COMPRESSED AIR
BEST PRACTICES
airbestpractices.com

# Balancing Energy Efficiency & Dewpoint with Desiccant Dryers

Brought to you by:

KAHN

For your free subscription, please visit
http://www.airbestpractices.com/magazine/subscription.

COMPRESSED AIR
BEST PRACTICES
airbestpractices.com

# Balancing Energy Efficiency & Dewpoint with Desiccant Dryers

Introduction by Rod Smith, Publisher,
Compressed Air Best Practices® Magazine

For your free subscription, please visit
http://www.airbestpractices.com/magazine/subscription.

COMPRESSED AIR
BEST PRACTICES
airbestpractices.com



**All materials presented are educational. Each compressed air system is unique and must be evaluated on its own merits.**

COMPRESSED AIR
BEST PRACTICES
airbestpractices.com

# About the Speaker

Hank van Ormer, Air Power USA

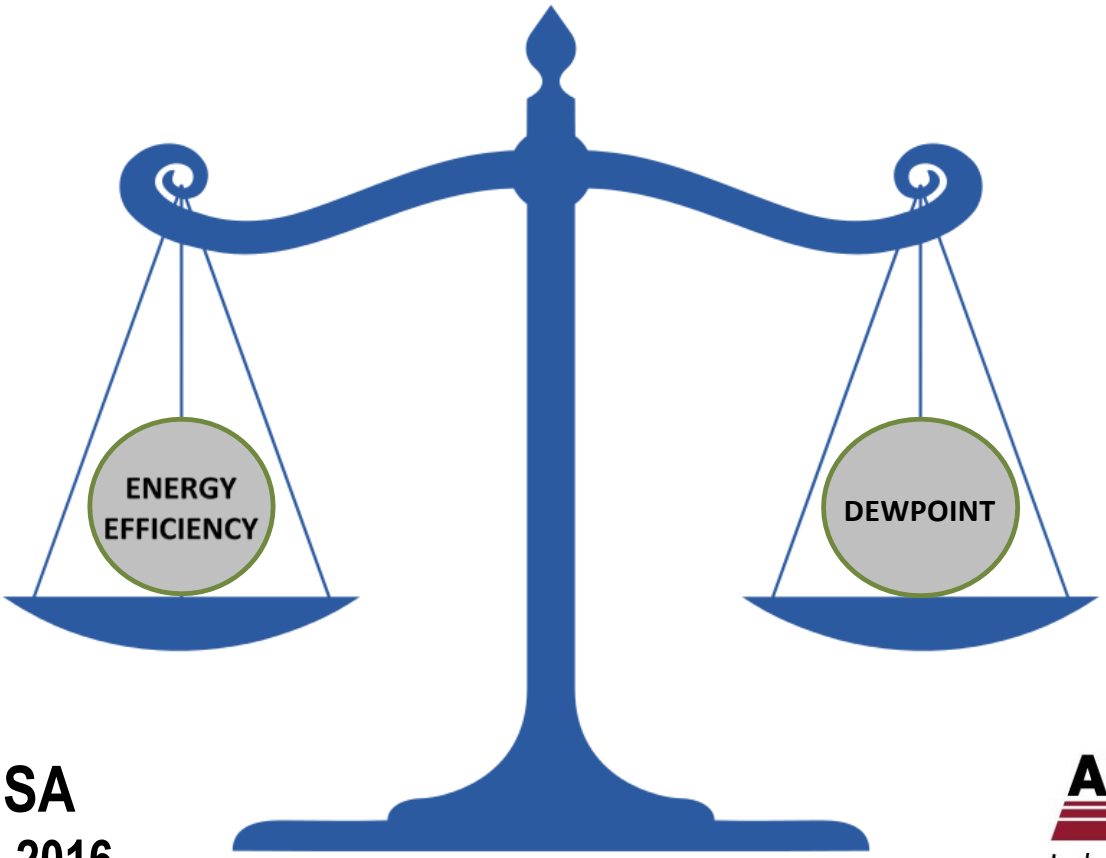
- Founded Air Power USA in 1986
- Over 50 years of experience in the compressed air and gas industry

Brought to you by:

KAHN

For your free subscription, please visit http://www.airbestpractices.com/magazine/subscription.

# Balancing Energy Efficiency & Dewpoint with Desiccant Dryers




Air Power USA
September 29, 2016

AIR POWER USA
Independent and Brand Neutral

# Introduction

This webinar presentation will explore the opportunities of energy savings with modern dewpoint controls correctly applied to dual-tower desiccant dryers both heatless and heated type.

We will not review other types such as selective membrane; fixed desiccant; split stream heat-of-compression; vacuum purge etc.

**Refrigerated Dryers (+40°F / 4.4°C Pressure Dewpoint)**

- Fixed kW value for the BTU's / hour to cool the RATED FLOW at RATED conditions (unless cycling)

**Dual Tower / Desiccant Dryers (used to reach lower pressure dewpoint) (-40°F / 40°C or lower)**

- Desiccant dryers are more complicated to identify and balance the necessary performance levels and optimize net energy usage.

# Compressed Air Dryer: Rating Conditions

AIR POWER USA
Independent and Brand Neutral

Most commercial standard compressed air dryer performance and flow ratings are based on the Compressed Air and Gas Institute (CAGI) standard ADF 200 conditions of inlet air pressure of 100 psig (7 Bar) and inlet air temperature saturated of 100°F (38°C).

