GAS PULSATION EFFECTS ON COMPRESSOR PERFORMANCE

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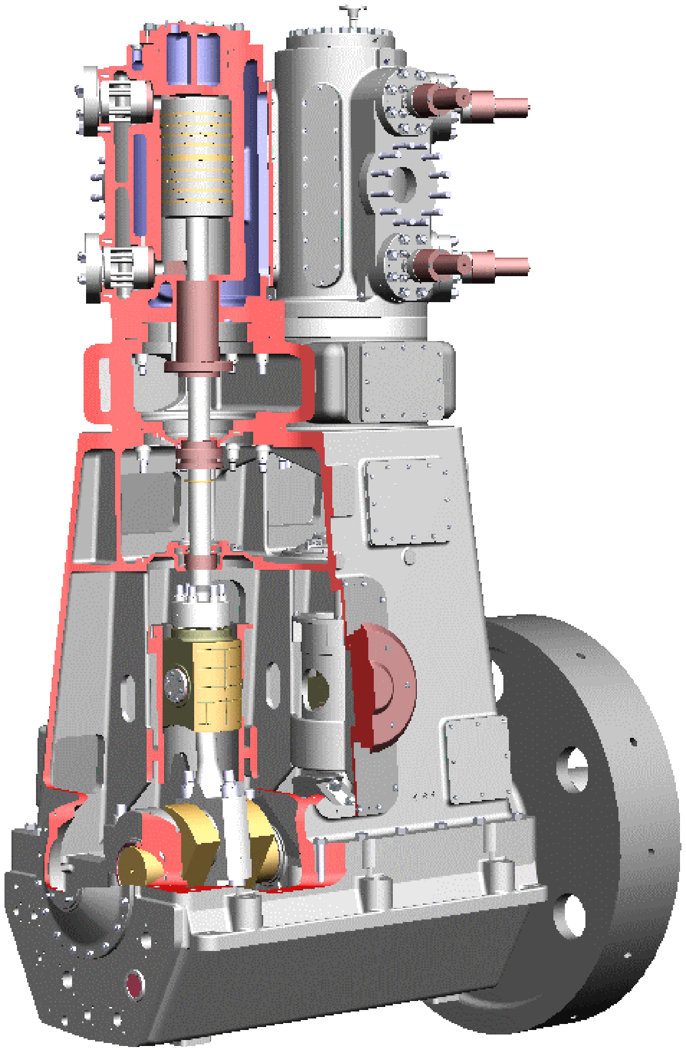
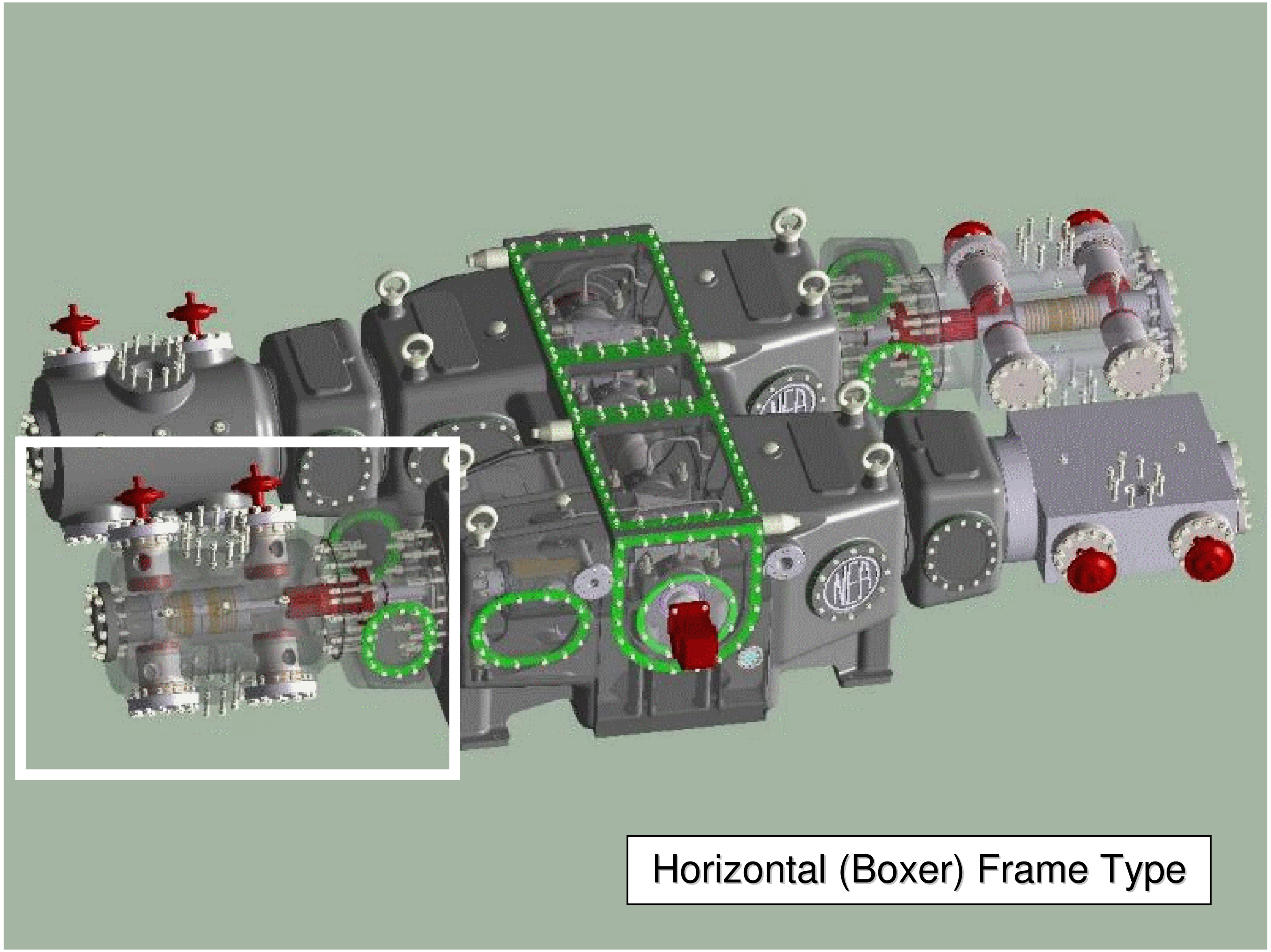
BASICS

