Refrigerating Engineers & Technicians Association

Answers to Questions in the CIRO Study Guide

Sample CIRO Screen 300 HP Screw Compressor – NH3 Normal Conditions				
Suction Pressure	32 psig		Screw Compressor Motor Amps	295 AMPS
Discharge Pressure	154 psig		Screw Compressor Motor Voltage	480 VAC
Oil Pressure	55 psid		Screw Compressor Slide Valve Position	100%
Suction Temp	26°F		Condenser Water Sump Temp	75°F
Discharge Temp	171°F		Condensed Liquid Temp	85°F
Oil Temperature	136°F		Condenser Outlet Pressure	151 psig
Oil Cooler – Oil Inlet Temp	171°F			
Oil Cooler – Refrigerant Outlet Temp	85°F		**- Thermo Siphon Oil Cooling** **- Condenser Outlet Not Subcooled**	
NOTES: Power Factor is 0.86 **Motor Efficiency is 93%** **Condenser Type is Evaporative**			**Motor Type is 3 Phase**	

Sample CIRO Screen 300 HP Screw Compressor – NH3 Abnormal Conditions				
Suction Pressure	32 psig		Screw Compressor Motor Amps	339 AMPS
Discharge Pressure	184 psig		Screw Compressor Motor Voltage	480 VAC
Oil Pressure	55 psid		Screw Compressor Slide Valve Position	100%
Suction Temp	26°F		Condenser Water Sump Temp	75°F
Discharge Temp	192°F		Condensed Liquid Temp	95°F
Oil Temperature	154°F		Condenser Outlet Pressure	181 psig
Oil Cooler – Oil Inlet Temp	192°F			
Oil Cooler – Refrigerant Outlet Temp	95°F		**- Thermo Siphon Oil Cooling** **- Condenser Outlet Not Subcooled**	
NOTES: Power Factor is 0.86 **Motor Efficiency is 93%** **Condenser Type is Evaporative**			**Motor Type is 3 Phase**	

Answers related to this sample screen appear in boldface red.

Questions based on **NORMAL Conditions**

1. **What is the superheat at the compressor inlet?**

How to answer this question
Saturation temperature at suction pressure of 32 psig = 19°F from PT chart
Actual suction temperature = 26°F in the sample screen
Suction superheat: **26°F - 19°F = 7°F**

Why this matters?
If this system is saturated at the suction of the compressor, this indicates possible liquid carryover. Too much suction superheat could indicate starving coils, a vessel, or compromised insulation.

2. **What is the temperature differential between the oil cooler oil inlet and the oil outlet?**

How to answer this question
Compare the oil inlet temperature in the sample screen (171°F) to the oil outlet temperature (136°F). **171°F - 136°F = 35°F**

Why this matters?
An operator needs to know that for thermosyphon oil cooling to be truly efficient there needs to be between 30°F-40°F (delta T) “temperature differential” of sensible heat removed from the oil.

3. **What is the temperature differential between the oil cooler coolant outlet and the oil outlet?**

How to answer this question
Subtract the oil cooler refrigerant outlet temperature of 85°F from the oil inlet temperature of 136°F. **136°F - 85°F = 51°F**

Why this matters?
This is important because it shows that the oil cooler is doing its job.

4. **What is the superheat at the compressor outlet?**

How to answer this question
The discharge pressure at 154 psig in screen shows 86°F in the PT chart.
Discharge temperature in the screen is 171°F. **171°F - 86°F = 85°F**

Why this matters?
Excess superheat can affect the effectiveness of oil in the system. This may incidate a problem in the oil cooling process or that the compressor has too much suction superheat.

5. **What is the theoretical discharge temperature of the compressor under these conditions?**

How to answer this question
Convert both the suction pressure (32 psig = 47 psia) and condensing pressure (151 psig = 166 psia) to absolute pressure. Remember that suction temperature is 26°F. **Begin at the saturated vapor temp (19°F) in the Mollier diagram. Follow the compression line to intersect the discharge pressure (169 psia).**

Why this matters?
It there are issues with the oil cooling process this would be the actual discharge temperature. If theoretical discharge temperature is too high, the operator should determine why. Theoretical discharge temperature will be lower if compression ratio is reduced.

