Failure Mode Analysis

Presented by: Brunno Covolan
What is Failure Mode Analysis?

• Looking at the compressor to determine what was the cause of the failure.

Why do we need to conduct Failure Mode Analysis?

• Helps us fix the system to prevent further damage.
• Helps understand what we need to do.

How do we conduct a Failure Mode Analysis?

• Open the compressor.
• Examine the compressor and analysis the broken pieces.
Common Failures

Failures can be caused at 3 different times of a compressor’s life
  • During Installation
  • During Operation

The following slides will examine the common failures at each of the individual stages
### Common Failures – During Installation

<table>
<thead>
<tr>
<th>Error</th>
<th>Failure mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage to pipe fittings, threads, and O-rings</td>
<td>Refrigerant leaks</td>
</tr>
<tr>
<td>Damage to rotor or armature</td>
<td>Noise, burned clutch, rotor bearing collapsed</td>
</tr>
<tr>
<td>Crack on ear mount</td>
<td>Refrigerant leaks, mounting failure</td>
</tr>
<tr>
<td>Wrong coil polarity</td>
<td>No clutch engagement – diode failure</td>
</tr>
<tr>
<td>Inadequate refrigerant charge</td>
<td>Compressor seizure</td>
</tr>
<tr>
<td>Insufficient oil amount</td>
<td>Compressor seizure</td>
</tr>
</tbody>
</table>
## Common Failures – During Operation

<table>
<thead>
<tr>
<th>Error</th>
<th>Failure mode</th>
</tr>
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<tbody>
<tr>
<td>Expansion Valve problems</td>
<td>Compressor seizure</td>
</tr>
<tr>
<td>Obstructed hoses/pipes</td>
<td>Compressor seizure</td>
</tr>
<tr>
<td>Leaks through porosity</td>
<td>Compressor seizure</td>
</tr>
</tbody>
</table>
Common Failures – During Operation

The pressure switch on high pressure side may not protect in case of small leak

The pressure curve in static circuit depends only on the ambience temperature.

Vapour pressure R134a

\[ \text{Pressure (Bar abs)} \]

\[ \text{T °C} \]

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
-40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70

LIQUID

GAS

LIQUID

GAS
Common Failures – During Operation

**Contamination**

- Particles introduced during installation
- System was not flushed before installation of compressor
- Defective receiver dryer/ accumulator, desiccant
Common Failures – During Operation

**Accumulation of liquid refrigerant in the compressor**

- Noise, burned clutch
- Washout
- Piston damage

**Presence of moisture**

- Acid formation, corrosion
- TXV blockage
Compressor Teardown Procedure

When tearing down a compressor to determine failure mode, it is important to follow the correct procedure. These procedures ensure that nothing will be missed and that the correct diagnosis is found.

<table>
<thead>
<tr>
<th>Item</th>
<th>Check Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Check body for damages</td>
<td>hits, corrosion, overheat</td>
</tr>
<tr>
<td>2  Check electrical connection</td>
<td>Wire cut, original connector</td>
</tr>
<tr>
<td>3  Check ports</td>
<td>O-tings, threads, particles</td>
</tr>
<tr>
<td>4  Check clutch airgap</td>
<td>Between 0.4mm to 0.8mm</td>
</tr>
<tr>
<td>5  Check armature plate</td>
<td>Leaf spring, deformation, overheating</td>
</tr>
<tr>
<td>6  Check pulley</td>
<td>Hit marks, noise, smooth rotation</td>
</tr>
<tr>
<td>7  Check coil</td>
<td>Resistance, diode</td>
</tr>
<tr>
<td>8  Check oil plug</td>
<td>Torque 15Nm</td>
</tr>
<tr>
<td>9  Check oil quality</td>
<td>Color</td>
</tr>
<tr>
<td>10 Check compressor shaft rotation</td>
<td>Smooth rotation</td>
</tr>
</tbody>
</table>
## Compressor Teardown Procedure

<table>
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<th>Item</th>
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<tr>
<td>11 Remove armature plate</td>
<td>Surface not glassed</td>
</tr>
<tr>
<td>12 Remove Pulley</td>
<td>Check snap ring fitment</td>
</tr>
<tr>
<td>13 Remove Coil</td>
<td>Check snap ring fitment</td>
</tr>
<tr>
<td>14 Remove felt ring</td>
<td>Not saturated with oil</td>
</tr>
<tr>
<td>15 Remove cylinder head</td>
<td>- Check for even torque</td>
</tr>
<tr>
<td></td>
<td>- Check liquid line, signs of overheating</td>
</tr>
<tr>
<td>16 Check valve plate</td>
<td>Check deformation, overheating, particles</td>
</tr>
<tr>
<td>17 Check pistons</td>
<td>Overheating, particles</td>
</tr>
<tr>
<td>18 Open front housing</td>
<td>- Check for even torque</td>
</tr>
<tr>
<td></td>
<td>- O-rings, particles, overheating</td>
</tr>
<tr>
<td>19 Pull out pistons</td>
<td>piston rings, centering ball, gears</td>
</tr>
<tr>
<td>20 Cylinder block</td>
<td>Particles, cracks</td>
</tr>
</tbody>
</table>
Let's take a look at some examples

How this will work
1: We will see a set of pictures representing the same problem.
2: We will discuss what we see on every picture.
3: At the end we will discuss the problem.
Failure Mode Analysis
Failure Mode Analysis
Failure Mode Analysis
Failure Mode Analysis

What do you think is the problem?

• Overheating.
• Overheating occurs when there is a lack of oil in the compressor.

What could cause low oil amount?

• Liquid compression.
• System blockage.

Let's go to the next set
Failure Mode Analysis
Failure Mode Analysis
Failure Mode Analysis
Failure Mode Analysis
What do you think is the problem?

- Moisture in system.
- Moisture + Oil + Refrigerant + Heat will cause acid to form and corrode lines and compressor.

How to avoid this issue?

- Vacuum.
- Replace receiver dryer every time the system is opened.
Failure Mode Analysis
Failure Mode Analysis

What do you think is the problem?

• Dye non-compatibility.

How to avoid this issue?

• Check for compatibility.
• Research receiver dryer.
Failure Mode Analysis
Failure Mode Analysis
Failure Mode Analysis

What do you think is the problem?

- Improper installation.
- To much torque when installing ports.

How to avoid this issue?

- Use torque wrench.
Failure Mode Analysis
Failure Mode Analysis
Failure Mode Analysis
What do you think is the problem?

• Contamination.
• Partials from other components and past failures.

How to avoid this issue?

• Flush system before installing new component.
• Replace broke components.
Failure Mode Analysis

**DIAGNOSIS BY OIL COLOR**

Clear oil or oil with UV tracer: Compressor probably inside O.K.

Silver-grey oil: Foreign particle from A/C System or internal seizure

Black oil: AC system overheated due to malfunction of condenser, defect pressure switch or lack of refrigerant

Orange oil: Contamination with humidity
THE END!