- Lower pressure will allow more water vapor than rated to enter the dryer.
- High air temperature will allow more water vapor than rated to enter the dyer.

**Identify and control inlet & discharge conditions to maintain projected dryer performance**

# Typical OEM Temperature & Pressure Correction Chart – Heated Type

AIR POWER USA
Independent and Brand Neutral

| Pressure (psig) | Inlet Temperature °F (°C) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 60 (15.6) | 70 (21.1) | 80 (26.7) | 90 (32.2) | 100 (37.8) | 110 (37.8) | 120 (48.9) |
| 60 (4.2) | 1.03 | 1.01 | 0.99 | 0.80 | 0.58 | 0.43 | 0.32 |
| 70 (4.9) | 1.10 | 1.08 | 1.07 | 0.94 | 0.68 | 0.50 | 0.37 |
| 80 (5.6) | 1.17 | 1.15 | 1.14 | 1.08 | 0.79 | 0.58 | 0.43 |
| 90 (6.3) | 1.24 | 1.22 | 1.20 | 1.18 | 0.89 | 0.66 | 0.49 |
| 100 (7.0) | 1.30 | 1.28 | 1.26 | 1.24 | 1.00 | 0.74 | 0.55 |
| 110 (7.7) | 1.36 | 1.34 | 1.32 | 1.30 | 1.11 | 0.82 | 0.61 |
| 120 (8.40 | 1.42 | 1.40 | 1.38 | 1.36 | 1.22 | 0.90 | 0.67 |
| 130 (9.1) | 1.48 | 1.46 | 1.44 | 1.42 | 1.33 | 0.99 | 0.74 |
| 140 (9.8) | 1.53 | 1.51 | 1.49 | 1.47 | 1.44 | 1.07 | 0.80 |
| 150 (10.6) | 1.58 | 1.56 | 1.54 | 1.52 | 1.50 | 1.16 | 0.87 |

Pressure deration applies to heatless but temperature deration does not. **Desiccant does not work at >130°F**

# What Pressure Dewpoint do you Need?

AIR POWER USA
Independent and Brand Neutral

## Identify the pressure dewpoint first and design to it.

**ISO 8573.1 Quality Classes**

"As dry as possible is not a class"

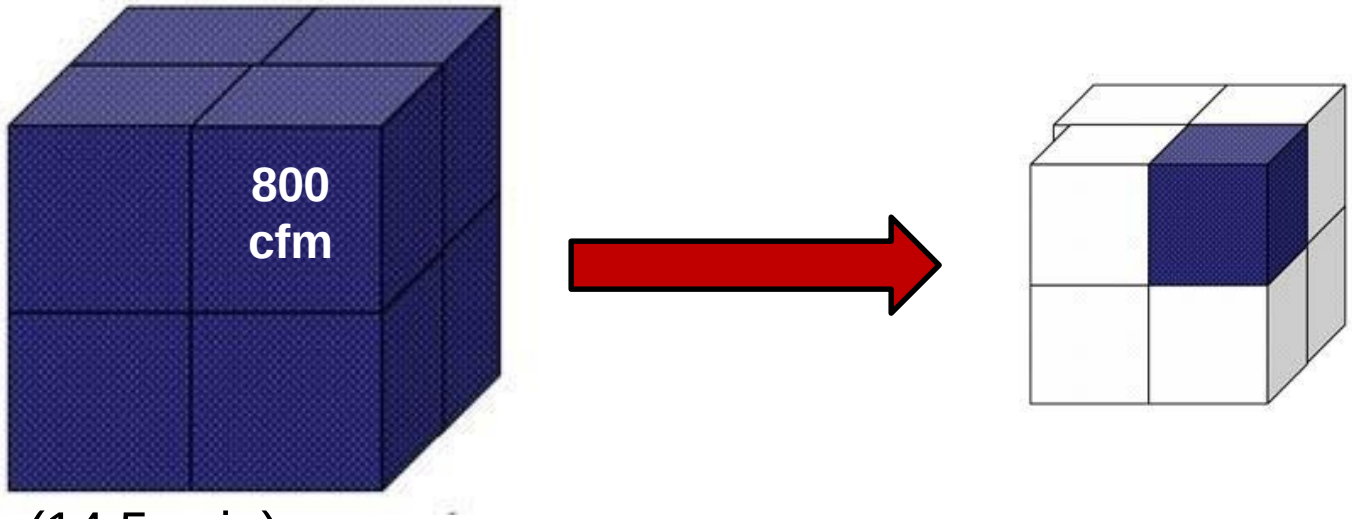
Some processes with hygroscopic material are very low relative humidity (RA) dependent and may require a very low constant pressure dewpoint.

| Quality Classes | SOLIDS Maximum particle size in microns | MOISTURE Dewpoint | | OIL Liquid & Gas | |
|---|---|---|---|---|---|
| | | °C | °F | mg / m3 | ppm / w/w |
| 0 | As specified | As specified | | As specified | |
| 1 | 00.1 | -70 | -94 | 0.01 | 0.008 |
| 2 | 1 | -40 | -40 | 00.1 | 0.08 |
| 3 | 5 | -20 | -4 | 1 | 0.8 |
| 4 | 15 | 3 | 38 | 5 | 4 |
| 5 | 40 | 7 | 45 | >5 | >4 |
| 6 | -- | 10 | 50 | -- | -- |

# Basic Rule: #1

AIR POWER USA
Independent and Brand Neutral

#1 Hot air holds more water in vapor form than colder air per actual cubic feet of air.



