

Scroll Compressors For CO₂ Refrigeration

Cooling with Carbon Dioxide

28th March 2007, London

Eric Winandy

Copeland

Copeland[®]

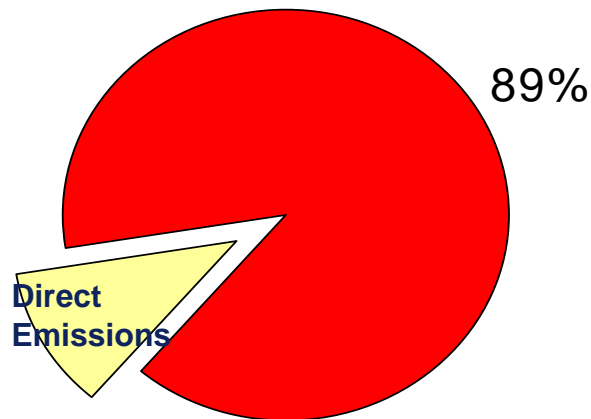

EMERSON[™]
Climate Technologies

Content

- Copeland Position On CO2
- Product Status By Target Application
- CO2 Subcritical Scroll Compressors
 - Product Overview
 - Why Scroll?
 - Field Experience
- CO2 Transcritical Scroll Compressors
- Conclusions

Copeland Position On CO₂ As A Refrigerant

- Environmental Concerns Opening Up Regional Markets For Refrigerant CO₂
 - Eliminating Risk From Direct Emissions
 - Legislation And Tax Incentives
 - *Green Image* Driver

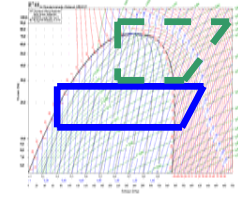


Refrigeration System Related
CO₂ Emissions In Supermarket

Copeland Position On CO₂ As A Refrigerant (2)

- Copeland In Support Of EPEE And Its Views:
 - *HFCs Are The Most Environmentally Responsible And Economically Justified Refrigerants On The Market Today*
 - *Refrigerant Choice, i.e. CO₂ and HFCs, Will Drive Innovation*
- There are applications where the use of CO₂ as a refrigerant makes more and some where it makes less sense!
- Make Your Choice Based On **Lowest Carbon Emissions**

CO₂ Target Applications And Product Development Status



- CO₂ Suits Supermarket Refrigeration
 - Could Become A Viable Alternative To HFC
- CO₂ Not A Likely Refrigerant For AC And Space Heating (Heat Pumps)
 - Unless Legislation Forces HFC-elimination
 - Performing Lower Than All Other HFCs In AC And Space Heating
 - Potential Advantage For Domestic Hot Water Generation

