The “System Evaluation Manual” and “Chiller Evaluation Manual” have been revised and combined into this new book; the “Air Conditioning and Refrigeration System Evaluation Guide“.

It will be available soon as an 8.5 X 11 paperback.

If you’re interested, please check back with the site, www.Air-Conditioning-and-Refrigeration-Guide.com, around the end of June 2008.

For now, please feel free to study this digital edition.

For easier navigation through the e book, use the table of contents.

Clicking on a page heading will take you to that page.

Air Conditioning and Refrigeration System Evaluation Guide

BY

Mike Taitano

FOREWARD

The Rules of Thumb in this book are within the acceptable pressure and temperature ranges recommended in service manuals and technical literature from Bristol, Carrier, Copeland, Trane, and the RSES SAM Manual.

I hope that this book will help make the process of evaluating refrigeration systems easier for you.

ISBN:

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CHAPTER ONE

Standard Air Conditioning and Refrigeration Systems

INTRODUCTION TO THE CYCLE DIAGRAM, SUPERHEAT, AND SUBCOOLING

Take a look at the cycle diagram on the next page.

When you're troubleshooting a system; every factor in the diagram will affect the system's capacity, so take every pressure and temperature, build a complete picture of the system's operating characteristics, and evaluate the entire system.

After you get used to taking these readings on every possible service call, you'll probably find that accurate superheat and subcooling readings are such clear indicators of the refrigerant level inside the condenser and evaporator coils that it can be like looking inside the coils with x-ray vision.

I'll explain the pressures and temperatures you can expect to find in an example air conditioning system on page 4, and in an example medium temperature system on page 5; but first I'd like to explain how I build a mental picture with the superheat and subcooling readings.

I imagine that both the evaporator coil and condenser coil are designed to be most efficient when they're half full of liquid refrigerant. (This might not be scientifically accurate, but it's a mental picture that helps me keep my thinking clear while I'm evaluating a system.)

So:
When I measure 20° to 30° of superheat on the suction line somewhere from 6" to 12" from the compressor, I imagine that the evaporator is about 1/2 full of flashing (boiling and evaporating) refrigerant - which is exactly what I want.

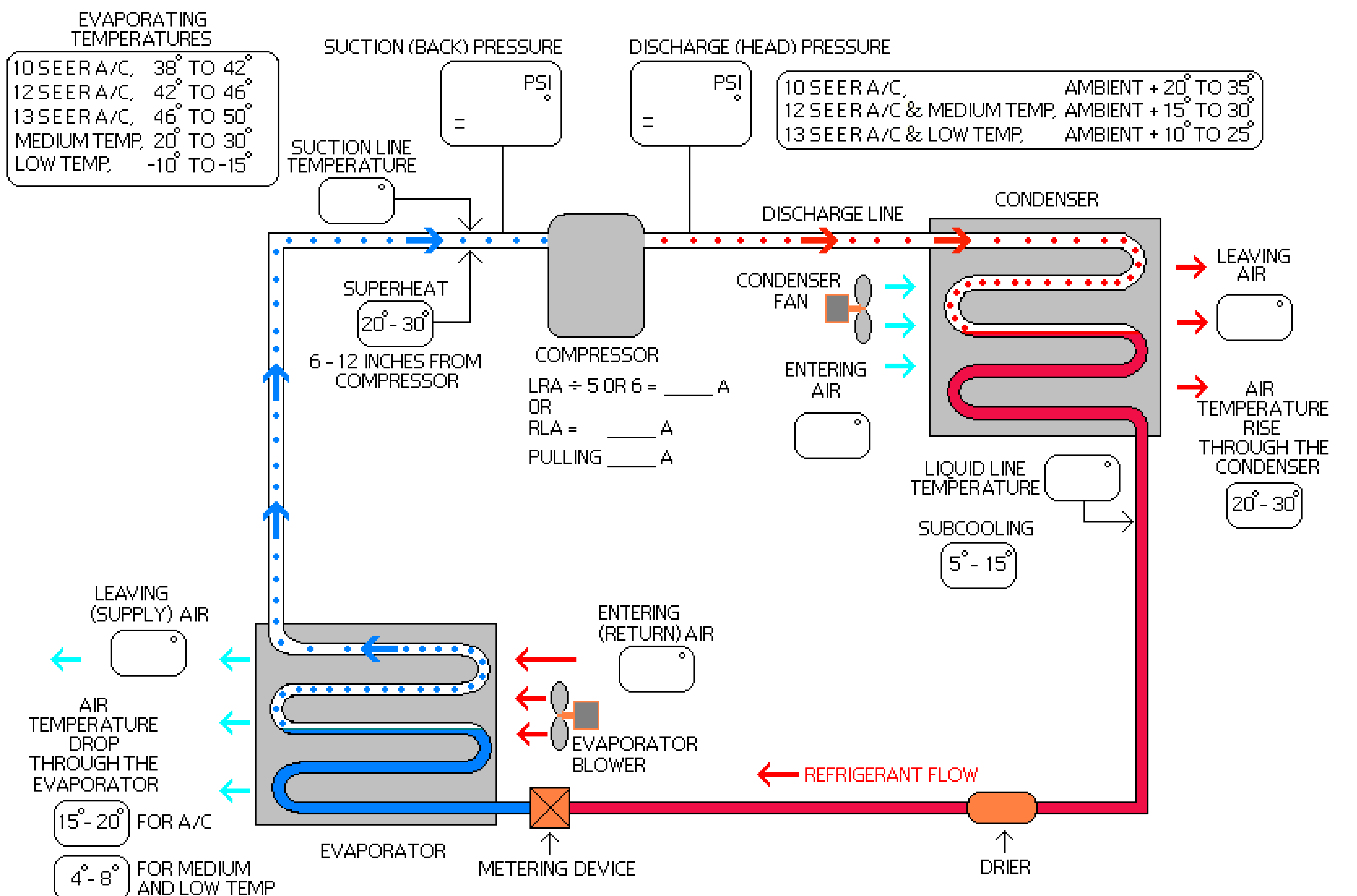
And when I measure 5° to 15° of subcooling at the outlet of the condenser or receiver, in my mental picture I see the condenser being 1/2 full of liquid refrigerant - which is again exactly what I want.

These two checks help me build a pretty clear picture of how full of liquid refrigerant the condenser is, and how full of flashing (boiling and evaporating) refrigerant the evaporator is.

