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ONLINE

23-24/06/2020



Design, Manufacturing and Performance Testing of Large Capacity R290 Rooftop Package Air Conditioning Units



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Presentation Contents:

1- About Petra

2- About Project

3- Project Design

4- Prototype Performance Analysis

5- Refrigerant Charge Comparison

6- Safety Consideration

7- Cost Analysis

Petra Engineering industries Co. Headquarters, KSA and Mafrag Facilities



- ***First Factory Jordan**
- 250,000 m² Build up Area
- 36 Plant Station
- 1500 Employee



- *** Third Factory**
- KAEC Saudi Arabia
- 45,000 m²Build up Area
- Six Plants
- 250 Employees



- *** Second Factory**
- Mafrag - Jordan
- 200,000 M² Build up Area.
- Five Plant Stations.
- 250 Employee



REIMBURSEMENT OF EXPENDITURES ASSOCIATED TO THE DEVELOPMENT OF PROTOTYPES AND CONVERSION OF MANUFACTURING OF ROOFTOP AIR-CONDITIONING UNITS OF UP TO 400 KW FROM HFC (R-134A, R-407C, R-410A) TO LOW-GWP REFRIGERANTS (R-290, R-32, HFOs) AT PETRA ENGINEERING INDUSTRIES CO. – INCREMENTAL OPERATING COSTS



3-PROJECT DESIGN UNITS Nomenclature

Prototype Units Nomenclatures

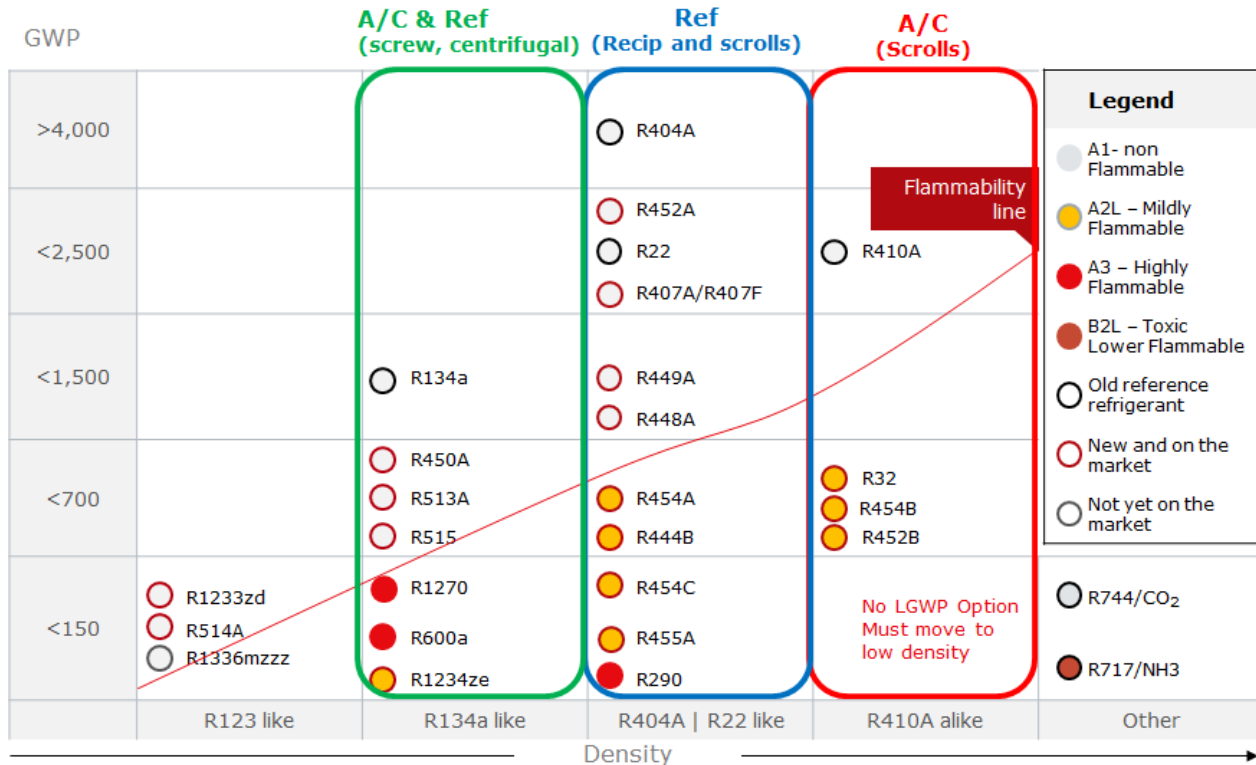
Three prototypes produced under this project will have the following unit model:

