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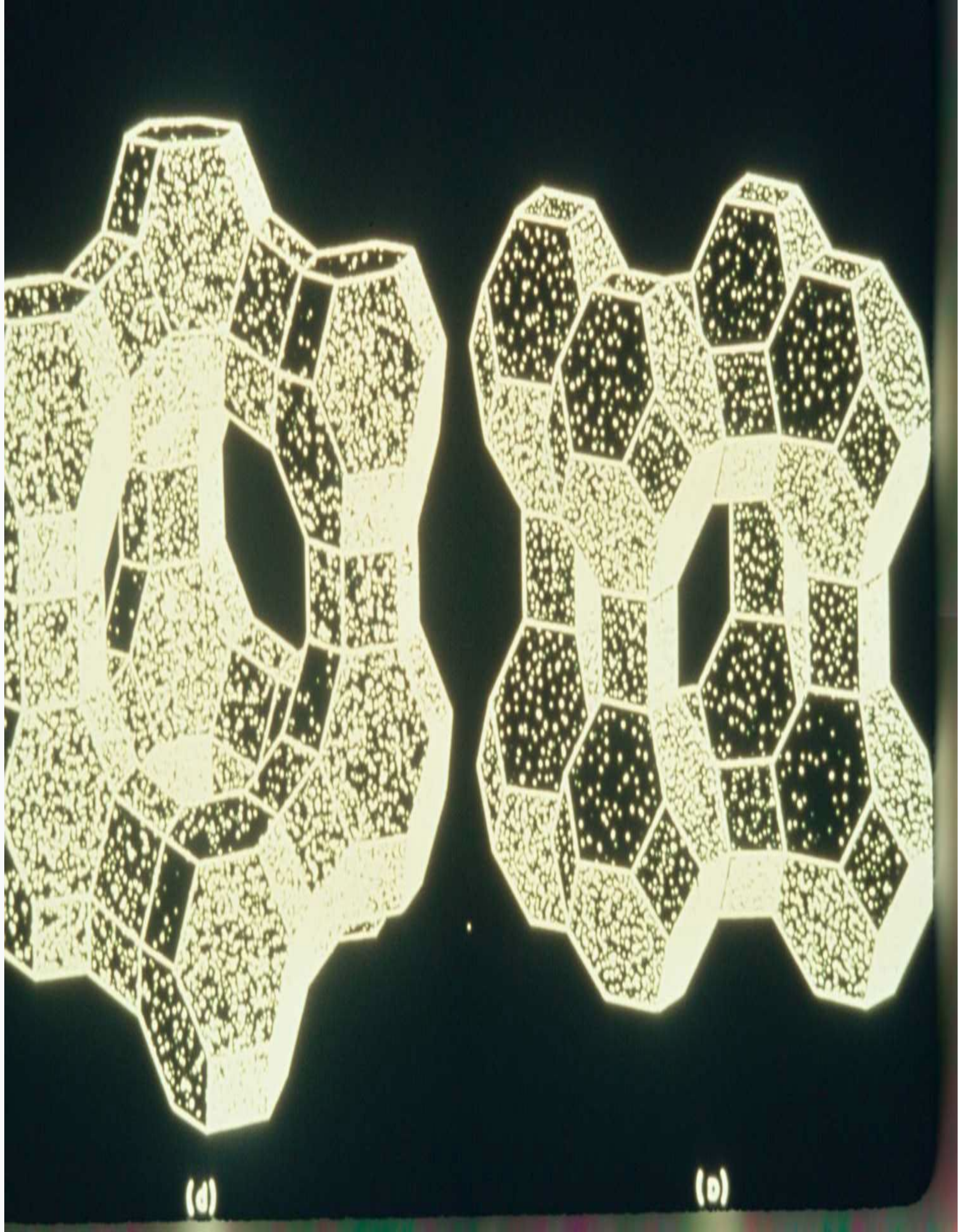
M3 TECHNICAL SESSION · 2026

Molecular Sieve Unit Maintenance

Predictive · Preventive · On-going

Keeping ethanol dehydration beds alive — and what your DCS is already telling you.



