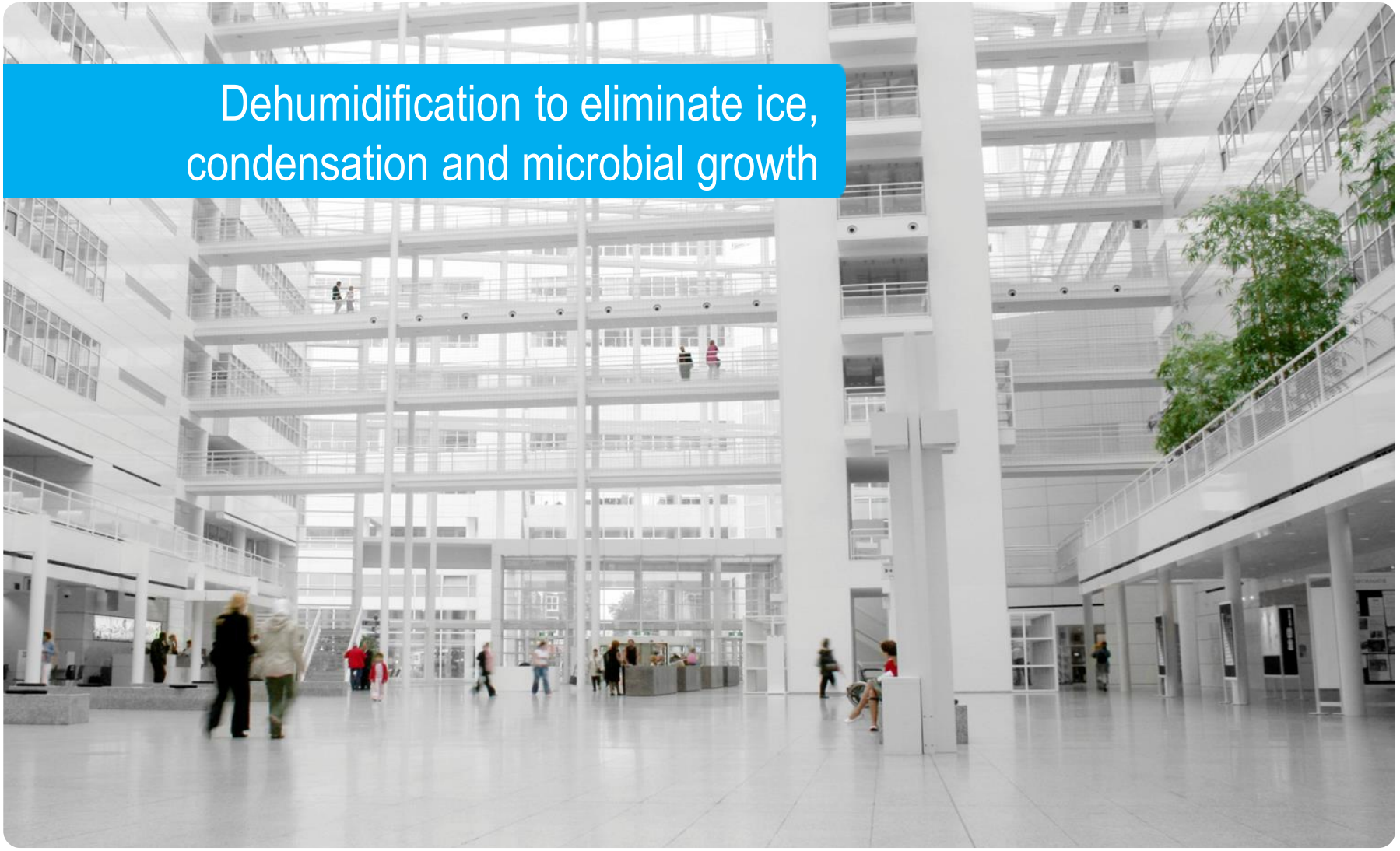
Munters
Your Perfect Climate

Dehumidification to eliminate ice, condensation and microbial growth



Martin Ginty, March 17th Kunming DCVMN Workshop

Munters Group

Key facts

- Munters began trading in 1946 and incorporated in 1955
- 3,000+ employees
- 16 major Manufacturing Plants
- 5 Logistics and Assembly Hubs
- 53 sales and service centres serving customers in more than 30 countries
- Headquarters in Stockholm, Sweden
- Over 300,000 air treatment systems installed

Munters Group


Agriculture


Automotive


Chemical Processing


Commercial & Public Buildings


Construction


Data Center & Telecom Cooling


Defense & Aerospace


Education


Electronics


Food & beverage


General Industry/Production


Greenhouse


Healthcare


Oil, Gas & Petroleum


Pharmaceutical


Power Generation & Distribution


Pulp, Paper & Printing


Recreation & Leisure


Retail & Supermarkets


Shipbuilding & Marine

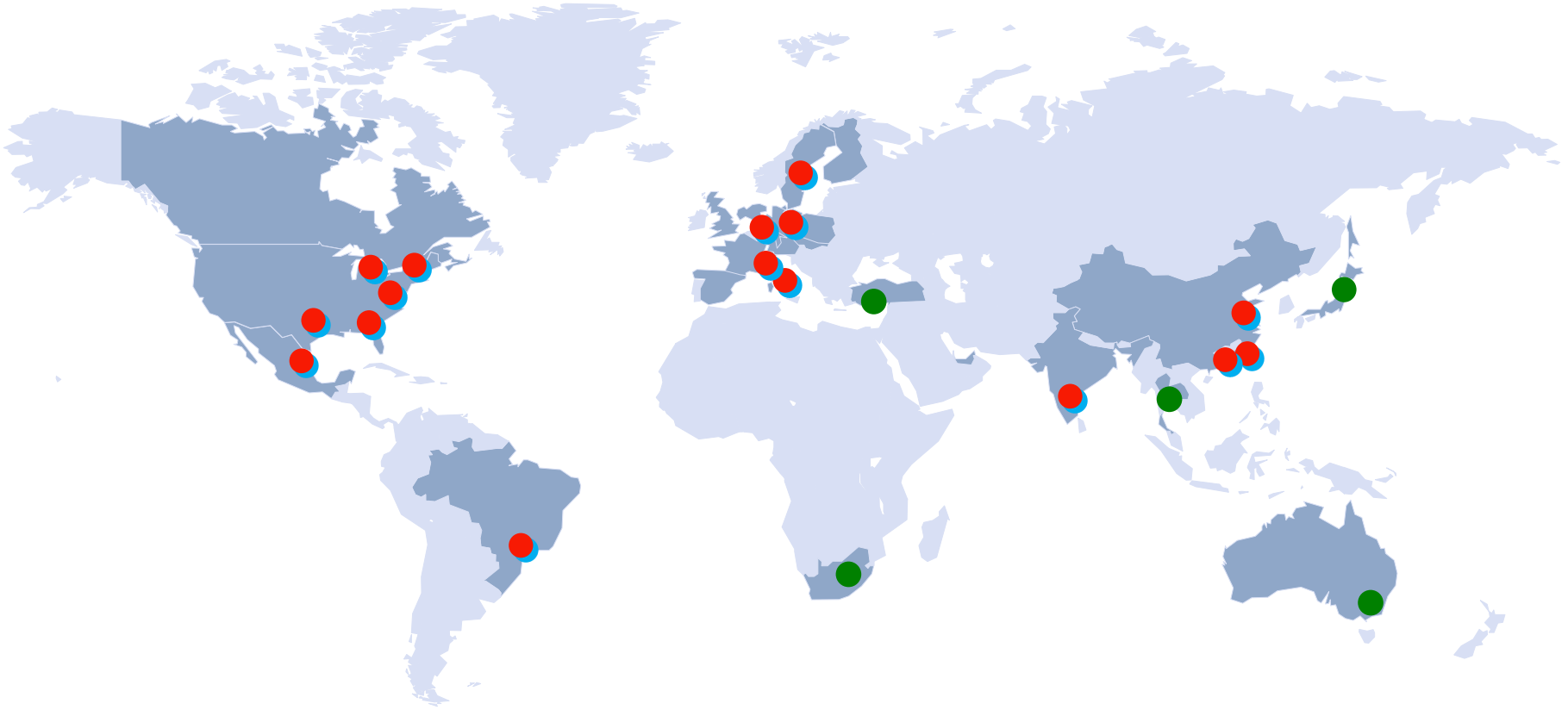

Steel Industry


Storage, Preservation & Archives


Temporary Structures


Water & Waste Water

Global Manufacturing & Logistics Support

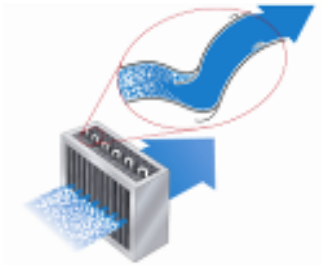


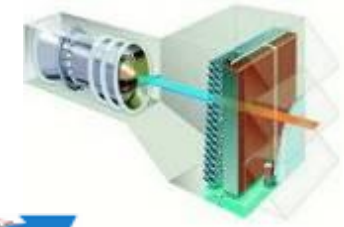
Manufacturing plants
Logistic & assembly hubs

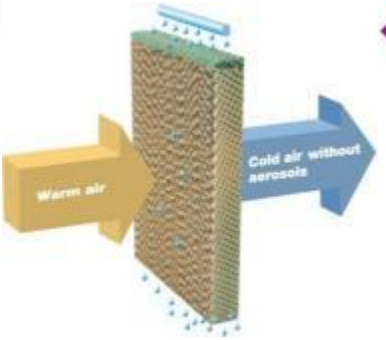
16 Manufacturing Plants
5 Logistic & Assembly Hubs
53 Sales & Service Centres

Munters Core Competencies

- Dehumidification
- Humidification
- Evaporative cooling
- Refrigeration
- Heating
- Energy recovery
- Mechanical separation liquid from gas







Pharma - Manufacturing of Tablets

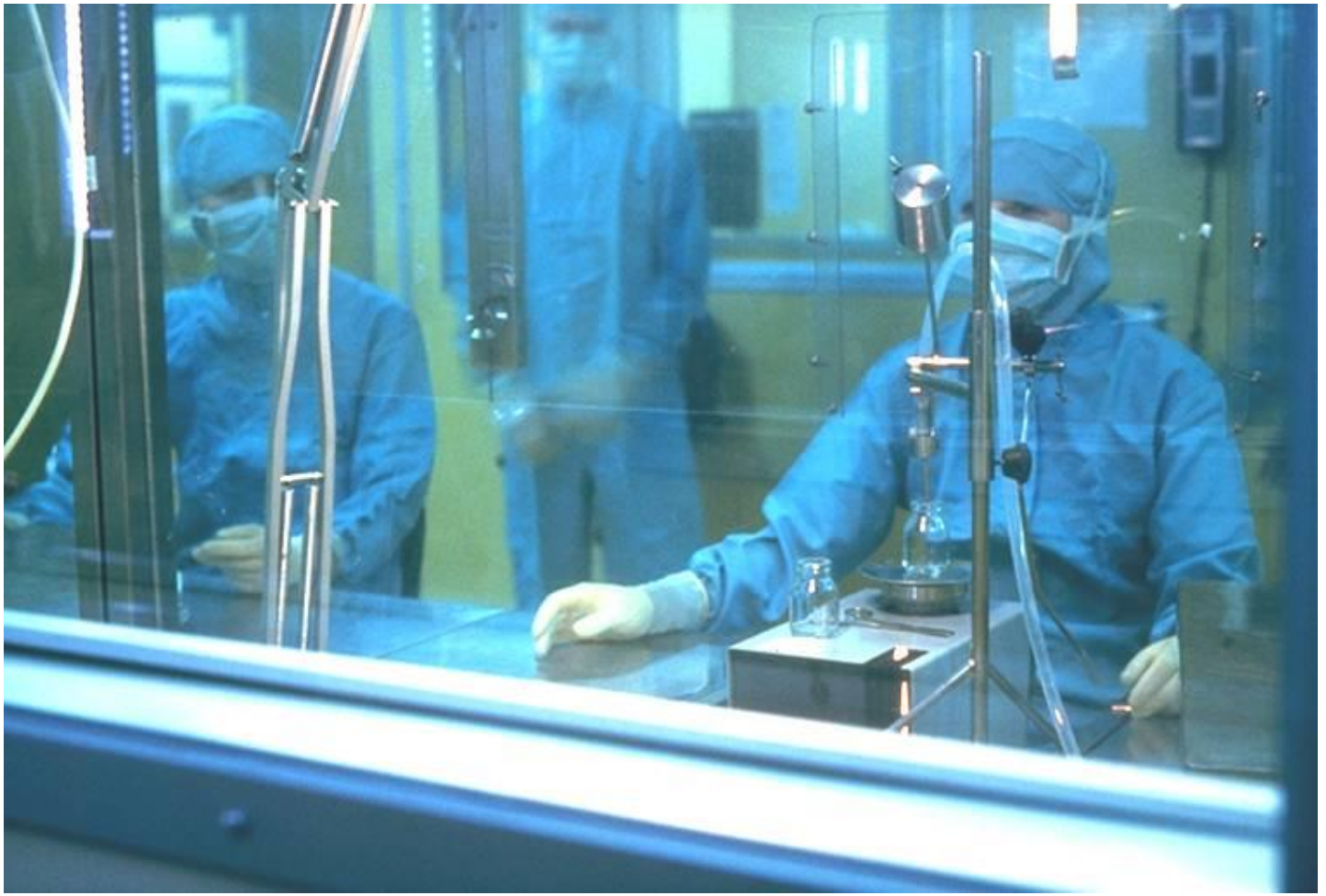
Pharma - Packaging of Effervescent Tablets

