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Heat of Compression Desiccant Dryers: Clearing up the Confusion

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Hank van Ormer, *Air Power USA*
Keynote Speaker

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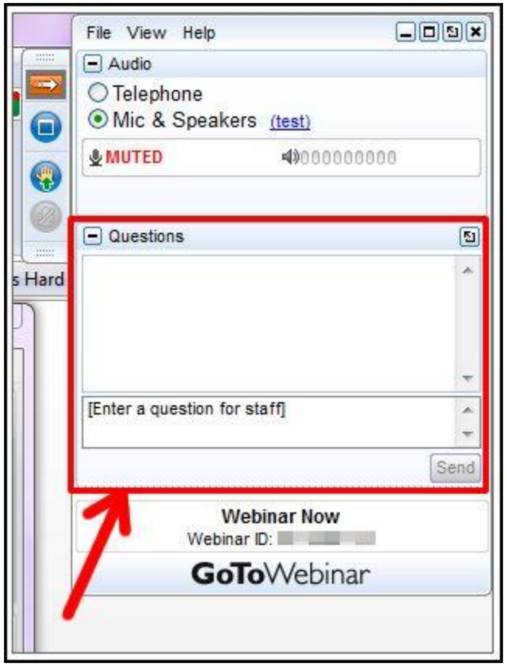
Q&A Format



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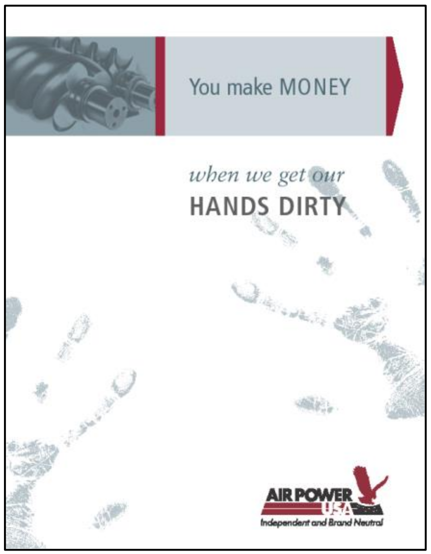

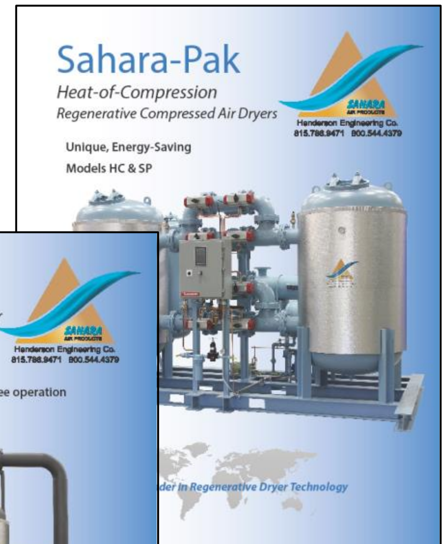

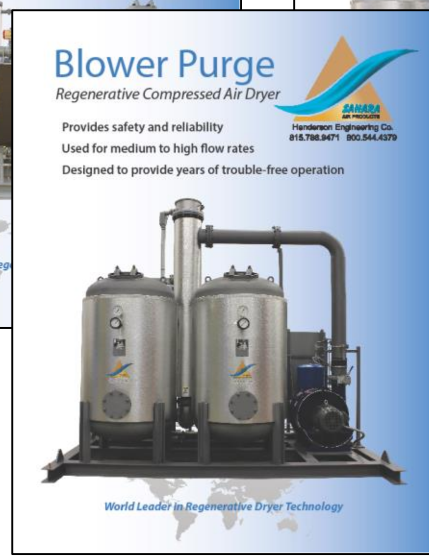

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Introduction by *Rod Smith*, Publisher

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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

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Heat of Compression Desiccant Dryers - Clearing up the Confusion

May 17, 2018

Air Power USA
Hank van Ormer – Technical Director
(740) 862-4112

AIR POWER USA
Independent and Brand Neutral

Introduction

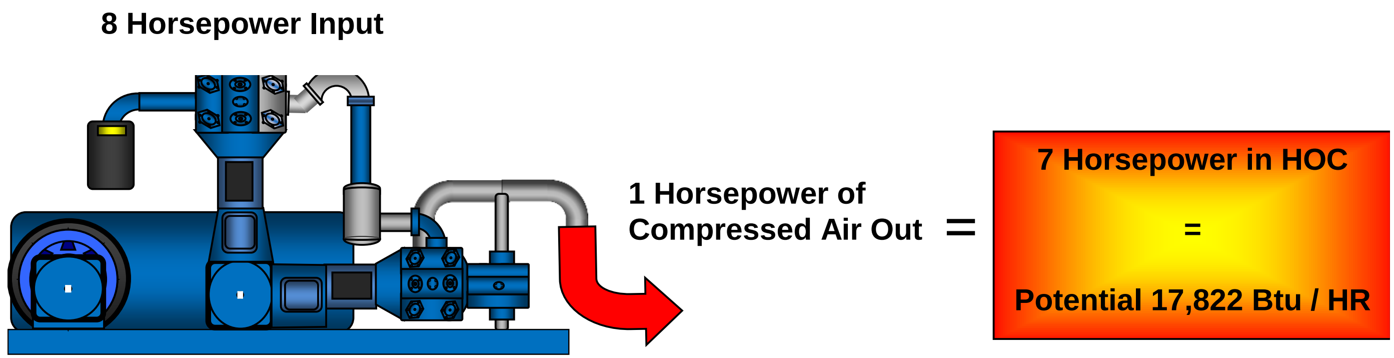
- The heat of compression dryer is an established heated type desiccant dryer which was introduced in the 1960's and has operated successfully all over the world for over 50 years.
- The basic operating principles are similar to other heated type desiccant dryers which utilize heat in their regeneration process to reduce the amount of dry compressed air used and establish lower operating costs.
- For various reasons, there are many misconceptions about this technology that often confuse the potential user with regard to its capabilities.
- Like all quality equipment, in order to select and apply the RIGHT dryer for the conditions, the appropriate personnel must understand the basic operation.

Before looking at these misconceptions or myths – let's review the basic operating parameters that we have covered in previous webinars.

Where does the Heat of Compression (HOC) Come From?

