

AIR/HYDRAULIC ACTUATORS

Master cylinders, stem seal master cylinders, and
stem seal actuators with air chambers



Convert Air Pressure to
Hydraulic Pressure



ZF Off-Highway Solutions Minnesota Inc. designs, manufactures, and markets hydraulic components, controls, and brake systems, primarily for off-highway markets.

Many of the world's largest Off-Highway OEMs value the knowledgeable staff at ZF Off-Highway Solutions Minnesota Inc. and work with us to make their products better. Our custom-engineered products are designed with the customer requirements as the primary driver. It is our intent to help customers build their systems with our expertise in hydraulic components, braking systems, and controls. Our goal is to meet or exceed our customers' expectations in every aspect of our business.

ZF Off-Highway Solutions Minnesota Inc. continuously strives for improvement, while remaining a quality leader in our field. We are a successful, customer driven business. We look forward to working with you!

Air/Hydraulic Actuators

The same dependability and performance that goes into every ZF Off-Highway Solutions Minnesota Inc. product also goes into our versatile, high-performance Air/Hydraulic Actuators. This is an important consideration when you select an actuator for a system requiring air/hydraulic power.

The ZF Air/Hydraulic Actuators presented in this catalog are designed to take advantage of available pressurized air sources to produce high hydraulic pressures. This design feature is especially important for towing self-propelled hydraulically braked vehicles when towing vehicle is equipped with air. The towed vehicle's brakes are controlled by the air/hydraulic actuator when used with a remote air reservoir and relay emergency valve. These actuators can also be used for industrial applications.

Air chamber sizes are available from 12 to 36 square inches and hydraulic displacement from 1.4 to 5.9 cubic inches. Both remote or integral reservoir models are available for mineral base hydraulic oil or brake fluid.

System fluids other than DOT 3, 4, 5, or 5.1 brake fluid or mineral based hydraulic oils may require special seals. Consult ZF Off-Highway Solutions Minnesota Inc. for recommendations.

Combining the speed of air operation with the control and high force of fluid can result in an ideal circuit.

Air/Hydraulic Actuators are the combination of a fluid actuator and an air chamber. The air chamber is used to convert low air pressure to high hydraulic pressure. The conversion ratio is the ratio of the hydraulic output pressure to air input pressure.

There are three types of Air/Hydraulic Actuators to choose from; the master cylinder type, the stem seal master cylinder type with integral reservoir, and the straight bore actuator type for use with a remote reservoir. Each has its own advantages to offer.

This catalog is designed to assist you in making an initial selection of an Air/Hydraulic Actuator suited to your requirements. Complete the appropriate Application Data Sheet online, www.mico.com, and submit to sh-applications.NMN@ZF.com. The ZF Off-highway Solutions Minnesota Inc. Applications Department will analyze your specifications and based on your input recommend an Air/Hydraulic Actuator suitable for your requirements.

Edition 1

Version 1 (06.2023)

84-460-007 (en)

This publication is not subject to any update service. Information contained in this publication was in effect at the time the publication was approved for printing and is subject to change without notice or liability. ZF Off-Highway Solutions Minnesota Inc. reserves the right to revise the information presented or to discontinue the production of parts described at any time.

You will find the current edition at www.mico.com

Catalog Index

Master Cylinder with Air Chamber	4-5
Master Cylinder with Air Chamber	6-7
Master Cylinder with Air Chamber	8-9
Stem Seal Master Cylinder with Air Chamber	10-11
Stem Seal Actuator with Air Chamber	12-13
Stem Seal Actuator with Air Chamber	14-15
Fluid Reservoirs.....	16

Applications



Forestry Equipment



Agricultural Equipment



Heavy Construction Equipment



Marine Equipment



Multi-stop Vehicles



In-Plant & Warehouse Equipment



Railroad Equipment

Air/Hydraulic Actuator

(master cylinder with air chamber)

FEATURES

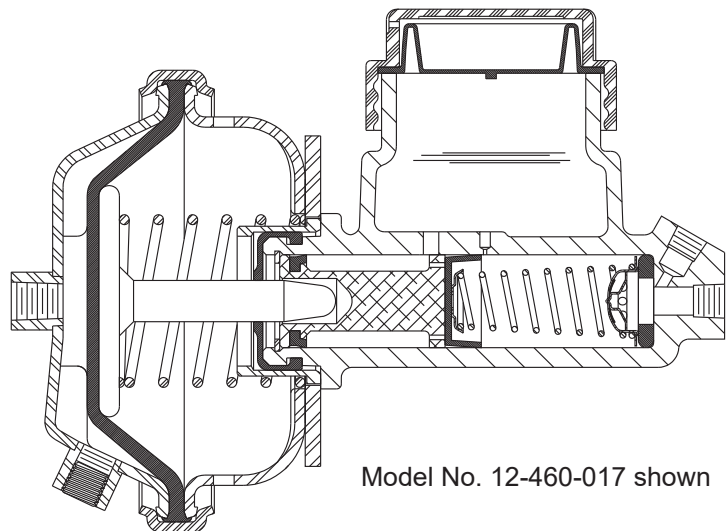
- Available with or without internal residual check valve
- Incorporates a conventional master cylinder
- Available for industrial and mobile applications
- Sealed diaphragm fluid reservoir



