Management thinker Peter Drucker was often quoted as saying that “you can’t manage what you can’t measure.” Drucker means that you can’t know whether or not you are successful unless success is defined and tracked.

Refrigeration Basics 101: “You can’t control what you can’t measure.”
Objective

• Objective: Extend the shelf life of a product!

• Action: Reduce and maintain the temperature of the product.

• Execution: Control the setpoint.
• Temperature control — if it was just that simple.

• Industrial refrigeration systems are:
  – A fundamental necessity for feeding today’s population!
  – Custom in design; no two systems are identical
  – High level of complexity — rely on engineers, contractors and trained operators to design, build and maintain
  – Large energy users — 20–60% of energy is used for food processing facility, and up to +80% for warehousing
  – High first cost capital
  – High risk — life safety, product integrity
Industrial Refrigeration Control System Expectations

1. Safety — life safety is paramount!
   - Code compliance: ammonia, carbon dioxide, halocarbons, etc.
   - Alarming and emergency actions
   - Operator training

2. Performance and reliability
   - Deliver reliable heat transfer, as the refrigeration system was designed to do
   - React to alarms expeditiously and effectively

3. Energy efficiency
   - Deliver refrigeration as efficiently as possible
Controls Introduction

• Basic Control
  – Pressure switches, relays, thermostats, defrost clocks, switches, etc.
  – Requires continuous monitoring
  – Safety risks
  – Inefficient

• Local Control
  – Individual equipment controls: individual equipment controllers, i.e., compressor micros, electronic level control, etc.
  – Improved safety
  – Some efficiency capabilities

• Full Automation
  – Holistic approach
  – High level of safety
  – Precise control
  – Energy-efficiency capable
  – Monitoring, data logging, alaming and notification
Automatic Control System Components

- **Hardware**
  - Controller — brains
  - Relays — digital signal
  - Switches — digital signal
  - Sensors — analog signal
  - Transducers — analog signal

- **Software**
  - Refrigeration control logic
    - Relay logic
    - Ladder Logix
    - Hard coding
  - Human-Machine Interface (HMI)

- **Communications**
  - Instruments to the controller
  - Controller to the HMI
  - Controller to third party devices
  - HMI to the facility network and internet
## Hardware

<table>
<thead>
<tr>
<th>Programmable Logic Controller</th>
<th>Micro Controller</th>
<th>Desktop Computer Control</th>
<th>Commercial Refrigeration Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Programmable Logic Controller (PLC)</td>
<td>• Solid-state reliability</td>
<td>• Inexpensive</td>
<td>• Commercial-grade = commercial result</td>
</tr>
<tr>
<td>• Originally used simple ladder logic to replace relays</td>
<td>• Mission-specific application</td>
<td>• Desktop PCs are not industrial grade</td>
<td>• Limited feature set</td>
</tr>
<tr>
<td>• Software capability has steadily grown</td>
<td>• Allows sophisticated control programming</td>
<td>• Subject to component failures</td>
<td>• Limited capabilities and expandability</td>
</tr>
<tr>
<td>• Jack of all trades: a good solution for many applications, but not great for any one</td>
<td></td>
<td>• Subject to Windows operating issues, viruses, etc.</td>
<td></td>
</tr>
</tbody>
</table>
Control Software

• The satisfactory and safe control of your system is heavily dependent upon the logic developed and embedded into the controller.

