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VARIABLE VOLUME RESERVOIR (VVR)
FOR INDUSTRIAL AND MOBILE APPLICATIONS

NEW CONCEPT derived from aerospace and military technology

Do you wish to eliminate bulky reservoirs involving large quantities of oil?

Reservoirs that could be supplied alone or as a complete package with instrumentation manifold.

It *is now available* to suit **many applications**

This package will provide:

- reduced oil volume and weight
- reduced oil, maintenance and recycling costs
- environment friendly and will greatly reduce potential liabilities in the event of an oil spill
- better pump performance
- increased fluid and components life expectancy by up to 5x
- increased components reliability

In conventional systems, the reservoir oil capacity is sized in relation to pump flow rate whereas the new solution requires to size reservoir only from your system oil displacement and thermal expansion. **The reservoir size can be reduced up to 100 times!**

Should you wish to learn more about the present matter, the following technical description will be of assistance

US patent # 6,772,794 B2 (exp. Sept 2022) / #6,981,523 (exp. Jan 2022)
Canada #2,464,829 (exp. Jan 2023)

VVR : Variable Volume Reservoir

INTRODUCTION

The real purpose of a reservoir is to serve as a juncture for fluid either to be reconditioned or for that already reconditioned. Cooling is realized with the existing coolers while contamination control is dealt by the filters and air pockets are almost non existent with this technology.

Most hydraulic systems should be supplied only with the amount of oil required for their operations. In the case of hydraulic motor circuits, the only variable volume required, after filling the lines and the components volume, arises from thermal expansion and contraction of the fluid, which means a relatively small variation volume of-/+ 10%. With respect to cylinder actuation, the variable volume required originates from thermal expansion/contraction and from the rod volume (only on differential cylinders).

The reservoir should be designed to expand and retract according to the system demand. Supplying the minimal required amount of fluid to a fluid power system is a technology available and effective in all aerospace systems and on many military vehicles. Incidentally recall that living beings contain the most sophisticated “hydraulic’’ system without the need of a reservoir!

VVR SIMPLE DESIGN

The VVR design with a proposed volumes of 400 in^3 (6.6L)* is based on a expanding/contracting bellows. The fluid is sealed from atmosphere and kept slightly pressurized inside using a compression spring (up to 9 psi / 0.6 bar). The spring is located inside a guide-tube to prevent buckling also to minimize the dead fluid volume and, consequently thermal expansion effects. The inside of the bellows is built in such a way that it will also minimize the fluid dead volume. Connection port(s) to the hydraulic network is provided on the base cover. An air bleed valve and a low level sensor switch are provided on the top cover. Finally, a visual level indicator is mounted on the side of the bellows

NOTES:

VVR’s can be installed in series to increase volume.

And / Or

On each pump inlet to isolate circuits

*Other displacement are available

OPTIONAL instrumentation manifold;

This manifold can be added to one of the VVR service port to provide through flow monitoring capability (junction between system return and pump inlet). It includes;

a) Reservoir pressure indicating gauge
b) Adjustable temperature switch
c) Air bleed & fluid sampling valve
d) Dry disconnect fill valve
e) Visual fluid temperature indication
f) Over board protection relief valve
g) Different inlet/outlet ports available (SAE-16, 20, 1 ½ & 2 flange)

VVR LOCATION AND ORIENTATION

The unit can be installed ''in-line'' or "off-line" depending on the user preference. Between the main system return line and the pump(s) inlet. On hydrostatic drive systems it should be located in the charge pump circuit. The VVR will operate in any orientation, preferably with the bellows facing up for air bleeding purposes if no other bleeding point is assigned in the network. (See diagram)

VVR HISTORICAL UTILISATIONS

The VVR has been tested over a 6-year period and been under 1,250,000 cycles with no degradation of the performance.

