

Development of Hot Water Heat Pump Using A3 Refrigerant R290

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MITSUBISHI ELECTRIC CORPORATION

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- **Education**

- Majored in Heat Transfer in Mechanical Engineering at university.

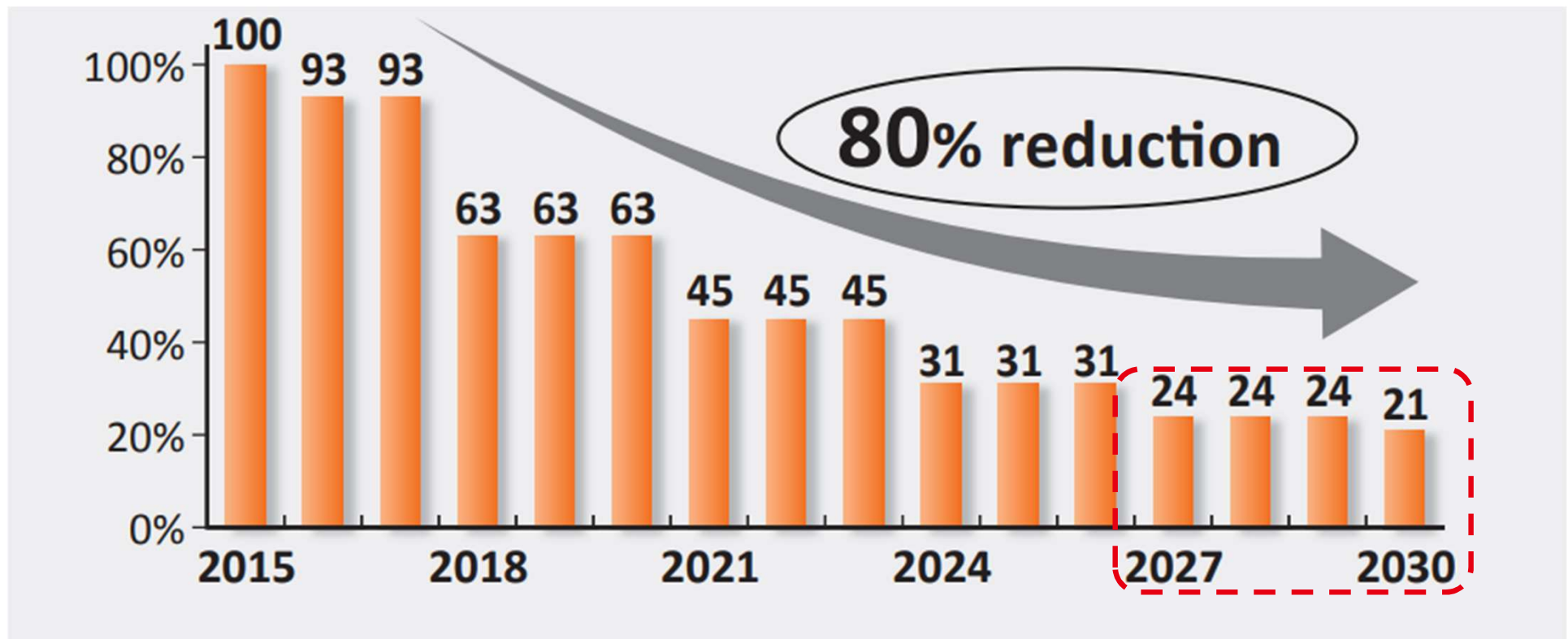
- **Work Experience**

- Joined Mitsubishi Electric Corporation in 2018
- Engaged in research and development of air conditioners, chillers, and heat pumps.

1. Introduction
2. Target system
3. Characteristics of R290
4. Field test in Europe
5. Safety measures from storage to recycling
6. Conclusions

- In Europe, the goal is to be carbon neutral by 2050.
- Heating and hot water supply systems in commercial buildings are being converted from boilers to heat pump systems.
- On the other hand, the F-gas phase-down has been implemented for HFC refrigerants used in heat pumps.

