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Research, Engineering Innovation

Heat Pump Closed Loop Spray Drying

Environmental Benefits, United States

- Natural Gas Mitigation, Therms per Year: 7.7 Billion
- CO_2 Mitigation, Tons per Year: 46.7 Million

End User Benefits, Food and Dairy Sector

- Operating Cost Saved per Dryer Year: $1.2 Million
- Typical ROI: 3 Years

Spray Drying is the only practical method for converting liquid into powder at scale.

Industrial Spray Dryers are a ubiquitous critical link in supply chain infrastructure.

Spray Dryers affect myriad aspects of industrial production. Modern life effectively depends on them.

Spray Dryers are used for Food & Dairy, Pharmaceutical, Chemical, and many other products.

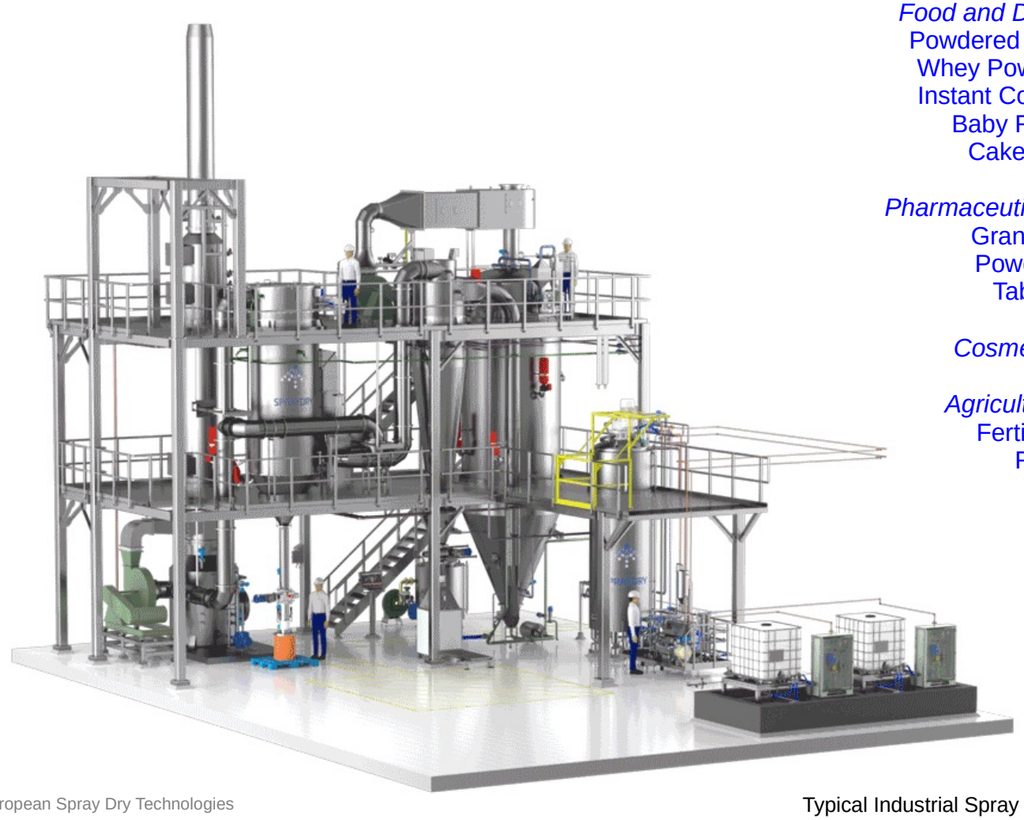


Image: European Spray Dry Technologies

Food and Dairy
Powdered Milk
Whey Powder
Instant Coffee
Baby Food
Cake Mix

Pharmaceuticals
Granules
Powders
Tablets

Cosmetics

Agricultural
