

Joint Technical Committee Report SSPC-TR 3/NACE 6A192

Dehumidification and Temperature Control During Surface Preparation, Application, and Curing for Coatings/Linings of Steel Tanks, Vessels, and Other Enclosed Spaces

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Foreword

The use of dehumidification and temperature control has become more common during coating/lining operations and much has been learned about ways to optimize its use to achieve maximum benefits at minimum cost. This technical committee report presents current information about why and how dehumidification and temperature control are being used to achieve higher-quality coating/lining projects. It is intended to be a resource for engineers and coating consultants who write specifications for coating projects involving tanks or enclosed spaces.

This report was originally prepared by NACE Task Group T-6A-60 on The Need for Dehumidification Equipment in the Application of Linings. This revision was prepared by NACE Task Group 003 on Dehumidification. This Task Group is administered by NACE Specific Technology Group (STG) 80 on Intersociety Joint Coatings Activities, and is sponsored by STG 03 on Protective Coatings and Linings – Immersion/Buried. The Task Group also has representation from SSPC Group Committee C.2 on Surface Preparation. This report is published by SSPC and by NACE International under the auspices of STG 80.

Introduction

The use of dehumidification and temperature control during surface preparation and coating/lining application can be beneficial in a variety of ambient conditions. When used properly, dehumidification (DH) provides air dew points well below the surface temperature and reduces the relative humidity (RH) at the surface. Reducing the RH at the surface can retard rust bloom.

The health and safety of personnel is also a factor in the design of a dehumidification system. Dehumidification equipment that is properly sized for a given space provides air flow for safe working conditions. The lower explosive

limits (LELs), toxicity levels, and oxygen levels are all evaluated at each stage of the project.

The volume of coating to be sprayed per hour and the percentage of solvent and solids to be added is calculated using manufacturers' data sheets. The formulas for these calculations can be found in NFPA⁽¹⁾ 33.¹ The appropriate air-flow rate of the dehumidified and of the exhausted air through the enclosure and the proper instrumentation to be used for monitoring during both stages of the project are also determined.

Glossary of Terms

Terms used in this report are widely used in several engineering disciplines. Precise definitions are contained in other references, notably the ASHRAE⁽²⁾ *Handbook of Fundamentals*.² The explanatory definitions contained here are sufficient for this report but are not as precise and detailed as the ASHRAE definitions.

Absorbent: A desiccant material that holds water vapor through a hydration reaction that is reversible when the material is heated. Sodium chloride (table salt) and lithium chloride are examples of absorbent desiccants.

Adsorbent: A desiccant material that holds water vapor on its surface without a change in the chemical or physical structure of the material. Silica gel and the naturally occurring zeolites used for pet-waste granules are examples of adsorbent desiccants.

Dehumidification: The removal of moisture from the air.

Desiccant: A material commonly used to absorb moisture from the air; a solid or liquid material that has

the ability to collect moisture from the air and later release the water vapor when the material is heated. A desiccant used for dehumidification has a vapor pressure below that of the air to be dehumidified is in its active, dehydrated state.

Dew Point: The temperature of the air at which the moisture it contains condenses on nearby surfaces or suspended dust particles. At constant pressure, each dew point temperature represents a single value of air moisture content. As a result, air dew point is often used to describe air moisture content in absolute terms rather than relative humidity, which does not define the absolute amount of moisture in the air unless the air temperature is also known.

Flash Rusting: (1) Rusting that occurs on metal within minutes to a few hours after cleaning is complete. The speed with which flash rusting occurs may be indicative of salt contamination on the surface, high humidity, or both; (2) Appearance of rust spots on the surface of newly applied water-borne film during the drying phase.

⁽¹⁾ National Fire Protection Association (NFPA), P.O. Box 9101, Quincy, MA 02269-9101.

⁽²⁾ American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle NE, Atlanta, GA 30329-2305.