- PPH2-300 optimized for R290 88 Kw
- PPH3-300 optimized for R32 88 Kw
- PPH2-640 optimized for R290 185Kw

PSC (2 OR 3) H 40			
PP	H	2 3	300 640
Series Petra Air Cooled Package Unit	High efficient	Refrigerant 2: R290 3: R32	Nominal Capacity (MBH) 88 KW (2 prototypes) 185 KW (1 prototype)

3-PROJECT DESIGN

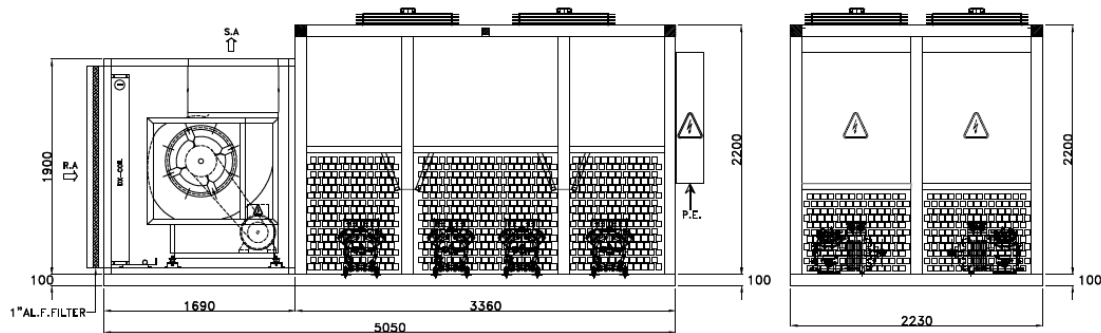
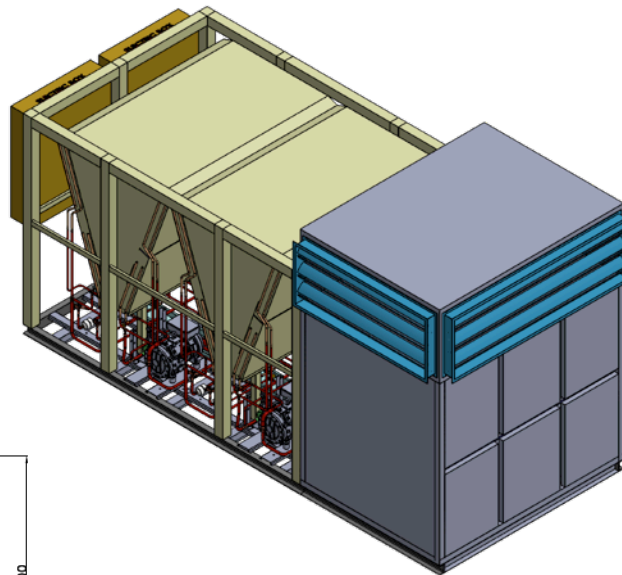
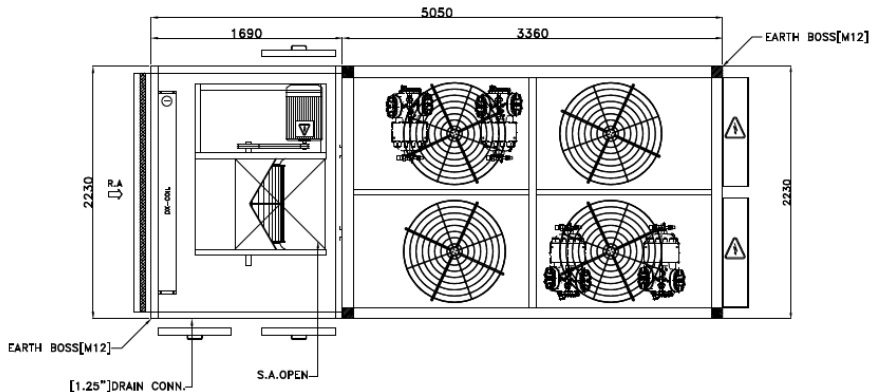
Compressors availability





Sheet Metal Design

PROTOTYPE DRAWING PPH 640





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3-PROJECT DESIGN PROTOTYPE UNIT MODEL PPH640



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4-PROTOTYPES PERFROMANCE ANALYSIS



Testing Map

Prototype Model/ Refrigerant	R290	R32	R410A	R407C
PPH2-300 88 KW	√	X	X	√
PPH3-300 88 KW	X	√	√	X
PPH2-640 185Kw	√	X	X	√

Testing Apparatus



Rooftop Package unit – condenser side



Rooftop Package unit – AHU side

1- PPH2-300

Performance Optimization Option

Through testing prototypes the unit undergone of steps to increase the unit performance using R290 refrigerant as below options:

Optimization Option 1:

Unit testing with 4-row and 16 circuiting evaporator. Using a unit equipped with standard efficiency fan.