Fertilizer
Feed

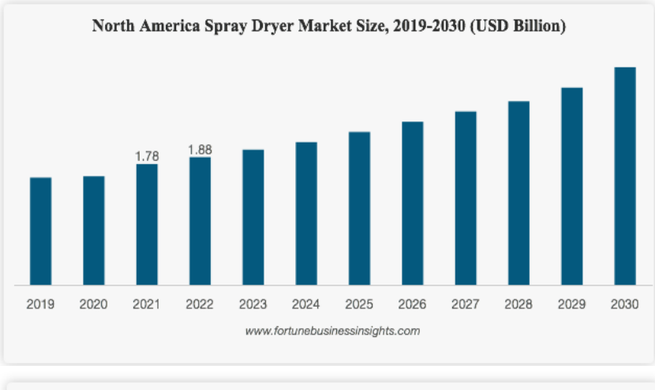
Typical Industrial Spray Dryer

US Market Trends

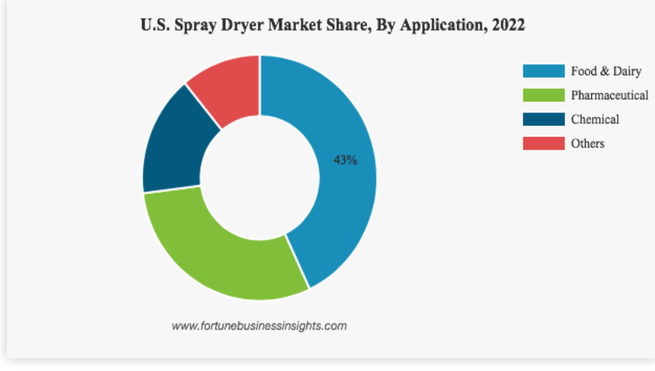
Industrial Spray Dryer Market

Spray Dryer Market Size (2023)	US$ 4.98 Bn
Spray Dryer Market Size (2030)	US$ 7.64 Bn
Spray Dryer Market CAGR	4.4%

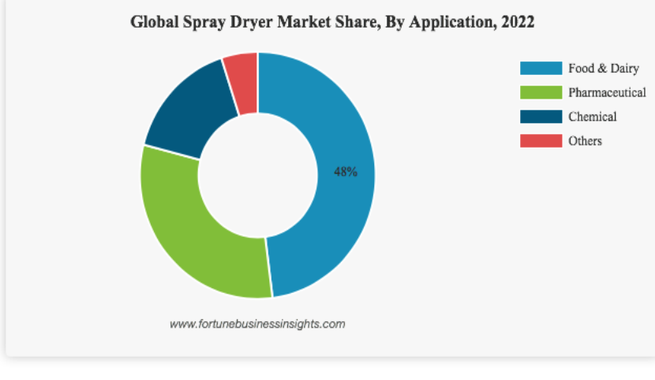
North America Projection



United States Market Share



Global Market Share



Sources:
Fortune Business Insights
Fortune Market Insights
Global Market Insights
Mordor Intelligence
Fact.MR

Annual market trends and projections shown are for new transactions.
The HPCL Dryer market comprises the entire installed base, new dryers and retrofits.

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Conventional Spray Dryer *Key Issues*

Convection drying is always driven by the *humidity* of the drying air.

This air must be very dry, on the order of 2% rH.

Conventional dryers heat incoming ambient air *to reduce its humidity*.

