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Hot Gas Havoc

Clarifying Hot Gas Reheat & Hot Gas Bypass

BY MATT PRICE, MEMBER ASHRAE

My first day in the HVAC industry was marked by a disagreement. I began listening after the conversation had already begun. The controls contractor misspoke—"hot gas bypass" inserted itself where "hot gas reheat" should have been. It was too late. The manufacturer's rep scrunched his face and said, "But we aren't talking about hot gas bypass. We are talking about hot gas reheat! Completely different things!"

Looking back, it was the sharpest (and most condescending) tone I heard from the manufacturer's rep during our time working together. He was a good guy, but this tipped him over the edge. Why that reaction? It was most likely due to the frustration of hearing this flub too often—the terms "hot gas bypass" and "hot gas reheat" are used frequently in many HVAC roles without the benefit of fully distinct names. Further, rather than just hearing the mistake too often, could it be that he had too often made the mistake himself?

Though our story ended happily ever after (an apology and lunchtime pizza go a long way), very often this hot gas bypass/hot gas reheat misunderstanding, oversight or mistake shows itself in more permanent scenarios: inaccurate construction documents, rushed change orders or incorrectly ordered equipment. In other words, confusion between hot gas bypass and hot gas reheat causes our industry untold millions of dollars, thousands of improperly functioning systems and many, many uncomfortable conversations.

Therefore, it is critical that we clarify these two terms until we stamp out this confusion completely. After all, a packaged rooftop unit installed with hot gas bypass in the place of hot gas reheat cannot be fixed with pizza alone.

Air, Conditioning and Equipment

Applying hot gas bypass (HGBP) or hot gas reheat (HGRH) begins with a single problem: the air in a commercial space needs conditioning, and we design, buy, install and operate HVAC systems and equipment to do this conditioning.

In short, air must be conditioned to offset heat loads in spaces, including those from envelope loads, internal

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loads and ventilation loads. These loads are split into two parts: sensible heat load and latent heat load. Sensible heat is dry temperature heat and latent heat is humidity heat.

Loads are not static, and they vary over time due to changes in weather, season and use. Most often, building loads are a fraction of the full-load calculation—this condition is called part-load operation. Further, sensible and latent loads dynamically change with respect to each other. For example, a hot, dry day is a higher sensible heat day and a warm, humid day is a higher latent heat day.

HVAC equipment operates with one or more of the four psychrometric processes to offset loads: cooling (removing sensible heat), heating (adding sensible heat), dehumidification (removing latent heat) and humidification (adding latent heat).

Air cooling and heating processes in HVAC use heat exchangers called air coils. An air coil has air passing over the outside of it, with fluid flowing internally. In HVAC, fluids can be liquid, vapor or a liquid-vapor mixture. Common fluids are chilled water, heating hot water (not domestic hot water!), steam and refrigerant.

The second law of thermodynamics is refreshingly simple at the fundamental learner level: heat transfers spontaneously from high to low temperature only.[1] If the fluid is hotter than the air, then heating of the air occurs. If the fluid is cooler than the air, then cooling of the air occurs. Dehumidification occurs when moisture is removed from the air when coil tube surfaces are below the dew-point temperature, and humidification occurs when moisture is added to the air.

Sometimes a piece of equipment uses refrigerant as the fluid within a system's cooling and/or heating coils. The refrigerant is cooled or heated as needed using a refrigeration process based on the vapor compression cycle (also commonly called direct-expansion or DX).

The vapor compression cycle uses a refrigerant that is compressed into a superheated vapor within a compressor, condensed into a liquid state through a condenser (releasing heat), changed into a liquid-vapor mixture in an expansion device and evaporated into a vapor again through an evaporator (picking up heat).[2]

An important takeaway is that hot gas bypass and hot gas reheat are only present in equipment with refrigeration circuits.

Hot Gas Bypass

During design, vapor compression equipment is nearly always selected using peak design load conditions. In other words, the compressor, condenser coil, expansion device and evaporator coil are all sized for the largest load conditions.

As mentioned, most hours of operation are spent at part-load conditions. Unfortunately, especially historically, these components are not very adaptable to part-load conditions, and the control scheme is simply to turn the full system on or off periodically once a space setpoint is achieved.