Basic Compressed Air Inefficiency

- 8 hp of electric energy input = 1hp of compressed air work
- Energy not used in work goes off as heat



This heat was generated when the air was compressed – when utilized, it is in effect “free.” If you don’t use, you lose it.

A Very Simple Technology

- Utilize the heat of compression (HOC) from an oil-free air compressor “before” it goes to the aftercooler to supply some or ALL of the regeneration heat in the desiccant dyer

Are there Limitations?

Must Have Hot Oil-free Compressed Air

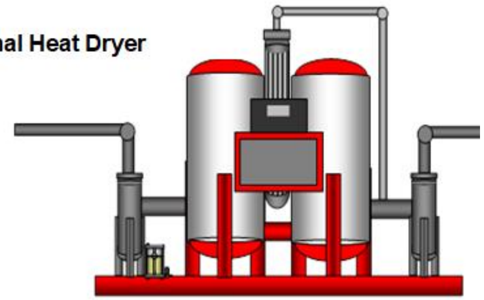
- Early in the development years the use of oil-free air was often avoided. The majority of air compressor installations were lubricated.
- Many did not understand the process and were not interested because it did not affect them.
- Over the last several decades the trend has been more and more oil-free air compressor installations. This trend continues today – each one opening the door to utilizing HOC dryer technology and delivering SIGNIFICANT ENERGY SAVINGS.

There is no other dryer technology with lower operating energy costs and inherent low maintenance costs than HOC, when conditions are correct. For most commercial plant air systems the HOC is a viable choice when oil-free compressed air is available.

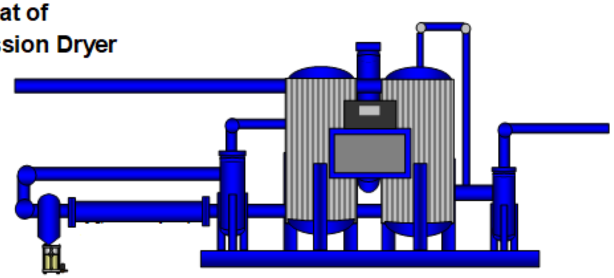
Additional details on application and selection will be covered in the following presentation by Chuck Henderson.

Common Heated Full Flow Type Desiccant Dryers – Drying Process

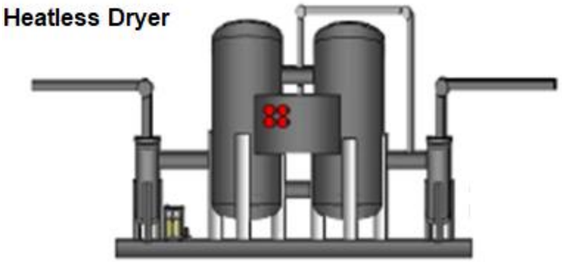
External Heat Dryer



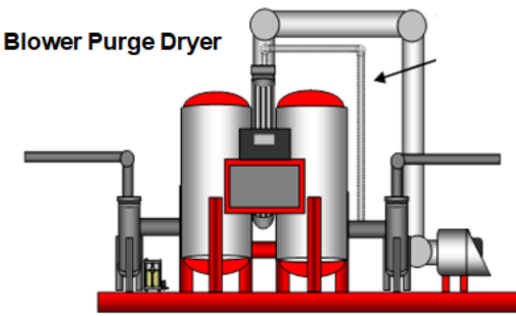
Heat of Compression Dryer



Heatless Dryer

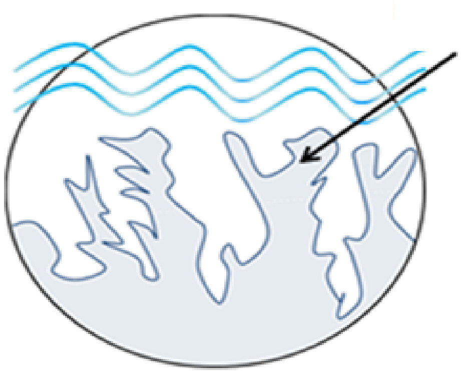


Blower Purge Dryer



Desiccant Dryers (-40°F / °C Class Pressure Dewpoint)

Desiccant ADSORPTION of water vapor



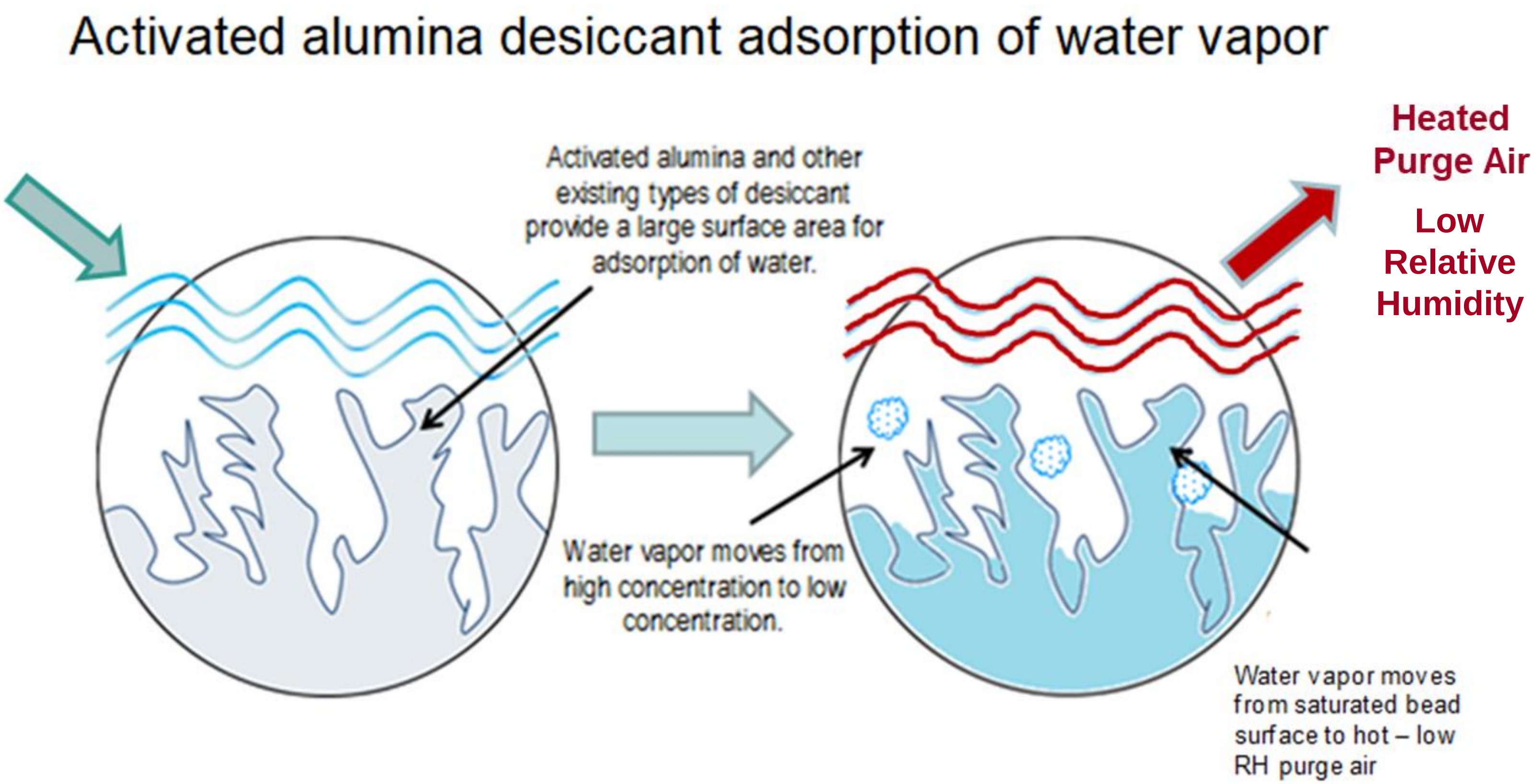
Activated alumina and other existing types of desiccant provide a large surface area for adsorption of water.

