Maintaining your RTUs in Optimal Health with Automated Fault Detection and Diagnostics

Tuesday, May 16
3:45-5:00
Agenda

- BBA Space Conditioning Team Activities
  - Advanced RTU Campaign
  - HVAC Resource Map
  - RTU AFDD
- Optimized retail retrofits – Robert King
- Comprehensive large system retrofit – Eric Friedman
- Advanced energy research projects – Jennifer Gerbi
Panelists

Todd Rossi: President & CEO, Field Diagnostic Services, Inc.

James McClendon: Director of Building Systems Engineering, Walmart Stores, Inc.
Advanced RTU Campaign

National Campaign to promote high-efficiency RTU solutions

- High-efficiency RTU replacements and new installations
- Advanced control retrofits
- Automated fault detection and diagnostics
- Quality Installation and Quality Maintenance

www.advancedRTU.org
Awarding Leadership in RTU Efficiency

2017 Advanced RTU Campaign Award Winners!

H&M
ULTA Beauty
LIFE TIME HEALTHY WAY OF LIFE
GIANT TIGER
Fontana Unified School District
TARGET
CLEAResult
Xcel Energy
U.S. Department of Energy
The HVAC Resource Map is an intuitive graphical interface that provides quick access to a broad array of quality information on operations and maintenance best practices and energy and water efficiency measures.
HVAC Resource Map – components

Chiller

General Description and Uses

Chillers use one or more forms of energy to transfer thermal energy from one place to another. Chillers are typically the most expensive component and largest contributor to energy consumption and peak demand. There are two main categories of chillers used in buildings:

- **Vapor compression chillers** use mechanical work with a working fluid (the refrigerant) to move thermal energy and are categorized as dynamic (centrifugal) or positive displacement (reciprocating, rotary, and orbital).
- **Absorption chillers** use thermal energy to drive the refrigeration cycle and have two working fluids – the sorbent and the refrigerant.

Absorption chillers have a lower efficiency compared to vapor compression chillers and are best suited in places where waste heat is generated, for example in a campus with a cogeneration plant. For additional information about using low-grade waste steam to for absorption chiller, refer to the Energy Tip Sheet for Steam by U.S. D.O.E.

<table>
<thead>
<tr>
<th>Vapor Compression Chiller</th>
<th>Reciprocating</th>
<th>Centrifugal</th>
<th>Screw/ Rotary</th>
<th>Scroll</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Types</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hermetic sealed</td>
<td>Hermetic sealed</td>
<td>Single screw</td>
<td>Single unit</td>
<td></td>
</tr>
<tr>
<td>Open construction</td>
<td>Open construction</td>
<td>Twin screw</td>
<td>Manifolds</td>
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<tr>
<td><strong>Advantages</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low cost</td>
<td>Cost effective in larger sizes (&gt; 200 tons)</td>
<td>Few moving parts</td>
<td>Few moving parts</td>
<td></td>
</tr>
<tr>
<td>Improved part load efficiencies</td>
<td>Light website</td>
<td>Compact design</td>
<td>Low noise</td>
<td></td>
</tr>
</tbody>
</table>

CHILLER RESOURCES

- General Info
- Performance Ratings
- Energy Efficiency Measures
- Calculators & Tools
- Operation & Training
- Procurement & Performance
- Case Studies
Automated Fault Detection and Diagnostics

What is AFDD?
- A technology that continuously monitors the performance of building systems, identifies faults, and clearly communicates faults externally

Why use AFDD?
- Improve performance
- Help avoid failures and downtime
- Improve tracking of maintenance needs
- Provide a record of performance
AFDD for RTUs Planned Activities

- AFDD definition and landscape white paper
- AFDD specification
- Case study of AFDD applications