You'll find more explanations about the importance of subcooling and superheat further along in the guide.

You might want to photocopy the cycle diagram so it will be easier to refer to it as you continue reading through the guide.

I think that by the time you finish going over the material in this guide, the cycle diagram will start making a lot of sense; and I hope this information helps make troubleshooting easier and faster for you.



READINGS WILL BE MOST ACCURATE IF TAKEN WITHIN 5° OF THE DESIRED FINAL TEMPERATURE

USING THE CYCLE DIAGRAM: AIR CONDITIONING EXAMPLE

The cycle diagram has almost all of the essential information in the first chapter, condensed onto one page.
The suction and discharge pressure blocks are left blank, because these readings will depend on the type of system you're working on, and the refrigerant being used.
The compressor running amps should be very close to the RLA (Rated Load Amps) specified on the nameplate of the equipment.
If there's no information on the equipment indicating RLA, dividing the LRA by 5 or 6 will give you a close approximation to the normal running amps for the compressor.
Get your pressure/temperature conversion chart ready, and let's take a look at a couple of systems.

10 SEER Air Conditioning Example
Lets start with an R-22 10 SEER air conditioner; outside ambient is 95°, inside temperature is 80°, the coils and filters are clean, and the fans and blowers are running fine.
And, let's say the compressor is rated for 60 LRA.
60 divided by 5 or 6 would be around 12 or 10, so if the compressor is pulling around 12 amps or a little less, and has been running reliably until your service call, consider this amp draw to be normal.

High Side
Discharge pressure should be somewhere between 242 to 295 psi. (Equivalent to ambient plus 20° to 35°.)
Air temperature leaving the condenser should be about 115° to 125°. (The temperature of the air entering the condenser will usually rise about 20° to 30° as it passes through the condenser coil.)
Liquid line temperature leaving the condenser should be around 100° to 125°. (5° to 15° subcooling.)

Low Side
Suction pressure should be around 66 to 72 psi. (Evaporating temperature should be somewhere around 38° to 42° when the unit is running normally.)

Suction line temperature about 6" to 12" from the inlet of the compressor should be somewhere in the range of 58° to 72°. (20° to 30° of superheat.)

Air temperature leaving the evaporator should be 60° to 65°. (The temperature of the air entering the evaporator will usually drop about 15° to 20° as it passes through the evaporator coil.)

So:
If this unit is correctly sized for the space it's cooling; and if your readings are within these ranges, this system should be cooling just fine.

MEDIUM TEMPERATURE REFRIGERATION SYSTEM EXAMPLE

For a medium or low temperature system use the same procedure; just use the pressure/temperature chart for the correct refrigerant, and use the pressure and temperature ranges that the evaluation guide and diagram specify for medium and low temperature equipment.

This example will be a medium temperature R-404a walk in refrigerator.
Outside ambient is 85°, the temperature inside the box is 45°, the coils are clean, and the fans all run.

Let's say the compressor is rated for 55 LRA.
55 divided by 5 or 6 would be around 11 or 9, so if the compressor is pulling around 11 amps or a little less, and has been running reliably until your service call, consider this amp draw to be normal.

High Side
Discharge pressure should be somewhere around 235 to 290 psi. (Equivalent to ambient plus 15° to 30°.)

Air temperature leaving the condenser should be about 100° to 110°. (The temperature of the air entering the condenser will usually rise about 15° to 25° as it passes through the condenser coil.)

Liquid line temperature leaving the condenser should be around 85° to 110°. (5° to 15° subcooling.)

Low Side
Suction pressure should be about 56 to 70 psi. (Evaporating temperature should be about 20° to 30° when the system is running normally.)

Suction line temperature about 6" to 12" from the inlet of the compressor should be somewhere in the range of 40° to 60°. (20° to 30° of superheat would be perfect; but if a liquid line/suction line heat exchanger is installed, a suction line temperature of 65° at the inlet of the compressor is acceptable.)

Air temperature leaving the evaporator should be 37° to 41°. (The temperature of the air entering the evaporator will usually drop about 4° to 8° as it passes through the evaporator coil.)

So:
If this unit is correctly sized for the box it's cooling; and if your readings are within these ranges, this system should be cooling just fine.

With both of the examples; you can see that at each of the critical points of the system, there is a range of possible readings that can be considered normal.
The exact readings you find will depend on the outside ambient temperature, the temperature of the space that's being cooled, and the efficiency of the whole system.

Please keep in mind, when we say "design conditions" or "normal running conditions", we mean that the equipment is all in working order with no mismatched components installed, that it's being used under the conditions that it was designed for, and that the space being cooled is within about 5° of the desired final temperature.

NORMALLY RUNNING A/C & REFRIGERATION SYSTEM CHARACTERISTICS

Before moving on to more thorough explanations; I thought it might be a good idea to provide this quick guide to the general range of operating characteristics you can expect to find on air conditioning and refrigeration systems that are running normally.

Air Conditioning:
This example is for a 10 SEER system. 12 and 13 SEER systems are discussed later in the guide.
The unit is running normally, and the space is within about 5° of the desired final temperature.
Condensing pressure should be equivalent to somewhere around 20° to 35° above ambient.
Evaporator pressure should be equivalent to about 38° to 42°.
Look for 20° to 30° of superheat at the compressor; less than 20° of superheat is not acceptable.
Look for 5° to 15° of subcooling on the liquid line at the outlet of the condenser.
Look for return air temperature to drop about 15° to 20° as it passes through the evaporator coil.
The temperature of the air entering the condenser should rise about 20° to 30° as it passes through the condenser coil.

Medium Temperature Reach In or Walk In:
The unit is running normally, and the box is within about 5° of the desired final temperature.
Condensing pressure should be equivalent to somewhere around 15° to 30° above ambient.
Evaporator pressure should be equivalent to about 20° to 30°.
20° to 30° would be the perfect range of superheat; but if a suction line/liquid line heat exchanger is installed, a temperature reading of about 65° or less on the suction line at the compressor inlet would be acceptable.
Less than 20° of superheat is not acceptable.
Look for 5° to 15° of subcooling on the liquid line at the outlet of the condenser.
The temperature of the air entering the evaporator should drop about 4° to 8° as it passes through the evaporator coil.
The temperature of the air entering the condenser should rise about 15° to 25° as it passes through the condenser coil.

