Universidad Tecnológica de Panamá

HCR 410 Refrigerant Tests Report

AUGUST 2011

ecofreeze Natural Refrigerants

Client: BHCR Hq, Corp S.A.

Facility: UTP Administration Building

Address: Via Ricardo J. Alfaro, Panama, Rep. de Panamá

Date: July 2011

Reference: INF-CRT-01-11

2011/23

Unidad de Ahorro Energético
UNIVERSIDAD TECNOLÓGICA DE PANAMÁ

Study Information

Coordinator: Dr. Edilberto Hall

Measurements taken by: Ing. Cesar Jaramillo, with the assistance of Tec. Ref. Jose Mosquera (UTP Maintenance Dept.) and Ing. Jacob Adi (Eco Kold).

Report prepared by: Ing. Cesar Jaramillo

Reviewed by:

Dr. Edilberto Hall,

Ph.D. Ing. Italo

Petrocelli

Measurements taken at:

The Administration Building of Universidad Tecnológica de Panamá, located in the Panama District, Panama.

Report No.: INF-CRT-008-2011

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1. Introduction

Eco Kold refrigerant (HCR 410) was developed by BHCR Hq, Corp S.A. de C.V. It is noted for having greater energy performance than conventional refrigerants. HCR 410 is a zeotropic mixture of natural gases, therefore it is environmentally friendly, since it is harmless to the ozone layer and does not contribute to global warming.

Applications: Domestic and industrial refrigerant applications. Air conditioning.

Compatibility with lubricants: Eco Kold (HCR 410) natural refrigerant is compatible with the vast majority of lubricants, from natural to synthetic products.

Compatibility with polymers: The information available to date shows that HCR 410 demonstrates compatibility with plastics such as Kel-F, Teflon, Tefzel, Kynar and PVC, and with the elastomers Buna-N and Viton, however its use with materials such as polycarbonate, Kalrez, Neoprene and Polyurethane is subject to conditions since to date, sufficient information is not available to determine whether it is compatible and/or whether its compatibility is satisfactory. It is important to note that laboratory tests and field experience indicate that the HCR 410 refrigerant presents no compatibility issues with materials present in refrigeration equipment designed to work with R 410.

Figure 1. Air Conditioning Equipment

2. Objective

- To measure the efficiency of HCR 410 refrigerant in split-type air conditioning equipment in comparison to conventional R 410 refrigerant gas.
- To verify compatibility of the HCR 410 refrigerant in conventional equipment for R 410 refrigerant gas.
- To verify the electrical power consumption of air conditioning equipment using HCR 410 refrigerant gas in comparison to R 410 refrigerant gas.

3. Scope

Tests were conducted for the sole purpose of attaining the stated objectives, therefore electrical and mechanical measurements were only carried out in the air conditioning equipment compressor, since the refrigerant gas works directly with the compressor in a refrigeration system.

In addition, tests were conducted in a real environment where external environmental variables, services rendered by the office being studied and the number of persons entering and leaving were not controlled. In this manner, the refrigerants were able to be subjected to operation under actual day-to-day conditions.

The electrical tests conducted on the refrigerants will present the operating conditions and electrical power consumption of the air conditioning unit compressor.

7. Technical and Human Resources

7.1. Technical Resources

In order to carry out the study, the following equipment owned by UTP and Eco Kold de Panamá had to be used.

Specialized equipment:

- Vacuum pump and refrigerant gas recovery equipmen 
- CIRCUTOR AR-5 power quality analyzer  
- Three (3) CVM CIRCUTOR network analyzers
- Amprobe Model ACD31 Ammete 
- SONY DSC-W110 7.2 MP Digital Still Camer 
- Pressure Gauges and Refrigeration Hoses 

7.2. Human Resources

The study was carried out by UTP

personnel:

- Ing. Cesar Jaramillo
- Ing. Jacob Adi
- Jose Mosquera, Refrigeration Technician

The work was performed with the authorization of Eco Kold de Panamá, Universidad Tecnológica and in the presence of UTP maintenance/administration staff.

8. Applicable Documentation

- ✓US National Electrical Code (NEC), 2008 in force in Panama
- ✓ASHRAE Standard 37 2009

9. Facility Features

Tests will be conducted in an administrative office with a regular M-F schedule of 8:00 a.m. to 4:00 p.m. Occupancy is 3 people, three personal computers with printers, a paper shredder, a small radio and office furnishings. For lighting, it has four 2x4 flush mount ceiling light fixtures, 4x32 w.

The air conditioning equipment will work at 22°C and relative humidity of 53%.

Office dimensions: 3.90m x 4.80m x 2.4m.; the ceiling is a suspended ceiling with plaster panels.

Air Conditioning Equipment

The equipment to be tested is a Split-type air conditioning unit, described as follows:

- Brand: FLOW ECONOMY GOLD FINS
- Model: FECH-36FR
- Electric Supply: 220-230/60/1 phase
- Power Input: 3610W
- Current Input: 16.2 A
- Cooling Capacity: 36000 BTU/Hr.
- Refrigerant: R-22
- Refrigerant amount (basic installation): 2100g
- Max. HS operating pressure: 2.7 MPa
- Max. LS operating pressure: 0.7 MPa
- Compressor: Mitsubishi LHT53NBDC

10. Installation Conditions

In order to carry out the study measurements, a preliminary visit to the facilities was planned, prior to installation of the precision measurement equipment. Measurements were taken using a multimeter in order to verify voltage and current levels, and to determine the equipment conditions, in order to be able to adjust the measurement equipment.

The air conditioning equipment is currently supplied with power by a single phase 120/208 V power supply.

Measurements using R 410 Refrigerant Gas

Operating pressure levels: HS 95 psi, LS 52 psi.

External conditions: 35.8°C, 75%Rel. Humidity

Approx. quantity used: 6.5lbs

Measurements using HCR 410 Refrigerant Gas

Operating pressure levels: HS 75 psi, LS 52 psi.

