Condensation Control in

Properly controlling condensation in metal building systems is critical to maintaining the thermal performance of the insulation system and prolonging the service life of the building components. Condensation can occur on any surface within the building envelope that is at or below the dew point temperature of the ambient air within the structure. Said differently, when warm moist air comes in contact with a cold surface, such as framing members, windows and other building accessories, it cools to the temperature below its dew point and condensation forms. Consider the following:

- The amount of moisture the air can hold is proportional to its temperature (i.e., warmer air can hold more moisture).
- Dew point is the temperature at which the air is fully saturated and can hold no additional moisture.
- When the air temperature drops below its dew point, moisture is released from the air in the form of condensation, which forms on cold surfaces.

The key to avoiding condensation is to ensure the components of the building envelope do not drop below the dew point temperature. When it does, there are some generally accepted recommendations that are worth reviewing to mitigate the effects of condensation.

Signs of Condensation

Condensation may be visible or concealed. Signs of visible condensation are water, frost or ice on the exposed surface of windows, doors, frames, ceilings, walls, floors, insulation vapor retarders, skylights, cold water pipes and ducts. Some ways to control these types of condensation include:

- Reducing the relative humidity in the building through ventilation and/or dehumidification. This will decrease the dew point temperature of the air and reduce the potential for condensation.
- Increasing the insulation levels on cold pipes and ducts where applicable. This will increase the surface temperature and further reduce the potential for condensation.

Concealed condensation occurs when moisture vapor has breached the exposed surfaces and condenses within the walls, roof or mechanical system insulation. Some signs of concealed condensation include stains, rust, mildew on walls or ceilings, delaminating surfaces, and damp insulation. This type of condensation is the most challenging since it may not be readily visible. The key is to find the pathway that is allowing the moist air to reach the cold surfaces.

Here are some of the most common questions I get asked about condensation issues in metal buildings:

How would you begin to address a potential condensation issue in a metal building system?

Water dripping from the ceiling doesn't necessarily mean that you have a roof leak. It is advisable to rule out any obvious breaches of the exterior envelope that may be allowing liquid water to enter the building. Things to consider here are roof leaks, ice damming, ponding water or the flow of

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water around trim, flashing/sealants and wicking. If problems persist after these have been addressed, condensation must be considered.

When troubleshooting potential condensation problems, factors to consider are:

- **Relative humidity in the building:** Reducing the relative humidity reduces the vapor pressure and vapor drive. Relative humidity is the ratio (typically expressed as a percentage) of the amount of water vapor in the air at a specific temperature to the maximum amount that the air can hold at that temperature.
- **Holes or penetrations in the vapor retarder:** All holes, penetrations and seams should be sealed.
- **Air leakage and pressure balance:** In cold climates, air leakage has the potential to transport significant quantities of moisture around the vapor retarder to the cold exterior panels where it can condense. Ideally, a building's HVAC system should be operating at neutral pressure to the outside. When this is not practical, operating at a slightly negative pressure in cold climate during the winter will reduce air leakage and can prevent warm moist air from ever reaching the cold exterior panels. The converse can also be said for an air conditioned building during the summer in a hot humid climate. Here, operating at a slight positive pressure can help keep the warm exterior air from reaching the cool interior surfaces via infiltration. Care should be taken not to operate at excessively negative pres sures to avoid drawing water into the structure.

Can you expound upon some of the sources that would elevate the humidity levels?

In new construction, there can be significant amounts of moisture introduced into the building due to exposed excavated earth, freshly poured concrete, or flue and exhaust gasses from temporary heaters and heavy equipment. In cold weather, when the concrete is poured after the building has been enclosed, it is critical that the building is well ventilated to reduce the relative humidity. Left unventilated, the humidity can easily approach 100 percent and result in condensation, which can damage the insulation system and other exposed surfaces.

Some other examples of high humidity situations are indoor swimming pools, ice rinks, wineries, livestock, vehicle-maintenance garages and waste-processing facilities. Even the building's occupants give off a significant amount of water through perspiration and respiration.

How can one measure the humidity and dew point temperature?

One effective way to measure relative humidity at various locations is by using hygrometers that will read the humidity and interior room temperature. Hygrometers have been around since the early 1800s. Today, hygrometers provide readings in analog or digital format. Wireless hygrometers may be ideal to measure the relative humidity of building spaces from up to 100 feet away by placing a few remote sensors throughout the building. The main unit can receive and display data while highlighting trends in rising and falling humidity levels.

Once you have established the relative humidity level and the interior temperature, you can measure the surface temperature of various interior building components by way of an infrared or laser thermometer. If the surface temperature is at or below the dew point temperature shown in Surface Dew Point Temperature Table below, then you have the high probability that condensation will occur on that surface.

What role does proper ventilation play in controlling condensation?

All buildings require some level of ventilation. A lack of ventilation can create an uncomfortable working condition through elevated heat levels, excessive humidity and stale air. Ventilation can best be represented by the number of times per hour the building air is replaced with outside air. This is referred to as air changes per hour. The number of air changes required per hour widely varies per building end use and the climate in which the building is located. Allowances must be made for a place for air to enter and exit the building, and the airflow must be evenly distributed throughout the building. Typical methods for moving air include exhaust and supply fans, ridge ventilators and louvers. Letting the outside air into the building and controlling the exhaust of warm moist air out of the building is one effective way to reduce condensation and is an essential part of the building HVAC design that should not be skipped.