Low Temperature Reach In or Walk In:
The unit is running normally, and the box is within about 5° of the desired final temperature.
Condensing pressure should be equivalent to somewhere around 10° to 25° above ambient.
Evaporator pressure should be equivalent to -10° to -15°.
20° to 30° would be the perfect range of superheat; but if a suction line/liquid line heat exchanger is installed, a temperature reading of about 20° to 40° or less on the suction line at the compressor inlet would be acceptable.
Less than 20° of superheat is not acceptable.
Look for 5° to 15° of subcooling on the liquid line at the outlet of the condenser.
The temperature of the air entering the evaporator should drop about 4° to 8° as it passes through the evaporator coil.
The temperature of the air entering the condenser should rise about 10° to 20° as it passes through the condenser coil.

SUPERHEAT

When I measure 20° to 30° of superheat on the suction line about 6” to 12” from the inlet of the compressor; in my mental picture I see the evaporator being 1/2 full of flashing (boiling and evaporating) refrigerant - exactly where I want it to be.

If superheat is less than 20°; in my mental picture I see the evaporator full of flashing refrigerant, with liquid refrigerant flowing into the suction line and heading back towards the compressor.

Less than 20° of superheat is too low and risks liquid flood back and valve damage.

If superheat is more than 30°: in my mental picture I see a very low level of flashing refrigerant in the evaporator.

More than 30° of superheat is too high, and doesn’t provide sufficient cooling to the compressor. (The exceptions for some medium and low temperature refrigeration equipment are explained on page 6.)

On any type of system, at or near the desired final temperature:
If superheat is less than 20° and subcooling is normal, you‘ll need to reduce the refrigerant charge.

When you reduce the charge: if superheat increases to normal but subcooling starts to drop lower than 5°; check other system factors.

(Keep in mind; less than 5° of subcooling may be normal with residential window a/c units, and residential and commercial reach in refrigeration equipment.)

When you reduce the charge on a TXV system; if superheat stays below 20° and subcooling starts dropping; the TXV is probably flooding.

Check the bulb mounting and the valve adjustment; then if necessary, replace the TXV.

On a cap tube or orifice system:

Changes in evaporator entering air temperature can affect superheat, but usually have little effect on evaporator pressure.

On a TXV system:

Changes in evaporator entering air temperature can affect evaporator pressure, but usually have little effect on superheat.

NOTE: On any type of system: if the temperature of the air entering the evaporator is too high, superheat will be high.

REMEMBER:
Superheat readings will be most accurate if they’re taken when the system is running normally; preferably when the space or box is within 5° of the desired final temperature.

SUBCOOLING

Almost all standard air conditioning and refrigeration systems are designed to run with a range of 5° to 15° of subcooling, so:

> When I read 5° to 15° of subcooling at the outlet of the condenser or receiver; in my mental picture I see the condenser being 1/2 full of liquid refrigerant, exactly where I want it to be.

If subcooling is more than 15°; in my mental picture I see the condenser being almost totally full of liquid refrigerant.

If subcooling exceeds 15° the system is possibly over charged, or it may have mismatched components installed.

With more than 15° of subcooling, there is less area in the tubing of the condenser coil for the entering vapor to cool and condense, which reduces the system's efficiency.

High side pressure and the compressor amp draw will probably start to rise, which will contribute to further reduction of the system's efficiency.

Recover refrigerant until subcooling is 15° or less, then check and evaluate other factors in the system:

> Check superheat, air flow, air temperature rise and/or drop through the coils, etc.

Also, with 15° or more subcooling: if superheat stays much higher than 30°, the system is probably restricted. Evaluate all other system factors.

With less than 5° of subcooling; in my mental picture I see the condenser coil being less than 1/2 full of liquid refrigerant.

> With less than 5° of subcooling the system is possibly undercharged, or it may have mismatched components installed.

Subcooling increases system efficiency, and prevents the liquid refrigerant from flashing if there's a pressure drop in the liquid line between the condenser and the metering device.

With less than 5° of subcooling; there is a possibility that the liquid refrigerant might flash in the liquid line and reduce the efficiency of the metering device - which will reduce the efficiency of the system.

So with low or no measurable subcooling:

1. Check and evaluate system components, locate and repair any leaks.
2. Charge in refrigerant to correct subcooling.

REMEMBER:
Subcooling readings will be most accurate if they're taken when the system is running normally; preferably when the space or box is within 5° of the desired final temperature.

CAP TUBE OR ORIFICE SYSTEMS

Charge cap tube and orifice systems to the correct range of superheat.

Between 20° and 30° of superheat, with less than 15° of subcooling, is the correct charge.

Window air conditioners and reach in refrigeration equipment are usually equipped with capillary tube metering devices, and may be designed to run without measurable subcooling.

NOTE: Always follow the manufacturer's specifications.

If the space or box temperature is higher than normal, superheat and subcooling readings will not be normal; so take final superheat and subcooling readings when the box or space is within about 5° of the desired final temperature.

It would be a good idea to keep on eye on superheat at the compressor until the unit cycles off on the temperature control.

You want to be sure superheat doesn't drop below 20°.

If you're working on a system with 15° of subcooling and superheat consistently stays higher than 30°; the system is very likely restricted.

Check for dirt or debris in the capillary tube or orifice, and in the drier, and keep in mind that moisture can restrict a system intermittently.

TXV SYSTEMS

Charge TXV systems to the correct range of subcooling; 5° to 15°.

Under normal running conditions:
subcooling should be 5° to 15°, superheat should be 20° to 30°.

If there's no subcooling, and more than 30° of superheat, the charge is probably low.

Charge in refrigerant until subcooling is somewhere around 5° to 15°.

IF superheat has dropped to less than 30°, the system was undercharged.
Determine whether or not there's a leak; and repair it if there is.

If you suspect a restriction in a TXV system, don't forget to check the inlet screen of the TXV carefully.

Always make sure the bulb is mounted correctly.

When the space or box temperature is much higher than normal, suction pressure and superheat will not be normal.

When the temperatures drop to the operating range of the TXV; if it is operating correctly you will see the saturated evaporating temperature stay consistently lower than the space or box temperature.

The evaporating temperature will lead the load temperature as the TXV maintains a steady level of superheat.

Always use an externally equalized TXV if there is an equalizer line in the installation.

