

# Active Control Technologies for VRF Heat Pump Cycle

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**MULTI V™** 

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## Self Reliability

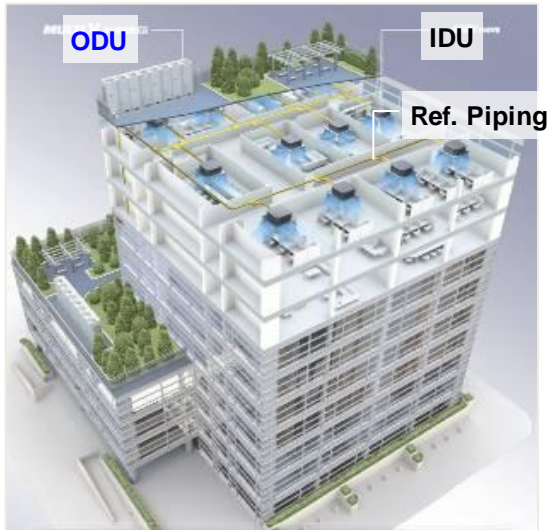
- 01 | Emergency Operation Function
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## Etc.

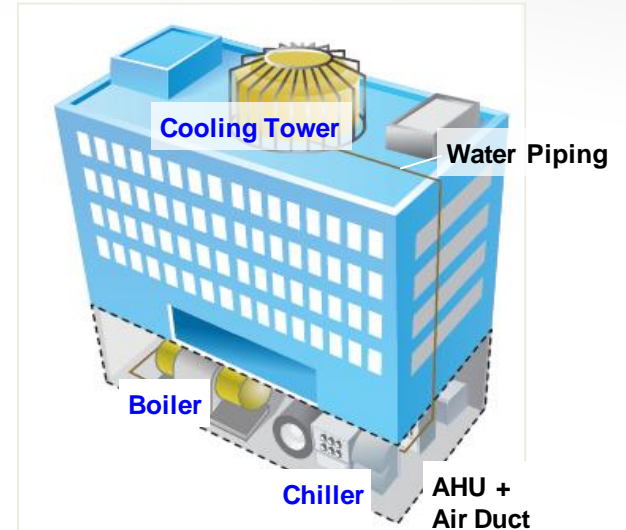
- 01 | Smart-phone Monitoring and Control

VRF (Variable Refrigerant Flow) System is more effective than others.

## VRF System



## Chiller System



VRF Heat Pump Outdoor Unit (Cooling and Heating)	Facilities	Cooling: Chiller + Cooling Tower
		Heating: Boiler
52%	Installation Space	100% (Mechanical Facility Room)
low	Operating Cost	high
Local Control	Control Type	Central Control

# Technologies for VRF

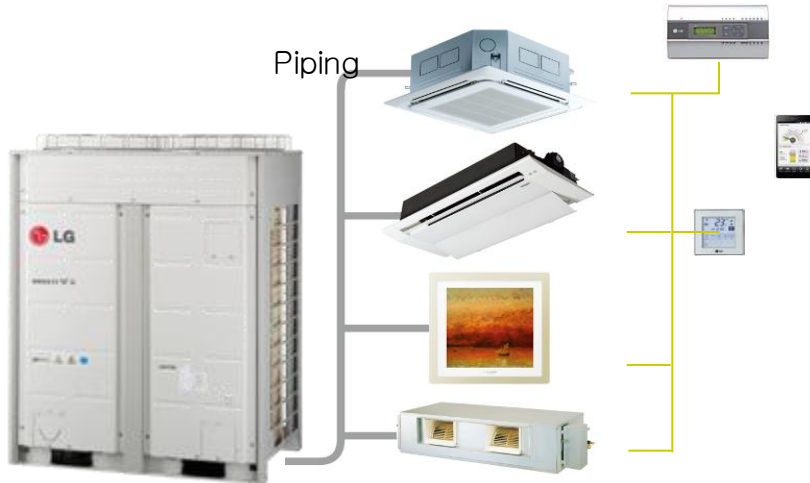
Technologies for VRF are as follows.

## VRF System

### Outdoor Unit

### Indoor Units

### Controller



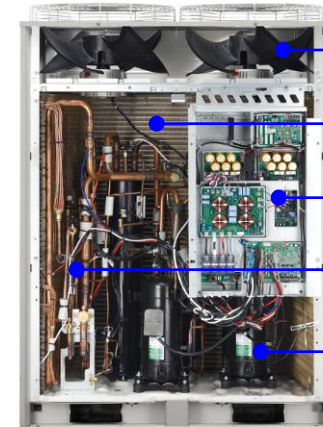
## Basic Technologies for VRF

### 8~12HP

### 14~20HP



Inverter 1 Comp



Inverter 2 Comps

- Fan & Motor
- Heat Exchanger
- Inverter Controller
- Active Cycle
- Compressor

# Innovative Technologies for Multi V IV

Multi V IV has innovative active control technologies for VRF heat pump cycle.

## Active Control Technologies

## Customer Values

# MULTI V™ IV



World Best

LG Scroll Comp.

World First

HiPOR

World First

Active Oil Control

World First

Active Ref. Control

World First

Active Var. HEX

Higher Efficiency

Powerful Capacity

Highest Comfort

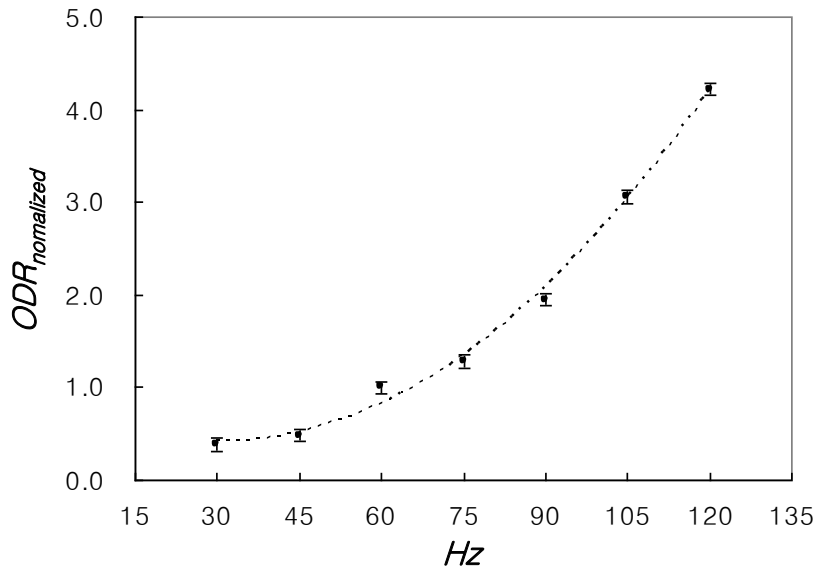
Easy Installation

More Reliable

## Oil Return Capillary Bypass Effect (Conventional System)

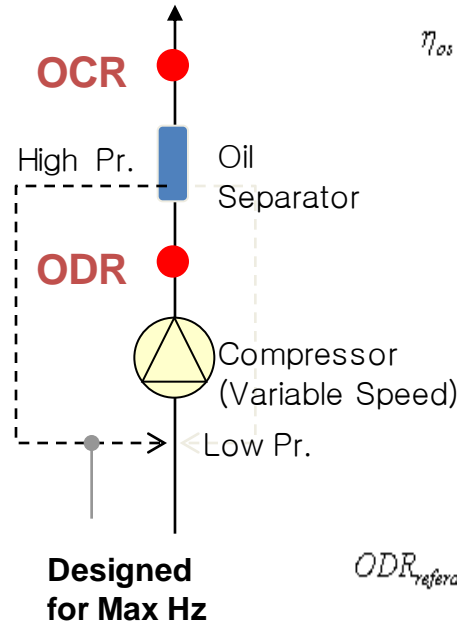
### Oil Discharge Ratio

- ODR: Oil Discharge Ratio,
- OCR: Oil Circulation Ratio



Oil discharge ratio vs. compressor frequency.

### Calculation of OCR



$$\eta_{os} = 1 - \frac{\dot{m}_{o,circulation}}{\dot{m}_{o,discharge}} = 1 - \frac{OCR}{ODR} = 1 - \frac{OCR_{normalized}}{ODR_{normalized}}$$

$$ODR_{normalized} = \frac{ODR(wt\%)}{ODR_{reference}(wt\%)}$$

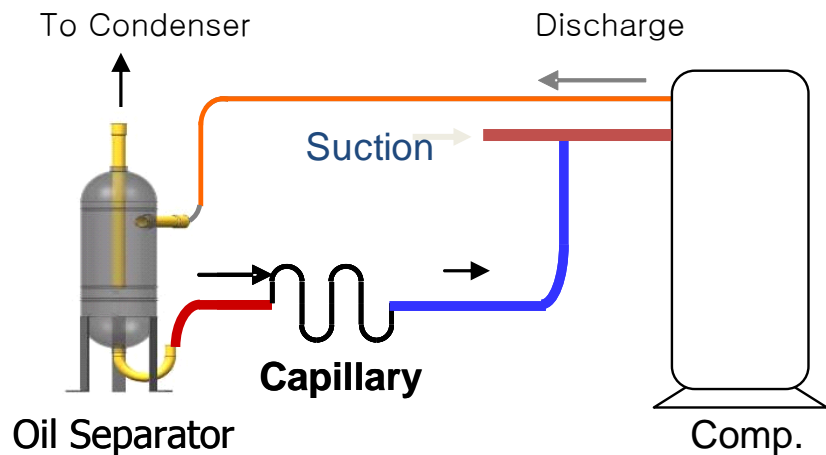
$$OCR_{normalized} = \frac{OCR(wt\%)}{ODR_{reference}(wt\%)}$$

$$ODR = OCR \quad \text{without Oil Separator}$$

$$ODR_{reference}(wt\%) = \frac{\dot{m}_o}{\dot{m}_y + \dot{m}_o} \times 100 \quad \text{at 60Hz, ARI Condition}$$

