

# **MBMA CONDENSATION FACT SHEET**



## **METAL BUILDING MANUFACTURERS ASSOCIATION®**

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# CONDENSATION FACT SHEET

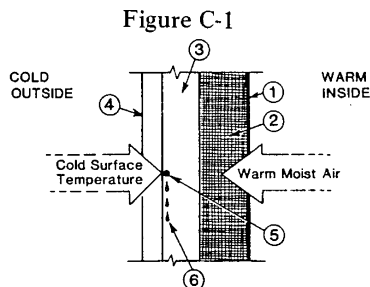
Metal buildings offer the opportunity for outstanding energy efficiency at relatively low costs. Well insulated buildings have fewer natural air changes, so it is important to understand how condensation forms and how to avoid it.

Most states have adopted energy standards and codes for various categories of buildings such as commercial, hospital, community, manufacturing and office facilities, all of which are in the metal building market area. Metal building manufacturers and insulation suppliers have developed various insulation systems to help meet these requirements. Much work is being done to improve the state-of-the-art in providing energy efficient buildings.

This fact sheet has been prepared to provide answers for some of the questions concerning condensation such as: what is condensation; what causes condensation; how is it best controlled?

## THE CONDENSATION PROCESS

The condensation process occurs when warmer moist air comes in contact with cold surfaces such as framing members, windows and other accessories, or the colder region within the insulation envelope (if moisture has penetrated the vapor retarder). Warm air, having the ability to contain more moisture than cold air, loses that ability when it comes in contact with cool or cold surfaces or regions. When this happens, excessive moisture in the air is released in the form of condensation. If this moisture collects in the insulation, the insulating value is decreased (see Figure C-1) as wet insulation has about the same heat conductance value as water.



1. Vapor Retarder
2. Insulation
3. Cold (attic) region
4. Weather barrier (panel)
5. Dew point surface (Typical - can vary within wall cavity)
6. Condensation

In dealing with condensation, air may be considered to be a mixture of two gasses - dry air and water vapor. One thousand cubic feet of air at 75° F can hold up to 1.4 pints of water. At 45° F, it can hold only 0.5 pints.

Relative Humidity is a percentage measurement of the amount of water vapor present in the air in relation to the amount it is capable of holding at that temperature. Therefore, 50% relative humidity would mean that the air is carrying only one-half of the total amount of moisture that it could be holding at that particular temperature. Cold, outside air is usually much drier than warm inside air. Therefore, the indoor relative humidity can be lowered by bringing in outside air to mix with and dilute the moist inside air. At 100% Relative Humidity, the air is "saturated."

The temperature at which the air is saturated and can no longer hold the moisture is called the dew point temperature (see Table C-1 at the end of this fact sheet for more information). Whenever air temperature drops below its dew point, excess moisture will be released in the form of condensation. Condensation problems are most likely to occur in climates where temperatures frequently dip to 35° F or colder over an extended period of time.

## CONDENSATION CONTROL

Two things must be present for condensation to occur: warm moist air, and cool surface temperatures below the dew point. The proper control of these two factors can minimize condensation.

In metal buildings, we are concerned with two different areas or locations: visible condensation which occurs on surfaces below dew point temperatures; and concealed condensation which occurs when moisture has passed into interior regions and then condenses on a surface below dew point temperature.

### Visible Condensation

To effectively control visible condensation, it is necessary to reduce the cold surface areas where condensation may occur. It is also important to minimize the air moisture content within a building by the use of properly designed ventilating systems.

## Concealed Condensation

Concealed condensation is the most difficult to deal with and can be the most damaging to any kind of structure. This type of condensation may be controlled in metal buildings by the proper use of vapor retarders and by minimizing moisture content within the building by proper ventilation. Additional condensation control can be accomplished by venting the cavities of the walls and roof.

## VAPOR RETARDERS

A vapor retarder is used to inhibit the passage of warmer moist air into the inner regions of the roof or wall system. The proper selection and installation of the vapor retarder can help control condensation problems in a building. Vapor retarders are rated by the amount of moisture that can pass through them. The lower this rating, called a perm rating, the less vapor transmission will occur and the more effective the vapor retarder will be. Materials with perm ratings of 0.5 and higher may not be suitable where conditions of high humidity and moisture exist. Materials with perm ratings of 1.0 or above are considered to be at the minimum level of vapor retarders.

There are various types of vapor retarders available, such as:

1. **Structural Membranes**, including rigid steel sheets or other impermeable material.
2. **Flexible Membranes**, such as foils, coated papers, or plastic films. Usually, these membranes are rated by "perm" of 1.0 or less, per ASTM E-96. (The most familiar to the metal building industry are the membrane retarders laminated to fiberglass blanket insulation). Plain white vinyl with a

perm rating of 1.0 is not an effective vapor retarder, especially in buildings with a high relative humidity.

