Tray Drying Before 1920

Stack Dryer

- Energy efficient
- High capital cost
Pothole

- For small lots
- High labor cost

Hopper-bottom Trailer

- Low capital cost
- Need to operate in a building to recirculate air
- Separate fan & burner for each 12 ton unit.
Stadium

- Low labor cost
- High capacity - 25 ton increments

Grain Bin

- Large Lots
- No air recirculation
Dryer size

• Handle peak harvest
  – Nut volume = 80 - 85 ft³/ton
  – Large dryers are built in trailer load increments (12 to 13 tons)

• Number of lots

Bin Geometry

Self unloading  Pallet bin  Self unloading

30°
Fan Selection

- **Fan type**
- **Airflow**
- **Static pressure**

**Centrifugal (squirrel cage)**
- High Volume
- Slow speed = low energy use

**Axial**
- Noisy
- Portable
Fan Selection

- Fan type
- **Airflow**
- Static pressure

Airflow Capacity

- High airflow
  - Faster drying
  - Less MC variability
  - Higher fuel cost
  - Higher electricity cost
  - Higher capital cost
Airflow Controls Drying Time

Effect of Airflow on Costs
Static Pressure (in w.c.)

. Thru nuts

<table>
<thead>
<tr>
<th>Airflow (cfm/ft³)</th>
<th>Nut depth (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4'</td>
</tr>
<tr>
<td>10</td>
<td>0.1</td>
</tr>
<tr>
<td>20</td>
<td>0.4</td>
</tr>
<tr>
<td>30</td>
<td>0.9</td>
</tr>
</tbody>
</table>

. Plus pressure drop at fan inlet and in plenum (<1/2" w.c.)

Fan Curve - Table

Size 35 DWBI Backward Inclined Airfoil

Outlet Area: 13.99 ft²

Max. RPM = 21.52 x (RPM - 1000)³
Fan Curve - Graph

<table>
<thead>
<tr>
<th>Customer</th>
<th>Fan Type</th>
<th>CFM</th>
<th>40,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job ID:</td>
<td>Model 305 GMT-DX</td>
<td>SP</td>
<td>1.5 hrmps</td>
</tr>
<tr>
<td>RPM</td>
<td>951</td>
<td>HP</td>
<td>21.9</td>
</tr>
</tbody>
</table>

Outlet Velocity: 2.301
Density: 0.076

TWIN CITY FAN AND BLOWER PERFORMANCE CURVE

Burner Installation and Air Recirculation

Don Osias
Air Pollution Regulations

- Air Quality Management Districts enforcing NOx limits
- Each AQMD is different
- Check with your local AQMD before building a new dryer
- Low NOx burners available but $$

Burner Capacity

- Minimum air temperature during drying season is about 50°F.
- Air recirculation increases minimum to about 70°F.
- Maximum outside air temperature during drying = 100+ °F.
- Turn-down ratio, at least 10 to 1
Burner Control System

- Modulating gas flow control.
- Flame out detection.
- Digital controls better and cheaper than analog or gas bulb.
- Should meet Safety Codes!
- Must have PID to use with VFD.
- Digital communication a plus.

Air Recirculation
Air Recirculation

**Daytime operation - minimal recirculation**

Door open

Cold air drops out

**Nighttime operation - Recirculate 50% when air when off **
**nuts is 10°F cooler than outside air.**

Partially close door

Warm air rises
Recirculation System

Relative Humidity

In typical drying weather, air heated to 110°F has an RH = 15%.
Effects of Air Recirculation

- **Dry Time (hour)**
- **Gas Use (therms/ton)**

Drying Costs

- **6 ft bin**
- **25% initial moist.**
- **110°F air temp.**
- **16.7 cfm/ft³**

Cost ($/ton) vs Time (hours):
- **natural gas**
- **electricity**
- **overdrying**
Recirculation Myths

- It rains inside the dryer at night. The air is too wet. Recirculation is useless.
Recirculation Psychrometrics