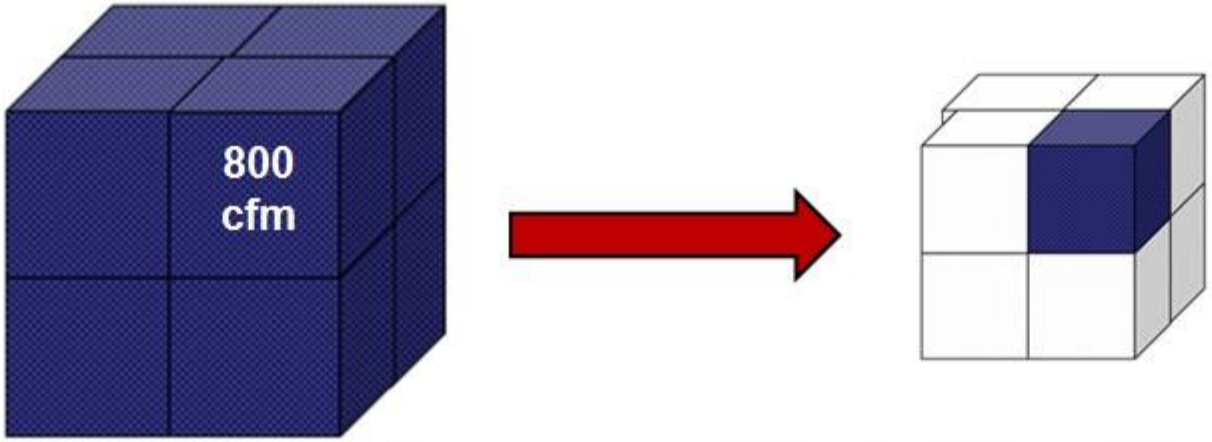

0 psig (14.5 psia)
Atmospheric Dewpoint – 70°F
Temperature – 80°F
Actual Cubic Feet – 800 cfm

100 psig (114.5 psia)
Pressure Dewpoint – 160°F
Air Temperature – 250-300°F+
Actual Cubic Feet – 100 cfm

# Basic Rule: #2

AIR POWER USA
Independent and Brand Neutral

#2 High pressure air holds less water in vapor form at the same temperature **because** there is less actual cubic feet. Pressure dewpoint is now 160°F not 70°F.



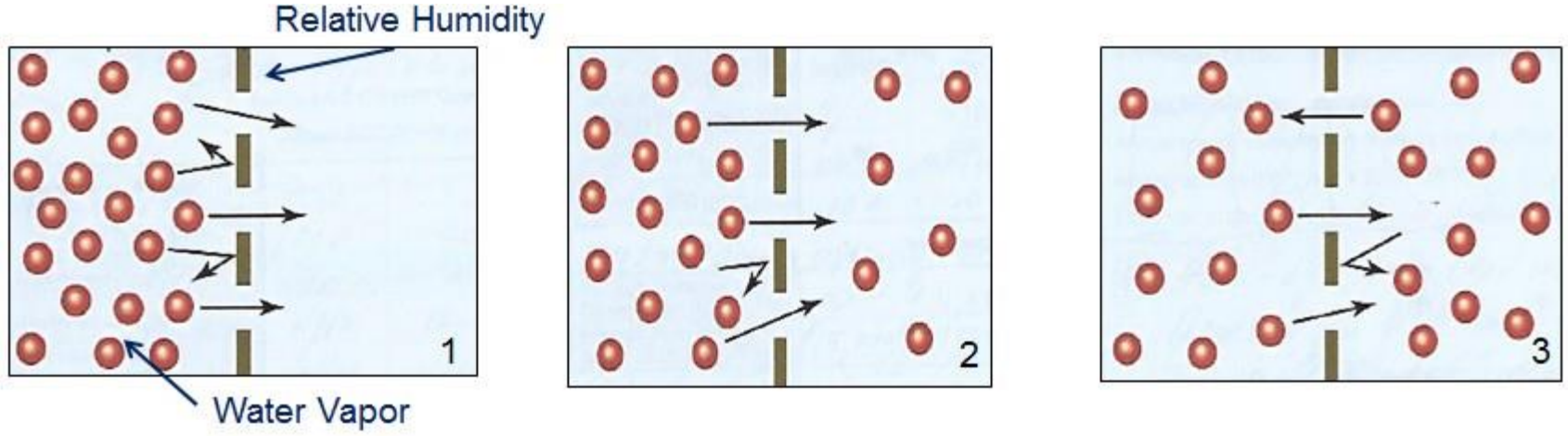

0 psig (14.5 psia)
Atmospheric Dewpoint – 70°F
Temperature – 80°F
Actual Cubic Feet – 800 cfm

100 psig (114.5 psia)
Pressure Dewpoint – 160°F
Air Temperature – 250-300°F+
Actual Cubic Feet – 100 cfm

# Basic Rule: #3

AIR POWER USA
Independent and Brand Neutral

#3 Fick's Law of Dispersion: When there is an imbalance in concentration – (water vapor / relative humidity) the vapor will always move from the high concentration level to the low concentration level to try to equalize regardless of flow direction.



