Compressors for Industrial Refrigeration

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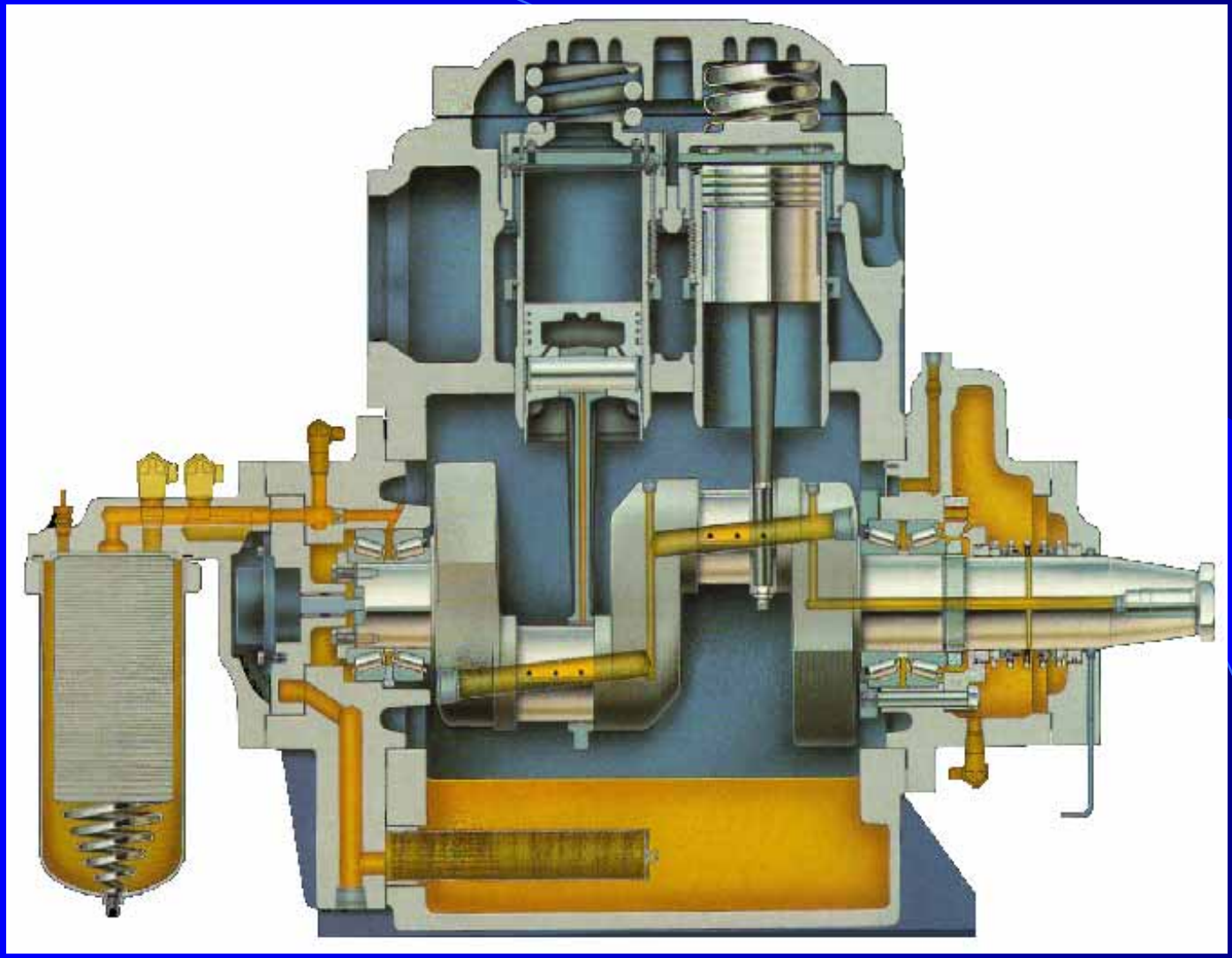
Compressor Types

- Reciprocating
- Rotary Screw
  - Single Screw
  - Twin Screw
- Centrifugal

Reciprocating Compressor

Reciprocating Compressor Features

- Common in 2 through 16 cylinder configurations.
- Individual step unloading
- Liquid resistant safety head protection

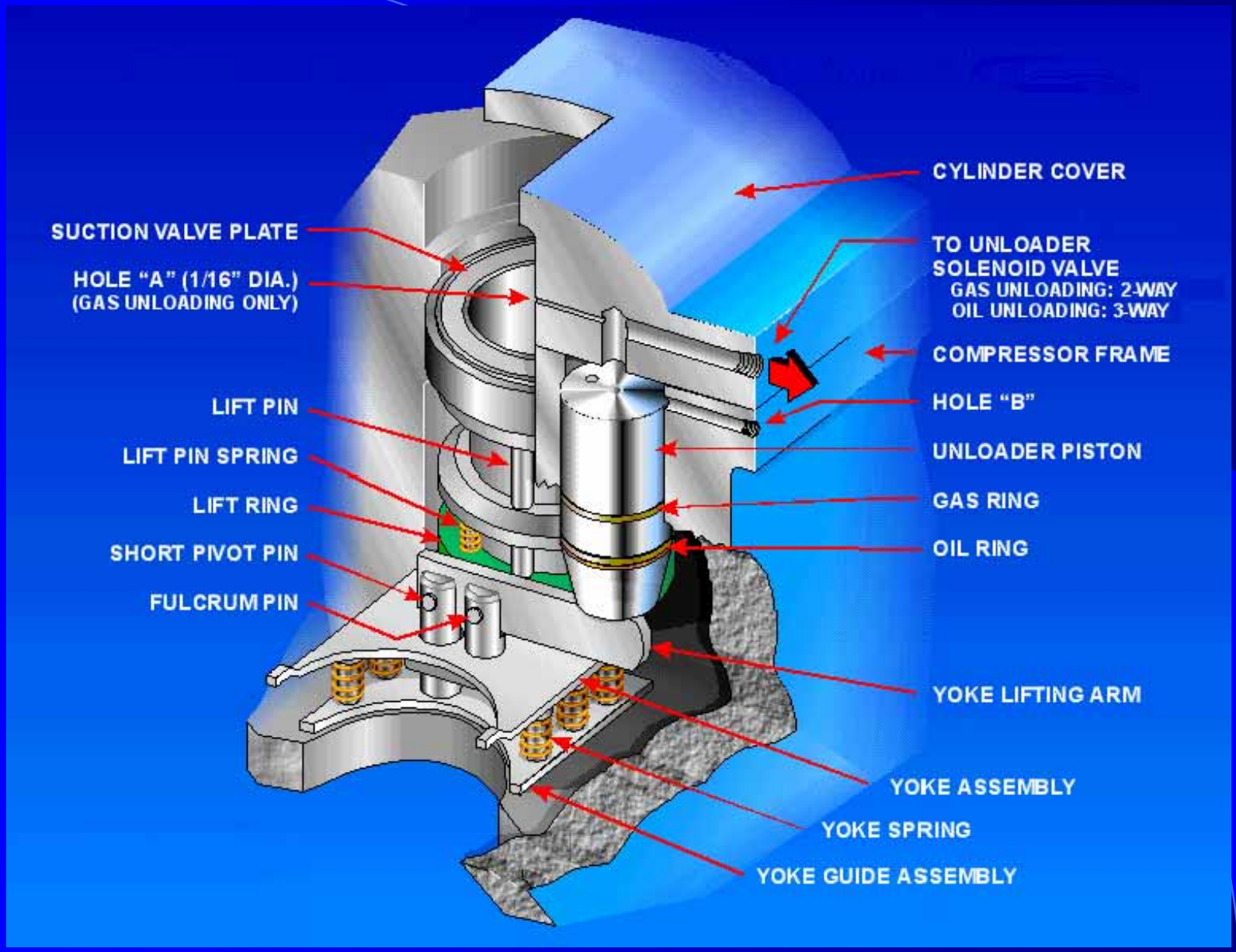


Efficient Compression

- Piston rings provide positive sealing and minimal leakage
- Valve springing allows compressor to operate at any pressure ratio
  - Valve plate inertia is function of speed
  - Throttling losses function of effective flow area

Capacity Control System

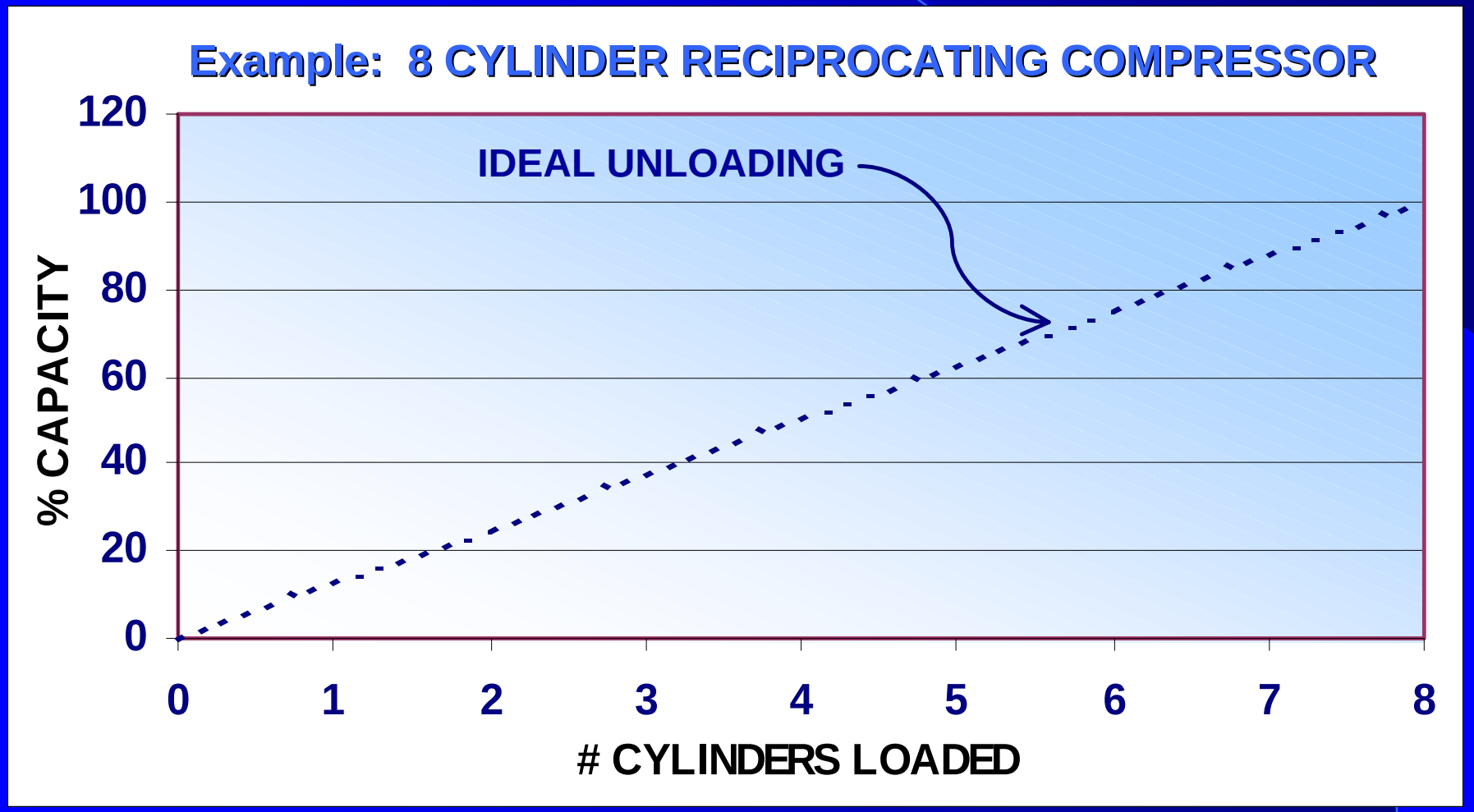
- Consists of piston actuated unloading mechanism
- Mechanism uses spring-loaded pins to raise the suction valve plate from its seat
- Can be actuated with either high pressure gas or oil


