Humidification for pressurized steam applications:

Short absorption and energy savings with pressurized condensate return

As commercial and industrial steam humidification systems grew in complexity and demand since the mid 1900s, unique application requirements inspired 50 years of innovation. But each new breakthrough required new trade-offs:

Non-jacketed steam dispersion tubes were efficient and easy to install; however, their steam absorption distances were too long for some applications, and they were prone to spitting.

Steam jacketed dispersion tubes eliminated spitting and made pressurized condensate return possible. However, their hot metal jackets — constantly on in most systems — were inefficient and increased the airflow temperature. Also, their large profiles prevented close tube spacing and increased absorption distances.

Steam dispersion panels were a breakthrough in short absorption, and efficiency was improved by closely spaced dispersion tubes that cooled to duct temperature when not dispersing steam. However, they required P-traps with requisite clearance, and drains or pumps for unpressurized condensate.

The biggest breakthroughs in steam humidification systems have happened only recently, and their impact on the humidification industry is only just now dawning. A fusion of two innovations provides — for the first time in one steam dispersion panel, and with no trade-offs — short absorption, significant energy savings, and pressurized condensate return:

Insulated (high-efficiency) steam dispersion tubes reduce wasted energy and condensate production up to 85% in evaporative and pressurized steam applications.

Dispersion panels with integral heat exchangers save additional energy while eliminating water waste and the need for P-traps and condensate pumps in pressurized steam applications.

In the not-so-distant past, wasting dispersion-generated condensate to the nearest drain was not an issue, and it saved on installation labor. There was no incentive for saving energy and resources. So why is a steam dispersion panel with insulated tubes and a heat exchanger that manages condensate a breakthrough?

Clearly, energy and water are a bigger issue and more expensive today than ever before. Thoughtful individuals and proactive institutions, hospitals, and manufacturers now seek to reduce consumption and hold down operating costs. In turn, facility designers, building managers, and consulting engineers seek to reduce waste and improve efficiency in buildings.

Humidification for people, processes, and preservation

As hospitals and other buildings are built or retrofitted for improved indoor environments, relative humidity (RH) is a critical design factor. Studies confirm that properly maintained RH is a key factor in building occupants' health and comfort.[1] Clean rooms and semiconductor manufacturing facilities require tight RH control as a process variable, and proper RH prevents static electricity and moisture damage in components. RH control is also a preservation concern: As room RH levels fluctuate, materials absorb and release moisture. Such changes impact material properties and may damage artifacts and shorten their longevity.

Indoor RH control has become a critical need, and the number of commercial and industrial steam humidification systems in the world has never been higher.

Thanks to recent steam dispersion breakthroughs, short absorption and energy savings with pressurized condensate return has never been easier.

Operators in a clean room[2]
Image courtesy of Rakon Limited

Now a steam dispersion panel can provide short absorption, high efficiency, and pressurized condensate return with zero water waste.

Energy and water saved by insulated tubes and heat exchanger
72" wide × 48" high steam dispersion panels running 2000 hrs/yr, tubes on 3" centers, 1000 fpm air speed, 50 °F air

Steam dispersion panel type	Energy	Water
Uninsulated tubes (condensate wasted to drain)	**Wastes** 162,910,200 Btus/yr	**Wastes** 144,600 lbs/yr (17,359 gal/yr)
Insulated tubes (condensate wasted to drain)	**Saves*** 122,329,600 Btus/yr	**Saves*** 108,800 lbs/yr (13,061 gal/yr)
Insulated tubes & heat exchanger (condensate recycled to boiler)	**Saves*** 127,950,200 Btus/yr	**Saves** 144,600 lbs/yr (17,359 gal/yr) Zero wasted to drain

* Savings compared to steam dispersion panel in top row of table (uninsulated tubes, no heat exchanger)

Unmanaged condensate wastes energy, water

Why do steam humidification systems generate so much condensate? When operating, uninsulated dispersion tubes have a surface temperature of about 212 °F and typically disperse steam into 50 to 55 °F airstreams. Cool air flowing across hot dispersion tubes causes some steam inside the tubes to condense. In steam humidification systems where this condensate is sent to the drain, there is a direct correlation between the volume of wasted condensate and the amount of wasted energy:

> Every gallon (8.33 pounds) of condensate wastes about 8,000 Btus — the energy used to change the water into steam.

In pressurized steam humidification applications, condensate from steam dispersion panels is often not returned to the boiler, because it is not pressurized and cannot be reclaimed without additional pumps, valves, and controls. Condensate drains may even be piped in close proximity to pressurized condensate return mains, only to empty into floor drains. While the pressure differential between dispersion-generated condensate and boiler water has been the biggest obstacle to condensate management, the solution begins with dispersion tubes and their reduced volume of condensate.

