Causes & Prevention of Compressor Failure

Copeland™ by Emerson

Causes & Prevention of Compressor Failure

Note that all supplemental curriculum is for **reference and educational purposes only**. Please refer to Application Engineering Bulletins for any specific procedures.

Scroll Compressor Basics

Standard Operation

EMERSON

How Does a Scroll Compressor Work?

- Refrigerant enters through the **suction tube**
- The **moving scroll orbits** about the fixed scroll, driven by the crank shaft
- The refrigerant is forced to **follow the path** created by the moving scroll – inwards **towards the center** of the fixed scroll
- As it approaches the center, the packet **grows smaller**, and the **pressure & temperature** of the working fluid **increases** as a result
- The **compressed, high-temperature** working fluid is then discharged from the **center of the scroll** and out the discharge tube

Get to Know the Copeland Scroll Compressor

Compressing a Pocket of Gas

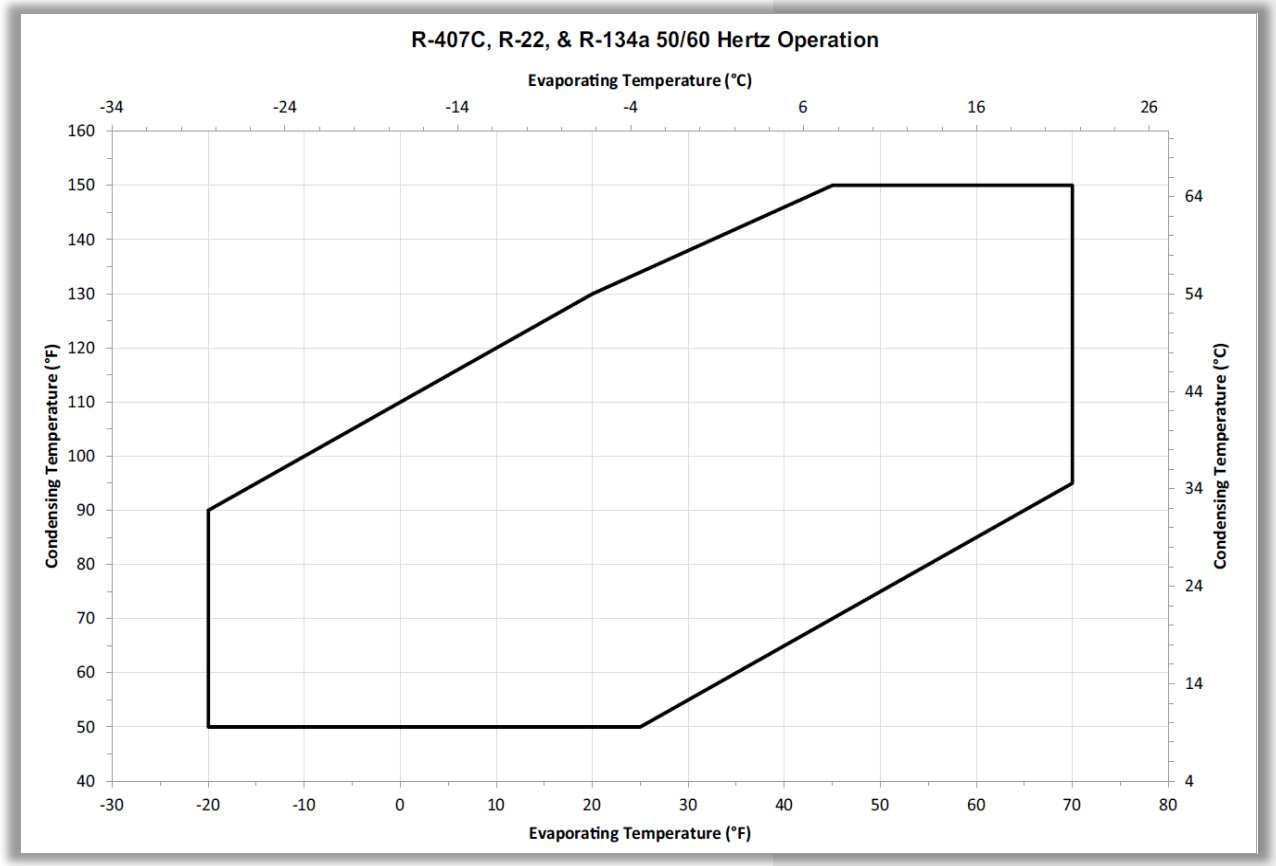
A moving scroll orbits about a path defined by a fixed scroll, capturing a pocket of gas between the two scrolls and forcing it into an increasingly smaller packet, resulting in its compression

What Are The Operating Characteristics Of The Compressor?

All compressors are designed for a specific application with specific operating conditions:

- Temperature Ranges
- Pressure Ranges
- Refrigerants
- Lubricants

Operating Envelope Example



Repeated operation for long durations outside the envelope may result in reduced compressor life or failure.

What Are Some General Guidelines For Compressor Operation?

- Running in Vacuum will cause Terminals to Arc
- Voltage must be within 10% of rating
- > 20 lb. of refrigerant, add 1 fl. oz of oil per 5 lb. of refrigerant charge. Follow OEM Guidelines
- Retrofit must have minimum 95% POE
- Compression Ration:
  - ❑ 3:1 High Temp
  - ❑ 5:1 Medium Temp
  - ❑ 10:1 Low Temp

- Discharge line < 225˚F 6” from Compressor.
- POE Oil thins at 310-320˚F
- Superheat must be present and within OEM Specification.
- Moisture on Shell can be normal depending on application. Verify with Superheat.
- Bottom of Shell < 200˚F

*Refer to specific compressor model **application engineering bulletin** for more information*

What Causes Compressor Failure?

