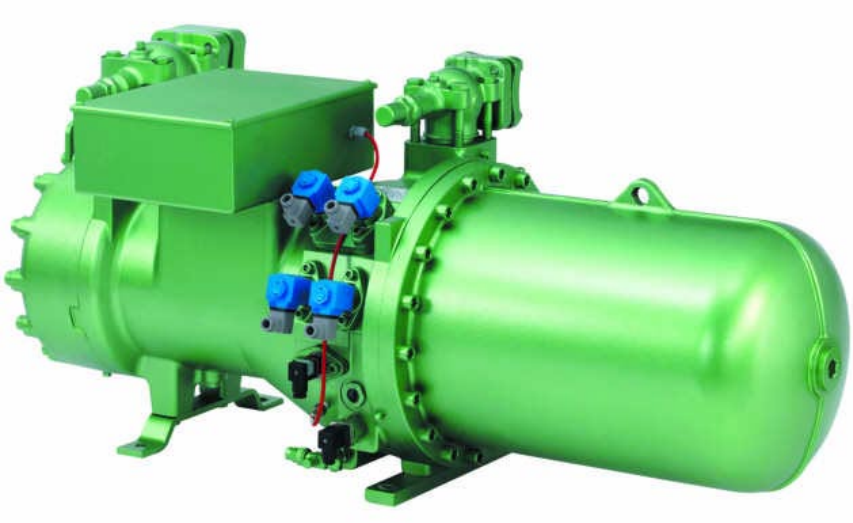
Modulation Techniques for Compressors – Part II

Performance and Efficiency Behavior of Screw Compressors – Comparison between Slider Unloading System and Frequency Inverter Operation



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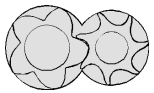
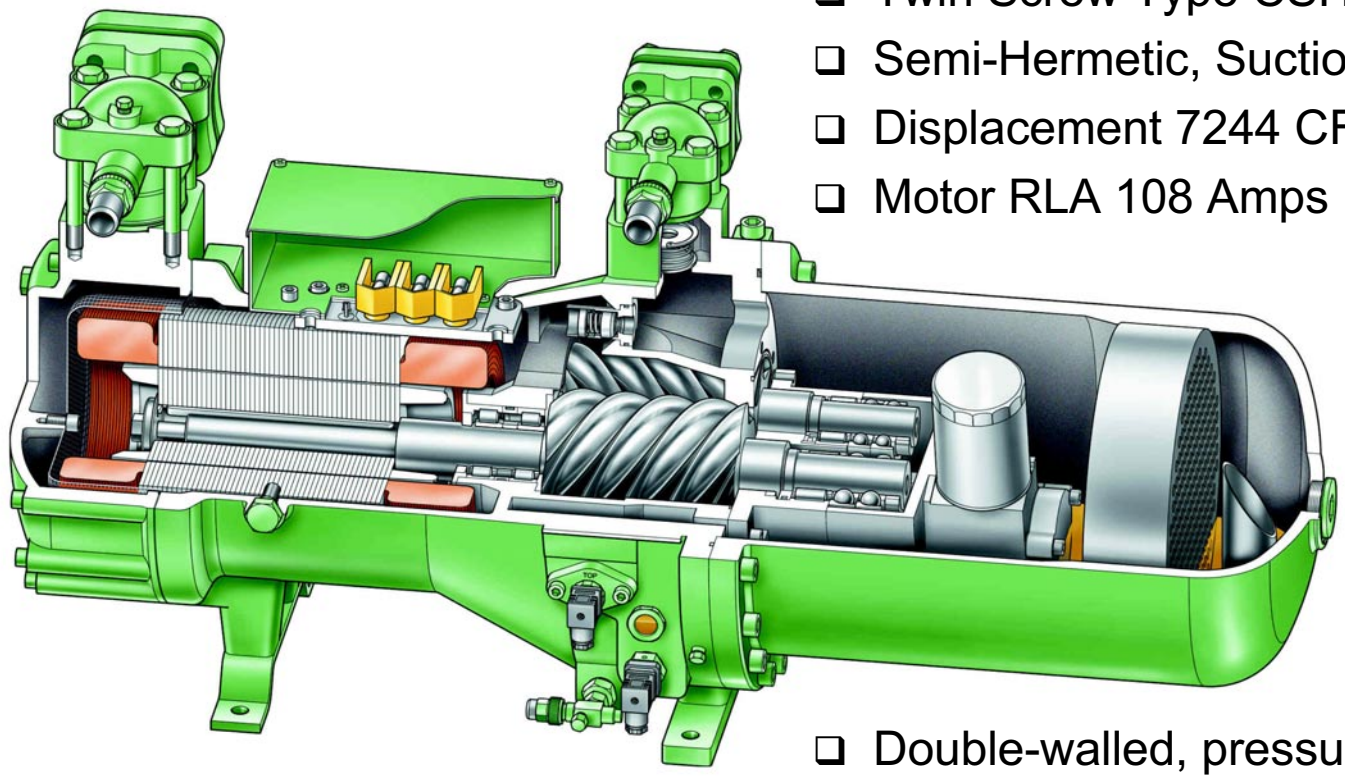
Modulation Techniques for Compressors – Part II
– Agenda –

- Introduction
- Compressor Design Features
- Comparison of Modulation Systems
  - Slide Valve for Infinite or Step Unloading
  - Variable Speed Drive (VSD) with Frequency Inverter
- Test Conditions
- Full and Part Load Behaviour with
  - Slide Valve vs. VSD
- Summary



