CHAPTER 10

REFRIGERANT CONTAMINATION AND REFRIGERANT IDENTIFIER

CHAPTER 10

REFRIGERANT CONTAMINATION AND REFRIGERANT IDENTIFIER

10.1 INTRODUCTION

In this chapter we will discuss a brief note on contaminated refrigerant and how to check on these refrigerants by using different methodologies.

Contaminated refrigerant: Two or more undesired types of refrigerants mixed in a cylinder or in a refrigeration system which affect the performance of the refrigerant.

10.2 EFFECT OF CONTAMINATED REFRIGERANT TO THE RAC SYSTEM

When the refrigerant is contaminated, it will work at different temperature and pressure than pure refrigerant. The changes may damage the refrigerant system as the system is normally designed for pure refrigerant only. Due to the presence of contaminants, it will greatly reduce the cooling capacity of the system and will consume more energy than usual. If the system is contaminated with high concentration of the flammable refrigerants, and then chances of causing explosion will be relatively high. The consequences of refrigerant contamination are:

1. Damage refrigerant and air conditioning system;
2. Reduced cooling capacity, high electrical energy consumption and reduced system efficiency;
3. Explosion hazards.

10.3 CASE OF COUNTERFEIT REFRIGERANT

There are some contaminated refrigerant being sold in the market. Sometimes even the dealers and resellers themselves are unaware of the purity of the refrigerants they are selling. For example, there are some fake R-134a refrigerant, which consists of 60% R-22 and 40% R-40 methyl chloride, being sold in the market with a standard cylinder of 13.2 kg. The fake refrigerant usually can be recognized by the poor quality label printing and the design of the cylinder collars. Therefore, it is recommended to buy the refrigerants from an authorized dealer outlet to ensure the authenticity of the refrigerants.

Example of a counterfeit R-134a refrigerant being sold in the market:

Properties: 60 % R-22 (+ R-30, R-142b – traces); 40 % R-40 – methyl chloride.

Standard cylinder size: 13.2 kg

Figure 10.1: Example of counterfeit Refrigerant (sample on right)

10.3.1 First referred case in Vietnam

Case studies/news: The first case of fake refrigerant accident happened in Vietnam at two different places. As shown in the figure 10.2, the machinery was damaged completely after the explosion.

1. Two different cases referred in Asia;
2. Catastrophic explosions;

Figure 10.2: Incident caused by misuse of fake refrigerant

10.3.2 Case in North America

An engineer found that the refrigerant gas was combusting when in contact with air. He later found that was caused by alkyl metal halide.

1. Terminal engineer reported gas combusting in contact with air;
2. Concluded it must be an alkyl metal halide;
3. Finally managed to get a sample to a laboratory.

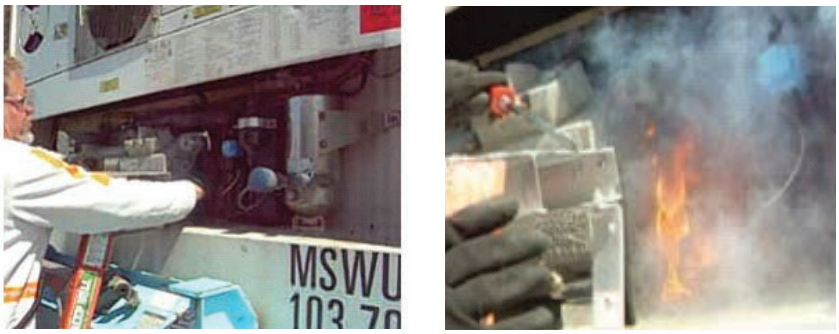


Figure 10.3: Case in North America

10.3.3 Case in South America

A catastrophic explosion happened during maintenance of refrigerant system. Sludge was found during explosion and white powder with alumina smoke was remained as residue.

1. Catastrophic explosion during maintenance;
2. Similar damage to those in Asia;
3. Sludge found in the explosion;
4. No sign of aluminum components;
5. White powder, alumina smoke residue.

Figure 10.4: Case in South America

10.4 HALIDE FLAME TEST

Normally the counterfeited refrigerants contain R-40. We can use the halide torch to verify the present of R-40. This is one of the economical tests for chlorine. However, this test involves flame and will release hazardous by-products. We must use the refrigerant identifier before performing the halide flame test to prevent any HC refrigerant in the sample (HC is highly flammable).

1. Easy cheap test for chlorine. Cautious on HCs content. Before this test, always perform the HC test with refrigerant identifier;
2. Involves a flame;
3. Harmful by-products may be released during testing.

Figure 10.5: Halide flame test

10.5 FAKE REFRIGERANTS CYLINDER

Figure 10.6 shows some of the contaminated refrigerants' cylinders. It can be identified by verification testing. The cylinders were labeled with normal refrigerant code in order to confuse the consumers. The ingredients in the cylinder were found to be the mixture of various types of substances. If those refrigerants are being charged into the system, it can damage the whole system and can cause accident that ever imagine.

Figure 10.6: Fake refrigerant cylinder

10.6 REASONS WHY R-40 MIXTURES IN THE MARKET

There are reasons behind the use of R-40 in most of the counterfeited refrigerants:

a) The price of HFCs has increased rapidly whilst R-40 is much cheaper choice.

b) HCFCs are available excessively in the market.

10.7 CONTAMINATED REFRIGERANT AND REFRIGERANT IDENTIFIER

Identification of Ozone depleting Substances (ODS) refrigerant can be done in many ways.

a) Measuring a cylinder pressure and the ambient temperature, and then comparing those results to a common chart. This can effectively identified the pure and single component ODS such as R-22.
b) Use of specific infrared identifiers / infrared component analyzers. It is widely used in indentifying the contamination of refrigerants in the automotive industry particularly during the replacement from CFC-12 to HFC-134a. This type of technology has been improved in the past seventeen years and it is widely applied in the current analyzers.
c) Gas Chromatographs and Mass Spectrometers. These are high-end laboratory instruments testing with very high accuracy. However, it is associated with higher cost and limited facility availability in some region.

10.8 REFRIGERANT IDENTIFIER

Refrigerant Identifier – a portable electronic device that allow a reliable identification or detection of the purity of the refrigerants and the percentage on composition of the selected substances in the CFCs, HCFCs, HFCs, hydrocarbons (HC) and air.

The machine is able to identify single substance and the identifier is based on infrared technology to provide the test results. Each identifier has four filters specifically optimized for detection of the desired refrigerant. The filter wavelength is between 2 and 30 microns, which can detect R-12, R-134a, R-22 and Hydrocarbons. Vapour refrigerant is passed through the infrared bench and a known value light source is turned on. The light passes through the vapour and through the filters to a receiver. By measuring the amount of energy at the receiver, the concentrations for each measured refrigerant is interpreted and displayed.