A RECIPROCATING COMPRESSOR IN ACTION

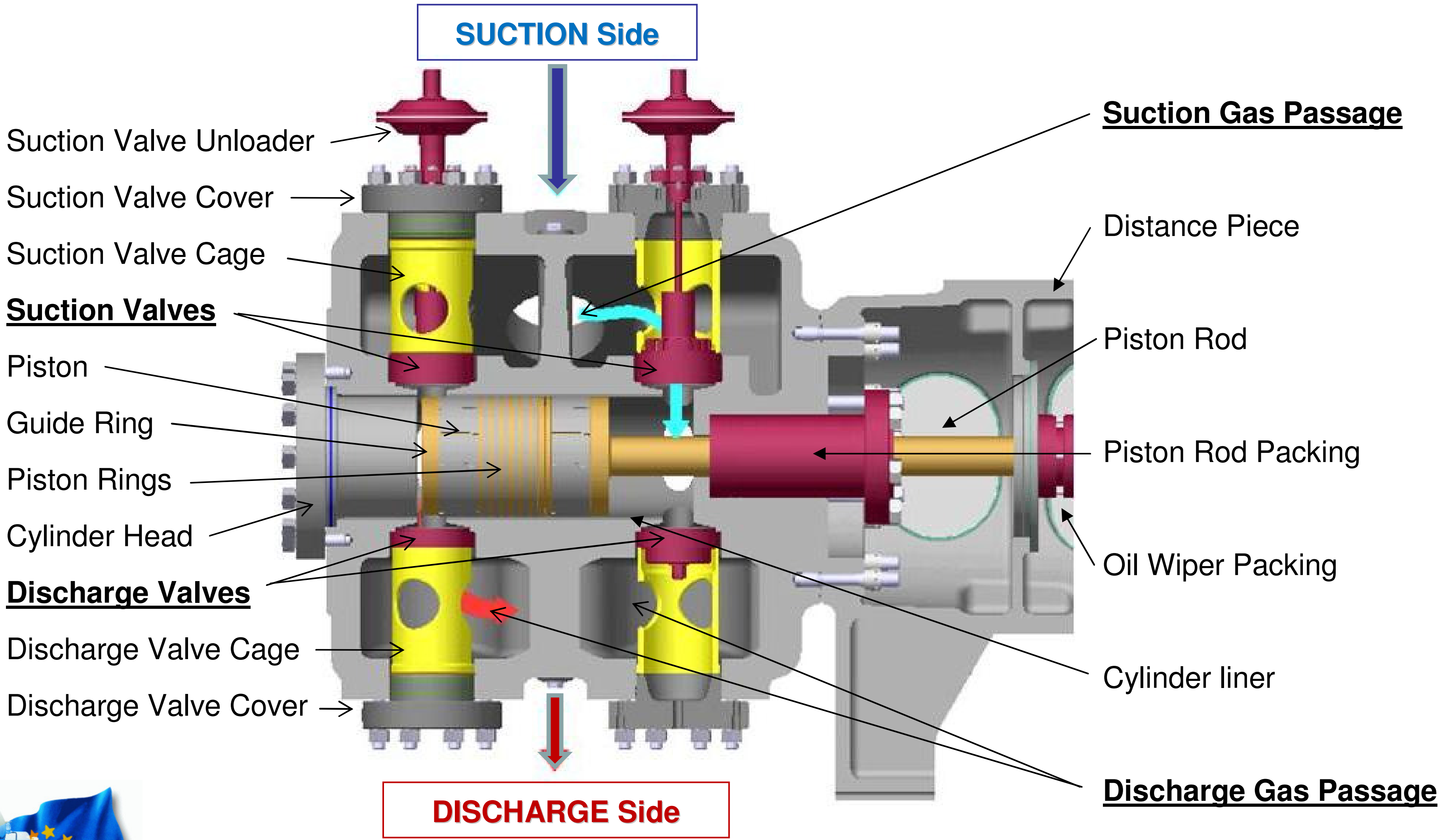


Vertical Frame Type

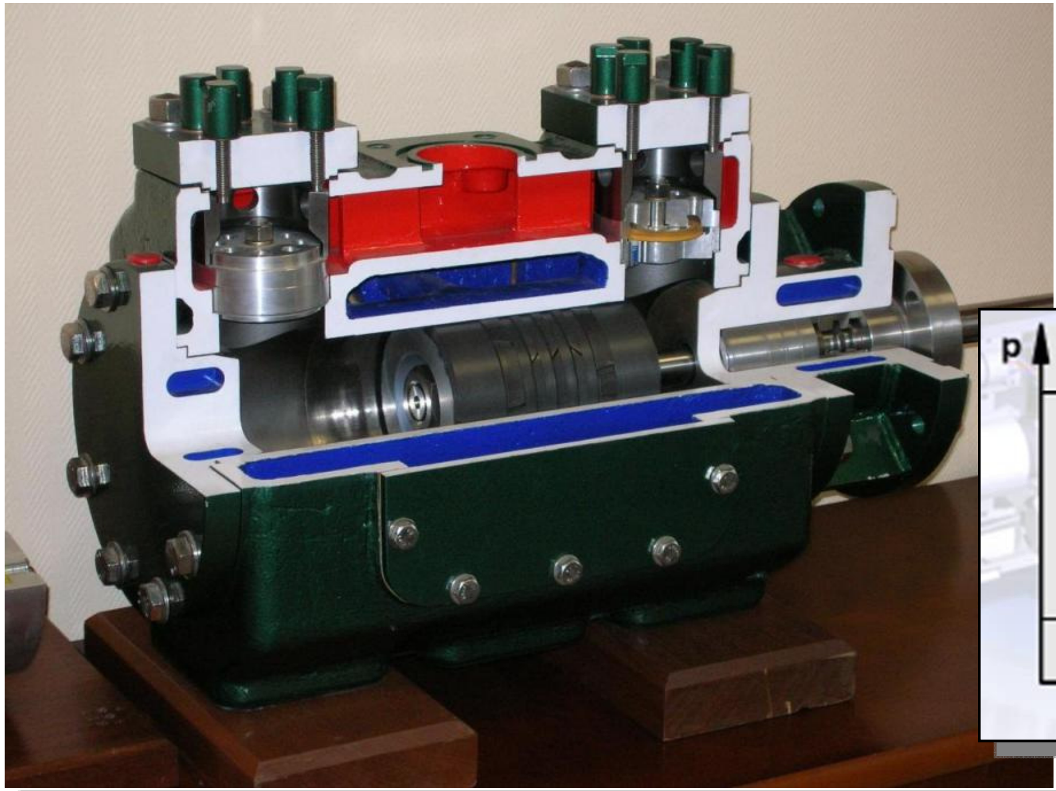
A RECIPROCATING COMPRESSOR IN ACTION

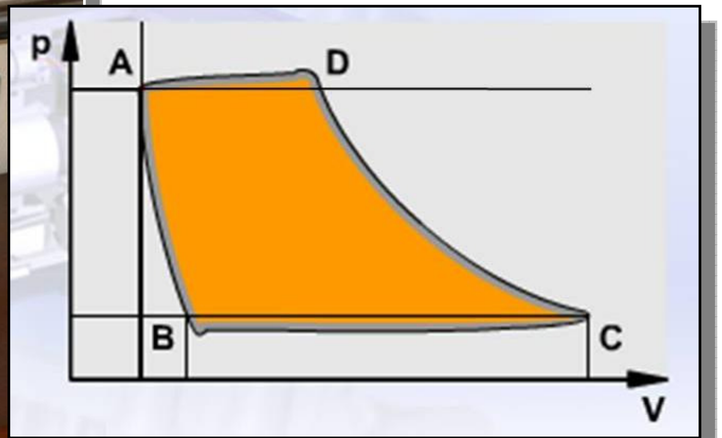


VIEW INSIDE A TYPICAL CYLINDER (DETAILS)



