



INTRODUCTION TO:
THERMAL KINETICS

DEVELOPMENT ••• DESIGN ••• FABRICATION



Vision Statement

Innovation Driven → Solutions Focused...

See alternatives not recognized before. Deliver best process solutions which enable the success of our customers, adds value to their enterprise, and protects our community. Rely on our internal teams and partnering with suppliers and customers to bring all the ideas to the effort. Know that blending many perspectives and talents in a trusting environment accelerates innovation and builds the best solutions. Finally by executing this vision we elevate our life work and inspire excellence.





Our Values

- **Respect** - is our priority requiring trust and accountability for staff, customers, suppliers, and the environment.
- **Integrity** - we take responsibility, accept accountability, “do the right thing”
- **Partnering** - for strong team involvement of staff, customers and suppliers
- **Team building** - help everyone strive for greatness. “Have your teammates back.”
- **Responsiveness** - urgency in action and communication. Delays breed mistrust.
- **Continuous learning** - for staff growth, highest quality of service and solutions for our customers, which sparks innovation and creativity.

We are building for the future solving energy and environmental problems for the next generation. We achieve team building through mutual respect, partnering to solve the most difficult engineering problems for the benefit of our customers and the environment.





Mission Statement

We solve a diverse range of difficult heat/mass transfer process applications, while promoting sustainability, excellence and value for our customers.





Sustainability Statement

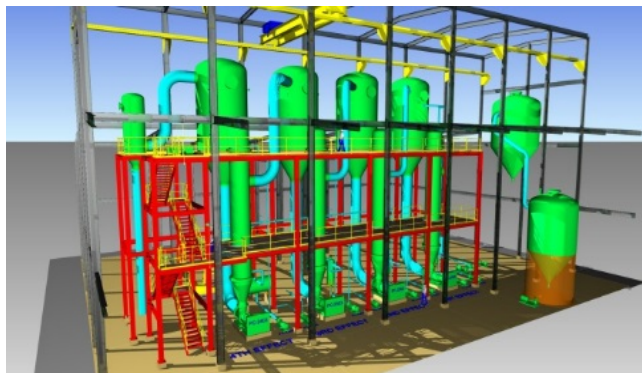
Thermal Kinetics is committed to providing process equipment solutions that help sustain and conserve environmental resources.

Our renewable fuels initiatives offer major energy conservation benefits to our clients and support energy independence for the USA.

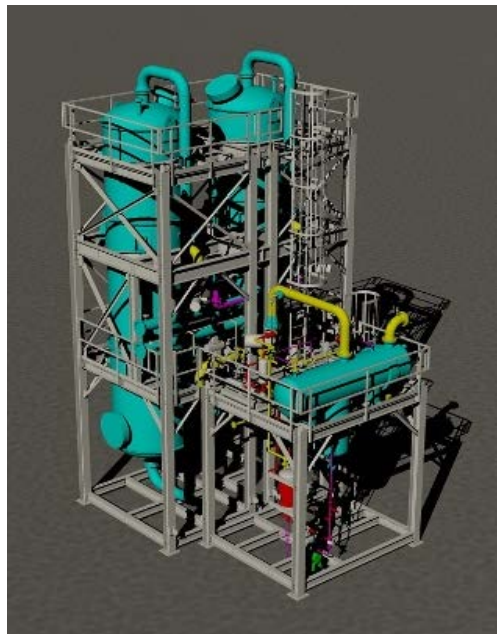




Development, Design, & Supply



PROCESS
FACILITIES



MOLECULAR SIEVE
ADSORBERS



MODULAR SKID
MOUNTED PLANTS



Development, Design, & Supply

Submerged Circulating Crystallizer

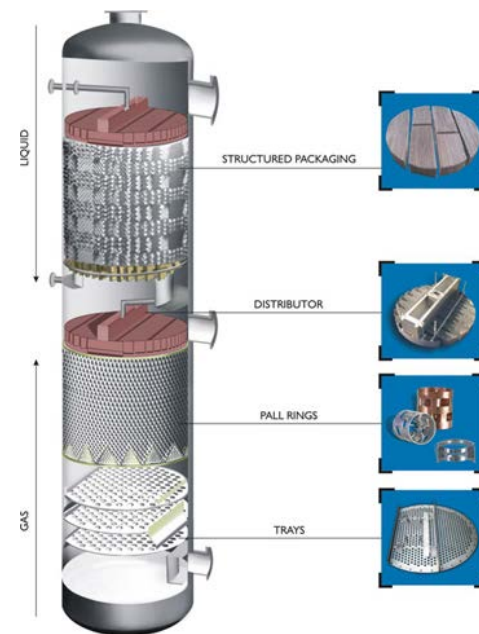


CRYSTALLIZERS

Falling Film Evaporator



EVAPORATORS



DISTILLATION EQUIPMENT





“What we do”

- System design, supplying cost effective equipment and process solutions to our customers
 - Minimizing energy input
 - Maximizing product output
 - Optimizing project value





“What we do”

- Emission control systems using absorption and adsorption technologies
- Chemical purifications systems using distillation, adsorption, and evaporation technologies
- Diverse experience in the chemical, food processing, distillery, industrial operations, including metals processing
- Customized process development through rigorous analysis, process simulation, and equipment design development





What we have done lately...

- DD&E (Distillation, Dehydration & Evaporation) system supplied for fuel ethanol production at Dakota Spirit AgEnergy
- Cellulosic ethanol plant molecular sieve system for DuPont in Iowa
- First ultra low moisture industrial alcohol MSU system achieving 150 ppm moisture consistently
- Sodium Sulfate anhydrous four effect crystallizer in Mexico. MOC are titanium and duplex stainless steel
- Thermal BioMass Conversion Process designed for extraction of organics (biofuels) from mixed waste and plastics under subcritical hydrothermal conditions





Overview and Supplied Equipment





Markets Served

- Chemical industries
- Renewable fuels and chemicals
- Food processors
- Industrial manufacturers
- Pharmaceutical processing





Renewable Fuels, Chemicals & Polymers

- Alcohols (i.e ethanol, methanol, glycerol)
- Grain-based fuel ethanol production
- Cellulosic-based fuel ethanol production
- Biomass gasification processes
- Biopolymers (i.e. PLA, PHA, etc.)
- Chemicals recovery from algae processes
- Platform chemicals (i.e. C2-C6, succinic acid, etc.)