Recirculation Myths

- It rains inside the dryer at night. The air is too wet. Recirculation is useless.
- If I add some exhaust fans in the roof I can get rid of that wet air and dry better.
Hot Air Rises (Really…)

Recirculation Myths

• It rains inside the dryer at night. The air is too wet. Recirculation is useless.
• If I add some exhaust fans in the roof I can get rid of that wet air and dry better.
• I do not have a wall between the fan and bins but recirculation works fine.
Recirculation Myths

- It rains inside the dryer at night. The air is too wet. Recirculation is useless.
- If I add some exhaust fans in the roof I can get rid of that wet air and dry better.
- I do not have a wall between the fan and bins but recirculation works fine.
- **Recirculation is complicated and expensive.**
Recirculation Instrumentation

- Outside Temperature
- Temperature at Roof Inside
- Monitor Recirculated Air Flow
- Keep Plenum Humidity Below 40%

Recirculation Myths

- It rains inside the dryer at night. The air is too wet. Recirculation is useless.
- If I add some exhaust fans in the roof I can get rid of that wet air and dry better.
- I do not have a wall between the fan and bins but recirculation works fine.
- Recirculation is complicated and expensive.

- Got anymore??
25 Ton Dryer Design

Holding Volume for 25 tons of nuts:

25t x 80ft³/ton = 2000ft³

25 Ton Dryer Design

Airflow for 2000 ft³ of nuts:

2000 ft³ x 20 cfm/ ft³ = 40,000 cfm
25 Ton Dryer Design

Burner capacity for 40,000 cfm:

40,000 cfm x 60,000 Btuh/1,000 cfm = 2.4 million Btuh

60,000 Btuh/1000 cfm is a rule of thumb for California conditions, assuming a maximum temperature rise of 60°F.

25 Ton Dryer Design

Air plenum area:

40,000 cfm / 1500fpm = 27 ft²
Bin Depth

Control Systems and Moisture Meters

Don Osias
Moisture Meters

• Hand - held
  – Dickey-john
  – John Deere

• Membrane test
  – Usually brittle at 6%.

Applied Instrumentation
Variable Speed Drives

• Variable speed or variable frequency drives now readily available.
• Huge advantage for outdoor dryers.

Trends

• Shrinking Season Requires More Capacity
• Capital costs force longer rows with larger fans & burners
• VFDs now cost effective
• Electronics allow more automation
Variable Speed Drives

- Variable speed or variable frequency drives now readily available.
- **Huge advantage for outdoor dryers.**
- Recirculation better for indoor dryers.
Variable Speed Drives

• Variable speed or variable frequency drives now readily available.
• **Huge advantage for outdoor dryers.**
• Recirculation better for indoor dryers.
• Require burners with combustion air supply. More expensive. Less flexible.

Burners for VFDs
Decided a VFD is for You?

Specify Variable Speed Drive

• Specify Carefully!
• Must use PID control.
• Someone must program and provide user interface. May cost more than the drive!
• MUST have proper burner and burner controls!
Problems in Larger Dehydrators

- Longer rows, shorter transitions, bigger burners, higher plenum velocities make temperature and air flow uniformity MUCH worse
- Pushing burners too hard may increase flame length beyond safe limit
- Standard Temperature sensors not working

Longer Rows

50 or 60 Tons

8 ft Burner?

Short Transition

High air velocity
Uniformity of Airflow and Temperature

- Low airflow to first bin
- Turning vane
- Temperature Sensor
- Burner

Temperature & Airflow Solutions

- Profile plates
- “H”, “Box”, or other burner configurations
- Must RAMP burner up slowly on startup
- Baffles to create turbulence
- Multi-point temperature sensors
- Tunnel in a tunnel?
Moisture Meters

• Hand-held
  – Dickey-john
  – John Deere

• Membrane test
  – Usually brittle at 6%.