Insulated tubes reduce wasted energy, condensate by up to 85%

Insulated tubes use polyvinylidene fluoride (PVDF) insulation to reduce their thermal conductivity, resulting in up to 85% less wasted energy and condensate. The gray row in the table at left quantifies the energy and water saved by a steam dispersion panel with insulated tubes. Compare these savings to the energy and water wasted by a steam dispersion panel with uninsulated tubes in the next row up.

PVDF-insulated tubes have been available since early 2007. See the inset on the back cover for a white paper explaining the physics behind the value of insulated tubes.

Although insulated tubes are most notable for how quickly they pay for themselves on energy savings alone, they are the building block to the next breakthrough because of their drastic condensate reduction.

Heat exchanger provides additional energy savings, pressurized condensate return, zero water waste

Insulated tubes set the stage for a new paradigm in condensate management for pressurized steam humidification: An integral heat exchanger that vaporizes, pressurizes, and recycles dispersion tube-generated condensate. All humidification steam entering the header is dispersed into the airstream, while pressurized condensate and its heat energy are returned to the boiler.

The simultaneous interactions in and around the integral heat exchanger are as follows:

- Humidification steam flows up the dispersion tubes, exits the tubelets, and disperses in the airstream. Any condensate that forms in the dispersion tubes falls to the heat exchanger and is vaporized into humidification steam.
- Condensate vaporized in the header causes an equal volume of pressurized condensate in the heat exchanger. The pressurized condensate is returned to the boiler via the condensate return main without additional pumps, valves, or controls.

Going back to the table on page 2, the bottom row quantifies the incremental energy savings and the 100 percent water savings provided by a dispersion panel with insulated tubes and integral heat exchanger. As shown in the table at right, it saves nearly 4300 gallons of water and over 5.6 million Btus of energy in a 2000-hour year, plus boiler chemicals.

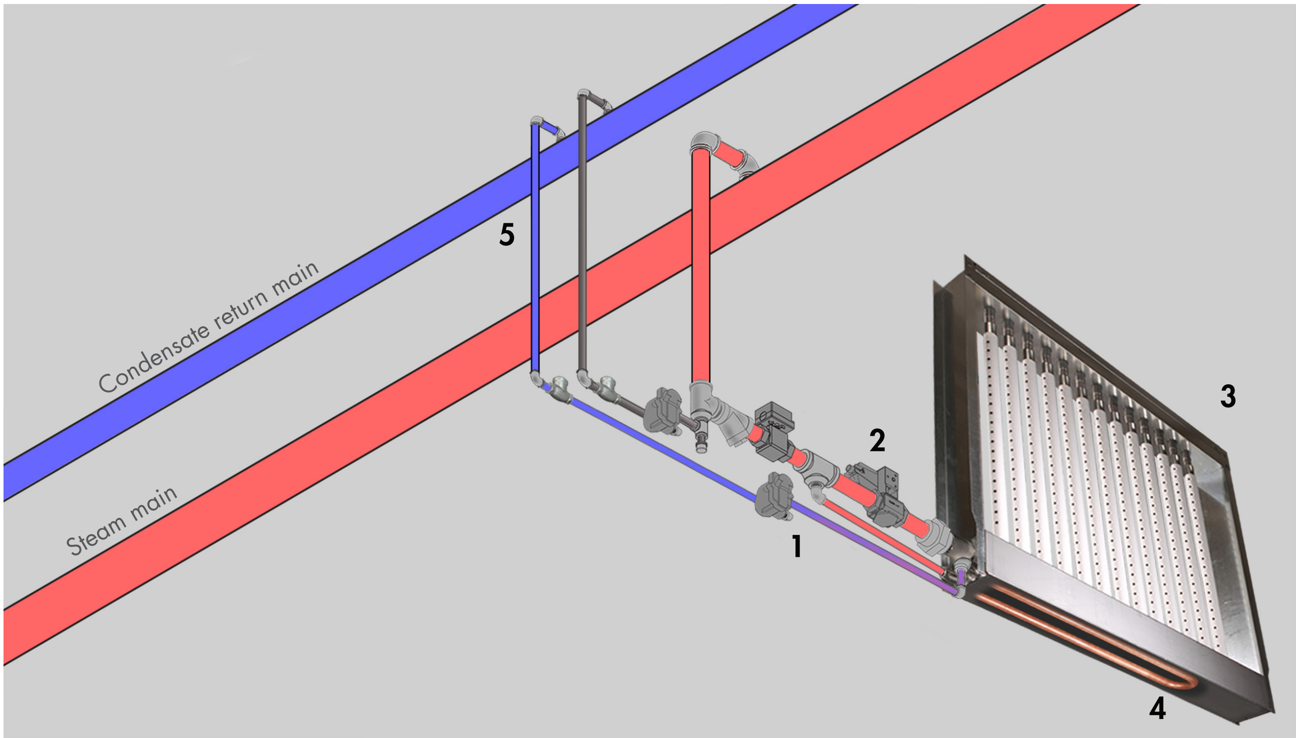
Recycling condensate, energy, chemicals

72" wide × 48" high steam dispersion panel with insulated tubes and integral heat exchanger running 2000 hrs/yr, tubes on 3" centers, 1000 fpm air speed, 50 °F air