WHY WE'RE HERE

We asked the industry what hurts. One theme recurs.

After interviewing plant managers, maintenance managers, and operators across the industry…

Valve Maintenance

Valves — with their solenoids and control air — decide the pressure profile. The pressure profile decides whether your beads live or die.

01

How the sieve works

Pressure & temperature run the show

02

How beds die

Fluidization, wetting, channeling

03

Read your DCS

Failure signatures on your screens

04

The playbook

Practices that catch problems early

The molecular sieve: the last line of defense against water

Final dehydration

The sieve removes the last of the water from ethanol before denaturing — 190 proof in, anhydrous out.

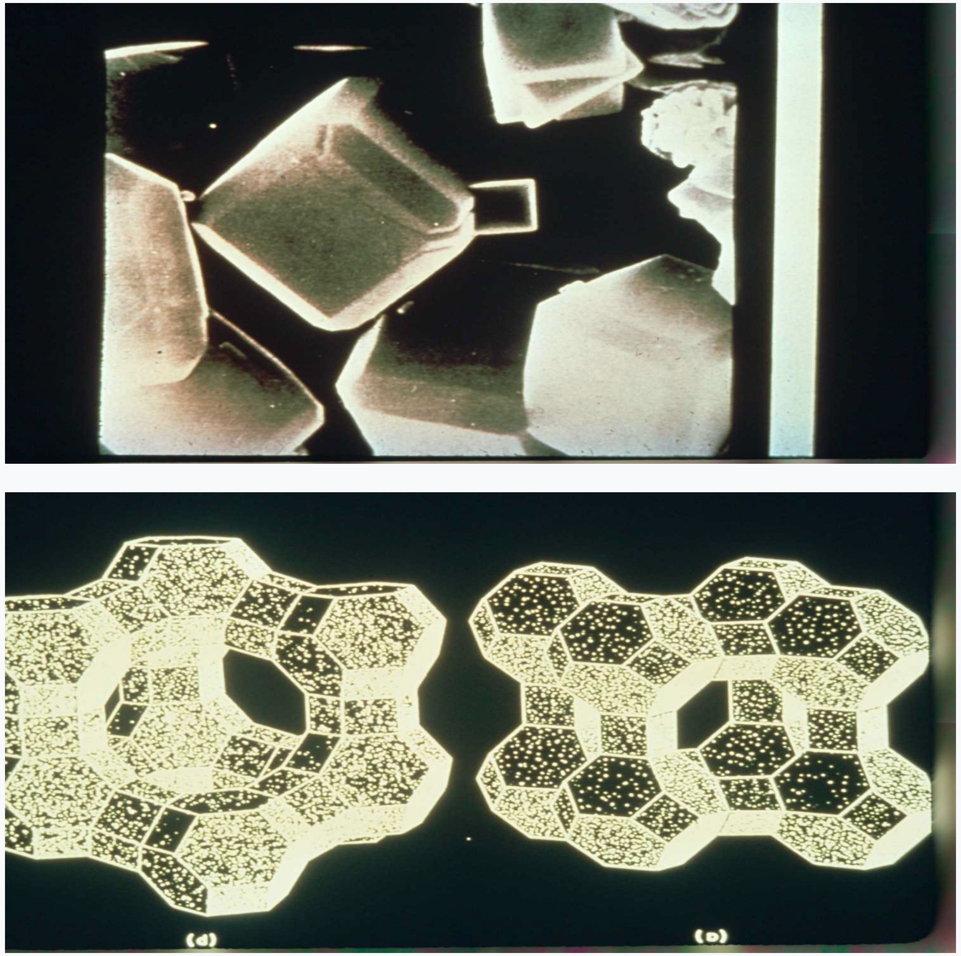
Size-selective adsorption

Water fits inside the crystal and is trapped; ethanol cannot fit and passes through to the day tank.

Capacity follows conditions

Directly proportional to pressure — inversely proportional to temperature.

