
# Spray Polyurethane Foam Systems for Cold Storage Facilities Operating Between - 40 °C and + 10 °C (- 40 °F and + 50 °F )

**RECOMMENDED DESIGN CONSIDERATIONS AND GUIDE SPECIFICATIONS**

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To order copies of this publication, call 800-523-6154 and request Stock Number AY-111

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1. Review existing documents and serve as a clearing house to ensure the "Continuity of Value" of technical information published by SPFA and others concerning the products and services of the SPF industry;
2. Review, research, develop and issue documents concerning new products, systems and services AND
3. To identify, explore, develop and communicate an understanding of technical issues facing the SPF Industry.

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# DESIGN CONSIDERATIONS

## GENERAL CONSIDERATIONS

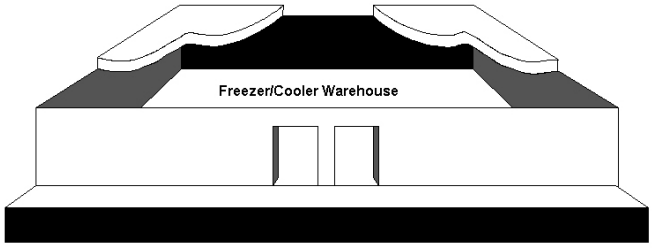
The performance of a spray applied polyurethane foam insulation (SPF) system for cold storage facilities can be affected by all the component parts of the building structure, as well as the atmospheric conditions inside and outside the structure.

Proper structural design, specifications review, contractor and material selection, coupled with the compatibility and positioning of the various components of the building are a necessity to produce a successful cold storage facility.

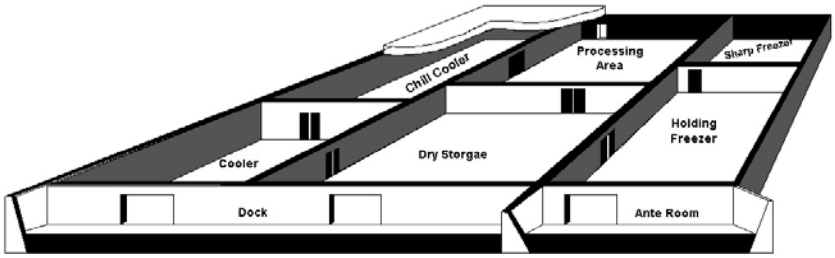
Consult with the designer/specifier and the successful contractor to receive written confirmation of their agreement/opinion to all facets of the cold storage project, including, but not be limited to, material selection, moisture vapor transmission, load design, expansion joints, and refrigeration requirements, flashing details, and floor, wall, ceiling preparation, and pull down schedule (see Appendix).

## TYPES OF COLD STORAGE FACILITIES

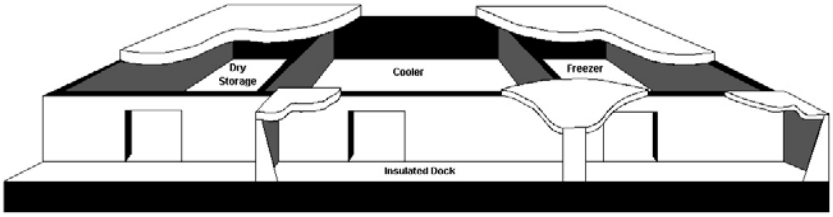
1. **Refrigerated warehouses** generally have a single function of storing previously processed or frozen food at a constant temperature between -40°C (-40°F) and 10°C (50°F). They are often one room buildings. Packaged goods are stored on pallets or food racks.
2. **Processing plants** for meats, poultry, dairy or other food products are multi-functional type structures which are quite complex. They typically consist of many rooms, each with a certain function, operating temperature and humidity condition.
3. **Distribution centers** are multi-room buildings for packaged dry goods, frozen foods, fresh produce, baked goods and dairy products. In addition to the above, these centers may contain specialty rooms such as banana rooms or ice cream holding rooms.
4. **Existing facilities** may be converted to another use, i.e., a cooler may be converted to a freezer, or a new room may be added within an existing structure.