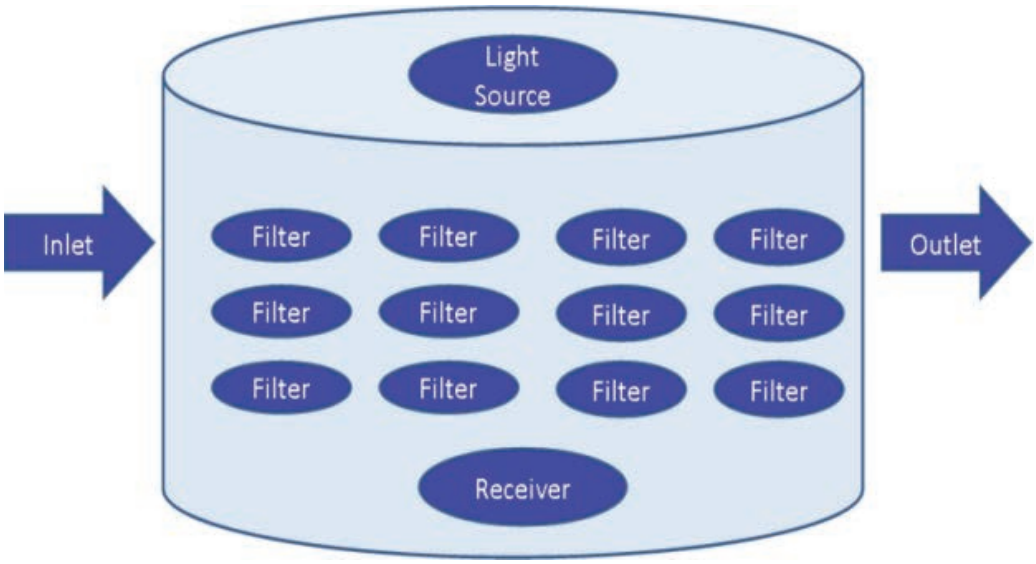


Figure 10.7: Refrigerant identifier

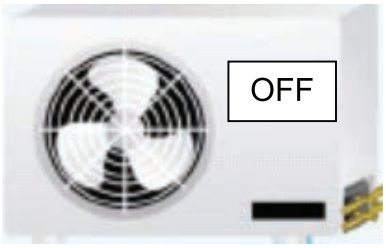
10.8.1 Infrared Component Identifier

To address the problem of multi-component ODS refrigerants; a new Refrigerant Analyzer has been developed. This new analyzer technology shares the same external physical characteristics and infrared operating principle of the single substance identifier. The differences are the number of filters have increased from four to twelve and tuning of each filter to measure the different components in the sample. This analyzer is able to accurately identify 25 common refrigerants (with +/- 1% accuracy). In addition, the software of the analyzer can be access with computer and updated by the user anywhere in the world.

There are different models of single substance refrigerant identifiers or multi substance refrigerant analyzers are work on the same principle of Non Dispersive Infrared. The new technology which is equipped with a single detector in multi channel filter wheels has enabled the instrument to identify the refrigerant blends as well.

10.8.2 Safety Precaution In Operating The Refrigerant Identifier

• Always turn the compressor off before connecting the testing instrument to an air conditioning system.



Testing on OFF system condition

Figure 10.8: Off the system before connecting to the testing instrument

• Always wear eye and skin protection when working with refrigerants. The refrigerant vapour can caused freezing danger. DO NOT contact the refrigerant vapour with skin.

Figure 10.9: Wear PPE during work

• Always place the Identifier on a flat and sturdy surface.

Figure 10.10: Place the Identifier on a flat and sturdy surface

• DO NOT utilize any hose other than those supplied with the instrument. The use of other hose types will cause errors on the result and affects the instrument calibration.

Figure 10.11: Use the correct hose

• Always verify that the refrigerant sample to be tested does not contain oil or will not emit heavy loads of oil.

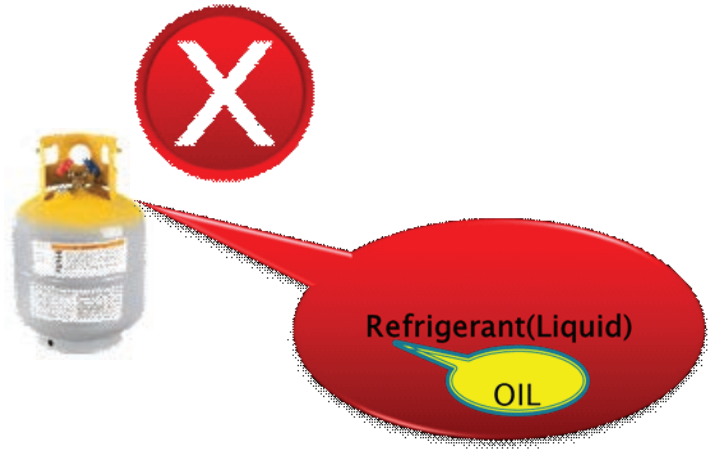


Figure 10.12: Verification of oil free refrigerant

• NEVER load the instrument with any sample pressures exceed 300 psig.

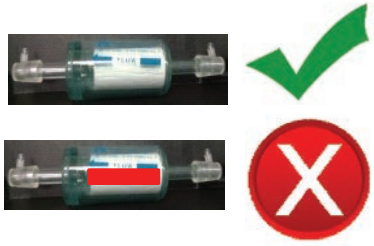
Figure 10.13: No sample at pressure in excess of 300 psig

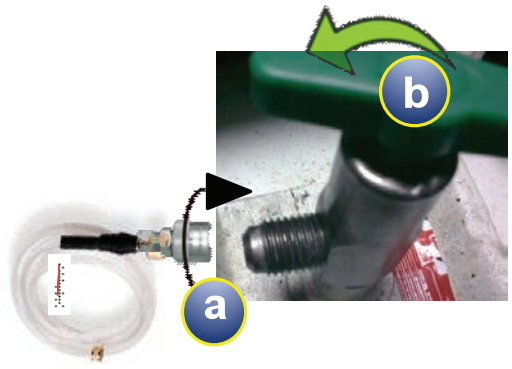
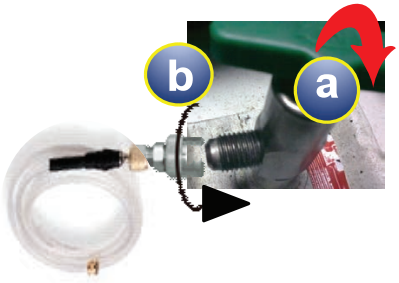
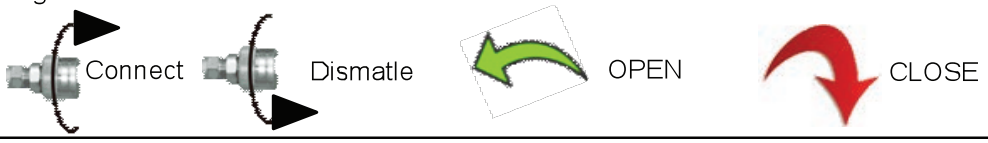
- NEVER obstruct the air intake, sample exhaust or venting ports of the instrument during use.

Figure 10.14: Never obstruct air intake

10.8.3 Standard Operation Procedure (SOP) Refrigerant Identifier (RI)

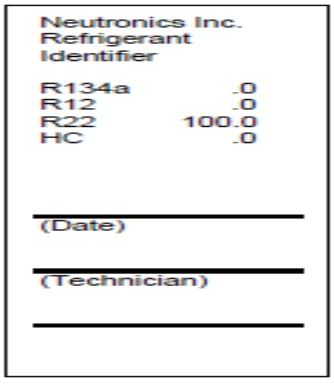
Table 10.1: Standard Operation Procedure Handling Refrigerant Identifier

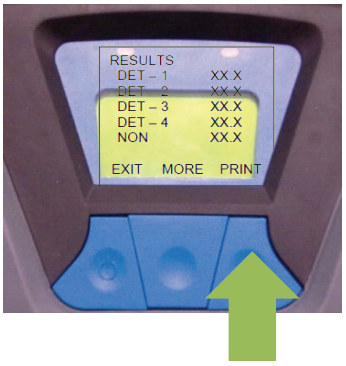
STEP	PROCESS
	Proper handling of refrigerant identifier
1.	Turning On the Unit by pressing left button. 
2.	Proceed calibration by pressing right button. 
3.	Replace filter when white element begins to show red spots on outside diameter.  

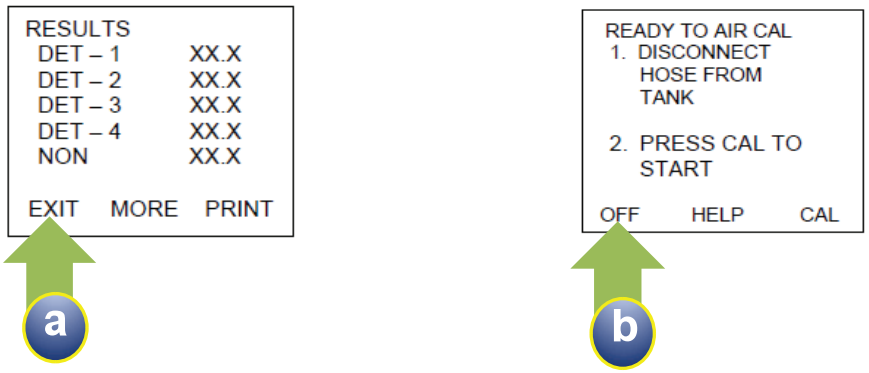
STEP	PROCESS	
	Proper handling of refrigerant identifier	
4.	a	Select suitable sample hose and connect between to the cylinder and instrument.
	b	Open the cylinder valve.
	c	Begin the analysis by pressing the right button (Test).
	 	
