PROTECTION OF NATURAL GAS MEASUREMENT EQUIPMENT AGAINST MOISTURE AND CORROSION

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ABSTRACT

This presentation addresses problems associated with moisture and corrosion caused by high relative humidity and airborne contaminants. By controlling moisture and corrosion long-term, many problems associated with sensitive field electronics can be avoided.

INTRODUCTION

The natural gas industry relies very heavily on sensitive electronic equipment utilized in the production, gathering, transportation, and distribution phases. There is an increasing reliance on the use of electronics for performing important tasks relating to measurement, control, and safety. Coupled with increased reliance is the demand by users for increased reliability.

Failures in electronic equipment causes:

- Increased man hours for maintenance
- Inaccurate data
- Loss of data
- Overall increased cost

While there are many factors that contribute to failures in sensitive field electronics, this paper will focus on two: High Relative Humidity (RH) and Corrosion. Having a keen understanding of RH is very helpful for controlling RH and corrosion in field electronics. What follows is an explanation of RH, saturation, and water dew point.

WHAT IS RELATIVE HUMIDITY

What is Relative Humidity (RH)? RH is a term which indicates the amount of moisture in the air, as compared to the amount of moisture it can hold at a given temperature. It is important to note the distinction between percent water vapor and percent RH. Percent water vapor is the ***actual*** amount of water vapor in the air. Percent RH is the ***percentage*** of the air's water vapor ***capacity***, at a given temperature, relative to the amount of water vapor that it currently holds.

As an example, Figure #1 indicates, that at a temperature of 20^{o} C, air can hold up to 2.3% of water vapor. When it does contain 2.3% water vapor, it is considered saturated. Therefore, it is at a 100% Relative Humidity level. Relative Humidity values less than 100% reflect the degree, or percentage, to which the air is saturated. In this example air can hold 2.3% water vapor at 20^{0} C. However at 20^{0} C, if only 1.15% of water vapor is present in the air, then it contains only 50% of what it can hold, and the RH is 50%.

The RH can be increased or decreased by two means. One way is to raise or lower the temperature. For instance, lowering the temperature from 20^{o} C to 15^{o} C reduces the air's water vapor capacity from 2.3% to 1.68%. Therefore a water vapor content of 1.15% represents 68% of the air's capacity, and the % RH is 68%. In a similar manner, raising the air temperature to 25^{o} C increases the air's water vapor capacity to 3.12%. Now a water vapor concentration of 1.15%, at 25^{o} C produces a Relative Humidity of only 36.8%. This is much less than the 50% RH which it produced when the air was at 20^{o} C. This clearly demonstrates that, with the actual amount of water vapor remaining constant, the %RH can be changed by variations of air temperature.

A second means for changing the %RH is to vary the water vapor content. Figure #2 shows that, at 20^{o} C, if the water vapor content increased from 1.15% to 1.73%, the %RH would rise from 50% to 75%. This occurs because the amount of water in the air is increased while the air's water capacity remained constant.

Figure #2 also shows that if the air were now cooled to 15^{o} C, its water vapor capacity would drop to 1.68%. Since its new capacity is only 1.68% and the actual amount of water in the air is 1.73%, some of the water would condense. The air is now saturated (at its capacity) and its dew point is 15^{o} C. This is how fog is formed in ambient air. When nighttime cooling drops the temperature of air below its dew point, some of the water vapor condenses producing fog. The dewpoint (temperature) of air is the temperature at which condensation begins. At the dew point, the air is saturated and the RH is 100%.

EFFECTS OF MOISTURE ON ELECTRONICS

During the past few years electronics have become smaller causing components on printed circuit boards to be more closely spaced. Closely spaced components have substantially increased the sensitivity of the equipment to moisture and corrosion. Moisture has more effect on the performance of sensitive electronic equipment which contain closely space components.

