ENER-SAVE Hydrocarbon Refrigerants Training Manual

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ENER-SAVE Hydrocarbon Refrigerant Products:

1. ENER-SAVE R290, UN1978
2. ENER-SAVE R600a, UN1969
3. ENER-SAVE R1270, UN1077

To replace existing synthetic refrigerant, as greener and highly efficient refrigerant.

MALAYSIAN STANDARD MS 2678:2017 compliance

Flammable refrigerant system- code of practice, ICS: 27.080;27.200 Department of Standard Malaysia.

GUIDELINES FOR THE USE OF HYDROCARBON REFRIGERANTS IN STATIC REFRIGERATION AND AIR CONDITIONING SYSTEMS

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TRAINING MANUAL "ENER-SAVE Hydrocarbon Refrigerants Table of Contents

ENER-SAVE Hydrocarbon Refrigerant Selection

The major consideration of utilizing Hydrocarbon refrigerant gas in refrigeration systems are safety matters, and the right selection of refrigerant type. These include Thermodynamic Properties, component selection and compatibility.

ENER-SAVE Hydrocarbon refrigerants are natural organic compound with **zero Ozone Depleting Potential** and negligible **Global Warming Potential of 3** if compare to Carbon Dioxide = 1, per 100 years basic**.**

Refrigerant Selection

Table 1: Application ranges of **ENER-SAVE Hydrocarbon refrigerants (For study purposes)**:

Refrigerant	Application Range	Replacement, 100% mass	Equivalent Mass Charge
ENER-SAVE R290, HC-22a	High/Medium Temperature; domestic appliances; commercial, industrial	R22, R407c R410a	40% - 45% 35% - 40% 35% - 42% Required to change TXV
ENER-SAVE R600a, R436A, HC-12a, Duracool-12a	High/Medium Temperature; domestic appliances; commercial; Industrial; Automotive	R12 R134a	35% - 40% 35% - 42%
ENER-SAVE R1270, HC-502a Duracool-502a	Medium/Low Temperature; commercial; Industrial; Industrial process refrigeration; chillers	R502 R404a R408a R507a	35% -42% 35% -42% 35% -42% 35% -42%

Notice:

Use only purified hydrocarbon as refrigerants. Commercial grade hydrocarbon contain significant moisture will contribute to oil degradation and shorten lifespan of compressor. Another issue of using commercial LPG that is not refrigerant grade will cause damage on refrigerating system.

Refrigerant Properties

Table 2: Physical Properties of Refrigerants

Refrigerant	Molecular Weight (g/mol)	Initial Boiling Point (°C)	Latent Heat of Vaporization @ Boiling Point (kJ/kg)
ENER-SAVE R290	41.1	-42.0	426
ENER-SAVE R600a	58.1	-12.0	363
ENER-SAVE R1270	42.0	-47.7	440
R22	86.5	-40.8	233
R12	120.9	-29.8	165
R502	116.63	-45.4	172

Please consult the MSDS for more comprehensive information.

Compatibility

Ener-Save Hydrocarbon Refrigerants possess full chemical compatibility with nearly all lubricants, system components, all common elastomer and plastic refrigeration materials.

Lubricants

Good miscibility is maintained with most lubricant under all operating conditions.

Table 3: Compatibility of various Lubricant with Refrigerants found in the Market

Refrigerant	Appropriate Lubricant				
	Mineral Oil (MO)	Alkyl benzene (AB)	Polyol Ester (POE)	Poly alpha olefins (PAO)	Poly alkyl glycol (PAG)
ENER-SAVE R290	/	□	/	/	□
ENER-SAVE R600a	/	□	/	/	□
ENER-SAVE R1270	/	□	/	/	□
R22	/	/	□	□	x
R407c	x	x	/	x	□
R410a	x	x	/	x	□
R12	/	/	□	□	X
R134a	x	x	/	x	□
R502	/	/	/	□	X
R507a	x	x	/	x	□
R404a	x	x	/	x	□

Features: / - suitable and good; x - not suitable; □ - suitable but limited application, required to change lubricant up to certain period.

Things like high head pressure and undercharged conditions caused high discharge temperatures. The oil will break down into carbon, sludge's and if moisture present; it will form acids compound.

Table 4: Oil break down and its effects

Discharge Temperature	Effects
150 ^{o}C	Piston and Ring Failure
135 ^{o}C	Break down Condition
120 ^{o}C	Danger
105 ^{o}C	Desirable

Notice:

Lubricants containing silicone or silicate (often used in anti-foaming agent) are not suitable with hydrocarbon refrigerants and shall not be used.

Elastomer and Plastic Refrigeration Materials

Such as 'O' Rings, valve seats, seals and gaskets

Table 5: Compatibility of Elastomer and plastic materials

Compatible Materials	Non-Compatible Material
Neoprene	EPDM
Viton	Natural Rubbers

Nitrile rubbers	Silicone Rubbers
HNBR	*These are rarely found with modern's compressors but may be used in older systems.*
PTFE	
Nylon	

General System Components

Table 6: compatibility of general system components

Description	Compatible	Non-compatible
Compressor	Reciprocating, Scroll and Screw Compressor (Compression Type)	Centrifugal Compressor
Evaporators and condensers	Virtually same design and same size that used for conventional fluorocarbon refrigerants that operate at similar pressure	
Refrigerant Control Devices	Thermostatic Expansion Valve (TEV) and Electronic Expansion Valve (EEV)	EEV which not comply to safety
Desiccants	Most commonly used desiccants within filter dryers are compatible with Hydrocarbon refrigerants. Type XH-5, XH-6 or equivalent.	
Pipe Size Selection	Typically refer to pressure and pipe size of system. No major differs from common design.	

Flammability Properties and Safety Measures

All ENER-SAVE Hydrocarbon refrigerant are highly flammable but non-toxic.

This gives them an “A3” class in MS 2678:2017, flammable refrigerant system- code of practice.

Flammability Properties

The flammability values are necessary in the design stage when determining maximum refrigerant charge, allowable refrigerant charge, ventilation, flow rate of exhaust fan and maximum allowable temperatures of components.

Table 7: Flammability Properties for ENER-SAVE Hydrocarbon Refrigerants

Refrigerant	Lower Flammability Limit (LFL)		Auto Ignition Temp (°C)	Higher Flammability Limit (HFL), %
	By Volume (%)	By Mass (kg/m^3)		
ENER-SAVE R290	2.0%	0.038	450	10.0%
ENER-SAVE R600a, HC-12a	1.85%	0.043	460	8.5%
ENER-SAVE R1270	2.4%	0.046	455	11.0%

The Practical Limit for detection as defined in MS 2678:2017 is 20% LFL.