EMERSON

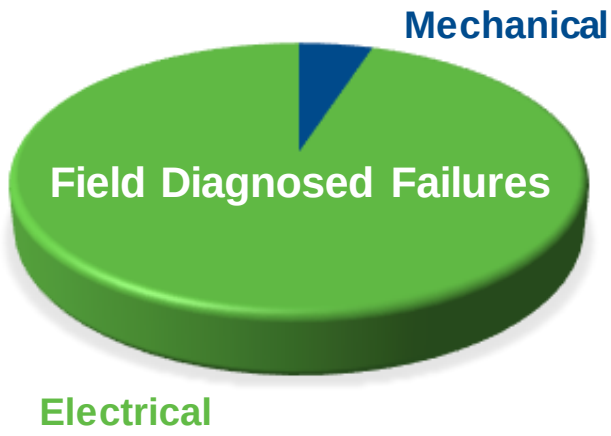
What Are Common Causes of Compressor Failure?

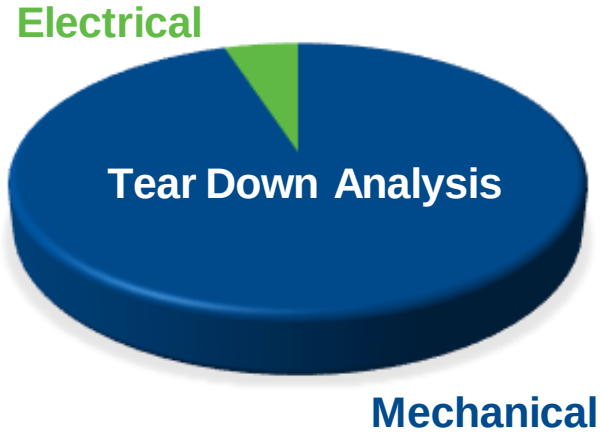
Mechanical

- Oil dilution/ Lack of Oil
- Refrigerant Floodback
- Flooded Starts
- Misassembled
- Overheating

Electrical

- Mis-Wire
- Faulty Start Components
- Low Voltage
- Voltage Spike
- Faulty Contactor Contacts





Terminology Check

Floodback is when liquid refrigerant enters the compressor during operation

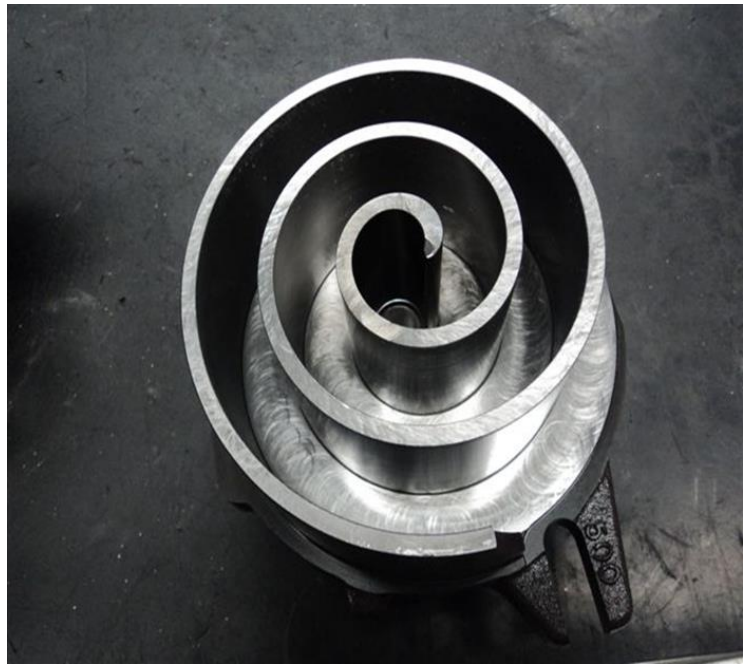
Flooded Start is when vapor refrigerant migrates during the off cycle and condenses in the sump of the compressor. Upon start up, oil is brought into the scroll instead of refrigerant

What Are The Results of Oil Dilution/Lack of Lubrication?

Lack of Oil/Dilution Leads to Heavy Bearing Wear & Galled Scroll Set.

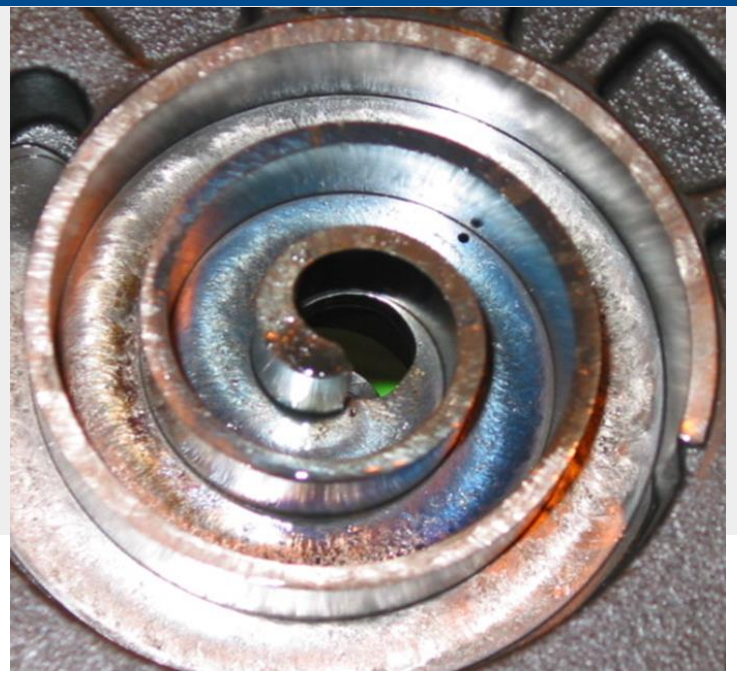
Caused by

- Horizontal traps in the line set.
- No vertical traps in long line applications.
- Short cycling
- Oil dilution
  - Flooded start
  - Liquid floodback



What Are The Results of Compressor Over Heating?

Overheating Reduces the Life of the Compressor's Mechanical and Electrical Components.