Due to ambient temperature changes, very large swings of RH occur daily in enclosures. Enclosure RH can spike to very high levels for short periods, especially early in the morning when temperatures are generally at their minimum. **All** surfaces exposed to air containing moisture adsorb water molecules. The number of water molecules that attach themselves to surfaces varies in direct proportion to RH, not the absolute water vapor content. Therefore, as %RH rises, the quantity of moisture adsorbed by surfaces also rises. Hence, in electrical and electronic circuits, the insulating materials between conductors begin to lose their insulating properties as % RH rises. This can produce destructive stray electrical currents. Many intermittent electronic failures are caused by changes of the RH inside enclosures. Many components, such as switches and connectors, cannot be conformal coated to protect against high RH and corrosion. Therefore, it is important to control the enclosure's Relative Humidity.

Often problems may seem to disappear when an electronic enclosure is opened for maintenance. This occurs because the atmosphere in the enclosure is exchanged with outside ambient air having a lower RH.

EFFECTS OF MOISTURE ON CORROSION RATE

Corrosion in electronic enclosures is largely influenced by two factors, airborne contaminants and high RH. The presence of airborne contaminants, such as salt and H_2S, cause corrosion to occur. The rate of corrosion by these contaminants is increased exponentially with increased %RH. Therefore RH spikes can have an enormous impact on the rate of corrosion. A few hours at a high %RH may cause as much corrosion to occur as would normally occur over several weeks at a lower %RH. RH spikes most frequently occur near sunrise when the air temperature is typically at its minimum. Therefore, preventing RH spikes is very important.

HOW MOISTURE ENTERS AN ENCLOSURE

For the purposes of this paper, there are only two types of enclosures:

(1) Enclosures that are not completely airtight and, therefore, "breathe"
(2) Enclosures that are completely airtight and do not "breathe"

ENCLOSURES THAT ARE NOT COMPLETELY AIRTIGHT

Temperature variations account for the bulk of RH changes in enclosures. An enclosure subjected to atmospheric weather conditions undergoes daily temperature cycling. A 30ºF change in ambient temperature is quite common. For this example Figure #3 the assumption is that the enclosure is essentially weatherproof, but not airtight. Large enclosures are rarely absolutely airtight.

On a typical day, as soon as the sun goes down, the ambient internal temperature begins to drop. Air in the enclosure contracts as it cools, causing a slight reduction of pressure, which draws air into the enclosure from outside. As the air cools, its moisture holding capacity is also lowered, and as previously discussed, this results in an increase of the % Relative Humidity in the enclosure. As %RH increases, so does the amount of moisture adsorbed on internal surfaces. This process continues until morning, at which time the ambient temperature has reached its lowest point.

This drop in temperature, accompanied by the increase of the %RH, can cause condensation to occur in the enclosure. However, even without condensation occurring, short-duration RH spikes can produce more damage, by enhancing corrosion and causing stray current paths, than occurs during the rest of the day.

As the sun rises Figure #4, ambient and enclosure temperatures increase. This causes the air within the enclosure to expand, forcing some air to escape. The temperature rise also causes the enclosure's RH to drop. Moisture, previously adsorbed on enclosure and electronic surfaces, takes more time to desorb than for the air to escape. This results in an increasing %RH in the enclosure over time.

The temperature cycle is repeated daily with high RH spikes occurring at regular intervals.

ENCLOSURES THAT ARE COMPLETELY AIRTIGHT

How does moisture enter an enclosure that is completely airtight? Either the moisture is trapped in the enclosure from the factory or it enters when the enclosure is opened for installation, calibration or maintenance. In any case, air trapped within the enclosure has a definite water vapor capacity that is dependent on the ambient temperature in the enclosure, as previously discussed. As the temperature in the enclosure rises and falls, the %RH inside the enclosure will also change. The RH changes which take place in airtight enclosures due to temperature changes are as detrimental as RH changes resulting from "breathing" in high humidity air.

HOW TO CONTROL RELATIVE HUMIDITY AND CORROSION IN AN ENCLOSURE

There are several methods for controlling %RH and corrosion in airtight and breathing enclosures:

(1) The use of desiccants to remove moisture from the enclosure.
(2) Passivating the metals associated with the electronic components so that they are not susceptible to corrosion by airborne contaminants.
(3) Conformal coating printed circuit boards and components to make them impervious to moisture and corrosion.
(4) Moisture and Corrosion Control Packets that control humidity and prevent corrosion long-term.

