Designing a Grocery Store Refrigeration System from Scratch

Presented by Nick Shockley, PE
Founded 1970

Locations
- Kansas City
- Bentonville
- Dallas
- Houston
- Las Vegas
- New York Metro
- Philadelphia Metro
- Phoenix
- Tampa

Services
- Mechanical
- Electrical
- Plumbing
- Acoustics
- Architectural Lighting
- Audio/Visual
- Code Consulting
- Commissioning
- Fire Protection
- Refrigeration
- Security
- Sustainable Design
- Technology

Licensed in
- 50 States
- District of Columbia
- Canada
- Puerto Rico
- US Virgin Islands
- British Columbia

Size
- More than 450 employees
- More than 150 PEs
- More than 100 LEED® APs
- Licensed in all 50 states
Grocery Experience
The Cost Equation: What Drives Cost?
Life-Cycle Cost

- Floor space requirements
- Life expectancy
- First Cost
- Tax & utility incentives
- Maintenance cost
- Refrigerant regulations
- Retail Sales
- Energy Cost
Life-Cycle Cost

- Floor space requirements
- Life expectancy
- First Cost
- Energy Cost
- Retail Sales
- Refrigerant regulations
- Maintenance cost
- Tax & utility incentives
- Energy Cost
Maintenance Cost

“I have a limited service base. Please design a simple system!”

- Dedicated/home run circuits
- No subcooling
- Single suction groups
- Single stage comps, evenly sized
Maintenance Cost  Circuited System

- 24,000 linear ft. copper pipe
- 14,500 lbs. copper pipe
- 4,500 lbs. R404A
**Maintenance Cost**

**Circuited System**

**Pros**
1. Control valves in one location
2. Single stage compressors
3. Can handle large range of capacity
4. Service friendly

**Cons**
1. Centralized location leads to longer piping and electrical runs
2. Large refrigerant charge
Life-Cycle Cost

- Tax & utility incentives
- Maintenance cost
- Retail Sales
- Refrigerant regulations
- Energy Cost
- First Cost
- Life expectancy
- Floor space requirements
First Cost

“Copper pricing is through the roof! How can we reduce it?”

- Loop piping
- Subcooling
## First Cost

Loop Piping with Mechanical Subcooling

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Smaller pipe diameters</td>
<td>1. Control valves (LLSVs, EPRs) located at fixtures</td>
</tr>
<tr>
<td>2. Less refrigerant</td>
<td>2. Less service friendly</td>
</tr>
<tr>
<td>3. Fewer brazed joints (leaks)</td>
<td>3. Subcooler setup and control</td>
</tr>
<tr>
<td>4. More energy efficient</td>
<td></td>
</tr>
<tr>
<td>5. Lower installed cost</td>
<td></td>
</tr>
</tbody>
</table>
First Cost  Piping Comparison

<table>
<thead>
<tr>
<th></th>
<th>Copper (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuited (Not Subcooled)</td>
<td>14,500</td>
</tr>
<tr>
<td>Loop (Not Subcooled)</td>
<td>8,500</td>
</tr>
<tr>
<td>Loop (Subcooled)</td>
<td>6,000</td>
</tr>
</tbody>
</table>

Piping Savings calculated for San Antonio bin hours on a typical grocery store load (290 MBH LT, 770 MBH MT); 404A, Subcooled to 50 degrees for both low and medium temp.
First Cost  Subcooling

10% Reduction in Installed Compressor Horsepower

<table>
<thead>
<tr>
<th></th>
<th>LT1</th>
<th>MT1</th>
<th>LT2</th>
<th>MT2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Subcooled</td>
<td>32.5</td>
<td>37.5</td>
<td>65.0</td>
<td>65.0</td>
<td>200.0</td>
</tr>
<tr>
<td>Subcooled</td>
<td>21.5</td>
<td>24.5</td>
<td>30.0</td>
<td>105.0</td>
<td>181.0</td>
</tr>
</tbody>
</table>