Optimization Option 2:

Unit testing after adjusting the evaporator rows from 4 to 6 Rows using same number of circuiting 16 with same standard efficiency fan.

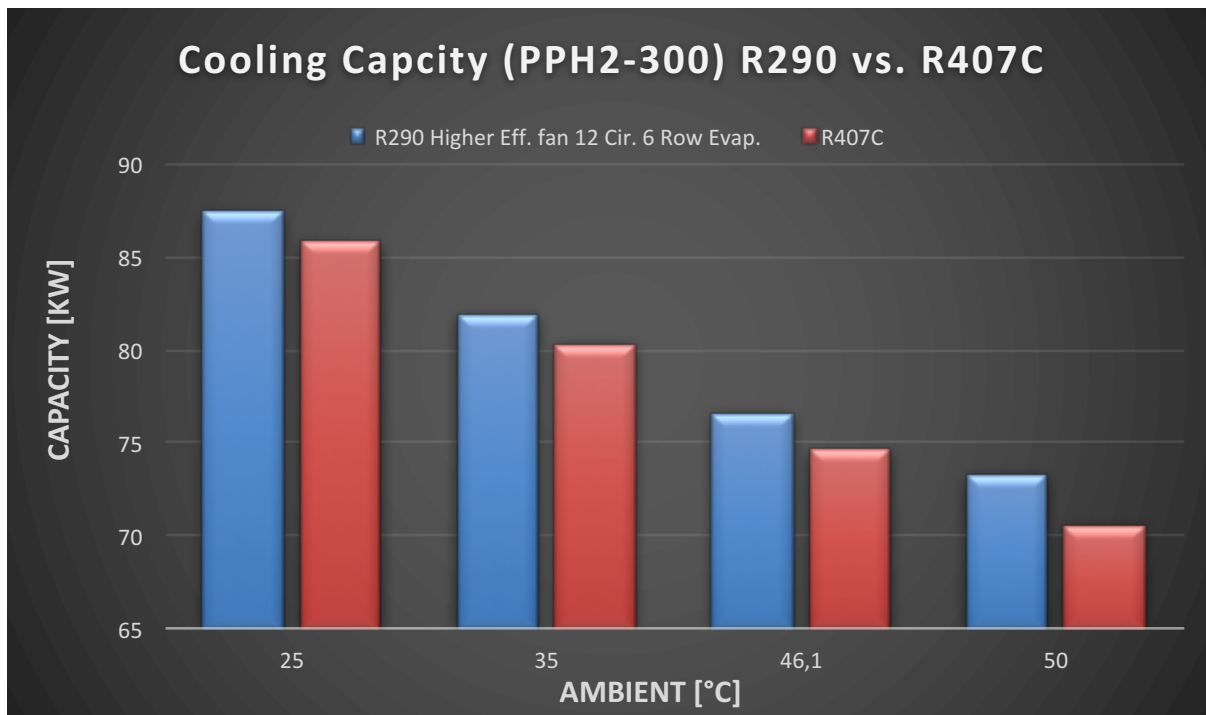
Optimization option 3:

Testing the unit with a new higher efficiency fan and by changing evaporator circuiting numbers to 12 circuits – This test also used R407C as a drop in refrigerant.

1- PPH2-300 (Third Optimization)

comparing the two refrigerant R290 test and the drop in refrigerant R407C on the prototype we notice the R290 refrigerant is higher on the cooling capacity 2-4 % and 4-9.5 % on the energy efficiency ratio along ambient variation.

Ambient [°C]	R290 Higher Eff. fan 12 Cir. 6 Row Evap.	R407C
	Cooling Capacity kW	
25	87.34	85.77
35	81.81	80.25
46.1	76.56	74.57
50	73.23	70.49