**Refrigerated Warehouse**




**Processing Plant**




**Distribution Center**

## STRUCTURE PREPARATION, PROCEDURES AND CONSIDERATIONS

1. **Freezer Floors**

A. The ultimate load capacity of the SPF insulated floor is dependent on the thickness and compressive strength of the insulation and

strength of the concrete wearing slab. The concrete wearing slab is placed directly on the SPF and slip sheet.

B. All freezer floors are to be vented or heated. This may be in the form of ducts to circulate warm air, pipes for warm fluid, or electric heating cables. The capacity of the heat supply should be sufficient to prevent freezing of the subfloor soil. Thermocouples should be installed to allow monitoring of under-floor temperature during operation of the facility. The design of the subgrade heating system will be based on local soil conditions and the thermal conductivity of the SPF insulation system.

C. Sequence of floor construction:
   1. Apply vapor retarder and SPF insulation to base columns.
   2. Install heated mechanical equipment and vent pipes. Pour base slab (recess to allow for thickness of insulation). Allow new concrete to cure a minimum of 28 days before applying vapor retarder.
   3. Apply vapor retarder and SPF insulation.
   4. Secure slip sheet and pour concrete wearing slab.

2. **Cooler Floors** may not need to be insulated.

3. **Walls and Ceilings**

A. Conduits, pipes less than 50 mm (2 inches) in diameter, and hanger rods that project through the insulation should be insulated a distance of four times the regular wall insulation thickness. Insulate columns and pipes larger than 50 mm (2 inches) in diameter, a distance of 1.2 m (4 feet) from the wall, ceiling or floor.

B. Suspended ceilings should have sufficient working space above and should be vented.

C. Hanger rods should be insulated and spaced to provide safe support for anticipated loads.

D. All penetrations should be made before vapor retarder and SPF are applied.

E. Hollow wall is between two freezers are not recommended.

F. Walls which separate a low-temperature space from a heated space require more insulation than would be used on walls that separate cold spaces from each other.

4. **Roof Decks**

A. Metal decking or other conductive material should not be continuous between rooms of varying temperature.

B. SPF should not be applied directly over a lightweight concrete fill deck.

5. **Other Design Considerations**

When a vapor retardant material is used on the cold side of the insulation in a cold storage facility, such as in panels of metal roof decks, breaks in the exterior vapor retarder will result in the build-up of ice or moisture within the insulation. Routine maintenance inspections should be done to repair vapor retarder breaks before this can occur.

**SURFACE PREPARATION**

1. The surface to be insulated should be securely fastened and conform to load limits of good engineering practices.

2. Priming should be done in accordance with the recommendations of the spray polyurethane foam, primer, and/or vapor retarder manufacturer.

**SELECTION OF A VAPOR RETARDER**

The following items should be considered when choosing a vapor retarder:
1. Permeance required.
2. Surface preparation required.
3. Adhesion of all system components.
4. Manufacturer's recommendations.
5. Environment in which it is to be used.

**SELECTION OF THE SPRAY POLYURETHANE FOAM (SPF) SYSTEM**

A wide range of SPF systems are available, each exhibiting different temperature limitations, combustibility characteristics and physical properties. Most published data are run on laboratory samples. The thickness of polyurethane foam sprayed, number of lifts, temperature of substrate, ambient temperature, etc., may have an effect on all polyurethane foam properties.

From a fire safety standpoint, polyurethane foams can be used safely. It is important, however, that all

persons associated with the design, fabrication, storage and installation understand the materials and environments involved. Special care is recommended to prevent accidental ignition during construction.

**Polyurethane foam insulation is combustible and should be treated as such. Flame spread ratings provided for polyurethane products using small scale tests are not intended to reflect the hazards presented by this or any other materials under actual fire conditions. Care must be taken to ensure that the foam is not exposed to heat or flame.**

**SELECTION OF A THERMAL BARRIER**

Many types of thermal barriers are available on the market today including but not limited to:

1. Gypsum wallboard
2. Spray applied cementitious materials
3. Spray applied cellulose materials
4. Portland cement plaster
5. Various proprietary materials

The thermal barrier should have a currently valid building code certification that lists a report number and date. In some cases, a local building code official will allow the use of a thermal barrier which has been tested to the satisfaction of the official but is not yet certified by a code agency.

