Removing The Potential For Condensation In An Electronic Cabinet

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REMOVING THE POTENTIAL FOR CONDENSATION IN AN ELECTRONIC CABINET

The age old problem of keeping condensation from forming has been exacerbated by current day micro electronics with devices and printed circuit lands that are so small that it takes a 100 power microscope to see them. The advantage to the system designer is that much more capability can be provided in a smaller space due to the reduction in equipment size and increased speed due to less transmission paths lengths between circuits and devices. Equipment that is designed for extreme environments typically has some type of conformal coating placed on the circuit cards to prevent condensation and containments from effecting the operation of the equipment. This is an expensive process since there are additional steps in the manufacturing process and additional design requirements since the transfer of heat from the circuit cards must be provided by heat sinks due to the fact that the devices are no longer cooled by convective air flow in contact with the devices.

First we need to understand how condensation forms in its most basic form. Condensation is initially moisture in the air that is in a gas form just like air. When this air comes in contact with a surface that its temperature is at or below the dew point the moisture is converted to a liquid state which we refer to as condensation. Many people have the misconception that salt and fog filters will prevent moisture from entering an area and if you think about it for a minute it is obvious that the moisture is contained within the air itself. This same air freely flows through the filter. A NEMA 4 cabinet is water resistant and dust proof and is not an air sealed enclosure. Air will flow in and out of the enclosure depending on the inside vs. outside air pressures.

The laws of physics govern how moist air reacts within various temperature conditions. The study of moist air properties is technically referred to as "psychrometrics." A psychrometric chart is used by professionals to determine at what temperature and moisture concentration water vapor begins to condense. This is called the "dew point." By understanding how to find the dew point, you will better understand how to avoid moisture problems in your system.

Relative humidity (RH) refers to the amount of moisture contained in a quantity of air compared to the maximum amount of moisture the air could hold at the same temperature. As air warms, its ability to hold water vapor increases; this capacity decreases as air cools. For example, according to the psychometric chart, air at 68ºF (20ºC) with 0.216 ounces of water (H2O) per pound of air (14.8g H_2O/kg air) has a 100% RH. The same air at 59ºF (15ºC) reaches 100% RH with only 0.156 ounces of water per pound of air (10.7g H_2O/kg air). The colder air holds about 28% of the moisture that the warmer air does. The moisture that the air can no longer hold condenses on the first cold surface it encounters (the dew point.) If this surface is within a cabinet then condensation will form.

Air Temperature in Degrees Fahrenheit

Air Temp °F	% Relative Humidity																		
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
110	110	108	106	104	102	100	98	95	93	90	87	84	80	76	72	65	60	51	41
105	105	103	101	99	97	95	93	91	88	85	83	80	76	72	67	62	55	47	37
100	100	99	97	95	93	91	89	86	84	81	78	75	71	67	63	58	52	44	32
95	95	93	92	90	88	86	84	81	79	76	73	70	67	63	59	54	48	40	32
90	90	88	87	85	83	81	79	76	74	71	68	65	62	59	54	49	43	36	32
85	85	83	81	80	78	76	74	72	69	67	64	61	58	54	50	45	38	32	
80	80	78	77	75	73	71	69	67	65	62	59	56	53	50	45	40	35	32	
75	75	73	72	70	68	66	64	62	60	58	55	52	49	45	41	36	32		
70	70	68	67	65	63	61	59	57	55	53	50	47	44	40	37	32			
65	65	63	62	60	59	57	55	53	50	48	45	42	40	36	32				
60	60	58	57	55	53	52	50	48	45	43	41	38	35	32					
55	55	53	52	50	49	47	45	43	40	38	36	33	32						
50	50	48	46	45	44	42	40	38	36	34	32								
45	45	43	42	40	39	37	35	33	32										
40	40	39	37	35	34	32													
35	35	34	32																
32	32																		

There are three basic methods of providing cooling in electronics equipment enclosures which are an Air Conditioner, Heat Exchangers and Direct Air Cooling (DAC). The first two methods are closed loop and essentially the air in the cabinet is isolated from the outside ambient air.

