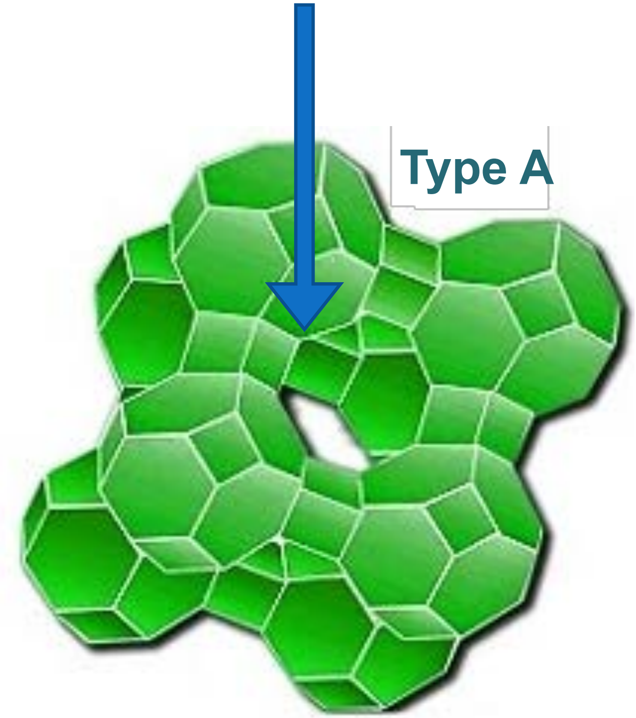
Molecular Sieve

An overview for optimizing molecular sieve dehydration units

What is Molecular Sieve?

- also called **zeolite** and **mole sieve**
- tiny, hollow crystals that separate smaller molecules from larger molecules
- able to selectively adsorb molecules due to pore diameter of the crystals
- used in dehydration units or beds

Water Molecule size = 2.8A
Molecular Sieve Pore size = 3A
Ethanol Molecule size = 3.6A



What really matters?

THEORY

- used to dehydrate ethanol
- quality of bead does matter
- ion exchanges
- crystal growth
- clay binders

PROPERTIES

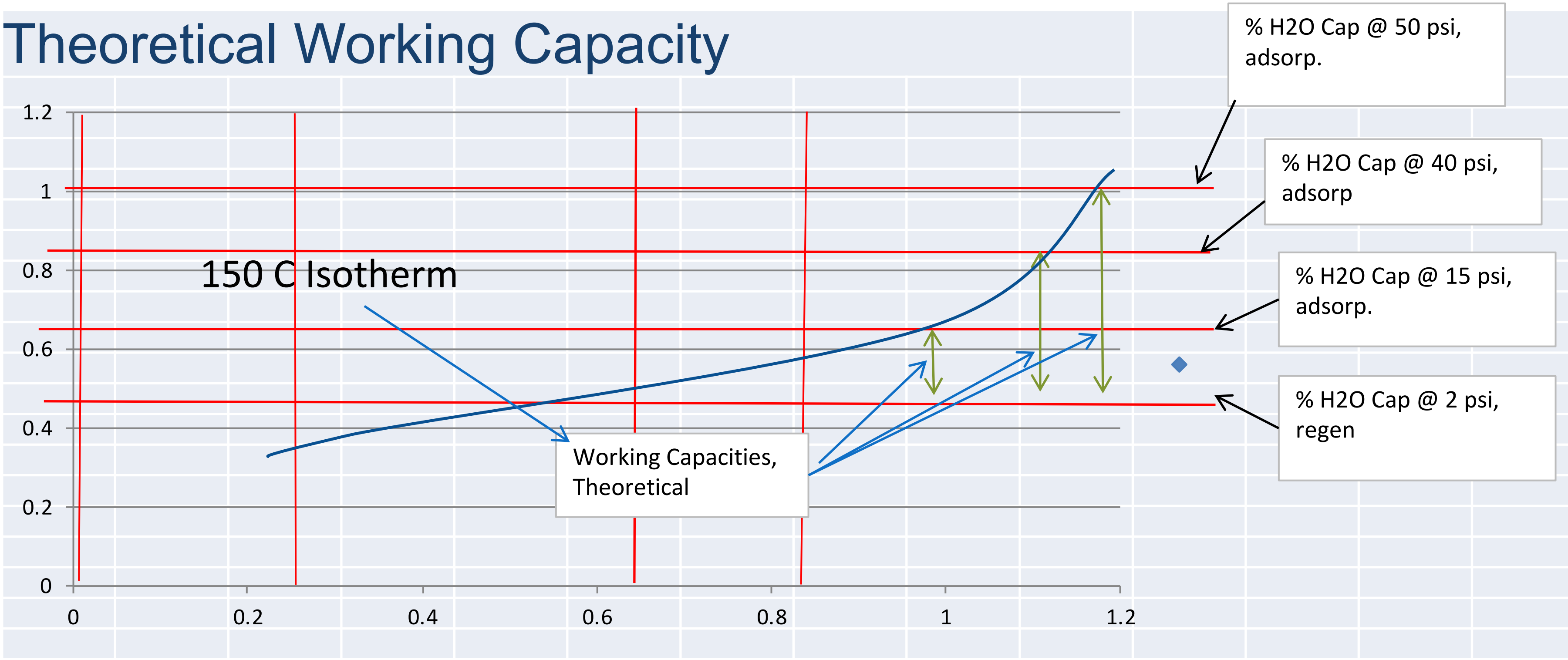
- crush strength
- bulk density
- bead distribution
- adsorption
- mass transfer rate

