 min. avg. (ASTM 4851)

iv. Strip Tensile, After Crease Fold (lbs./in., avg.):

a) Dry, Warp 195 min. to 760 min. avg. (ASTM 4851)

b) Dry, Fill 165 min. to 735 min. avg. (ASTM 4851)

v. Trapezoidal Tear (lbs./in., avg.):

a) Warp 17 min. to 95 min. avg. (ASTM 4851)

b) Fill 18 min. to 120 min. avg. (ASTM 4851)

vi. Solar Transmission Fabric Membrane(%): 7 to 27 nom.

(ASTM E424)

vii. Solar Reflectance (%): 65 to 73 nom. (ASTM E424)

3. Materials.

a. Base Fabric: The yarns used shall be of the highest commercial quality, essentially free of broken fibers and fully suitable for coating. The fabric shall be woven with uniform tension and crimp in the warp and fill yarns and free of defects deleterious to the coating process.

b. Fluorocarbon Coatings: The coating materials shall be fluorocarbon resins formulated specifically for architectural applications. These materials shall be applied to form a weatherized barrier between the fiberglass yarns and the environment. The bulk of the coating shall be formulated dispersions of PTFE fluoropolymer resin and additives to enhance abrasion and tear resistance, impart pigmentation, or modify solar transmission. The additives shall not constitute more than 20% by weight of the total coating or 25% by weight of any individual layer. The surface shall be totally a fluoroethylenepropylene (“FEP”) resin to facilitate heat welding.

c. After weaving, the base fabric shall be cleaned and primed to achieve optimum mechanical properties of the coated membrane. The coating, described above, shall be virtually free of mud cracks and pinholes. The coating shall be applied evenly to both sides of the fabric and the FEP fluorocarbon resin topcoat shall be of sufficient thickness to permit proper heat fusion of joints with the recommended die pressure and temperature.

1. INSULATION
2. General: The insulation blanket used in these structures shall be Nanogel® Thermal Wrap® aerogel insulation blanket as manufactured by Cabot Corporation / Aerogels of Billerica, MA, USA.
3. The insulation blanket shall meet the following general requirements:
	1. Source Quality Control: The primary materials shall be obtained from a single manufacturer. Secondary materials shall be those recommended by the primary manufacturer.
	2. Physical Characteristics: The following indicates a range of physical properties typical of a Nanogel aerogel insulation blanket. The determination of specific characteristics and selection of the insulation blanket shall be derived from project engineering by the Project Engineer.
		1. Thickness (mm): 7-9
		2. Density (kg/m^3): 65-85
		3. Thermal Conductivity (W/mK): 0.021-0.023@12.5°C (ASTM C518)
		4. Light Transmission (%) 11% (ASTM E424)

c. Durability:The Subcontractor shall demonstrate by test and experience the capacity of the insulation blanket to be fabricated within the composite membrane panel, shipped, installed and be exposed during its use to the specified design loadings without damage and without loss or dislocation of more than 1% of the total aerogel contained within the blanket.

1. Vibratory Drum Test: Test procedure shall utilize a minimum 200mm by 200mm insulation blanket specimen. Specimens shall be mounted at an angle of approximately 15 degrees from horizontal to a standard drum vibrator, with applied acceleration magnitude of positive and negative 0.6g. Measure blanket specimen weight at test start, and after 500,000 cycles (+/-1%). Insulation specimen weight after cyclic testing shall be a minimum of 99% of insulation specimen weight prior to testing.
2. Dynamic Bending (Flutter) Test: Test procedure shall utilize a minimum 200mm by 1000mm composite specimen. Support specimen in uniaxual tension in the 1000mm direction, clamped at ends and with a roller support at midpoint. Specimen shall be subjected to a minimum 200mm amplitude rapid displacement and return of the midpoint support (one cycle). Sample shall be evaluated after a minimum of 100,000 displacement cycles. Insulation shall be weighed separately from other composite materials prior to testing, then weighed separately after cyclic testing, with all loose material removed. Insulation specimen weight after cyclic testing shall be a minimum of 99% of insulation specimen weight prior to testing.
3. Materials.
4. Nanogel translucent aerogel: The aerogel used shall be hydrophobic, translucent to light, and of the highest commercial quality. Its Thermal Conductivity shall remain permanently constant, at minimum, when tensioned or put under compression in the final assembly.
	* 1. Mold/Fungus Resistance: Insulating material shall show no evidence of fungal growth as tested per ASTM G21.
5. Fibers: The fibers used for the blanket shall be polymer fibers formulated specifically for non-woven processing.

