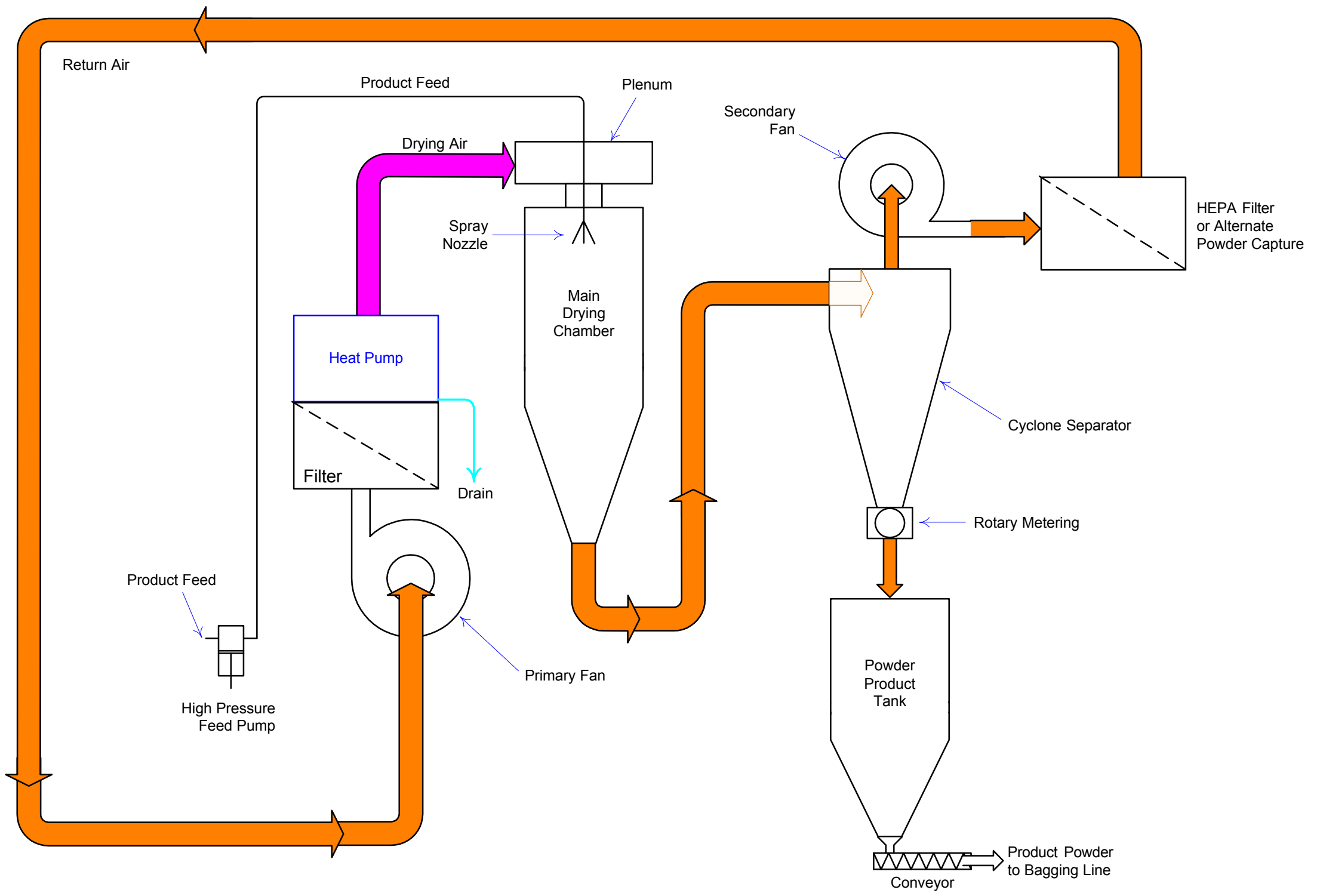


Heat Pump Closed Loop
Spray Dryer
Quick Overview

- Heat Pump
- Drying Chamber
- Cyclone Separator
- Powder Capture
- Closed Loop Air Return



Heat Pump Closed Loop Spray Dryer Operation Heat Pump

The primary fan draws drying air through the filter, to the heat pump.

The drying air exits the heat pump, and travels to the main drying chamber.

The heat pump removes moisture of drying from the drying air, much like a dehumidifier.