THERMODYNAMICS

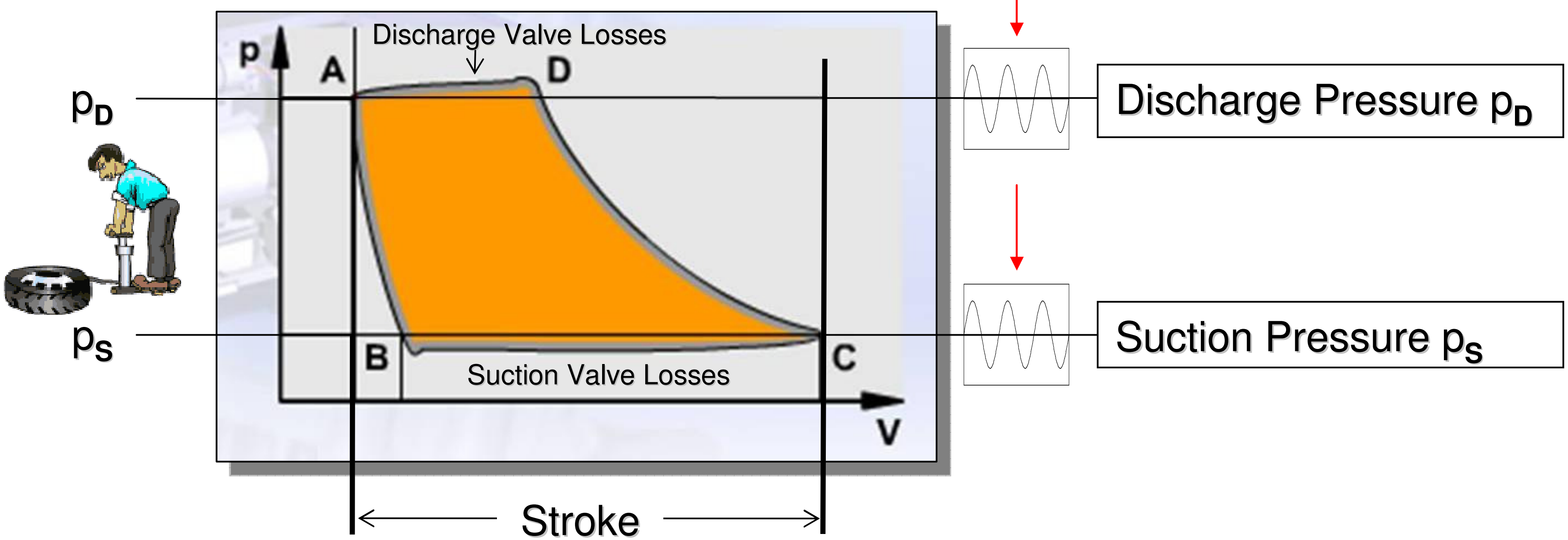




THERMODYNAMIC POWER

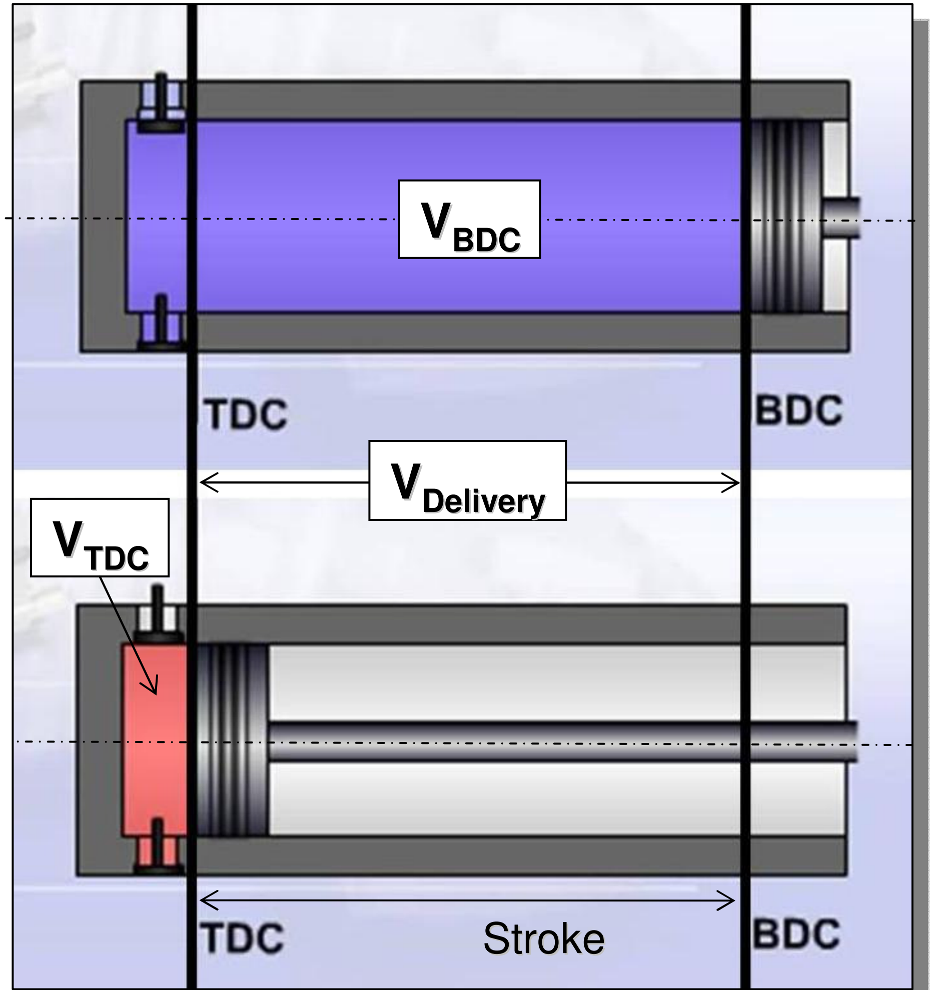
Pressure-over-Volume Card: The encircled area – shown here in orange colour – equals the thermodynamic power of one cycle. The shape of this pv-diagram is a direct scale and indication for the absorbed power.

Any distortion of the pv-cycle – e. g. <u>through pressure pulsations</u> - has an immediate impact on the power consumption.