It's been successfully installed on numerous applications over the years and no significant issues have been encountered

BENEFITS

Reduced:
- fluid volume requirement
- fluid maintenance cost
- filter cost
- space requirement
- total weight
- shipping cost
- oil disposal problem (environment regulations)
- environmental and fire hazard
- pump noise (positive pressure at pump inlet)
- fluid contamination when filling hydraulic system
- air borne contaminant (closed and sealed system)
- fluid chemical reaction from air and water exposure
- warm-up time from oil heater or system operation (thermal equilibrium)

As a matter of point:

<u>Example 1:</u>
An open loop motor drive system with a total pump flow of 130 GPM (492 L/min.) would typically use a 250 gallons reservoir (950L) or larger say @$3.10/L; it would cost $2,945 and more for fluid alone.

<u>Example 2:</u>
An hydrostatic drive system with a 30 GPM (113L/min.) charge pump would typically use a 60 to 80 gallons reservoir (230-310L) at a fluid cost varying between $715 to $930.

A 400 in^3 (6.6L) VVR would replace these conventional reservoirs at a fluid cost of $20! And provide further savings…

VVR REQUIREMENTS

VVR systems guide-lines for optimum performance and benefits are as follows:

- The hydraulic network should use O-ring type fittings (system should be perfectly sealed);
- Pre-fill and bleed the system with a low flow fluid transfer unit with a reservoir and filter; (Pre-fill/bleed unit), takes about 10 minutes
- Final filling should be done with the cylinders retracted.
- Bleed air when filling;
- If possible, cycle all the actuators a few times using the Pre-fill/bleed unit (see diagram)
- Start-up : run the system no load for 15 minutes and bleed air at VVR bleed valve or other bleeding points;
- When in full operation, monitor bellow displacement and boost pressure until operating temperature is reached.

WARNING: To avoid cavitation, it is vital that the system be completely bled of its air pockets before full system operation

SYSTEM LIMITATIONS

This design cannot be used when large differential volumes cylinders are in operation, i.e.: large rod and / or long stroke or single acting, telescoping & rams cylinders, nor on systems using large accumulators or accumulator banks. In most applications, the VVR is difficult to justify replacement of small atmospheric reservoir (to about 30 gal / 110L) because of cost difference (when it is the sole consideration). Lube systems where atmospheric return pressure is required do not permit their use

FIELDS OF APPLICATION

They include any hydrostatic drive system and most open and closed loop fluid power systems that control one or many hydraulic motors and/or rotary actuators for the mobile, industrial, marine, agriculture, mining industries, O&G E&P among others

Possible applications:

- Drilling rigs
- Hydrostatic systems;
- Wheel drives
- Hagglunds drives
- Track drives
- Snow removal equipment
- Rotary crushers
- Winches
- Valve actuators
- Fan drives
- Wind turbines
- Sawing machines
- Power steering
- Marine thrusters
- Spindle drives
- Marine steering systems
- Starter units
- Antenna positioning drives
- Inching drives
- Tunneling machines
- Mixing machines
- Conveyors
- Feeders
- Test stands drive section
- Dredging machine (bucket wheels)

VVR SIZING

On non-differential volume applications (motors, double rod cylinders and rotary actuators) the required volume applies only to thermal expansion / contraction which is 10% of the total system trapped fluid volume (network and components volume). For differential volume applications (differential cylinders, small accumulators) the required volume is the total cylinder rod volume and/or accumulator displacement + 10% of the total system trapped fluid volume.
(Network and components volume)

Note: fluid volume increases by 10 % for a differential temperature of:

