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Clean/Dry Rooms for Lithium Ion Battery Manufacturing

The most cost effective design concepts

The most significant hurdles in implementing those concepts

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Manufacturing Process

The exact reaction that generates the electrons varies, depending on the type of battery. In a **lithium-ion** battery, you'll find pressurized containers that house a coil of metal and a flammable, lithium-containing liquid. The manufacturing process creates tiny pieces of metal that float in the liquid. **Manufacturers can't completely prevent these metal fragments, but good manufacturing techniques limit their size and number.** The cells of a lithium-ion battery also contain **separators** that keep the **anodes** and **cathodes**, or positive and negative poles, from touching each other.

If a piece of metal gets too close to the separator, it can puncture the separator and cause a short circuit. There are a few possible scenarios for what can go wrong in the case of a short circuit:

If it creates a spark, the flammable liquid can ignite, causing a fire.

If it causes the temperature inside the battery to rise rapidly, the battery can explode due to the increased pressure.

If it causes the temperature to rise slowly, the battery can melt, and the liquid inside can leak out.

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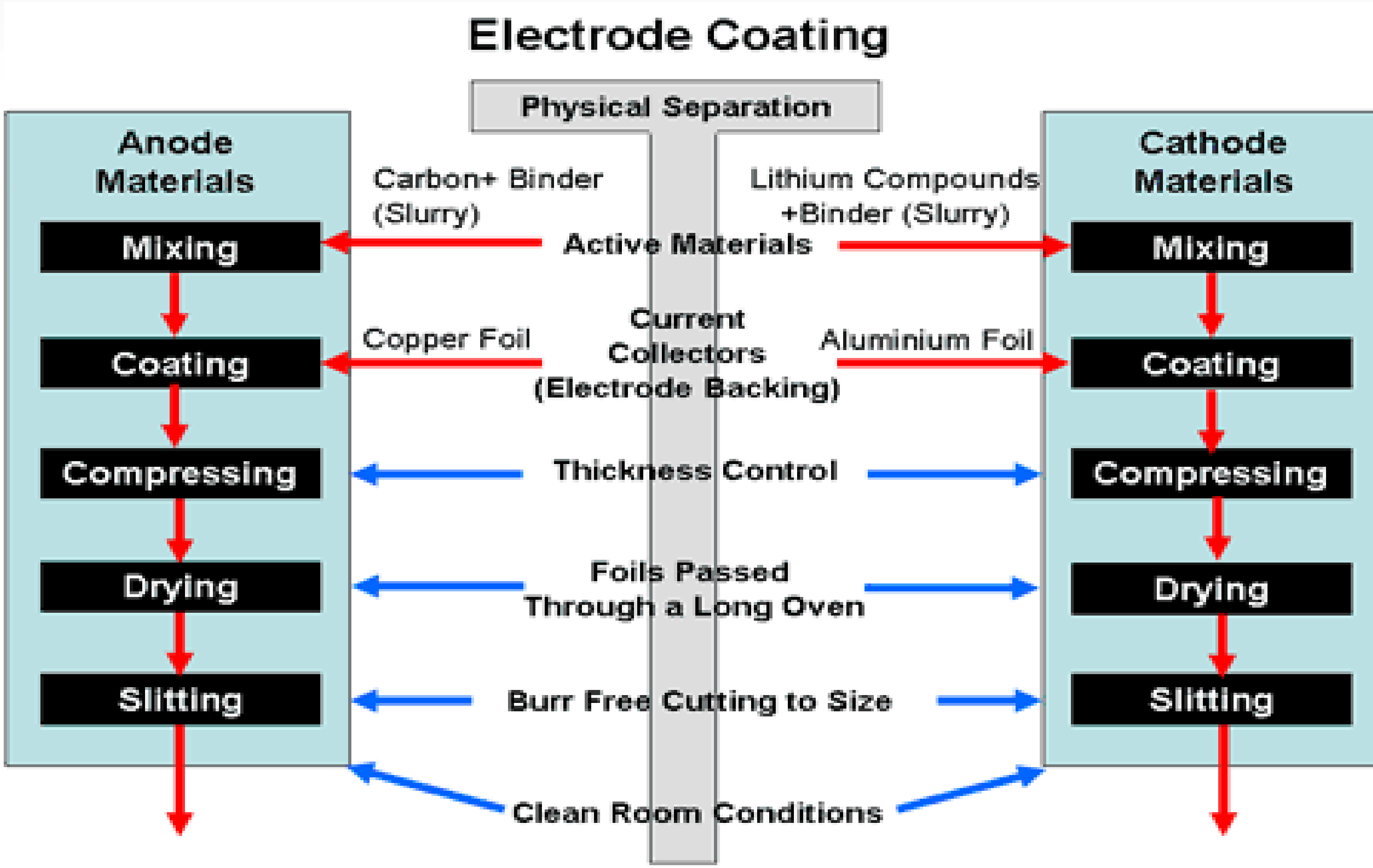
Battery Manufacturing Process