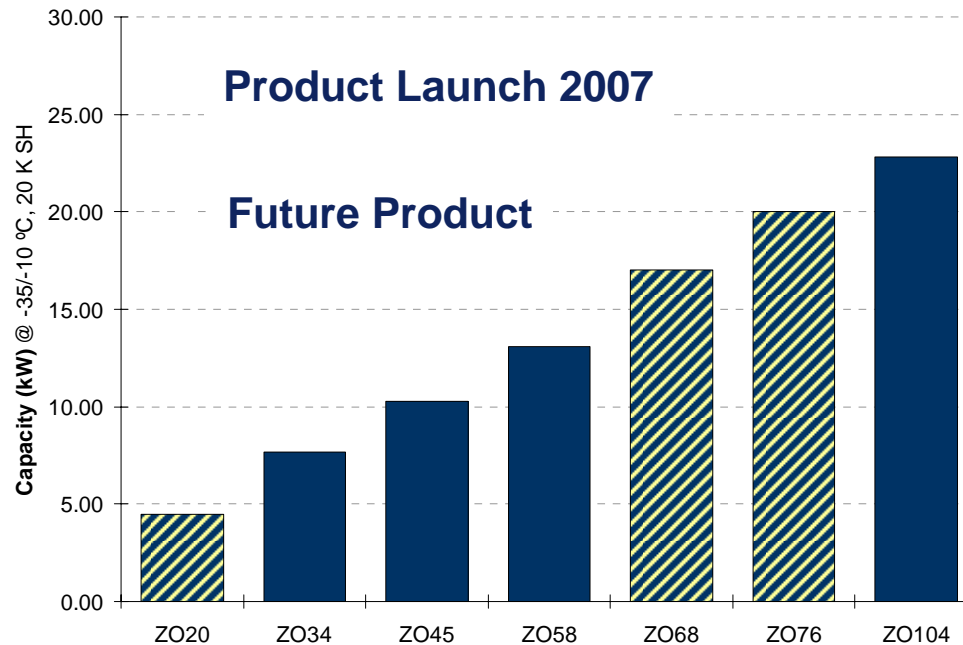
Copeland Product Development Status

- Product Launch For Subcritical Refrigeration: April '07
- Product Development For Transcritical Refrigeration: In Progress
- Heat Pump: Assessing

Copeland CO₂ Subcritical Scroll Product Overview & Outlook

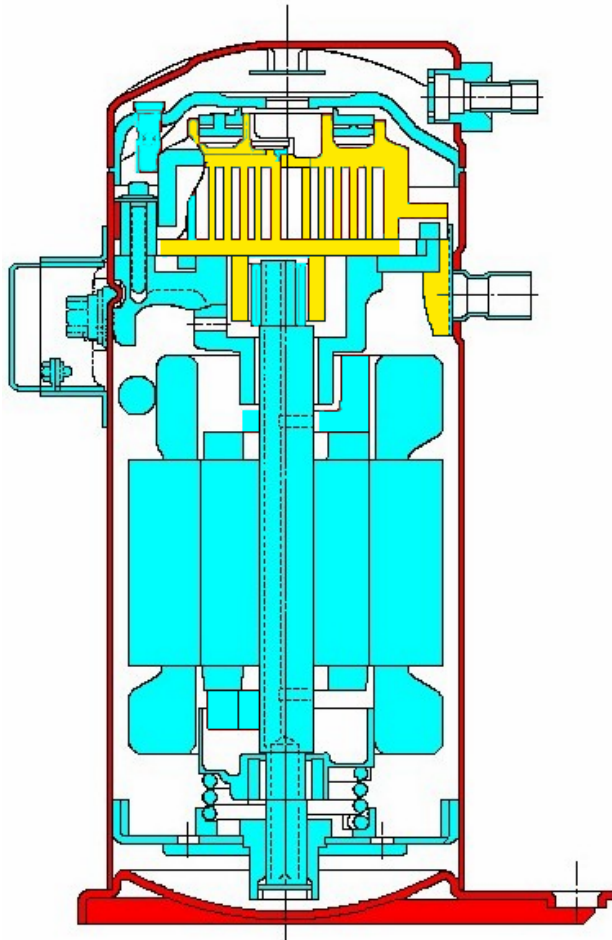
Model	Motor Size Hp	Cooling Capacity @ 100% kW ⁽¹⁾	Displacement m ³ /h	Net Weight kg
ZO 34 K3E	1.9	8	4.1	31
ZO 45 K3E	2.6	11	5.4	32
ZO 58 K3E	3.4	13	6.9	34
ZO 104 KCE	6.0	23	11.7	40