Causes:

- High Compression Ratio
- High Return Gas Temperature
- High Superheat
- Undercharge/ Loss of Charge
- Scroll Separation

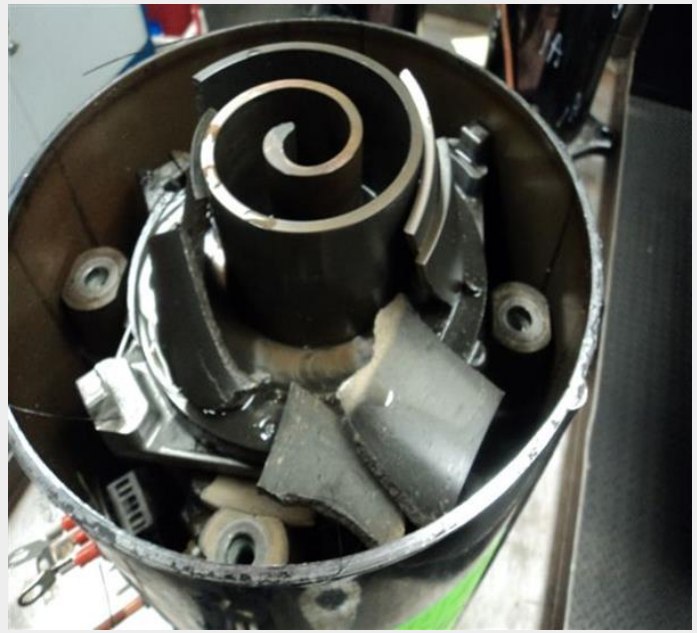
What Are The Results Of Refrigerant Slugging?

Broken Scroll Set from an Attempt to Compress a Liquid. Worn Contact Parts from Lack of Lubrication.

Causes:

Refrigerant migration during the off cycle

- Refrigerant migrates to the coldest place as a vapor and condenses
- Refrigerant settles below oil
- On startup, oil is pulled into the scroll set



What Are The Results Of Non-Condensable In The System?

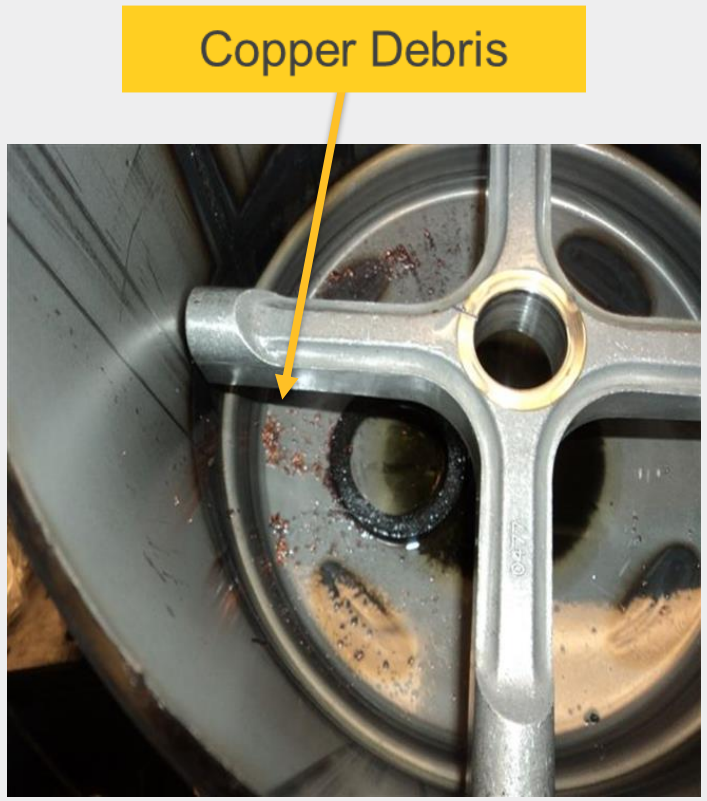
Copper Plating, Oxidation, & Pitting of Components Are All Results of Non-Condensable in the System.

Causes:

- Improper Vacuum
- Leak- operation in vacuum

What Happens When Foreign Debris Enters The Compressor?

Refrigerant Systems Are Designed For Two Things: Refrigerant and Oil!



Causes:

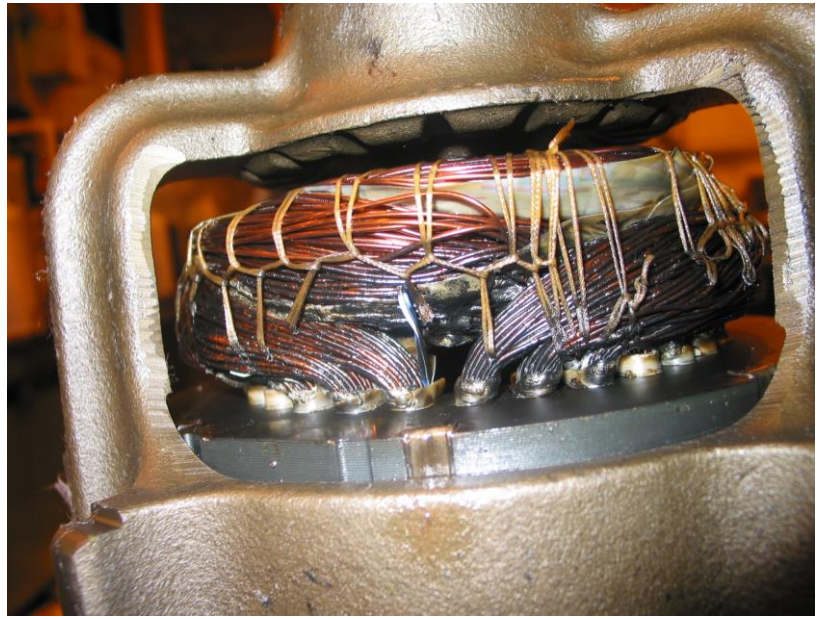
- Copper Shavings from line set install.
- Copper shavings from motor failure.

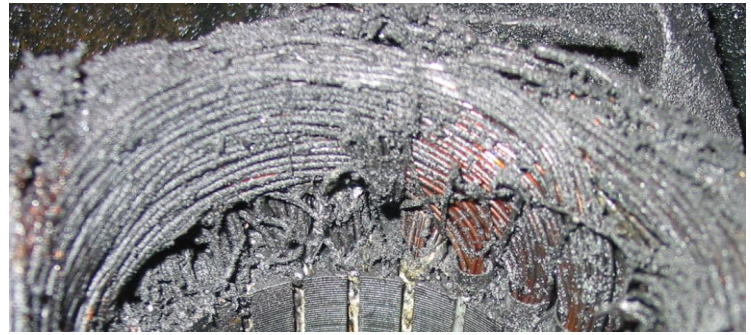
What Are The Results Of Electrical Failures?