TIPS ABOUT EVAPORATOR CHARACTERISTICS

On 10 SEER air conditioning systems, evaporator pressures should be equivalent to about 38° to 42°.

On 12 SEER air conditioning systems, evaporator pressure should be equivalent to about 42° to 46°.

On 13 SEER air conditioning systems, evaporator pressure should be equivalent to about 46° to 50°.

The temperature of the air entering the evaporator should drop about 15° to 20° as it passes through the evaporator coil.

A 25° temperature drop would be ok only if all other system factors are balanced and the coil is not icing up.

On medium temperature systems:
Under normal running conditions, evaporating temperature should be around 20° to 30°.

The temperature of the air entering the evaporator should drop about 4° to 8° as it passes through the evaporator coil.

On a medium temperature system that‘s running with normal superheat and subcooling; if you find evaporating temperatures of around 30° to 35°, the system may have been built specifically to maintain a high relative humidity for certain types of produce or flowers.

On low temperature systems:
Under normal running conditions evaporating temperature should be around -10° to -15°.

The temperature of the air entering the evaporator should drop about 4° to 8° as it passes through the evaporator coil.

When checking evaporators:

- Make sure the coil is clean.
- Make sure the evaporator fan blades or blower wheels are the right size, and turning in the right direction.
- Make sure the evaporator fan motors are rated correctly for voltage, speed, rotation, and horsepower.
- Make sure the b.t.u. capacity of the evaporator matches the rest of the system.

Keep in mind that if a system is trying to cool a space or box down from higher than normal temperatures, evaporator pressure and superheat will both probably be higher than normal.

If cooling capacity is low, and evaporator pressures stay consistently higher than normal; evaporator capacity may exceed compressor capacity.

If cooling capacity is low, and evaporator pressures stay consistently lower than normal; evaporator capacity may be less than compressor capacity.

TIPS ABOUT CONDENSER CHARACTERISTICS

For air cooled condensers:
For a 10 SEER air conditioner; condensing pressure should be equivalent to ambient plus 20° to 35°.
Look for a 20° to 30° temperature difference between entering and leaving condenser air.
A temperature rise of more than 35° would be too high. Check air flow through the coil.

For a 12 SEER air conditioner or a medium temperature refrigeration system; condensing pressure should be equivalent to ambient plus 15° to 30°.
Look for a 15° to 25° temperature difference between entering and leaving condenser air.
A temperature rise of more than 30° would be too high. Check air flow through the coil.

For a 13 SEER air conditioner or a low temperature refrigeration system; condensing pressure should be equivalent to ambient plus 10° to 25°.
Look for a 10° to 20° temperature difference between entering and leaving condenser air.
A temperature rise of more than 25° would be too high. Check air flow through the coil.

If condensing pressures are significantly lower than the ranges specified,
- the condenser coil may be too large,
- the compressor may be too small,
- the compressor may be inefficient, or may have lost capacity.

Keep in mind that condensing pressure will be low at low ambient conditions.

Water cooled condenser characteristics:
First, always check the manufacturer's specifications.

Most water cooled condensers are designed for entering water to be in the temperature range of 75° to 95°, 85° is ideal.

Water temperature rise through the condenser is normally in the range of 10°.

Condensing pressure should be equivalent to leaving water temperature + 10°.

A difference of more than 20° between saturated condensing temperature and entering water temperature is too high.

If you find this:
- Check the manufacturer's specifications,
- Check for insufficient water flow or a dirty condenser,
- Check operation of the water regulating valve, if installed,
- Verify that the entering water temperature is in the normal range.

Look for 5° to 15° of Subcooling.

COMPRESSOR TIPS

Remember that 20° to 30° of superheat not only gives you cooling capacity; it also protects the compressor.

Troubleshooting tips:
Under normal running conditions (when the space or box is cool):
high evaporator pressure,
with low condensing pressure,
can be an indication of low compressor capacity.

If you have a very low air temperature drop through the evaporator,
with a low air temperature rise through the condenser,
unusually high evaporator pressure,
unusually low discharge pressure,
and a low compressor amp draw;
your compressor probably has failed valves.

Selection:
If you're not able to get the exact same make and model as a replacement for a failed compressor; get a compressor rated for the same voltage, application, and b.t.u. capacity at the system's normal evaporating temperature.

Check the compressor performance chart yourself.

Don't depend on matching LRA ratings.

OIL PRESSURE & MISCELLANEOUS TIPS

The oil pump is pumping against suction pressure.

The oil pressure safety will open if oil pump pressure doesn't stay at a consistently higher pressure than suction pressure.

If there seems to be an oil pressure problem:

If the oil looks normal through the sight glass, observe the oil pump pressure and suction pressure for a few minutes to see what happens.

If oil pump discharge pressure doesn't stay consistently higher than suction pressure in the crankcase, you'll probably need to repair or replace the oil pump.

If oil pump discharge pressure does stay consistently higher than suction pressure in the crankcase; check the differential rating on the oil safety switch, and check the switch. It may have failed.

Keep in mind that a compressor that is leaking oil internally might maintain satisfactory oil pressure for a minute or two at start up, then oil pressure will drop off.

To check for suspected air or non-condensables,

1. Shut down the system for 15 minutes and let the pressures equalize.
2. Measure the high side pressure, and take a temperature reading on an exterior part of the condenser coil.
3. If the high side pressure is equivalent to a temperature that's higher than the temperature you found on the exterior part of the condenser coil, it is an indication of non-condensables in the system.

A similar comparison can be made at the evaporator coil if it is more convenient.

Restriction

If you suspect a restriction, check the temperature of the liquid line from the outlet of the condenser to the metering device, including the drier.

If the temperature doesn't drop significantly from the condenser to the metering device, then it's the metering device that's restricted.

That is IF

Superheat is over 30° and subcooling is in the normal to high range.
(Subcooling will usually be high if the metering device is restricted.)

Check the drier carefully. If it's partially restricted, it will usually sweat and feel cool to the touch.

CHAPTER TWO

Reciprocating Chilled Water Systems With TXV

INTRODUCTION TO CHILLER SYSTEM OPERATING CHARACTERISTICS

When you work on a chilled water system, there should be an operating log for the chiller.

The operating characteristics that I'll discuss in this chapter should be recorded in the log sheet on a regular basis, not only during troubleshooting.

For troubleshooting purposes, you may want to make a log sheet of your own for the operating characteristics you'll be evaluating.