⁽¹⁾ Evaporating -35°C, Condensing -10°C, Suction Superheat 20 K, Subcooling 0K



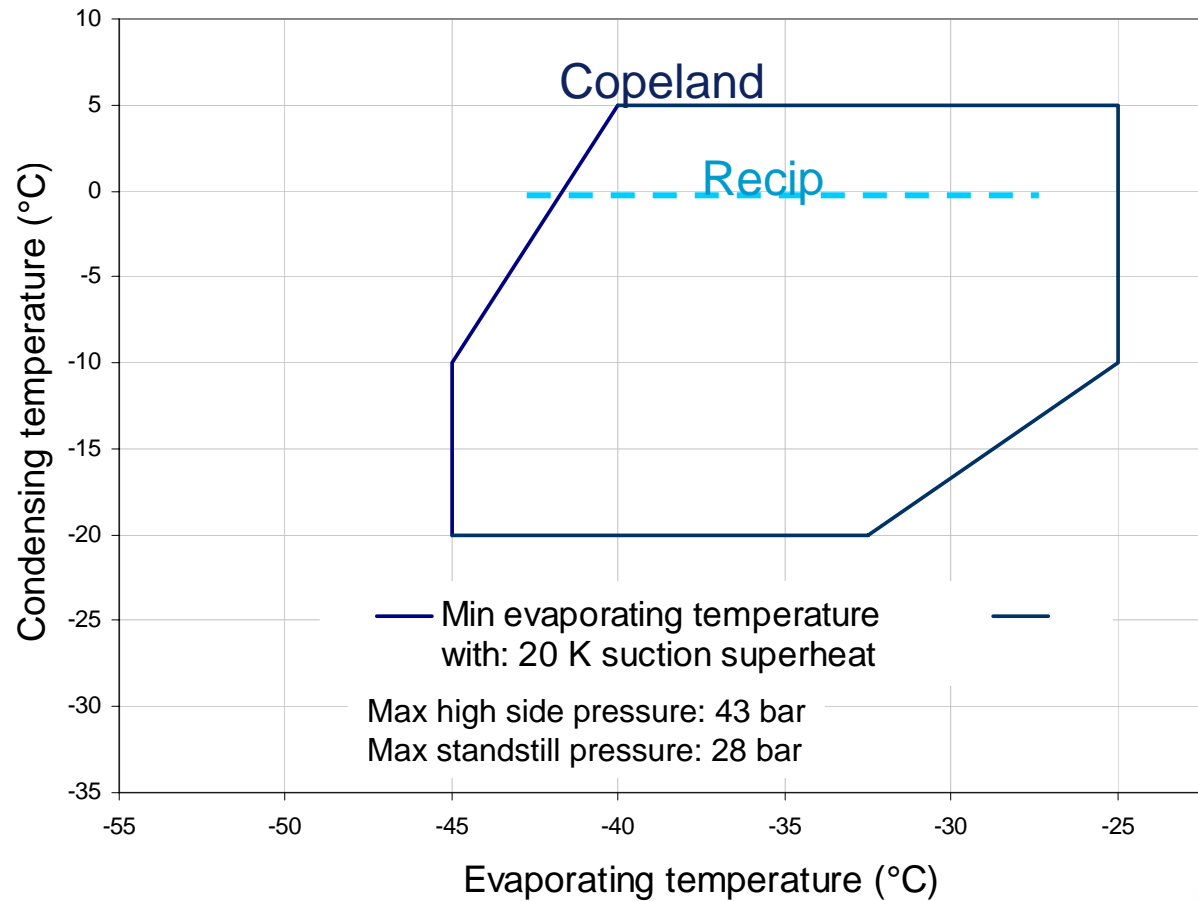
Just like scroll

Low Temperature Refrigeration Scroll For CO₂ Vs Other High Pressure Scrolls



- Lubrication Capabilities
- Oil
- Sight Glass
- Rotalock Connections
- Liquid Handling