Pharma - Manufacturing of Gelatine Capsules

- Drying of gelatine
- Production of capsule shape
- Capsule content
- Packaging

Pharma - After freeze-drying

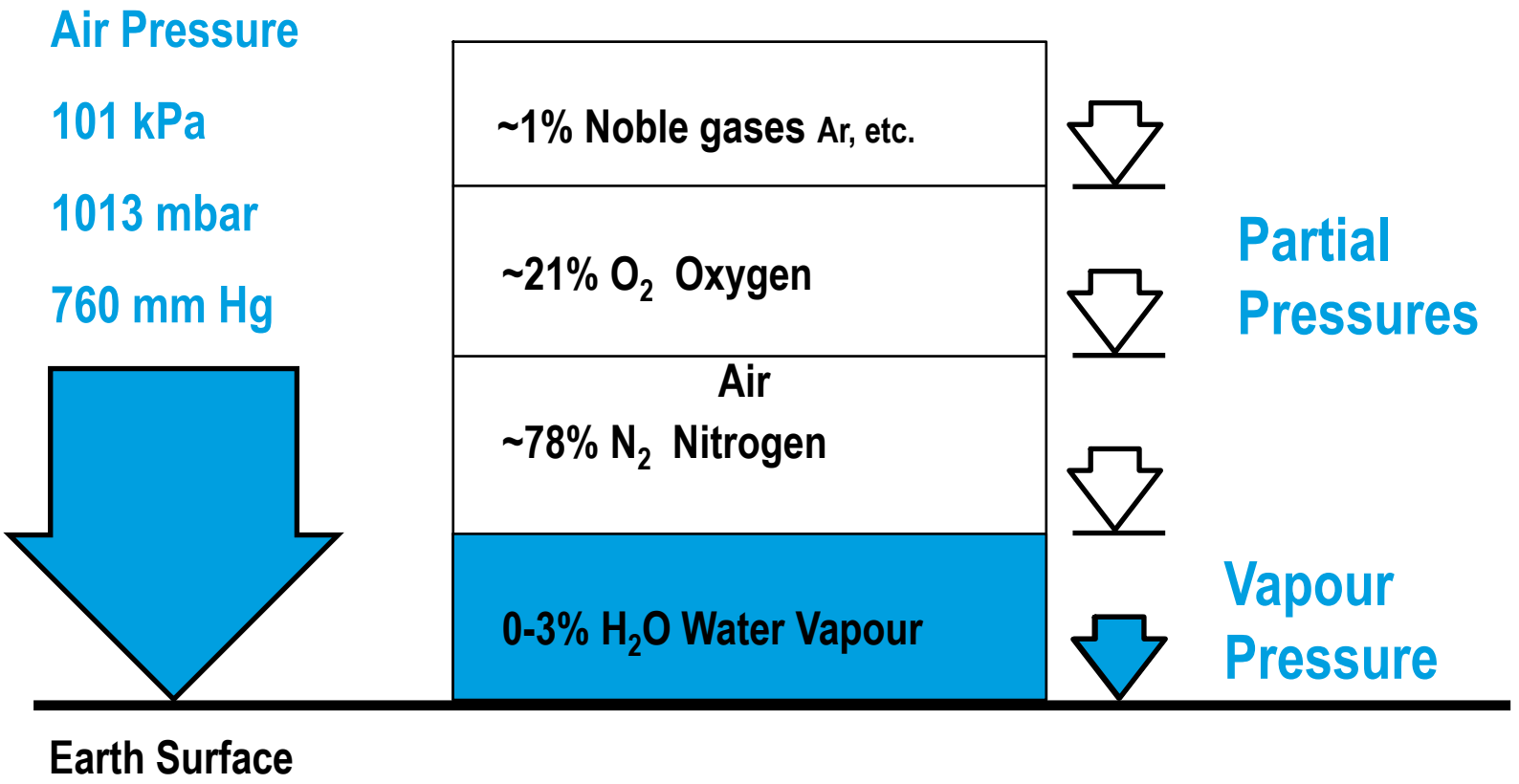
Pharma - Cleanrooms



Pharma – Chilled and Cold Storage

Humidity

The Composition Of Air



How To Quantify Humidity

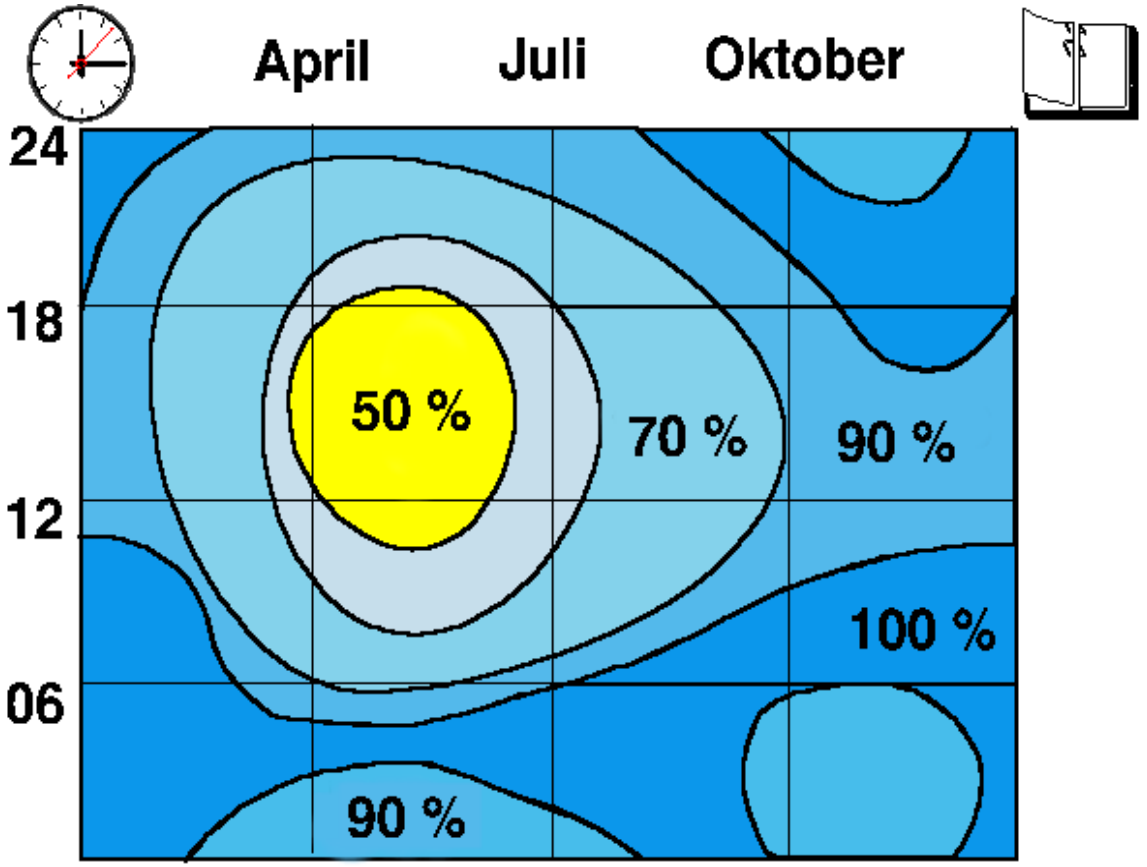
- Absolute Humidity (or “Humidity Ratio”)
  - The amount of (kilo)grams of water vapour per kilograms of (dry) air (g/kg)

- Relative Humidity
  - The ratio (in %) between the actual quantity of water vapour in the air and the maximum quantity of water vapour that the air can contain at a certain temperature

Humidity And Temperature

- Warm air can contain more water vapour than cold air
- Air at a certain temperature will have a corresponding maximum content of water vapour
- When too much water vapour is in the air (at a certain temperature), the air is “saturated” and the excess moisture will condense out
- This can happen when the temperature falls

Outdoor Relative Humidity



Typical summer temperature and humidity conditions

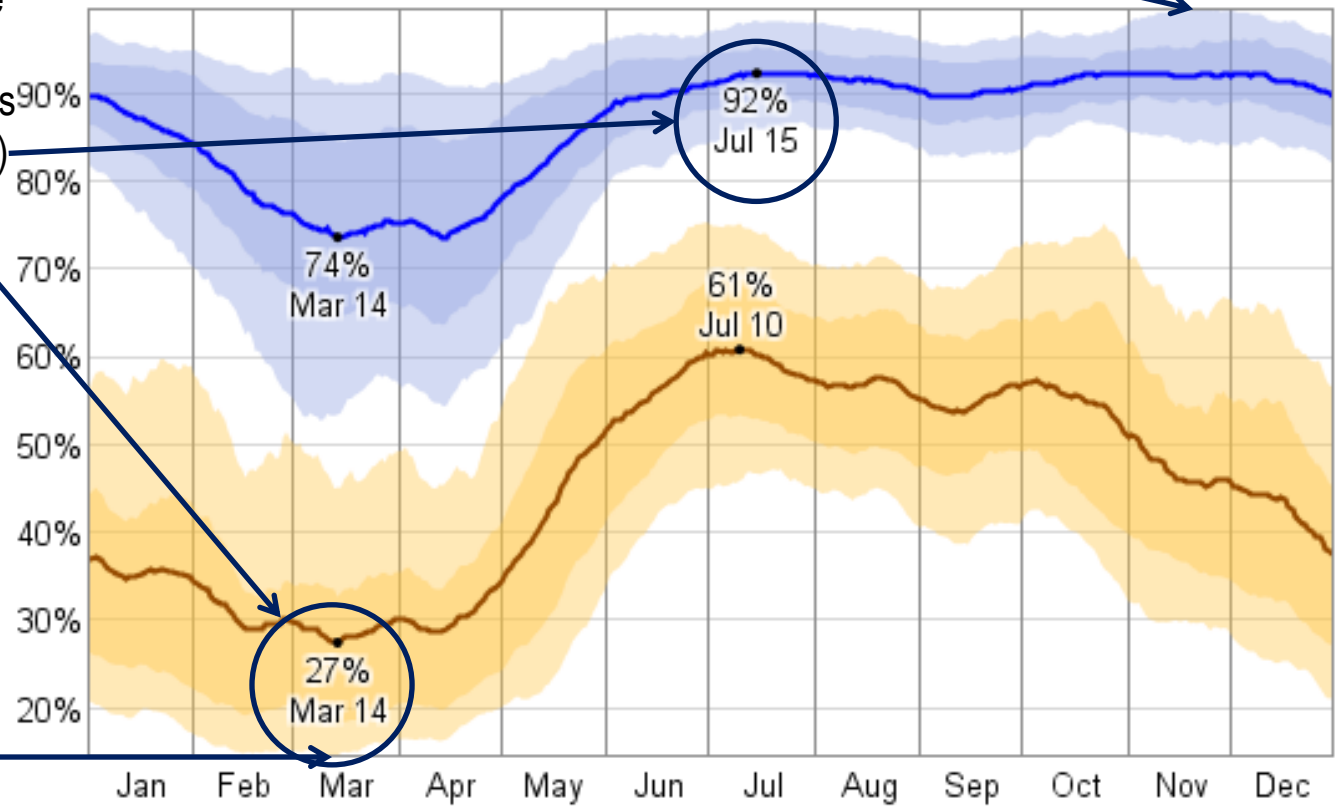
	Dry temp	X-value g/kg
Stockholm	19,8	12,2
Riyadh	22,9	13,0
Sydney	24,8	16,4
New York	26,8	17,8
Tokyo	28,0	20,4
Rio de Janiero	30,1	21,5
Singapore	28,9	21,7
Shanghai	31,0	23,0
Caracas (We)	31,7	27,2
Raufahofn (Isl)	13,9	8,9

Local Relative Humidity Levels – Kunming Example

Reaches as high as 100% (very humid).