(1) DESSICANTS

Desiccant packs are often used in an attempt to eliminate the effects of high RH on sensitive electronic equipment. However, most all desiccants have a very small capacity to absorb moisture. Often, the amount of water vapor they can remove from the air is only a fraction of their own weight. Having absorbed water vapor to their capacity, they are ineffective and need to be either replaced or regenerated. Although their initial purchase cost is very low, the overall cost to constantly replace or regenerate those products is very high. Since their capacity is very small, it is often expended before ever leaving the factory from which they were installed. Even if a customer is willing to pay the expense and manpower required to replace these products consistently, the problem of knowing when to replace the products still exists.

(2) PASSIVATION OF METALS ASSOCIATED WITH ELECTRONIC COMPONENTS

Passivation of metals associated with electronic components can be achieved by using a vapor corrosion inhibitor (VCI). There are many VCI's on the market today to accomplish this task. Some VCI's attract moisture, become soggy, disintegrate and crumble onto the electronics they are trying to protect. Lastly, there is the question of when to change the VCI. How does one know when the product is working or not?

(3) CONFORMAL COATING

Conformal coating of electronic components is a fairly common practice for protection against moisture and corrosion. However, not all components lend themselves to being conformal coated. For instance, edge-card connectors on printed circuit boards, potentiometers and dip switches are components which cannot be coated. Therefore, they are susceptible to moisture and corrosion induced failures.

(4) MOISTURE AND CORROSION CONTROL PACKETS

The most effective way to control corrosion is to control the RH spikes that accelerate corrosion rate and to passivate the metals associated with the electronics. Moisture and Corrosion Control Packets are available which can accomplish both tasks. The packets contain two types of revolutionary, granular materials that have the ability to control RH and release a vapor to passivate the electronic metals against corrosion. One granular humidity control material has the ability to absorb moisture when the RH is high and release moisture when the RH is low, thereby keeping a constant long-term %RH in the enclosure. The packets have the ability to absorb and release water vapor under ambient conditions, (this is known as self-regenerating) and therefore they do not need to be replaced. This results in a lower overall installed cost of the product. The packets have moisture absorbing capacity approximately 10 times greater than that of ordinary desiccants. This allows the packets to be effective in very humid environments for many years. These features make this product more cost efficient and more practical to install than strip heaters or ordinary desiccants.

The second granular material, a vapor corrosion inhibitor (VCI), solves the problem associated with conventional VCI's. It is a special granular formulation of vapor corrosion inhibitors in a semi-permeable packet material. The packet is very durable and electrically non-conductive. It is not hygroscopic and its packaging material does not deteriorate over time.

There is a synergy between granules when they are present in the same packet. When first placed in an enclosure, the moisture controlling granules absorb moisture from the atmosphere and the VCI granules release parts per million concentrations of vapors thereby passivating all of the metals associated with electronics. Once the initial passivation is complete, the amount of vapor from the granules required to maintain protection is miniscule. Upon absorbing moisture from the air, the humidity control granules become putty-like and "encapsulate" the VCI granules. This slows the vaporization rate of the VCI granules. This lower rate is more than adequate to maintain the corrosion protection in the enclosure. Slowing the vaporization rate of X-Corrode extends its life to more than 10 years.

Applications

Moisture and corrosion packets are effective in protecting all sensitive electronic circuits in field service. They are particularly well suited for use in transmitter housings, analyzer electronic enclosures, flow computers, and electrical hardware such as on/off switches.

Conclusion

In conclusion, there are many factors that contribute to failures in electronic equipment. However, by controlling the %RH within an enclosure and by passivating the metals associated with sensitive electronic equipment, the failures produced by moisture and corrosion will be significantly reduced.