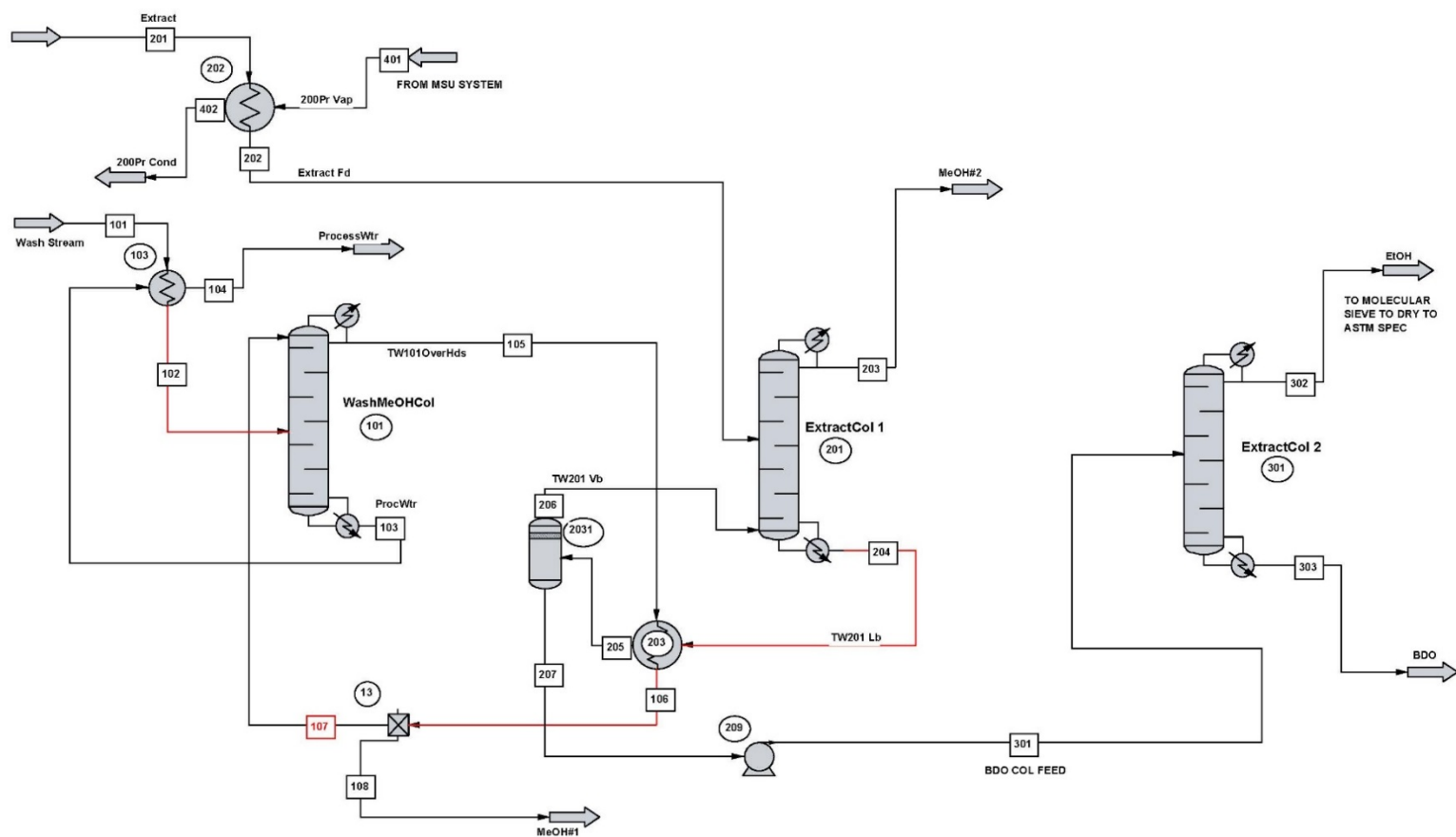
Services & Equipment Provided

- Fully integrated process systems development and design
- Detailed equipment design and supply
- Commissioning and start-up services
- Design/construct on-site
- Fully modularized skid mounted systems





Services & Equipment Provided – Process Modeling





Services & Equipment Provided

Thermal Kinetics provides a number of core technologies, designs and process operations including:

- Process evaporation
- Distillation systems
- Adsorption drying systems – molecular sieves
- Scrubbers/absorbers – emission control
- Specialized chemical recovery and reaction systems





Materials of Construction

Experience in a wide variety of construction materials:

- Carbon steel and austenitic stainless steels
- Duplex and specialty stainless steels
- Titanium Gr 2, Gr 7, and Gr 11
- Inconel, Nickel 200/201, Monel, Hastelloy(s) and special alloys
- Impervious graphite equipment
- Lined piping (PTFE, ETF, PVDF...)
- Fiberglass composite systems





Industrial Experience

- Agricultural chemicals and fertilizers
- Animal byproducts and rendering
- Fats, oils and soap
- Food products and processing
- Breweries and distilleries
- Inorganic chemicals
- Pharmaceutical
- Sugar and corn products
- Steel processing and metals industries





Examples

Acids:

- Hydrochloric acid absorption/well brine production by reaction of HCl & CaCO₃
- Hydrochloric acid recovery from waste phosgene gas stream
- Hydrochloric acid distillation and recovery with calcium chloride dehydrator
- Recovery of HCl from a mixture of HCl and H₂SO₄
- Pickle liquor temperature control and HCl recovery
- Phosphoric acid evaporation (30% to 54% P₂O₅)
- Sulfuric acid: high purity electronics grade production facility
- Sulfuric acid concentration systems
- Citric acid fermentation, filtration, purification, evaporation, crystallization, and drying
- Gluconic acid evaporator





Examples

Caustic and Alkalies:

- Caustic Soda (NaOH): evaporation to 50% & anhydrous flake w/ material handling
- Caustic Soda (NaOH): recovery from mercerizing process (textile facility)
- Caustic Potash (KOH) concentration and flaking

Organic and Specialty Chemicals:

- ABS latex solvent recovery system and vacuum condensing operation
- Glycerin concentration and distillation systems
- Terpene resin solvent evaporation and stripping system
- Ethylene glycol distillation and purification
- Rolling oil emissions control and distillation recovery (2 mm Hg abs/360 F)





Examples

Sugar, Corn Products, Grain-based Ethanol:

- Corn/Sorghum to ethanol distillation, evaporation and dehydration
- Corn steep liquor evaporator
- Dextrose evaporator and crystallizer
- Invert sugar evaporator
- Brewery effluent alcohol recovery

Fats and Oils, Rendering, Specialty:

- Sorbitol processing – evaporation and drying
- Odor stripping of oils and fats
- Solvent stripping of fatty acid miscella
- Turkey processor wastes to renewable oils conversion





Examples

Salts and Inorganics:

- Sodium Sulfide (Na_2S): evaporator and flake plant
- Ammonium thiosulfate production facility and reactor design
- Calcium chloride (CaCl_2): production of flake road salt
- Ammonium sulfate – reaction of ammonia and sulfuric acid with crystallization
- Calcium hypochlorite production
- Sodium sulfate production and crystallization plant from ore





Evaporation Systems

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EVAPORATOR DESIGN QUESTIONNAIRE



85 Northpointe Parkway #2
Amherst, NY 14226-1886
Ph: (716) 691-3291 / Fax: (716) 691-3294

Please supply as much information as possible.
Thermal Kinetics will supply typical values based
on experience when missing data is encountered.

Your reference: _____
Thermal Kinetics quotation required by: _____
Price Basis: Order of Magnitude Budget Firm

Inquiry Date: _____

Approximate installation date: _____

| | |
|-----------|------------|
| Company | |
| Address | |
| Telephone | Contact |
| Fax | Position |
| E-mail | Department |

Test facilities are available for determining physical properties of process fluids and if needed pilot testing can be arranged.

| | | | |
|---|---|--------------------------|---------------------------------------|
| PROCESS LIQUIDS | | | |
| Solution to be concentrated: | | | |
| Scaling Tendency? | If so, what type? | | |
| Will solute crystallize? | Send solubility data if this is the case. | | |
| Is solution corrosive? | Describe: | | |
| Is feed being concentrated now? | By what method? | | |
| Preferred materials of construction (CS, 316L, etc.): | | | |
| PHYSICAL PROPERTIES | | Feed | Concentrate |
| Total solids content | | % | % |
| Specific Gravity | | | |
| Viscosity | | cps at °F | cps at °F |
| Specific Heat in Btu/lb °F | | | |
| Boiling point elevation | | °F | °F |
| Are quart samples available? | | | |
| EVAPORATOR DUTY | | | |
| Feed rate | lb/hr | Feed temperature | °F |
| Operating time: | hrs/day | hrs/yr | Turn-down required: % design capacity |
| Is concentrate cooled? | Temp: °F | Maximum processing temp: | °F |

