



# HYDROCARBON REFRIGERANTS

THEIR USE IN LARGE CHILLERS



The Energy Resources Group and Nat-Energy Resources identified many years ago the very real potential for Natural Refrigerants, and in particular Hydrocarbon.

At the beginning, we faced these major problems

- ▣ Distribution
- ▣ Availability
- ▣ Quality
- ▣ Training
- ▣ Fluorocarbon propaganda



## Training

While the use of HC refrigerants is very similar to other types of refrigerants, there are a couple of additional items that the technicians need to be aware of. To a degree, it is not additional training but more of a reminder of the correct way of doing things that was taught when they were learning their trade or skills. We educate technicians about the “bad habits” and shortcuts that they have picked up over the years.

The training ensures when converting to Natural Refrigerants that the quality taught will be reflecting the best results for the environment and energy saving. In the refrigeration industry many technicians have adopted improper procedures particularly in dealing with Hydrocarbon refrigerants. The technician needs to fully understand the characteristics of hydrocarbon and he cannot cut corners or do sub standard procedures he must follow ERG conversion systems which comply to International standards.



## Conversions of Large Chillers Using Hydrocarbon Refrigerant

Over the past eight years, the Energy Resources Group in association with key partners in Asia, especially Nat-Energy Resources of Singapore, have developed a program to offer companies the opportunity to reduce or eliminate their reliance on ozone depleting or high GWP chemical refrigerants and reduce their refrigeration or air-conditioning operating costs.



Conversions generally follow the same procedure:

- ▣ Introduction
- ▣ Equipment survey and report
- ▣ Safety audit
- ▣ Pre retrofit repairs and servicing
- ▣ Pre retrofit system and energy consumption monitoring
- ▣ Fitting of safety devices
- ▣ System conversion
- ▣ Post retrofit system and energy consumption monitoring
- ▣ Conversion report
- ▣ Regular service and maintenance – unless client opts for in-house personnel to be trained



Most projects have come by references or website enquiries from organisations looking for green solutions in line with ISO 1401 certification requirements or from energy savings solution providers looking for partnerships.

There has, and always will be some projects, sites or chillers that are not suitable for conversion to hydrocarbon refrigerant. This could be due to reasons like location, serviceability etc. and is the reason why a full survey and a safety audit must be carried out.



## Case Studies

Project	Far East Square – Singapore
Client	China Classic Pte Ltd (Subsidiary of Far East Organisation)
Project Management	Nat-Energy Resources – Singapore
Project Date	1 <sup>st</sup> April 2005
Equipment Make/Model/Size	York Air-Cooled Chillers, Model: YDAJ98MU7-50PA, Capacity: 200tr x 5



## **General information**

After conversion, these 8 year-old chillers saw an achievement of 16.1% savings in energy consumption, as well as a drop of 12.2% in total current (amps) consumed. Cooling efficiency improved by 16.88%.

## **Equipment survey and report**

A standard inspection on the system was carried out and reports were submitted to client. In case of leaks or defects, appropriate action should be taken.





## **Safety Audit**

As these chillers were on the open rooftop, leak detectors were not required. An officer from Singapore Civil Defence Force (SCDF) inspected the site after conversion and gave an official approval, which was submitted to the National Environment Agency's (NEA).

We carry out safety survey to ensure that there is adequate ventilation, no exposed electrical or fire source nearby, no smoking signs, proper control of access by public. Seal all electrical components and panel. Please refer to attached Pre-conversion Safety Audit report for detail.



### **Pre retrofit repairs and servicing.**

Leaks were detected and repaired before the conversion. Monthly routine checks are carried out. Only normal servicing is required.

### **Pre retrofit system and energy Consumption monitoring:**

Install kWh and run-hour meter to capture and determine Pre & Post HC conversions data.

Monitoring Devices Installation Date: 19<sup>th</sup> February 2005

Pre-conversion Monitoring Period: 19<sup>th</sup> February 2005 – 8<sup>th</sup> March 2005

Baseline kW per hour consumption: 193.82 kW per hour (2 compressors)

Cooling Performance: LCWT = 7.7 Deg C, ECWT = 10.1 Deg C



### **Fitting of safety devices:**

Gas leak sensors are only required when concentration of air for HC in an enclosed area falls into the flammability window between 1.9% and 10%.

These sensors will be connected to the ventilation fans and an alarm that will be triggered once a leak is detected.

In such a case, clear warning labels such as, “**Chiller Refrigerant is Flammable**” and “**No Smoking**” signs should be prominently displayed.

In addition, a safety talk should be given to engineers and contractors in charge of the chillers. In the case of Far East Square, it was not necessary to install leak sensors.



