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Bry-Air®

Dry Rooms for Lithium Battery Production

Dehumidifier Installations

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Dry Room Installations

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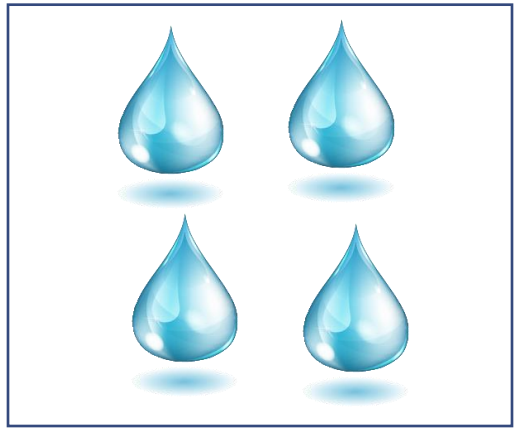
Clean Room Classes

Standard	ISO 14644-1	Federal Standard 209E	
	ISO Class	English	Metric
Class	ISO-1	-	
	ISO-2	-	
	ISO-3	Class 1	M1.5
	ISO-4	Class 10	M2.5
	ISO-5	Class 100	M3.5
	ISO-6	Class 1000	M4.5
	ISO-7	Class 10000	M5.5
	ISO-8	Class 100000	M6.5
	ISO-9	-	

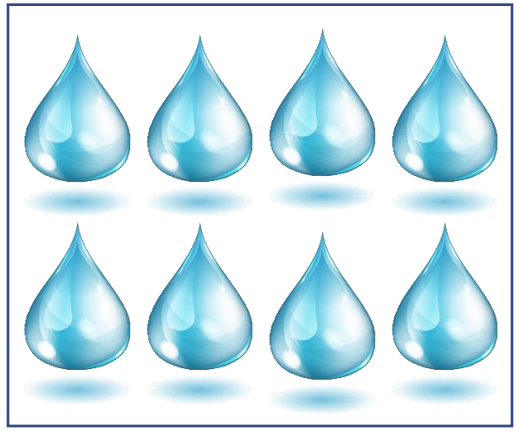
Basics of Dehumidification

Understanding Properties of Air

What is Relative Humidity?



Room at 21°C (70°F)
4 gr/cuft
55.5 gr/lb
(7.9 gm/kg)
RH is 50%



Room at 21°C (70°F)
8 gr/cuft
111 gr/lb
(15.7 gm/kg)
RH is 100%

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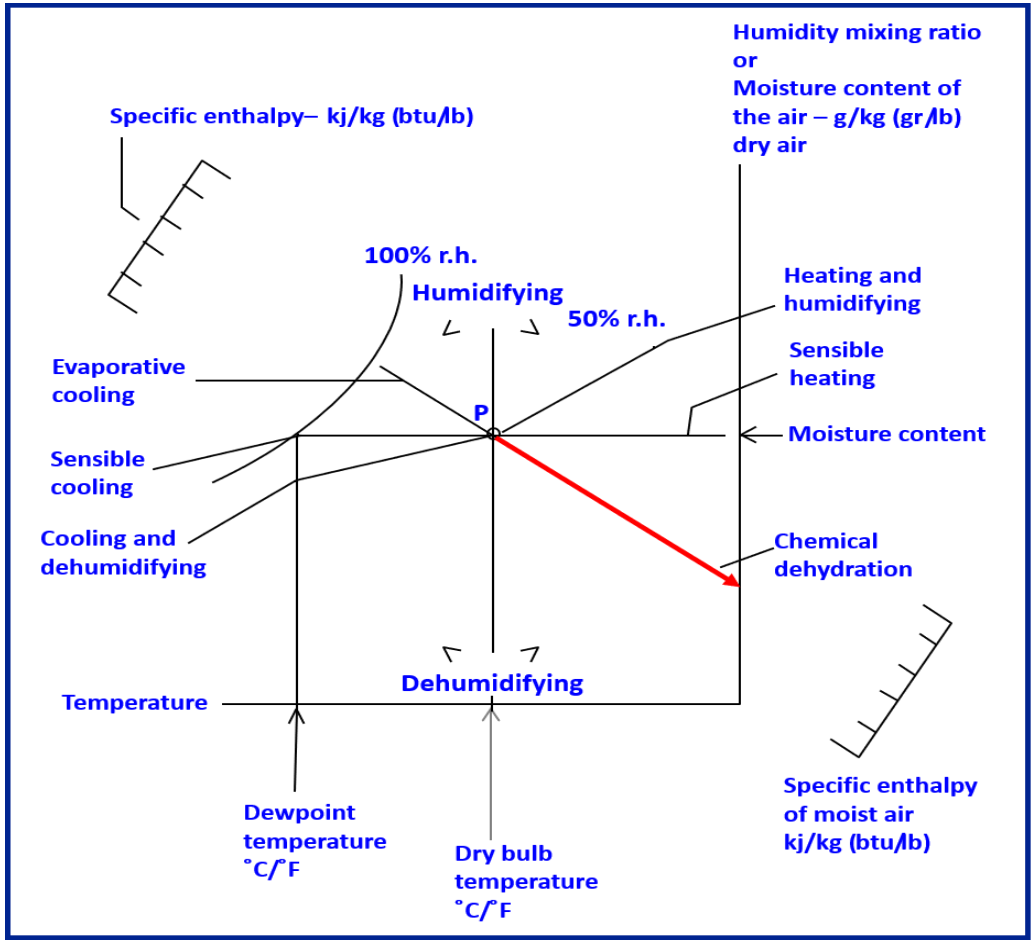
Dew Point Table

