• Humidity & Customer Problems
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
Munters Core Competencies

- Dehumidification
- Humidification
- Evaporative cooling
- Refrigeration
- Heating
- Energy recovery
- Mechanical separation liquid from gas
Pharma - Packaging of Effervescent Tablets
Pharma - Manufacturing of Gelatine Capsules

- Drying of gelatine
- Production of capsule shape
- Capsule content
- Packaging
Pharma - Cleanrooms
Humidity
The Composition Of Air

Air Pressure
101 kPa
1013 mbar
760 mm Hg

Partial Pressures

~1% Noble gases Ar, etc.

~21% O₂ Oxygen

~78% N₂ Nitrogen

Vapour Pressure

0-3% H₂O Water Vapour

Earth Surface
• **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
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

- April: 50%
- Juli: 70%
- Oktober: 100%

06: 90%
12: 90%
18:
24:
Typical summer temperature and humidity conditions

<table>
<thead>
<tr>
<th>City</th>
<th>Dry temp</th>
<th>X-value g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stockholm</td>
<td>19,8</td>
<td>12,2</td>
</tr>
<tr>
<td>Riyadh</td>
<td>22,9</td>
<td>13,0</td>
</tr>
<tr>
<td>Sydney</td>
<td>24,8</td>
<td>16,4</td>
</tr>
<tr>
<td>New York</td>
<td>26,8</td>
<td>17,8</td>
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<td>28,0</td>
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<td>Rio de Janiero</td>
<td>30,1</td>
<td>21,5</td>
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<td>Singapore</td>
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<td>Shanghai</td>
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<td>Caracas (We)</td>
<td>31,7</td>
<td>27,2</td>
</tr>
<tr>
<td>Raufahofn (Isl)</td>
<td>13,9</td>
<td>8,9</td>
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</table>
Sources Of Humidity In a “Closed” Environment

1. Unintentional ventilation
2. Intentional ventilation
3. Evaporation from water surfaces
4. Emission from people
5. Diffusion
6. Evaporation from hygroscopic materials
7. Emission from combustion engines
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
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
Visible Humidity - Condensation on cold surfaces or in cold air
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

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 (25-30°C) and high humidities.

Below 70% Relative Humidity mould growth is virtually ZERO.
High Humidity Speeds Up Mould Growth – Hanoi Example

Hanoi, Hoàn Kiếm, Hanoi, Vietnam
Wednesday 8:00 AM
Mostly Cloudy

25°F | °C
Precipitation: 8%
Humidity: 74%
Wind: 16 km/h

Relative Humidity by month

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
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<td>67</td>
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</tr>
</tbody>
</table>
Materials and substances will have changing properties at different humidities

Storage and production in the right, constant climate will optimise quality of the product and the production process and reduce cost
Some manufacturing and curing processes require a product to be dried. Product drying is a delicate process, especially if heat is a concern.
Human comfort feeling depends on a combination of room temperature, air speed, wall temperature and RELATIVE HUMIDITY.

At lower RH less cooling is required to maintain a comfortable climate.

Other benefits are no condensation and mould growth is the duct system.... much healthier!
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
How to determine Relative Humidity and Dew Point

21°C Dewpoint Condensation will occur on cold surfaces
Relative Humidity Cycle During 24 Hours
Relative Humidity in Winter – Outdoors versus Indoors
Changing Environment - Methods

- 0°C to 10°C
- 10°C to 20°C
- 20°C to 30°C
- 30°C to 40°C

- t_{WB} = 10°C
- t_{DB} = 10°C

- Sorption
- Heating
- Cooling

- 5 g/kg
- 15 g/kg

- 0% to 30%
- 50% to 100%
Costs Comparison - Condensation vs Sorption

Lower operational costs; Sorption

Approximately equal Prices and Capacities

Lower operational costs; Condensation

$t_{DP} = +5^\circ C$

$t_{DB} = 10^\circ C$

5 g/kg

15 g/kg

30%

40%

50%

100%
Costs Comparison - Condensation vs Sorption

- Example of real Munters customers
  - Sample size: 52 Pharmaceutical clean room applications
  - Average Dew Point: -5°C
  - Highest Dew Point: 7°C
  - Lowest Dew Point: -27°C
- 51 of these applications are below 5°C DP
- 36 of these applications are below 0°C DP
- In almost all cases condensation type dehumidification (DX / refrigeration / chillers) would not be suitable
Desiccant vs Cooling - D/H Capacities at 50% RH

4 times more capacity at 10°C!
Sorption Dehumidifier - Munters Rotor Principle
• A non-crystalline (amorph) silicon dioxide based material which has water molecules in its composition. Adsorption takes place in cavities and pores.
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