Note: Will not dry at all above 130°F

All desiccant dryers utilize the process of adsorption – water vapor moves from the saturated compressed air to the surface of the desiccant bead – in their drying cycle.

They will NOT remove liquid water!

Desiccant Regeneration Process

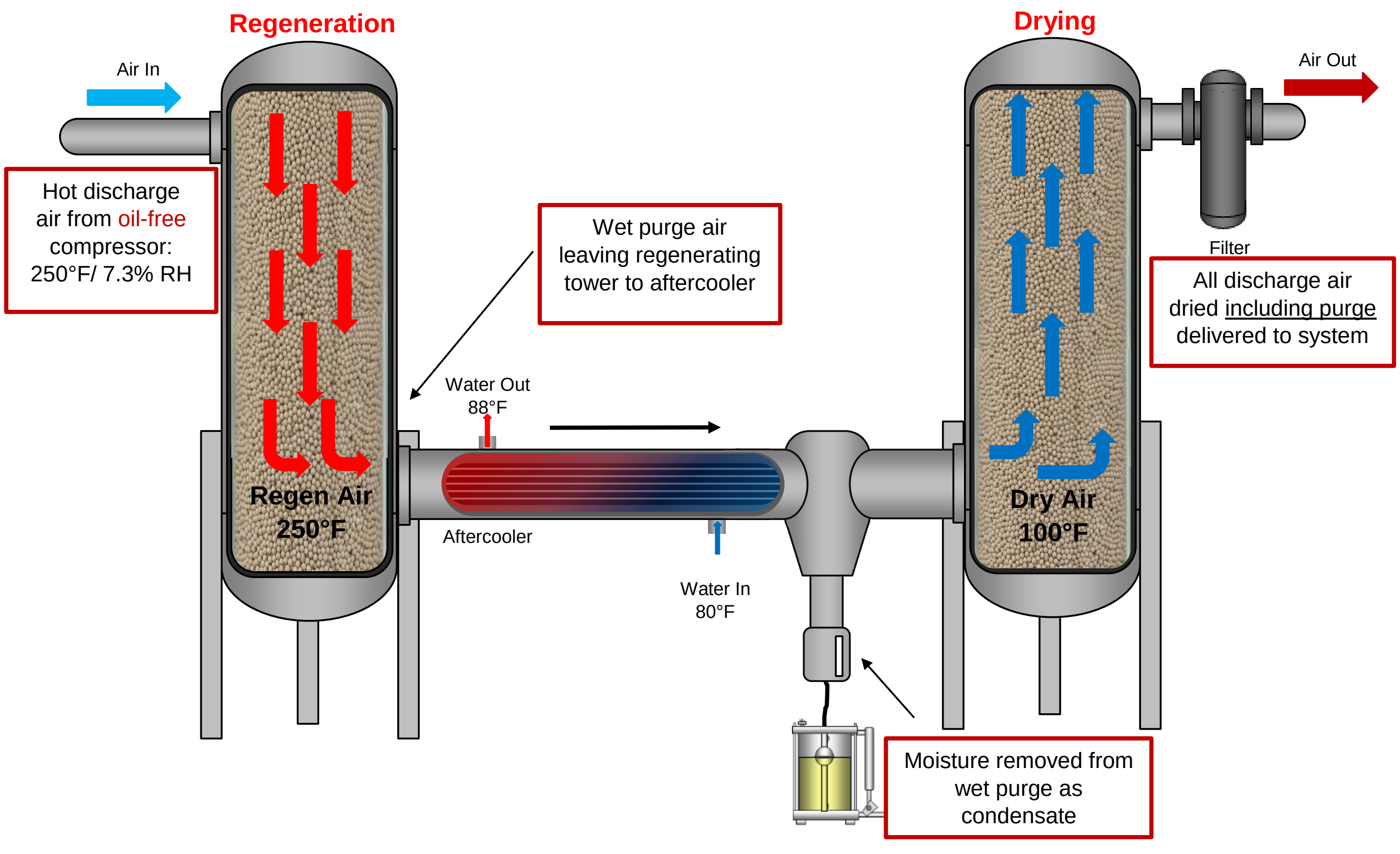


All desiccant dryers regenerate the wet bed by creating low RH purge air to remove the water vapor on the surface of the beads.

A common way of doing this is to add **heat** to increase the RH differential. This is called "heated type" – one heated type of dryer is **HEAT OF COMPRESSION OR HOC**.

Heat of Compression-
Desiccant Dryer Technology

No lost purge water vapor removal by HOC



Getting Started –
Clearing up the Confusion

With these thoughts in mind, lets try to clear up the confusion and misconceptions in relation to HOC technology.

The rising interest in energy savings and the growth of oil-free installations create a need to clarify these misconceptions that will lead to more energy saving opportunities.