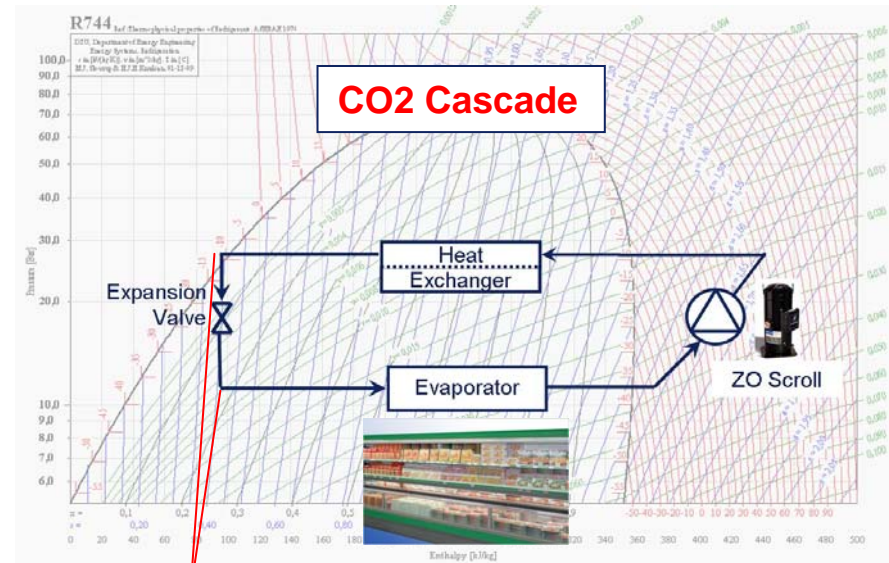
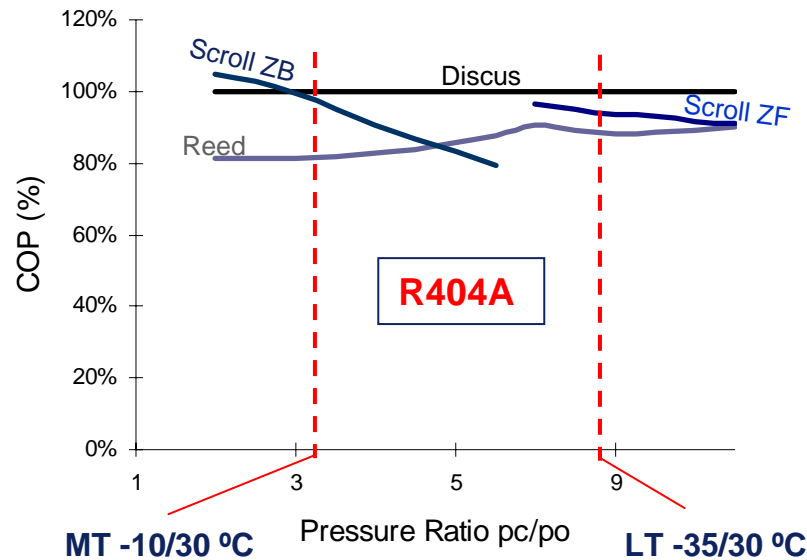
CO₂ Subcritical Scroll Envelope



Why Scroll?

- Copeland Has Thoroughly Assessed The Technology Options For CO₂ Compressors: Scroll Provides The Best Basis
- Copeland Could Draw On Its Experience With R410A Compressors For CO₂ Subcritical Applications
- Further Considerations:
 - Efficiency
 - Low Δp Found In Subcritical Applications Suits Scroll
 - Potential Operational Issues (Liquid Flooding.....)
 - Liquid Handling Capability.....
 - Compactness (Weight & Size)
 - Cost & Price