Generally accepted tests for thermal barriers include:

- UL 1715 Fire Test of Interior Finish Material
- UL 1040 Insulated Wall Construction
- FM 4880 Building Corner Fire Test
- U.B.C. Standard 26-2 Test Method for the Evaluation of Thermal Barriers.

**Caution:** Just because a material is advertised as a "thermal barrier" does not mean that it has been approved by a code agency or a local code official. Ask for test data and code body approvals, listings, or other written indications of acceptability under the code to be sure that the product selected offers the fire protection that the code demands.

Consider the following items in the selection of a thermal barrier:

1. USDA and building code requirements.
2. Adhesion to the SPF.
3. Environment in which it is to be used.
4. Aesthetic qualities.
5. Ease of maintenance.

**PULL DOWN SCHEDULE**

The gradual lowering of the facility's temperature allows for the materials of construction to adjust to dimensional changes, reduces stress from sudden moisture changes, and allows for more accurate monitoring of vapor retarder and mechanical equipment performance. See Appendix I for more detailed information.

**MAINTENANCE PROCEDURES**

It is recommended that maintenance procedures, including annual inspections, be established with your selected contractor for any insulation system requiring periodic maintenance.

CONTACT THE RESPECTIVE MANUFACTURER/ SUPPLIER AND CONTRACTORS FOR RECOMMENDED MAINTENANCE PROCEDURES.

**RECOMMENDED GUIDE SPECIFICATION**
**FOR INSULATION OF COLD STORAGE FACILITIES**

Note: This guide is designed to help the specifier insulate a cold storage facility. It is the responsibility of the specifier to consult the chosen manufacturers of materials specified as to their recommendations.

## PART 1 — GENERAL

This guide discusses the application of a vapor retarder and spray polyurethane foam (SPF) with a protective thermal barrier for use as an insulation system in cold storage facilities. Your contractor, systems manufacturer, and local code agencies can assist you, as each project must be assessed individually.

### 1.01 SCOPE OF WORK

Furnish all labor, materials, tools and equipment necessary for the application of a SPF insulation system to a cold storage facility, including accessory items, subject to the general provisions of the contract.

### 1.02 RELATED WORK SPECIFIED ELSEWHERE

| | | |
|---|---|---|
| A. | Cast-in-Place Concrete | Section 03300 |
| B. | Metal | Section 05300 |
| C. | Rough Carpentry | Section 06100 |
| D. | Insulation | Section 07200 |
| E. | Membrane Roofing | Section 07500 |
| F. | Flashing and Sheet Metal | Section 07600 |
| G. | Roof Specialties and Accessories | Section 07700 |
| H. | Mechanical | Division 15 |
| I. | Electrical | Division 16 |

### 1.03 QUALITY ASSURANCE

A. Contractor Qualifications: The proposed contractor will provide information concerning projects similar in nature to the one proposed, including location and person to be contacted. Some manufacturers of SPF systems and thermal barriers have approval programs and/or licensing methods that could be required.
B. Manufacturer Qualifications: Polyurethane foam, primer, thermal barrier, and vapor retarder manufacturers shall show evidence of sufficient financial resources and manufacturing facilities to furnish materials on this project. References shall be required, sufficient project lists, and building code approvals shall be submitted for verification.
C. Inspections: The polyurethane foam and thermal barrier manufacturers may provide qualified representatives to monitor and inspect the installation of their products.

### 1.04 SUBMITTALS

A. Published data sheets or letters of certification from manufacturers that their products comply with the materials specified. This is to include primers (if required), SPF, vapor retarders and thermal barriers.
B. Shop drawings on sheet metal, accessories, or other fabricated items.
C. Manufacturer's application or installation instructions.
D. Contractor/applicator certification from polyurethane foam and/or thermal barrier manufacturers and evidence of contractor/applicator qualification and experience. SEE SECTION 1.03
E. Approval and information guides for applicable building codes.
F. Safety and handling instructions for storage, handling and use of the materials to include appropriate Materials Safety Data Sheets (MSDS).
G. Field Quality Control Procedures to be utilized by the contractor/applicator to insure proper preparation and installation of SPF, primers, vapor retarders, thermal barriers, detail work, and follow-up inspection.