Dew Point (°C)	Absolute Humidity (g/kg)	RH % @ 20°C DBT
-30	0.2346	1.6
-40	0.0793	0.56
-50	0.0243	0.17
-60	0.0066	0.05
-70	0.0016	0.01
-80	0.0003	0.002
-90	0.0001	0.0004

Various Process on Psycrometric Chart



Methods of Control

- Heating the air
- Compression
- Refrigeration

<u>Most Suitable</u>

Chemical Dehumidification

- It operates independent of dewpoint i.e. independent of temperature control
- Specially suitable where products are temperature sensitive

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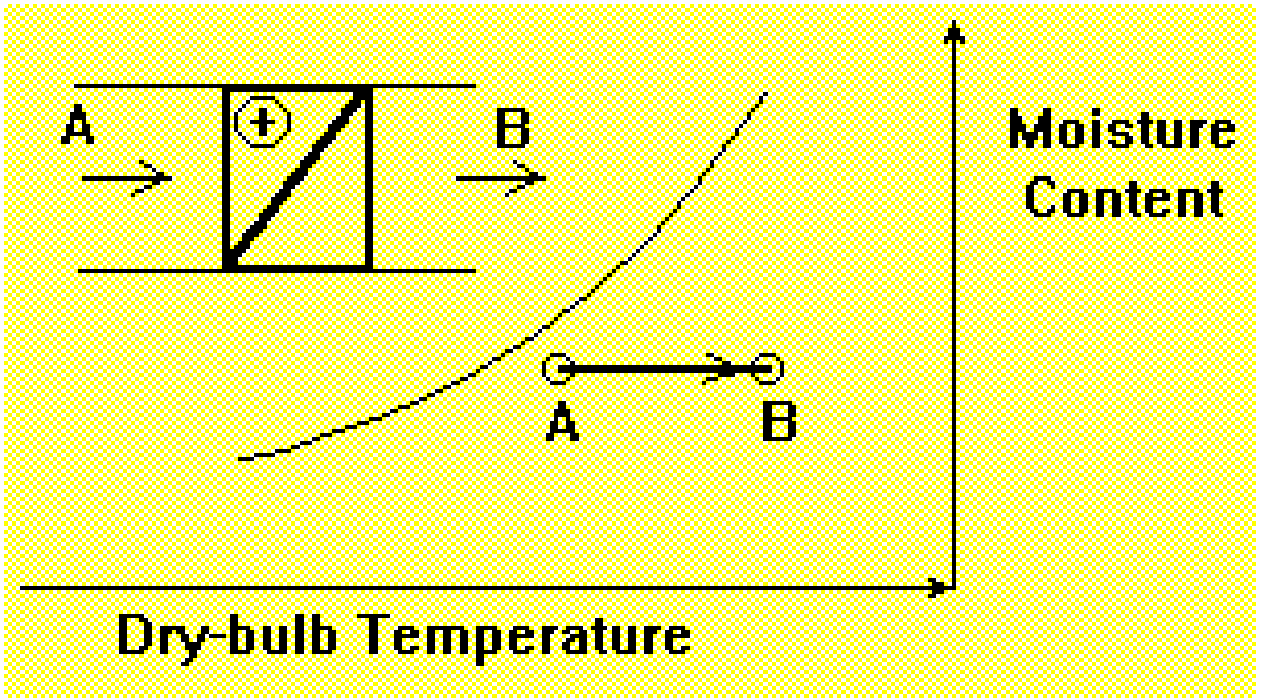
Heating