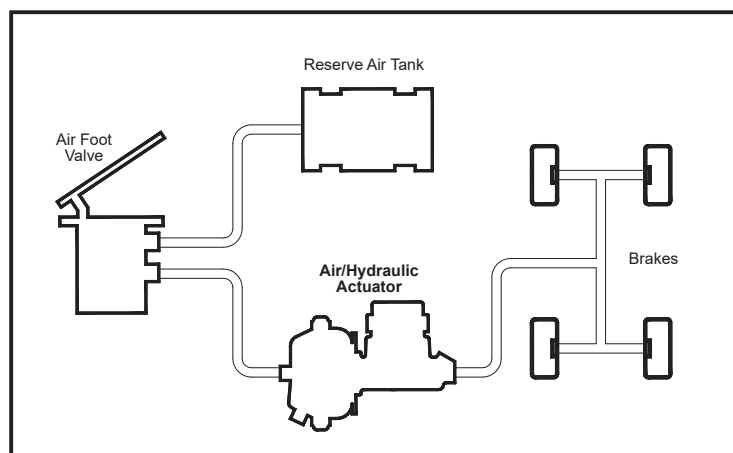
DESCRIPTION

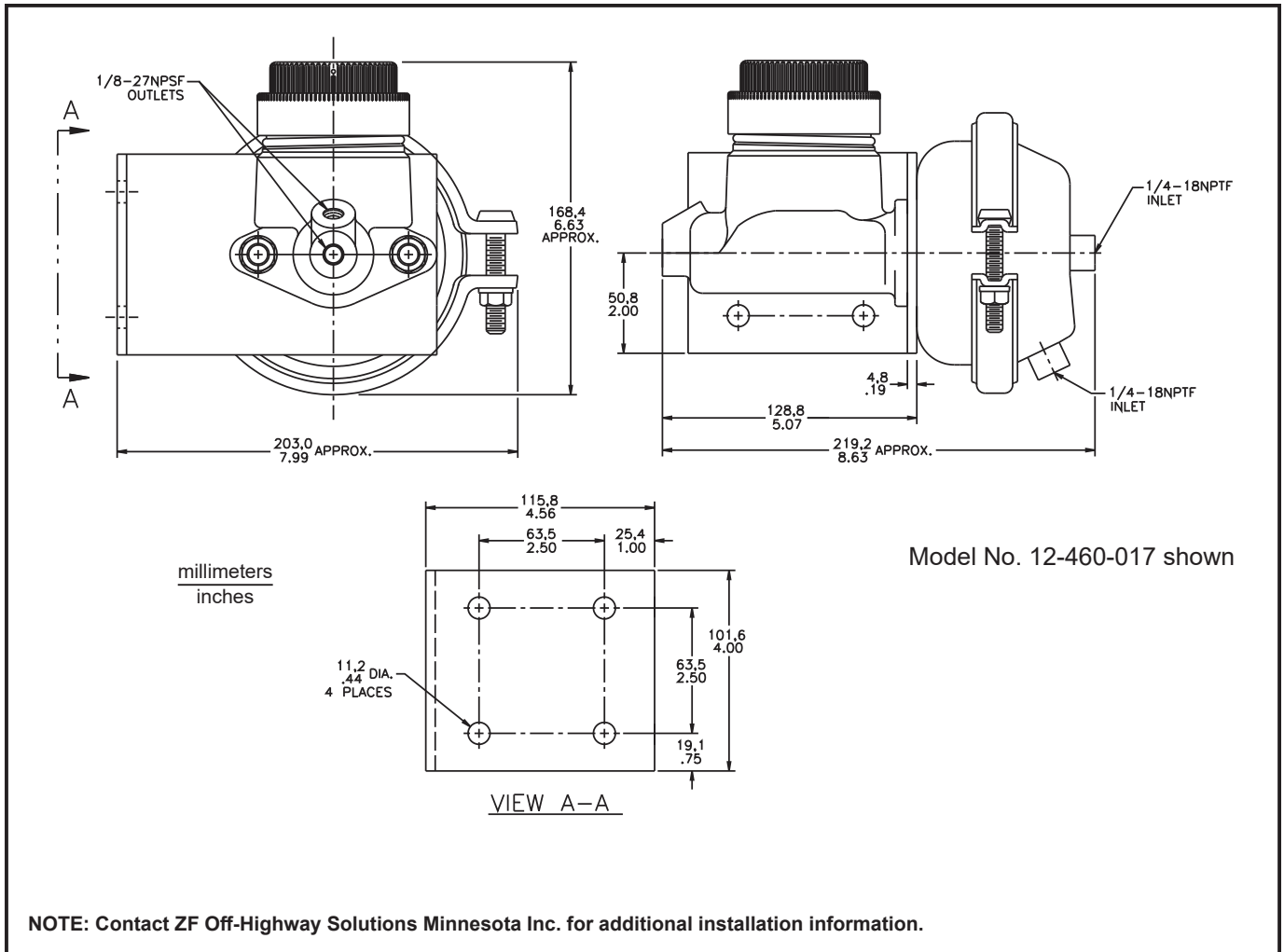
The ZF Off-Highway Master Cylinder Type Air/Hydraulic Actuator is the combination of a conventional master cylinder and an air chamber. The master cylinder is a single acting type with one piston.

Air pressure is used to actuate a push rod in the air chamber. The push rod in turn moves the piston in the master cylinder which forces the hydraulic fluid into the system.



Typical System Schematic





SPECIFICATIONS

Model Number	Fluid Type	Internal Residual Check Valve	Air Chamber Size	Hydraulic Pressure @ 6.9 bar (100 PSI) Air Pressure	Effective Displacement	Effective Stroke	Bore Diameter
12-460-017	BF	Yes	30 cm ² (12 in ²)	83 bar (1200 PSI)	23.0 cm ³ (1.4 in ³)	35.1 mm (1.38 in)	28.6 mm (1.125 in)
12-460-025	BF	No	30 cm ² (12 in ²)	83 bar (1200 PSI)	23.0 cm ³ (1.4 in ³)	35.1 mm (1.38 in)	28.6 mm (1.125 in)

BF = DOT 3, 4, 5 and 5.1 brake fluid.

All model numbers have a maximum air pressure rating of 8 bar (120 PSI).

All model numbers have right side mounting brackets when viewed from the air chamber end of actuator.

Air/Hydraulic Actuator

(master cylinder with air chamber)

FEATURES

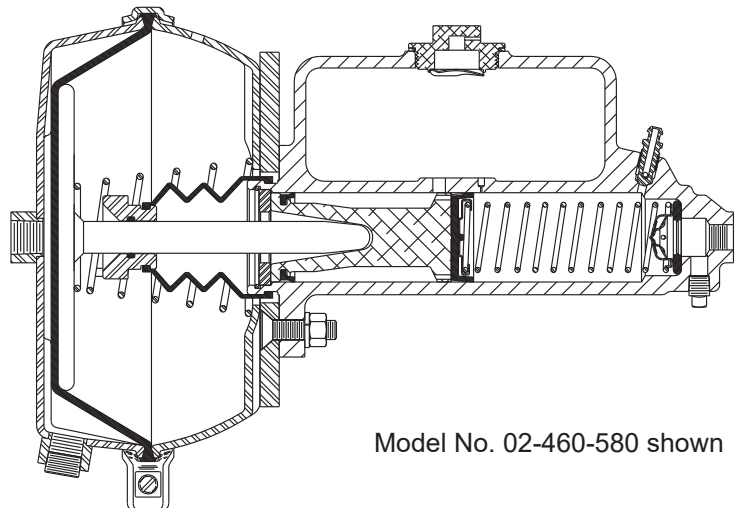
- Available with or without internal residual check valve
- Incorporates a conventional master cylinder
- Available for industrial and mobile applications
- Actuator components are protected from environmental contaminants



DESCRIPTION

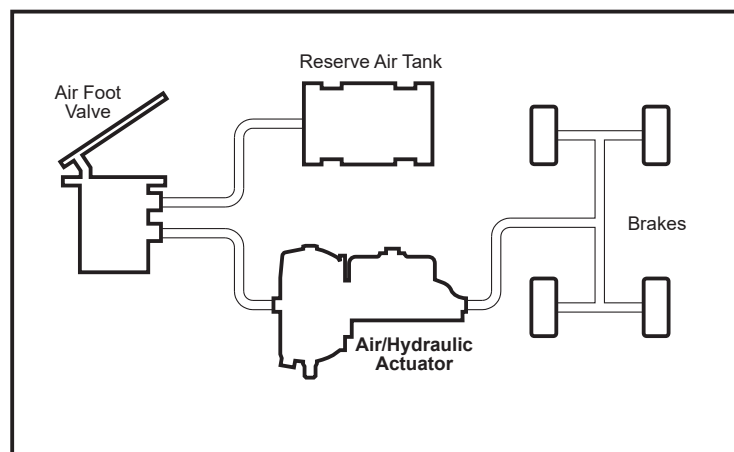
The Air/Hydraulic Actuators listed here are similar to those found in the previous section. The models in this section however, use a larger straight bore master cylinder for more displacement and a larger air chamber for more pressure.

