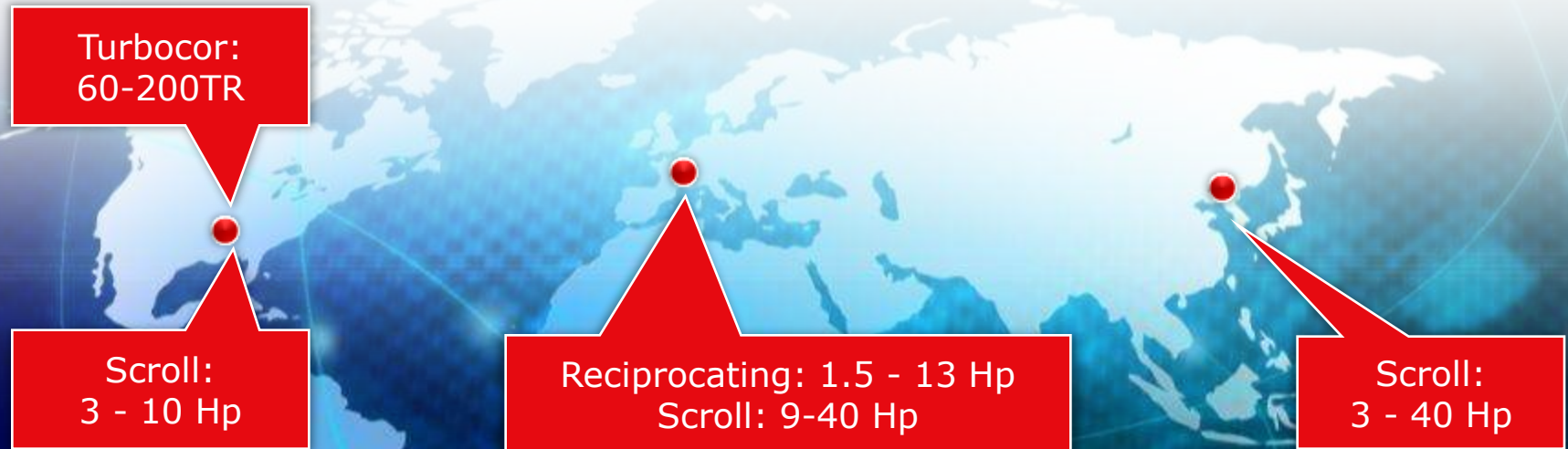


Scroll compressors for Low GWP **Heat Pumps** using **R290** natural refrigerant

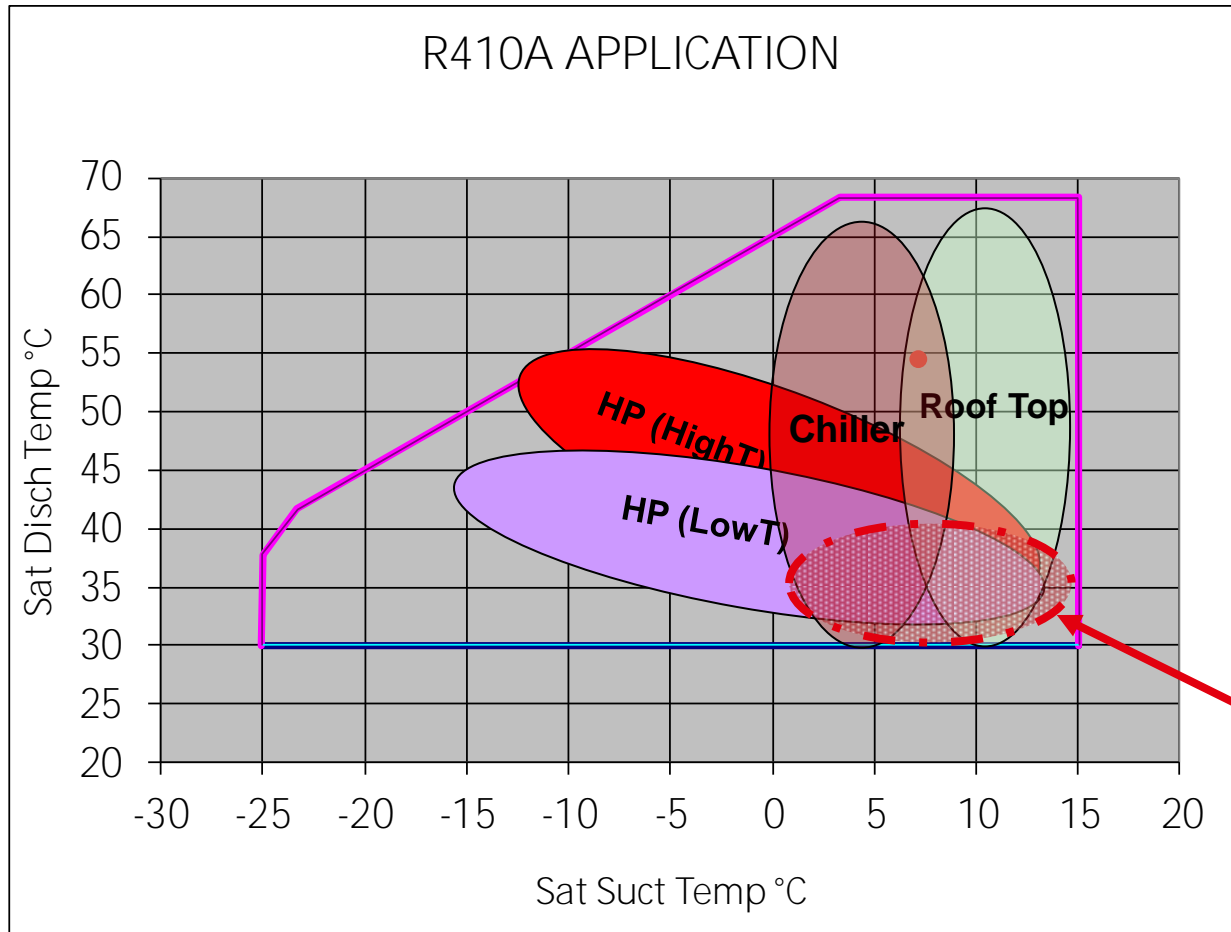
Pierre Ginies, Next Heat Pump Generation 2015
p.ginies@danfoss.com