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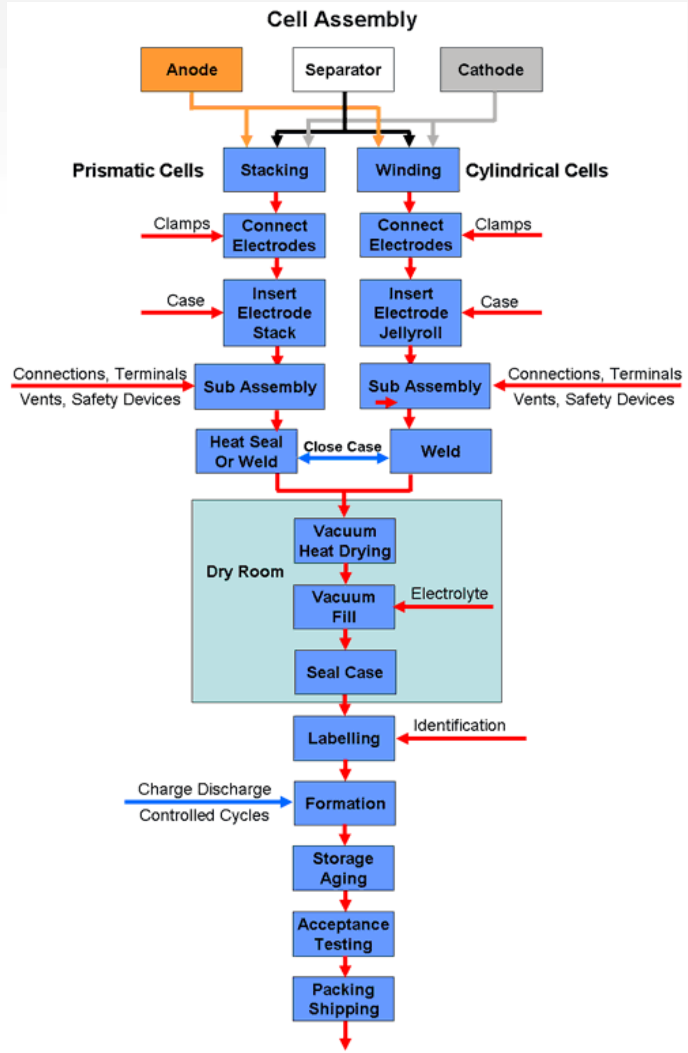
Battery Manufacturing Process



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How Does the Requirement for Cleanliness Effect a Dry Room Design Concept?

- Increase airflow to achieve cleanliness class from non classified to Dry Room space.

- Create more return paths to get cleanliness at work surfaces.

- Ceiling mounted filtration used as final filtration versus central air handling as final filtration.

- Reduce horizontal protrusions that cause particle accumulation.

- Rooms require certification by ISO 16446 requirements.

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Principles of Dry Room Design

•Dry rooms use simple psychometric engineering principals!

•Deliver a predetermined volume of air to the box at a predetermined dewpoint based on factors of load.

•Make sure there is no moisture infiltration into that volume of air after it comes off the desiccant wheel.

•Control every possible point of moisture infiltration so it can be quantified.

•Make sure every possible point of moisture infiltration is included in your calculations.

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What are we trying to achieve?

<u>Dewpoint off the wheel- translates to Relative Humidity</u>

- 2% RH or less= 1.8 grain/lb= -20 degree FDP
- 1% RH or less= 1.0 grain/lb= -30 degree FDP
- ½% RH or less= .56 grain/lb= -40 degree FDP

WE ACHIEVE THE DEWPOINT BY THE SPEED OF THE AIR ACROSS THE DESICCANT WHEEL.

THE OFF WHEEL DEWPOINT REQUIREMENT TRANSLATES INTO A SET VOLUME OF AIR YOU CAN ACHIEVE OFF THAT WHEEL.

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What factors effect what we are trying to achieve?

<u>Loads Effecting The Room Are:</u>

- People
- Airlock Infiltration
- Make Up Air Load
- Openings in the Envelope
- Vapor Transmission at the Box (Permeance)

WE MUST CONTROL AND PROPERLY ACCOUNT FOR EACH AND EVERY ONE OF THESE FACTORS.

THERE ARE ENGINEERING CALCULATIONS FOR THEM.