2.3 CABLES AND END FITTINGS

A. Materials.

1. All structural wire rope cables shall conform to the latest revision of ASTM A603.

2. All structural strand cables shall conform to the latest revision of ASTM A586.

3. All cables shall be coated to “Class A” zinc coating throughout.

4. All cables in contact with the membrane shall be white PVC coated. All other cables may be galvanized only.

B. Fabrication.

1. Cable fabricator shall provide effective quality control over all fabrication activities. Inspection of the place of fabrication may occur at any time to verify proper quality control. This inspection does not relieve the fabricator from meeting the requirements of this specification.

2. Cables that are designated to be prestretched shall be prestretched per ASTM A603 for wire rope and ASTM A586 for structural strand. Cables of the same type shall have the same modulus of elasticity.

3. All cables shall be manufactured to the following length tolerances at 70 degrees Fahrenheit (23 degrees Celsius):

a. Length < 70 feet (213 meters) ¼ inch (6.4 mm)

b. Length 70 to 270 feet (32.3 to 82.3 meters) 0.03% of length

c. Length > 270 feet (82.3 meters) 1 inch (25.4 mm)

4. Cables shall have a continuous longitudinal paint stripe (¼ inch wide max.) along their top surface unless noted otherwise.

5. Index markings shown shall be a circumferential paint stripe (¼ inch wide max.).

6. All cables and end fittings shall be delivered clean and dry.

7. All swaged and speltered fittings shall be designed and attached to develop the full breaking strength of the cable. Thimble end fittings shall develop a minimum of 90% of the cable breaking strength.

8. Swaged end fittings, pins, nuts, and washers shall be hot dip galvanized per ASTM A153. Any damage to the zinc coating shall be cleaned and painted with a gray zinc-rich paint per ASTM A780.

9. Speltered end fittings shall be hot dip galvanized per ASTM A153. Any damage to the zinc coating shall be cleaned and painted with a gray zinc-rich paint per ASTM A780.

2.4 ALUMINUM CLAMPING SYSTEM

A. Materials.

1. All structural aluminum clamping systems shall be ASTM alloy 6061-T6.

2. Bent plates shall be formed from ASTM alloy 6061 and then heat-treated to T6.

3. All structural “U straps” shall be stainless steel, Type 316.

4. All structural aluminum clamping shall have the following finish [Select one finish.]:

a. Clear anodized per MIL-A-8625C Type 2, Class 1 [OR]

a. Polyester thermosetting powder coating with a tri-glycidyl isocyanurate (i.e. TGIC) curing agent/hardener per AAMA 2603 to a thickness of 3 mils, white in color.

5. Structural sheet aluminum shall be ASTM alloy 5052-H32.

6. Non-structural sheet aluminum shall be ASTM alloy 1100 series.

B. Fabrication.

1. Aluminum fabricator shall provide effective quality control over all fabrication activities. Inspection of the place of fabrication may occur at any time to verify proper quality control. This inspection does not relieve the fabricator from meeting the requirements of this specification.

2. Fabricated aluminum shall have no sharp edges.

3. Stamp all parts with the appropriate mark number.

4. All fabricated aluminum shall be free of oil, grease, and machining chips.

5. Tolerances shall be as follows:

a. Cross sectional dimensions +/- 10%, 0.03-inch (0.8 mm) max.

b. Bolt hole locations +/- 1/32 inch (0.8 mm)

c. Overall length +/- 1/16 inch (1.6 mm)

6. All welded joints shall conform to AWS D1.2.

2.5 STRUCTURAL STEEL [Edit scope as necessary]

A. General: The structural steel fabrication shall comply with the latest revision of all applicable codes, standards, and regulations including the following:

1. ASTM (as referenced).

2. AISC: “Specification for Structural Steel Buildings” and “Code of Standard Practice for Steel Buildings and Bridges.”

3. SSPC: “Steel Structures Painting Manual, Volumes 1 and 2.”

4. Research Council on Riveted and Bolted Structural Joints: “Specification for Structural Joints Using ASTM A325 or A490 Bolts.”