Remember: *everything that follows is about protecting those crystals.*



Zeolite sieve crystals — electron micrographs

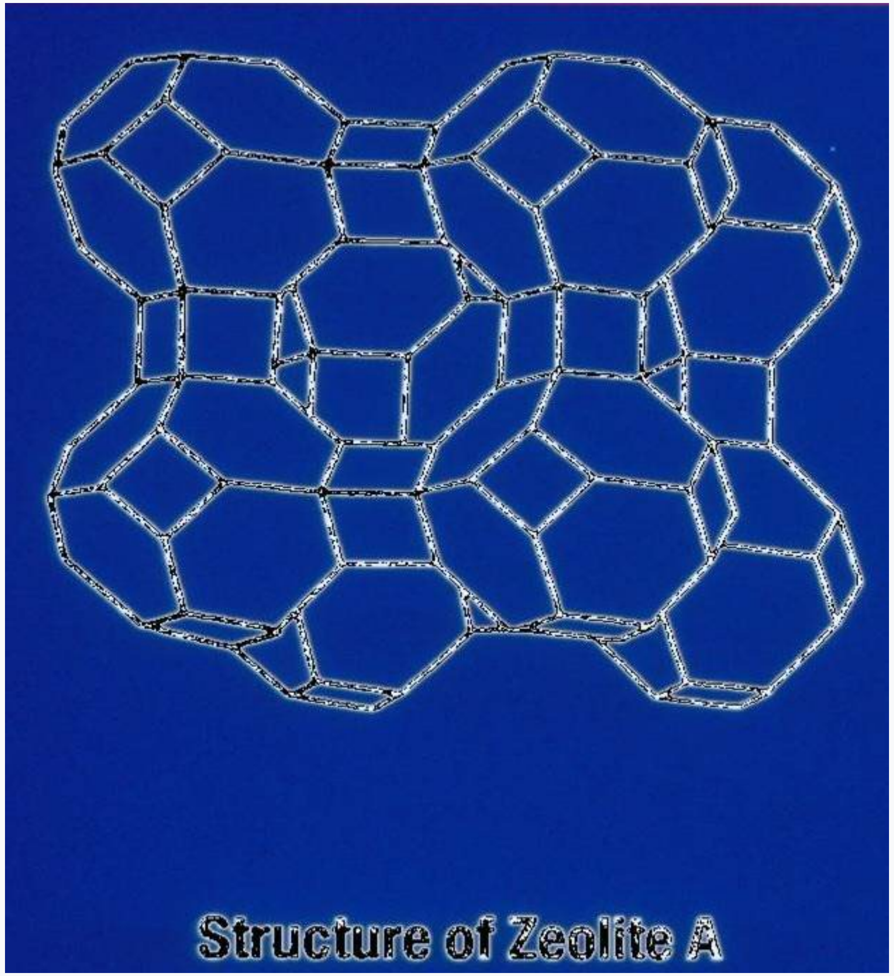
A 3Å doorway: water fits, ethanol doesn't

3.0 Å pore opening of the 3A zeolite cage

2.8 Å water — slips in, gets trapped

3.6 Å ethanol — too big, passes by

Pure geometry — no chemistry to wear out. As long as the crystal survives, selectivity survives.