250ºF ΔT or 1% per 25ºF
150ºC ΔT or 1% per 15ºC

$$\Delta V = \alpha_{vol} \times V_h \times \Delta T$$

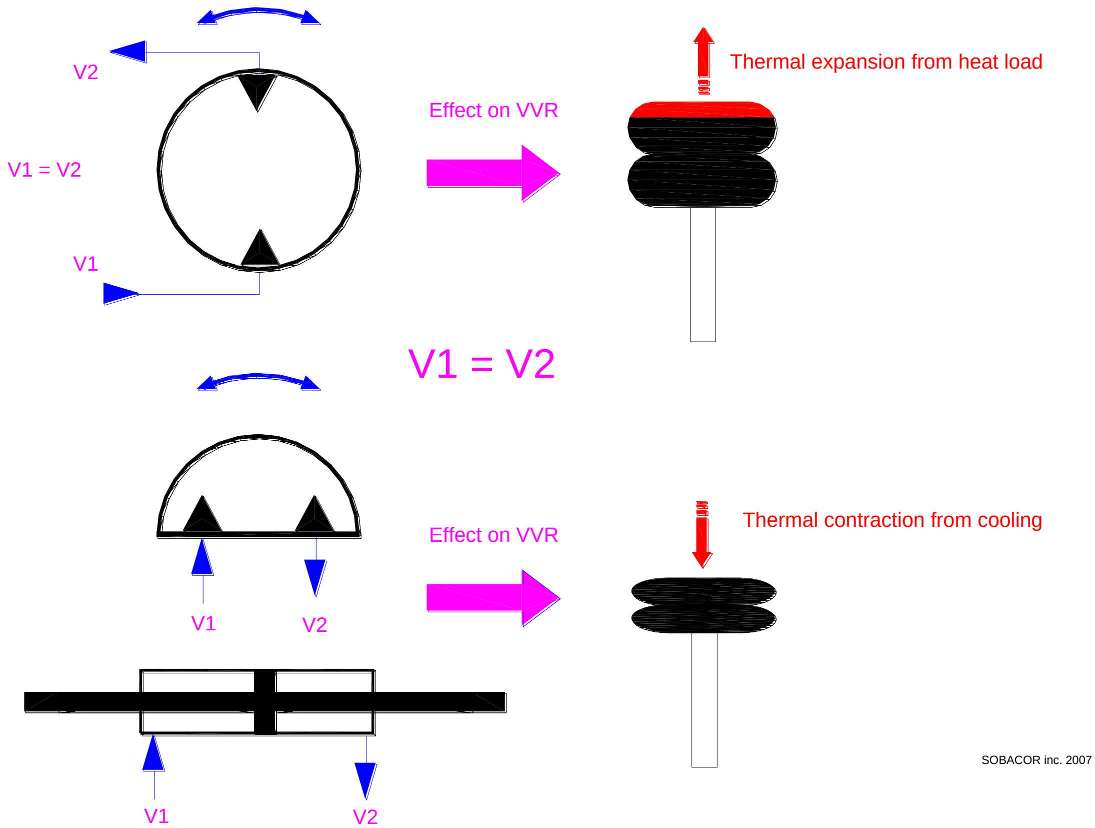
ΔV: volume variation

α_{vol}: volume expansion coefficient
V_h: initial fluid volume
ΔT: operating temperature range

