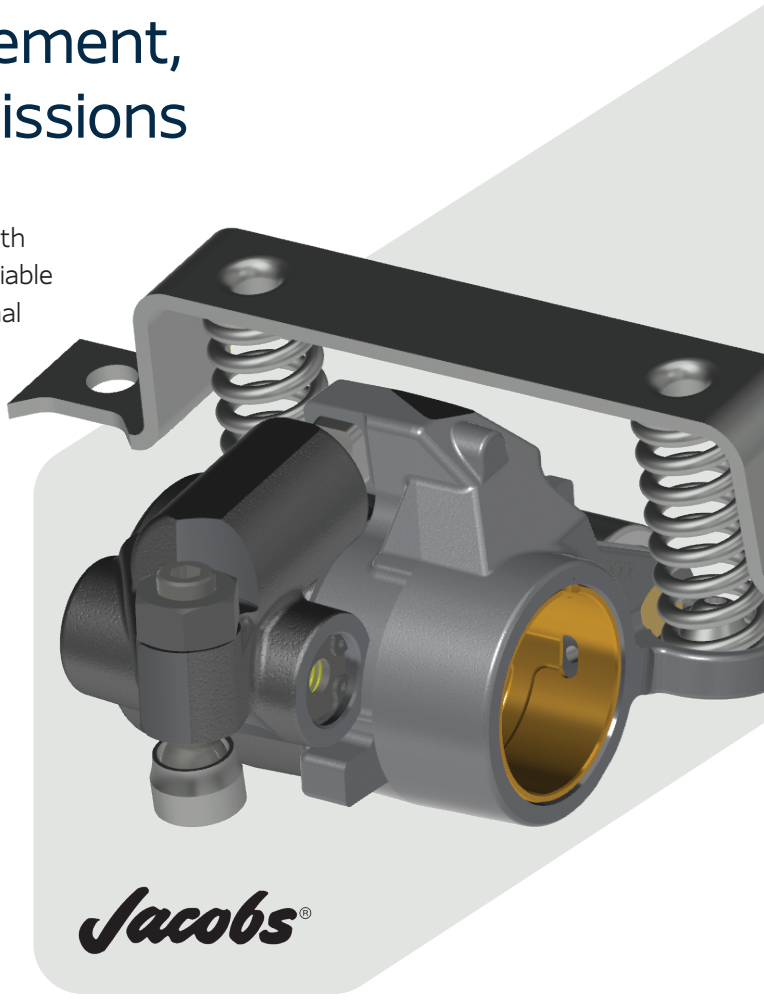
Two-step Variable Valve Actuation

For exhaust thermal management, engine performance and emissions

Two-step Variable Valve Actuation (VVA) is for OEMs challenged with meeting future transient emissions and fuel economy targets. A variable lift valvetrain opens up possibilities to meet these needs with minimal changes to the base engine and aftertreatment system while using proven mechanisms to achieve these benefits.

Developed with over 60 years of engine braking and integrated valvetrain experience, our Two-step VVA system is compatible with other valvetrain technologies such as cylinder deactivation and engine braking. The system is available for multiple valvetrain and fuel types including diesel, natural gas and hydrogen. Applicable to all engine displacements, including large engines, the system provides the benefits of a fully flexible VVA system with a less complex, more cost-effective system.



BENEFITS

IMPROVES ENGINE OUT NO_x EMISSIONS

to help OEMs meet 2027/2029 regulations

REDUCES FUEL CONSUMPTION

KEEPS AFTERTREATMENT SYSTEM HOT

during low load operation to lower emissions

LEARN MORE & SEE
Two-step VVA in action

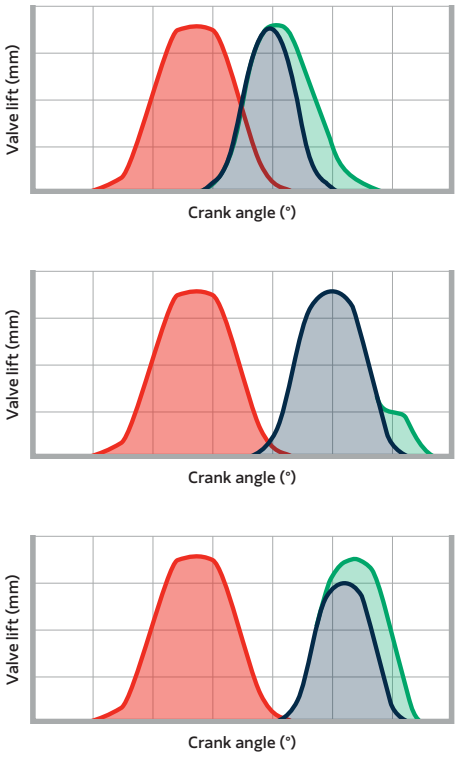
BENEFITS

EARLY INTAKE VALVE CLOSING (EIVC) OR OR LATE INTAKE VALVE CLOSING (LIVC)

- Reduces fuel consumption 1-2%
- Reduces engine out NO_x up to 3 g/kWh at equivalent brake specific fuel consumption (BSFC)

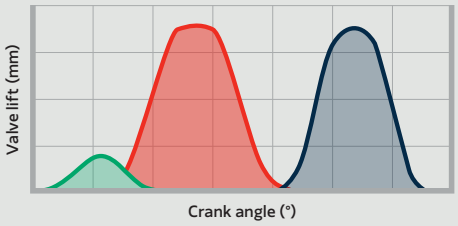
  VVA benefits over fixed Miller

  - Optimizes compression ratio for two operating modes with up to 20% reduced peak cylinder pressure (PCP)
  - Eliminates engine start problem due to compression ratio
  - Faster transient torque response
  - Better low engine speed performance
  - Corrects engine brake power losses and allows for even higher brake power potential due to greater net compression ratio
- Compatible with hydraulic lash adjuster
- Lashless auxiliary rocker arm design reduces maintenance and provides accurate valve motion for the life of the engine



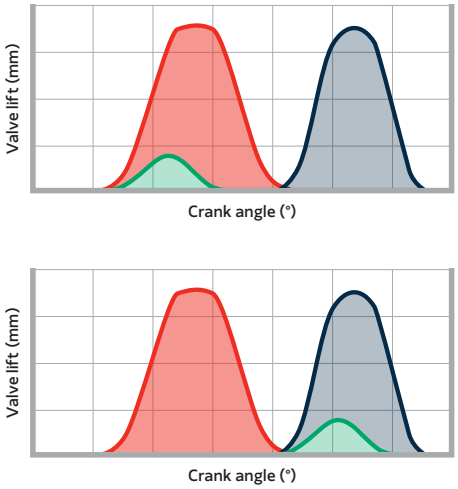
EARLY EXHAUST VALVE OPENING (EEVO)

- Faster warm up of engine and aftertreatment system
- Improves transient turbocharger response
- Improves torque at lowest engine speeds
- In-cylinder solution for diesel particulate filter (DPF) regeneration replacing expensive exhaust heaters and dosers



INTERNAL EXHAUST GAS RECIRCULATION (IEGR)

- Improves emissions and reduces fuel consumption
- Stabilizes cold start-up combustion
- Improves engine warm-up time
- Eliminates or downsizes problematic external exhaust gas recirculation (EGR) systems and intake throttles
- Provides up to 40% EGR at low loads
- Faster response than external EGR systems
- Improves aftertreatment performance
- Improves transient emissions
- Intake or exhaust opening systems available
- Compatible with hydraulic lash adjuster
- Lashless auxiliary rocker arm design reduces maintenance and provides accurate valve motion for the life of the engine
- Accommodates single or two-valve opening iEGR



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