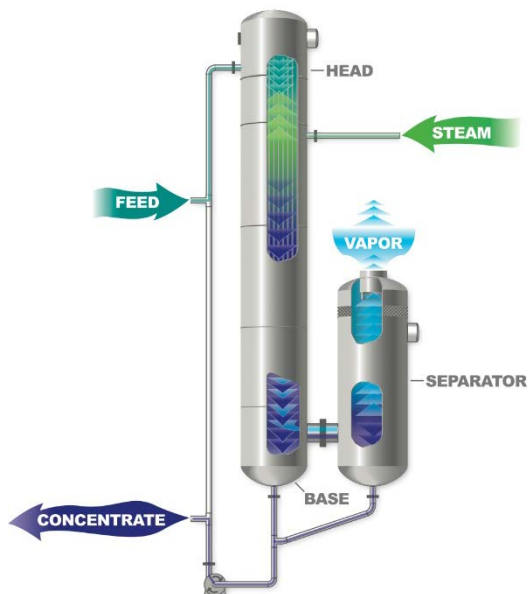
- Single/multiple effect systems
- TVR: Thermo-vapor recompression
- MVR: Mechanical vapor recompression
- Anhydrous caustic flake systems
- Salt flake systems
- Corrosives (H₂SO₄...)
- Crystallization systems
- Foaming and heat sensitive materials