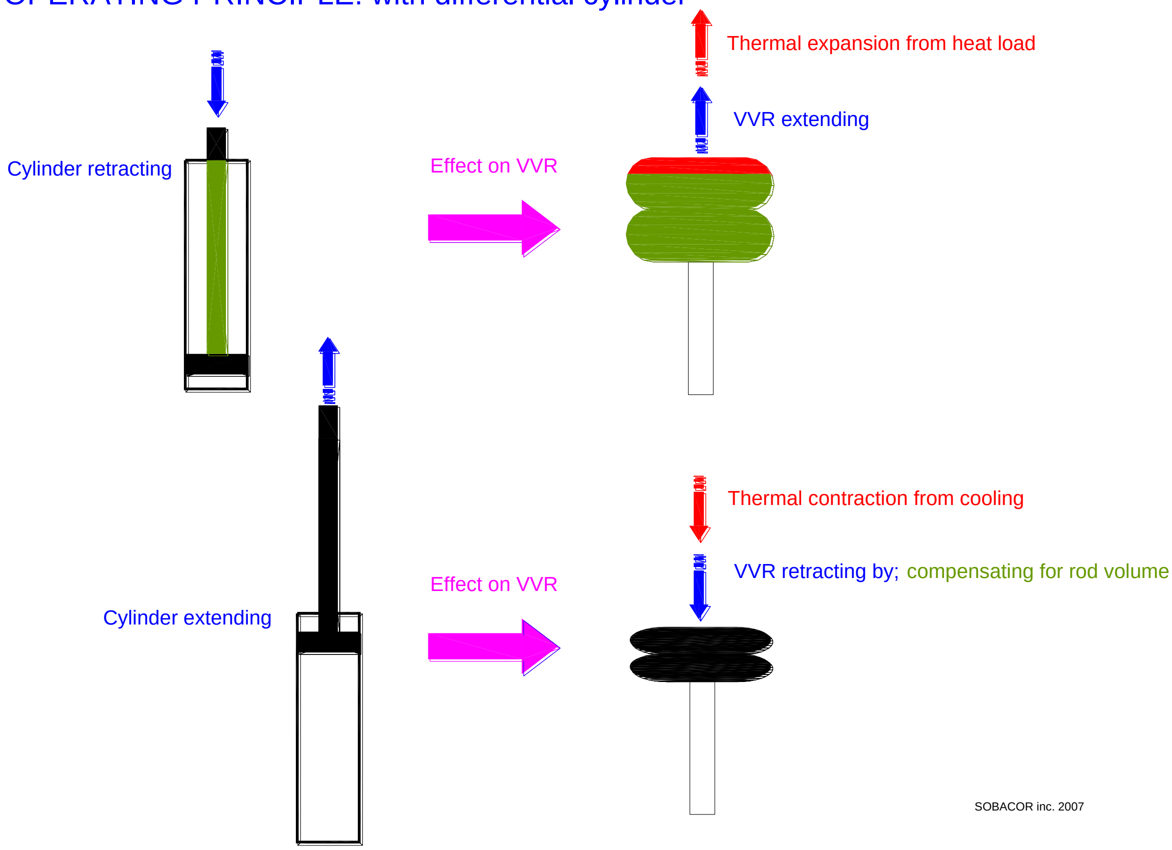
For mineral fluids : $\alpha_{vol} = 4 \times 10^{-4}$ (ΔT in ºF)

$\alpha_{vol} = 7 \times 10^{-4}$ (ΔT in ºC)

OPERATING PRINCIPLE: with motor, rotary actuator or double rod cylinder



OPERATING PRINCIPLE: with differential cylinder



VVR SIZING PROCEDURES (imperial units)

Applications with:
- **Motors**
- **Rotary actuators**
- **Double rod cylinders**

1) System volume

$V_S = (0.79d^2L) + V_C$

V_S : system volume (in^3)
d : line I.D. (in)
L : network length (in)
V_C: components internal volume (in^3)

2) Required reservoir volume

$V_R = 0.1\ V_S$

3) Minimal fill volume

$VF_1 = 100\ (0.48V_R\ /\ V_{VVR})$

VF_1 : % fill volume min.
V_{VVR} : selected VVR displacement (in^3)

4) Maximum fill volume

$VF_2 = 100\ \{(V_{VVR} – (0.56V_R))\ /\ V_{VVR}\ \}$

VF_2 = % fill volume max

NOTE:

The above procedure is based on 2 conditions;

- Operating temperature of: -40F to +210F
- Filling fluid temperature: approx. 70F

FYI, VVR400 stands for a 400 in^3 VVR

EXAMPLE: Winch drive circuit

1 gear pump
1 radial piston motor
1 control valves manifold
1 filter
1 cooler

Estimated $V_C = 550\ in^3$

Hydraulic network of; 20ft of ¾'' I.D. line

1) System volume

$V_S = (0,79 \times (0.75in)^2 \times 20ft \times 12\ in/ft\ ) + 550\ in^3$

$V_S\ = 657\ in^3$

2) Required reservoir volume

$V_R = 0.1 \times 657\ in^3$
$V_R = 66\ in^3$

VVR400 is selected

3) Minimal fill volume

$VF_1 = 100\ (0.48\ .\ 66\ in^3\ /\ 400\ in^3)$
$VF_1 = 8\%$

4) Maximum fill volume

$VF_2 = 100\ \{(400\ in^3 – (0.56\ .\ 66\ in^3))\ /\ 400\ in^3\ \}$
$VF_2 = 91\%$