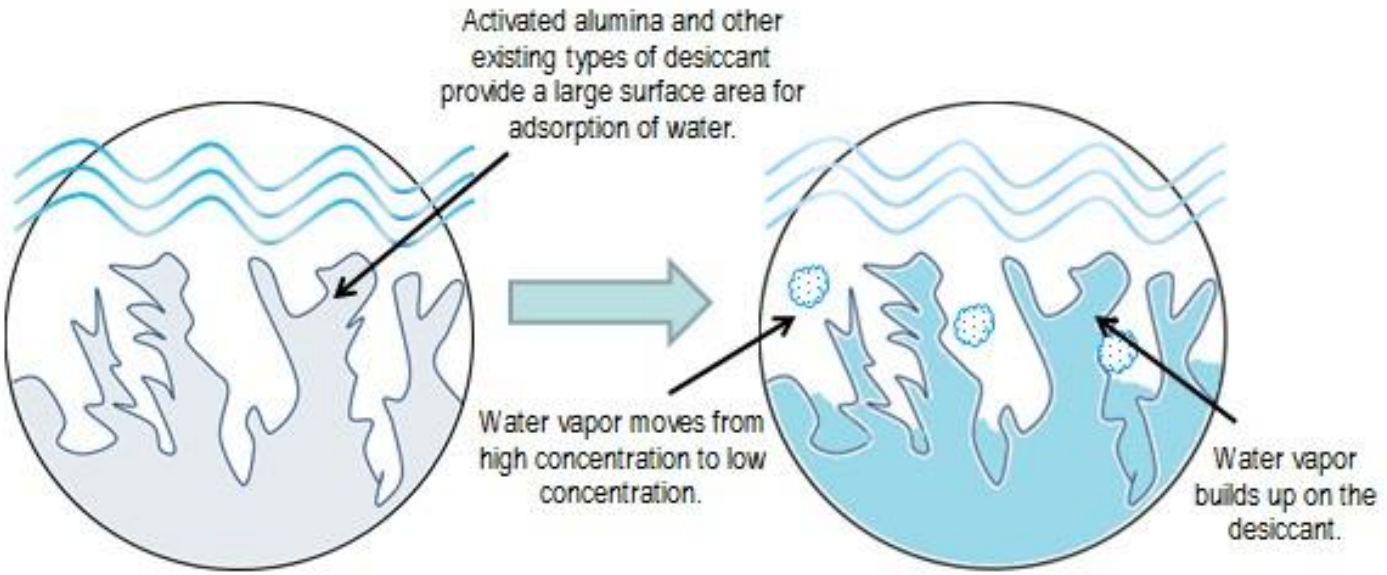

**The greater the imbalance the FASTER the transfer!**

# Desiccant Drying Process

AIR POWER USA
Independent and Brand Neutral

Desiccant Dryers {-100ºF to - 40ºF Pressure Dewpoint Nominal}

**Desiccant ADSORPTION of water vapor**




**NOTE: WILL NOT DRY AT ALL OVER 130ºF**

The desiccant is hygroscopic in nature and attracts the water vapor in the compressed air to its surface.

# Desiccant Drying Process

AIR POWER USA
Independent and Brand Neutral

- **All desiccant dryers** dry with the same process – the water vapor moves from the saturated compressed air to the bead surface via adsorption.
- Desiccant dryers differ by how they regenerate the wet tower. Regeneration occurs when we pass dry air and/or heated dry air (lower RH) over the bed – the water vapor purges out.

AS IN ALL COMPRESSED AIR CONTROLS - FIXED TIMER DRYER CONTROLS **CAN NOT DELIVER OPTIMUM OPERATING COSTS!**

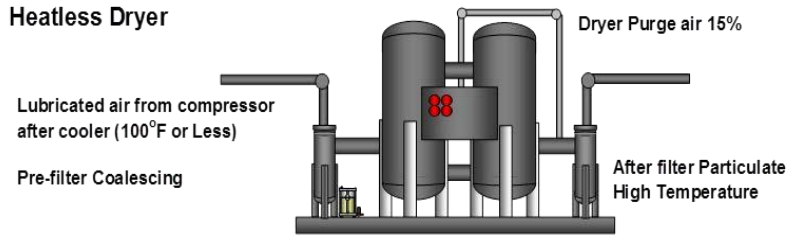
# Types of Dual-Tower Desiccant Dryers

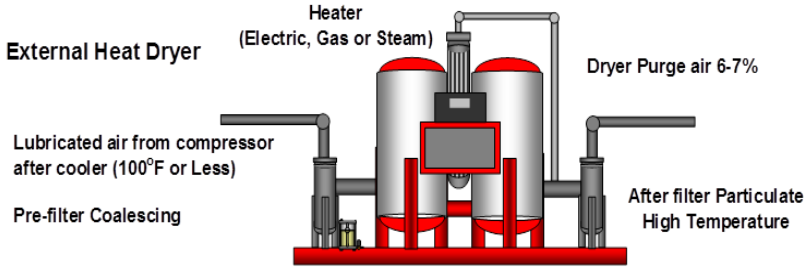
AIR POWER USA
Independent and Brand Neutral