You've probably seen its beaded or beaded form…

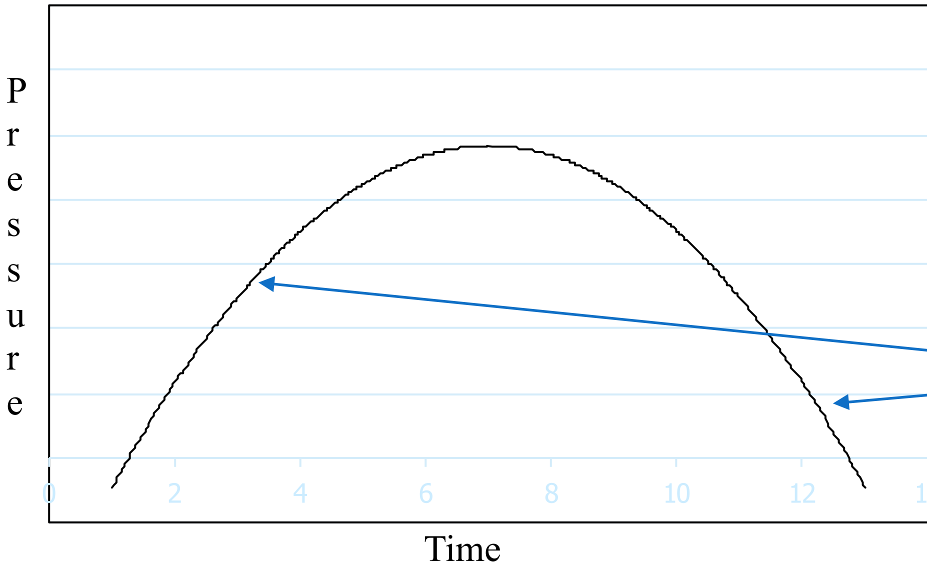
...this is Molecular Sieve in its crystal form