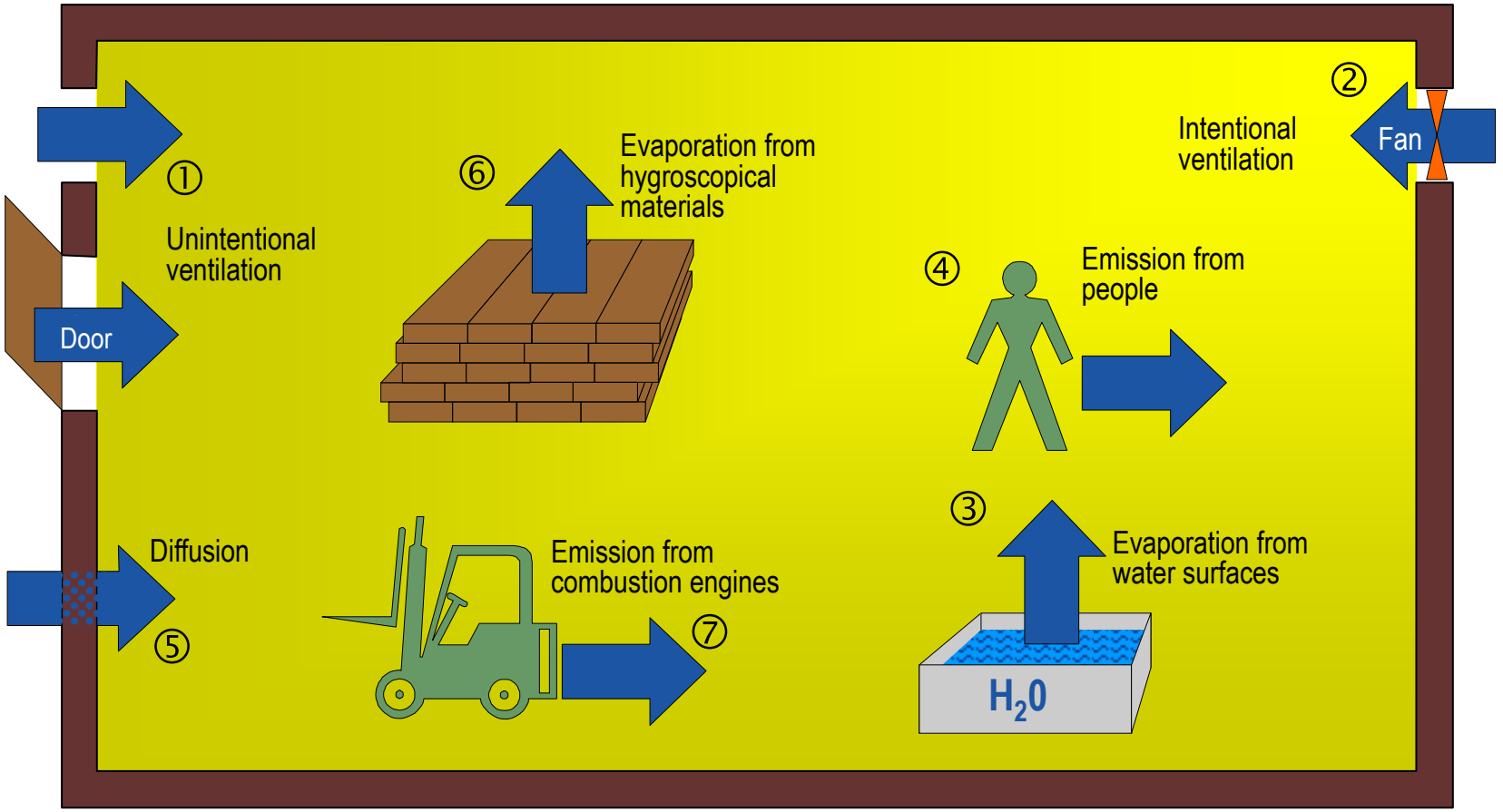
Over the course of the year the average relative humidity ranges from 92% (very humid) to 27% (dry)

Rarely drops below 15% (very dry)



The average daily high (blue) and low (brown) relative humidity with percentile bands (inner bands from 25th to 75th percentile, outer bands from 10th to 90th percentile).

Sources Of Humidity In a “Closed” Environment

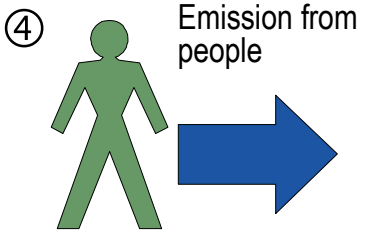


Sources Of Humidity In a “Closed” Environment

Humidity emitted depending on activity, clothing and room temperature

Average value at 20 - 25 °C and normal clothing:

- High activity 200 g/h
- Medium activity 125 g/h
- Low activity 40 g/h



Does Humidity Cause Problems?

We will quickly walk through a list of humidity related processes that cause damages, quality loss and/or cost increases.

- Condensation (water) and frost formation (ice – i.e. condensation below 0°C)
- Corrosion of metals
- Influence of moisture on resistance values (electronic malfunctions)
- Mould affecting hygiene in ducts, systems, buildings and manufacturing processes
- Property and quality change of materials and substances
  - Storage and production processes that require a stable, optimal climate
  - Product drying (deliberate moisture reduction, avoiding too high temperatures)
- Chemical reactions with moisture in the air
- Special cases of humidity impact
  - Comfort impact
  - Energy impact

Visible Humidity - Condensation on cold surfaces or in cold air

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Visible Humidity - Condensation on cold surfaces or in cold air

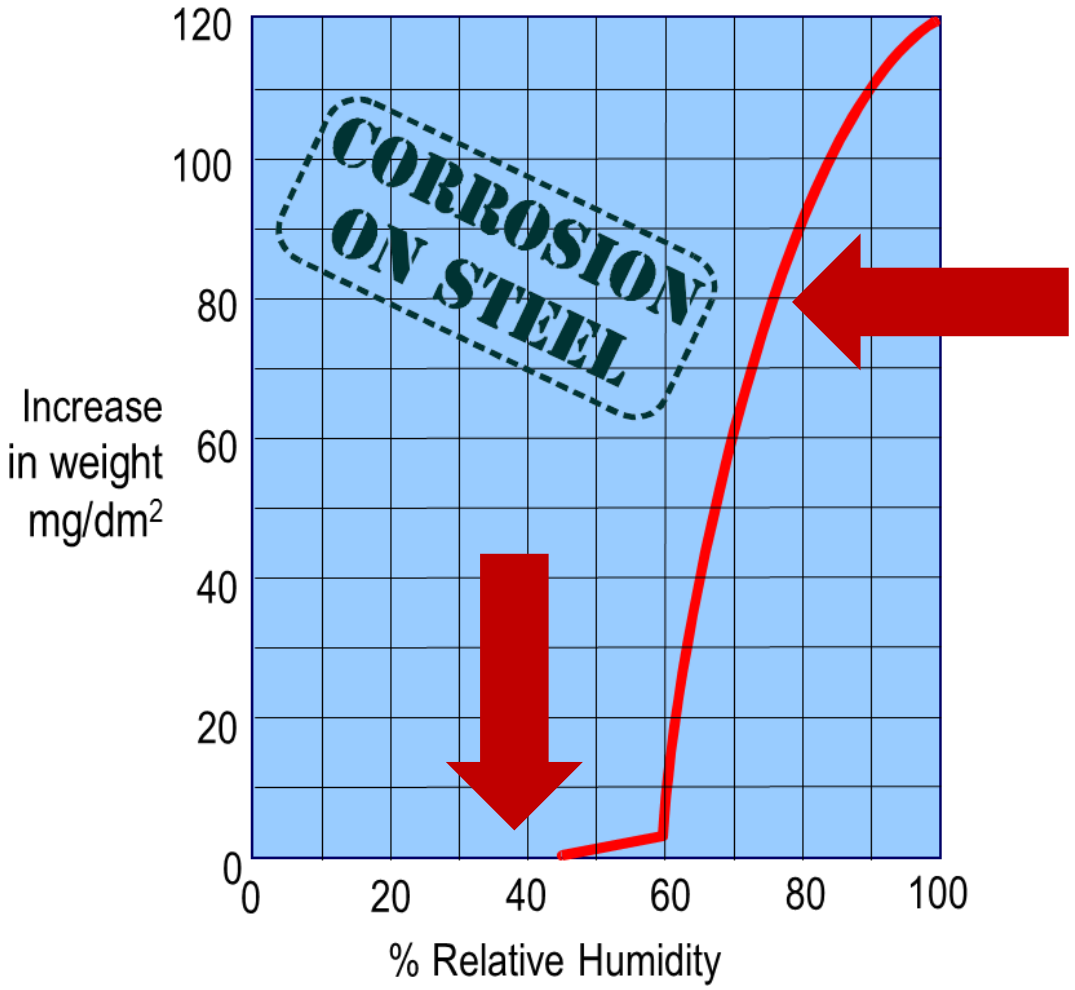
Source: www.myallergo.de

Source: www.teachingengineering.org

Source: www.bontott-tetoablak.hu

Source: www.szelloztetes.hu

High Humidity Causes Corrosion

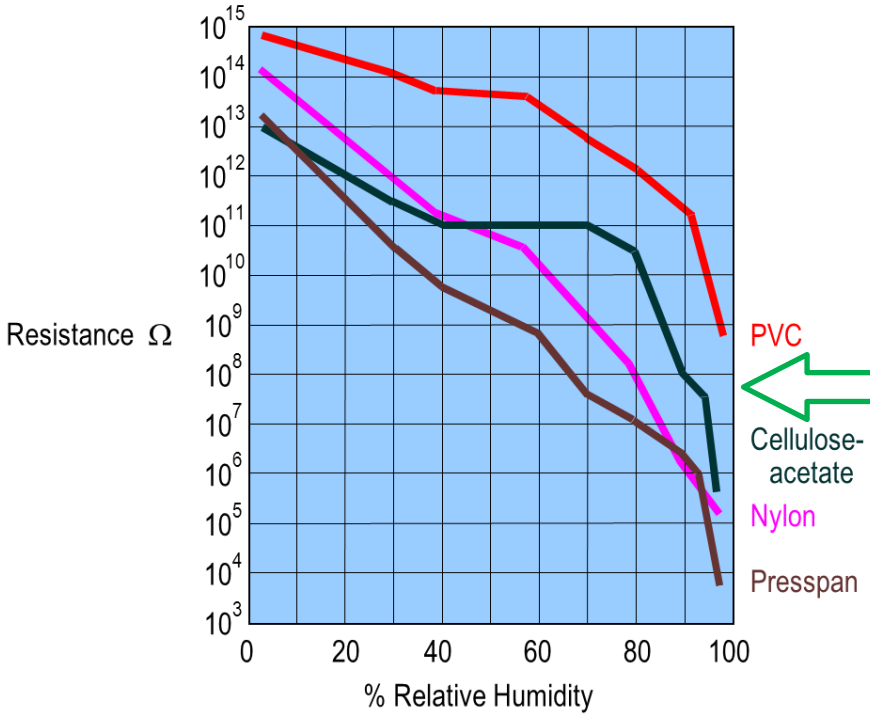


Above 60% Relative Humidity (RH) the speed of corrosion on steel rises exponentially

Below 45% RH corrosion development on steel is virtually ZERO

Humidity control can be used to stop or slow down corrosion

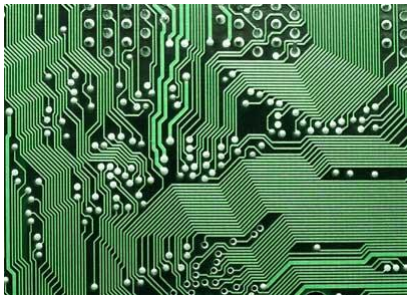
Influence of Moisture on Resistance Values