GWP: Global Warming potential



F-gas phase down

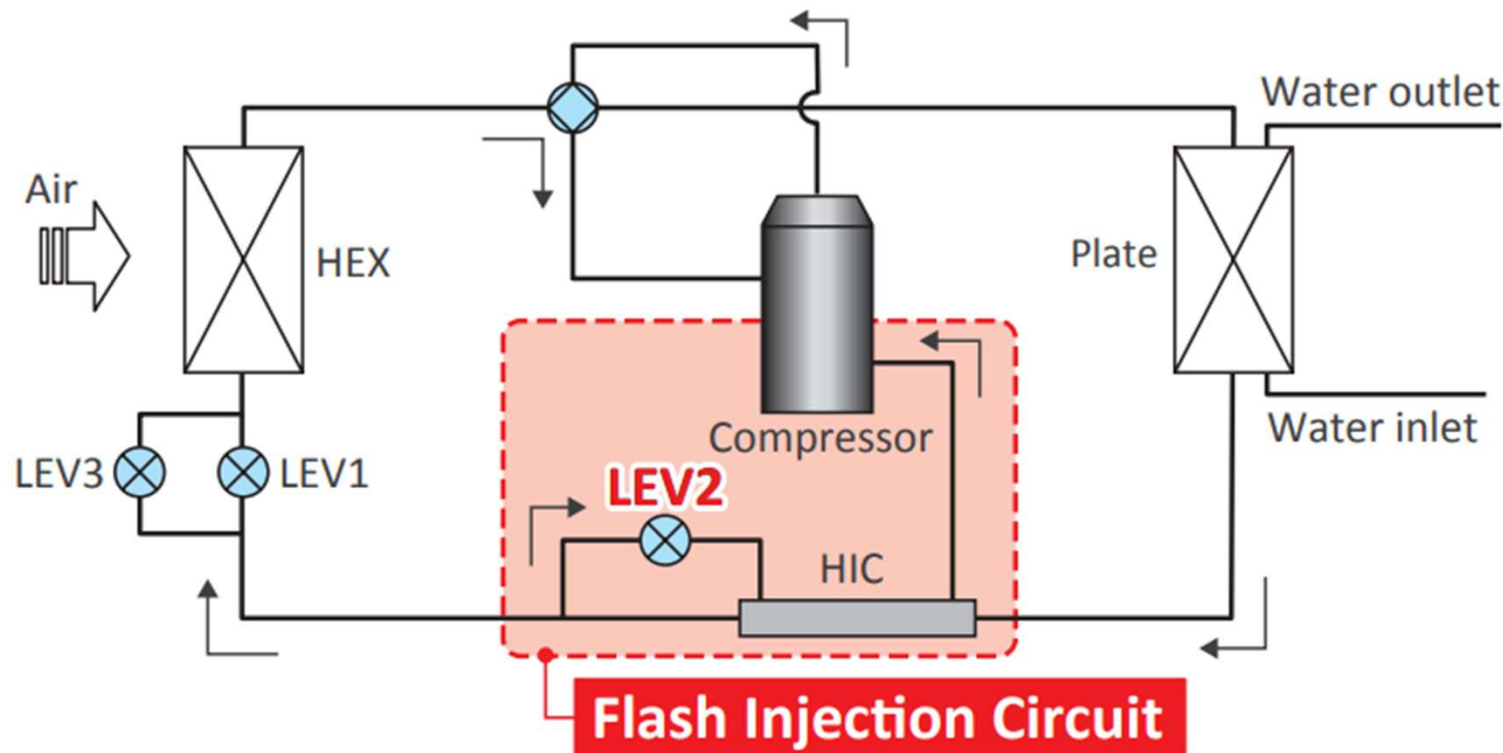
Lower GWP refrigerants will be necessary for heat pumps.

- For carbon neutral, Mitsubishi Electric is developing Hot Water Heat Pump (HWHP / CAHV-Z) using natural refrigerant **R290** for commercial market.
- R290 has a higher condensing temperature at lower pressure, making it suitable for **high temperature water**.
- R290 has a **better** coefficient of performance **COP** compared with our existing product, R454C HWHP (CAHV-R).