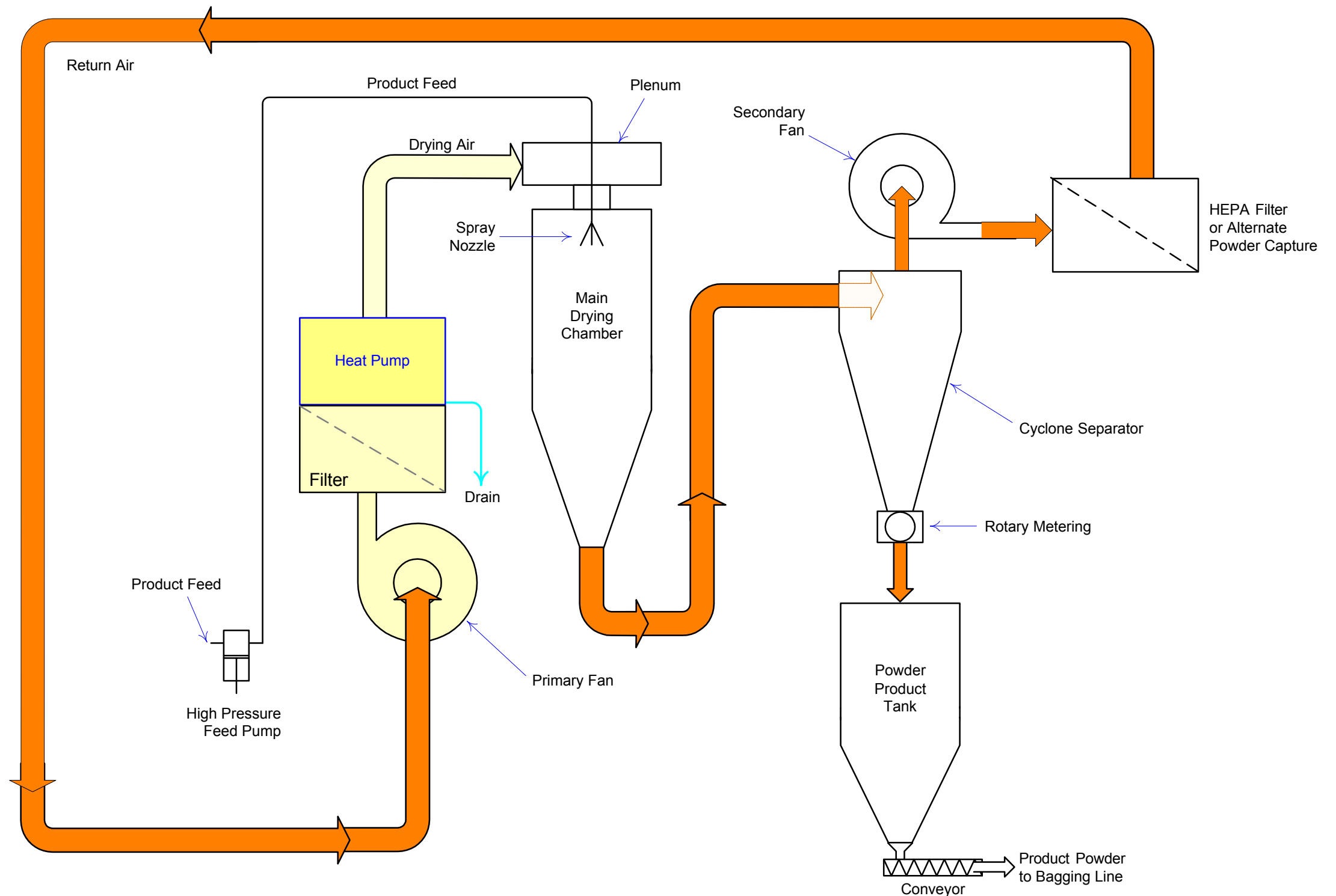
Drying air is very dry, on the order of 2% rH, at less than 200 ° F.

Nominal energy consumption is one third of an equivalent gas furnace.

The heat pump produces external heat output equal to its energy input.

This heat may be used for external processes, such as space heat or evaporator preheat.

When this external process heat is used, dryer net energy consumption is effectively zero.



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Heat Pump Closed Loop Spray Dryer Operation Drying Chamber

The feed pump transfers liquid product to be dried, e.g. milk or whey, to the spray nozzle, typically under high pressure.