5% Reduction in Condenser THR

<table>
<thead>
<tr>
<th></th>
<th>LT1</th>
<th>MT1</th>
<th>LT2</th>
<th>MT2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Subcooled</td>
<td>220</td>
<td>460</td>
<td>560</td>
<td>906</td>
<td>2146</td>
</tr>
<tr>
<td>Subcooled</td>
<td>124</td>
<td>248</td>
<td>321</td>
<td>1334</td>
<td>2027</td>
</tr>
</tbody>
</table>

Compressor HP Savings calculated for San Antonio bin hours on a typical grocery store load (290 MBH LT, 770 MBH MT); 404A, Subcooled to 50 degrees
First Cost

“I want the best price for my systems.”

- System selection and bid
- Competitive bid
- Performance spec/allow OEMs to leverage their buying power
Life-Cycle Cost

- Floor space requirements
- Refrigerant regulations
- Tax & utility incentives
- Maintenance cost
- Retail Sales
- Life expectancy
- First Cost
- Energy Cost
- Refrigerant regulations
Refrigerant Regulations

“What refrigerant should I be using? How can we reduce our exposure?”

• The R-22 phase-out
  – A large portion of existing stores are R-22
  – R-22 is currently at $15/lb and increasing

• The Carbon Tax threat
  – Natural refrigerant system options

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Other Names</th>
<th>ODP</th>
<th>GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-22</td>
<td>HCFC</td>
<td>0.055</td>
<td>1700</td>
</tr>
<tr>
<td>R-404A</td>
<td>HFC</td>
<td>0</td>
<td>3784</td>
</tr>
<tr>
<td>R-407A</td>
<td>HFC</td>
<td>0</td>
<td>2107</td>
</tr>
<tr>
<td>R-410A</td>
<td>HFC</td>
<td>0</td>
<td>1975</td>
</tr>
<tr>
<td>R-717</td>
<td>NH₃, Ammonia</td>
<td>0</td>
<td>&lt;1</td>
</tr>
<tr>
<td>R-744</td>
<td>CO₂, Carbon Dioxide</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
## Refrigerant Regulations

### Alternate Refrigerants – other considerations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R22</td>
<td>-26%</td>
<td>-33%</td>
<td>+6%</td>
<td>-5%</td>
<td>-11%</td>
</tr>
<tr>
<td>R404A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>R407A</td>
<td>-26%</td>
<td>-23%</td>
<td>+1%</td>
<td>-1%</td>
<td>-6%</td>
</tr>
<tr>
<td>R410A</td>
<td>-34%</td>
<td>-30%</td>
<td>-33%</td>
<td>-30%</td>
<td>-25%</td>
</tr>
<tr>
<td>R422D</td>
<td>+6%</td>
<td>+5%</td>
<td>+23%</td>
<td>16%</td>
<td>+11%</td>
</tr>
</tbody>
</table>

### ENERGY EFFICIENCY RATIO$^{1,2,3}$

1 - Energy Efficiency Ratio (EER) is a measure of the quantity of heat in BTU/H removed at the refrigerated fixture divided by the compressor energy in Watts.

2 - Low temp EER evaluated at -18°F SST / 100°F SCT / 90°F liquid / 30°F return gas / 10°F useful superheat/ 275°F liquid injection setting - measured as max internal compressor discharge temp / 65% isentropic efficiency.

3 - Med temp EER evaluated at 20°F SST / 100°F SCT / 90°F liquid / 50°F return gas / 10°F useful superheat/ 275°F liquid injection setting - measured as max internal compressor discharge temp / 65% isentropic efficiency.