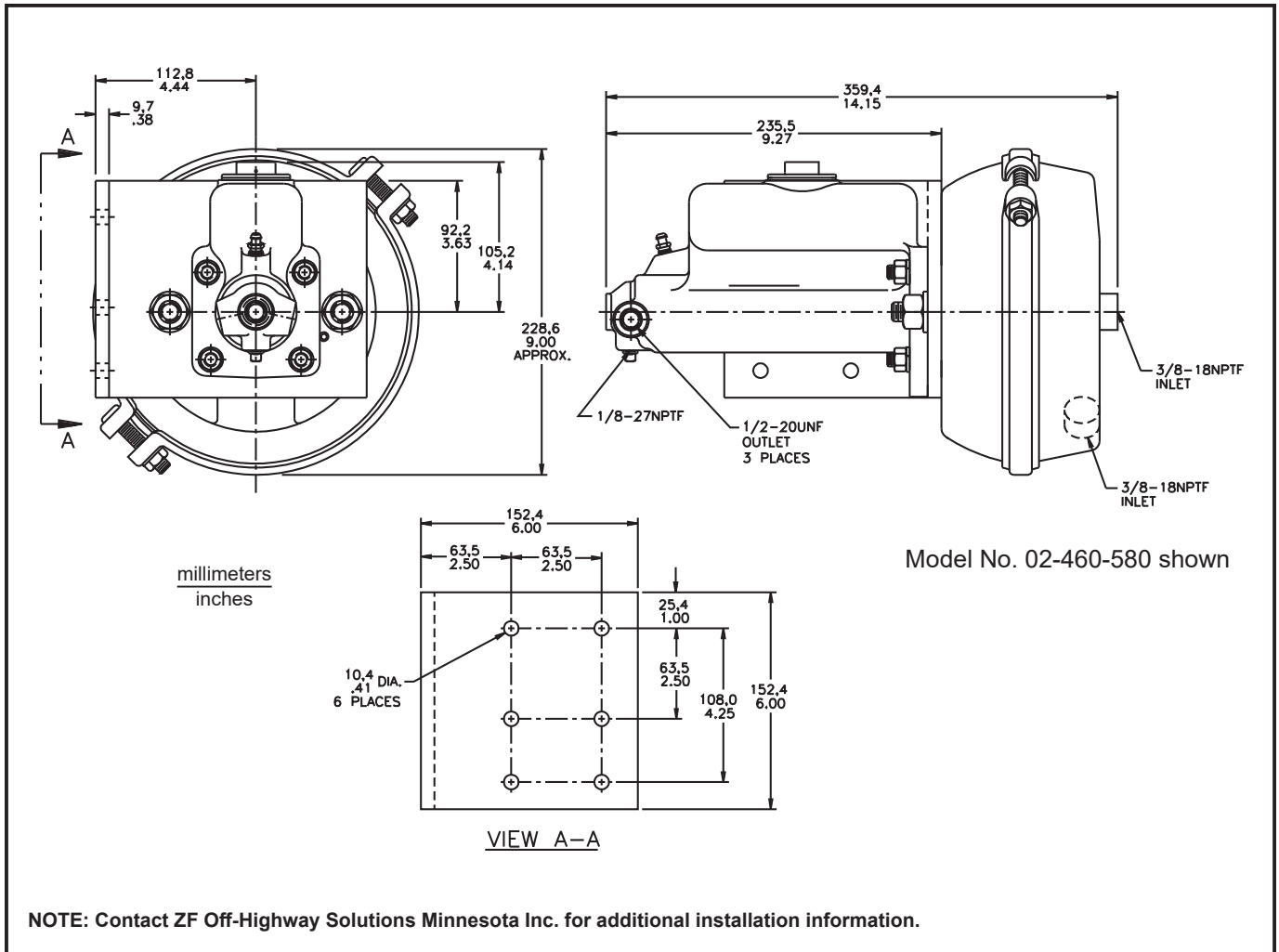
Like the models in the previous section, air pressure is used to actuate a push rod in the air chamber. In turn the push rod moves the master cylinder piston which forces hydraulic fluid into the system.



Model No. 02-460-580 shown

Typical System Schematic





SPECIFICATIONS

Model Number	Fluid Type	Internal Residual Check Valve	Air Chamber Size	Hydraulic Pressure @ 6.9 bar (100 PSI) Air Pressure	Effective Displacement	Effective Stroke	Bore Diameter	Filler Cap
02-460-580	BF	Yes	91 cm ² (36 in ²)	103 bar (1500 PSI)	96.7 cm ³ (5.9 in ³)	62.2 mm (2.45 in)	44.5 mm (1.750 in)	Vented
02-461-580	BF	No	91 cm ² (36 in ²)	103 bar (1500 PSI)	96.7 cm ³ (5.9 in ³)	62.2 mm (2.45 in)	44.5 mm (1.750 in)	Vented
* 03-460-437	BF	Yes	76 cm ² (30 in ²)	50 bar (720 PSI)	88.5 cm ³ (5.4 in ³)	57.2 mm (2.25 in)	44.5 mm (1.750 in)	Ported / 1/2-20UNF

BF = DOT 3, 4, 5 and 5.1 brake fluid.

All model numbers have a maximum air pressure rating of 8 bar (120 PSI).

All model numbers have right side mounting brackets when viewed from the air chamber end of actuator.

* Special mounting bracket. Contact ZF Off-Highway Solutions Minnesota Inc. for more information.

Air/Hydraulic Actuator

(master cylinder with air chamber)

FEATURES

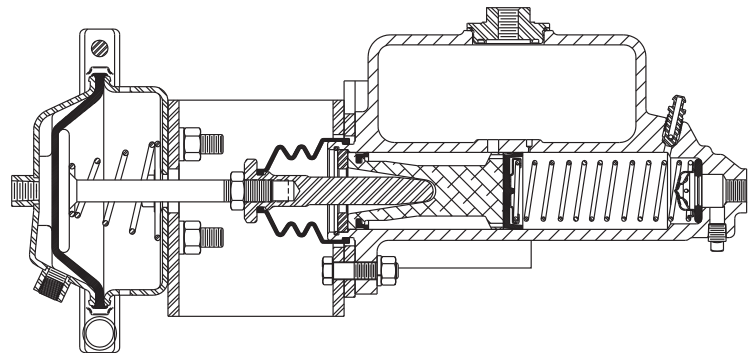
- Contains an internal residual check valve
- Incorporates a conventional master cylinder
- Available for industrial and mobile applications
- Actuator components are protected from environmental contaminants



DESCRIPTION

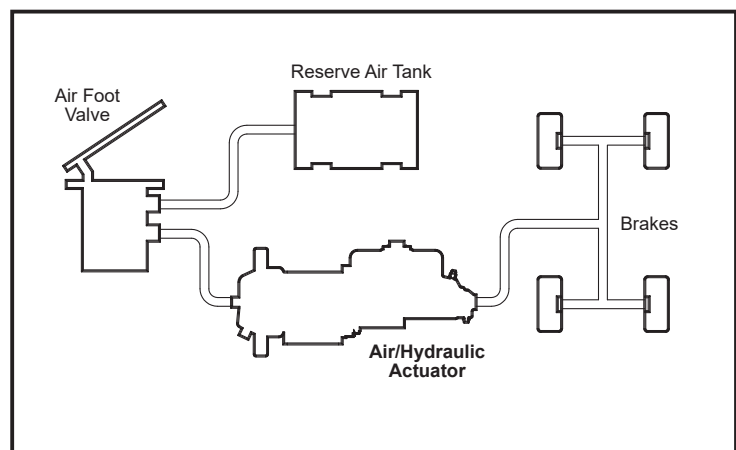
This actuator is also the combination of a conventional master cylinder and an air chamber. The model in this section uses a large straight bore master cylinder for greater displacement.

