Comparison of MACS Forced-Air Cooler vs. Conventional Cooling Tunnels

MACS COOLER™
MODULAR AUTOMATED COOLING SYSTEM
www.macscooler.com
PreCooling

Definition:  Removal of field heat from produce prior to shipping and distribution

Purpose: To slow down post-harvest degradation thereby increasing shelf life and making nationwide and worldwide distribution of fresh produce possible.
Using conventional cooling methods, the field-packed produce is unloaded...
stacked in front of a fan forming a tunnel...
then tarped and cooled.
Conventional Tarped Tunnels

- Heat from door openings and other "sacrificial" loads.
- Room air mixing and heat "dilution".
- Less airflow at end of tunnel.
- Optional dividing walls and doors.
- Optional dividing wall.
- Heat from door openings and other "sacrificial" loads.
The Forced-Air Cooling Cycle

WARM AIR TO EVAPORATOR

REFRIGERANT

COLD AIR TO BERRIES

WARM AIR TO FAN
The Refrigeration Cycle

Compress

Condense

Evaporate

Expand

Heat In

Low Pressure Gas

High Pressure Gas

Low Pressure Liquid

High Pressure Liquid

Heat Out
Temp Gradients, One-Way Air
Temp Gradients, Two-Way Air
Conventional Tunnel
One-Way Cooling
Automated Cooler
Two-Way Cooling
Automated Forced-Air PreCooler History

1988 – Bob Ohling’s portable reverse-air cooler, Santa Maria / Mexico
   - 10 pallets, manual load and unload   - Airflow reversing mechanical dampers

1993 – Autocoolers installed at Driscoll’s in Santa Maria, CA
   - Conveyorized, 10 pallets each zone, batch loading
   - Conveyed into the cold room   - Airflow reversing mechanical dampers

1997 – Autocoolers installed at Driscoll’s in Watsonville, CA
   - Conveyorized, 8 pallets each zone, semi-continuous loading
   - Airflow reversing mechanical dampers
Automated Forced-Air PreCooler History

2000 - 2004 – MACS Cooler design conceived and developed
- Configured into shippable module
- Airflow change by zone (no dampers)
- Inflatable air seals (hang-ups, pallet sizes)
- 6 pallets each zone

2005 – 1st MACS Cooler operational at Watsonville Berry Cooler
- 4 modules long
- Improved cooling quality
- Good uptime record
- Reduced cooling costs

2005 - 2007 – Design modifications and enhancements
- Improved cleanability and serviceability
- Galvanized frame
- Improved air filtration for seals
- Vacuum doors
- Controls and instrumentation
- Seal changes
- Pallet side shift option

2008 – Redesigned MACS Coolers installed in Santa Maria, CA
- 2 – Two module units at Frontier Cooling
- 1 – Single module unit at MJA Cooling

MACS Cooler, Pajaro, CA
Automated Forced-Air PreCooler History

2000 - 2004 – MACS Cooler design conceived and developed
- Configured into shippable module
- Airflow change by zone (no dampers)
- Inflatable air seals (hang-ups, pallet sizes)
- 6 pallets each zone

2015 - 2016 – New generation MACS Cooler
- Improved PLC and Display
- Many new automatic features
- Real-time notifications
- Cooling improvements
- Efficiency improvements
- Emailed reports

MACS Coolers, Castroville, CA
Section view of MACS Cooler with Product loaded on Infeeds, Zones 1-4, and Outfeeds. Rendered in AutoCAD 3D.
500 Pallet/Day Cooler

10 Conventional Tunnels
500 Pallet/Day Cooler

4 Conventional Tunnels + One Automated Cooler
4500 S.F. Smaller Building
### Tunnel Design Comparisons

The following is based on 108 cartons/pallet, 8 lbs strawberries/carton, 65° start, 33° finish

<table>
<thead>
<tr>
<th>Tunnel Design</th>
<th>Fan Data</th>
<th>Pallets Cooled</th>
<th>Cooling Time (min.)</th>
<th>Fan Hp-Hr per Pallet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type</td>
<td>Qty.</td>
<td>Hp ea.</td>
<td>Hp Tot.</td>
</tr>
<tr>
<td>A</td>
<td>Prop.</td>
<td>2</td>
<td>7.5</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Prop.</td>
<td>1</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>B</td>
<td>Prop.</td>
<td>2</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Prop.</td>
<td>1</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>Prop.</td>
<td>5</td>
<td>15</td>
<td>75</td>
</tr>
<tr>
<td>D</td>
<td>Cent.</td>
<td>1</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>E</td>
<td>40&quot; AF</td>
<td>1</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>F</td>
<td>44&quot; AF</td>
<td>1</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>MACS Cooler</td>
<td>40&quot; AF</td>
<td>4</td>
<td>15</td>
<td>60</td>
</tr>
</tbody>
</table>

Average Conventional Tunnel: 4.84
## Electrical Usage Comparison

The following is based on 108 cartons/pallet, 8 lbs strawberries/carton, 65° start, 33° finish