External conditions: 35.8°C, 75%Relative Humidity

Approx. quantity used: 2.5lbs

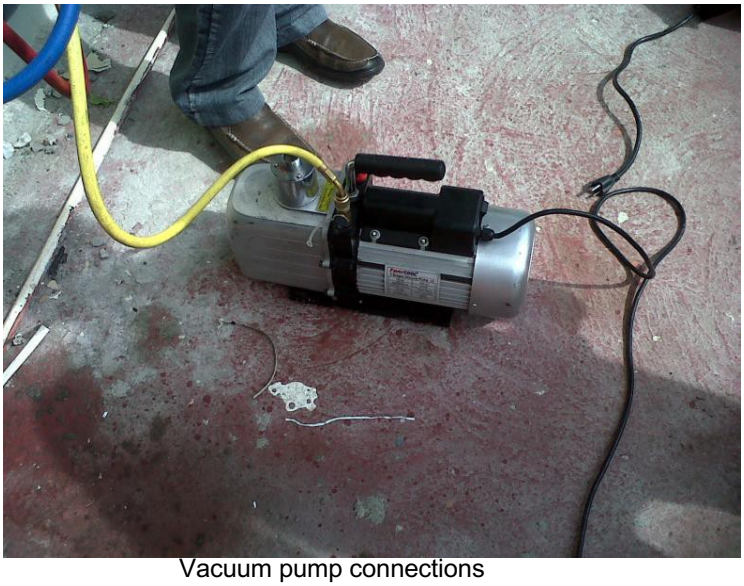
R 410 Refrigerant Gas Charging Procedure

In order to charge one or the other gas we must be sure which refrigerant gas is in the air conditioning equipment, since the gasses cannot or must not be mixed, so we will check the manufacturer's information plate to ensure that R 410 gas is being used. Before charging the refrigerant gas, a check was conducted to ensure that the entire installation is completed and sealed (all tubing nuts are correctly tightened), creating a vacuum and ensuring that no pressure level is restored after ½ to 1 hr. minimum. If we have a leak, it is not helpful to recharge gas and we are consciously venting contaminant gas into the atmosphere and it is harmful to the atmosphere.

VACUUM

We created a vacuum, a MANDATORY task for correct operation: We connected the low BLUE pressure gauge to the service valve and the YELLOW hose to the vacuum pump. We opened the pressure gauge shutoff valve, turned on the pump and started the vacuum which will last approximately 30 minutes. After this period, we will first close the shutoff valve (Blue) and then we will shut off the pump. We will wait at least 1 hr. to ensure that the circuit does not recover (pressure + 0 = leaks), WITHOUT the needle rising again to 0. If we can wait several more hours or all night, it is better. We will be sure that the circuit does not have even a miniscule leak. But since

we are using the same R 410 gas, we can partially recharge. It is not necessary to vent the remaining gas in order to recharge from a vacuum.



Vacuum pump connections

VACUUM PUMP DISCONNECT – GAS TANK CONNECTION

Once the vacuum is achieved and verified, we will disconnect the vacuum pump (air will enter through the YELLOW hose) due to the fact that there will be aspiration since there is a vacuum. We will connect the hose to the R 410 gas tank, tighten the hose to the tank, loosen the end of the YELLOW hose on the pressure gauge side, then we will slightly open the shutoff valve of the tank to very briefly purge the hose, approximately 2 sec. We will quickly thread the hose onto the pressure gauge, in order to not vent refrigerant GAS. We will already have the unit ready to start GAS charging, with the GAS tank in vertical position.

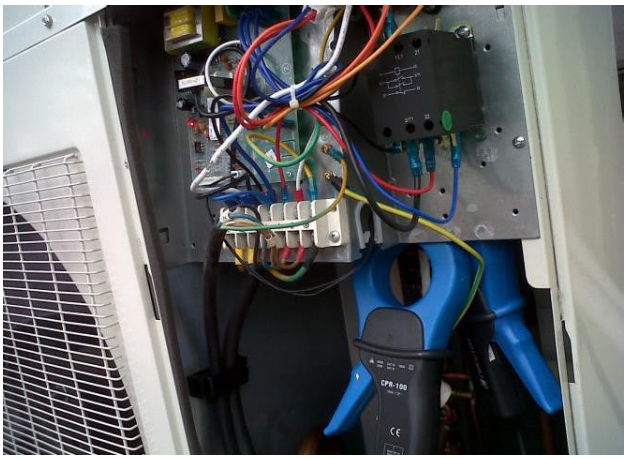
IMPORTANT

Gas charging into SPLIT-type residential equipment with R 410 is carried out the GASEOUS phase, NEVER IN LIQUID PHASE BY INVERTING THE TANK. We charge using the LOWER service connection, the only one available on low- and mid-range equipment.

STARTING R 410 GAS CHARGING

The R 410 gas must be charged in GASEOUS phase. In this case, it is much more complicated to use a scale, therefore we will charge the gas by checking the three basic parameters—the pressure gauge, current clamp and thermometer; we then remotely start up the equipment to be charged and after approximately 30 seconds, we release bursts of GAS, the first of which may be 2 minutes or more, since the circuit is empty, we close the shutoff valve, and we wait for 30 to 40 seconds for

the compressor to balance out the pressure and circulating gas through the circuit. Then we release another burst of GAS for approximately 15 seconds and we wait, and we continue in a similar manner.




REVIEW OF THE CHARGING PHASE

In this case, since we are charging a GAS, we do not run the risk of damaging the compressor, as is the case when we are using liquid with HCR 410. As the circuit is being loaded, the pressure gauge will indicate the increase in pressure, the ammeter will show an increase in amperage, and the thermometer will show a decrease in temperature. As we approach the correct load, the GAS must be spread out over time and the duration shortened, to 3 sec., for example, allowing several minutes to pass for the compressor to normalize pressure throughout the circuit. It is preferable to keep it short, rather than exceeding the charge, and IT IS VERY IMPORTANT TO NOT EXCEED THE AMPERAGE MARKED ON THE MACHINE PROPERTIES FOR COOLING OPERATION. If we overcharge, the thermal gap starts to be reduced, and the equipment starts to work harder (consuming higher amperage) and cools less, therefore part of the gas must be purged.