Structure of Zeolite A — 3A crystal framework

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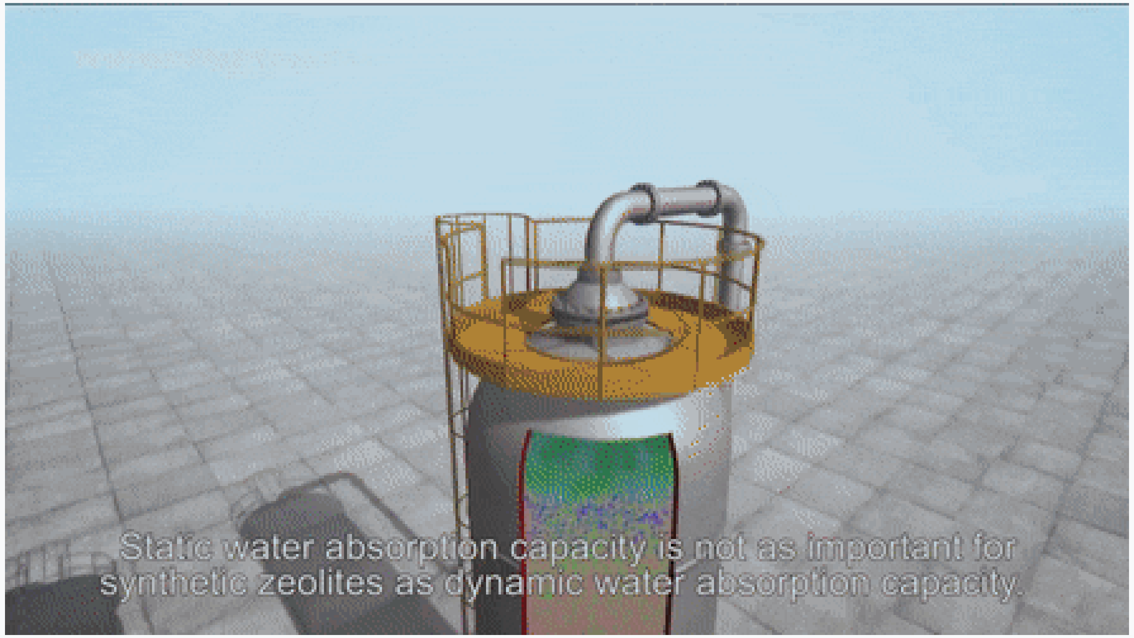
This is what healthy looks like: ideal plug flow

Green — dry ethanol passing through. **Blue** — water trapped in the sieve.

A uniform adsorption front moves down the vessel as one flat wave. Every bead does its share.

Keep this picture in mind. Every failure mode is a different way of destroying this flow.



Animation: "About Molecular Sieve" (Gfycat) — plays in slideshow

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Efficiency — and survival — ride on pressure control

Higher pressure → higher capacity

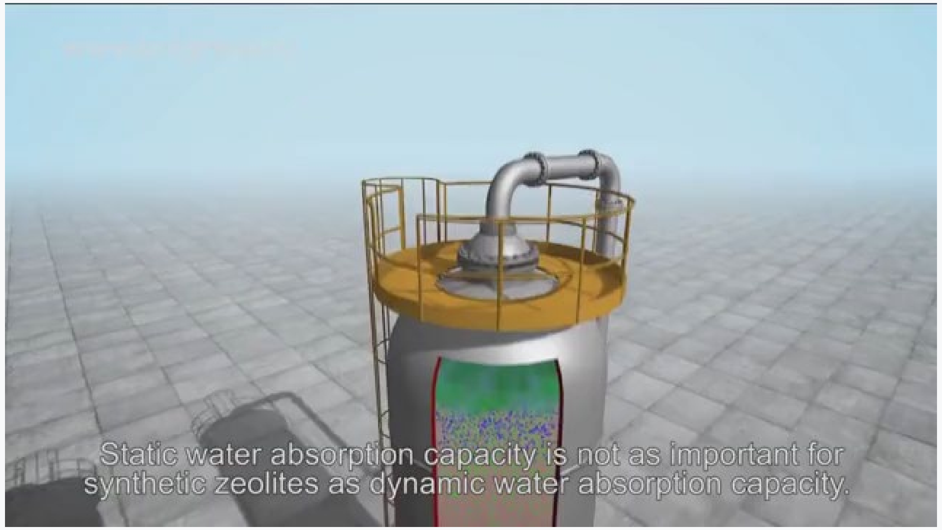
Run adsorption at the highest consistent pressure.

Fluidization KILLS beads

Pressure swings bounce the bed — beads grind to dust.

Liquid carryover KILLS beads

Liquid on hot beads weakens and agglomerates them.



Molecular sieve vessel — adsorption in progress

Pressure control decides the life of the system — and it depends on valve, solenoid, and control-air maintenance.

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Three ways a bed dies — all preventable

Each starts as a pressure or temperature excursion — and each leaves fingerprints on your DCS.

Fluidization

Pressure moves faster than 0.7 PSIA/sec — the bed lifts and grinds itself to dust.

"Popcorn" = grinding

Bed Wetting

Liquid lands on hot beads. They break, dust — and agglomerate.