All ENER-SAVE Hydrocarbon Refrigerant contains odorant ethyl mercaptan (25mg/kg)

Allowable Refrigerant Charge

Systems with charge size of 0.15kg or less than 0.15kg may be installed in any size of room. Systems with charge size of more than 0.15kg should be referred to table below and controlled under sudden loss of refrigerant but not exceeding the concentration in the room above the practical limit of 20% LFL and the refrigerant container always located above ground level.

Table 8: Occupancy Classification and Charge limit:

Category	Examples	Volumes Calculated
A (Domestic/ Public)	Hospitals, Prisons, Theatres, Schools, Supermarkets, Malls, Hotels, Dwellings	~ Human Comfort (500g on flaring connection), 0.98kg (Welded) ~ 20% x LFL x Room Volume and not more than 1.5kg per sealed system or **~5kg per sealed system in special machinery room or in the open air**
B (Commercial/ Private)	Business or Professional Offices, Places for General Manufacturing and where people work	~20% x LFL x Room Volume and not more than 2.5kg per sealed system or **~10kg per sealed system in special machinery room or in the open air**
C (Industrial/ Restricted)	Cold Room, Meatpacking, refineries, non-public area of malls, plant rooms	~20% x LFL x Room Volume and not more than 10kg per sealed system in human occupied spaces **~20% x LFL x Room Volume and not more than 25kg per sealed system if High pressure side located in special machinery room of in the open air**

		~No charge restriction if all refrigerant containing parts located in a special machinery room and in the open air

Consult the Malaysian Standard MS 2678:2017 for the complete charge size requirements.

Safety Control Measures

Piping and joints for the installation of split system equipment using A3 class refrigerant shall be made with permanent joints except joints directly connecting the piping to indoor units.

Every equipment shall be identified by flammable marking and be visible.

Figure 1: Flammable material symbol, W021

Installer/supplier/service personnel should provide adequate documentation and be trained with all relevant technical skills. Please use the ENER-SAVE Hydrocarbon Application Risk Assessment From below:

TABLE 9: HYDROCARBON APPLICATION RISK ASSESSMENT FORM

Client:			
Address:		**Date:**	
		PO. No.:	
Tel:			
Fax:		**Doc. No:**	
Project Name			
Location:		**Refrigerant type/ weight:**	
Equipment No.:		**Room Size (m^3):**	
Type of Facility	Above ground / below ground		Please Tick (/) below
1. **Category A** - Hospitals, Prisons, Theatres, Schools, Supermarkets, Malls, Hotels, Dwellings			
~20% x LFL x Room Volume and not more than 1.5kg per sealed system			
~5kg per sealed system in special machinery room or in the open air			
2. **Category B** - Business or Professional Offices, Places for General Manufacturing and where people work, small shop, small restaurant			
~20% x LFL x Room Volume and not more than 2.5kg per sealed system			
~10kg per sealed system in special machinery room or in the open air			
3. **Category C** - Cold Room, Meatpacking, refineries, non-public area of malls, plant rooms, control room			

~20% x LFL x Room Volume and not more than 10kg per sealed system in human occupied spaces	
~20% x LFL x Room Volume and not more than 25kg per sealed system if High pressure side located in special machinery room of in the open air	
~No charge restriction if all refrigerant containing parts located in a special machinery room and in the open air	
Hydrocarbon Info:	
ENER-SAVE R290 – LFL = 0.038kg/m^3	
ENER-SAVE R600a – LFL = 0.043kg/m^3	
ENER-SAVE R1270 – LFL = 0.046kg/m^3	
Hydrocarbon Type Used:	
Hydrocarbon Weight charge, kg:	
Concentration of Hydrocarbon kg/m^3	
Required Emergency Ventilation and Hydrocarbon Sensor?	
Any Ignition source nearby?	
Electrical contacts being sealed or non-sparking?	
Can use Hydrocarbon in this Application?	
Other Comment:	

Prepared by (Certified/Trained HC personnel) Date:	Acknowledged by (Client) Date:

Doc No.: RAF/ES/280817-01

End users shall be advised by installer/supplier to engage trained service personnel to carry out any installation, repair, servicing or disposal of the system. The service personnel shall be trained to handle equipment using flammable refrigerant and follow safety procedures in accordance to relevant safety standards and industry best practices.

ENER-SAVE Hydrocarbon Refrigerants Charging

Under no circumstances should the system be overcharged with hydrocarbon refrigerant. It is important that the Hydrocarbon refrigerant are much lighter than CFC and HCFC. The charging volume is typically double to CFC and HCFC compare to similar weight. Therefore, overcharge systems pose increased of pressure and reduce the performance of system. It is potentially causing damage to systems and components.

Allowable Refrigerant Charge for Category A, Domestic

Table 10: Domestic Air Conditioners' Allowable Charging Guide

Air Conditioner Size	Typical Room Size	Typical Hydrocarbon Weight Charging Size, kg, Category A, Domestic < 1.5kg	20% LFL Check List (< 0.008kg/m^3), kg/m^3
1.0 hp	3m x 4m x 3mH = 36m^3	0.28	0.0078
1.5 hp	4m x 4m x 3mH = 48m^3	0.38	0.0079
2.0 hp	4m x 6m x 3mH = 72m^3	0.56	0.0078
2.5 hp	5m x 6m x 3mH = 90m^3	0.68	0.0076
3.0 hp	6m x 6m x 3mH = 108m^3	0.82	0.0076
4.0 hp	6m x 8m x 3mH = 144m^3	1.10	0.0076
5.0 hp	8m x 8m x 3mH = 192m^3	1.45	0.0076

Figure 2: Liquid Charge Position

Figure 3: Vapor Charge Position

Table 1 shown its equivalent mass charge for various type of replacement for commonly found refrigerant in the market.

Executing change of refrigerant to Ener-Save Hydrocarbon Refrigerant

It is crucial to identify existing refrigerating system whether suitable to replace with Ener-Save Hydrocarbon. It includes identifying the compatibility of components, refrigerant type, condition of existing unit, ventilation and surrounding where source of ignition could exist.