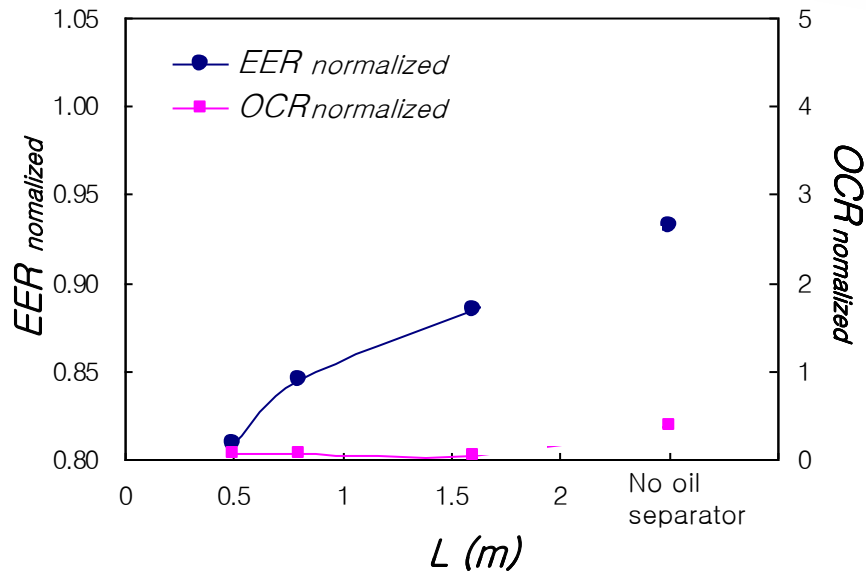
## Oil Return Capillary Bypass Effect (Conventional System)

### Conventional Oil Return



Oil flow in compressor and oil separator.

### Demerits of Conventional System



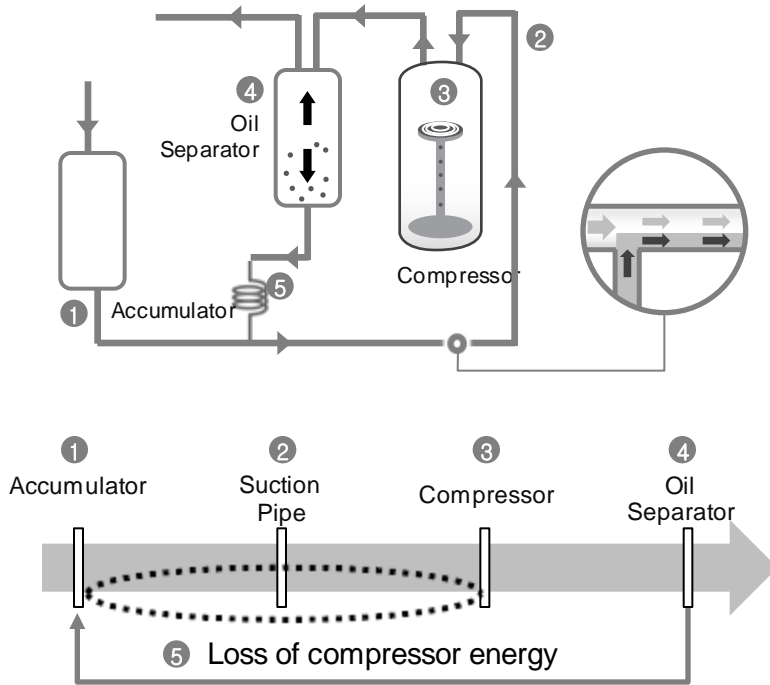
EER and OCR at various capillary lengths.  
(Comp 30Hz, ARI condition)

# HiPOR™ Technology

With patent HiPOR™ technology, fundamental cause of energy loss due to oil circulation has been reduced to maximize efficiency of the compressor.

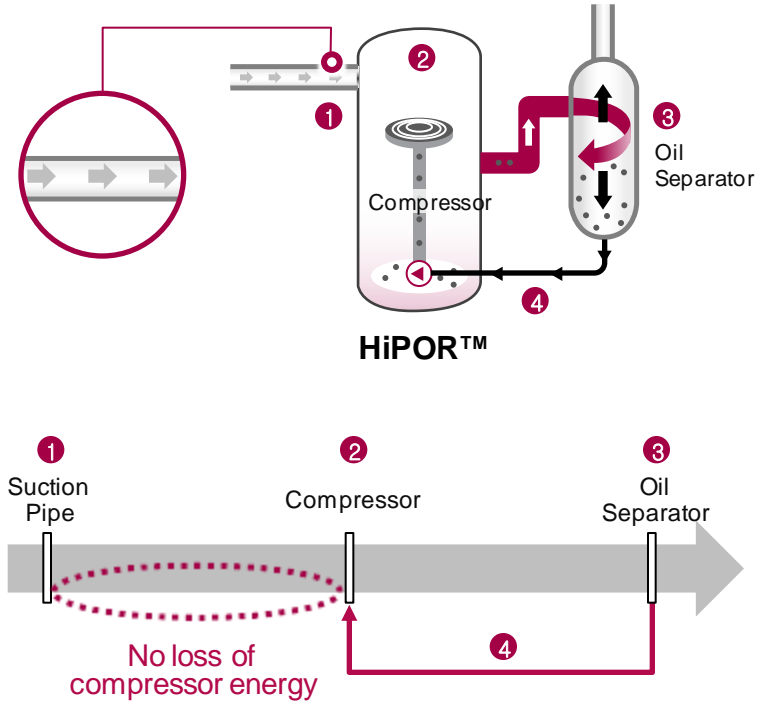
## Conventional

- Volume Loss
- By-pass loss of high pressure refrigerant



## MULTI V™ IV

- HiPOR™ method (High Pressure Oil Return)



※ HiPOR™: High Pressure Oil Return

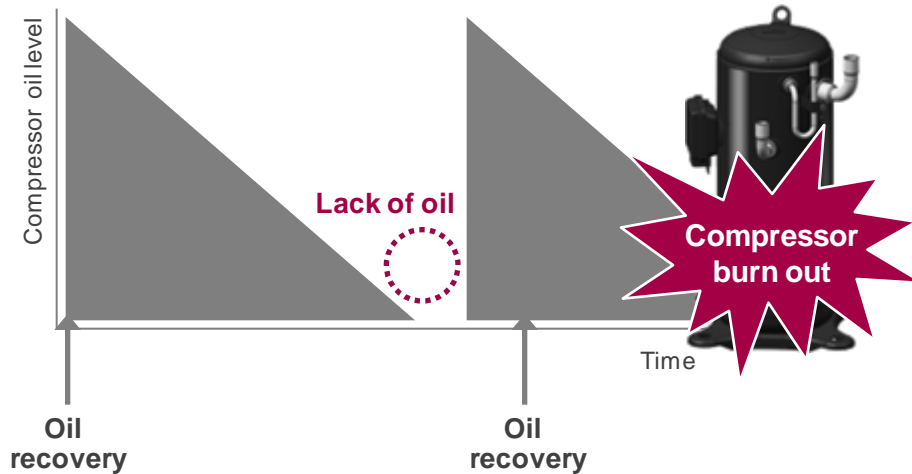


# Real-Time Oil Level Detection

Multi V IV applied Smart Oil Return technology, the real-time oil level detection improved compressor reliability.

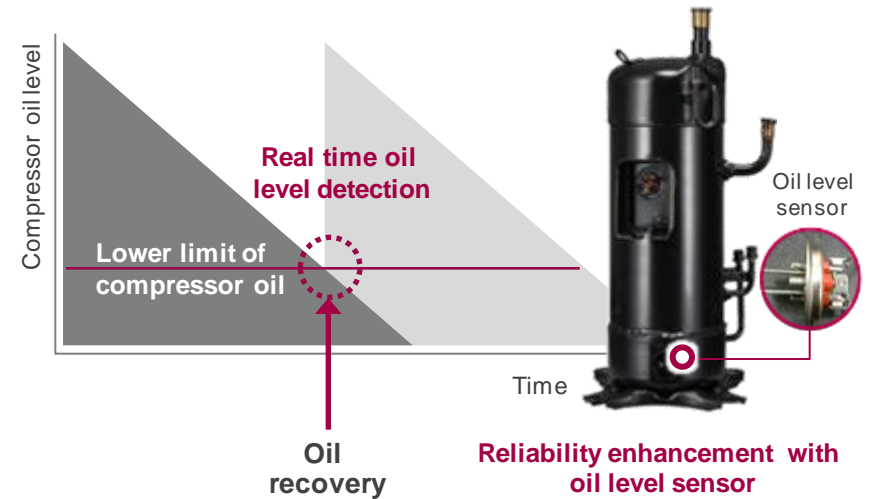
## Conventional

- No warning during lack of oil state
- Compressor burnt problem due to lack of oil status before oil recovery operation period (8hr)