6. **What is the pressure drop from the compressor discharge to the condenser outlet?**

How to answer this question
Compare discharge pressure of 154 psig to condensing pressure of 151 psig.
154 psig – 151 psig = 3 PSI

Why this matters?
There must be a pressure differential to move the vapor from the low side of the system to the high side of the system. If there is no pressure drop, the compressor will have to recompress the gas. This results in over-compression and could indicate the need for slide valve calibration.

7. **What is the excess pressure due to non-condensables in the system?**

How to answer this question
Determine the saturation pressure of condensed liquid temperature at 85°F (151 psig). Compare that to the condenser outlet pressure in the screen (151 psig).
151 psig – 151 psig = 0 psig

Why this matters?
Non-condensables will increase the pressure on the High-Pressure Side of the system, which causes both the compressors on the Low-Pressure Side as well as the condensers on the High-Pressure Side to work much harder. This increases the cost per ton of refrigeration. Any non-condensables must be purged from the system.

8. **What is the condition of the refrigerant leaving the oil cooler?**

How to answer this question

Pressure of the refrigerant entering the oil cooler is the same as the condensing pressure (151 psig) when oil cooler refrigerant outlet temperature is 85°F based on the PT chart. The saturation chart indicates that the refrigerant leaving the oil cooler is **Saturated**.

Why this matters?

A latent heat exchange is needed in the oil cooler for the best heat removal. Refrigerant leaving the oil cooler that is slightly superheated indicates that the oil cooler is being starved. Refrigerant that is subcooled when leaving the oil cooler indicates that the oil cooler is flooded. Either condition minimizes heat transfer.

9. **How much horsepower is being developed by the compressor motor under the normal conditions?**

How to answer this question

Bhp = (Amps * Volts * PowerFactor * Efficiency * 1.73)/746

Bhp = ((295*480*0.86*0.93)*1.73)/746 = 262.63 HP

Why this matters?

This information can assist with capacity control when running compressors with VFDs and helps determine how many compressors should be online under current running conditions.

10. **What is the instantaneous Kw demand developed by the compressor motor under normal conditions?**

How to answer this question

kW = (amps * Volts * PowerFactor * 1.73)/1000

kW = (295*480*.86*1.73)/1000 = 210.67 kW

Why this matters?

Knowing the difference in cost per ton of refrigeration allows an operator to make proper adjustments to the system so that it can run more efficiently. This also allows an operator to determine the Heat Load of a room based on 1 Kw putting out 3,412 BTU/HR.

11. If power is $0.17 per kwh, how much does it cost to run the motor under normal conditions for one hour? For 24 hours? For one week? For a 5000 run-hour year? Round to two decimal places for each calculation.

How to answer this question
First determine the kW used under these conditions.
kW = (Amps * Volts * PowerFactor * 1.73)/1000
kW = (210.67 kW.

Cost for one hour:	**210.67 * $0.17 = $35.81**
Cost for 24 hours:	**$35.81 * 24 hours = $859.54**
Cost for one week:	**$859.54 * 7 days = $6,016.73**
Cost for a 5000 run-hour year:	**$35.81 x 5000 hours = $179,050**

Why this matters?
This information is important when trying to get a MOC (Management of Change) approved to raise suction pressure to save cost among other things that need financial justification in the industry

Questions based on ABNORMAL Conditions

12. What is the superheat at the compressor inlet?

How to answer this question
Saturation temperature at suction pressure of 32 psig = 19°F from PT chart
Actual suction temperature = 26°F in the sample screen
Suction superheat: **26°F - 19°F = 7°F**

Why this matters?
If this system is saturated at the suction of the compressor, this indicates possible liquid carryover. Too much suction superheat could indicate starving coils, a vessel, or compromised insulation.