To change the existing refrigerant to Ener-Save Hydrocarbon shall follow the method below or any other standard code of practice. Such as MS 2678:2017

1. Record the full set of system operating parameters to establish benchmarking.
2. Repair existing issues before carry out refrigerant changes.
3. Conduct a thorough leak check and identify any joints and seals to be replaced.
4. Recover the existing refrigerant using recovery unit and appropriate empty cylinder.
5. Drain some lubricant to check the condition of the existing lubricant oil (change the lubricant oil if necessary)
6. if lubricant oil remaining no change, purging using dry nitrogen is required to dilute the residual of existing refrigerant.
7. Charge some lubricant oil if required
8. Change the joint, seals, sensing and control devices, filters, oil filters, driers and relief valves as required.
9. Secure and seal all electrical terminal and wiring connection
10. Vacuum the system to below 1000micron and hold the pressure for at least 15minutes and maintain the vacuum level
11. Charge with ENER-SAVE Hydrocarbon refrigerant (using proper recommended mass charge as per Table 1)
12. Adjust sensing and control devices, including software modifications, if required
13. Review all indications to suit the new refrigerant, and fine tuning
14. Checking any potential leak before hand-over
15. Provide appropriate warning sticker
16. Record full set of system operating parameters and compare the previous parameters

TABLE 11: HYDROCARBON CONVERSION FORM (to be filled by installer)

Client:			
Address:		**Date:**	
		PO. No.:	
Tel:			
Fax:		**Doc. No:**	
Project Name			
Location:		**Refrigerant type/ weight:**	
Equipment No.:		**Room Size (m3):**	
Type of Facility	Above ground / below ground	**New Refrigerant**	

Comparison		
Descriptions	**Before Converted to HC**	**After Converted to HC**
Refrigerant Weight, Suction/Discharge Pressure		
System 1		

System 2		
System 3		
System 4		
A/C Temperature Set Point (^oC)		
Water Cooled System Parameter		
Condenser Water Inlet Temp (^oC)		
Condenser Water Outlet Temp (^oC)		
Air Intake Temp (On-coil), ^oC		
Air Outlet Temp (Off-Coil), ^oC		
Cooling Coil Differential Temp, ^oC		
Forecasted Cooling Capacity, RT		
Average Hourly Power Consumption (kW)		
Voltage (avg)		
Current (avg)		
P.F		
Specific Power kW/RT		
Coefficient of Performance, COP		
Operating Hour(s) x Day(s) per month		
Power Saving (kW)		
Saving Achievement		
Monthly Saving kWh		
CO_2 emission reduction per year		
Prepared by (Certified/Trained HC personnel) Date:	Acknowledged by (Client) Date:	

Doc No.: HCF/ES/280817-02

Maximum Ener-Save Hydrocarbon Refrigerant Charge in a specific room

The Maximum allowable Ener-Save Hydrocarbon Refrigerant Charge in a specific room is outlined in the Standard as defined by the location of installation. We recommend that the Malaysian Standard MS 2678:2017 be consulted where the relevant charge size as summarized in table 8.

If the facility located below ground level, the maximum charge would be 1kg in all circumstances but not more than 20% LFL of Hydrocarbon refrigerants charge. Or following the **table 8** for the facility which located above ground level.

Maximum Hydrocarbon Charge Size per sealed system, $m_r = 0.20 \times (LFL) \times V_{room}$ **[Formula 1]**

Where, LFL = lower flammability limit of refrigerant (kg/m^3) from **table 7**,

Vroom = room volume (m^3)

Site Installation

General

Systems using ENER-SAVE Hydrocarbon should not be located in a space or room where its entire refrigerant leak would cause a refrigerant and air mixture of a concentration higher than one-fourth (25%) of the lower flammability limit of the particular refrigerant. If this happen and the installation is in a machinery room then the use of an ENER-SAVE hydrocarbon refrigerant detector and mechanical ventilation should be installed.

If ENER-SAVE Hydrocarbon Refrigerant installed in a room with floor void, the floor void should either be sealed or the space ventilated against refrigerant collecting in drains. Similar to case of installation on the roofs of a building, should the refrigerant leak not enter into the building.

Water Piping

For system using an indirect cooling circuit, there is possibility that refrigerant leak into the condenser shell or chiller barrel. This should have dealt with installing an air vent or air separator within the secondary circuit.

Installing ENER-SAVE Hydrocarbon Detector

Ener-Save hydrocarbon refrigerants detector shall be installed in machinery room or room where is exceeding the practical limit but away from open flame and any other ignition source in order to trigger an alarm and to automatically switch on ventilation fans once leak event occurred. Detectors shall be used to isolate the electrical equipment and to warn persons who work inside or outside the machinery room. Sampling point should be located at strategic area within the machinery room. The air movement shall be identified to create effective detection. Ener-Save Hydrocarbon refrigerant heavier than air, sampling points shall be one feet above the ground. You could consult Malaysian Standard MS 2678:2017 for more information.