<u>Note:</u> The sections below the p_S- and above the p_D-lines represent the power which is absorbed as a consequence of the valve pressure drop.

VOLUME DELIVERY



Gas Volume $\mathbf{V_{BDC}}$:
End of Suction Phase
(Piston BDC Position)

Compression and Delivery

Gas Volume $\mathbf{V_{TDC}}$:
End of Discharge Phase
(Piston TDC Position)

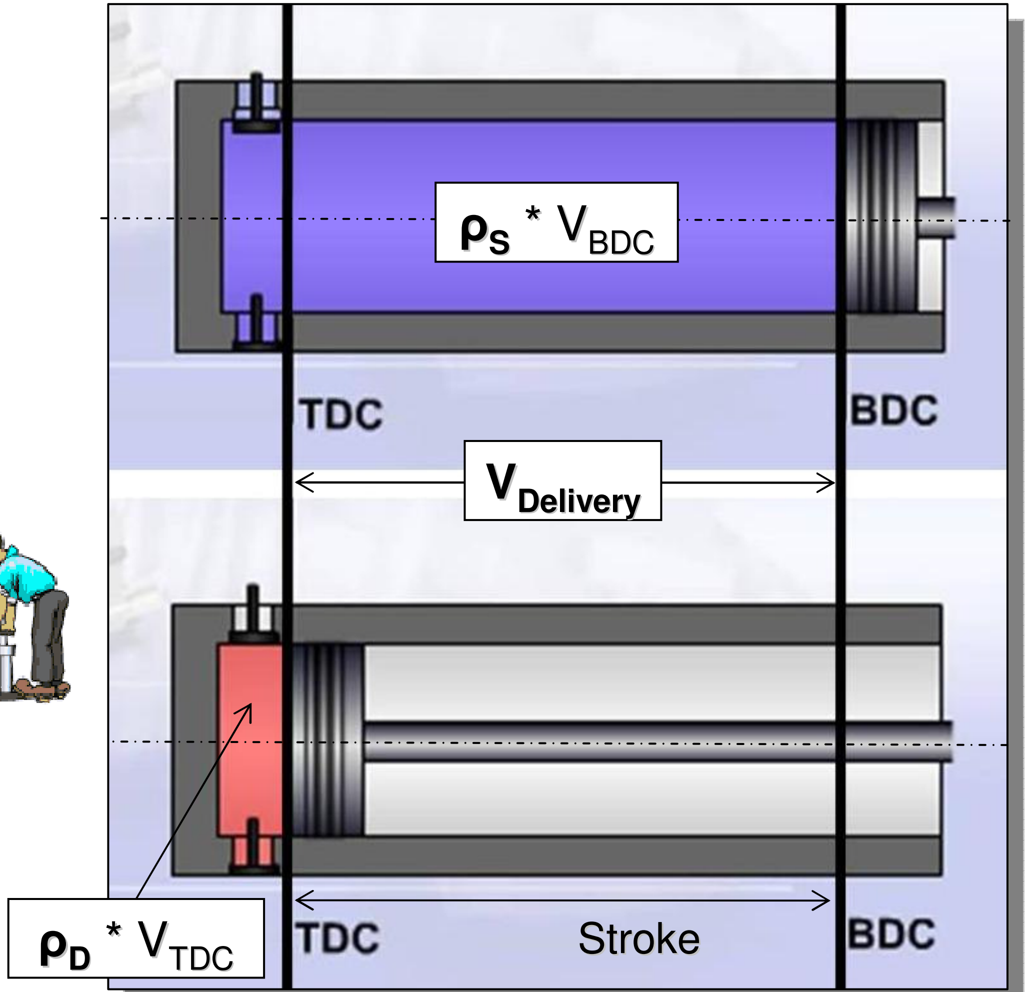
Gas Delivery of the Cylinder (Volume): $V_{Delivery} = V_{BDC} - V_{TDC}$