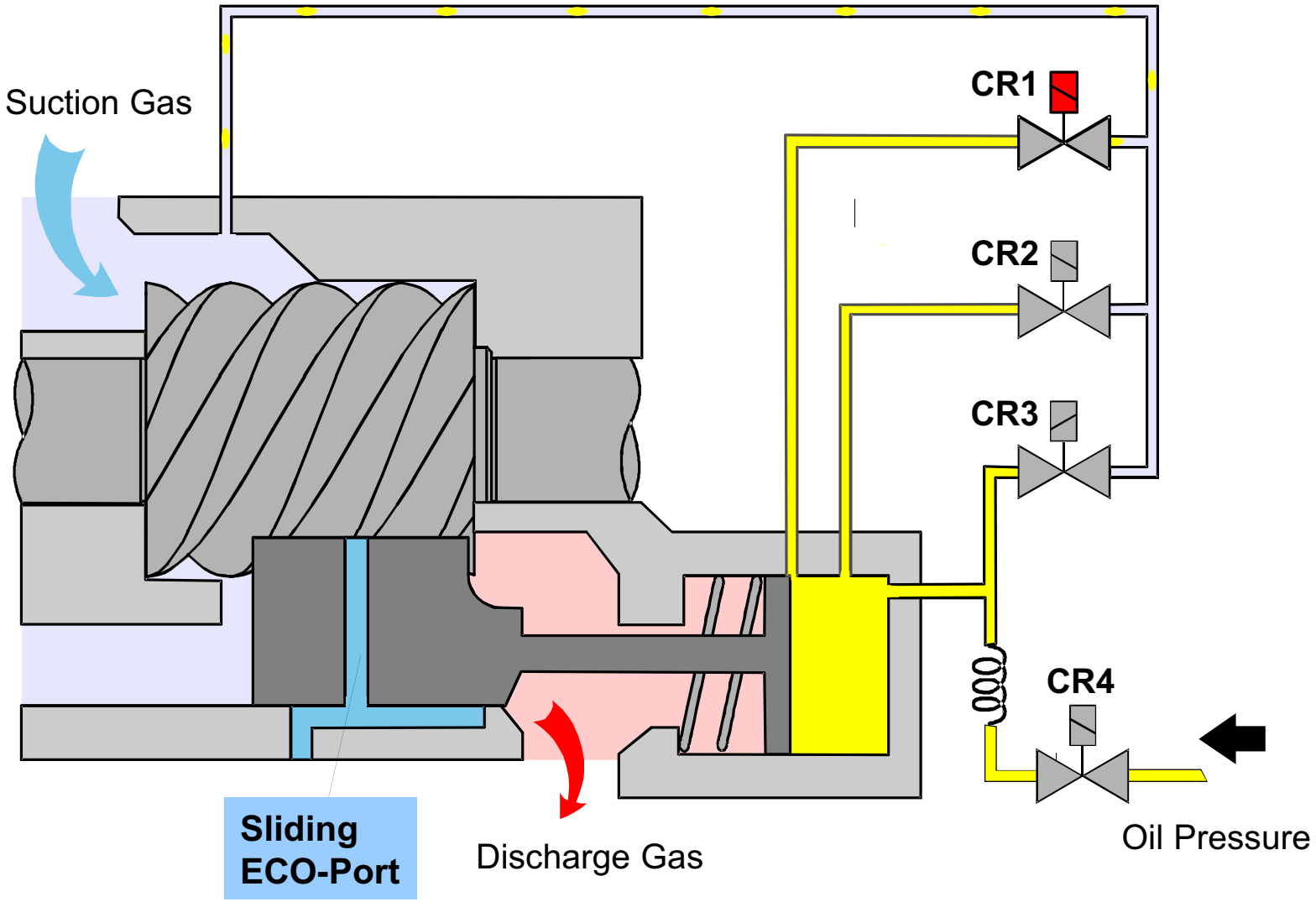
Compressor Design Features



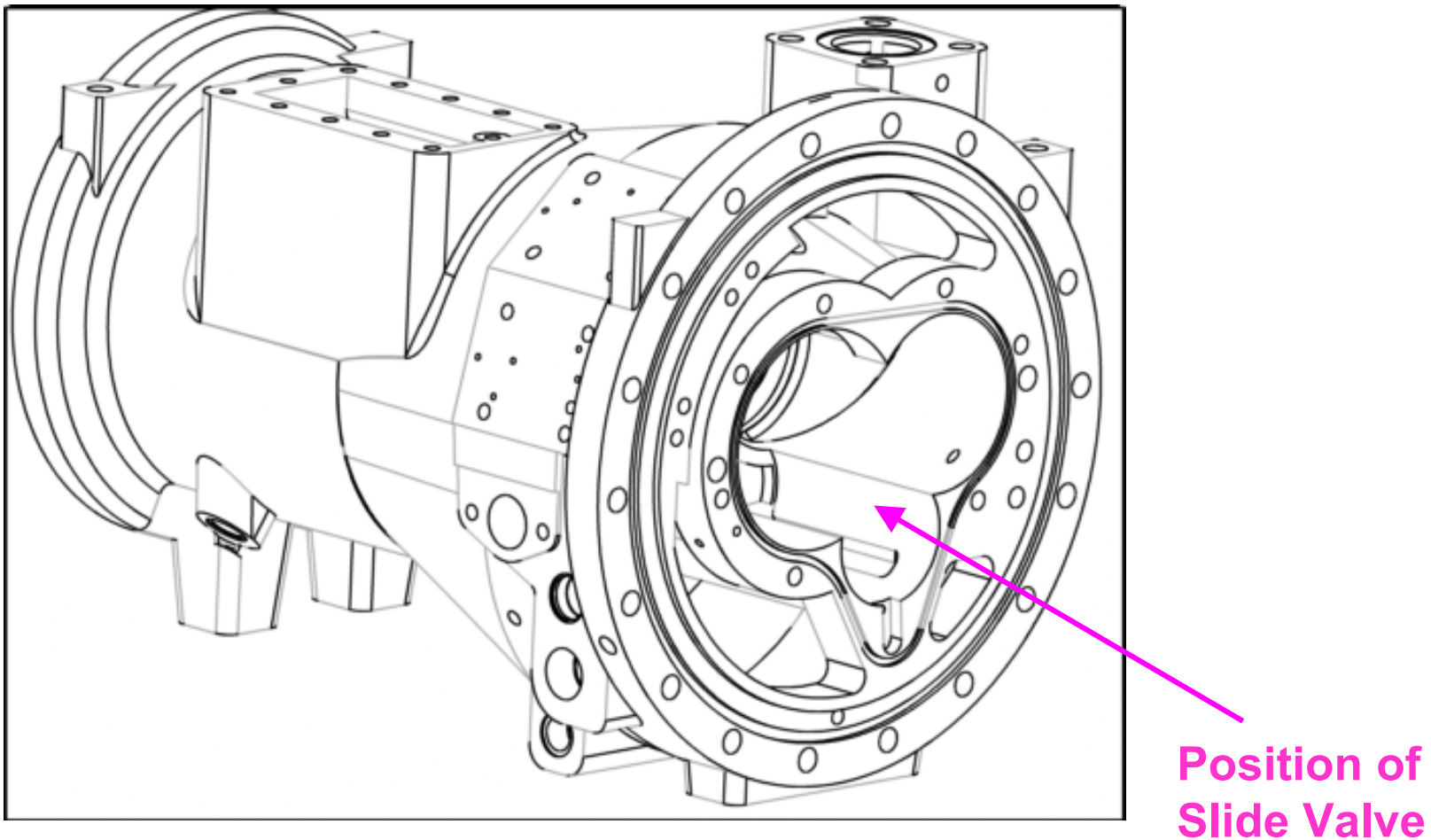
- Twin Screw Type CSH6561-60Y
- Semi-Hermetic, Suction Gas Cooled
- Displacement 7244 CFH (3500 RPM)
- Motor RLA 108 Amps