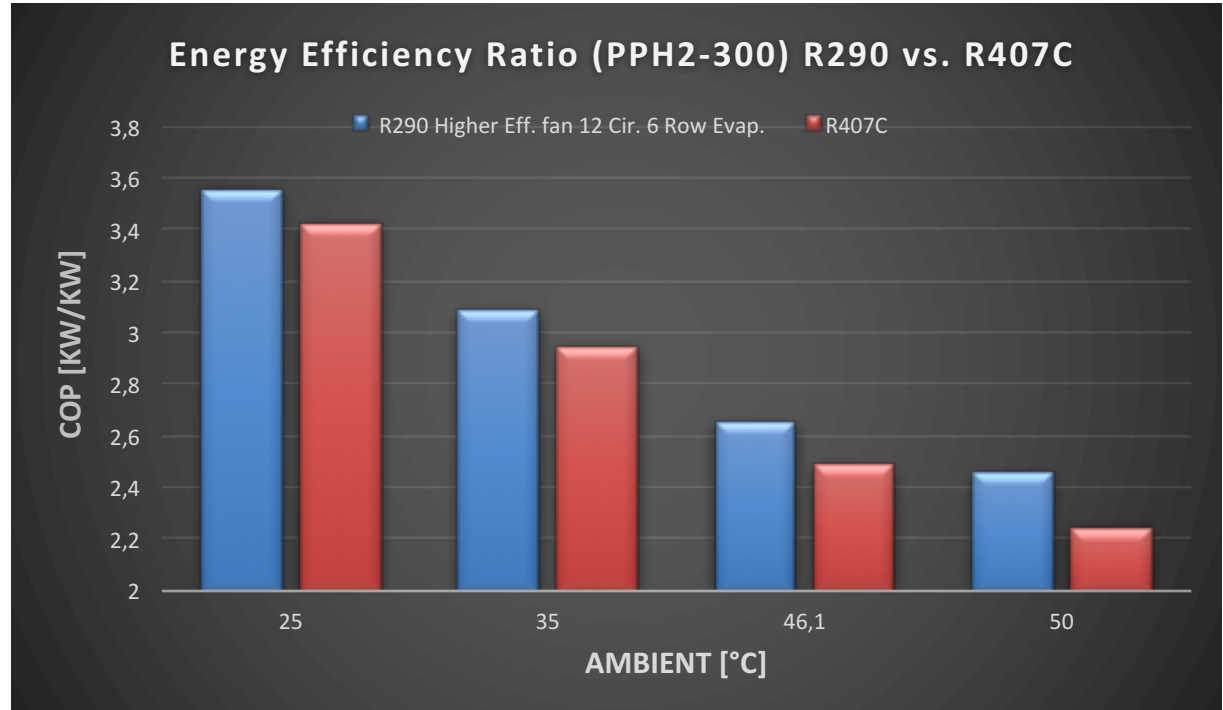




1- PPH2-300 (Third Optimization)

4-9.5 % on the energy efficiency ratio along ambient variation.

	R290 Higher Eff. fan 12 Cir. 6 Row Evap.	R407C
Ambient [°C]	EER kW/kW	
25	3.55	3.42
35	3.08	2.94
46.1	2.65	2.48
50	2.45	2.24