Burned Windings are the Most Common Failure Due to Electrical Failures.

Failure Process

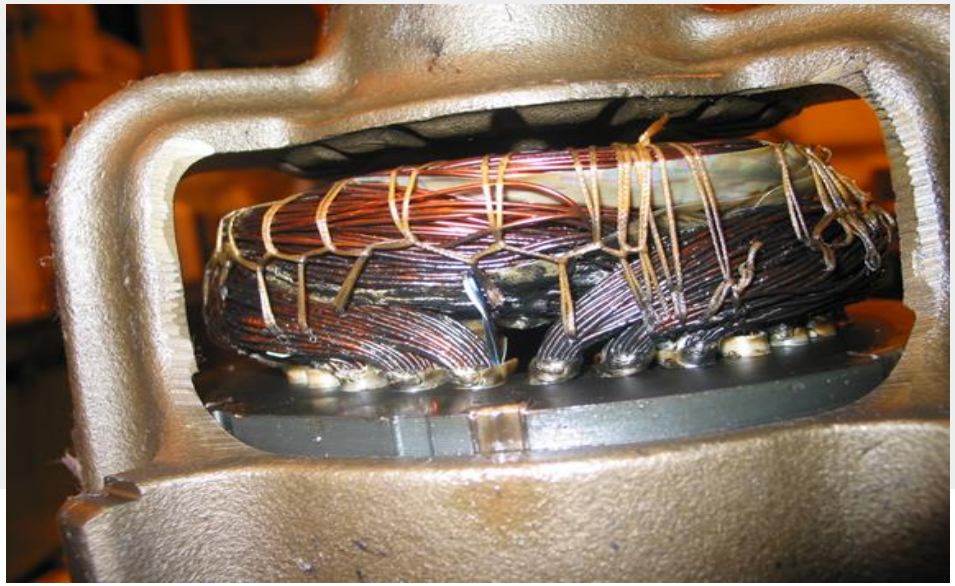
1. Bearing Wear
2. Rotor Mis-Alignment
3. Rotor Rubbing on Stator
4. Debris Build Up on Motor
5. Electrical Failure





What Are The Different Types Of Motor Failures?

The Electrical Failure can be Determined by the Extent of the Stator Burn of the Part of the Stator Affected.



1: General Burn - Entire Windings Burned

- Voltage Problems
- Lack Of Motor Cooling

2: Spot Burn - Localized Burn

- Voltage Spike
- Foreign Material

3: Start Winding Burn - Only Start Winding Burned

- Start Relay, Capacitor, “Outside The Motor”

4: Leads Shorted

What Needs To Be Done While Replacing a Failed Compressor?

Mechanical Failure

- Recover Refrigerant.
- Cut current compressor from system (do not sweat out).
- Install new compressor and starting components.
- Install new liquid line drier.
- Pressure test system for 30 minutes.
- Evacuate to 500 microns.
- Charge with correct amount and type of refrigerant.
- Verify proper operation with SH and SC.
- **Fix the Root Cause of the Failure!!!**