- Double-walled, pressure compensated rotor housing
- Integral Oil Separator and Oil Management
- Slider Unloading System

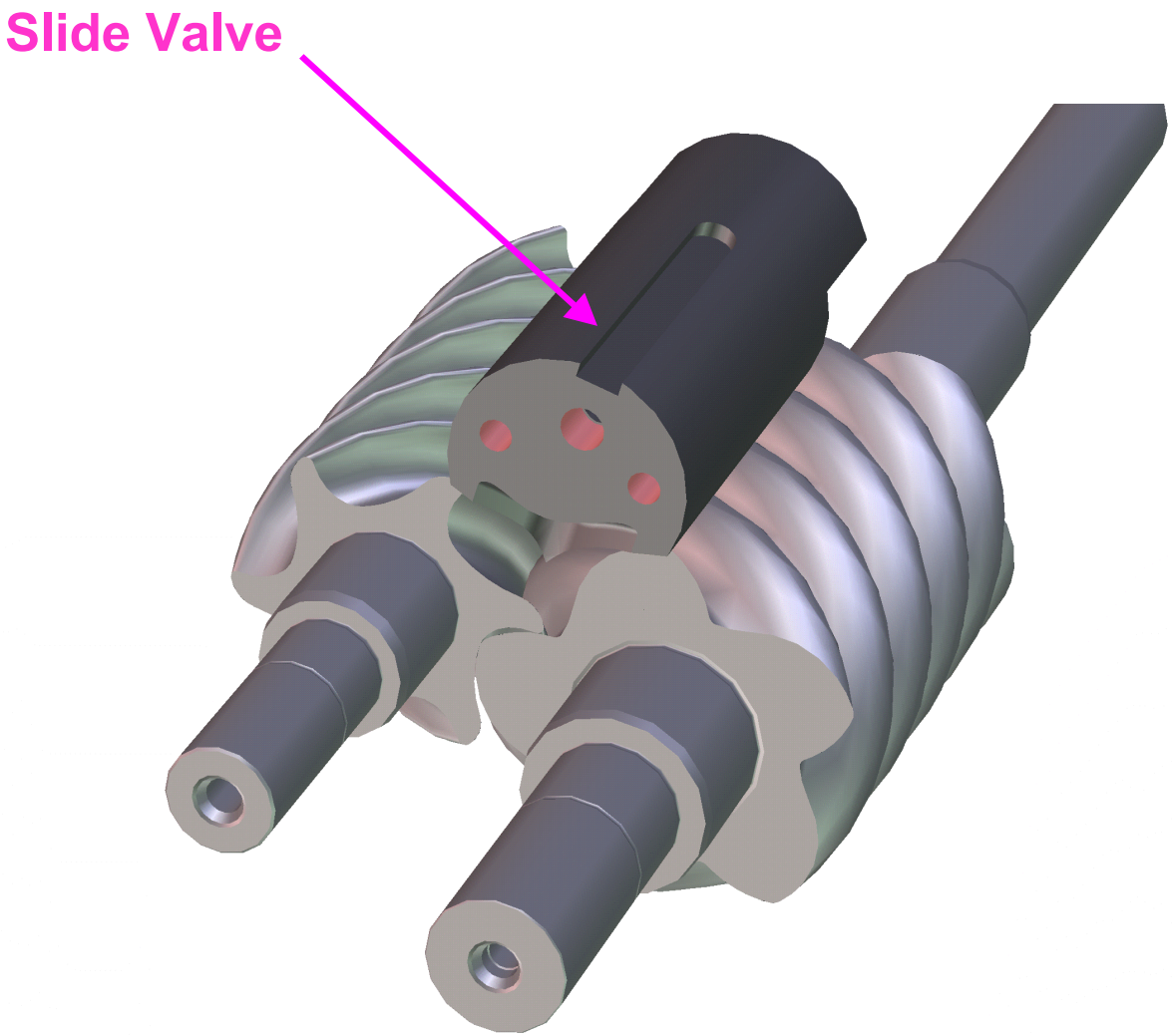
Comparison of Modulation Systems
– Slide Valve for Infinite or Step Unloading –