## MULTI V™ IV

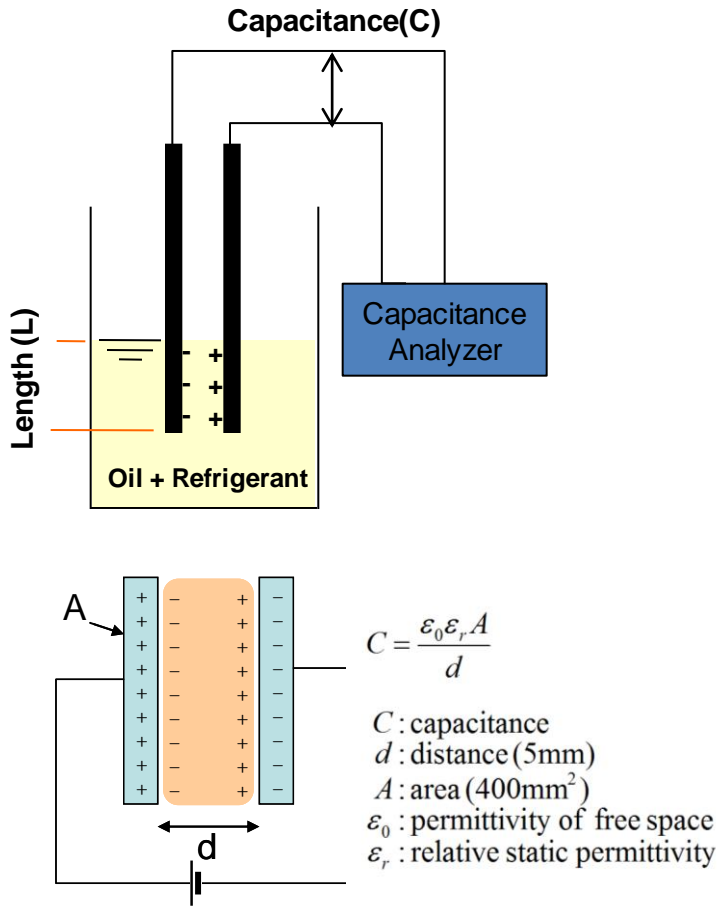
- Oil recovery operation carried out only during oil shortage
- Fundamentally prevent risk of compressor burnt out



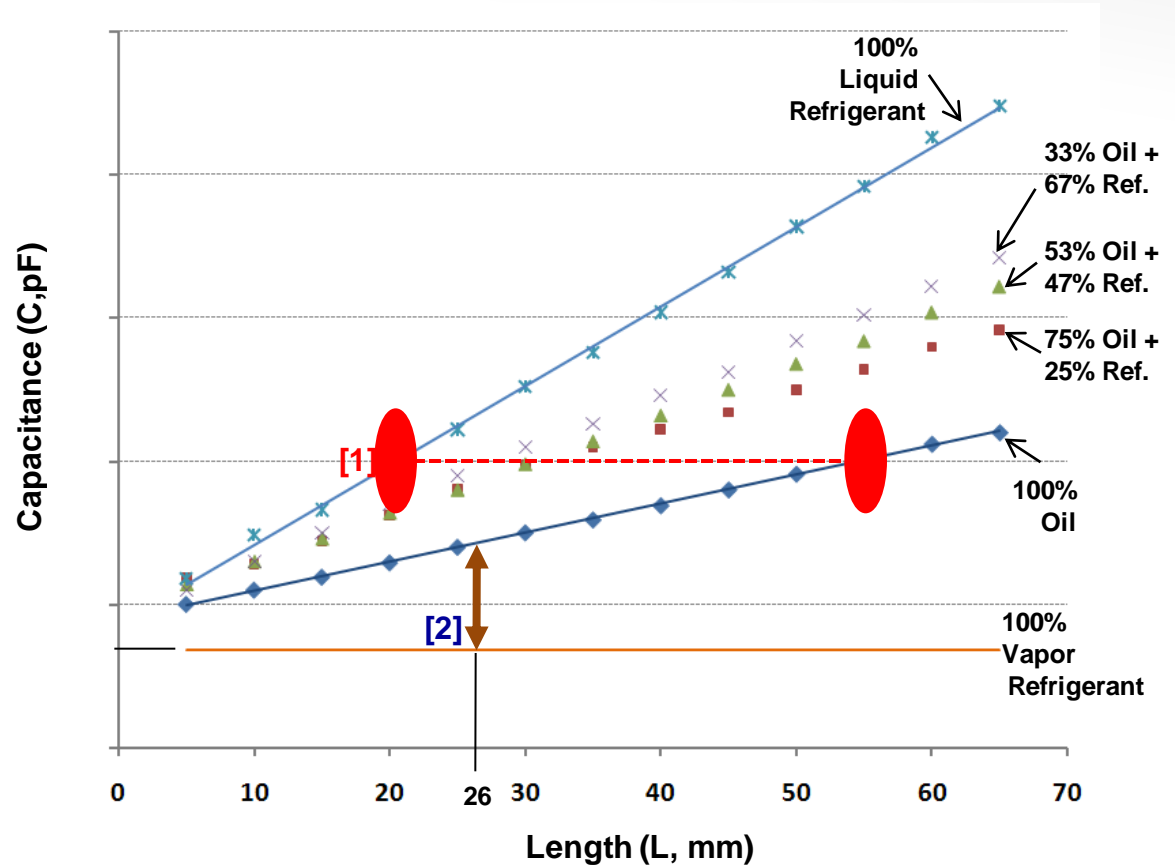
# Real-Time Oil Level Detection, Basic Experiment

Capacitive characteristics changes greatly with oil & refrigerant mixture ratio [1]  
 Difference is distinguishable between 100% vapor refrigerant and 100% oil [2]

## Capacitance type detector



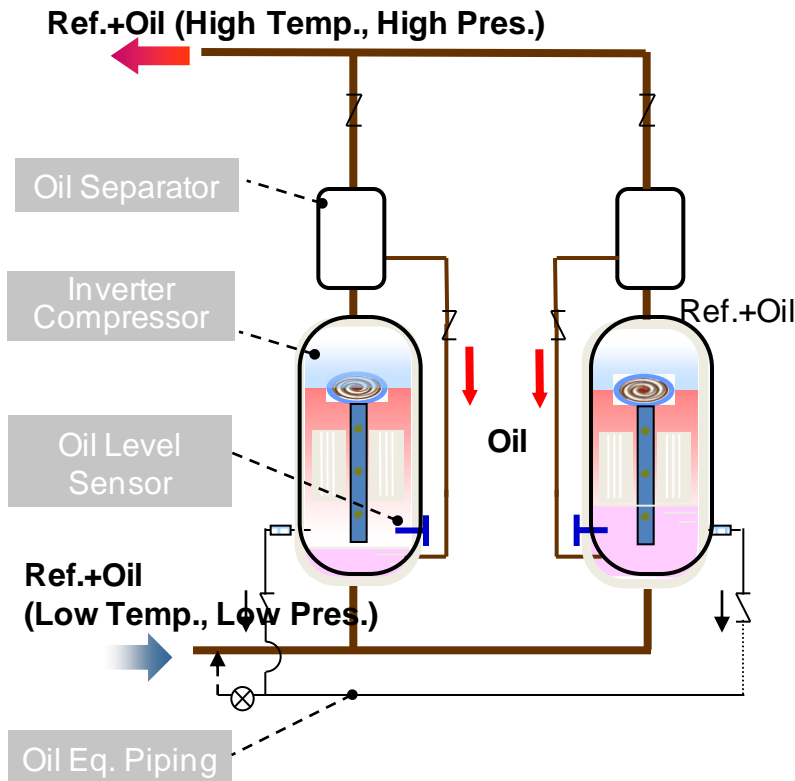
## Capacitive Characteristics



# Real-Time Oil Level Detection, Balancing and Return

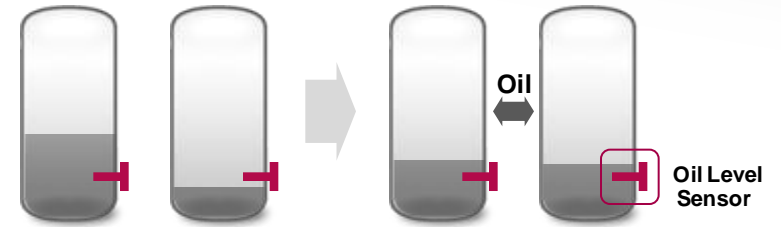
Refrigerant Effect inside compressor

## Cycle Diagram for Oil Level Detection

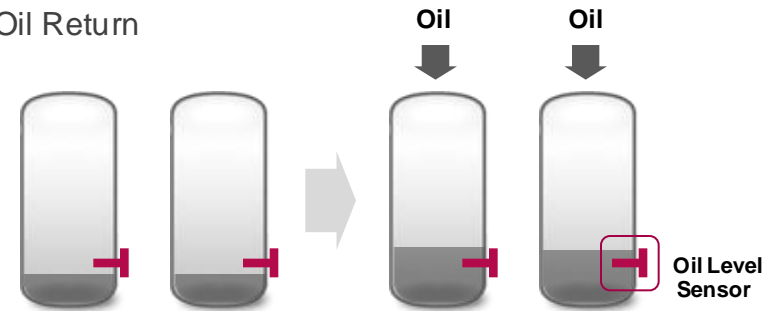


## Auto Oil Balancing and Smart Oil Return

▪ Auto Oil Balancing



▪ Smart Oil Return



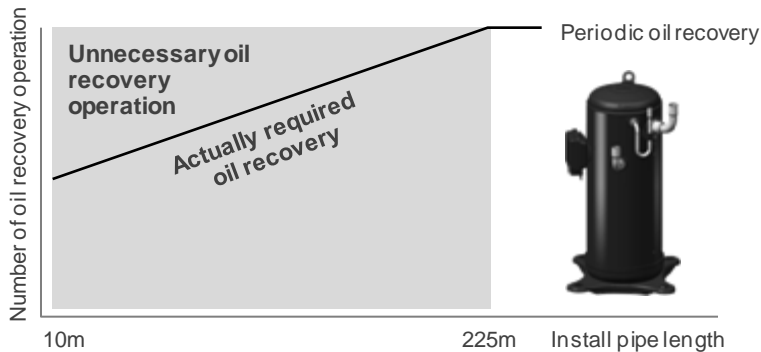
Oil Balancing and Oil return algorithm with Oil level sensor

# Real-Time Oil Level Detection, Smart Oil Return

VRF system is required oil recover for reliability. Multi V IV recover oil when oil level sensor detects low oil level. It can reduce energy consumption and minimize heating operation stop time.