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



HFC Applications in A/C & HP



**Conditions for
Seasonal
Performances**

**97% of
running time**

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

Case 1 NxtHPG051 + Inverter

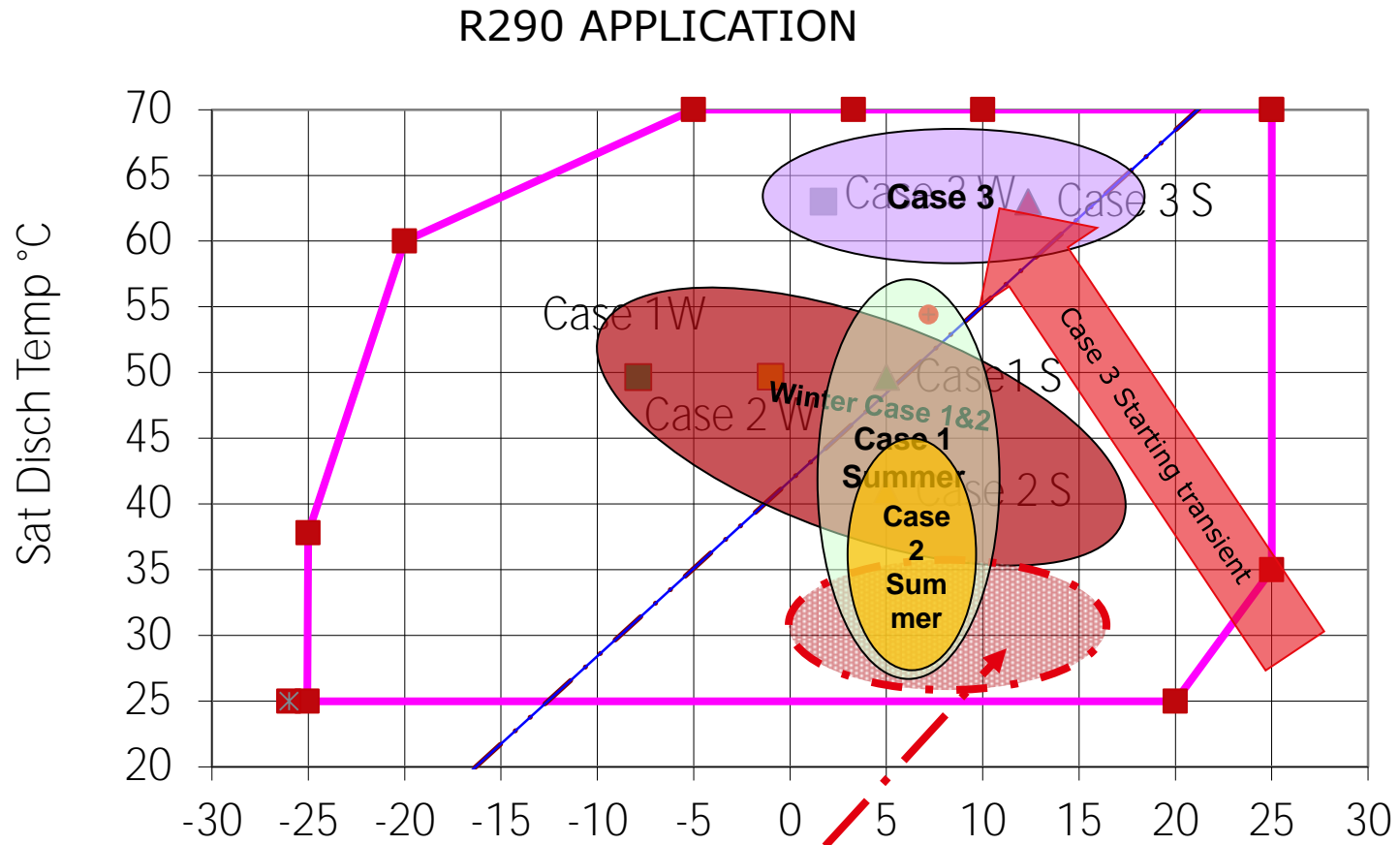
Case 2&3 NxtHPG038

Note

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

2 Case 3 will use R290

R290 NxtHPG Applications Project



Mild weather conditions A/C
(could be a large % of the yearly running time)

