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Technical Bulletin #15

Condensation Fact Sheet

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What is Condensation?
Condensation occurs when air is cooled to temperature at which it is 100% saturated.
Simply, air has a given capacity to hold water vapor. Warmer air has a greater capacity to hold water vapor than cooler air. Consequently, the total amount of water vapor that the air can hold is primarily a function of its temperature. As air is cooled, its capacity to hold water vapor is diminished. When cooled to a temperature at which it can no longer hold the water vapor it contains, the air is said to be saturated and **"condensation"** (liquid water) will become visible on surfaces.

What is Relative Humidity?
Relative humidity is a ratio of how much moisture vapor is in the air, compared to the air's total moisture vapor capacity at a given temperature. It is a measure of the moisture loading in the air.

If the relative humidity is 50% at 73ºF, the air contains 50% of its water vapor capacity at that temperature. If this same air is then cooled, the relative humidity of the air will increase. This is because the air has less total capacity to hold that same quantity of water vapor when its temperature is reduced. When the air is cooled to a temperature at which its relative humidity increases to 100%, it is saturated and condensation will form.

What is Vapor Pressure?
- Vapor pressure is the driving force that moves water vapor through a vapor retarder.
- The higher the temperature and humidity of the air… the greater the vapor pressure.
- High vapor pressure exists on the warm side of the vapor retarder while low vapor pressure exists on the cool side.
- Moisture vapor moves from areas of high vapor pressure to areas of low vapor pressure.

How are Dew Point Temperature, Condensation and Relative Humidity Related?

The **dew point temperature** is the temperature at which air cools to its saturation point and condensation begins to form. Dew point temperatures can be determined, in Table 1, if the temperature and relative humidity of the air are known.

Troubleshooting Condensation Problems:

High Interior Relative Humidity:

Excessively high interior relative humidity equates to high interior vapor pressure and is often the cause of condensation problems. High interior relative humidity can be a function of the building's end use, HVAC system, or improper construction practices. Human respiration and perspiration can also contribute to a significant amount of moisture in the buildings environment. Other common sources of indoor moisture include:

- **Combustion**
  Oil and gas fired heaters give off a significant amount of moisture to the air. Water vapor introduced to the air through combustion is sometimes very difficult to detect because hot exhaust gasses can hold large quantities of moisture. As exhaust gasses cool, condensation can form on cold exterior surfaces. To avoid this situation, flue gases should always be vented outside.

- **Excavated Earth**
  Significant amounts of moisture can be introduced into a building before it is completed. As damp soil within the building is excavated, moisture will likely evaporate. If the building is enclosed, this

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moisture will become trapped within the structure and elevate the relative humidity within the structure. As soon as the temperature drops below the dewpoint of that air/water mixture, condensation will form. NOTE: The higher the relative humidity, the higher the dewpoint temperature.

- **Concrete**
  Fresh concrete is another large source of moisture within a building. A 100,000 ft^2 freshly poured 4"concrete slab has the potential to give off approximately 24,000 gallons of water into the building. When concrete is poured after the building has been enclosed, proper ventilation is critical to remove the excess moisture vapor. Ventilation should always be considered as a preventive measure during the construction schedule.

Types of Condensation and How to Control It:

- **Visible Condensation**
  Visible condensation is evident when water appears on cool surfaces; it can be clearly seen. This type of condensation can form on windows, purlins or exposed exterior fasteners. While a nuisance, this type of condensation is far less damaging than hidden condensation. It can be controlled by adding insulation, proper ventilation and by reducing relative humidity levels.

- **Concealed Condensation / Moisture**
  Concealed condensation is the most difficult to deal with and can be the most damaging. It occurs when moisture vapor condenses within the insulation system behind the vapor retarder or in other concealed building cavities. Potential causes for concealed condensation are as follows:

- Improper vapor retarder selection
- Improper placement of the vapor retarder
- Improper installation of the insulation system
- Roof leaks
- Water Infiltration
- No structural air barrier
- High humidity levels
- Inadequate ventilation
- Incorrect pressure differential between the inside and outside of the building. This is critical factor that must not be overlooked.

What are the Effects of Moisture on Metal Buildings?
Moisture from rain, ground water, and concrete all increase the relative humidity in a building and increase the probability of condensation. Liquid moisture has the potential to create severe problems in metal buildings.

- **Metal and Condensation**
  Most of the surfaces in a metal building are protected against corrosion/rust under normal operating conditions. However, when metal parts are exposed to moisture for extended periods of time they can oxidize, become weaker, and shorten the life expectancy of the building. Even though many surface treatments are applied to ferrous and non-ferrous metals to prevent oxidation, the best protection is to eliminate a key component — moisture.

- **Fiberglass Insulation and Condensation**
  Fiberglass is the most commonly used thermal insulation in metal buildings. The presence of condensed water in fiberglass insulation will increase its thermal conductivity and reduce its insulating value. Fiberglass insulation however, is durable. If allowed to fully dry and return to its design thickness, fiberglass will revert back to its original insulating value. (Note: This statement pertains only to thermal performance. No claims are being made with respect to mold related issues associated with condensation or roof leaks)

The Importance of Vapor Retarders
Vapor retarders inhibit the passage of moisture into the insulation and reduce the potential for condensation on the cold side of the insulation. Vapor retarders do not totally stop water vapor transmission; they significantly reduce its movement.