AFDD levels of capabilities

<table>
<thead>
<tr>
<th>Level</th>
<th>Features</th>
</tr>
</thead>
</table>
| 1     | - Continuous monitoring  
       | - Basic detection  
       | - Basic diagnosis  
       | - Communicate the faults |
| 2     | - Level 1 plus …  
       | - Prioritize faults  
       | - Check sensors |
| 3     | - Level 2 plus …  
       | - Store data and trend performance  
       | - Improved detection, diagnosis and communication of faults |
| 4     | - Level 3 plus …  
       | - Detect simultaneous faults  
       | - Initiate fault advanced detection mode  
       | - Adjust control to reduce fault impact |
Maintaining your RTUs in Optimal Health with Automated Fault Detection and Diagnostics (AFDD)

Todd M. Rossi, Ph.D.
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rossi@fielddiagnostics.com

DOE Better Building Summit
Washington DC
May 15-17, 2017
Introduction

• Scope
  • Medium to small commercial buildings
  • Unitary HVAC equipment – RTUs, not chiller plants
  • About ½ of the commercial building HVAC capacity in the US

• RTUs are Rooftop units – Packaged (self-contained) heating, ventilating and cooling equipment usually located on building roofs

• AFDD is automated fault detection and diagnostics
  • Automated - Complete end-to-end software solution providing analysis outcomes without not involving human effort
  • Fault detection – Is something significant broken that requires intervention
  • Diagnostics – Narrow possibilities or completely specifying needed repair
Agenda

• What is RTU AFDD?
  • Roof top unit
  • Automated Fault Detection and Diagnostics
• Why should I care?
  • Codes and standards compliance
  • Competitive differentiation
  • Better building performance at lower cost
• What can I do now?
• What’s coming next?
What is RTU AFDD?

Rooftop Unit
- Self contained factory manufactured appliance
- Generally installed out-of-sight on rooftop
- Primary purpose
  - Heating
  - Cooling
  - Ventilation (outside air)
- Other purposes
  - Air filtration
  - Humidity control
What is RTU AFDD?

Types of Automated Fault Detection and Diagnostic products

- Portable tools
- Component OEM embedded
  - Airflow
  - Refrigeration cycle
  - Economizer
    - Bottom up: Sensor failure (e.g. outdoor air temperature)
    - Bottom up: Actuator failure or shift slipping
    - Top down: Mechanical cooling when cool outside
- RTU OEM embedded
- Control system (e.g. Cloud, EMS and thermostat)
- Electric and gas interval and bill data (e.g. Cloud)
Why should I care?
Codes and Standards

AFDD is starting to appear in Codes and Standards (Economizer FDD)

• Building codes (CA Title 24) first step
  • Honeywell JADE and Belimo Zip first major products in the market
  • Carrot: Utility incentives available for adoption in CA
  • Stick: Requirements and enforcement ramping up

• Testing standards (AHSRAE SP207) (Pre-public comment)
  • Committee working to clarify Title, Purpose and Scope (TPS) by separating economizer, refrigeration cycle and airflow diagnostics
  • Economizer testing procedure for testing performance claims defined
  • Other two test procedures are far less well developed
Why should I care?
Codes and Standards

There are challenges to adoption of AFDD in code requirements

• Lack of a competitive market or dominate product
  • Economizer AFDD codes were largely written to the specifications of the existing products that were developed independently of codes or each other
  • Refrigeration and airflow AFDD have too few competitive and widely accepted products

• OEMs want to keep their value priced product lines
  • Many HVAC units do not use digital controls. Adding an AFDD code would invalidate those whole lines of business everywhere or force an exit of that market.