APPENDIX

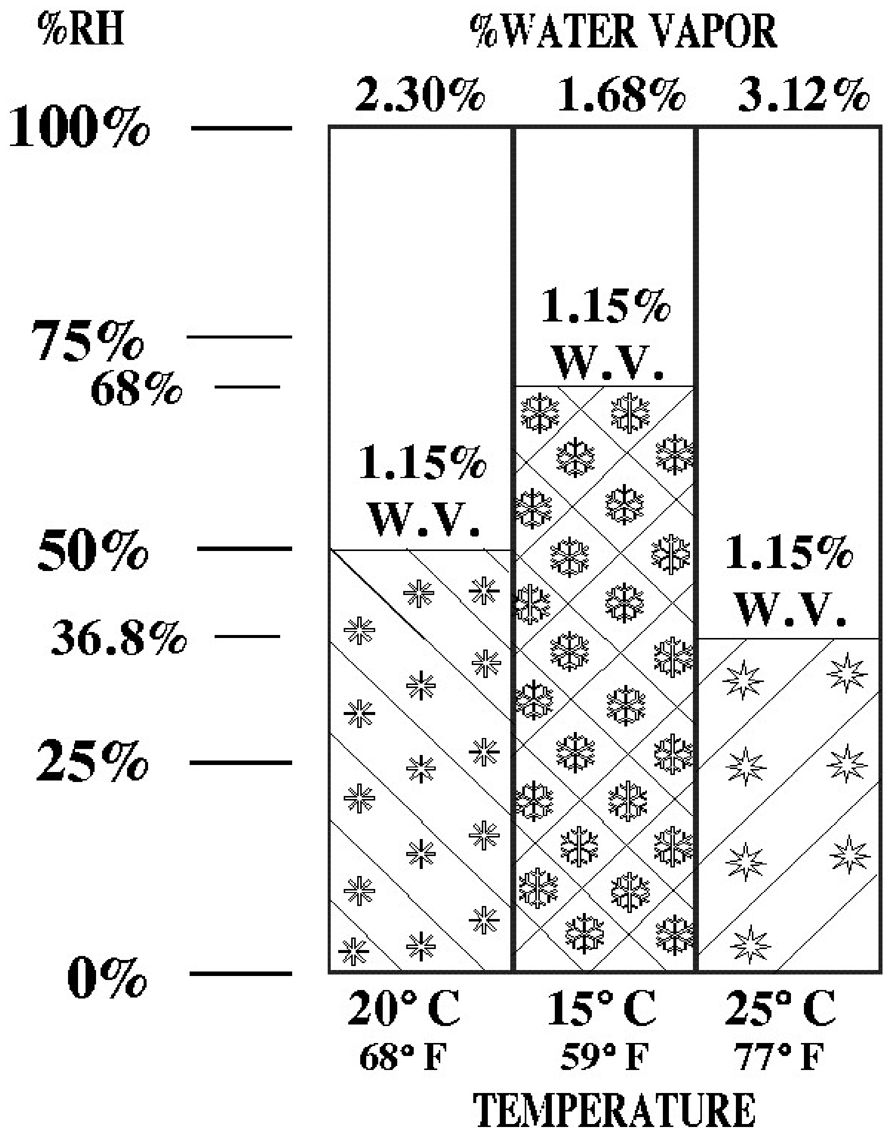

FIGURE 1. % RH and % Water Vapor Relationship