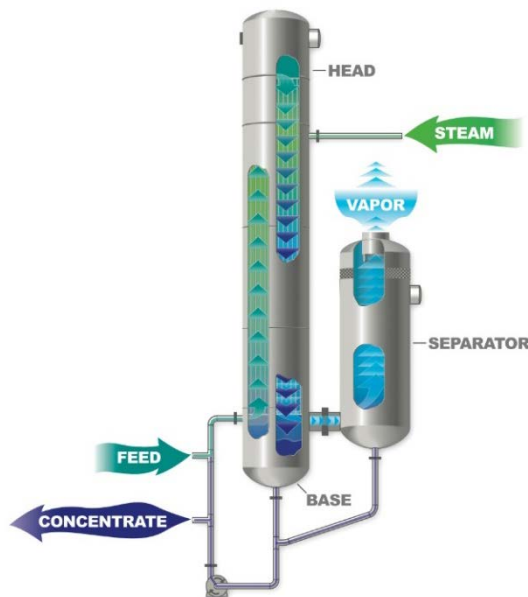


Standard Evaporator Styles

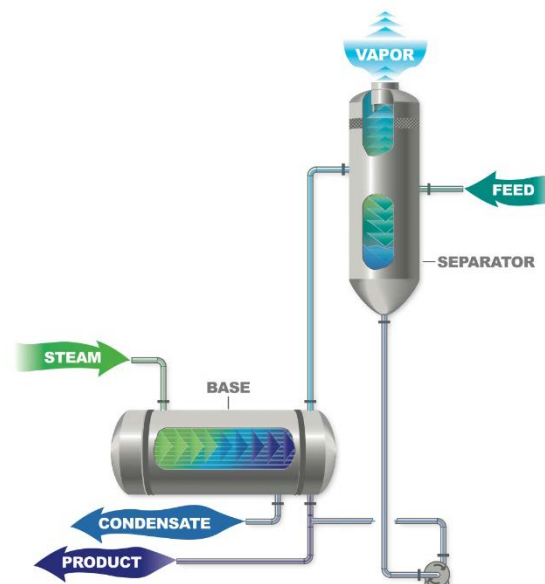
Falling Film Evaporator



Rising/Falling Film Evaporator



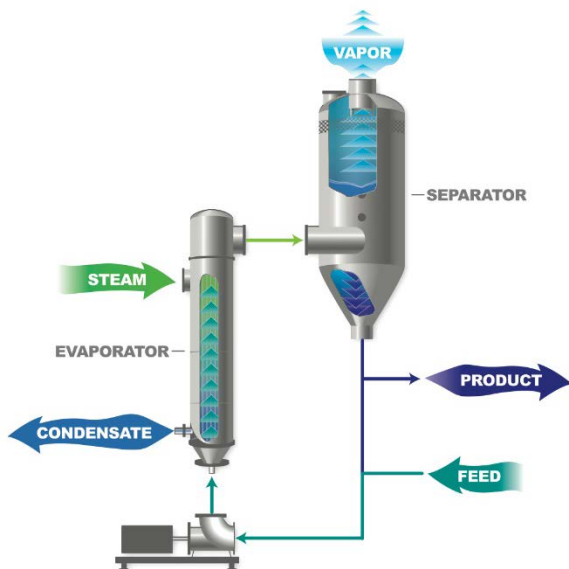
Forced Circulation Film Evaporator



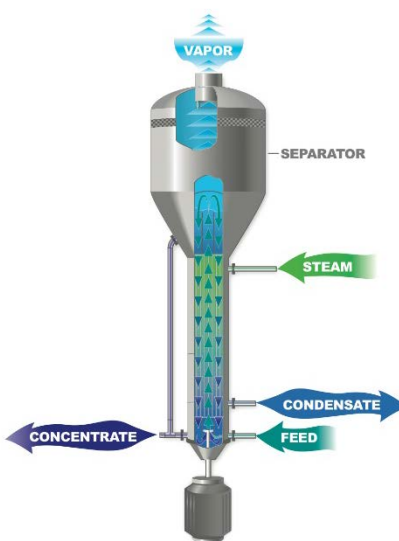


Standard Crystallizer Styles

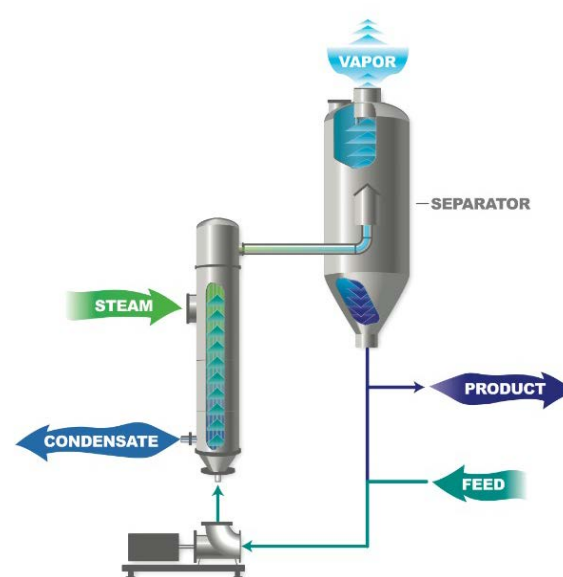
Submerged Circulating Crystallizer



Internal Pump Circulating Crystallizer



Draft Tube Crystallizer





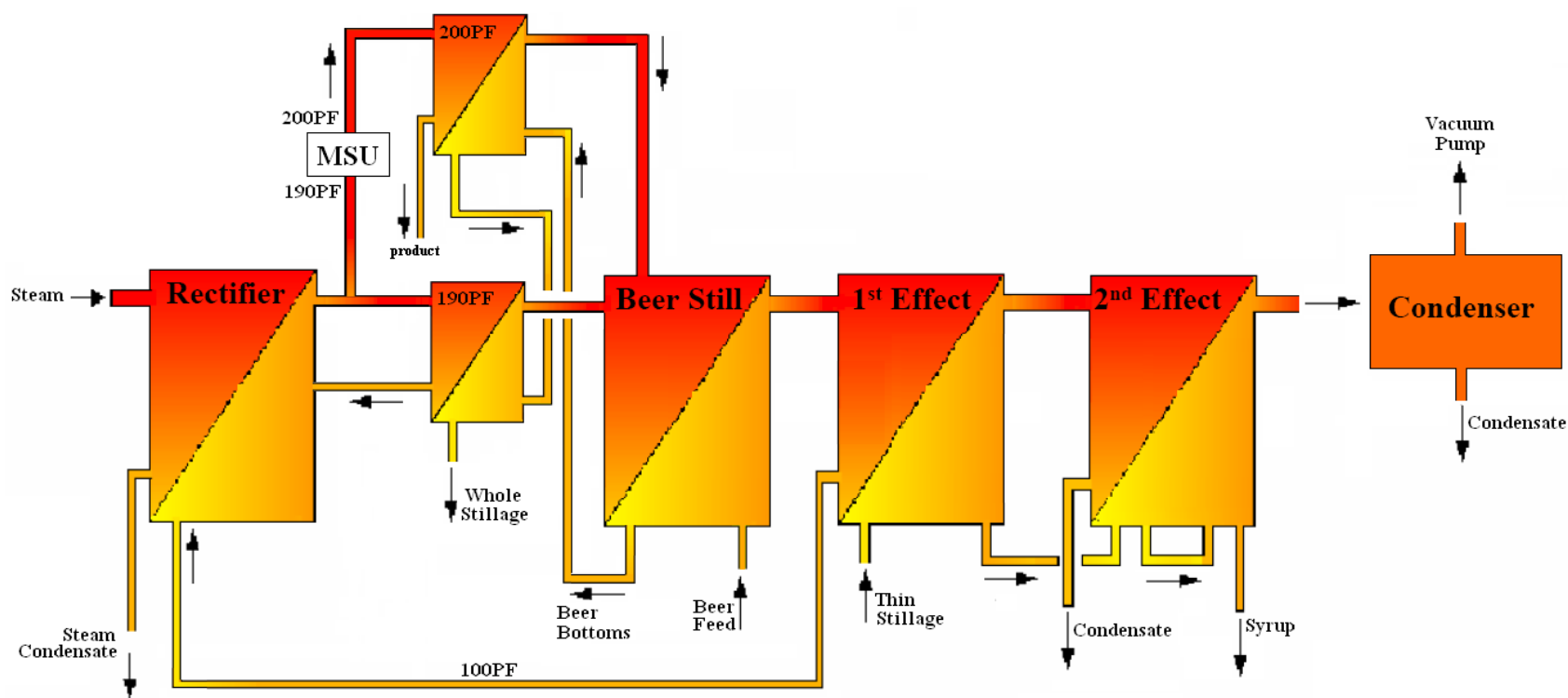
Thermal Kinetics Patents

- Distillation/Dehydration/Evaporation (DD&E)
 - **Saves 15% of steam compared to prevalent systems**
- Ethanol, methanol, solvent purification, dehydration and advanced adsorption separations technologies
- Improved methods for pressure swing adsorption for ethanol dehydration
- Ethanol drying with co-production of methanol, hydrogen, heat and chemicals from syngas





DD&E Patented Configuration (Six Plants Constructed and Operating)





DD&E Patent Comparison

| | TK PATENTED PROCESS | PLANT BY OTHERS |
|--|---------------------|------------------------|
| | | "Industry Traditional" |
| TOTAL STEAM REQ'D | 56,210 LB/HR | 71,525 LB/HR |
| EQUIVALENT HEAT | 49.8 MM BTU/HR | 63.37 MM BTU/HR |
| WHOLE STILLAGE FLOW | 247,063 LB/HR | 296,564 LB/HR |
| WHOLE STILLAGE CONC | 16.22 WT% | 13.51 WT% |
| CENTRIFUGE LOAD | 430 GPM | 529 GPM |
| EVAP FEED | 243 GPM @ 8.65% | 232 GPM @ 7.03% |
| RECYCLE TO FERMENTATION (BACKSET) | 87.7 GPM | 205.4 GPM |
| FUSEL OIL DECANter | YES | NO |
| PROCESS CONDENSATE FOR RECYCLE RECOVERED | 123,969 LB/HR | 79,187 LB/HR |
| | 247.9 GPM | 158.4 GPM |
| 1 st EFFECT EVAP TEMP (F) | 152 | 199 |
| 2 nd EFFECT EVAP TEMP (F) | 127 | 185 |
| BEER COLUMN BOTTOM (F) | 203 | 185 |





“The Bottom Line” - DD&E Results

| Financial Benefit at 13.1 Wt% Ethanol | | | | | |
|---------------------------------------|---------------------|----------------|-------|----------------------|-----------------------|
| | TK Patented Process | Standard Plant | Delta | 50 MM GPY Plant (\$) | 100 MM GPY Plant (\$) |
| Total Steam Req'd (lb/hr)* | 56,210 | 71,525 | -21% | \$836,199 | \$1,672,398 |
| Total Financial Benefit | | | | \$836,199 | \$1,672,398 |

*Assumption: \$6.50/1000 lbs steam

Basis:

Beer feed of 13.1 wt % ethanol, 12.72 % total solids

Note: Reduced backset of non-fermentable solids has allowed Calgren in Pixley, CA to achieve 15.5 wt% ethanol on a consistent basis for far greater savings.





Distillation Equipment

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SEPARATION DESIGN QUESTIONNAIRE



Distillation, Evaporation, Adsorption, and other Process Systems Supply

85 Northpointe Parkway #2
Amherst, NY 14229-1986
Ph: (716) 691-3291 / Fax: (716) 691-3294

MORE INFORMATION AND SPECS SHOULD BE SUPPLIED AS NEEDED TO DEFINE PROJECT

Please supply as much information as possible.
Thermal Kinetics will supply typical values based
on experience when missing data is encountered.
Inquiry Date: _____

Your reference: _____
Thermal Kinetics quotation required by: _____
Price Basis: ☐ Order of Magnitude ☐ Budget ☐ Firm
Approximate installation date: _____

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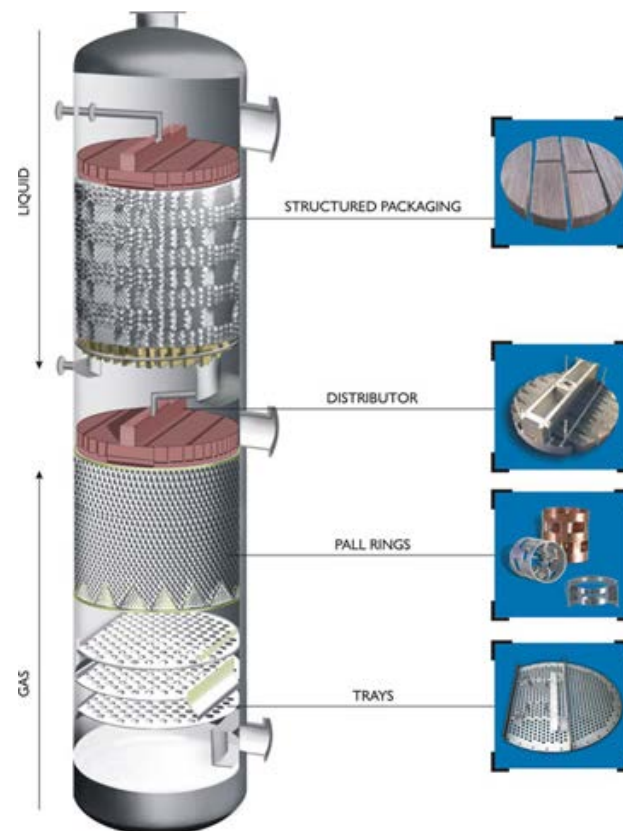
Test facilities are available for determining physical properties of process fluids and if needed pilot testing can be arranged.