Vapor Retarder Ratings

Vapor retarders, commonly referred to as "Facings" are rated by the amount of moisture that can pass through them. Facings with lower perm ratings are more effective vapor retarders. Flexible vapor retarders come in a wide variety of materials and perm ratings. The most common are membrane vapor retarders, which are typically laminated to fiberglass metal building insulation. Materials with ratings of greater than 1.0 perm are not classified as vapor retarders. Plain white vinyl with a perm of 1.0 is not an effective vapor retarder in buildings with a high relative humidity. Perm ratings for the facings most commonly used on metal building insulation are shown in the table below:

Type		Perm Rating
PSK	Polypropylene/Scrim/Kraft	0.02 - 0.09
FSK	Foil/Scrim/Kraft	0.02
PSKP	Polypropylene/Scrim/Kraft/Metallized Polyester	0.02
PSP	Polypropylene/Scrim/Metallized Polyester	0.02
PSF	Polypropylene/Scrim/Foil	0.02
VRP	Vinyl/Scrim/Metallized Polyester	0.02
Vinyl	Plain Vinyl	1.0

For applications where a permeable insulation covering is required, most membrane vapor retarders can be perforated to increase the permeability and allow moisture migration.

Installation Guidelines

- Install the vapor retarder on the warm side of the insulation. In most locations within the United States, this is the inside surface. However, in warmer humid climates, the warm side may be to the exterior of the insulation. It is best to consult the architect or engineer on the project when this is the case. Refrigerated buildings and coolers are also applications in which the vapor retarder may be placed to exterior side of the insulation.

- The insulation must be thick enough to maintain the surface temperature of the facing above the inside ambient air dewpoint temperature.

- Seams, joints, and penetrations should be sealed to retard the passage of water vapor around facing and into the insulation.

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Seam Sealing Techniques
Insulation is supplied with the vapor retarder facing wider than the fiberglass insulation. Most facings are 6" wider than the laminated insulation. The extra facing may be supplied as two 3" tabs, or one 6" tab. There are a number of different techniques employed for fastening these tabs. Sealing can be achieved by gluing, taping or stapling. Three most common techniques are shown below:

- **Two 3" Tabs- stapled, folded and re-stapled.**
  When two 3" tabs are supplied, the tabs are pulled between adjacent runs of insulation and stapled every 8", approximately 1/4" to 3/8" from the bottom of the faced side of the insulation. After the first stapling, the tabs are then folded over and stapled again. The second row of staples is to be placed between the original staples yielding tabs with staples every 4". Caution: Do not staple too close to the base of the tabs because the staples may pull out and result in a poor vapor seal.

- **One 6" Tab- overlapped but not sealed**
  When the insulation is supplied with one 6" tab along the length of the fiberglass, the 6" tab should overlap the adjacent run of fiberglass. No tape or sealant is applied.
- **One 6" tab- overlapped and sealed with double faced tape**
  This is the same technique as #2 above; however, a strip of double faced tape is applied under the tab to seal the tab to exposed surface on the adjacent run of insulation.

Which Technique is Preferable?
A study sponsored by Lamtec and conducted at the Johns Manville Technical Center compared the relative performance, with respect to water vapor movement, of the three most commonly used metal building insulation sealing techniques. For comparison, a test was also performed with an unseamed section of facing.

The tests were run with the only variable being the seaming technique used to join the two adjacent runs of insulation. The data below shows the relative performance of the various closure techniques. The water vapor transmission rate shown here is in terms of grains per hour-ft^2.

Sealing Technique	**grains/hr-ft^{2}***
No seam, 0.02 perm facing	0.174
1 — 6" Tab, Taped	0.265
2 — 3" Tabs, Folded/Stapled/Folded	0.906
1 — 6" Tab, No Sealant	1.306

*These values should not be confused with the "US Perm" (grains/hr-ft^2-in Hg) rating commonly used to classify vapor retarders.

As can be seen, the 6" single tab with tape performed best in this study, followed by the staple /fold/staple system and the 6" single tab without tape. It should also be noted that the data shown above only represents one data point at each test condition. This data should only be used for comparative purposes.
Table 1: Dew Point Temperatures

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% RH

ºF

0	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
5																		
10																	9	9
15													9	9	9	12	12	15
20										9	9	12	12	15	15	17	17	20
25								9	12	12	15	15	17	20	20	22	23	23
30						9	12	12	15	17	20	22	23	23	25	27	28	29
35					9	12	15	17	20	22	23	25	27	28	29	31	32	33
40				9	12	17	20	22	23	27	28	29	31	33	35	36	37	39
45			9	15	17	22	23	27	28	31	32	35	36	38	39	41	42	44
50			12	17	22	25	28	29	32	35	37	39	40	42	44	46	48	48
55		12	17	22	25	28	31	35	37	39	41	43	46	48	49	51	52	53
60		15	20	25	29	32	36	38	41	44	46	48	51	52	54	55	57	59
65	9	17	23	29	33	37	40	43	46	48	51	53	55	57	59	60	62	63
70	12	22	25	32	37	41	45	48	51	53	55	58	60	61	63	65	67	68
75	17	25	32	37	41	46	49	52	55	58	60	62	64	67	68	70	72	73
80	20	25	36	41	46	50	53	56	60	62	65	67	69	71	73	75	77	78
85	23	32	39	45	50	55	58	61	64	67	70	72	74	76	78	80	82	83
90	27	36	43	50	55	59	62	66	69	72	74	77	79	81	83	85	87	88
95	31	40	48	54	59	63	67	70	73	76	79	81	84	86	88	90	92	93
100	33	44	52	58	63	68	71	75	78	81	84	86	88	91	93	94	96	98
105	37	48	56	62	67	72	76	79	83	86	88	91	93	95	89	10 0	10 2	10 3
110	41	52	60	66	72	76	80	84	87	90	93	95	98	10 0	10 2	10 4	10 6	10 8

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