---

**EMERSON Climate Technologies**

**Measure, Manage, Optimize, Sustain**
Refrigerant Regulations

Direct Expansion System

CONDENSER
DIRECT EXPANSION LOOP
COMP.
EVAPORATOR
RECEIVER

Secondary Coolant System

CONDENSER
PRIMARY REFRIGERANT LOOP
COMP.
CHILLER
SECONDARY COOLANT LOOP
PUMP
HEAT EXCHANGER
RECEIVER
### Refrigerant Regulations

#### System Comparison

<table>
<thead>
<tr>
<th>Traditional</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Proven technology, reliable</td>
<td>+ Significant decrease in refrigerant volumes</td>
</tr>
<tr>
<td>+ Central system, Serviceable</td>
<td>+ Less case maintenance</td>
</tr>
<tr>
<td>+ Equipment 1(^{st}) cost</td>
<td>+ Leak potential isolated to machine room</td>
</tr>
<tr>
<td></td>
<td>+ Improved temperature control</td>
</tr>
<tr>
<td></td>
<td>+ Case controls</td>
</tr>
</tbody>
</table>

- Long pipe runs
- Quantity of joints/welds
- Large volume of refrigerant
- Valve adjustments

- System controls
- Parasitic heat gains
- Energy
- Service Tech base
- First cost
Refrigerant Regulation

Why Secondary?

Lifecycle Refrigerant Usage (lbs, 20 years)

- Circuited (Not Subcooled), 27,000 lbs
- Loop (Not Subcooled), 18,000 lbs
- Loop (Subcooled), 14,400 lbs
- Air Cooled Secondary (Glycol/CO2), 1,200 lbs
- Modular Water Cooled Secondary, 336 lbs

Measure, Manage, Optimize, Sustain
## Refrigerant Regulation

**Why Secondary?**

<table>
<thead>
<tr>
<th>System Description</th>
<th>HFC Refrigerant Charge (lbs)</th>
<th>System Leak Rate*</th>
<th>Annual Leakage (lbs)</th>
<th>Lifecycle Refrigerant (lbs, 20 years)</th>
<th>Lifecycle Carbon (lbs, 404A)</th>
<th>Refrigerant Replacement Cost ($/lb)</th>
<th>Lifecycle Cost (20 Years)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuitted (Not Subcooled)</td>
<td>4,500</td>
<td>25%</td>
<td>1125</td>
<td>27,000</td>
<td>102,168,000</td>
<td>$10</td>
<td>$270,000</td>
</tr>
<tr>
<td>Loop (Not Subcooled)</td>
<td>3,000</td>
<td>25%</td>
<td>750</td>
<td>18,000</td>
<td>68,112,000</td>
<td>$10</td>
<td>$180,000</td>
</tr>
<tr>
<td>Loop (Subcooled)</td>
<td>2,400</td>
<td>25%</td>
<td>600</td>
<td>14,400</td>
<td>54,489,600</td>
<td>$10</td>
<td>$144,000</td>
</tr>
<tr>
<td>Air Cooled Secondary (Glycol/CO2)</td>
<td>600</td>
<td>5%</td>
<td>30</td>
<td>1,200</td>
<td>4,540,800</td>
<td>$10</td>
<td>$12,000</td>
</tr>
<tr>
<td>Modular Water Cooled Secondary</td>
<td>240</td>
<td>2%</td>
<td>4.8</td>
<td>336</td>
<td>1,271,424</td>
<td>$10</td>
<td>$3,360</td>
</tr>
</tbody>
</table>

*Does not include the labor for leak detection

**Does not include the labor for leak detection**
Energy Cost

“I want an energy efficient system.”

- Medium Temperature doors
- Subcooling
- VFDs – condensers and floating head pressure control
- Variable capacity control – compressors
- Heat reclaim
- Suction Float
Annual Energy Use Intensity (EUI)

Grocery is second only to Fast Food!
Grocery Store Energy Use

EUI (KBtu/ft²/year) BY END-USE*

Energy Costs

How many residential refrigerators without doors are on the market?
Adding doors reduces compressor horsepower by 83% and energy usage by 75%!
Energy Cost Subcooling