The death spiral begins

Channeling

Vapor abandons plug flow and tunnels through voids.

Efficiency collapses

Bed wetting: liquid is poison to a hot sieve bed

Unbalanced P & T invite two-phase flow

Drift toward the feed's dew point, and liquid condenses on the bed.

Wet beads lose their strength

They break, dust — and agglomerate into clumps. The death spiral.

Too little superheat costs the bed

Too much heat wastes steam; too little wets the bed.

THE RULE

50°F

of superheat above the feed's condensation temperature, at consistent adsorption pressure.

Channeling: when the vapor stops using the bed

Turbulent flow replaces plug flow

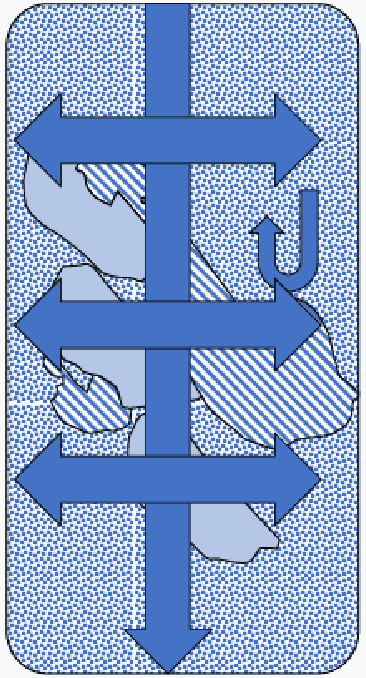
Vapor tunnels through voids and clumps, not the beads.

Water refluxes in the void space

It never leaves — zones stay wet and dead.