*Refer to AE 24-1105 for more details

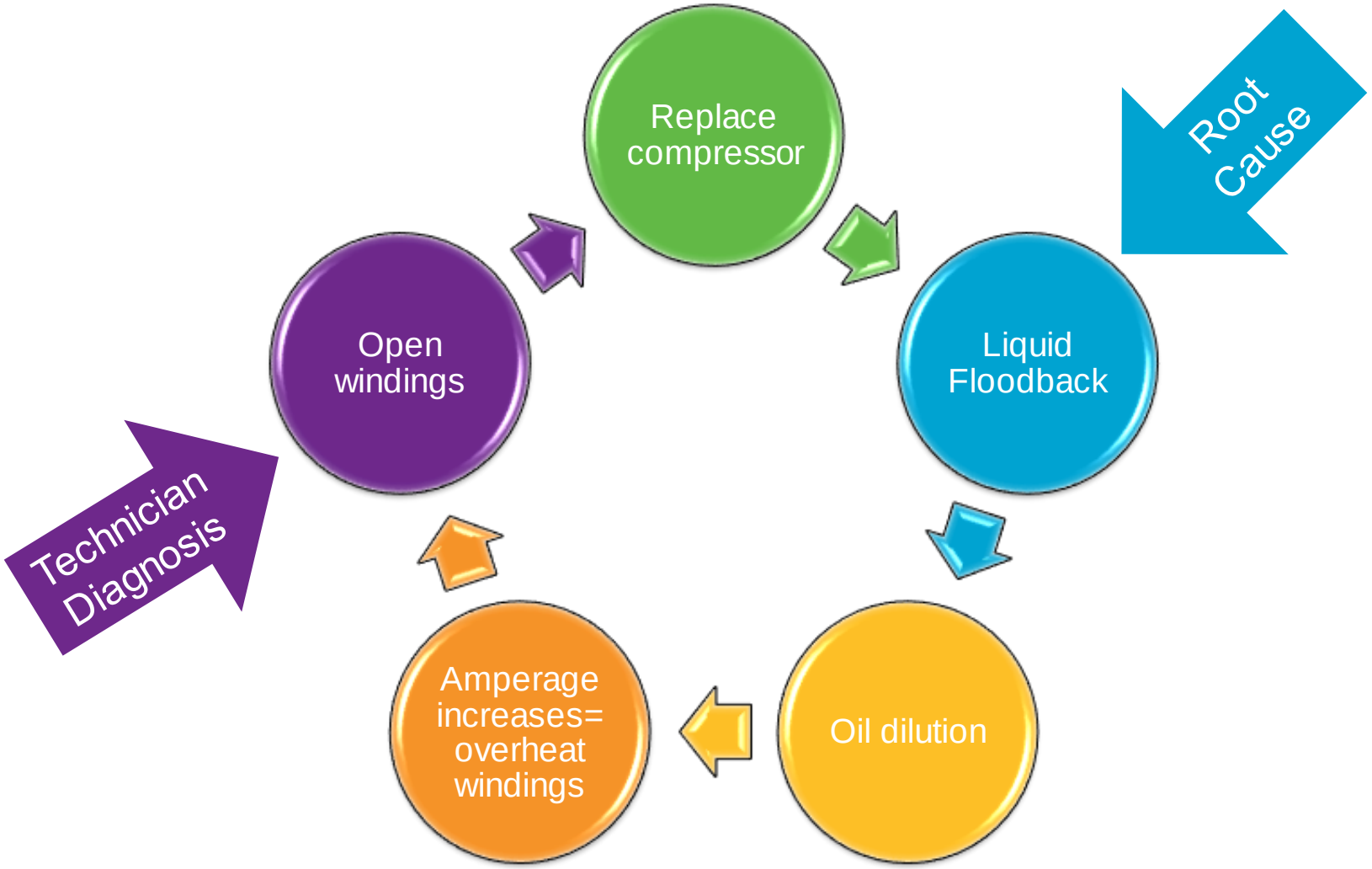
Electrical Failure

- Recover Refrigerant into a contaminated tank- Refrigerant most likely contains sludge, water, and corrosive acid.
- Cut current compressor from system.
- Install new compressor and start components.
- Install suction line drier- Acid Removal.
- Install new liquid line drier.
- Pressure test for 30 minutes.
- Evacuate to 500 microns.
- Charge with new, correct amount, and type of refrigerant.
- Verify proper operation with SH and SC
- **Fix the Root Cause of the Failure!!!**

Not Properly Cleaning a System After a Compressor Failure Will Lead to Another Failure!

Root Cause Diagnosis

What Is The Importance of Root Cause Diagnosis?



Understanding Root Cause of Failure the First Time Prevents Repeat Failures!

What Is The Best Method To Troubleshoot Compressors?

Trouble Shooting System Checklist

This form is to be used to submit system information to help develop solutions to system issues.

Company Name: _____ Phone or E-mail Contact info: _____

Contact Name: _____ Date: _____

Readings at Compressor Discharge Outlet

- Discharge Pressure _____
- Saturated Discharge Temperature _____
- Discharge Temperature _____
- Calculated Discharge Super Heat _____
- DLT Design Limit _____

Compressor Electrical Readings (1 or 3 phase)

- Voltage(s) _____
- Amperage(s) _____
- Winding Resistance _____
- System Controller _____
- Any Alarms or Trips _____
- Oil Level in Sight Glass _____

Readings at Compressor Suction Inlet

- Suction Pressure _____
- Saturated Suction Temperature _____
- Suction Temperature _____
- Calculated Super Heat * _____
- Compressor Sump Temperature _____
- Low Pressure Cut Out Set Point _____

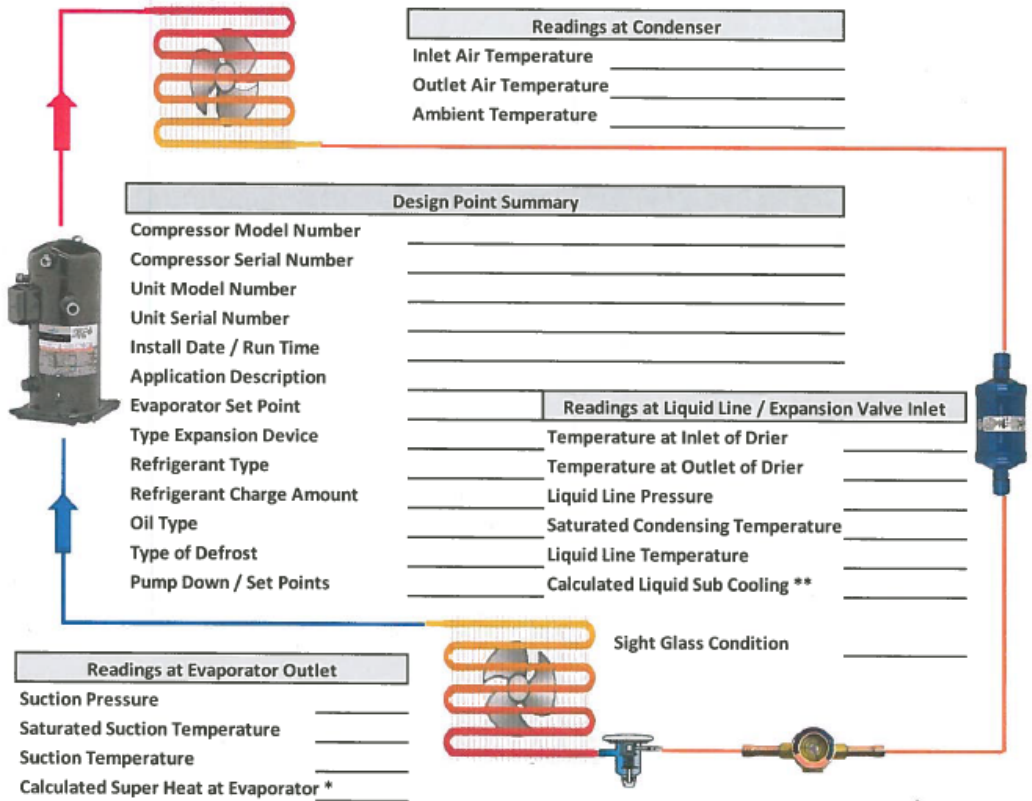
Other System Related Notes

_____

_____

_____

_____



Readings at Condenser

- Inlet Air Temperature _____
- Outlet Air Temperature _____
- Ambient Temperature _____

Design Point Summary

- Compressor Model Number _____
- Compressor Serial Number _____
- Unit Model Number _____
- Unit Serial Number _____
- Install Date / Run Time _____
- Application Description _____
- Evaporator Set Point _____
- Type Expansion Device _____
- Refrigerant Type _____
- Refrigerant Charge Amount _____
- Oil Type _____
- Type of Defrost _____
- Pump Down / Set Points _____

Readings at Liquid Line / Expansion Valve Inlet

- Temperature at Inlet of Drier _____
- Temperature at Outlet of Drier _____
- Liquid Line Pressure _____
- Saturated Condensing Temperature _____
- Liquid Line Temperature _____
- Calculated Liquid Sub Cooling ** _____