Compressor Housing & Position of Slide Valve



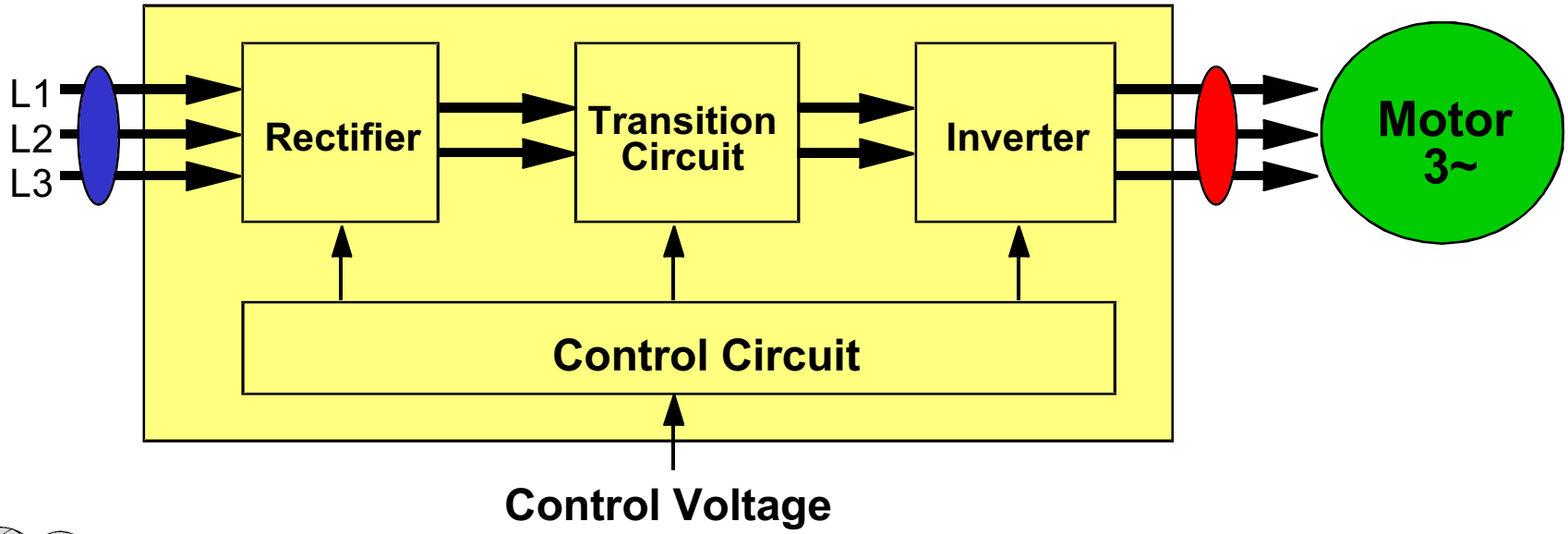
Screw Rotors with Slide Valve



Comparison of Modulation Systems – VSD with Frequency Inverter –

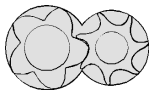
Components for Performance Tests

- Frequency Inverter KIMO Type 75FEP
  - max. Operating Current 105 Amps
- Screw Compressor CSH6561-60Y
  - Frequency Range 25 .. 80 Hz