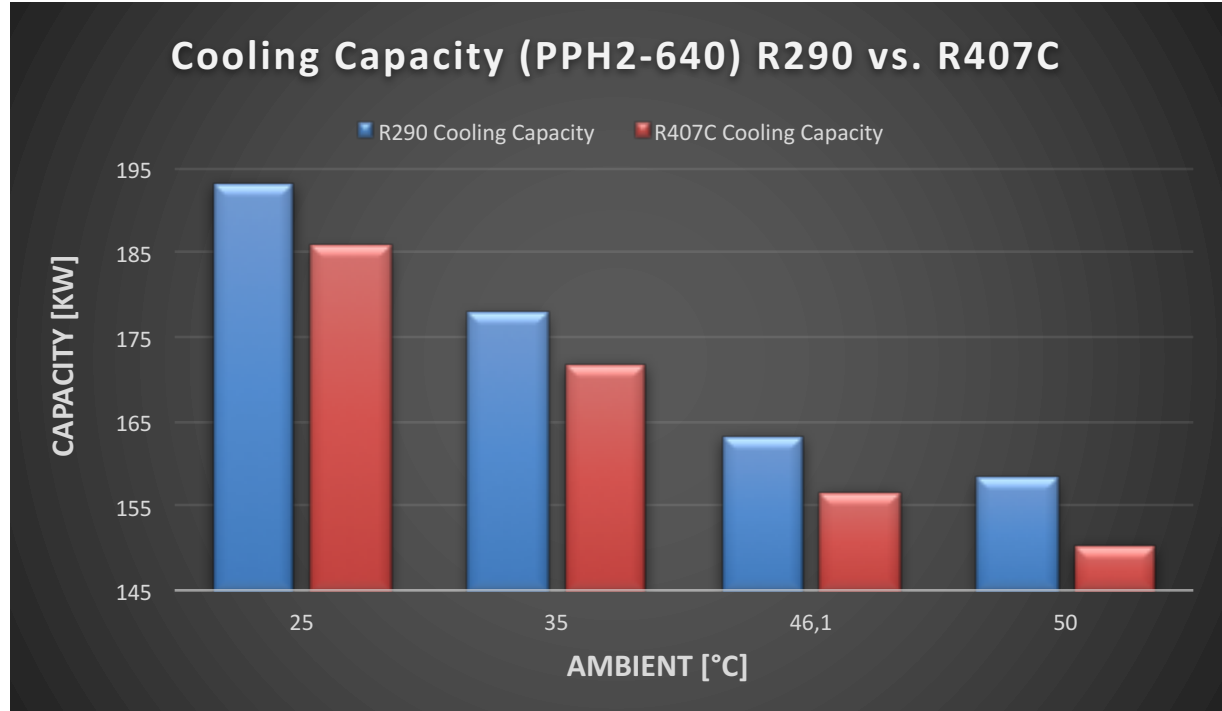




3- PPH2-640

R290 unit is better than R407c unit in cooling capacity by 3-6% at different ambient conditions

	R290	R407C
Ambient [°C]	Cooling Capacity kW	
25	193.08	185.76
35	177.87	171.58
46.1	163.15	156.50
50	158.23	150.19

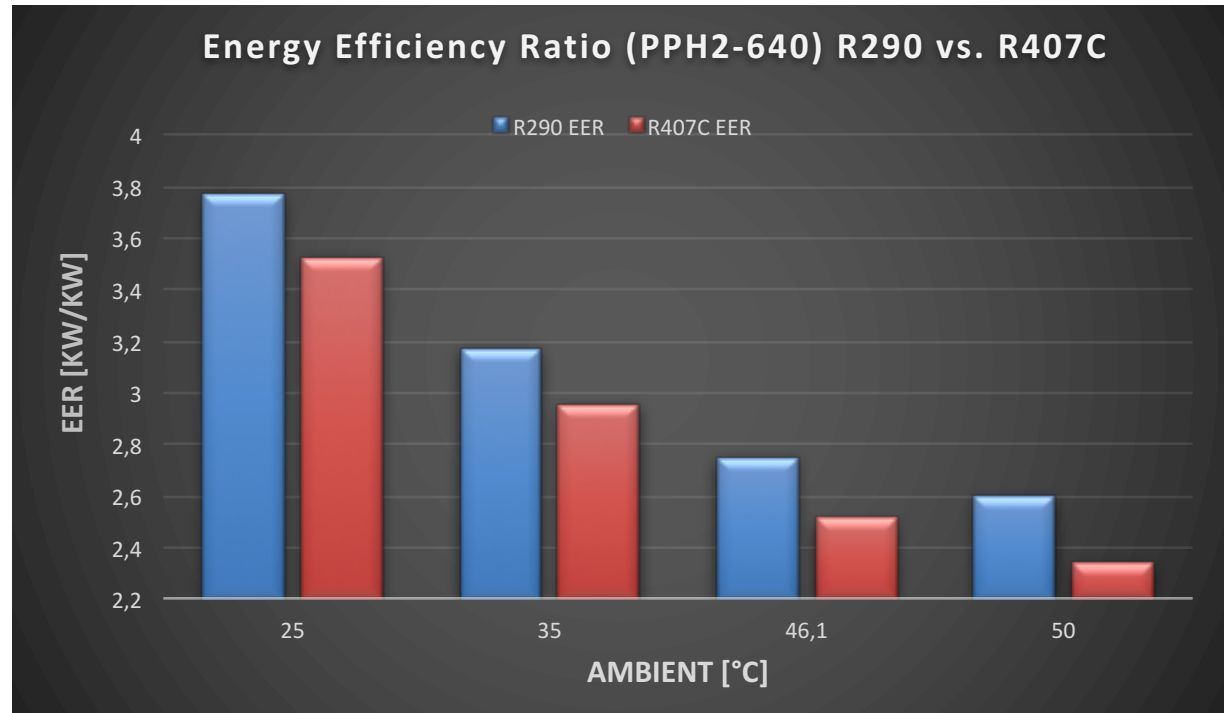




3- PPH2-640

7-11% on the energy efficiency ratio along ambient variation.