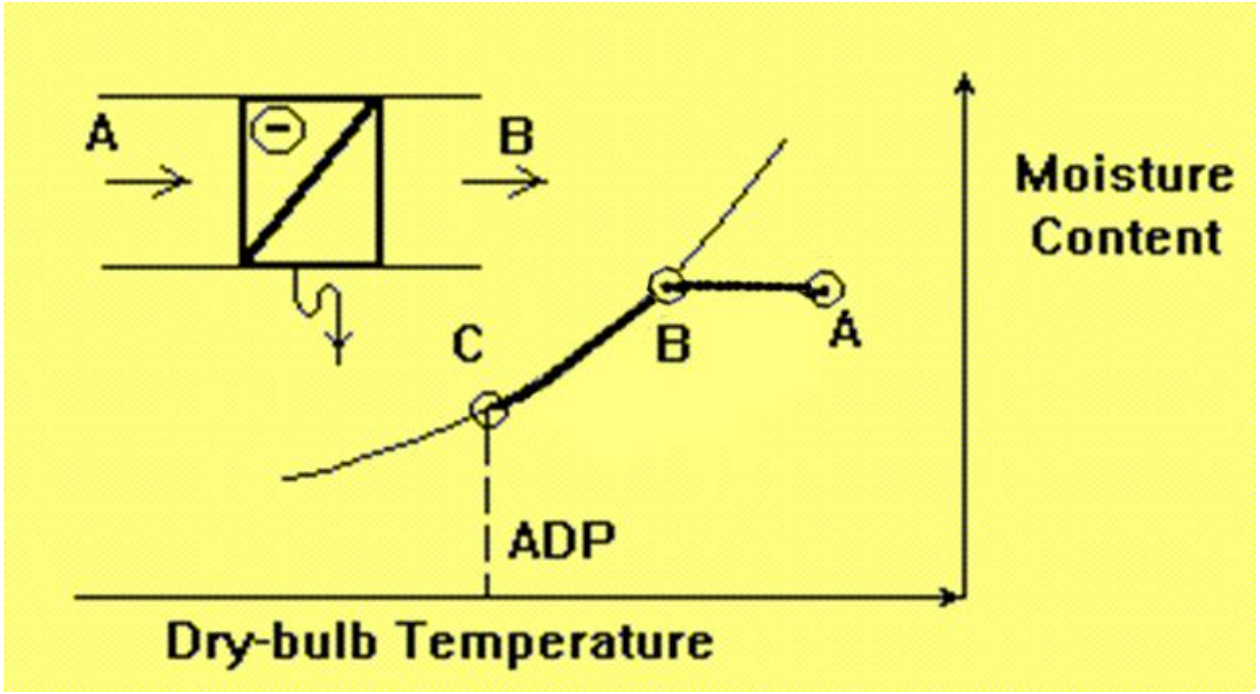
When sensible heat is applied to air the temperature increases. However, there is no change in the moisture content of the air. This effect is shown on the psychrometric chart as a straight horizontal line starting at the left and extending to the right.

The Dry bulb reading increases, wet bulb reading increases, the dew point remains unchanged, and the RH is lowered. However, the moisture content of the air remains unchanged.