Simulated Arcing Event

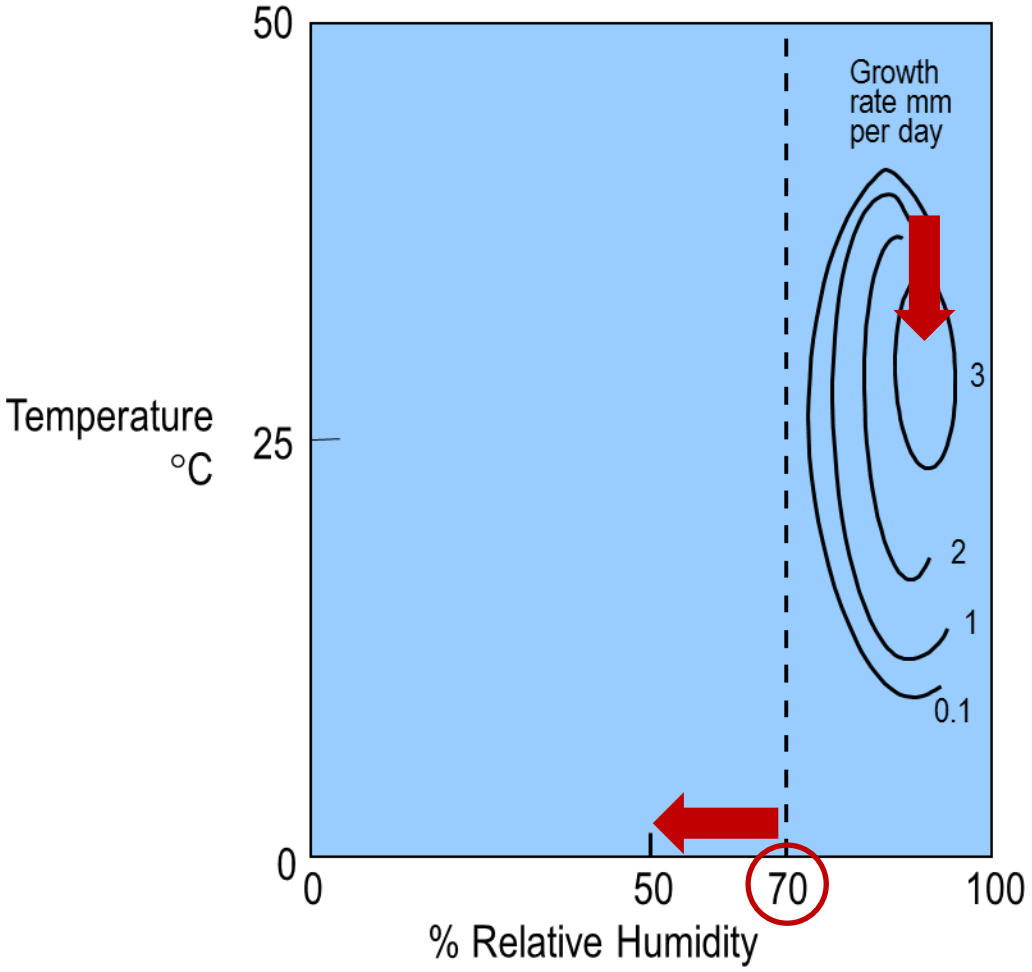
Electric conductivity increases in moist environments

Over insulation material



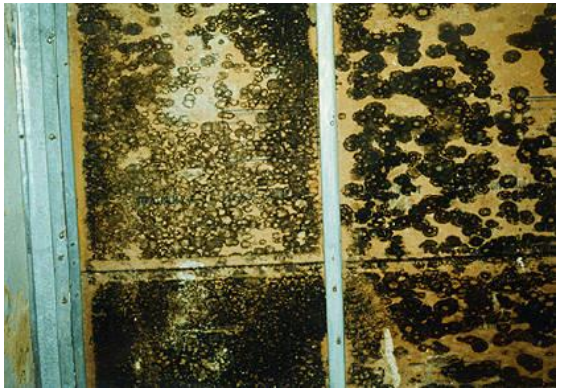
But also through air…..

High Humidity Speeds Up Mould Growth

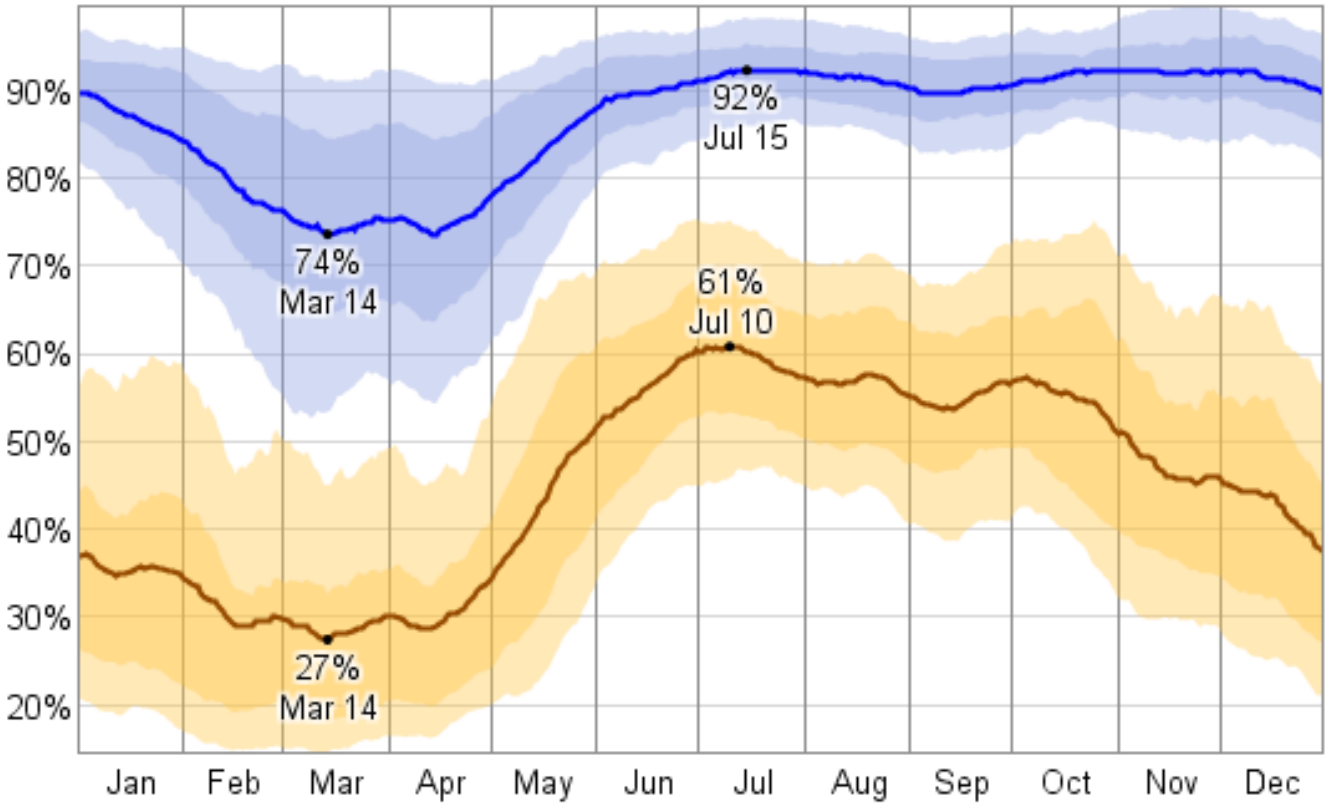


Mould has high growth rates at higher temperatures (20-30°C) and high humidities. They can extract water from moist air.

Below 70% Relative Humidity mould growth is virtually ZERO

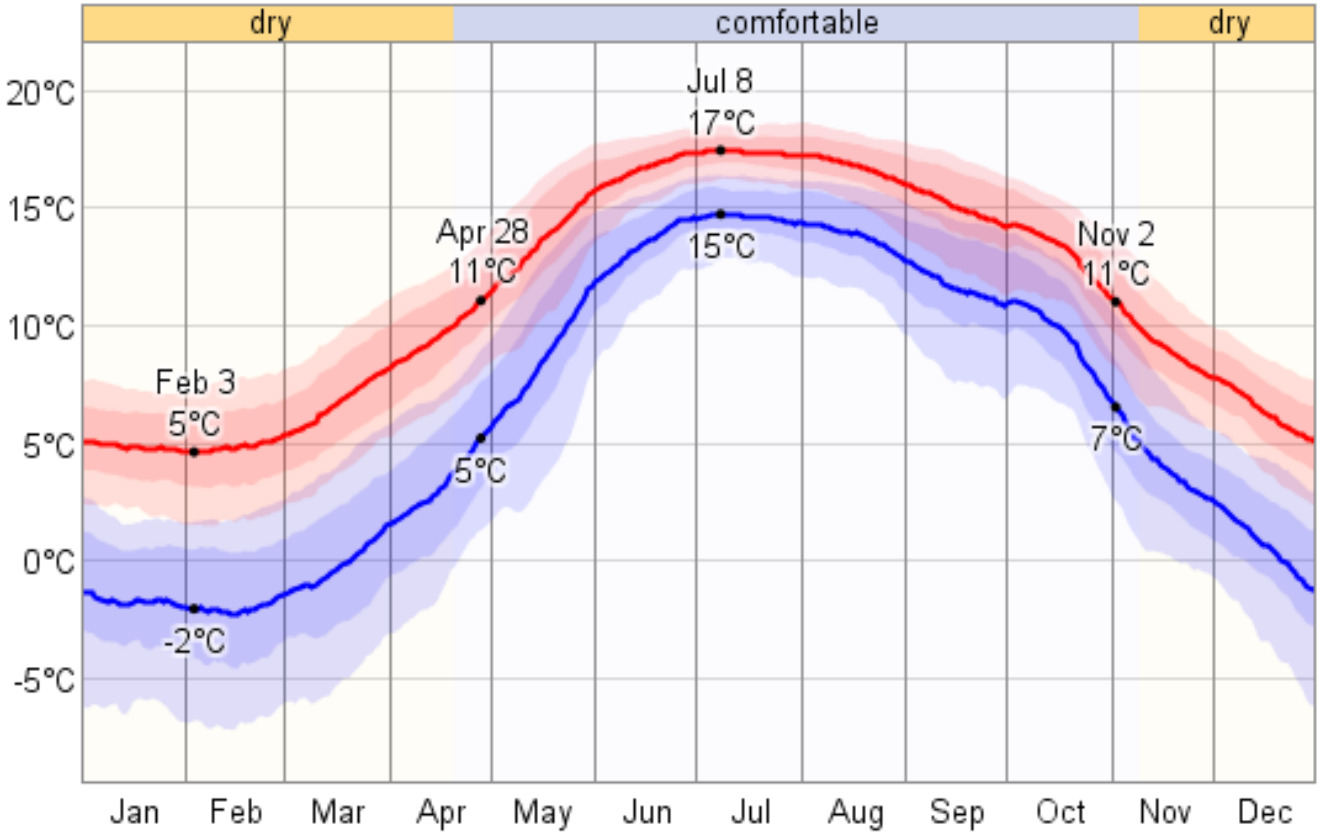


Local Relative Humidity Levels – Kunming Example



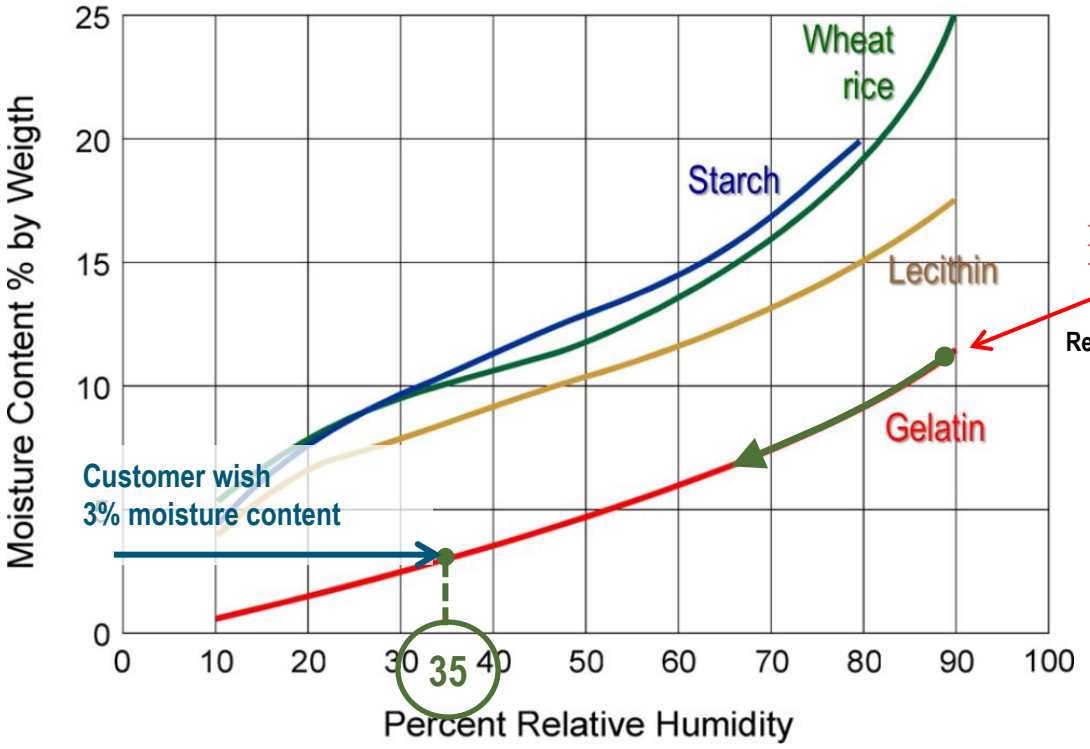
The average daily high (blue) and low (brown) relative humidity with percentile bands (inner bands from 25th to 75th percentile, outer bands from 10th to 90th percentile).

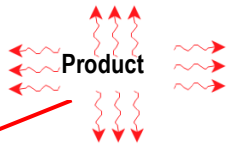
Local Dewpoint Levels – Kunming Example



The daily average low (blue) and high (red) dew point with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile).