PROCESS LIQUIDS FOR DISTILLATION, ABSORPTION, OR OTHER MASS TRANSFER OPERATION

| | | | |
|---|--|-------------------------|------------------------|
| Feed Composition: | | | |
| Scaling Tendency? No | | If so, what type? | |
| Foaming Tendency? Yes | | | |
| Is solution corrosive? Yes | | Describe: | |
| Is this a new or retrofit project? Yes | | Add description: | |
| Preferred materials of construction (CS, 316L, etc.): | | | |
| SPECIAL PHYSICAL PROPERTIES | | Feed | Bottoms Product |
| Total Non-volatile solids content | | % | % |
| Specific Gravity | | | |
| Viscosity | | cps at °F | cps at °F |
| Specific Heat in Btu/lb °F | | | |
| Thermal Conductivity (Btu/hr ft °F) | | | |
| Are quart samples available? | | Yes | Yes |
| COMPOSITION OF PRODUCTS | | Overhead Product | Bottoms Product |
| Component and purity: Separation #1 | | % | % |
| Component and purity: Separation #2 | | % | % |
| Component and purity: Separation #3 | | % | % |
| Component and purity: Separation #4 | | % | % |

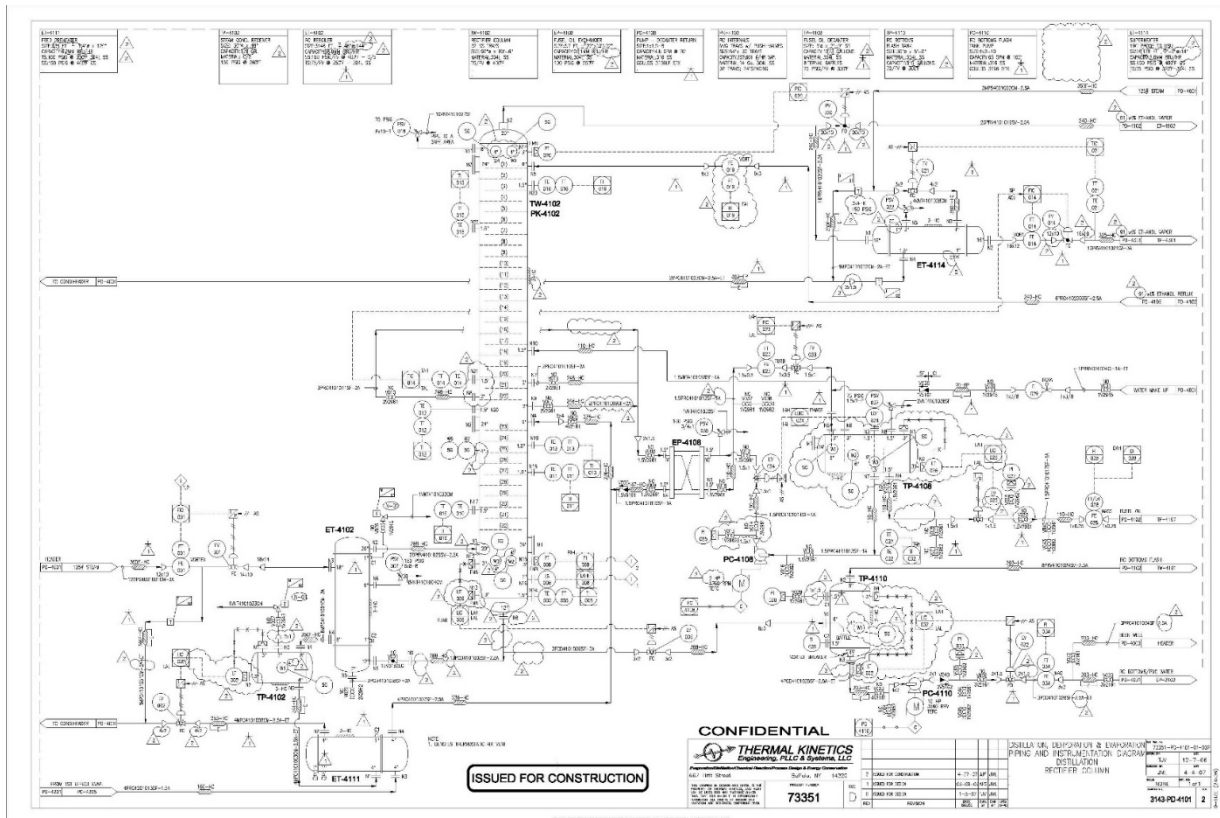
PROCESS DUTY, RATES, CONDITIONS

| | | | |
|--------------------------------|----------|--------------------------|-------------------|
| Feed rate | lb/hr | Feed temperature | °F |
| Operating time: | hrs/day | Turn-down required: | % design capacity |
| Are products to be cooled? Yes | Temp: °F | Maximum processing temp: | °F |





Services & Equipment Provided – Detailed Process Development





Renewable Fuels Initiative – Technology for Energy Independence

Innovation:

- Science-centered technology, development and innovative engineering
- Advanced solutions for energy independence
- Scientific publications reporting TK advances in molecular sieve ethanol dehydration
- Patented inventions for renewable fuels production

Successful Operating Facilities:

- Engineered, supplied and commissioned – traditional DD&E plants and TK process
- Experienced engineering resources to support construction, start-up and optimization

Effective Project Development Partner:

- Thermal Kinetics works with our clients to build successful projects in traditional dry mill ethanol plants and emerging cellulosic and thermo-chemical technologies





Services & Equipment – Biomass Conversion

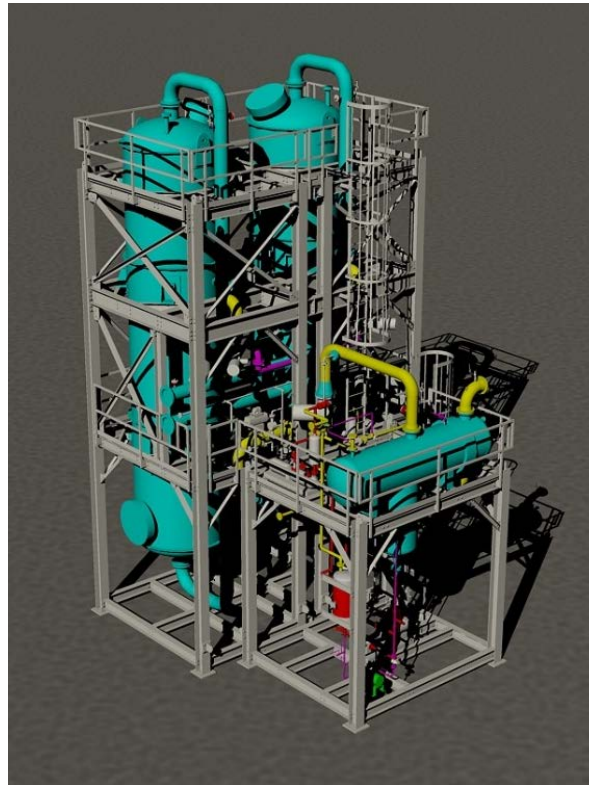
Thermal Kinetics excels in the development of innovative processes for the conversion of biomass to chemicals and fuel.

It is our ability to understand, adapt to and design for the various challenging physical properties associated with biomass derived mixtures that sets us apart.