### **Recover existing refrigerant**

Existing refrigerant in the system was recovered and stored in dedicated recovery cylinders. Amount of refrigerant was weighed to ascertain current refrigerant charge.

### **Replace spare parts where necessary**

Pre-conversion servicing was carried out i.e. filters, driers or valve cores were replaced where necessary. Leaks were repaired; oil quantity and quality were checked and replaced if necessary. The system was flushed with nitrogen in order to ensure the removal of any residue substance.



### **Vacuum/leak test system**

The system was vacuumed overnight. After this was completed, a tight vacuum was held for 30 minutes to test for leakages on the system.

### **Charging of Hydrocarbon**

The original gas charge/weight was determined by documents or nameplates provided by the manufacturer or from the quantity of recovered gas.

With this knowledge of the original charge, divide the number by three, then take 90% of the resulting number. For example, if the original R22 charge was 10 kg, the calculation would be  $10 \text{ kg} \div 3 = 3.3 \text{ kg} \times 0.90 (90\%) = 2.97 \text{ kg}$ .



### **Post retrofit system and energy consumption monitoring**

Kw/h and run-hour meters were installed to monitor the monthly energy consumption. These readings were recorded monthly for billing purposes.

Example:

HC Conversion date: 28<sup>th</sup> March 2005 – 30<sup>th</sup> March 2005

Post-Conversion Monitoring Period: 1<sup>st</sup> April 2005 – 11<sup>th</sup> April 2006

kW per hour consumption: 162.64 kW per hour (2 compressor)

Cooling Performance: LCWT = 6.4 deg C, ECWT = 11.2 deg C

Savings Achieved: 31.18 kW per hour or 16.10%











## COSTS

*For some customers there are no up-front cost, and the project is funding by us taking a % of the proven savings for a fixed period.*

*Other customers prefer to pay up front, and this will normally work out to approximately the total savings for 12 months.*

*So return on investment ranges from 1 day to 1 year.*



## EXAMPLES OF CHILLERS/UNITS THAT CANNOT OR SHOULD NOT BE CONVERTED

- Basement units with no option to ventilate
- Poorly maintained units with existing major problems
- Units adjacent to ignition sources that cannot be isolated<sup>1</sup>
- Large units where the public have access

<sup>1</sup>Gas /Oil fired burners – Old / Faulty Electrical Panels



Energy Resources Group

## SINGAPORE CIVIL DEFENCE FORCE

HQ SINGAPORE CIVIL DEFENCE FORCE  
91 Ubi Avenue 4 Singapore 408827  
Website: <http://www.scdf.gov.sg>



Please quote our ref. no. in all future correspondence

Our Ref: CD/FSSD/12/01/23/01 Vol 10

DID: 68481454  
FAX: 68481489

11 May 2005

Nat Energy Resources Pte Ltd  
5 Shenton Way, #27-08  
UIC Building  
Singapore 068808

Dear Sirs

### HYDROCARBON AS REFRIGERANT

We refer to the joint site inspection between your Ms Helen Yauw and our Lta Tan Chung Yee and Mr Chan Hong Meng on 11 Apr 2005 at Far East Square regarding the above mentioned caption.

Please be informed that we have no objection to the use of hydrocarbon as refrigerant of air-conditioning system, subject to the following conditions:

1. Chiller with the use of the hydrocarbon refrigerant shall be located at the space/area opens to sky (such as open roof); and
2. Caution notice depicting "Chiller Refrigerant is Flammable gas" with a caution label complies with SS 286 shall be provided. The letterings should be in red colour and height not less than 50mm. Back ground of the notice should be in white colour. These warning signs should be located at the conspicuous space such as on the control panel, or entry point to the chiller.

Yours faithfully,

Chan Hong Meng  
for Commissioner  
Singapore Civil Defence Force

cc NEA  
Attn: Mr Tan Kok Kwang

A PROUD MEMBER OF THE HOME





<b>Data Recording</b>						
<b>Description</b>	<b>Parameter Before</b>		<b>Parameter After</b>		<b>% Saving</b>	
Start Date of Data Recording						
End Date of Data Recording						
Entering Chilled Water Temperature, deg C ( ECWT )	10.1		11.2			
Leaving Chilled Water Temperature, deg C ( LCWT )	7.7		6.4			
Delta T	2.4		4.8			
Average Current, Comp 1 ( Amp )	202.2		178.8			
Average Current, Comp 2 ( Amp )	167.1		145.6			
Total Current ( Amp )	369.3		324.4			12.2%
Low / High Pressure, Comp 1 ( Psi )	59	251	52	221		
Low / High Pressure, Comp 2 ( Psi )	65	237	53	208		
Starting kW-hr Meter ( Comp 1 & Comp 2 )	343,230		479,260			
Ending kW-hr Meter ( Comp 1 & Comp 2 )	397,900		499,920			
Total kW-hr Consumed	54,670		20,660			
Starting Running-Hr Meter Reading ( Comp 1 / Comp 2 )	2,439.48	2,439.39	3,153.76	3,121.18		
Ending Running-Hr Meter Reading ( Comp 1 / Comp 2 )	2,726.83	2,716.15	3,281.08	3,247.92		
Average Running Hour	282.06		127.03			
Average Power ( kW per Hour )	193.83		162.64		16.1%	