Misconceptions that Create Confusion

#1 "There must be a 350°F discharge temperature from the oil-free air compressors to work"

- There are many applications over the last 50 years operating effectively at or near 200°F discharge temperature.
- Regeneration air needs a significant difference in relative humidity to pick up the moisture off the bed.

For example:

Inlet air 14.5 psia / 90°F / 60% relative humidity = 8.976 gr/CuFt. at 100 psig (7.9 cr.) = 70.91 gr/CuFt.

Discharge air multi-stage compressor (condensate and moisture drained by intercoolers) = 35 gr / ft^3

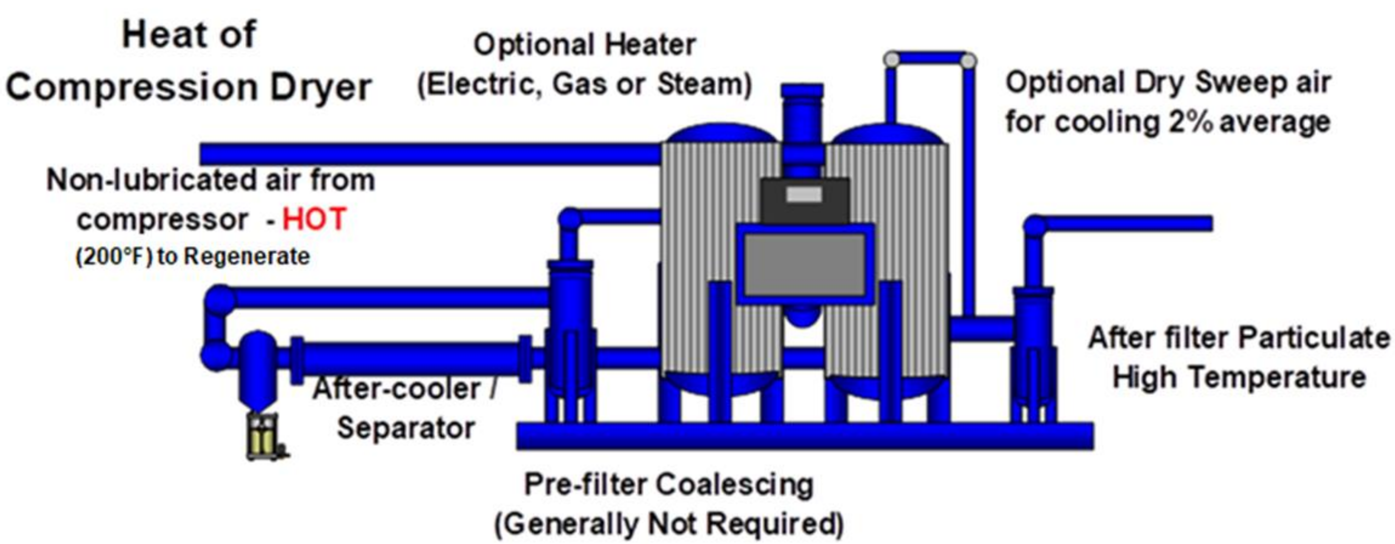
- at **200°F** the air will hold at 385 gr/ft. (35 ÷ 385) .... **9% RH**
- at **350°F** the air will hold 1,083 gr/CuFt t or .... **3.2% RH**

When a continuous and stable low pressure dewpoint is required, the dryer should be equipped with such options as auxiliary heat source, dry air cooling etc. When well controlled, it will only run when needed.

Misconceptions that Create Confusion

#2 "The air compressor must run 100% of the time"

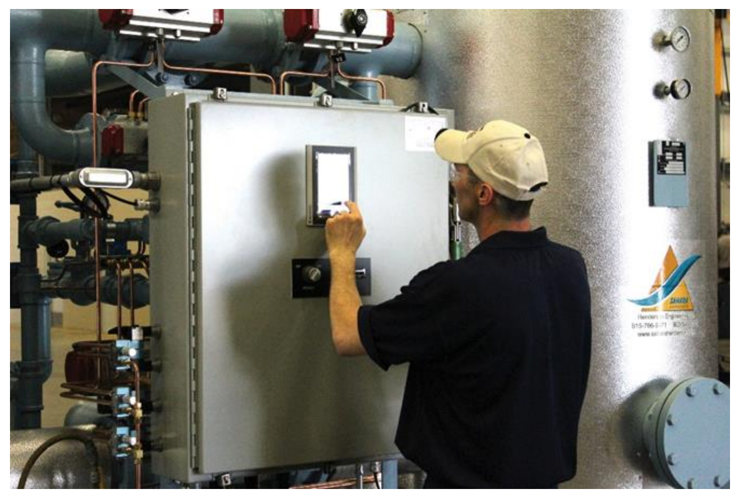
- The HOC dryers will operate successfully under varying loads.
- The air compressor must be loaded high enough to deliver 200°F air to the dryer – if not, the options described in misconception #1 will correct the problem.



Misconceptions that Create Confusion

#3 "If the air compressor is down, the dryer is down"

- Many HOC dryers are integrally tied to the air compressor.
- If the air compressor is down for maintenance or repair and you need air from another source such as rental, there are HOC dryers than can easily run as a heatless dryer with an optional feature – and go back to HOC when the primary air compressor is ready.



Misconceptions that Create Confusion

#4 "You have to run one air compressor to one dryer"