The diagram on page 17 is a chiller with a water cooled condenser.

The diagram on page 18 is a chiller with an air cooled condenser.

The pages that follow the diagrams explain the normal range of operating characteristics that you can expect to find, and what problems might be indicated by abnormal readings.

Take careful readings and record them in a log sheet accurately.

As you go through the diagrams and operating characteristics step by step; make notes of which of your readings are abnormal.

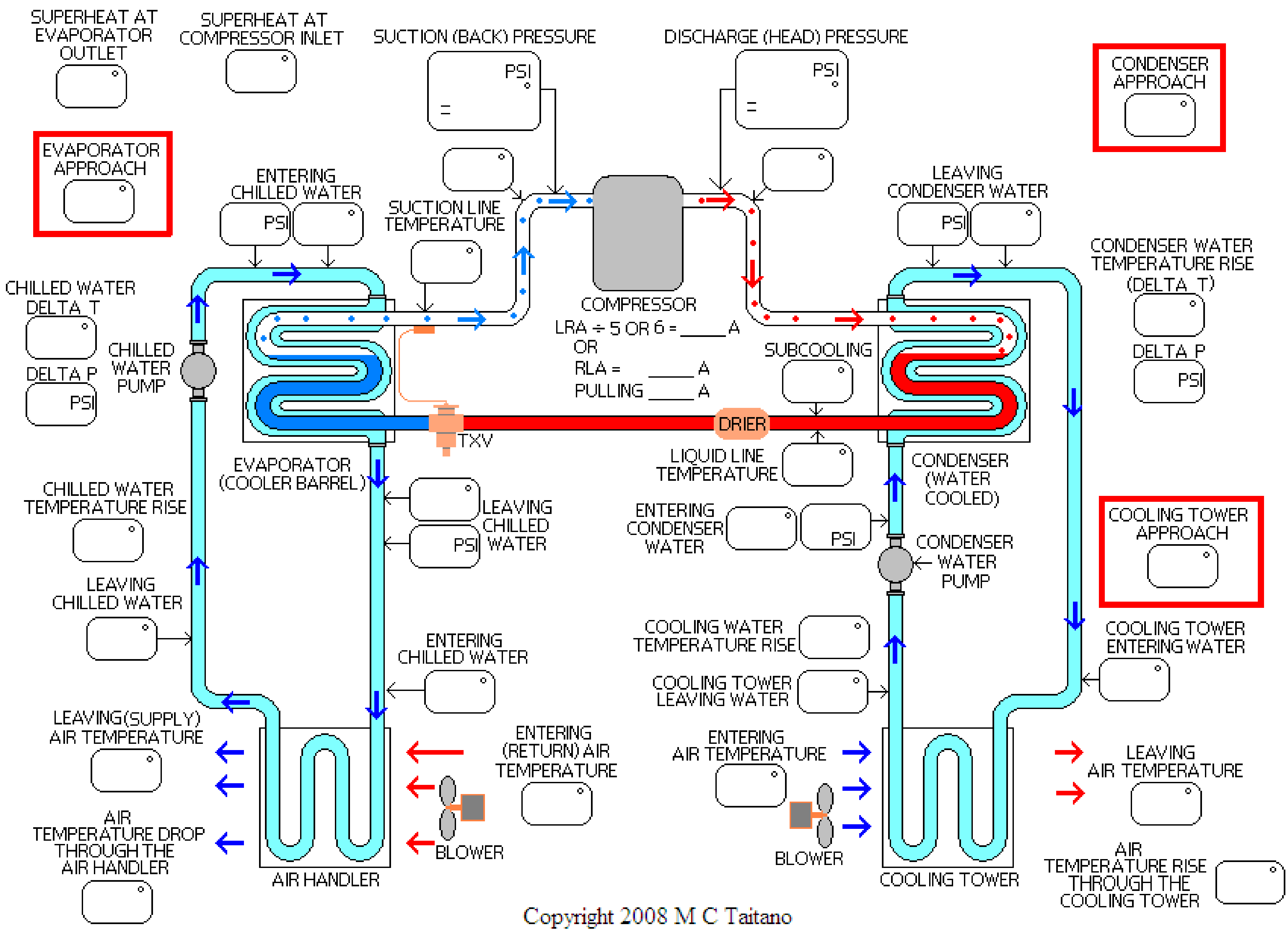
Find and correct the causes of the abnormal readings, one by one.

Please keep in mind that in the following pages the word "design" will mean the normal, standard operating conditions that you can expect to find.

You should be able to determine what the normal operating conditions are from the chiller logs, the manufacturer's start-up/installation and service manuals, and from the start-up/commissioning report for the chiller.

NOTE:
These recommendations are most applicable for systems with reciprocating compressors and TXV's.

If you're on an emergency service call working on a system with screw compressors and EXV's without the factory service manuals and without a log of what the system's normal operating characteristics are; these recommendations can help you get the system running close to it's design specifications.