5.	Analysis process will take 30 second. TESTING SAMPLE THIS WILL ONLY TAKE 30 SECONDS	
6.	Once analysis completed, kindly proceed the follow:	
	a	Close the valve
	b	Dismatle the sample hose
		
	Legend : 	

STEP	PROCESS
	Proper handling of refrigerant identifier
7.	Result show as follow: RESULTS R134a XX.X R12 XX.X R22 XX.X HC XX.X AIR XX.X EXIT PRINT If > 90% pure PROBABLE R410A REFRIGERANT EXIT DONE If pure R-410A RESULTS DET – 1 XX.X DET – 2 XX.X DET – 3 XX.X DET – 4 XX.X NON XX.X EXIT PRINT If < 90% pure RESULTS DET – 1 XX.X DET – 2 XX.X DET – 3 XX.X DET – 4 XX.X NON XX.X EXIT MORE PRINT
8.	For < 90% pure refrigerant (blend),kindly refer to the chart.
9.	Press the right button for print out the result.

Blend	Det -1	Det -2	Det -3	Det -4	Non
R401A	<10	<10	85-95	0	0
R401B	<10	<10	87-97	0	0
R402A	<10	<8	75-95	<10	<20
R402B	<10	<6	87-97	<10	<6
R407C	70-90	<6	<5	10 - 25	15-35
R408A	45-65	0	35-55	0	0
R409A	<10	<15	75-95	0	0
R502	50-70	0	30-50	0	0





STEP	PROCESS
	Proper handling of refrigerant identifier
10.	a Return to main page by pressing left button (Exit).
	b Off the power by pressing left button (OFF).
	

CHAPTER 11

MAINTENANCE OF EQUIPMENT

(Recovery Machine, Vacuum Pump and Charging Scale)

CHAPTER 11

MAINTENANCE OF EQUIPMENT

(Recovery Machine, Vacuum Pump and Charging Scale)

11.1 INTRODUCTION

Technicians are well informed about the necessity of maintenance of the recovery machine. The proper maintenance can lead to the long life span of the recovery machine and good image of the project. This chapter will discuss about the importance of the maintenance on recovery machine. The lack of maintenance will cause the following issues:

1. Shorter life span of the machine;
2. Bad reputation of the service;
3. Improper performance of the machine;
4. Longer time to complete the recovery process (Waste time and money).

11.2 PROPER MAINTENANCE METHOD FOR RECOVERY MACHINE

To get the optimum performance of recovery machine, these steps should be followed:

1. Clean the condenser regularly to avoid any dust accumulation;

2. Keep the drier always capped when not in use. After running the recovery operations for 25-30 times, replace the input drier as the absorption capacity may deteriorate;

3. Always wash the internal filter screen (optional accessory) regularly to avoid the low suction of the refrigerant.

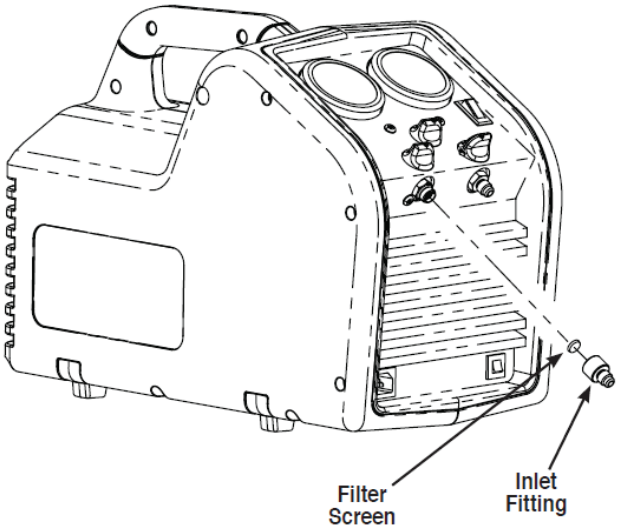


Figure 11.1: Internal filter screen

4. Always check the zero error of the gauges. Rotate the screw clock wise or anti-clock wise for adjustment. Never remove the needle or modified the gauges.

Figure 11.2: Zero error of the gauges

5. Drain the oil from the oil separators regularly (if the machine is fixed with oil separator).

6. Completely evacuate any residual refrigerant in the machine and purge it with dry nitrogen before storage for long time period. Solvent or gasoline product is not allowed for purging as it will damage the plastic enclosure and they impose hazard to the users too.

7. Make sure the inlet and outlet port are protected and kept clean by replacing the plastic caps after use.

8. Filter drier must replace according to manufacturer specification.

9. Always check the hose condition, make sure without any crack and choking.

10. When storing the recovery machine for the season, or for long periods of time, PURGE unit with an inert gas such as Nitrogen.

11. When performance of the machine has decreased sharply, check the compressor seals, and they normally need to be replaced.

12. Identify and keep the essential replacement spare parts in stock all the time.

11.3 MAINTENANCE OF THE EVACUATION AND CHARGING STATION

Evacuation is very important to remove the non-condensable gases and moisture from the system. HFC systems need deep vacuum (500 microns or lower) because of hygroscopic nature of polyol ester oil. A two-stage vacuum pump, capable of pulling vacuum between 20-50 microns at blank off is required.

Every running machine has a life span. If we want to run the evacuation and charging station for longer years, then first we must learn the importance of maintenance.

For getting the optimum performance of the equipments, we should follow the monthly check up schedule or as per recommended by the manufacturer. Well maintained equipment can contribute to the smooth progression of the project and build the good reputation. Besides, with regular maintenance can increase the life span of the equipment which can save money and time.

Not well maintained machines will cause the following issues:

1. High vacuum capability will ensure moisture removal and the high pumping capacity reduces evacuation time. Without the proper maintenance, this will cause much longer time to achieve required vacuum microns reading (500 microns)

2. Unable to achieve the required vacuum microns reading will cause improper removal of the moisture and will greatly affect the performance of the air conditioning system.

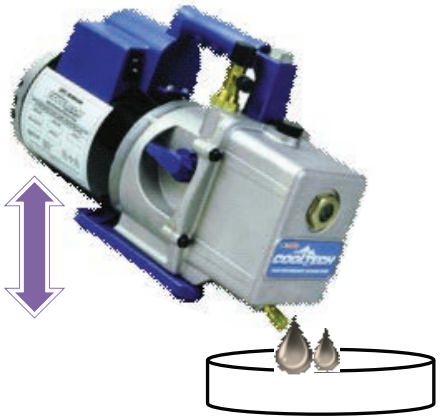
11.4 STANDARD OPERATION PROCEDURE - TO MAINTAIN THE VACUUM PUMP

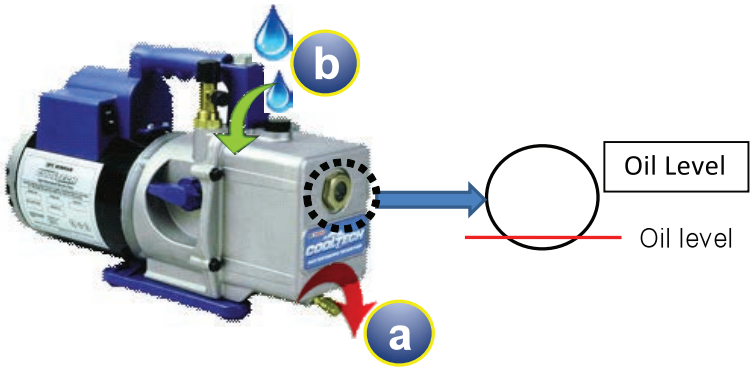
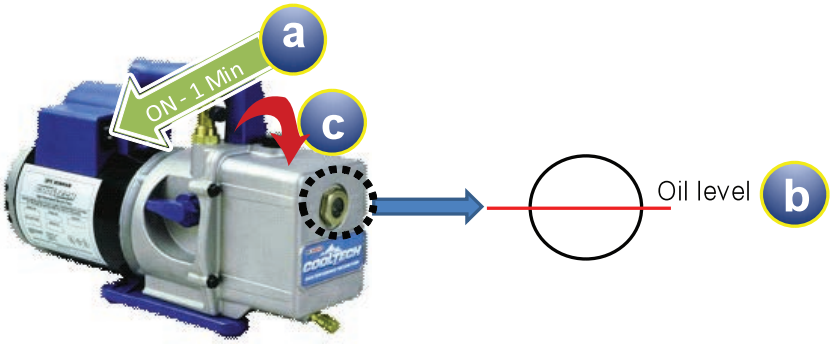
Moisture from the air-conditioning system tends to combine with the vacuum pump oil. When moisture contaminates the vacuum pump oil, it reduces the pump's ability to reach its ultimate deep vacuum level.