GAS VOLUME AND MASS DELIVERY

- **A reciprocating piston compressor is pumping VOLUME**
- **Production is looking for MASS**
- The relationship between both is the density ‘ρ‘ (rho)
- $m = \rho * V$ (Mass = Density * Volume)
- $V_{Delivery} = V_{BDC} - V_{TDC}$
- $m_{Delivery} = m_{BDC} - m_{TDC} = (\rho * V)_{BDC} - (\rho * V)_{TDC} = \rho_S * V_{BDC} - \rho_D * V_{TDC}$
- With volumes given from the geometry of the cylinder the density is the major key factor for the gas delivery in terms of mass

The density of the gas - with given molecular weight - is a function of the actual temperature and pressure (compressibility is neglected here)

MASS DELIVERY

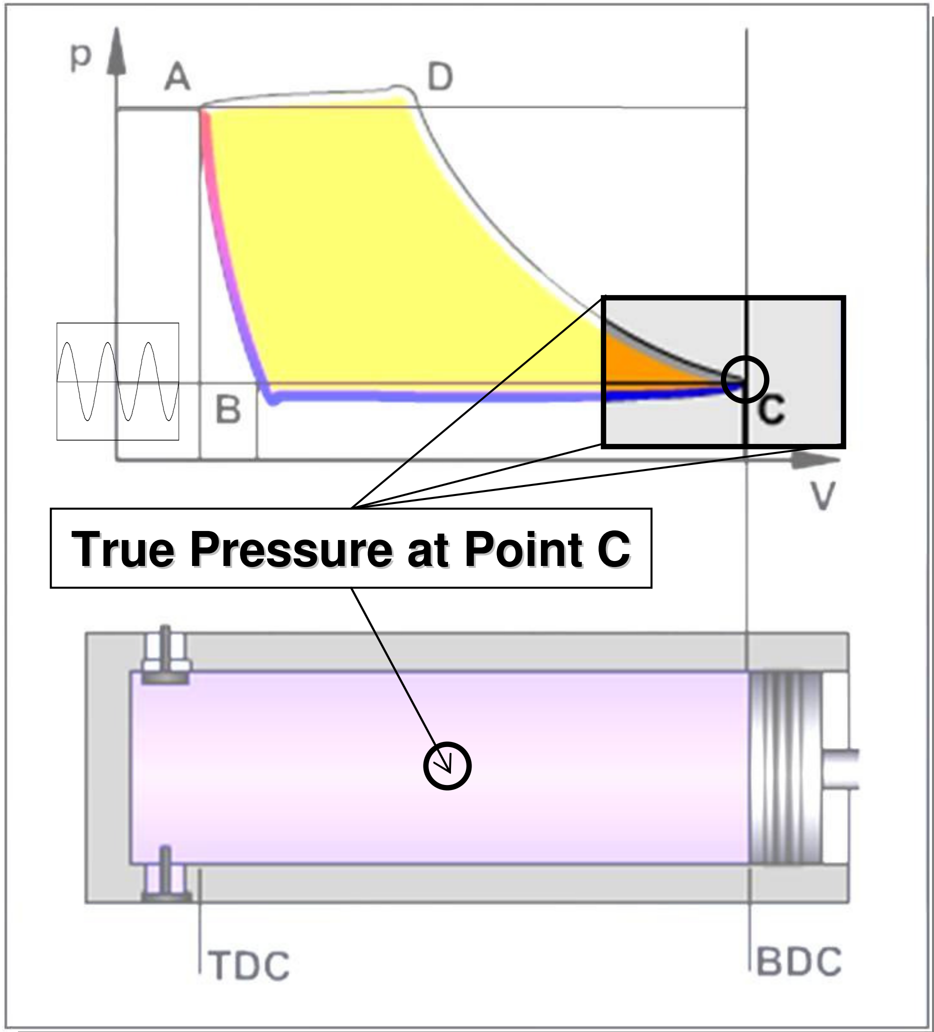


With the given Volume V_{BDC} it is the actual density ρ_S at the **End of the suction** phase which determines the amount of gas in the cylinder volume at the **Start** of the compression phase.

With the given Volume V_{TDC} it is the actual density ρ_D at the **End of the compression** and discharge phase which determines the amount of the remaining gas in the 'dead' cylinder volume.

Gas Delivery (Mass): $m_{Delivery} = m_{BDC} - m_{TDC} = \rho_S * V_{BDC} - \rho_D * V_{TDC}$

MAX. CYLINDER FILLING AT SUCTION CONDITION (BDC)



