

Next
Heat Pump
Generation

NxtHPG



NxtHPG project

"Next Generation of Heat Pumps working with Natural fluids"

ENGINEERING
TOMORROW

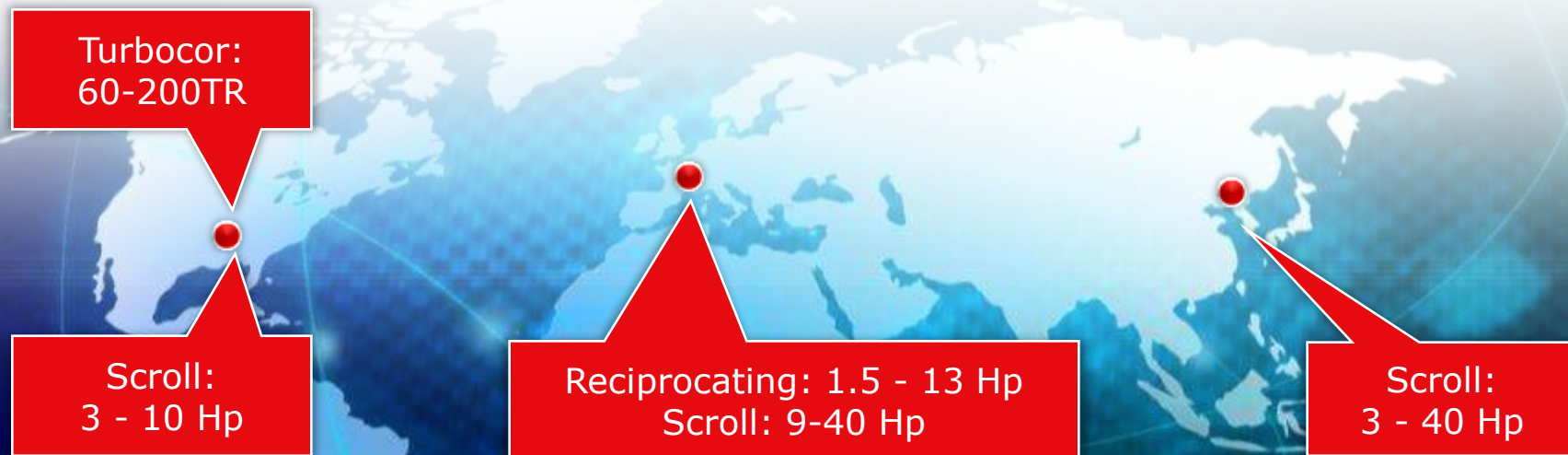
Danfoss

Scroll compressors for Low GWP **Heat Pumps** using **R290** natural refrigerant

Pierre Ginies

Danfoss Commercial Compressors

- Leading compressor R&D and manufacturing for commercial air conditioning, heating and refrigeration applications since 1971
- Manufacturing in Europe, USA, China
- Leading the market in commercial inverter scrolls with prequalified drives
- Pioneers of Danfoss Turbocor Compressors with oil-free, magnetic bearing technology



NxtHPG Project baseline

NxtHPG Project aims

- Heat pumps reaching higher efficiency and lower carbon footprint than current state of the art HFCs/HFOs or Sorption heat pumps
- Include efficient capacity modulation and the highest capabilities for combination and integration with other renewable sources in the energy systems of Buildings and Industry
- Hydrocarbons (HCs): air or water to water heat pumps supplying hot water at (40-50°C) for heating applications as well as to produce sanitary hot water at 60°C

NxtHPG Project baseline

Heat pump application

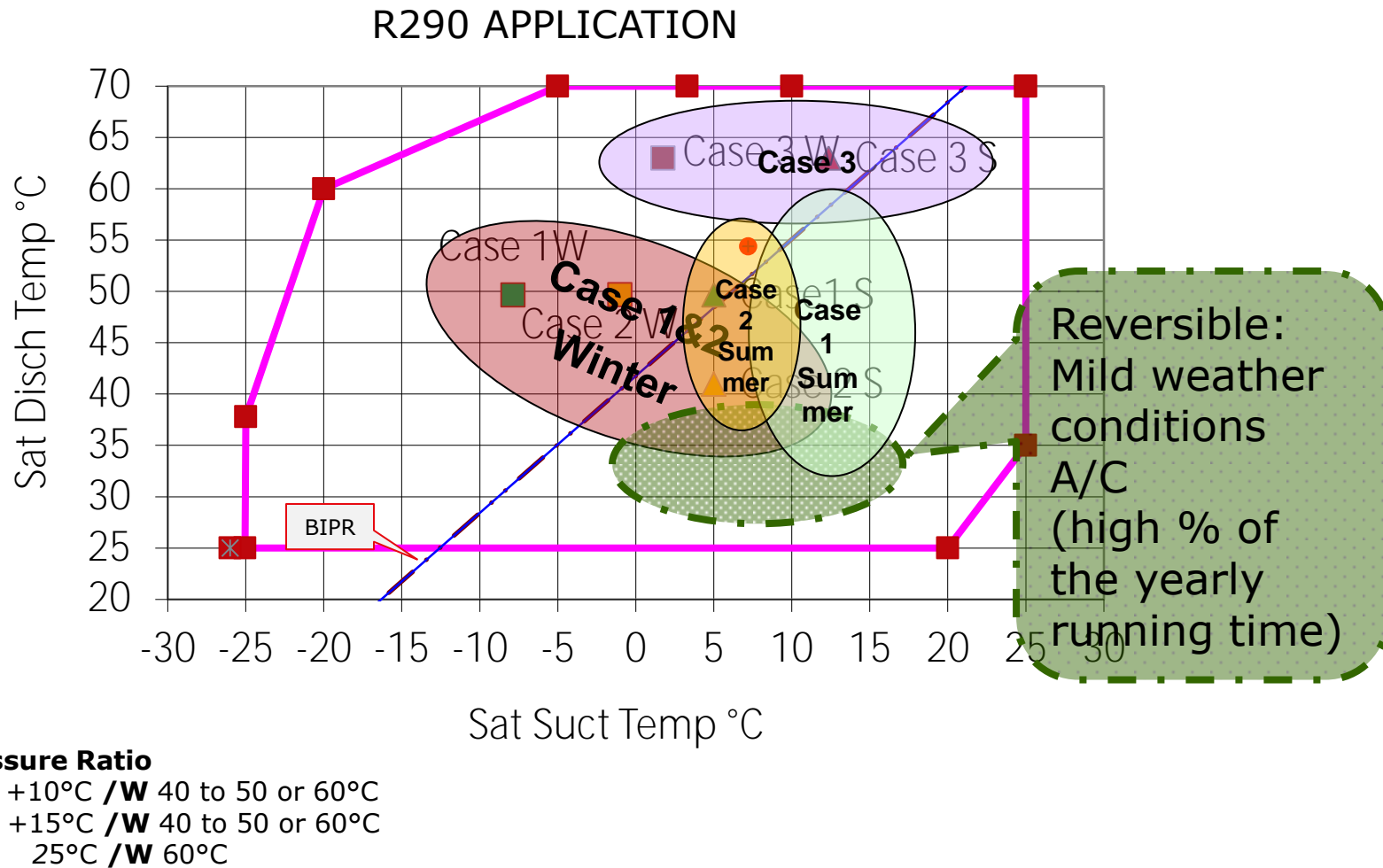
Case	Fluid	Source	T(°C)	Sink	T(°C)	Application	(kW)
1	HC (Propane)	Air	-10 to 10	Water	40 to 50	Heating water production	50
					60	Low demand of Sanitary hot water	
2	HC (Propane)	Water (brine)	-5 to 15	Water	40 to 50	Heating water production	100
					60	Low demand of Sanitary hot water	
3	HC (Butane)	Water	Neutral loop at 25	Water	60	Sanitary hot water production	50