Scroll compressor for **R290** refrigerant heat pump adaptation

- Compression process efficiency improvement
 - Lubricants selection
 - Compressor design
 - Compressor reliability
-
- Case 1 NxtHPG051 + Inverter
 - Case 2&3 NxtHPG038

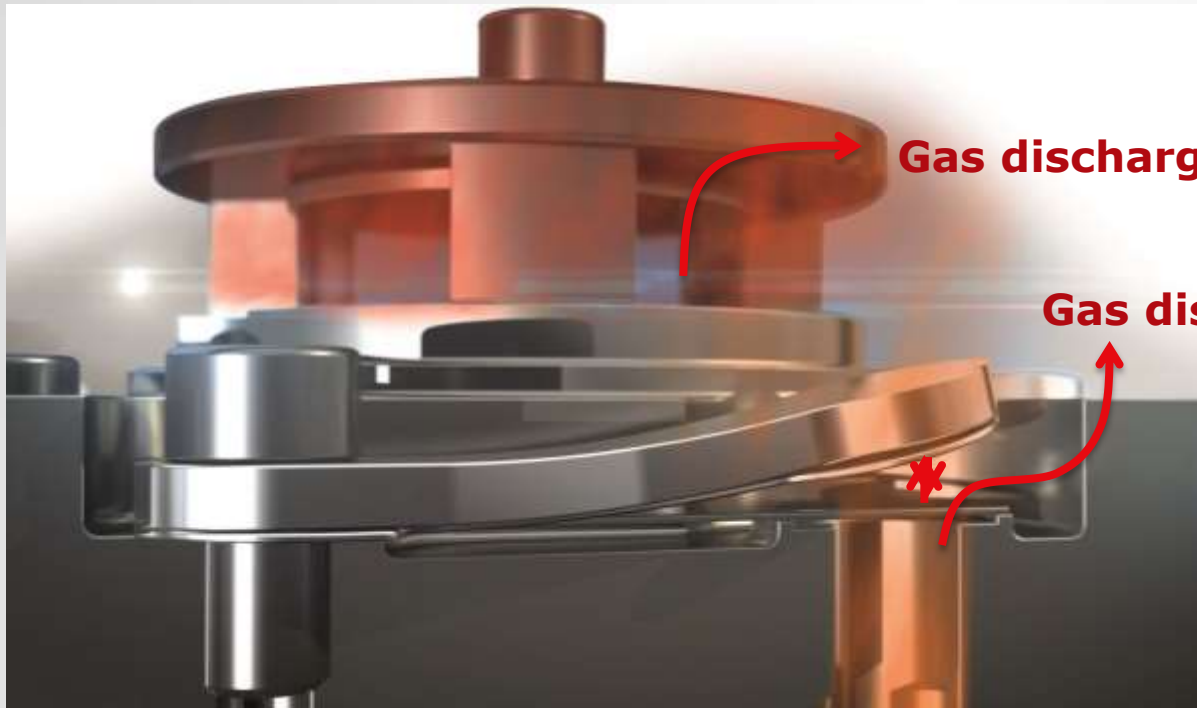
Compression process efficiency improvement: Intermediate Discharge Valve



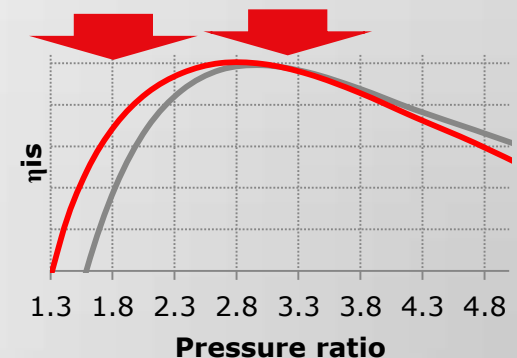
Description: Mechanical valve that adapts the motor effort to the pressure conditions in the system to improve part-load efficiency of air conditioning systems