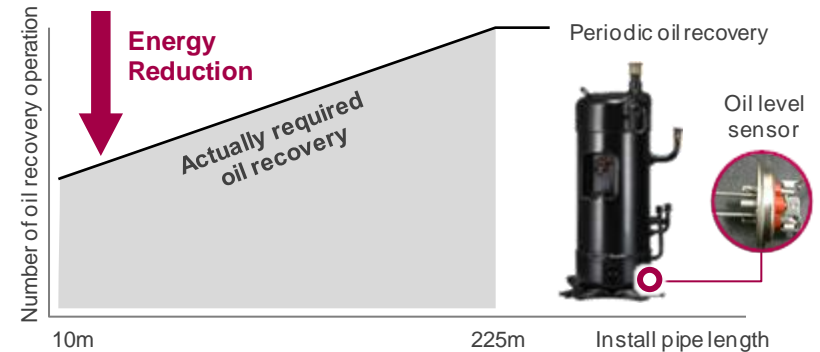
## Conventional

- Periodic oil recovery is performed to secure reliability
- Stop heating operation and energy consumption are reduced due to oil recovery operation

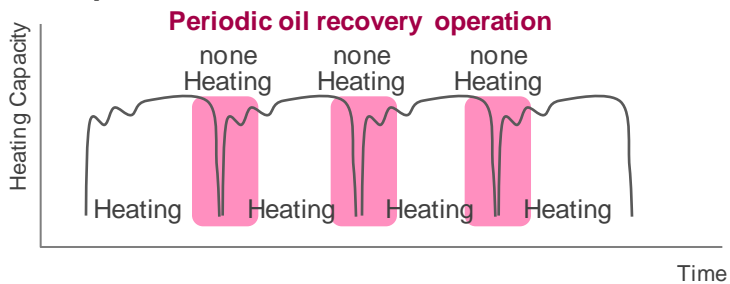


## MULTI V™ IV

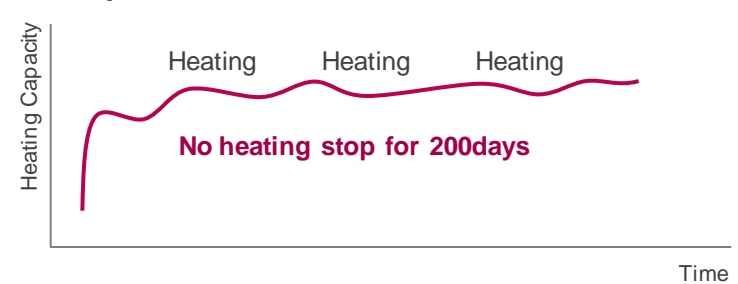
- Apply oil level sensor - Reliability up
- Required oil recovery operation - Efficiency up
- Oil distribution technology between compressors



## Real Operation Test



## Real Operation Test

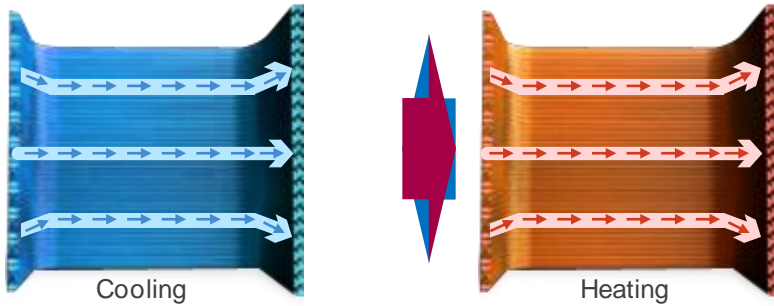


# Variable Heat Exchanger Circuit

The optimization of heat exchanger's path number has improved in heating and cooling efficiency.

## Conventional

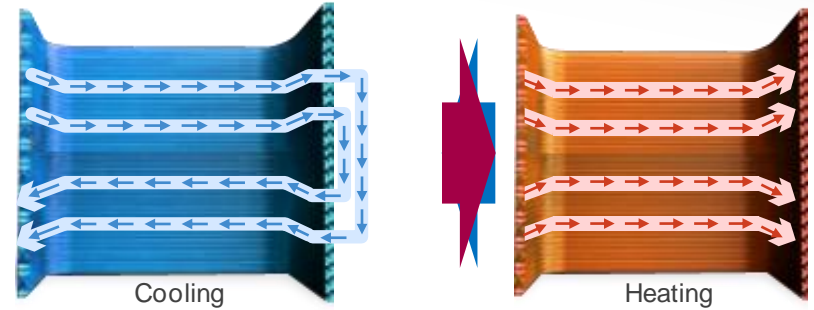
Low efficiency for fixed refrigerant speed and path



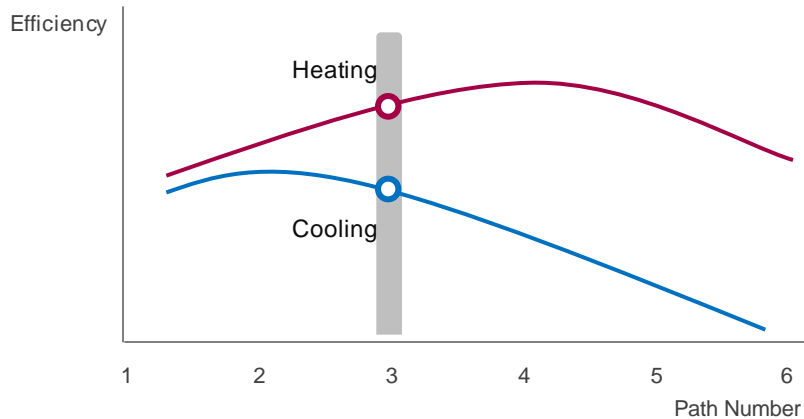
## MULTI V™

Path (less), Velocity (high)

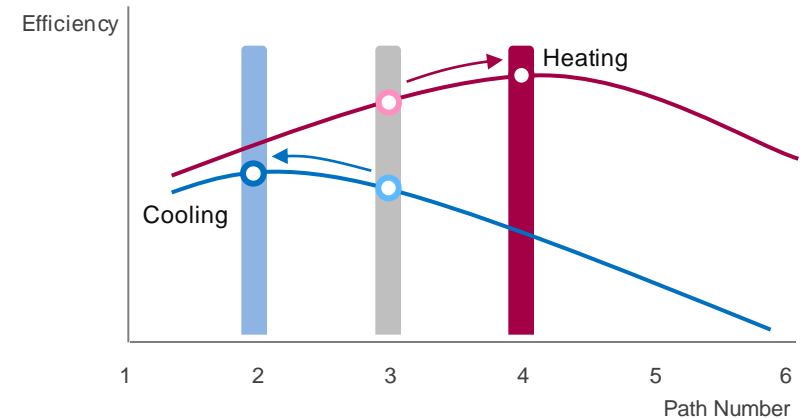
Path (more), Velocity (low)



Fixed path number, low efficiency



Variable path number according the operation mode

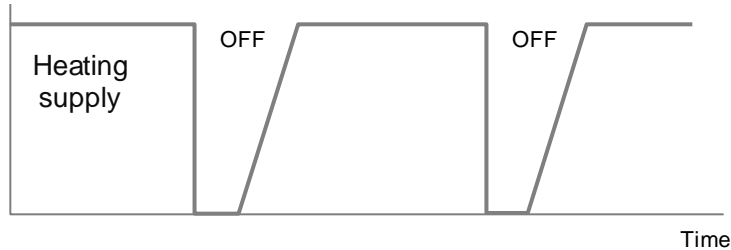


# Continuous Heating Operation in Defrosting

Multi V IV has split-defrosting cycle control technology for continuous heating.

## Conventional

- In case of defrost mode, the unit cannot maintain heating supply
- Customer have to wait until the defrost operation stop

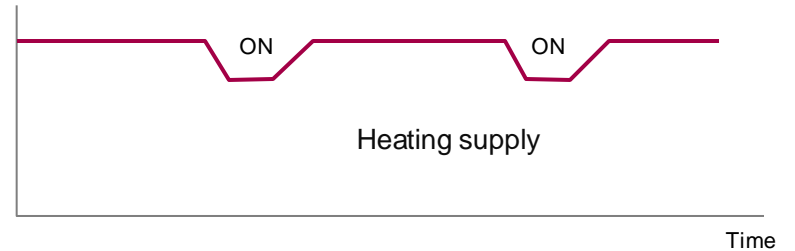


Full defrost      Normal operation      Full defrost

**Defrost cycle Sequence**

## MULTI V™ IV

- Even in defrost mode, it can keep supply heating
- By separating heat exchanger into 2 part, it can defrost without stop



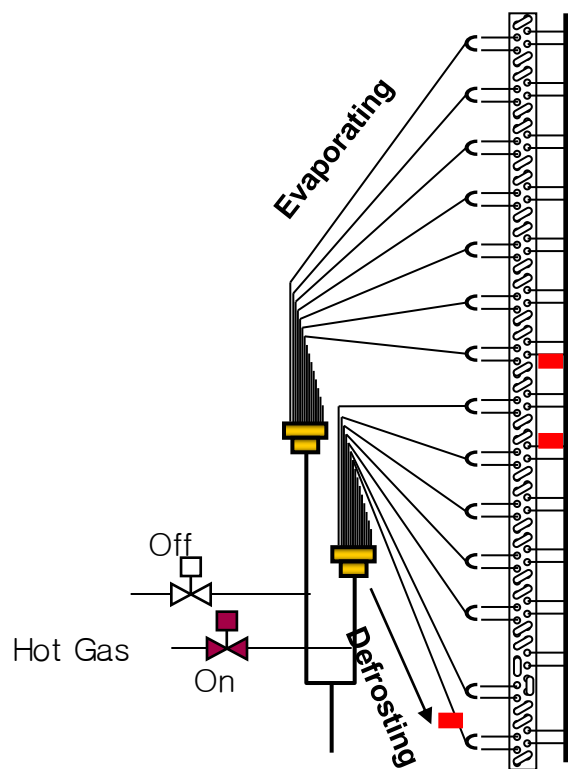
Lower defrost      Upper defrost      Lower defrost

