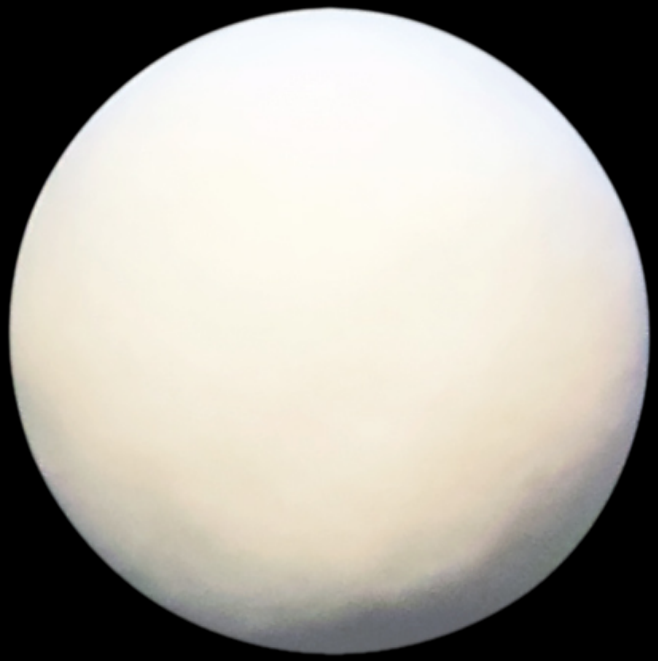
Molecular Sieve

Theory, Properties, and Process Optimization

HENGYE®

Hi

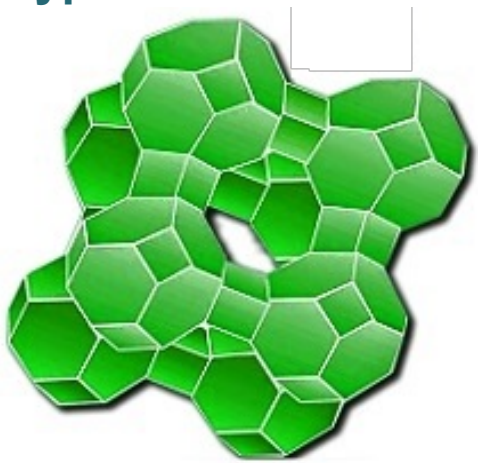


HENGYE

Did you know that Molecular Sieves are…

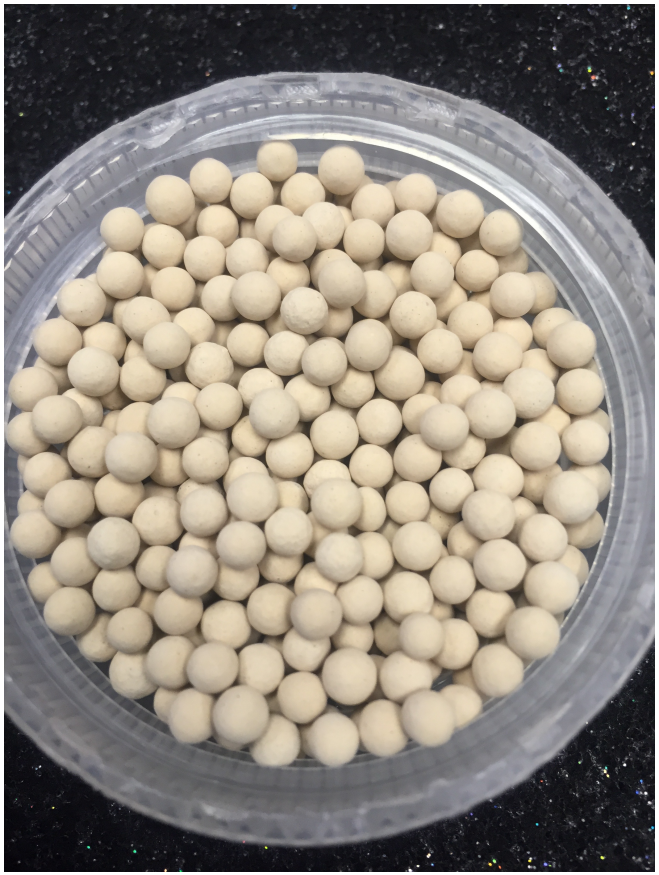
- used in dehydration units or beds
- also called zeolite and mole sieve
- tiny, hollow crystals that separate smaller molecules from larger molecules
- able to selectively adsorb molecules due to pore diameter of the crystals