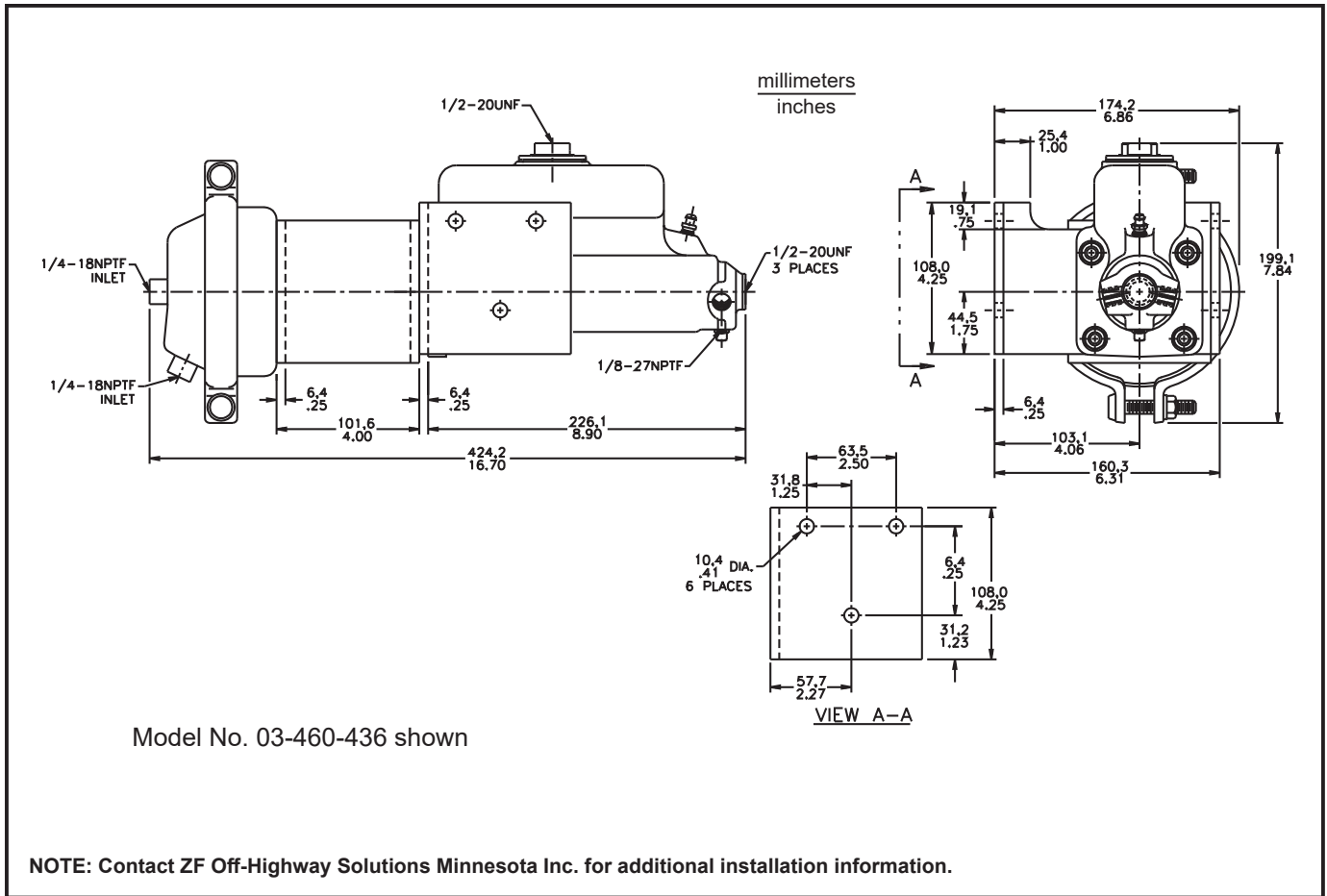
Air pressure is used to actuate a push rod in the air chamber, which moves the master cylinder piston and forces hydraulic fluid into the system.



Model No. 02-460-436 shown

Typical System Schematic





SPECIFICATIONS

Model Number	Fluid Type	Internal Residual Check Valve	Air Chamber Size	Hydraulic Pressure @ 6.9 bar (100 PSI) Air Pressure	Effective Displacement	Effective Stroke	Bore Diameter
03-460-436	BF	Yes	30 cm ² (12 in ²)	31 bar (450 PSI)	85.2 cm ³ (5.2 in ³)	44.5 mm (1.75 in)	44.5 mm (1.750 in)

BF = DOT 3, 4, 5 and 5.1 brake fluid.

Maximum air pressure rating of 8 bar (120 PSI).

Air/Hydraulic Actuator

(stem seal master cylinder with air chamber)

FEATURES

- Positive alignment of actuating components eliminates cup wear
- Actuator components protected from environmental contaminants
- Ideal for spring brakes
- Available for industrial and mobile applications using hydraulic oil or brake fluid
- Includes stroke indicator
- Internal valving enhances bleeding process and extends normal service life of primary seal

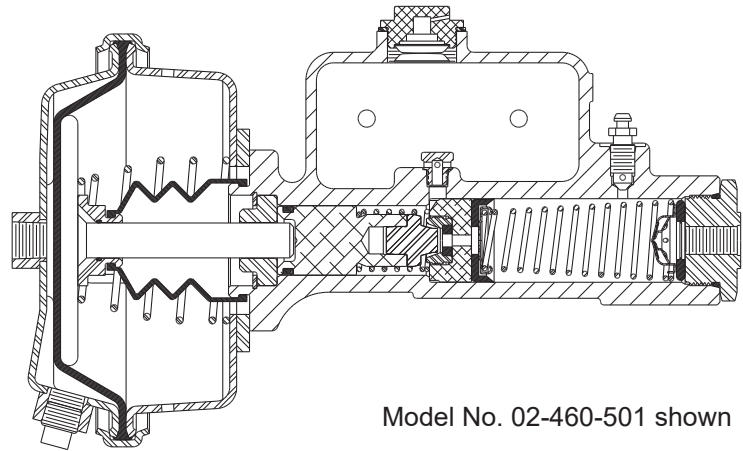


DESCRIPTION

These Air/Hydraulic Actuators are a combination of a fluid actuator and an air chamber. They are designed to take advantage of available pressurized air sources to produce hydraulic pressure. This design feature allows them to be used in many brake applications in the construction, material handling, mining, forestry and farming industries as well as many industrial applications.

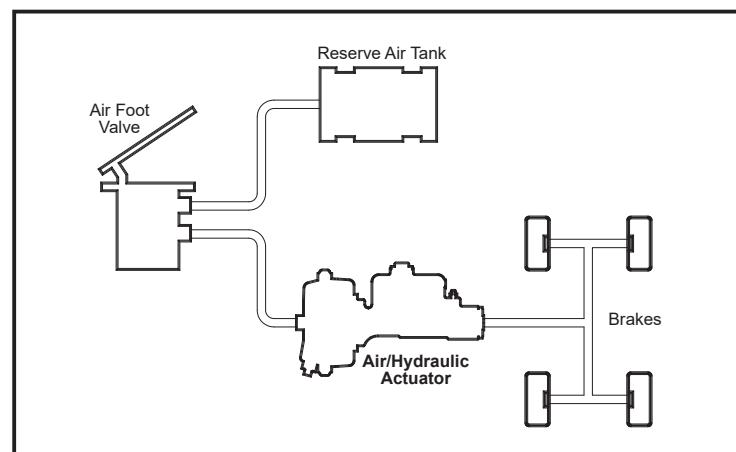
When sizing an air/hydraulic actuator to a particular application, the hydraulic displacement and required system pressure must be determined. The required system fluid depends upon the type of wheel brake system on the vehicle. These air/hydraulic actuators have a greater displacement output than the wheel brake system input plus an adequate reserve. Consult the brake or axle manufacturer for the needed displacement.