### 3. **Coating Membranes** which include paints.

The proper location and installation of vapor retarders is very critical. Some important guidelines to follow to insure the performance of the vapor retarder are:

1. Install the vapor retarder at the warm side of the insulating surface. Vapor retarders should not be used above any other form of retarder at ceiling level.
2. When installing either a membrane type or structural type, make sure that all seams, laps and joints are properly sealed. Sealing a vapor retarder may be achieved by gluing, taping or stapling. A method of stapling is described below.
3. In the case of a membrane type retarder, make sure that any punctures or tears in the material are repaired.

Because there is a growing trend to add insulation to existing metal buildings, a proper vapor retarder is of critical concern. One of the most common methods is to add an additional layer of insulation to the bottom flange of the purlin system. This can create an air space where moisture laden air can accumulate if the integrity of the new vapor retarder closest to the warm insulating surface of the building has not been maintained. It is important that an intact vapor retarder is not left within the insulation mass.

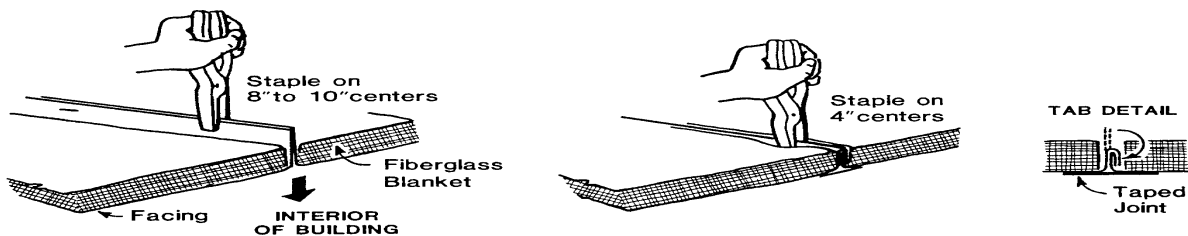


Figure C-2

(Optional)

## PROPER VENTILATION OF A BUILDING

Proper ventilation in a building can be an effective measure for condensation control. This includes the venting of attic and wall spaces. The end use of the building must be considered when designing ventilation parameters, especially above drop ceiling areas. Ventilation system design is most effective when done at the initial building design stage. Use of a design professional is strongly recommended to assure the best possible system.

## SIGNS OF CONDENSATION

1. Visible Surface Condensation - Condensation occurring at cold exposed surfaces.
  - a. Water, frost or ice on windows, doors, frames, ceilings, walls, floors, insulation vapor retarders, skylights, cold water pipes and/or cooling ducts.
2. Concealed Structural Cavity Condensation.
  - a. Damp spots, stains, mold and/or mildew on walls or ceilings.
  - b. Delamination of laminated surfaces, bubbles or blisters in asphaltic surfaces and peeling paint.
  - c. Damp insulation

## CONTROLLING CONDENSATION

1. At the Source - Limit the amount of water vapor within the heated interior.
  - a. Provide a well drained base course such as crushed rock or washed gravel under grade level slabs to prevent moisture from permeating into the building through the slab.
  - b. Provide for adequate ground water drainage.
  - c. Divert rain and melt water accumulations away from the foundation.
  - d. Vent all mechanical heating apparatus with hydrogen-oxygen by-product exhausts to the outside.
  - e. Reduce supplemental interior humidification.
2. By Insulating - A proper insulation scheme effectively raises surface temperatures within the building envelope above the dew point temperature. This is accomplished by controlling the heat loss at the exposed (exterior) sides of those surfaces. However, insulation added above an existing roof should be placed at the existing roof level and not against the retrofit roof if possible. Adequately ventilated space is required because any trapped warm air may condense at the cold metal roof.
  - a. Provide additional insulation in ceiling and/or wall cavities or replace existing damp or water soaked insulating material within these cavities.
  - b. Install double or triple glazed windows or insulated storm panels with thermal break frames.
  - c. Install insulated doors.
  - d. Install insulation wrap (with exterior vapor retarder) around cold pipes and/or cold air duct work.
  - e. Insulate floor slab edges exposed to exterior temperatures with a rigid insulation-pressure treated plywood combination.
  - f. Paint condensation prone surfaces with moisture absorbing paints.
3. With Vapor Retarders - A vapor retarder is a vapor resistant membrane of polyethylene film, aluminum foil, paint, asphaltic laminate and/or glazed, asphalt saturated building paper that exhibits a permeance of less than one perm. Since the membrane is, in effect, a seal to prevent water vapor from combining with a given cavity air mass, it must be continuous and unbroken. All joints and seams must be lapped, sealed, and secured.
  - f. Be aware that the pouring of concrete within a newly erected structure presents special considerations. While the practice should be held to a minimum, an individual project assessment must be made to prevent both visible and concealed condensation.