Property and Quality Change of Materials and Substances





Some manufacturing and curing processes require a product to be dried

Product drying is a delicate process, especially if heat is a concern

Humidity Control and Energy

Moisture Removal Cost Comparison

Typical Energy Cost to Remove 120 Pounds of Water Per Hour

Dehumidifier	$1.00
Air Conditioner	$7.86
Produce/Dairy Cases	$9.13
Meat/Deli Cases	$10.62
Frozen Food Cases	$14.83
Ice Cream Cases	$16.72

Source: Tyler Refrigeration Advance Development

Desiccant dehumidification can save a lot of energy

Depending on the temperature and initial humidity level, moisture removal through condensation can be costly and ineffective

If applied properly, it is much more cost effective to dehumidify than to heat objects and buildings

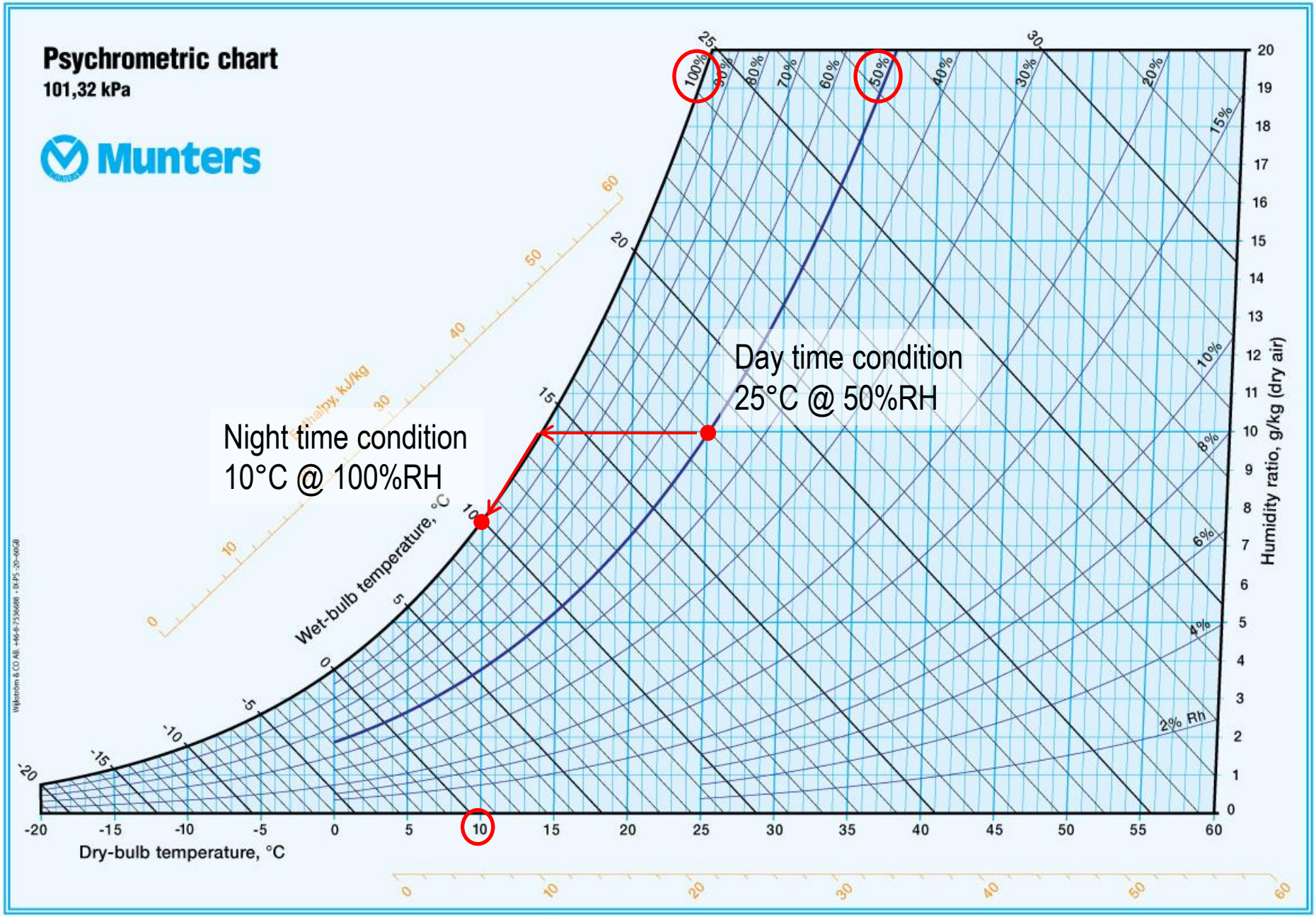
Dehumidification can be combined with cooling to reach the desired climate at optimal energy efficiency

Humidity Control

The Benefits of Humidity Control

- Condensation prevention
- Corrosion prevention
- Electrical resistance optimisation
- Mould prevention
- Property change optimisation, incl. drying
- Chemical reaction prevention
- Comfort optimisation
- Energy optimisation
- Other reasons (damping, ionisation prevention, etc.)

Mostly, the benefits are found in a combination of above reasons


Psychrometric chart
101,32 kPa
Munters
Day time condition
25°C @ 50%RH
Night time condition
10°C @ 100%RH
Dry-bulb temperature, °C
Wet-bulb temperature, °C
Humidity ratio, g/kg (dry air)
Enthalpy, kJ/kg
100%
90%
80%
70%
60%
50%
40%
30%
20%
15%
10%
8%
6%
4%
2% Rh

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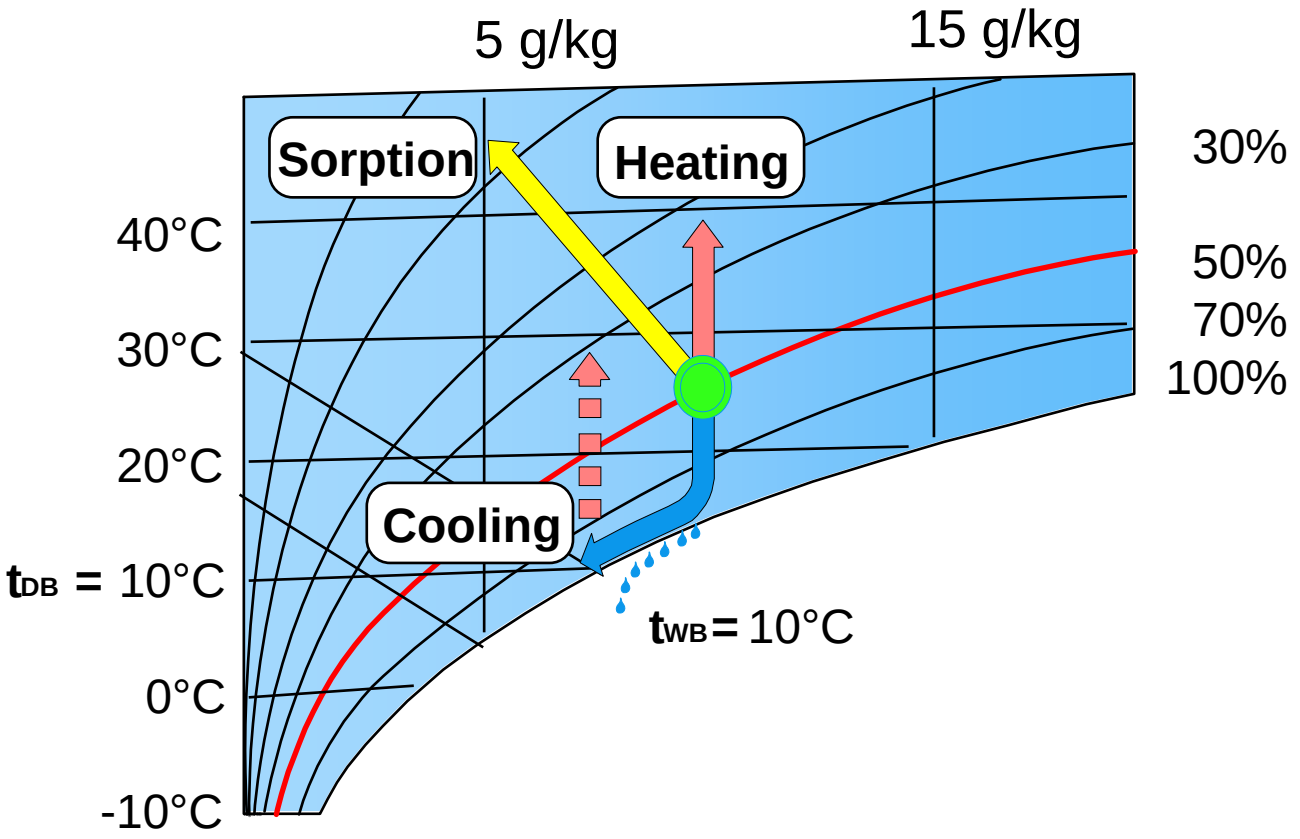
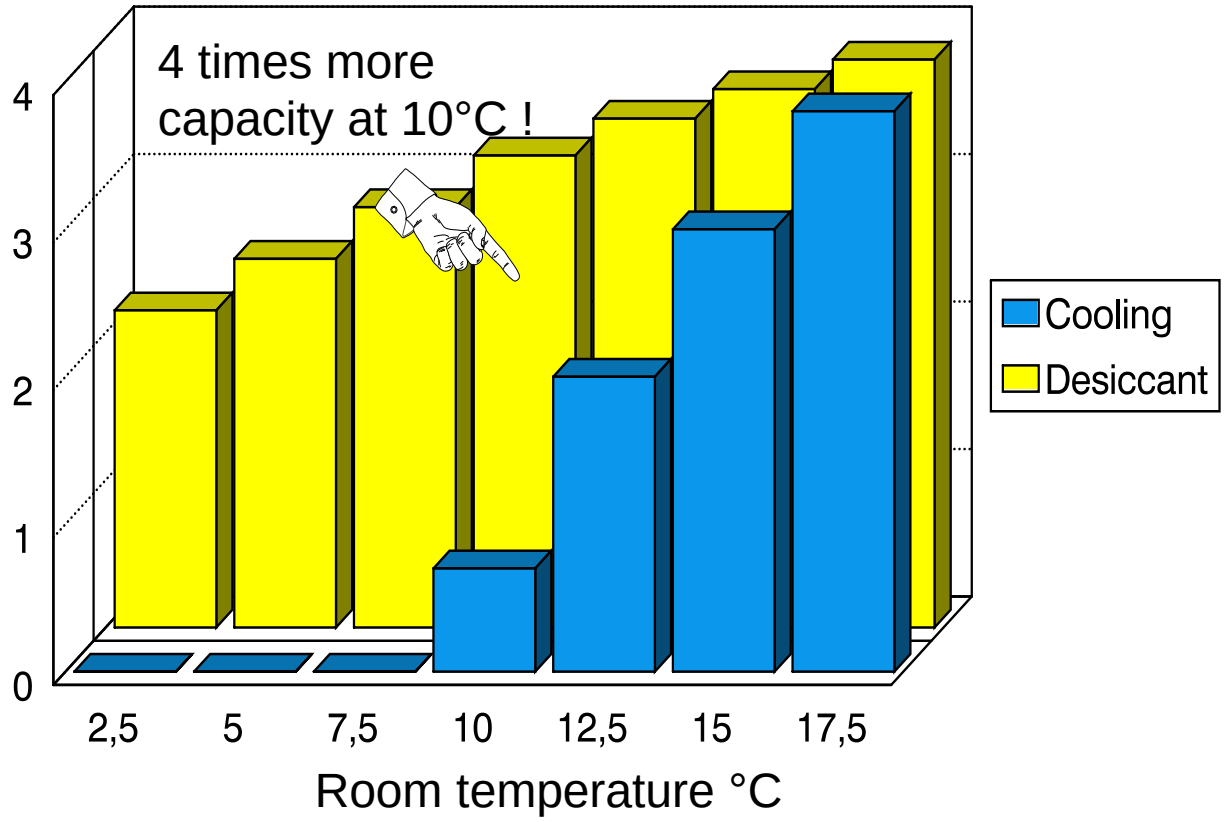
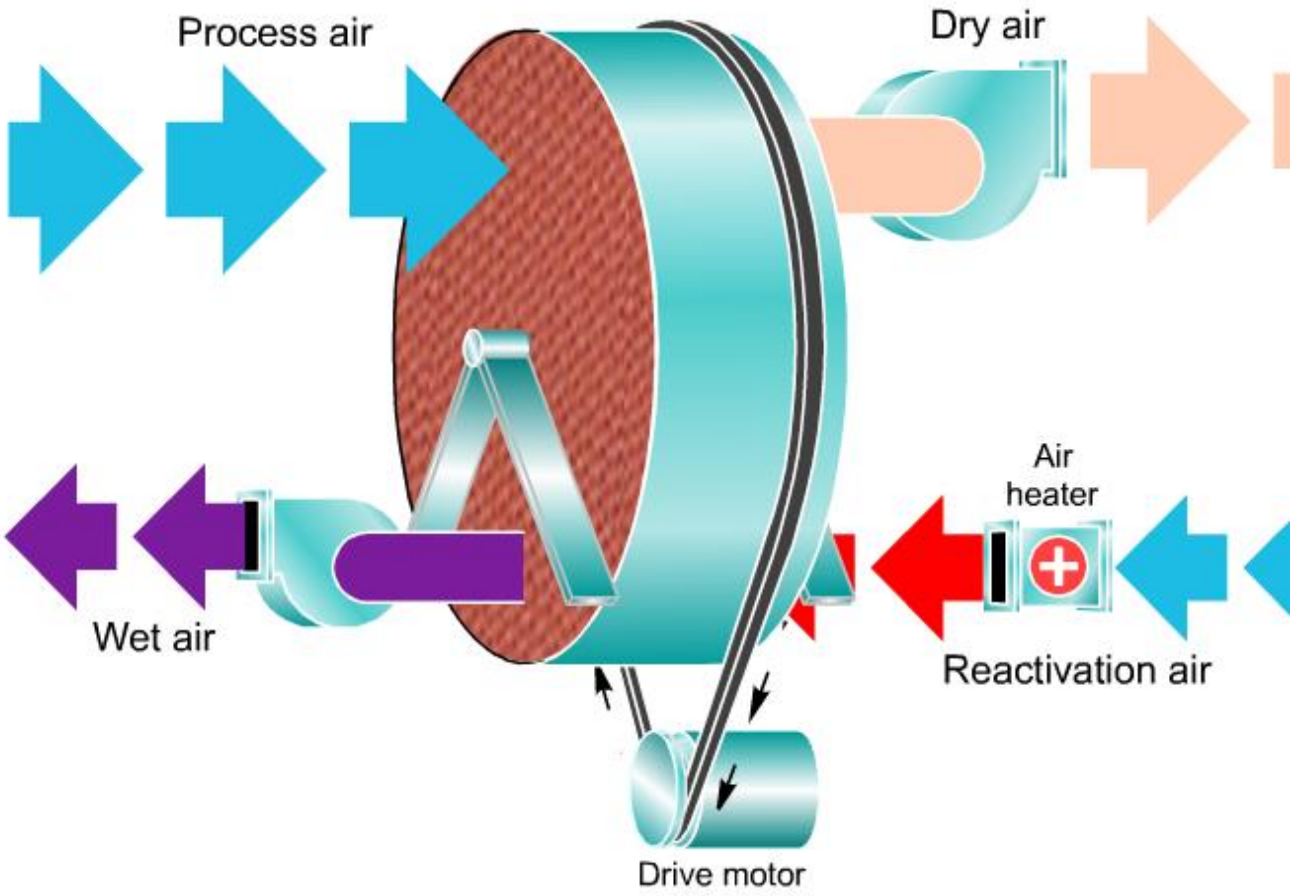
Changing Environment - Methods