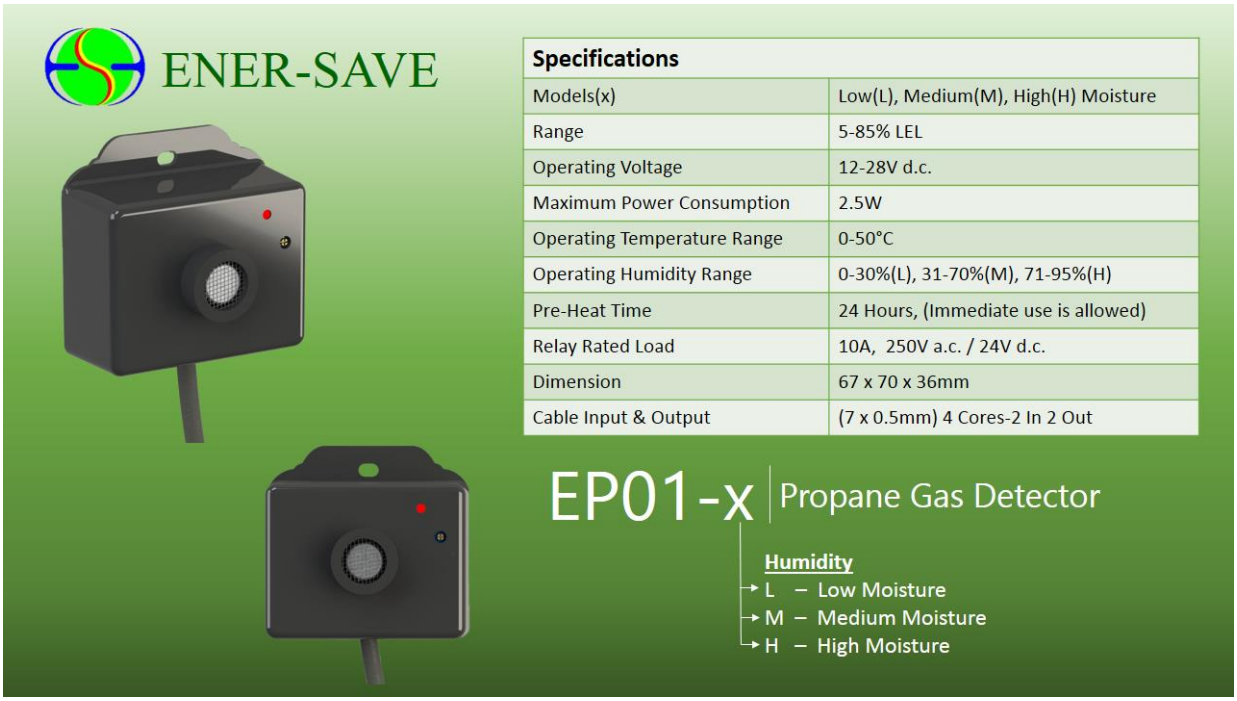


Figure 4: ENER-SAVE Hydrocarbon Detector

Ventilation

A room where at least one of the longer walls is open to outside air by means of louvres with 75% free area and covering 80% of the wall area is considered as being in open air. Hydrocarbon equipment located in the open air or in machinery room, in the event of leak, the refrigerant shall be drawn-out by natural or forced ventilation. Ener-Save strongly advise to install emergency mechanical ventilation, the air flow for emergency mechanical ventilation shall be ten (10) air charges per hour or the air flowrate obtained by formula 2,

$v = 0.004 \times m / LFL$ **[Formula 2]**

where

v = air flow rate in m^3/s;

m = mass of refrigerant charge in the refrigerating system with the largest charge, any part of which is located in the machinery room.

LFL = lower flammability limit of the refrigerant

Notice:

All charge limit applies to single refrigerant system, on the basic of probability that two systems will not have catastrophic leak simultaneously. The fan could be connected to a detector and activated only when the detection of leak is evident. Or for more convenient duty, the ventilation fan should be on as long as hydrocarbon system/ equipment is located in the machinery room.

Sources of Ignition

The components to consider as possible sources of ignition are

- On/Off switch
- Pressure switch
- Thermostat
- Oil differential switch
- Fan delay switch
- Liquid level switch
- Flow switch
- Start relay
- Contactor
- Thermal overload relay
- Isolator switch
- Timer switch
- Defroster switch
- Fan speed controller
- Humidity controller
- Programmable controller

Electrical items that have the potential to become source of ignition shall be eliminated by

- Insulate terminals
- Locate within appropriate enclosures
- Replace with solid state type components

- Replace with explosion proof components
- Locate externally

Motors, including fans, pumps and compressors should be of brushless design so as not to cause potential sparks. In machinery room, it is sufficient to fit leak detector to isolate all electrical appliance upon detection of hydrocarbon refrigerant.

All Metallic parts in machinery room and occupied areas where the hydrocarbon refrigerant is present shall be electrically bonded and earthed to avoid electrostatic ignition. The earthing should achieve a resistance in continuous earthing path less than 10 Ohm.

Marking and Instruction

The marking of Hydrocarbon system shall be visible and at least contains following information:

1. Installer's name and address
2. The year of installation
3. The refrigerant type and number
4. The operating pressures for the system
5. The refrigerant mass charges

It is suggested also all hydrocarbon systems should have flammable gas sticker placed on compressor, receiver and any other part of the system would an engineer access to the refrigerant. The flammable symbol should be 3cmL x 3cmH (BOMBA Requirement)

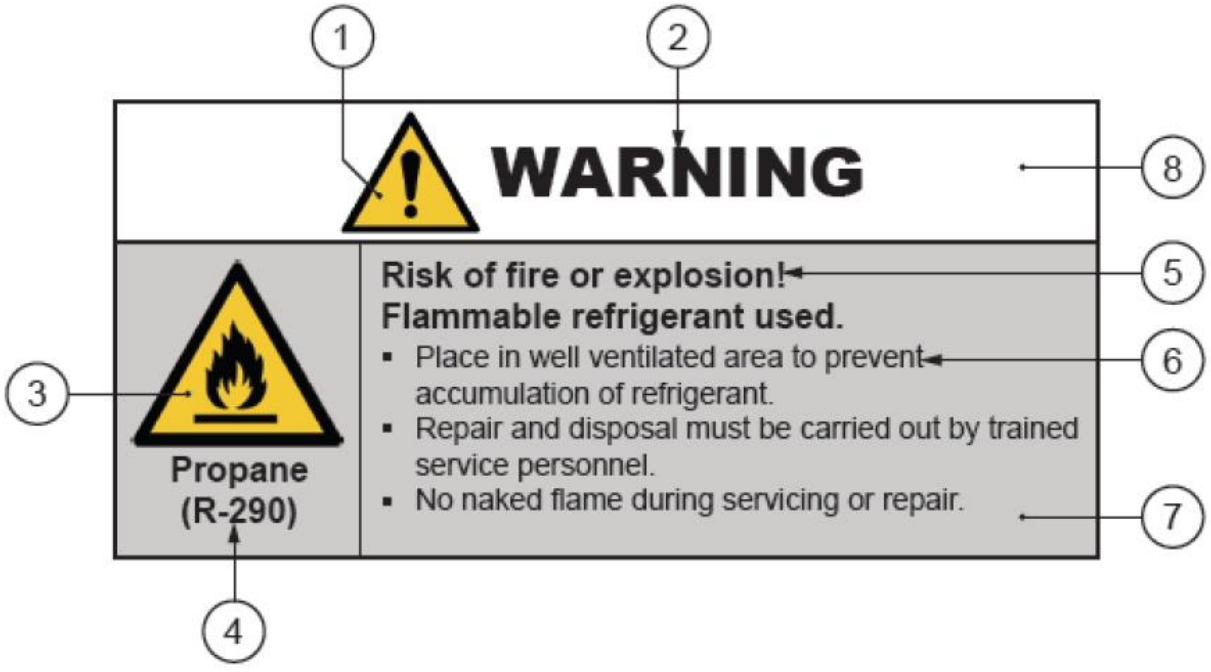


Figure 5: Advisory label for installer/service/supplier

Features:

1 Hazard warning symbol

2 Main cautionary sign

3 Flammable symbol

4 Type of refrigerant

5 Cautionary statements

6 Safety pre-caution and advise

7 Light grey background (MS Standard MS 2678:2017)

8 White background (MS Standard MS 2678:2017)

RISK PHRASES: Liquified flammable gas. Flammable air-vapor mixtures may form if allowed to leak into atmosphere.

PRECAUTIONS: Keep away from heat sparks and flames. Container temperature should not exceed 49^{o}C. Store and use with adequate ventilation. Wear protective equipment during handling. Avoid skin or eye contact.