**Split-defrosting cycle Sequence**

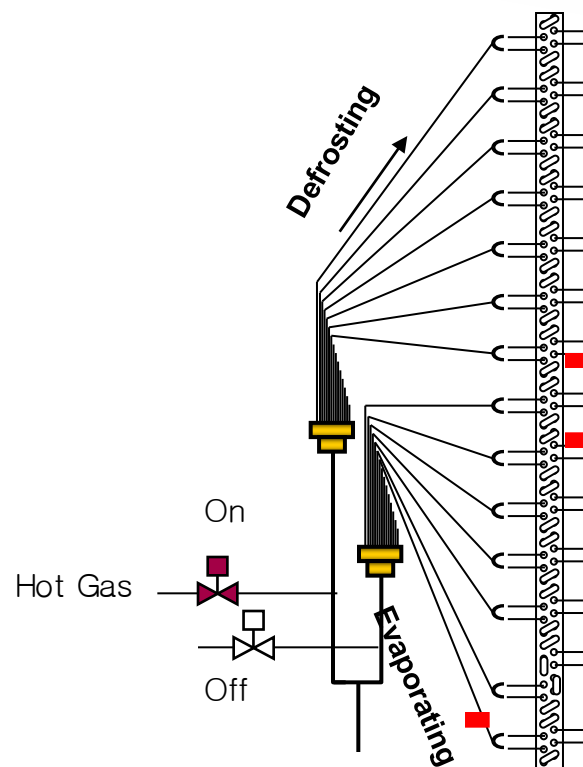
## Continuous Heating Operation in Defrosting

Some amount of hot gas is supplied for defrosting HEX without stopping heating

### Low Side HEX Defrosting



### High Side HEX Defrosting

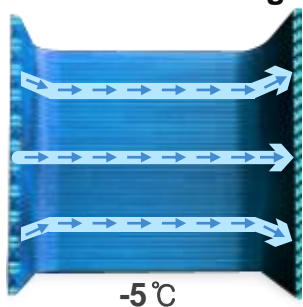


# Cooling Operation Range Down

Multi V IV continuous cooling range in low temperature is extended from  $-5^{\circ}\text{C}$  to  $-10^{\circ}\text{C}$   
 Better solution for low cooling zone like server rooms.

## Conventional

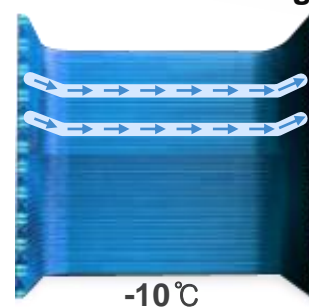
### Full heat exchanger usage



- Excessive low pressure by Full Heat Exchanger area
- Frequent on / off compressor operation by low pressure protect function

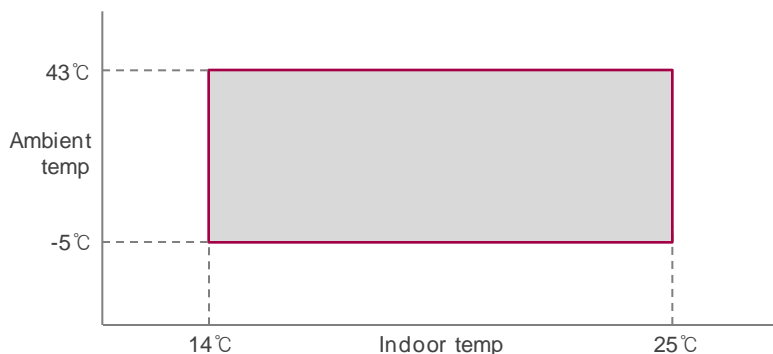
## MULTI V™ IV

### Part heat exchanger usage

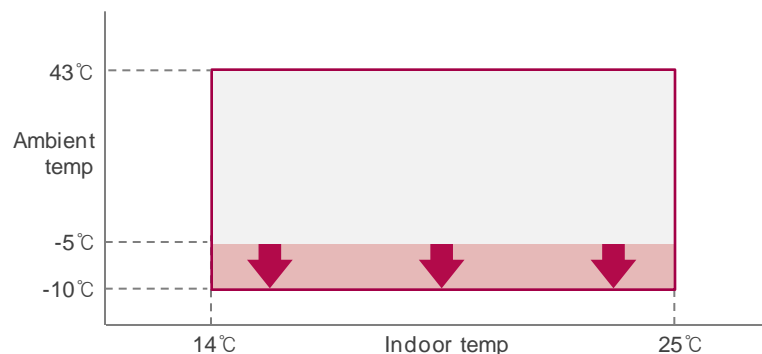


- Moderate low pressure by Part Heat exchanger area
- Continuous cooling operation

### Cooling operation area



### Cooling operation area

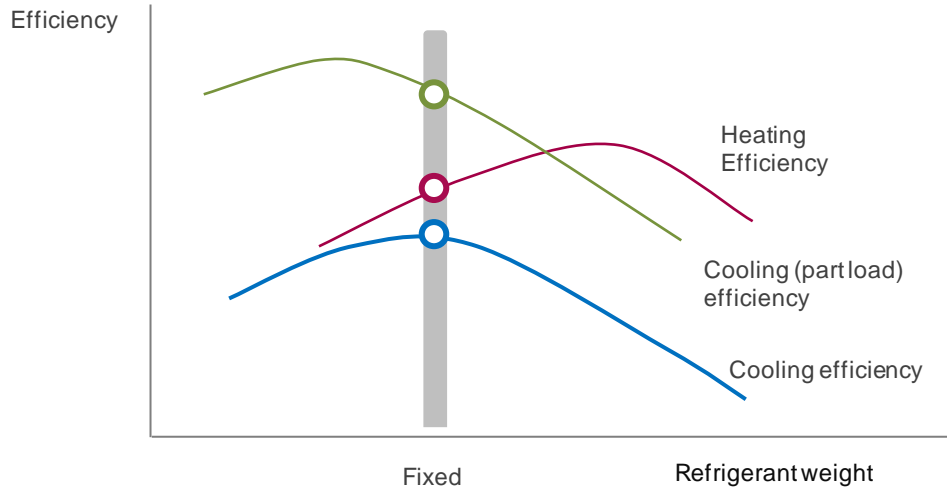




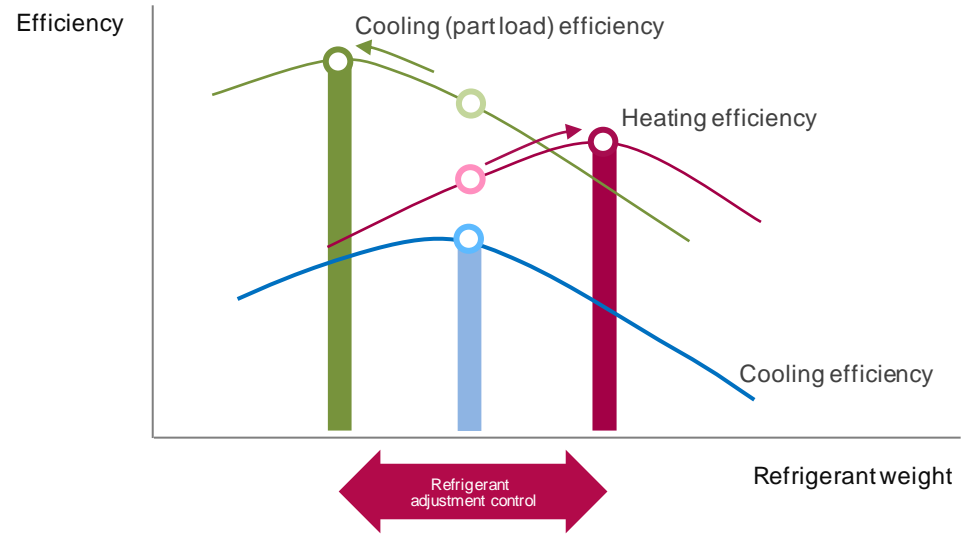
# Effect of Active Refrigerant Control

Real time optimal refrigerant control according to change in load maximizes system efficiency.

## Conventional



## MULTI V™

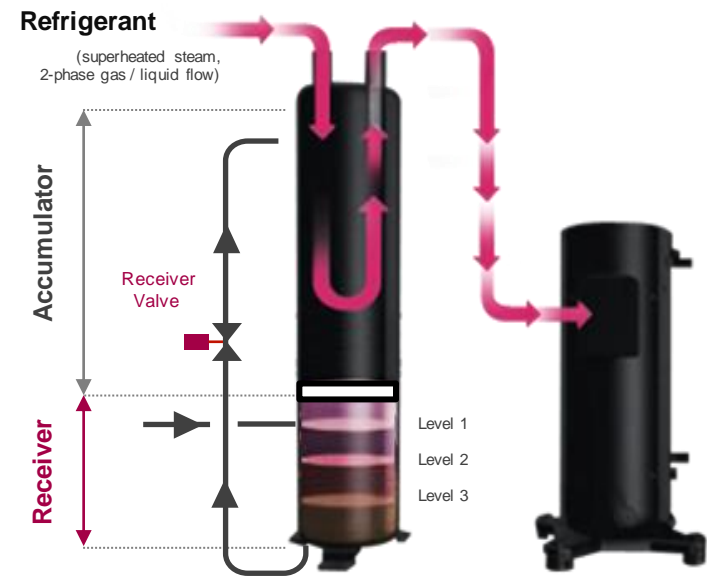
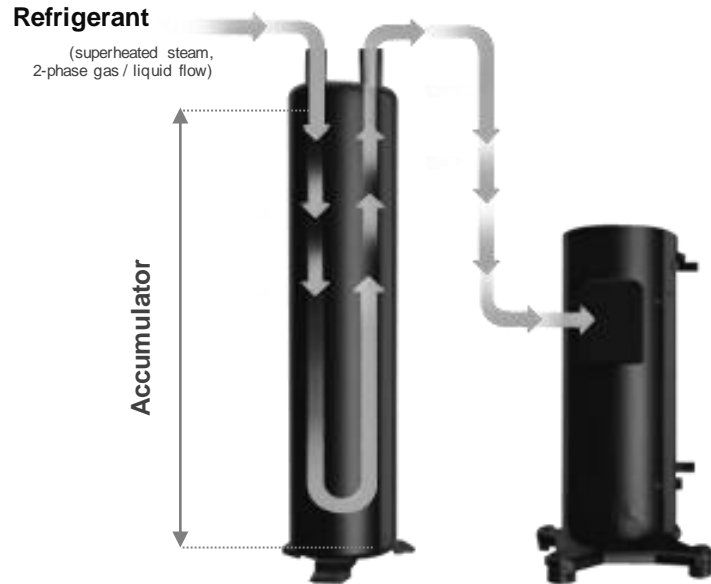


# Active Refrigerant Control

Real time optimal refrigerant control according to change in load maximizes system efficiency.