5. AWS D1.1 and AWS A2.4.

B. In the event of conflict between pertinent codes and regulations and the requirements of the referenced standards or these specifications, the provisions of the more stringent shall govern.

C. Submittals.

1. General: Submit the following in accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.

2. Shop Drawings.

a. The structural steel fabricator shall submit shop drawings to the Subcontractor for approval.

b. The drawings shall show all shop and erection details including cuts, copes, connection holes, threaded fasteners, bolts, studs and spacing, etc.

c. The drawings shall show all welds, both shop and field, by the currently recommended symbols of the AWS.

d. A welding procedure must be submitted to the Subcontractor for approval of welds that are not prequalified.

e. Shop drawings shall be carefully checked before being submitted for approval, and shall be submitted in the order in which they are needed for the execution of the work, well in advance and not all at one time. Submitted drawings shall show all structural steel required for the work, whether or not indicated on the drawings.

f. The fabricator shall not fabricate any material until after receipt of approved drawings.

g. The fabricator shall immediately make all corrections to his drawings as required by the Subcontractor and shall keep a satisfactory history of all changes by separately numbered and dated revision block on a convenient portion of each drawing affected.

h. Certification of material conformance that includes chemical and physical properties for all structural elements shall be submitted to the Subcontractor.

D. Materials.

1. Structural steel for plates and bars shall conform to the requirements of ASTM A36 or ASTM A572, Grade 50, unless noted otherwise.

2. Structural pipe shall conform to ASTM A53, Types E or S, Grade B.

3. Structural tubing shall conform to ASTM A500 Grade B.

4. Structural bolts.

a. High strength bolts: ASTM A325, unless noted otherwise.

b. Common bolts and nuts: ASTM A307.

c. Threaded rods: ASTM A36, unless noted otherwise.

5. Other materials: All other materials, not specifically described but required for a complete and proper installation of structural steel, shall be provided and shall be new, free from rust, first quality of their respective kinds, and subject to the approval of the Subcontractor.

E. Accessories.

1. Base Plates and Anchor Bolts.

a. Base plates supported on concrete, whether shop attached or shipped loose, shall be furnished and set on shims, leveling plates or leveling nuts. Grouting shall be by the General Contractor.

b. Anchor bolt locations shall be furnished by the Subcontractor and used by the General Contractor to set the bolts. The General Contractor is to check carefully the setting of the bolts to their proper position prior to placing of concrete. Anchor bolts, provided by the General Contractor, shall have two (2) nuts and washers. Damaged threads shall be repaired or be cut to permit full tightening of nuts.

F. Fabrication.

1. Workmanship: All members, when finished, shall be true and free of twists, bends, and open joints between the component parts. Members shall be thoroughly straightened in the shop by methods that will not injure them, before being worked on in any way.

a. Properly mark materials, and match-mark when directed by the Subcontractor, for field assembly.

b. Grind all edges and corners that could contact membrane to a minimum 1/16” (1.6mm) radius.

2. Connections.

a. Connections shall be as indicated on the drawings. When details are not shown the connections shall conform to the requirements of the AISC.

b. Provide high-strength threaded fasteners for all structural steel bolted connections, unless noted otherwise.

c. Combination of bolts and welds in the same connection are not permitted, unless otherwise detailed.

d. Welded Connections.

1. Definitions: All terms herein relating to the welds, welding and oxygen cutting shall be construed in accordance with the latest revision of “Standard Definitions of Welding Terms and Master Chart of Welding Processes” of the AWS.

2. Operators: Welds shall be made only by operators who have been previously qualified by tests, as prescribed in AWS D1.1 to perform the type of work required.

3. Welding equipment shall be of sufficient capacity and maintained in good working condition, capable of adjustment in full range of current settings. Welding cables shall be adequate size for the currents involved and grounding methods shall be such as to insure proper machine operation.

