PREVENTATIVE MAINTENANCE
& When to Say When

A Reliability & Maintainability Implementation Certification (RMIC) Project

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LOCKHEED MARTIN
Lockheed Martin / MFC-Orlando

- Opened in 1957 in anticipation of increased space race activity at Cape Canaveral.
- 1970’s 1st Monorail Cars
- Built for Disney

Today
- 8,000 Employees
- 30+ Buildings
- 3,000,000 sqft
- 700+ HVAC Units
- 12 HVAC Techs cover 24/7
The primary goal of this project was to employ Reliability Centered Maintenance (RCM) principles through the RMIC program to measure the effectiveness of the current PM program.
Project Objectives

1. Determine PM frequency by task
   - Time Based? Condition Based?

2. Establish a PM Review Cycle
   - How Much? How Often?

3. Create a PME/PMO Data Collection Plan
   - What? From Where? What’s Good? What’s Bad?
The Good - Easy as 1,2,3

1. Asset identification and data collection
   - Spreadsheet creation and data input

2. Identify top performing units, revise PM frequency
   - Group PM’s by building/floor

3. Calculate savings
   - Impress your boss
Finding Needles in Haystacks

Challenges
• Units not in CMS
• Data plates painted over
• Inaccurate location data
• Missing documentation

Solution
• Field verification of all units with new labels incorporating QR codes
The Good Continues

Identify

• 600 HVAC assets were in our CMS

Research

• 107 additional were found through field verification, Property Management records, retired CMS systems and word of mouth

Results

• 707 HVAC assets are now being tracked for maintenance effectiveness
## Calculating the Ratio

<table>
<thead>
<tr>
<th>PM EVENT</th>
<th>REPAIR EVENT</th>
<th>PM TO REPAIR</th>
<th>PM FREQ</th>
<th>LABOR HOUR</th>
<th>X PER YEAR</th>
<th>LABOR COST/ YEAR</th>
<th>FILTER COST/ YEAR</th>
<th>TOTAL COST/ YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS FOUND</td>
<td>38</td>
<td>1</td>
<td>38:1</td>
<td>Quarterly</td>
<td>1.5</td>
<td>4</td>
<td>$432</td>
<td>$1152</td>
</tr>
<tr>
<td>UPDATE FREQ.</td>
<td>Semi Annually</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td>$288</td>
<td>$576</td>
<td>$864</td>
</tr>
<tr>
<td>AMOUNT SAVED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$144</td>
</tr>
</tbody>
</table>
Calculating the Ratio

6:1

• If the ratio was 6:1 or better, the duration between PMs was moved out to a higher time span.
Opportunities

1. PM schedules were adjusted to group equipment by building/floor to minimize wasted time traveling between jobs.

2. Units were reviewed for location, inside or outside, high traffic and debris. This factored into the PM frequency choice.
The Good - Results

**Labor**
- 700+ labor hours were saved

**Filters**
- $63,000 in filters were saved annually
Additional Benefits

125 machine fluid chillers were able to be added to pm

Production noticed the HVAC techs working on their machines and expressed their appreciation for the efforts
## The Bad

166 of the 707 units fell below the 6:1 ratio
This particular group of units feed our precision machining area.