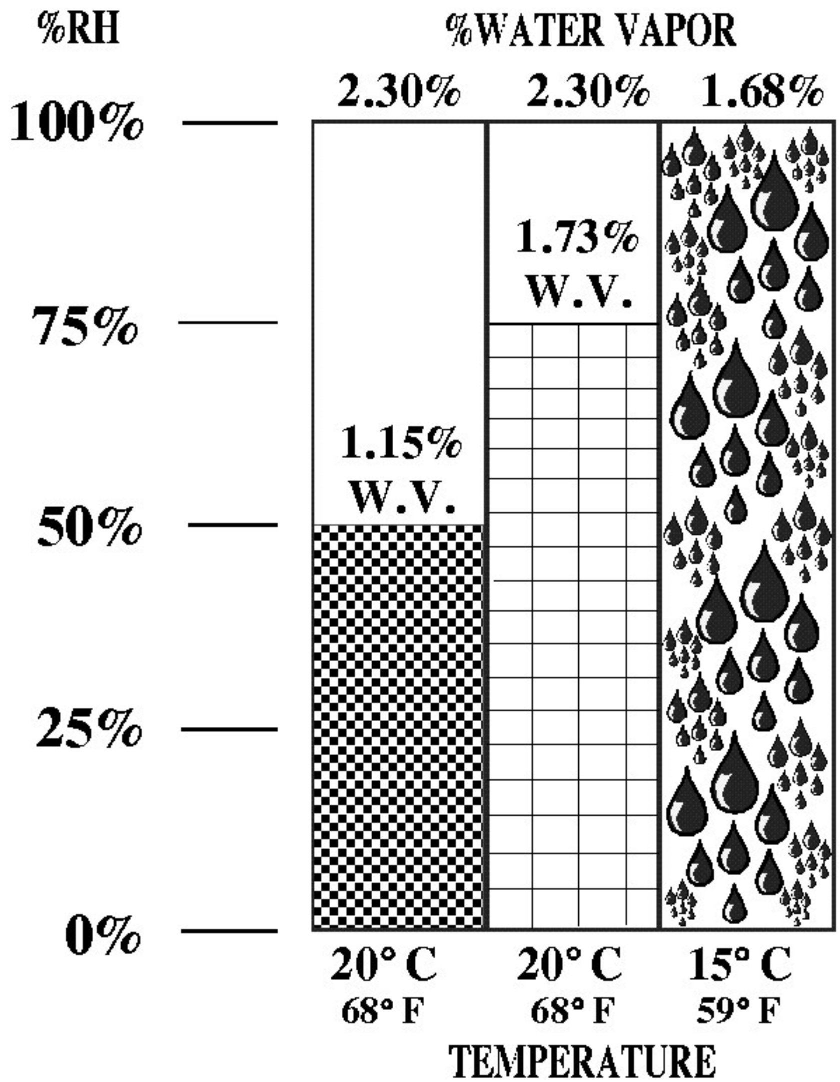

FIGURE 2. % RH and % Water Vapor Relationship

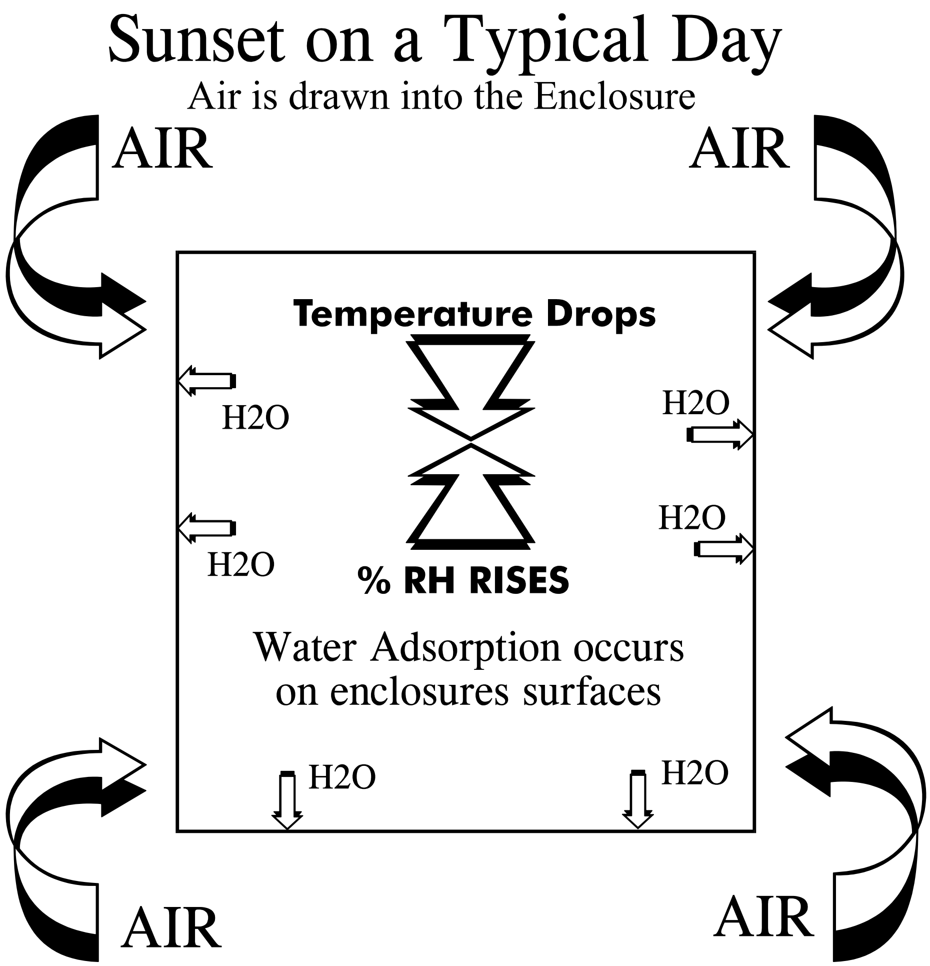