SUPERHEAT AT EVAPORATOR OUTLET
SUPERHEAT AT COMPRESSOR INLET
SUCTION (BACK) PRESSURE
PSI
=
DISCHARGE (HEAD) PRESSURE
PSI
=
CONDENSER APPROACH
EVAPORATOR APPROACH
ENTERING CHILLED WATER
PSI
SUCTION LINE TEMPERATURE
LEAVING CONDENSER WATER
PSI
CONDENSER WATER TEMPERATURE RISE (DELTA T)
CHILLED WATER DELTA T
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PSI
CHILLED WATER PUMP
COMPRESSOR
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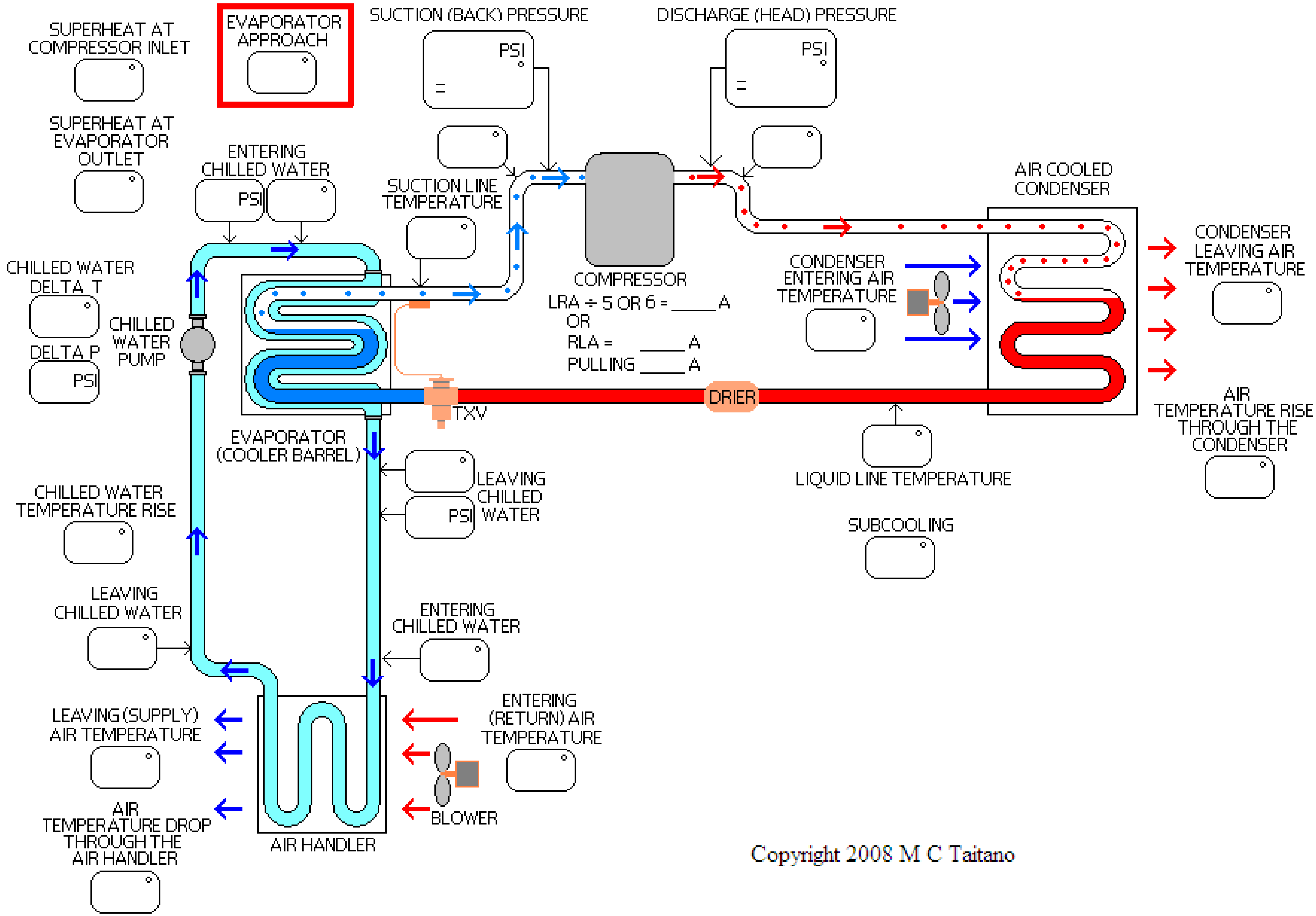
OR
RLA = _____ A
PULLING _____ A
SUBCOOLING
DELTA P
PSI
DRIER
TXV
EVAPORATOR (COOLER BARREL)
LIQUID LINE TEMPERATURE
CONDENSER (WATER COOLED)
CHILLED WATER TEMPERATURE RISE
LEAVING CHILLED WATER
PSI
ENTERING CONDENSER WATER
PSI
CONDENSER WATER PUMP
COOLING TOWER APPROACH
LEAVING CHILLED WATER
COOLING WATER TEMPERATURE RISE
COOLING TOWER ENTERING WATER
ENTERING CHILLED WATER
COOLING TOWER LEAVING WATER
LEAVING (SUPPLY) AIR TEMPERATURE
ENTERING (RETURN) AIR TEMPERATURE
ENTERING AIR TEMPERATURE
LEAVING AIR TEMPERATURE
AIR TEMPERATURE DROP THROUGH THE AIR HANDLER
BLOWER
BLOWER
AIR HANDLER
COOLING TOWER
AIR TEMPERATURE RISE THROUGH THE COOLING TOWER



SUPERHEAT AT COMPRESSOR INLET
EVAPORATOR APPROACH
SUCTION (BACK) PRESSURE
PSI
=
DISCHARGE (HEAD) PRESSURE
PSI
=
SUPERHEAT AT EVAPORATOR OUTLET
ENTERING CHILLED WATER
PSI
SUCTION LINE TEMPERATURE
AIR COOLED CONDENSER
CHILLED WATER DELTA T
CHILLED WATER PUMP
DELTA P
PSI
COMPRESSOR
LRA ÷ 5 OR 6 = _____ A
OR
RLA = _____ A
PULLING _____ A
CONDENSER ENTERING AIR TEMPERATURE
CONDENSER LEAVING AIR TEMPERATURE
DRIER
TXV
AIR TEMPERATURE RISE THROUGH THE CONDENSER
EVAPORATOR (COOLER BARREL)
LEAVING CHILLED WATER
PSI
LIQUID LINE TEMPERATURE
CHILLED WATER TEMPERATURE RISE
SUBCOOLING
LEAVING CHILLED WATER
ENTERING CHILLED WATER
ENTERING (RETURN) AIR TEMPERATURE
LEAVING (SUPPLY) AIR TEMPERATURE
BLOWER
AIR TEMPERATURE DROP THROUGH THE AIR HANDLER
AIR HANDLER

EVAPORATOR (COOLER) READINGS

TAKE ALL READINGS AT FULL LOAD

Look for entering water temperature to be about 54° at full load.

Look for leaving water temperature to be about 44° at full load.

Look for chilled water temperature to drop about 5° to 15° as it passes through the evaporator.
This is called the chilled water Delta T. A Delta T of 10° is normal.

Take the suction pressure reading, and compare it to design specifications and normal readings.

Look for the saturated evaporating temperature to be at the very least, a few degrees above 32°.
At 32° or lower, there is a danger of freeze-up.

Calculate the Evaporator Leaving Temperature Difference, or LTD.
This is leaving chilled water temperature minus saturated suction temperature.
It is also called Cooler Approach.
On older systems, expect 8° to 12°.
On newer systems, expect 6° to 8°.

Calculate and record; and compare your reading to design specifications and normal readings.

