



# PNEUMATICS LIBRARY

Overview



# AGENDA


















- About Product Name
- Key Benefits
- Key Capabilities
- Key Applications
- Library Contents
- Modelon Compatibility
- Latest Release



# ABOUT PNEUMATICS LIBRARY

- Modelica library for pneumatic systems and pneumatic circuits
  - Based on the ideal gas law assumption
- Components
  - Most models needed for pneumatic applications available, both mobile and stationary
  - More can be built from basic building blocks
- Open Code means user is in control
  - View, extend, modify models
  - Ideal for model sharing (encryption)
- Simulation of pneumatic systems for
  - Overall system dynamics
  - Verification of dimensioning
  - Parameter studies



- >  Information
- >  Examples
- >  Interfaces
- >  Templates
- >  Cylinders
- >  DirectionalControl
- >  Elements
- >  Lines
- >  Restrictions
- >  RotaryActuators
- >  Sensors
- >  Sources
- >  ThermoFluid
- >  Valves
- >  Volumes
- >  Utilities
- >  Gases



# KEY BENEFITS

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- Easy-to-Use yet powerful
  - Wide range of predefined components
- Well suited for control design and validation
- True multi-engineering tool
  - Modeling of multi-domain systems, combine with multibody mechanics, control system etc.
- Visualization
  - Easily visualize system behavior
  - Graphical workspace looks like a pneumatic schematic



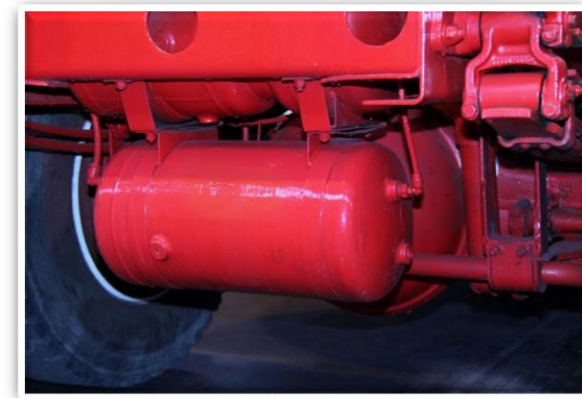
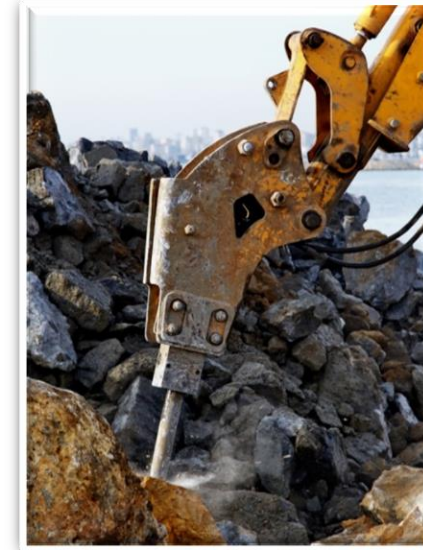


# KEY CAPABILITES



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- Integration of pneumatic systems in wide range of multi-physics models
- Parametric studies of designs
- Deployment
  - Design of experiment
  - Optimization
- List of applications
  - Industrial Equipment:
    - Road construction, drills, hammers etc.
  - Vehicles
    - Brake systems, air suspension