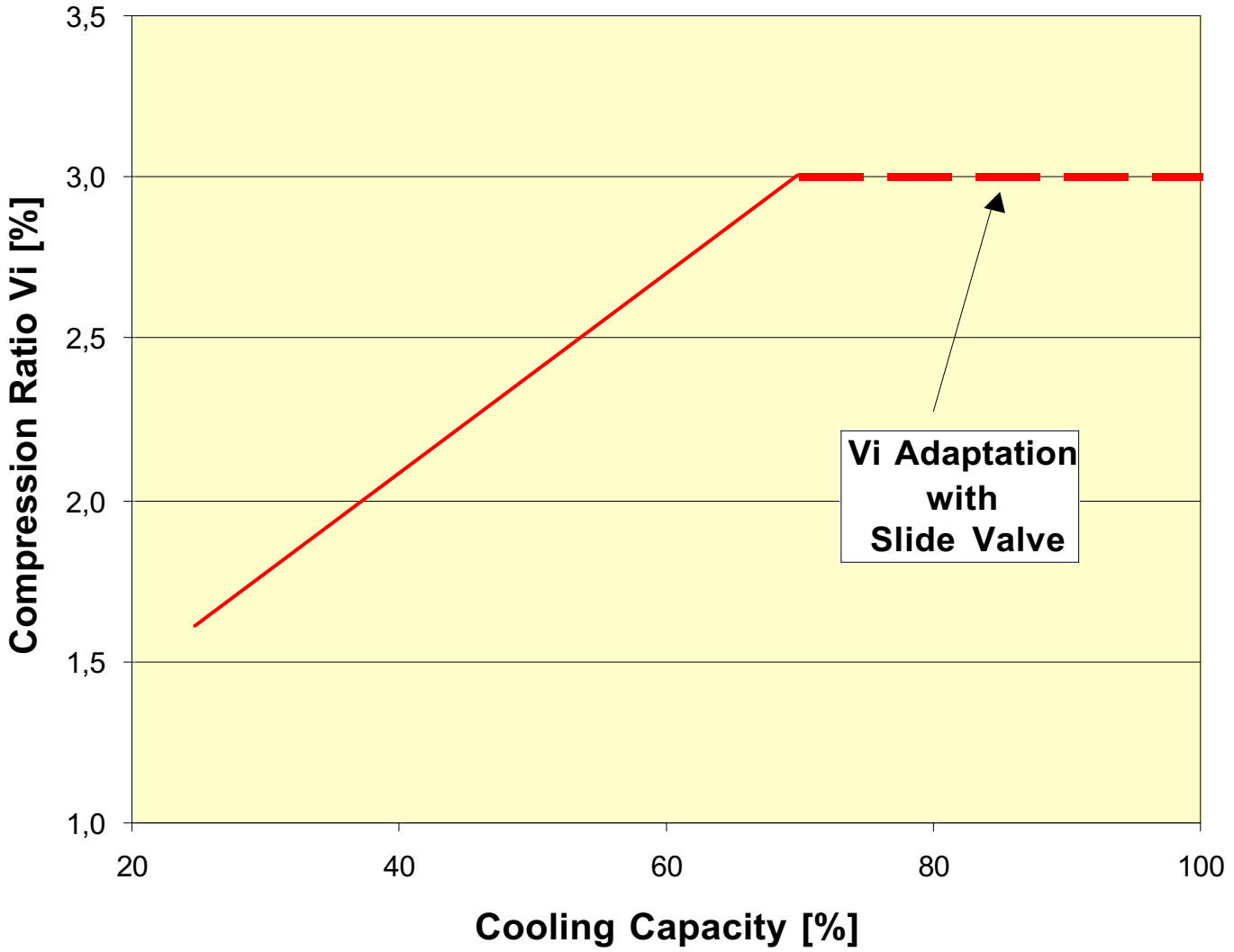


Basic Test Conditions
– Slider Unloading System –

- Power supply with fixed frequency (60 Hz)
- Capacity modulation by axial movement of unloading slider
  - Vi-Control at part load conditions
    - ➔ by adaptation of discharge port
- Capacity steps during test: 100 – 75 – 50 – 25%
  - 75 – 50 – 25% are nominal values
  - real capacity steps depend on SST and SDT