CO₂ Subcritical Cascade Conditions Favourable To Scroll

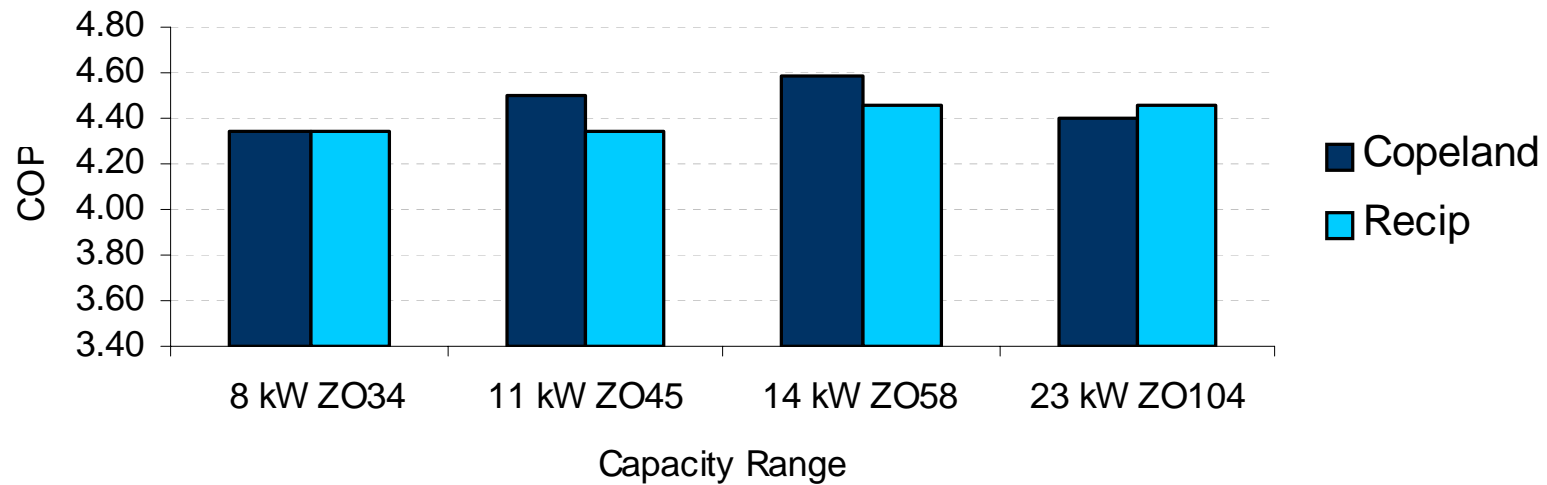


-35/-5 °C - Pressure Ratio: 2.5

- CO₂ Cascade Pressure Ratio Favours Optimised Scroll Without Discharge Valve
- No Need For Liquid Injection Valve (Low Discharge Temperature)
- Copeland Scroll Inherent Potential For **Higher Efficiency** Than Recip

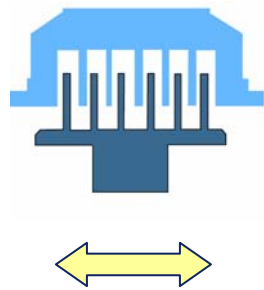
CO₂ Subcritical Cascade Conditions Favourable To Scroll

- Results (-35/-10°C/20K):



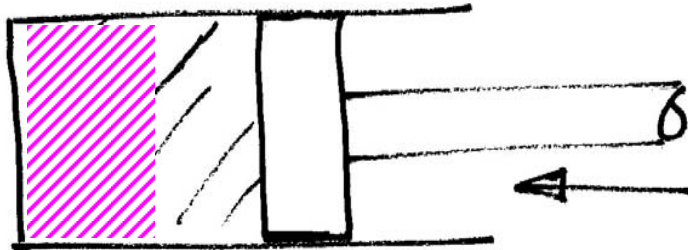
Copeland CO₂ Scroll Liquid Handling Capabilities

- Likelihood Of Liquid Entering Compressor
 - High Miscibility Of Refrigerant In Oil With CO₂ Applications

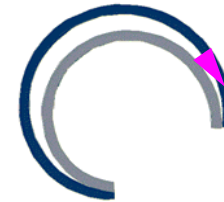


- Copeland Compliance Principle Allowing Scroll Set To Disengage In Case Of Particles Or Liquid Entering
- Compressor Specifically Designed To Cope With Severe Lubrication Requirements
 - Bearing Design And Other Moving Parts

Scroll Runs at 2-pole Motor Speed



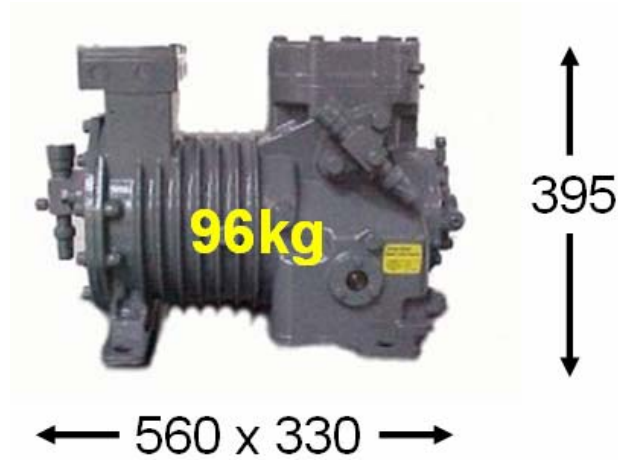
Piston Compressor:
300cc



Scroll Compressor:
94cc to do the same job

- 2-pole (2900rpm) Requires Less Displacement Than 4-pole Motor
- No Clearance Volume In Scroll Compressors
 - Higher Volumetric Efficiency
- Smaller Displacement Ultimately Influences Size And Material Content