Short-cycling means the refrigeration circuit is quickly turned on and off, introducing the potential for mechanical wear. Coil freezing occurs when the refrigerant becomes colder than the freezing temperature of water and moist air begins to condense and freeze on the outside of the coil. To avoid these concerns in part- and low-load conditions, hot gas bypass forces a fraction of hot gas from the compressor discharge (high-pressure side of the circuit) to the line between the expansion device and evaporator (low-pressure side of the circuit). This hot gas mixes with and adds heat to the refrigerant moving into the evaporator coil, raising the coil temperature and helping avoid coil frosting. This false loading of the evaporator can also help the compressor remain running longer, preventing short-cycling regardless of evaporator load.[3]

Pressure-enthalpy (P-h) diagrams are widely used in HVAC practice to visualize the vapor compression cycle. Enthalpy (with units Btu/lb_m [kJ/kg]) combines the internal energy and flow work terms of a state to provide a single, easier-to-use property.[4] Prior to the 1930s, enthalpy was often called "heat content" and "total heat."[5] Though not totally consistent with modern thermodynamic terminology, in fundamental HVAC learning we can still think of enthalpy in this way—it acts as our heat accounting tool for HVAC analysis.

Saturated suction temperature (SST) is the refrigerant boiling temperature in an evaporator at a particular operating condition and correlates with the bottom horizontal suction pressure line of an idealized P-h diagram. *Figure 1* assumes a SST of 45°F (7.2°C), common for comfort cooling. Under low load—and without other capacity reduction—evaporating pressure can drop, driving SST downward. If SST drops toward water's freezing point in a specific operating scenario, the risk of coil frosting becomes acute. Hot gas bypass sustains the desired SST by adding hot gas refrigerant prior to the evaporator, providing a false load on the evaporator. This effectively raises the evaporating temperature and reduces the likelihood of ice formation on the coil.

Compressor sections can be turned down in other ways, such as multi-compressor staging on the same circuit or variable capacity compressors. ASHRAE/IES Standard 90.1-2022 requires that hot gas bypass only be applied when "the system is designed with multiple steps of unloading or continuous capacity modulation."[6] Hot gas bypass, therefore, is now most often relegated to equipment reliability duty and is not the primary means of load matching when cooling.

As it is practically impossible to order a chiller with hot gas reheat (and therefore the confusion should not exist), we have focused on airside operation, but HGBP is used in chillers for essentially the same goals as in air systems. Further, refrigeration applications (HVAC&R) widely use hot gas bypass systems.

FIGURE 1 Idealized P-h diagram of a DX vapor compression cycle showing low-load impact on suction pressure and SST.

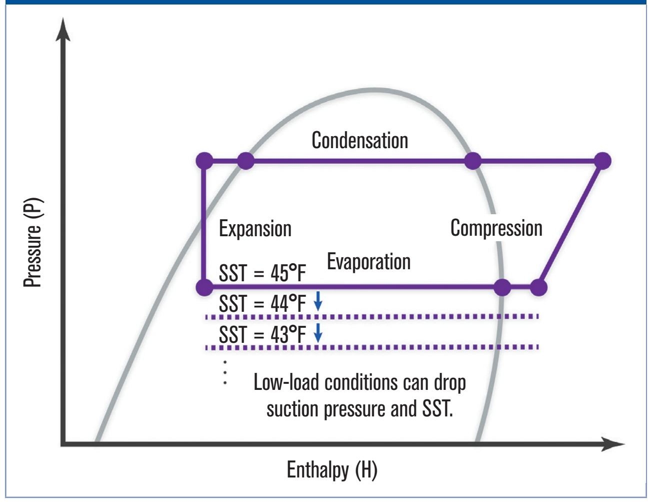
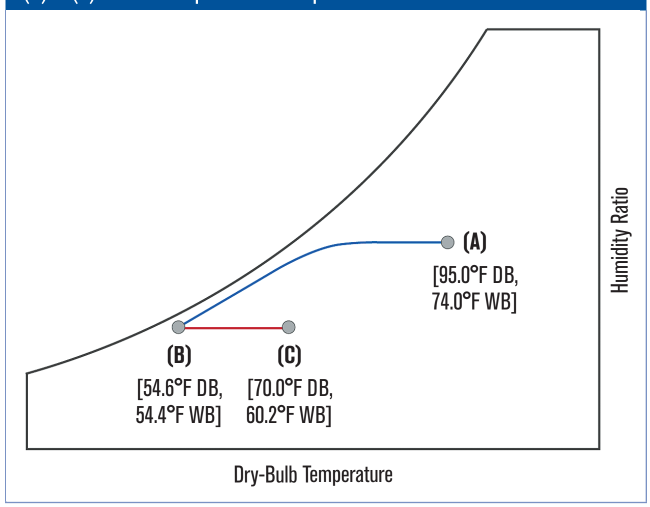


FIGURE 2 Typical DX cooling process with reheat shown on psychrometric chart. (A)→(B) is a coupled cooling and dehumidification process. (B)→(C) is a reheat process. Example conditions are shown in brackets.