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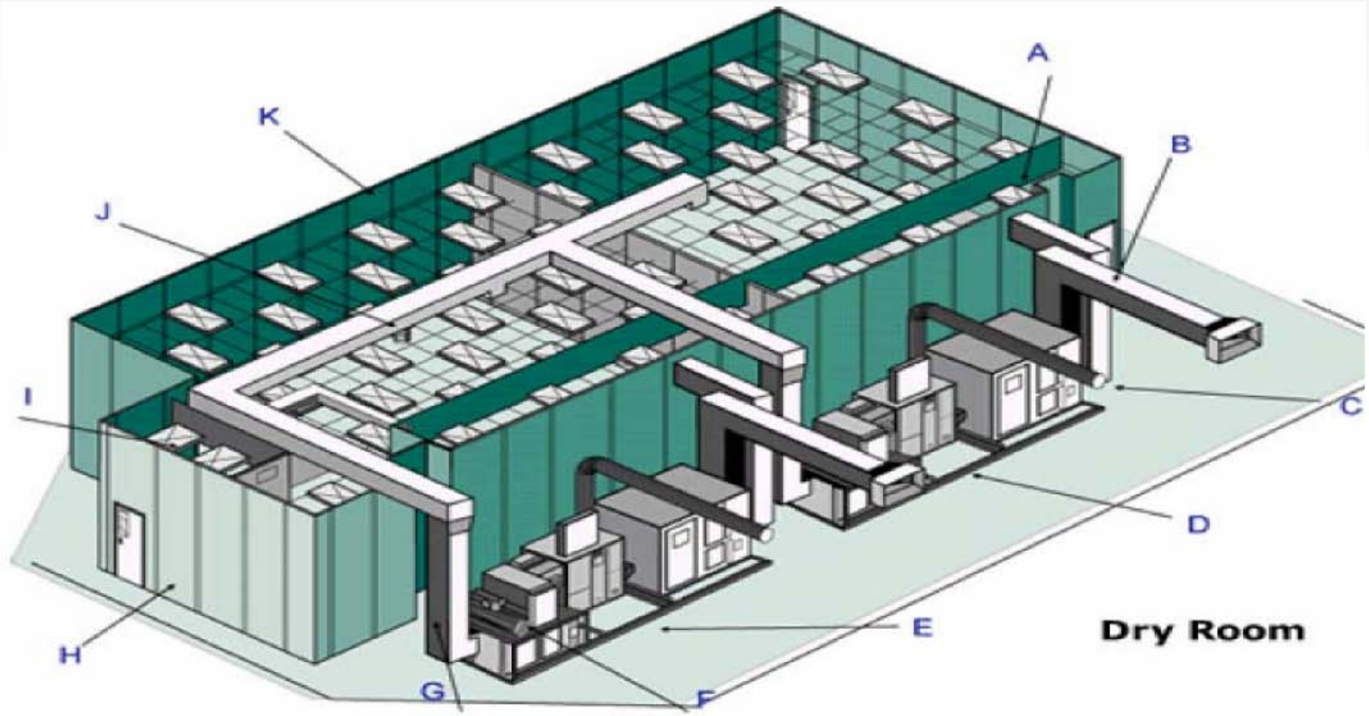
The Traditional Dry Room Design Concept



A.	Return air plenum wall room.	E. Redundant Dryer System
B.	Makeup air duct.	F. Cooling System
C.	Reactivation duct	G. & J. Ductwork- welded to prevent leakage
D.	Redundant Dryer System	H. & K Modular 4” Insulated panels
		I. Airlocks for Limiting Infiltration

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How do we apply what we know from cleanrooms and have learned in other industries toward these facilities?

•The air systems are the polar opposite of BSL designs.

•The entry procedures will require controlled access with air locks and interlocks.

•The envelopes will need to be resistant to chemicals utilized, be static dissipative, have a significant vapor barrier requirements, and be clean.

•Modular components will provide a significant advantage to use of funding or leasing.

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How Do We Design These Facilities?

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HVAC DESIGN CONCERNS

- Ducting systems must be inspected and maintained on continual basis. Duct systems to be built with low leakage joints. A buffer zone is appropriate for interstitial area.
- Minimize make up air to maintain positive pressure but minimize desiccant equipment size.
- Cleanliness requires significant airflow that causes desiccant equipment to be upsized.

How Do We Design These Facilities?

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ENVELOPE DESIGN CONCERNS

- Need sealed panel junctions for seal to insure zero vapor transmission.
- Must create vapor barrier and maintain seal. Can't move with building movement, independent support from floor. (Not an issue if floor above is fan deck and not single story.)
- Must use materials that do not hold moisture (drywall or fiberboard ceiling tiles are an issue) or dry and crack.
- Maintenance must be achieved without compromising the envelope seal.
- Properly seal, insulate and protect from moisture penetration from concrete slabs if on grade.
- Details for sealing all penetrations for all trades are crucial to performance.