Desiccant vs Cooling - Dumidification Capacities at 50% RH

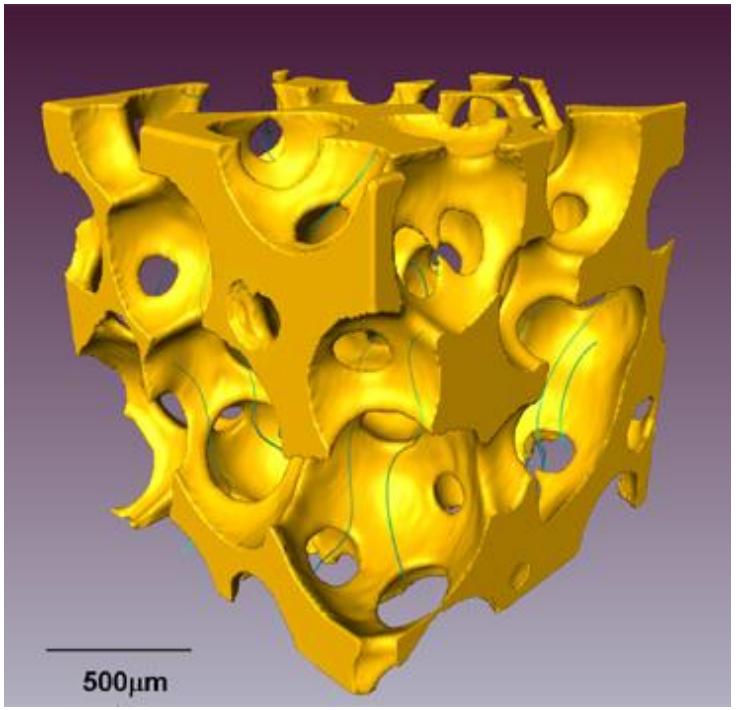


Sorption Dehumidifier - Munters Rotor Principle



Silica Gel

- A non-crystalline (amorph) silicon dioxide based material which has water molecules in its composition. Adsorption takes place in cavities and pores.



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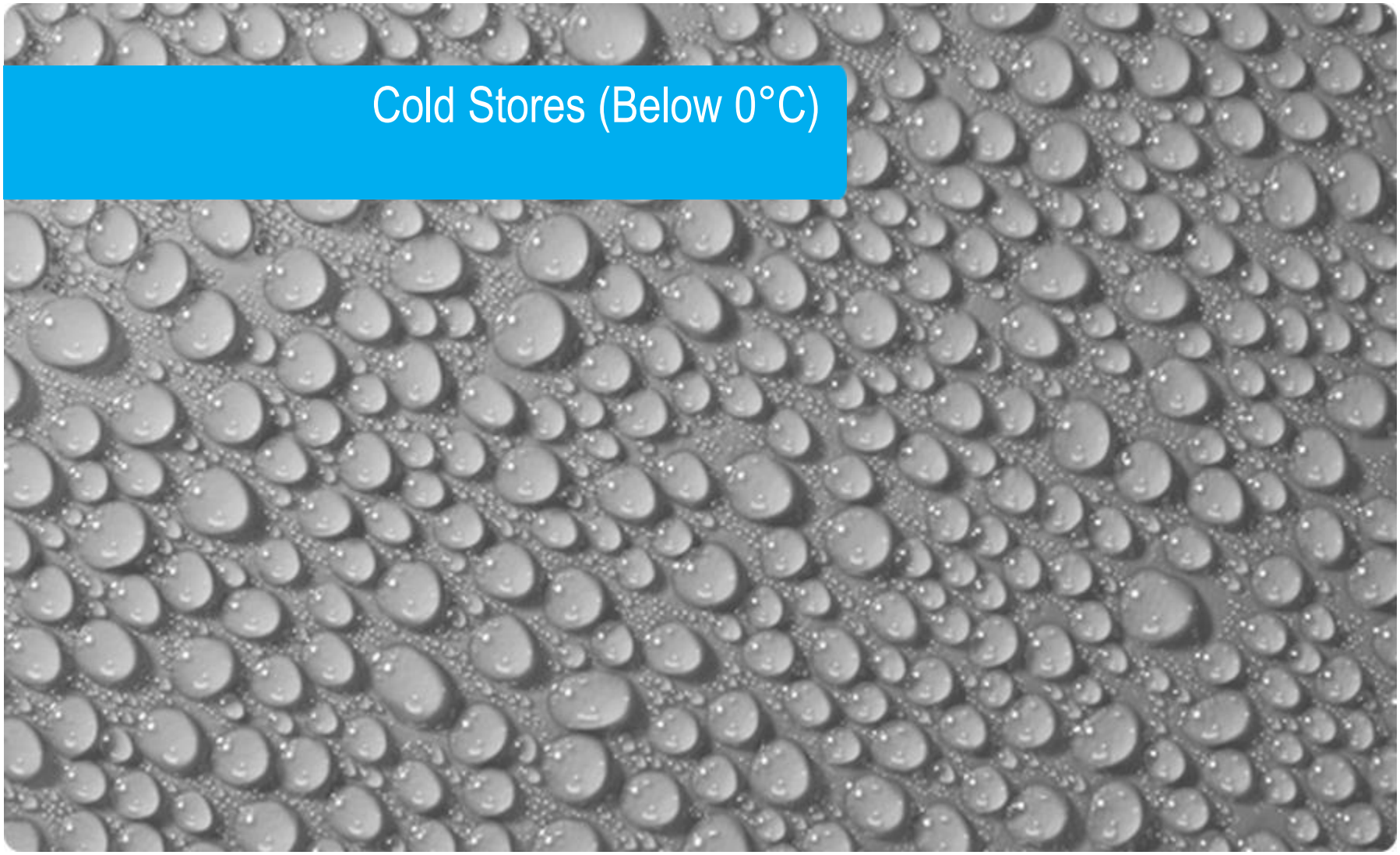
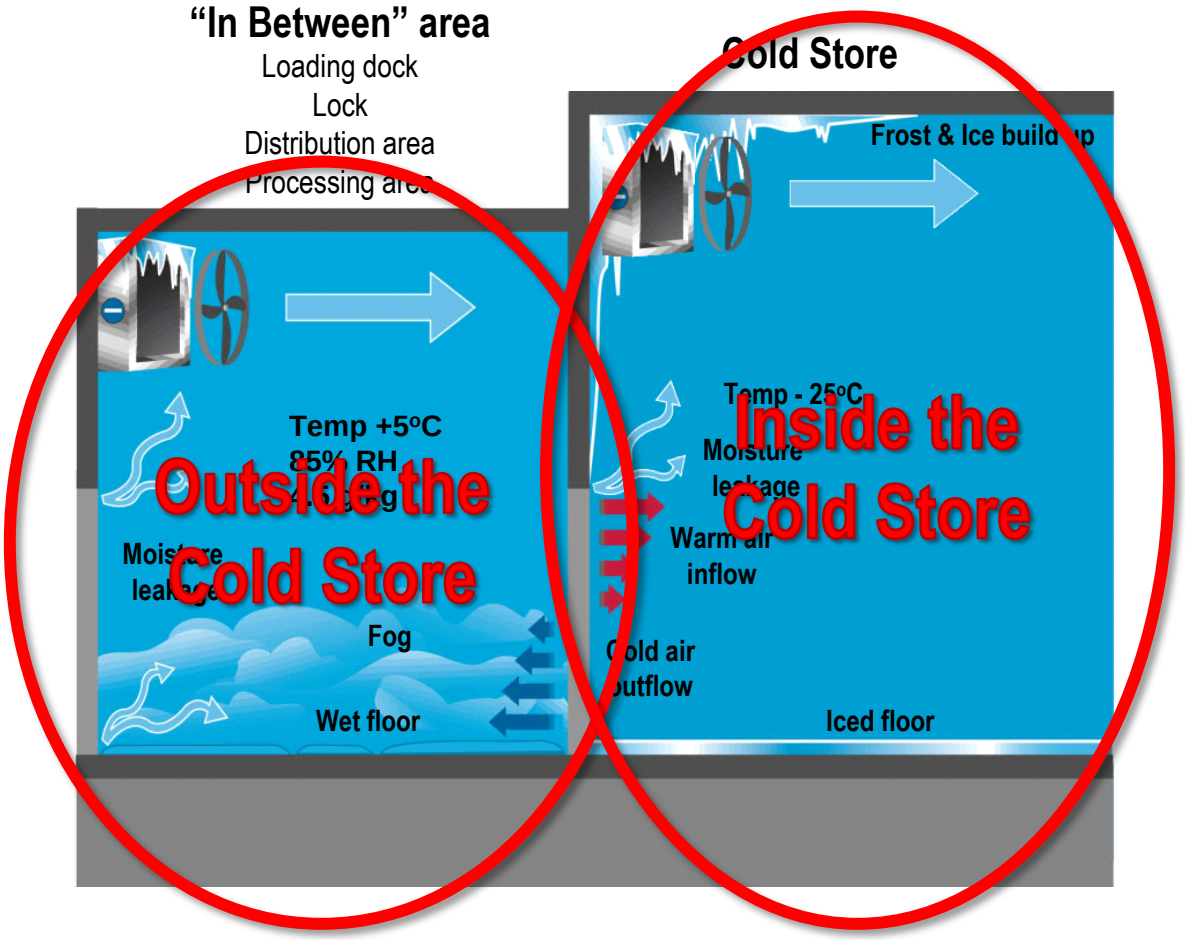
Cold Stores (Below 0°C)



Cold Store problems have two dimensions….