FIRST AID: If inhaled, remove victim to fresh air. If not breathing, give artificial respiration. For skin or eye contact with liquid, flush with lukewarm water for at least Fifteen [15] minutes. Seek medical attention if irritation persists. For use by qualified personnel only. See Material Safety Data Sheet.

Safety Alarm and Revolving Light

Refrigerant leak detection and alarm should be provided for all machinery room. The revolving light should be located at visible area to warn there is refrigerant leak detected and draw attention the person surrounding. The alarm audible power should be at least of 90dbA or 10dbA above the ambient, whichever is the louder.

The system must be activated and alert an authorized person to take appropriate action at 25% lower flammability limit of refrigerant in the machinery room.

Notice

Backup power using batteries can be used for the alarm system.

Practical Competence

Any person who is involved with working on or handling the hydrocarbon refrigerant system should hold a valid certificate of competency from an industry accredited assessment authority, which authorize their competence to handle hydrocarbon refrigerant.

General Tools and equipment to Hydrocarbon Refrigerant Handling

It is important that appropriate safety requirements are observed at all times during working with flammable refrigerant. Any equipment used in the process of repairing must be suitable and safe for use with flammable refrigerant. All tools and equipment (including measuring equipment) are to be checked whether suitable for handling the hydrocarbon refrigerant system or not. Particularly:

- Refrigerant recovery unit (no external brushes)
- Electrical test meters
- Refrigerant leak detectors
- Refrigerant recovery cylinders
- Portable lighting
- And others

Safety Checks

Before work on hydrocarbon system, safety checks are necessary to ensure there is not risk of ignition or to minimize the risk of ignition. Trained personnel must ensure the surrounding is clear of any ignition source, no leak of hydrocarbon refrigerant from the system inside the working area, electrical devices are secured, adequate ventilation for dilute of hydrocarbon refrigerant if the leak of hydrocarbon presents and to have a dry powder or CO_2 fire extinguisher adjacent to the working area (especial working with hot work).

It is recommended to place a portable exhaust fan during handling hydrocarbon refrigerant gas.

The required flowrate given as

$Q = 10 / RCL$ **[Formula 3]**

Where

Q = the ventilation airflow, m^3/h

RCL = the Refrigerant Concentration Limit, kg/m^3, as given in ISO 817.

Table 12: RCL for ENER-SAVE Hydrocarbon refrigerants

Refrigerant Designation	Safety Group	Refrigerant Concentration Limit, RCL
ENER-SAVE R290	A3	0.008 kg/m^3
ENER-SAVE R600a	A3	0.009 kg/m^3
ENER-SAVE R1270	A3	0.002 kg/m^3

Maintenance

Maintenance should be taken as preventive type, maintenance should refer to non-hot work activity such as brazing or welding of parts. Trained personnel should wear portable hydrocarbon gas detector when entering the machinery room or when carry out the maintenance job. The detector should provide audible alert if 25% of LFL of refrigerant gas detected. Trained personnel should stop all work and identify the potential risk of working area. Do not enter the working space unless hydrocarbon refrigerant vented out thoroughly. Maintenance works are monitoring of system performance, diagnostic system error, normal service or cleaning, resetting control parameter, resetting electrical fault, start-up or shut down of system and etc.

Repair

Repair should be taken as breaking into a system either non-hot work or hot work type, similar to maintenance procedure, trained personnel should wear portable hydrocarbon gas detector when entering the working space. Prepare fire extinguisher adjacent at working area. Use only appropriate tools and equipment to carry out hydrocarbon refrigerant system repairs.

It is mandatory to install a portable exhaust fan or switch on the emergency ventilation fan all the times during the work. For breaking into Hydrocarbon refrigerant system, hydrocarbon refrigerant should be recovered into approved recovery cylinder. Always vacuum the hydrocarbon refrigerant system to avoid flammable concentration before open the circuit by cutting or brazing. Do not vent the hydrocarbon refrigerant into drain, into occupied area or into source of ignition.

Commissioning

A hydrocarbon refrigerating system is commissioned in exactly the same manner of system containing CFC/HCFC/HFC refrigerants. Please ensure the marking and labeling is correct.

Decommissioning

Before carrying out decommissioning, it is essential to know the details of plant, equipment and refrigerant type. The oil and refrigerant sample should be taken and case analysis is required prior to re-use of reclaimed refrigerant.

Steps

1. Be familiar with the equipment and its operation.
2. Isolate system electrically
3. Ensure trained personnel wear protective equipment, wear hydrocarbon detector, with recovery knowledge, use the right tools, use the right procedure and aware of Risk Assessment.
4. Pump down refrigerant if required
5. If a vacuum is not possible, make a manifold so that refrigerant can be removed from various parts of the system
6. Make sure the recovery cylinder is approved type
7. Start the recovery machine and operate according to manufacturer instructions
8. Do not overfill cylinder (80% volume liquid charge typically)
9. Make sure all equipment removed from site promptly and all isolation valves on the equipment are closed off.
10. Recovered refrigerant should not be charged into another system unless it has been checked.
11. Always vacuum the system where contains residual of hydrocarbon.

12. Label the equipment and state the equipment's last used refrigerant is hydrocarbon.

Notice

Do not mix hydrocarbon refrigerant with other refrigerants in recovery units and especially not in cylinders

Transportation of Hydrocarbon in Cylinders

Ener-Save Hydrocarbon refrigerant is classified as dangerous goods class 2. The cylinder must be refillable cylinder; design of the cylinder is based on Standard AS 2469:2005 Welded Steel with water capacity 0.1 liters to 11 liters.