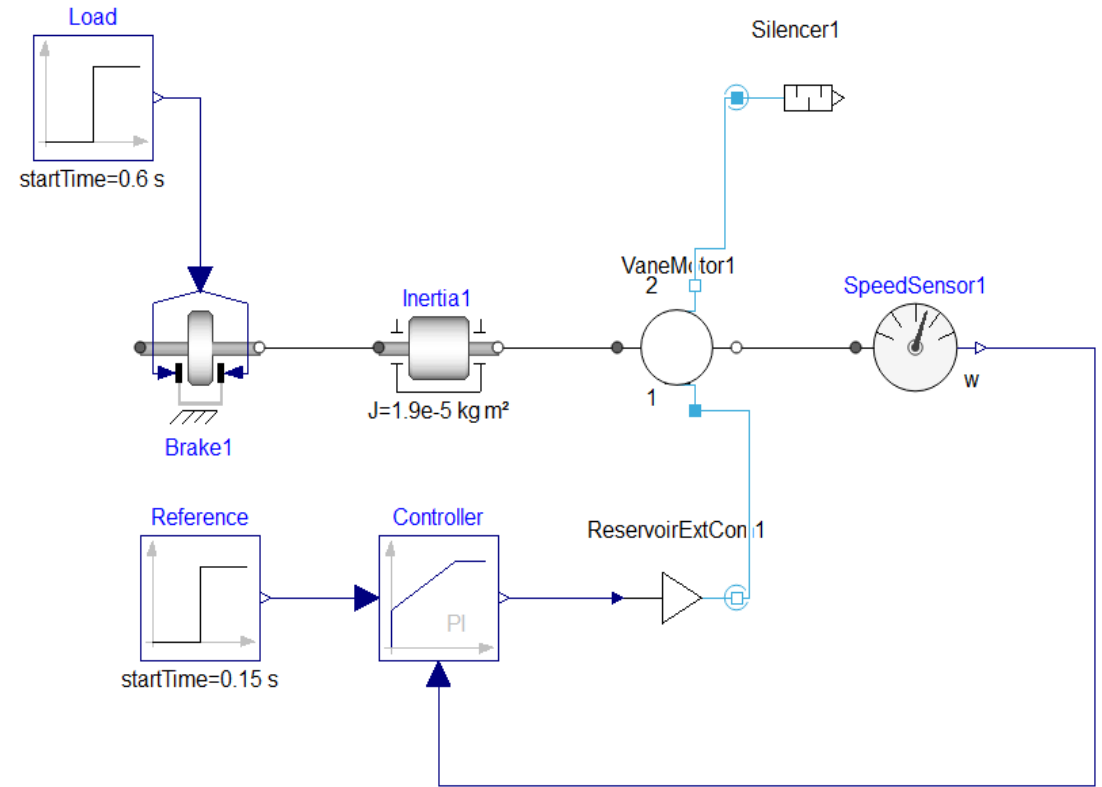


# KEY APPLICATIONS



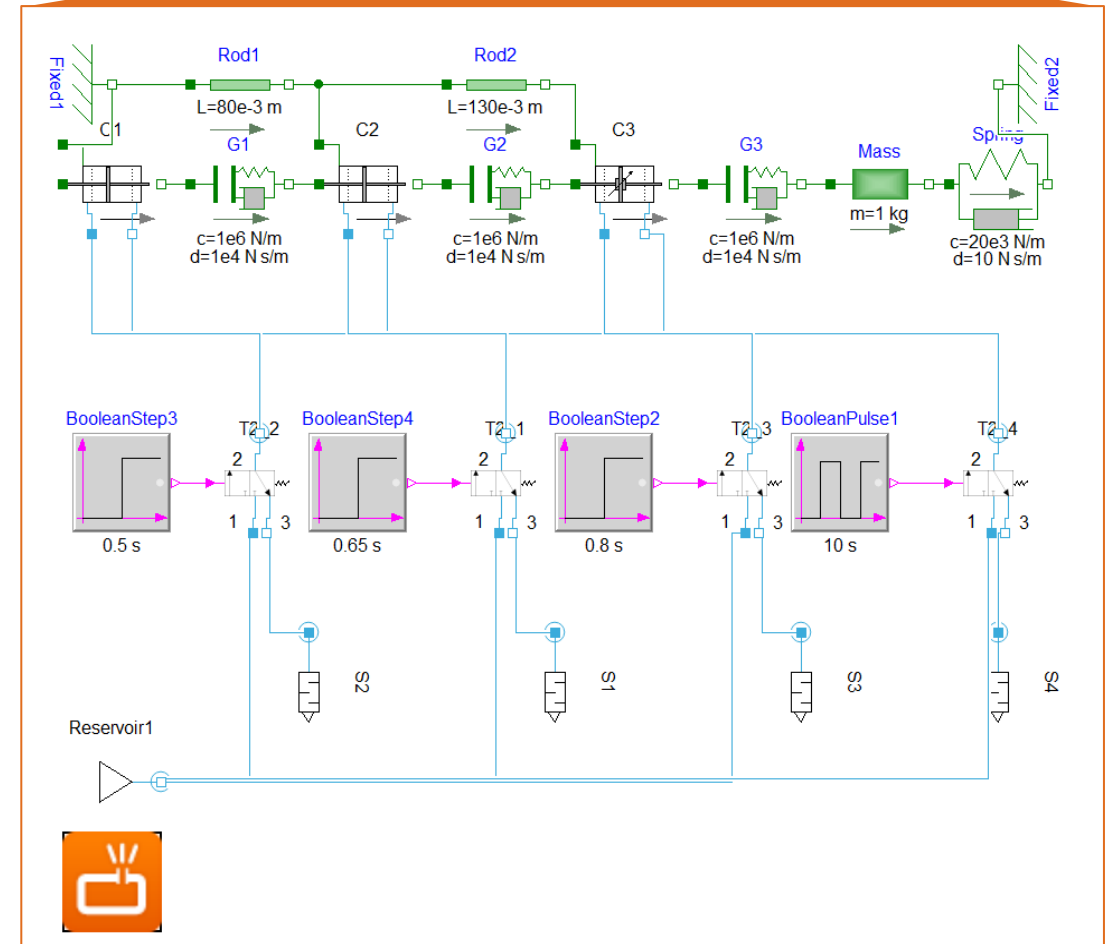
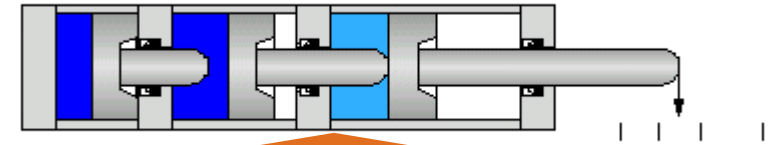
# EXAMPLE: MOTOR CONTROL

This example model demonstrates a PID controller that tries to maintain the vane motor at a constant speed. By controlling the air pressure in to the motor the controller can control the speed of the vane motor. A load is model through a brake that is activated at 0.6 s. Pneumatic vane motors can be used to start large engines e.g. industrial engines