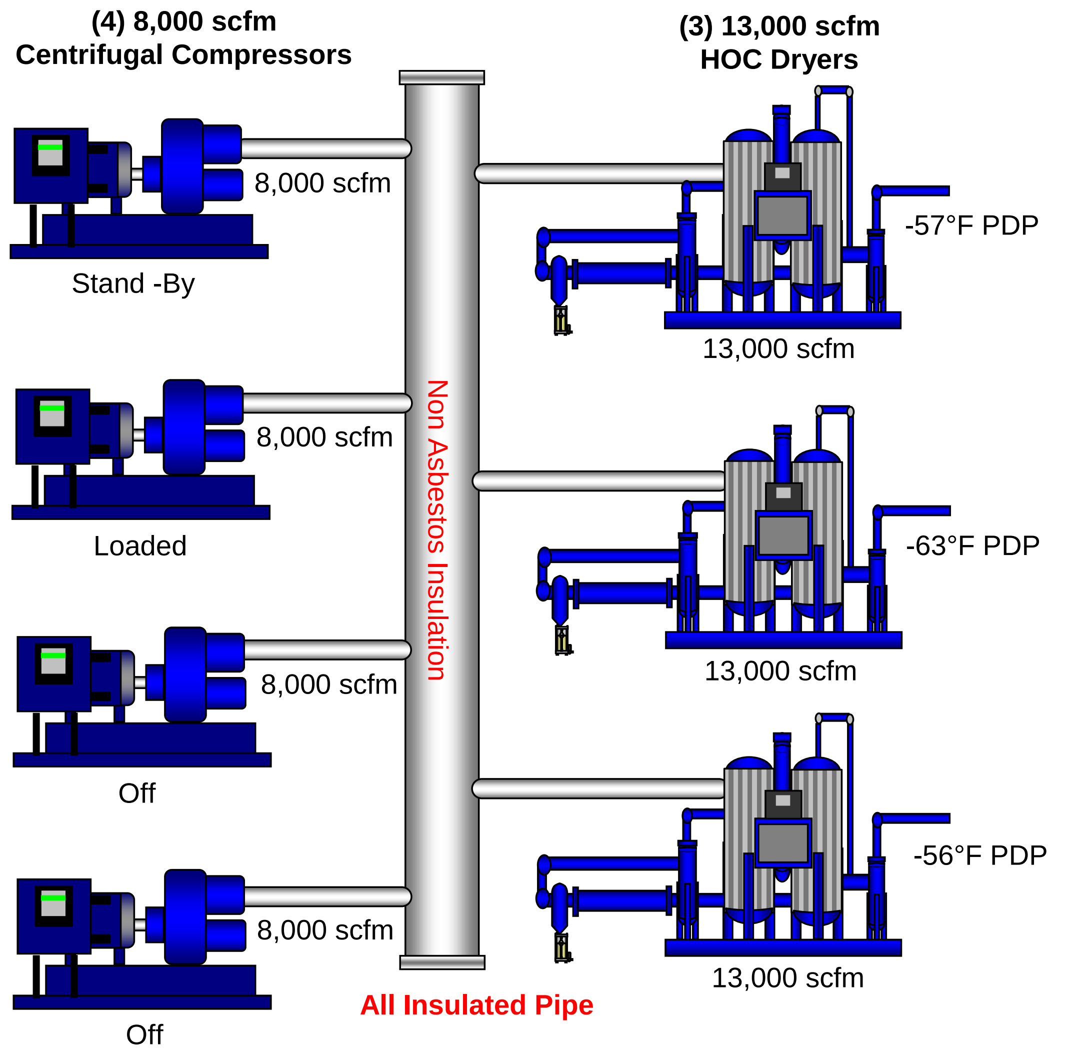
- This is not accurate when the system is well designed. Multiple oil-free air compressors can feed multiple HOC dryers.

Example:

This screen shot is of an actual operating system in a large automotive assembly plant.

The following diagram illustrates very clearly that this misconception is just that…a MISCONCEPTION!

Misconceptions that Create Confusion

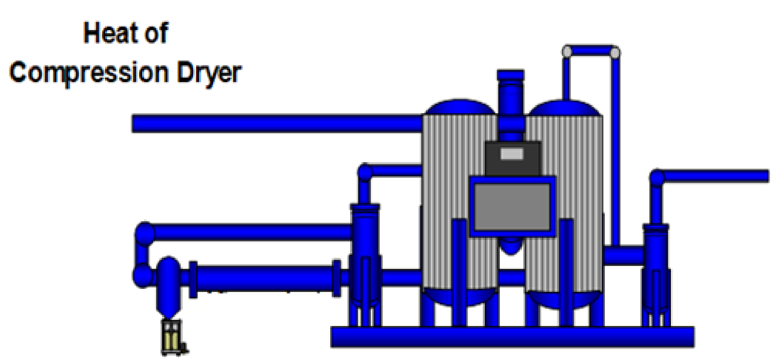


Inlet air to dryer – 234°F / -57°F PDP

Misconceptions that Create Confusion

#5 "HOC's have high pressure drop"

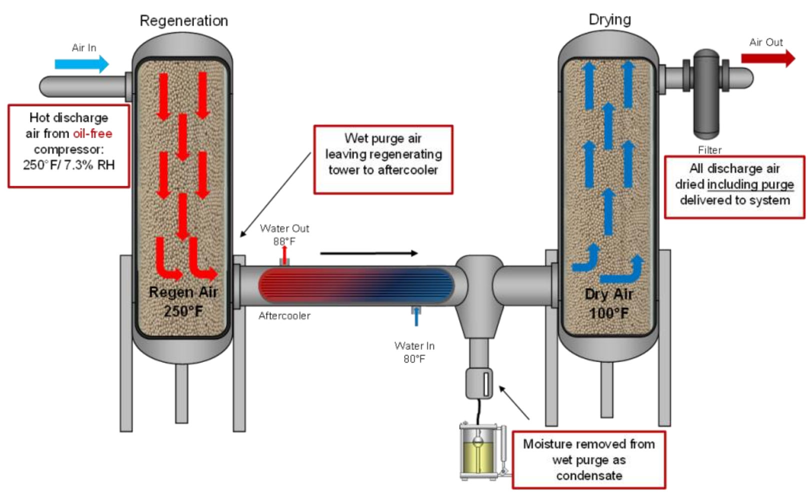
- The HOC dryer includes the aftercooler and separator – which with other type of dryers is on the air compressor discharge and this pressure loss will be about the same.
- Because the loss inside the air compressor unit doesn't show, the perception is the HOC has more pressure loss.
- The pressure loss in a full flow with no trim is about the same as other high quality twin tower desiccant dryers and with the heater and dry gas cooling, possibly slightly higher.



Misconceptions that Create Confusion

#6 “HOC dryers lose a lot of air”

- Nothing could be further from the truth
- The full flow model with no trim heater loses no compressed air. Other types of twin tower dryers lose approximately 5-15% of dry air with “purge sweeps” up to several hours
- Some full featured HOC dryers have a stripping and cooling cycle to optimize performance. Stripping is only 90 minutes with a typical air loss of 2%, only during this time and when needed.



Misconceptions that Create Confusion

#7 “If the air compressor discharge temperature is low, you have to heat all of the inlet air”

- If the air compressor discharge temperature is low and the application requires a lower PDP - in some models a heater can be added to the stripping line. This heater would be comparable to other heated dryers but <u>only operates for 90 minutes</u> of the cycle and still delivering energy efficient dry air.