## TRACK RECORD

Conversions carried out successfully by us and our associate companies across Asia:

### **Singapore**

- Far East Square Shopping Mall using York 200TR Water-cooled Recip Chiller recorded 16% savings.
- Defence Science & Technology Agency using Carrier 1hp Air-cooled split unit recorded 16% savings.
- Dapenso Building using Carrier 21TR Water-cooled Packaged Unit recorded 32% savings.
- Watson's Stores using Daikin Air-cooled Split Unit recorded 24% savings.
- The Moomba Restaurant, Boat Quay using McQuay 8hp Air-cooled split unit recorded 16% savings



## TRACK RECORD

### Malaysia

- 7-eleven Stores Kuala Lumpur, Topaire Air-cooled Split Unit recorded 24% savings.
- Flairis Kota Tinggi, Water-cooled Packaged Unit recorded 19% savings.
- Nichicon Bangi, Topaire Water-cooled Packaged Unit recorded 20% savings.
- Sumiden Electronics Shah Alam, Topaire Air-cooled Split Unit recorded 22% savings.
- Hosiden Electronics Bangi, Air-cooled Split Unit recorded 25% savings
- Alps Electric Nilai, Dunham-Bush Water-cooled Packaged Unit recorded 17% savings
- Panasonic AVC Network Shah Alam, Air-cooled Split Unit recorded 19% savings
- Venture Tebrau I Johor, Dunham-Bush 65TR Water-cooled Packaged recorded 47% savings.
- Panasonic Communication Senai Johor, National 20hp Water-cooled Packaged recorded 20% savings.
- Celestica Electronics Tampoi Johor, Topaires 3 x 80TR Water-cooled Packaged recorded 24% savings.
- Menara Ansar Johor, Carrier 23TR Water-cooled Packaged recorded 13% savings.
- Bangunan PharmaCARE KL, Topaires 26TR Air-cooled Packaged recorded 23% savings.
- Sumitomo Electronics Tebrau II Johor, York 32TR Water-cooled Packaged recorded 21% savings.
- Taiko Electronics Senai Johor, York 21TR Water-cooled Packaged recorded 20% savings.
- GG Circuits Industries Tampoi Johor, Carrier 35TR Water-cooled Packaged recorded 14% savings.
- YKJ Industries Kulai Johor, Acson 4TR Air-cooled Split Unit recorded 27% savings.
- Tru-Tech Electronics Ulu Tiram Johor, York 20TR Air-cooled Packaged recorded 19% Savings.
- Matsushita Electric Company Shah Alam, Carrier 35TR Water-cooled Packaged recorded 15% savings.
- Menara AmFinance KL, York 21TR Water-cooled Packaged recorded 16% savings.
- Li Tat Mfg Masai Johor, York 17TR Air-cooled Ducted Type Split Unit recorded 29% savings.
- OYL HQ (R&D Lab) where new 3TR split units recorded 27% savings.
- UiTM Shah Alam Campus using Hitachi screw chiller recorded 19.7% savings.
- Damansara Realty using Carrier 10TR Packaged units recorded 32% savings.
- Pantai Medical Centre Bangsar, York 80TR Heat Recovery Unit recorded 24% savings.
- Pantai Medical Centre Bangsar, York Air-cooled Chiller Packaged recorded 18% savings.
- Lam Wah Ee Hospital Penag, Carrier Water-cooled Packaged recorded 20% savings.
- Elecan SemiConductor Penang, Air-cooled Packaged recorded 14.8 % savings.
- Comfort Engineering Puchong, Carrier Air-cooled Packaged recorded 18.5% savings.
- Cekap Rea Johor, National Air-cooled Split Unit recorded 16.7% savings



## TRACK RECORD

### Thailand

- Carrier HQ Building using Carrier 150TR recip chiller recorded 14% savings.
- Two 7-11 stores using split unit and walk-in-freezer recorded 20% savings.