CYLINDER COVER
SUCTION VALVE PLATE
HOLE "A" (1/16" DIA.)
(GAS UNLOADING ONLY)
TO UNLOADER
SOLENOID VALVE
GAS UNLOADING: 2-WAY
OIL UNLOADING: 3-WAY
COMPRESSOR FRAME
HOLE "B"
LIFT PIN
LIFT PIN SPRING
UNLOADER PISTON
LIFT RING
GAS RING
SHORT PIVOT PIN
OIL RING
FULCRUM PIN
YOKE LIFTING ARM
YOKE ASSEMBLY
YOKE SPRING
YOKE GUIDE ASSEMBLY

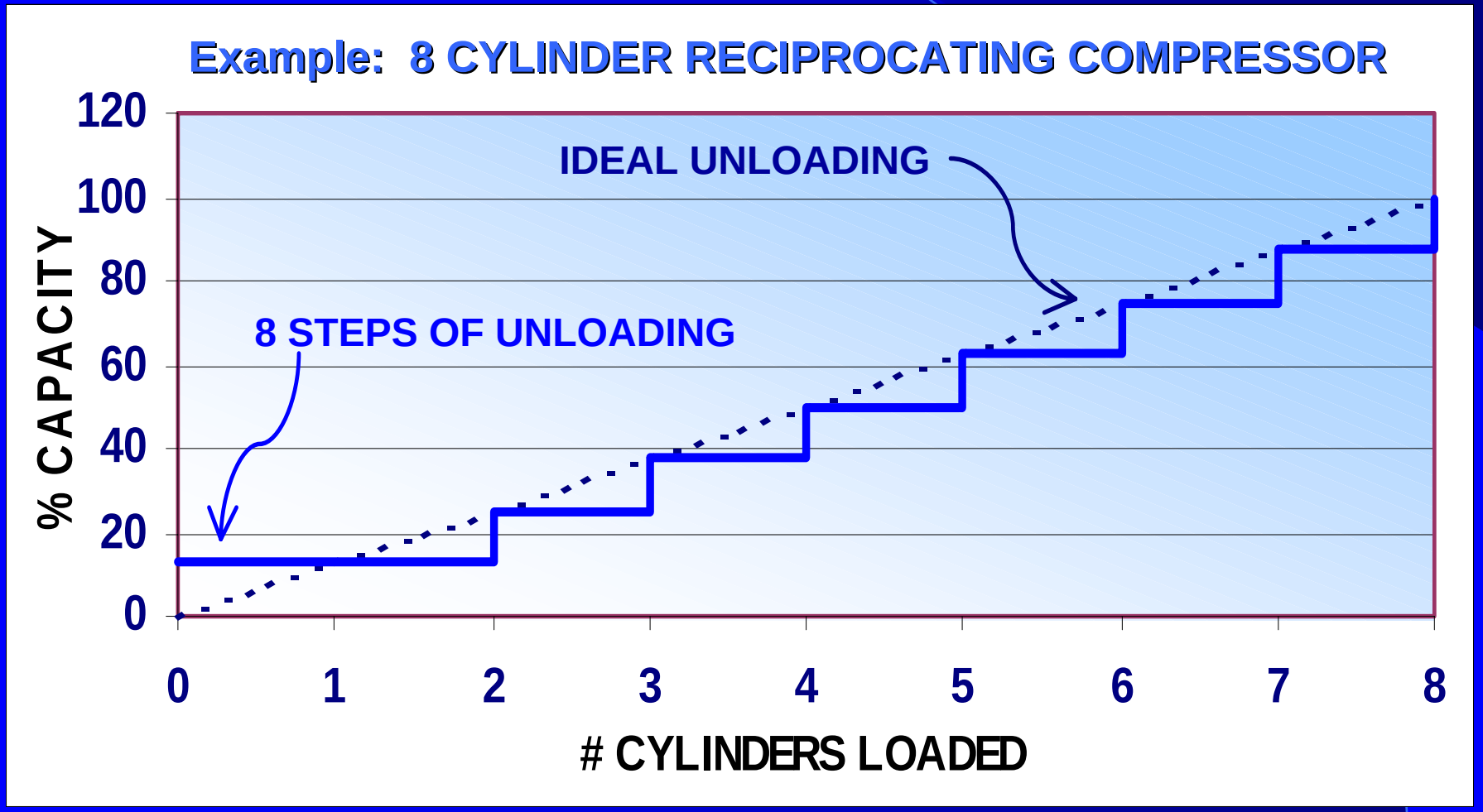
Compression

- Maximum Efficiency
  - Efficient at Full Load Operation
  - Efficient at Part Load Operation
  - Greater than Rotary Screw Compressor

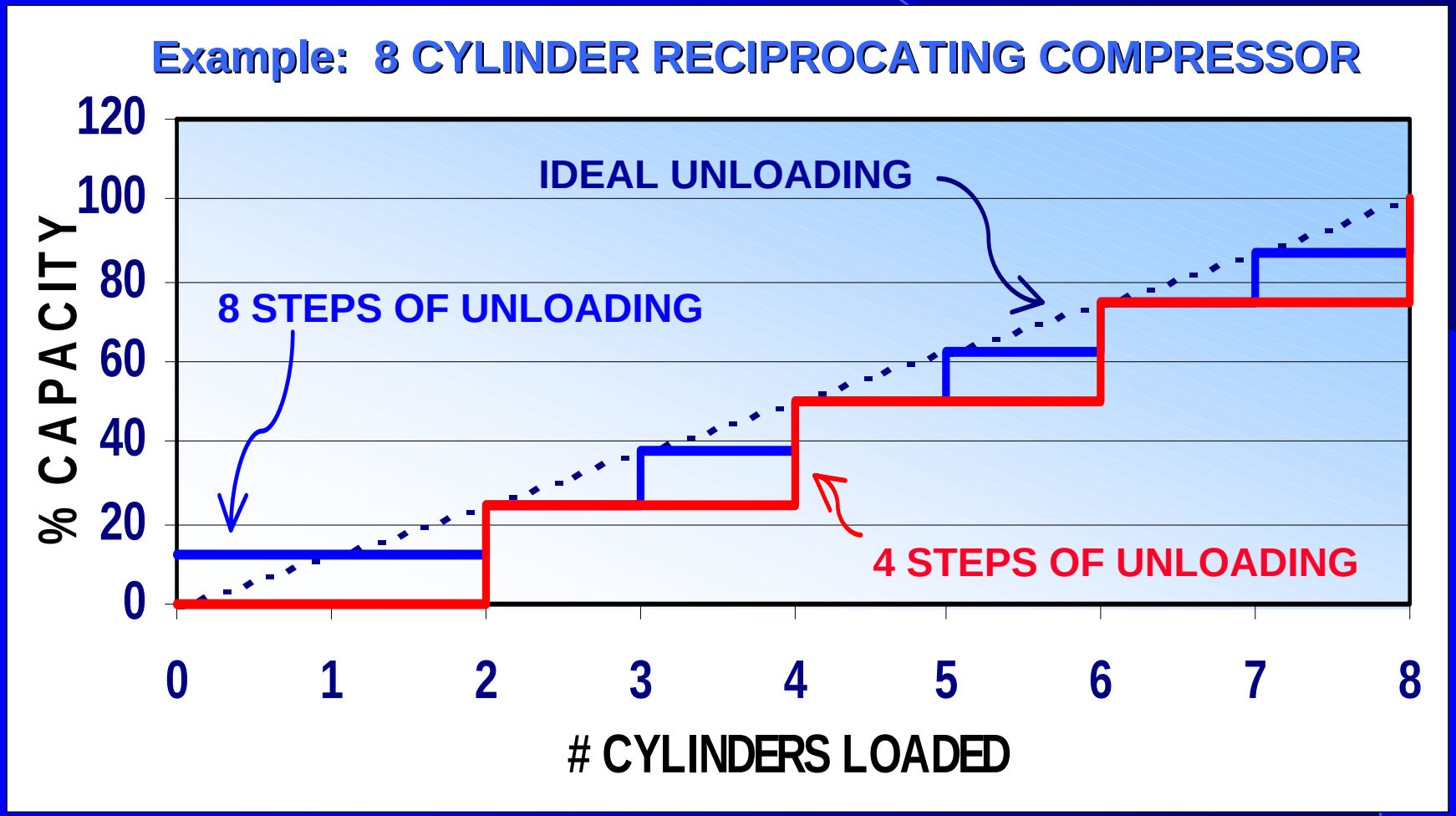
RECIPROCATING COMPRESSOR
UNLOADING



RECIPROCATING COMPRESSOR
UNLOADING



RECIPROCATING COMPRESSOR
UNLOADING



Reciprocating Compressor Advantages

- Efficient at part and full load
- Instantaneous unloading
- Simple controls
- Direct and belt drive
  - adjust capacity by speed ie belts