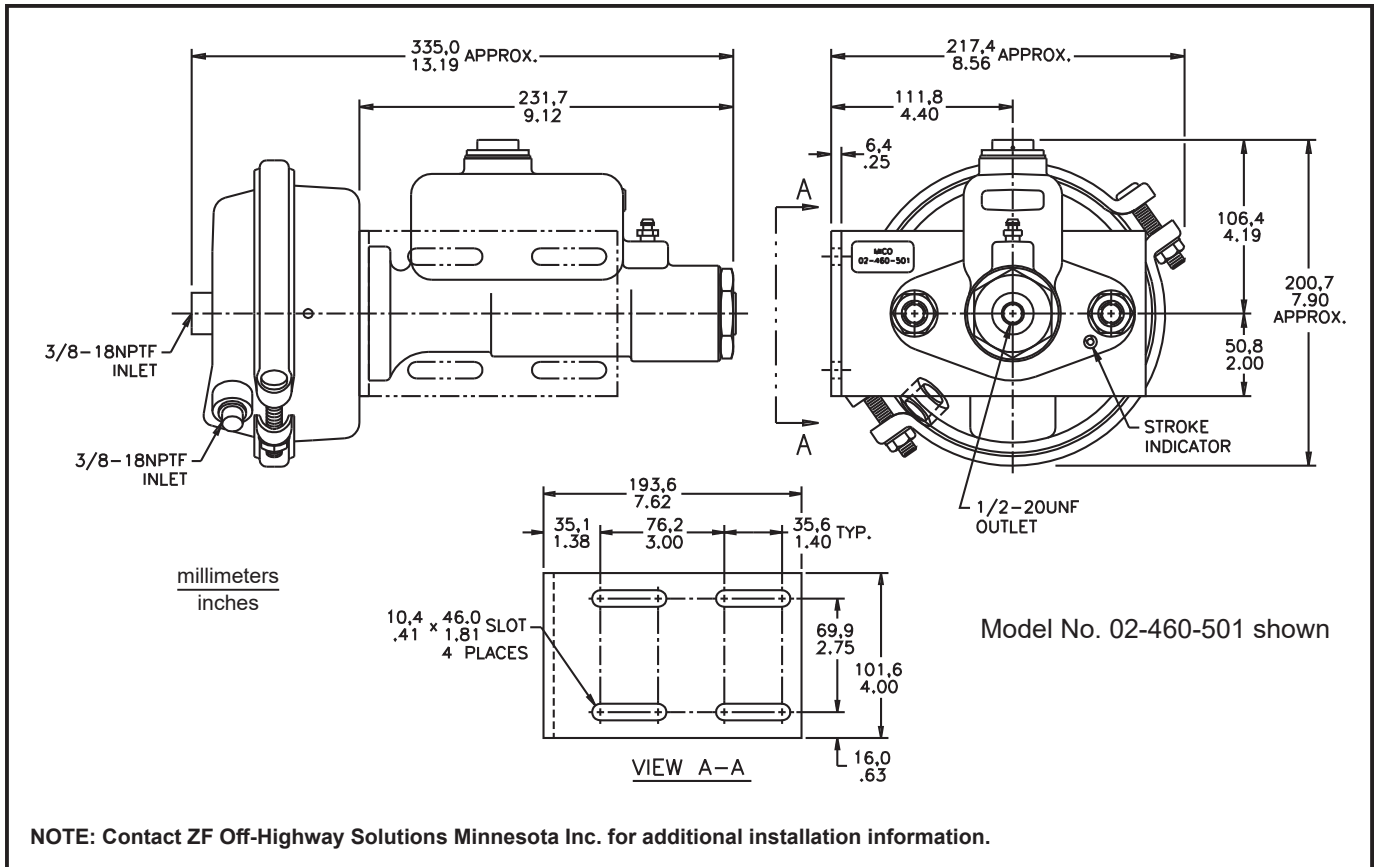
The stem seal master cylinder eliminates cup cutting by allowing the cups to move freely in the master cylinder without passing over any ports.



Model No. 02-460-501 shown

Typical System Schematic





SPECIFICATIONS

Model Number	Fluid Type	Internal Residual Check Valve	Air Chamber Size	Hydraulic Pressure @ 6.9 bar (100 PSI) Air Pressure	Effective Displacement	Effective Stroke	Bore Diameter	Filler Cap	★ Mounting Bracket
02-460-501	BF	Yes	61.cm ² (24 in ²)	93 bar (1350 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Right
02-460-502	HO	Yes	61.cm ² (24 in ²)	93 bar (1350 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Right
02-460-503	BF	No	61.cm ² (24 in ²)	93 bar (1350 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Ported / 1/4-18NPTF	Right
02-460-504	HO	No	91.cm ² (36 in ²)	138 bar (2000 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Ported / 1/8-27NPTF	Left
02-460-505	BF	Yes	76.cm ² (30 in ²)	117 bar (1700 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Right
02-460-506	HO	Yes	76.cm ² (30 in ²)	117 bar (1700 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Right
02-460-507	BF	Yes	91.cm ² (36 in ²)	138 bar (2000 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Right
02-460-514	HO	No	91.cm ² (36 in ²)	141 bar (2045 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Ported / 1/8-27NPTF	Left
02-460-515	BF	No	76.cm ² (30 in ²)	117 bar (1700 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Left
02-460-516	HO	No	61.cm ² (24 in ²)	93 bar (1350 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Ported / 1/8-27NPTF	Top
02-460-517	BF	No	76.cm ² (30 in ²)	117 bar (1700 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Ported / 1/4-18NPTF	Right
02-460-518	HO	No	91.cm ² (36 in ²)	138 bar (2000 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Left
02-460-519	BF	No	91.cm ² (36 in ²)	138 bar (2000 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Ported / 1/8-27NPTF	Right
02-460-521	BF	Yes	61.cm ² (24 in ²)	93 bar (1350 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Left
02-460-523	BF	No	61.cm ² (24 in ²)	93 bar (1350 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Ported / 1/4-18NPTF	Left
02-460-527	BF	No	91.cm ² (36 in ²)	138 bar (2000 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Ported / 1/4-18NPTF	Right
02-461-501	BF	No	61.cm ² (24 in ²)	93 bar (1350 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Right
02-461-502	HO	No	61.cm ² (24 in ²)	93 bar (1350 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Right
02-461-505	BF	No	76.cm ² (30 in ²)	117 bar (1700 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Right
02-461-506	HO	No	76.cm ² (30 in ²)	117 bar (1700 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Right
02-461-521	BF	No	61.cm ² (24 in ²)	93 bar (1350 PSI)	57.4 cm ³ (3.5 in ³)	50.8 mm (2.00 in)	38.1 mm (1.500 in)	Vented	Left

BF = DOT 3, 4, 5 and 5.1 brake fluid.

All model numbers have a maximum air pressure rating of 8 bar (120 PSI).

★ When viewed from the air chamber end of actuator.