• Programming should include the basic control strategies:
  – Standard refrigeration equipment control, i.e., evaporator defrost scheduling, vessel control, etc.
  – Ammonia detection and response
  – Built-in energy efficiency strategies
  – Alternate control strategies
  – Emergency shutdown and startup strategies

• Key points to consider when implementing a control system:
  – Develop functional description of the logic
  – Factory testing of the program with the hardware
  – Field testing prior to startup
HMI Software

• The HMI is the window to your refrigeration system
  – Easy to navigate
  – Multi-level password protection
  – Displays all settings, setpoints, conditions and states
  – Ability to log all access and setpoint changes made to the system
  – Backup data capability
  – Remote access
  – Remote alarm notification
Network Communications

- Keep the refrigeration system on its own communication network
- Integrate with third party microprocessors, i.e., compressors, spiral freezers and other equipment
- Server supports computer networking, internet access, email alarm messaging
- Phone and text remote alarm notification
- Incorporates refrigerant gas detection and response
Energy Efficiency

• Automation and energy efficiency go hand in hand
  – Refrigeration systems are always in a state of flux; conditions and loads are always changing
  – Automation and energy-efficiency control strategies will reduce energy usage
Energy-Efficiency Strategies

Compressor Control
• Compressors are the biggest energy consumer in the refrigeration system.
Energy-Efficiency Strategies (cont’d.)

Compressor Sequencing

• Staging is a coordinated control to a single objective.

• Avoid running multiple compressors at partial load.

• Keep compressors operating at 100% slide valve, and assign one compressor to be in trim mode.

• Shield compressors from erratic loads.

Screw Compressors Without Trim Control

- Suction
- Discharge

Screw Compressors With Trim Control

- Suction
- Discharge

Motor amps = 38%
Motor amps = 49%
Motor amps = 62%
Motor amps = 0%
Motor amps = 100%
Motor amps = 62%
Energy-Efficiency Strategies (cont’d.)

**Screw Compressor With Variable-Speed Drive**

- Costly; should require a financial analysis prior to deciding.
- Payback can range from 3 to 15+ years
- VFD should be only added to a trim compressor in each suction group.
- Minimum speed limitation (~40–50%)
- Pick the largest HP compressor to provide a large throttling range.
- Retrofitting issues to existing compressors; consult the compressor package manufacturer.
Condenser Control

- Wet bulb is the atmosphere’s true ability to absorb heat.
- Continually float staging setpoint to wet bulb.
- Avoid fan-only or pump-only operation.
- VFD fans provide a huge opportunity and control.
- Determine system minimum head pressure.
Energy-Efficiency Strategies (cont’d.)

Floating Head Pressure

- Allow the head pressure to float with the outdoor wet bulb temperature.
Floating Head Pressure

- As the approach temperature increases, the compressor power increases.
Energy-Efficiency Strategies (cont’d.)

Floating Head Pressure

- As the approach temperature increases, the condenser becomes more efficient.
Energy-Efficiency Strategies (cont’d.)

Air Units

- Fan cycling
- Fan VFDs
- Defrost control

![Fan Power vs. Control Method diagram]

The diagram illustrates the comparison between Fan Power and Control Method (Cycling vs. VFD) across different capacities.
Types of Incentive Programs

• New Construction
  – Designing and executing a new construction project that exceeds a minimum baseline or government code, i.e., California’s Title 24 energy-efficiency standards

• Retrofitting Existing Systems
  – Replacing older, less efficient equipment with higher efficiency — compressors, condensers, etc.
  – Adding variable-speed drives
  – Adding improved control strategies

• Retro-Commissioning
  – Retro-commissioning is fine-tuning existing buildings and systems in order to make them operate optimally and more efficiently through scheduling, sequencing, controls programming and optimizing setpoints.
Utility Incentive Programs

• Demand Response
  – Control system should have demand response capability
  – Auto DR
  – Load shedding
  – Permanent load shift
Summary

• Benefits of Enhanced Automation
  – High visibility and control for the operators
  – Improved temperature control — maintain product stability and quality
  – Alarming and notification — keep on top of operating issues
  – Life safety — minimize the risk of operating a refrigeration system
  – Energy saving and cost reduction — proven savings
  – Data logging and trending — you can’t control what you can’t measure
  – Improve equipment life — avoid driving with your brakes on
  – Reallocate labor — reduce babysitting your refrigeration system
Questions?

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