Once the correct thermal gap is achieved, an approximately 16° difference between the discharge temperature and the intake temperature, ALWAYS GREATER THAN 12°.
29º In - 13º Out = 16º Thermal gap OK

On the pressure gauge, looking at the R 410 temperature scale, we see that it is evaporating between 0° and 3° to 5°, corresponding to approximately 4 to 4.75 bar. The amperage consumed by the compressor will have been increasing, since it was already at or very near to the rated amperage of the equipment. We should not charge more GAS, we leave the machine running for a half hour, to see if it remains stable. To disconnect the hose, we close the pressure gauge shutoff valve, we close the tank shutoff valve, we disconnect the Yellow hose from the tank, some gas will escape, and we quickly disconnect the Blue hose from the service valve, so that as little gas as possible is lost.

FINISHING AND DISCONNECTION

We disconnect the ammeter clip, install the cabling cover and we install and correctly tighten the service valve cap since frequently there is a small gas leak at that point. We install the Armaflex cover that protects the valves, to avoid condensation.

Then we install the measurement equipment for test days for the R 410 refrigerant gas.

Once R 410 gas measurement days are completed, we continue with the HCR 410 refrigerant gas.

USING THE REFRIGERANT GAS RECOVERY SYSTEM

When extracting the R 410 refrigerant gas, since it is a gas that is harmful to the ozone layer, we must store it in a container. We use the refrigerant gas recovery system for this purpose.

The procedure is the same as for the vacuum pump, except that it is vented into the gas container.

HCR 410 Refrigerant Gas Charging Procedure

The charging of HCR 410 refrigerant gas entails the same steps as seen previously for the R 410 gas, with the fundamental difference that the charging is carried out in LIQUID PHASE, NEVER IN GASEOUS PHASE, THEREFORE THE TANK MUST BE INVERTED.

Measurements are then conducted for the HCR 410 refrigerant gas.

IMPORTANT
Risk Condition:
Due to the fact that this fluid may form inflammable mixtures with the air in ranges of 2-9% by volume, ensure the correct handling and safety of the product. **Consult the manufacturer or an authorized distributor in order to obtain all the regulatory parameters for completely safe use of the product.** The container may break due heat from fire. Do not turn off flames due to the risk of reignition. This product forms vapors that may travel or be transported by air currents and ignited by pilot lights or other flames, cigarettes, sparks, heaters, electrical equipment, static discharges or other ignition sources at sites distant from the area where the product is handled. Due to the fact that inflammable atmospheres may form and remain after a spill, before entering the area, in particular in enclosed areas, check the atmosphere with an approved device. No part of the container may be subjected to temperatures greater than 52ºC (125ºF). The majority of containers have a pressure relief device when they are exposed to elevated temperatures.
Combustion of this product produces CO2.
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11. Analysis of Measurements using R 410 Refrigerant

11.1 Compressor Voltage

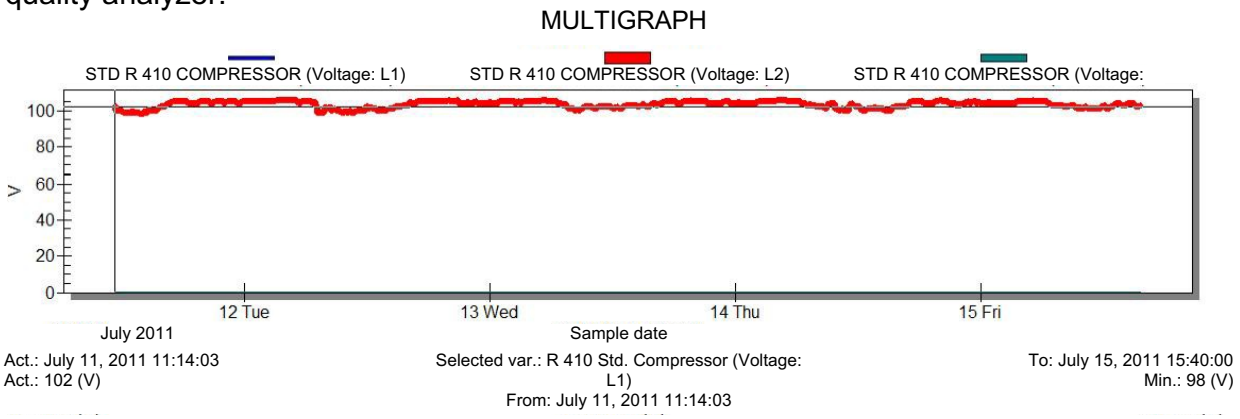
It is vitally important to determine the voltage (tension) levels of electrical equipment in order to reveal the quality of the power supplied by the distribution company.
Table 1 shows the most representative values for the entire measurement sample.

Table 1. Representative measurement values for the AA equipment intake.

	Voltage
	Neutral
Min. voltage (V)	98
Max. voltage (V)	106
Average voltage (V)	100

The voltage values determined from the average measurements are line to neutral voltages, as is shown in **Graph 1**. The behavior of voltage varies greatly and maintains intermittent levels, due to the start-up and shutdown of equipment.

The measurements analyzed below were taken using the CIRCUTOR AR5 power quality analyzer.



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13 GRAPH 1

In Graph 1, we observe regular voltage behavior within the required level. The voltage levels established by ASEP per Resolution JD-764, Technical Service Quality Standards, for urban areas, must be kept within a voltage regulation range of ±5% of the nominal value.

The electrical system presents voltage variations, however this is due to several factors which may include transformer adjustment, power factor or others. For tests, it is within the tolerable operating range of the air conditioning equipment.

