WHITE PAPER

Quiet by Design:

How Dual Stepper Valve Control Gives PolyScience Chillers Both Heating and Cooling

Prepared by PolyScience
August 2026

Executive Summary

The valve that meters refrigerant through a chiller has always done more than just control temperature — it has also been the source of one of the most common customer complaints about chiller operation: noise. Conventional on/off solenoid valves click and "breathe" as they cycle open and shut, and pulse-width-modulated (PWM) valves trade that click for an audible buzz. Neither limitation is necessary. PolyScience chillers use stepper motor-driven valves for refrigerant control, which meter flow with continuous, proportional precision and hold position without the noise-producing mechanics of a solenoid.

On the PolyScience DuraChill® CA series, that same stepper technology is applied to a second valve dedicated to hot gas bypass — a refrigeration control technique that protects the evaporator from freezing, reduces energy-wasting compressor cycling, and, as a side benefit, gives the chiller a modest built-in heating capability. Together, these two coordinated stepper valves — one metering refrigerant into the evaporator, one metering hot discharge gas back into it — give the chiller precise, silent control over both its cooling and heating behavior. This paper explains how each valve works, why stepper control eliminates the noise associated with older solenoid and PWM designs, and how hot gas bypass turns waste compressor heat into a useful control tool.

The Noise Problem: Why Conventional Valves Click and Buzz

Most chillers control refrigerant flow with some form of solenoid valve — an electromagnetic coil that pulls a plunger or armature to open or close a port. Solenoid valves are inexpensive and reliable, but they are fundamentally an on/off device: to modulate cooling capacity for a partial load, the valve has to snap fully open, then fully closed, repeatedly. Each transition ends with the armature seating against the valve body, producing the audible click — and, under some load conditions, a repeated clicking or "breathing" pattern — that many chiller operators have come to associate with normal operation.

Pulse-width-modulated (PWM) solenoid valves attempt to smooth this out by cycling the same on/off solenoid rapidly (many times per second) and varying the ratio of on-time to off-time to approximate an intermediate flow position. That reduces the discrete click, but it does not eliminate the underlying mechanism — the coil is still energized for the "on" portion of every cycle, which both draws continuous power and tends to produce an audible buzz or hum at the pulse frequency. In a lab or process environment where the chiller sits near sensitive instrumentation or people, that hum is often just as noticeable as the click it replaced.

Stepper Valve Control: Precision Without the Noise

A stepper-driven valve replaces the solenoid's plunger with a needle or pintle positioned by a small stepper motor. Rather than snapping between two states, the motor turns in small, discrete increments — modern electronic expansion valves use fine micro-stepping across hundreds of individual steps — continuously and proportionally adjusting how far the valve is open. Because the valve can hold at any intermediate position, it meters refrigerant flow to match the load directly, instead of faking an intermediate flow rate by rapidly toggling between fully open and fully closed.

This has two practical consequences. First, there is no armature slamming shut and no rapidly pulsing coil, so the valve itself operates silently — what the operator hears is just the ordinary sound of the compressor and fan. Second, a stepper motor only draws power while it is actively moving to a new position; once it reaches that position, it holds it without continuous current, unlike a PWM solenoid that stays energized through the "on" portion of every cycle. The result is quieter, more precise, and more efficient refrigerant metering — the foundation both valves in PolyScience's dual stepper valve architecture are built on.

Inside the Refrigeration Cycle

To see why the valve controlling refrigerant flow matters so much, it helps to walk through what a chiller is actually doing. The chiller pumps cold fluid out to the customer's process. Because heat always moves toward cold, heat from the process transfers into that fluid. The now-warmed fluid returns to the chiller and passes through a heat exchanger called the evaporator, which also has cold refrigerant flowing through it. Heat transfers a second time, this time from the process fluid into the refrigerant — leaving cold fluid to go back out to the process, and warming the refrigerant in the process.

That warmed refrigerant then passes through the compressor and into a second heat exchanger, the condenser, where a fan blows across the coil and rejects the heat into the room. The now-cooled refrigerant returns to the evaporator to begin the cycle again.

The condition of the refrigerant leaving the evaporator governs how the compressor behaves. If it is not warm enough, the compressor has to work harder — cycling on and off more frequently — which increases both energy consumption and mechanical wear. Managing that evaporator condition, especially when the customer's process is placing little or no load on the chiller, is exactly the problem hot gas bypass is designed to solve.

Hot Gas Bypass: Turning Waste Heat Into a Control Tool

One of the features on the PolyScience DuraChill CA series is a return to hot gas bypass to help manage the refrigeration cycle inside the chiller. It is a return because PolyScience used hot gas bypass in past chiller generations, but not for approximately the past twenty years. During that period, capacity was instead metered with a mechanical/magnetic (solenoid) valve — the same category of valve described above, which is what sometimes produced the clicking or breathing sound customers noticed during normal operation.