Cooler Approach is a significant indication of the efficiency of the water-to-refrigerant heat transfer in the cooler.

The higher the LTD, the greater the resistance to heat flow.

What your readings might be indicating so far:

- High LTD with low Delta T could indicate:
  - Low refrigerant charge (check superheat and subcooling),
  - A high rate of water flow through the cooler,
  - Fouled cooler tubes:
    - Saturated refrigerant temperature will be lower as tubes become fouled.
    - (Superheat will be at or near design specs.)

- Low LTD with a high Delta T would indicate a low rate of water flow through the cooler.
  - (Saturated suction temperature will be lower than normal.)

SUCTION LINE AND CHILLED WATER READINGS

Evaporator Readings Continued:
Check superheat at the TXV bulb location, and on the suction line about 6” to 12” from the inlet of the compressor.

SUPERHEAT:

Traditional TXV: superheat should be 8° to 12° leaving the evaporator.
Newer EXV: superheat should be 4° to 7° leaving the evaporator.

NOTE: To protect the compressor from flood back and overheating; superheat should be 20° to 30°, measured at a point about 6” to 12” from the inlet of the compressor.

You’ll want to verify that you have the correct rate of chilled water flow.

Measure and record the entering and leaving chilled water pressures.

Subtract the leaving water pressure from the entering water pressure.
This is called the chilled water Delta P.
To correct for any difference in gauge heights, divide the difference (in feet) by 2.31.
If the entering gauge is higher, add the correction.
If the entering gauge is lower, subtract the correction.

Compare the calculated Delta P to design specifications.

Calculate the rate of flow by using the factory pressure drop chart for the unit.
Pressure drop in measured PSIG X 2.31 = feet of head.
Check the flow chart for the unit to determine the GPM of flow.
Compare to factory specifications for the unit, and start-up/normal readings.

Chilled water flow rate through the cooler should be 1.2 to 4.8 GPM per ton.

The chilled water loop should be sized to hold 3 gallons per ton for air conditioning, 6 gallons per ton for process cooling.

NOTE:
If Delta P is higher than design specifications or higher than the start up/normal readings; check for dirty tubes or a restricted tube bundle, or check to see if the water flow rate is too high.

CONDENSER READINGS

Water Cooled Condenser:
Measure and record the condenser entering water temperature and compare to normal readings.
Look for 75° to 95°, 85° is normal.
Below 70° is too low.
Head pressure must stay high enough to supply liquid refrigerant through the TXV.

Measure and record the condenser leaving water temperature and compare to normal readings.
At full heat load, temperatures should not exceed design specifications.
Under less than full load, temperatures will be less than design.

Leaving condensing water temperature minus entering condensing water temperature is called Condenser Water Delta T.
A 10° water temperature rise through the condenser at full load is normal.
This is an indicator of the efficiency of the refrigerant-to-water heat transfer in the condenser.

Measure and record the condensing pressure and compare to normal readings.

If condensing pressures don't look normal:
When operating at full heat load, with normal water temperatures and water flowing through the condenser tubes at design flow rate:

> If condensing pressure is higher than design, it is an indication that the chiller is operating inefficiently.
>
> An abnormally low condensing pressure may indicate low charge or an inefficient compressor.

Condenser Readings Continued:
Calculate and record the saturated condensing temperature and compare to normal readings.

Condensing pressure should be equivalent to entering water temperature + 20°, or leaving water + 10°. (This is the normal range for approach.)

Calculate the Condenser Leaving Temperature Difference, or LTD.
This is saturated condensing temperature minus leaving condenser water temperature.
It is also called Condenser Approach.
Look for 6° to 12°, normally 10° at full load.

Calculate and record; and compare your reading to design specifications and normal readings.

Condenser Approach is a significant indication of the efficiency of the refrigerant-to-water heat transfer in the condenser.

WHAT THE CONDENSER READINGS MAY BE INDICATING

If Condenser LTD is high:
Fouled tubes will cause a higher than normal LTD and Delta T, with low subcooling.
Saturated condensing temperature will rise as tubes become fouled.

In a once-through system, more and more water will be needed to maintain normal pressures and temperatures.

In a cooling tower system; over time, condensing pressure will increase for the same cooling load.

An overcharge will result in a higher than normal level of liquid refrigerant in the tubes; leaving less area in the tubes available for discharge vapor to cool and condense.

This will show as high LTD, high subcooling, high head pressure, and high amps.
You will probably see a full 10° water temperature rise through the condenser.

Low condenser water flow will show as high Delta T across the condenser, and high head pressure.
Check the water pressure drop through the condenser.

Non condensables reduce effectiveness of the condenser, and cause head pressure to rise.
It can look like an overcharge.
Check subcooling.
Subcooling will tend to increase with an overcharge.
Subcooling will tend to stay about the same with non condensables.

Condenser Readings Continued:
Measure and record the temperature if the liquid refrigerant at the outlet of the condenser.

Look for 10° to 15° of subcooling at the outlet of the condenser.

Compare your readings to normal readings and design specifications.

Water Cooled Condenser:
You'll want to verify that you have the correct rate of condenser water flow.

Measure and record the entering and leaving condensing water pressures.

Calculate condenser water Delta P by subtracting leaving water pressure from entering water pressure.

Calculate condenser water flow by multiplying Delta P (pressure drop) in PSIG X 2.31.

The answer will be the 'feet of head' being pumped through the condenser.

(See 'Chilled Water Delta P' on page 20 for the explanation of how to calculate the correction factor if the water pressure gauges are at different heights.)

WATER COOLED AND AIR COOLED CONDENSERS

Calculating Water Cooled Condenser Water Flow Continued:
Check the factory pressure drop chart for the unit, then compare your calculations to normal readings and design specifications.
From 1.6 to 6 GPM per ton is normal.

If pressure drop through the coil is higher than design specifications (or higher than normal), the possibilities are:
the tubes are dirty or plugged,
or the water flow rate is too high.

Tube fouling indications: (Compare your readings to unit history.)

Saturated evaporating temperature will be lower as evaporator tubes become fouled.

Saturated condensing temperature will rise as condenser tubes become fouled.

In a once-through system:
More and more water will be needed to maintain design conditions.

In a cooling tower system:
Over time, condensing pressure will increase for the same cooling load.

Air Cooled Condenser:

Measure and record the temperature of the air entering the condenser, and compare to normal readings.