• No consensus on how to judge the value of AFDD
  • Compare the effectiveness of one over an other
  • Limited validation fault annunciation communication
Why should I care?
Better building performance at lower cost

Energy analytics points to the opportunities

Electric energy use

Electric peak demand
Why should I care?
Better building performance at lower cost
Pushed Exception Reports allows timely responses, verification

<table>
<thead>
<tr>
<th>Customer</th>
<th>Site</th>
<th>City</th>
<th>State</th>
<th>Thermostat</th>
<th>Alert Date</th>
<th>Duration (h)</th>
<th>Alert Name</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSR Corp</td>
<td>Quick-serve</td>
<td>Pembroke</td>
<td>FL</td>
<td>RTU #1</td>
<td>1/23/2017</td>
<td>14</td>
<td>Zone Too Hot</td>
<td>View Charts</td>
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<td>QSR Corp</td>
<td>Quick-serve</td>
<td>Pembroke</td>
<td>FL</td>
<td>RTU #4</td>
<td>1/23/2017</td>
<td>3.5</td>
<td>Zone Too Hot</td>
<td>View Charts</td>
</tr>
</tbody>
</table>

Warm zone temperature above cooling set point

100% cooling thermostat runtime

Are you looking forward to smarter HVAC equipment with AFDD to help you achieve better building performance? Lower cost?
What can I do now?
Solving Current Challenges

• Assess data, tools and AFDD outcomes available today in products you have can purchase in the future
• Determine how they can be incorporated into workflows (e.g. facility management, monitoring center and field service)
• Establish measurable performance improvement goals and assess business value (e.g. better performance, lower costs)
• Track metrics and encourage and support new solutions with workforce until well established
• Continuously improve – new AFDD tools and better workflow

Is the expertise and resources to do this a challenge? How do you see it being provided? In house? Service providers? Consultants?
What can I do now?
Solving Current Challenges

Don’t make common mistakes

• **Usefulness** – valuable AFDD outcomes
• **No tolerance for false positives** - value diagnostic reliability over problem sensitivity
• **Avoid floods of alarms** - exceptions reports and ranked opportunities cut through overload
• **Availability to mobile workforce** – only ones that can directly effect the outcomes
• **Customer summaries** - communicate the bigger picture and effectiveness of the program
What’s coming next?
OEMs

• Embedded OEM AFDD from the factory is expanding
  • Title 24 compliant economizer diagnostics is available
  • Johnson Controls – York are currently delivering refrigeration cycle diagnostic modules in RTUs
  • Other OEMs are currently working on a variety of AFDD products

• Asset management systems designed to accept diagnostic data and provide system alerts with diagnostic statements are emerging

• Service delivery business models are developing to respond to AFDD outputs
What’s coming next?
More distant future... Industry predictions

Integrated AFDD systems to make control adjustments to achieve:

• Fault tolerant equipment
  • VFDs on all fans and compressors and EXVs compensates for component faults – reducing fault impact and protects equipment
  • Automatically shift to better performing nearby units

• Modular equipment
  • Error codes outputs advise when a fault or degradations exceed the ability to compensate
  • A technician removes and cleans, or replaces a self-contained modules
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James McClendon

Walmart Stores, Inc.
AFDD Opportunity

Walmart Stores Inc.
Global Footprint 2016

- Canada: 410 Units
- Mexico: 2411 Units
- Central America: 661 Units
  - Guatemala
  - Honduras
  - Nicaragua
  - El Salvador
  - Costa Rica
- Brazil: 498 Units
- Argentina: 107 Units
- Africa: 379 Units
- UK: 631 Units
- US: 5332 Units
- China: 439 Units
- Japan: 341 Units
- India: 20 Units

Total Square Feet: > 1.1 B
Customers/Week: > 250 M
Associates: > 2.2 M
Suppliers: > 100k
Total Stores: > 11k
Formats
Over 4,000 Energy Projects this Year

- LED lighting upgrade (Lamps/Retrofit kits)
- Refrigeration Upgrades
- HVAC Improvements
- Solar PV
- Fuel Cells
- EV Charging Stations
- Batteries, Gen-Sets

~700-800 Remodels, Special Projects, Merch Changes

Advanced Optimization Activities...
CENTRAL MONITORING US Footprint

**Systems / Points**

- ~7,000,000 Total Points
- ~150,000 RTUs
- ~20,000 Refrigeration Units
- ~4,000 Dimming Systems
- ~80,000 GUH
- Fans, pumps, chillers, irrigation,...