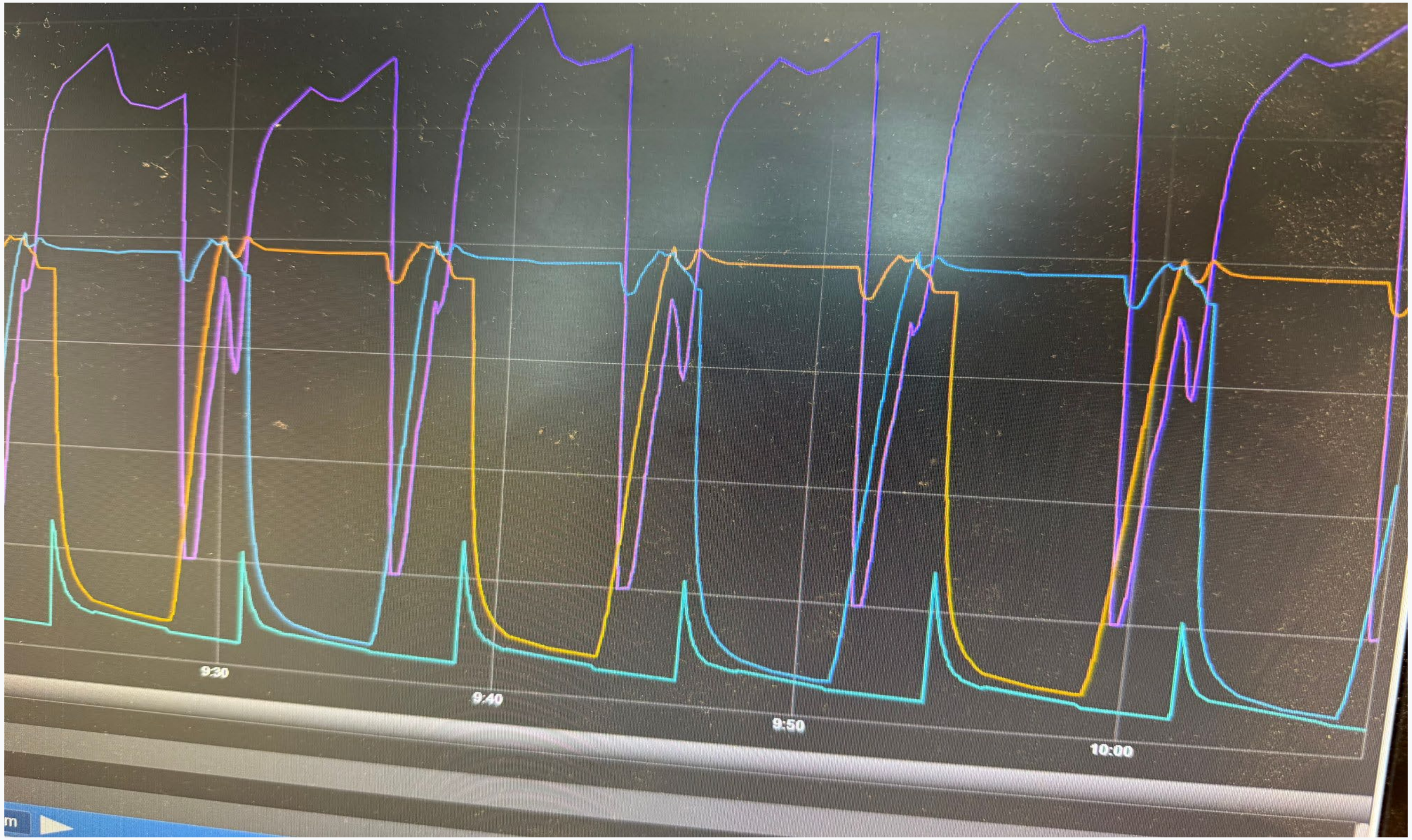
“Dead” beads do no work

Capacity collapses — visible in BPV behavior and the temperature profile.



Agglomerated, channeled bed — flow short-circuits (diagram right)

Your DCS already shows you the damage



Live plant DCS — pressure traces across one cycle set

A textbook cycle…