Hot gas bypass works by routing a metered portion of hot refrigerant gas from the compressor discharge back into the evaporator. Under low- or no-load conditions, this raises the evaporator's operating temperature, which does two things at once: it prevents evaporator freeze-up — a failure mode that can be catastrophic for a chiller — and it extends compressor run time between cycles, since the evaporator no longer reaches its low-temperature cutout as quickly. Fewer, longer compressor cycles mean less of the energy penalty and mechanical wear that comes with frequent starting and stopping, which is the source of the efficiency improvement hot gas bypass provides.

Because hot gas bypass is built entirely on heat the compressor is already generating, it gives the chiller a genuine, if modest, heating capability at essentially no additional energy cost. With no external process load at all, a DuraChill CA chiller can still produce a small amount of usable heat — approximately one-quarter of its rated cooling capacity, measured at 20°C. That is not a substitute for a dedicated process heater, but it is a real and useful side effect of a control strategy whose primary job is protecting the evaporator and stabilizing compressor cycling.

The Dual Stepper Valve Architecture

On the DuraChill CA series, hot gas bypass is not implemented with the mechanical/magnetic valve PolyScience used for the past two decades — it is implemented with a second stepper motor-driven valve, working alongside the stepper-driven electronic expansion valve that already meters refrigerant into the evaporator for cooling. That pairing is what "dual stepper valve control" refers to: two independently positioned, continuously modulating stepper valves, coordinated by the chiller's controller in real time based on return fluid temperature and setpoint.

The division of labor is straightforward. The expansion valve meters refrigerant into the evaporator to deliver cooling capacity matched to the process load. The hot gas bypass valve meters hot discharge gas back into the evaporator to protect against freeze-up, stabilize compressor cycling under low load, and supply that modest supplemental heat described above. Because both valves are stepper-driven rather than solenoid- or PWM-actuated, both operate with the same silent, proportional precision — so returning to hot gas bypass did not mean returning to the noise that came with it the last time PolyScience chillers used the feature.

What This Means in the Field

The table below summarizes how PolyScience's dual stepper valve control compares with the conventional solenoid-based approaches most chillers still rely on.

Characteristic	On/Off Solenoid Valve	PWM Solenoid Valve	PolyScience Dual Stepper Valve Control
Flow control method	Fully open or fully closed (bang-bang)	Rapid on/off cycling at a fixed frequency to approximate a position	Continuous, proportional positioning across hundreds of steps
Audible signature	Clicking or "breathing" as the armature seats	Buzz or hum at the pulse frequency	Silent — no armature slam, no pulsing coil

Characteristic	On/Off Solenoid Valve	PWM Solenoid Valve	PolyScience Dual Stepper Valve Control
Power draw while holding position	Coil energized whenever open	Coil energized for the “on” portion of every cycle	No continuous current needed to hold a position
Evaporator freeze protection	Indirect, via on/off cycling only	Indirect, via rapid cycling only	Direct, via dedicated hot gas bypass valve
Supplemental heat at no load	Not available	Not available	~25% of rated cooling capacity (@ 20°C)

Table 1. Comparison of refrigerant valve control strategies. Heating figure applies to the PolyScience DuraChill CA series specifically; consult PolyScience for model-specific ratings.

DuraChill® CA Series

PolyScience's DuraChill CA series is built around dual stepper valve refrigerant control: a stepper-driven electronic expansion valve for precise cooling capacity, paired with a dedicated stepper-driven hot gas bypass valve for evaporator freeze protection, reduced compressor cycling, and supplemental process heat — all without the click, breathe, or buzz of conventional solenoid or PWM valve control.

Contact PolyScience to learn more about the DuraChill CA series or to discuss it for your

Conclusion

The valve controlling refrigerant flow through a chiller has an outsized effect on how that chiller sounds, how efficiently it runs, and how well it protects itself under low-load conditions. Solenoid and PWM valves manage flow by rapidly toggling a coil on and off — an approach that reliably produces the clicking, breathing, or buzzing noise many chiller operators have simply learned to live with. Stepper motor-driven valves solve that problem structurally, by holding a precise, proportional position instead of toggling between two states.

PolyScience's DuraChill CA series applies that same stepper technology twice: once for cooling, and once for hot gas bypass — a technique the industry uses to protect evaporators and stabilize compressor cycling, and that happens to produce a useful amount of supplemental heat as a side effect. The result is a chiller that runs quietly, handles low-load conditions gracefully, and does both its cooling and its incidental heating job through the same precise, silent valve technology.

This white paper describes general refrigeration control principles and the DuraChill CA series design approach. Performance figures, including supplemental heat output, vary by model and operating conditions — consult PolyScience for model-specific specifications.