ENER-SAVE Hydrocarbon Cylinder

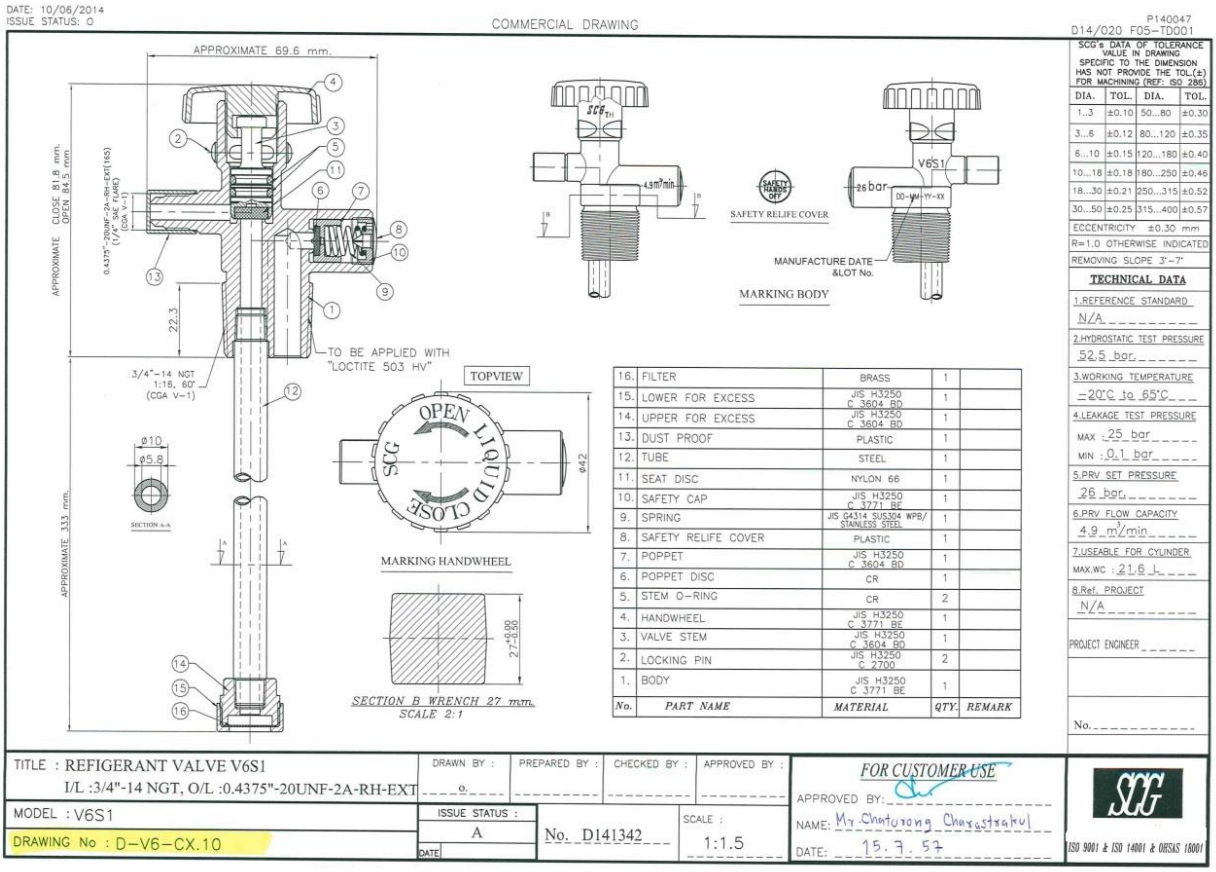


Figure 6: Refrigerant Valve V6S1

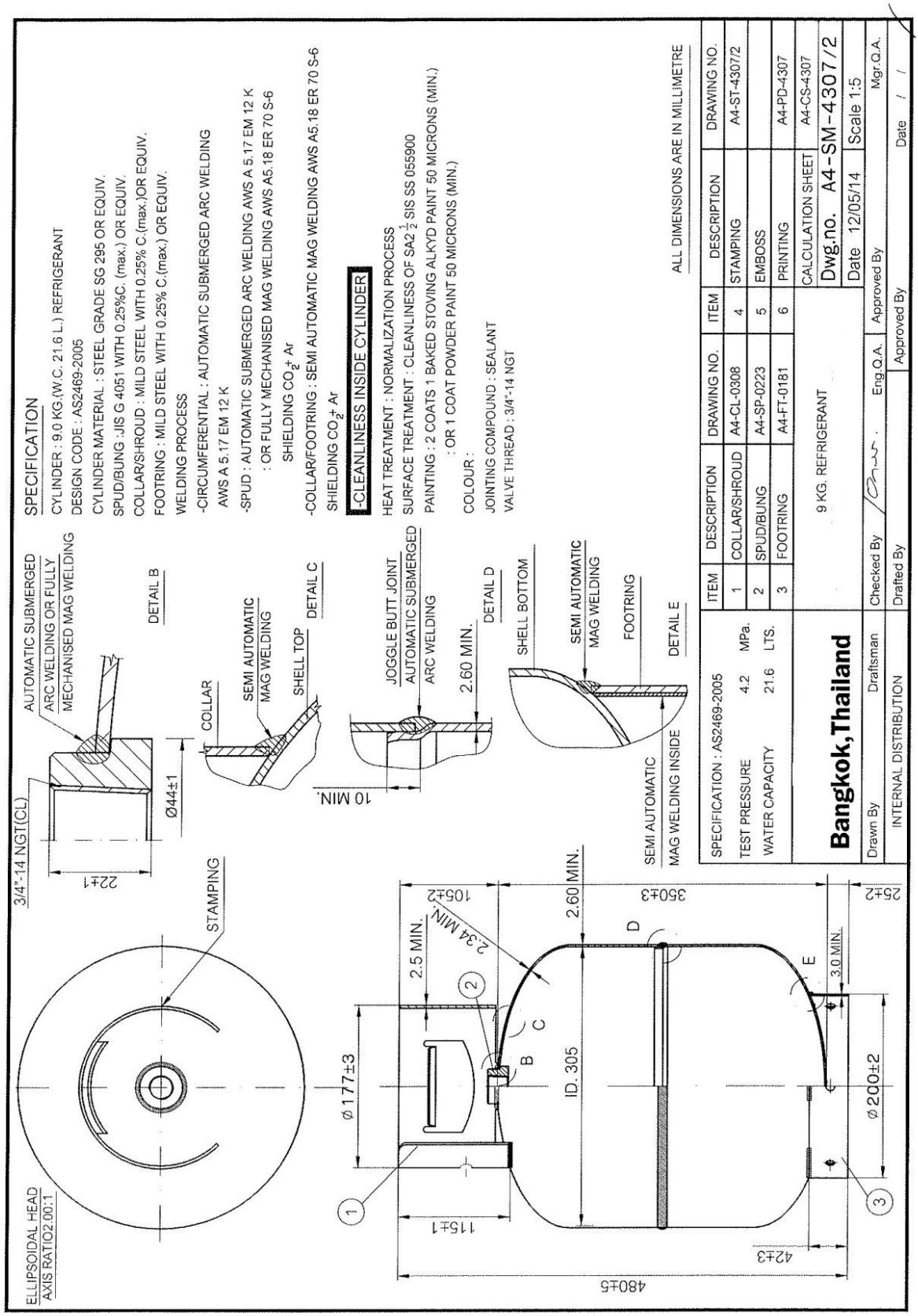