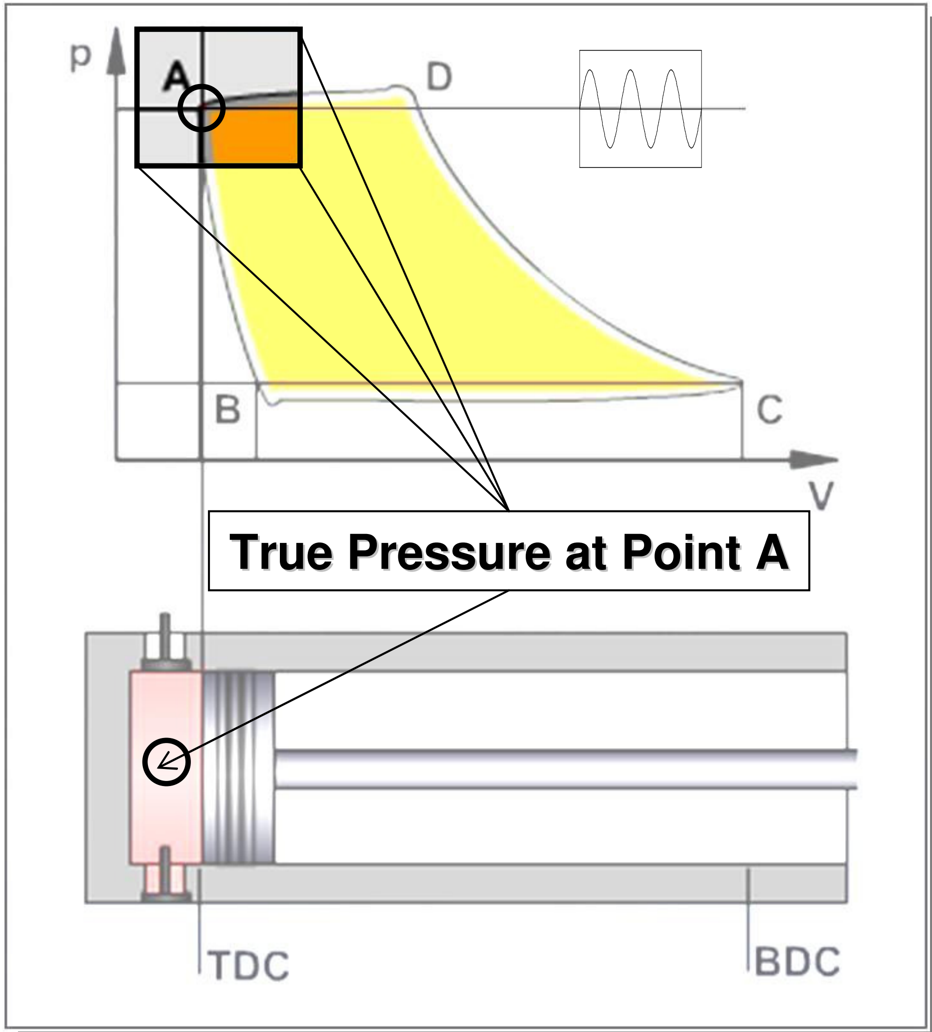
At the **Start** of the **Compression** phase the actual density ρ_S is of the essence for the cylinder filling.

The density is a function of pressure and temperature; here with:

$$\boldsymbol{\rho_S} = f\,(p_S, t_S)$$

Any distortion of the pressure - e. g. through pressure pulsations - has a direct impact on the cylinder filling and on the delivery

MIN. CYLINDER FILLING AT DISCHARGE CONDITION (TDC)



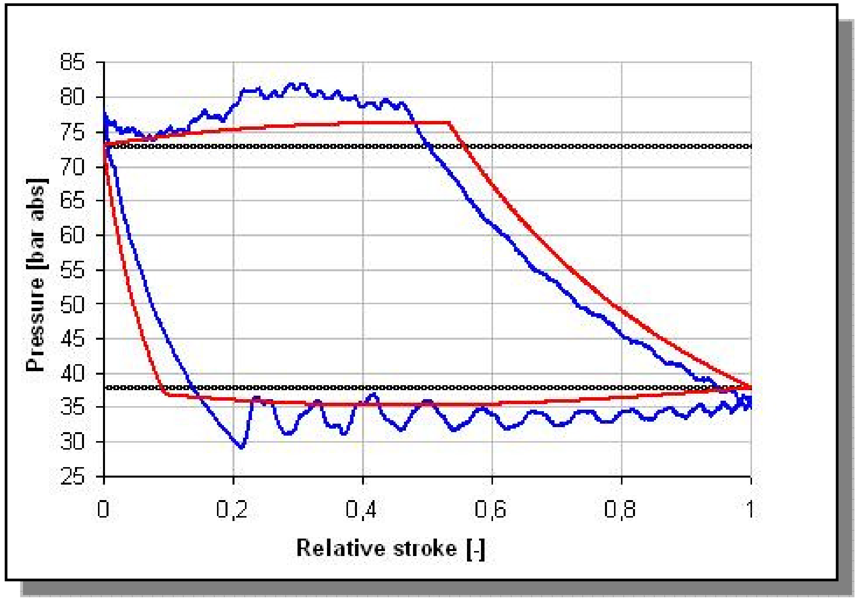
At the **End** of the **Discharge** phase the actual density $\boldsymbol{\rho_D}$ is of the essence for the amount of remaining gas in the cylinder.

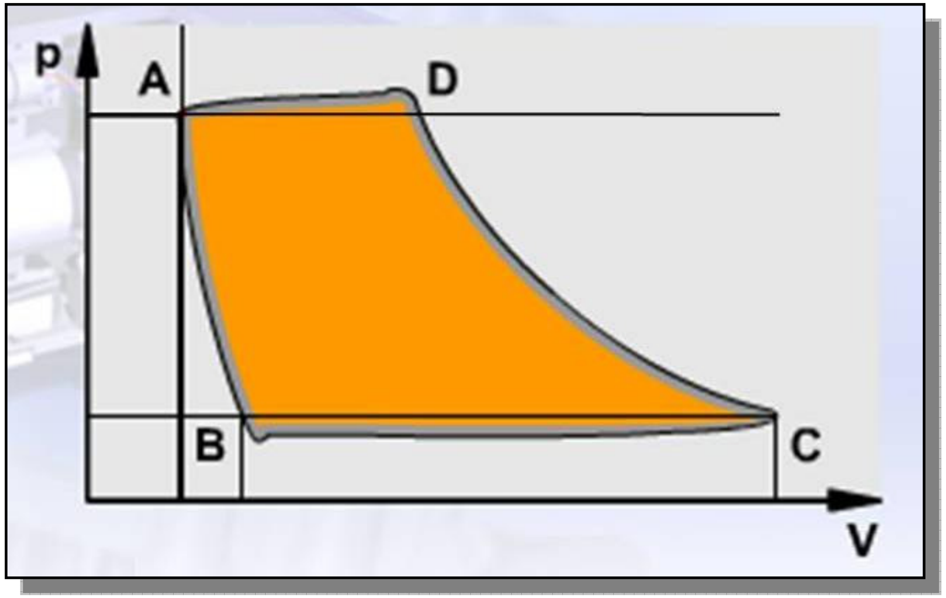
The density is a function of pressure and temperature; here with:

$$\rho_D = f\,(p_D, t_D)$$

Any distortion of the pressure - e. g. through pressure pulsations - has a direct impact on the delivery