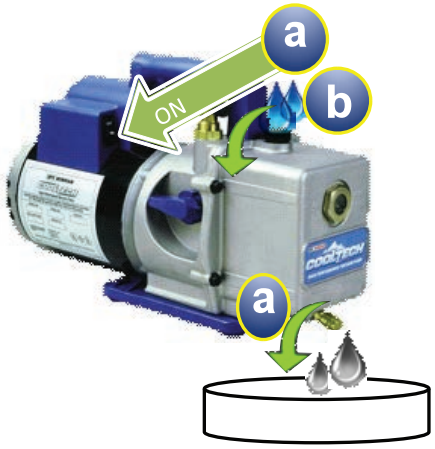
Vacuum pump oil should be changed frequently follows the manufacturer specification (e.g.: every 10 or 50 running hour interval).

Kindly refer to the standard operation procedures step by step.

Table 11.1: Standard Operation Procedure – Changing vacuum pump oil

STEP	PROCESS	
	Standard operation procedure - Change vacuum pump oil	
1.	**Warm up and drain oil**	
	a	Be sure the pump is warmed up (Run the vacuum pump for 3 minutes). This is due to lower the oil viscocity for drain out easily.
	b	Remove the OIL DRAIN cap. Drain contaminated oil into a suitable container and dispose of correctly. Oil can be forced from the pump by opening the inlet and partially blocking the exhaust with a cloth while the pump is running. Do not operate the pump for more than 20 seconds using this method.
		
2.	**Warm up and drain oil**	
	When the flow of oil has stopped, tilt the pump forward to drain residual oil.	
		
	Legend : Used oil New oil OPEN CLOSE	

STEP	PROCESS	
	Standard operation procedure - Change vacuum pump oil	
3.	a	Replace the OIL DRAIN cap.
	b	Remove the OIL FILL cap, and fill the reservoir with new vacuum pump oil until the oil just shows at the bottom of the sight glass.
		
4.	**Oil level check**	
	a	Verify the inlet ports are capped. Turn ON the pump, and allow it to run for one minute.
	b	Check the oil level. If the oil is below the sight glass OIL LEVEL line, add oil slowly (with the pump running) until the oil reaches the OIL LEVEL line.
	c	Replace the OIL FILL cap, cap the inlet, and tighten the drain cap
		
	Legend : Used oil New oil OPEN CLOSE	

STEP	PROCESS
	Standard operation procedure - Change vacuum pump oil
5.	**If the oil is badly contaminated, you may need to flush the pump.**
	a — Remove the pump drain cap and start the pump.
	b — Slowly pour a small quantity of new pump oil through the oil fill inlet. Repeat this procedure as required until the contamination is removed.
	
6.	**Proper oil quantity**
	Under filling will result in poor vacuum performance.
	Overfilling can result in oil blowing from the exhaust.
	
	Legend : Used oil New oil OPEN CLOSE

11.5 MAINTENANCE SERVICE FOR THE CHARGING STATION

11.5.1 Improper Maintenance Of The Charging Station Will Cause The Following Issues:-

- Undercharge: low cooling capacity.
- Overcharge: High pressure will cause poor cooling performance and high energy consumption.

This chapter gives the insight of generalize maintenance of the machine. We can check the charging station visually for:

1. Traces of oil;
2. Damage oil ring;
3. Operate the valves and check for smooth operation;
4. Check all gauges;
5. Check all valves.

Charging station major components listed as follow:

1. Charging scale;
2. Gauges;
3. Valve.

11.5.2 To Maintain The Charging Scale

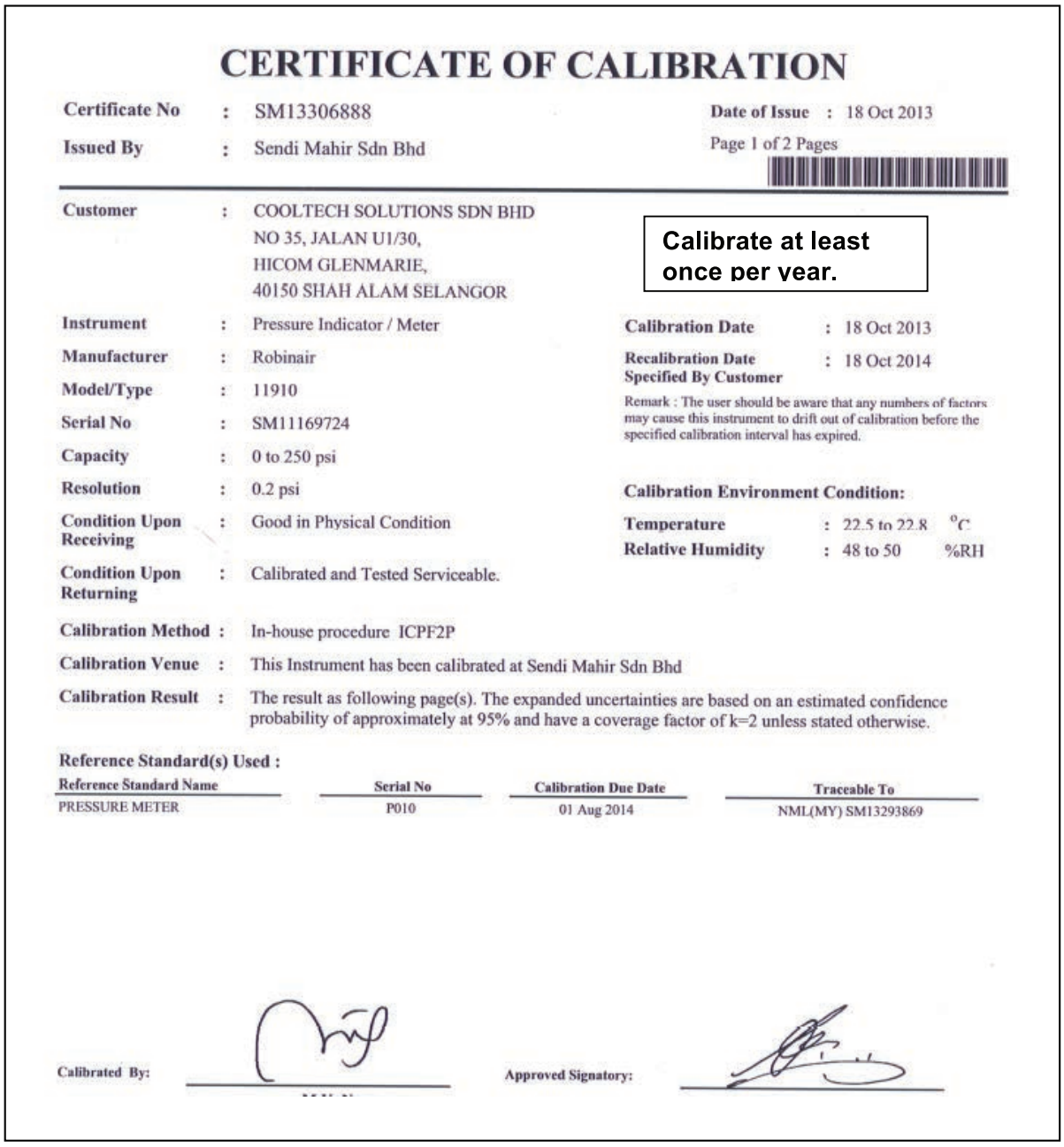
The charging scale inlet and outlet ports has the fine mesh screen filters to prevent dirt or particulate from entering the valve and causing the seat to leak. In the event that you noticed the reducing in flow, or if you have recovered dirty/contaminated refrigerant, it is recommended that these filters to be cleaned.