  This available option is relatively inexpensive and delivers full performance under virtually any operating conditions.

Misconceptions that Create Confusion

#8 "HOC dryers cannot deliver low pressure dewpoint (PDP)"

- This misconception has been promoted by some otherwise knowledgeable people stating: "HOC dryers with multi-stage air compressors cannot provide better than a -20°F PDP below 180 psig."
- Much of the support for this inaccurate conclusion comes "from a study" prepared using molecular sieve desiccant in the drying bed.
- The calculations use the appropriate isotheres for the molecular sieve desiccant and a 125°F desiccant bed operating temperature.

The math is correct….the premise and conclusion incorrect – and irrelevant!

Molecular Sieve Product

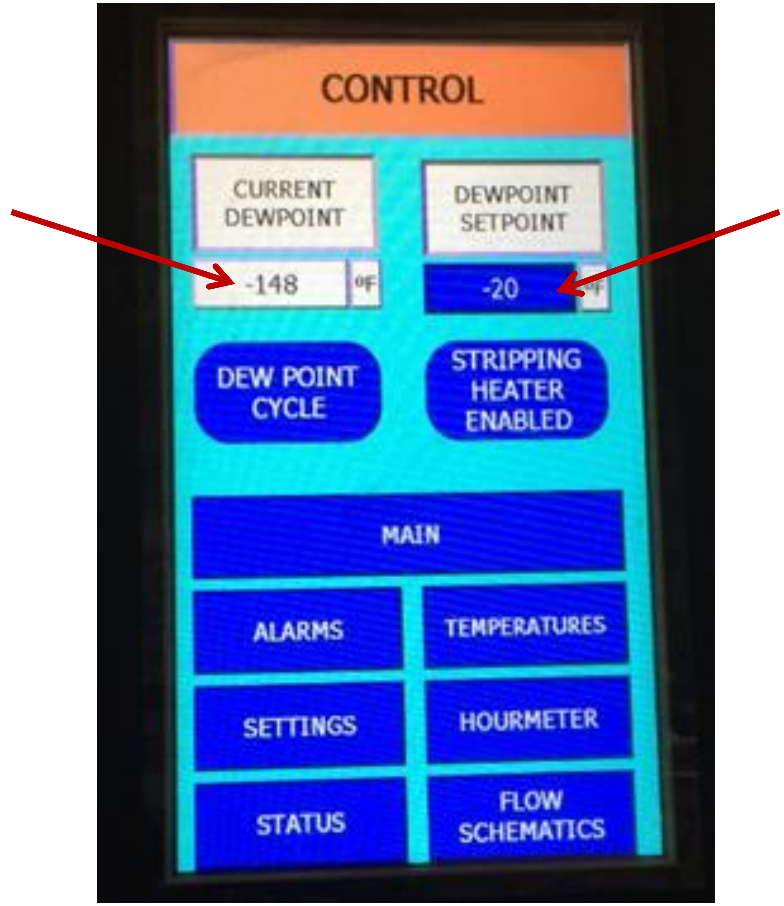
What is molecular sieve?

- Molecular sieve is a synthesized product designed for specific uses and used often in the gas separator field.
- Industrially it may be used as a final drying agent at the tower exit, taking advantage of its ability to dry effectively in areas of low RH.
- The recommended regeneration temperature is usually from **300°F to 500°F or more – NOT 125°F**.

The conclusion reached by this data is not relevant. Molecular sieve is not the bed desiccant used in HOC dryers. Most HOC desiccant dryers use a basic desiccant selection called activated alumina.

Misconceptions that Create Confusion

HOC dryers can be optimized to deliver lower than -40°F / C on a continual basis throughout the year.



Final Thoughts

Desiccant dryers usually compared at -40°F – Why? What pressure dewpoint do you actually need?

Example - Often HOC dryers are selected instead of refrigerated type for several reasons:

- HOC dryers operating in acceptable environment and conditions without trim heater and dry gas cooling can hold an average PDP from +10 to +20°F - about twice the moisture removal of a well performing refrigerated dryer.
- No issue with Freon
- Low life cycle operating costs

As in the case of <u>all</u> dryer selection - do not **"over dry"**.
If you need -5°F, or some other level – run at that level for optimum performance.

Final Thoughts

Energy savings (based on 8,760 hours/year and $.05 kWh)

- 4,000 scfm non-cycling refrigerated dryer cost = $9,679 yr.
- 4,000 scfm full flow no trim HOC dryer cost = $43.68 yr.

DRYER OPERATING COSTS

DRYER OPERATING CONDITIONS		AMBIENT	RELEVANT OPERATING COSTS	
FLOW RATE, SCFM	4,000	PSIA – 14.5	ELECTRICITY - $.05 KWh	$0.050
PRESSURE, PSIG	100	TEMPERATURE – 90°F	COMPRESSED AIR - $.30 / 1,000 scfm	$0.300
TEMPERATURE, F	100	Rh – 60%		
OPERATING HOURS PER DAY	24	COOLING H_2O – 80°F		
OPERATING DAYS PER WEEK	7			
OPERATING HOURS PER YEAR	8,760			

	Heatless	Externally Heated	Blower Purge (With Sweep)	Blower Purge (Without Sweep)	HOC Full Flow With Trim Heater	HOC Full Flow Without Trim Heater	Non Cycling Refrigerated
RATED PRESSURE DEWPOINT (PDP)	-40° to -100°F	-40°F	-40°F	-40°F*	-40°F	0 TO -40°F	+40°F
*DESICCANT REQUIRED (POUNDS)	2,122	2,046	2,046	2,046	2,046	1,044	NA
DRYER RATED FLOW	4,000	4,000	4,000	4,000	4,000	4,000	4,000
PURGE RATE / SCFM – LOST COMPRESSED AIR	15% / 600 SCFM	7% / 280 SCFM	5% / 200 SCFM	** / 0 SCFM	2% / 80 SCFM	0%	NA
HEATER KW / REFRIGERATED COMP. KW	0	22.05	78.74	78.74	11	0	22.16
HRS HEATING PER 24 HOURS	0	18	18	18	4.5	0	24
HEATER ELECTRIC COST / 24 HRS	$0.00	$19.84	$70.87	$70.87	$2.47	$0.00	-
MOTOR ELECTRIC COST / 24 HRS	$0.00	$0.00	$15.92	$21.22	$0.00	$0.00	$26.69
CONTROLS ELECTRIC COST / 24 HRS	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12	-
COMPRESSED AIR PURGE COST / 24 HRS	$229.22	$106.97	$26.74	$0.00	$11.46	$0.00	-
TOTAL COST PER DAY	$229.34	$126.93	$113.65	$92.21	$14.05	$0.12	$26.59
TOTAL COST PER WEEK	$1,605.38	$888.51	$795.55	$645.47	$98.35	$0.84	$186.15
TOTAL COST PER YEAR	**$83,479.76**	**$46,202.73**	**$41,368.60**	**$33,564.44**	**$5,114.20**	**$43.68**	**$9,679**

Thank you for the opportunity to present!