Compressor Energy Savings around 10% per year

Energy Cost Per Year

- Not Subcooled, $79,121
- Subcooled, $73,487

Compressor Energy Savings calculated for San Antonio bin hours on a typical grocery store load (290 MBH LT, 770 MBH MT), 404A, $0.08 kwh, Subcooled to 50 degrees
<table>
<thead>
<tr>
<th>SCT</th>
<th>LOAD MBH</th>
<th>RACK MBH</th>
<th>RACK % OF LOAD</th>
<th>THR MBH</th>
<th>AMBIENT F</th>
<th>Bin Hours</th>
<th>CONDENSER TD F</th>
<th>CONDENSER FAN SPEED (VFD)</th>
<th>CONDENSER POWER VFD (KW)</th>
<th># OF FANS W/ CYCLING</th>
</tr>
</thead>
<tbody>
<tr>
<td>107.5</td>
<td>159.39</td>
<td>164.15</td>
<td>103.0%</td>
<td>360.5</td>
<td>97.5</td>
<td>24</td>
<td>10</td>
<td>92%</td>
<td>9.36</td>
<td>6</td>
</tr>
<tr>
<td>102.5</td>
<td>156.82</td>
<td>158.43</td>
<td>101.0%</td>
<td>327.8</td>
<td>92.5</td>
<td>167</td>
<td>10</td>
<td>84%</td>
<td>7.04</td>
<td>5</td>
</tr>
<tr>
<td>97.5</td>
<td>154.24</td>
<td>157.66</td>
<td>102.2%</td>
<td>320.8</td>
<td>87.5</td>
<td>279</td>
<td>10</td>
<td>82%</td>
<td>6.60</td>
<td>5</td>
</tr>
<tr>
<td>92.5</td>
<td>151.67</td>
<td>160.91</td>
<td>106.1%</td>
<td>313.3</td>
<td>82.5</td>
<td>631</td>
<td>10</td>
<td>80%</td>
<td>6.15</td>
<td>5</td>
</tr>
<tr>
<td>87.5</td>
<td>149.09</td>
<td>160.99</td>
<td>108.0%</td>
<td>305.8</td>
<td>77.5</td>
<td>766</td>
<td>10</td>
<td>78%</td>
<td>5.71</td>
<td>5</td>
</tr>
<tr>
<td>82.5</td>
<td>146.52</td>
<td>149.28</td>
<td>101.9%</td>
<td>267.8</td>
<td>72.5</td>
<td>759</td>
<td>10</td>
<td>69%</td>
<td>3.84</td>
<td>5</td>
</tr>
<tr>
<td>77.5</td>
<td>143.94</td>
<td>146.76</td>
<td>102.0%</td>
<td>261.7</td>
<td>67.5</td>
<td>628</td>
<td>10</td>
<td>67%</td>
<td>3.58</td>
<td>4</td>
</tr>
<tr>
<td>72.5</td>
<td>141.37</td>
<td>141.82</td>
<td>100.3%</td>
<td>244.1</td>
<td>62.5</td>
<td>780</td>
<td>10</td>
<td>63%</td>
<td>2.91</td>
<td>4</td>
</tr>
</tbody>
</table>

**VFD SAVINGS KWH**

**Energy Cost**

Condenser VFDs

[Graph showing VFD savings in kWh]
Compressor variable capacity control

Using variable capacity compressor control to exactly match the load not only results in compressor energy savings but also reduces the THR and results in further condenser energy savings.
Energy Cost

Compressor and Condenser KWH

<table>
<thead>
<tr>
<th>Year</th>
<th>Fixed Speed Compressors</th>
<th>VFD Condenser</th>
</tr>
</thead>
<tbody>
<tr>
<td>894</td>
<td>446</td>
<td>72,425</td>
</tr>
<tr>
<td>236</td>
<td>262</td>
<td>65,283</td>
</tr>
</tbody>
</table>

Measure, Manage, Optimize, Sustain

Technology in Action Conference
### Energy Cost

**Compressor and Condenser KWH ($)**

<table>
<thead>
<tr>
<th>Compressor + Condenser</th>
<th>$/Year</th>
<th>Total Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Speed Compressors</td>
<td>$71,556</td>
<td>$90,457</td>
</tr>
<tr>
<td>Condenser Fan Cycling</td>
<td>$18,901</td>
<td></td>
</tr>
<tr>
<td>Fixed Speed Compressors</td>
<td>$71,556</td>
<td>$77,350</td>
</tr>
<tr>
<td>VFD Condenser</td>
<td>$5,794</td>
<td></td>
</tr>
<tr>
<td>Variable Capacity Compressors</td>
<td>$68,558</td>
<td>$73,781</td>
</tr>
<tr>
<td>VFD Condenser</td>
<td>$5,223</td>
<td></td>
</tr>
</tbody>
</table>
# Heat Reclaim