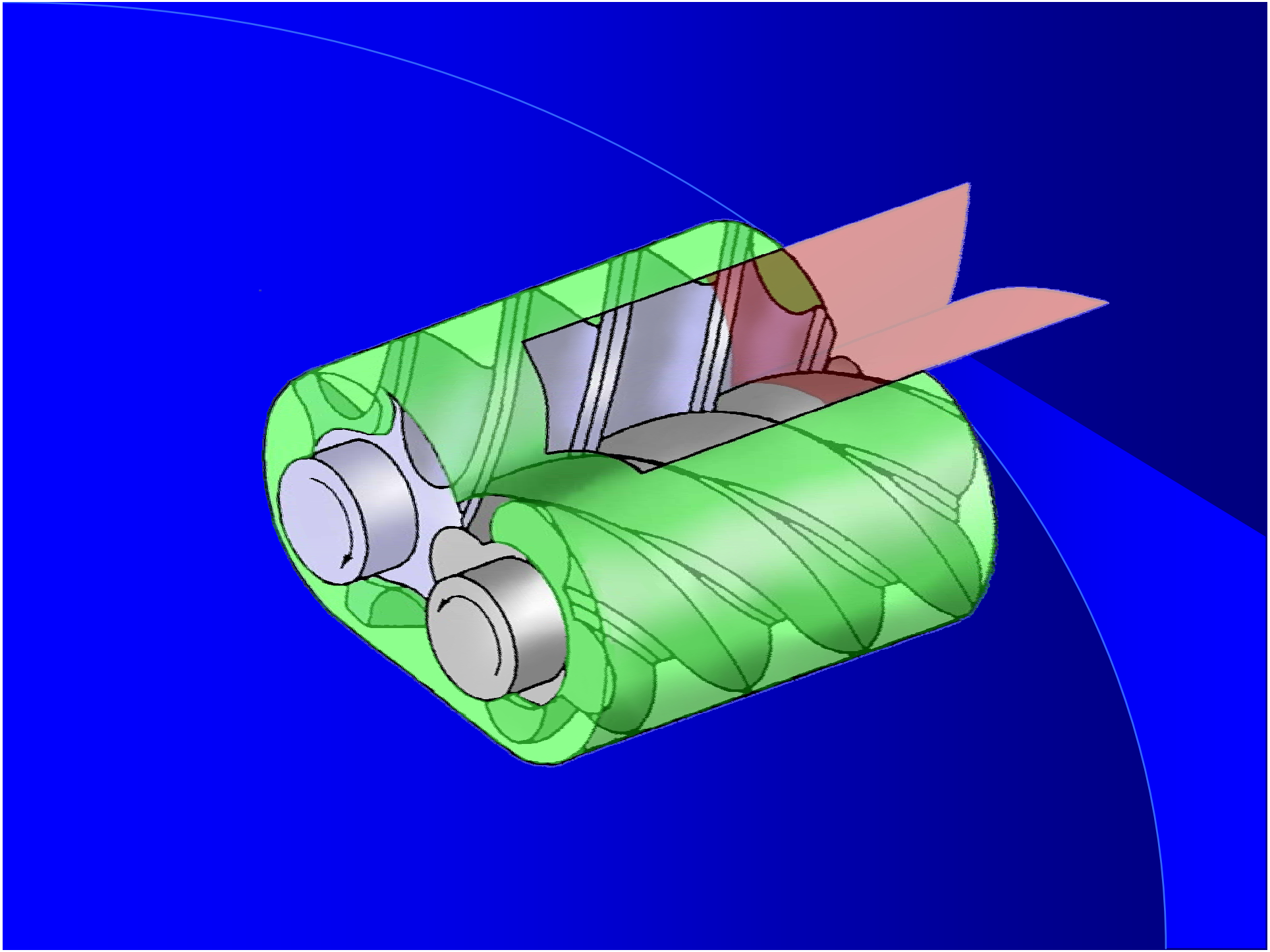
Rotary Screw Compressor Types

- Single Screw
- Twin Screw

Compression

- Rotating components reduce volume of groove compressing gas
- Oil seals clearances between rotary components
- Oil absorbs heat of compression
- Compression occurs until the port in slide or port in housing is open