1. To clean the filters: Turn the unit ON, press SET; enter an amount, press SET and then the GO key to open the valve.

2. Connect a source of clean and dry air (80-100 psi recommended) to the OUTLET (right) port

3. Warning: Ensure that the INLET (left) port is pointed away from body, then turn on the source and allow the compressed air to run backwards through the valve for several seconds.

Caution : To maintain accurate charging, we must perform scale calibration at lease once per year (Figure 11.3)



CERTIFICATE OF CALIBRATION

Certificate No : SM13306888
Date of Issue : 18 Oct 2013
Issued By : Sendi Mahir Sdn Bhd
Page 1 of 2 Pages

Customer : COOLTECH SOLUTIONS SDN BHD
NO 35, JALAN U1/30,
HICOM GLENMARIE,
40150 SHAH ALAM SELANGOR

Calibrate at least once per year.

Instrument : Pressure Indicator / Meter
Manufacturer : Robinair
Model/Type : 11910
Serial No : SM11169724
Capacity : 0 to 250 psi
Resolution : 0.2 psi
Condition Upon Receiving : Good in Physical Condition
Condition Upon Returning : Calibrated and Tested Serviceable.

Calibration Date : 18 Oct 2013
Recalibration Date Specified By Customer : 18 Oct 2014

Remark : The user should be aware that any numbers of factors may cause this instrument to drift out of calibration before the specified calibration interval has expired.

Calibration Environment Condition:
Temperature : 22.5 to 22.8 °C
Relative Humidity : 48 to 50 %RH

Calibration Method : In-house procedure ICPF2P
Calibration Venue : This Instrument has been calibrated at Sendi Mahir Sdn Bhd
Calibration Result : The result as following page(s). The expanded uncertainties are based on an estimated confidence probability of approximately at 95% and have a coverage factor of k=2 unless stated otherwise.

Reference Standard(s) Used :

Reference Standard Name	Serial No	Calibration Due Date	Traceable To
PRESSURE METER	P010	01 Aug 2014	NML(MY) SM13293869

Calibrated By: **Approved Signatory:**

Figure 11.3: Sample of calibration certificate

11.5.3 To Maintain The Gauge

Using inaccurate gauge may lead to error in servicing or trouble-shooting. Thus we must always make sure the gauge is in good condition.

To ensure the gauge is in good condition, kindly refer to the following steps:

1. If the “0” error setting exists, adjust the adjusting screw or replace it with new one. When the gauge giving error reading, do not remove the needle from the gauge and re-fix to zero point. Do the setting only by rotating the screw clock wise or anti-clock wise.

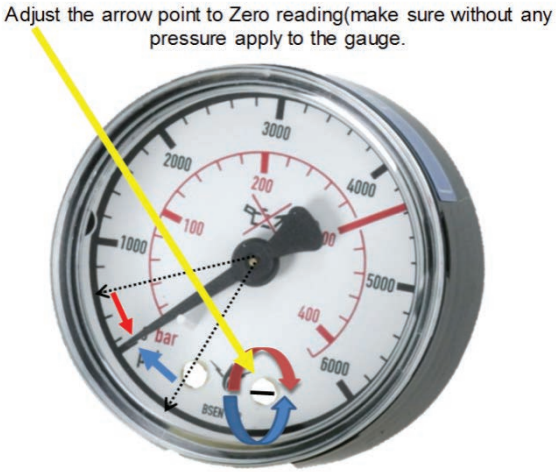


Figure 11.4: To Maintain the Gauge

2. Change the adapter if damaged, if the flare is leaky then make new flare.

3. Change the glass if broken.

4. Accuracy test by a certified personnel or laboratory (in one time per year interval).

CHAPTER 12

MAXIMISING BENEFITS OF CLIMATE ACTION THROUGH SERVICING SECTOR

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12.1 INTRODUCTION

Refrigeration and air conditioning (RAC) service sector plays an important part in protecting environment and climate change i.e. the HCFC phase-out program. The RAC service sector is important in making sure the success of the HCFC phase-out program as they are the end user of the refrigerant and their choice is crucial for the demand/supply of the ozone depletion substances like CFC or HCFC.

Figure 12.1: Save mother earth

Good service practices may greatly contribute to the protection of the ozone layer and reduction of greenhouse gas (GHG) emissions in preventing the climate change. Besides, a good handling in RAC can improve efficiency and reduce energy consumptions, hence will increase the economic yield.

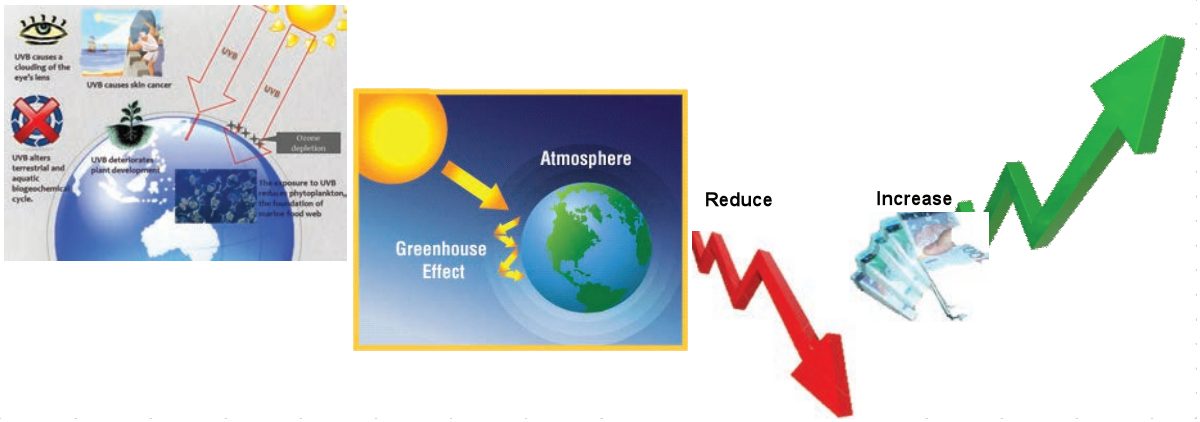


Figure 12.2: Saving money by reducing energy consumption

12.2 CLIMATE ACTION IN RAC SERVICE FACTOR

There are four areas where technician have opportunity to save energy: installation, repair, servicing and recommendations to customers. If technicians follow the good practices in all these processes, they can significantly save the energy consumption of the equipments. The four areas of focus are:

1. Installation
2. Repair
3. Servicing
4. Recommendation

12.3 INSTALLATION

12.3.1 Example Of Good And Bad Installation

12.3.1.1 Condensing unit with restricted air flow

Installing a condensing unit with restricted air flow leads to poor condensation. This will associate with higher energy consumption. During the installation, always keep minimum of 200mm gap between wall and condensing unit in order to provide a proper air circulation, so that system can operate at its optimum energy consumption.

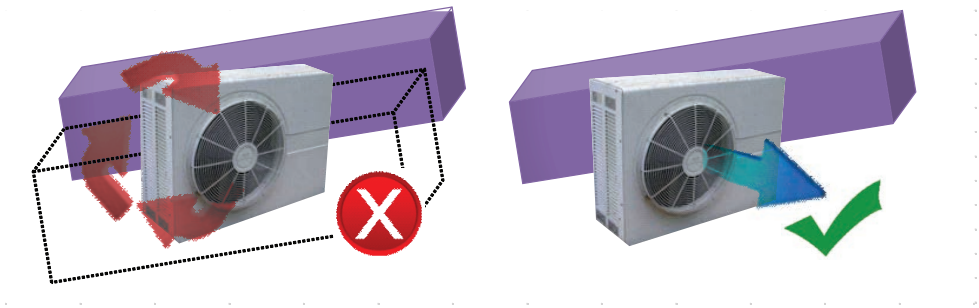


Figure 12.3: Condensing unit with restricted air flow

12.3.1.2 Condensing unit directly under sun

Installing a condensing unit directly under sun causes poor condensation, which leads to higher energy consumption. Always affix a canopy on top of the condenser or install it under a sunshade area. This will make a good condensation condition which leads to optimum consumption of energy.