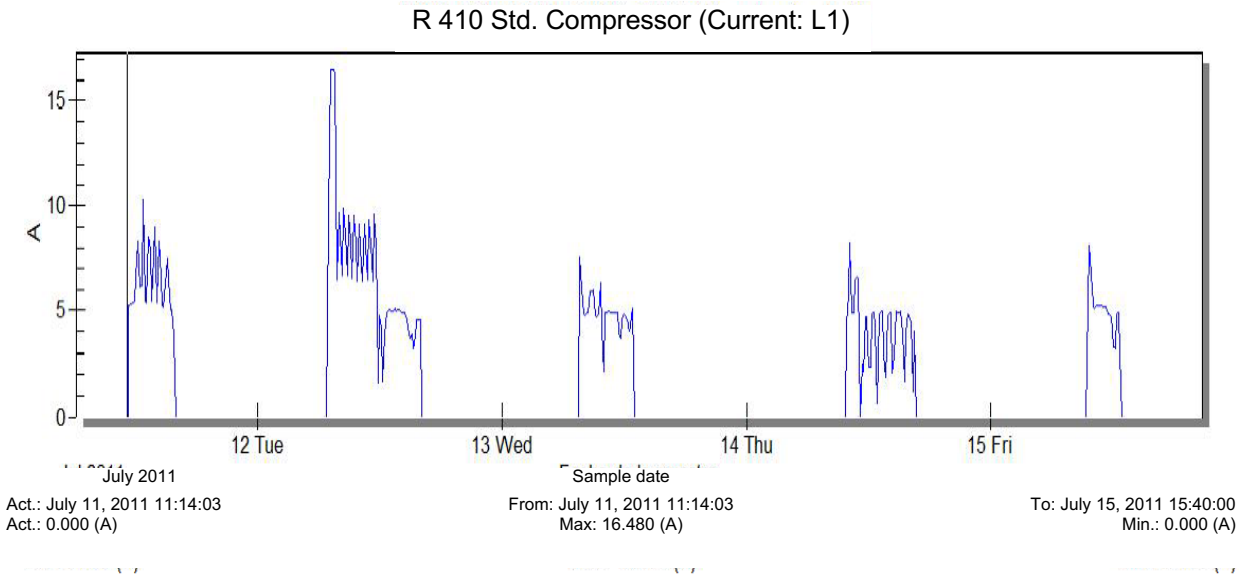
11.2 Amperage at the Compressor

Current levels show us the power consumption moments. Measurements taken yielded the values shown in Table 2:

Table 2. Representative amperage measurement values

	Amperage in each Phase (Amps)
Minimum Amperage (A)	0
Maximum Amperage (A)	16.48
Average Amperage (A)	6.44

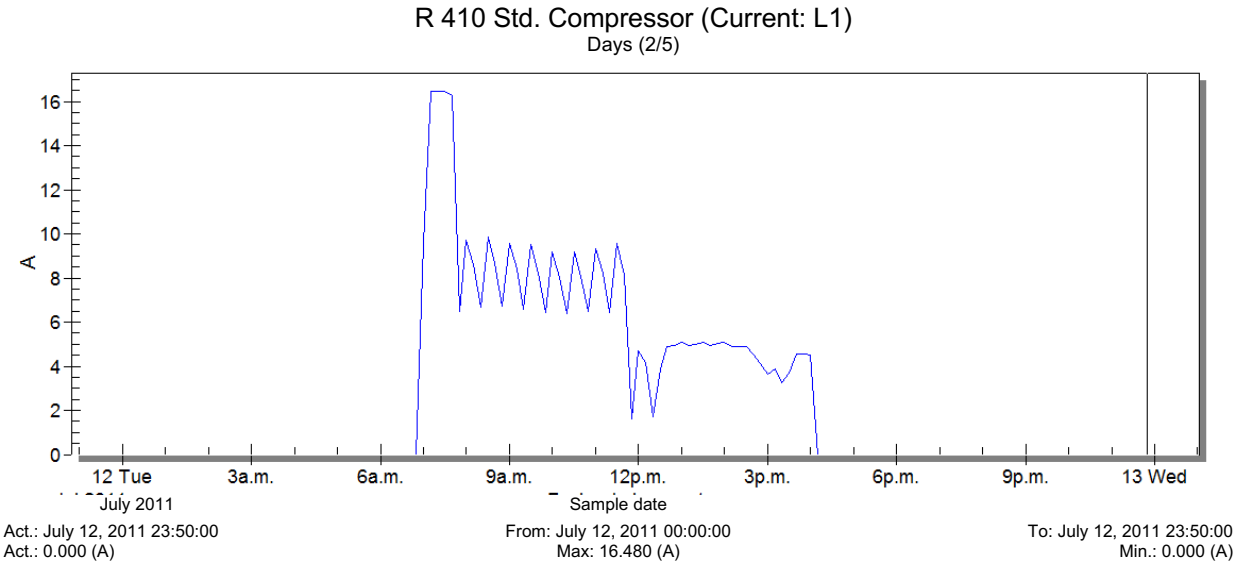
The measured values are shown in Graph 2, showing the amperage behavior during a full week. The demand amperage depends directly on the time of day and the day of the week, since during midday hours on weekdays the greatest amperage levels are shown, while Saturdays show no consumption.



The compressor current exhibits typical behavior in which it is high at startup and then decreases, seeking an equilibrium point. This is due to the fact that the compressor must initially increase the refrigerant gas pressure, and then it works to balance out the pressure throughout the system, and works at a lower effort level when the operating pressure level is reached.