13. What is the temperature differential between the oil cooler inlet and the oil outlet?

How to answer this question
Compare the oil inlet temperature in the sample screen (192°F) to the oil outlet temperature (154°F). **192°F - 154°F = 38°F**

Why this matters?
An operator needs to know that for thermosyphon oil cooling to be truly efficient there needs to be between 30°F-40°F (delta T) “temperature differential” of sensible heat removed from the oil. This is higher than the Normal Conditions because of differences on the high side of the system.

14. What is the temperature differential between the oil cooler coolant outlet and the oil outlet?

How to answer this question
Subtract the oil coolant refrigerant outlet temperature (95°F) from the oil outlet temperature (154°F). **154°F - 95°F = 59°F**

Why this matters?
This is important because it shows that the oil cooler is doing its job.

15. What is the oil cooler coolant?

How to answer this question
The screen indicates that the system is using Thermosiphon Oil Cooling. That means that the oil cooling coolant is **Saturated Liquid Ammonia**.

Why this matters?
First, Thermosyphon Oil Cooling uses an Amot valve which is known to stick and cause high discharge temperatures. The second reason would be for pump out to perform any work on the Oil Cooler.

16. What is the superheat at the compressor outlet?

How to answer this question
Use the saturation chart to look up the discharge pressure (184 psig), which has a saturation temperature of 96°F. Compare this to the discharge temperature (192°F). **192°F - 96°F = 96°F**

Why this matters?
Excess superheat affects the ability of oil to do its job. This may indicate that a system has problems with oil cooling or that the compressor has too much suction superheat.

17. **What is the theoretical discharge temperature of the compressor under these conditions?**

How to answer this question
Convert both the suction pressure (32 psig = 47 psia) and condensing pressure (181 psig = 195 psia) to absolute pressure. Suction temperature is 26°F. **The theoretical discharge temperature in the Mollier diagram = 220°F.**

Why this matters?
It there are issues with the oil cooling process this would be the actual discharge temperature. If theoretical discharge temperature is too high, the operator should determine why. Theoretical discharge temperature will be lower if compression ratio is reduced.

18. **What is the pressure drop from the compressor discharge to the condenser outlet?**

How to answer this question
Compare discharge pressure of 154 psig to condensing pressure of 151 psig.
154 psig – 151 psig = 3 PSI

Why this matters?
There must be a pressure differential to move the vapor from the low side of the system to the high side of the system. If there is no pressure drop, the compressor will have to recompress the gas. This results in over-compression and could indicate the need for slide valve calibration.

19. **What is the excess pressure due to non-condensables in the "abnormal" systems?**

How to answer this question
Determine the saturation pressure of condensed liquid temperature at 95°F (181 psig). Compare that to the condenser outlet pressure in the screen (181 psig).
181 psig – 181 psig = 0 psig.

Why this matters?
Non-condensables will increase the pressure on the High-Pressure Side of the system, which causes both the compressors on the Low-Pressure Side as well as the condensers on the High-Pressure Side to work much harder. This increases the cost per ton of refrigeration. Any non-condensables must be purged from the system.

20. What is the condition of the refrigerant leaving the oil cooler?

How to answer this question

Pressure of the refrigerant entering the oil cooler is the same as the condensing pressure (181 psig) when oil cooler refrigerant outlet temperature is 95°F based on the PT chart. The saturation chart indicates that the refrigerant leaving the oil cooler is **Saturated**.

Why this matters?

A latent heat exchange is needed in the oil cooler for the best heat removal. Refrigerant leaving the oil cooler that is slightly superheated indicates that the oil cooler is being starved. Refrigerant that is subcooled when leaving the oil cooler indicates that the oil cooler is flooded. Either condition minimizes heat transfer.

21. How much horsepower is being developed by the compressor motor?

How to answer this question

Bhp = (Amps * Volts * PowerFactor * Efficiency * 1.73)/746

Bhp = (339*480*0.86*0.93*1.73)/746 = 301.8 HP

Why this matters?