Main Benefits

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

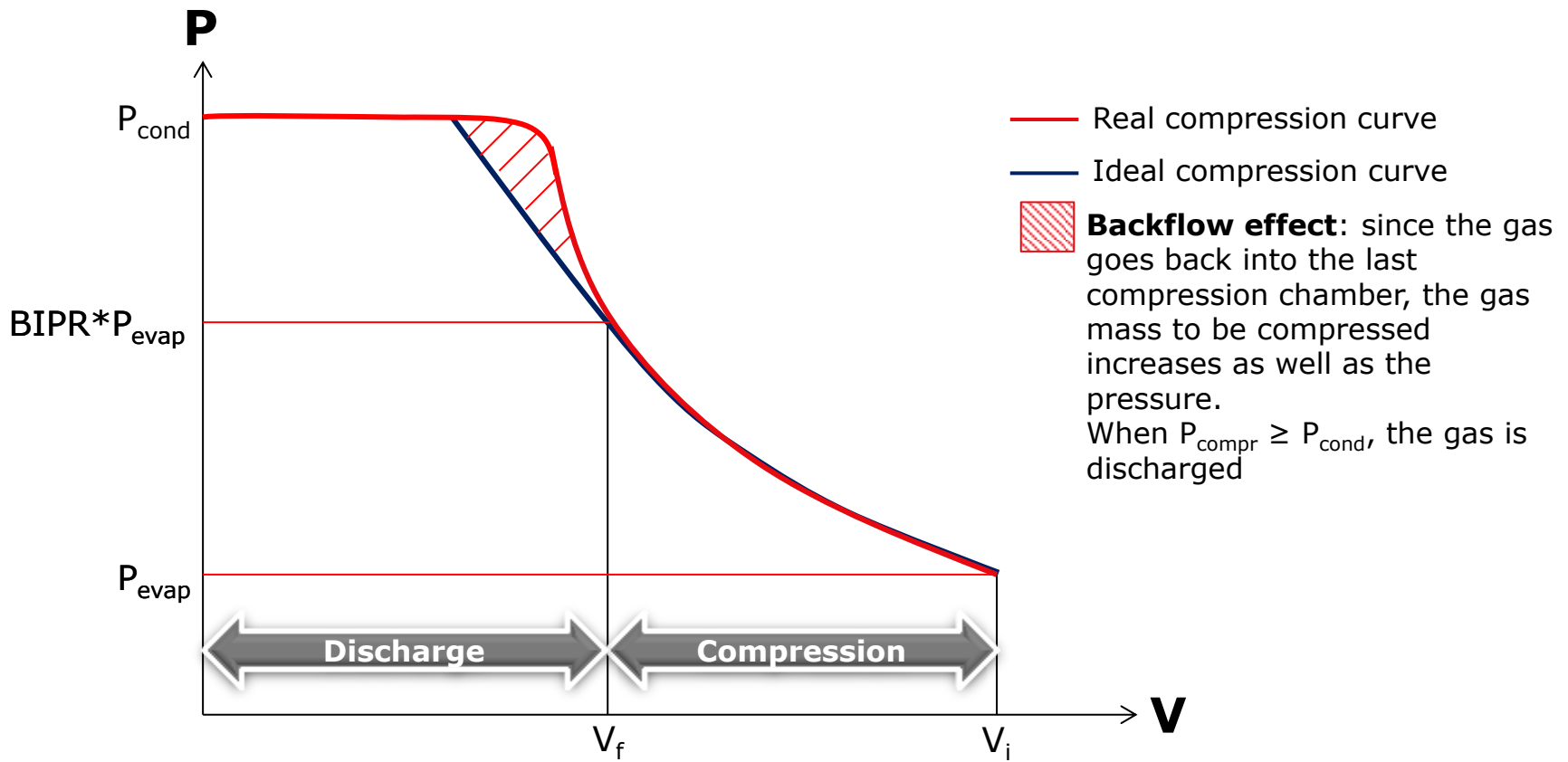


**High Pressure Ratio:
IDV opens**



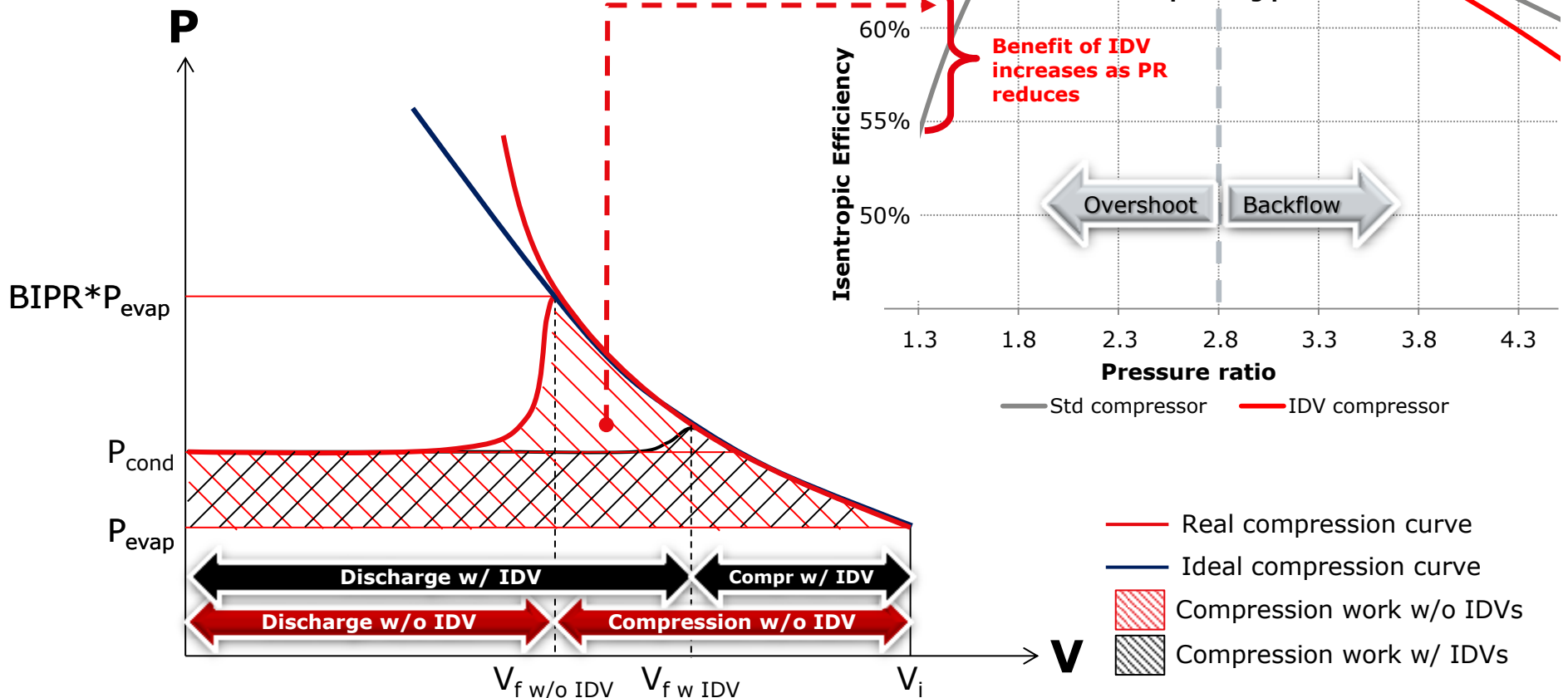
Compression process efficiency improvement: High Pressure Ratio Conditions

