Regenerative Dryer Terms

**Regenerate:**
- Renew - restore.

**Absorbent Desiccant:**
- Used in HP dryers.

**Adsorbent:**
- To collect on and within the surface in condensed (liquid) form.

**Adsorbent Desiccant is more hygroscopic than Absorbent Desiccant**

**Adsorbent Desiccant:**
- Used in regenerative dryers. The desiccant does not deliquesce. The liquid water collects on and within the surface of the desiccant. Adsorbent desiccant can be regenerated (renewed).
Types of Desiccant Dryers

Dual Tower, Regenerative Type

For:

- A continuous supply of compressed air at low dew points.

Operation:

- One tower is on-line drying the air while the other tower is off-line being regenerated.
- Towers alternate so that the air stream is always exposed to dry desiccant.
How They Work

- Compressed air passes through a vessel filled with desiccant.
- Water vapor is attached to the surface of the desiccant by the process called adsorption.
- Dry air exits the dryer.
Activated alumina desiccant - Why is it used?

- Readily available and economical.
- Performs well at saturated conditions.
- Doesn’t degrade in presence of liquid water.
- High crush strength.
Methods of Regeneration

**Pressure-Swing (Heatless) Regeneration**

- Dried compressed air is expanded to near atmospheric pressure.
- This low pressure, extremely dry air pulls water from the desiccant and carries it out of the dryer.
Methods of Regeneration

Heat Regeneration
- Heat forces desiccant to release the adsorbed water.

Internally Heated
- Internal heaters warm desiccant.
- Purge air circulates heat and carries off water vapor.
Methods of Regeneration

Externally Heated

- External heaters heat purge air (dried compressed air or atmospheric air).
- Purge air carries heat to desiccant and removes water vapor.
Types of Regenerative Dryers

Sahara manufactures all types of regenerative dryers, standards and specials, high pressure and low.

- Heatless
- Exhaust Purge
- Blower Purge
- Closed System/Split Stream
- Heat-of-Compression SP
- Heat-of-Compression HC
# Regenerative Air Dryers

## Sources of Regenerating Power

<table>
<thead>
<tr>
<th>Compressed Air SCFM</th>
<th>Ambient Air</th>
<th>Additional Power</th>
<th>Type of Dryer</th>
<th>Cost (to purchase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15%</td>
<td>None</td>
<td>None</td>
<td>HL Heatless</td>
<td>Lowest</td>
</tr>
<tr>
<td>7%</td>
<td>None</td>
<td>Heater</td>
<td>EP Exhaust Purge</td>
<td>Higher</td>
</tr>
<tr>
<td>None</td>
<td>All</td>
<td>Bigger Heater Blower</td>
<td>BP Blower Purge</td>
<td>Highest</td>
</tr>
</tbody>
</table>

15% at 100 PSIG expands to atmospheric = super dry

7% at 100 PSIG expands - super dry + heat = super, super dry

Ambient at atmospheric blow/heat = same results
Regenerative Dryer Performance

Heatless

-10
-20
-30
-40
-50

5 Min. 10 Min. 15 Min. 20 Min.

Constant -40 F dewpoint at line pressure

Exhaust Purge

-10
-20
-30
-40
-50

1 Hr. 2 Hr. 3 Hr. 4 Hr.

Constant -40 F dewpoint at line pressure

Blower Purge

-10
-20
-30
-40
-50

1 Hr. 2 Hr. 3 Hr. 4 Hr.

Dewpoint rises to -10 F for approx. 10 minutes during tower shift
Sahara Electrical

Electrical Controls

Direct Reading Dew Point Indicator

Simple, reliable, field-adjustable, multi-cam timer controls tower switching, depressurization.

Dew Point Demand System saves energy and allows you to monitor exact outlet dew point.
Dew Point Demand System

Probe measures the exact outlet dew point customer is receiving. Dryer switches “on demand”.

Dew point controller is equipped with Direct Reading Dew Point Indicator.

One probe in each tower can not indicate outlet dew point, only measures moisture front - not as energy efficient - switches more often.
The Dew Point Demand System allows the dryer to utilize the full capacity of the desiccant regardless of inlet flow.

After a complete regeneration, the regeneration system is turned off and the dryer sits dormant, simply drying the air.

When the full capacity of the desiccant is used and the outlet dew point rises to a preset level, the dryer automatically switches towers.

The net result is a reduction in the operating cost of the dryer. With new desiccant, the operating cost will be reduced by at least 50%.
Dew Point Demand System Cuts Operating Costs

Operating Cost in Percentage

At Full Capacity  At Half Capacity

0%  25%  50%  75%  100%

Regenerative Dryer
Sizing Factors

Three factors determine the proper size of a regenerative dryer:

- Maximum inlet flow rate
- Maximum inlet temperature
- Minimum inlet pressure
To Determine Correct Dryer Size
Use Temperature & Pressure Modifiers

<table>
<thead>
<tr>
<th>Maximum Temperature</th>
<th>Multiplier</th>
<th>Minimum Pressure</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>120°F</td>
<td>1.78</td>
<td>150 PSIG</td>
<td>.70</td>
</tr>
<tr>
<td>115°</td>
<td>1.55</td>
<td>140</td>
<td>.74</td>
</tr>
<tr>
<td>110°</td>
<td>1.34</td>
<td>130</td>
<td>.79</td>
</tr>
<tr>
<td>105°</td>
<td>1.16</td>
<td>125</td>
<td>.82</td>
</tr>
<tr>
<td>100°</td>
<td>1.00</td>
<td>120</td>
<td>.85</td>
</tr>
<tr>
<td>95°</td>
<td>.86</td>
<td>110</td>
<td>.92</td>
</tr>
<tr>
<td>90°</td>
<td>.73</td>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td>85°</td>
<td>.63</td>
<td>90</td>
<td>1.10</td>
</tr>
<tr>
<td>80°</td>
<td>.53</td>
<td>80</td>
<td>1.21</td>
</tr>
<tr>
<td>75°</td>
<td>.45</td>
<td>70</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60</td>
<td>1.54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>1.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
<td>2.10</td>
</tr>
</tbody>
</table>

Maximum flow x temperature multiplier x pressure multiplier = corrected flow.