This information can assist with capacity control when running compressors with VFDs and helps determine how many compressors should be online under current running conditions.

22. What is the instantaneous Kw demand developed by the compressor motor?

How to answer this question

Kw = (Amps * Volts * PowerFactor * 1.73)/1000

Kw = (339*480*0.86*1.73)/1000 = 242 Kw

Why this matters?

This information can assist with energy management of the system among other things.

23. If power is $0.17 per kwh, how much does it cost to run the motor under normal conditions for one hour? For 24 hours? For one week? For a 5000 run-hour year? Round to two decimal places for each calculation.

How to answer this question
First determine the kW used under these conditions.
kW = (Amps * Volts * PowerFactor * 1.73)/1000 = 242 kW.

Cost for one hour:	**price * kwh = $0.17 * 242 = $41.14**
Cost for 24 hours:	**$41.14 * 24 hours = $987.36**
Cost for one week:	**$987.36 * 7 days = $6,911.52**
Cost for a 5000 run-hour year:	**$41.14 x 5000 hours = $205,700**

Why this matters?
This information is important when trying to get a MOC (Management of Change) approved to raise suction pressure to save cost among other things that need financial justification in the industry.

24. What is the excess cost per hour for running poorly? Round to two decimal places for each calculation.

How to answer this question
Compare the cost of operating in Normal and Abnormal conditions.

Added cost for one hour:	**$41.14 - $35.81 = $5.33**
Added cost for 24 hours:	**$987.36 - $859.44 = $128.16**
Added cost for one week:	**$6911.52 - $6016.08 = $895.44**
Added cost for 5000 run-hour year:	**$205,700 - $179,050 = $26,650**

Why this matters?
This shows the difference in cost to run the system efficiently.

25. What would happen to the condenser sump temperature if the fans is not running and you assume the wet bult temperature is the same as under NORMAL conditions?

How to answer this question
Consider what rejects the heat load from the refrigerant (air and water). Without the fans running, the water is rejecting all heat and will return to the condenser sump warmer. **The condenser sump temperature will increase.**

Why this matters?
An operator who can read the condenser sump temperature has a good troubleshooting tool. On days when the Wet Bulb Temp is high, the fans will be very critical.

26. What would happen to the condenser pump sump water temperature if the pump is not running and you assume the wet bulb temperature is the same as under NORMAL conditions?

How to answer this question
If the system is not supplying water to the condenser, the condenser sump temperature would decrease because the system should be set up to bleed 3 gpm to removed dissolved solids and the sump will be supplied cool water makeup to maintain the condenser sump level. **The sump water temperature will go down.**

Why this matters?
If condensing pressure begins to rise and the condenser sump temperature begins to drop, the operator should immediately go to the pumps.

27. What might happen to the condenser sump water temperature if the coils are sealed up significantly?

How to answer this question
If the condenser boils are significantly sealed, the system is not evaporating much water. **There should be no significant change in the condenser sump temperature.**