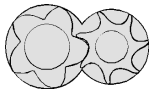


Vi-Control at Part Load Conditions – with Slider Unloading System –

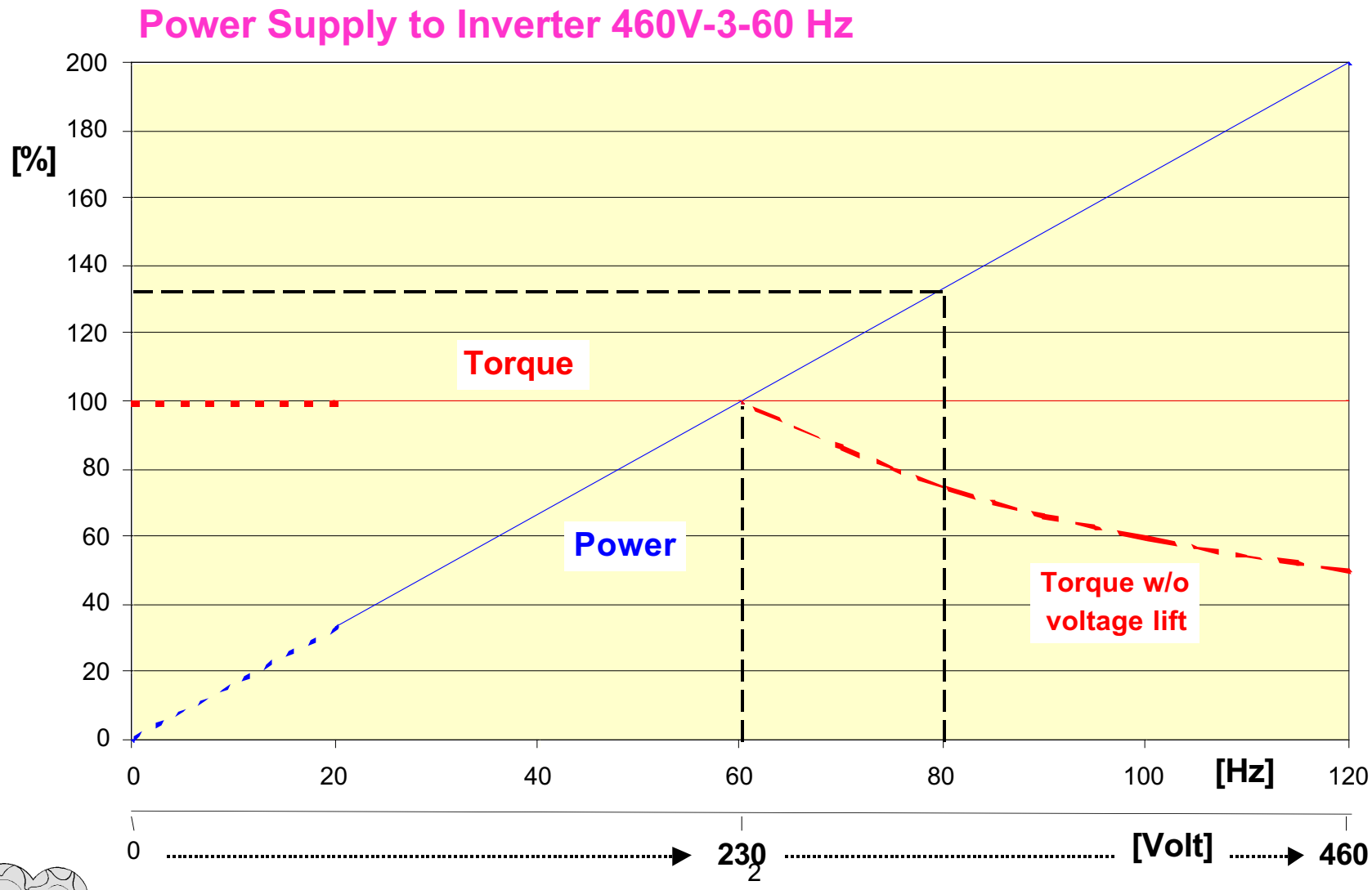


Basic Test Conditions
– VSD with Frequency Inverter –

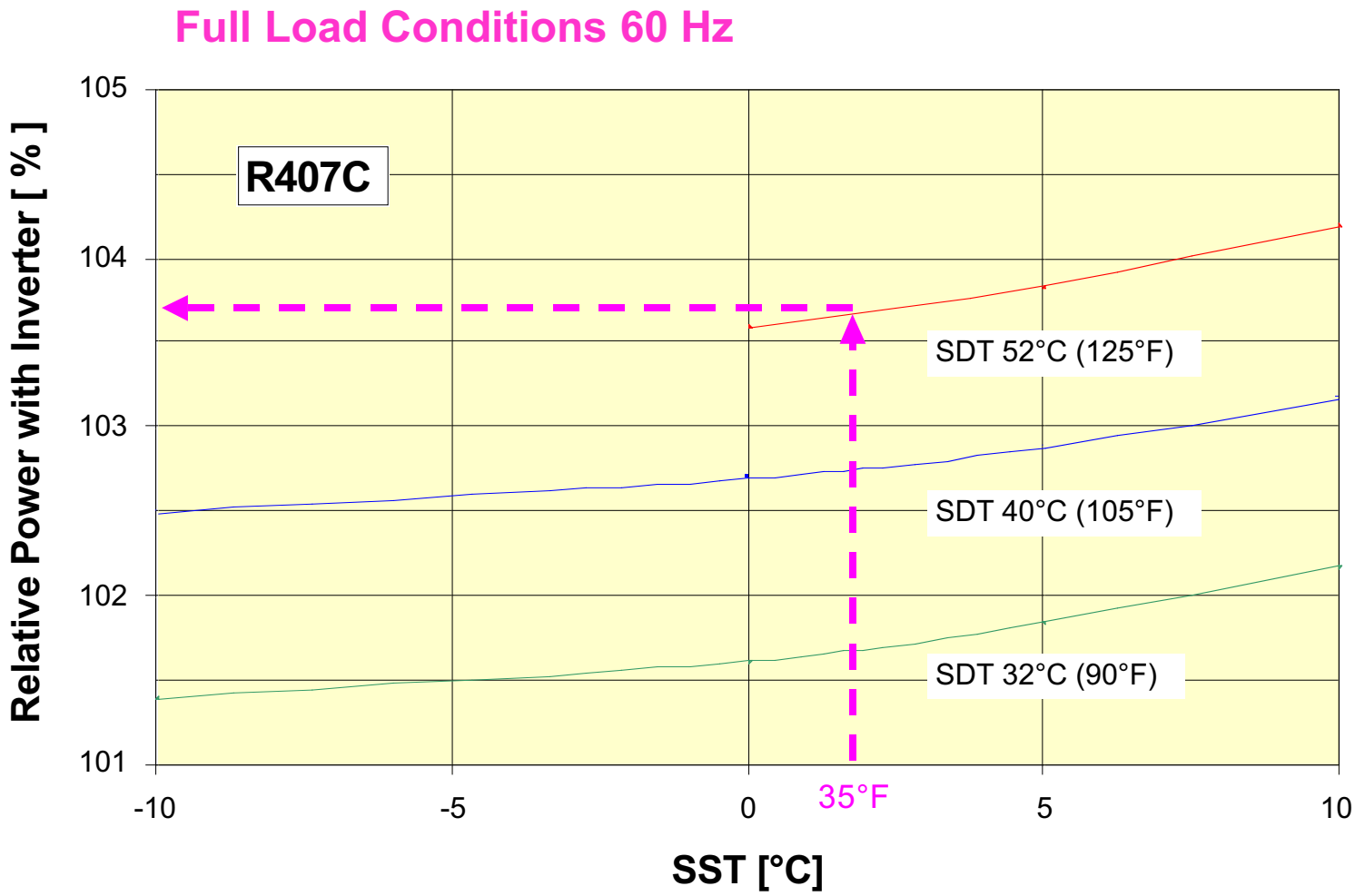
- Capacity control by VSD with frequency modulation
  - Compressor slide valve at 100% position
  - Ratio Voltage / Frequency U / f ⇨ constant
    - ➔ torque remains constant with speed change
- Capacity steps during test
  - 100% for comparison with “direct power supply 60 Hz”
  - Nominal 75 – 50 – 25% steps
    - ➔ by speed adaptation to reach identical cooling capacities as with slider control
  - Trans-synchronous speed range with **U / f** ⇨ constant
    - ➔ voltage lift for test above power supply (transformer)
      - – real systems ⇨ motor: e.g. 460V at max. frequency