AIR CONDITIONER: The Air Conditioner is probably the best method of preventing the formation of condensation. The Air Condition has an evaporator coil that is operated significantly below the dew point temperature and as the return air is presented to the evaporator coil moisture forms as condensation on the evaporator coil and is directed to a drip pan that is dumped outside the Air Conditioner. The humidity inside an Air Conditioned cabinet initially swings between 30 to 60 % with 30% when the compressor is on and 60% when the compressor is off. After three to four hours of operation the humidity will be in the range of 40 to 45%. Since this is a closed loop system the Air Conditioner will continue to remove moisture the longer it operates.

HEAT EXCHANGER: With the heat exchanger the temperature inside the cabinet will always be above the ambient temperature outside the cabinet. This prevents the temperature inside the cabinet reaching the dew point. This does require that the internal heat load of the equipment is sufficient to maintain the temperature differential between inside and outside. The heat exchanger should have a thermostat or electronic control to prevent temperatures within the cabinet from reaching the critical dew point when the outside ambient conditions are extremely cold.

DAC: The DAC method is open loop in that ambient outside air is drawn into the cabinet through a filter to provide cooling. This system requires the use of a thermostat to control the air flow into the cabinet. The equipment heat load is also a critical item in that the temperature inside the cabinet must be maintained above the dew point or condensation will form. Typically the internal cabinet temperature of a DAC cooled system must be maintained between 95 to 104 degrees F to prevent the forming of condensation.

Air Temperature in Degrees Fahrenheit

Air Temp °F	% Relative Humidity																	
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
110	110	108	106	104	102	100	98	95	93	90	87	84	80	76	72	65	60	51	41
105	105	103	101	99	97	95	93	91	88	85	83	80	76	72	67	62	55	47	37
100	100	99	97	95	93	91	89	86	84	81	78	75	71	67	63	58	52	44	32
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90	90	88	87	85	83	81	79	76	74	71	68	65	62	59	54	49	43	36	32
85	85	83	81	80	78	76	74	72	69	67	64	61	58	54	50	45	38	32	
80	80	78	77	75	73	71	69	67	65	62	59	56	53	50	45	40	35	32	
75	75	73	72	70	68	66	64	62	60	58	55	52	49	45	41	36	32		
70	70	68	67	65	63	61	59	57	55	53	50	47	44	40	37	32			
65	65	63	62	60	59	57	55	53	50	48	45	42	40	36	32				
60	60	58	57	55	53	52	50	48	45	43	41	38	35	32					
55	55	53	52	50	49	47	45	43	40	38	36	33	32						
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35	35	34	32																
32	32																		

The above chart depicts the relationship between air temperature and humidity. As you can clearly see at high levels of humidity the dew point temperature can easily be within 2 to 3 degrees F of the air temperature. This is why it is critical to maintain the cabinet temperature above the dew point. Keep in mind that the air temperature and the metal structures that make up the equipment can and most often are at lower temperatures than the free air temperature. This is due to the density of these materials. Also these materials are slow to change temperature due to their density.

The DAC method of cooling has the greatest potential for the formation of condensation and is why the internal temperature must be maintained to a level sufficient to mitigate condensation formation. The Air Conditioner method of cooling is not as susceptible to condensation due to the evaporator coil in the air conditioner providing cool dry air to the enclosure. Operating the air conditioner when the door to the cabinet is open for an extended period is not recommended since this may cause excessive condensation that may freeze under certain conditions on the evaporator coil.

Condensation in liquid form is essentially distilled water and as such has a resistance value far above 5000 ohms per centimeter so except for micro electronics density between pins is not a consideration for conduction between two electrical points. The combination of condensation and other containments such as sodium (salt) which is present in coastal areas and the salt from human hands that come in contact with equipment in the installation and maintenance of equipment, this now becomes a caustic component. This can attack power and data connectors as well as other equipment in the cabinet. Corrosion can lead to high resistance paths that over time can provide maintenance issues.

So the bottom line is that the system designer must consider the options to reduce or eliminate the potential for condensation. This can be caused by having to doors open during high humidity. Small amounts of condensation are inevitable during the servicing of the equipment in the cabinet and in many cases the equipment heat load or cabinet cooling will cause this condensation to evaporate in a short period of time and not cause a serious problem. Extended periods of condensation should be avoided.