

Steam for Humidification in HVAC Systems: Key Design Considerations

Introduction

The DRM outlines acceptable humidity ranges for laboratories, Animal Research Facilities (ARFs), and Aseptic Production Facilities (APFs). As the HVAC systems for these facilities utilize 100% outdoor air, significant humidification is necessary to maintain the required design relative humidity within the space(s); NIH uses low pressure steam for humidification in all referenced applications. This article reviews the different types of steam and some of the appropriate applications and design requirements for each.

Steam Types and Applications

Steam for humidification can be separated into three common types: Clean Steam (CS), Chemical Free Steam (CFS), and utility steam. CS for humidification is produced from high purity water (ASTM D1193, Type III or IV) by reverse osmosis (RO). CFS for humidification is produced from potable water that is filtered and softened without chemical additives (i.e., amines and hydrazines commonly used in plant steam). Utility steam is typically generated from either a central plant or building steam boilers and contains chemical additives to prevent pipe corrosion. The central plant steam at the Bethesda campus is continuously monitored to ensure chemical levels are well below FDA/OSHA limits; it is therefore widely used for most HVAC humidification applications.

Engineers should utilize a risk-based approach early on to determine the appropriate steam type for humidification applications. An approach that considers capital cost, operational cost, and the facility's Critical Quality Attributes (CQA) will help define the risks of humidity to potential product or process contamination and occupant comfort. Generally, when steam is used for indirect humidification (i.e., injected into the HVAC air system), it does not need to be purer than the air that it is being mixed with. While campus plant steam is acceptable for most laboratories and ARFs, there are specialized areas, including APFs, where either CS or CFS is required. Most APFs at NIH are closed-process facilities, with open processing conducted inside ISO 5 biosafety cabinets (BSCs), meaning CFS steam would be adequate. CS steam may be considered for pharmaceutical open processing, higher-grade clean rooms, and other critical applications where risk of volatile contaminants can adversely impact the product and the room's environmental quality.

Steam System Design Considerations

Applications that use different types of steam have different system design requirements. For instance, in CS systems, the feedwater distribution system shall fully recirculate back to the water production system to prevent stagnation and biofilm growth. In CFS systems, a controlled (slow close solenoid) drain valve shall be located directly adjacent to the steam-to-steam converter's connection to ensure routine water turn-over during periods of low/no demand. Regardless of specific system requirements, Preventative Maintenance (PM) shall include defined cleaning/sanitization schedules of the feedwater piping system and routine/seasonal service of steam-to-steam generator vessels.

Where either CS or CFS is determined necessary for the application, the design should provide a robust production system with redundancies. In general, these steam systems include sanitary design, 316L stainless steel construction, pressurized steam generators (ASME vessels), double wall heat exchangers, properly sloped piping (to low point drains), and sample valves. Independent modulating control and isolation valves for each AHU unit humidification distribution grid are required (per DRM 6.2.6). CS and CFS systems shall be designed so that low pressure steam is continuously available to meet demand, including periods of steam generator vessel filling and blow-down. Dispersion grids in AHUs shall be located directly upstream of cooling coil(s) to ensure efficient distribution and absorption in the air stream. Where jacketed distribution tubes are utilized, provide automatic isolation valve to prevent steam circulation when humidification is not active to prevent unwanted heat gain to the supply air.

Conclusion

Proper humidification control is necessary to maintain stable relative humidity inside the facility over the full range of outdoor humidity conditions. Evaluation of a recent NIH facility installation confirmed that commercial humidification systems which utilize atmospheric steam and control of the steam generator's heating rate in response to humidification demand changes are incapable of maintaining the DRM-specified relative control range(s). However, incorporating the key design elements reviewed in this article will ensure robust systems that perform as required.