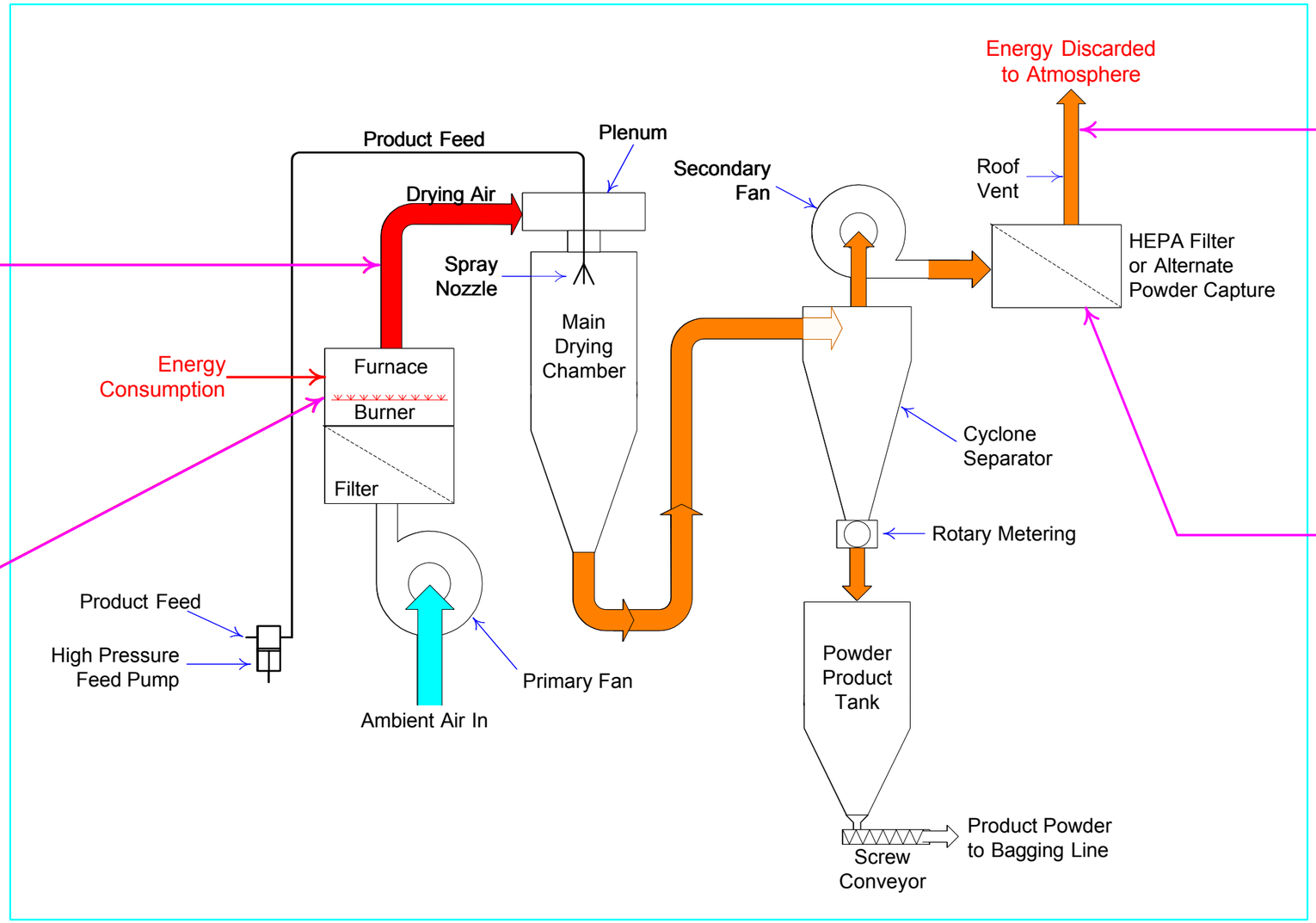
In order to achieve sufficiently low humidity, they run very hot, typically 400º to 500º F.

This presents significant powder product degredation issues.

Conventional spray dryers, typically gas or steam heated, are highly energy intensive.

A typical industrial dairy dryer, with water removal capacity of 8,000 - 10,000 Lb/Hr., consumes 15 - 20 Million BTU/Hr.

Typical energy consumption is then 100 - 130 Billion BTU/Year.



Present day dairy spray dryers are variations on the same shared theme:

Large quantities of energy are consumed and discarded to the atmosphere.

Hot drying air passes through the drying chamber *once*.

Much of the drying air bypasses the product entirely, and exits without doing useful work.

Conventional spray drying produces powder fines, a significant air pollutant.

Powder fines must be removed from the dryer discharge airstream before it is vented, via HEPA filtration or equivalent means.

These requirements impose operational and regulatory burden and expense.

Heat Pump Closed Loop Drying mitigates or eliminates all of these issues.