<table>
<thead>
<tr>
<th>Asset</th>
<th>Class</th>
<th>MFG</th>
<th>Description</th>
<th>Commission Date</th>
<th>Location</th>
<th>PM</th>
<th>Repair</th>
<th>PMs to repairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA014567</td>
<td>AC-DXAHU</td>
<td>MCQUAY</td>
<td>AC UNIT, DX, AIR HANDLER, (F334), MCQUAY, RDT050DSY, M131-ROOF</td>
<td>10/1/2009</td>
<td>M131-ROOF</td>
<td>27</td>
<td>29</td>
<td>0.9</td>
</tr>
<tr>
<td>BE500055</td>
<td>AC-DXPKG</td>
<td>MCQUAY</td>
<td>AC UNIT, DX PACKAGE, F332, MCQUAY, RDT090CSY, M131-ROOF</td>
<td>6/29/1999</td>
<td>M131-ROOF</td>
<td>49</td>
<td>28</td>
<td>1.8</td>
</tr>
<tr>
<td>CA008964</td>
<td>AC-DXPKG</td>
<td>MCQUAY</td>
<td>AC UNIT DX PACKAGE (F333), MCQUAY, RDT080CSY, M131 ROOF</td>
<td>12/1/2005</td>
<td>M131-ROOF</td>
<td>47</td>
<td>23</td>
<td>2.0</td>
</tr>
<tr>
<td>CA017858</td>
<td>AC-DXPKG</td>
<td>MCQUAY</td>
<td>AC UNIT, DX PACKAGE, F330, MCQUAY, RPS080DSY, M131-ROOF</td>
<td>8/21/2012</td>
<td>M131-ROOF</td>
<td>20</td>
<td>18</td>
<td>1.1</td>
</tr>
<tr>
<td>CA014564</td>
<td>AC-COND</td>
<td>MCQUAY</td>
<td>AC UNIT, CONDENSER, (F335) MCQUAY, RDT 050 DSY, M131-ROOF</td>
<td>10/1/2009</td>
<td>M131-ROOF</td>
<td>11</td>
<td>17</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Preventive Maintenance & When to Say When

Range of Despair

Ideal ratio for PM to Repair is 6:1

Actual ratios of the bad units were between

0.3:1 (4 pm to 16 repair)
and
5.8:1 (35 pm to 6 repair)
Unit Age by %

- Less than 5 years
- 6 to 10 years
- 11 to 15 years
- 16 to 20 years
- 21 to 25 years
- 26+ years

- All Units
- Bad Units
The 15 worst performing units were selected for an in depth review. Their work order histories were studied in depth and failure codes were assigned to each of the failures.

<table>
<thead>
<tr>
<th>Date Reported</th>
<th>Date Completed</th>
<th>Action</th>
<th>WO #</th>
<th>Problem</th>
<th>Tech Comments</th>
<th>Problem</th>
<th>Cause</th>
<th>Failure</th>
<th>Action</th>
<th>Does the action prevent reoccurrence?</th>
<th>Part replaced?</th>
<th>Part replaced?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 11, 2020</td>
<td>Dec 11, 2020</td>
<td>Breakdown/Repair</td>
<td>1550004</td>
<td>Replace Blower Motor.</td>
<td>Remove old blower motor by lowering the blower assembly. After replacing and aligning new motor we had to reassemble the blower assembly.</td>
<td>Not running</td>
<td>Tripped</td>
<td>Failed Part</td>
<td>Replaced Part</td>
<td>Yes</td>
<td>Blower motor</td>
<td></td>
</tr>
<tr>
<td>Jun 25, 2020</td>
<td>Aug 11, 2020 PM</td>
<td>Breakdown/Repair</td>
<td>1495103</td>
<td>Repair Liebert Unit In Substation 24</td>
<td>Found no cooling on arrival. Compressor #1 is grounded. Compressor #2 has a burnt contactor and 2 bad fuses. Swapped contactors and replaced fuses for compressor #2 to run and repaired burnt wires. Replaced transducer for compressor #2 because keypad said it was low on refrigerant but really was not. Added refrigerant to circuit #2 due to losing some while replacing transducer.</td>
<td>Poor Performance</td>
<td>Tripped</td>
<td>Failed Part</td>
<td>Replaced Part</td>
<td>Yes</td>
<td>compressors 2, contactors 2, drier 2, sight glass 2</td>
<td></td>
</tr>
</tbody>
</table>
## The Ugly

### Frequent Failures

**Most Frequent Failures of the Lowest Performing Units**

<table>
<thead>
<tr>
<th>Failure Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humidifier/Dehumidifier</td>
<td>5</td>
</tr>
<tr>
<td>Controls</td>
<td>10</td>
</tr>
<tr>
<td>Unknown</td>
<td>15</td>
</tr>
<tr>
<td>Refrigerant Leak</td>
<td>20</td>
</tr>
<tr>
<td>No Access to Controller</td>
<td>25</td>
</tr>
<tr>
<td>Clogged Coil</td>
<td>50</td>
</tr>
<tr>
<td>Failed Part</td>
<td>70</td>
</tr>
</tbody>
</table>

-Bar chart showing the percentage of most frequent failures for the lowest performing units.