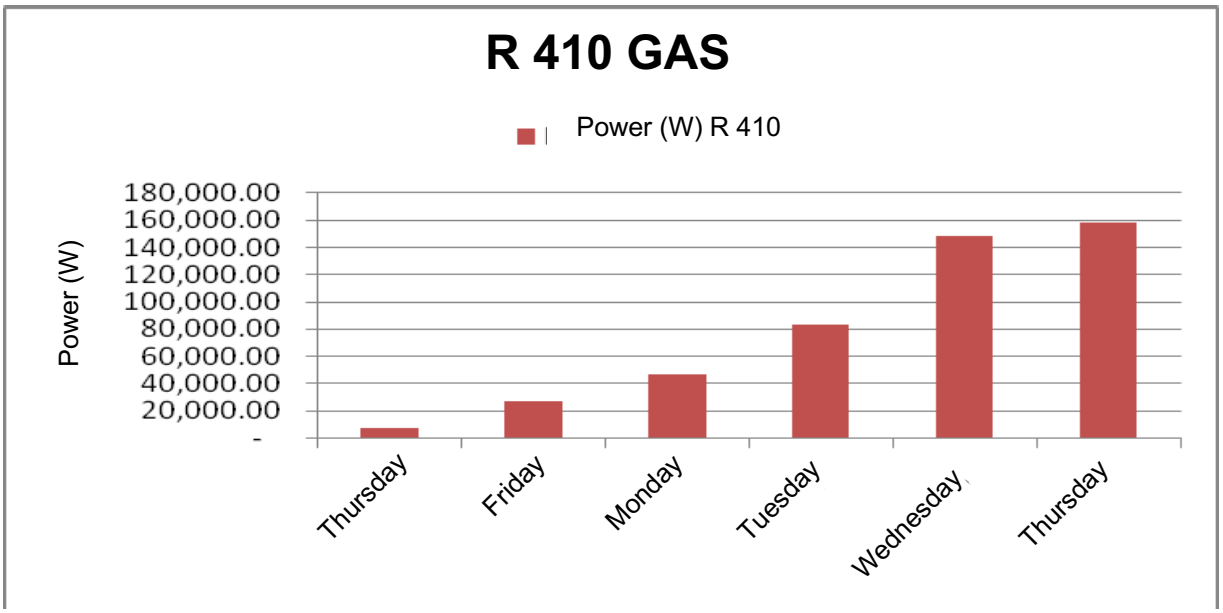
The startup amperage, the first is higher than other startup amperage values during the work day since the air conditioning was shut off for an extended period of time

(since the previous day). The remaining the startup amperage values seek out the operating pressure level, and therefore the adjusted temperature of the area.



It must be noted that the intake amperage specified by the manufacturer is 16.2 A an the most critical amperage during measurements was 16,480 A, therefore at times it approaches the current limit of the equipment. In addition, amperage spikes are kept constant for periods and then drop abruptly, i.e. the pressure levels are irregular.

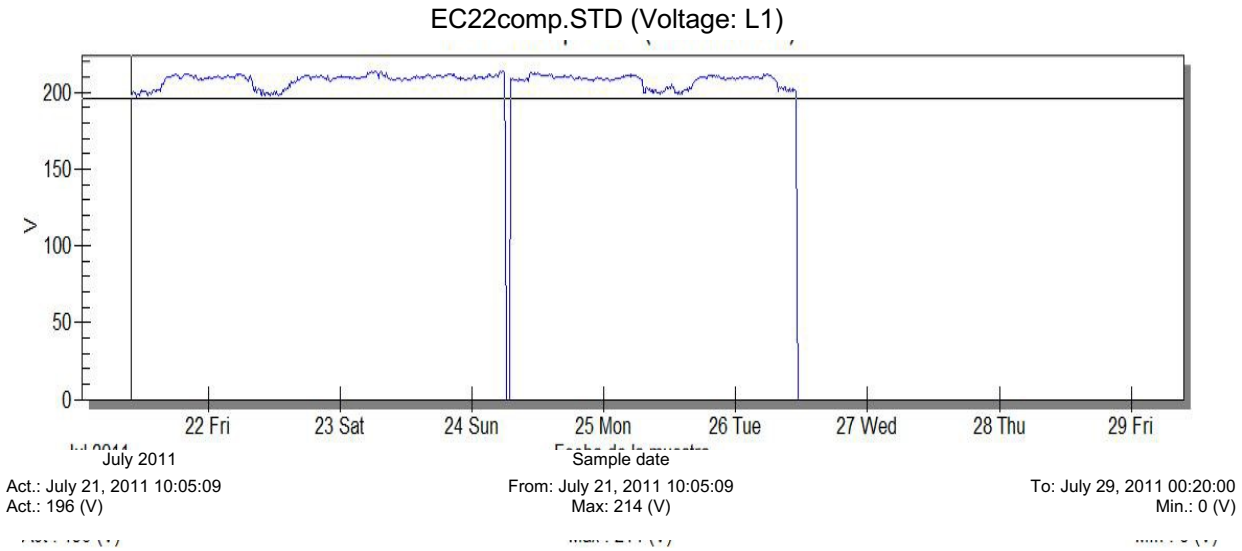
11.3 Power Consumed



The power consumed during the measurement days yielded a total of 158.61 kW and average consumption of 6.75 KWh.

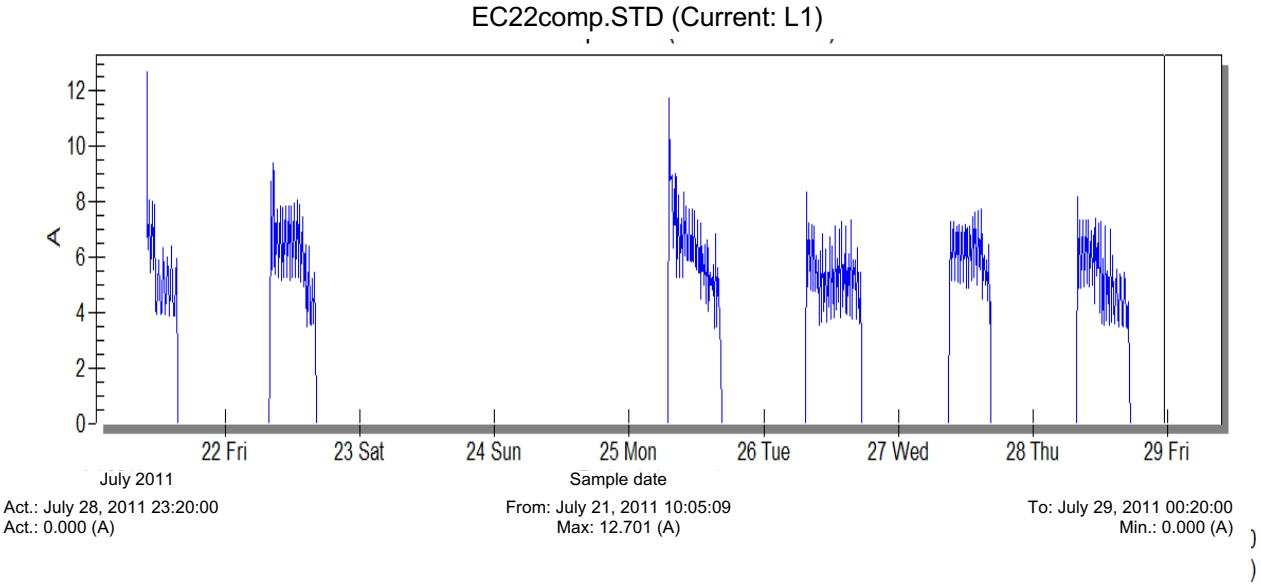
12. Analysis of R 410 Refrigerant Measurements