Theoretical Working Capacity

Isothermal Capacity Changes as a Function of Pressure

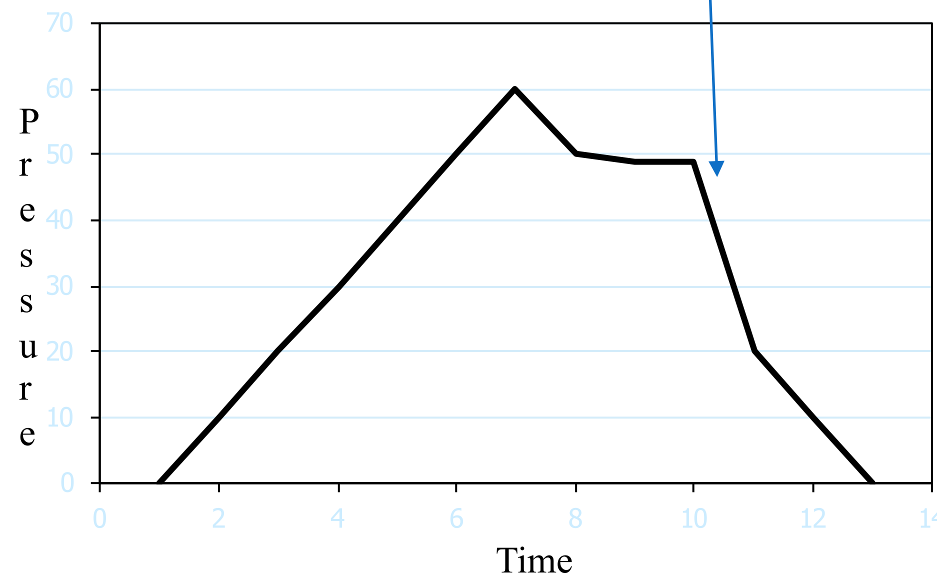


Normal Curve, *Smooth*



The slope of any pressure vs time change line should never be greater than 0.83 psi/second – fluidization velocity

Valve Sticking, *Jerky*



Sudden Pressure Changes

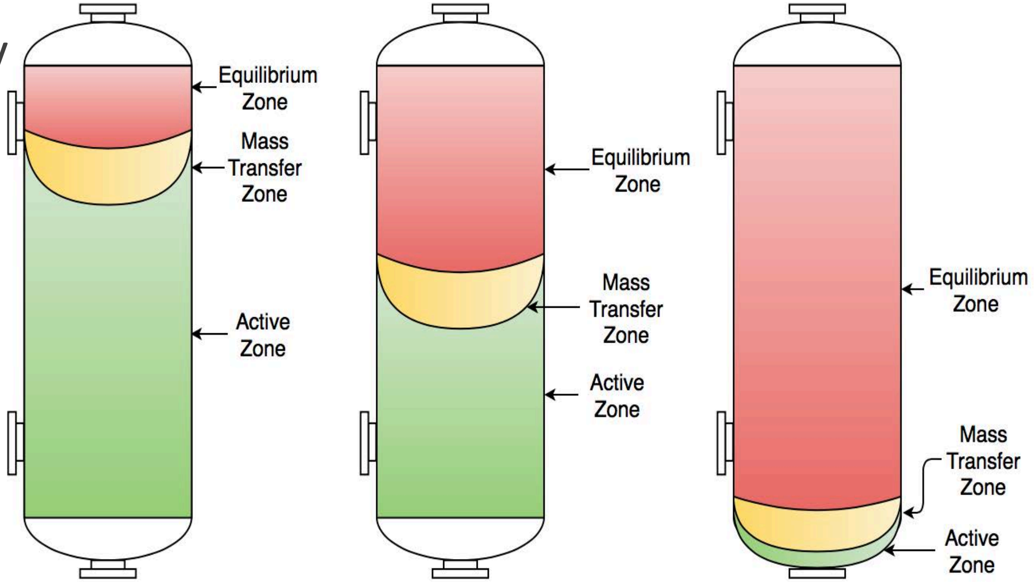
Watch the pressure traces on the control room screen

Process Optimization

MASS TRANSFER ZONE

- Measured by shape and velocity
  - Smaller, tighter zones are better
  - Determines breakthrough point
- Affected by bead quality:
  - Size distribution
    - Channeling
    - Larger beads have slower Mass Transfer Rates
  - Bulk density
    - Denser beads have slower Mass Transfer Rates
- Well maintained MTZs offer longer cycle times and fewer regenerations