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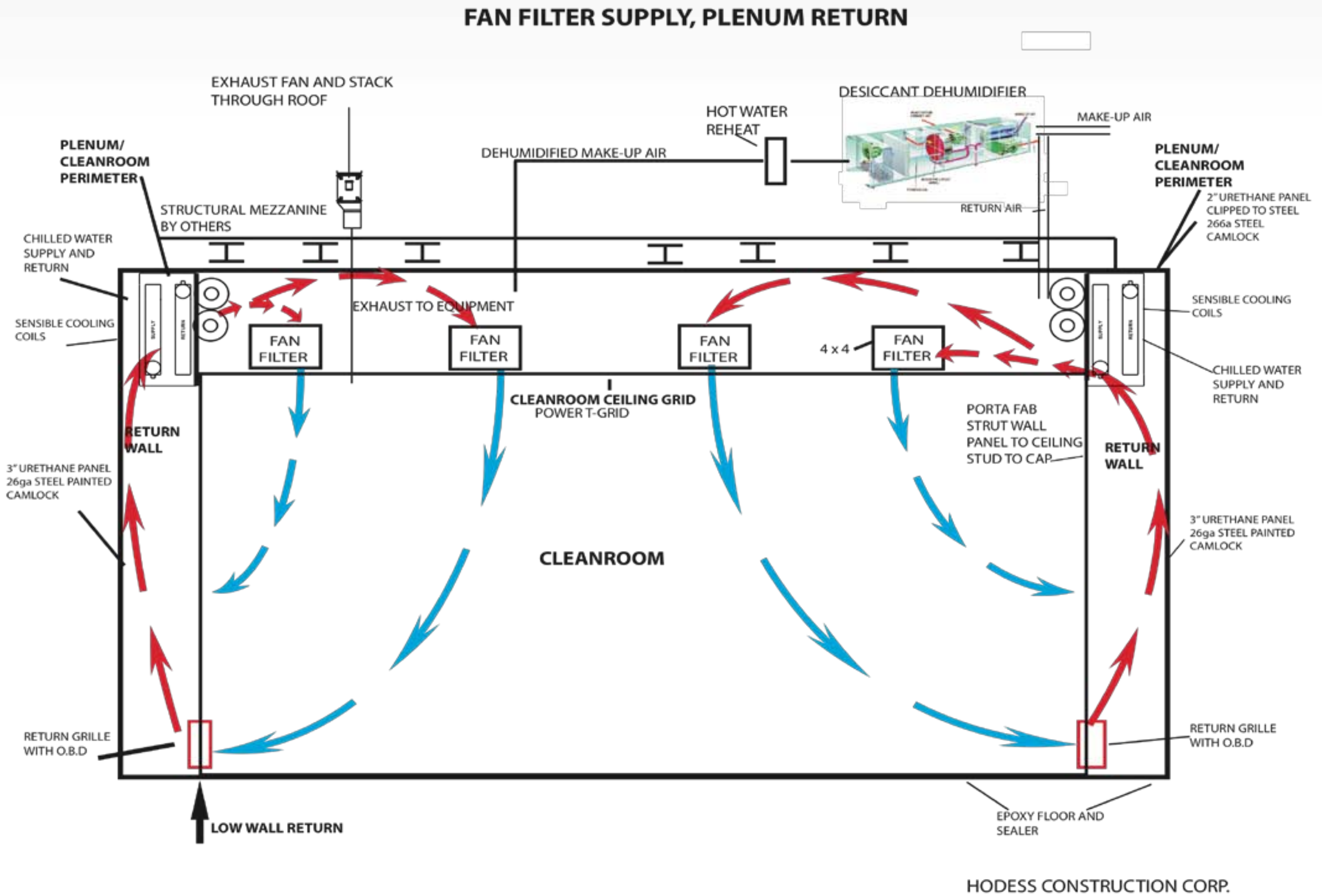
How Do We Design These Facilities?



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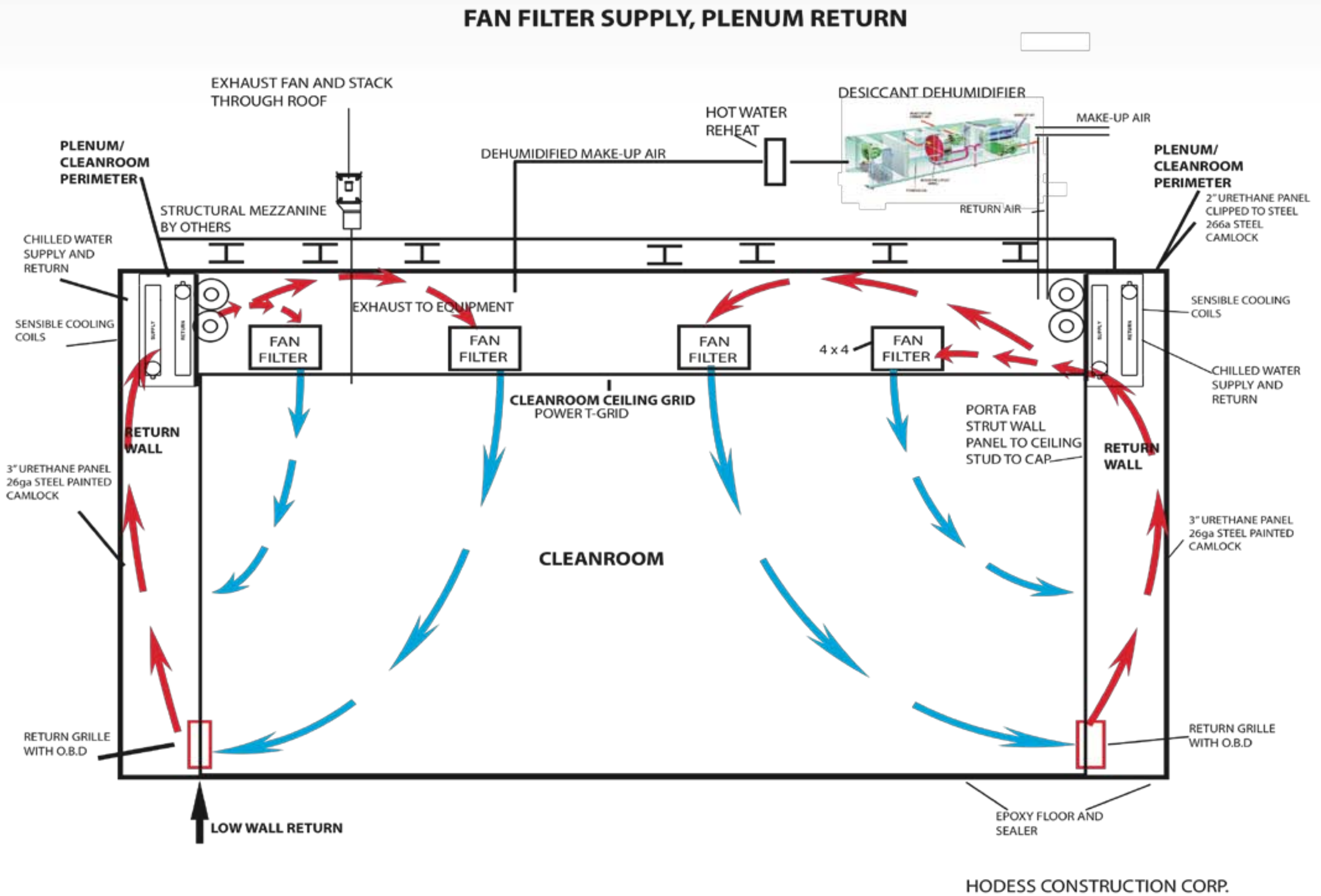
Precondition the make up air with cooling before you dry it with desiccant