	R290	R407C
Ambient [°C]	EER kW/kW	
25	3.77	3.52
35	3.17	2.95
46.1	2.74	2.51
50	2.59	2.33





5-Refrigerant Charge Comparison



Comparing the charge amount cost and quantities used in the prototypes

Unit Model	Charge Amount Each (kg)	Difference	Refrigerant Type
PPH2-300	4.5 (2 stage)	47%	R290
PPH2-300	8.5 (2 stage)		R407C
PPH2-640	4 (4 stage)	46.7%	R290
PPH2-640	7.5 (4 stage)		R407C



6-Safety Considerations

SAFETY CONSIDERATION

***Additional control dampers in plenum of the return/supply air tunnel

Units that operate with highly and mildly flammable refrigerant gases need to further consider safety considerations,

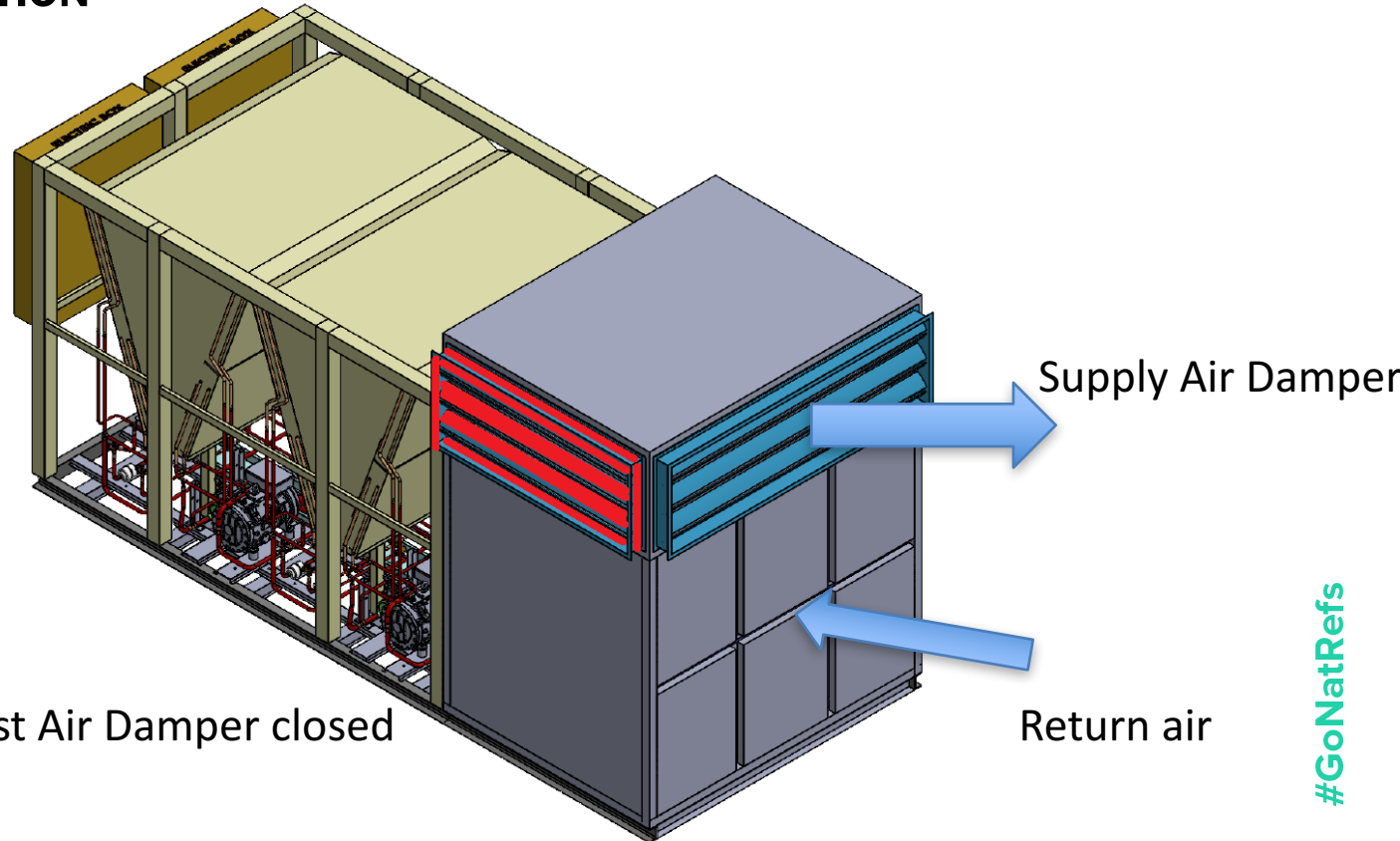
We add plenum section located on supply fan to control the direction of the supply air flow by using motor actuated dampers to open exhaust damper once the leak detector hits the flammable or mildly flammable refrigerant gases and closing the supply damper to prevent the flammable gases to return to the building.