- Domestic hot water – desuperheating yields 15-20% of THR
- Full condensing for ventilation air preheat – can yield up to 100% of THR in cold ambient conditions

<table>
<thead>
<tr>
<th>SCT (F)</th>
<th>EVAP LOAD MBH</th>
<th>RACK NRE MBH</th>
<th>RACK CAPACITY % OF LOAD</th>
<th>THR CAPACITY MBH</th>
<th>AMBIENT F</th>
<th>Heating Load MBH</th>
<th>Bin Hours</th>
<th>Heating Load Offset by Reclaim MBH</th>
<th>Heating Load Offset by Reclaim MBTU/YEAR</th>
<th>% of THR Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>107.5</td>
<td>159.39</td>
<td>159.39</td>
<td>100.0%</td>
<td>342.6</td>
<td>97.5</td>
<td>0</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>102.5</td>
<td>156.82</td>
<td>156.82</td>
<td>100.0%</td>
<td>324.5</td>
<td>92.5</td>
<td>0</td>
<td>167</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>97.5</td>
<td>154.24</td>
<td>154.24</td>
<td>100.0%</td>
<td>304.9</td>
<td>87.5</td>
<td>0</td>
<td>279</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>92.5</td>
<td>151.67</td>
<td>151.67</td>
<td>100.0%</td>
<td>291.9</td>
<td>82.5</td>
<td>0</td>
<td>631</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>87.5</td>
<td>149.09</td>
<td>149.09</td>
<td>100.0%</td>
<td>278.4</td>
<td>77.5</td>
<td>0</td>
<td>766</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>82.5</td>
<td>146.52</td>
<td>146.52</td>
<td>100.0%</td>
<td>266.3</td>
<td>72.5</td>
<td>0</td>
<td>759</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>77.5</td>
<td>143.94</td>
<td>143.94</td>
<td>100.0%</td>
<td>256.7</td>
<td>67.5</td>
<td>3</td>
<td>628</td>
<td>2.7</td>
<td>1696</td>
<td>1.0%</td>
</tr>
<tr>
<td>72.5</td>
<td>141.37</td>
<td>141.37</td>
<td>100.0%</td>
<td>243.4</td>
<td>62.5</td>
<td>30</td>
<td>780</td>
<td>29.7</td>
<td>23166</td>
<td>12.0%</td>
</tr>
<tr>
<td>70</td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>57.5</td>
<td>57</td>
<td>540</td>
<td>56.7</td>
<td>30618</td>
<td>24.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>52.5</td>
<td>84</td>
<td>529</td>
<td>83.7</td>
<td>44277</td>
<td>35.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>47.5</td>
<td>111</td>
<td>605</td>
<td>110.7</td>
<td>66974</td>
<td>46.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>42.5</td>
<td>138</td>
<td>503</td>
<td>137.7</td>
<td>69263</td>
<td>58.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>37.5</td>
<td>165</td>
<td>761</td>
<td>164.7</td>
<td>125337</td>
<td>69.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>32.5</td>
<td>192</td>
<td>593</td>
<td>191.7</td>
<td>113678</td>
<td>80.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>27.5</td>
<td>219</td>
<td>513</td>
<td>218.7</td>
<td>112193</td>
<td>92.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>22.5</td>
<td>246</td>
<td>263</td>
<td>238.5</td>
<td>62732</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>17.5</td>
<td>273</td>
<td>224</td>
<td>238.5</td>
<td>53430</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>12.5</td>
<td>300</td>
<td>130</td>
<td>238.5</td>
<td>31008</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>7.5</td>
<td>327</td>
<td>47</td>
<td>238.5</td>
<td>11211</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>140.08</td>
<td>140.08</td>
<td>100.0%</td>
<td>238.5</td>
<td>2.5</td>
<td>354</td>
<td>18</td>
<td>238.5</td>
<td>4293</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCHEDULE</th>
<th>749876</th>
</tr>
</thead>
<tbody>
<tr>
<td>$</td>
<td>7,499</td>
</tr>
</tbody>
</table>
Commissioning Commission and Measure

On average, the operating costs of a commissioned building range from 8% to 20% below that of a non-commissioned building.