12.1 Compressor Voltage

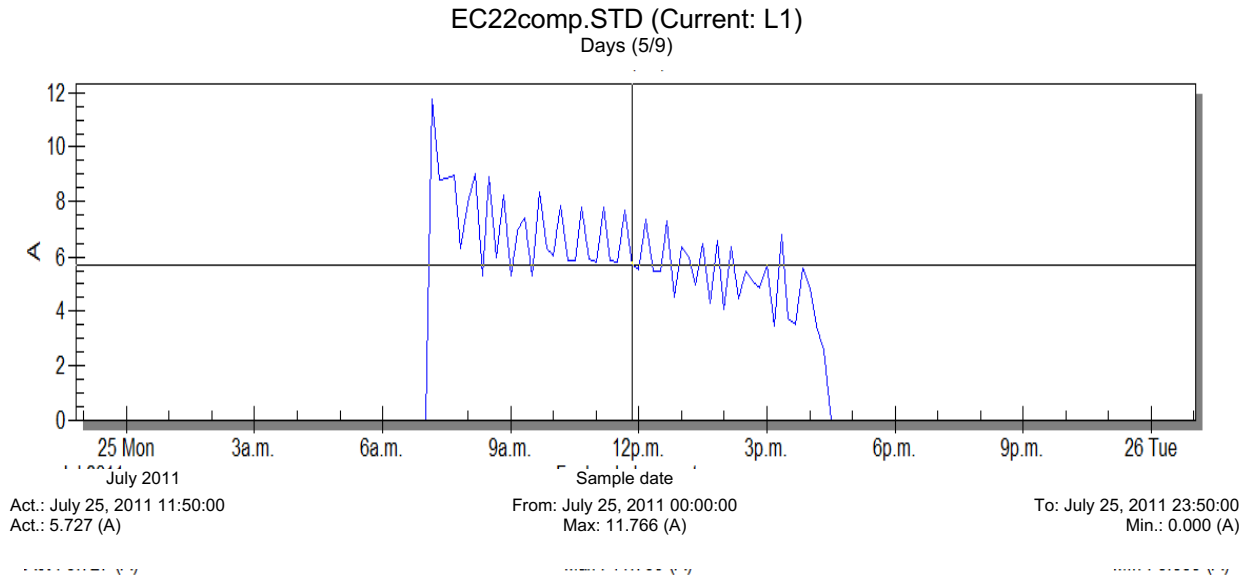


The electrical system supplying the compressor is the same, therefore we also measured the line to line voltage behavior. The drop in voltage during the weekend did not affect testing since the equipment was shut off.

12.2 Amperage at the Compressor

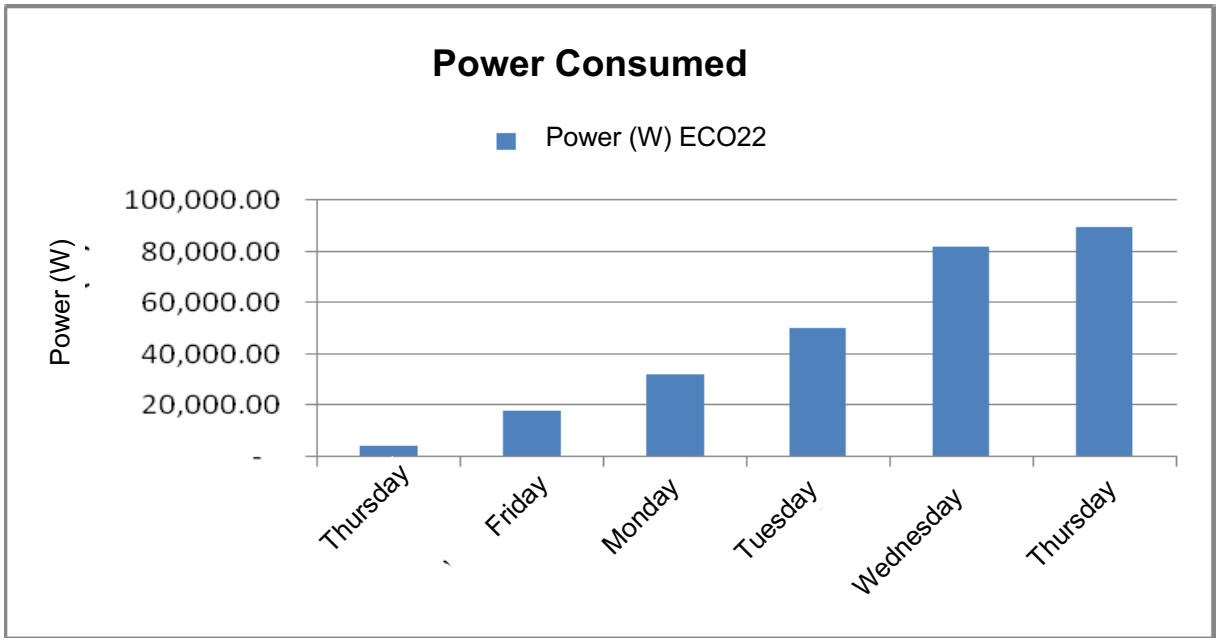


The compressor amperage exhibits typical behavior, with the difference that during measurements, the maximum critical amperage was 11,776, which is below the 16.2 A specified by the manufacturer. The amperage that is flagged when starting measurement is an error due to the initial contact by the measurement equipment with the cables.



The daily operating cycle for a compressor with HCR 410 refrigerant gas is more regular, since as the compressor balances the refrigerant gas pressure levels, it does so more gradually and with less abrupt current surges.