Air Power USA
Hank van Ormer – Technical Director
(740) 862-4112

About the Speaker

Chuck Henderson
Henderson Engineering Company

- Vice President of Henderson Engineering Company

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Energy Efficient Heat of Compression Dryers Installation Guidelines

Chuck Henderson
Henderson Engineering Company
chuckhenderson@saharahenderson.com

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Misunderstanding Misapplications

- When HOC was first developed in the 60's, most dryer companies didn't offer this design and discounted its benefits.
- Some dryer companies installed HOC with poor choices of components, leading to dissatisfied customers.

Heat of Compression

- Must be oil-free
- Must be located near the compressor

Heat-of-Compression Considerations

Two factors with any mechanical equipment:

1) Basic Design

2) Choice of Component

Basic Design

- Regeneration must be full flow.
- Cooling with wet air preloads desiccant and increases dew point.
- Inlet heaters add to pressure drop and consume significant energy.
- Using 2 aftercoolers doubles GPM.

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Choice of Components

- Valves must be high performance bubble tight; leakage across the valve means high dew points.
- Multi-port valves leak and should never be used in HOC applications.
- Drain traps must work; single traps fail. Where does the water go?
- Separators must be efficient at 0-100% flow. Cyclone and centrifugal separators are flow dependent; coalescing separators are not.

HOC Dryer Sizing Factors

SEVERAL FACTORS DETERMINE THE POWER, SIZE, AND TYPE OF AN HOC DRYER

- Minimum discharge temperature of oil-free air
- Maximum inlet flow rate
- Maximum cooling water temperature
- Minimum inlet pressure

→ Desired continuous pressure dew point at site conditions

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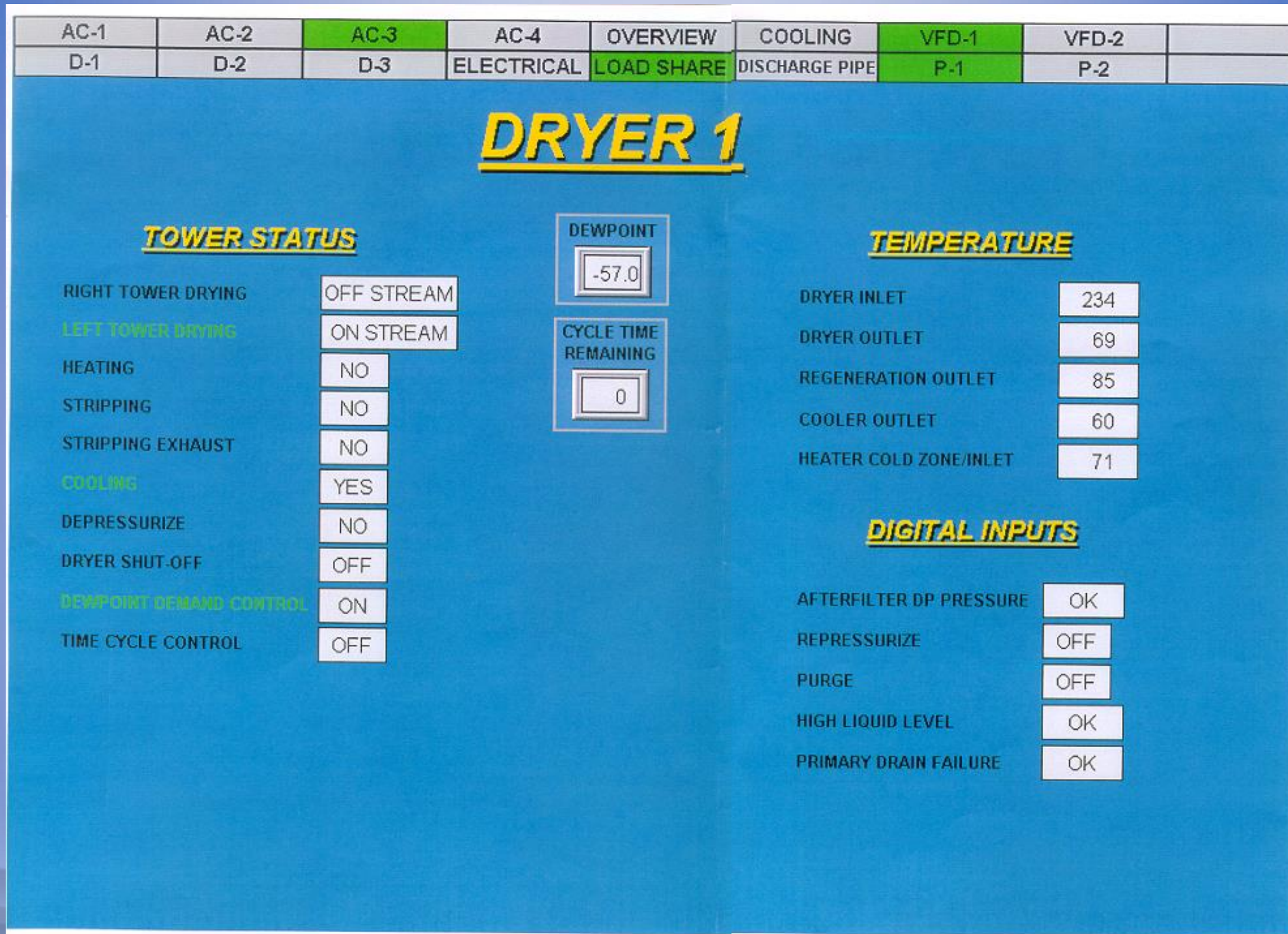