The new HWHP (CAHV-Z)

- In order to achieve higher temperature water supply at low ambient temperature, the new HWHP adopts the flush injection circuit.
- Partial two-phase refrigerant flows into the injection port in the compressor via flash injection circuit for controlling the increase of the discharge temperature.



The refrigerant circuit of the new HWHP

- System consists of the refrigerant circuit in the heat pump and a water circuit on-site.
- The heat generated by the heat pump is used for hot water, floor heating or radiator and other applications.
- **R290 circulates only within the heat pump (unit) installed outside.**



Configuration of Heat pump heating and heat supply

- R290 has a low GWP value, and it is **not consisted of F-gas material**.
- Its Flammability is classified as **Class 3**.
- There is no temperature gradient because of a single refrigerant.

Comparison of refrigerant properties

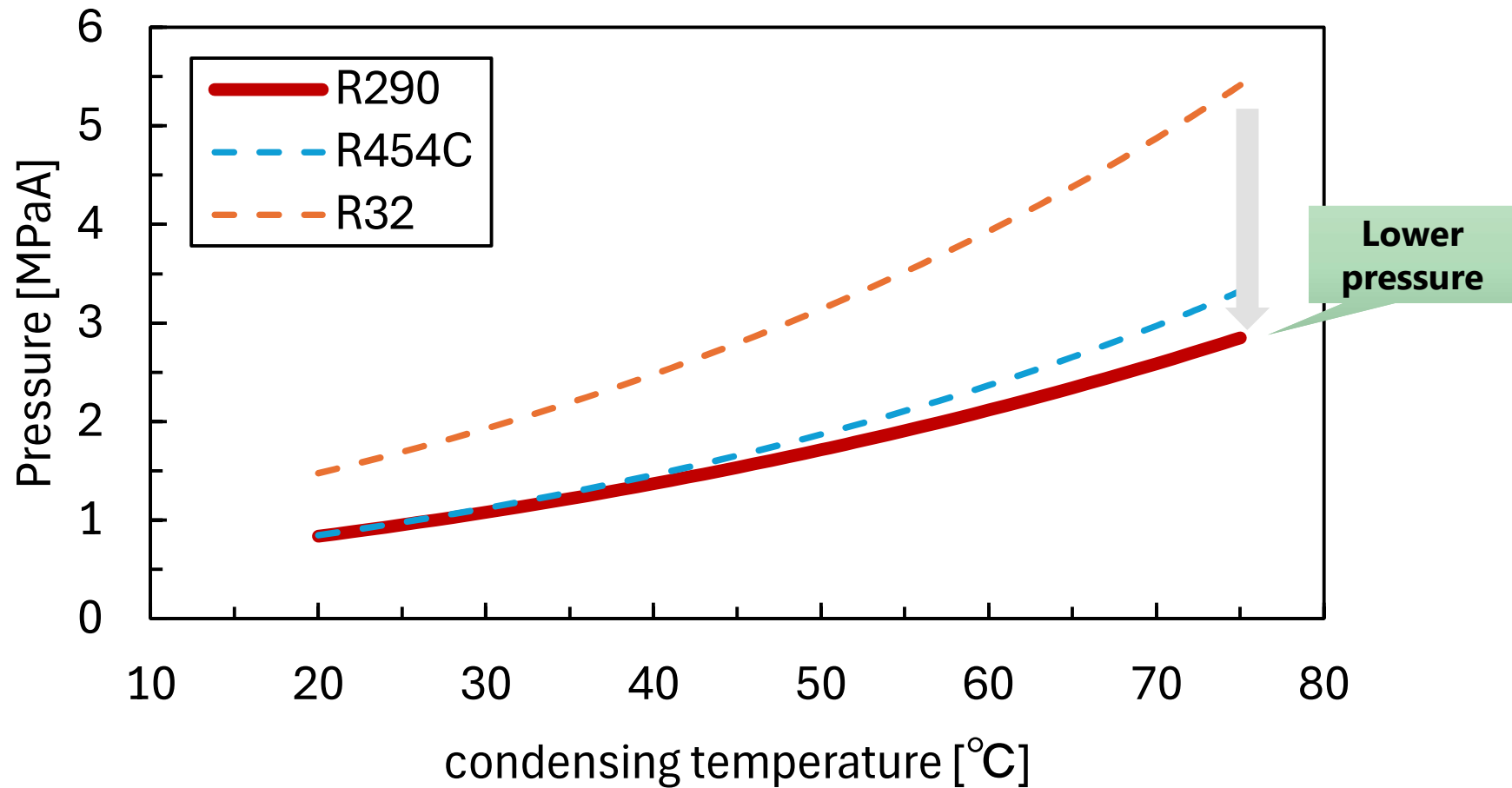
	R290	R454C	R32
GWP *1	3	148	675
Flammability	Higher Flammability	Lower Flammability	Lower Flammability
Temperature gradient *2	0	7.8	0