12.3 Power Consumed

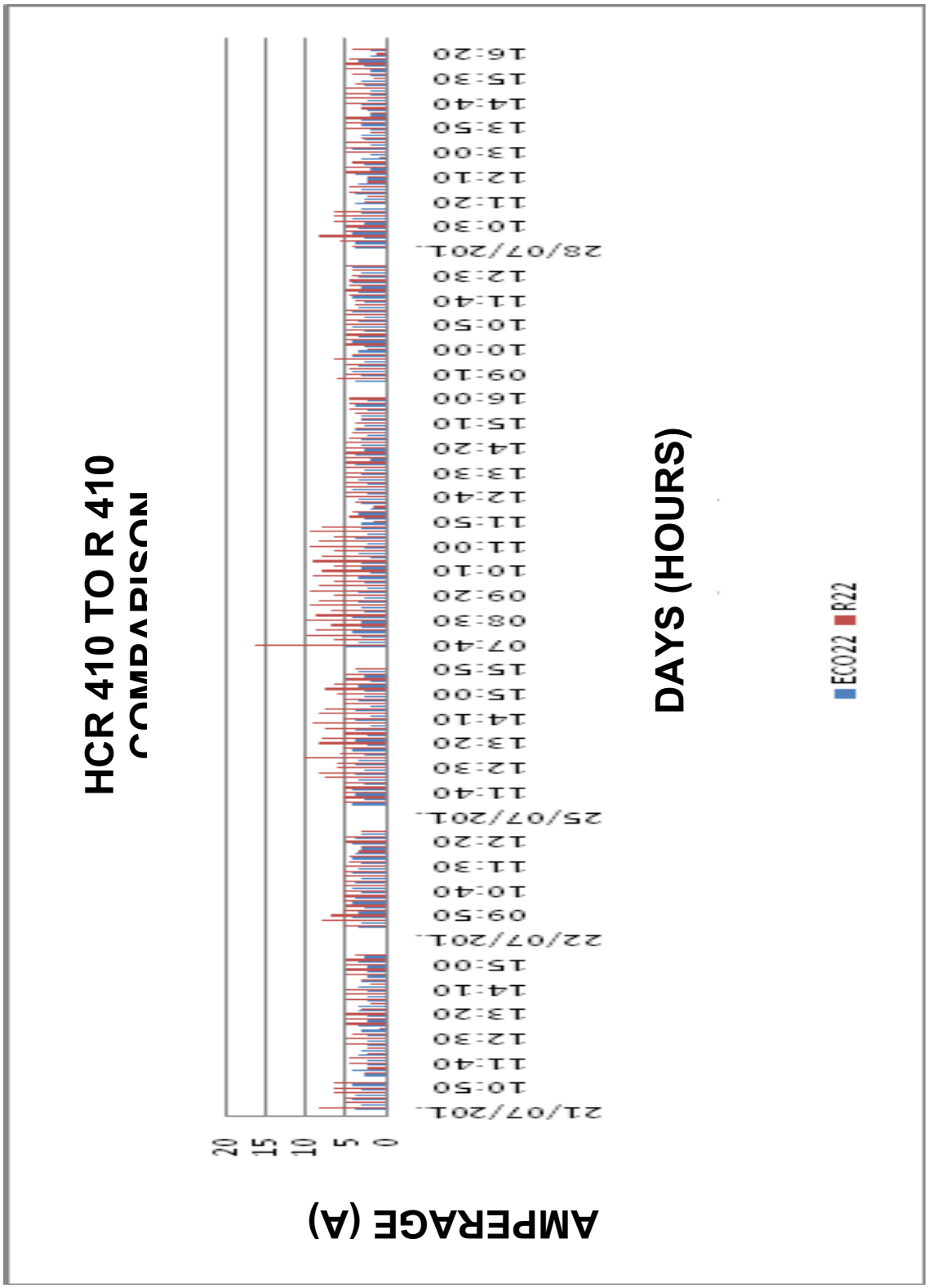


The power consumed on days when measurements were taken yielded a total of 89,319 kW and an average consumption of 3.8 KWh.

Comparison of HCR 410 and R 410 Refrigerant Gases

The comparison will be made using tests conducted on 36,000 BTU Split-type air conditioning equipment, based on the parameters measured in the unit compressor, using HCR 410 and R 410 refrigerant gases.