4. No welding shall begin until joint elements are clamped in proper alignment and adjusted to dimensions shown on the drawings with allowance for any weld shrinkage that is expected. No members are to be spliced without prior approval.

5. All welding shall be done in accordance with the reference specifications, with the following modifications and additions:

a. All field welding shall be done by manual shielded metal-arc welding.

b. All groove welds shall have complete penetration, unless otherwise specified on the drawings.

c. The minimum preheat and interpass temperature requirements shall be as required per AWS D1.1.

6. Welding Sequence: Heavy sections and those having a high degree of restraint must be welded in a sequence with the proper preheat and post-weld heat treatment such that no permanent distortion occurs. Submit a welding sequence for approval for these types of connections.

7. Oxygen Cutting: Manual oxygen cutting shall be done only with a mechanically guided torch. Alternatively, an unguided torch may be used provided the cut is not within 1/2 inch of the finished dimension and the final removal is completed by chipping or grinding to produce a surface quality equal to that of the base metal edges. The use of oxygen-cut holes for bolted connections will under no circumstances be permitted, and violation of this clause will be sufficient cause for the rejection of any pieces in which oxygen-cut holes exist.

3. Tolerances: All tolerances shall be as per the AISC “Code of Standard Practice for Steel Buildings and Bridges.”

4. Paint System, Two-Coat; Zinc Polyurethane: [Select either this two-coat shop paint system for non-aggressive environments more than 15 miles from salt water, or the three-coat paint system for aggressive environments immediately following as an alternative Section 2.5(F)(4).]

a. Source Quality Control: Primary materials shall be obtained from a single manufacturer. Secondary materials shall be those recommended by the primary manufacturer.

b. Surface Preparation and Prime Coat:

1. Surface preparation shall be commercial blast cleaning SSPC-SP-6, after all fabrication operations such as machining and welding are complete. There shall be a maximum of eight hours elapsed time between surface preparation and application of the prime coat.

2. Protect all drilled and tapped holes and/or threaded studs prior to painting such that all bolted connections can be made by subcontractor or membrane structure erector without first cleaning threads.

3. Primer shall be International Paint Interzinc 315 or approved equal, and shall comply with the composition and performance requirements of SSPC paint specification No. 20.

4. Primer shall be mixed and applied in accordance with manufacturer’s instruction and technical product datasheets. The dry film thickness shall be 2.5-3 mils.

c. Finish Coat:

1. Finish coat shall be International Paint Interthane 870 series or approved equal, and shall comply with the composition and performance requirements of SSPC paint specification No. 36.

2. Finish coat shall be mixed and applied in accordance with manufacturer’s instructions and technical product datasheets. The dry film thickness shall be 4-5 mils.

3. Total system dry film thickness shall be 6.5-8 mils.

d. Color:

1. The paint color shall be as specified on the drawings or selected by the Architect.

e. Finish Quality:

1. Dry paint shall be uniform and continuous with no voids or puddles and shall not be broken by scratches or nicks. Although Birdair or the steel fabricator may witness the painting operation, this does not relieve the painting subcontractor of the responsibility for meeting the quality and workmanship requirements of this specification.

f. Care and Handling:

1. Painting subcontractor shall make every reasonable effort to ensure the painted steel is thoroughly dry and it is handles carefully to prevent aesthetic or structural damage. Nylon slings shall be used when handling painted steel.

g. Certification:

1. Painting Subcontractor shall certify the paint manufacturer’s name, paint identification, conformance with manufacturer’s written instructions, and the paint dry mil thickness.

4. Paint System, Three-Coat; Epoxy-Polyurethane: [Note: Select either this three-coat shop paint system for aggressive environments within 15 miles of salt water, or the two-coat paint system immediately above as an alternative Section 2.5(F)(4).]

a. Source Quality Control: Primary materials shall be obtained from a single manufacturer. Secondary materials shall be those recommended by the primary manufacturer.

b. Surface Preparation and Prime Coat:

1. Surface preparation shall be near-white blast cleaning SSPC-SP-10, after all fabrication operations such as machining and welding are complete. There shall be a maximum of eight hours elapsed time between surface preparation and application of the prime coat.