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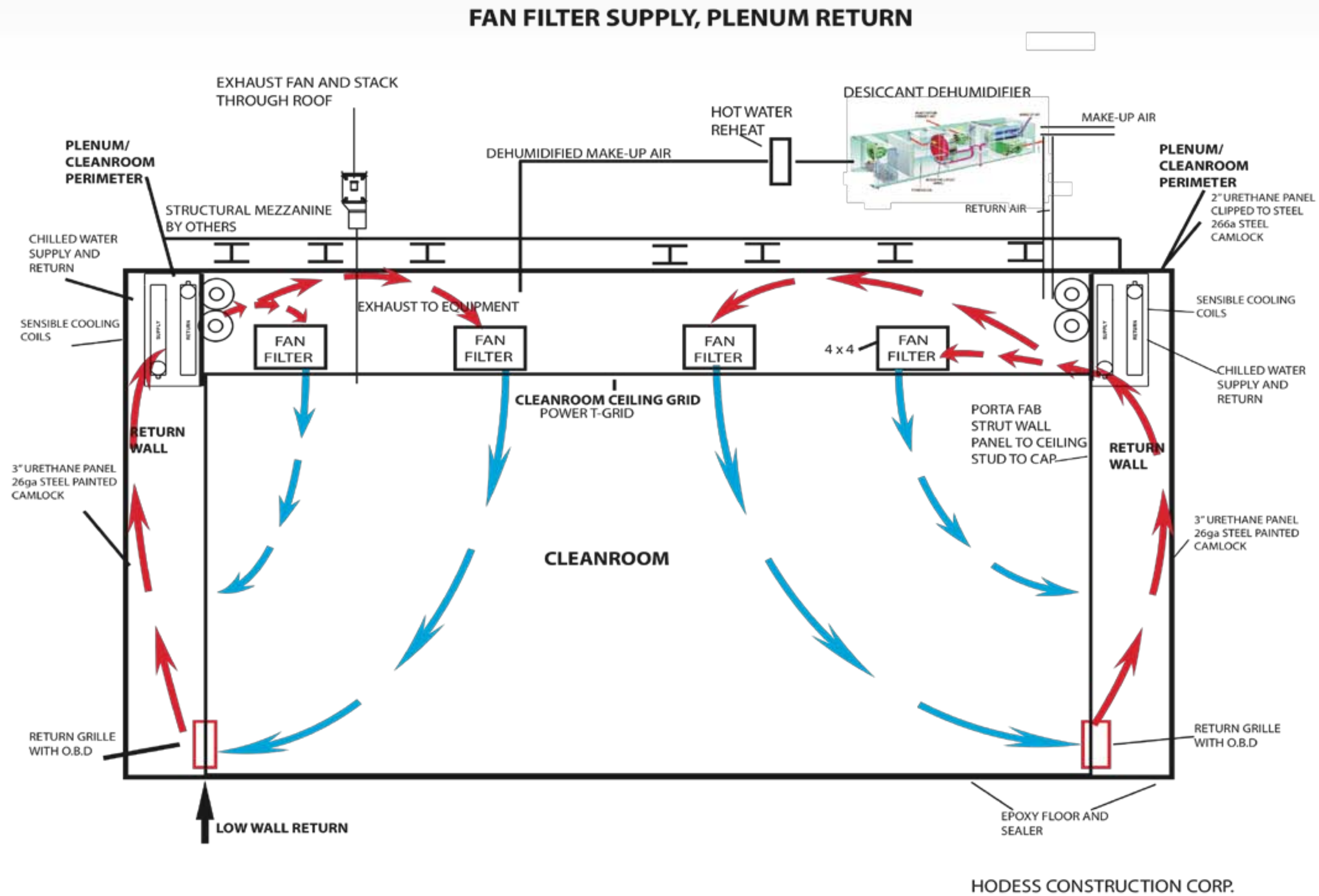
Extend the envelope to incorporate the air recirculating function