Applied Instrumentation
Automation

- Automate Air-Doors, Fill Doors, Fans & Burners
- Monitor Moisture, Time, Temp, RH, etc
- Track Drying Times & Costs by Customer
- Record all Lot and Job data for track-back

Variable Speed Drives

- Variable speed or variable frequency drives now readily available.
- **Huge advantage for outdoor dryers.**
Variable Speed Drives

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Burners for VFDs
Decided a VFD is for You?

Specify Variable Speed Drive

- Specify Carefully!
- Must use PID control.
- Programming and user interface may cost more than the drive!
- MUST have proper burner and burner controls!
Trends

• Changing variety mix shortening season
• Shrinking season requires more dryer capacity
• Harvesting earlier, wetter nuts
• Capital costs force longer rows, larger fans & burners, shorter transitions

Evolving Dryer Design

• Longer rows but same size plenum
• Higher plenum air velocity, 3000fpm
• Poor temperature and flow uniformity
• In-Line burner will not fit in plenum
Uniformity of Airflow and Temperature

Low airflow to first bin

Turning vane

Burner

Longer Rows

50 or 60 Tons

8 ft Burner?

Short Transition

High air velocity
Uniformity of Airflow and Temperature

Relocate Temperature Sensor (Bad Idea)

Poorly Mixed Hot & Cold Air

Profile Plate
Profile Plate Dimensions

Profile Plate Do’s

Note:
To compensate for changes in actual air flow versus calculated, provide adjustable profile plates so that final settings can be made in the field. Figure 3.6 shows an example of an adjustable profile plate design.
Profile Plate Don’t’s

Profile Plate

¾ to 1”

AH-MA Burner

Profile Plate

Caution: Profiles plate should be positioned upstream of the firing end of the burner. If necessary, the plates can be located up to 1” back from the firing end, but under no circumstances should they be in front of the burner.

Temperature & Airflow Solutions

- Profile plates
- “H”, “Box”, or other burner configurations
- Must RAMP burner up slowly on startup
- Baffles to create turbulence
- Multi-point temperature sensors
Problems in Larger Dehydrators

- Temperature and air flow uniformity MUCH worse
- Pushing burners too hard may increase flame length beyond safe limit
- Standard Temperature sensors may not work

Fire Safety

- Prevent fire by regularly cleaning air plenum.
- Adjust and control burner to produce short flame.
- Adequate transition length.
- Have a water supply available.
Extinguish a Fire

1. Turn off burner.
2. Direct a spray of water into fan inlet.

Huller/Dryer Cost Survey and How to Minimize Costs

Jim Thompson
Survey

• 11 respondents, 2 years each - provided cost information on energy, labor, maintenance, & production.
• Equipment capital cost information from huller/dryer manufacturer.
• Electronic sorter information from Woodside Electronics, Woodland.

Huller Profile

• Mean capacity = 1890 tons per season
• Range  = 114 to 5143 tons per season
Energy Use

• Gas use = 12 therms/ton (7-21 range)
  – 55% of operations use propane
  – In 1976 average gas use was 21 therms/ton
• Electricity use = 24 kWh/ton (13-42 range)

Energy Conservation Techniques Used

<table>
<thead>
<tr>
<th>Technique</th>
<th>No of operations</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-bin moisture meter</td>
<td>9</td>
<td>(82%)</td>
</tr>
<tr>
<td>Air recirculation</td>
<td>9</td>
<td>(82%)</td>
</tr>
<tr>
<td>Turn off dryer at night</td>
<td>3</td>
<td>(27%)</td>
</tr>
<tr>
<td>Solar</td>
<td>1</td>
<td>(9%)</td>
</tr>
<tr>
<td>Auto shut off</td>
<td>1</td>
<td>(9%)</td>
</tr>
</tbody>
</table>
Labor Cost

• With electronic sorter = $7.50/ton
  ($4.60-$13.60/ton range)
• Hand sorting only = $31.21/ton
  ($20.30 -$70.60/ton range)
  – 45% of operations had electronic sorter(s)