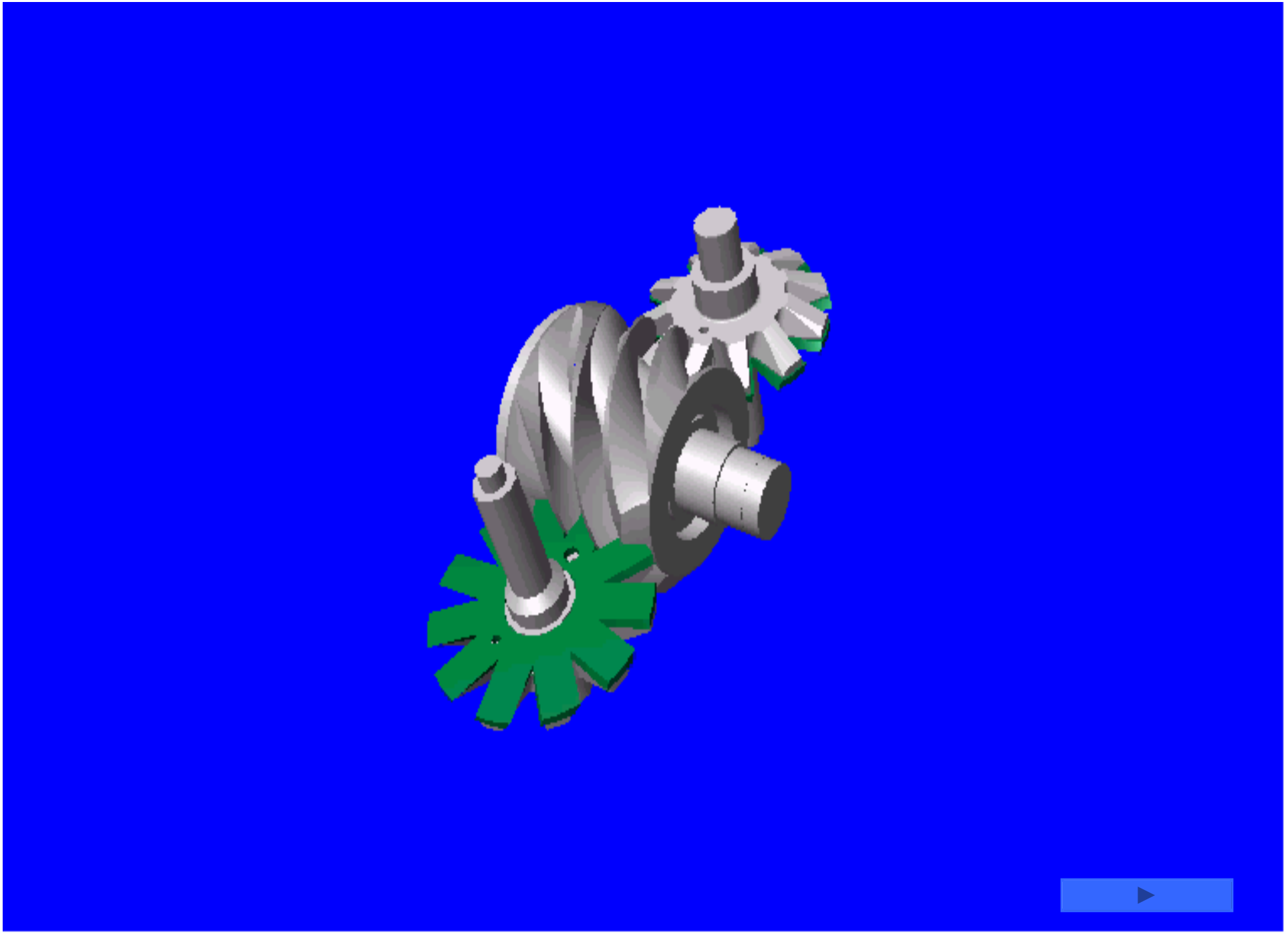
Twin Screw Compressor



Single Screw Compressor

Major Components

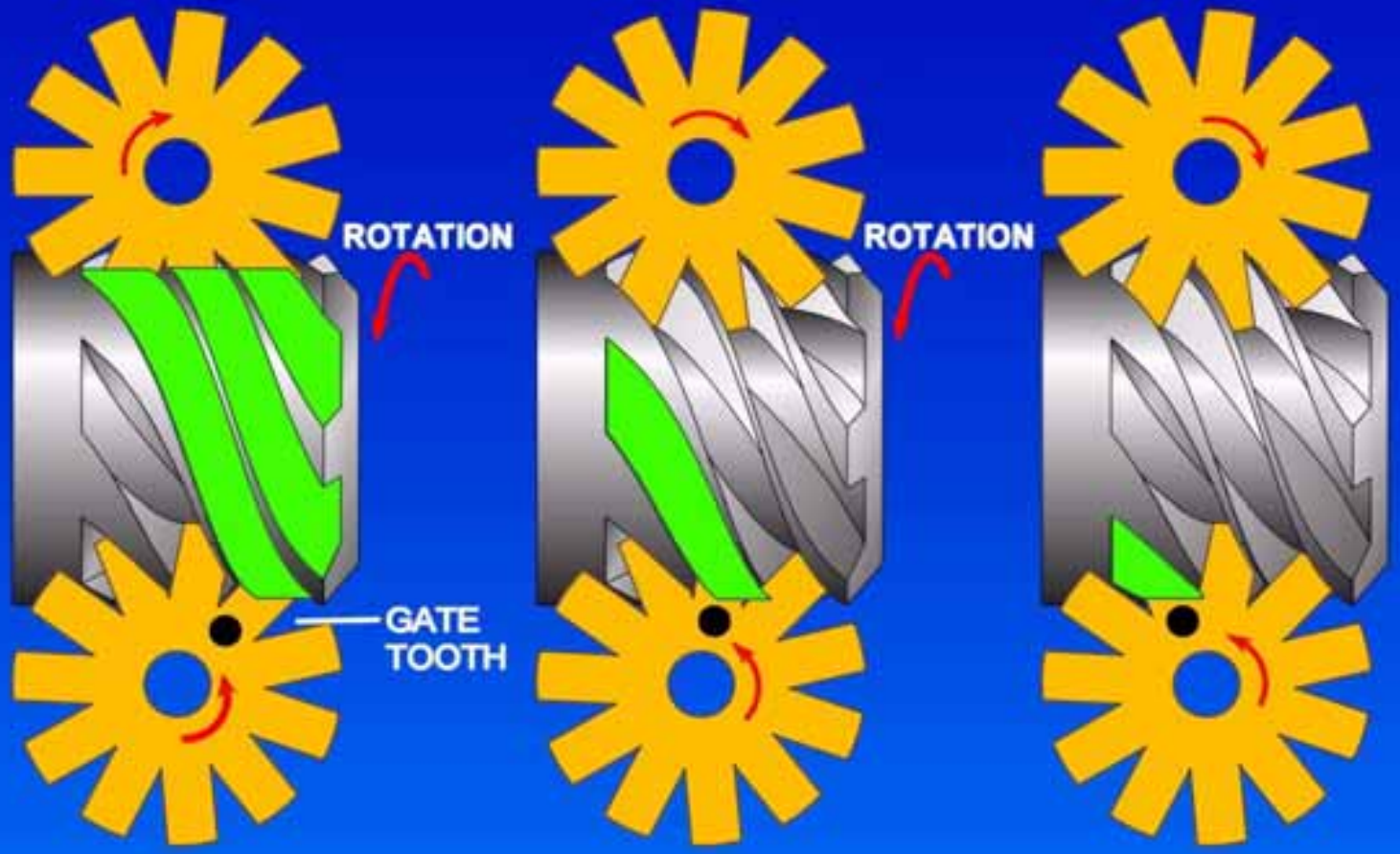
- Main Screw
  - Six Helical Grooves
  - Cast Iron Material
- Two Gaterotors
  - Eleven Teeth
  - Rotate at 6/11 of Driveshaft Speed
  - PPS Composite Material



Compression

- Operation at 3600 RPM Results in 21,600 Simultaneous Compression Strokes Per Minute
- Smooth Operation with Low Torque and Pulsation Levels

Compression Cycle



BEGINNING OF COMPRESSION CYCLE

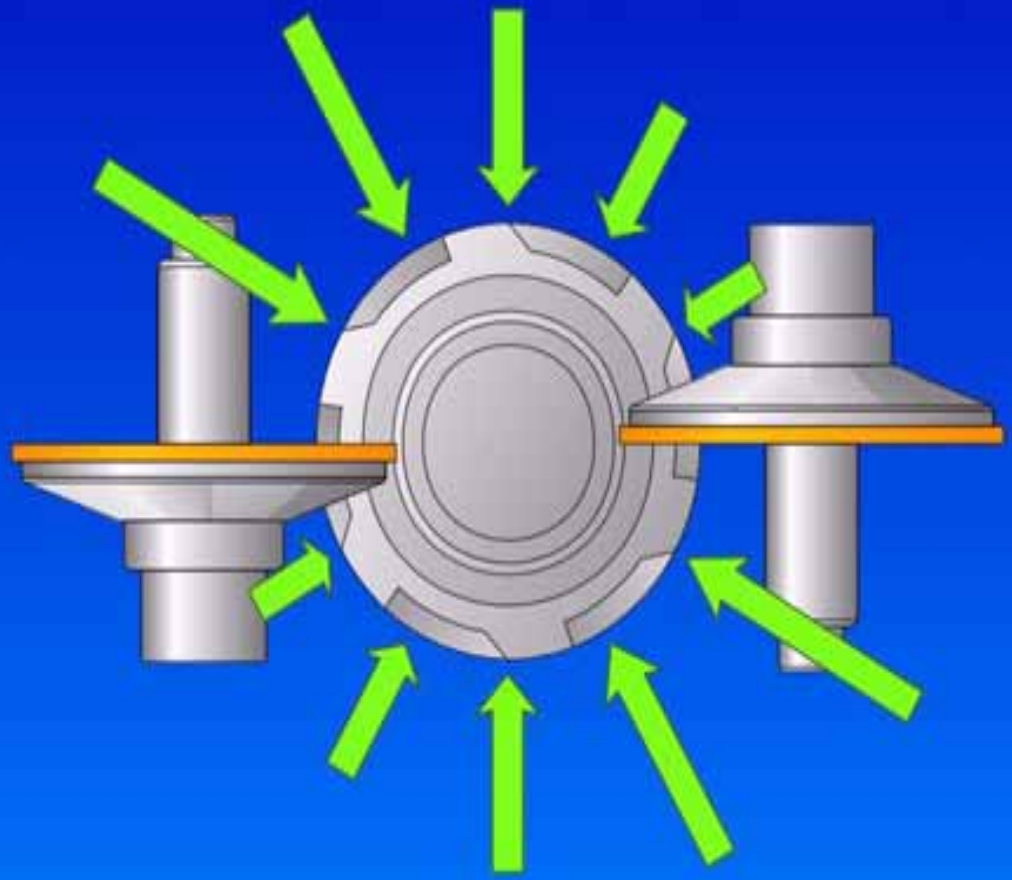
GATEROTOR TOOTH TRAPS GAS IN FLUTE

GAS COMPRESSION AT MAXIMUM VALUE JUST PRIOR TO DISCHARGE

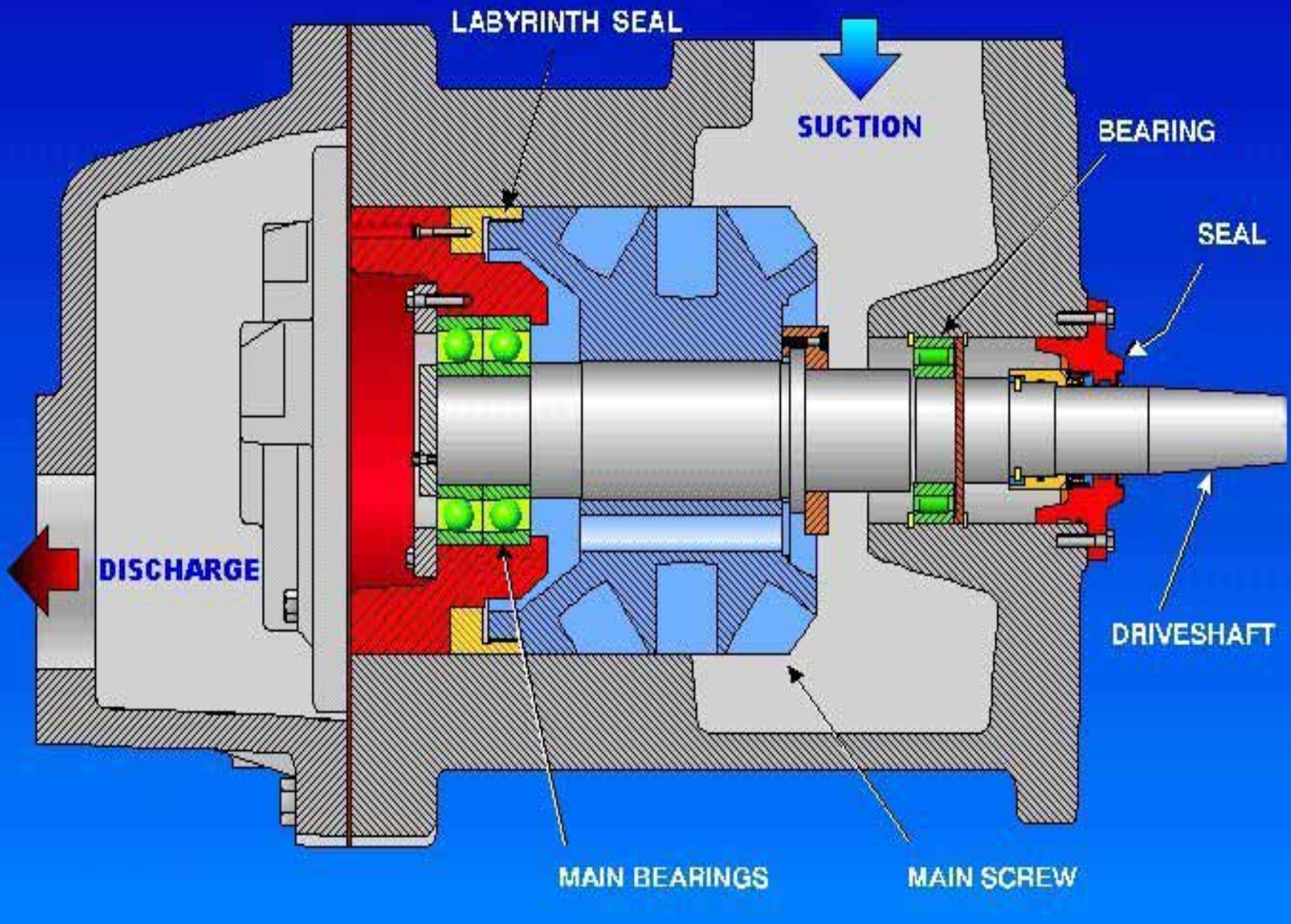
Design Features

- Balanced Loading of the Main Screw
  - Radially Balanced
  - Axially Balanced
  - Resulting Low Bearing Loads