**Annual Alarms**

- ✓ 6 M Emergency-Critical
- ✓ 14 M Medium Priority
- ✓ 136 M All Alarms
Legacy (current) Alarm Flow

Bldg Controller → Sys-A Alarm Receiver → Alarms (WARP) → BPC Associate JOB Interface

Bldg Controller → Sys-B Alarm Receiver → Alarms (WARP) → BPC Associate JOB Interface

Bldg Controller → Sys-C Alarm Receiver → Alarms (WARP) → BPC Associate JOB Interface

Simple FIFO w/Repeat Function

Work Order
Check Back
Resolved Issue
Doors Open
Unit in Defrost
Non Crit WO
Parts on Order
PM/Case Cleaning
Tech Forced Def
Return to Normal
Special Store
Maint Case Change
Elect Override

Fixed Options
Alarm Category / Prioritization

- Emergency priority alarms losses can exceed $250,000. Service is expected immediately.

- Critical priority alarms losses can be anywhere from $5,000 to $100,000. Service is expected within 2-3 hours.

- Medium priority alarms represent little to no chance of loss. Service is expected in next 2-3 days.

- Low priority alarms that represent ‘off-normal’ conditions or false alarms. Service is expected in 2-3 weeks…if at all.
Critical Alarm Trend

…not emergency
So, What are Emergency Alarms?
Data Rich…

Utility…
Sub-meters…
BAS…
Asset Mgmt…
Forward Architecture

Future System Design

CLOUD

Flow of Information

Ethernet / IP

Fire
POS
Pharmacy

BAS
Serial
RTU 1
RTU 2
RTU N
AHU 1
AHU 2
AHU N

BAS
Serial
G3 Lighting Panel Number 1
G3 Lighting Panel Number 2
G3 Lighting Panel Number N

BAS
Serial
Lead Case 1
Lead Rack LT Rack A

BAS
Serial
Case 2
Case 3
Case 120
LT Rack B
MT Rack C
MT Rack D

New Devices & Sensors
How it Works

Walmart Store with multiple assets under different BAS:
- Refrigeration
- HVAC
- Lighting
- Sub-metering

Dell Edge Gateway 5000

Linux, Open source, OpenStack software suited for connecting edge devices to servers and the cloud

Platform software offers communication, standardization, severity management and application of business rules and policies.
Applying this to Walmart

Forward Integrated Alarm & AFDD Goals

Complex Legacy Infrastructure

The problems we solve together

- Stock loss
- Freeing up associate time
- Lost sales
- Poor quality for customers
- Wasted maintenance time
- Faster fix times & fewer failures
- Automation
- Lowering resource costs
- Insights on improvements
- Energy reduction
- Better store environment
Forward (new), Integrated Alarm & AFDD Objectives

- Asset - track downtime and maintenance by product category
- Efficient use of resources
- Prioritize repairs based on impact to the business
- Identify energy savings for devices offline (load shedding)
- Analytics to identify energy consumption (online)

Reduce Perishable Loss

- Improve equipment uptime
- Address alarms prior to affecting product
- Diagnostic tools to identify human factors

Predictive Analysis

- Asset - track downtime and maintenance by product category
- Efficient use of resources
- Prioritize repairs based on impact to the business

Energy Savings

Visibility of Assets

- Improved response time to stores/technicians
- Increase freshness and shelf life
- Improved Customer Experience

Reduce Perishable Loss

Visibility of Assets
System Performance

- 21% Warp Accuracy
- 99% IMS Accuracy

False Positives: 78% Less

Events that breach alarm policies are presented to associates on a Ticket in just over a minute:
- Current time to manage = 23 minutes for prioritized alarms
- POC 2 Target = 5 minutes
- POC 2 actual time = 73 seconds for all product affecting alarms

55,388 WARP

3,705 IMS

= 93% Reduction
Thank You
Thank You

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