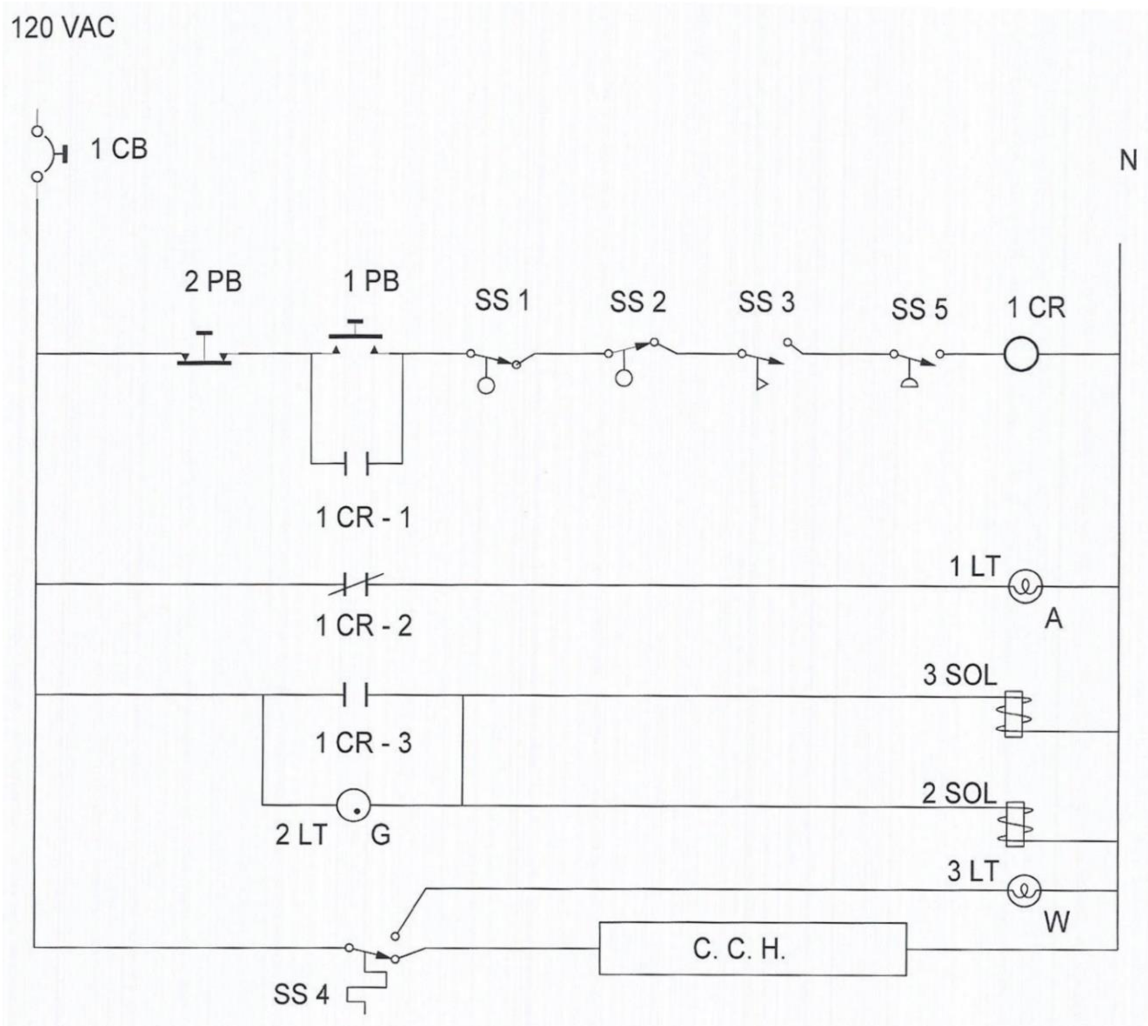
Why this matters?
If condensing pressure goes up, the operator has evaluated the system for partial pressures, and validated that fans and pumps are in good operation, it is more likely that the system has a problem with scaling.

28. What might be going on that causes higher condensing conditions?

How to answer this question
If the problem is on the High Side and there is no change in the condenser sump temperature, then the operator can rule out a fan or pump issue and evaluate the system for non-condensable gasses. **Based on available information, it is most likely that there is scaling in the system.**

Why this matters?
This is very important for an operator to effectively troubleshoot a system.

Figure 18 Electrical Diagram



Answers related to Figure 18 appear in **boldface red**

1. **How many neon lamps are in the drawing?** **One (2LT)**
2. **Is there a latching circuit in the drawing?** **Yes (1CR-1)**
3. **Which level switch closes on "low"?** **SS1**
4. **What does 1CR do?** **1CR-1 Latches, 1CR-2 Opens, 1CR-3 Closes**
5. **What switch is single pole – double throw?** **SS4**
6. **What happens if 1CB trips?** **Everything shuts off**
7. **When is 2LT illuminated?** **When 1CR-3 is open**
8. **What has to happen for 1CR to be energized?**
   1PB closed with all safety switches satisfied