Measure and record the temperature of the air leaving the condenser, and compare to normal readings.

Look for a 20° to 30° temperature difference between entering air and leaving air.

Look for the saturated condensing temperature to be equivalent to ambient plus about 20° to 35°.
Compare to normal readings and design specifications.

A dirty condenser coil will show a higher than normal leaving air temperature, high head pressure, increased LTD, and decreased subcooling.

VOLTAGES, AMPERAGES, AND UNIT HISTORY

CHILLER LOG SHEET ENTRIES CONTINUED

VOLTAGES:
Measure and record, compare to normal readings, and verify there is no voltage unbalance.

Calculate the average voltage by adding the 3 readings together, then dividing the total by 3.

The average voltage should be within 10% of the nameplate voltage for the unit.

If any one voltage reading is more than 2% different from the average, it should be corrected.

AMPERAGES:
Measure and record, compare to normal readings, and make sure there is no amperage unbalance.

Run the unit for 30 minutes and make sure it is running at 100%, and that the compressor is running at full load amps.

Take an amperage reading on all 3 lines.

Add the 3 readings together then divide the total by three to get the average.

If the amp draw on any of the 3 lines is not within 10 % of this average, it should be corrected.

Also, the average amperage should not exceed the nameplate amperage rating for the unit.

COMPRESSOR OIL LEVEL:
Check the oil level, enter it in the log, and compare it to normal readings and design specifications.

When anyone adds oil, a record should be kept about the reason and the quantity.

REFRIGERANT ADDED:
When anyone charges in refrigerant, a record should be kept about the reason and the quantity.

HISTORY:
A record should be kept of any barrel freeze ups, motor burnouts, recent repairs, and if any of the heat exchanger tubes are plugged.

PUMPS, WATER FLOW, DISCHARGE SUPERHEAT, UNIT CAPACITY

Heat Exchanger Water Pumps:
Pumps should always pump towards the heat exchanger, not draw from it.
When shutting down and isolating a heat exchanger, only close one water valve, not both.

Water flow problems:
HIGH WATER FLOW = Low Delta T and high Delta P.
LOW WATER FLOW = High Delta T and low Delta P.

Flow problems can be caused by:

- A worn out pump impeller.
- A blocked or dirty pipe strainer.
- An improperly adjusted balancing valve.
- Air lock in the piping or heat exchanger tube bundles.

Thermometer wells should extend into the pipe at least 3/4 of the pipe diameter.

<u>Discharge Superheat in Centrifugal Chillers</u>
Check at full load, 100% load and demand.
Measure the temperature on the discharge line close to the compressor.
Measure condensing pressure and convert to temperature.
Subtract condensing temperature from discharge line temperature.

This is discharge superheat.
Normal range for discharge superheat is 10° to 20°.

High discharge superheat can indicate a low refrigerant level in the condenser.
Low discharge superheat can indicate a high refrigerant level in the condenser.

Verify all other operating characteristics before adding or removing refrigerant.

TO CALCULATE UNIT CAPACITY:
Multiply chilled water flow (GPM) times cooler Delta T, then divide by 24.
The result is tons of unit capacity.

CHILLED WATER AIR HANDLER & COOLING TOWER TIPS

Chilled water air handlers:

Under normal running conditions look for the temperature of the air entering a chilled water air handler to drop about 15° to 25° as it passes through the coil.

The target temperature for the leaving air temperature will be in the range of 50° to 60°.

Look for the temperature of the chilled water entering the coil to be in the range of 42° to 45°, and look for the chilled water temperature to rise about 10° as it passes through the coil.

If you're working on a system with a possible cooling capacity problem; the next page explains how to check the air handler's cooling capacity.

Cooling towers:

Look for the temperature of the water entering the cooling tower to rise about 10°.

In geographical locations where 78° F wet bulb temperature would be considered an average outdoor ambient; look for the Cooling Tower Approach to be 5° to 7°. (7° would be considered optimum.)

Cooling Tower Approach is the difference between the wet bulb temperature of the air entering the cooling tower, and the temperature of the cooled water leaving the cooling tower.

> Cooling Tower Approach is a significant indication of the efficiency of the water-to-air heat transfer taking place in the cooling tower.

If the average outdoor ambient conditions in your geographic location are different than 78° F wet bulb; check with the chiller manufacturer to determine what the exact cooling tower approach should be for the installation you're working on.

CHILLED WATER AIR HANDLER CAPACITY CHECKS

If the chiller operation seems normal, and the chilled water temperatures look good, but air conditioning capacity seems low in the building or room; check your filters, coils, and blowers and make sure they're clean.

At each air handler:

1. Verify that the blower is the correct size and running in the correct direction, and that the blower drive motor is the correct size and speed for the blower.
2. Verify that the chilled water pressure drop through the air handler coil is in the normal range.
   Compare the present readings to normal, or start up/commissioning readings.
   Also check the readings against the factory pressure drop chart for the coil.
   This will tell you your water flow rate, and whether or not you have the correct water flow through the air handler.
3. Verify that the water control valve is not closed or bypassing.
4. Open and inspect the chilled water strainers and clean them if necessary.

Then check the ducting and make sure there are no air leaks.

Find out whether or not the space being cooled has been increased during renovations.

If everything looks normal, and there is still a cooling capacity problem, you'll have to do a capacity check on the air handler(s).

1. Measure the air pressure in the supply and return ducting to the air handler.
2. Compare the pressure drop to the manufacturers chart to verify the volume of air flow (CFM) through the coil. (You can use other methods to determine the volume of air flow through the coil.)
3. Measure the wet bulb temperatures of the air entering and leaving the coil.
4. Use a psychrometric or enthalpy chart to calculate Δh (difference in enthalpy (heat content)) between the two wet bulb readings.

The formula to determine how much heat the coil is moving is: $4.5 \times CFM \times \Delta h$ = capacity (in b.t.u.).

This will tell you whether or not the air handler is moving the designed amount of heat.

If the air handler <u>is</u> moving the design amount of heat and the space is not cooling, the air handler is simply too small.

If the air handler <u>is not</u> moving the designed amount of heat; start again at the second paragraph of this page, and verify that every operating characteristic of the air handler matches factory specifications.

If there's a log book, compare the present readings to normal and/or the start up/commissioning readings.

Correct any problems you find during your troubleshooting and evaluation.