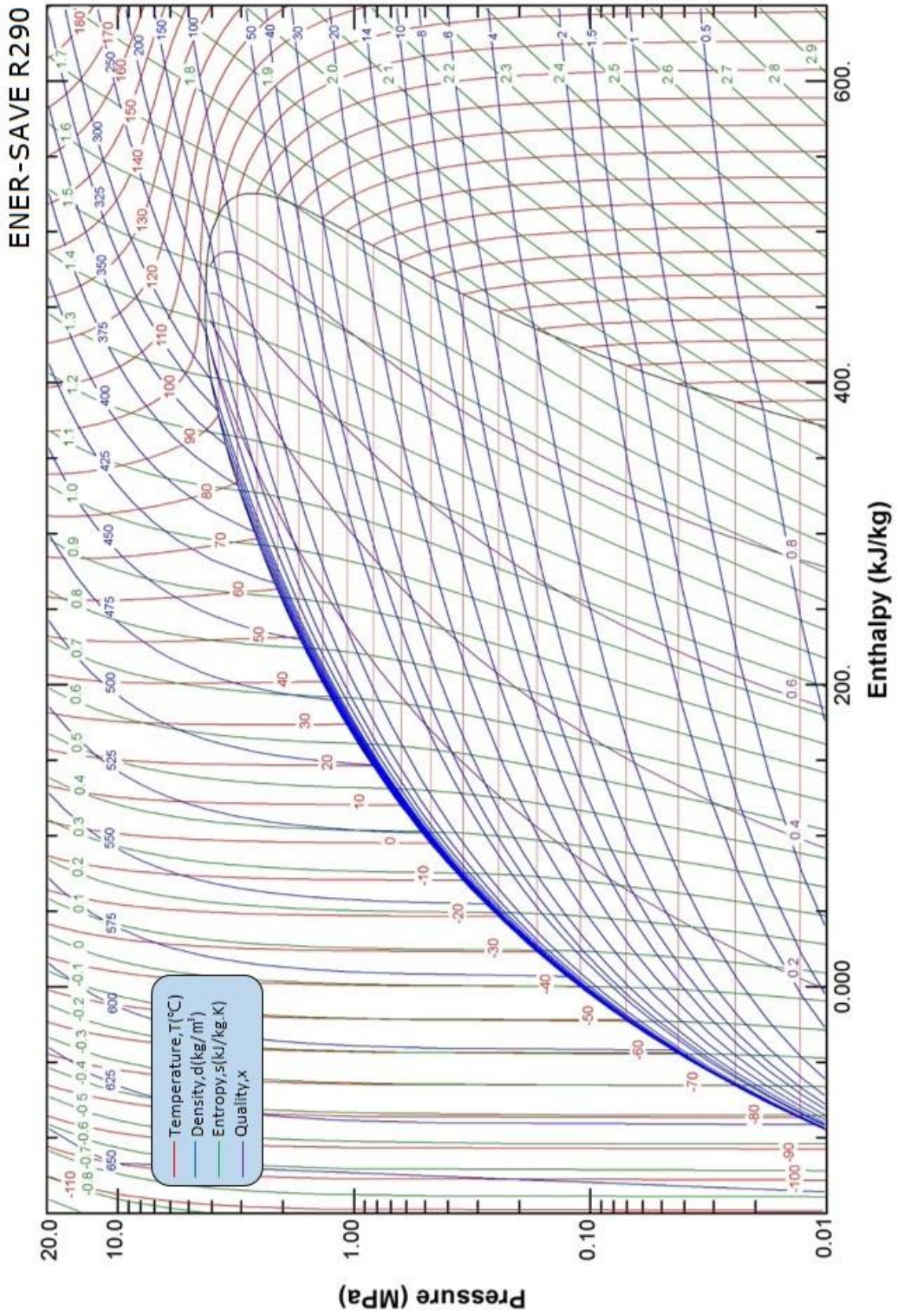
Figure 7: AS 2469: 2005 Refrigerant Cylinder, Made in Thailand

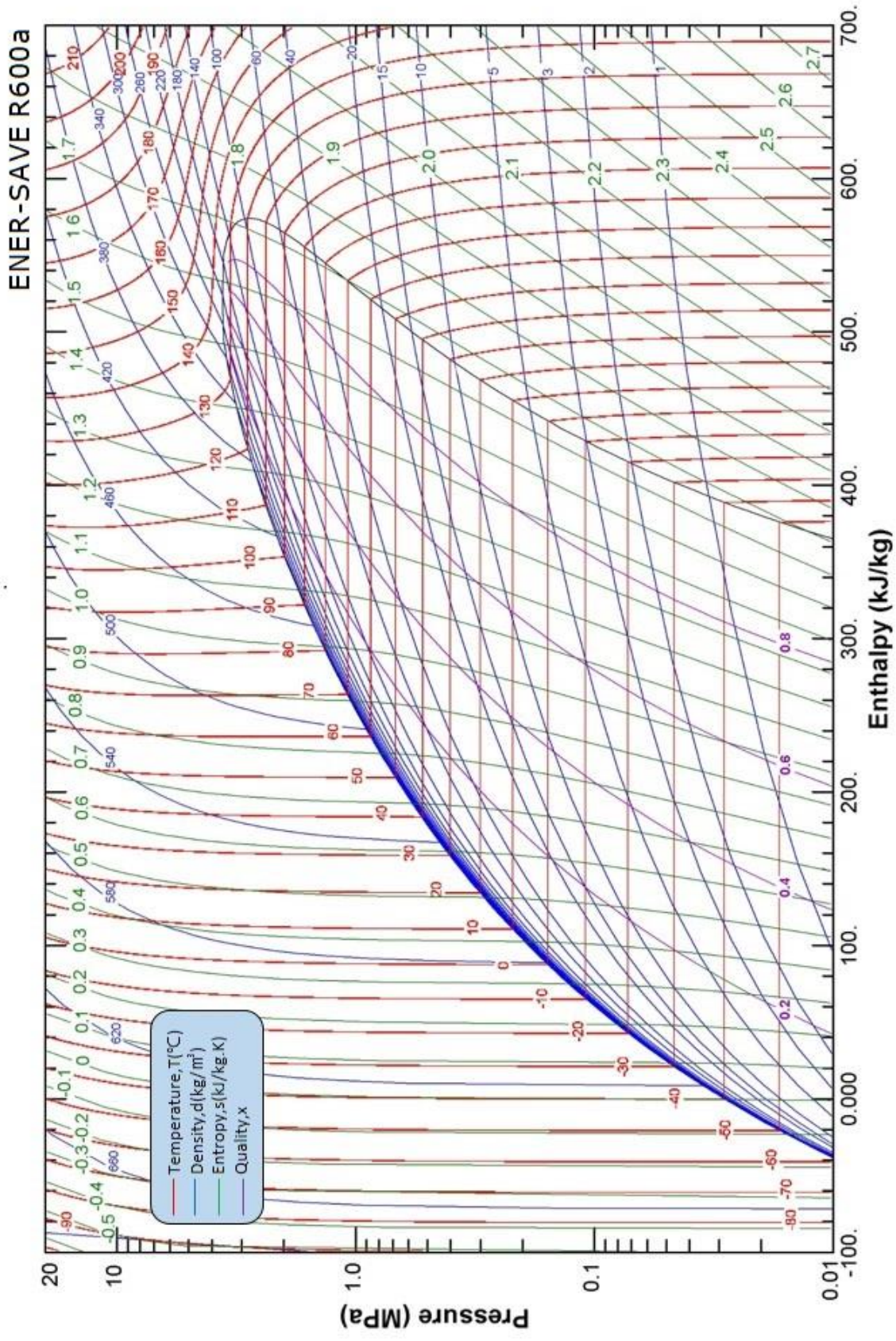
Storage of Hydrocarbon Refrigerant Cylinders