Air/Hydraulic Actuator

(stem seal actuator with air chamber)

FEATURES

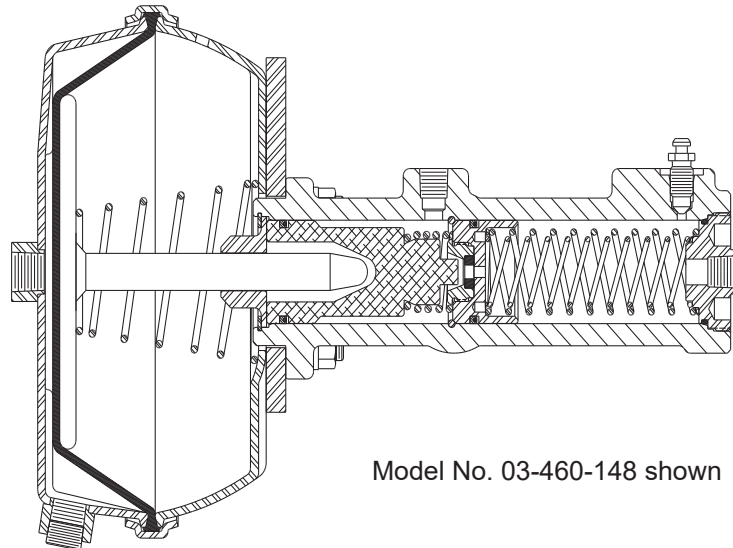
- Allows towed vehicle's brakes to be controlled from brake pedal of towing vehicle
- Ideal for spring brakes - cup seals never pass over ports
- Available for industrial and mobile applications



DESCRIPTION

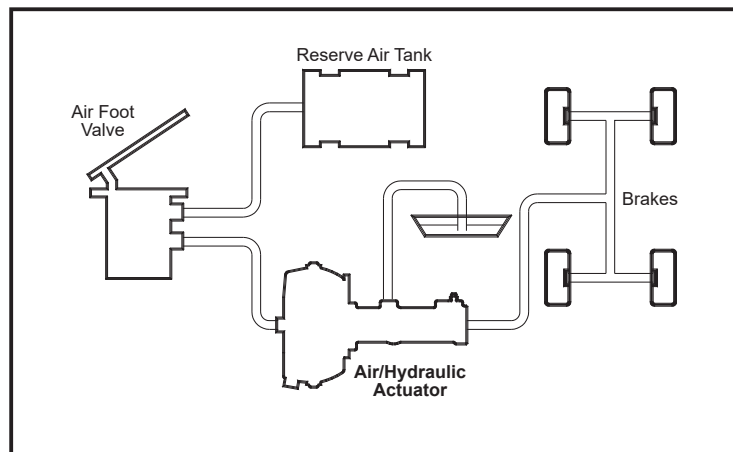
The Straight Bore Actuator Type Air/Hydraulic Actuator is also the combination of a remote actuator and an air chamber.

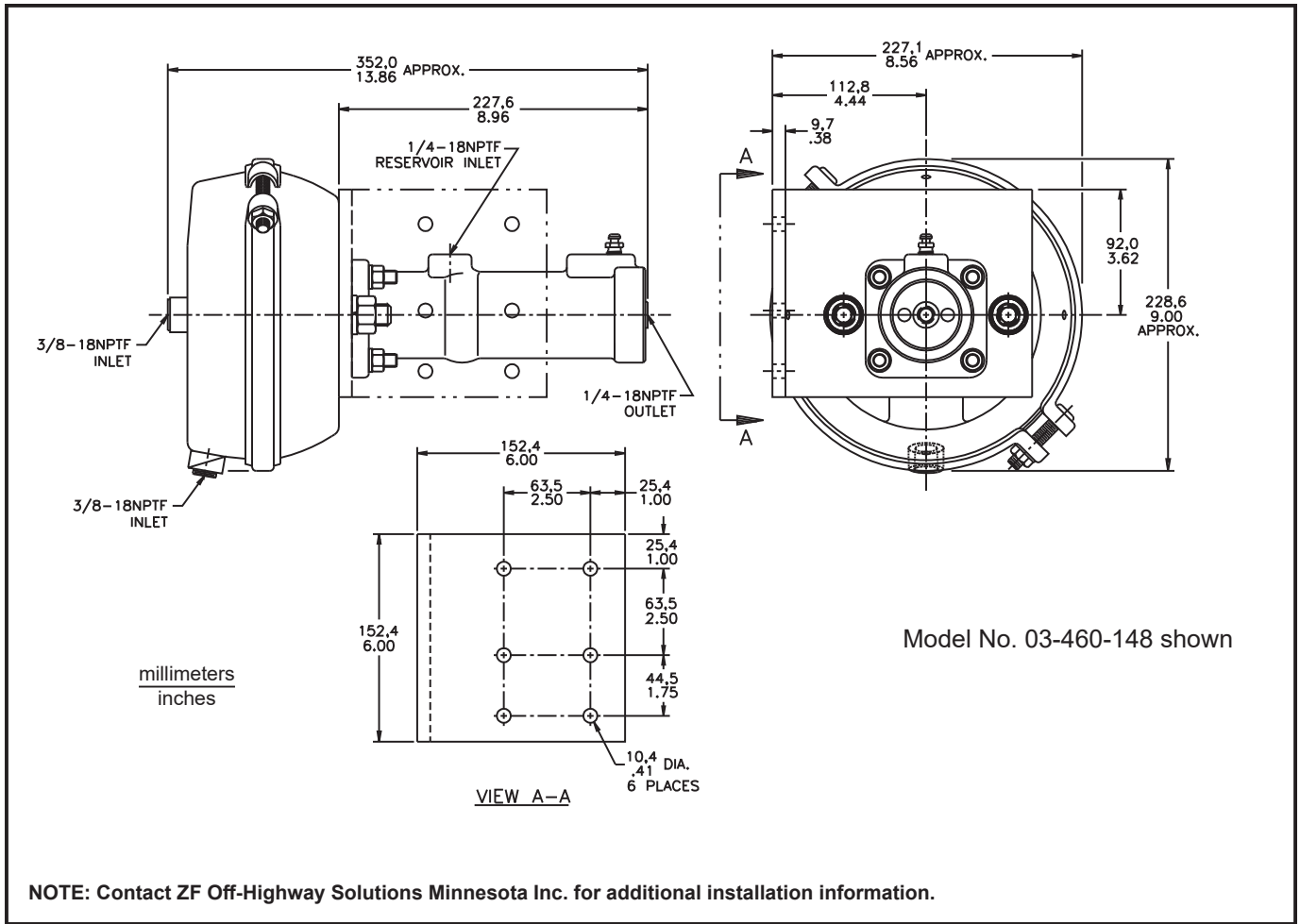
Air pressure is used to actuate a push rod in the air chamber. The push rod in turn moves a piston in the hydraulic chamber which closes the reservoir feed port of the high pressure piston. The continued movement of the hydraulic piston then generates high hydraulic pressures at the outlet port. The stem seal actuator eliminates cup cutting by allowing the cups to move freely in the actuator without passing over any ports.