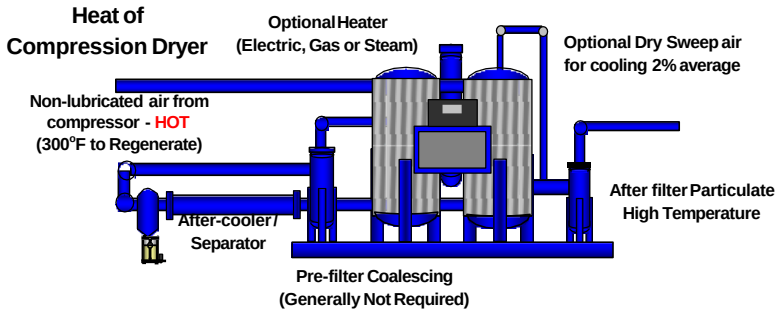
**Rated Purge Air**

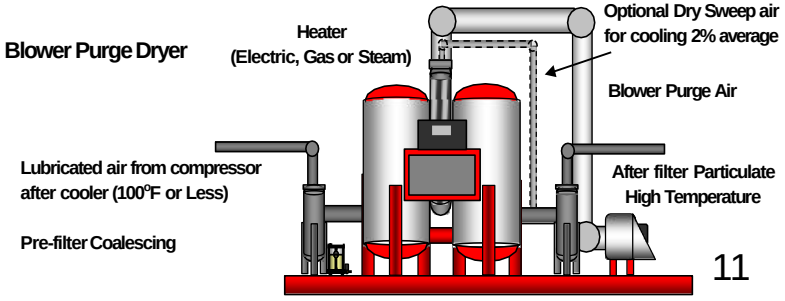
- Internal Heat = 3-5%
- Heatless = 15-20% (purge air)
- Heated Purge = 7-8% (may default to heatless = 15-20%) – kW heater
- Blower Purge = 3-4% (blower & kW heater)
- Heat-of-Compression = 0 to ? – depends on pressure dewpoint requirements and how equipped.

Internally Heated



# Heated Dryers are Vulnerable

AIR POWER USA
Independent and Brand Neutral

## Operating Bed Temperatures and Cooling Cycle

The ***challenge*** in operating heated desiccant dryers is to maintain consistent rated performance.

- To dry effectively the bed must be heated to about 300-400°F. When ready to switch the cooling cycle must reduce this temperature to below 120-130°F.
- At the tower switch the controls are critical to avoid “thermal bump” and “dewpoint spike” or some other appropriate action.

# Regenerating the Wet Towers

AIR POWER USA
Independent and Brand Neutral

Optimizing the energy use in twin-tower desiccant dryers and retaining the projected performance is primarily a function of controlling the regeneration cycles and knowing where you are in pressure dewpoint (PDP).

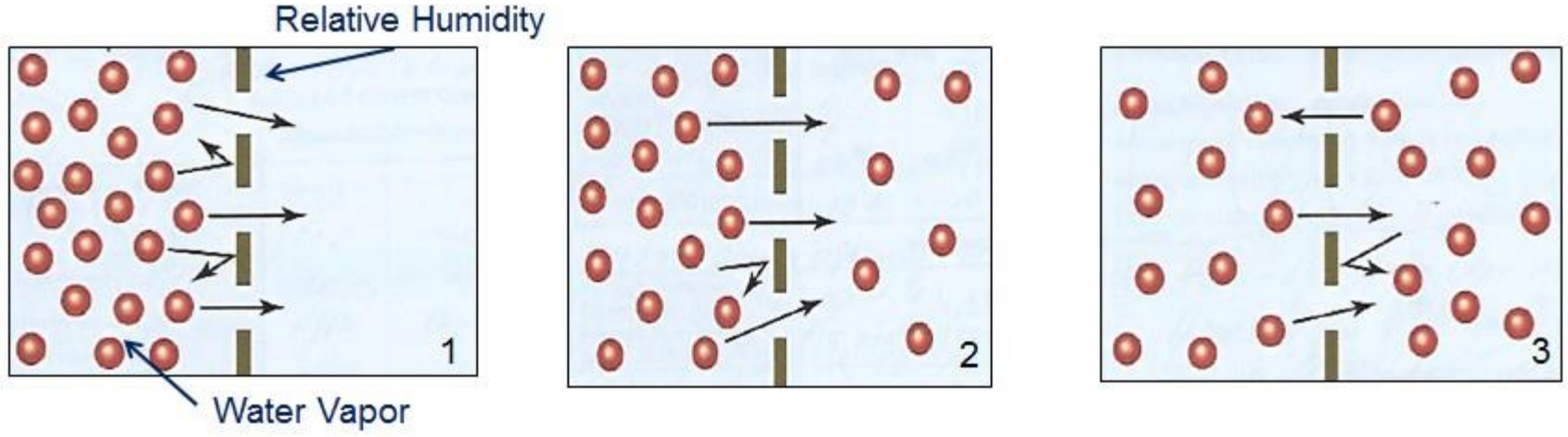
Two-step Regeneration:

- Relative humidity differential bed to purge air – for timely removal.
- Cooling cycle in heated dryer – nominal 1-hour of a total 4-hour regeneration cycle.

Standard dryers usually have fixed timer controls for these functions but the operating conditions are not fixed.

# Fick's Law of Dispersion

Fick's Law of Dispersion is key to understanding why responsive dewpoint demand and operational controls are critical to operating within proper performance targets – at the optimum energy costs!




- Vapor (water) will always move from an area of high concentration to low concentration (relative humidity).
- 100 psig – nominal and 40°F dry air without auxiliary heat has 15 to 20% purge air
- Heated air – lower the RH / faster removal when properly controlled allows less total purge air and heater kW.

# Effects of Dewpoint Demand on Dryer Operating Costs

AIR POWER USA
Independent and Brand Neutral

All Average Annualized Operating Costs in the Following Tables Were Calculated Using $.06 per kWh at 8,000 Hours Per Year.