Repair & Maintenance

• $5.50/ton  ($0.60-$13.00/ton range)
## Major Operating Costs

**hand sorting**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>31.21</td>
</tr>
<tr>
<td>Repair &amp; Maintenance</td>
<td>5.48</td>
</tr>
<tr>
<td>Propane* ($1.95/therm)</td>
<td>23.71</td>
</tr>
<tr>
<td>Electricity ($0.142/kWh)</td>
<td>3.35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$63.75</strong></td>
</tr>
</tbody>
</table>

* Natural gas = $0.94/therm, $11.38/ton

## Major Operating Costs

**with electronic sorter**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>7.51</td>
</tr>
<tr>
<td>Sorter installation and rental</td>
<td>6.21</td>
</tr>
<tr>
<td>Repair &amp; Maintenance</td>
<td>5.48</td>
</tr>
<tr>
<td>Propane* ($1.95/therm)</td>
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</tr>
<tr>
<td>Electricity ($0.142/kWh)</td>
<td>3.35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$46.25</strong></td>
</tr>
</tbody>
</table>

* Natural gas = $0.94/therm, $11.38/ton
Cost Savings with Electronic Sorter

- Reduces labor cost by $23.71/ton.
- Sorter installation and rental = $6.21/ton.
- Net savings = $17.50/ton.

Cost of Overdrying

<table>
<thead>
<tr>
<th>Item</th>
<th>$/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor (with electronic sorter)</td>
<td>7.51</td>
</tr>
<tr>
<td>Sorter installation and rental</td>
<td>6.33</td>
</tr>
<tr>
<td>Repair &amp; Maintenance</td>
<td>5.48</td>
</tr>
<tr>
<td>Propane ($1.95/therm)</td>
<td>23.60</td>
</tr>
<tr>
<td>Electricity ($0.142/kWh)</td>
<td>3.35</td>
</tr>
<tr>
<td>Total</td>
<td>$46.25</td>
</tr>
<tr>
<td>Revenue loss by drying to 6% ($0.85/lb)</td>
<td>$34.00</td>
</tr>
</tbody>
</table>
Do Not Over Dry

Nut MC variability caused by

– Differences in maturity
– Position in bin
– Airflow

Incoming Moisture Content Variability

Moisture Content
Simulated MC after 25h of Drying

**Nut Depth**

*Example 1*

- **A**
  - 400 ft³
  - 5 tons
  - 20 cfm/ft³
  - 8000 cfm

- **B**

  
  
- **Velocity**
  - 80 ft/min
  - 160 ft/min

- **Pressure**
  - 0.4 in wc
  - 3.5 in wc

- **Motor**
  - 2.0 HP
  - 8.0 HP
**Nut Depth**

**Example 1**

- 400 cuft
- 5 Tons
- 20 cfm/cuft
- 8000 CFM

- Air velocity 80 fpm 160 fpm
- Drying Time 21 hr 21 hr
- Top Moisture 10% 10%
- Bottom Moisture 5% 5%

**Example 2**

- 400 cuft
- 5 Tons

- Velocity 160 ft/min 80 ft/min
- cfm/ft³ 20 10
- CFM 8000 4000
- Pressure 3.5 in wc 1.0 in wc
- Motor 8.0 hp 1.2 hp

---

**Moisture Uniformity**

**Example 2**

- 400 cuft
- 5 Tons

- Velocity 160 ft/min 80 ft/min
- cfm/ft³ 20 10
- CFM 8000 4000
- Pressure 3.5 in wc 1.0 in wc
- Motor 8.0 hp 1.2 hp
**Moisture Uniformity**

Example 2

- Velocity: 160 ft/min, 80 ft/min
- Drying Time: 21 hrs, 31 hrs
- Top MC: 10%, 10%
- Bottom MC: 5%, 3.5%
- Average: 7.5%, 5.5%