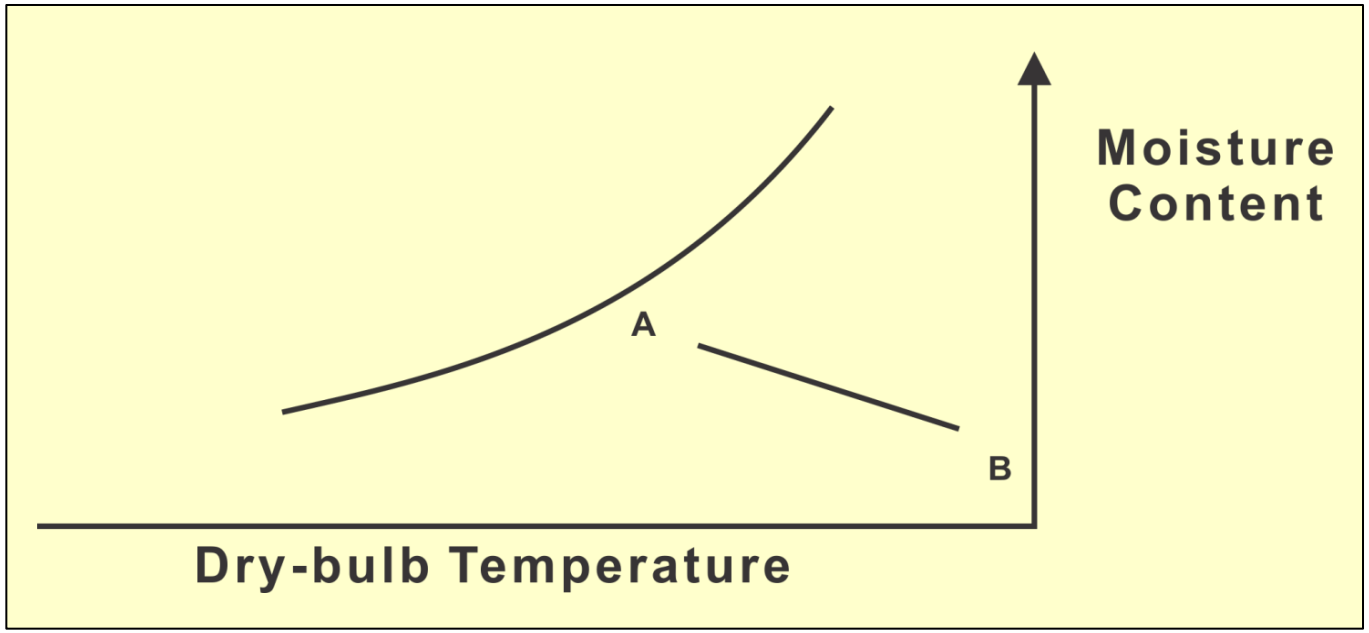
Cooling and Dehumidifying

When air is cooled, the capacity to hold water decreases, and the extra water vapour condenses. In the process, both sensible heat and latent heat are removed and the process takes place along a line sloping downward and to the left. Change occurs in dry bulb, wet bulb and in dew point temperature.