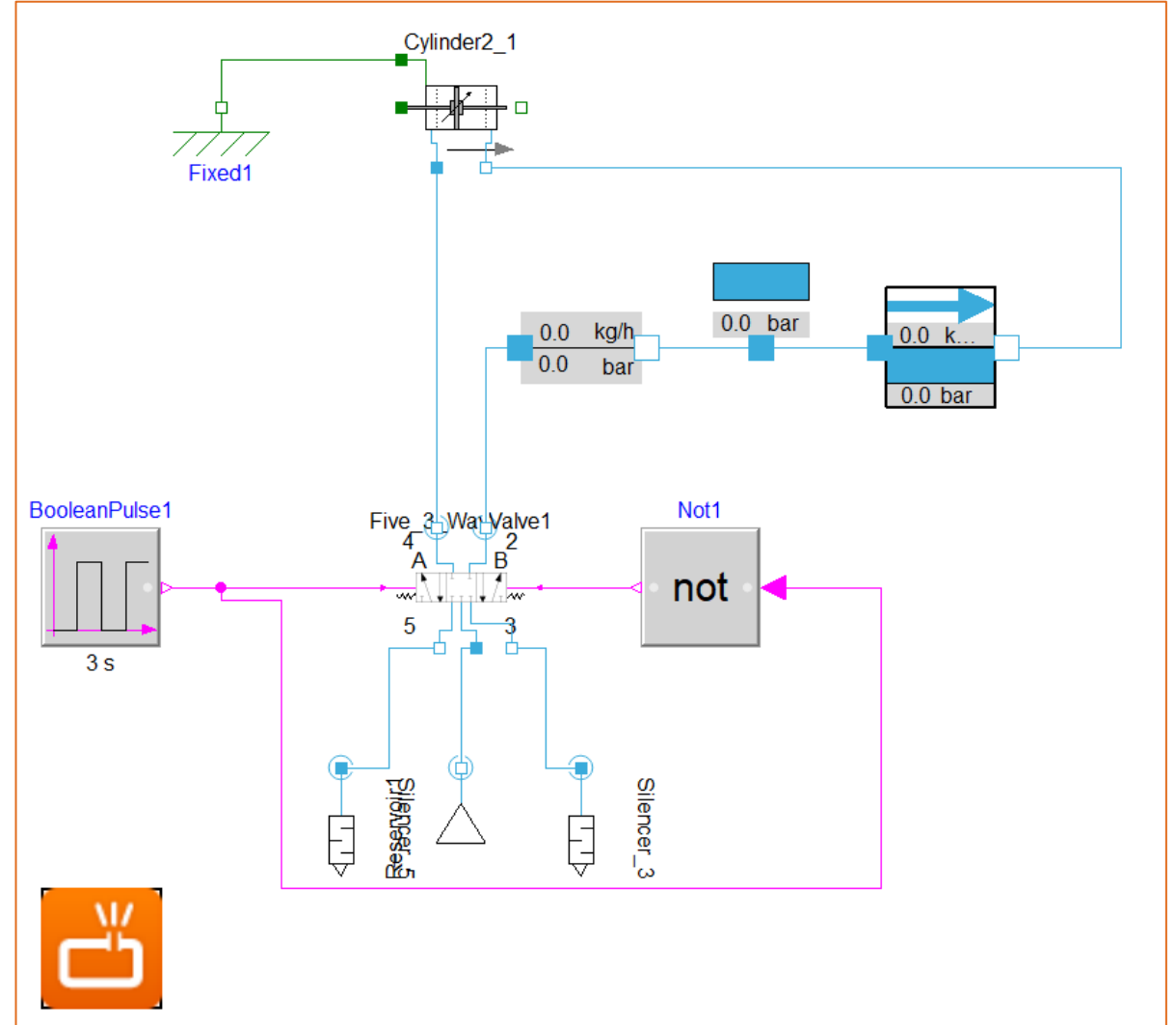
# EXAMPLE: MULTI-POSITION CYLINDER

This example shows how easy even a complex systems can be modeled with Pneumatics Library. Multi position cylinders typically consist of two or three connected cylinders to reach three or four end positions. There is typically one port for every head-end chamber and one port for the connected rod-end chambers. In this example three double acting cylinders are used from the library. One of the cylinders (C3) has pneumatic stroke cushioning enabled, indicated by an arrow over the piston in the icon. The rods (Rod1 and Rod2) places the housing at the correct positions. The cylinders are connected by ElastoGaps.



# EXAMPLE: LINEAR ACTUATOR

This example shows the principle of pneumatic stroke cushioning. A typical cylinder drive can very easily be modeled with the cylinder models in the library.

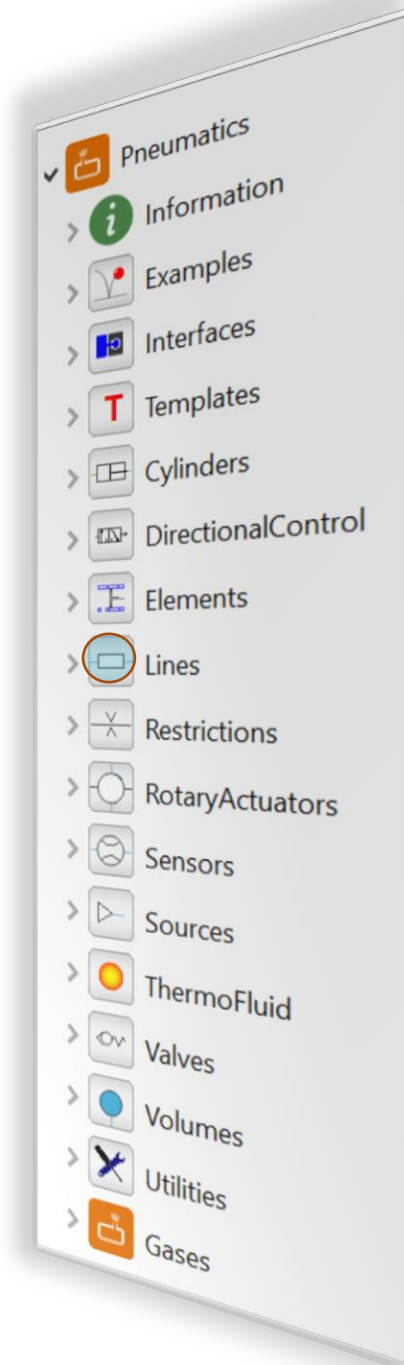
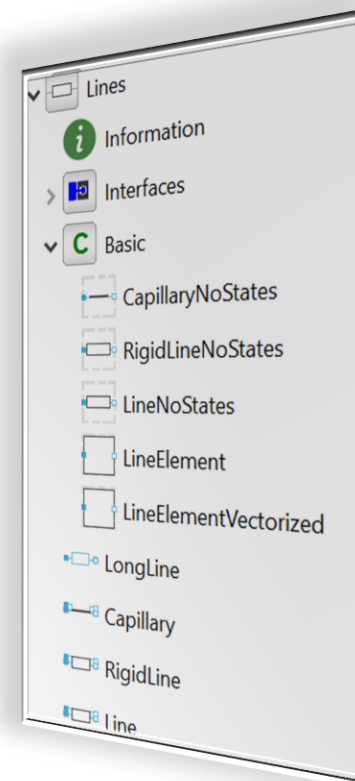