- 400 cuft
- 5 Tons

**Initial MC Effects Uniformity**

- 8% Moisture
- 13% Moisture

Drying top nuts to 8% moisture
Drying to 8% average moisture
Moisture Uniformity

Nut Moisture Content At Top of Bin Which Corresponds To An 8% Average Moisture

<table>
<thead>
<tr>
<th>Bin depth</th>
<th>Air velocity (fpm)</th>
<th>4 foot</th>
<th>6 foot</th>
<th>8 foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial moisture</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td>15%</td>
<td>11.6</td>
<td>9.9</td>
<td>9.4</td>
<td>12.8</td>
</tr>
<tr>
<td>25%</td>
<td>14.0</td>
<td>11.3</td>
<td>10.4</td>
<td>16.9</td>
</tr>
<tr>
<td>35%</td>
<td>16.7</td>
<td>12.6</td>
<td>11.1</td>
<td>20.4</td>
</tr>
</tbody>
</table>

What is 1% Worth?

At 8% MC a lot weighs 25 tons, what does it weigh at 7%, 6%, 5%?

<table>
<thead>
<tr>
<th>MC wb%</th>
<th>Weight tons</th>
<th>Weight difference</th>
<th>Weight difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>25.0</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>7</td>
<td>24.7</td>
<td>-1.1%</td>
<td>-538 lb</td>
</tr>
<tr>
<td>6</td>
<td>24.5</td>
<td>-2.1%</td>
<td>-1064 lb</td>
</tr>
<tr>
<td>5</td>
<td>24.2</td>
<td>-3.2%</td>
<td>-1579 lb</td>
</tr>
</tbody>
</table>
Overhead & Capital Cost

New hulling & drying equipment $58.47/ton  
Taxes & Insurance 8.42  
Total $66.89/ton

Assumptions:
- Capital cost = $1.85 million
- Hulling capacity = 10 tons/hr
- Drying capacity = 150 tons
- Seasonal throughput = 2000 tons
- Life = 30 yr
- Interest rate = 4.75%

Cost Summary - Hull & Dry

<table>
<thead>
<tr>
<th></th>
<th>$/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>58.47</td>
</tr>
<tr>
<td>Energy</td>
<td>26.95</td>
</tr>
<tr>
<td>Taxes &amp; Insurance</td>
<td>8.42</td>
</tr>
<tr>
<td>Labor</td>
<td>7.51</td>
</tr>
<tr>
<td>Sorter</td>
<td>6.33</td>
</tr>
<tr>
<td>Repair &amp; Maintenance</td>
<td>5.48</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>$113.14</strong></td>
</tr>
</tbody>
</table>

Contract hull & dry = $130/ton (2007 No. San Joaquin Valley)
Increase Throughput

Reduce Energy Cost

- Do not turn off burners in the daytime.
- Recirculate air when ambient air cools.
- Minimize overdrying.
Minimize Drying in Early Morning

- Keep burner on during the day

![Graph showing temperature and drying rates]

Total Cash Costs*

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cultural</td>
<td>363</td>
</tr>
<tr>
<td>2x shake, sweep, haul</td>
<td>140</td>
</tr>
<tr>
<td>Hull and dry</td>
<td>130</td>
</tr>
<tr>
<td>CWAB assessment</td>
<td>16</td>
</tr>
<tr>
<td>Total harvest</td>
<td>286</td>
</tr>
<tr>
<td>Total cash overhead</td>
<td>107</td>
</tr>
<tr>
<td>Interest on operating capital</td>
<td>14</td>
</tr>
<tr>
<td><strong>Total cash cost</strong></td>
<td><strong>$770</strong></td>
</tr>
</tbody>
</table>

*2007 No. San Joaquin Valley cost study, yield = 3.0 tons/ac
Future Developments in Walnut Drying

Jim Thompson

Separate Wet and Dry Nuts Before Drying

1. Reduces over drying.
2. Increases huller/dryer throughput.
3. Reduces energy use.
Walnut moisture content before hulling - Howard variety