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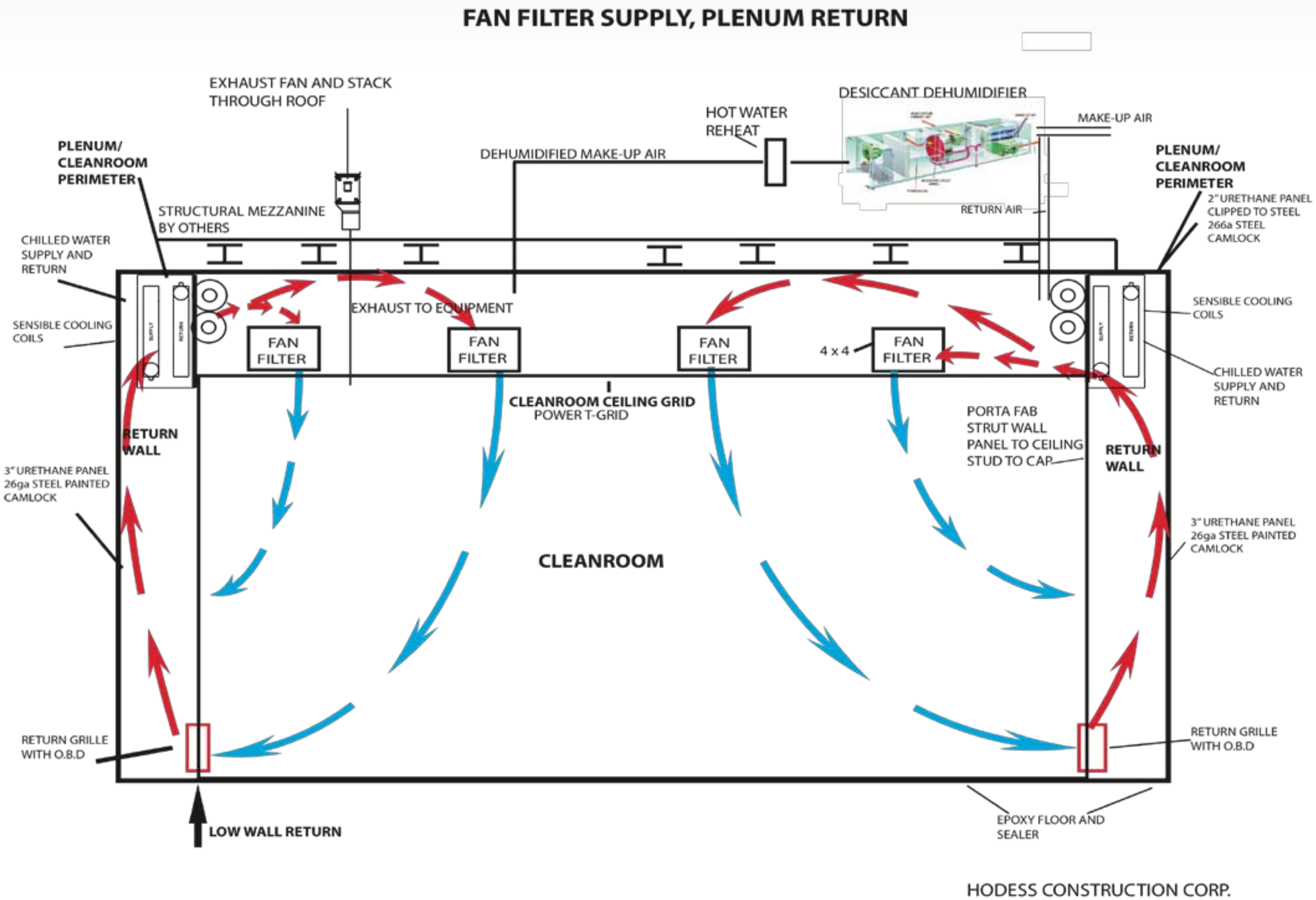
Get the duct distribution into the envelope (buffer zone) immediately after discharge from the drier