Model No. 03-460-148 shown

Typical System Schematic





SPECIFICATIONS

Model Number	Fluid Type	Internal Residual Check Valve	Air Chamber Size	Hydraulic Pressure @ 6.9 bar (100 PSI) Air Pressure	Effective Displacement	Effective Stroke	Bore Diameter
03-460-147	BF	No	91.cm ² (36 in ²)	103 bar (1500 PSI)	96.0 cm ³ (5.8 in ³)	62.0 mm (2.44 in)	44.5 mm (1.750 in)
03-460-148	HO	No	91.cm ² (36 in ²)	103 bar (1500 PSI)	96.0 cm ³ (5.8 in ³)	62.0 mm (2.44 in)	44.5 mm (1.750 in)
03-460-338	HO	No	51.cm ² (20 in ²)	55 bar (800 PSI)	83.8 cm ³ (5.1 in ³)	54.0 mm (2.13 in)	44.5 mm (1.750 in)

BF = DOT 3, 4, 5 and 5.1 brake fluid. HO = mineral base hydraulic oil.

All model numbers have a maximum air pressure rating of 8 bar (120 PSI).

All model numbers have right side mounting brackets when viewed from the air chamber end of actuator.

Air/Hydraulic Actuator

(stem seal actuator with air chamber)

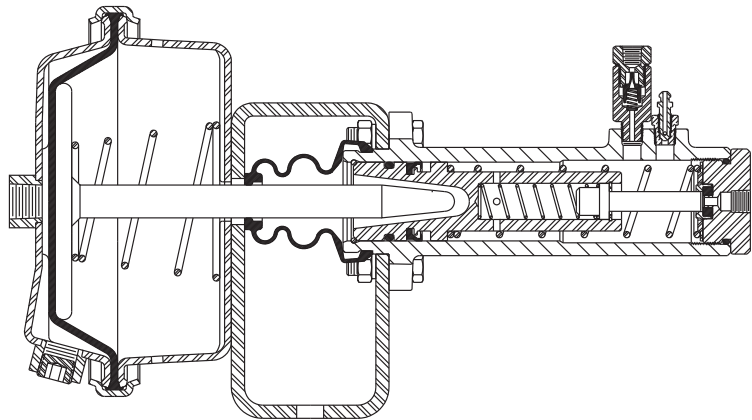
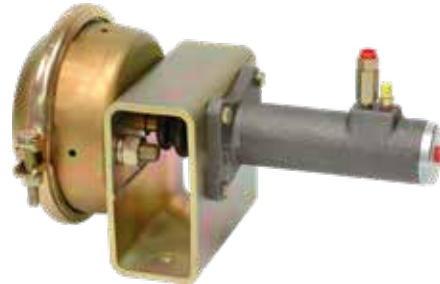
FEATURES

- Allows towed vehicle's brakes to be controlled from brake pedal of towing vehicle
- Ideal for spring brakes - cup seals never pass over ports
- Available for industrial and mobile applications

DESCRIPTION

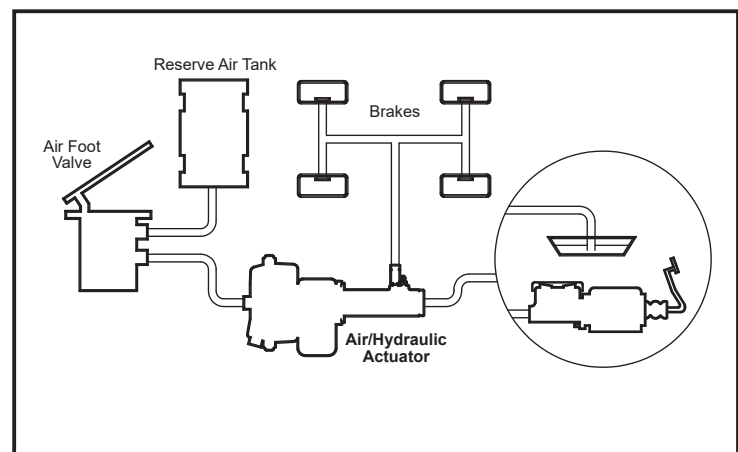
The Straight Bore Actuator Type Air/Hydraulic Actuator is the combination of a remote actuator and an air chamber. The remote actuator has a single acting piston with a stem seal. Air pressure is used to actuate a push rod in the air chamber. The push rod in turn moves a piston in the hydraulic chamber which causes the stem seal to close off the fluid reservoir port. The continued movement of the hydraulic piston then generates high hydraulic pressures at the outlet port. The stem seal actuator eliminates cup cutting by allowing the cups to move freely in the master cylinder without passing over any ports.

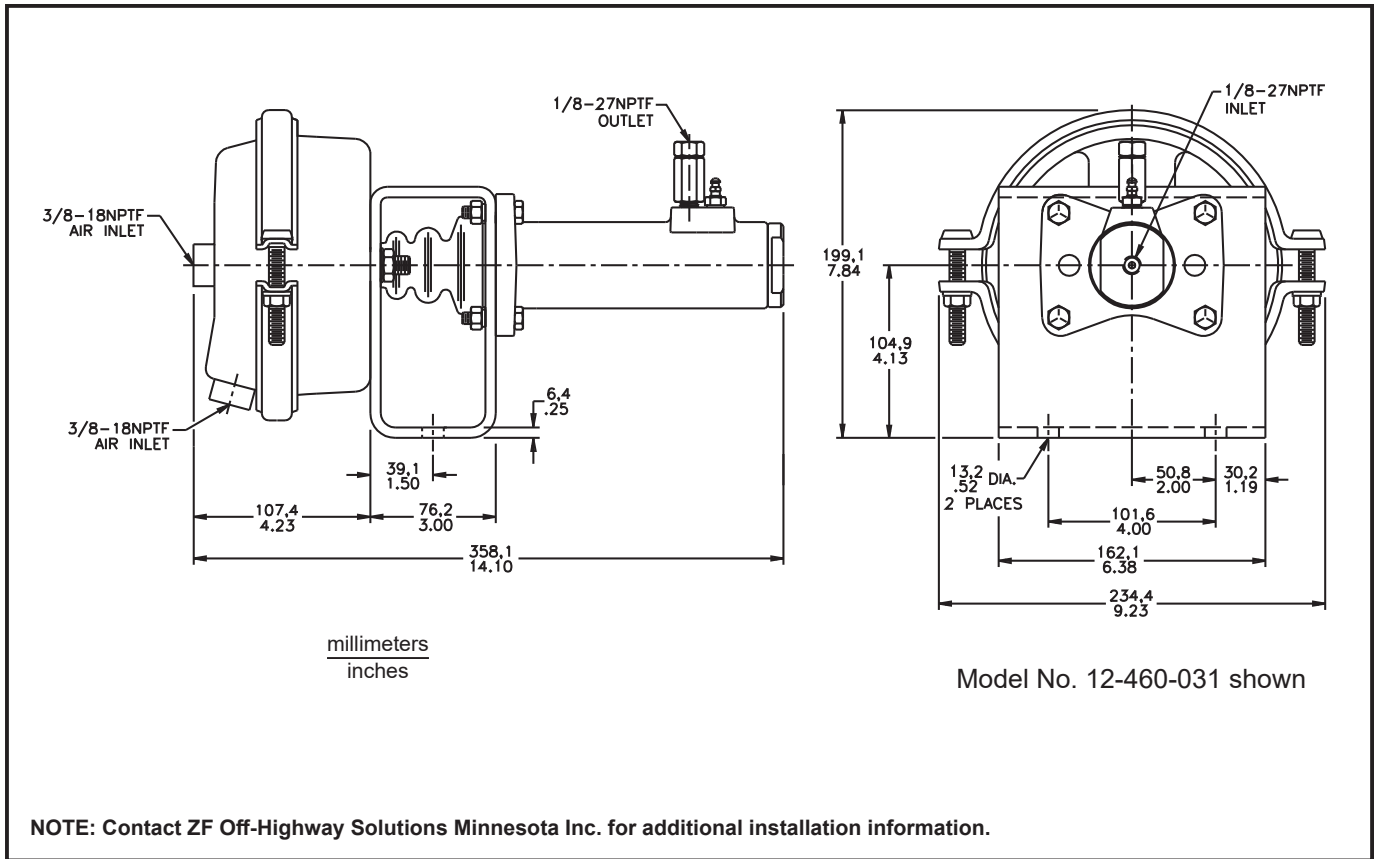
This Air/Hydraulic Actuator allows either one of two pressure sources to operate a slave cylinder, brake or other device. If connected to a remote reservoir this actuator can be used as a single source.



