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Are Neutralizing Amines Safe in Steam Humidification Systems?

Facility engineers and managers face a myriad of challenges, from providing a safe and comfortable workplace for building occupants to maximizing the service life and efficiency of their facility's HVAC system. At times, their response to maintaining their operating system seemingly puts the building engineer or owner at odds with the safety and health of building occupants. Building owners and operators face such an apparent dilemma when their system uses boiler steam for direct humidification.

The steam/condensate system is subject to corrosion due primarily to the presence of carbon dioxide (CO_2) in the steam. CO_2 is produced when carbonate and bicarbonate alkalinities in boiler feedwater thermally decompose in the boiler. Carbon dioxide is driven off as a gas and is carried with the steam. It then dissolves in the condensate to form carbonic acid, which causes corrosion in condensate piping, receivers and traps. If not addressed, this corrosion will result in severe damage to the entire condensate system, and corrosion by-products will be carried back to cause fouling and deposition in the feedwater tank and boiler.

Fortunately, this problem is readily prevented through the use of condensate corrosion inhibiting chemicals called neutralizing amines. Neutralizing amines are volatile alkaline compounds that are added to the boiler water, where they flash off and are carried with the steam. When the steam condenses, the amines neutralize the resulting carbonic acid, raising the pH of the condensate and preventing corrosion to the condensate system.

This sounds simple enough, but the dilemma appears when amine-treated steam is used for direct humidification of human occupied space. Since the amines are volatile, some amount may be present in the humidified air supply. The amines commonly used in direct steam humidification systems have been implicated, based on anecdotal evidence, in the occurrence of various upper respiratory and eye irritations. Such an indoor air quality (IAQ) issue is an anathema to facility managers.

Most of the publicity about this issue has come from an investigation by the National Institute for Occupational Safety and Health (NIOSH) into incidents at Cornell University in 1982 and Cincinnati Electronics Corp. in 1998. In both cases, which involved complaints of eye, nose and throat irritations, amine-treated steam was used in direct humidification of occupied space. While no conclusive evidence was presented that the amines used caused the problems, NIOSH recommended against the use of neutralizing amines in these types of systems.

So engineering, maintainance and management personnel who have direct steam humidification systems are faced with difficult questions. Do they eliminate the use of amines in their system, knowing that costly damage due to corrosion will result? Do they continue the use of amines, blindly hoping that no occupant health issues arise? Or do they look at purchasing expensive alternate means of humidification that don't use direct boiler steam?

If time and money are available, the third option – alternate means of humidification, such as steam-to-steam heat exchangers or stand-alone humidifiers – is a viable solution to the problem. However, this option is time consuming and expensive, and many cash-and time-strapped managers will reject it on that basis. Most engineering managers will not be enthusiastic about the other two options – the first puts their equipment at risk; the second potentially exposes building occupants to harmful or irritating chemicals in the humidified air.

Fortunately, there is another option. The Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental and Industrial

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CHEMTEX
INTERNATIONAL CHEMTEX CORPORATION

8287 - 214th Street West
Lakeville, MN. 55044
(952) 469-4965

Hygienists (ACGIH) have established permissible exposure limits (PELs) for the three most commonly used amines - morpholine, cyclohexylamine and diethylaminoethanol (DEAE). The PELs for these chemicals are based on an 8-hour day and 40-hour week. The PELs for the three chemicals are:

Morpholine	20 ppm
Cyclohexylamine	10 ppm
DEAE	10 ppm

Studies have shown that, when these amines are added to boiler water at levels normally required to prevent condensate system corrosion, the amine level in steam-humidified air will be several orders of magnitude below the PEL for the amine. For example, in one study where DEAE and cyclohexylamine were evaluated, the levels in the steam leaving the boiler were 5.33 and 2.93 ppm for DEAE and cyclohexylamine, respectively. In a room in which this steam was used to humidify the air to 61% relative humidity, the air-borne DEAE and cyclohexylamine levels were 0.0024 and 0.008 ppm respectively. In another study involving the use of morpholine, the level of morpholine in the steam was incrementally increased to 64.8 ppm, a level far in excess of that required for condensate system corrosion inhibition. The corresponding air-borne morpholine level in the humidified air was 0.018 ppm, again far below the PEL for that amine.

With careful monitoring of water chemistry, along with direct testing for amine levels in the humidified air space, operators of steam humidification systems can be assured that room air amine levels will be well below that necessary to cause adverse effects in humans. Facility engineers and managers should consult a qualified water treatment professional to arrange for an evaluation of their steam humidification system, including possible airborne amine testing.

For a complete evaluation of your steam humidification system, contact your Chemtex Representative today!