One feed valve: clean, repeatable waves.

…next to a damaged one

Its neighbor: ragged, asymmetric traces.

The BP valve gives it away

Working overtime to compensate — your early warning.

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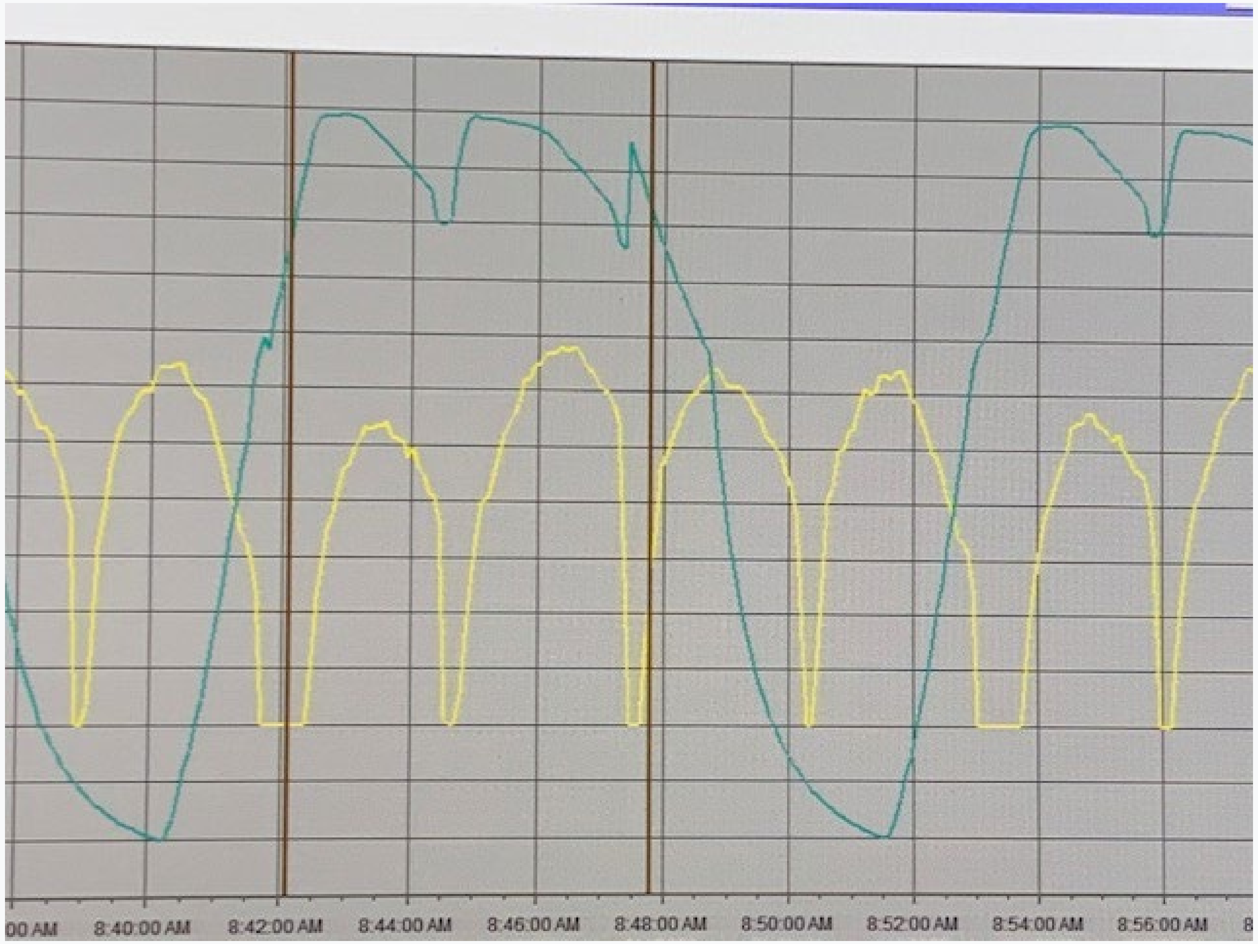
Signature #1 — “flat” back pressure