Compressor Amperage


HCR 410 TO R 410
DAYS (HOURS)
AMPERAGE (A)
ECO22
R22
20
15
10
5
0
21/07/201-
10:50
11:40
12:30
13:20
14:10
15:00
22/07/201-
09:50
10:40
11:30
12:20
25/07/201-
11:40
12:30
13:20
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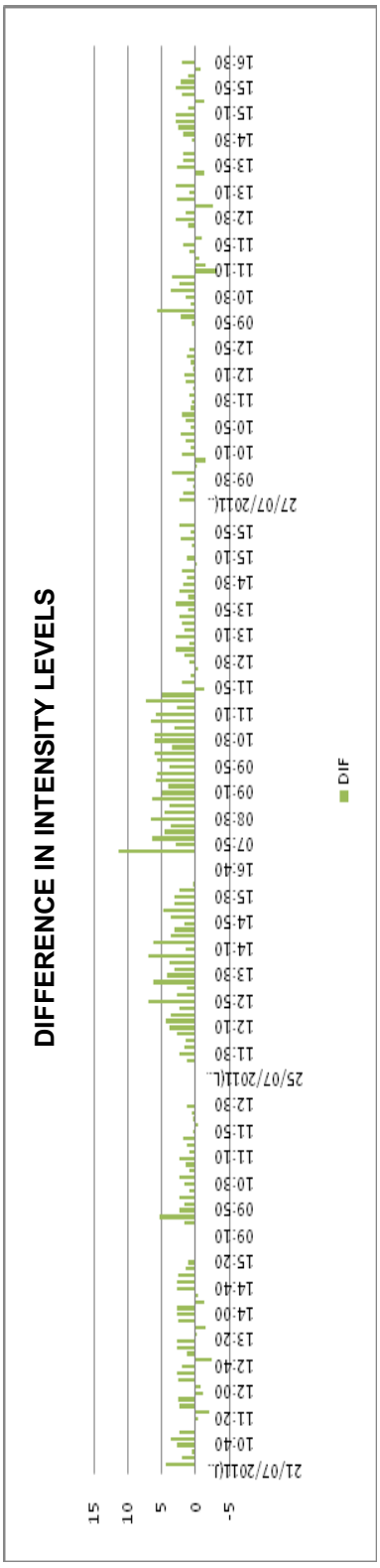
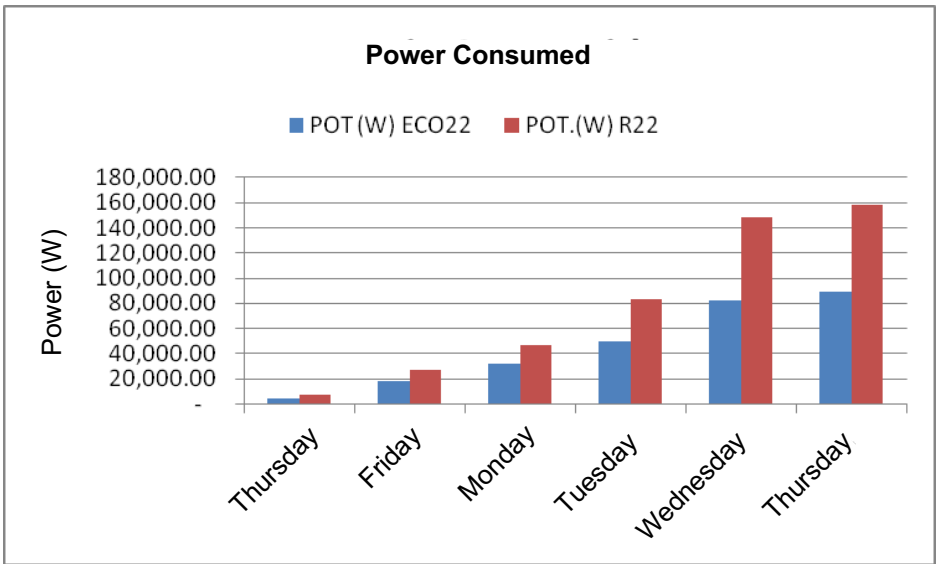
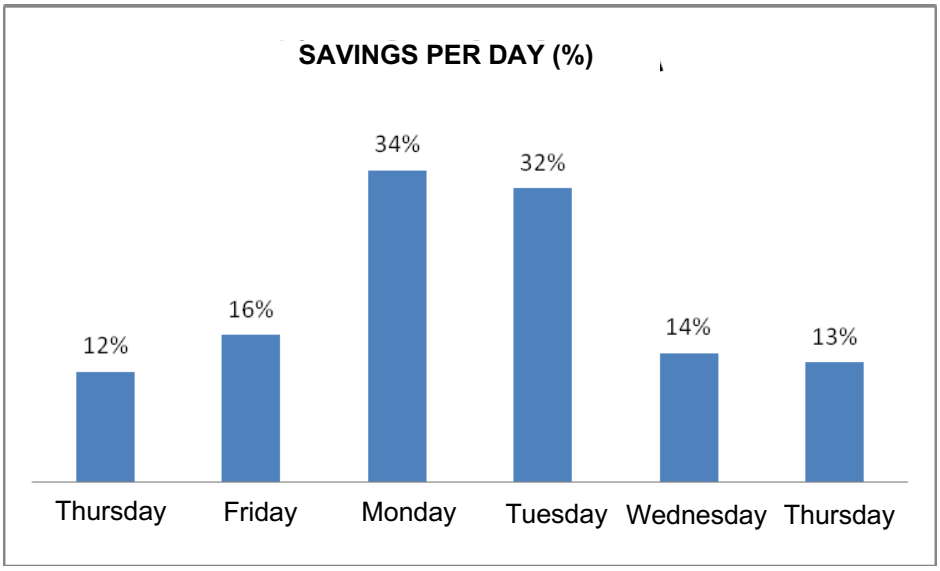

DIFFERENCE IN INTENSITY LEVELS
DIF
15
10
5
0
-5
21/07/2011(...
25/07/2011(...
27/07/2011(...



As days increased [sic], the comparative power consumption difference between HCR 410 refrigerant versus R 410 refrigerant increased..



Savings are proportional, since the greater the power consumption by the air conditioning equipment, the greater the difference in consumption for HCR 410 gas in comparison to R 410 gas. Measurements taken on Monday, i.e. the warmest day and the day with the highest thermal load, showed consumption that was 34% higher.

Inspection after Tests using the Refrigerant gases

The inspection consists of a survey of the service rendered during and after tests, with a technical review of the tested equipment.

All inspection results were satisfactory.

It must be noted that to date the equipment is in operation using HCR 410 gas and no damage or impact on service has been reported.

13. Findings

Operating pressure levels for the air conditioning equipment were high pressure (HS) of 95 psi and low pressure (LS) of 52 psi and 6.5 lbs. of gas for R 410 refrigerant gas, while for HCR 410 refrigerant gas levels were 75 psi high pressure (HS) and 52 psi low pressure (LS) and 2.5 lbs of gas.

The HCR 410 refrigerant works at lower operating pressure levels than the R 410 refrigerant. Therefore, the compressor requires lower power consumption in order to reach operating pressure levels.

14. Conclusions

The use of HCR 410 refrigerant gas made the air conditioning system described in this test more efficient in its power consumption, specifically in the compressor stage.

The efficiency of the HCR 410 refrigerant in comparison to conventional R 410 refrigerant, installed in split-type air conditioning equipment is **36%.**

HCR 410 refrigerant gas is compatible with conventional equipment that uses R 410 refrigerant gas.

TOTAL(W)	**89,318.79**	**158,610.78**
TOTAL(MINS.)	1410	
TOTAL(HRS.)=	23.5	
TOTAL(KWH)=	3.80	6.75
% SAVINGS	36%	