



## TECH BRIEF: Hull Freeze Dyer Energy Efficient Features

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Out of the many steps required to produce pharmaceuticals and other products, freeze drying is perhaps the most energy intensive of the various processes. Most of the energy consumed by a freeze dryer goes into the refrigeration system which must initially freeze the product and heat transfer shelves, and then condense water vapor that sublimates and desorbs out of the product during primary and secondary drying respectively. Since the introduction of Smart Cool<sup>®</sup> almost two decades ago, Hull has been at the forefront of pioneering ever more efficient use of the energy required to drive the lyophilization process.

Below is a summary of both standard and optional energy saving features available on every Hull Freeze Drying System. Many of these features can be retrofitted to existing dryers made by Hull or any other manufacturer.



- **Smart Cool<sup>®</sup> 4.0** Standard on every new freeze dryer, Hull's fourth generation Smart Cool utilizes the inherent flexibility of electronic expansion valves to capture greater compressor capacity under heavy loads (such as fast cooling of product) while at the same time allowing precise shelf control within +/- 1°C. The result is that a standard Hull Freeze Dryer can meet or exceed the performance of competitive brands with fewer and/or smaller compressors, especially when combined with the MultiFlex<sup>®</sup> refrigeration design described below. For example, the shelves of a typical 220 ft<sup>2</sup> (20 m<sup>2</sup>) freeze dryer can be cooled from +20°C to -50°C in less than 60 minutes using only a single 50hp screw compressor.\* The system can also condense 400 kg of water vapor per day using only the one compressor.
- **MultiFlex<sup>®</sup> Refrigeration** Standard on all multi-compressor systems, the heart of MultiFlex design is the addition of a heat transfer fluid cooled condenser that allows Smart Cool to reach its full potential. The fluid condenser offers several advantages. First, for multi-compressor systems, it allows any one compressor to cool the shelves, the entire condenser, or both. Thus,

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\* With MultiFlex, and a clean, dry and empty system, as measured at shelf fluid inlet.

complete redundancy is easily built into the system simply by adding an additional compressor circuit.

Multiflex takes its second advantage from the two heat exchangers per compressor. During product freeze (thermal treatment), both exchangers are directed to shelf cooling which allows the utilization of the full refrigeration capacity of the compressor(s). Under low load (soak) or during drying, only one exchanger is directed to the shelves which allows for precise shelf fluid temperature control. As described above under Smart Cool, this design allows Hull to meet process needs with fewer and/or smaller compressors, which results not only in significant energy savings, but overall reduced operational costs due to decreased maintenance requirements.

As a third advantage on multi-(non-redundant) compressor systems, MultiFlex, when combined with Hull's Lyo Link es<sup>®</sup> control system, allows the user to select the number of compressors to be run during a cycle segment. In many cases, cold soaks and/or secondary drying steps can be run using just one compressor for even more energy savings. For more information, please see the *Hull Tech Brief: Fluid versus DX Condensers*.

- **Screw Compressor Technology** Available on most Hull Freeze Drying systems, screw compressors can be over 50% more efficient than reciprocating compressors under heavy loads. When combined with Smart Cool, Multiflex Refrigeration and Variable Frequency Drives (VFDs), they offer the most energy efficient mechanical refrigeration system available. For more information, please see the *Hull Tech Brief: Comparison of Screw and Reciprocating Compressors for Pilot and Production Freeze Dryers*.
- **Variable Frequency Drives (VFDs)** Available on all Hull Freeze Drying Systems, VFDs are extremely practical because of widely varying refrigeration loads of a typical lyophilization cycle. The typical amount of refrigeration required to cool loaded shelves quickly is several times more than is required during cold soaks, and approximately ten times what is required for condensing during secondary drying. Under these conditions, Hull's Lyo Link es<sup>®</sup> control system automatically slows all active compressors to 50% speed, reducing instantaneous energy consumption by about 40%.
- **Water Cooled Heat Exchanger:** As efficient as Hull's refrigeration systems are, for simple uncontrolled cooling at warm (> +10°C) fluid temperatures (such as after a Steam-In-Place (SIP) process), a compressor inherently cannot compete with heat removal directly to water. For over twenty years, Hull has offered a Water Cooled Heat Exchanger that is completely integrated to the freeze dryer's heat transfer system and connects directly to the same tower or chiller circuit used to remove heat from the compressor circuit(s). As part of the SIP cycle, the valves to the exchanger automatically activate after a system drying phase and automatically close once a setpoint is reached. The only electrical energy consumption by the dryer during this phase is by the heat transfer fluid pump. The Water Cooled Heat Exchanger is available on all systems with SIP.

- **Liquid Nitrogen Systems:** Hull's experience in energy efficiency does not stop with mechanical refrigeration. Hull offers a liquid nitrogen refrigeration option on virtually all systems that employs a proprietary heat exchanger design whose efficiency is second to none. While most competitive systems actually extract only about 60 to 80 BTUs<sup>†</sup> per pound of LN2, the Hull system extracts over 110 BTUs by capturing additional cooling capacity of the exhaust gas. Many factors (such as distance from gas plant, amount of gas used, local labor rates, etc.) are involved to determine if an LN2 system is more cost efficient for your installation than mechanical refrigeration, but if LN2 is your preference, no other system can approach the efficiency of a Hull.



If you would like more information regarding energy efficient cooling technology or information about retrofitting energy saving technology to an existing freeze dryer, please contact the SP Industries sales department at 1-800-523-2327.

*Charles D. Dern is a Project Engineer with SP Industries.*

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<sup>†</sup> BTU = British Thermal Unit and is the amount of energy required to heat one pound of water from 60 to 61 degrees Fahrenheit.