FIGURE 3. Sunset on a Typical Day

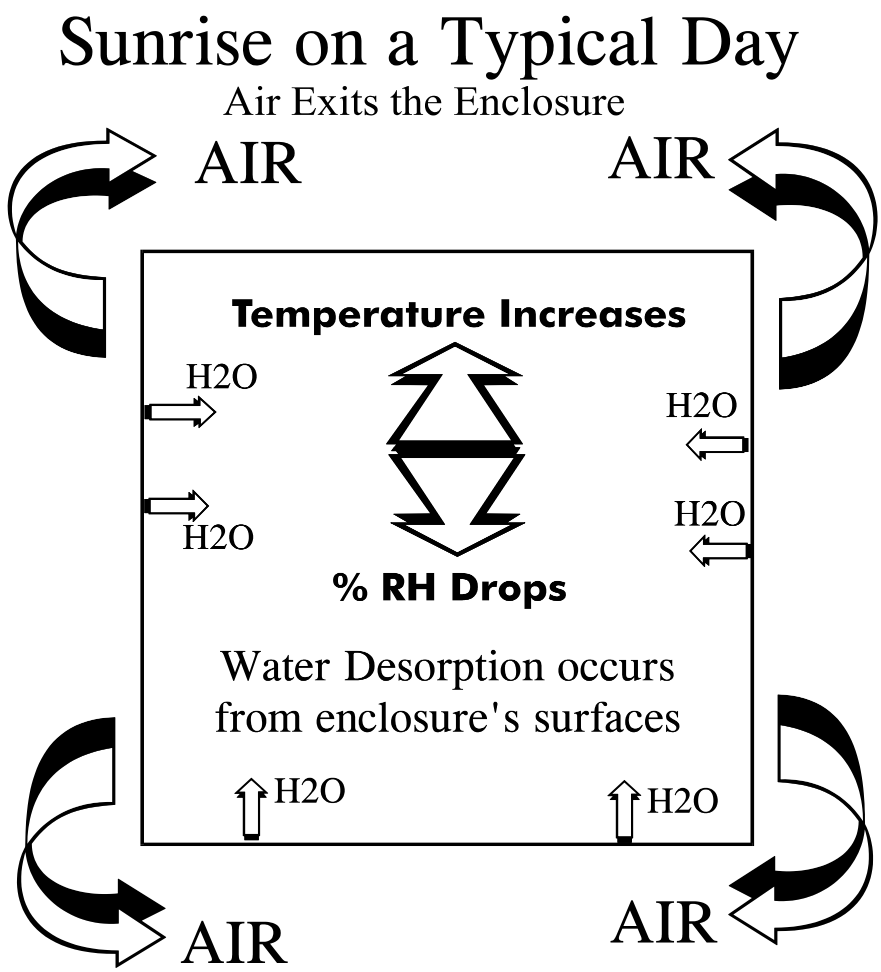

FIGURE 4. Sunrise on a Typical Day