All Projected Operating Costs in The Following Tables are Based on Delivering or Trying to Deliver a -40°F Pressure Dewpoint at the Stated Inlet Conditions.

# Dryer Specifications Without Dewpoint Demand Controls

AIR POWER USA
Independent and Brand Neutral

## Some Typical Desiccant Dryer Operating Energy Profiles Without Dewpoint Demand Control – 100°F

| Dryer Type | Heatless | External Heat | Internal Heat | Blower Purge | Heat-of-Compression |
|---|---|---|---|---|---|
| Rated Flow (scfm) | 1.000 | 1,000 | 1,000 | 1,000 | 1,000 |
| Temperature In (°F) | 100°F | 100°F | 100°F | 100°F | 100°F |
| Pressure In (psig) | 100 | 100 | 100 | 100 | 100 |
| Heater Power (kW) FL | N/A | 12 kW | 20 kW | 36 kW | N/A |
| Blower Power ( FL kW) | N/A | N/A | N/A | 4 kW | N/A |
| Amount of Purge Air (scfm) | 150 | 75 | 30 | 0 | 0 |
| Heater kW Percentage Average (FL kW x .75) | N/A | 9 kW | 15 kW | 27 kW | N/A |
| Utilization (%) Dewpoint Control | N/A | N/A | N/A | N/A | N/A |
| Purge and Prospective Energy Costs | | | | | |
| Average Annual Energy Cost ($/yr.) | - | $4,320 | $7,200 | $14,880 (31 kW) | - |
| Average Annual Purge Air ($100 per scfm/yr.) | $15,000 | $7,500 | $3,000 | $0 | $850 |
| Total Average Annual Cost ($/yr.) | **$15,000** | **$11,820** | **$10,200** | **$14,880** | **$850** |

**Sized for 100°F / 100 psig inlet**

# Desiccant Dryer Operating Energy Profile

AIR POWER USA
Independent and Brand Neutral

## Some Typical Desiccant Dryers Operating Energy Profiles With Dewpoint Demand Control – 100°F

| Dryer Type | Heatless | External Heat | Internal Heat | Blower Purge | Heat-of-Compression |
|---|---|---|---|---|---|
| Rated Flow (scfm) | 1.000 | 1,000 | 1,000 | 1,000 | 1,000 |
| Temperature In (°F) | 100°F | 100°F | 100°F | 100°F | 100°F |
| Pressure In (psig) | 100 | 100 | 100 | 100 | 100 |
| Heated Power (kW) FL | N/A | 12 | 20 | 36 | N/A |
| Average kW / Blower Power (kW) | N/A | N/A | | | N/A |
| Amount of Purge Air (scfm) | 105 | 22.5 | 9 | 0 | N/A |
| Heater kW Percentage Average (FL kW x .75 kW) | N/A | 2.7 | 4.5 | 8.1 | N/A |
| Utilization (%) Dewpoint Control | 70% | 30% | 30% | 30% | 30% |
| Prospective Energy Costs | | | | | |
| Average Annual Energy Cost ($/yr.) | - | $1,296 | $2,160 | $4,464 | - |
| Average Annual Purge Air ($100 per scfm/yr.) | $10,500 | $2,250 | $900 | 0 | $250 |
| Total Average Annual Cost ($/yr.) | **$10,500** | **$3,546** | **$3,060** | **$4,464** | **-** |
| TOTAL ANNUAL SAVINGS BY ADDING DEWPOINT DEMAND CONTROL (100°F) | **$4,500** | **$8,274** | **$7.140** | **$10,416** | **TBD** |

**Sized for 100°F / 100 psig inlet**

# Final Thought:

AIR POWER USA
Independent and Brand Neutral

For Optimum Operating Cost -- Don't Control the Dryer With a TIMER!

**Take Advantage of Modern Electric Dewpoint Demand Controllers.**

# Thank you for the opportunity to present.

## Hank van Ormer – Technical Director

**Air Power USA Inc.**

**September 29, 2016**

AIR POWER USA

Independent and Brand Neutral

COMPRESSED AIR BEST PRACTICES
airbestpractices.com

# About the Speaker

- Product Manager for Kahn Instruments

Robert Bailey, Kahn Instruments

KAHN

For your free subscription, please visit
http://www.airbestpractices.com/magazine/subscription.

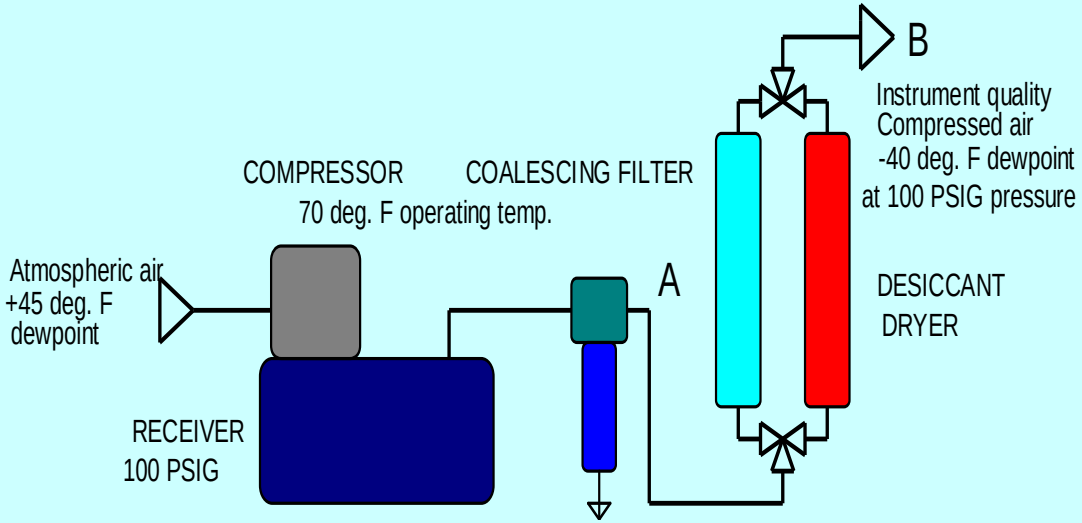
# On-Board Desiccant Dryer Dewpoint Measurement