# LIBRARY CONTENTS

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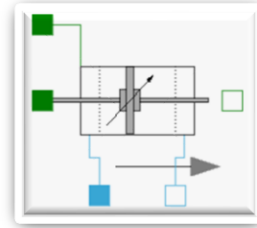
- Standard package order
  - Information
  - Examples
  - Interfaces
  - Templates
  - Components by type
- 2 Levels of components
  - Top level components for end user
  - Basic components are sub-components, building blocks for new, user-defined components



# LIBRARY CONTENTS

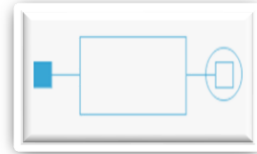
## Cylinders

- With or without cushioning effect
- Bellows



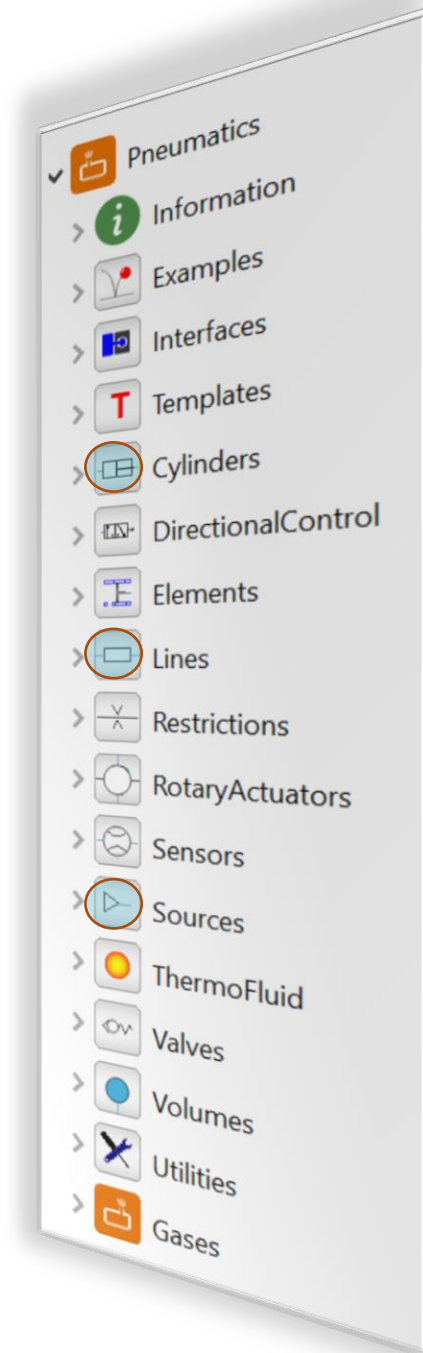
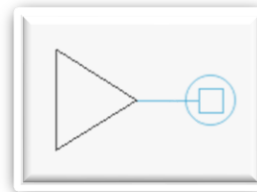
## Lines

- Long line
- Capillary



## Sources

- Reservoirs
- Silencers





# LIBRARY CONTENTS

## Constant

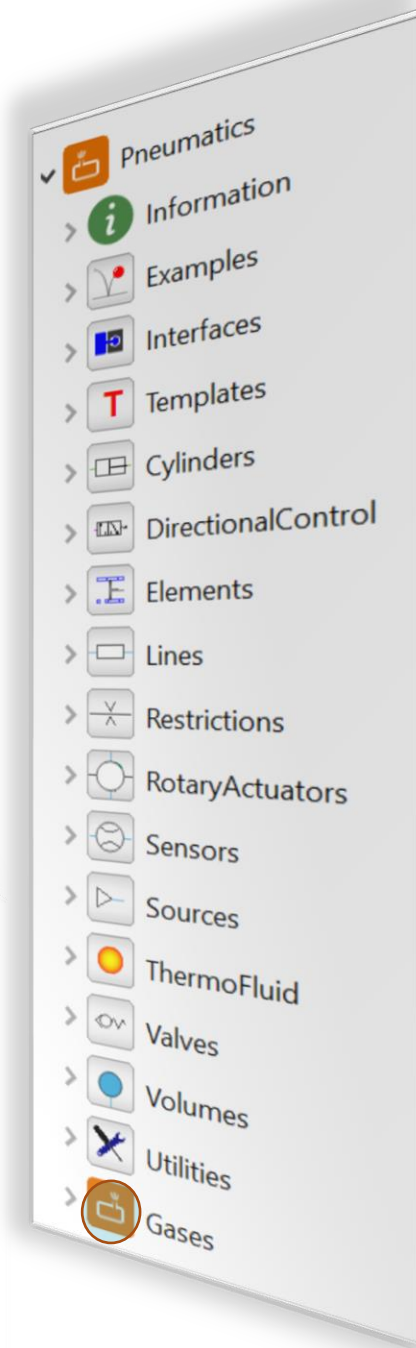
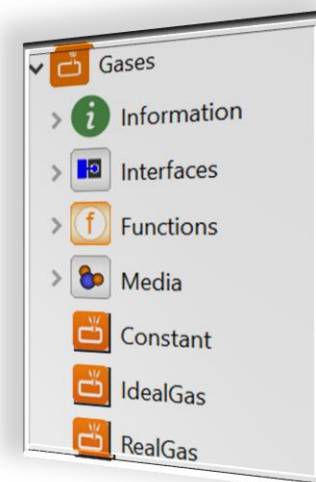
- Constant gas property model
- Backward compatible with old Environment component

## IdealGas

- Ideal gas model compatible with fluids from Modelon Base Library
- 7 pre-defined fluids: Moist air, dry air, argon, nitrogen, oxygen, carbon dioxide

## Real gas

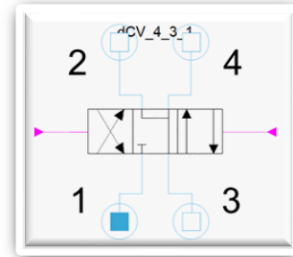
- Fast switching between real and ideal gas
- High pressure media - H2 and N2 models
- Visualize compressibility factor for gas model validity