## Conventional

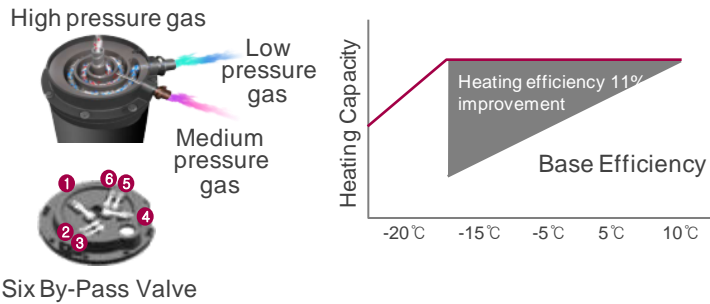
## MULTI V™ III



Multi V IV has high efficiency all inverter scroll compressor with frequency range 15Hz~160Hz.

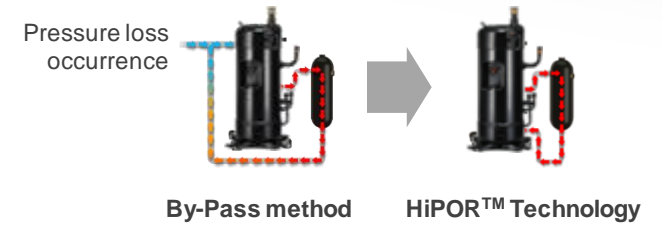
## VI (Vapor Injection)

- VI Technology applied to improve heating performance and efficiency



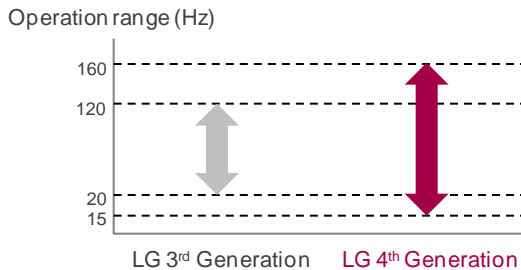
## HiPOR™ (High Pressure Oil Return)

- Direct oil return mechanism towards Compressor  
→ Prevent volume loss caused by oil



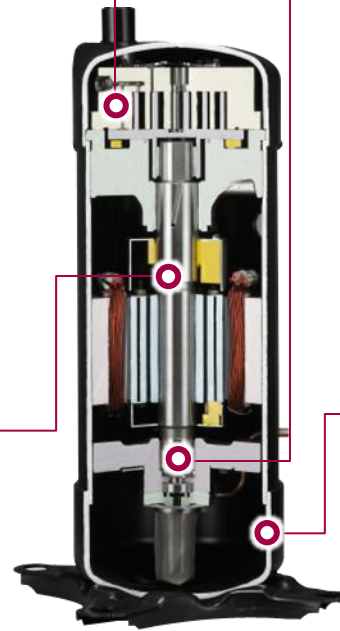
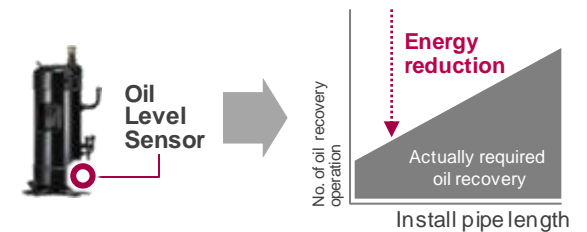
## World best compressor speed 160Hz

- Rapid response capability
- Compact core design (concentrated motor)
- Down to 15Hz → part load efficiency improvement



## Smart Oil Return

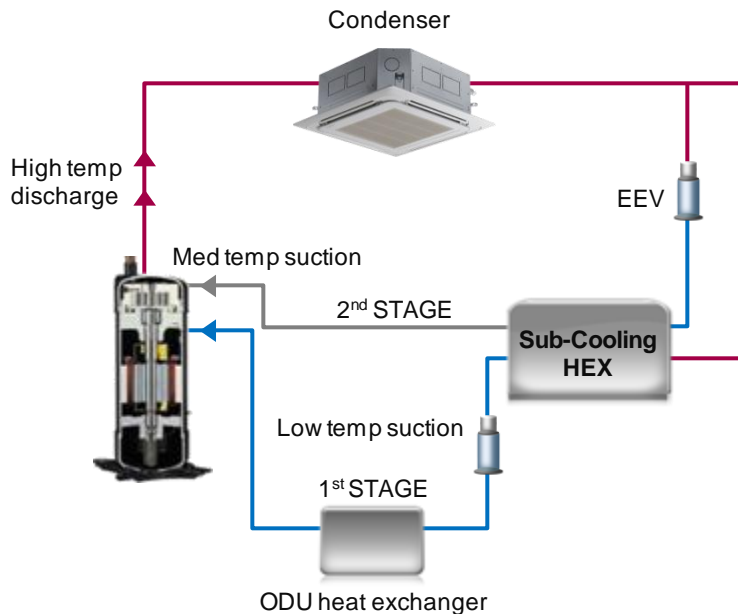
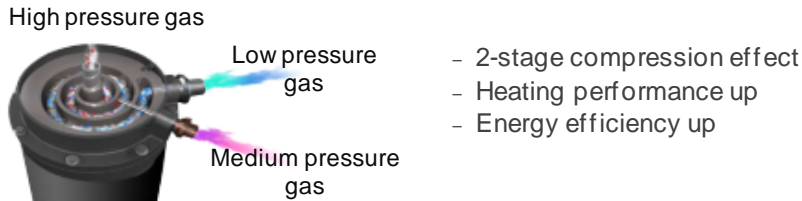
- Required oil recovery operation by oil Level Sensor  
→ Minimize energy consumption



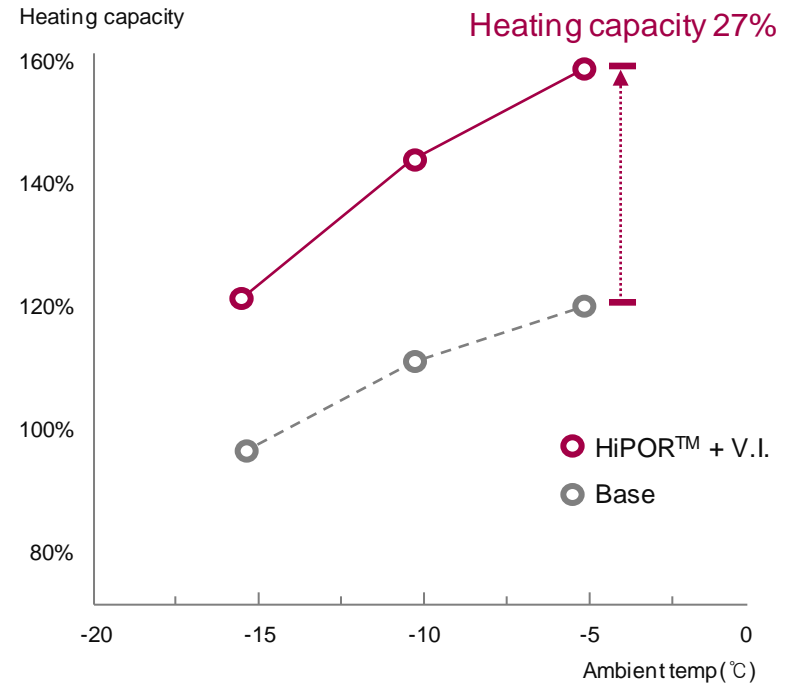
# Vapor Injection

Improved heating performance and enhanced heating temp. range with new Vapor Injection and HiPOR™ technology. There is 27% increase in heating capacity and 11% improvement in heating efficiency

## Vapor Injection



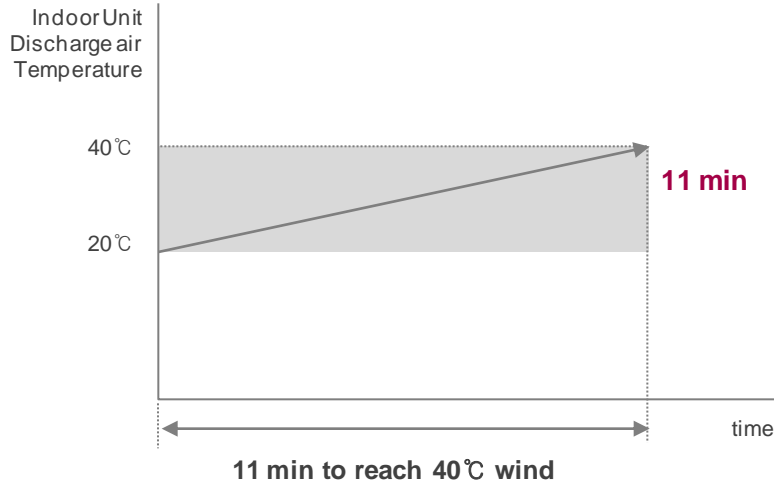
## Combined effect (VI + HiPOR™)