Note

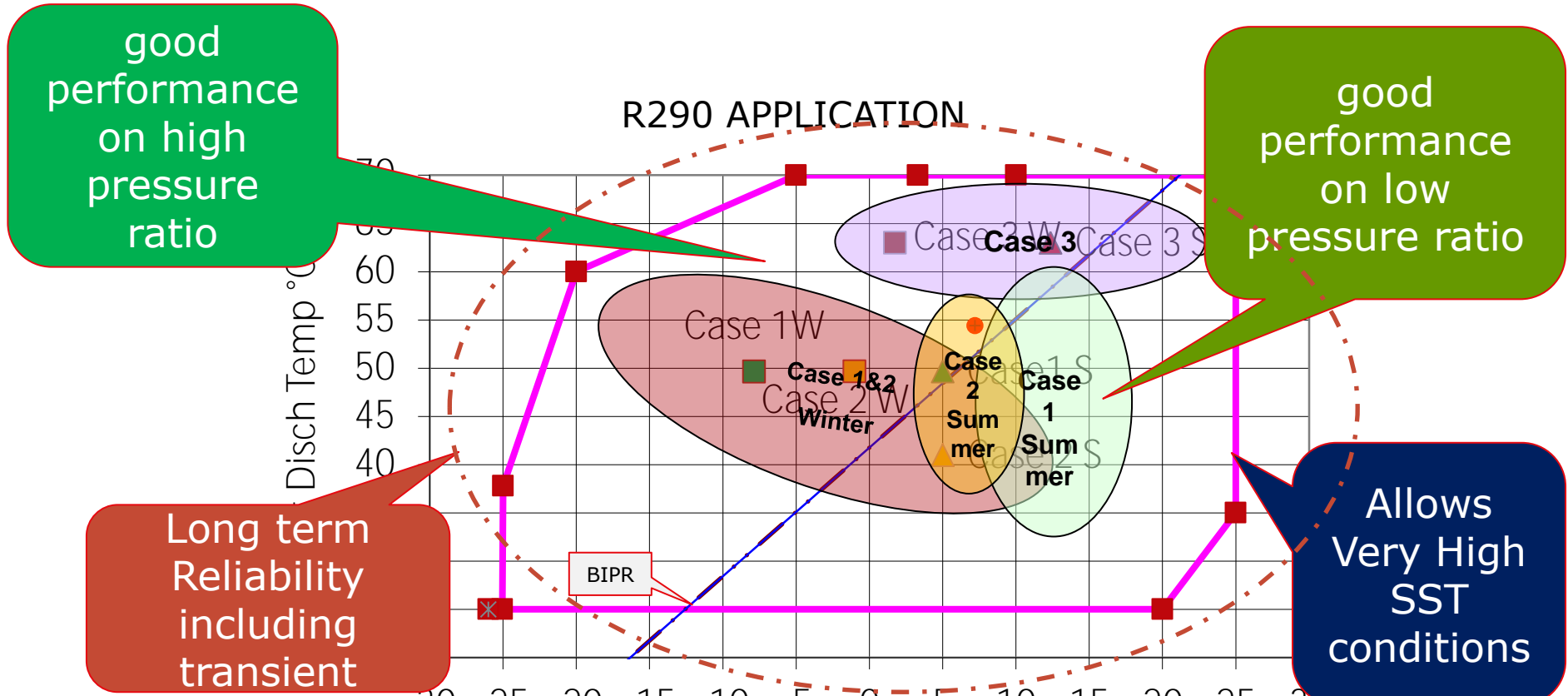
1 Case 1 & 2 should be suitable for reversible application.