### Average moisture contents of whole walnuts with and without hulls (%wb)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Ethephon treatment</th>
<th>Harvest</th>
<th>Category</th>
<th>With hull</th>
<th>Without hull</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tulare</td>
<td>Treated</td>
<td>First</td>
<td>37.64±5.47</td>
<td>17.28±6.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second</td>
<td>31.33±3.63</td>
<td>13.03±6.08</td>
<td></td>
</tr>
<tr>
<td>Howard</td>
<td>Treated</td>
<td>First</td>
<td>34.66±4.67</td>
<td>15.38±7.90</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second</td>
<td>31.68±3.58</td>
<td>15.15±6.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td>First</td>
<td>34.43±3.65</td>
<td>10.29±6.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second</td>
<td>31.90±4.93</td>
<td>14.95±6.36</td>
<td></td>
</tr>
<tr>
<td>Chandler</td>
<td>Treated</td>
<td>First</td>
<td>29.28±3.21</td>
<td>13.71±4.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td>Second</td>
<td>11.09±2.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Separate handling of high MC and Low MC Nuts

1. Separate nuts with & without hull
   – Dry in separate bins

   ![Diagram](chart1.png)

   This system requires installing additional conveyor capacity so that both wet or dry nuts can simultaneously transferred to any bin in the dryer.

Separate handling of high MC and Low MC Nuts

2. Separate nuts after hulling
   – Dry in separate bins

   ![Diagram](chart2.png)

   This system requires installing additional conveyor capacity so that both wet or dry nuts can simultaneously transferred to any bin in the dryer.
Separate handling of high MC and Low MC Nuts

2. Separate nuts after hulling
   – Dry in separate bins.

Separation and storage are used to accumulate drying bin quantities of nuts. When a storage is filled then one or two dryer bin quantities are transferred to the dryer.

Separate handling of high MC and Low MC Nuts

2. Separate nuts after hulling
   – Partially dry wet nuts with fast, high temperature dryer and remix with dry nuts

Separation and high temperature infrared dryer are used to dry high moisture content nuts. Low moisture content nuts are dried for a longer time in the bin dryer.
Separate handling of nuts with hulls from nuts without hulls

3. Shake less and sweep more.

New Cultivars Needed

- Extend harvest before and after Chandler.
- Maintain nutrition and flavor but have more stable oils and can be dried at higher temperature.
- Need to test temperature sensitivity of new cultivars.
Solar Heat

Figure 1: SOLARWALL panels on roof of drying building

Biomass

Dixon Ridge Farms
Recirculation Control

- Automatically start recirculation based on temperature of air off nuts and ambient.
- Automatically control amount of air recirculation.

10 – 12 Ton Capacity Bins

- Better fit with high capacity hullers.
- Separate fan for each bin.
  - Smaller air plenum.
  - No fan speed control needed.
  - Better match recirculation needs.
  - Option to use high air temperature during initial drying.
Improved Burner Installation

Alan Reiff
UNEVEN TEMPERATURE DRYER BIN STUDY

Wizard manufacturing completed an engineering study on a typical dryer system. The purpose was to find a correction for uneven temperatures that occur in some drying systems.

Wizard has installed this modification in a few test sites and the customers have seen improvement in temperatures being more even throughout their bins. More tests will be completed this 2010 harvest season.

Please understand this methodology is in the experimental stage. If installing a similar modification, one should be aware that changes can affect the safety and operation of their dryer system.
Fig 1 - Standard Design - Air Heat Burner with Profiling Plates

Temperature Distribution with Standard Installation.
Colors represent temperatures in degrees Rankin, subtract 457 to determine °F. Temp Ranges from 140 °F to 80 °F
Cross Section of Temperature Distribution with Standard Installation.
Sections are at 16’ and 24’ after the burner. Temp ranges from 130 °F to 90° F.

Side View of Modified Cross Deflector.
Deflector is installed 8’ – 10’ beyond the burner.
Profiling wings alongside the burner are to increase airflow, Laminar flow principle.

Side View of Temperature Distribution with Modified Installation. Temperature range is reduced.
Temperature range is now 10°F

Dehydrator Safety

Richard Bruce
Additional Resources

1. Lock Out Tag Out procedures
2. Food Safety Guidelines
3. Complete UC Cost Study