- a. Employ (or repair) a vapor retarder at the warm side surface of all insulating material. In the case of the fiber blanket insulations, the retarder may be laminated to the insulating fiber. All joints at crawl spaces, under slab ductwork, attic openings, ceiling fixtures and/or other wall, ceiling and floor penetrations must be properly sealed.
  - b. Install a vapor resistant ground cover over interior, exposed ground surfaces.
  - c. Install a vapor retarder between sub-flooring and ground slab.
  - d. Install a clear vapor retarder over skylight openings and seal off to warm side insulation barrier.
  - e. Install a vapor retarder on both sides of the insulation in buildings with a cooler, controlled atmosphere and in cold storage buildings to prevent condensation inside the insulation.
4. Through Ventilation - The dilution of a moist interior air mass with drier outside air for the express purpose of lowering the relative humidity of the air mass. For retrofit applications, venting above existing roof may not be necessary if the source below is eliminated by adequate means of vapor retarders. The natural amounts of water vapor from outside air exchange will dissipate gradually without any effect.
- a. Cold Side Venting - The venting of “exterior” cavities (cavities at the cold side of the insulation envelope but contained within the general building envelope) of the building’s structural elements. One square foot of “free” vent area must be provided for each 300 square feet of convective cavity area. Vents should be uniformly distributed to provide the best overall air flow and also should be screened and louvered to prevent insects and rain from entering the cavity.
    - 1. Provide ridge and eave vents in building “attic” areas.
    - 2. Provide for base and eave line ventilation to wall cavities.
  - 3. Install foundation vents to any crawl space areas.
  - 4. Install exhaust fans.
- b. Warm Side Venting - The venting of the interior building envelope.
- 1. Install convective type venting apparatus.
  - 2. Install remote exterior air changers with heating and distributing systems as required.
  - 3. Install exhaust fans. (Note: Borderline effectiveness - depends heavily upon infiltration for air change.)

<b>Condensation Problem</b>	<b>Methods of Control (See Controlling Condensation)</b>
1. Moisture, frost or mold on underside of uninsulated metal roof.	1d, 1e, 2a, 2f, 3a, 3b, 4b1, 4b2, 4b3
2. Moisture or frost on skylights.	1d, 1e, 3b, 3d, 4b1, 4b2, 4b3
3. Moisture or frost formations on interior vapor retarder.	1d, 1e, 2a, 3b, 4b1, 4b2, 4b3
4. Moisture dripping from ceiling fixtures.	2a, 4a1, 4a4
5. Moisture, dampness and/or mildew on floor areas.	1b, 1c, 2e, 3c, 4a3
6. Moisture and/or frost on exterior windows, doors and metal frames.	1d, 1e, 2a, 2b, 2c, 4b1, 4b2, 4b3
7. Dampness, stains, mildew or blistering and peeling paint on ceilings.	1d, 1e, 2, 2a, 2f, 3a, 3b, 4a1, 4a4, 4b1, 4b2, 4b3
8. Dampness, stain, mildew or blistering and peeling paint on walls.	1d, 1e, 2, 2a, 2f, 3a, 3b, 4a2, 4a4, 4b1, 4b2, 4b3
9. Moisture dripping from cold water pipes or cold air ducts.	1d, 1e, 2d, 2f, 3b, 4b1, 4b2, 4b3
10. Soggy or damp insulation in ceiling or walls.	1d, 3a, 4a1, 4a2, 4a4

Note: All listed possible cures do not address the possibility of a leak defect through the roof membrane. This Fact Sheet is a general guide to condensation problems and possible remedial measures. It is not designed to address specific difficulties in specific buildings. Your architect or builder should be consulted if you encounter problems. MBMA disclaims any responsibility of liability for condensation problems or the use of this Fact Sheet in connection with any specific building.

**Table C-1**

Dew Point Temperature (°F) <sup>1</sup>															
Relative Humidity	Design Dry Bulb (Interior) Temperature (°F)														
	32°F	35°F	40°F	45°F	50°F	55°F	60°F	65°F	70°F	75°F	80°F	85°F	90°F	95°F	100°F
100%	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90%	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80%	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70%	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60%	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50%	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40%	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30%	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20%	6	7	8	9	13	16	20	24	28	31	35	40	43	48	52
10%	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

1. Chart adapted from ASHRAE Psychrometric Chart, 1997 *ASHRAE Fundamentals Handbook*.