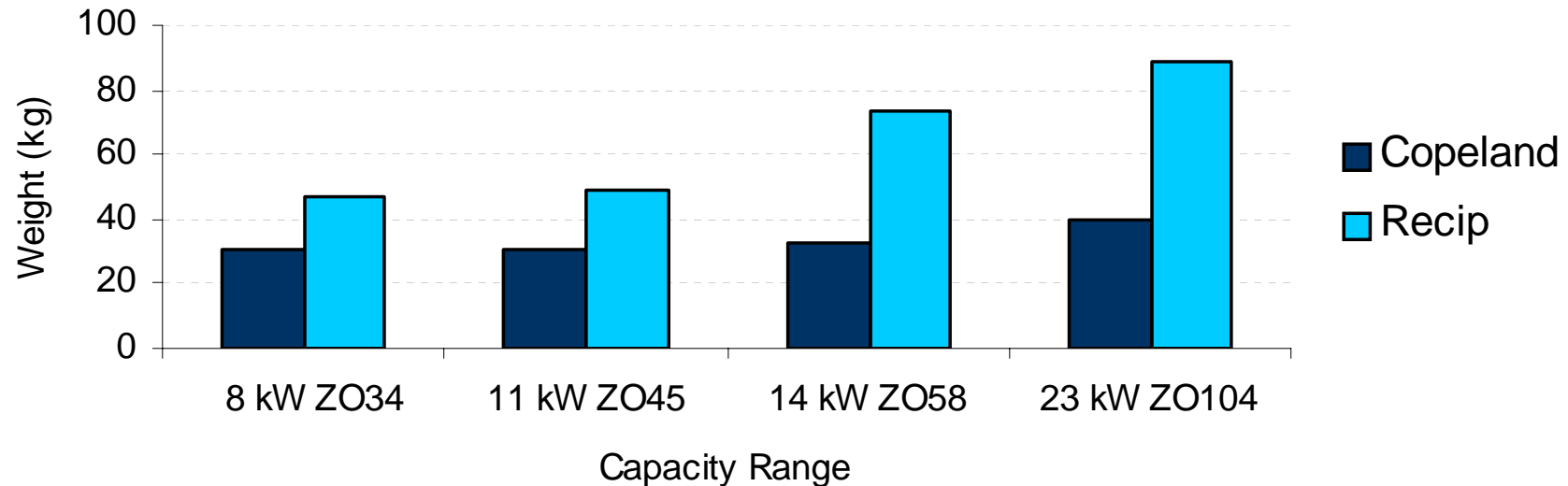
Material Content - Size



- Smaller Footprint, More Compact
- Less Material Used, Less **Environmental Impact** In Manufacture And Disposal

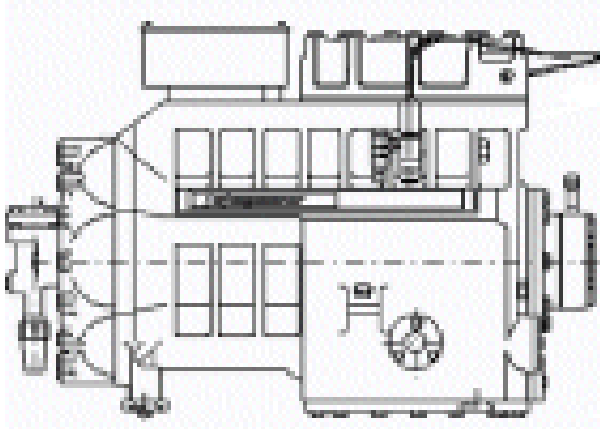
Material Content - Size

- Results for CO2 Subcritical Scroll Compressors:



- Handling During Rack Manufacturing,
- Installation And Maintenance
- Lighter Rack/Frame Structural Design – Potential First Cost Savings
- Better Suited To Roof Top Design For Distributed Systems