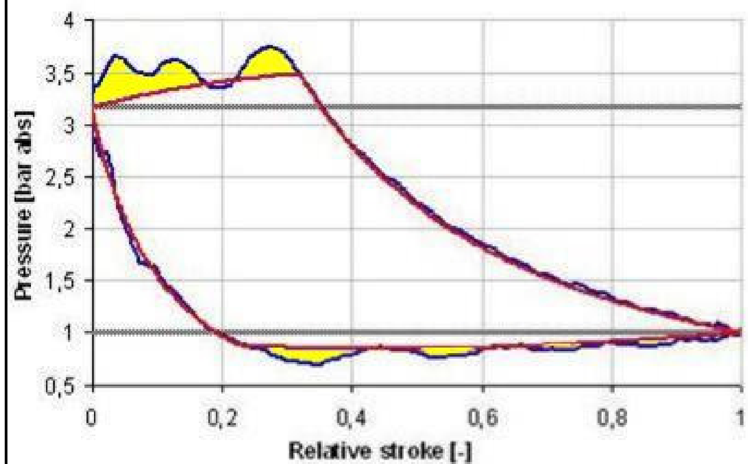
EXAMPLES



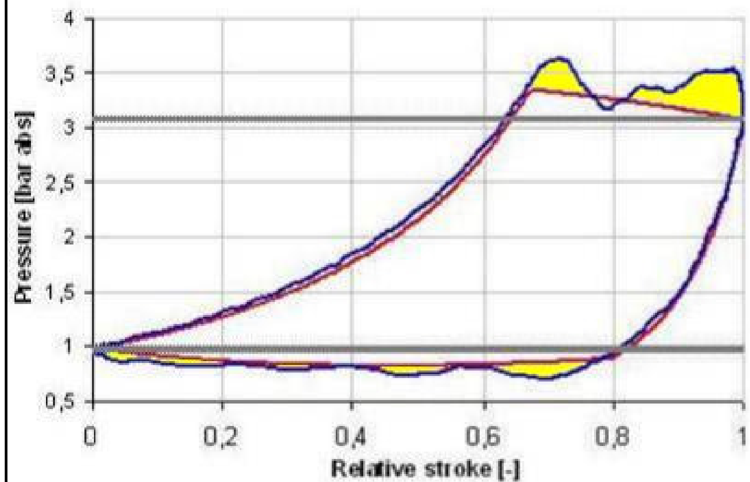


Note: True pv-cycle-diagrams hardly ever look like the perfectly simulated charts !

IMPACT OF PRESSURE PULSATION ON POWER CONSUMPTION



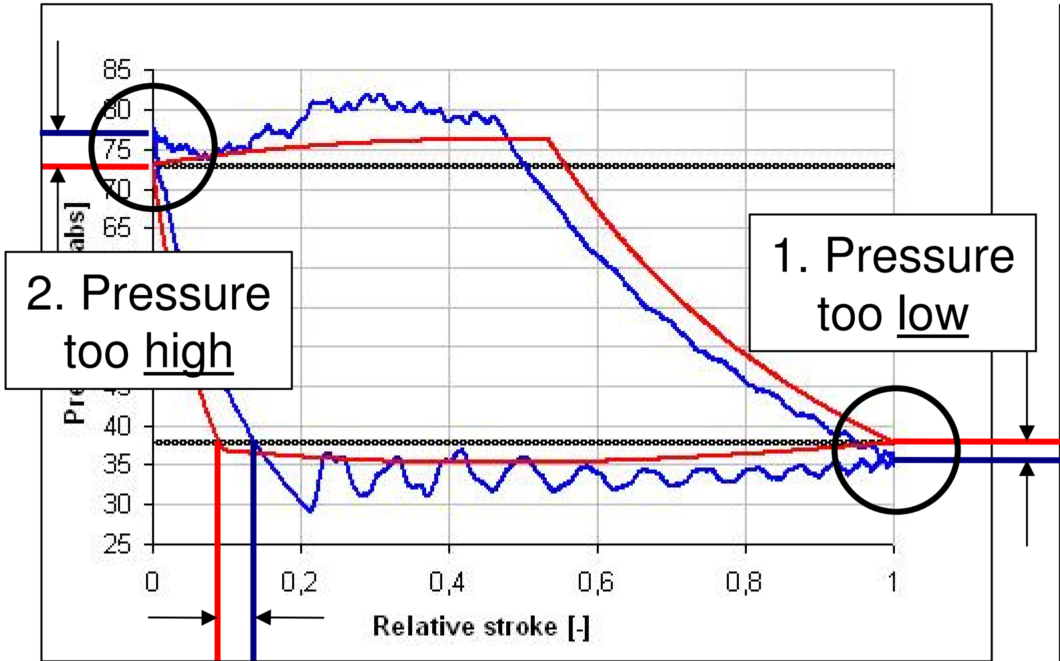
Perfect (RED) and true (BLUE) pv-cycle



- Significant deviations between perfect and true pv-cycle-lines during discharge phases in both cylinder ends.
  - Additional power consumption of some 20% – due to pulsation phenomena (depicted in yellow).

IMPACT OF PRESSURE PULSATION ON MASS FLOW CAPACITY

Significant pressure pulsations are visible during the suction and discharge phase.