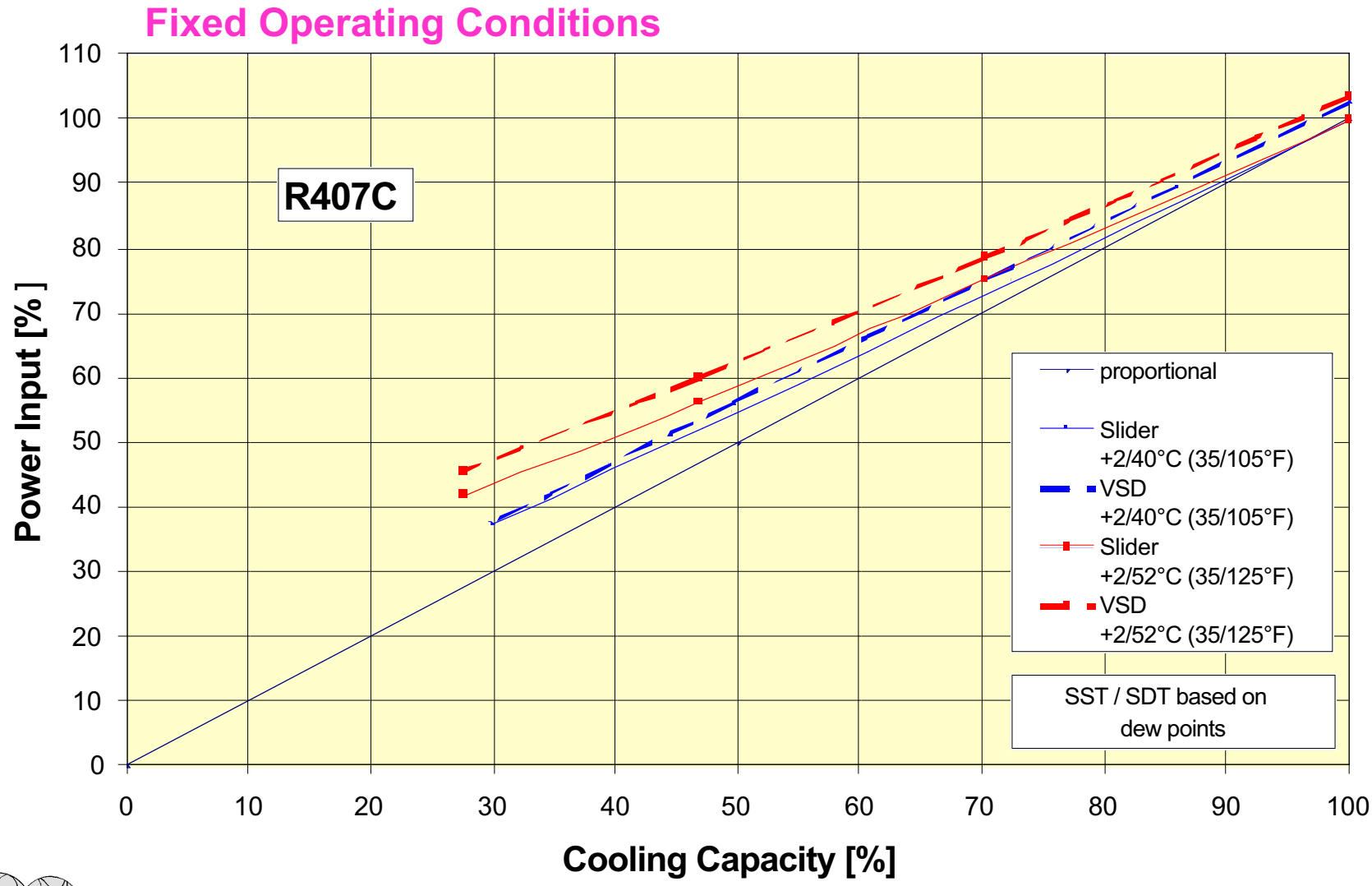
VSD with Frequency Inverter – Power & Torque with Winding Layout 230V-3-60 Hz



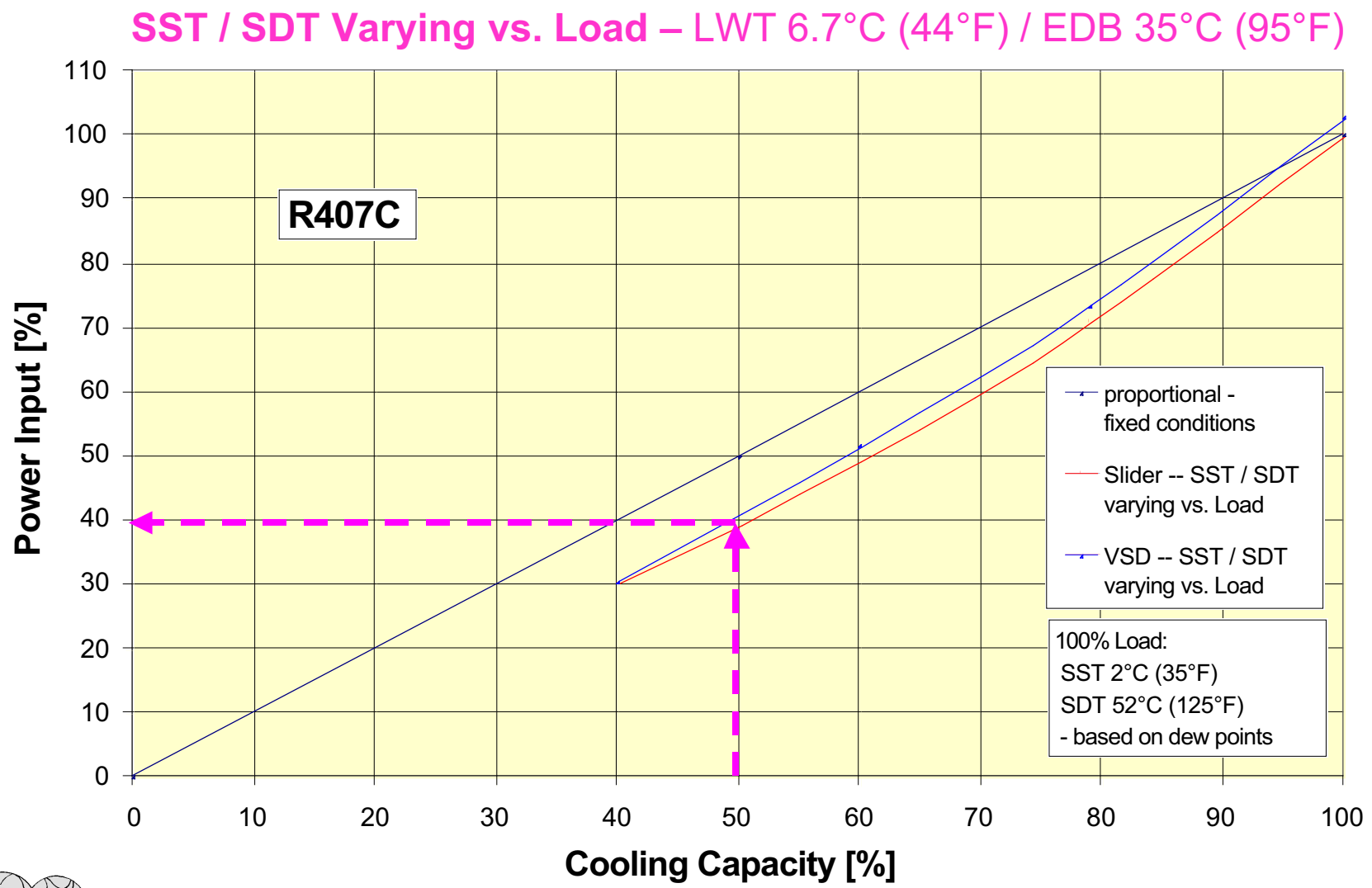
Power Consumption of CSH Screw – VSD vs. Direct Power Supply –