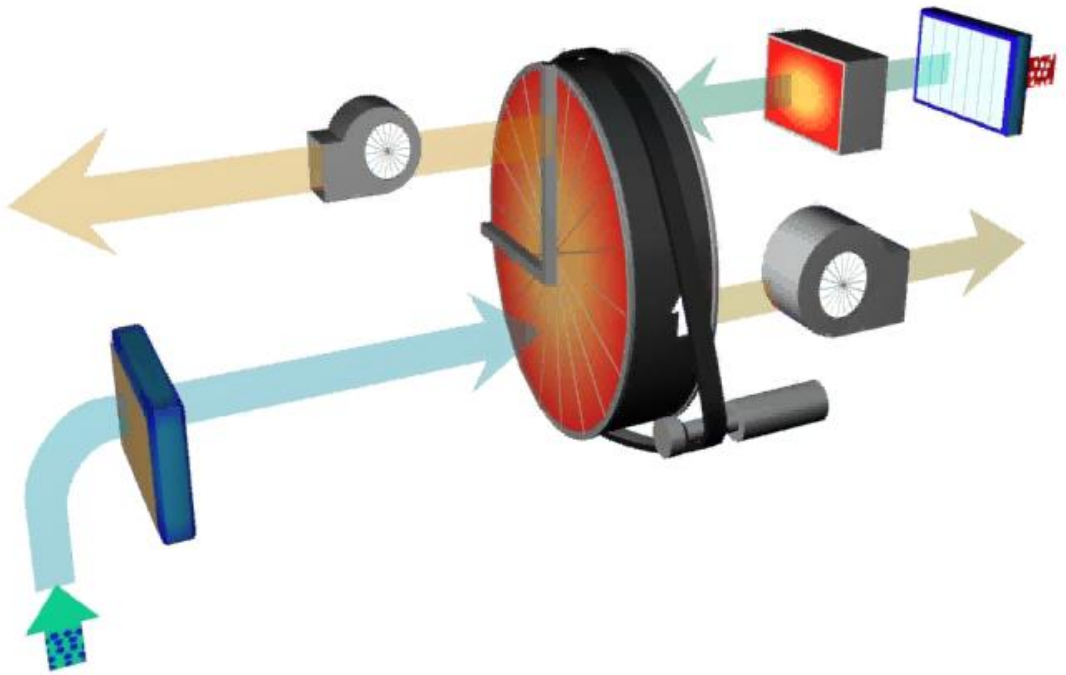
Chemical Dehumidification

In chemical dehumidification, the air is brought in contact with a chemical which either absorbs or adsorbs moisture from the air. The process is indicated by a line sloping downward approximately along the wet-bulb line. The slope may be either greater or less than the wet bulb line depending upon whether heat is stored, liberated, or absorbed in the process.



Operating Principle of the solid Desiccant Dehumidifier (Rotary)

React Air in



Wet Air out

Process Air out

Fresh Air in

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Tailored Exclusively for Li-ion Battery Manufacturing Patented Green DryPurge Technology

Incorporating BHP™ (Bry-Air High Performance) Rotor with special Geometry and Chemistry

Ultra low dew point up to (-) 80 °C

Global Patent held for the heart of Dry Room, the **most** energy efficient **Dehumidifier** for <1% RH Dry Rooms using Bry-Air Green DryPurge® (GDP) Technology

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Compact Dry Room

- Dry Room design is a complex process.
- Handling needs special knowledge of heat load and moisture load calculation.

MADE WITH PRIDE IN INDIA FOR THE WORLD

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4 Important Consideration *for* Lithium Battery Manufacturing

- Technology
- Component/Materials
- Machinery and
- **Dry Rooms + Environment Control Equipment**

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Technology

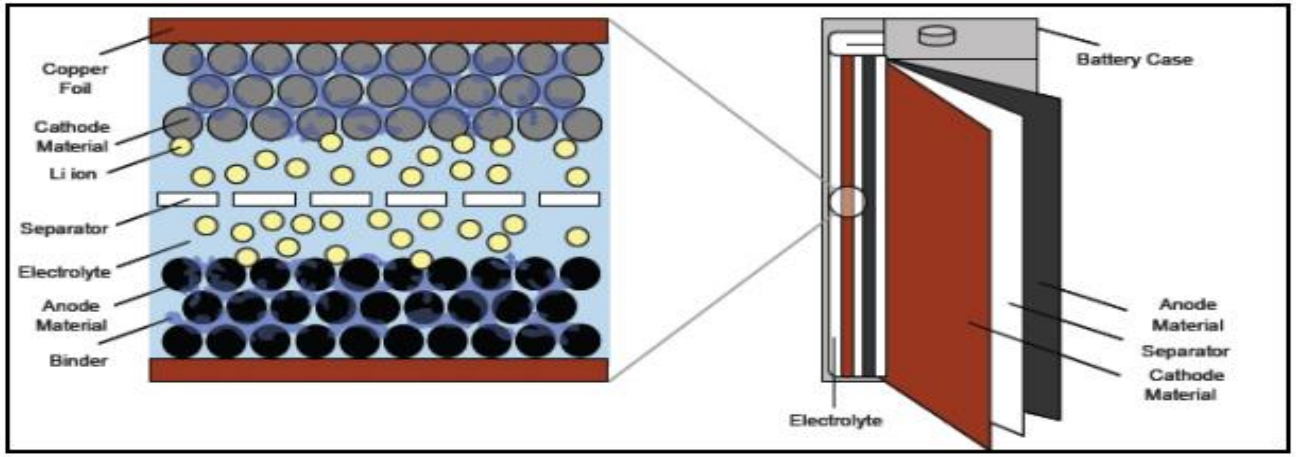
- Lithium Ion battery technology currently is based on insertion-reaction electrodes and organic liquid electrolytes
- Presently, the commercial lithium ion technology is largely limited to cells with low-medium gravimetric and volumetric energy density
- In India, ISRO – ARAI together is providing lithium ion battery technology to private companies
- Internationally, players like LG Chem, Samsung, Panasonic, Boston Power, Toshiba, etc are having the lithium ion battery technology and production capabilities
- Innovation both in component materials and engineering (fabrication of the cell) is the way forward

Component/Materials

3 primary functional component of Lithium-ion battery are positive and negative electrode and electrolyte