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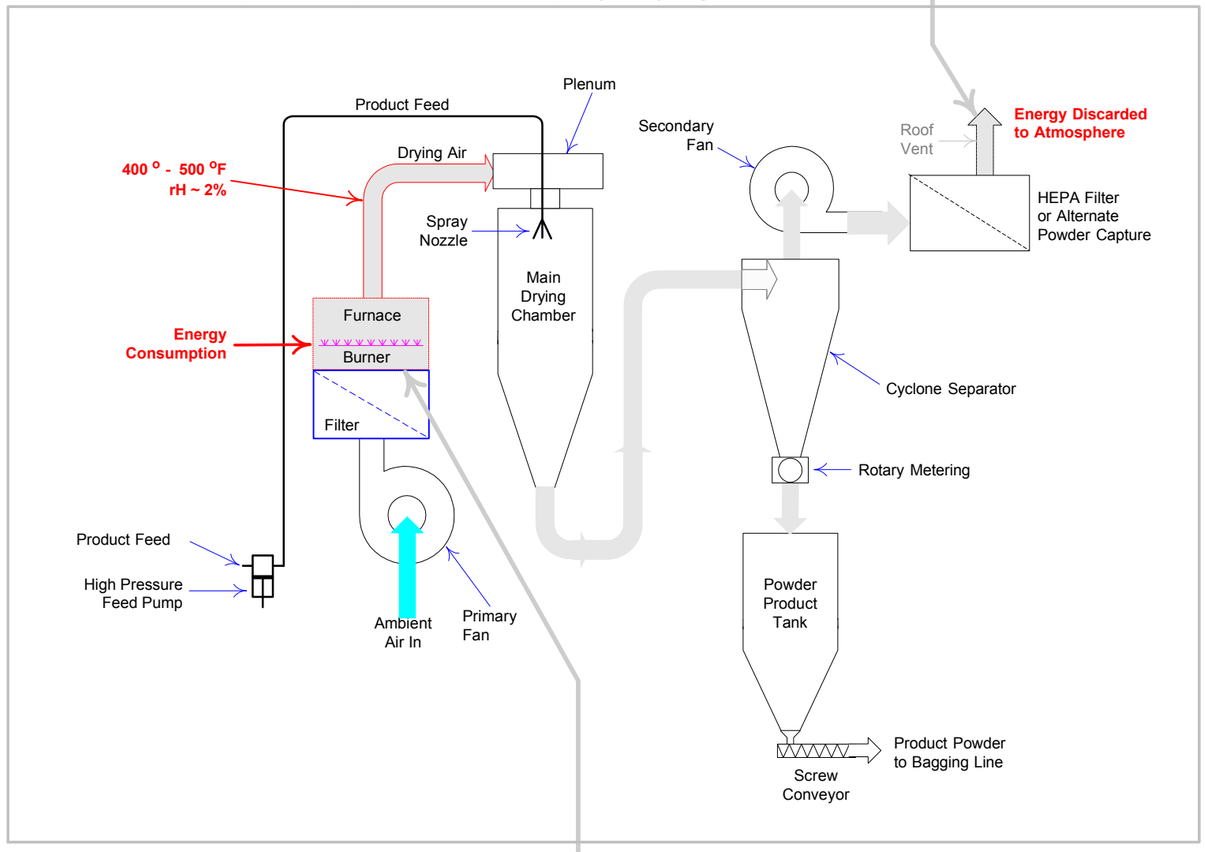
Heat Pump Closed Loop Spray Dryer *Difference*