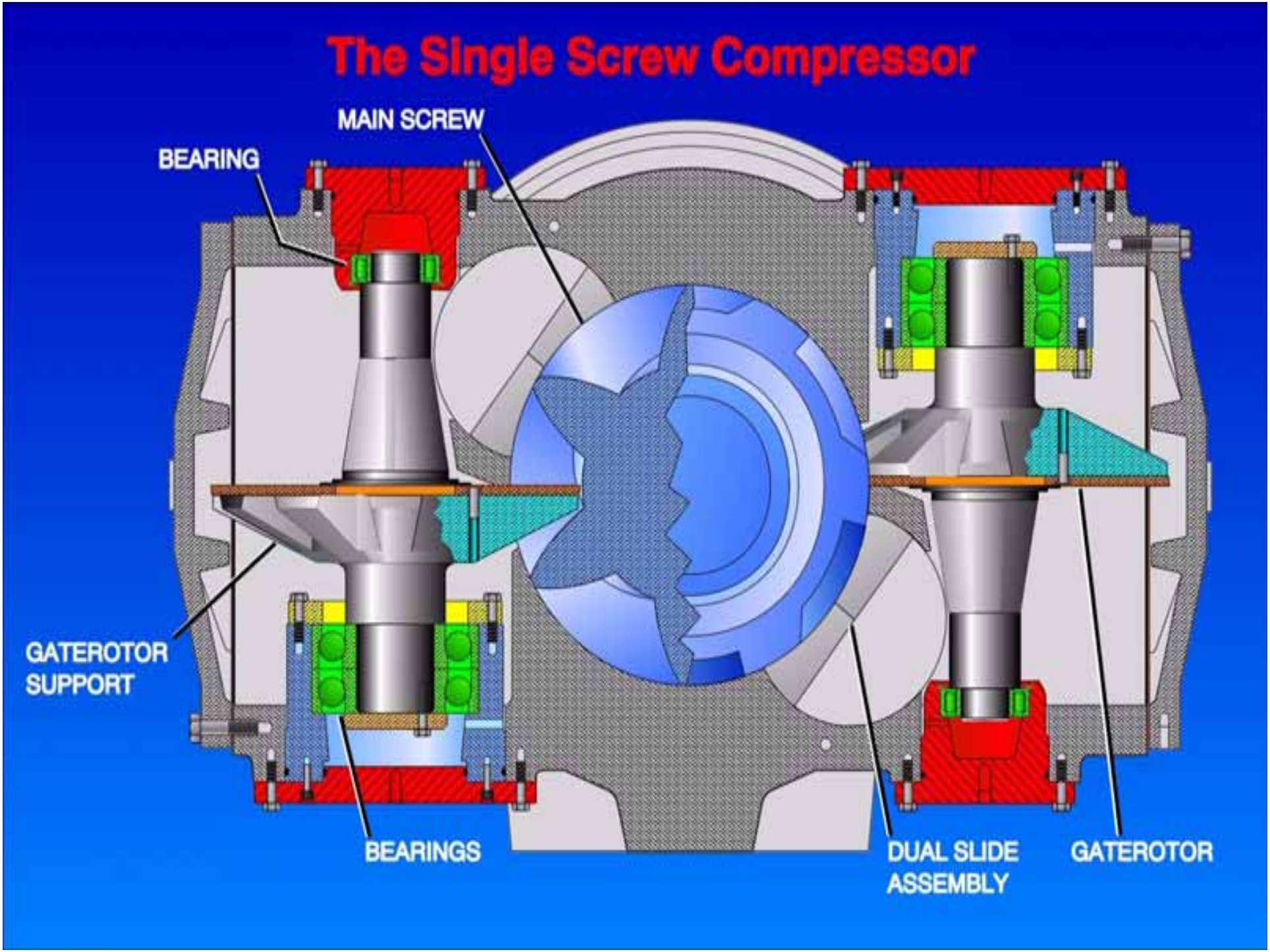
Balanced Loading



The Single Screw Compressor

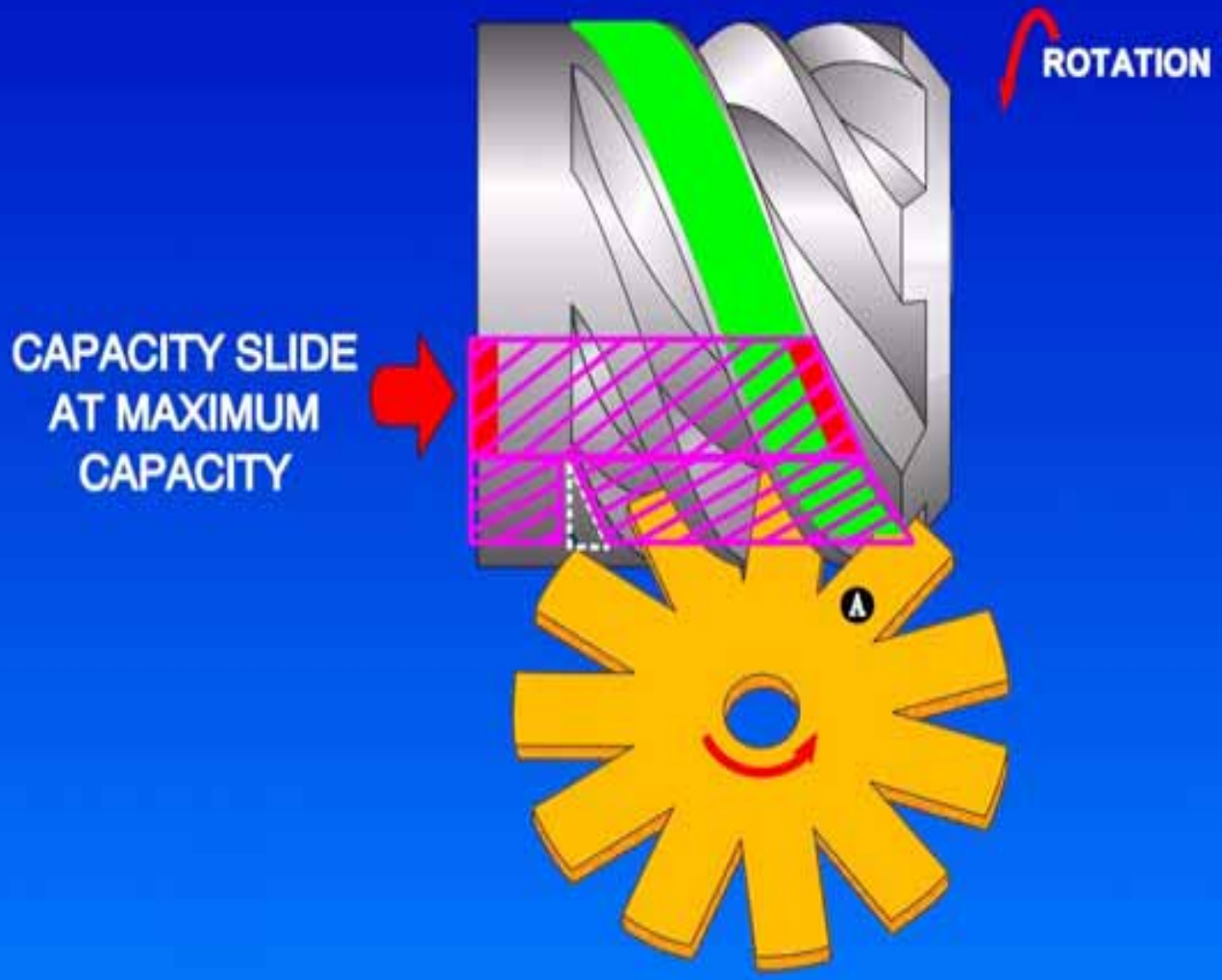


The Single Screw Compressor



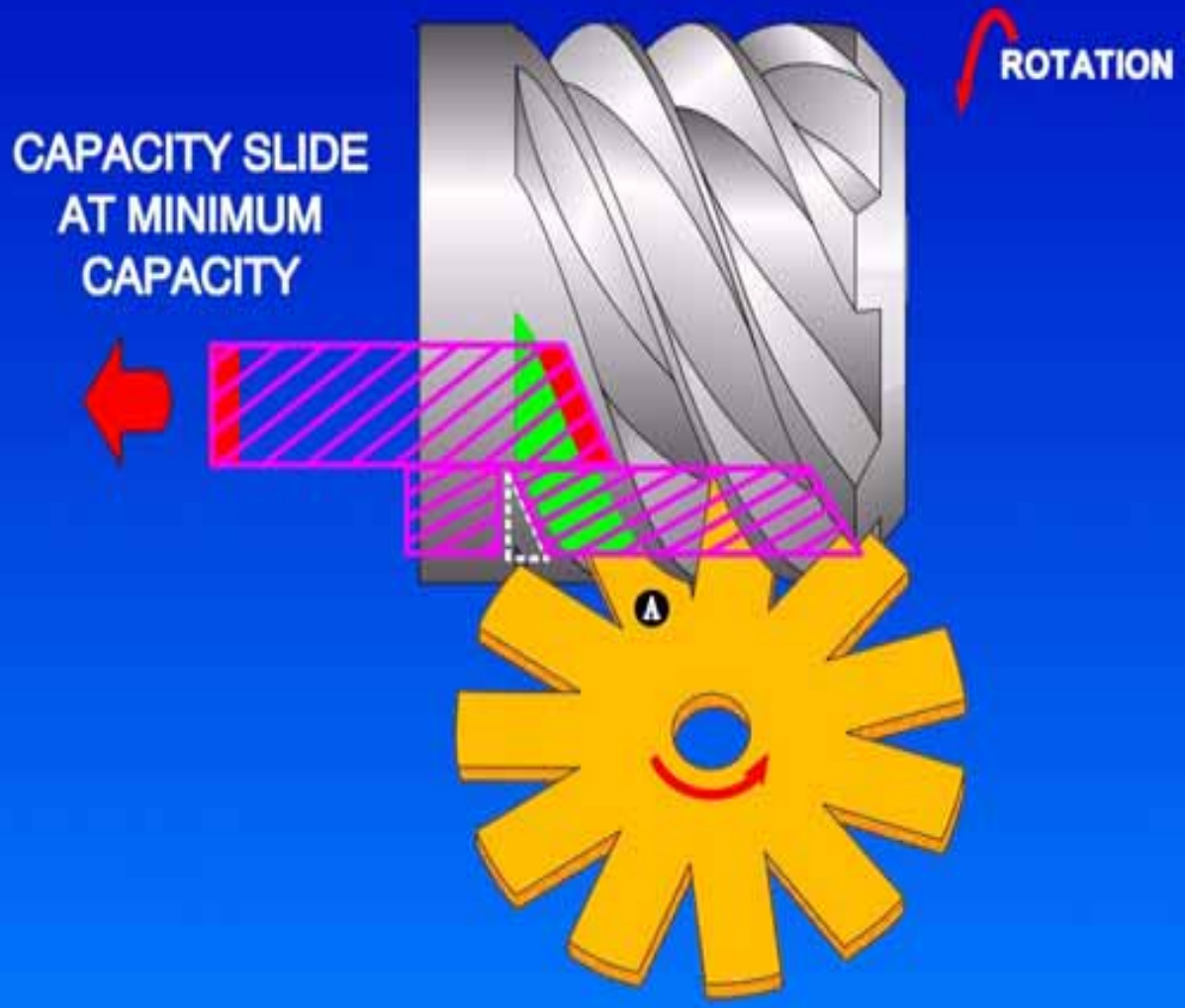
The Single Screw Compressor

CAPACITY CONTROL



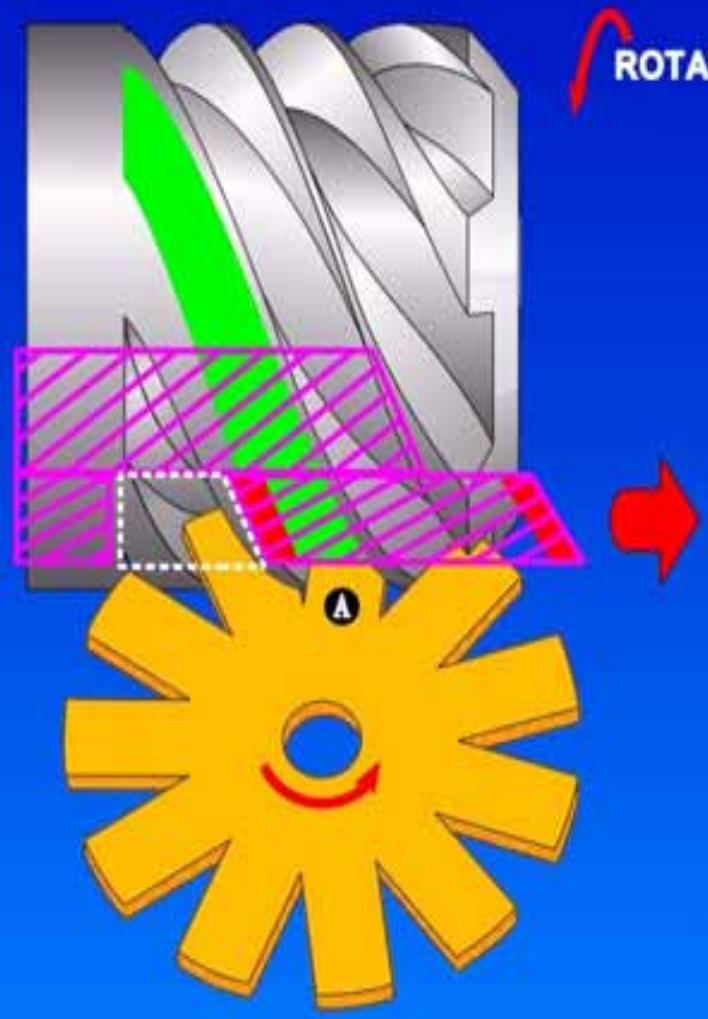
The Single Screw Compressor

CAPACITY CONTROL



The Single Screw Compressor