# Fast Heating via Advanced Inverter

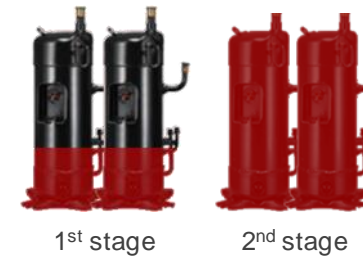
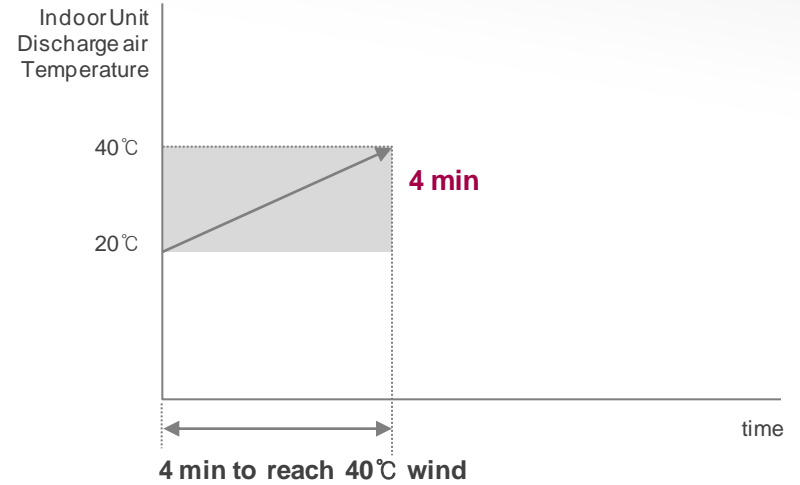
World Best Level heating performance by All Inverter Compressor and Optimized Cycle Design.  
Indoor unit discharge air temperature reaching time is reduced up to 63%.

## Multi V III



Compressor sequence control

## MULTI V™ IV

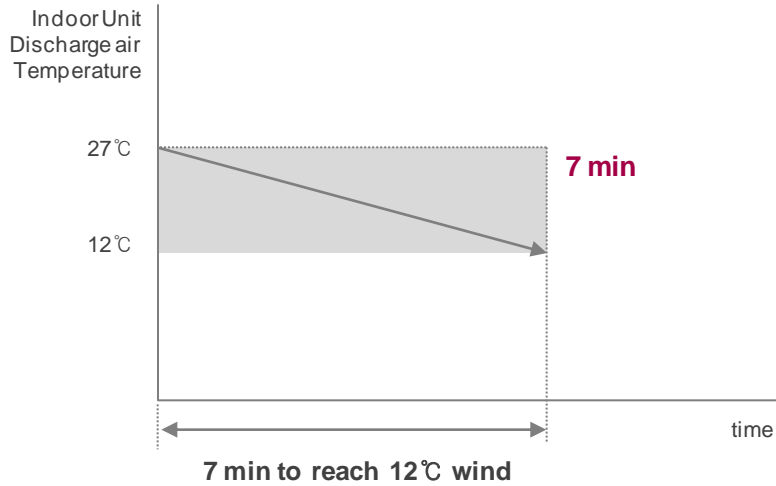


All inverter simultaneous control

# Fast Cooling via Advanced Inverter

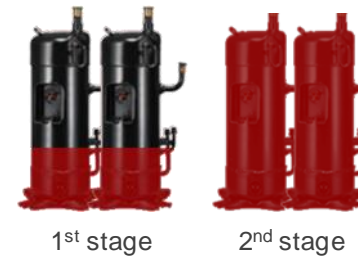
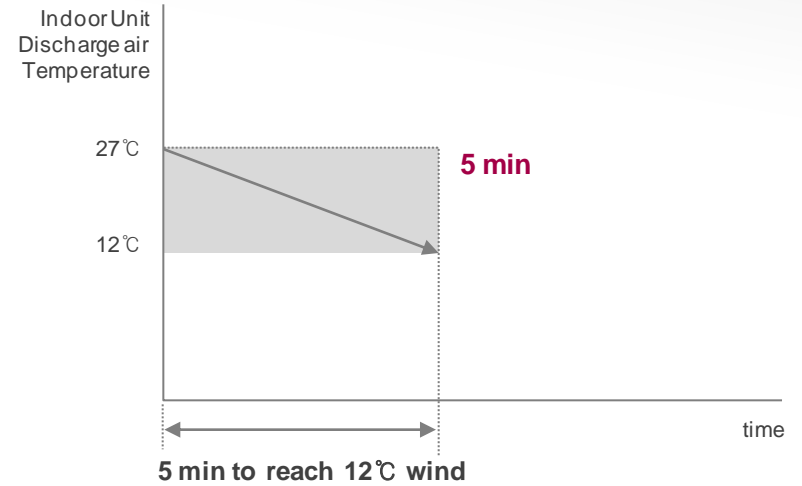
World Best Level cooling performance by All Inverter Compressor and Optimized Cycle Design.  
Indoor unit discharge air temperature reaching time is reduced up to 28%.

## Multi V III



Compressor sequence control

## MULTI V™ IV



All inverter simultaneous control

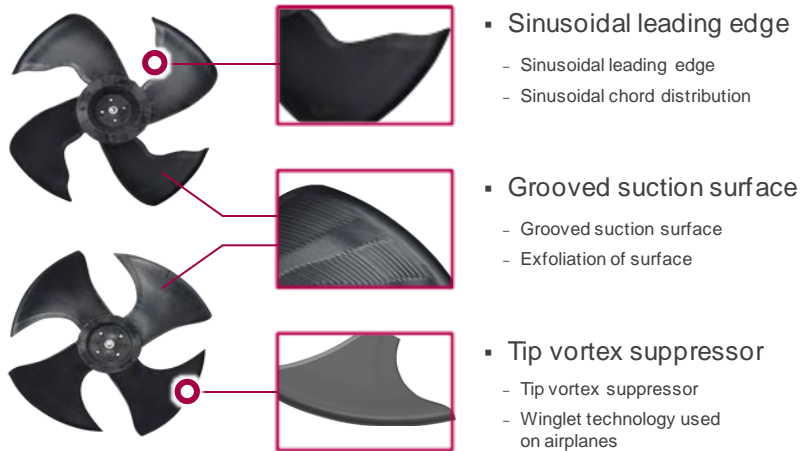
# Low Noise Operation

Operation sound level is decreased by New Fan Technology.  
 Low noise operation at night is possible thanks to inverter technology.

## New Fan Technology

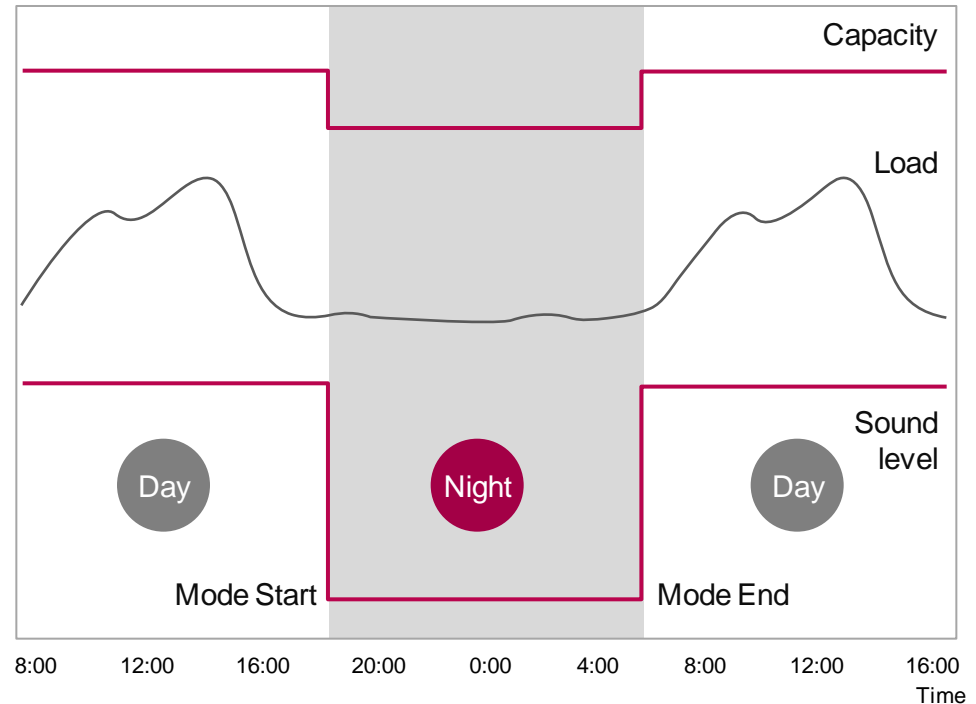
- Cannon Fan

- Due to decrease of vortex and separation close to the blade, the air volume is increased in 50CMM and the noise level is decreased by 4dB(A).