# LIBRARY CONTENTS

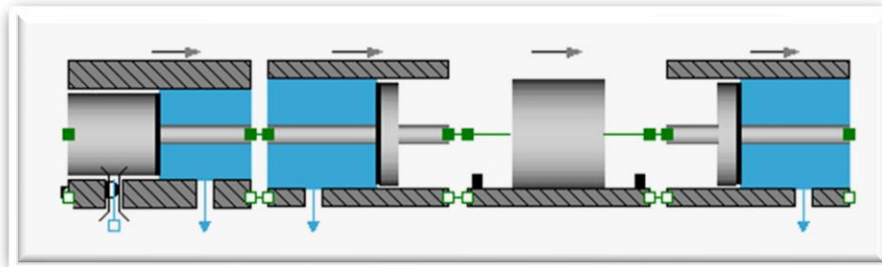
## DirectionalControl

- For flow control
- First order spool dynamics



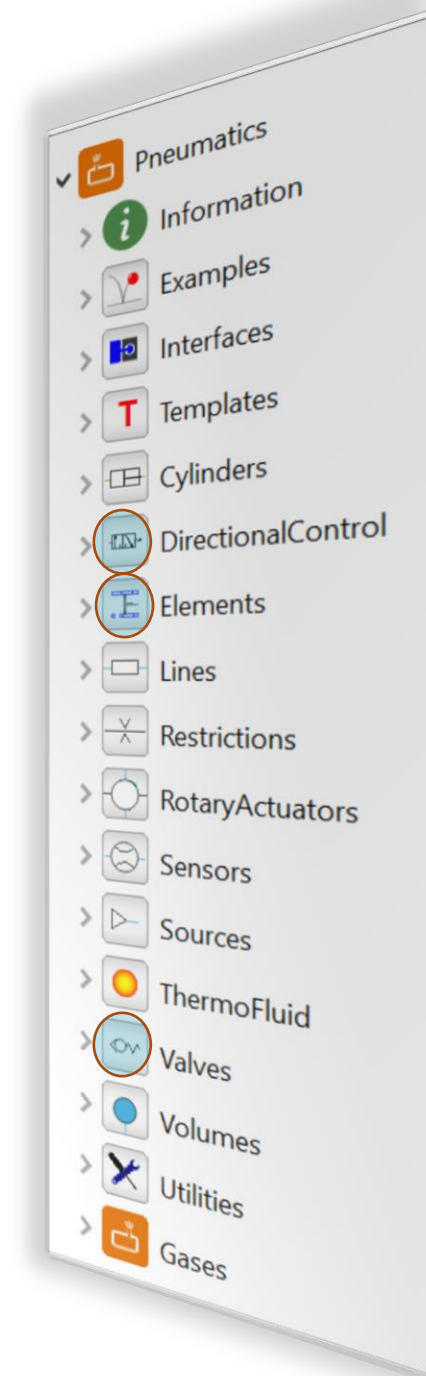
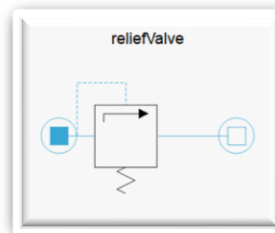
## Elements

- Primitives for detailed component design



## Valves

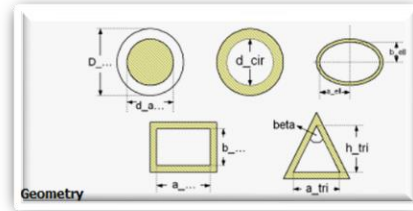
- Pressure and flow actuated



# LIBRARY CONTENTS

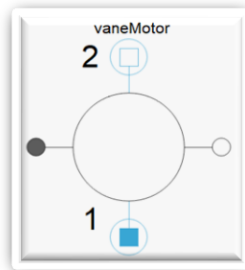
## Restrictions

- Fittings
- Geometry based restrictions
- Nozzles and orifices



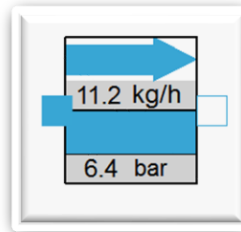
## Rotary Actuator

- Vane motor
- Rotary actuator



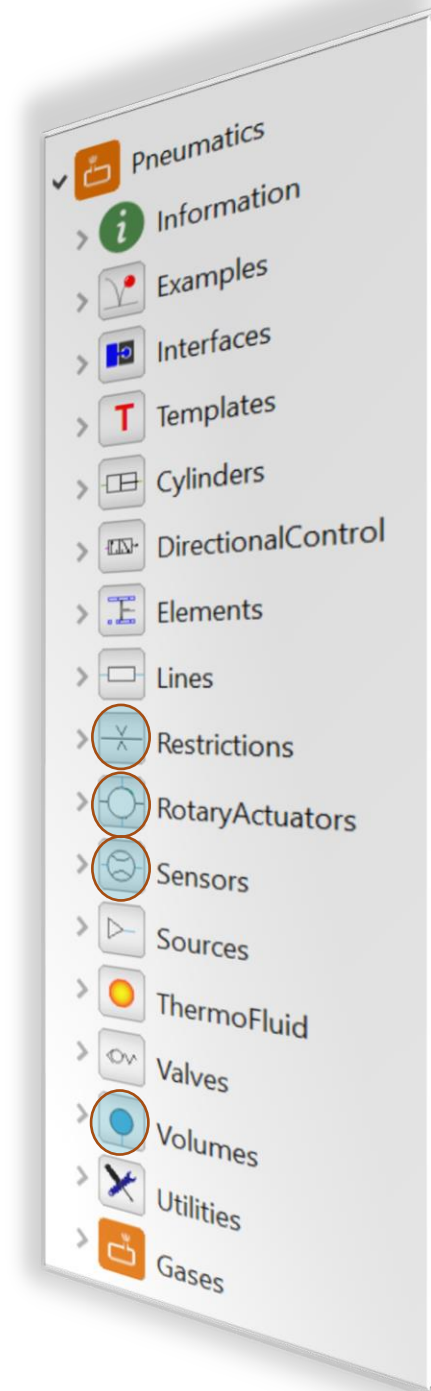
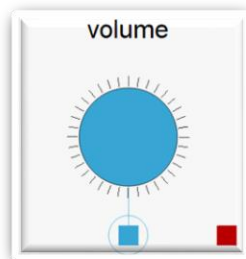
## Sensors and Utilities. Visualizers