Presented by: Robert T. Bailey, Product Manager
Kahn Instruments, Inc.
Wethersfield, CT
September 29, 2016

# Why Measure Dewpoint?

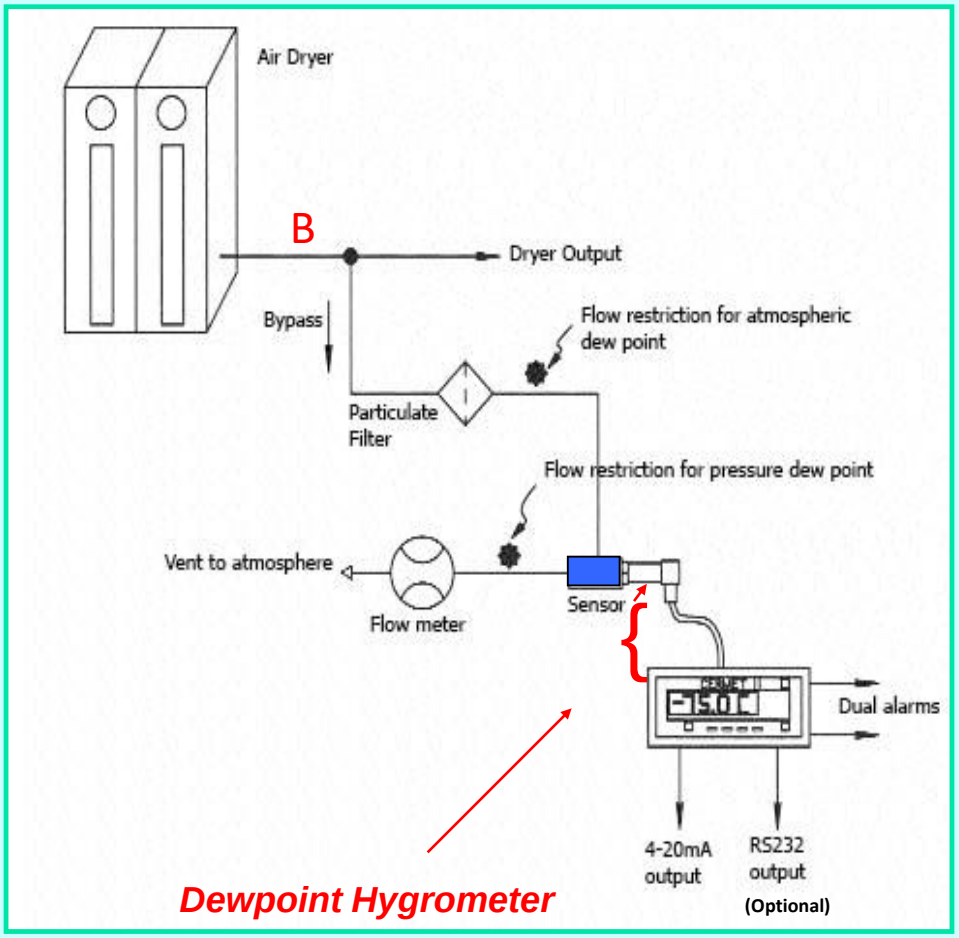
- Determine the temperature at which condensation will form in process gas or piping
- Verify the performance of the compressed air dryer
- Use the measured dewpoint to control the dryer's tower switching cycle

# Compressed Air System




- Compressor Brands
  - Atlas Copco
  - Chicago Pneumatic
  - ELGI
  - Gardner Denver
  - Hitachi
  - Ingersoll Rand
  - Kaeser
  - Kobelco
  - Quincy
  - Sullair
  - Others
- Air Dryer Brands
  - Airtek
  - Atlas Copco
  - Ingersoll Rand / Zeks
  - Kaeser
  - Pneumatech
  - Pneumatic Products
  - Quincy
  - SPX
  - Sullair
  - Xebec
  - Others

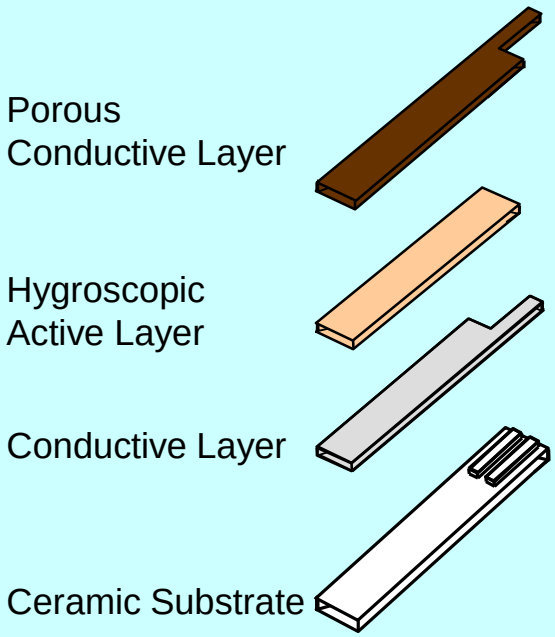
# Compressed Air Dryer
# Dewpoint Measurement Location