Liquid product exits the spray nozzle as a very fine mist or fog of nearly microscopic droplets.

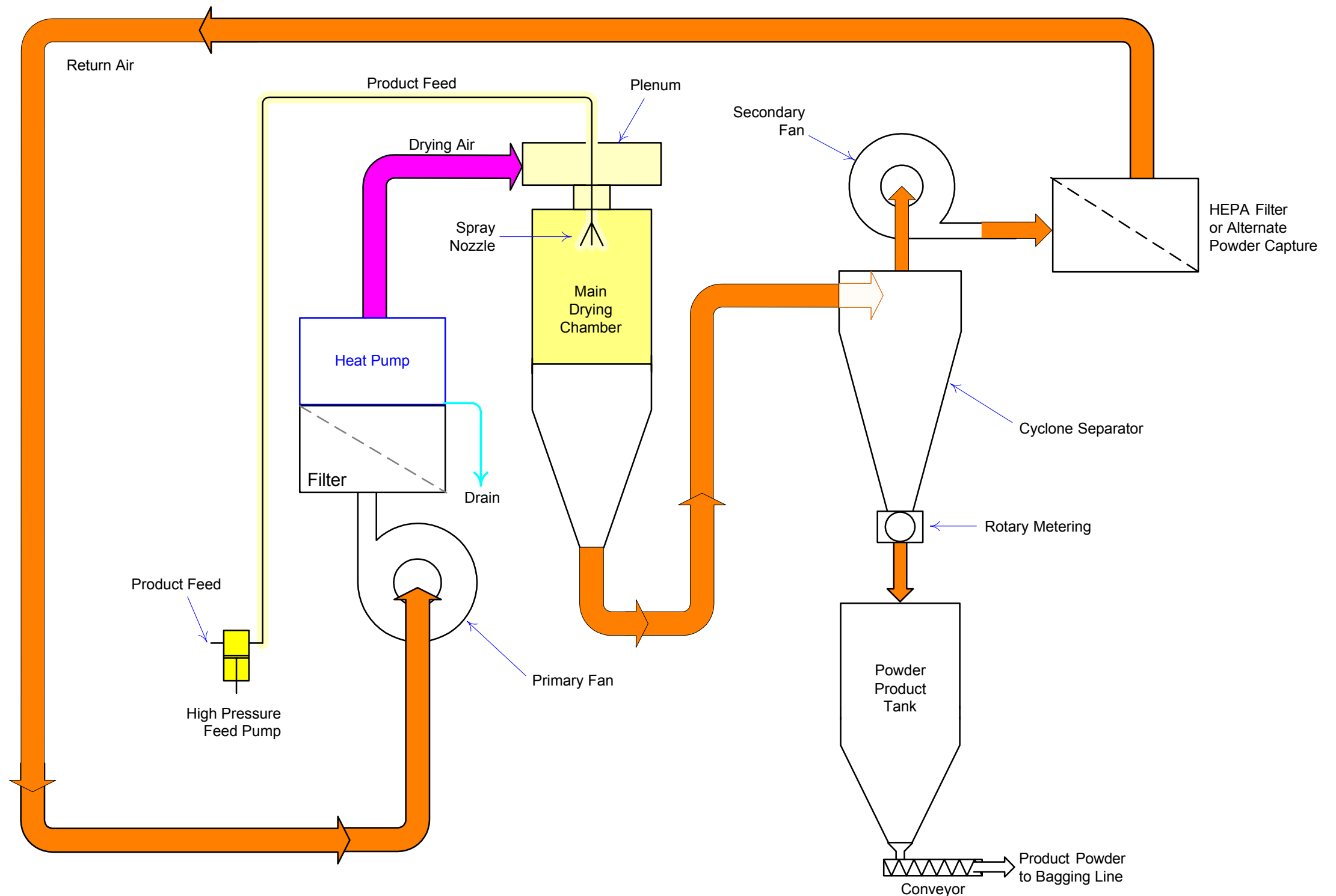
When the droplets contact the warm, near zero moisture drying air, they dry in milliseconds.

They become dry powder before they contact the inside surface of the drying chamber.

Drying air is very dry, on the order of 2% rH, at less than 200° F.

Low temperature drying materially reduces product heat degradation.

Drying performance is comparable to conventional drying.