VOLUME RATIO CONTROL



The Single Screw Compressor

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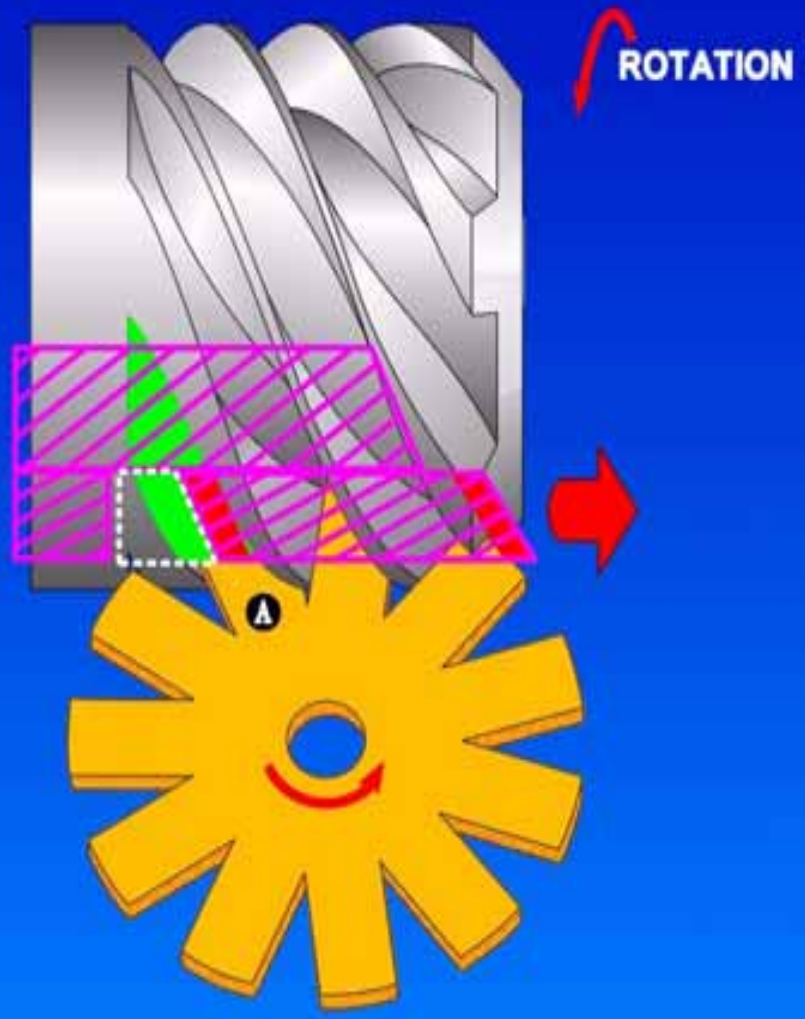


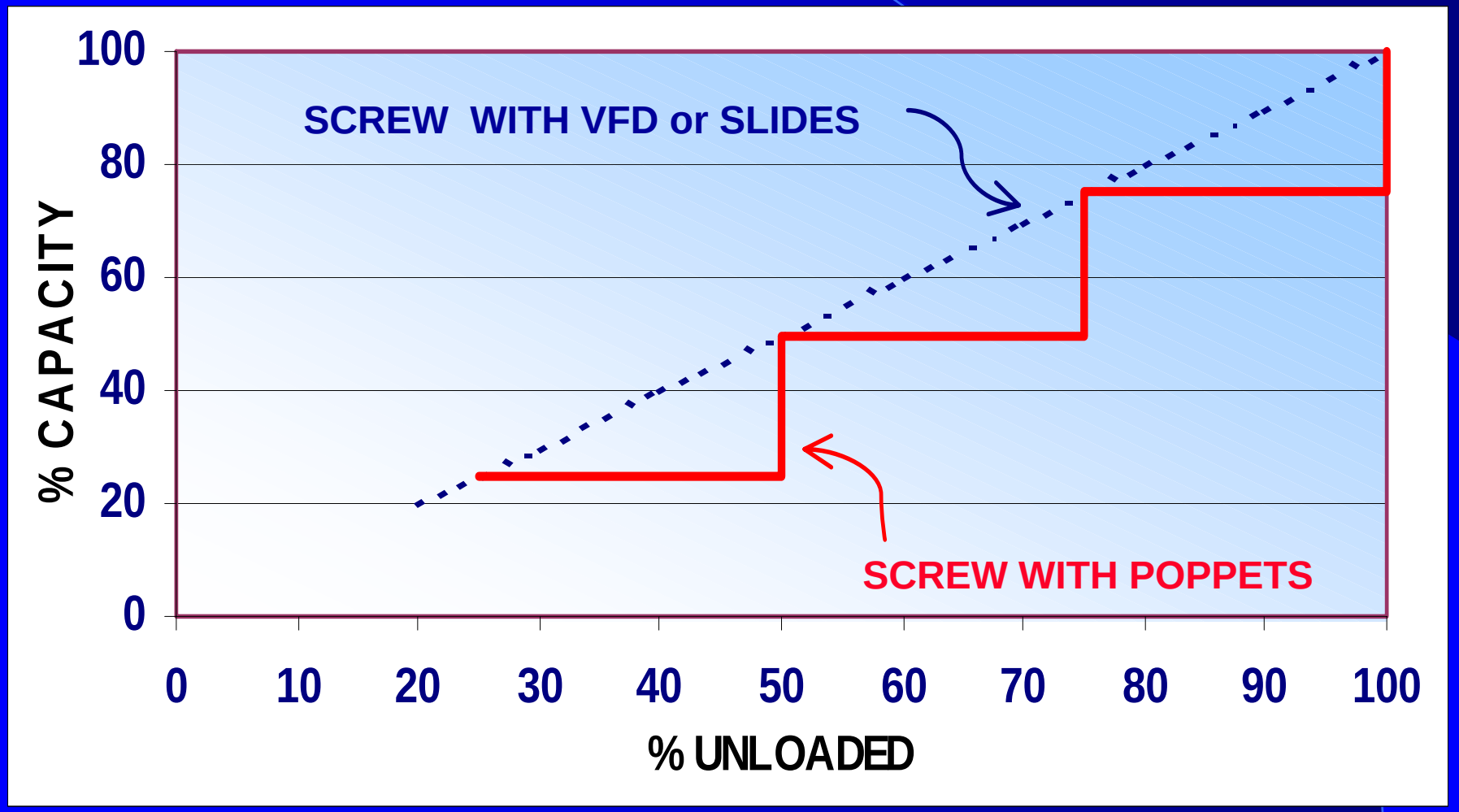
Rotary Screw Compressor Capacity Control

- Electronic Capacity Control
  - VFD Drive (Speed Control)
  - Internal Leakage in Compressor Increases at Slower Speeds
- Mechanical Capacity Control