1.05 MATERIALS, DELIVERY AND STORAGE

A. Material shall be delivered in the manufacture's original, tightly sealed containers or unopened packages, all clearly labeled with the manufacture's name, product identification, safety information, and batch or lot numbers where appropriate. Where materials are covered by a referenced specification, the labels shall bear the specification number, type and class, as applicable.
B. Containers shall be stored out of the weather and direct sunshine where the temperatures are within the limits specified by the manufacturer.
C. All materials shall be stored in compliance with fire and safety requirements.

1.06 ENVIRONMENTAL CONDITIONS

A. Do not apply the SPF below the temperature and/or above humidity specified by the manufacturer for ambient air and substrate.
B. Apply primers, vapor retarder and thermal barrier in accordance with the material manufacturer's application instructions.

1.07 SEQUENCING AND SCHEDULING

New construction requires that the contractor/applicator must apply vapor retarder and the SPF insulation systems at different times during the construction project.

1st Phase Floors and Columns (see Design Considerations)
2nd Phase Roof
3rd Phase Walls and Ceiling
4th Phase Doors

Penetrations must be in place before application of primer, vapor retarder and SPF insulation.

1.08 SAFETY REQUIREMENTS

A. See:
1. API Bulletin AX-151, *Guide for the Safe Handling and Use of Polyurethane and Polyisocyanurate Foam Systems*, Alliance for the Polyurethane Industry, 1300 Wilson Boulevard, Arlington, VA 22209;
2. *Six Steps for Fire Safety During Construction*, Alliance for the Polyurethane Industry, 1300 Wilson Boulevard, Arlington, VA 22209.

B. Refer to Material Safety Data Sheets (MSDS) for additional safety information.

**PART 2 — PRODUCTS**

2.01 SPRAY POLYURETHANE FOAM (SPF) Spray Polyurethane Foam Insulation: The cured SPF shall possess the following physical characteristics:

| PROPERTIES | ASTM TEST | METRIC UNITS | U.S. UNITS |
|---|---|---|---|
| Density (sprayed in place)* | D-1622 | 32 - 48 kg/$m^3$ | 2.0 - 3.0 lbs/$ft^3$ |
| Compressive Strength | D- 1621 | 140 kPa min | 20 psi min |
| Closed Cell Content | D-2856 | 90% min | 90% min |
| R-Value | C- 177 or C-518 | As reported | As reported |
| Flammability ** | E-84 | #75 or as required by applicable building code | |

* In freezer applications, generally increase specified SPF density with decreasing freezer temperatures. Consult SPF manufacturer for specific recommendations.

**This standard is used solely to measure and describe properties of products in response to heat and flame under controlled laboratory conditions. This numerical flame spread rating is not intended to reflect hazards presented by this or any other material under actual fire conditions.

2.02 VAPOR RETARDER

Physical properties: The vapor retarder will be chosen for its compatibility to the substrate and SPF. Moisture Vapor Transmission: As tested by ASTM E-96 Method E shall be 0.01 perm or less. Refer to AY-118, *Moisture Vapor Transmission.*

2.03 THERMAL BARRIER

If required, must meet applicable building codes. Refer to AY-126, *Thermal Barriers for the Spray Polyurethane Foam Industry*.

2.04 PRIMER

If required, as recommended by manufacturer.

2.05 ACCESSORIES AND MISCELLANEOUS MATERIALS

A. Flashings and waterproof coverings for expansion joints shall be compatible with specified vapor retarder and SPF system and shall be as recommended by the manufacturers of the systems used.
B. Miscellaneous materials such as adhesives, elastomeric caulking compounds, metal, vents, and drains shall be a composite part of the cold storage facility and shall be those recommended by the systems manufacturer.
C. Insulation Boards: If required over floors or roof decks, follow manufacturer's instructions for fastening and/or other design requirements. Multiple layers should have staggered seams.