VVR SIZING PROCEDURES (Imperial units)

Applications with differential cylinders

1) Total cylinder rod volume

$V_{RT} = (0.79r_1^2 s_1) + \dots (0.79r_n^2 s_n)$

V_{RT} : total rod volume (in^3)
r : cylinder rod diameter (in)
s : cylinder stroke (in)

2) System volume

$V_S = (0.79b_1^2 s_1) + \dots (0.79b_n^2 s_n) + (0.79d^2 L) + V_C$

V_S : system volume (in^3)
b : cylinder bore (in^2)
d : line I.D. (in)
L : network length (in)
V_C: components internal volume (in^3)

3) Required reservoir volume

$V_R = 0.1V_S + V_{RT}$

4) Minimal fill volume

$VF_1 = 100 \{((0.48V_R + V_{RT}) / V_{VVR})\}$

VF_1 : % fill volume min
V_{VVR} : selected VVR displacement (in^3)

5) Maximum fill volume

$VF_2 = 100 \{((0.56V_R + V_{RT}) / V_{VVR})\}$

VF_2 = % fill volume max

NOTE:

The above procedure is based on 2 conditions;

- Operating temperature of: -40C to +210C
- Filling fluid temperature: approx. 70C

EXAMPLE: Circuit consisting of;

1 piston pump +
3 directional valves
1 filter

$V_C = 200\ in^3$

Hydraulic network of; 30 ft of 1'' I.D. lines
3 identical cylinders: 6'' bore, 36'' stroke, 2'' rod

1) Total cylinder rod volume

$V_{RT} = 3\ (0.79\ (2^2) \times 36)$
$V_{RT} = 341\ in^3$

2) System volume

$V_S = 3\ (0.79(6^2) \times 36) + (0.79(1^2) \times 30 \times 12in/ft) + 200in^3$
$V_S = 3{,}556\ in^3$

3) Required reservoir volume

$V_R = 0.1\ (3{,}556\ in^3) + 341\ in^3$
$V_R = 697\ in^3$

Two VVR400 are selected

4) Minimal fill volume

$VF_1 = 100 \{(((0.48 \times 697) + 341) / 800)\}$
$VF_1 = 85\%$

5) Maximum fill volume

$VF_2 = 100 \{(((0.56 \times 697) + 341) / 800)\}$
$VF_2 = 92\%$

VVR SIZING PROCEDURES (metric units)

Applications with:
- **Motors**
- **Rotary actuators**
- **Double rod cylinders**

1) System volume

$V_S = (0.79d^2L) + V_C$

V_S : system volume (cm^3)
d : line I.D. (cm)
L : network length (cm)
V_C: components internal volume (cm^3)

2) Required reservoir volume

$V_R = 0.0061\ V_S$

V_R: **in^3**

Reservoir selection in^3

3) Minimal fill volume

$VF_1 = 100\ (\ 0.48V_R\ /\ V_{VVR})$

VF_1: % fill volume min
V_{VVR}: selected VVR displacement (**in^3**)

4) Maximum fill volume

$VF_2 = 100\ \{(V_{MVR} – (0.56V_R))\ /\ V_{VVR}\ \}$

VF_2 = % fill volume max

NOTE:

The above procedure is based on 2 conditions;

- Operating temperature of: -40C to +100C
- Filling fluid temperature: approx. 21C

EXAMPLE: Winch drive circuit

1 gear pump
1 radial piston motor
1 Control valves manifold
1 filter
1 cooler

Estimated V_C = 9,013 cm^3

Hydraulic network of; 610 cm of 2cm I.D. line

1) System volume

$V_S = (0,79\ (2\ cm)^2 \times 610\ cm\ ) + 9,013\ cm^3$

V_S = 10,940 cm^3

2) Required reservoir volume

$V_R = 0.0061 \times 10,940\ cm^3$
V_R = 67 **in^3**

VVR400 is selected

3) Minimal fill volume

$VF_1 = 100\ (0.48 \times 67\ in^3\ /\ 400\ in^3)$
VF_1 = 8%

4) Maximum fill volume

$VF_2 = 100\ \{((400\ in^3 – (0.56 \times 24\ in^3))\ /\ 400\ in^3)\}$
VF_2 = 91%