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



Compression process efficiency improvement: IDV Benefits

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



Compressor performance testing

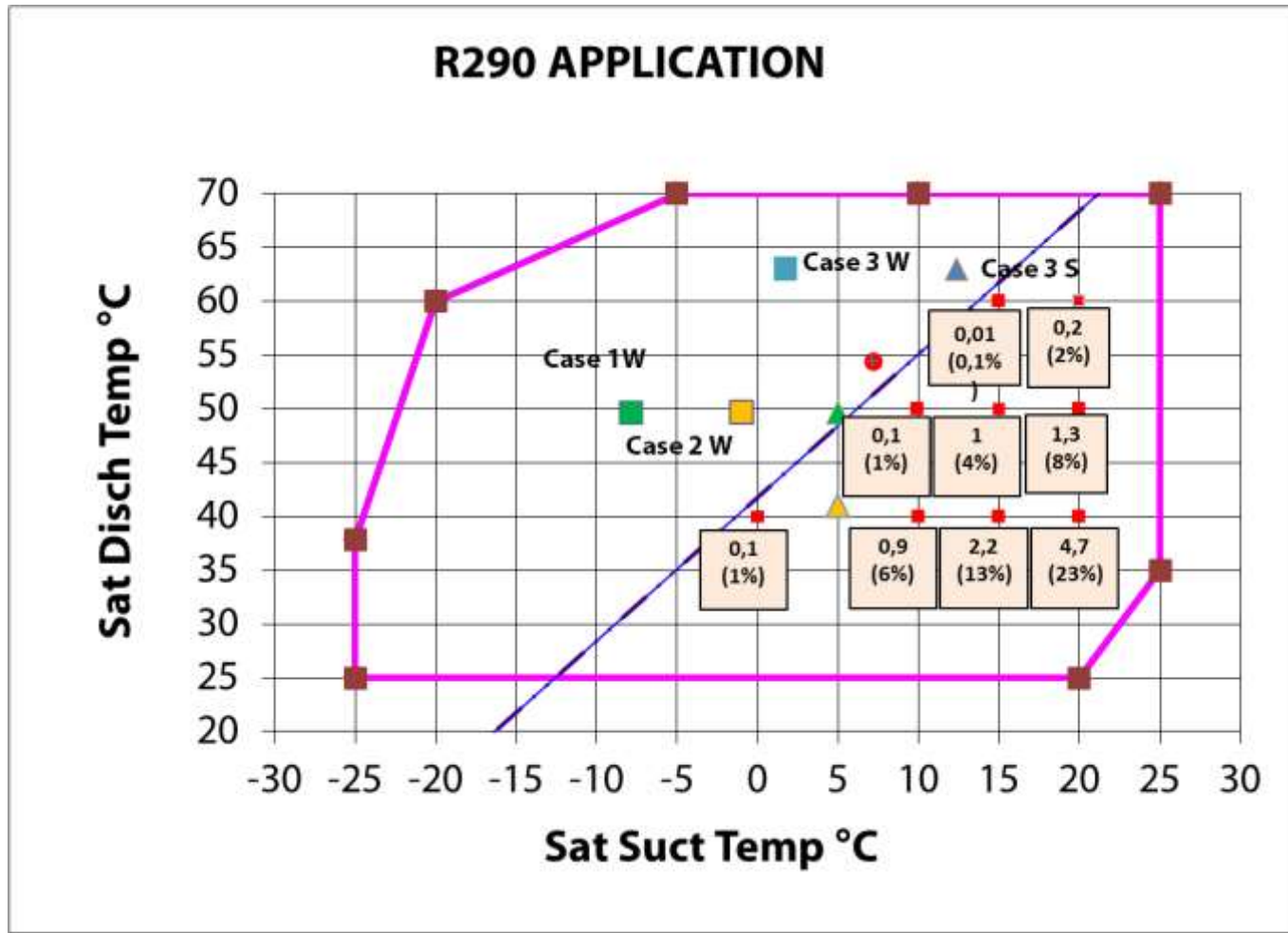
Note Hardware:

- 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])

Compression process efficiency improvement: extra **IDV** Benefits

Danfoss Intermediate Discharge Valves...

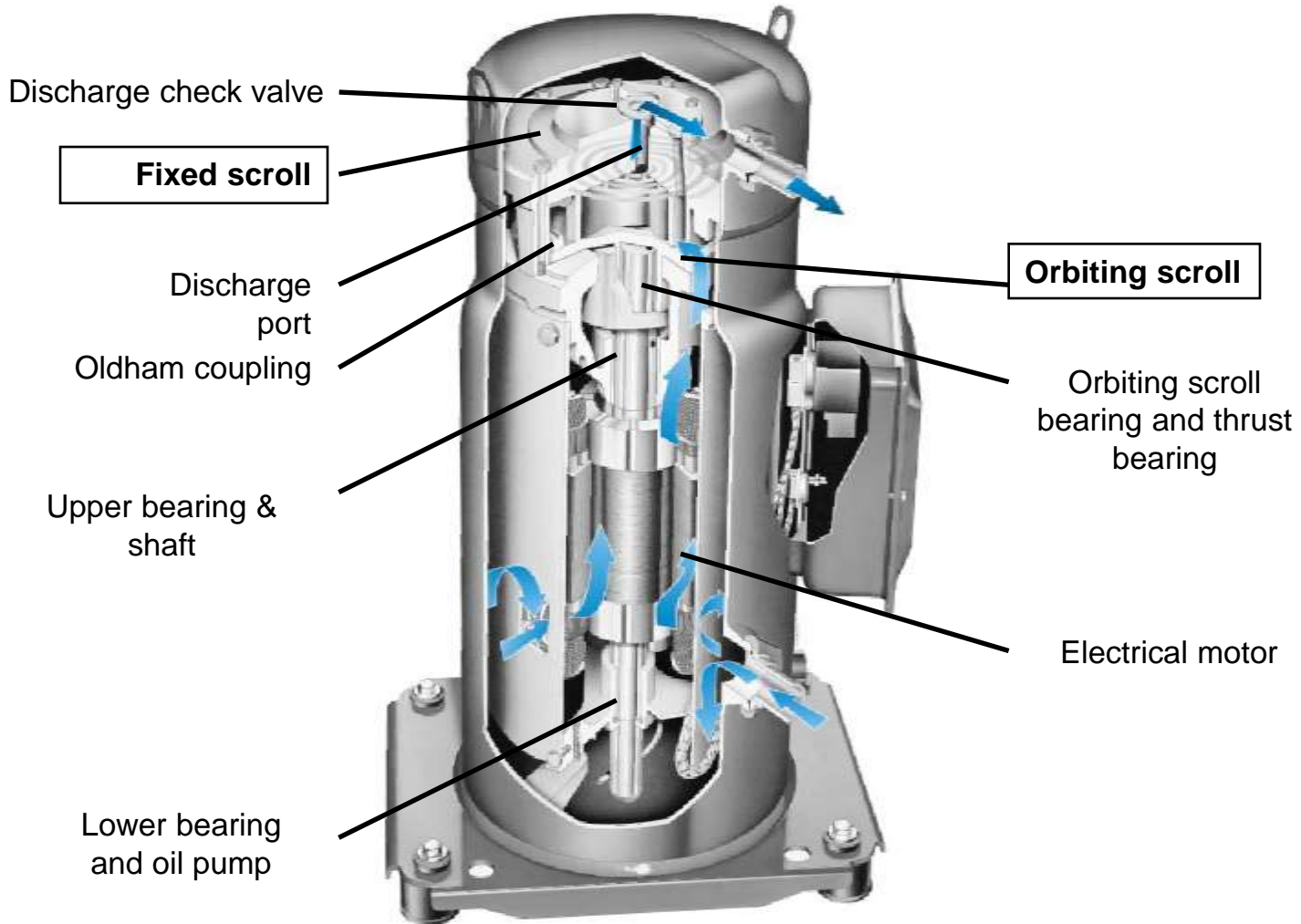
- reduce the compression mechanism torque
- reduce line amps during starting transient period
- allow to start at higher Saturated Suction Temperature