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Heat Pump Closed Loop Spray Dryer Operation Cyclone Separator

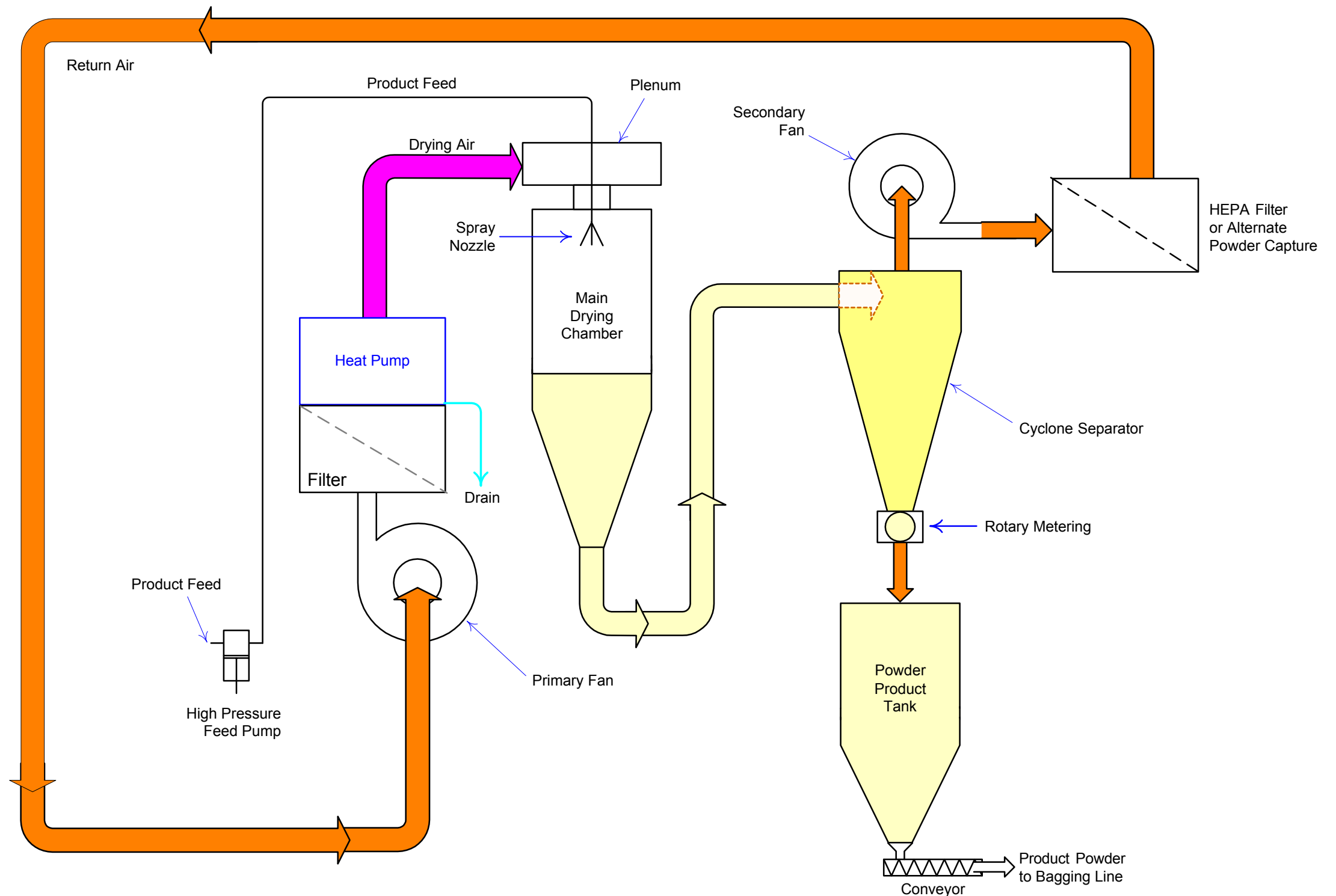
The drying air, with dry powder product in suspension, exits the drying chamber at the bottom.

The drying air and powder product enters the cyclone separator, which centrifugally separates the powder from the bulk airstream.

Powder product falls to the bottom of the separator, and is collected in the powder product tank.

This stage is similar to conventional dryers, except the delivered powder product is significantly cooler.

Dry powder cooling is typically not necessary.