**PART 3 — EXECUTION**

3.01 SURFACE PREPARATION AND PRIMING

A. Metal Deck

1. The metal roof deck shall be constructed of minimum 22-gauge steel. Construction shall conform to local building codes.
2. Ferrous Metal: Sandblast iron and steel surfaces which are not primed, shop painted, or otherwise protected in accordance with SSPC SP-6, Commercial Blast Cleaning. Remove loose rust and un-sound primer from shop-primed iron and steel surfaces by scraping or wire brushing.
3. Non-Ferrous Metal: Clean galvanized metal, aluminum, and stainless steel surfaces as recommended by the manufacturer issuing the warranty.
4. If the metal surface is free of loose scale, rust, weathered or chalking paint, it can be cleaned using compressed air jet, vacuum equipment, and hand or power broom to remove loose dirt. Grease, oil or other contaminants shall be removed with proper cleaning solutions.
5. Fluted metal decks require a suitable method of covering or filling the flutes prior to polyurethane foam application. Flutes may be covered with mechanically fastened board stock, open weave mesh fabric, or filled with precut board stock or spray applied polyurethane foam.

B. Concrete

1. Remove loose dirt, dust and debris by using compressed air, vacuum equipment or brooming. Oil, grease, form release agents or other contaminants shall be removed with proper cleaning solutions.
2. All joint openings in concrete decks that exceed 6 mm (1/4 inch) shall be grouted or caulked prior to application of polyurethane foam.
3. Priming is required on concrete surfaces, and it is recommended that poured concrete decks be permitted to cure for twenty-eight (28) days prior to the application of primer or sprayed polyurethane foam.
4. Sprayed polyurethane foam is not recommended for lightweight or insulating concretes unless tests have been made to determine that adequate adhesion can be obtained or unless an overpayment is installed.

C. Wood

1. Plywood shall be exterior grade not less than 13 mm (1/2 inch) thick, nailed firmly in place. Attachment must meet building code requirements for resistance to wind uplift.
2. Plywood shall contain no more than 18% water, as measured in accordance with ASTM D 4444, or ASTM D 4442.
3. All untreated and unpainted surfaces shall be primed with an exterior grade primer. Priming is required to minimize moisture absorption and eliminate potential polyurethane foam adhesion problems.
4. Plywood joints in excess of 6 mm (1/4 inch) shall be taped or filled with a suitable sealant material.
5. Deck shall be free of loose dirt, grease, oil or other contaminants prior to priming or foam application. Remove loose dirt or debris by use of compressed air, vacuum or brooming. No washing shall be permitted.
6. Tongue & Groove, Sheathing, Planking: Due to the frequency of joints, possibility of variable
7. openings and effects of aging and shrinking, these surfaces must be overlaid with a minimum of 6 mm (1/4 inch) thick exterior grade plywood or suitable covering.

D. Other Surfaces (i.e. Gypsum Board, Isocyanurate Board)

1. These materials are generally used over fluted metal decks and must be fastened to achieve necessary wind uplift requirements.
2. Boards shall be firmly butted together along all edges without gaps or openings. Joints exceeding 6 mm (1/4 inch) shall be caulked with a suitable sealant material.
3. Special care must be taken to prevent these materials from getting wet in storage on the job site and after installation prior to being protected by polyurethane foam. Moisture exposure will damage these materials and may be a cause for replacement.
4. Remove loose dirt and debris by using compressed air, vacuum or light brooming. No power brooming is permitted due to possibility of damage.
5. The installed materials shall be protected from spills of contaminants such as oil, grease, solvents, etc., as these materials cause soiling that cannot be readily removed from the board surfaces.

3.02 VAPOR RETARDER APPLICATION

A. Interior Application.

1. The vapor retarder shall be applied in accordance with the manufacturer's specifications and instructions.
2. The vapor retarder shall be applied to all surfaces to be insulated and extend 150 mm (6 in) beyond where the insulation will end. Metal surfaces do not require vapor retarders. However, seams and/or penetrations must be sealed.
3. The vapor retarder shall be cured before the SPF insulation is applied.
4. The vapor retarder shall be a continuous film; floor to wall to ceiling or roof. (See Design Details.)