*1 IPCC 4th assesment report

*2 NIST REFPROP ver10.0

Saturation vapor temperature 0°C

- Compared to R32 and R454C, R290 can achieve a higher condensing temperature at lower pressure, making it easier to produce **high temperature water**.

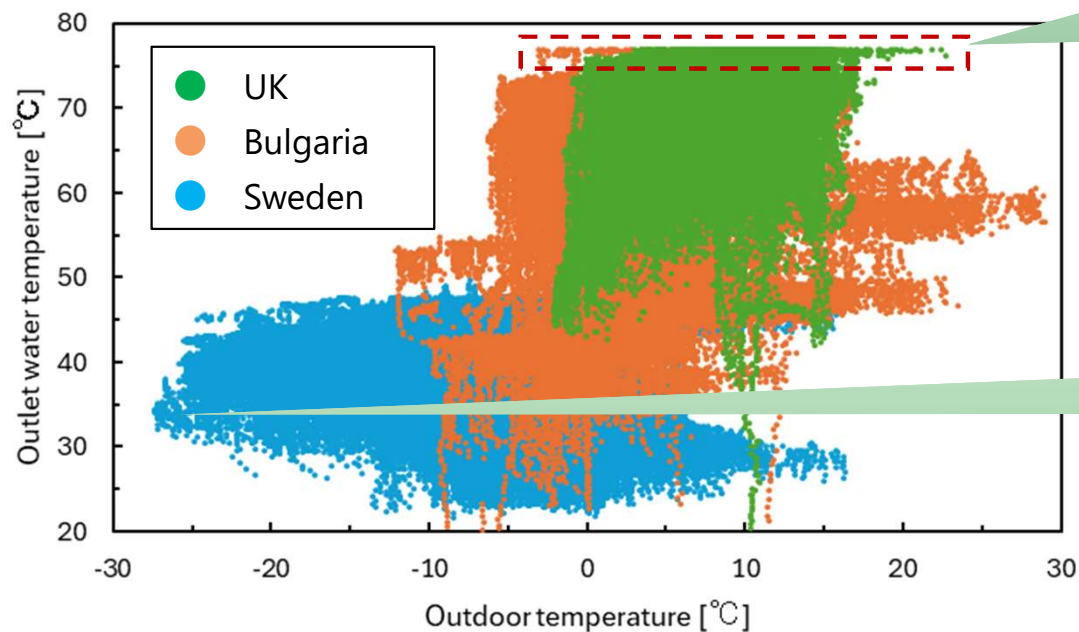


Pressure variation with condensing temperature

- Evaluated the quality and performance in three regions of Europe as the field test.
- The features of prototype is below;
 - The rated capacity is 40 kW, equivalent to existing R454C HWHP.
 - Can provide hot water at 75°C at low ambient temperatures.
 - Safety measures are implemented to minimize the risk of ignition in the event of R290 leakage.
 - The refrigerant amount is limited to less than 4.94 kg in accordance with IEC standards.