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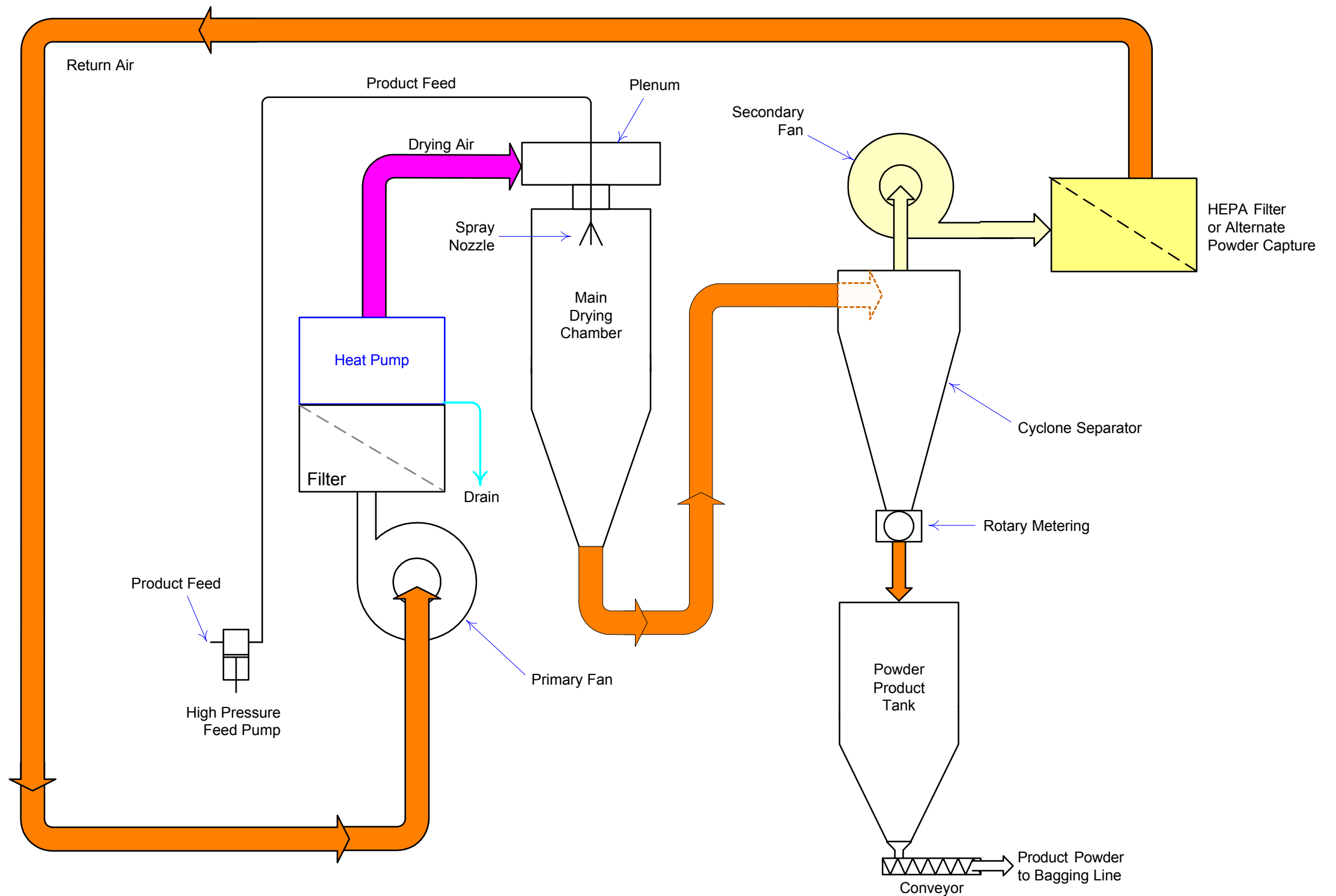
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Heat Pump Closed Loop Spray Dryer Operation Powder Capture

The drying air, with most of the powder removed, passes through the secondary fan to the HEPA filter. This captures powder fines that escape the cyclone separator.

The cyclone separator, and HEPA filter serve only to keep the closed loop clean internally.

Powder fines are never discharged to the atmosphere.



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**Heat Pump Closed Loop
Spray Dryer Operation
Closed Loop Air Return**

The drying air exits the HEPA filter, and returns to the heat pump, in a **continuous closed loop**.

*There is no atmospheric discharge,
no powder fines, no wasted heat.*

This is a zero emissions process.