Humidity Ratio: The amount of moisture in the air, expressed as the weight of the water vapor compared to the weight of the air if it were perfectly dry. This results in a small decimal fraction. For example, air at 70°F (21°C) with 50% relative humidity has a humidity ratio of 0.0079. In the SI measurement system, this ratio is expressed as g water vapor/kg dry air. In the U.S. customary system of measurement, the weight of water vapor is converted to a whole number by multiplying the humidity ratio by 7,000 (the number of grains of water vapor in 1 lb). Therefore, air at 70°F (21°C) with 50% relative humidity has a humidity ratio of 55 grains/lb (7.9 g/kg) of dry air.

Process Air: Dry air produced with a dehumidifier.

Reactivation Air: Air used to remove moisture from a desiccant material.

Relative Humidity (RH): The ratio, expressed as a percentage, of the amount of water vapor present in a given volume of air at a given temperature to the amount required to saturate the air at that temperature.

Rust Bloom: Discoloration of steel surface indicating the beginning of rusting.

Temperature: A measure of hotness or coldness usually recorded with a thermometer on either the Fahrenheit or Celsius scale; the dry-bulb temperature of the air, which is the temperature of the air as measured by a thermometer with a dry-sensing bulb properly shielded from heat radiation sources such as sun or electric heaters.

Vapor Pressure: The pressure exerted by water molecules, either suspended in an air sample or at the surface of a solid material. A desiccant material attracts water vapor because the vapor pressure at its surface is lower than the vapor pressure exerted by molecules suspended in the air. In an effort to equalize this pressure differential, water molecules move from the air to the desiccant surface.

Wet-Bulb Temperature: The temperature of the air flowing across a thermometer with its sensing bulb surrounded by a wetted wick. The water evaporating from the wick cools the sensing bulb in proportion to the amount of evaporation. The evaporation effect (therefore a cooling effect) is greater when the air is drier. By measuring the wet- and dry-bulb temperatures and plotting the values on a psychrometric chart, the amount of moisture in the air can be determined.

Methods of Dehumidification

Dehumidification can be accomplished by compression, refrigeration, desiccation (liquid sorption, solid sorption), or a combination of these systems. While compression and liquid sorption are common methods of dehumidification, their use is not generally applicable to field conditions. Therefore, only the refrigerant-based and desiccant solid-sorption techniques are discussed in detail in this report.

Refrigeration

The cooling of air to below its dew point is an economical method of dehumidification. This method is commonly used at ambient temperatures of approximately 85°F (29°C) and high humidity. Ambient air is circulated over a system of refrigeration coils. The surface temperature of the coils is set at temperatures considerably lower than the temperature of the incoming ambient air. As the air cools, it reaches saturation, and condensation forms. This condensation is collected and removed from the system. The air exits the cooling-coil section of the dehumidifier at a reduced temperature, dew point, and absolute humidity. This refrigeration-based dehumidification system is illustrated in Figure 1. The cooler air, which has a lower dew point, can then be reheated to lower the relative humidity.

Refrigeration is often used to pre-cool and dehumidify inbound air before it reaches a desiccant system in order

to obtain lower dew points after desiccation. The air can be re-cooled, if necessary, by refrigeration.

Desiccant

Solid-sorption dehumidification systems utilize either granular beds or fixed desiccant structures. These structures are contained within machines through which an air stream is passed. The desiccant used is in an active, dehydrated state and has a vapor pressure below that of the air to be dehumidified. The most commonly used desiccants are silica gel and lithium chloride. Air is passed through beds or layers of the desiccant, which absorb moisture from the air stream, producing a hydrated salt. Regeneration of the hydrated salt is accomplished with heated air, which drives off the water of hydration, returning the sorbent to its dehydrated state. The previously sorbed moisture is diverted to a separate air stream.

The exothermic hydration reaction typically raises the temperature of the exiting air stream by 10 to 15°F (6 to 8°C). Therefore, in hot climates, refrigeration-type dehumidifiers are frequently used in combination with desiccant equipment to cool the air entering the space. A typical desiccant dehumidification system is illustrated in Figure 2. Because this type of system absorbs moisture as vapor, it is commonly used at all temperatures and levels of humidity.