- Pressure and flow



## Volumes

- Chamber and volume models



# MORE LIBRARY VIEWS

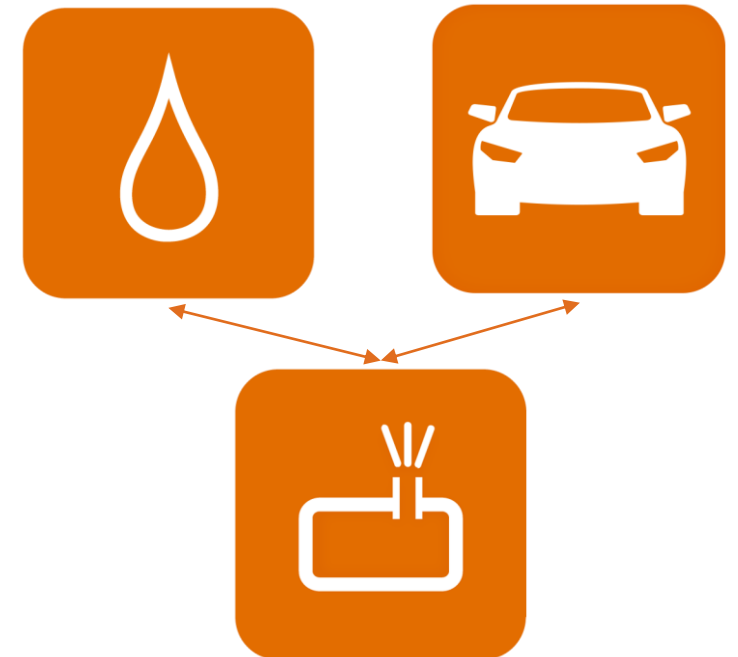
- Information
  - Interfaces
  - Templates
  - Basic
    - DCV\_5\_2
    - DCV\_5\_3
    - DCV\_4\_2
    - DCV\_4\_3
    - DCV\_3\_2\_Closed
    - DCV\_3\_2\_Open
    - DCV\_2\_2\_Closed
    - DCV\_2\_2\_Open
- Information
  - PreDefined
  - Examples
  - Interfaces
  - Templates
  - Functions
    - ZeroVolume
    - Volume
    - VolumeIsotherm
    - Leakage
    - Piston
    - SpoolValve
    - PoppetLift
    - PoppetLiftCone
    - PoppetLiftConicalSharpEdge
    - MassWithStopAndFriction
    - MassInMass
- Information
  - Fittings
    - Basic
      - BendCurve
      - BendEdge
      - Channel
      - SingleEdge
      - ThickEdge
      - StraightPipe
      - GenericValve
      - General
      - TeeConstant
      - Tee
      - Valve3Kmethod
      - BendCurve45deg
      - BendCurve90deg
      - BendEdge45deg
      - BendEdge90deg
      - BendCurve180deg
    - Basic
      - LinearResistance
      - Nozzle
      - Orifice
- Information
  - Basic
    - NonReturnOverrideValve
    - NonReturnValve
    - PressureRegulator
    - PressureRegulatorExtCom
    - PressureRegulatorExtRef
    - PressureRegulatorNoRelief
    - RapidExhaustValve
    - ReliefValve
    - ShuttleValve
    - SoftStartValve
    - ThrottleNonReturn
    - TwinPressureValve
    - VariableNozzle
    - ProportionalValve
    - ServoValve
- Information
  - DifferentialPressureSensor
  - MassflowSensor
  - PressureSensor
  - TemperatureSensor
  - Sources
    - Information
    - Interfaces
    - Basic
      - Reservoir
      - ReservoirExtCom
      - Silencer
      - Booster



# MODELON COMPATIBILITY

# RECOMMENDED MODELON LIBRARY COMPATIBILITY

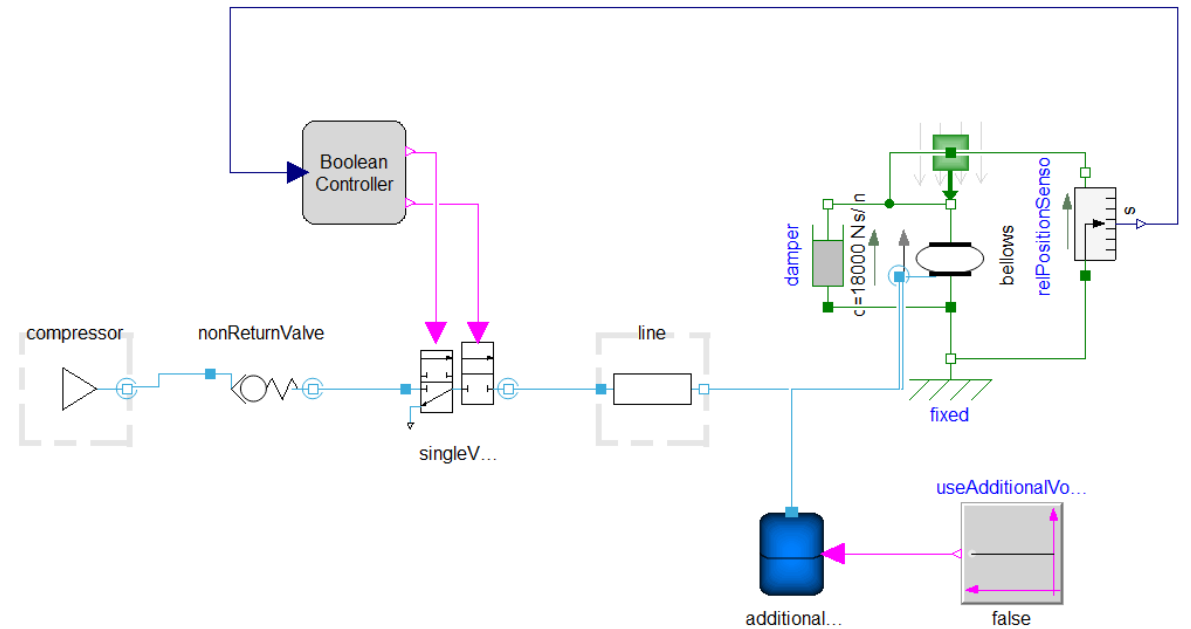
- Pneumatics Library can be combined with other Modelon libraries to solve specific engineering design tasks.
- Interesting libraries include the
  - Hydraulics Library
  - Vehicle Dynamics Library
- These libraries can also be used as a stand-alone solution.