## Night Silent Operation

- 3 Time Mode and 3 Step Noise Level
  - 3 time mode : 9 hr, 10.5 hr, 12 hr
  - 3 step noise level : 55 dB(A), 52 dB(A), 49dB(A)

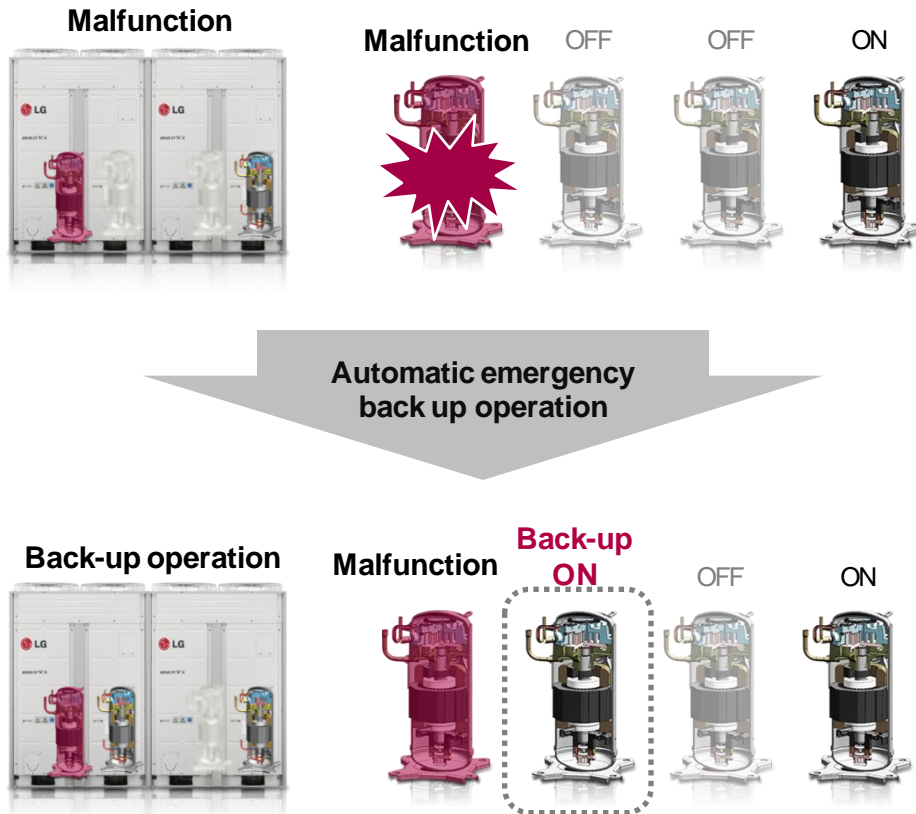


# Emergency Operation Function

Emergency Operation Function minimizes the inconvenience that may occur in an emergency and makes servicing very convenient and easy.

## Back-up Operation

- Automatic emergency back up function operates the alternate compressor during compressor failure.

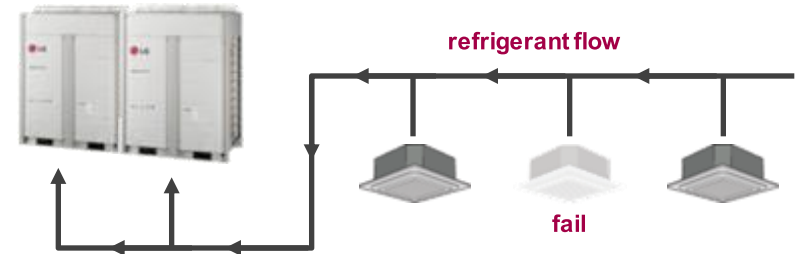


## Auto Refrigerant Collection Operation

- When an outdoor or indoor unit malfunctions, this function automatically collects its refrigerant before servicing.

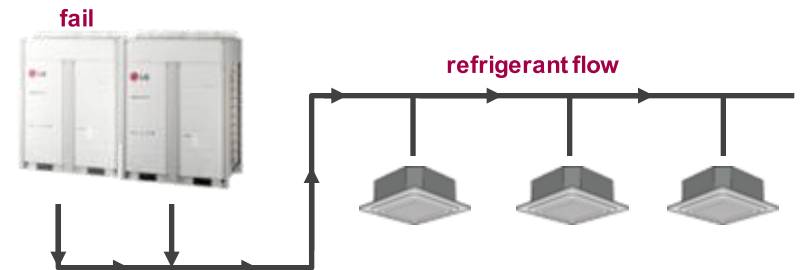
### PUMP DOWN

- in case indoor fail, refrigerant from indoor unit and pipe is collected to outdoor unit.



### PUMP OUT

- in case outdoor fail, refrigerant from outdoor unit pipe is pumped to indoor unit and pipe.



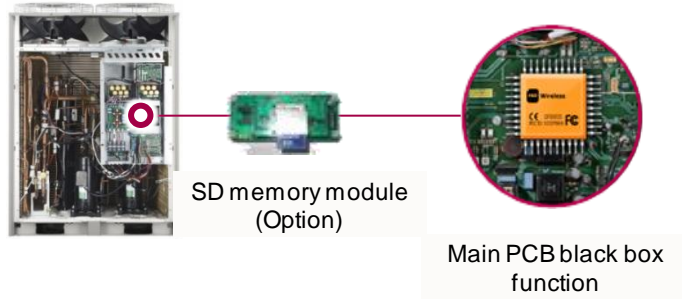


# Upgraded Fault Detection and Diagnosis

In Multi V IV has improved black box function, auto refrigerant charging and refrigerant recovery operation the reliability and ease of maintenance.

## Failure history storage(black box function)

- 3 years operation record data can be saved with SD memory card  
 ※ In case of Outdoor Unit 20HP, Indoor Unit 4ea



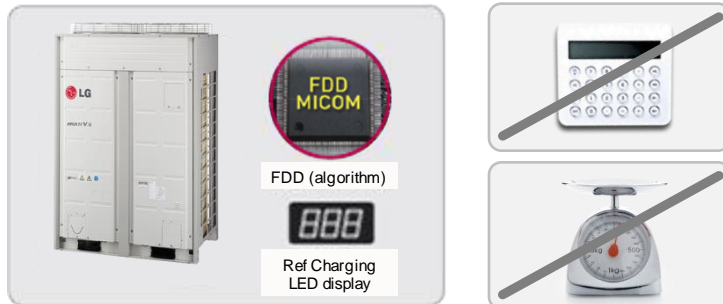
## Automatic refrigerant leakage and sensor check

- After product installation, refrigerant leakage is checked and then refrigerant charge is judged through start up operation



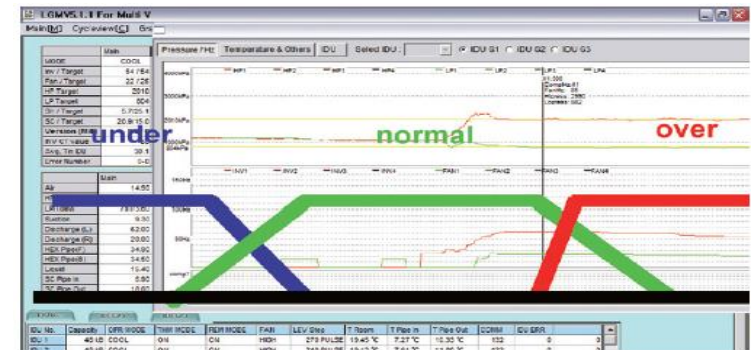
## Automatic refrigerant charge technology

- There is service port on outdoor unit, refrigerant can be charged even during winter
- Refrigerant calculation is possible even in case of minor refrigerant leakage



## Auto refrigerant charge check

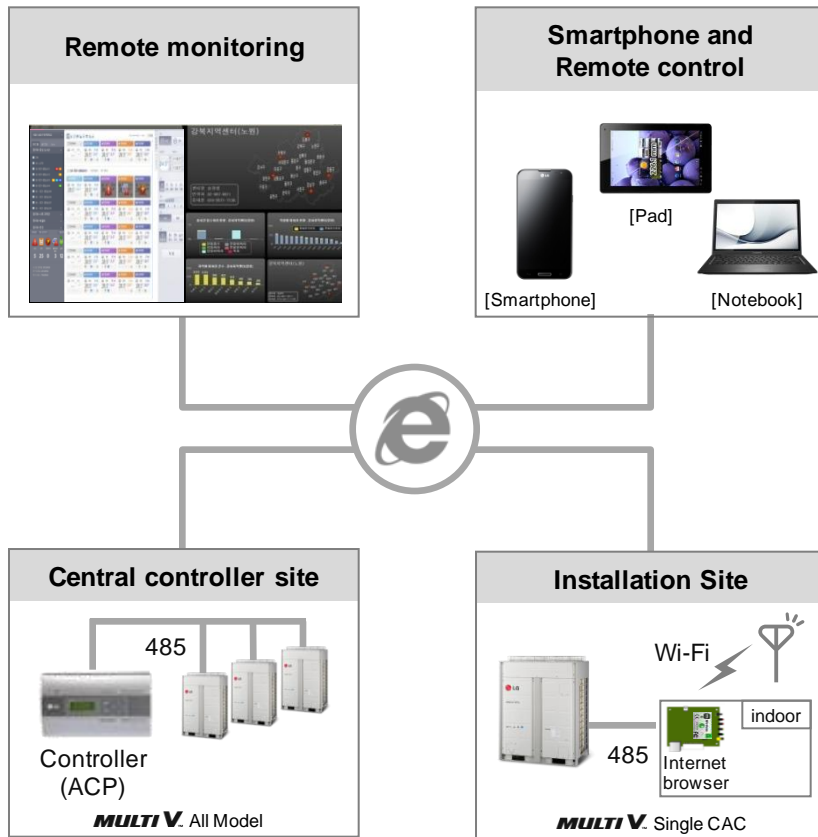
- Prevent refrigerant leakage due to sensor failure or compressor burnout.



# Smartphone Monitoring and Control

Real time monitoring and management of commissioning, maintenance of central controller site are possible through smartphone and remote control.

## Smartphone Control

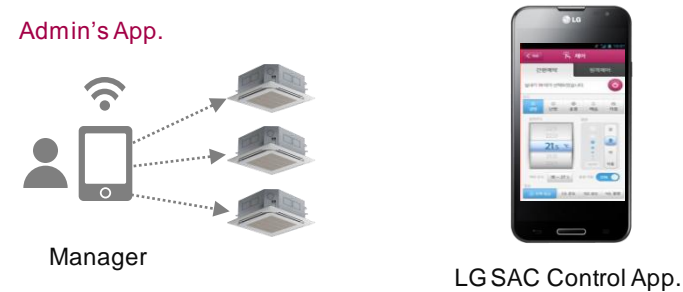


## Smartphone Application

- Cycle monitoring and control



- Group control





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