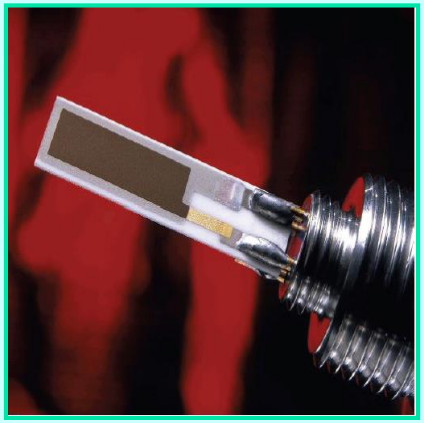


# Dewpoint Measurement Technologies

- Capacitive
  - Ceramic or Aluminum Oxide
- Chilled Mirror Optical
- Polymer Capacitive
- Electrolytic
- Color change

# Capacitive
# Ceramic Dewpoint Sensor



# What instruments are required?

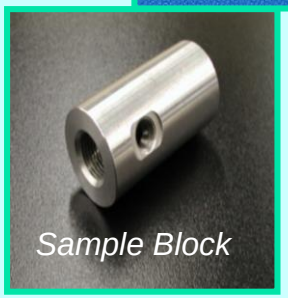
- Installed on the air dryer
  - Dewpoint Transmitter
    - 4-20 mA output and no display
    - Output signal wired to dryer control
    - **Easidew Dewpoint Transmitter**
  - On-Line Dewpoint Hygrometer
    - Dewpoint sensor, display, sensor cable, power cord
    - **Cermet II Hygrometer**

# Instrument Installed on the Air Dryer

***Easidew Dewpoint Transmitter***

- 4-20 mA analog output
  - -148 to +68°Fdp range
  - -100 to +20°Cdp range
- 12 to 28 VDC operating voltage
- NEMA 4 stainless steel housing
- Simple and economical

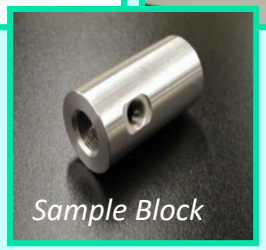
*Easidew Transmitter*


*Sample Block*

# Instrument Installed on the Air Dryer

***Cermet II Hygrometer***






- -148 to +68°Fdp range
- -100 to +20°Cdp range
- Ceramic dewpoint sensor
- Digital display
- 6-ft long sensor cable
- Power cord for 120 VAC
- 4-20 mA analog output
- Programmable alarm relays

# Dewpoint Demand

- Save energy and extend the drying cycle without purging
- Uses actual dewpoint instead of a timed tower switchover
- Cermet II Hygrometer
  - Two adjustable alarm relays
  - Wired to dryer control
  - First relay set at -40°Fdp
  - Second relay set for high dp alarm

# Reliable Dewpoint Measurement

- Select a reliable hygrometer
  - Dewpoint range and accuracy
  - Withstand saturation or liquid water
- Install the dewpoint sensor properly
  - Operate at correct pressure
  - Install a filter in sample line
  - Install an anti-diffusion coil
- Have the sensor calibrated regularly
- Use a portable hygrometer to check accuracy of the installed unit

# Calibration

- Follow the manufacturer's recommendation -- annual calibration
- Require a certificate of calibration to authenticate that calibration is traceable to a national standard (NIST)
- Participate in the manufacturer's calibration/exchange program
- If a new sensor is purchased as a spare or replacement, make sure it is fully calibrated and includes an NIST calibration certificate

# What instruments are required?

- To spot-check the dryer dewpoint or verify accuracy of installed sensor
  - Hand held portable


  - HygroPort Portable Hygrometer
    - -148°F to +68°F dewpoint range
  - Easidew *Plus* Portable Hygrometer
    - -58°F to +68°F dewpoint range

*Thank You!*

# Contact Information

Robert T. Bailey, Product Manager
Kahn Instruments, Inc.
885 Wells Road
Wethersfield, CT  06109
Phone: (860) 529-8643
Fax: (860) 529-1895
Email:  hygros@kahn.com
Web site: www.kahn.com

COMPRESSED AIR
BEST PRACTICES
airbestpractices.com

# Balancing Energy Efficiency & Dewpoint with Desiccant Dryers

## Q&A

Please submit any questions through the Question Window on your GoToWebinar interface, directing them to Compressed Air Best Practices. Our panelists will do their best to address your questions, and will follow up with you on anything that goes unanswered during this session.

**Thank you for attending!**

Brought to you by:

KAHN

For your free subscription, please visit http://www.airbestpractices.com/magazine/subscription.

BLOWER & VACUUM
BEST PRACTICES
blowervacuumbestpractices.com

October 2016 Webinar:

# Designing for 8 to 1 Aeration Blower Turndown

**Tom Jenkins, JenTech Inc.**
*Keynote Speaker*

Brought to you by:

KAESER COMPRESSORS

**Thurs., October 27, 2016 – 2:00 PM EST**

Register for free at:

www.blowervacuumbestpractices.com/magazine/webinars