Sight Glass Condition _____

Readings at Evaporator Outlet

- Suction Pressure _____
- Saturated Suction Temperature _____
- Suction Temperature _____
- Calculated Super Heat at Evaporator * _____
- Current Box Temperature _____

* Suction pressure converted to temperature minus suction temperature

** Liquid pressure converted to temperature minus liquid line temperature

EMERSON

System Problem	Discharge Pressure	Suction Pressure	Super Heat	Sub Cooling	Amps
Overcharged	↑	↑	↓	↑	↑
Undercharged	↓	↓	↑	↓	↓
Liquid Restriction (Drier)	↓	↓	↑	↓	↓
Low Evaporator Airflow	↓	↓	↓	↑	↓
Dirty Condenser	↑	↑	↑	↑	↑
Low Outside Ambient Temperature	↓	↓	↓	↑	↓
Inefficient Compressor	↓	↑	↑	↑	↓
TXV Bulb Loose	↑	↑	↓	↓	↑
TXV Bulb Lost Charge	↓	↓	↑	↑	↓
Poorly Insulated TXV Bulb	↑	↑	↓	↓	↑

Form Number: 2018ECT-3

What Is The Best Method To Troubleshoot Compressors?

Troubleshooting Guide – Not Starting/Running

Compressor not running

- Allow time for compressor protector to reset
- Check voltage at compressor terminals (1)
  - Proper voltage
    - Check amp draw
      - High or excessive amps
        - Check winding resistance and resistance to ground (1)
          - Improper resistance → Replace compressor
          - Proper resistance → Check wiring
            - Wired incorrectly → Fix – replace wiring (1, 4, 5)
            - Wired correctly → Check electrical connections
              - Bad → Fix – connections (3, 4, 5)
              - Good → Are the start components OK? (i.e. relays, motor starters, contactors and capacitors)
                - No → Do not replace compressor Verify system operation (3)
                - Yes → Is the compressor properly applied? Proper refrigerant, voltage application, temp
                  - No → Resolve application issues (2)
                  - Yes → Balance system pressure and attempt to restart while observing amps
                    - Restarts
                      - High amps → Replace protector (if accessible) or compressor
                      - Normal amps → Do not replace compressor Fix voltage issues Verify system operation (2, 4, 5)
                    - Does not restart → Replace compressor
        - Reset → Check amp draw
        - Did not reset → Replace protector (if accessible) or compressor
      - No amps → Allow time for compressor protector to reset
  - Improper voltage (4) → Do not replace compressor Fix voltage issues Verify system operation (4)
  - No voltage (5) → Do not replace compressor Fix voltage issues Verify system operation (4)

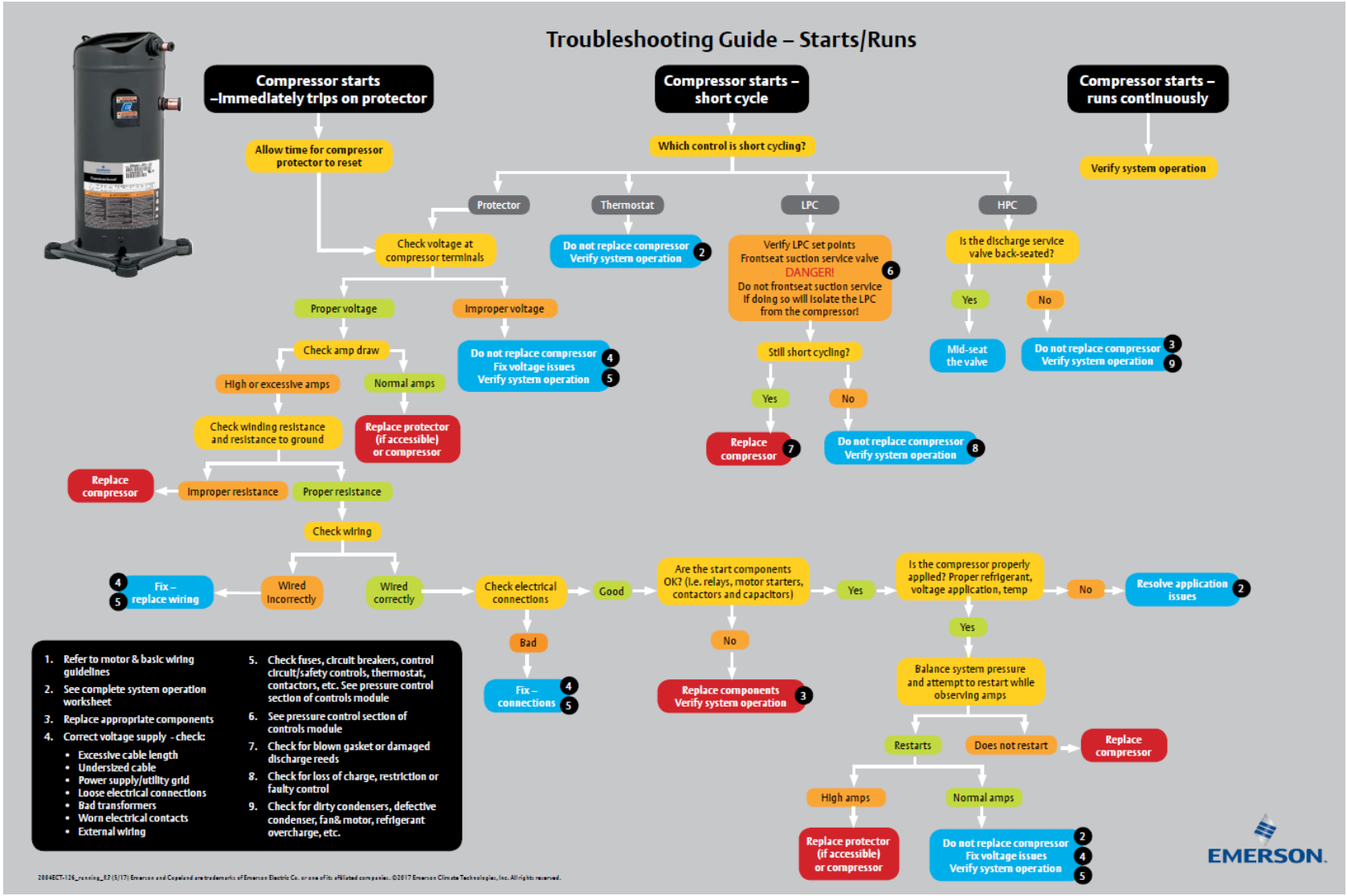
Does not start – Instantly blown fuses

- Is compressor grounded? (1)
  - Yes → Replace compressor
  - No → Check winding resistance using an ohmmeter
    - Windings OK → Do not replace compressor Fix voltage issues Verify system operation (4)
    - Windings not OK → Replace compressor