2. Protect all drilled and tapped holes and/or threaded studs prior to painting such that all bolted connections can be made by subcontractor or membrane structure erector without first cleaning threads.

3. Primer shall be International Paint Interzinc 315 or approved equal, and shall comply with the composition and performance requirements of SSPC paint specification No. 20.

4. Primer shall be mixed and applied in accordance with manufacturer’s instructions and technical product datasheets. The dry film thickness shall be 2.5-3 mils.

c. Intermediate Coat:

1. Intermediate coat shall be International Paint Intergard 475HS or approved equal.

2. The intermediate coat shall be mixed and applied in accordance with the manufacturer’s instructions technical product datasheets. The dry film thickness shall be 4-6 mils.

d. Finish Coat:

1. The finish coat shall be International Paint Interthane 870 series or approved equal, and shall comply with the composition and performance requirements of SSPC paint specification No. 36.

2. The finish coat shall be mixed and applied in accordance with the manufacturer’s instructions and technical product datasheets. The dry film thickness shall be 4-5 mils.

3. Total system dry film thickness shall be 10.5-14 mils.

e. Color:

1. Finish paint color shall be as specified on the drawings or as selected by Architect.

f. Quality:

1. Dry paint shall be uniform and continuous with no voids or puddles and shall not be broken by scratches or nicks. Although Birdair or the steel fabricator may witness the painting operation, this does not relieve the Painting Subcontractor of the responsibility for meeting the quality and workmanship requirements of these specifications.

g. Care and Handling:

1. Painting Subcontractor shall make every reasonable effort to ensure that the painted steel is thoroughly dry and that is handled carefully to prevent aesthetic or structural damage. Nylon slings shall be used when handling the painted steel.

h. Certification:

1. Painting Subcontractor shall be required to certify the paint manufacturer’s name, paint identification, conformance with manufacturer’s written instructions, and the paint dry mil thickness.

G. Source Quality Control.

1. Testing.

a. An independent testing laboratory paid for by the Owner shall perform testing and inspection of the structural steel and welding. All welds shall be tested by visual, dye penetrant, magnetic particle methods, or ultrasonic methods in accordance with instructions from the Subcontractor.

b. The Subcontractor and the testing laboratory inspector shall be permitted to inspect the work in the shop or field throughout fabrication and erection.

c. The inspector shall check for workmanship of steel, both in the shop and field, and check general compliance with the Contract Documents and steel shop drawings. The inspector shall record types and locations of all defects found in the work and measures required and performed to correct such defects.

d. The steel fabricator shall make all repairs to defective work to the satisfaction of the inspector and at no additional cost to the Subcontractor.

e. The inspector shall submit reports of his inspection and test findings to the Subcontractor. He shall record all defects found with subsequent repair operations and submit reports to the Subcontractor.

f. The work of the independent inspector shall in no way relieve the steel fabricator of his responsibility to comply with all requirements of the Contract Documents.

H. Product Handling and Protection: Use all means necessary to protect structural steel before, during, and after installation and to protect the installed work and materials of all other trades.

I. Rejection and Replacement.

1. In the event of damage to the steel, immediately make all repairs and replacements necessary to the approval of and at no additional cost to the Subcontractor.

2. Any materials or welding rejected through inspection either in the shop, mill or field must be promptly replaced to the satisfaction of, and at no additional cost to, the Subcontractor.

J. Qualifications of Steel Fabricator: The steel fabricator shall have not less than five (5) years’ continuous experience in the fabrication of structural steel.

2.6 FASTENERS

A. General: Provide fasteners used to secure clamp systems to curbs and cables, assemblage of clamp systems, and other fasteners as required to complete the work specified herein.

B. Materials.

1. All work shall comply with the latest edition of ASTM standards and American Iron and Steel Institute (AISI), as referenced herein.

2. Fasteners used in membrane clamping systems shall be stainless steel. Bolts and studs shall conform to ASTM F593, Type 304. Nuts shall conform to ASTM F594, Type 316. Washers shall be plain, narrow, and conform to AISI Type 18-8.

3. All clamping systems subjected to relative movement between clamping and curb shall receive a split-ring lock washer conforming to AISI Type 18-8.