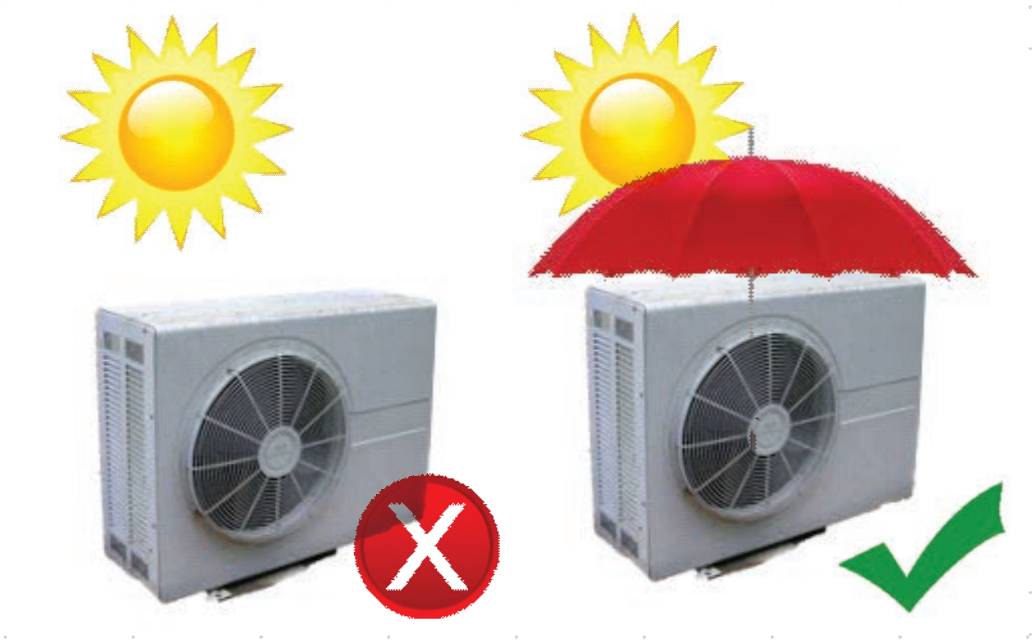


Figure 12.4: Condensing unit directly under sun

12.3.1.3 Arranging condensers one after the other

Putting condensers one after the other leads to poor condensation and high head pressure which makes the system consumes much more energy. Always make sure the condensing unit arrangement in the way that cool fresh air can circulate freely in every unit without obstacles or hot air from other unit around.

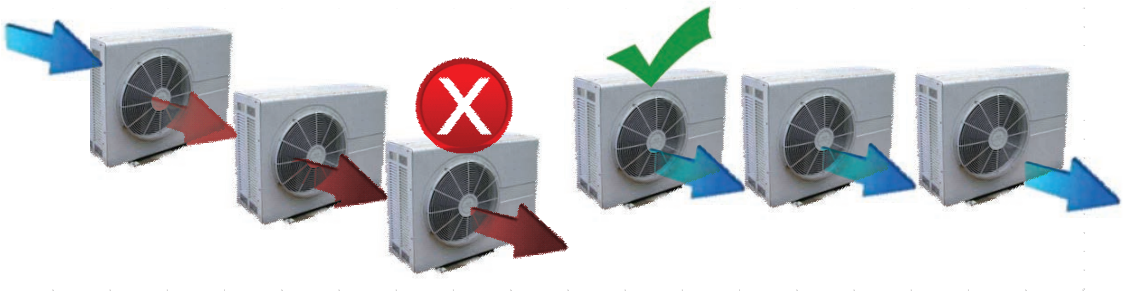


Figure 12.5: Putting condensers one after the other

12.3.2 Actions During Installation

Improper way of installation job can impose risk both to the installer and the equipment. The pictures in figure 12.6 show some of the examples of wrong way of installation.

Figure 12.6: Improper installation

12.3.3 Result Of Wrong Installation

Air flow: Hot air from the condenser can cause unwanted heat blown onto the wall, the door and the windows.

Circulation of air: Hot air will be short circulated and not well dispersed. This will reduce the condensation efficiency and increase head pressure which may lead to high current usage.

Installation in the wrong place will make the later service job become more difficult. Improper piping setting will cause vibration and cause frequent gas leaking and malfunction. All of this will significantly increase the maintenance cost (waste money) and increase the chance of green house gas emission (global warming).

12.4 REPAIR

12.4.1 Actions During Repair

Using the system compressor for vacuum job will not be able to evacuate all non-condensable gases in the system and will leads to:

- High refrigerant charge
- High head pressure
- High current usage (higher energy consumption).

Only recharge a system after a proper vacuum. Always use the two-stage vacuum pump to remove all non-condensable gases. These can significantly prolong the life span of the equipment while ensuring the optimum performance.

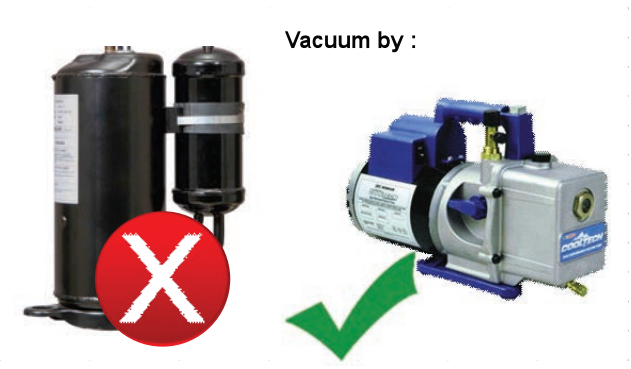


Figure 12.7: Proper vacuum

12.4.2 Results Of Wrong Repair

An improper repair leads to:

- High head pressure
- Reduced cooling capacity and high energy consumption
- Bad reputation for the service provider.

More details were discussed in Chapter 7 “Good Service Practices”.

12.4.3 What To Do While Repair

- Always follow the “Good Service Practices” as in Chapter 7. This can reduce refrigerant emissions to the open air.
- Good brazing skills will minimize the chance of gas leaking.
- Recover, recycle and reclaim the refrigerant minimize the release of ozone depletion substances.
- Optimal refrigerant charge will promise a high efficiency and low operating cost.

12.5 SERVICING

12.5.1 Servicing Management

A good and accountable system layout design prior installation is essential to determine the later system efficiency and reliability. A good system layout can contribute to greater cost efficiency of the system and minimizing the maintenance cost. Regular service or periodically maintenance should be encouraged for all operating RAC system to ensure the best performance and energy consumption.

12.5.2 Results Of Not Maintaining A System

System without regular maintenance can cause a lot of problem. For example, if the condenser is not clean regularly, accumulation of dust on the condensing coil will cause the system running on high electric current which resulting a higher energy consumption. Simple cleaning of the condenser will greatly reduce the running cost and increase the efficiency.