1. Refer to motor & basic wiring guidelines
2. See complete system operation worksheet
3. Replace appropriate components
4. Correct voltage supply - check:
   - Excessive cable length
   - Undersized cable
   - Power supply/utility grid
   - Loose electrical connections
   - Bad transformers
   - Worn electrical contacts
   - External wiring
5. Check fuses, circuit breakers, control circuit/safety controls, thermostat, contactors, etc. See pressure control section of controls module

EMERSON.

What Is The Best Method To Troubleshoot Compressors?



Quiz Questions

EMERSON

Quiz Answers – How Compressors Fail

Scroll Compressor Basics

1. Where during the compression process will the refrigerant be at the highest pressure and temperature?
   a) Entering the suction tube?
   b) As it is moving towards the center of the fixed scroll
   c) When it exits the discharge tube

2. What is **not** an operating characteristic of a scroll compressor designed for a specific application?
   a) Lubricants
   b) Refrigerants
   c) Pressure Ranges
   d) Elevation
   e) Temperature Ranges

3. Select the correct "General Guidelines" applicable for scroll compression operation
   a) Voltage must be within 10% of rating,
   b) Discharge line > 400 ˚F 6" from compressor
   c) Retrofit must have minimum 95% POE
   d) POE Oil Thins at 310-320˚F
   e) There should never be moisture on shell for any application

Study The "How Compressors Fail" Presentation

Quiz Answers – How Compressors Fail

What Causes Compressor Failure?

1. **Select all correct statements about floodback and flooded start.**

   a) Floodback occurs during operation while flooded starts begin during the off cycle

   b) The refrigerant is always a vapor during floodback and always a liquid during a flooded start

   c) During flooded start, oil is brought into the scroll instead of refrigerant

   d) During floodback, both oil and refrigerant are brought in through the suction fitting

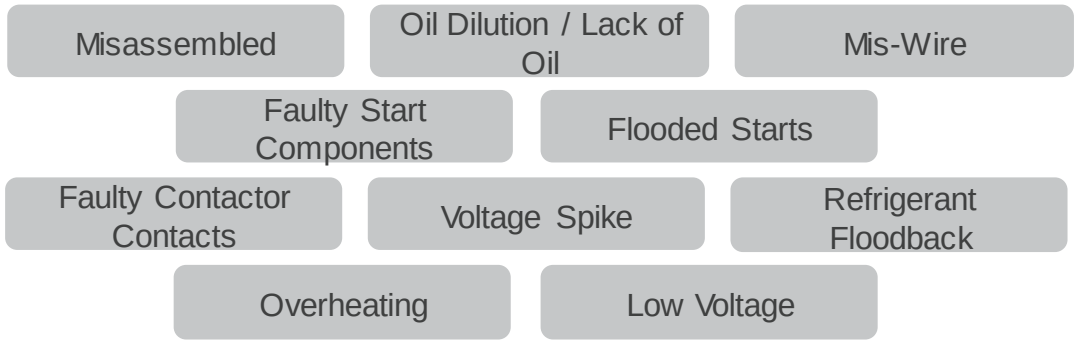
2. **Order the process of electrical failure from beginning (1) to end (5)**

   – Rotor Mis-Alignment, Electrical Failure, Rotor Rubbing on Stator, Bearing Wear, Debris Build Up on Motor

3. **Select the four types of motor failure from the list below**

   General burn (entire windings), Full compressor burn, Spot/Localized burn, Rotor burn, Start winding burn, Leads shortened

4. **Categorize each common cause of compressor failure into mechanical or electrical issues**



Study The "How Compressors Fail" Presentation

Quiz Answers – How Compressors Fail

What Causes Compressor Failure?

5. Match each compressor issue to the **causes** and **results** of the problem

Issue	Causes	Results
(A) Oil Dilution / Lack of Lubrication	**(1)** Vapor refrigerant migration to coldest place during the off cycle, resulting in refrigerant condensing and settling below oil. Oil pulled up into scroll set during startup.	**(I)** Reduced life of compressor's mechanical and electrical components
(B) Overheating	**(2)** Horizontal traps in the line set; not vertical traps in long line applications; short cycling; flooded start or liquid floodback	**(II)** Broken scroll sets, worn contact parts
(C) Refrigerant Slugging	**(3)** Improper Vacuum; Leak – operation in vacuum	**(III)** Heavy bearing wear and galled scroll set
(D) Non-Condensable in the System	**(4)** High compression ratio, return gas temp and superheat; undercharge/loss of charge; scroll separation	**(IV)** Copper embedded in flanks and debris in compressor
(E) Foreign Debris Entering Compressor	**(5)** Copper shavings from line set install or motor failure	**(V)** Copper plating, oxidation & pitting of components

Label the Major Compressor Scroll Components

Study Page 3 of the Instruction Manual

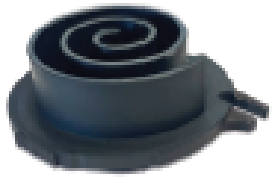
A Deeper Dive – Label These Additional Components (Scroll Set)