4. Unless otherwise specified on the drawings, all other bolts and nuts shall conform to ASTM A307-76B, zinc plated to conform to ASTM B633 Class Fe/Zn 8 type III.

C. Source Quality Control: The manufacturer shall certify that all fasteners comply with the above referenced specifications.

2.7 GASKETING

A. General: All work shall comply with the latest edition of ASTM standards, as referenced herein.

B. Sponge Neoprene Gasketing:

1. Material.

a. All sponge neoprene shall be of a cellular elastomeric compound of a firm grade, which has been manufactured in pre-formed shapes for use as gasket and sealing material, as specified in ASTM specification C509.

b. Cellular elastomeric materials furnished to this specification shall be manufactured from natural or synthetic rubber, or mixtures of these, with added compounds of such nature and quality that, with proper curing, the finished product will comply with this specification.

c. The cured compounds shall be suitable for use where resistance to sunlight, weathering oxidation, and permanent deformation under load are of prime importance.

d. The manufacturing process shall be such as will ensure a homogeneous cellular material free of defects that may affect serviceability.

e. The physical characteristics of the neoprene must meet or exceed ASTM C509, “Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Materials.”

f. Certification of material shall be provided that conforms to ASTM C509.

C. Dense Neoprene Gasketing:

1. All neoprene material shall conform to ASTM D 2000M hardness Grade 60. The material shall be homogenous, free from defects and shall be compounded and cured to meet the requirements specified herein.

2. All neoprene shall be non-staining formulation and shall consist of at least 50% by weight of basic rubber hydrocarbon. Material shall not contain crude or reclaimed rubber.

3. The physical characteristics of the neoprene must meet or exceed the following physical test requirements when tested using the standard ASTM test slab can compression set plug (or approved equal):

PROPERTY ASTM TEST METHOD UNITS

a. Shore A Durometer D 2240 55 – 65

b. Tensile Strength (Min.) D 412 1,100 PSI

c. Percent Elongation (Min.) D 412 300%

d. Percent Comp. Set (Max.) D 395, Method B, 35%

22 hrs at 212°F

e. Heat Aging, Change from D 573, 70 hrs @ 212°F

Original Properties:

1. Hardness Change (Max.) +15 Points Shore

2. Tensile Strength (Max.) -15%

3. Elongation Change (Max.) -40%

f. Flame Resistance Must Not

Propagate Flame

g. Temperature Range -30°C to 100°C

h. Ozone Resistance D 1171, Method A,

72 hrs @ 38°C and

50 mPa Ozone

i. Resistance to Oil Aging: D 471, 70 hrs @ 212°F

Immersion in

ASTM Oil No. 3

1. Tensile Strength (Max.) -70%

2. Elongation (Max.) -55%

3. Volume Change (Max.) +120%

PART 3 - FABRICATION AND ERECTION

3.1 FABRICATION OF INSULATED MEMBRANE PANELS

A. General.

1. Insulated membrane assembly shop drawings shall include all information necessary for the fabrication by the Subcontractor of the insulated tensile membrane structure. They shall include size and shape of envelope, type and location of shop and field connections, size, type, and extent of all heat-welded seams.

2. The Subcontractor shall take necessary care to plan and assemble the fabricated sections such that the assembly has no shop patches. Splices, if any, shall be patterned into a symmetrical and repetitive geometric arrangement within the assembly, shown on the shop drawings and, where feasible, hidden by structural members.

3. All fabricated inner and outer membrane joints shall have a minimum of 90% of the total strength of the coated membrane in strip tensile testing. All structural joints shall be fused in accordance with industry standards and shall maintain the integrity of the coating. PTFE-coated woven fiberglass membranes shall be heat-sealed only.

4. All fabricated insulation blanket joints shall be butt joints having a minimum of 5pli (pounds per lineal inch) tensile strength when tested using a 7mm to 9mm blanket thickness.

5. Biaxial Test: At least one (1) representative sample of the outer membrane shall be biaxially test loaded. Membrane compensation in patterning shall be based upon the results of the biaxial test loading. At least one (1) representative sample of the inner membrane shall be biaxially test loaded. Membrane compensation in patterning shall be based upon the results of the biaxial test loading.