2 Case 3 will use R290

R290 NxtHPG Heat Pump & reversible Applications



R290 NxtHPG Compressor requirement



- Legend:**
W: Winter
S: Summer
BPIR: Built In Pressure Ratio
- **Case 1: A** -10 to +10°C /W 40 to 50 or 60°C
 - **Case 2: W** -5 to +15°C /W 40 to 50 or 60°C
 - **Case 3: W** 25°C /W 60°C

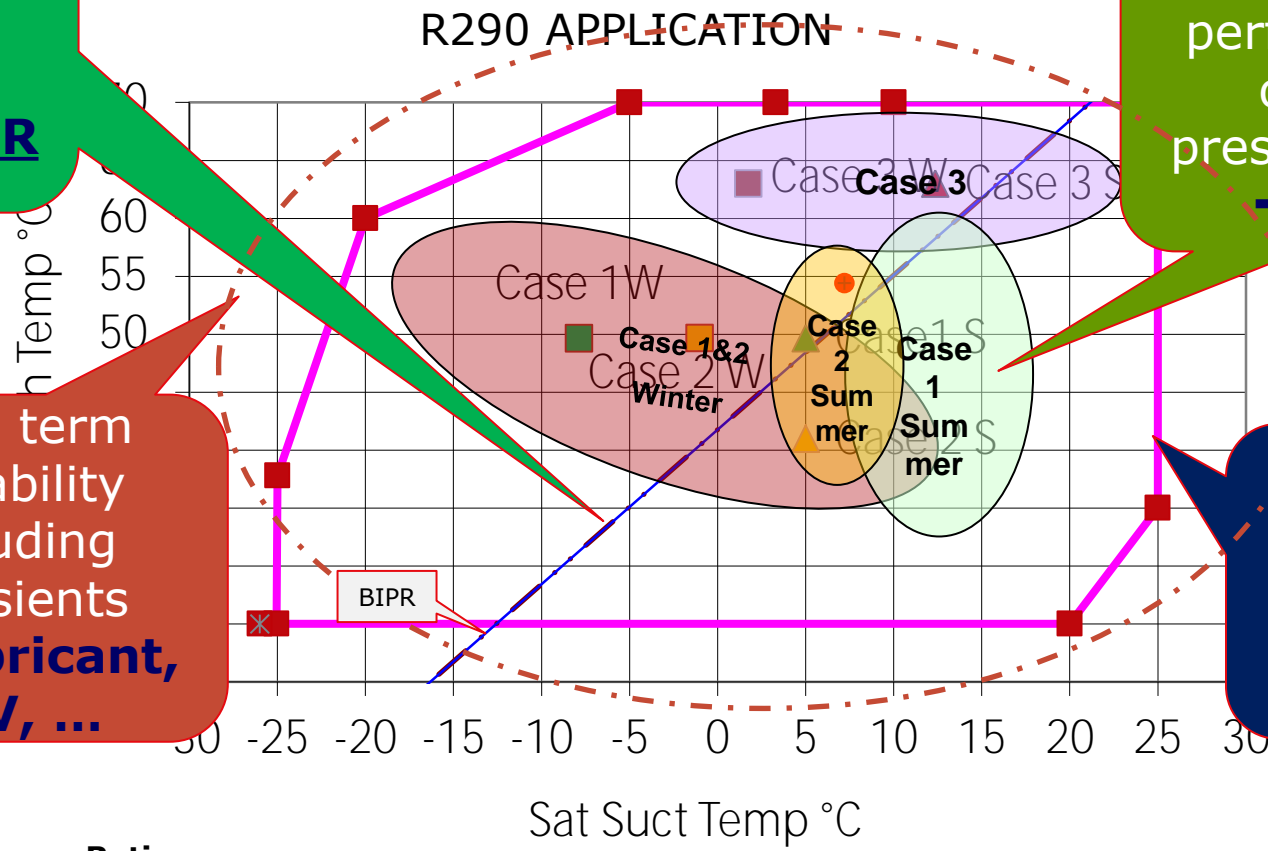
R290 NxtHPG Compressor requirement

good performance on high pressure ratio
 → **high BIPR**

good performance on low pressure ratio
 → **IDV**

Long term Reliability including transients
 → **Lubricant, IDV, ...**

Allows Very High SST conditions
 → **IDV, ...**



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BIPR: Built In Pressure Ratio
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Scroll Compressors for Heat pump application

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Note

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2 Case 3 will use R290



Case 1
Cases 2&3

NxtHPG051 + Inverter
NxtHPG038

NEW compressor family:

Compressor are coming from existing platform for economic
Compressor uses high BIPR
IDV implementation
New lubricant

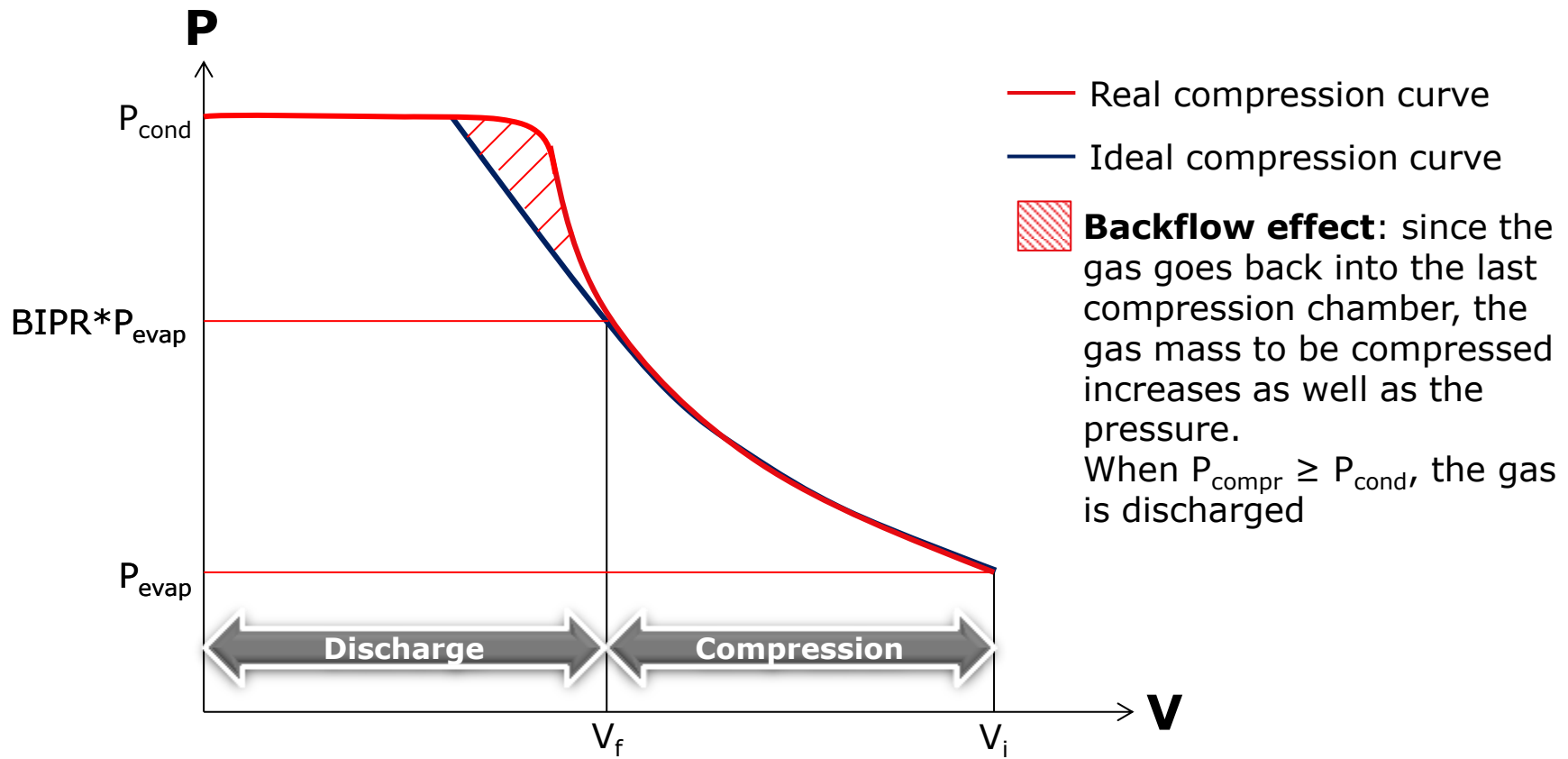
Scroll Compressors for Heat pump application