5. Any damage or defects to the vapor retarder film shall be repaired prior to the application of SPF insulation.
6. The vapor retarder film shall be free of moisture, frost, debris, or contaminants that will impair the adhesion of the SPF insulation to the vapor retarder and substrate.

B. Exterior Application

1. The vapor retarder shall be applied in accordance with the manufacturer's specifications and instructions.
2. The vapor retarder shall be applied as a continuous membrane to a clean, dry SPF surface.
3. The vapor retarder shall be without voids or holidays and shall extend 100 mm (4 in) beyond the termination of the polyurethane foam at projections and wall terminations.

See SPFA document AY 118 *Moisture Vapor Transmission*.

3.03 SPRAY POLYURETHANE FOAM APPLICATION

A. Application

1. The applicator shall not apply SPF insulation below the surface temperature and/or above the humidity specified by the manufacturer for ambient air and substrate.
2. The SPF insulation should be applied in a minimal lift thickness of 13 mm (½ inch), with a maximum thickness per lift as recommended by the SPF manufacturer.
3. The SPF insulation shall be applied uniformly to the minimum specified thickness over the entire surface.
4. SPF insulation thickness shall be determined by the specifier and shall be sufficient to provide the R-value required, and to prevent condensation. Factors, such as exterior temperature, facility temperature, and humidity should be considered to determine the final thickness of the SPF insulation.
5. The SPF insulation shall be allowed to cure. If the full thickness of the SPF insulation is not completed prior to the end of the day, the foam surface shall be prepared in conformity with the recommendations of the manufacturer.

B. Surface Finish

1. The finished surface shall be acceptable for the application of the thermal barrier.
2. Any damage or defects to the SPF insulation surface shall be repaired as necessary prior to the thermal barrier application.

3.04 THERMAL BARRIER APPLICATION

A. The thermal barrier shall be installed at the thickness required by the manufacturer to comply with applicable building codes.
B. Sprayed or troweled thermal barriers shall be allowed to cure. The thermal barrier should be inspected for uncured areas or defects. Any defects shall be repaired prior to subsequent applications or temperature pull-down.
C. Refer to API document, *Six Steps for Fire Safety During Construction*, Alliance for the Polyurethane Industry, 1300 Wilson Boulevard, Arlington, VA 22209.

3.05 ROOFS

Refer to SPFA *Spray Polyurethane Foam Systems for New and Remedial Roofing, Design Considerations and Guide Specifications* (SPFA Stock Number AY-104), Spray Polyurethane Foam Alliance, 4400 Fair Lakes Court, Fairfax, VA 22033.

# APPENDIX
# I

## Cold Storage Facility – Pull Down Schedule

Materials used to construct refrigerated rooms, like all materials used in building structures (i.e., steel frames, metal decks, etc.) are affected by temperature changes.