12.6 RECOMMENDATION

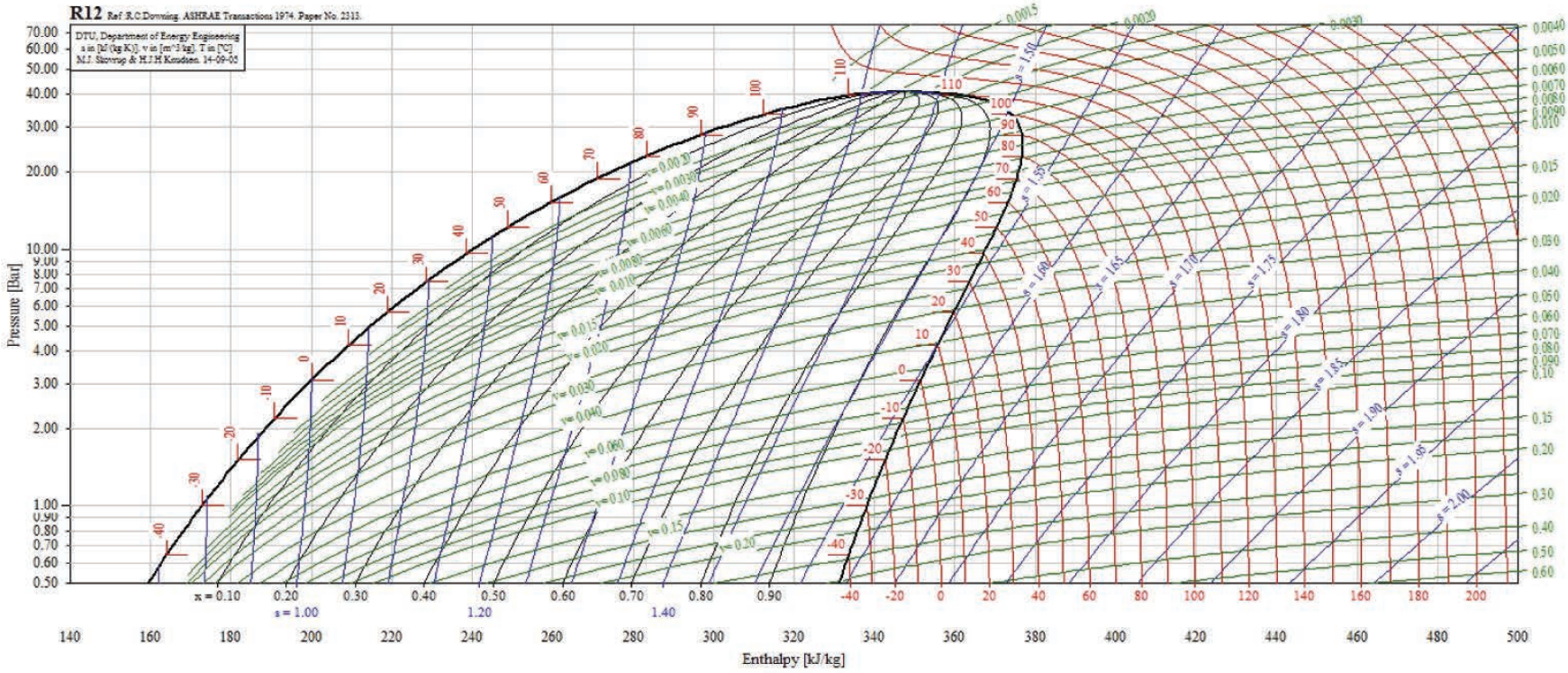
12.6.1 Best Investment: Training

Service technician should be encouraged to join training course regularly to equip themselves on latest technology and best service practices. The knowledge will directly benefit them in their daily job, particularly in the work safety and health. The technician also can make a great contribution toward protecting the environment especially in climate change.

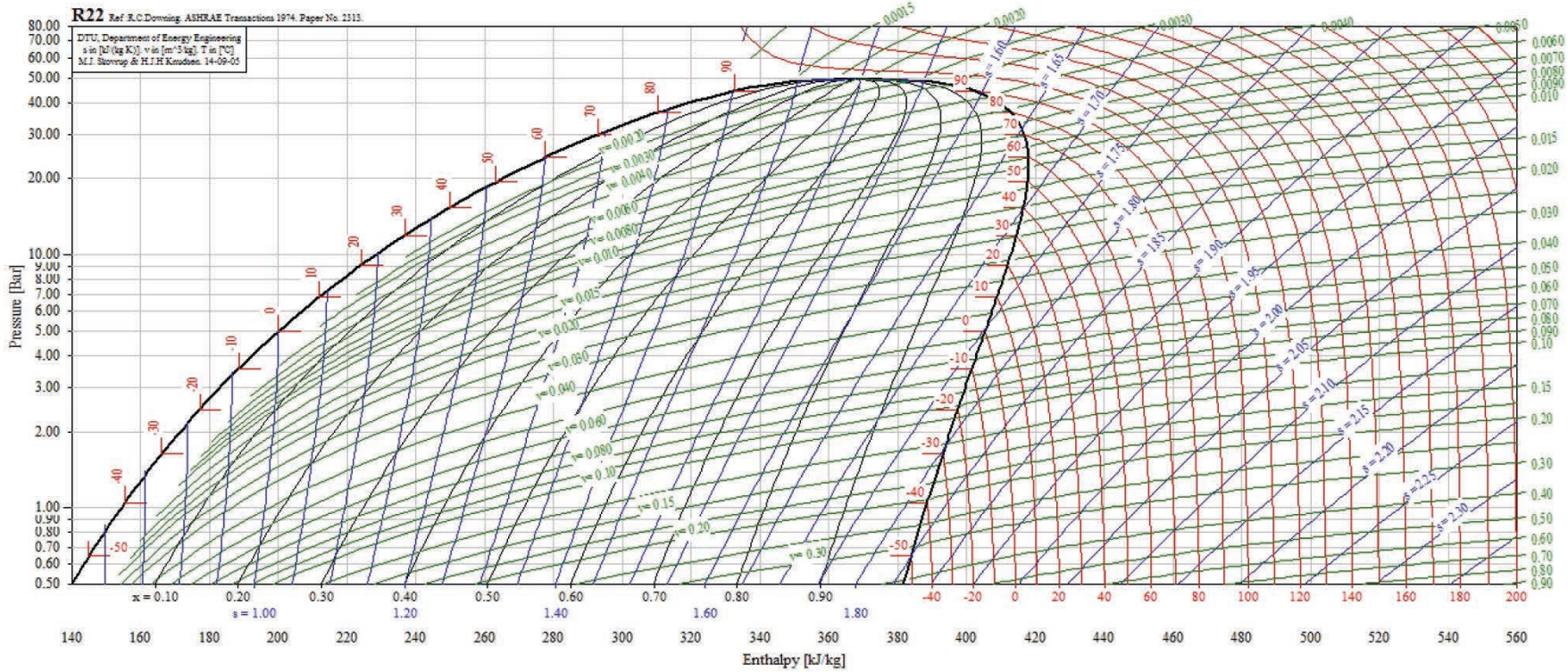
Figure 12.8: Training for service technicians