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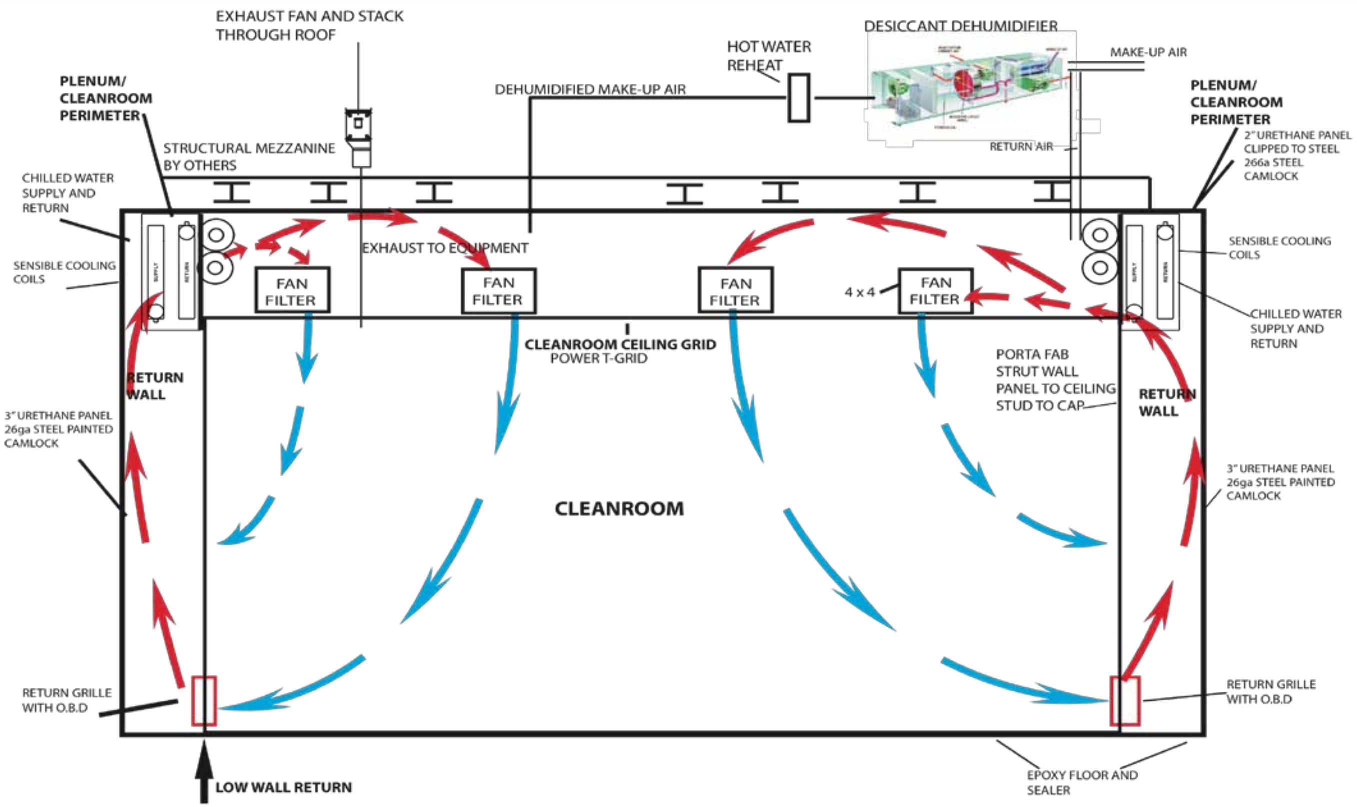
Use the return side of the air system as a buffer zone for the supply air

FAN FILTER SUPPLY, PLENUM RETURN



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Separate the drying function from the cleaning function

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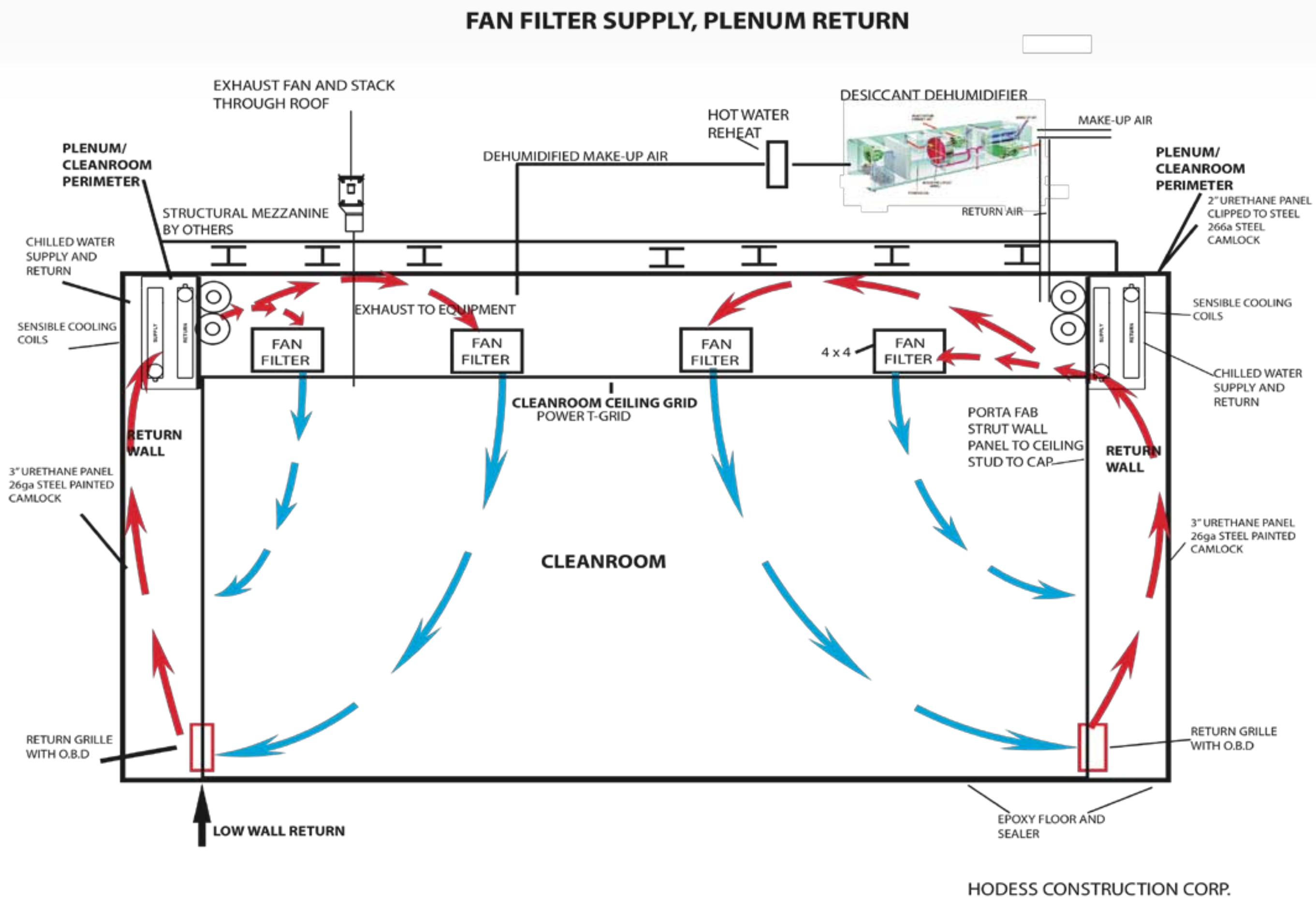