Note: For temperature lower than 80°F consult Henderson Engineering Co., Inc.
Pressure Modifier

\[ P_1 = \frac{114.7}{P + 14.7} \]

\( P_1 = \) Pressure Modifier
\( P = \) Minimum Inlet Air Pressure
## Temperature Modifier

<table>
<thead>
<tr>
<th>Max. Temperature</th>
<th>Multiplier</th>
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<tbody>
<tr>
<td>120° F</td>
<td>1.78</td>
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<tr>
<td>115</td>
<td>1.55</td>
</tr>
<tr>
<td>110</td>
<td>1.34</td>
</tr>
<tr>
<td>105</td>
<td>1.16</td>
</tr>
<tr>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td>95</td>
<td>0.86</td>
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<tr>
<td>90</td>
<td>0.73</td>
</tr>
<tr>
<td>85</td>
<td>0.63</td>
</tr>
<tr>
<td>80</td>
<td>0.53</td>
</tr>
<tr>
<td>75</td>
<td>0.45</td>
</tr>
</tbody>
</table>
Calculating Water Load

\[
\frac{S \times V \times TC \times 18}{P \times 379}
\]

S = inlet flow rate in SCFM
V = vapor pressure of water
TC = time cycle (hours and minutes)
P = absolute pressure; PSIG plus 14.7
18 = (constant) molecular weight of water
379 = (constant) molal volume

Example: 1000 SCFM, 125 PSIG, 100°F

\[
\frac{1000 \times .950 \times 60 \text{ min.} \times 24 \text{ hrs.} \times 18}{139.7 \times 379} = 465
\]

465 lbs. of water per day
## Vapor Pressure of Water

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Absolute Pressure PSIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>1.693</td>
</tr>
<tr>
<td>115</td>
<td>1.472</td>
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<tr>
<td>110</td>
<td>1.275</td>
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<tr>
<td>105</td>
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<td>95</td>
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<tr>
<td>55</td>
<td>.214</td>
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<tr>
<td>50</td>
<td>.178</td>
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<tr>
<td>45</td>
<td>.147</td>
</tr>
<tr>
<td>40</td>
<td>.122</td>
</tr>
<tr>
<td>35</td>
<td>.099</td>
</tr>
</tbody>
</table>
Calculating Air Velocity through the Desiccant Bed

\[ V = \frac{14.7 \times S}{(P + 14.7) \times A} \]

- \( V \) = velocity in feet per minute
- \( S \) = inlet air flow in SCFM
- \( P \) = inlet air pressure
- \( A \) = tower area in sq. ft.

To find tower area:

\[ A = \frac{TD^2 \times .785}{144} \]

- \( A \) = tower area in sq. ft.
- \( TD \) = tower diameter
Determining Air-to-Desiccant Contact Time

\[
CT = \frac{(P + 14.7) \times 60 \times AA}{14.7 \times S \times 45}
\]

CT = contact time in seconds
P = inlet pressure in PSIG
AA = pounds activated alumina per tower
S = inlet air flow in SCFM
Calculating Pressure Drop through the Dryer

\[ PD = \left( \frac{S}{M} \right)^2 \times \frac{344.1}{P + 14.7} \]

PD = pressure drop in PSIG
S = inlet air flow in SCFM
M = maximum air flow at 3 lbs. drop
P = inlet air pressure
Determining Kilowatts Needed by the Heater on a Heat Reactivated Regenerative Dryer

\[ KW = \frac{PR \times 1.08 \times TD}{3412} \]

KW = actual KW required
PR = purge rate in SCFM
TD = temperature differential between 375 and inlet air temperature
Calculating Annual Operating Cost for a Heatless Dryer

\[ C = \frac{PR \times 525600}{1000} \times S \]

C = annual operating cost
PR = purge rate in SCFM
525600 = constant, minutes in a year
1000 = constant, cost per 1000 cu. ft.
S = cost of compressed air, normally
    $.15 per 1000 SCF
Calculating Annual Operating Cost for an Exhaust Purge Dryer

\[ C = \frac{PR \times 525600}{1000} \times CA + (KW \times 6570 \times E) \]

C = annual operating cost
PR = purge rate in SCFM
CA = cost of compressed air per 1000 cu ft.
KW = actual KW required
E = cost of electricity
Calculating Annual Operating Cost for a Blower Purge Dryer

\[ C = [(HP \times 8760) + (KW \times 6570)] \times E \]

- \( C \) = annual operating cost
- \( HP \) = blower horsepower
- \( KW \) = calculated heater KW
- \( E \) = cost of electricity
Calculating Annual Operating Cost for a Closed System Dryer

\[ C = [\text{(HP} \times 8760) + (\text{KW} \times 6570)] \times E + \left( \frac{\text{GPM} \times 525600 \times \text{WC}}{1000} \right) \]

- \( C \) = annual operating cost
- \( \text{HP} \) = blower horsepower
- \( \text{KW} \) = heater KW
- \( E \) = cost of electricity
- \( \text{GPM} \) = water rate
- \( \text{WC} \) = water cost/1000 gals.
  (typically $0.25/1000 gals.)