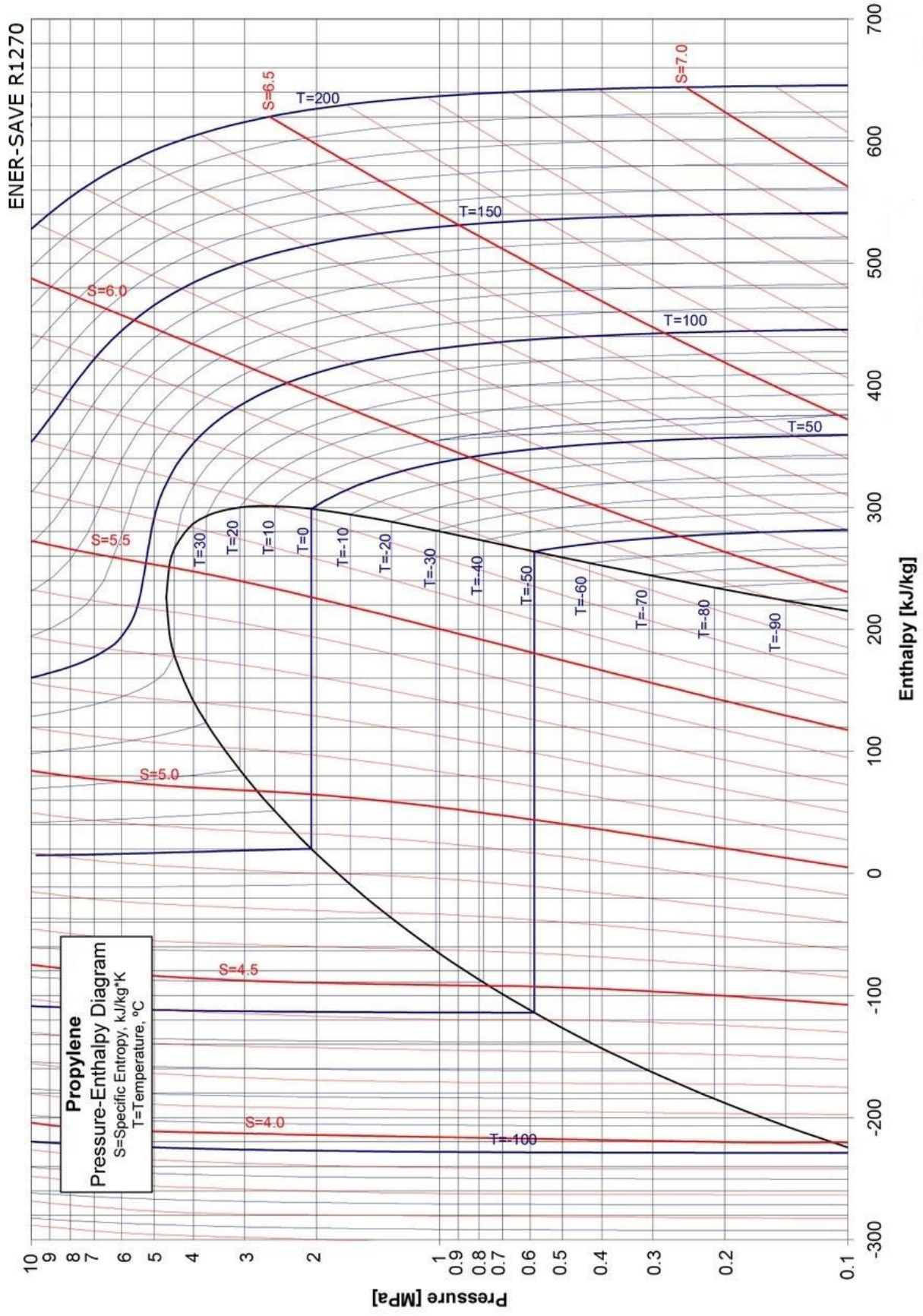
Cylinders should be stored in separate area from machinery room, preferably outdoor, otherwise in dry and ventilated place, away from fire risk, out of direct sunlight and away from ignition sources or other combustible or oxidizer storages. Storage area shall be on ground level and shall not be in basement. Storage area should be marked with no smoking, no naked flames signage and only allow authorized personnel to enter.

Consult the Malaysian Standard MS 2678:2017 for the complete set of requirements

Figure 8: Signage required for Hydrocarbon Machinery Room and Storage room.


ENER-SAVE R290
Temperature,T(°C)
Density,d(kg/m³)
Entropy,s(kJ/kg.K)
Quality,x
Pressure (MPa)
Enthalpy (kJ/kg)
20.0
10.0
1.00
0.10
0.01
0.000
200.
400.
600.


ENER-SAVE R600a
Enthalpy (kJ/kg)
Pressure (MPa)
Temperature,T(°C)
Density,d(kg/m³)
Entropy,s(kJ/kg.K)
Quality,x


ENER-SAVE R1270
Propylene
Pressure-Enthalpy Diagram
S=Specific Entropy, kJ/kg*K
T=Temperature, °C
Pressure [MPa]
Enthalpy [kJ/kg]
S=4.0
S=4.5
S=5.0
S=5.5
S=6.0
S=6.5
S=7.0
T=200
T=150
T=100
T=50
T=30
T=20
T=10
T=0
T=-10
T=-20
T=-30
T=-40
T=-50
T=-60
T=-70
T=-80
T=-90
T=-100