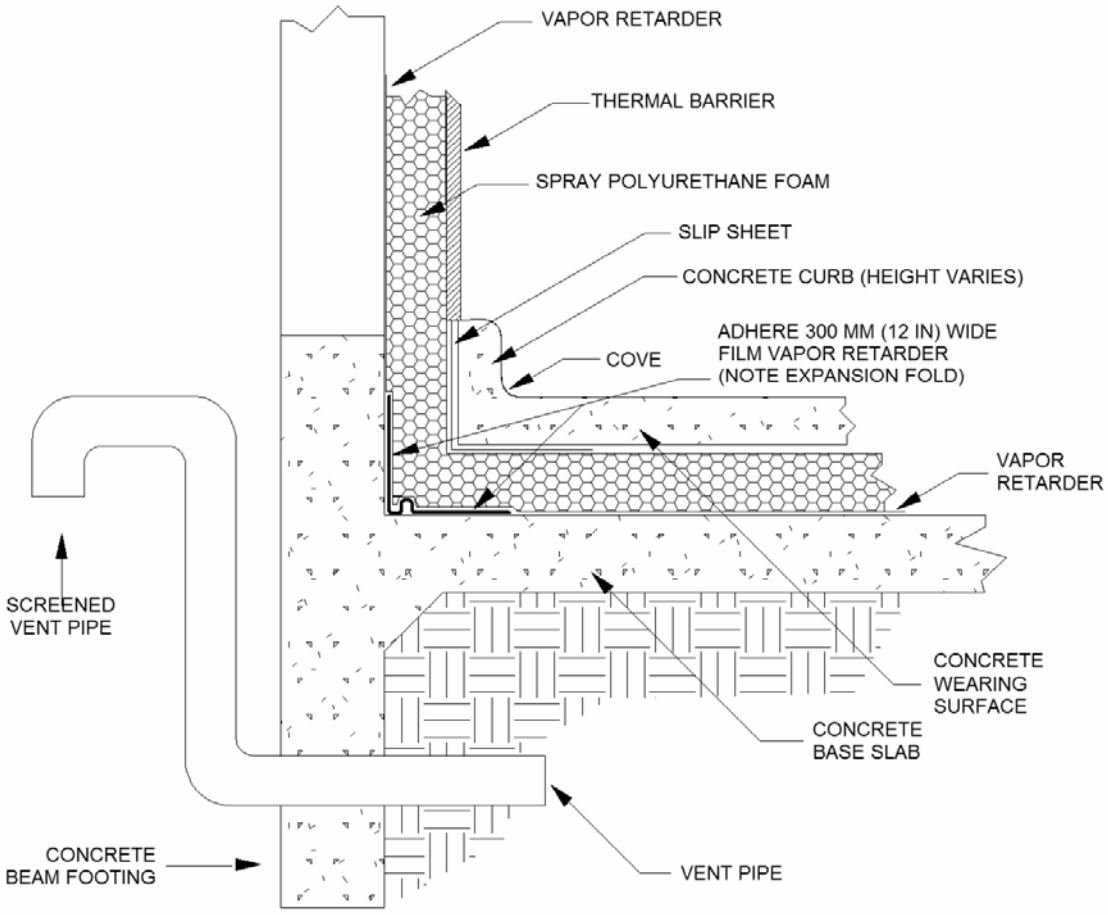
The gradual lowering of the facility's temperature allows for the materials of construction to adjust to dimensional changes, reduces stress from sudden moisture changes, and allows for more accurate monitoring of vapor retarder and mechanical equipment performance.

Listed below is an example of a typical pull down schedule:

| **Temperature Reduction Until Room is Dry** | | | | |
|---|---|---|---|---|
| **Time Period** | **Maximum Temperature Reduction** | | **Minimum Room Temperature** | |
| First 24 hours | — | — | 24 ºC | 75 ºF |
| Second 24 hours | 8 ºC | 15 ºF | 16 ºC | 60 ºF |
| Third 24 hours | 8 ºC | 15 ºF | 7 ºC | 45 ºF |
| Fourth 24 hours | 6 ºC | 10 ºF | 2 ºC | 35 ºF |
| Until room is dry (Observe moisture on cooling coils as an indicator) | 0 ºC | 0 ºF | 2 ºC | 35 ºF |