Type A



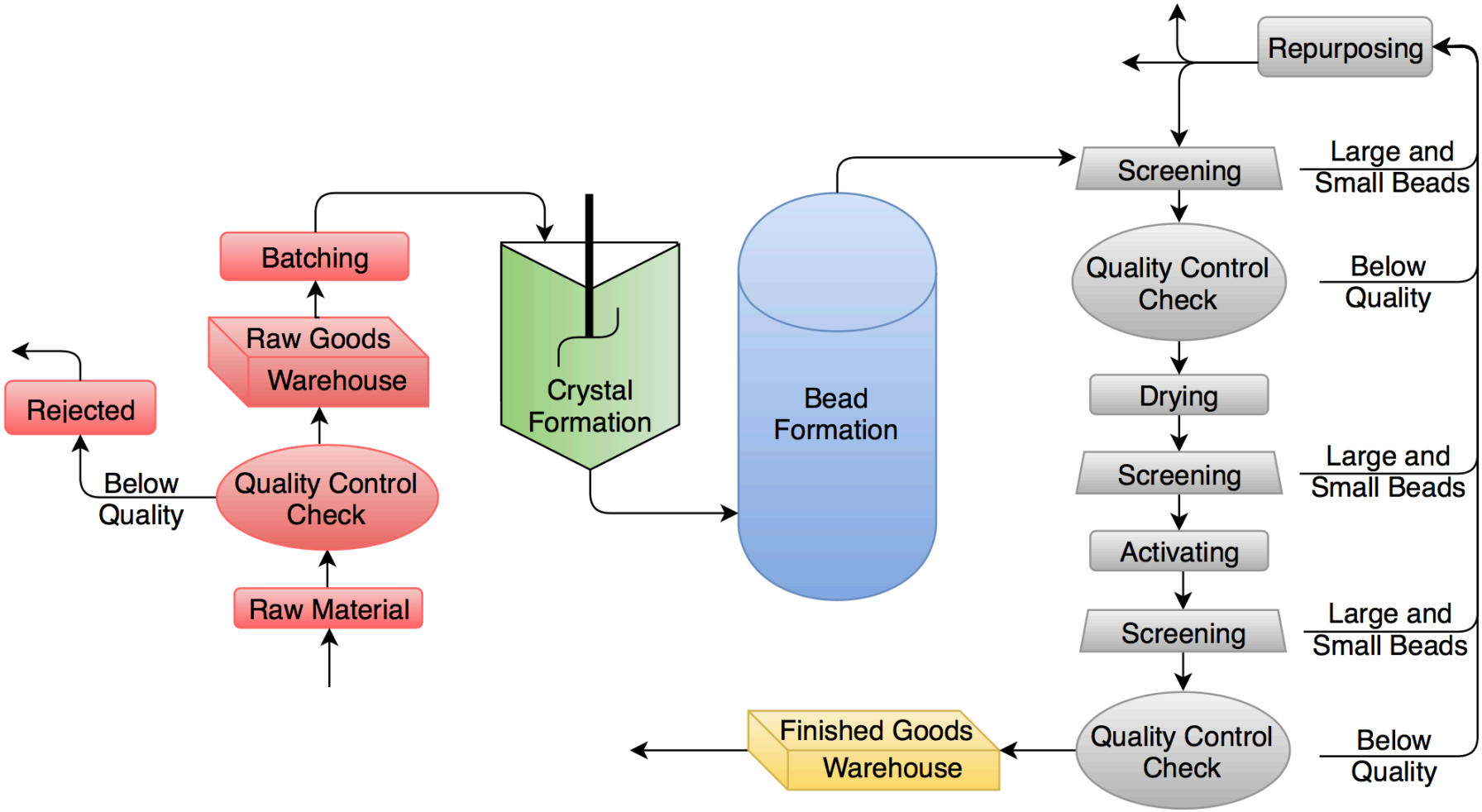
Water Molecule size = 2.8A
Molecular Sieve Pore size = 3A
Ethanol Molecule size = 3.6A

You've probably seen its beaded or beaded form…



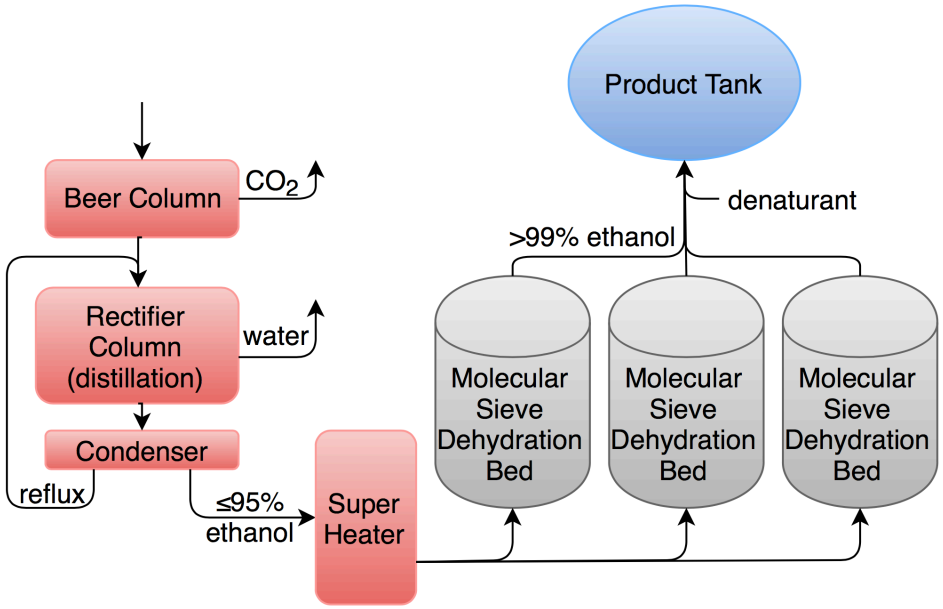
...this is Molecular Sieve in its crystal form