Adaption work on scroll compressors

- Efficiency improvement of the compression process with high BIPR
- IDV feature for performances and reversible application
- IDV feature for reliability
- Compressor reliability investigation
- Lubricants selection

Efficiency improvement of the compression process: High Pressure Ratio Conditions and BIPR impact

$$P_{\text{cond}} > \text{BIPR} * P_{\text{evap}}$$



Efficiency improvement of the compression process: with **I**ntermediate **D**ischarge **V**alves

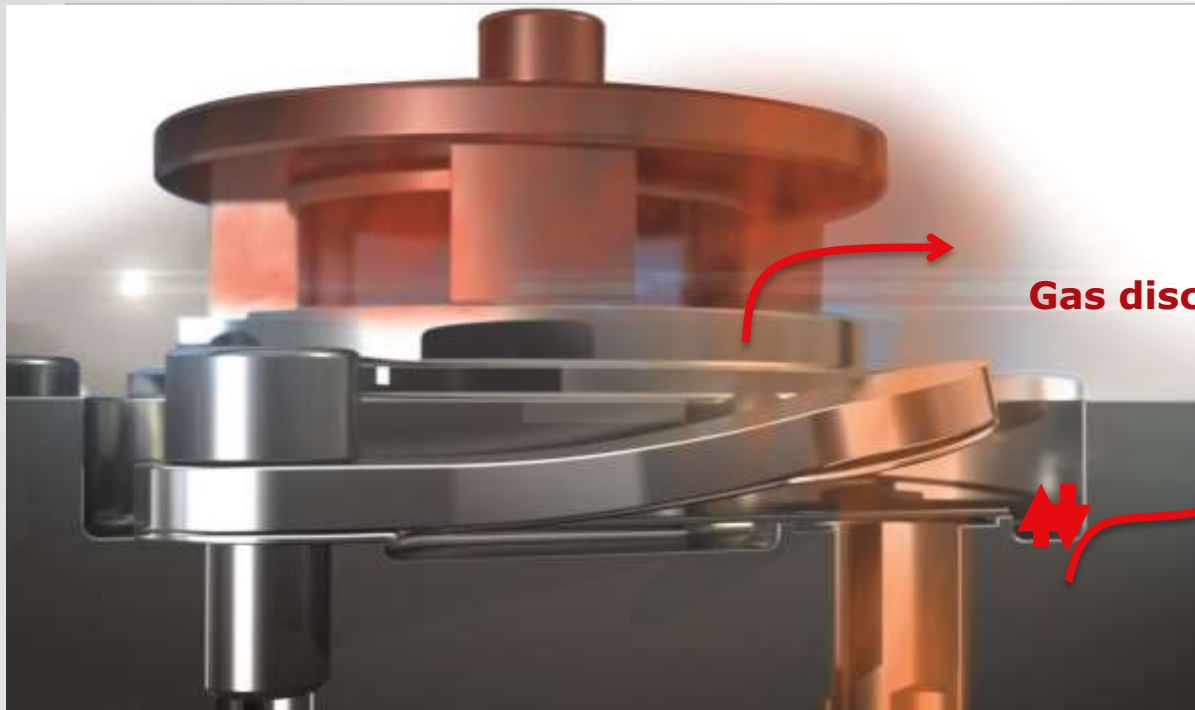


Description:

Mechanical valve that adapts the motor effort to the pressure conditions in the system to improve part-load efficiency of air conditioning systems

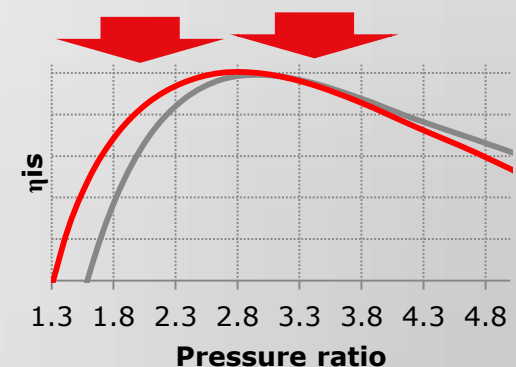
Main Benefits

- **Energy savings in part-load conditions**
- **Applied cost savings**
- **Lower starting load / stress on mechanical parts**