**In case of refrigerant leakage open exhaust air damper
close the supply air damper keep the return air damper open(if any)**

SAFETY CONSIDERATION

Sequence of operation

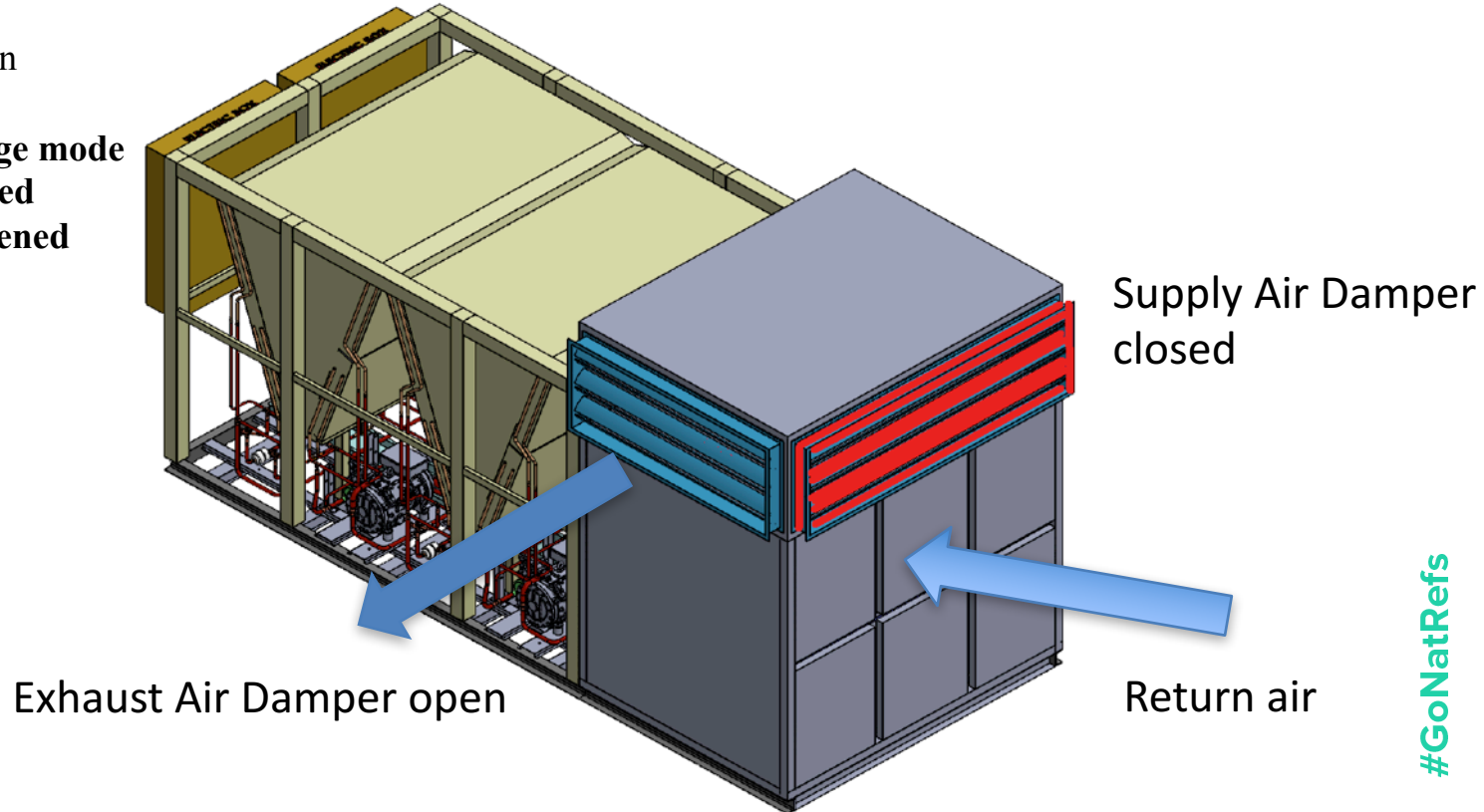
1- on normal mode
Exhaust damper closed
Supply damper opened