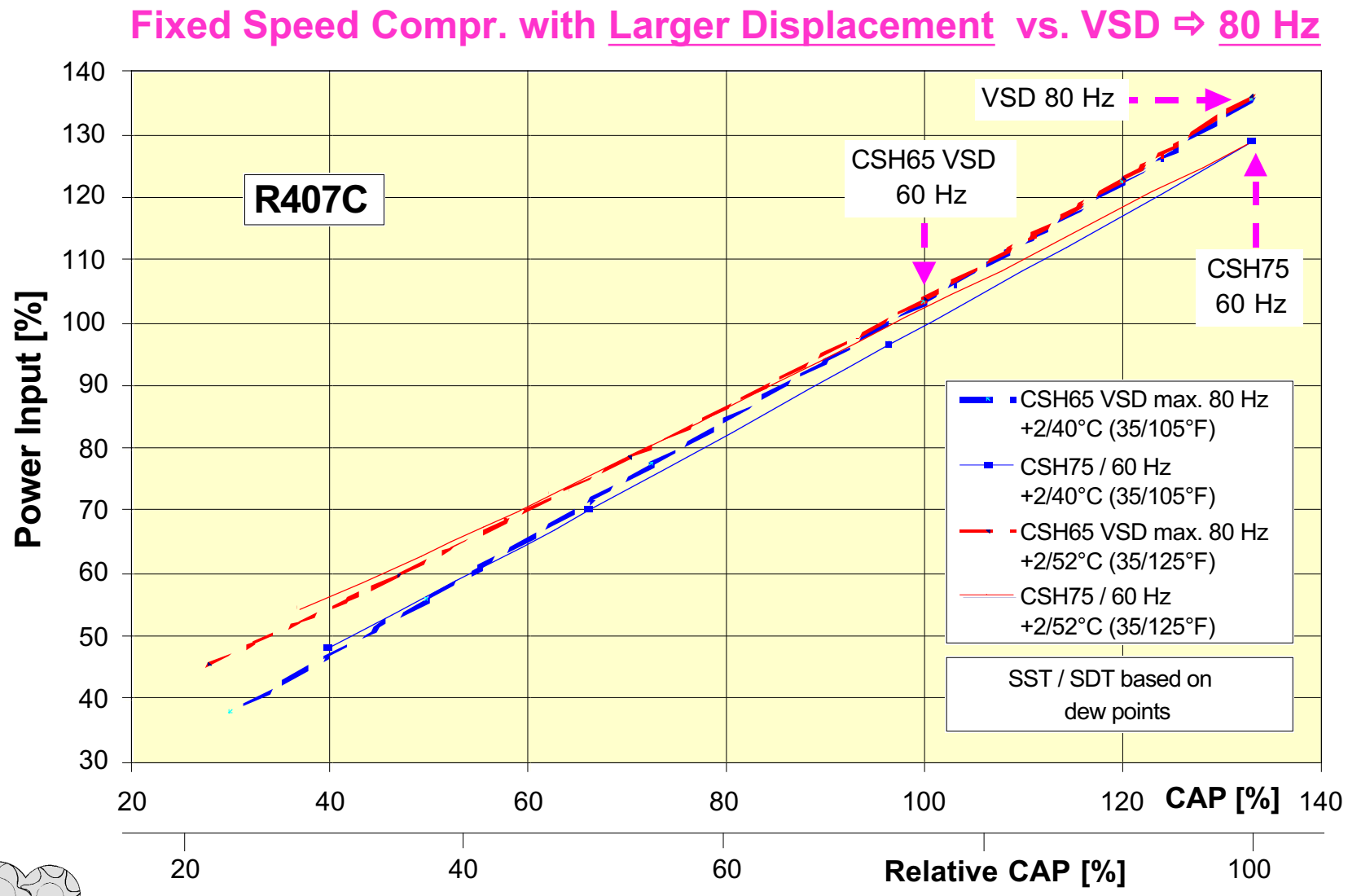
Performance Behaviour of CSH Screw – Slider Unloading vs. VSD –



Performance Behaviour of CSH Screw – Slider Unloading vs. VSD –



Performance Behaviour of CSH Screw – Slider Unloading vs. VSD ⇨ 80 Hz –

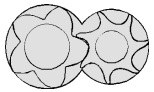


Modulation Techniques for Compressors – Part II
– Summary (1) –

- CSH Screw Compressors with slider modulation
  - Allow for infinite and step-wise capacity control
  - Show favourable part load efficiencies
  - Cost effective modulation technique
- VSD from 60 Hz to lower frequencies
  - Show higher energy demands than slider control
    - ➔ inverter and motor efficiency losses
    - ➔ reduced rotor tip speed – resulting in
    - ➔ increased internal leak losses during compression
  - Inverter cost much higher than slider arrangement

Conclusion

- No convincing solution



Modulation Techniques for Compressors – Part II
– Summary (2) –

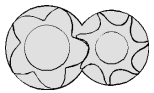
- VSD for trans-synchronous speed ranges

  ⇨ in comparison to a larger displacement fix speed compressor

  Pro's

  - Wider modulation range than with slider system
  - Smaller compressor, lower weight, simpler design (no slider)

    ➔Lower compressor cost, potential for high reliability
  - Soft starting, low inrush current
  - No need for Power Factor correction



Modulation Techniques for Compressors – Part II
– Summary (3) –

Con's

- Efficiency penalty against compressor with larger displacement
  - ➔ increased tip speed but higher throttling losses
- Very high inverter cost
  - ➔ exceeds (in the lower capacity range) compressor cost savings by far
- Bearing life is in direct counter-proportion to speed
- Increased sound levels with high speed

Conclusion

- Both modulation techniques offer specific benefits – the deciding factors for a final solution are therefore dependant on:
  - ➔ the entire system configuration, reliability, energy efficiency, investment and maintenance cost