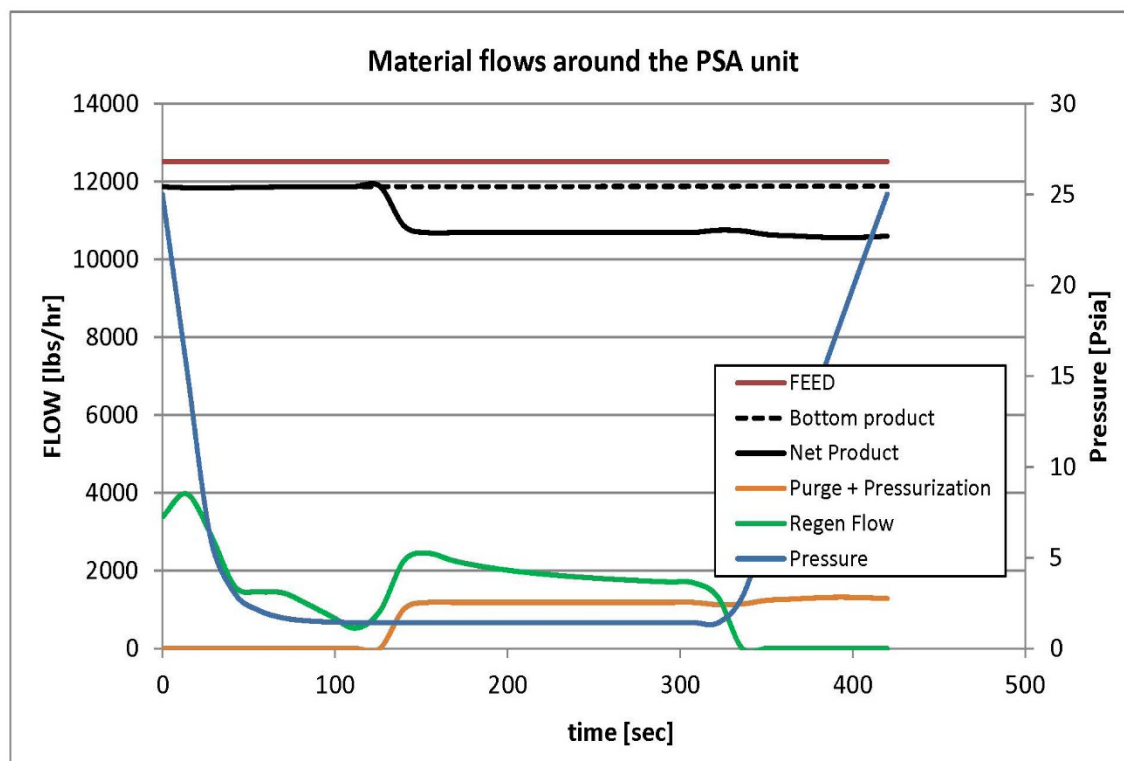


Molecular Sieve Ethanol Dehydration Module



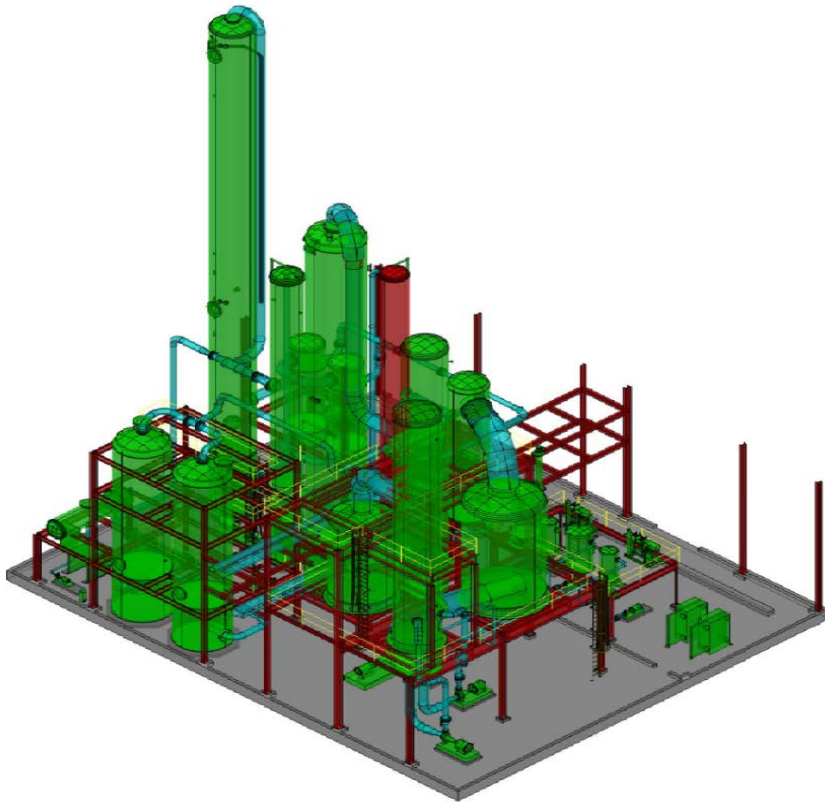


Molecular Sieve Dehydration Simulation





DSA Plant – North Dakota



Utilizing Thermal Kinetics Patented:

- Distillation
- Dehydration
- Evaporation



Calgren Renewable Fuels – Pixley, CA

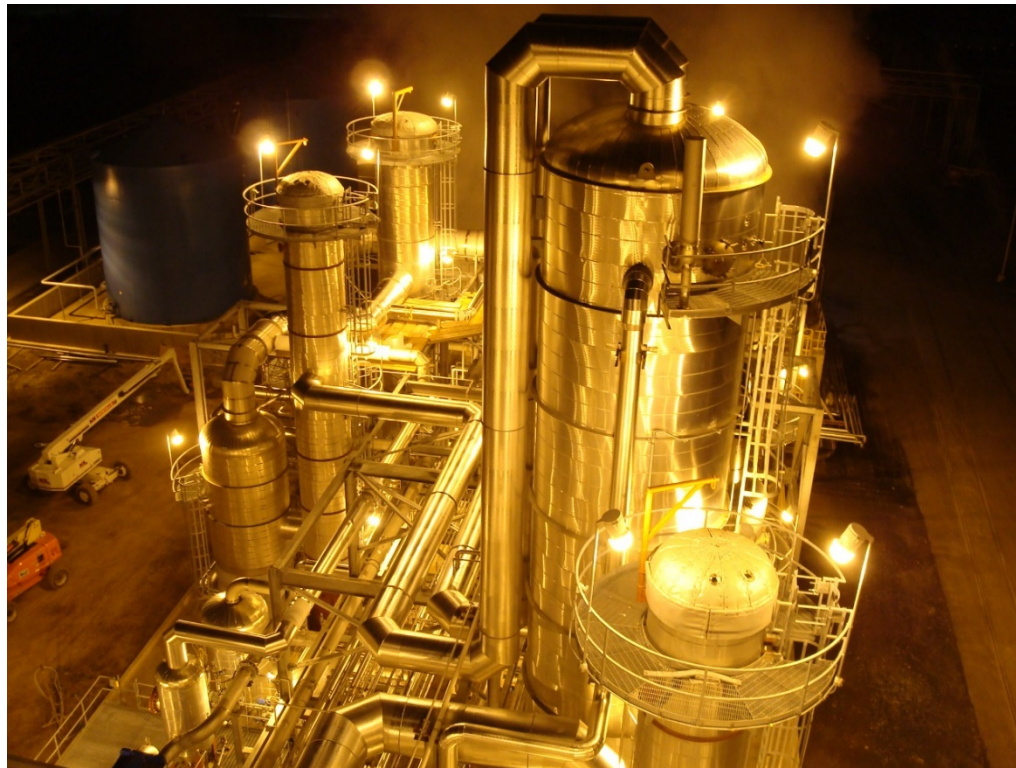
50 MMGPY (US Patent 7,867,365 B2)
Most efficient ethanol plant in the U.S.