Key constituents of Lithium-ion batteries:

- **Cathode materials** – Lithium Cobalt Oxide, Lithium Manganese Oxide, Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt (NMC), Lithium Nickel Cobalt Aluminum Oxide (NCA)
- **Anode materials** – Graphite coated on Copper Foil
- **Electrolytes** – LiPF6 salt, High Phosphorous Content Flame Retardant, DMMP
- **Separators** – Polypropylene (PP) and Polyethylene (PE)



Basic structure of Lithium-ion battery

Machinery

Equipments used to manufacture Lithium-ion batteries:

Cell Manufacturing (< 1% RH Dry Room)

- Calendaring Machine
- Slitting Machine
- Stacking Machine
- Ultrasonic Tab Welding Machine
- Laser Welding Machine

Battery Assembling (< 10% RH Dry Room)

- Mixing Machine –
  for Preparation of Cathode and Anode Slurry
- Coating Machine


Frontal view of RH rooms


Inside view of RH rooms

Source: ARCI

Dry rooms

- Need for Dry room- pure lithium metal is extremely sensitive to even tiny amounts of moisture
- Exothermic chemical reaction taking place when moisture in the air comes in contact with lithium metal

$$2Li + 2H_2O = 2LiOH + H_2$$

leading to reduced performance and battery life of Li-ion batteries. In certain cases resulting to degradation in power storage and battery explosion in extreme cases

- Hence, low humidity conditions - typically below 1% RH or lower (- 35˚C or -80˚C dew point) is required during lithium battery manufacturing

Environment Control Very Critical for Li-ion Battery Production

- The Root Cause
- Moisture Control is Required at Every Stage
- Solution for Ideal Environment Conditions
- System Design Parameters
- Dry Room Layout
- Green DryPurge Dehumidifier Technology & its Advantages

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Environment Control – Very Critical for Li-ion Battery Production

- **Li-ion battery production is undertaken in very critical and controlled (dry room) environment conditions**
- **Non maintenance of the desire RH during Li-ion cell manufacturing (< 1%) and battery assembling (< 10%) may lead to consequences such as:**
  - Degradation in power storage
  - Characteristics of lithium
  - Reduced performance and battery life
  - Explosion in batteries in extreme cases

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Moisture Control is Required at Every Stage of Manufacturing

Assembly & Manufacturing

- Battery Assembly Area
- Components of Lithium batteries
- Glass to metal seal
- Cathode Production
- Insertion of Electrodes
- Attachment of cover to current collector
- Filling the cell with electrolyte
- Slitting & coating area

Testing & R & D

Solution - Ideal Environmental Conditions for Low Humidity Requirement

- **Temperature:** Room Temperature around 23 - 25 °C , with tolerance of +/- 2 °C
- **Humidity:** Dew Point (-) 35 °C to (-) 45 °C (0.14 to 0.04g/kg) *(Advise: Keep the room temperature slightly warm to maintain comfortable environment)*
- **Filtration:** Adequate filters for dust control
- **Make-up air:** Maintain fresh air for people, positive room pressure
- **Air change rate:** between 15 to 20 air changes per hour
- **Positive pressure:** Positive pressure - 0.05 in w.c
- **Zero Leak Dry Room**
- **Air Distribution inside the room**