How do vapor retarders and insulation help solve the problem?

In properly designed systems, the vapor retarder is placed on the warm side of the wall or roof, and the insulation is of sufficient thickness to maintain the surface temperature of the vapor retarder above the dew point of the warm air. This prevents condensation from forming on the surface of the vapor retarder. The vapor retarder then functions by limiting the migration of water vapor into the insulation system, which helps to prevent condensation from forming on the opposing colder surfaces. As such, the vapor retarder and insulation work hand-in-hand to keep the moisture in the warm air from reaching a surface that is below the dew point temperature.

How does condensation control change in warm climates?

In the majority of climate zones, the low-permeance vapor retarder in a metal building is located on the exposed interior surface of the insulation. This reduces the migration of moisture in the interior air from coming into contact with the cold roof or wall panels during the cooler months.

Surface Dew Point Temperature (°F)

Relative Humidity	Design Dry Bulb (Interior) Temperature (°F)														
	32°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°	90°	95°	100°
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

Note: Chart adapted from ASHRAE Psychometric Chart, ASHRAE Handbook of Fundamentals.

However, the moisture dynamics in hot humid climates are different, and it is not uncommon for the low-permeance vapor retarder to be placed on the exterior side of the insulation, between the fiberglass and the metal roof or wall panels.

This is done to limit the migration of moisture vapor in the exterior air from reaching cooler interior surfaces. In systems such as this, a perforated, breathable insulation facing can be used on the interior side of the insulation. Low-permeance vapor retarders should not be installed on both sides of the insulation, as moisture could become trapped between the layers and condense there. It is important to consult with the building designer and a mechanical engineer to address buildings to be located in a hot humid climates.

What types of vapor retarders perform best in metal building systems?

Vapor retarders are classified by their permeance, which is a measure of the amount of moisture vapor that can pass through them under a specific set of conditions. Vapor retarders with low perm ratings (typically in the range of 0.02 to 0.1 US Perm) are most effective at controlling moisture migration. Insulation facings with Perm ratings greater than 1.0 are not considered vapor retarders.

The most common vapor retarders used in the metal building industry today are low-permeance, multi-layer reinforced facings that are often laminated to the insulation. These vapor retarders not only control water vapor migration, but they also provide other functional and aesthetic benefits. If laminated fiberglass is not used, the other option is to install a vapor retarder facing and insulation separately. Some common vapor retarders used in the metal building industry include: Polypropylene/Scrim/Kraft (PSK), Polypropylene/Scrim/Polyester (PSP), Polypropylene/Scrim/Kraft/Polyester (PSKP) and Foil/Scrim/Kraft. Each provides its own unique benefits in combination with low permeance.

The North American Insulation Manufacturers Association recommends that metal building insulation should be faced with a vapor retarder having a permeance of not greater than 0.10 US Perms for normal conditions, and 0.02 US Perms for high humidity interior conditions. Regardless of the building end use and in the event of high humidity, it is important that all seams, joints, and penetrations are sealed to limit the passage of water vapor around the facing.

Has the increase in energy code requirements changed how one controls condensation?

As the energy codes evolve, more emphasis is being placed on increased insulation levels in the roof and wall, and controlling air leakage throughout the building envelope. In older metal building systems you may see a single layer of laminated fiberglass insulation installed between the secondary framing (purlins and girts) and the roof or wall metal panels. Today the use of multi-layer fiberglass insulation, which fills the cavity between the purlins and girts, and/or rigid insulation systems are required to comply with code.

Additionally, the use of foam sealants, tapes and joint closures may be necessary to meet air leakage requirements. Consequently, buildings today are more energy efficient and tighter than ever before. As such, it becomes important to involve a mechanical engineer to help ensure the metal building has a properly sized HVAC system.

Metal buildings meeting today's energy codes are far more efficient, and may use a smaller HVAC system than typically used in the past for a comparable sized structure. This is easily overlooked. As a result, if the HVAC system is oversized it can result in short cycling and improper ventilation. A mechanical engineer should be consulted to properly size the HVAC system to assure adequate ventilation and humidity control while considering of the end use and insulation level of the building. This is an important aspect in controlling both visible and concealed condensation.

What are some of other causes of moisture entering the building envelope that may not necessarily be caused by condensation?

The weathertightness of a metal building is dependent on a variety of components working together to create a water tight exterior. The potential causes of unwanted water infiltration can be associated with roof leaks, ice damming, improperly installed insulation or missing closures, improper pressure balance, and wicking of moisture into the roof or wall insulation. Insulation can act as a wick when exposed to water; therefore it should not be installed as a closure under the metal panel ends at the eave or base of the slab. It is important to have the insulation contractor wrap the vapor retarder over the ends of the insulation so the fiberglass is unable to wick water into the insulation system.

Does the Metal Building Manufacturers Association (MBMA) have other recommendations to control condensation in addition to the ones you highlighted?

Yes, MBMA has a comprehensive Condensation Fact Sheet that offers solutions to condensation in metal building systems. This publication highlights common problem areas that may be causing condensation as well as methods to control it. This resource is available as a free download on **www.mbma.com** by clicking on the "Recent Publications" button on the home page, and then clicking "Brochures." MCN

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