Compressor lubricant selection

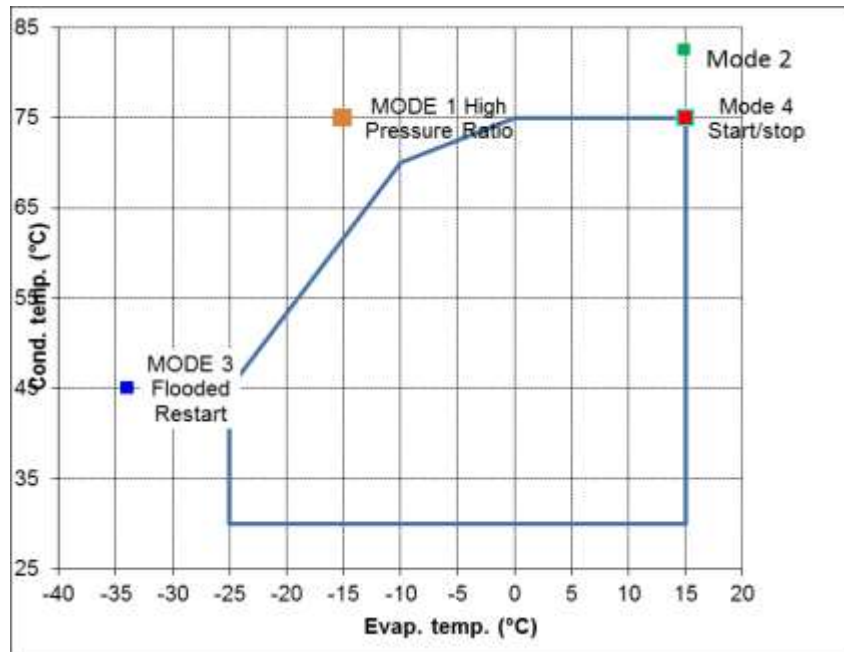
- R290 is very soluble in classic lubricants
- We investigated in the past:
 - MO
 - POE
 - AKB
 - Experience (rule of thumb) use two viscosity higher grades
- Based on Low HC soluble POE and PAG materials.
- Today we will focus on:
 - Compressor reliability
 - R290 solubility on oil compressor sump for reduced SH conditions

Compressors reliability testing



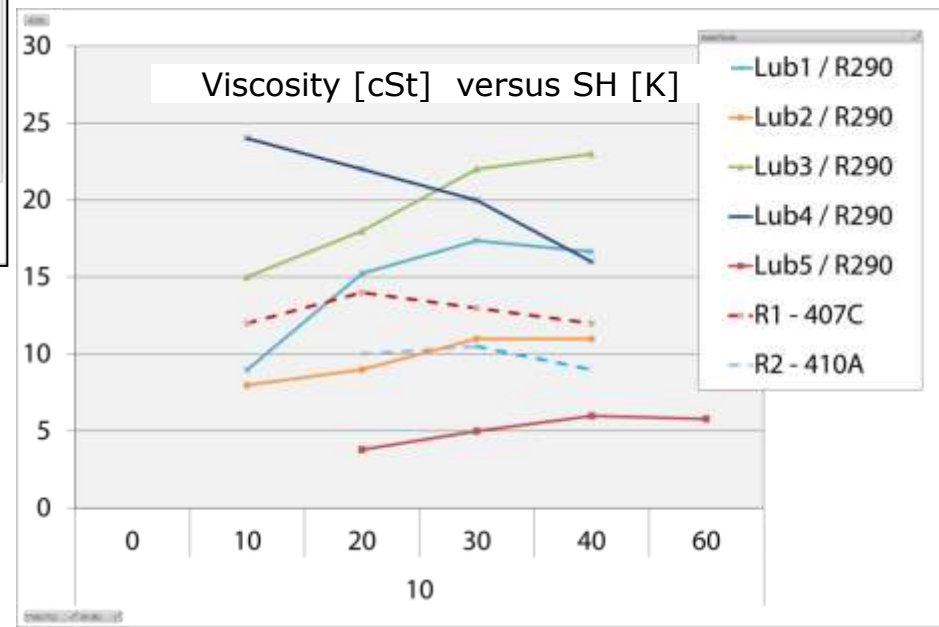
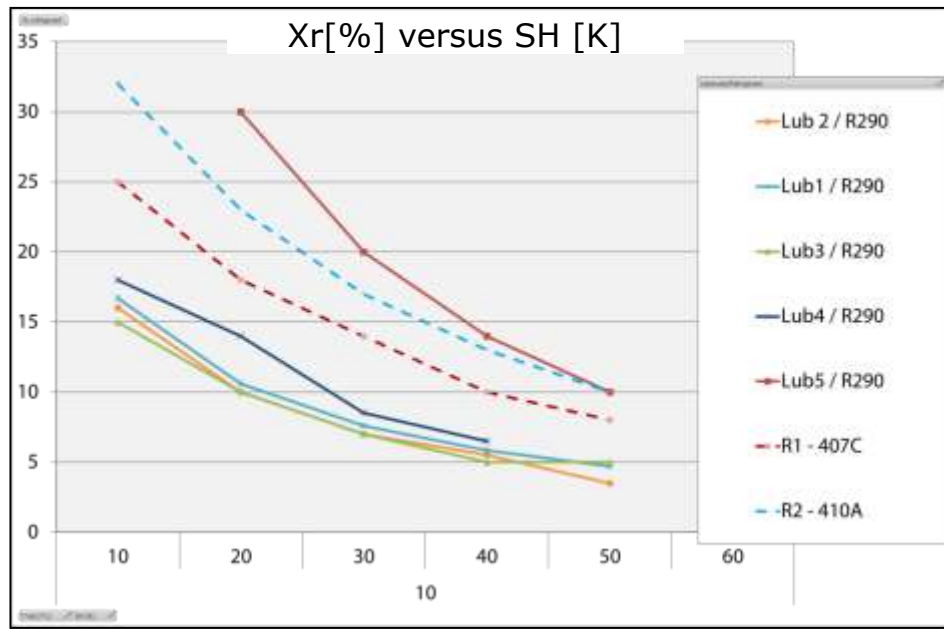
Compressors reliability testing