Ambient Outside



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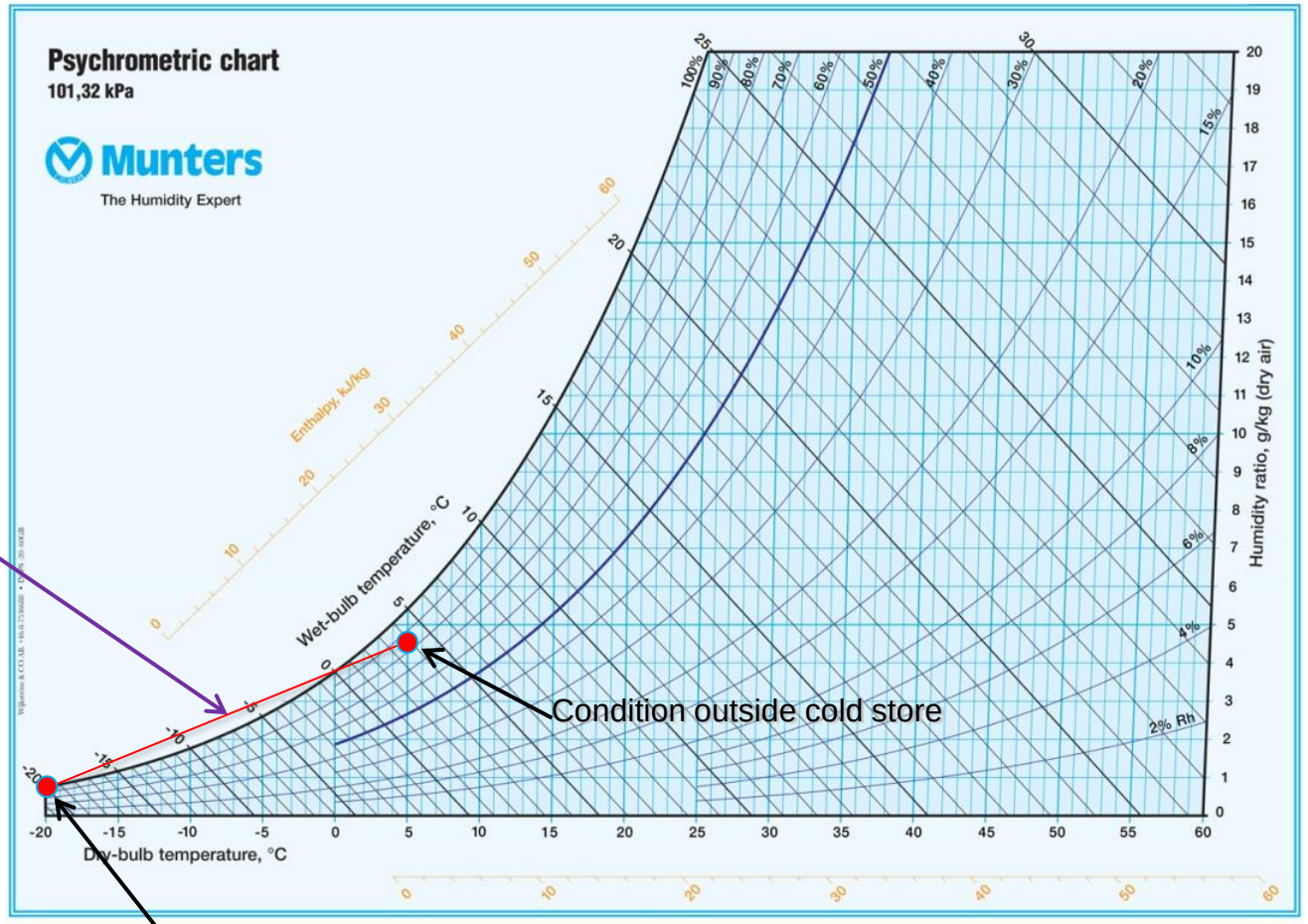
Dewpoint and Cold Stores

The line is cutting through the saturation line Water vapour turns into fog, below 0°C into ice particles



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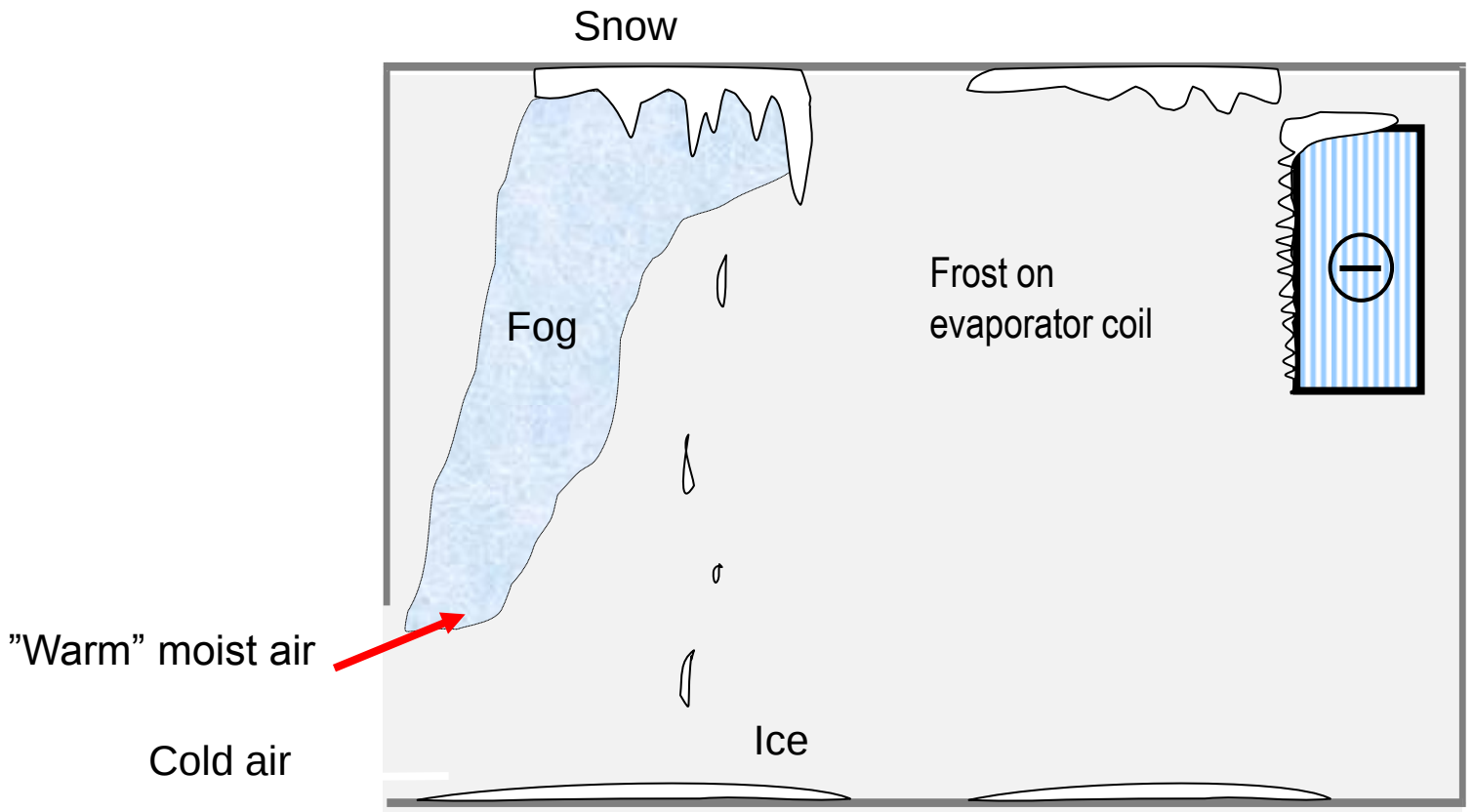
In the Cold Store



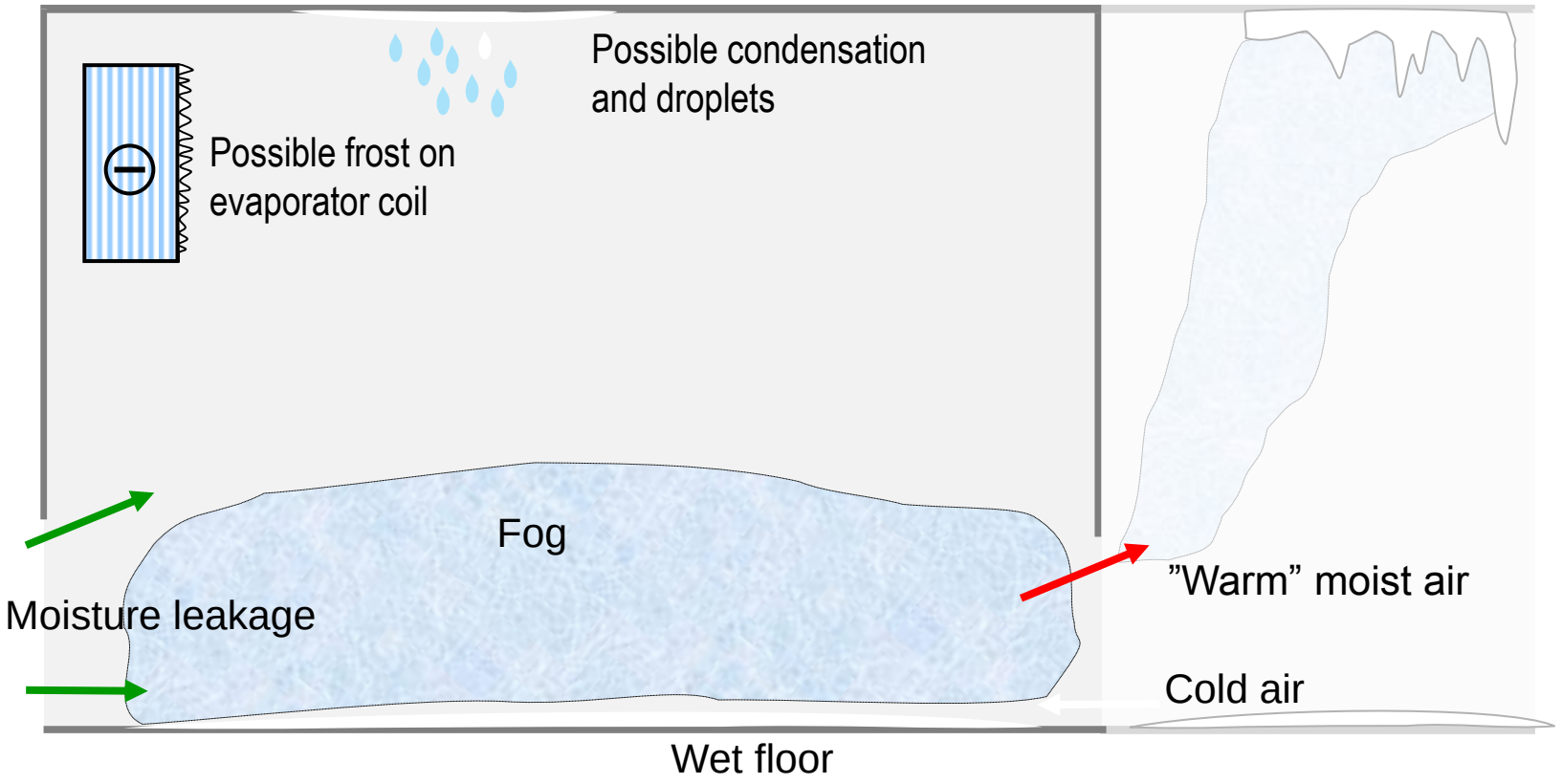
In the Cold Store

- High outside humidity causes ice formation inside Cold Store on cold surfaces
  - on the ceiling
  - the evaporator
  - on products, scaffolds and shelves
  - on entry door areas
- Ice formation on the ceiling also causes “snow” which falls down on the floor and on products
  - Ice on the floor (snow compressed by forklifts, pallet trucks, handling equipment)
  - Additional ice formation on products
- Fog around the door area

In the Cold Store

- Ice on the evaporator forms an insulated layer on the coil (COP degradation)
  - Reduced efficiency of the refrigeration process – increased energy consumption
  - Growing layers will reduce and ultimately block the airflow through the coil – again reducing efficiency of the refrigeration process
- Fog, Ice and Snow
  - SAFETY HAZARD
    - Slippery floors
      - Persons - personal hazard (people can slip)
      - Forklifts collisions with objects such as scaffolds/shelves and doors or with people
    - In the doors - enhanced chance of accident due to reduced visibility
      - Fog
      - Iced up flap doors - collisions with people or other forklifts
  - CONTAMINATION HAZARD - possible contamination of products by dirty snow
  - Accelerated degradation of cardboard packaging materials when it leaves the cold store
  - Decreased readability of bar codes (laser deflection on ice crystals)

Outside the Cold Store



Outside the Cold Store

- Combination of cold air coming from Cold Store, moisture leakage from outside and refrigeration creates excessive RH%
  - SAFETY HAZARD
    - Wet slippery floors - personnel hazard (people can slip)
    - Fog - reduced visibility leading to collisions with people or other forklifts
  - CONTAMINATION HAZARD
    - Possible condensation compromises hygiene