- Reasons for selecting the location below
 - UK: Operating conditions are close to standard conditions, equivalent to an ambient temperature of **7°C**.
 - Bulgaria: Operating conditions are close to frosting conditions, equivalent to an ambient temperature of **0°C**.
 - Sweden: Extremely low temperature conditions are equivalent to a low ambient temperature of **-20°C**.

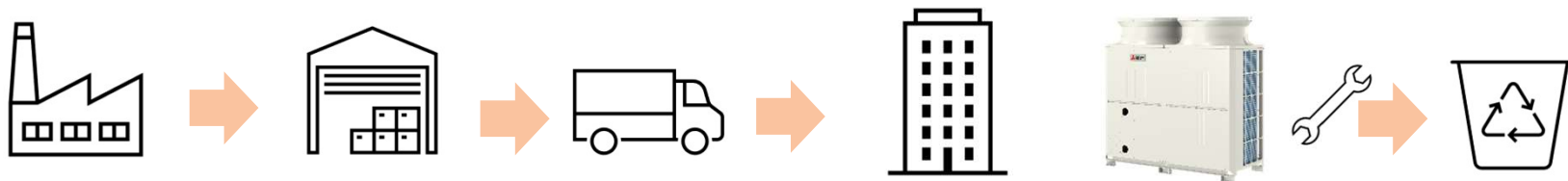


Confirmed that hot water can be supplied at 75°C from subzero to standard ambient temperature.

Confirmed that operation is possible even at an ambient temperature below -20° C.

Operation range of field tests

- The countermeasures to reduce the risk of ignition for R290 leakage after product manufacturing from storage to recycling
- Working items
 - Research and comply laws and regulations
 - Safety education using e-learning
 - Training for installers
 - Confirming the removal and repair procedures after installation



	Storage	Transport	Installation	Service & maintenance	Recycling
Laws and regulations	Research and comply with EU region including the UK and national laws and regulations				
Safety Education	Safety training and certification to handle R290				
Training				Hands on training	

Countermeasures from storage to recycling of R290 unit

- The field test units was utilized in the UK to demonstrate process below;
 - Refrigerant recovery
 - Compressor repair process
- Within Europe, the sales branch at Mitsubishi Electric has already established regulatory manuals and work procedures, enabling safe operations even when handling flammable refrigerants.



Leak detector used during the recovery process
(JAVAC 718-202-G21)



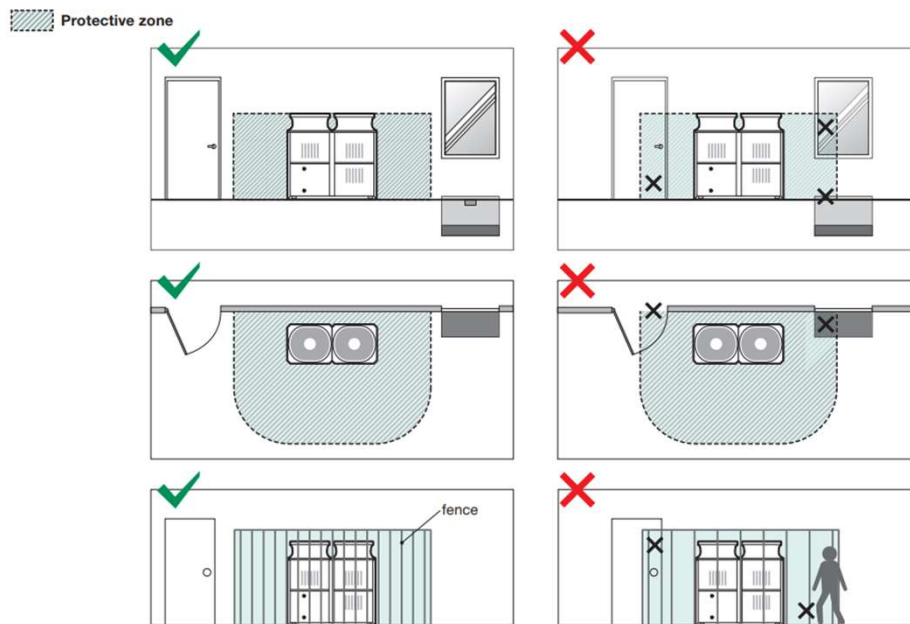
Cutting process of the compressor
without flame