### Indonesia - Jakarta

- Alfamart 649 stores in Jakarta using air-cooled split units recorded 25% savings.
- ITC Mangga Dua using 208 tr Carrier recip chillers recorded 34.7% savings.
- JW Marriott Hotel using 132 tr York recip chillers recorded 25% savings.
- Supermal Karawaci using 60 tr Hitachi screw AHU recorded 30% savings.
- Mulia Hotel using Copematic 5 tr semi-hermetic comp recorded 13.3% savings.
- Sol Elite Marabella Hotel using 1.5 tr Sanyo split unit recorded 24.4% savings.
- Maspion Plaza using 150 tr York recip chiller recorded 15% savings.
- Kondominium Simpruk Teras using 10 tr Fair pkg unit recorded 22% savings.
- Mal Kelapa Gading using 200 tr Carrier recip chillers recorded 28% savings.
- Darmawangsa Square using 2 tr General split unit recorded 24% savings.
- Siloam Gleneagles Hospital using 1 tr Mitsubishi split unit recorded 45% savings.
- Yayasan Pendidikan Permai using 1 tr Gree split unit recorded 22% savings.





## TRACK RECORD

### **Indonesia - Bali**

- Maya Ubud Resort & Spa recorded 41% savings.
- Sahid Jaya Hotel recorded 51% savings.
- Ritz Carlton Hotel recorded 28% savings.
- Kartika Plaza Beach Hotel recorded 55% savings

### **Indonesia - Lombok**

- Sahid Jaya Hotel recorded 72% savings.
- Oberoi Hotel recorded 18% savings.
- Novotel Hotel recorded 39% savings.
- Lombok Raya Hotel recorded 27% savings.
- Sheraton Senggigi Hotel recorded 53% savings.
- Senggigi Beach Hotel recorded 36% savings.
- Jayakarta Hotel recorded 25% savings.
- Intan Lombok Hotel recorded 21% savings.
- Holiday Inn Hotel recorded 20% savings





## TRACK RECORD

### Philippines

- Gaisano Country Mall - 50tr Hitachi Screw Type Compressor - 16%
- Park Square One (Ayala Mall) - 7.5tr Frascold Semi - Hermetic Reciprocating Compressor - 12%
- Delsa Chemicals Office - 5tr Maneurop Hermetic Reciprocating Compressor - 14%
- McDonalds Restaurant - 7.5tr Maneurop Scroll Type Compressor - 12%
- Legenda Hotel - 2tr Matsushita Rotary Type Compressor - 19%
- Federal Express (Fedex) - 7tr Copeland Hermetic Reciprocating Compressor - 21%
- Iglesia ni Cristo Church - 3tr Copeland Scroll Type Compressor - 15%
- INARP Research Inc. - 2tr Matsushita Rotary Compressor - 12%
- Building Care Corporation - 5tr Copeland Hermetic Reciprocating Compressor - 20%
- Mandarin Restaurant - 40tr Century Screw Type Compressor - 17%

# THE BUSINESS TIMES weekend

SINGAPORE 85 cents



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## A hundred new rooms on a fifth less energy

THE Changi Village Hotel was managed by Le Meridien up until 2001, when its owner, the Far East Organization, decided to take it back under active control and undertake a major revamp. In 2004, the hotel emerged with a hundred extra new rooms and a new, naturally-lit look.

The hotel took the chance to replace its old diesel boiler and chiller systems – which would not have kept up with the increased load – with “reverse refrigerant cycle” equipment that effectively produces hot water and cold air at the same time.

It thus improved energy intensity by 20 per cent to a current 372 KWh per square metre of gross floor area, according to Chia Swee Cheng, assistant director of the Central Engineering & Operations Department at Far East.

The chiller system now uses no more than 0.7 KWh

of electricity per tonne of chilled water, a vast improvement over the 1.2 KWh/tonne it used before. A significant part of the energy savings came from switching to hydrocar-

**‘Our corporate electricity bill across all properties in Singapore was \$33 million; imagine if we can cut that by 10%.’**

– *Chia Swee Cheng, assistant director of the Central Engineering & Operations Department at Far East*

bon-based refrigerants, said Mr Chia.

Hydrocarbons are naturally occurring gases that were used as early refrigerants in the 1930s but aban-

doned when found to be flammable. The industry switched to non-flammable fluorine gases, but had to find alternatives yet again when these were found to damage the ozone layer in

the 1970s. Unfortunately, these non-ozone depleting alternatives have been found to cause global warming, which has led the industry back to finding ways to safely use hydrocarbons.

Another improvement is a building management system to control the chiller system, which was previously manually operated.