Hot Gas Reheat

Real-world equipment processes are composed of one or more psychrometric processes. Sometimes, a real-world equipment process will have two psychrometric processes occurring within it, inseparably coupled. A real-world dehumidification process using an air coil for cooling will begin to dehumidify only after being cooled sensibly to saturation, when the cold coil begins to condense water out of the air.[7] In other words, cooling and dehumidification are inseparably coupled within this dehumidification process. This is equally true for both chilled water and DX systems.

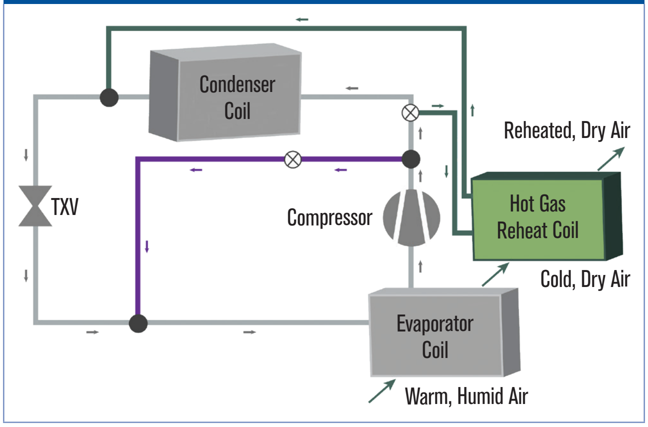
When a space needs a reduction in both sensible heat (cooling) and latent heat (dehumidification), this coupling is OK. Sometimes though, air needs to be dehumidified (removal of excess latent heat) without also being cooled. In this case, if you delivered this cold, dry air to the space the occupants would become overcooled (remember, they don't need any more sensible cooling, i.e., the space dry bulb thermostat is satisfied). "The challenge is not so much in being able to dehumidify but to do so without having to overcool."[8]

To dehumidify without overcooling, we reheat the air after cooling it. Any heating coil placed in the airstream after the cooling coil is called a reheat coil. Like a cooling coil, this coil can have any fluid within it—hot water, steam, heated flue gas (from combustion) or refrigerant *Figure 2*).

If reheating air sounds potentially wasteful (spending energy to cool the air, only then to spend energy to heat it back up), you are correct.

Hot gas reheat is the specific process where we use hot gas from the compressor as the fluid within the reheat coil. This special case is that the hot gas needs to reject (i.e., waste) its heat somewhere to operate its refrigeration cycle, and instead of rejecting it outdoors or underground, we reject some fraction of it back into the airstream. In other words, we are reheating with waste heat from the refrigeration system, avoiding using additional electricity or burning fossil fuel to generate

FIGURE 3 Typical air evaporator vapor compression refrigeration circuit in cooling mode. Green components and lines illustrate hot gas reheat. Purple lines illustrate hot gas bypass.



additional heat for the reheat coil.

When specifying or ordering hot gas reheat, the process therefore requires an extra coil post-cooling coil. Note that the hot gas reheat coil is only used for reheating during cooling operation, as it requires the refrigeration circuit's waste heat as the source of heat for the reheat coil.

HGRH operation can be on-off or modulating, and its coil piping can be routed in parallel or series with respect to the waste condenser coil. These decisions do not change the HGRH system's basic operation.

Now we can recognize that HGRH and HGBP are different processes but not inherently mutually exclusive and therefore can be present at the same time within the same piece of equipment.

Conclusion

Hot gas reheat and hot gas bypass are completely different processes with similar names. Accuracy identifying the need for HGBP and/or HGRH is critical to matching correct equipment hardware and application.

Hot gas reheat requires an extra heating coil (the hot gas reheat coil) post-cooling coil. This is an additional cost, as well as being one of the main reasons mistakenly ordering hot gas bypass in the place of hot gas reheat is miserable. There is no "quick" solution in the field for adding valves, piping and an extra coil. See *Figure 3* for a hot gas bypass and hot gas reheat simplified piping diagram.

Hot gas bypass requires an extra refrigerant line between the compressor discharge and evaporator inlet (not trivial in any system, especially in split ones).

Both require their own unique ancillary components for operation (valves, safeties, piping controls), which are not often easily field modifiable. Not to mention, any major "surgery" such as this in the field would likely affect the system's warranty (and not in a good way).

Do not make this mistake—any time you receive a request for HGBP or HGRH, take a moment and think. You'll be glad you did.

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