Condensate / Btus wasted to the drain	None / none
Condensate pressurized and returned to the boiler	35,800 lbs/yr (4,298 gallons/yr)
Btus returned to boiler	5,620,600 Btus/yr* Energy equivalents:[3] • 5404 cubic feet of natural gas • 468 lbs of coal
Boiler chemicals saved	Enough (per year) to treat 4,298 gallons of fresh make-up water

* 212 °F return water temperature

How condensate ruturn works



1. Pressurized steam enters and preheats heat exchanger.
2. Modulated humidification steam enters header.
3. Humidification steam enters airstream.
4. Heat exchanger vaporizes condensate from dispersion tubes; collapsing steam in heat exchanger draws live steam in.
5. Pressurized condensate returns to condensate return main (lifts condensate to elevated return main if needed).

Conclusion

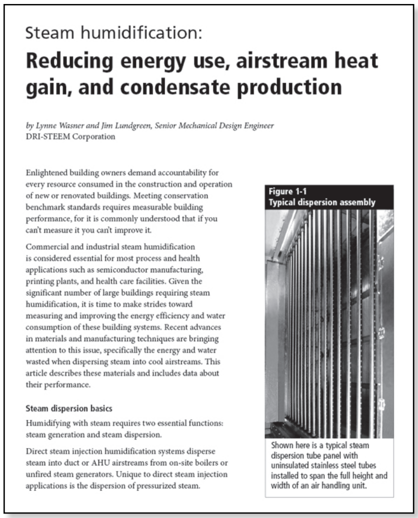
The sheer magnitude of energy, boiler chemicals, and water lost in wasted condensate in many steam humidification applications is staggering. Until recently, the typical condensate management strategy included a floor drain.

Condensate waste can be eliminated, and short absorption and unprecedented energy and water savings can be achieved, thanks to a steam dispersion panel incorporating two recent breakthroughs:

- Insulated tubes for evaporative and pressurized steam applications significantly reduce condensate production and downstream heat gain for up to an 85% reduction in wasted energy.
- An integral heat exchanger for pressurized steam applications vaporizes condensed humidification steam and returns pressurized condensate.

Now a steam dispersion panel can provide short absorption, high efficiency, and pressurized condensate return with zero water waste.

Insulated tubes reduce wasted energy up to 85%



Steam humidification:

Reducing energy use, airstream heat gain, and condensate production

by Lynne Wasner and Jim Lundgreen, Senior Mechanical Design Engineer
DRI-STEEM Corporation

Enlightened building owners demand accountability for every resource consumed in the construction and operation of new or renovated buildings. Meeting conservation benchmark standards requires measurable building performance, for it is commonly understood that if you can't measure it you can't improve it.

Commercial and industrial steam humidification is considered essential for most process and health applications such as semiconductor manufacturing, printing plants, and health care facilities. Given the significant number of large buildings requiring steam humidification, it is time to make strides toward measuring and improving the energy efficiency and water consumption of these building systems. Recent advances in materials and manufacturing techniques are bringing attention to this issue, specifically the energy and water wasted when dispersing steam into cool airstreams. This article describes these materials and includes data about their performance.

Steam dispersion basics

Humidifying with steam requires two essential functions: steam generation and steam dispersion.

Direct steam injection humidification systems disperse steam into duct or AHU airstreams from on-site boilers or unfired steam generators. Unique to direct steam injection applications is the dispersion of pressurized steam.

Figure 1-1
Typical dispersion assembly

Shown here is a typical steam dispersion tube panel with uninsulated stainless steel tubes installed to span the full height and width of an air handling unit.

See the white paper "Reducing energy use, airstream heat gain, and condensate production" on the **Education & Resources** page at www.dristeem.com (or click here).

For more information visit the Ultra-sorb XV page at dristeem.com.

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DriSteem U.S. operations are ISO 9001:2015 certified

U.S. Headquarters:
14949 Technology Drive
Eden Prairie, MN 55344
800-328-4447 or 952-949-2415
952-229-3200 (fax)

Europe, Middle East, Asia Pacific
+32 11 82 35 95
sales.europe@dristeem.com

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Notes

1 E.M. Sterling, "Criteria for Human Exposure to Humidity in Occupied Building." ASHRAE Winter Meeting. 1985.

2 2007. "Two in a clean room." Rakon Limited. http://www.flickr.com/photos/8879602@N07/1444516049/in/datetaken/

3 "Methods of Storing Energy." C. Johnson. 2007. http://mb-soft.com/public2/storing.html.