Model No. 12-460-031 shown

Typical System Schematic





SPECIFICATIONS

Model Number	Fluid Type	External Residual Check Valve	Air Chamber Size	Hydraulic Pressure @ 6.9 bar (100 PSI) Air Pressure	Effective Displacement	Effective Stroke	Bore Diameter
12-460-031	BF	Yes	61.cm ² (24 in ²)	94 bar (1360 PSI)	41.6 cm ³ (2.5 in ³)	36.6 mm (1.44 in)	38.1 mm (1.500 in)
12-460-032	HO	No	61.cm ² (24 in ²)	94 bar (1360 PSI)	41.6 cm ³ (2.5 in ³)	36.6 mm (1.44 in)	38.1 mm (1.500 in)

BF = DOT 3, 4, 5 and 5.1 brake fluid. HO = mineral base hydraulic oil.
 All model numbers have a maximum air pressure rating of 8 bar (120 PSI).
 All model numbers have a maximum fluid pressure rating of 172 bar (2500 PSI).

Fluid Reservoirs

For Direct or Remote Mounting



POLYALLOMER RESERVOIR

- Translucent for easy view of fluid level
- Diaphragm seals out environmental contaminants
- Adaptable outlet fittings
- Sediment trap inherent to design
- Easy screw on and off filler cap
- 238 cm³ (14.5 in³) usable fluid capacity
- For use with hydraulic oil or brake fluid
(contact ZF Off-Highway regarding phosphate ester fluids)

METAL RESERVOIR

- Rugged anodized aluminum housing
- Easy screw on and off filler cap with baffle and breather
- 54 cm³ (3.3 in³) usable fluid capacity
- Compact design for ease of mounting
- Adaptable outlet fittings
- For use with hydraulic oil or brake fluid
(contact ZF Off-Highway regarding phosphate ester fluids)

SPECIFICATIONS

Poyllallomer Reservoirs

Model Number	Fluid Type	Outlet Fitting	Mounting Bracket	Diaphragm Part Number
20-920-500	HO	9/16-18UNF-2A	Yes	32-490-009
20-920-520	HO	9/16-18UNF-2A	No	32-490-009
20-920-512	HO	1/4-18NPTF (internal)	Yes	32-490-009
20-920-514	HO	1/4-18NPTF (internal)	No	32-490-009
20-920-505	BF	9/16-18UNF-2A	Yes	32-490-010
20-920-509	BF	1/4-18NPTF (internal)	Yes	32-490-010
20-920-515	BF	1/4-18NPTF (internal)	No	32-490-010

HO = mineral base hydraulic oil.

BF = DOT 3, 4, 5 and 5.1 brake fluid.

SPECIFICATIONS

Metal Reservoirs

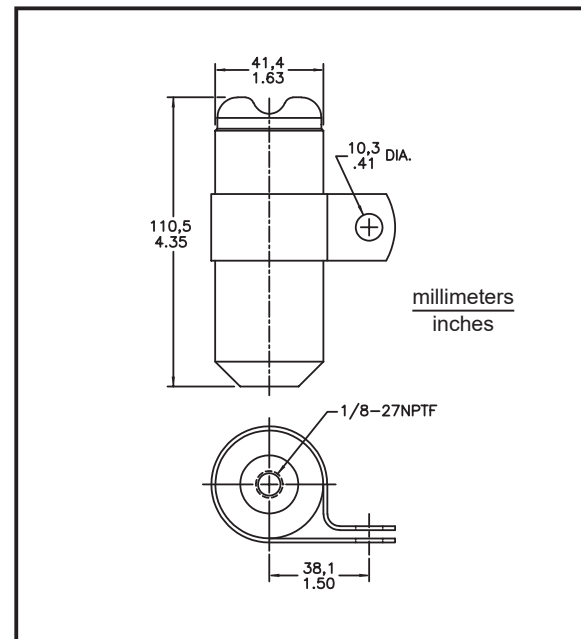
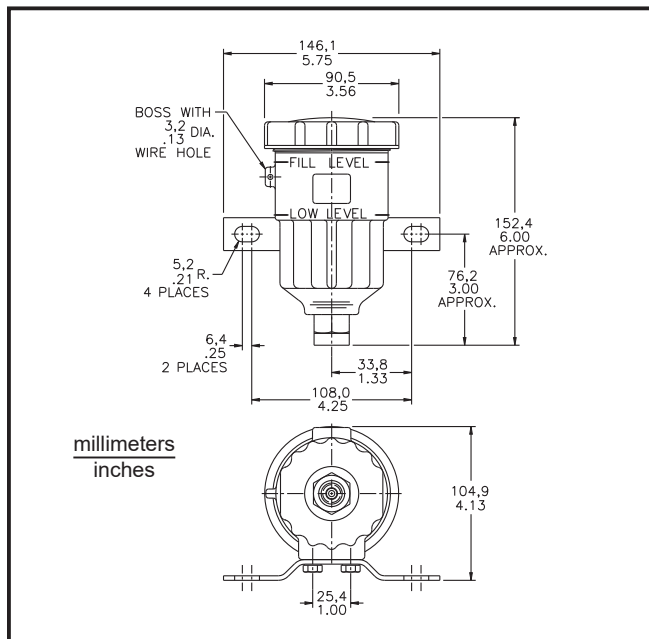
Model Number	Fluid Type	Mounting Bracket
* 20-920-002	BF or HO	No
** 20-920-006	BF or HO	Yes
20-920-009	BF or HO	Yes

* Includes 1/8-27NPTF male 90° elbow fitting.

** Includes two 1/4-27NPTF x 1/4 tube fittings.

HO = mineral base hydraulic oil.

BF = DOT 3, 4, 5 and 5.1 brake fluid.



NOTES



BRAKES



**HYDRAULIC OVER AIR
RELAY VALVES**



**ELECTROHYDRAULIC
VALVES**



**ACCUMULATOR
CHARGING VALVES**



**MODULATING BRAKE
VALVES**



QUADRIGAGE™



FLUID RESERVOIRS



ELECTRONIC PEDALS



REMOTE ACTUATORS



Learn more about our hydraulic products at:
www.mico.com

About ZF Friedrichshafen AG

ZF is a global technology company supplying systems for passenger cars, commercial vehicles and industrial technology, enabling the next generation of mobility.

ZF allows vehicles to see, think and act. In the four technology domains of Vehicle Motion Control, Integrated Safety, Automated Driving, and Electric Mobility, ZF offers comprehensive product and software solutions for established vehicle manufacturers. Learn more at ZF.com.

ZF Off-Highway Solutions Minnesota Inc.

1911 Lee Boulevard
North Mankato, MN U.S.A. 56003-2507
tel: +1 507 625 6426 fax: +1 507 625 3212