- 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



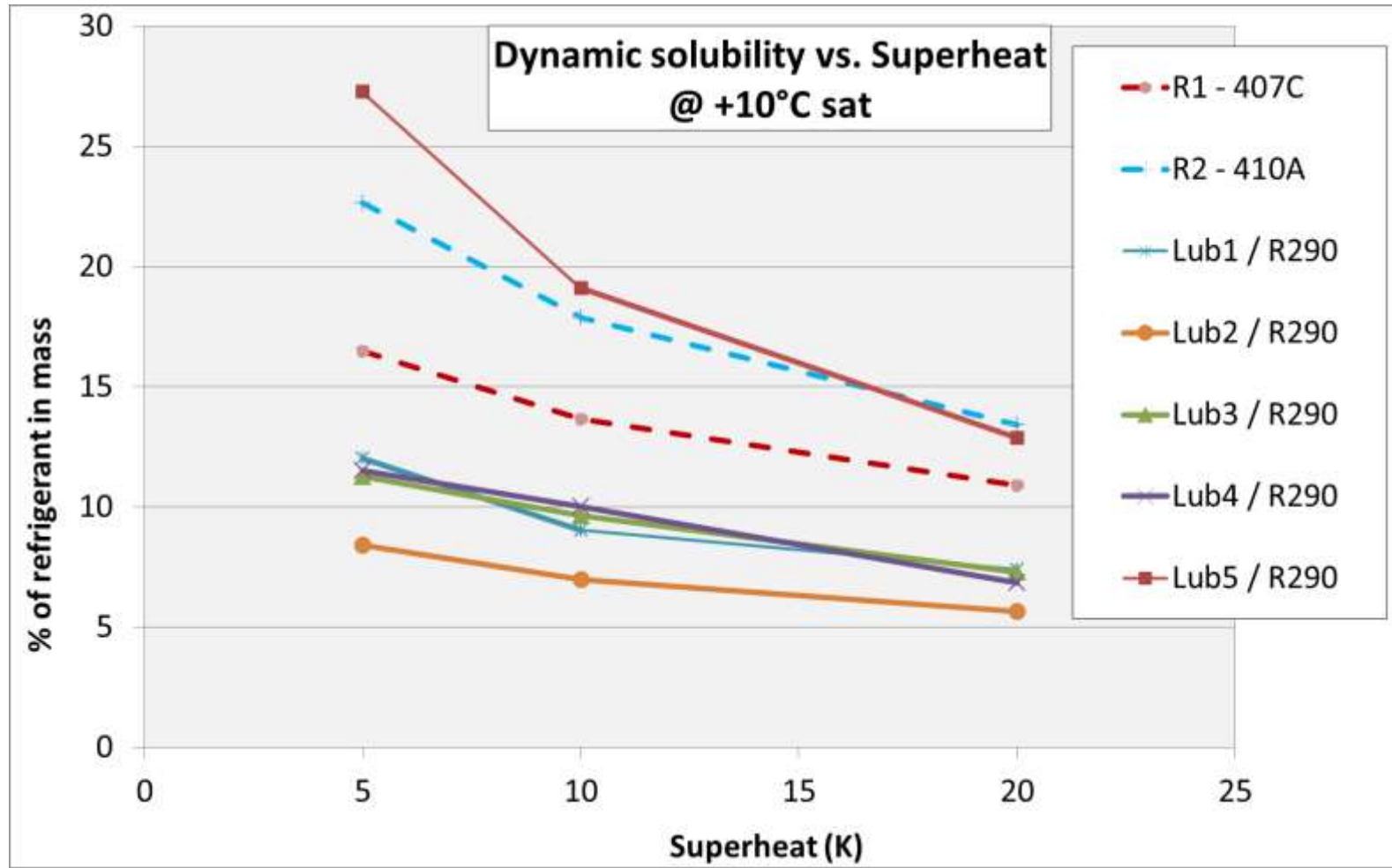
R290 Dynamic Solubility tests done

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
- **IDV integration on these R290 scrolls compressor brings:**
 - Better performances at lower pressure ratio running conditions
 - Same compressor can be used in a wider 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 are investigating the application of low miscibility lubricants
- Compressor design has been adjusted 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]".





**ENGINEERING
TOMORROW**