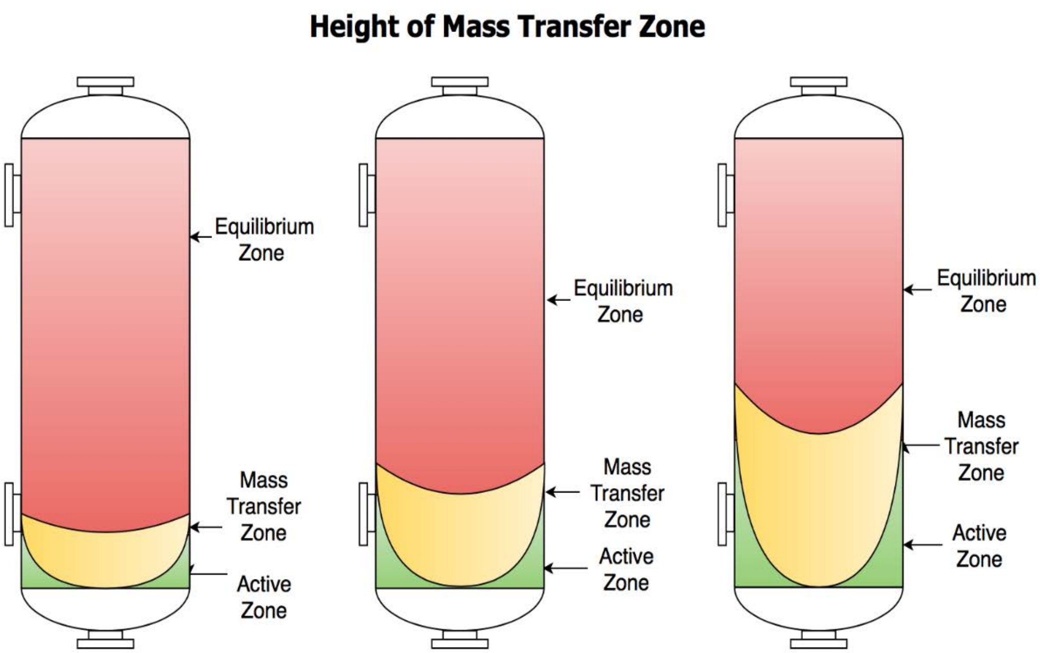
Mass Transfer Zone passing through the Molecular Sieve bed during an ethanol bed dehydration cycle



Process Optimization

WORKING CAPACITY

- Capacity increases as pressure increases
- Capacity decreases as temperature increases
- To optimize:
  - Operate at lowest temperature possible without phase change
    - Remain in vapor phase
    - Coolest temperature above boiling point based on ethanol/water composition
    - Liquid phase particles cover and block sieve beads from adsorption
  - Operate at highest pressure the system can allow
    - Check your P&IDs
    - Your design determines the maximum pressures able to be used



Process Optimization

SIEVE QUALITY - REQUIREMENTS

- Durable product to withstand conditions
  - A high crush strength can survive high pressure drops and the heat of the system
  - A durable product will offer a high working capacity throughout an increased lifespan
- High working capacity
  - Longer cycle times and fewer regenerations, energy savings
  - Lower regeneration proof, more efficient
  - ΔP at a constant temperature indicates your working capacity, bigger is better
- High selectivity for ethanol
  - Low ethanol co-adsorption, higher return
  - Capacity for water is not wasted

Don’ts of production

NO WET FEED

- keep feed stream more than 50˚F above the condensation temperature of the feed composition
  - 50˚F+ of superheat needed to ensure there is no bed wetting
- liquid phase water coats sieve beds and prevents adsorption
  - water has high surface tension and forms a liquid barrier around bead

FEED pH

- extreme pH levels can literally melt molecular sieve
- low pH is especially dangerous (strong acids)
  - feed pH should ideally never be below 5
  - below 4 and issues will likely arise
- high pH is also dangerous (strong bases, eg caustic soda)
  - feed pH should ideally never be above 10
- pH issues can cause fused clumps of old beads

HENGYE

Things to avoid

PRESSURE CHANGES

- sudden or extreme pressure changes should be avoided
- △ P should never be faster than 0.83 psi/sec during the instantaneous or "longer term" pressure change
  - causes fluidization in the bed
  - primary cause of dusting and bead break up.
- *Valve Maintenance*
  - Protect against pressure surges
  - you can create a sonic boom within the bed
  - repressure, feed, depressure, and vacuum legs of the cycle

CIP (contamination)

- do not let any CIP fluids into the sieve beds
  - avoid strong acids or bases, which can cause sieve to melt or degrade
- avoid introducing organic contaminants into the sieve beds
  - coking – have you ever seen old beads with black spots?
  - burned hydrocarbons coke up or leave a tar on the outside of sieve beds and limit working capabilities

Giving you the most

SYMPTOMS OF BAD BEADS

- Frequent filter changes
  - Caused by dust in system
  - Weak beads break and crack over time
- High regeneration proof
  - Caused by loss of adsorption capacity
  - 3A can change back to 4A
- Rapid changes in Pressure Drop
  - Can be caused by wide bead distribution
  - Broken and cracked beads cause irregularities
  - Reductions of Cycle Times

MOLECULAR SIEVE

Theory

- used to dehydrate ethanol
- quality of bead does matter
- ion exchanges
- crystal growth
- clay binders

Properties

- crush strength
- bulk density
- bead distribution
- adsorption

Thank you…

Now that you have the facts, we would be happy to take your questions. We can help understand what you're experiencing and offer solutions.