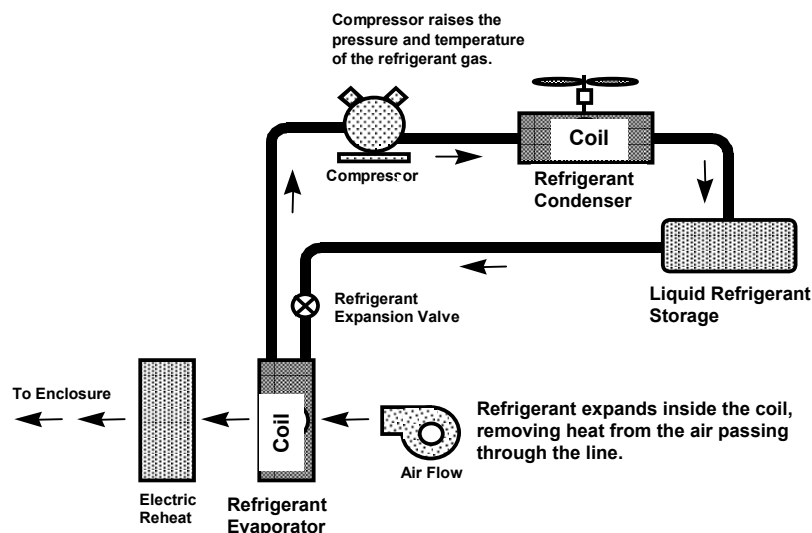


FIGURE 1: A Refrigeration-Type Dehumidifier

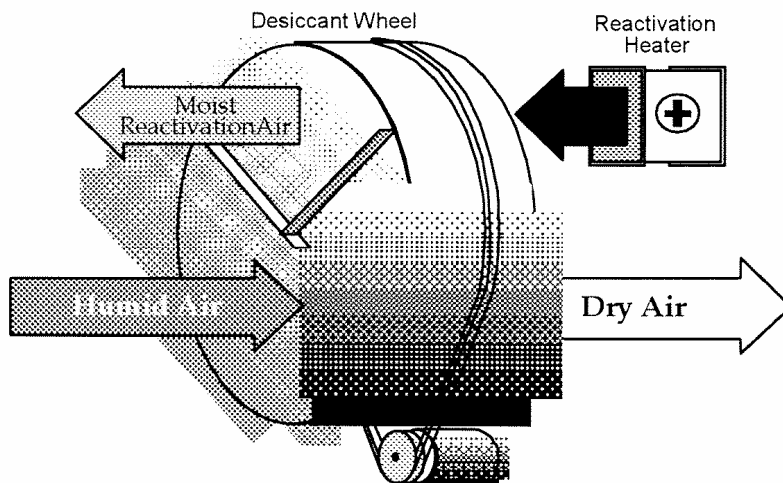


FIGURE 2: Desiccant Wheel

Sizing Equipment

The size of dehumidification equipment is typically determined by considering the balance between air extraction from the space and the dehumidification desired to accomplish the specified dew point depression from the surface temperature. If the capacity of the dehumidification equipment becomes marginal through unexpected weather changes, its efficiency can be improved by reducing the amount of air being extracted for dust control.

The appropriate air-change rate for maintaining a prepared surface during blasting and between shifts while maintaining a large differential between dew point and surface temperature for an extended period of time is dependent on air-space volume, equipment, geographical location, climate, and season. The number of openings in the enclosure, the airtightness of the structure, the distance of equipment from the space, and the amount of air to be extracted or exhausted by means other than DH

equipment also influence the DH capacity. Relatively airtight enclosures generally require less DH volume because little or no additional air or moisture is introduced into the space. Relatively large spaces usually require fewer air exchanges. Equipment contractors usually have guides that give volume data for their equipment.

The flow capacity of a dehumidifier for a given number of air changes per hour is calculated using the formula shown in Equation (1):