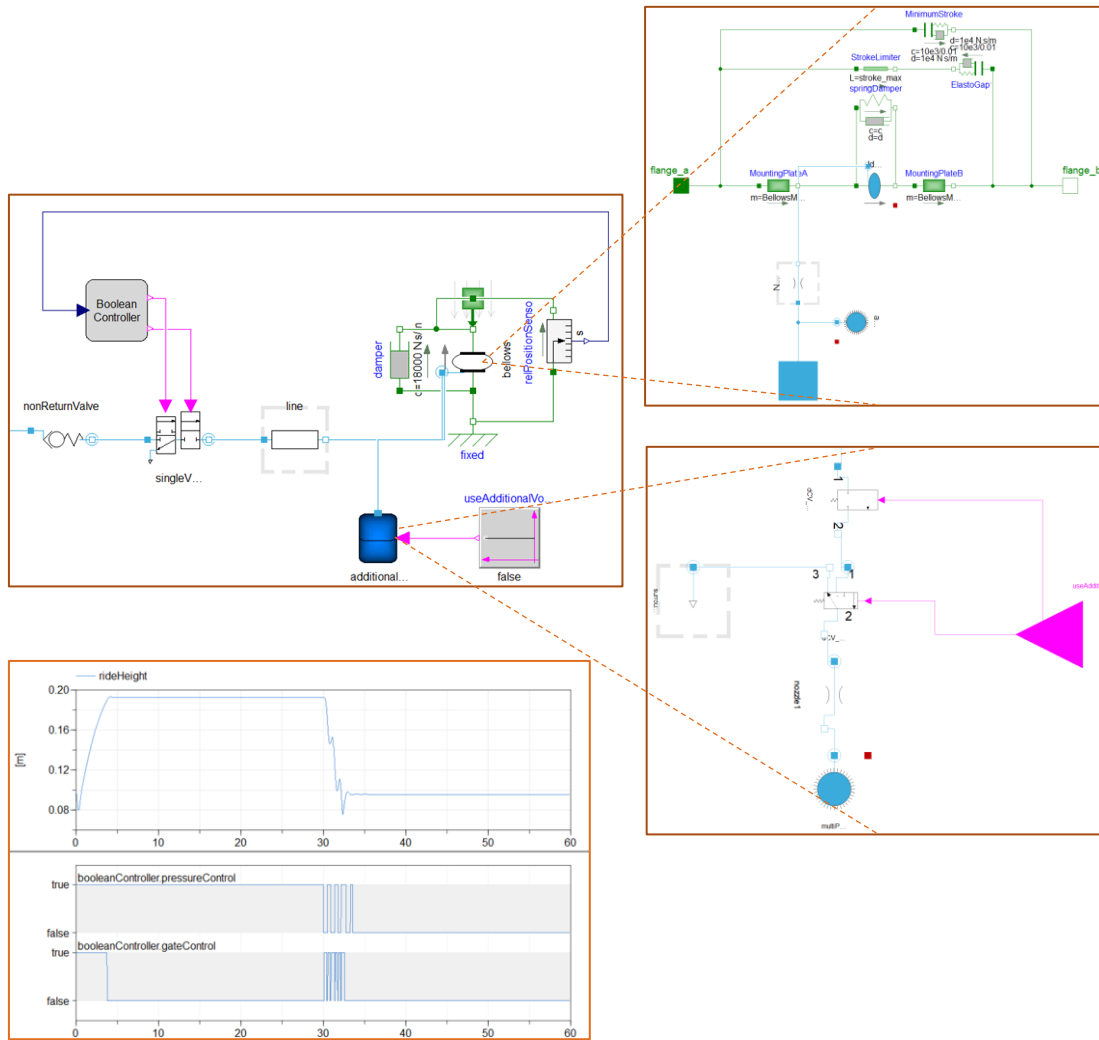


# EXAMPLE: AIR SUSPENSION SYSTEM

Air suspension model demonstrating vehicle ride height change



# AIR SUSPENSION MODEL

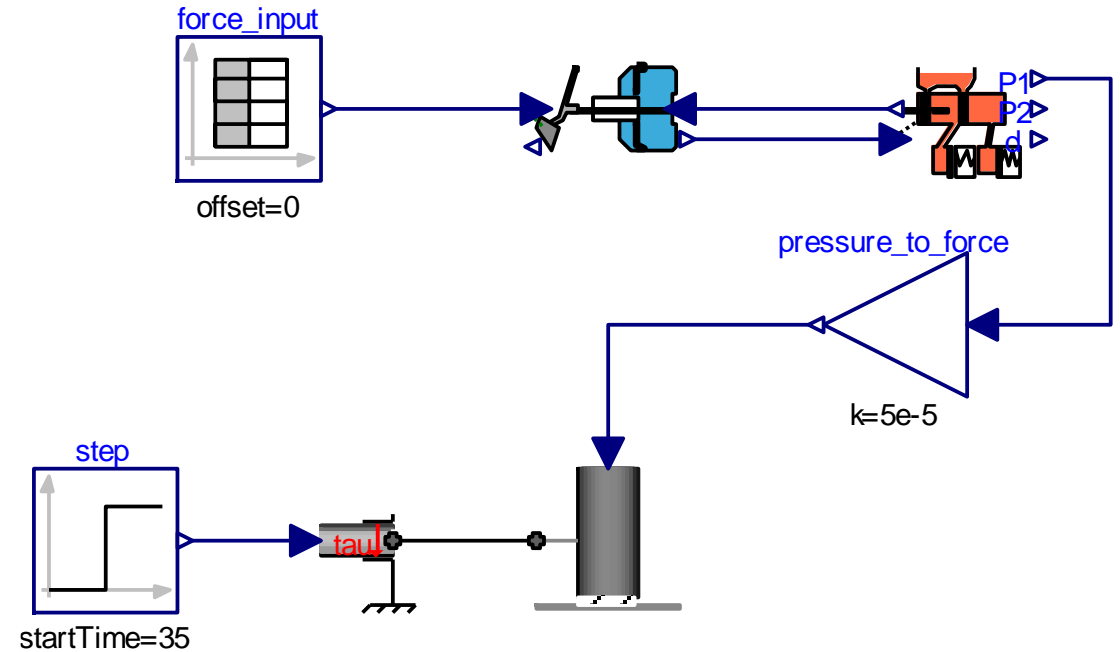


- Air suspension modeling using bellows
- Ride height changing circuit with other valves modeled

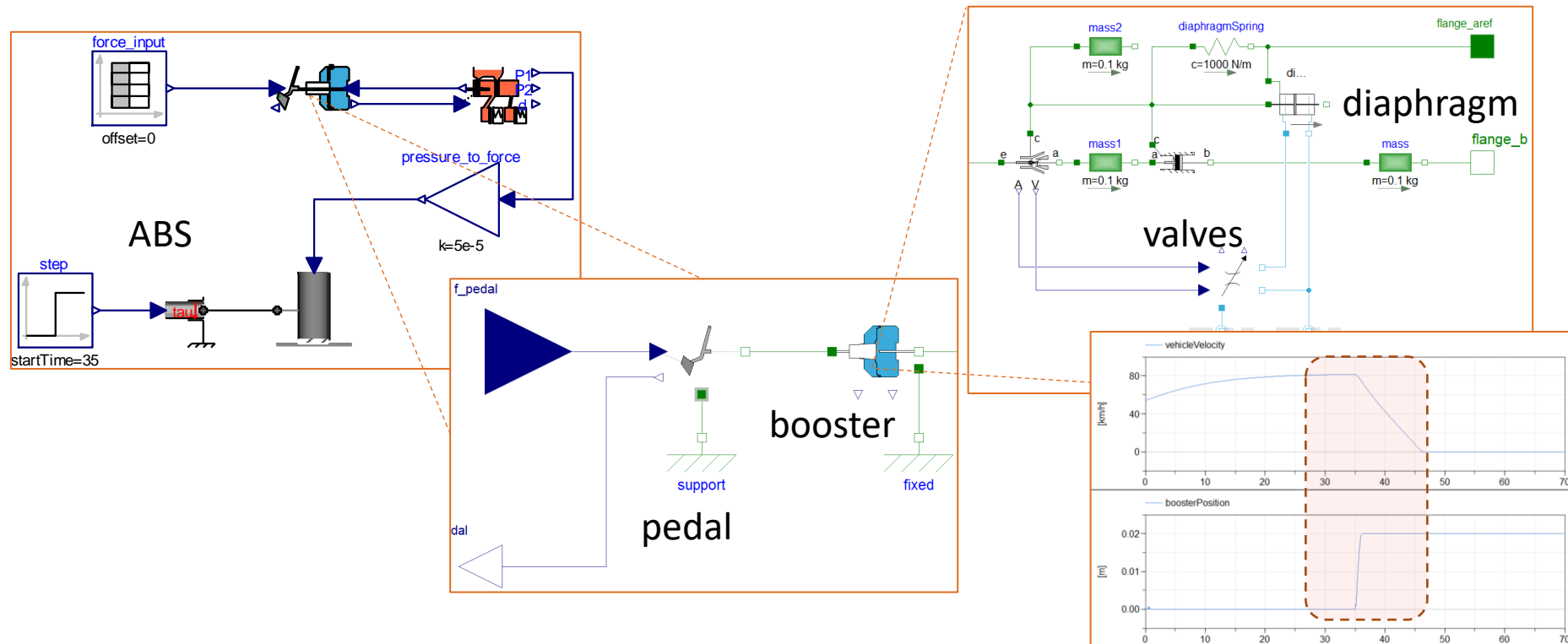


# EXAMPLE: BRAKE SYSTEM

Hydraulic brake system and pneumatic brake booster  
example demonstrating FMI capabilities



# BRAKE SYSTEM MODEL



- Anti-lock braking system involving the vacuum booster model
- Off-the-shelf component models from library used to build the booster circuit

# INDUSTRIAL EQUIPMENT

- Typical usage:
  - Model Calibration and verification of existing designs
  - Analyze system behavior of a new design
    - New design plausible?
  - Analyze possible design improvements
    - Depends on Design goals
  - Robustness of design

The background image is a composite of two scenes. On the left, a person is seen from the side, focused on a laptop. Their hands are on the keyboard, and they appear to be in a professional or technical setting. On the right, a large, detailed jet engine turbine is shown, highlighting the intricate blades and the central hub. The entire image is rendered in a dark, monochromatic blue-grey tone, with the text 'LATEST RELEASE' overlaid in a bright orange color.

**LATEST RELEASE**



# RELEASE: 2021.2

## Enhancements

- Improved initialization in the examples within AirSuspensionSystem
- Complete review of all experiment-annotations