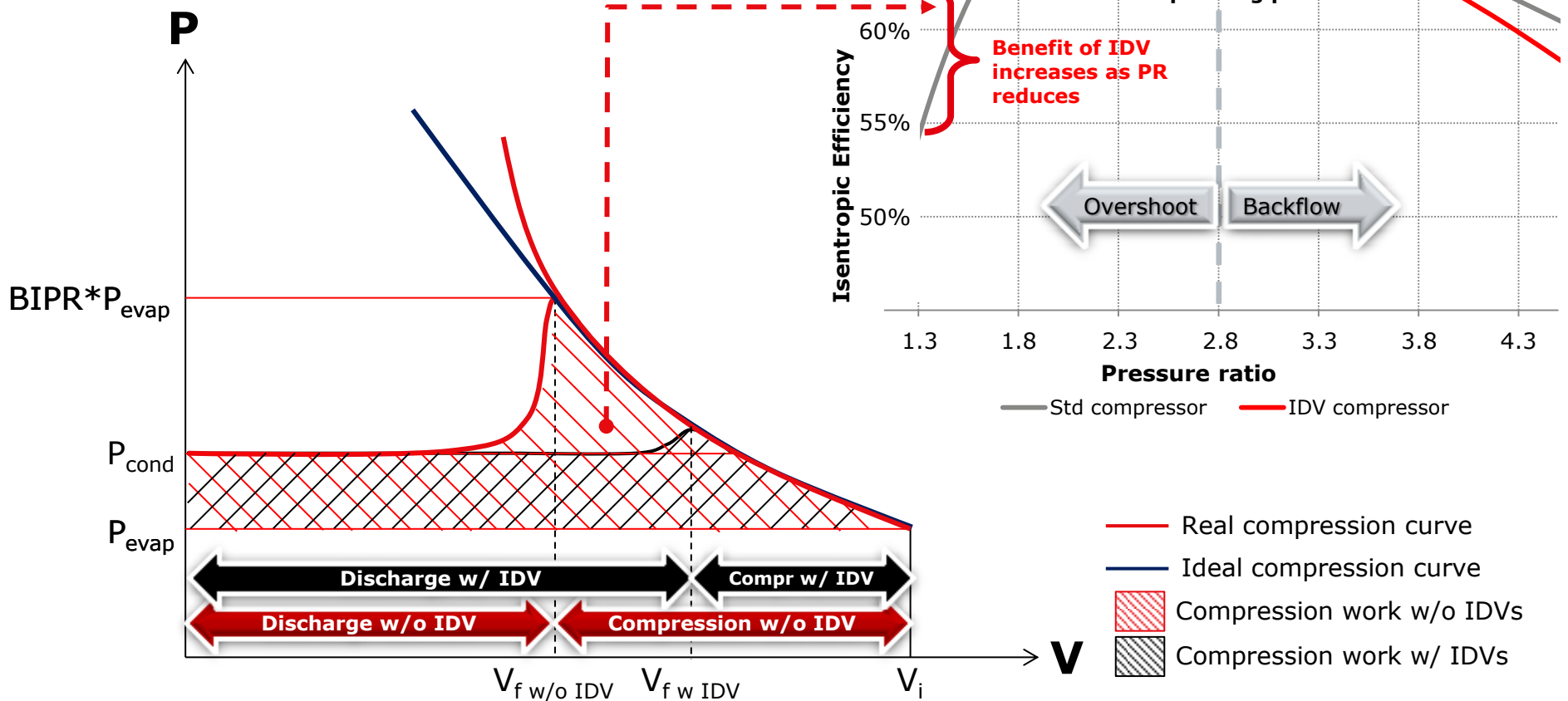
High Pressure Ratio:
IDV closes

Low Pressure Ratio:
IDV opens



Efficiency improvement of the compression process: IDV Benefits

$$P_{\text{cond}} < \text{BIPR} * P_{\text{evap}}$$



Compressor performance testing

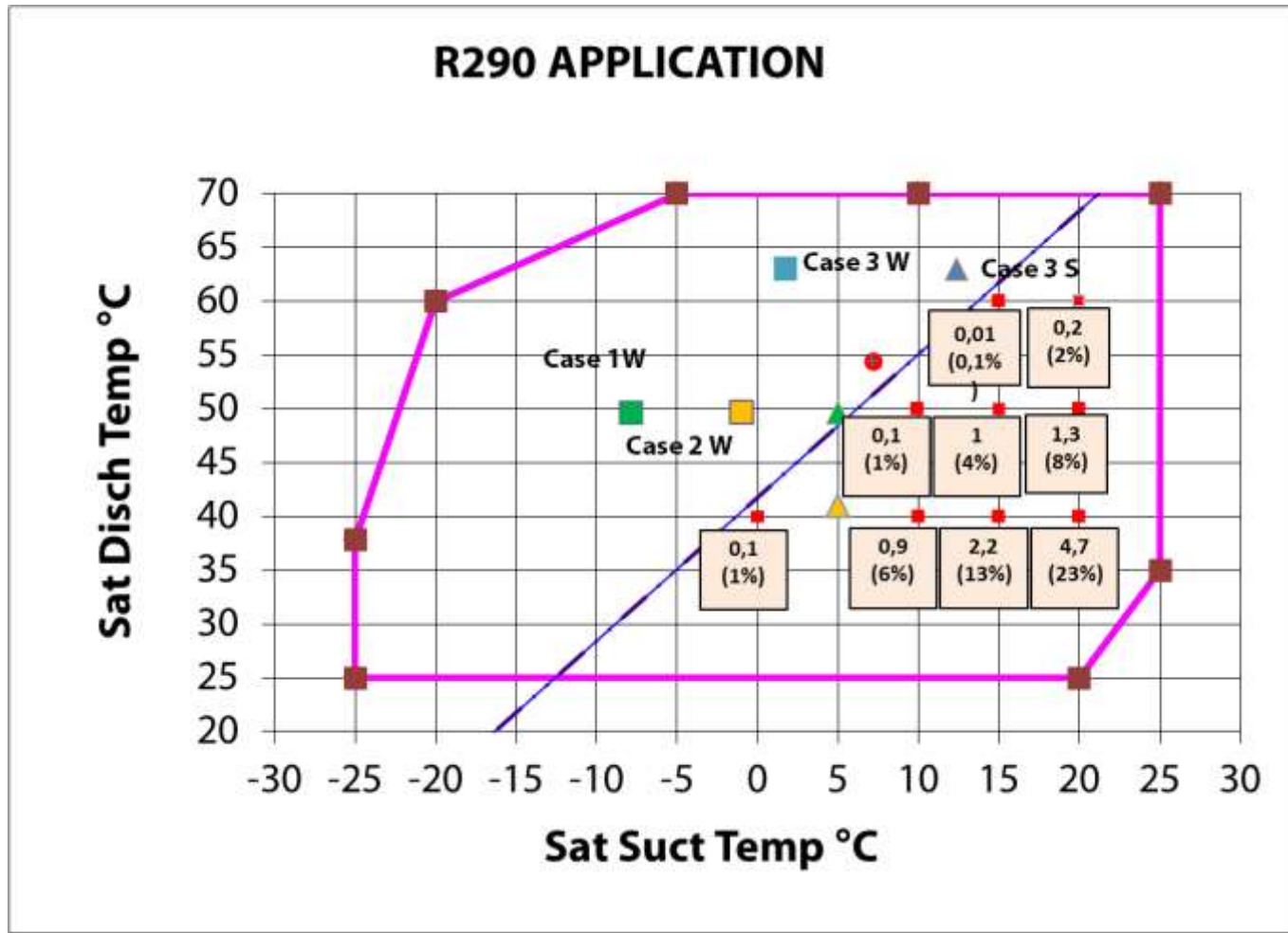
Note Hardware:

- Use secondary fluid HC lab 30kW calorimeter and large single fluid calorimeter >100kW
- Adapted to HC lab safety requirement



Calorimeter #12 on HC labs

Performance measurement: NxtHPG051 + drive @ 50Hz



IDV performance improvement Δ EER [W/W] and (Δ [% ratio])

Compressor Reliability: Extra Benefits with **IDV**

Danfoss Intermediate Discharge Valves...

- reduce the compression mechanism torque
- reduce line amps during starting transient period
- allow to start at higher Saturated Suction Temperature



Compressor mechanical loads reduction during start periods with **IDV**



Compressor starting load can be approached by equivalent SDT

Without IDV : *Pocket Disch. pressure = BIPR * Suction pressure*

Case			R290		No IDV	With IDV
1	2	3		BIPR	100%	~50%
A/W	W/W	W/W	SST °C		SDT °C equivalent	SDT °C equivalent
X	X		10		60	30
X	X		15		66	36
X		X	20		73	42
X		X	25		80	47
		X	30		93	53

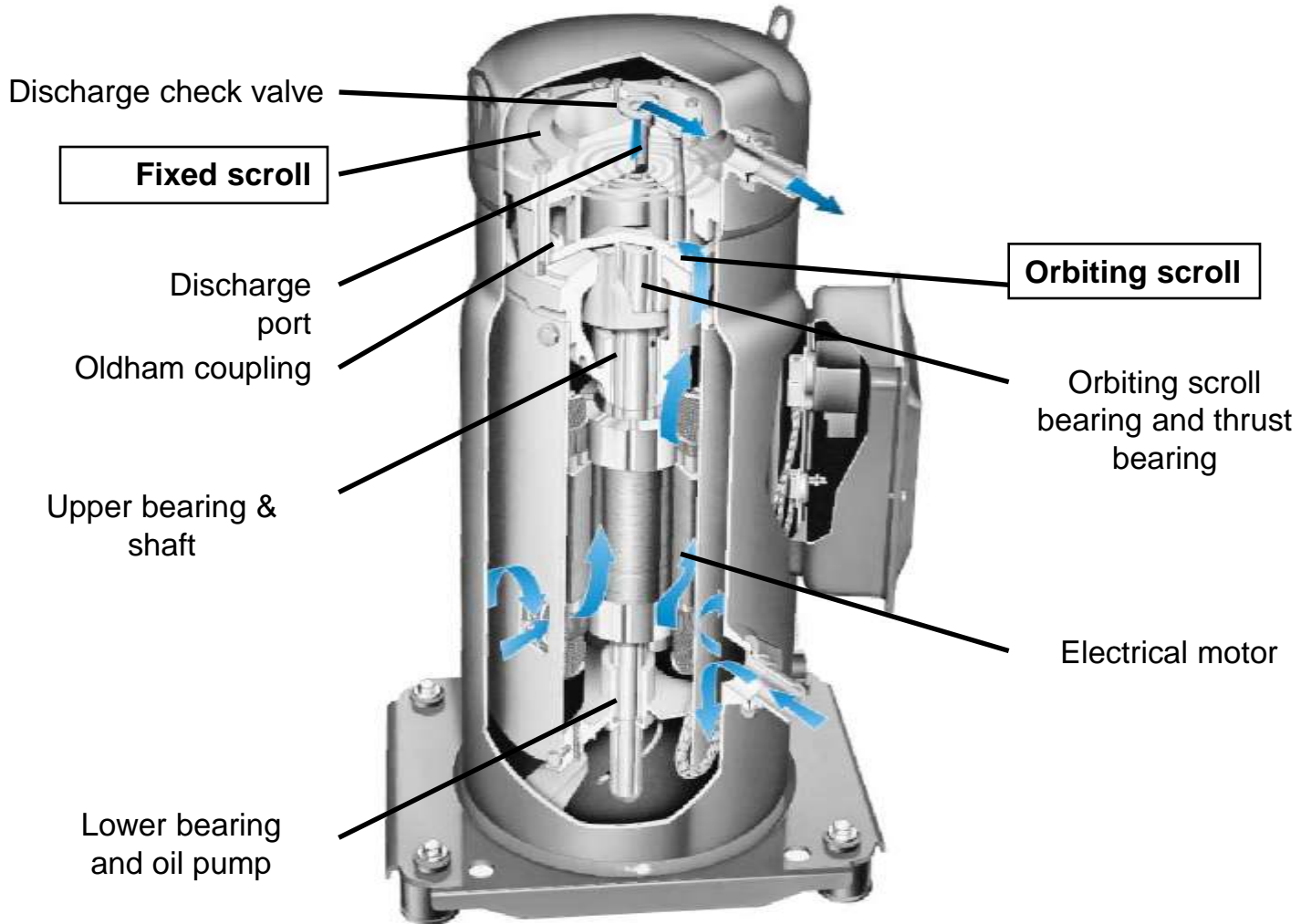
BIPR: Built In Pressure Ratio

IDV feature limits compressor load during high SST starting conditions

Compressor Reliability: Compressor **Lubricant** selection

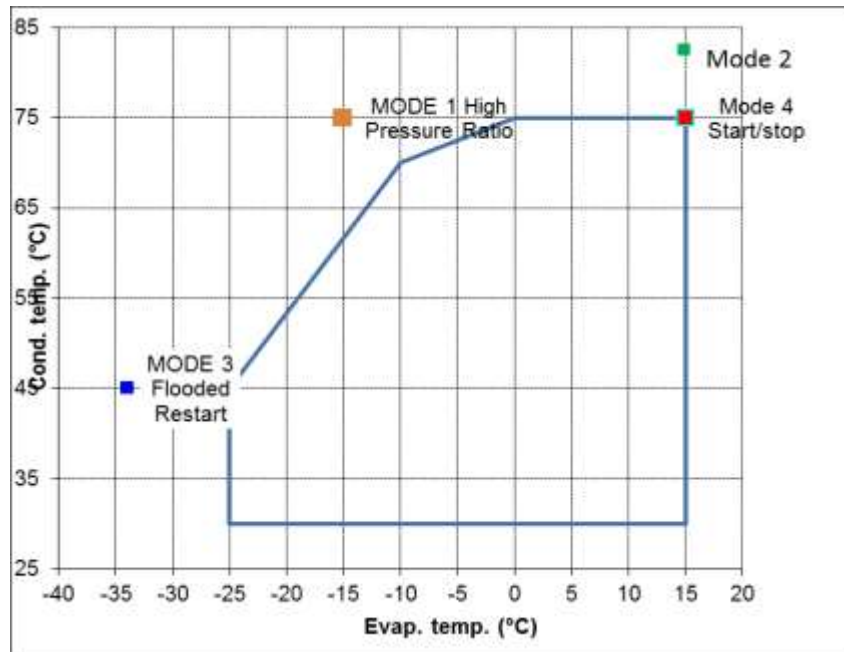
- R290 is very soluble in classic lubricants
 - We investigated in the past:
 - MO
 - POE
 - AKB
- Based on Low HC soluble POE and PAG materials.
- Today we will focus on:
 - Compressor reliability
 - R290 solubility on oil compressor sump for reduced SH conditions

Compressors reliability testing



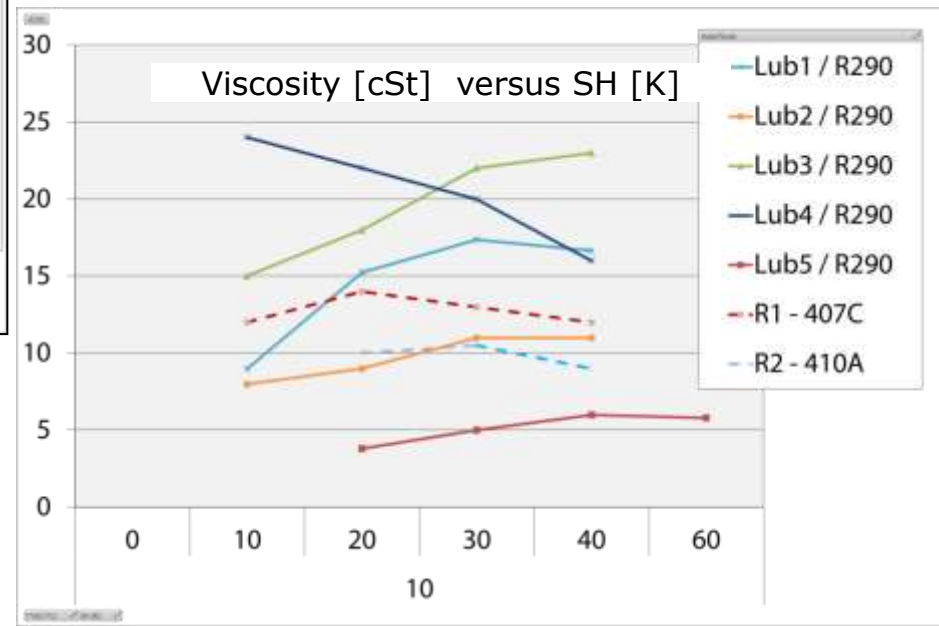
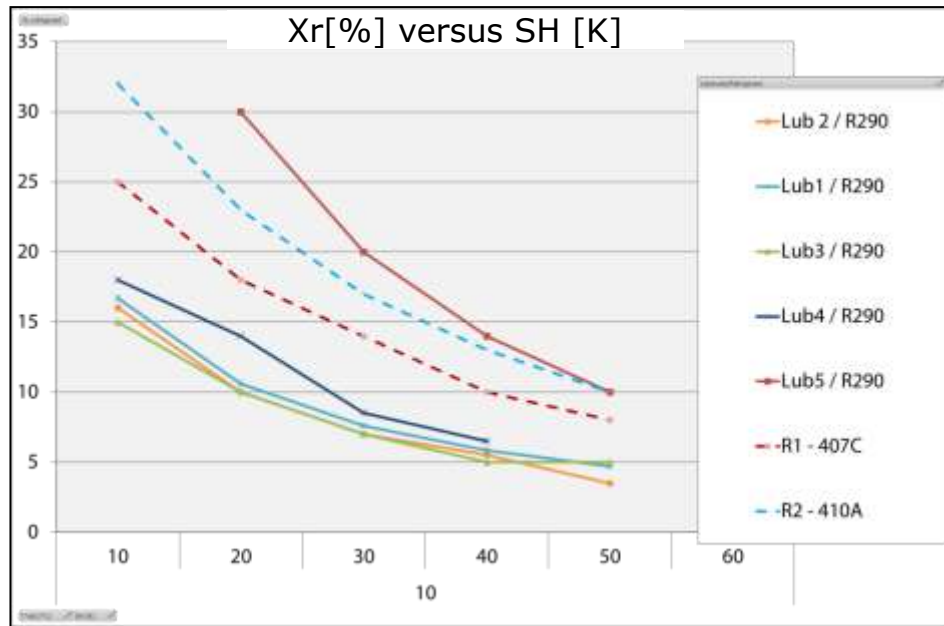
Compressor reliability testing