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**Preventive Maintenance & When to Say When**

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**Intro**

**Good**

**Bad**

**Ugly**

**Conclusions**

**Questions**

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**Reliability**

**Availability**

**Maintainability**

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**Clogged Coil**

**Failed Part**
Top 10 Most Replaced Parts for the 14 Lowest Performing AC Units

- Fan Motor
- Compressor
- Dryer
- Condenser coil
- Fuse
- Blower bearings
- Belt
- Contactor
- Blower motor
- Wire
The Ugly

Parts Used Most Frequently on the 14 Lowest Performing AC Units

<table>
<thead>
<tr>
<th>AC Unit</th>
<th>Number of Parts Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>S101</td>
<td>Fan Motor</td>
</tr>
<tr>
<td>F333</td>
<td>2</td>
</tr>
<tr>
<td>MAC1</td>
<td>2</td>
</tr>
<tr>
<td>F332</td>
<td>4</td>
</tr>
<tr>
<td>C101</td>
<td>2</td>
</tr>
<tr>
<td>B101</td>
<td>3</td>
</tr>
<tr>
<td>F330</td>
<td>3</td>
</tr>
<tr>
<td>F334</td>
<td>2</td>
</tr>
<tr>
<td>E315</td>
<td>2</td>
</tr>
<tr>
<td>M127</td>
<td>6</td>
</tr>
<tr>
<td>F335</td>
<td>1</td>
</tr>
<tr>
<td>E101</td>
<td>1</td>
</tr>
<tr>
<td>F316</td>
<td>1</td>
</tr>
<tr>
<td>P147</td>
<td>1</td>
</tr>
</tbody>
</table>

Legend:
- Fan Motor
- compressor
- dryer
- contactor
- belt
Fan Motor Failure Timeline

Fan motors were the most replaced part. A failure timeline was created to see how long replacement fan motors last. After market fan motors do not seem to hold up as well as the original.

<table>
<thead>
<tr>
<th>Asset</th>
<th>Description</th>
<th>Date of 1st failure</th>
<th>Duration between failures (days)</th>
<th>Date of 2nd failure</th>
<th>Duration between failures (days)</th>
<th>Lifespan difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE500055</td>
<td>AC UNIT, DX PACKAGE, F332, MCQUAY, RDT090CSY, M131-ROOF</td>
<td>4/14/2013</td>
<td>5038</td>
<td>10/14/2018</td>
<td>2009</td>
<td>40%</td>
</tr>
<tr>
<td>CA014567</td>
<td>AC UNIT, DX, AIR HANDLER, (F334), MCQUAY, RDT050DSY, M131-ROOF</td>
<td>10/4/2018</td>
<td>3290</td>
<td>1/30/2021</td>
<td>849</td>
<td>26%</td>
</tr>
<tr>
<td>CA008964</td>
<td>AC UNIT DX PACKAGE (F333), MCQUAY, RDT080CSY, M131 ROOF</td>
<td>12/24/2019</td>
<td>5136</td>
<td>10/25/2020</td>
<td>306</td>
<td>6%</td>
</tr>
<tr>
<td>CA014564</td>
<td>AC UNIT, CONDENSER, (F335) MCQUAY, RDT 050 DSY, M131-ROOF</td>
<td>8/14/2017</td>
<td>2874</td>
<td>9/7/2018</td>
<td>389</td>
<td>14%</td>
</tr>
</tbody>
</table>
What Does the Data Show?

• After Failed Part, clogged coils was the second highest failure. Compressors were the second highest part replaced. Dirty coils cause premature compressor failure.

• The 5 units in the Precision Machining area are in list of the worst performing units with a high frequency of fan motor failure.

• Unit MAC1 has lost 5 belts. Drive motor/blower alignment needs to be verified.

• Certain units have software for the controller that our technicians do not have access to and must call an outside service technician causing unnecessary downtime.
What did we do?

**Good**
- Increased time between PMs for the good units.
- Saved 700 hours of labor.
- Added an additional 125 machines to care for

**Bad**
- Created new PM instructions to address dirty coils and fan motors
- Adjusted frequencies based on mean time between failure (MBTF)

**Ugly**
- Increased documentation regarding equipment condition to justify replacement
- Replacement of small units that can be completed with inhouse labor