However, since the re-

vamp in 2004, Changi Village has not attempted other energy efficiency initiatives, as it had planned to operate the hotel for a “testing period” of two to three years to observe the building’s performance, said Mr Chia. But he said it targets an energy intensity of 334 KWh/m<sup>2</sup> (a 10 per cent reduction) within three years.

Mr Chia’s department, formed in 2000, drives efficiency initiatives across the Far East group. “Our corporate electricity bill across all properties in Singapore was \$33 million; imagine if we can cut that by 10 per cent,” he said.

To this end, the hotel – and the group at a broader level – is looking to further improve chiller efficiency, such as by using a German “ball clearing system” that unclogs condenser tubes. It will also experiment with waterless flushing systems, or using NEWater for cooling purposes.

**Customer Data**

Customer Name : Central Square

**Air Conditioning System Data**

Pre-conversion Meter Installation Date : 7th April 2007

Baseline Monitoring Period : 7th April 2007 - 14th April 2007

Conversion Date : 14th April 2007

Post-conversion Monitoring Period : 14th April 2007 - 24th April 2007

Location : Level #03-14

Type : Air-Cooled Split Unit

Capacity : **40,000**

BTU

3.33

TR

**Existing Refrigerant : R22****Nat Energy Hydrocarbon Product : MINUS 50****Data Recording**

Description	Parameter Before		Parameter After		% Saving	
Start Date of Data Recording	7th April 2007		14th April 2007			
End Date of Data Recording	14th April 2007		24th April 2007			
Room Temperature	26.3		25.6			
On-Coil / Air Temperature IN	27.4		25.6			
Off-Coil / Air Temperature Out	15.7		14.8			
Current, Comp 1, Red ( Amp )	7.0		6.3			
Current, Comp 1, Yellow ( Amp )	5.8		5.0			
Current, Comp 1, Blue ( Amp )	5.5		5.0			
Average Current ( Amp )	<b>6.1</b>		<b>5.4</b>			<b>10.9%</b>
Low / High Pressure, Comp ( Psi )	57	267	58	230		
Total Power Consumed ( kW-hr )	<b>224.90</b>		<b>291.10</b>		<b>13.6%</b>	
Average Running Hour Recorded ( Run-hr )	<b>59.41</b>		<b>88.99</b>			
Average Power ( kW per Hour )	<b>3.79</b>		<b>3.27</b>			
kW/TR	<b>1.14</b>		<b>0.98</b>			
COP ( BTU/Hrs. )	<b>3.10</b>		<b>3.58</b>			
EER	<b>10.57</b>		<b>12.23</b>			



**Customer Data**

Customer Name : Regency House  
 Address : 121 Penang Road,  
 Singapore 238464.  
 Tel. : (65) 6737 8828  
 Fax. : (65) 6737 8834

**Air Conditioning System Data**

Pre-conversion Meter Installation Date : 20th July 2007  
 Baseline Monitoring Period : 20th July 2007 - 23rd July 2007  
 Conversion Date : 23rd July 2007  
 Post-conversion Monitoring Period : 31st Aug 2007 - 3rd Sept 2007  
 Location : Room 407  
 Brand : Carrier  
 Model : 38NSB 048  
 Type : Air-Cooled Split Unit  
 Serial No. : 0012399  
 Capacity : **48,000** BTU 4.00 TR  
 Existing Refrigerant : R22  
 Nat Energy Hydrocarbon Product : **MINUS 50**

**Data Recording**

Description	Parameter Before		Parameter After		% Saving
Start Date of Data Recording	20th July 2007		31st Aug 2007		
End Date of Data Recording	23rd July 2007		3rd Sept 2007		
Room Temperature	22.7		22.6		
On-Coil / Air Temperature IN	23.5		20.2		
Off-Coil / Air Temperature Out	8.0		6.4		
Current, Comp 1, Red ( Amp )	7.6		7.2		
Current, Comp 1, Yellow ( Amp )	7.4		7.1		
Current, Comp 1, Blue ( Amp )	7.8		8.1		
Average Current ( Amp )	<b>7.6</b>		<b>7.5</b>		<b>1.8%</b>
Low / High Pressure, Comp ( Psi )	72	215	67	220	
Total Power Consumed ( kW-hr )	<b>194.70</b>		<b>71.40</b>		
Average Running Hour Recorded ( Run-hr )	<b>70.46</b>		<b>36.18</b>		
Average Power ( kW per Hour )	<b>2.76</b>		<b>1.97</b>		<b>28.6%</b>
kW/TR	<b>0.69</b>		<b>0.49</b>		
COP ( BTU/Hrs. )	<b>5.09</b>		<b>7.13</b>		
EER	<b>17.37</b>		<b>24.32</b>		