<table>
<thead>
<tr>
<th></th>
<th>Typical Conventional Tunnel</th>
<th>MACS Cooler Zone (1 Zone)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan Horsepower</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Pallets per Turn</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Cooling Time, minutes</td>
<td>105</td>
<td>44</td>
</tr>
<tr>
<td>Transition Time, minutes</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>Pallets Cooled per 10 hr day</td>
<td>40</td>
<td>77</td>
</tr>
<tr>
<td>Product Heat, Refrigeration Ton-Hrs/Pallet</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Fan Run Time, hrs/day</td>
<td>8.9</td>
<td>9.8</td>
</tr>
<tr>
<td>Fan Heat, Refrigeration Ton-Hrs/Pallet</td>
<td>1.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Bldg. Space for Cooling, s.f./tunnel</td>
<td>726</td>
<td>144</td>
</tr>
<tr>
<td>Space Cooling Load, Tons-hrs/Pallet</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>Refrigeration Tons-hrs/pallet, Total</td>
<td>5.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Fan kWh/Pallet</td>
<td>5.6</td>
<td>1.9</td>
</tr>
<tr>
<td>Refrigeration kWh/Pallet</td>
<td>8.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Total kWh/Pallet</td>
<td>14.1</td>
<td>7.4</td>
</tr>
</tbody>
</table>

**Electrical Savings 48%**
Cooling Expense Comparison

The following is based on per pallet costs (cooling only) for a typical strawberry cooler running 8 lb/carton, 108 cartons/pallet, 300 pallets/day, 30,000 pallets/year

<table>
<thead>
<tr>
<th>Cooling Expense Item</th>
<th>6 Conventional Tunnels</th>
<th>1 Two Module MACS Cooler</th>
<th>$ Saved per Pallet</th>
<th>$ Saved per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Electrical Energy</td>
<td>$ 2.12</td>
<td>$ 1.11</td>
<td>$ 1.01</td>
<td>$ 30,150</td>
</tr>
<tr>
<td>2) Cooler Forklift Driver Labor</td>
<td>$ 6.25</td>
<td>$ 2.50</td>
<td>$ 3.75</td>
<td>$ 112,500</td>
</tr>
<tr>
<td>3) Cleaning and Maintenance</td>
<td>$ 0.15</td>
<td>$ 0.33</td>
<td>$ (0.18)</td>
<td>$ (5,484)</td>
</tr>
<tr>
<td>4) Forklift Expense</td>
<td>$ 1.09</td>
<td>$ 0.65</td>
<td>$ 0.44</td>
<td>$ 13,088</td>
</tr>
<tr>
<td>Totals</td>
<td>$ 9.61</td>
<td>$ 4.60</td>
<td>$ 5.01</td>
<td>$ 150,254</td>
</tr>
</tbody>
</table>

52% Savings

Economic Considerations:

This savings is about 5¢/carton, less than 1% of selling price.

Cooling quality is also improved which maintains or increases product value.
## Capital Cost Comparison

The following is based on expanding the cooling capacity of an existing facility by 300 pallets of strawberries per day.

<table>
<thead>
<tr>
<th>Capital Cost Item</th>
<th>6 Conventional Tunnels</th>
<th>1 Two Module MACS Cooler</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Pre-Cooling Equipment</td>
<td>$300,000</td>
<td>$690,000</td>
</tr>
<tr>
<td>2) Evaporator Valve Groups</td>
<td>$30,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>3) Electrical Connections and Controls</td>
<td>$36,000</td>
<td>$6,000</td>
</tr>
<tr>
<td>4) Refrigeration High-Side Addition</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
<tr>
<td>5) Refrigerated Building Cost (new and/or retrofit)</td>
<td>$495,000</td>
<td>$30,800</td>
</tr>
<tr>
<td></td>
<td>$1,111,000</td>
<td>$996,800</td>
</tr>
</tbody>
</table>

**10% Savings**

### Additional Saving and Advantages
- Reduce cooling expenses (see "Cooling Expense Comparison" sheet)
- Steadier refrigeration load
- Accelerated asset depreciation
- Lower property taxes
- Lower permitting cost
- Faster project implementation
California Produce that can be Force-Air Cooled

- Apples
- Apricots
- Artichokes
- Avocados
- Bell peppers
- Blueberries
- Boysenberries
- Broccoli
- Cantaloupe
- Cauliflower
- Chili peppers
- Corn, sweet
- Cucumbers
- Dates
- Figs
- Grapes, table
- Honeydew
- Kiwifruit
- Leaf lettuce
- Lemons
- Mushrooms
- Nectarines
- Olives
- Oranges
- Peaches
- Pears
- Plums
- Raspberries
- Romaine lettuce
- Spinach
- Squash
- Strawberries
- Sweet cherries
- Tomatoes
- Watermelon
Engineered for MACS Cool, Inc. by Hawkins Engineering, Moss Landing, CA
Manufactured and Installed for MACS Cool, Inc. by C.I.M., Santa Maria, CA