Hermetic Design



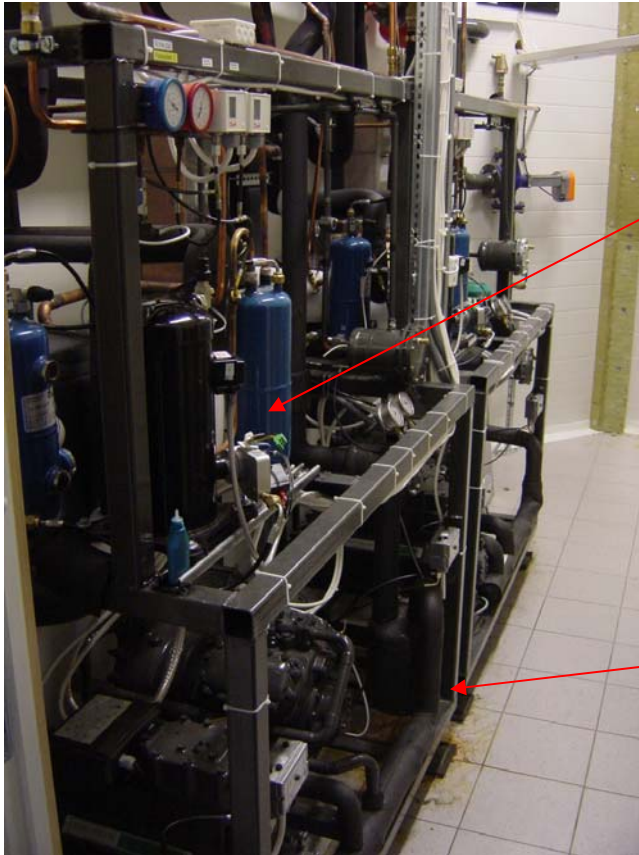
Joints and Connections: Field Service may cause emissions

- Less Leakage Potential Particularly Important
With High Pressure Refrigerants



Fully Welded, Inbuilt Protection

Copeland Subcritical Scroll Field Experience



LT R744/CO₂

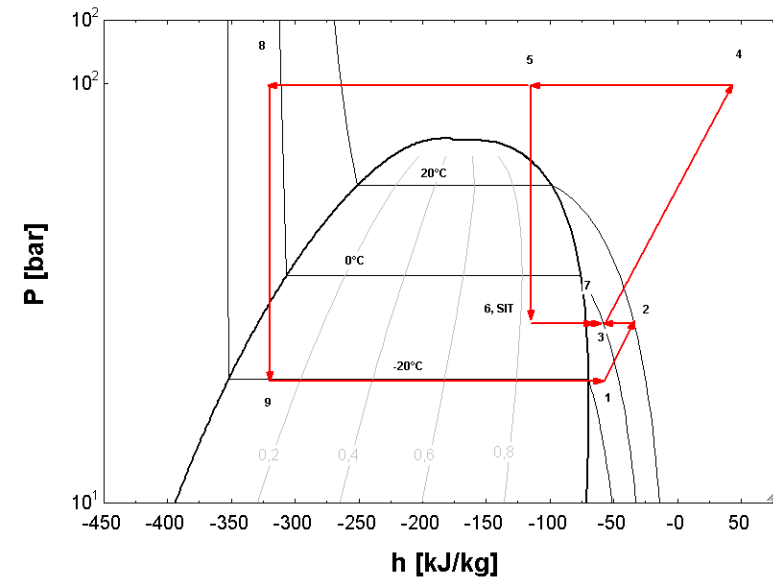


MT R134a

- Several Sites Across Europe
- Some running for more than 6 months

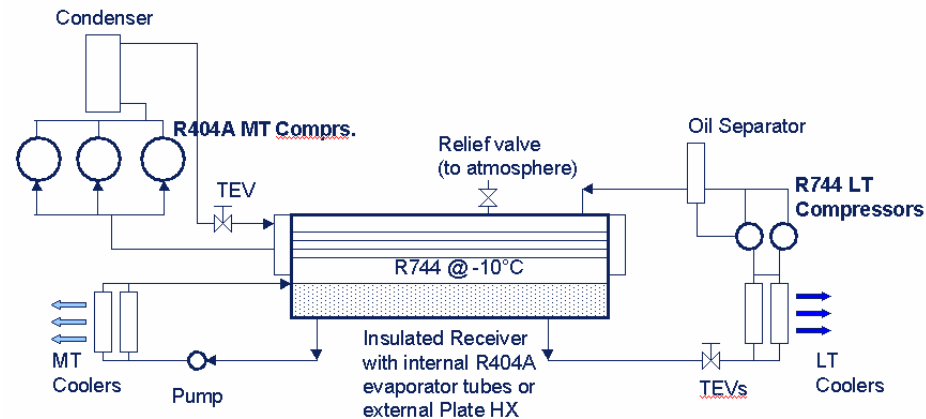
CO₂ Transcritical Scroll

- Main Applications
 - MT Refrigeration
 - Heat Pumps
- Scroll Compressor Technology Combined With Vapour Injection Offers Good Potential For System Advantage Vs Standard Cycles
 - Enhance System Cycle Efficiency
 - Increase Capacity At Higher Pressure Ratios
 - Enlarge Operating Map (Discharge Temperature Control)