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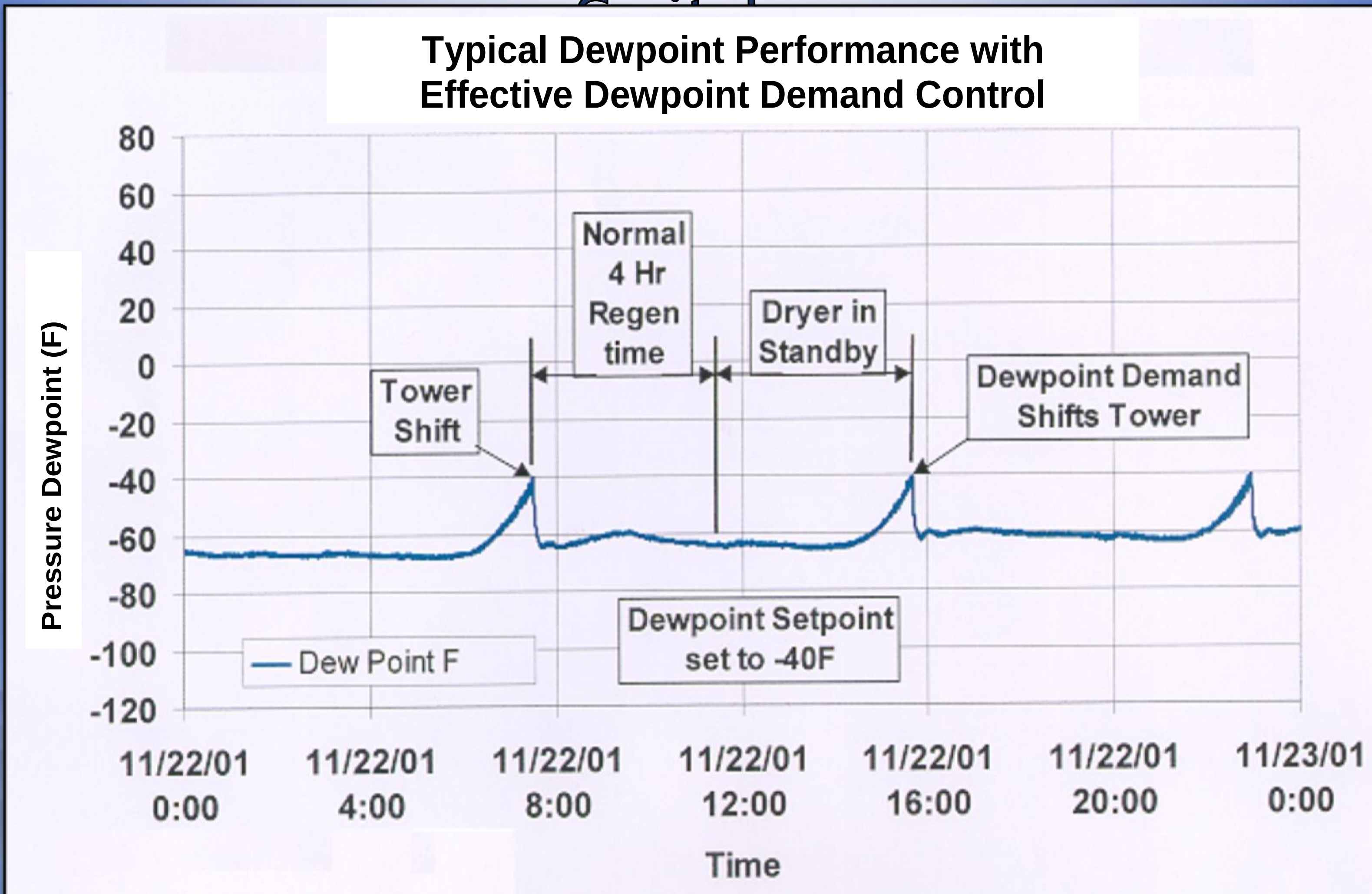
Dew Point Demand Often Control Dew Point & Temperature Spike at Tower Switch



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RELEVANT OPERATING COSTS

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Why Heat of Compression is Popular

1) Virtually no operating cost
2) More reliable than other dryers
3) Guaranteed performance

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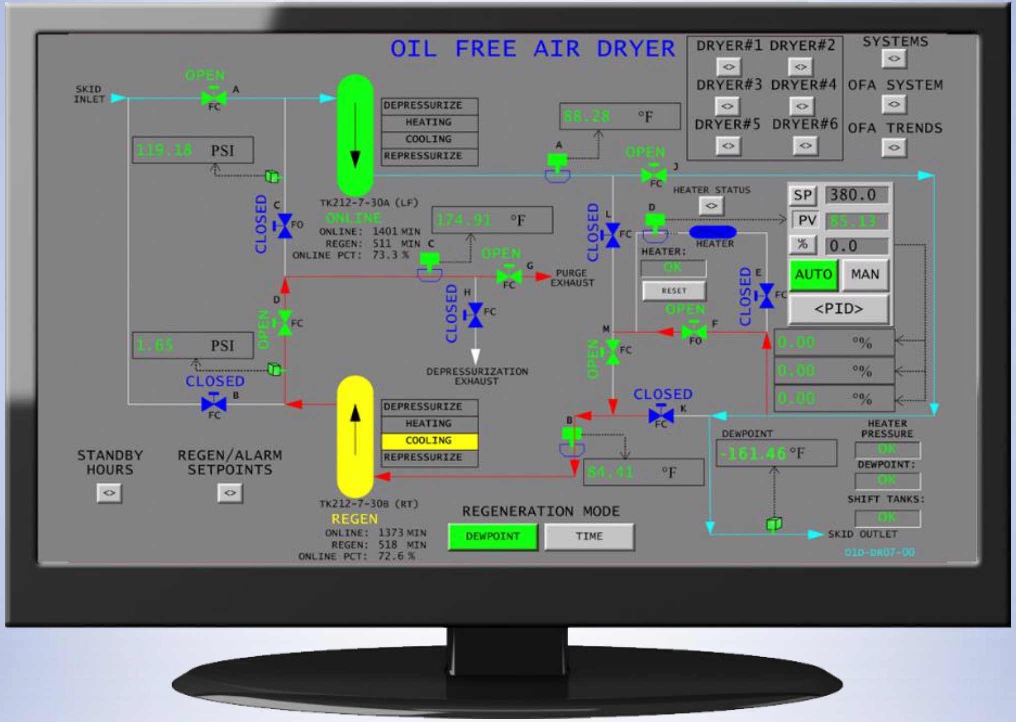
Dew Point Integrity to Ensure -40°F/C



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Q&A

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