SAFETY CONSIDERATION

Sequence of operation

2- refrigerant leakage mode
Supply damper closed
Exhaust damper opened





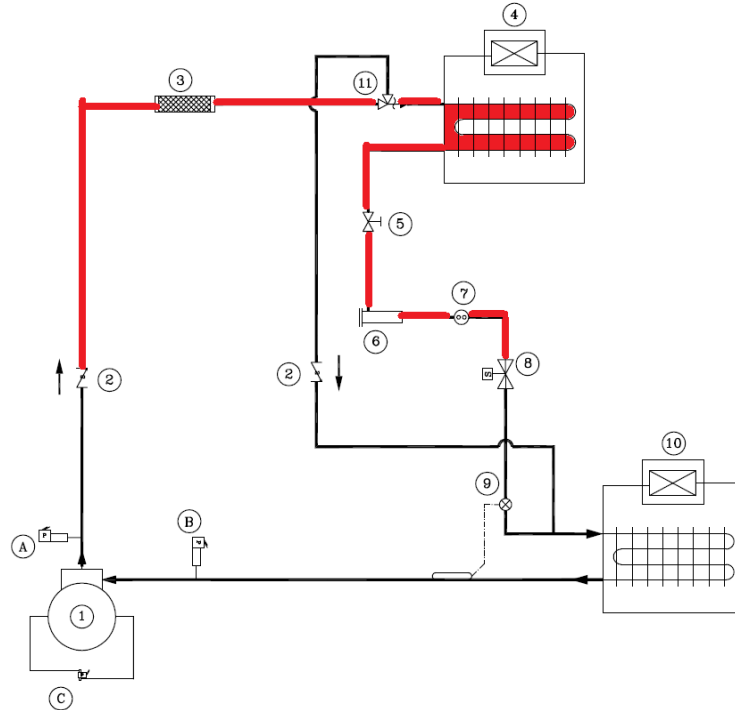
SAFETY CONSIDERATION

**** Automatic refrigerant pump down function in case of refrigerant leakage in the air stream

- 1- while turning off the unit
- 2- sensing the highly and mildly flammable refrigerant.

The purpose of the pump down is to move all the refrigerant along the refrigeration circuit to the condenser side which located outside the unit, that minimize the risk through of refrigerant leakage to the indoor air stream

Automatic pump down in case of refrigerant leakage in the air stream



C	Oil Differential Pressure Switch
B	Low Pressure Switch
A	Hi Pressure Switch
#	CONTROLLER

11	Relief Valve
10	Evaporator Coil
9	Expansion Valve
8	Solenoid Valve
7	Sight Glass
6	Filter Drier
5	Shut Off Valve
4	Condenser Coil
3	Discharge Muffler
2	Check Valve
1	Reciprocating Compressor
#	ITEM

SAFETY CONSIDERATION

Reducing Electrical Junction Boxes to increase the safety inside the unit electrical wise.



SAFETY CONSIDERATION

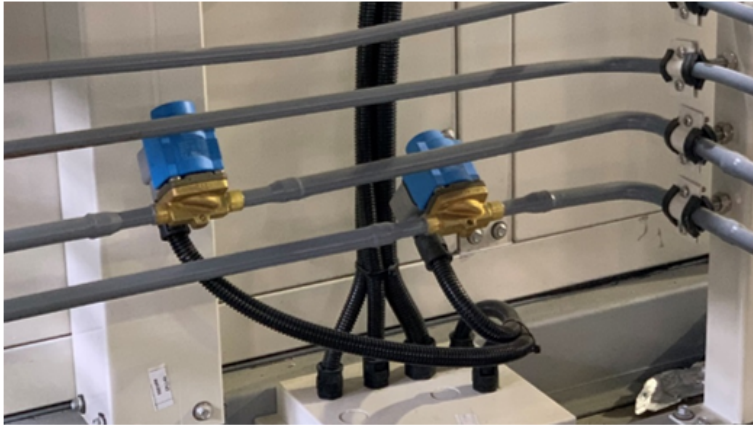
****R290 leak sensors in/outside the air stream and near to refrigerant pipes to detect the concentration of the flammable gas



SAFETY CONSIDERATION

***Additional Isolation and Control Valves

Prototypes are equipped with valves in order to reduce the refrigerant leakage from the system during maintenance.



Liquid Solenoid Valve



Compressor Suction Shut Off Valve



SAFETY CONSIDERATION

***Labels and Marking used on the unit are according to IEC 60335-40-2 standard



SAFETY CONSIDERATION

****Special Compressor and unit electrical enclosure and special compressor oil are used for R290 unit





7-COST ANALYSIS



Unit Cost Impact for two types of refrigerants R290 and R407C Units.

PPH2-300 Major Components Cost	R407C	R290
Compressor (2)	5785 Semi Hermetic Reciprocating (Polyol Ester Oil and normal enclosure)	6835 Semi Hermetic Reciprocating (Polyalkylene glycol oil and Special Electrical Enclosure)
Condenser Coil (2)	4557	4557
Evaporator Heat Exchanger	1253	1253
Expansion valves (2)	219	349
Electrical Panel and cables	3115	3115
Piping	1234	1234
Filter Drier (2)	490	490
Solenoid valve (2)	278	278
Refrigerant Leak Detector	0	107
Damper Actuator in case of leak	0	507
Major Components TOTAL	16,930	18,724
Percentage	100%	110.6%

*All Prices on Euro



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Thank you
for listening!