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Monitor & vary the cleanliness air during different process steps

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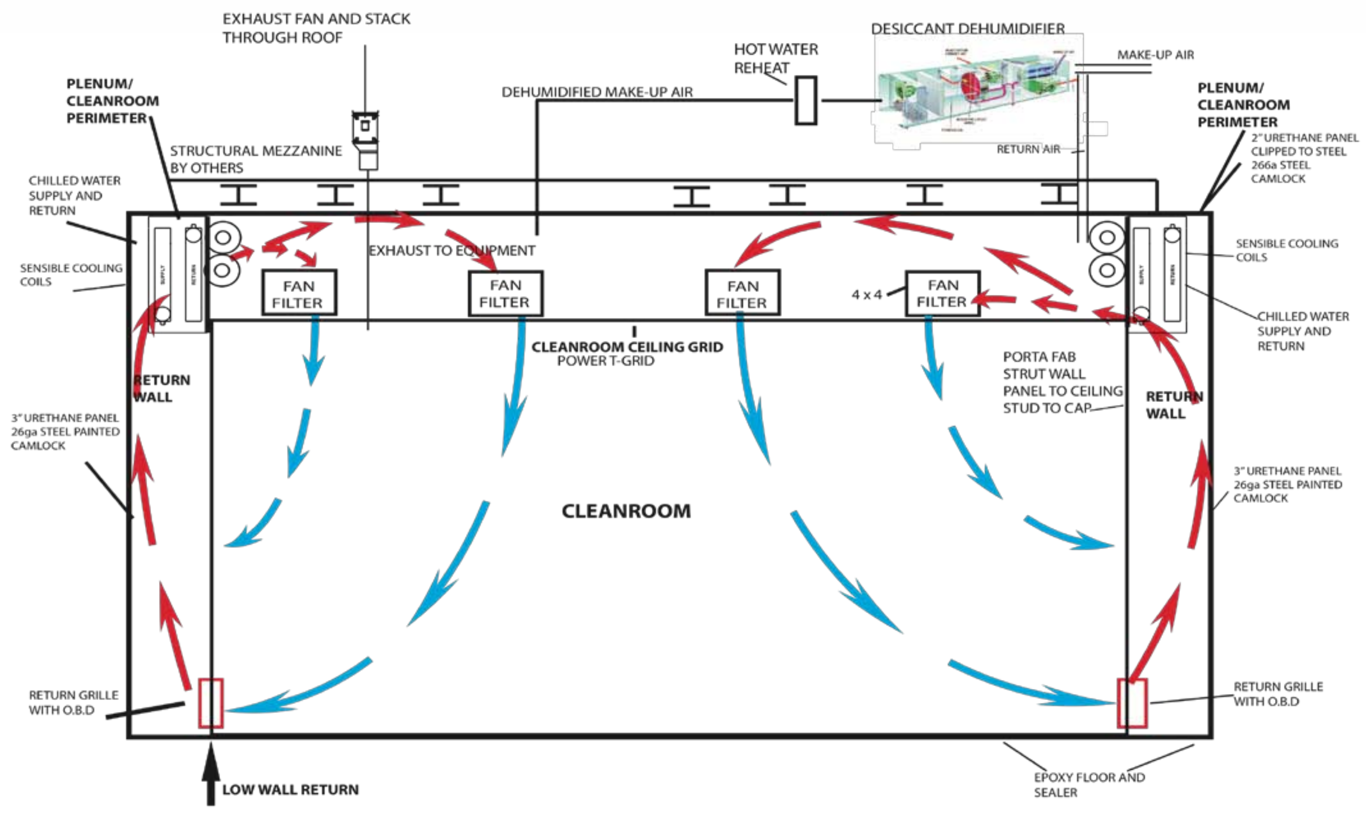

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Questions or Comments?

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