- Conditions outside the Cold Store drive the problems inside the Cold Store (earlier slides)

Existing customer strategies inside Cold Stores

- Existing solution strategies solve only parts of the problem and are temporary and/or costly
- Defrost cycles for evaporators
  - Costs energy
  - Loss of cold store condition
- Floor heating near the door (up to 8-10 kW)
- Manually removing ice/snow for the cold store (remove from walls, floors, product)
  - Labour intensive
  - Damage to cold store structure

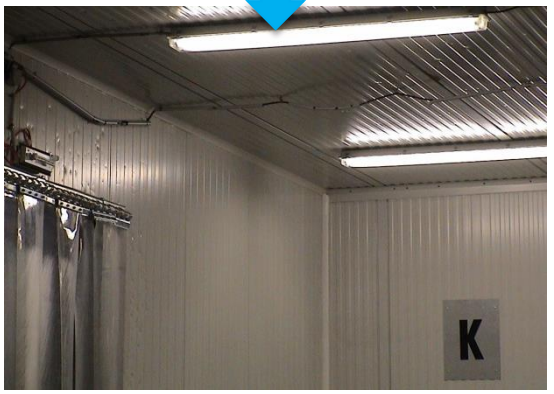
Benefits of dehumidification

- Less damage to the cold store and loading areas
  - No ice scraping
  - Less condensation damage
  - Better performance of automated equipment and sensors
  - Special impact on automated / robotic cold stores
  - Less corrosion damage
  - Cardboard packing boxes remain in better shape
- Higher speed of product movement
  - Better visibility
  - No slippery floors
  - Optimal bar code or label reading
  - Improved picking rates and handling of boxes
- Spaces faster to clean
  - Drying after cleaning

Benefits of dehumidification

- Keeping ice and condensation away from evaporator coils
  - Higher efficiency of the evaporator (COP)
    - Less latent load for the coils
    - Allows more economic setting for refrigeration system
  - Time between defrost considerably lengthened
  - Less energy loss due to defrost (can take up to 15% of the total energy consumption, in some cases reduced to 3%)
- No floor heating (up to 8-10 kW) needed near door (common in newer cold stores)
- Energy savings are bonus on top of the improvements in safety, hygiene and efficiency

Before and after dehumidification



Because of <u>ACTIVE</u> moisture removal capacity ice formation is sublimated

(Ice changes phase and turns directly into vapour without passing through the liquid phase)

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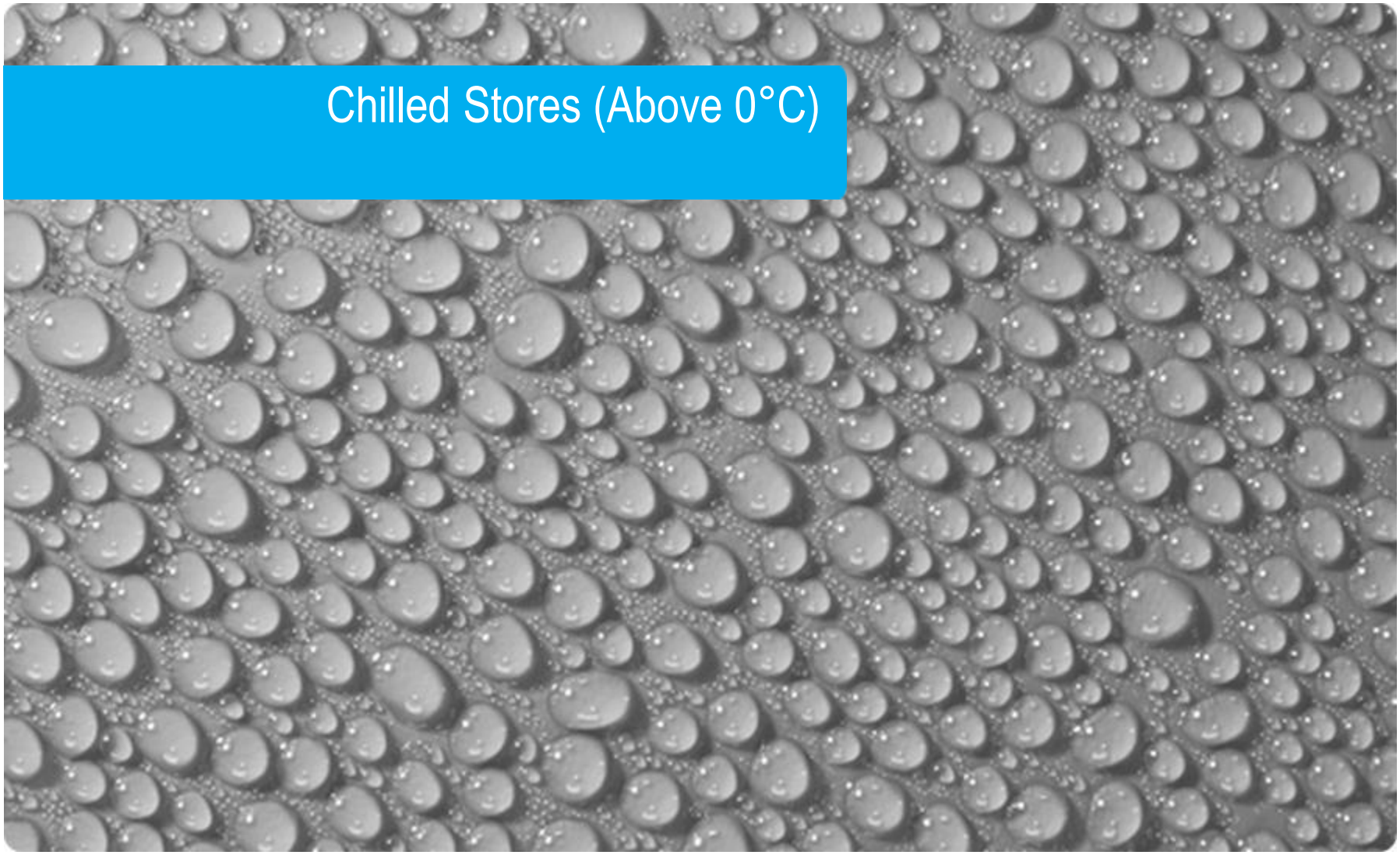
Chilled Stores (Above 0°C)

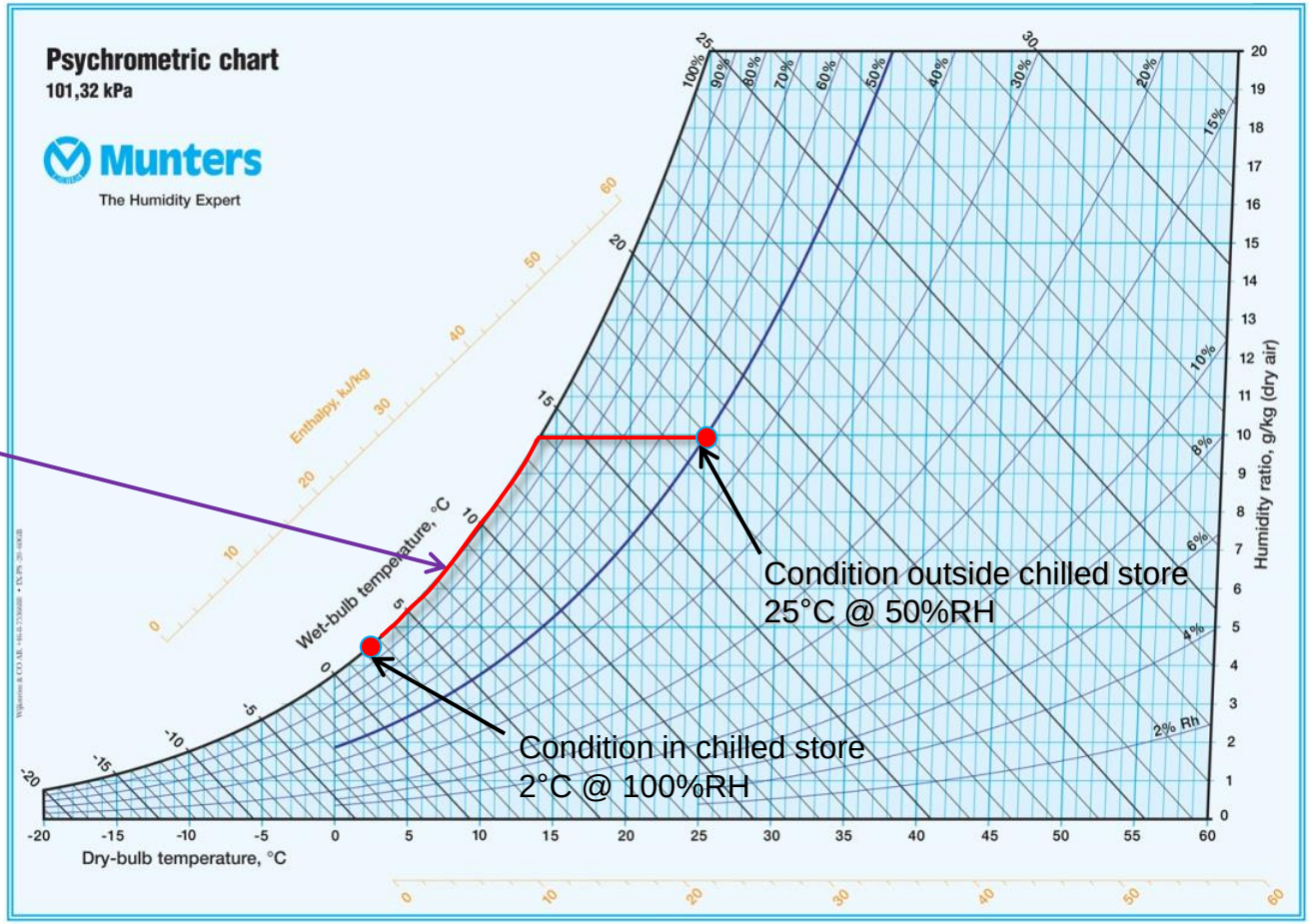


Particular Challenges with Chilled Stores

- Typically in the 2 to 8°C temperature range
- If humidity is not controlled then RH within the chilled space can be >90%
- Cold surfaces will allow condensation to occur
- If this is left untreated additional issues can arise
- Easy to treat with dehumidification

Dewpoint and Chilled Stores

The line hits the saturation line Water vapour turns into water and condenses out on cold surfaces



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Chillers, Humidity and Cold Surfaces

Chillers, Humidity and Cold Surfaces

- Water droplets form on the lighting fittings, ceiling or chiller units
- These droplets occasionally drop onto boxes of vaccine below.
- Mould, bacteria or yeast growths in the water droplets would be transferred onto the boxes.
- If enough droplets were to fall on a particular box in the same location over time, contaminants could enter the box and come in contact with the sealed vaccines inside.

Water Activity and Microbial Growth

- The growth and metabolism of microorganisms demand the presence of water in an available form, which is measured as water activity, a_w
- The a_w of a solution equals the ratio of the water vapour pressure of the solution (p) to that of pure water (p0) at the same temperature. When a solution becomes more concentrated, vapour pressure decreases and the a_w drops from a maximum value of 1 for pure water.
- Many microorganisms, including pathogenic bacteria, grow most rapidly at levels of a_w in the range of 0.99 – 0.98. Below this aw the growth rate decreases and the length of the lag phase increases
- No microorganisms can grow at an $a_w < 0.50$

Examples of Water Activity and Microbial Growth

Substance	a_w
Distilled Water	1.00
Tap water	0.99
Saturated NaCl solution	0.75
Typical indoor air	0.5 - 0.7

Microorganism Inhibited	a_w
Most bacteria	0.97 – 0.85
Most moulds	0.80
Xerophilic molds and yeasts	0.75 - 0.80
Yeasts	0.70 - 0.75
Osmophilic yeasts	0.65 - 0.70
Xerophilic molds, osmophilic yeasts	0.60 - 0.65
No microbial proliferation	0.50

Moulds

- Moisture plays an important role as the base for metabolism and therefore for any growth
- Moulds do not need droplets of water to form - water vapor concentrations of > 80% relative humidity are sufficient.
- Once established, some moulds can transport free water to dry areas. (For example, dry rot)
- Moulds can be highly hygroscopic due to large surface area. The result is that water molecules are filtered from the air (thawing effect). This process is particularly enhanced when mould develops on cold walls.

In closing

Humidity is present in all environments

Dehumidification can deliver the following benefits

- Eliminate Condensation (water) and frost formation (ice – i.e. condensation below 0°C)
- Prevent corrosion of metals
- Prevent influence of moisture on resistance values (electronic malfunctions)
- Stop mould formation and improve hygiene
- Prevent property and quality change of materials and substances

Thank you for your attention

Martin Ginty – martin.ginty@munters.de

www.munters.com