1 _____

2 _____

3 _____

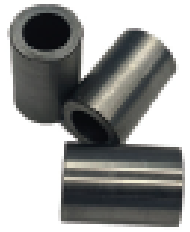
4 _____



5 _____

6 _____

7 _____



8 _____

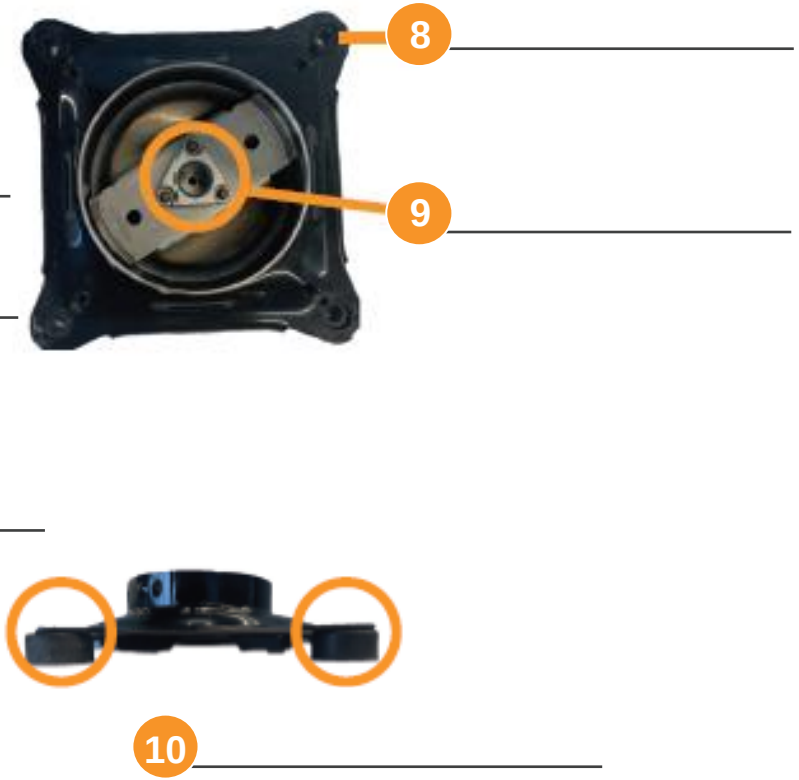
Study Page 13 - 15 of the Instruction Manual

A Deeper Dive – Label These Additional Components

Top Cap and Muffler Plate

Crankshaft and Rotor

Lower Cover



Study Page 13 - 15 of the Instruction Manual

Answer Key

EMERSON

Quiz Answers – How Compressors Fail

Scroll Compressor Basics

1. Where during the compression process will the refrigerant be at the highest pressure and temperature?
   - (A) Entering the suction tube? (B) As it is moving towards the center of the fixed scroll **(C) when it exits the discharge tube**
2. What is **not** an operating characteristic of a scroll compressor designed for a specific application?
   - (A) Lubricants (B) Refrigerants (C) Pressure Ranges **(D) Elevation** (E) Temperature Ranges
3. Select the correct "General Guidelines" applicable for scroll compression operation
   - **Voltage must be within 10% of rating,**
   - Discharge line > 400 ˚F 6" from compressor
   - **Retrofit must have minimum 95% POE**
   - **POE Oil Thins at 310-320˚F**
   - There should never be moisture on shell for any application

What Causes Compressor Failure?

1. Select all correct statements about floodback and flooded start.
   - a) **Floodback occurs during operation while flooded starts begin during the off cycle**
   - b) The refrigerant is always vapor during floodback and always a liquid during flooded start
   - c) **During flooded start, oil is brought into the scroll instead of refrigerant**
   - d) During floodback, both oil and refrigerant are brought into the compressor
2. Order the process of electrical failure
   - Rotor Mis-Alignment **(2),** Electrical Failure **(5),** Rotor Rubbing on Stator **(3)**, Bearing Wear **(1)**, Debris Build UP on Motor **(4)**
3. What are the four types of motor failure?
   1. **General burn (entire windings),** Full compressor burn, **Spot/Localized burn,** Rotor burn, **Start winding burn, Leads shortened**
4. Categorize each common cause of compressor failure into **mechanical** or **electrical** issues:

Misassembled	Overheating	Faulty Start Components	Mis-Wire
Oil Dilution / Lack of Oil	Refrigerant Floodback	Voltage Spike	Faulty Contactor Contacts
Flooded Starts		Low Voltage	

Quiz Answers – How Compressors Fail

What Causes Compressor Failure (Cont.)?

3. Match each issue to the causes and results of the problem **(A:2:III, B:4:I, C:1:II, D:3:V, E:5:IV)**

Issue	Causes	Results
(A) Oil Dilution / Lack of Lubrication	(1) Vapor refrigerant migration to coldest place during the off cycle, resulting in refrigerant condensing and settling below oil. Oil pulled up into scroll set during startup.	(I) Reduced life of compressor's mechanical and electrical components
(B) Overheating	(2) Horizontal traps in the line set; not vertical traps in long line applications; short cycling; flooded start or liquid floodback	(II) Broken scroll sets, worn contact parts
(C) Refrigerant Slugging	(3) Improper Vacuum; Leak – operation in vacuum	(III) Heavy bearing wear and galled scroll set
(D) Non-Condensable in the System	(4) High compression ratio, return gas temp and superheat; undercharge/loss of charge; scroll separation	(IV) Copper embedded in flanks and debris in compressor
(E) Foreign Debris Entering Compressor	(5) Copper shavings from line set install or motor failure	(V) Copper plating, oxidation & pitting of components

Label the Major Compressor Scroll Components – Answer Key

Study Page 3 of the Instruction Manual

A Deeper Dive – Label These Additional Components

Top Cap and Muffler Plate

1 Discharge Fitting

2 IPR

3 TOD

Crankshaft and Rotor

4 Crankshaft

5 Counterweight

6 Rotor

7 Counterweight Cover

Lower Cover

8 Base Plate

9 Lower Bearing

10 Rubber Grommets

Study Page 13 - 15 of the Instruction Manual

A Deeper Dive – Label These Additional Components (Scroll Set)

1 Floating Seal

2 Fixed Scroll

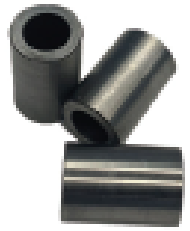
3 Oldham Coupling

4 Unloader Bushing

5 Orbiting Scroll

6 Main Bearing Housing

7 Bolts



8 Sleeve Guides

Study Page 13 - 15 of the Instruction Manual