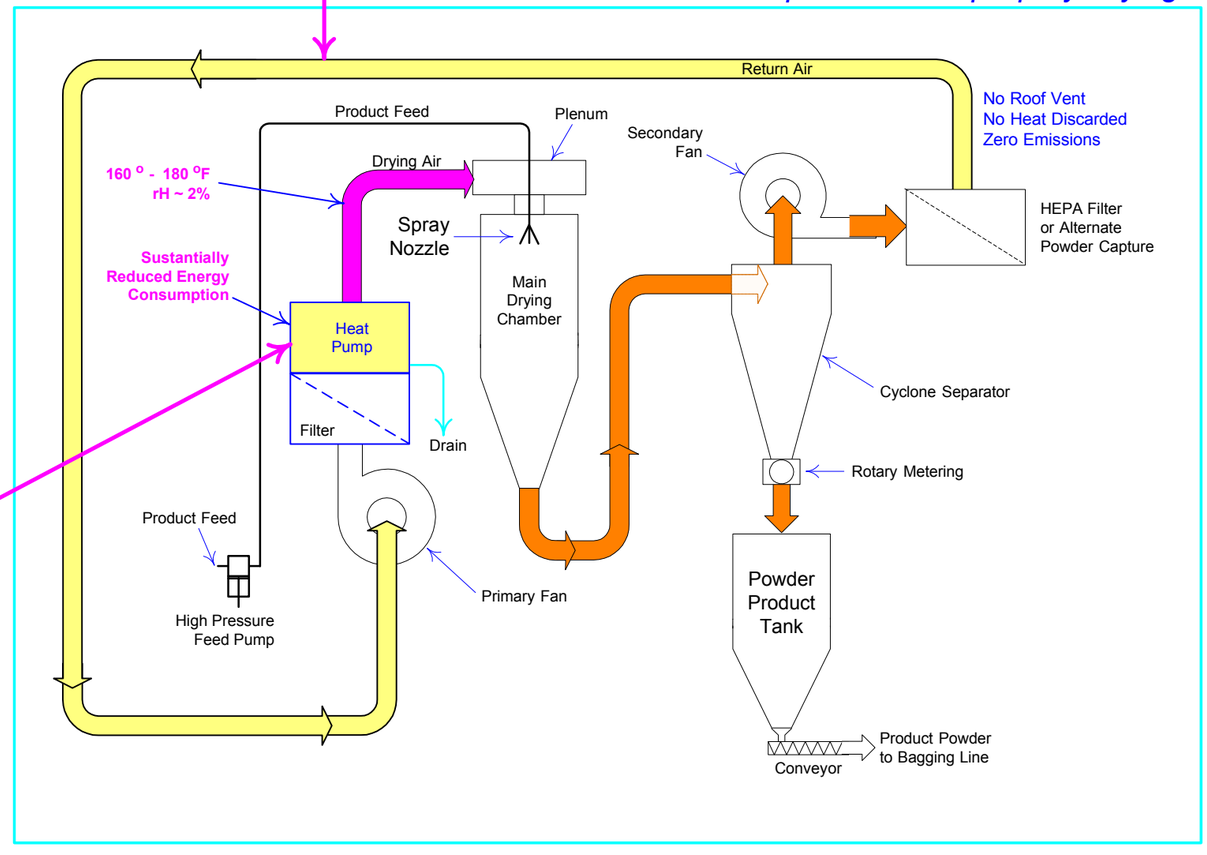
Conventional open loop; drying air, heat, and emissions are vented to the atmosphere.

Closed loop replaces roof vent; *drying air is not vented*, no heat loss, zero emissions.

Conventional Open Loop Fuel Fired Spray Drying



Heat Pump Closed Loop Spray Drying



Heat pump replaces furnace, *equals or exceeds conventional dryer performance, at low temperature, using one third of the energy.*

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Heat Pump Closed Loop Spray Dryer *Advantage*

Provides Very Low Drying Air Humidity, Typically 2% rH, at Low Temperature, Typically *160 º - 180 ºF.*