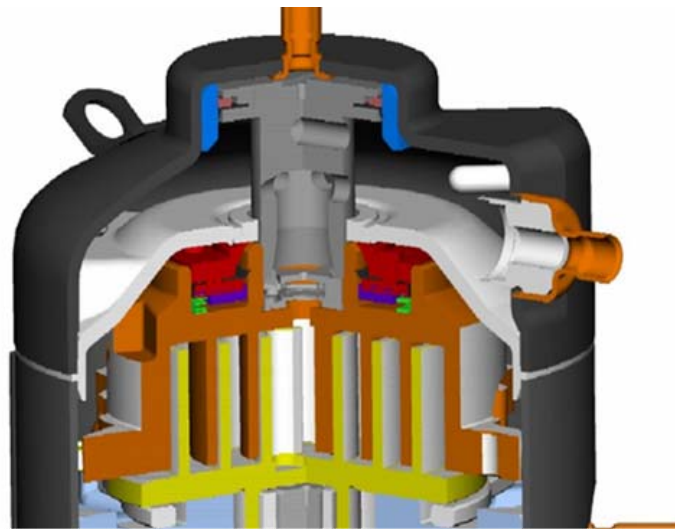
Summary And Outlook

- Scroll Compressors For Supermarket CO₂ Subcritical Applications Have Been Developed Based On R410A Compressors Experience
- LT Scroll Compressors For CO₂ Superior Vs Recips In Terms Of:
 - Efficiency
 - Reliability
 - Size
 - Cost & Price



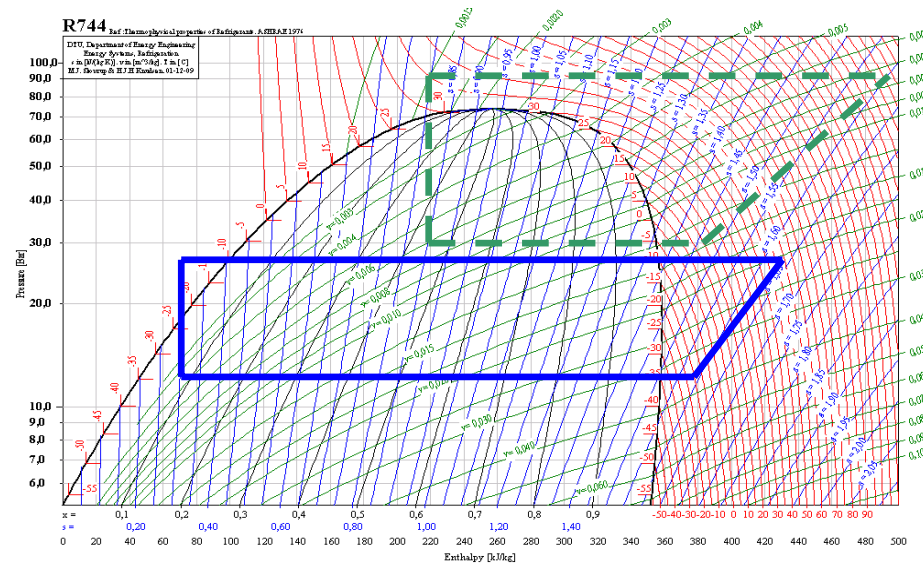
Summary And Outlook

- Main Design Focus For CO₂ As A Refrigerant:
 - Lubrication
 - Liquid Handling
- Potential For Latest AC Technology
 - Copeland Scroll Digital



Summary And Outlook

- Compressors For CO2 Transcritical Applications Under Evaluation
- Scroll Compressor Technology Combined With Vapour Injection Offers Good Potential For System Advantage Vs Standard Cycles
- Main Applications Can Be Foreseen In MT Refrigeration Applications
- Heat Pumps With A High Degree Of Domestic Hot Water Production Could Be A Viable Solution



Thanks!