Sunoco Renewable Energy – Fulton, NY

100 MMGPY (US Patent 7,867,365 B2)

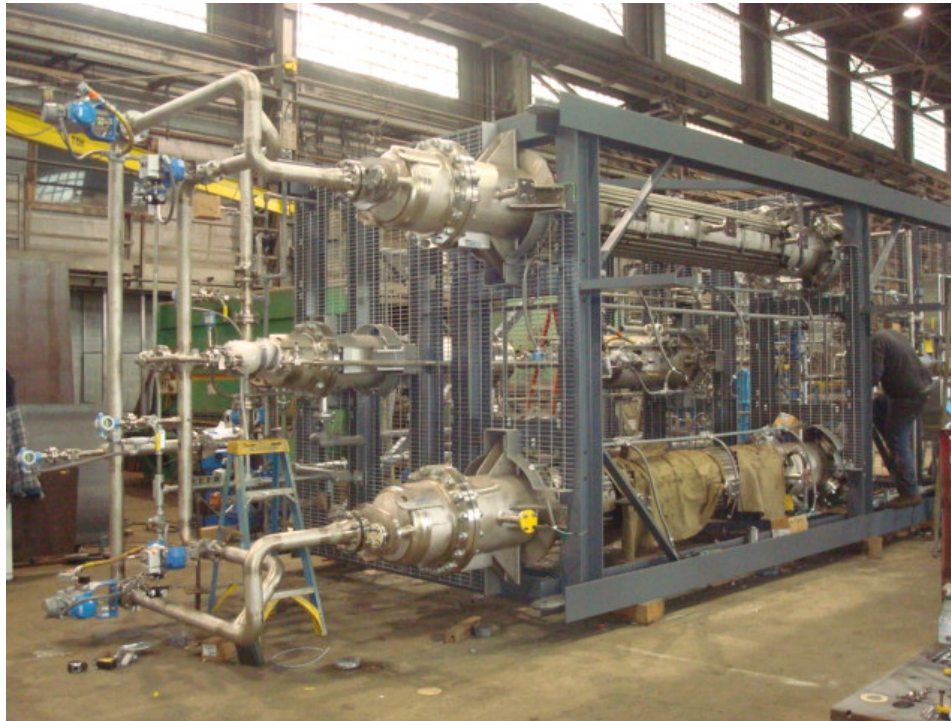




Example Projects – Cellulosic Based Fuel Ethanol

Pilot Plant Scale - Molecular Sieve Dehydration System

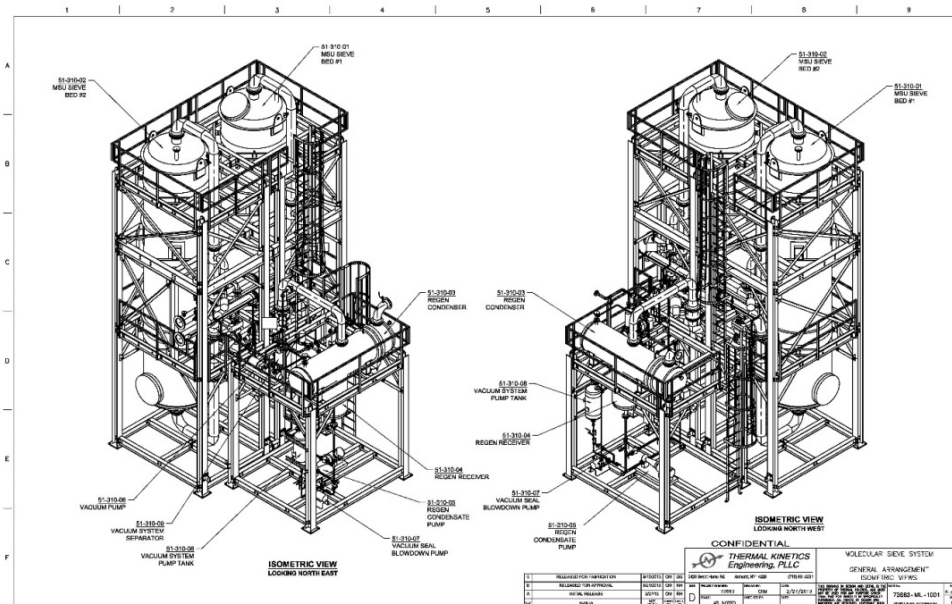
Unique low pressure adsorption to 8 psig with low moisture < 0.5% achieved





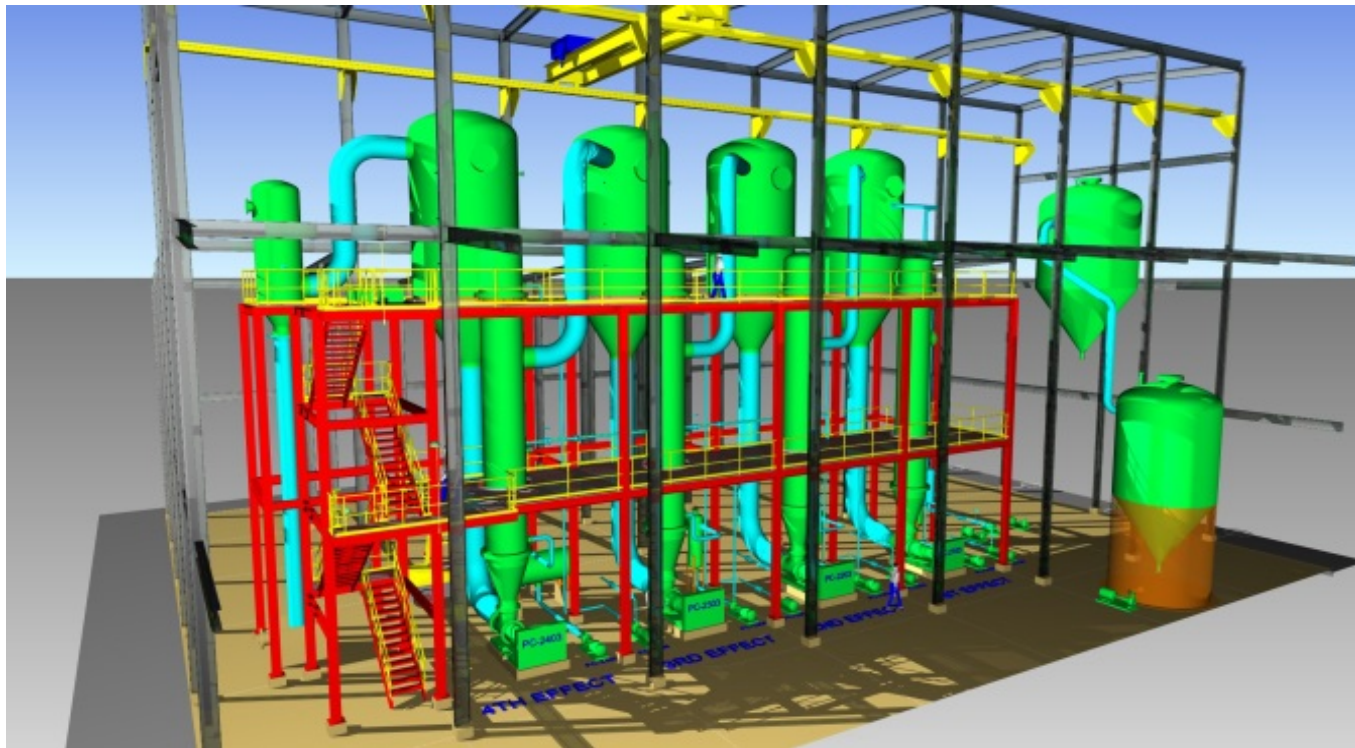
Example Projects – Cellulosic Based Fuel Ethanol