Mechanical Capacity Control

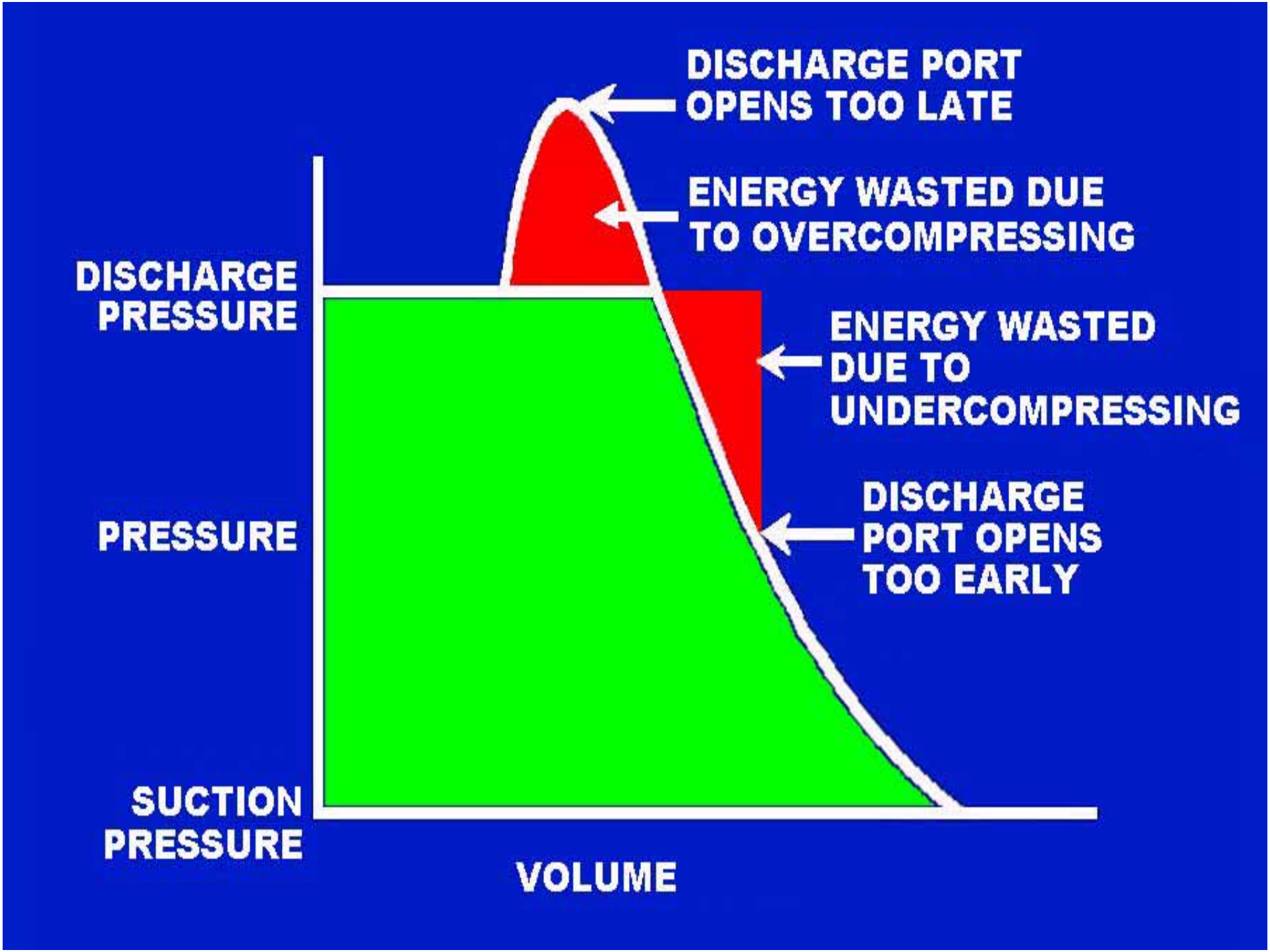
- Poppet Valves
- Single Slide Valve
  - Move slide (fixed volume ratio)
- Two Piece Slide in Series
  - Move single slide at part load
- Dual Parallel slides
  - Independent capacity and volume slide

SCREW COMPRESSOR
UNLOADING



Compression Efficiency

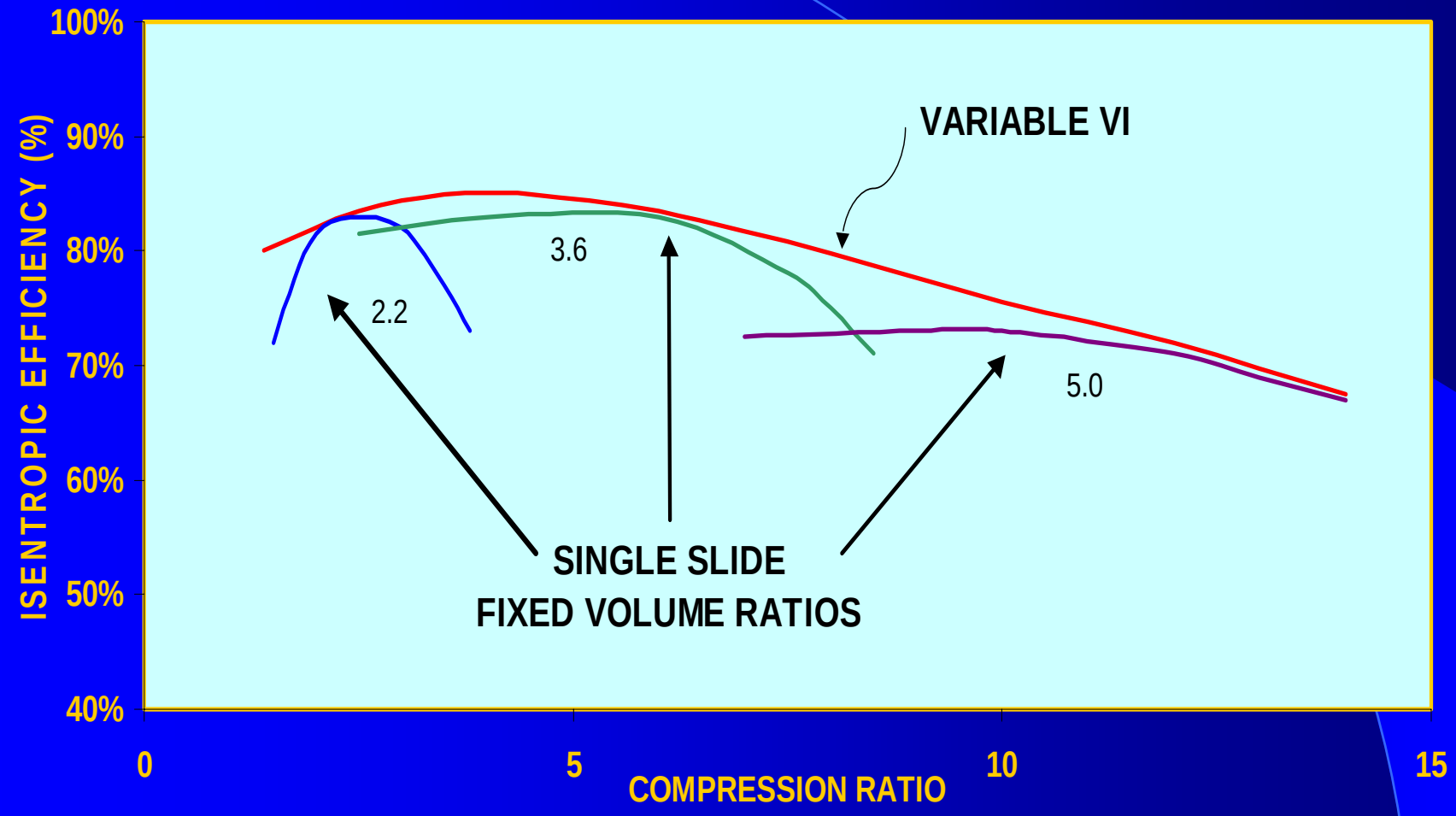
- Function of having the discharge port open at the correct time


DISCHARGE PORT
OPENS TOO LATE
ENERGY WASTED DUE
TO OVERCOMPRESSING
DISCHARGE
PRESSURE
ENERGY WASTED
DUE TO
UNDERCOMPRESSING
PRESSURE
DISCHARGE
PORT OPENS
TOO EARLY
SUCTION
PRESSURE
VOLUME