No Product Heat Degradation

Equals or Exceeds Conventional Dryer Performance

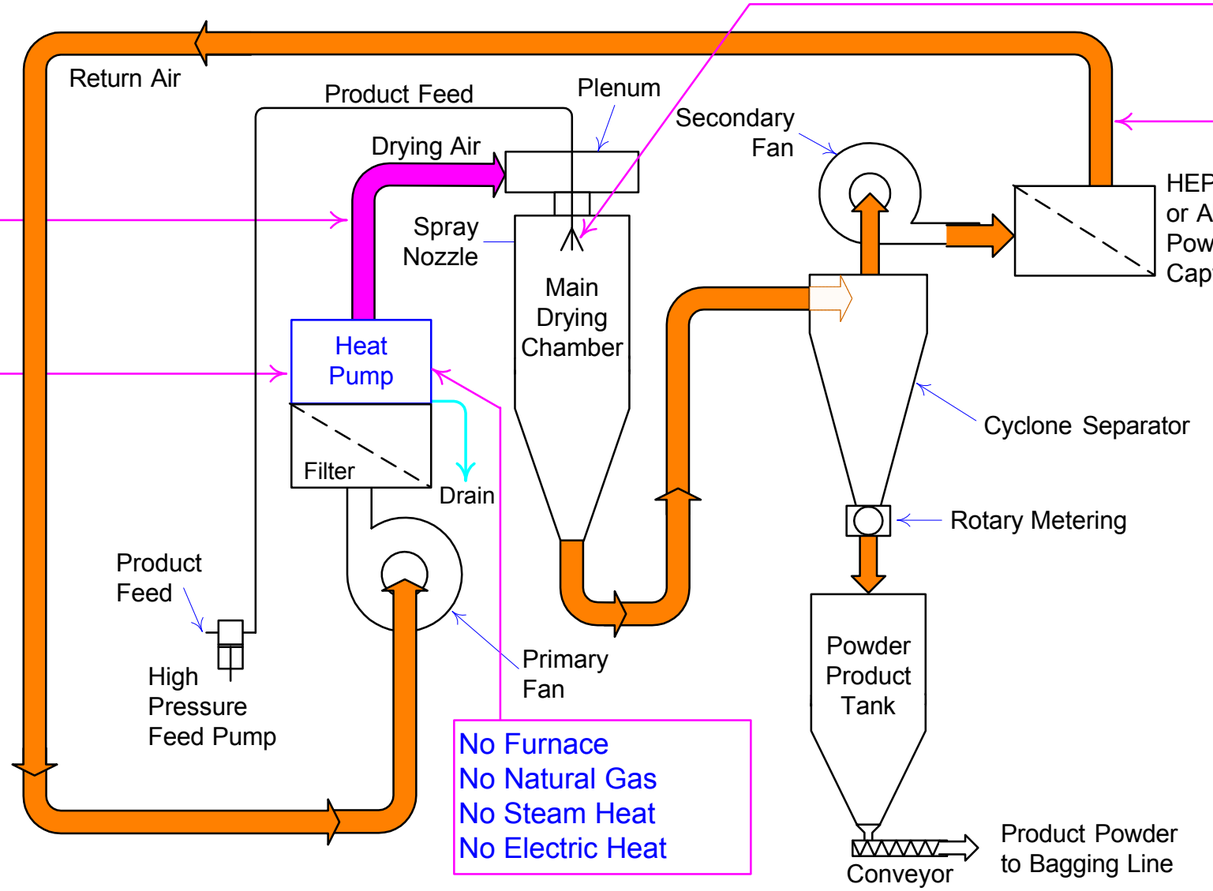
Nominal Energy Consumption is One Third of Conventional Drying

Produces Heat Output for External Processes, e.g. Space Heat or Evaporator Preheat

When External Process Heat is Used, Net Energy Consumption is Effectively Zero.

Typical energy savings is then 100 - 130 Billion BTU/Year.

CIP Compatible



No Furnace
No Natural Gas
No Steam Heat
No Electric Heat

Protected under patent claims issued and/or pending.

Equals or exceeds conventional dryer performance, at low temperature, using one third of the energy.

Compatible With All Industry Standard Nozzle Types, e.g. High Pressure, Rotary, Two Fluid

No Exhaust Air
No Powder Fines
No Roof Vent or Stack
Zero Atmospheric Emissions

Multistage:

Retrofit Installations:

Compatible with Existing Single, Two, and Three Stage Configurations

New Construction:

Low Temperature Drying, Cooling Stages Typically Not Required

Compatible with Air, or Inert Drying Gas, e.g. Nitrogen

Compatible with Aqueous, Non-Aqueous, and/or Flammable Solvents

Protected under patent claims issued and/or pending.