BP valve struggling to build pressure — flattened crests

What you see

The BP curve goes flat — the valve can't build pressure.

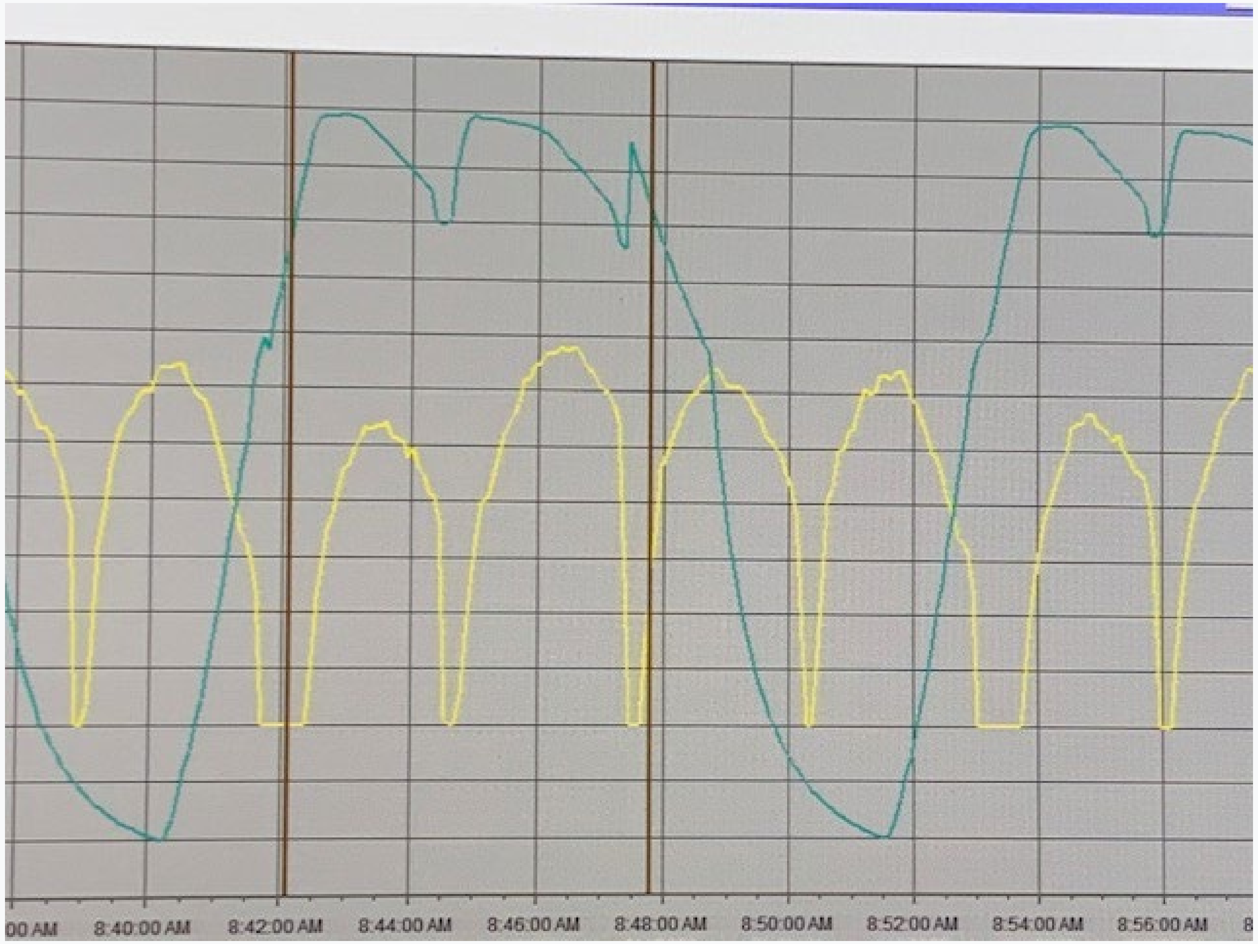
What it means

Vapor is running through channels, not beads. This bed is already damaged.

When to act

At the first glitch — check seats, solenoids, air lines.

Signature #2 — sharp moves at actuation points



One cycle: Feed → Depressurize → Regenerate → Repressurize

Watch each transition

Every actuation should hand off smoothly — beds in sync.

Sharp changes = danger

A spike means a valve, solenoid, or air line is sticking.

THE LIMIT

0.7 PSIA/sec

Any faster and the bed fluidizes — beads grind to dust.

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Signature #3 — ΔT shows how hard the bed works

Adsorbing water releases ~1,800 BTU per pound of water — so the temperature rise during feed directly measures the work being done.

HIGH-PRESSURE SYSTEM

~40°F ΔT during feed

≈ 0.7% w/w working capacity

LOW-PRESSURE SYSTEM

~15°F ΔT during feed

≈ 0.5% w/w working capacity

A shrinking ΔT is a shrinking working capacity. Trend it, per bed.

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The cheat sheet: symptom → diagnosis → action

What the DCS shows	What it means	What to do
“Flat” back pressure	Channeling — vapor bypassing beads	Check seats, solenoids, air lines
Sharp moves at actuation points (> 0.7 PSIA/sec)	Fluidization risk — sticking valve or solenoid	Cycle valves with field verification
Shrinking ΔT	Working capacity loss	Trend per bed; investigate early
One bed behaving differently	Something local to that bed	Always ask WHY

Share this table between operations and maintenance — catch failures while they're still valve problems.

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The maintenance playbook

Communication

Operator–maintenance feedback loop on every DCS anomaly.

Air lines

Regular blowdowns — slow valves wreck pressure profiles.

Solenoids

Every shutdown: cycle valves from the DCS with field verification.

Valve seating

Regular seat and seal checks.

Thermowells

Validate calibration; install ≥ 600°F range.

Parts inventory: one solenoid or valve seat can shut down the whole system. Stock a full valve rebuild kit — no parts, no production.

SUMMARY

If you remember three things

Valves are the heart of the process

The most common cause of molecular sieve bead failure.

Measure temperature where it matters

Thermowells top, middle, and bottom — all on the DCS.

Pressure × temperature = bed life

Their balance keeps flow single-phase and beds dry.

Predictive beats preventive. Preventive beats replacement. Replacement beats downtime — barely.

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THE MOST IMPORTANT PART…

Your questions.

Ask now — or come find us at the booth.
We love to talk mol sieve.

Hengye® Inc. can help.

Scan to connect