ANNEX A

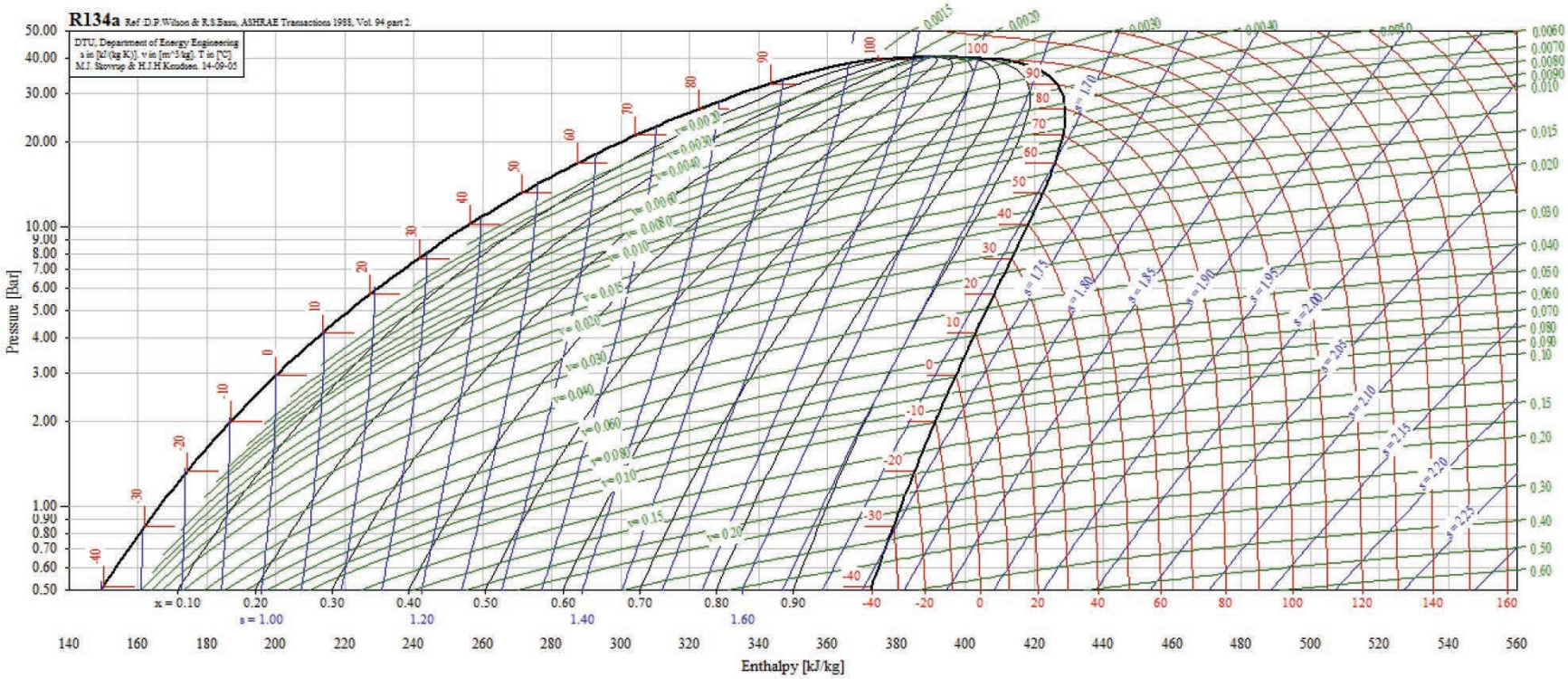
PRESSURE ENTHALPY CHART – R-12



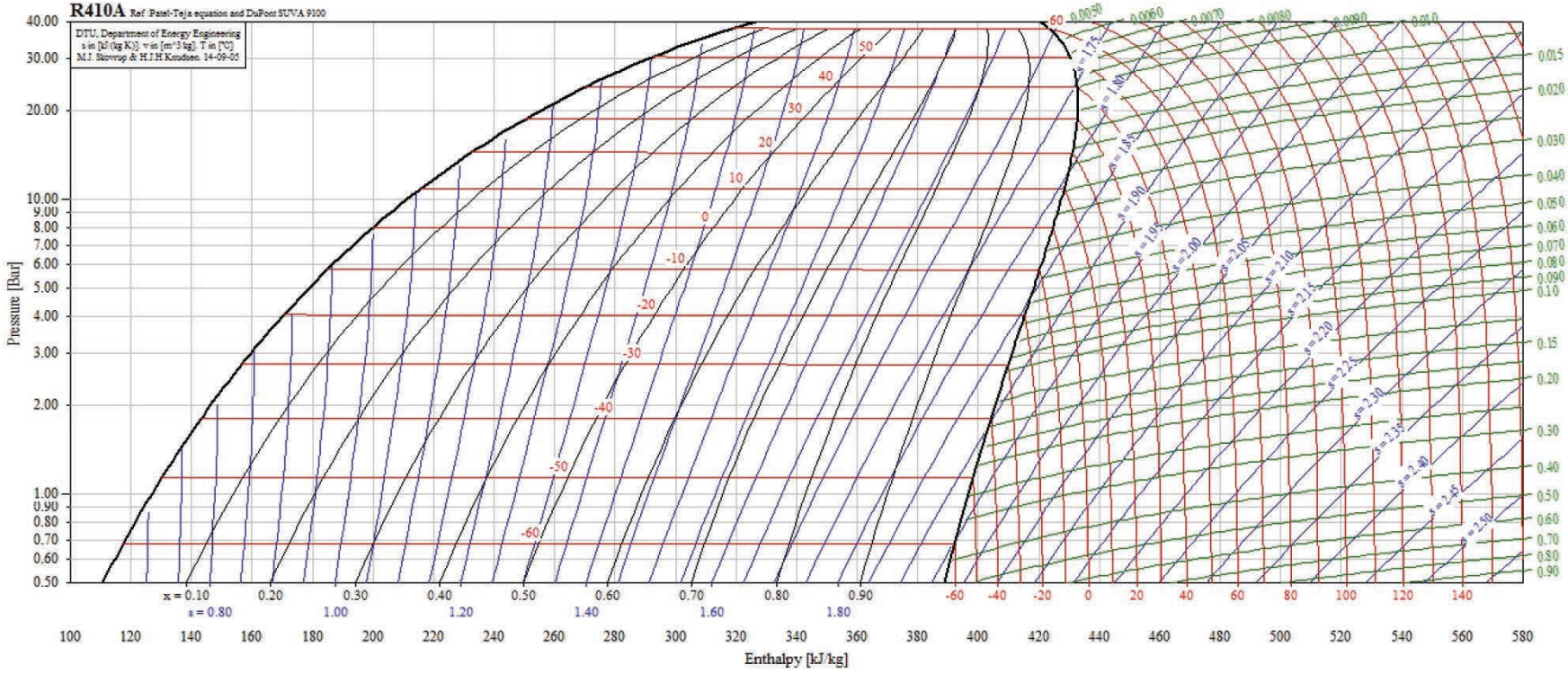
PRESSURE ENTHALPY CHART – R-22



PRESSURE ENTHALPY CHART – R-134a



PRESSURE ENTHALPY CHART – R-410A



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REFERENCE

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LIST OF ABBREVIATIONS

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A/C	Air-Conditioner
AB	Alkyl Benzene Oils
AELS	Allowable Exposure Limits
Ag	Argentum
AHRI	Air-Conditioning and Heating Refrigeration Institute
Amp	Ampere
ANSI	American National Standards Institute
AP	Approval permit
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
CDU	Condenser Unit
CFC	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon dioxide
COP	Coefficient of Performance
CTC	Carbontetracloride
DOE	Department of Environment
DOT	Department of Transport
e.g	*exempli gratia* (for example)
EN	European Standard
E&C	Evacuation and Charging
EHS	Environment, Health & Safety
Fe	Iron
GHG	Green House Gases
GWP	Global warming potential
HC	Hydrocarbons
HCFC	Hydrochlorofluorocarbons
HFC	hydrofluorocarbons
HP	Housepower
HPMP	HCFC Phase-out Management Plan
i.e	*id est* (that is)
IRG	Industry Recycling Guide
ISO	International Organization for Standards
kg	Kilogram
kWh	Kilowatt-hour
lbs	Pound (mass)
LFL	Lower Flammability Limit
LPG	Liquid Petroleum Gases
MDC	Methylene dichloride
MO	Mineral Oils
MP	Montreal Protocol

MS	Malaysian Standard
MSDS	Material Safety Data Sheet
N_2O	Nitrous Oxide
NGV	Natural gas vehicle
NH_3	Ammonia
O_2	Oxygen
O_3	Ozone
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substances
OEM	Original Equipment Manufacturer
OFDN	Oxygen Free Dry Nitrogen
PAFT	Program for Alternatives Fluorocarbon Toxicity
PAG	Poly Alkyl Glycol Oils
PAO	Poly Alpha Olefin Oils
PCE	Perchloroethylene
PELs	Permissible Exposure Levels
PFCs	Perfluorocarbons
PL	Practical Limit
POE	Polyol Ester Oils
PPE	personal protective equipment
PPM	Parts per Million
Psi	pound-force per square inch
R	Refrigerant
RI	Refrigerant Identifier
R & R	Recovery & Recycle
RAC	Refrigeration Air-Conditioning
SAE	Society of Automotive Engineers
SEER	Standard Energy Efficiency Ratio
SF_4	Sulfur Hexafluoride
SOP	Standard Operation Procedure
TAN	Total Acid Number
TCE	Trichloroethylene
TEWI	Total Equivalent Warming Impact
TLV	Threshold Limit Value
TW	Tare weight
TWA	Time Weighted Average
UFL	Upper Flammability Limit
UL	Underwriters Laboratories
UV	Utravoilet
WC	Water Content