3.2 ERECTION OF INSULATED MEMBRANE ASSEMBLIES

A. Prior to installation of the insulated membrane assemblies, the Subcontractor shall meet with the General Contractor to review the erection procedure and scheduling. The Subcontractor shall coordinate all work with other trades.

1. No trade shall have access to, or work from the insulated membrane, unless authorized by the Subcontractor in writing.
2. Weather conditions: The Subcontractor shall proceed with installation of the tensioned membrane and associated Work only when existing and forecast weather conditions permit Work to be performed in accordance with established procedures and an appropriate degree of safety. The Subcontractor shall proceed only when willing to guarantee the Work as required without additional reservations or restrictions. All mutual decisions or agreements to proceed with the Work under unfavorable weather conditions must be recorded in writing stating the reasons for proceeding and the name of the person or persons involved in the decision. Under no condition will the Subcontractor be required to erect in weather conditions not approved by them.
3. Patching and repairs:

1. Installation of the canopy fabric shall be made with due care and appropriate protection to limit abrasion, cuts and tears.

2. Small damaged areas, maximum dimension in any direction 4 in., in the roof membrane shall be patched. No more than one field patch in 2000 sq. ft. shall be allowed, and no more than one field patch per panel, and no more than 5 field patches in the entire Work shall be allowed.

3. All field patches shall be executed to achieve 100% of the virgin coated membrane's strength properties.

4. All patches shall be rounded corners.

E. Erection of Structural Steel. [Edit scope as necessary]

1. The Subcontractor shall employ a competent foreman to supervise all work of steel erection. This foreman shall be present at all times during the Subcontractor’s scope of work.

2. All precautions shall be taken to ensure an accurately located and completely safe and stable structure at all times. Adequate guy cables shall be used throughout the work and all erection bolts shall be drawn up tight.

3. All steel shall be accurately aligned before permanent connections are made.

4. Temporary bracing shall be left in place as long as may be required for safety. The bracing shall be located so it does not interfere with the erection of the tensile membrane structure, and can be removed as required during construction.

a. The structure is to be self-supporting and stable after the building is fully completed. It is the Subcontractor’s sole responsibility to determine the erection procedure and sequence and to ensure the safety of the building and its component parts during erection. This includes the addition of whatever temporary bracing, guys or tie-downs that may be necessary. Such materials shall be removed by the Subcontractor and remain his property after completion of the project.

 5. Erection tolerances shall be specified in the AISC “Code of Standard Practice for Steel Buildings and Bridges,” including those related to placement of anchor bolts, unless otherwise indicated.

a. Tensile membrane structures (including individual membrane panels, insulated and/or uninsulated) are pre-engineered and pre-fabricated to fit a specific theoretical dimension. For those primary and secondary structural elements to which the membrane structure (including an individual membrane panel) is connected, the erected position of member working points, including those of cantilevered members, shall not vary from the theoretical model by more than 1” (25mm) in any direction, either individually, *or cumulatively* across a shipping piece. This includes but is not limited to: cable connection points, membrane panel edges, membrane bearing locations, intermediate splice points of field-spliced members, hardware connections, weldments and their anchorages. For arched members, include the three-dimensional location of the member midpoint as a working point for tolerance measurement.

b. The *cumulative* effect of dimensional steel discrepancies shall be such that the distance between membrane panel support points does not vary more than 1” (25mm) from the theoretical dimension within each membrane panel.

c. All steel structures that support tensioned membrane must maintain an uninterrupted drainage path and a minimum constant slope of 5 degrees from all points of the membrane.

d. In the event of conflict between pertinent codes and regulations and the requirements of the referenced standards *or* these specifications, the provisions of the more stringent shall govern.

3.3 PROTECTION AND CLEANING

A. Protect work from damage and deterioration during installation.

B. Upon completion of the insulated tensile membrane structure installation:

1. The Subcontractor shall clean all surfaces of the system’s components in conformance with the membrane manufacturer’s recommendations.

2. Inspect the system and repair membrane panels that have become damaged. Repairs shall be executed in such a way that they minimize any visually unacceptable impact.

C. Further protection of the work and final cleaning, if necessary, shall be the responsibility of the General Contractor.

END OF SECTION 133110