Demonstration Scale - Molecular Sieve Dehydration Module





Sodium Sulfate Crystallizer System





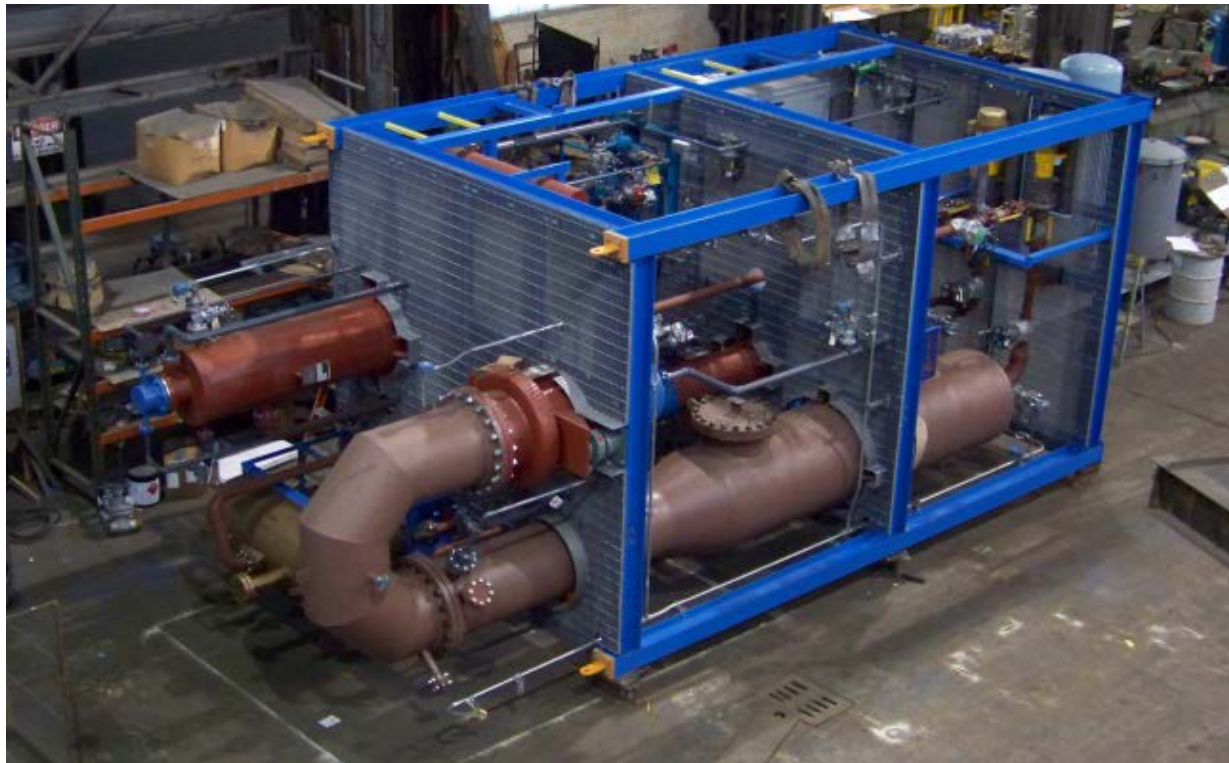
Chemicals Recovery from Waste Streams

- Steel processors
 - Chemicals recovery and associated chemical services
- Aluminum rolling mills
 - Emissions control systems
- Recovery of chemicals and waste streams from manufacturing processes



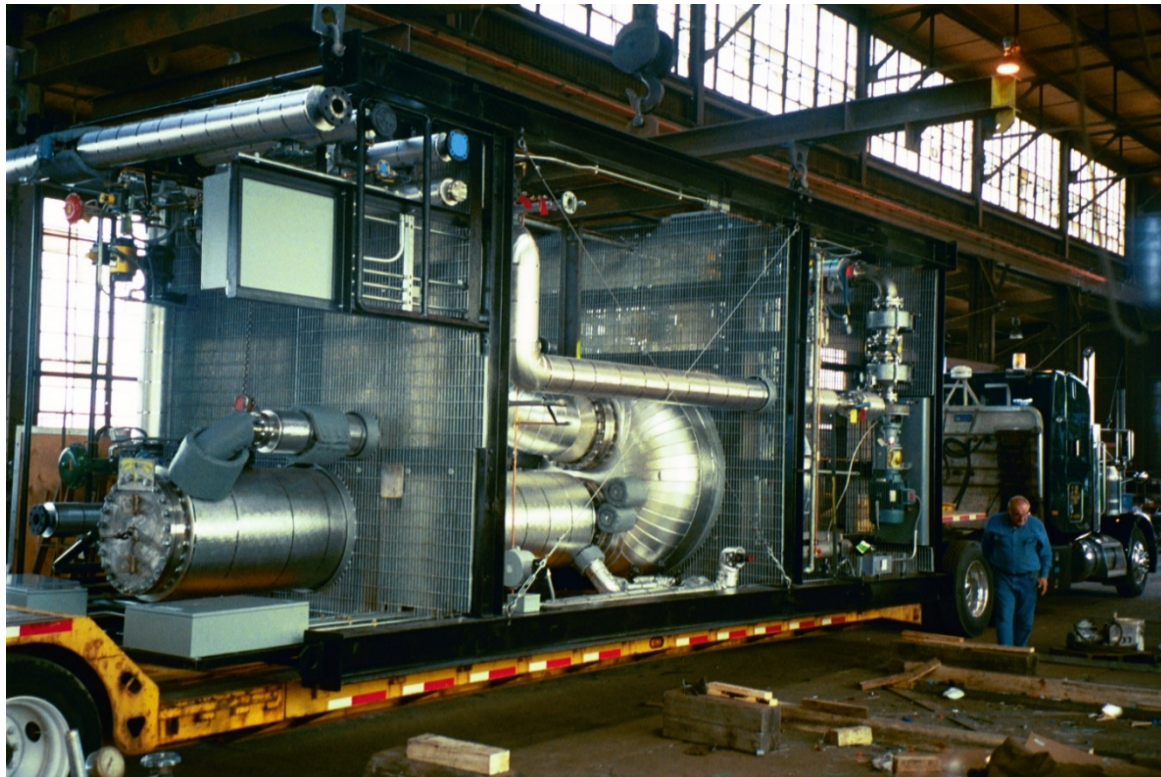


High Vacuum (2mm Hg abs 360 °F) Oil Separation – Modular Construction





Ethylene Glycol Purification System





Food Processing Industry

- Fruit juice processors
- Animal byproducts and rendering
- Fats and oil processors
- Food products and processing
- Breweries and distilleries
- Dairy processing





Example Projects – Sorbitol Concentration System





Bone Gelatin Concentration System

10,000 cps Final Product Viscosity





Thank You very much for allowing us to present our technology and expertise to you. We look forward to sharing our passion for process solutions with you on your next project...

Learn More About
Thermal Kinetics
CONTACT US TODAY! ➤

Thermal Kinetics Engineering
716 691-3291 | Fax: 716 691-3294
85 Northpointe Parkway, STE. 2, Amherst, NY 14228
www.thermalkinetics.net | info@thermalkinetics.net