System Design Parameters

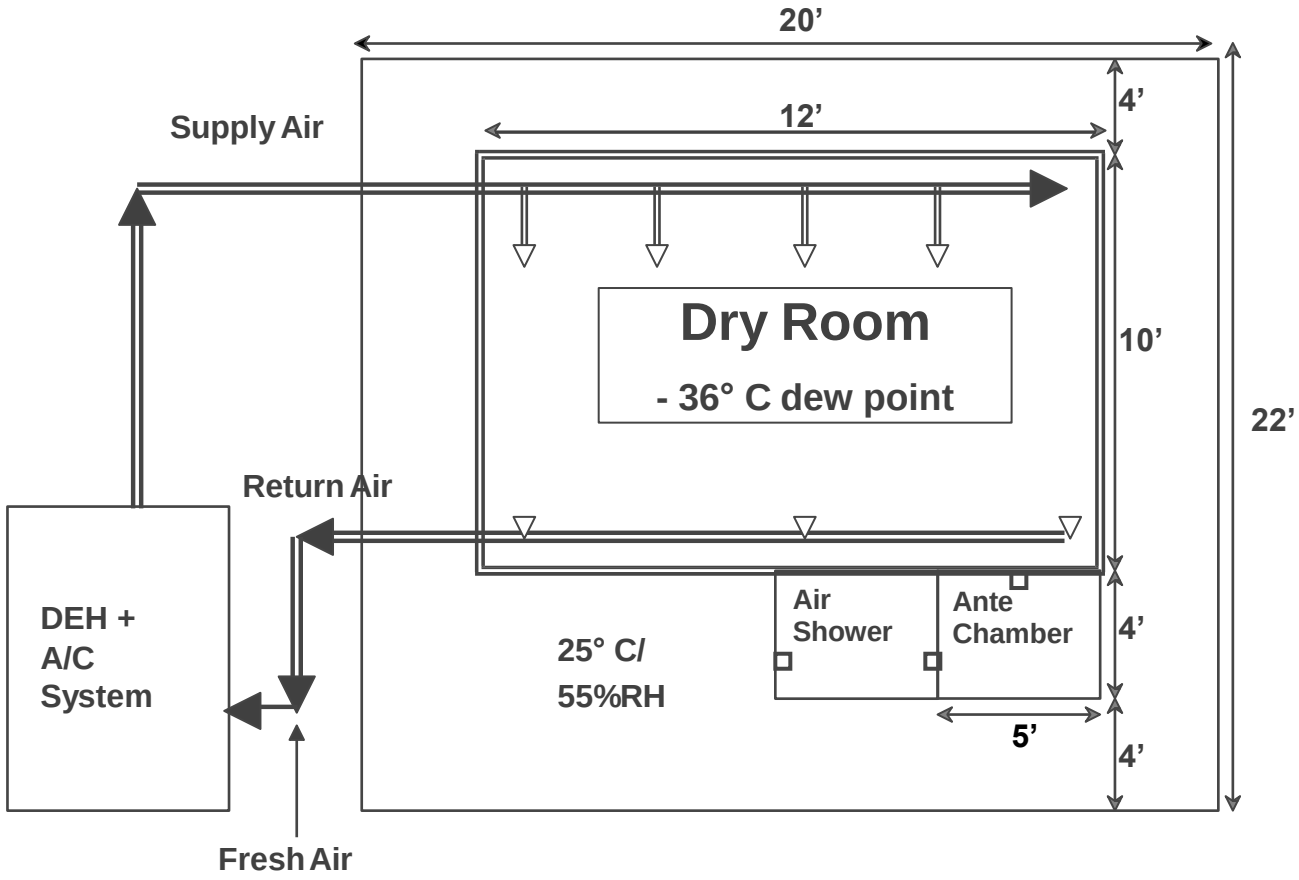
System designing requires determination of the following:

- **Moisture load in space**
- **Heat load in the space**

Moisture load determines the size of the dehumidifier

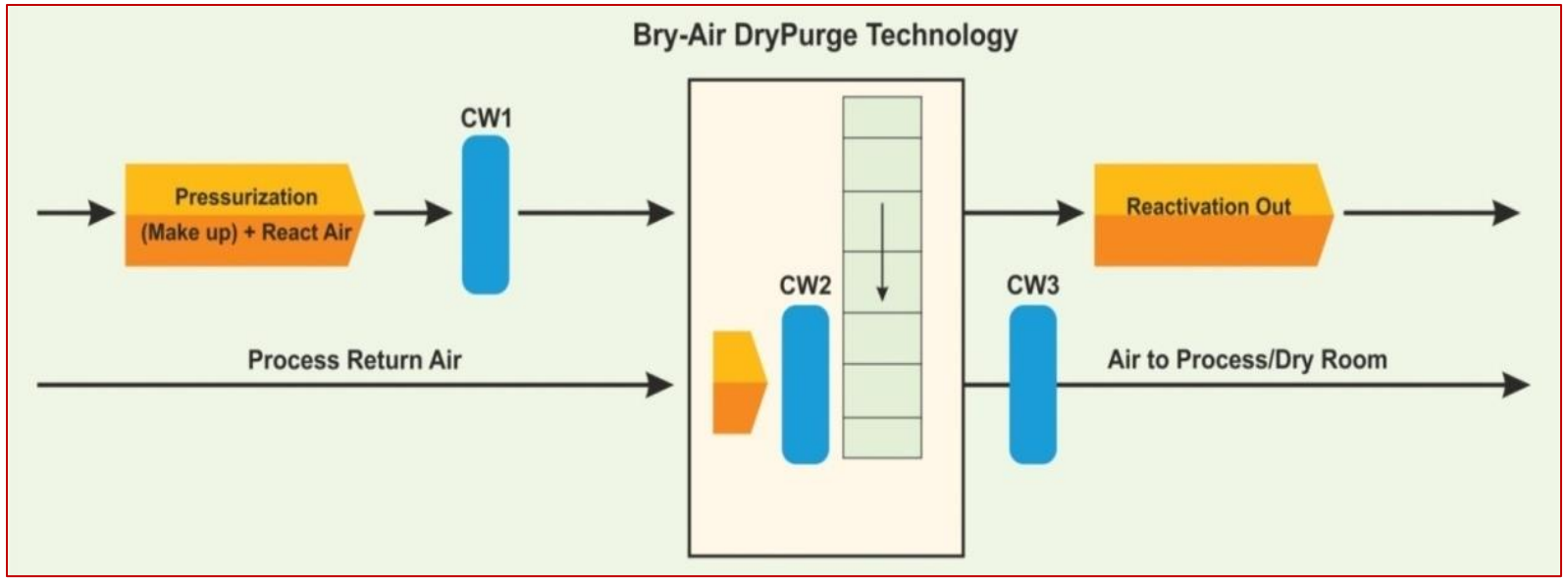
Heat Load determines the size of the refrigeration system

Typical Layout of Dry Room



Green DryPurge (GDP) Typical Dry Room Conditions for Li-ion Battery Manufacturing

- Moisture level in Lithium-ion battery processing areas should have less than (-) 35 °C dew-point and / or moisture content of 0.14 grams per kg of dry air
- Room temperature should be maintained at recommended levels, around 25 °C, with tolerance +/(-) 2 °C along with dew point of (-) 35 °C (0.14 g/kg)
- Fresh Air: 5~15% of supply air



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Green DryPurge (GDP) Technology…the cutting edge

- Green DryPurge® (GDP) patented technology for dehumidifiers ensures optimum performance of dehumidifiers, even at the ultra low dew point, up to (-) 80 °C
- Rotor made up of pH neutral and chemical resistant honeycomb matrix
- Inertness to gases such as Hydrogen Fluoride (HF) generated during the production of Lithium-ion batteries

11

patent(s) applications filed globally

and

8

granted/allowed already

including USA, China, Mexico, Japan, South Africa, Canada, Europe ….

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GDP Technology: Typical Applications

- Dry Rooms for:
  - Lithium Battery Manufacturing... 1% & 10% RH
  - Safety Glass... 10% RH
  - Automotive Hybrid Batteries
  - Medical Devices
  - Very Low RH Pharma Production
- Product Drying (Low Dew Point) using 100% Fresh Air

… and many more

Something about Pahwa Group

PAHWA™ GROUP

is a group of knowledge based, technology driven, '*airgineering*' companies
specializing in technologies, products & services
"*with desiccant at the core, in relation to air*"
operating within a broad framework of
'*energy and environment*'

Fastest Growing

Adsorption Technology Group

in the World

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Some Quick Facts

PAHWA GROUP

Over 55 Bry-Air years of excellence

DRI®

delair®

TDS®

Bry-Air® PROKON

- **Companies**: Four (4); Manufacturing - 3, Marketing & Services - 1
- **Worldwide Network**: India, Malaysia, China, Switzerland, Brazil, Philippines, Korea, Bangladesh, UAE, Nigeria, USA
- **Manufacturing Plants**: Thirteen (13); 9 in **India**, 1 in **Malaysia**, 1 in **China**, 1 in **Switzerland**, 1 in **Brazil**:
  - **India**: 7,12,587 sq.ft.
  - **Malaysia**: 17,000 sq.ft. (built up)
  - **China**: 20,229 sq.ft. (built up)
- **Resources**:
  - **Human**: **1500+** employees, out of which **750+** are Engineers/Technicians
  - **R & D Facility**: Registered & Recognized by Ministry of Science & Technology
  - **9 In-house R&D Test Labs**
  - **132 Int'l. patent applications filed for 13 new technologies, 55 patents granted/allowed already**

Contact Us

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Questions?

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