Process of Making



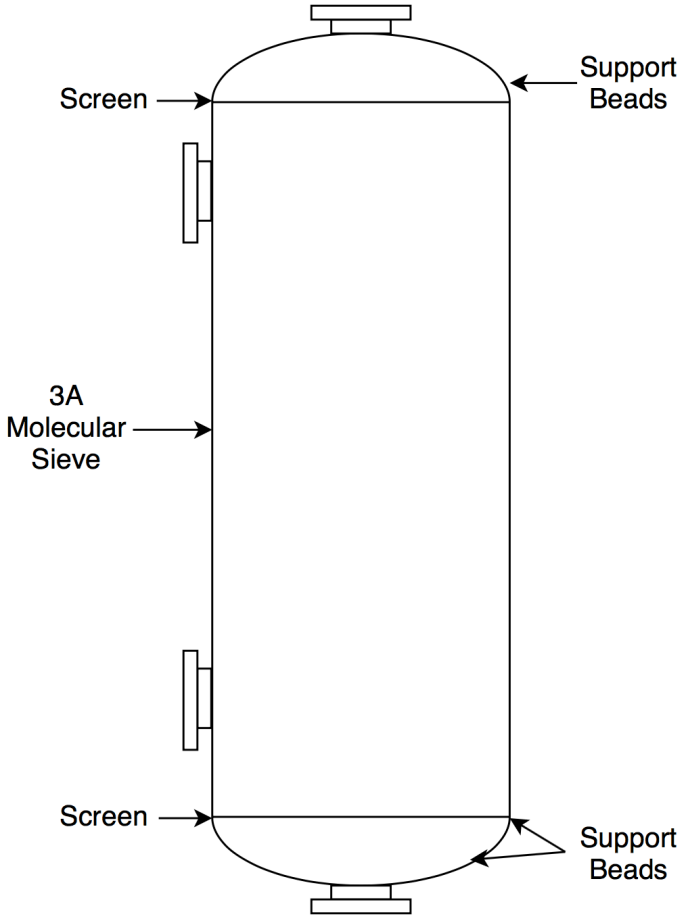
Sieve Purpose

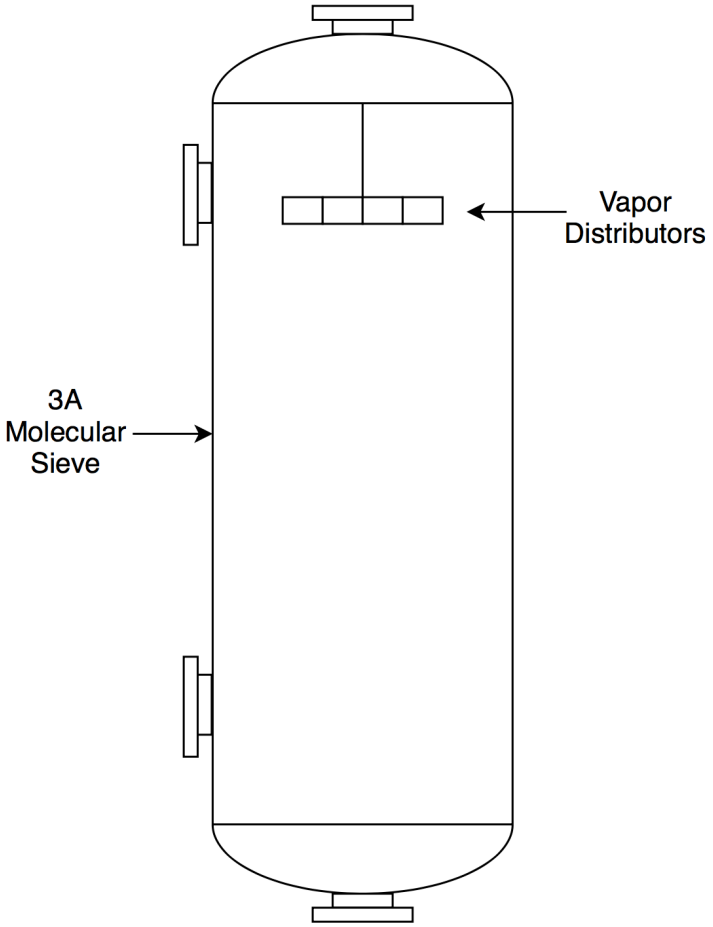
Why use Molecular Sieve



- 3A Molecular Sieve breaks the ethanol/water azeotrope
- Finishes dehydrating ethanol after distillation and removes final 5% of water
- Allows ethanol to be used as a fuel additive