- Setting the life test conditions
- Based on existing experience & knowledge
- We use 4 modes LFT for large scrolls



➔ Bearing improvement done for flooded conditions

Refrigerant Solubility % in Compressor Oil Sump: steady state comparison @ SST 10°C



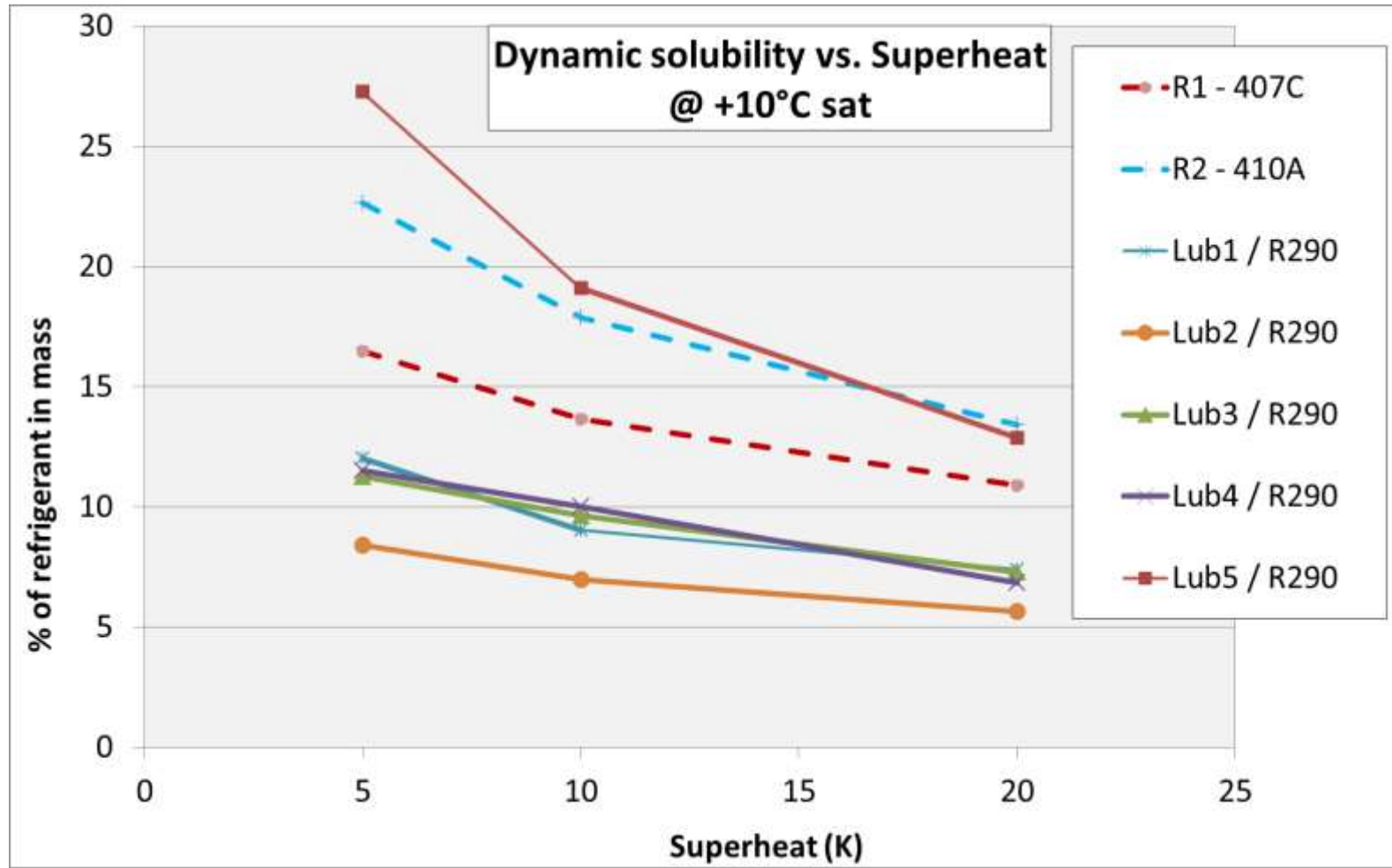
R290 Dynamic Solubility tests done

Principle:

- Run the compressor in required conditions
 - Various suction gas super heat
 - One or two saturated condensing temperatures
- In steady state conditions, sampled lubricant from oil sump and measured the R290 % solubilized in lubricant oil sump



Refrigerant % in oil sump



Conclusions

- NxtHPG scrolls are based on **existing HFC** platform
- **High BIPR & IDV integration on these R290 scrolls compressor bring:**
 - Better performances at lower pressure ratio running conditions
 - Same compressor can be used in a wide pressure ratio applications range
 - Improved reliability by lower mechanical load during pull down and/or pull up situations
 - Allows to enlarge application range in higher evaporating conditions
- **Lubricants:**
 - We have developed a new low soluble lubricant for Hydro Carbons operating in low SH conditions
 - We have investigated low miscibility lubricants
- Compressor design has been tuned to keep the **high reliability level**

Thank you for your attention



"This project has received funding from the European Union's Seventh Program for research, technological development and demonstration under grant agreement No [307169]".



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