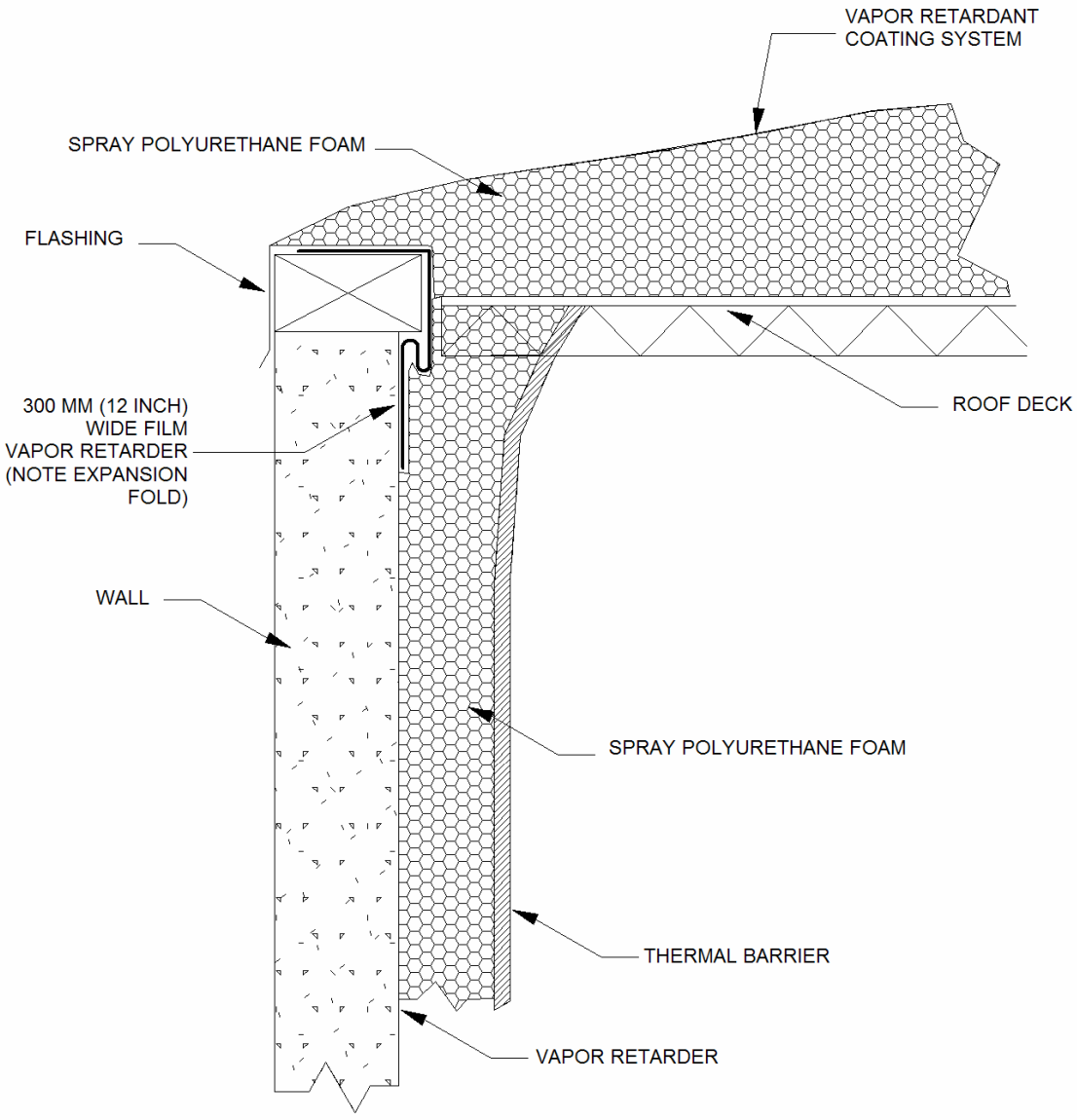
| **Temperature Reduction After Attaining Dry State** | | | | |
|---|---|---|---|---|
| **Time Period** | **Maximum Temperature Reduction** | | **Minimum Room Temperature** | |
| First 24 hours | 3 ºC | 5 ºF | -1 ºC | 30 ºF |
| Second 24 hours | 6 ºC | 10 ºF | -6 ºC | 20 ºF |
| Third 24 hours | 6 ºC | 10 ºF | -12 ºC | 10 ºF |
| Fourth 24 hours | 6 ºC | 10 ºF | -17 ºC | 0 ºF |
| Fifth 24 hours | 6 ºC | 10 ºF | -23 ºC | -10 ºF |

# COLD STORAGE FACILITY
# FLOOR/WALL JUNCTION




NOTE: COOLERS MAY NOT REQUIRE INSULATED FLOORS AND SUBSURFACE VENTING/HEATING.

# COLD STORAGE FACILITY
# ROOF/WALL JUNCTION



# COLD STORAGE FACILITY
# SUSPENDED CEILING