Reduced cylinder filling by some 5 %

1. **At the end of the suction phase the cylinder pressure is <u>below</u> the perfect value:**
   - ➢ **The cylinder mass filling is reduced (through low density)**
   - ➢ **The compressed and delivered gas mass is reduced**
2. **At the end of the discharge phase the cylinder pressure is <u>above</u> the perfect value:**
   - ➢ **More gas than normal remains in the cylinder**
   - ➢ **The expansion phase is extended.**
   - ➢ **The cylinder volume filling is reduced.**

Note: **The pulsation phenomenon identified from the pv-diagram do not explain *why* the pv-card-disturbance occurs**

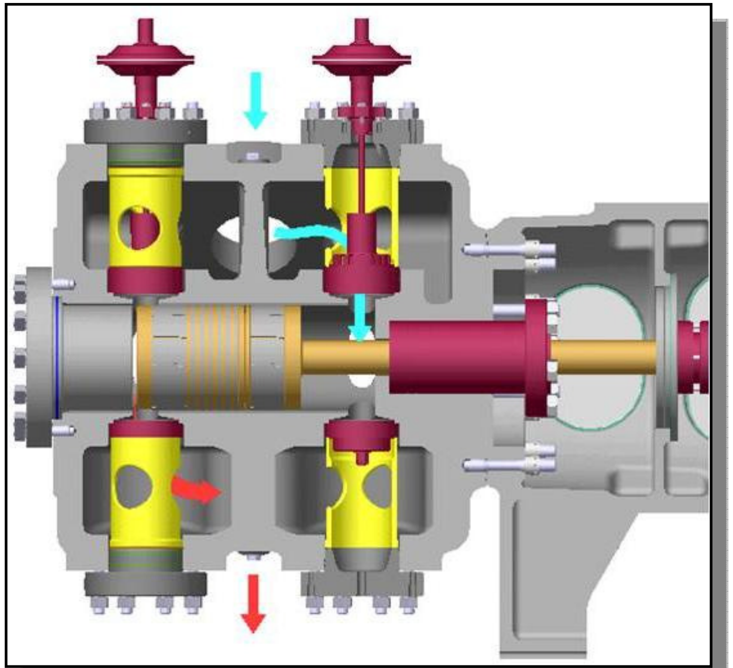
SUMMARY

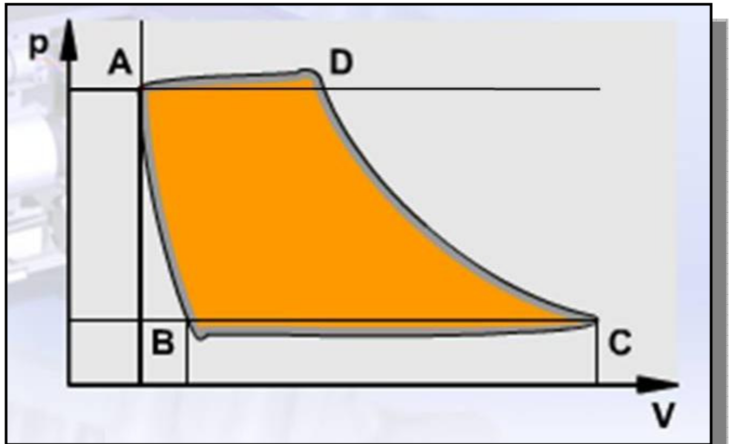
Pressure pulsations which are propagating along the pipeline are reaching into the gas passage of the cylinder right to the cylinder valve and – under certain circumstances - also into the cylinder volume.

Pressure pulsations may create a distortion of the pv-cycle (pv-diagram) with significant impact on:

- **POWER CONSUMPTION**
- **MASS FLOW CAPACITY**
- **PISTON ROD LOAD**
- **VALVE PERFORMANCE**

<u>Often these effects are linked !</u>





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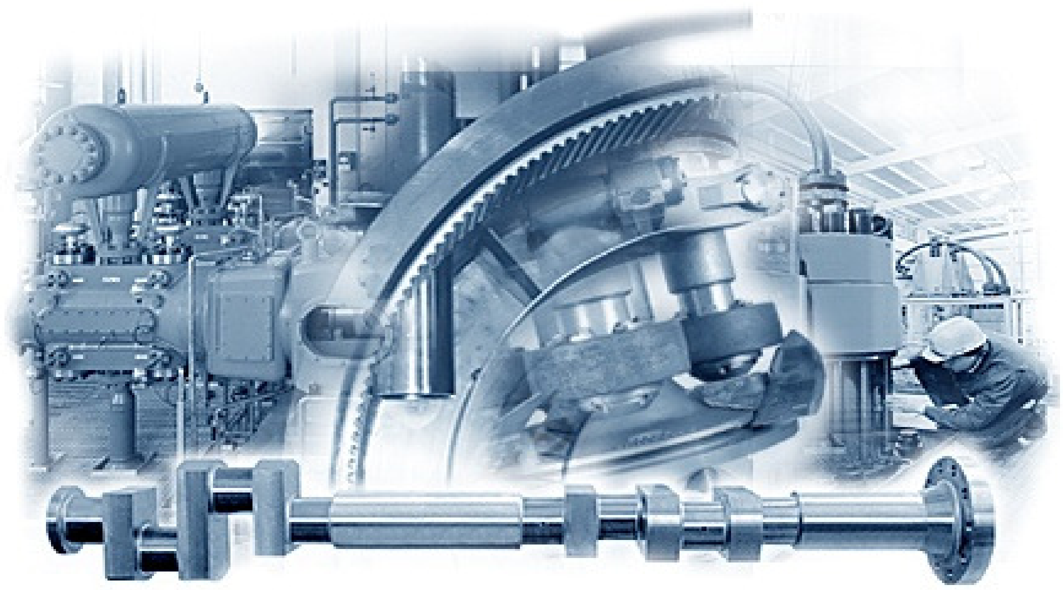
THE IMPACT OF PRESSURE PULSATION ON

PISTON ROD LOAD

and

VALVE PERFORMANCE

WILL BE COVERED BY FOLLOWING PRESENTATIONS



THANK YOU FOR YOUR ATTENTION

QUESTIONS ?