Source: US General Services Administration
Commissioning Benefits

<table>
<thead>
<tr>
<th></th>
<th>Q1 2011</th>
<th>Q1 2012</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stores</td>
<td>28</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Errors</td>
<td>656</td>
<td>523</td>
<td>20.3%</td>
</tr>
<tr>
<td>Errors %</td>
<td>100.0%</td>
<td>100.0%</td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>418</td>
<td>348</td>
<td>16.7%</td>
</tr>
<tr>
<td>Equipment %</td>
<td>63.7%</td>
<td>66.5%</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>196</td>
<td>141</td>
<td>28.1%</td>
</tr>
<tr>
<td>Controls %</td>
<td>29.9%</td>
<td>27.0%</td>
<td></td>
</tr>
<tr>
<td>Piping</td>
<td>37</td>
<td>31</td>
<td>16.2%</td>
</tr>
<tr>
<td>Piping %</td>
<td>5.6%</td>
<td>5.9%</td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td>5</td>
<td>3</td>
<td>40.0%</td>
</tr>
<tr>
<td>Insulation %</td>
<td>0.8%</td>
<td>0.6%</td>
<td></td>
</tr>
<tr>
<td>Avg.</td>
<td>23.4</td>
<td>17.4</td>
<td>25.6%</td>
</tr>
</tbody>
</table>
Commissioning Refrigeration Commissioning Overview

- Preliminary (in-office) work
- Walking the systems (visual and audible inspections)
- Testing the systems
- Reporting the results
- Post-GO performance logs
Commissioning Controls and Programming Reviews

- Preliminary controls reviews can avert performance issues in the field.

- Preliminary controls reviews will ensure the optimum parameters are loaded into the system before arrival on site.

- Performance testing is recommended after system startup but prior to the cases being loaded with product.
**Commissioning** Refrigeration Commissioning

- Why is the load profile important?

Example: the original defrost schedule for this store had 85% of the load defrosting simultaneously (all three dairy cooler circuits)
**Commissioning**  Refrigeration Commissioning

- Why is the load profile important?

Load profile reveals system instabilities or performance issues.

This store had problems with oil management, cases going into alarm three times a day and excessive compressor cycling.
Commissioning  Case Temperature Balance

Defrosts

cut-in = 32°F

target = 30°F

cut-out = 28°F

Cases that are too cold lead to excessive solenoid cycling and load instability.
Control valves tuned to stabilize temperature and reduce solenoid cycling.
Three cases in the lineup

About 5°F spread between warmest and coldest case

Coldest case drags down the average temperature, leading to excessive solenoid cycling

cut-in = 30F

target = 28F

cut-out = 26F
**Commissioning**  
Case Temperature Balance

*DF*  
*RX-300 5: RACK MTD*

![Graph showing temperature changes over time for different cases and product temperatures.]
Commissioning Suction Temperature Logs

- Oil and/or liquid returns to the rack in slugs after defrost
Commissioning  Rack Control Parameters

Floating Suction range of 15 – 21 psig enabled February 3rd.

Average suction pressure increased from 17 psig to approximately 19 psig
Condenser Control Parameters

Condensing Pressure set point changed from 200 psig to 165 psig on February 3rd.
Commissioning  Impact of Programming Changes

Before programming review...

-19°F SST = 17 PSIG R404A

89°F SDT = 200 PSIG R404A
Commissioning Impact of Programming Changes

After programming changes ...  EER increased from 7.8 to 10.2

-16°F SST = 19 PSIG  R404A

76°F SDT = 165  PSIG R404A
Questions and Answers

Thank You!