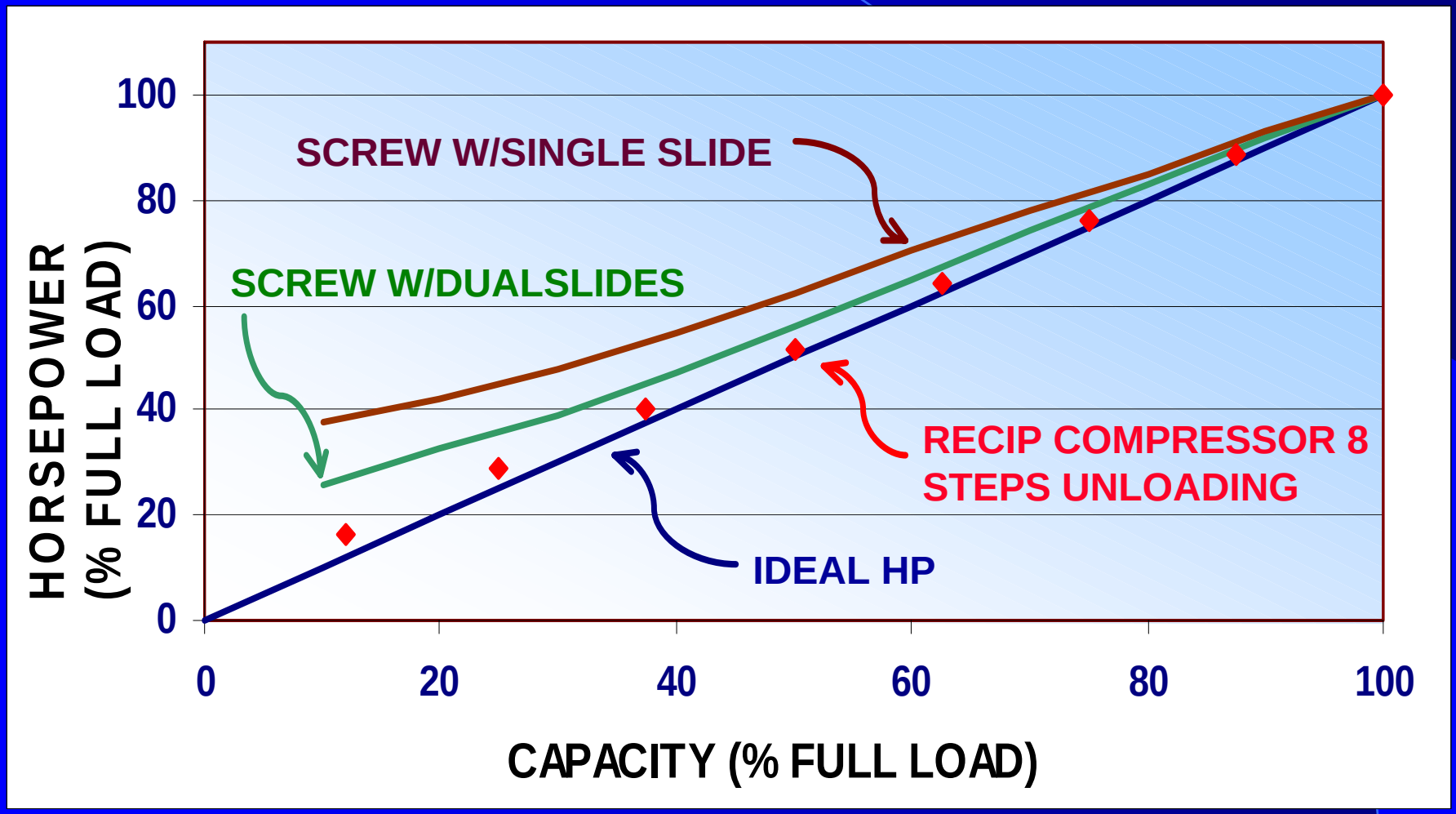
Compression Efficiency

- Function of having the discharge port open at the correct time
- Poppets and a Single Fixed Length Slide control capacity and when compression process begins, not when compression ends
- VFD controls rotative speed (capacity) not when compression ends

Full Load Performance



COMPRESSOR EFFICIENCIES AT PART LOAD CONDITIONS



Optimizing Performance for an Application

- Map out Load Profile
- Make Compressor Selections

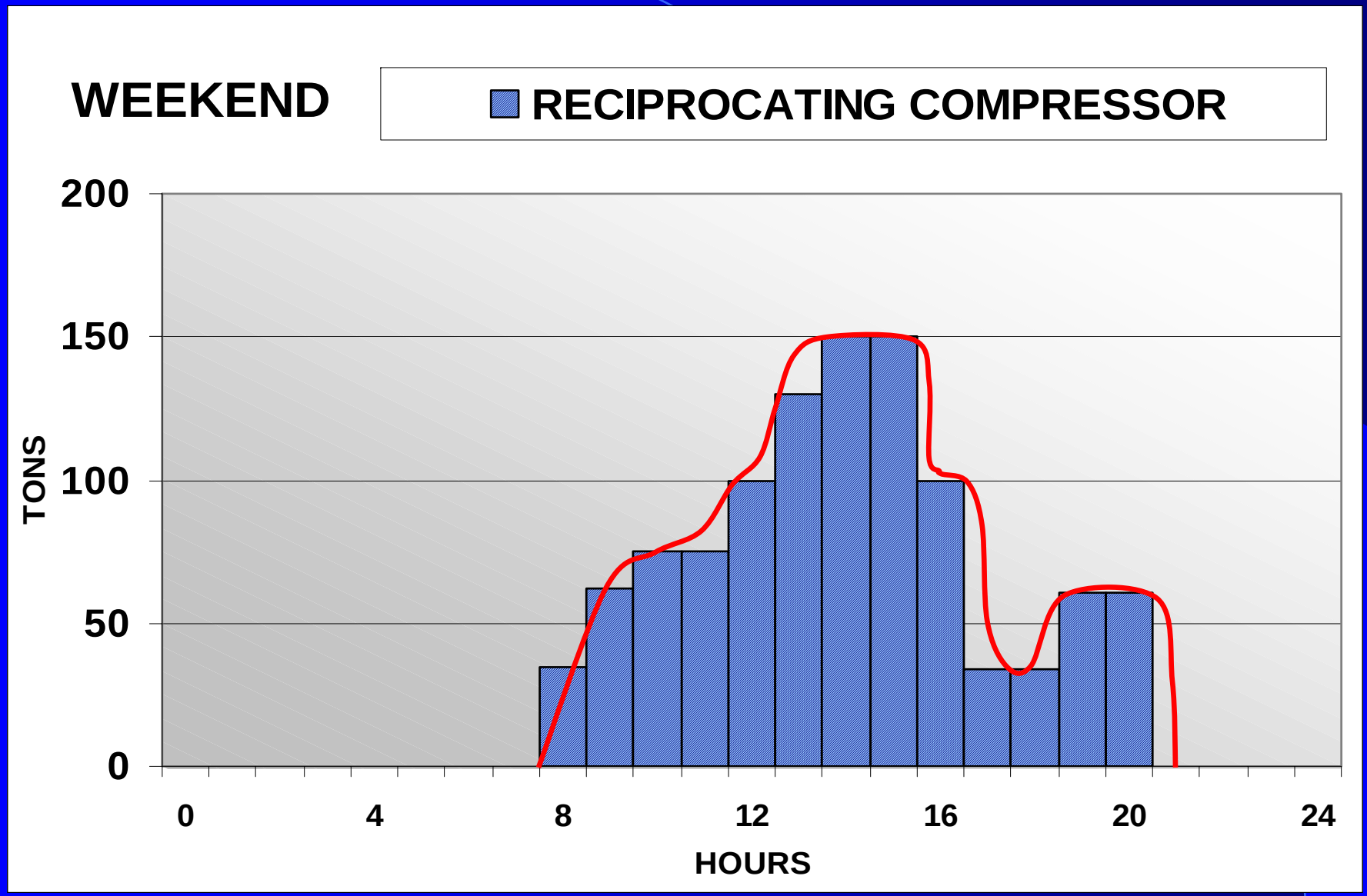
Making a Compressor Selection

- Critical- increasing energy costs
- Evaluate compressor selection
  - Understand Compressor Designs
  - Evaluate Full Load Performance
  - Evaluate Part Load Savings

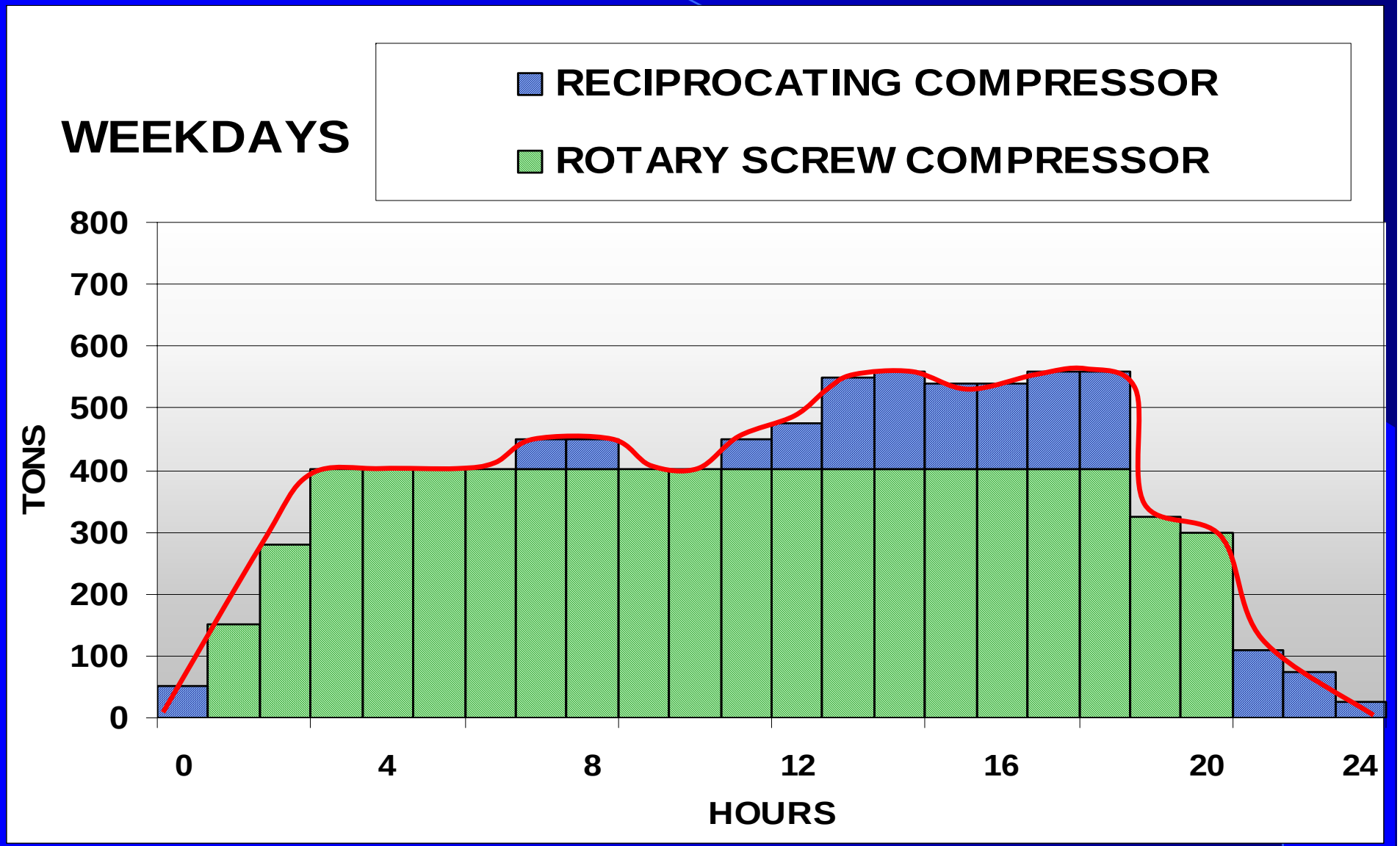
Application Example

- Map out Load Profile
- Define Base Load with screw compressor at max efficiency
- Define Trim Load with reciprocating compressor for max part-load efficiency

LOAD PROFILE



LOAD PROFILE



Summary

- Compressor Selection Critical with Increasing Energy Costs
- Evaluate Compressor Selections
  - Full Load Performance
  - Part Load Performance
- Consider Compressor Combinations for Maximum Efficiency

Thank You!