- **Visual indications**

-Need for **ventilation** during transportation

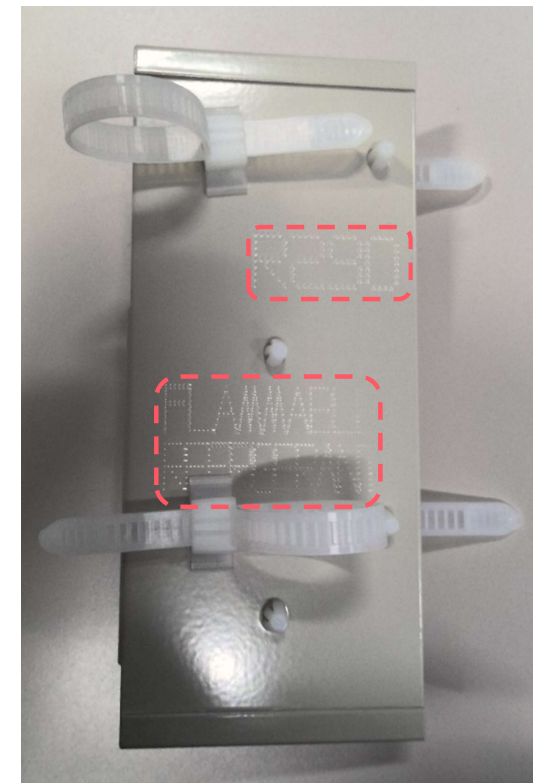


-Installation conditions



No openings to the interior in a protective zone.
Protective zone: Areas of high concentration
 when refrigerant leakage.

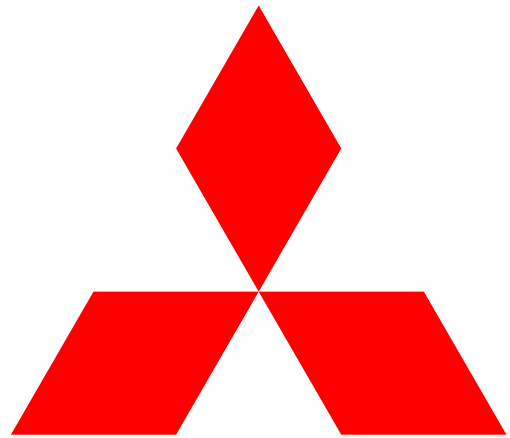
-**Engraving the use of R290** on the sheet metal inside the machine room for **semi-permanent indication** until recycling.



- The hot water heat pump using R290 is developing as the CAHV series to facilitate the replacement of boilers with heat pumps in commercial market of Europe.
- It is confirmed through field test that:
 - Hot water can be supplied at 75°C from subzero to standard ambient temperature.
 - The operation is possible even at low ambient temperature below -20°C.
- In order to achieve higher temperature water supply at low ambient temperature, the new HWHP adopts the flush injection circuit.
- The target refrigerant charge is less than 4.94kg in accordance with IEC standards, which contributes to the prevention of explosions risks based on our own risk assessment.
- The countermeasures have been taken to reduce the risk of ignition for R290 leakage in anticipation of after product manufacturing from storage to recycling.
- In Europe, heat pumps using flammable refrigerants are becoming increasingly common. Also, regulations regarding to flammable refrigerants have been established. It is expected that heat pumps using R290 will also become widespread in Japan in the future.

- **Future efforts**

- In preparation for mass production, we will enhance product quality through in-house testing.
- Update safety education and methods of notice to ensure safety for the use of the HWHP.
- Products that meet the specifications required by the European commercial market will be developed.



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