Common Bed Layouts





How to read a Specification Sheet

Hengye Inc. EthaDry HYD03C				Meaning of Property
Property	**Unit**	**Standard**	**Average**	
Bead Diameter	Mesh	4x8	-	important when considering Pressure Drop
Size Distribution	%<2.5mm	0	-	smaller Beads lead to high Pressure Drops and typically have a lower Crush Strength
	%>5mm	0	-	large Bead slows Mass Transfers Rate; inconsistent sizes can cause channeling or uneven wear
Bulk Density	lb/ft^3	43.7-47.4	*45.19*	low Bulk Density offers better movement of fluid through the bed; less weight required to fill the bed
	kg/m^3	696-761	*717.6*	
Crush Strength	lbf	≥20	*25.54*	Durable for extreme △T and △P; Pressure Drop less likely; resistant to cracking and dusting
	kgf	≥9	*11.6*	
Attrition	wt%	≤0.1	*0.07*	high Attrition causes Dust throughout the system, increases Friability
CO_2 Adsorption	%	≤1.0	*0.745*	can be used to infer the amount of Ethanol being adsorbed with the water, caused by residual 4A crystals, lower Ethanol co-adsorption is better
Ethanol Delta T	˚C	1.8	*1.6*	
Methanol Delta T	˚C	≤10	*5*	
Static H_2O Adsorption	%	≥21.0	*21.09*	higher Static Water Adsorption Capacity means potentially greater Working Capacity
Loss on Ignition	wt%	≤1.5	*0.225*	measure of residual organic matter in the sieve beads

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THINGS TO LOOK FOR…

- 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

TIME FOR A CHANGE

If you're experiencing these situations and you hope for improvement, you should talk to your ethanol community for a solution.

The opportunities for optimization are endless.

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 or design constructor
    - Your design determines the maximum pressures able to be used

Process Optimization

SIEVE QUALITY

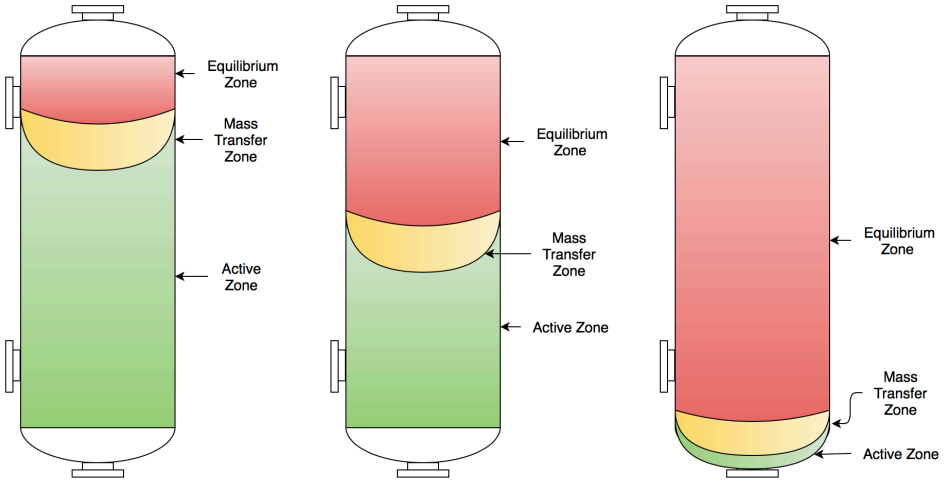
- Durable product to withstand conditions
  - A high crush strength can survive high pressure drops and the heat of the system
  - A durable product will offer a high working capacity throughout an increased lifespan
- High working capacity
  - Longer cycle times and fewer regenerations, energy savings
  - Lower regeneration proof, more efficient
  - $\triangle P$ 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

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



Giving you the most

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

PROCESS

Optimize

- determine boiling point
- find maximum allowed pressures
- increase production capacity

Watch for

- filter changes
- top offs
- high regeneration proof
- extreme pressure drops

Recognizing Value

Remember to

- choose the right Sieve
- take care of the system
- keep records of your day to day

There’s always an opportunity to

- optimize your process
- increase your production
- reduce your costs