VVR SIZING PROCEDURES (metric units)

Applications with differential cylinders

1) Total cylinder rod volume

$V_{RT} = (0.79r_1^2s_1) + \dots (0.79r_n^2s_n)$

V_{RT} : total rod volume (cm^3)
r : cylinder rod diameter (cm)
s : cylinder stroke (cm)

2) System volume

$V_S = (0.79b_1^2s_1) + \dots (0.79b_n^2s_n) + (0.79d^2L) + V_C$

V_S : system volume (cm^3)
b : cylinder bore (cm^2)
d : line I.D. (cm)
L : network length (cm)
V_C: components internal volume (cm^3)

3) Required reservoir volume

$V_R = 0.0061V_S + 0.061V_{RT}$

V_R : **in**^{3}

Reservoir selection in^3

4) Minimal fill volume

$VF_1 = 100 \{((0.48V_R + 0.061V_{RT}) / V_{VVR})\}$

VF_1 : % fill volume min.
V_{VVR} : selected VVR displacement (**in**^{3})

5) Maximum fill volume

$VF_2 = 100 \{((0.56V_R + 0.061V_{RT}) / V_{VVR})\}$

VF_2 = % fill volume max.

NOTE:

The above procedure is based on 2 conditions;

- Operating temperature of: -40C to +100C
- Fill fluid temperature: approx. 21C

EXAMPLE: Circuit consisting of

1 piston pump +
3 directional valves
1 filter

$V_{C\ total} = 3{,}277\ cm^3$

Hydraulic network of; 915 cm of 2.5 cm I.D. lines

3 identical cylinders; 15 cm bore
92 cm stroke
5 cm rod

1) Total cylinder rod volume

$V_{RT} = 3\ (0.79\ (5^2).92)$
$V_{RT} = 5{,}451\ cm^3$

2) System volume

$V_S = 3\ (0.79(15^2)\ x\ 92) + (0.79(1^2)\ x\ 915) + 3{,}277\ cm^3$
$V_S = 53{,}059\ cm^3$

3) Required reservoir volume

$V_R = 0.0061\ (53{,}059\ cm^3) + 0.061\ x\ (5{,}451\ cm^3)$
$V_R = 656$ **in**^{3}

Two VVR400 are selected

4) Minimal fill volume

$VF_1 = 100\{(((0.48\ x\ 656) + (0.061\ x\ 5{,}451)) / 800)\}$
$VF_1 = 80\%$

5) Maximum fill volume

$VF_2 = 100\ \{(((0.56\ x\ 656) + (0.061\ x\ 5451)) / 800)\}$
$VF_2 = 87\%$

Available; 400 in^3 (6.6 l) réservoir

VVR400

Includes;

- **-Low level switch**
- **-Air bleed valve**
- **-Support brackets**
- **-Air bleed hose**
- **-Isolation ball valve**

VVR400-R

Includes;

- **-Low level switch**
- **-Air bleed valve**
- **-Overboard relief valve**
- **-Support brackets**
- **- Air bleed hose**
- **-Isolation ball valve**

VVR400-IM- ☐

Includes;

- **-Low level switch**
- **-Air bleed valve**
- **-Instrumentation manifold ***
- **-2 sets of dry disconnect couplers**
- **-Air bleed hose**
- **-Isolation ball valve**

Available ports (Through flow)	
Code	**Port size**
S16	SAE-16
S20	SAE-20
F1.5	1 ½" Flange
F2	2" Flange
With the **IM** option the VVR must be supported by the manifold. Taped holes are provided on 2 faces (see dwg)	

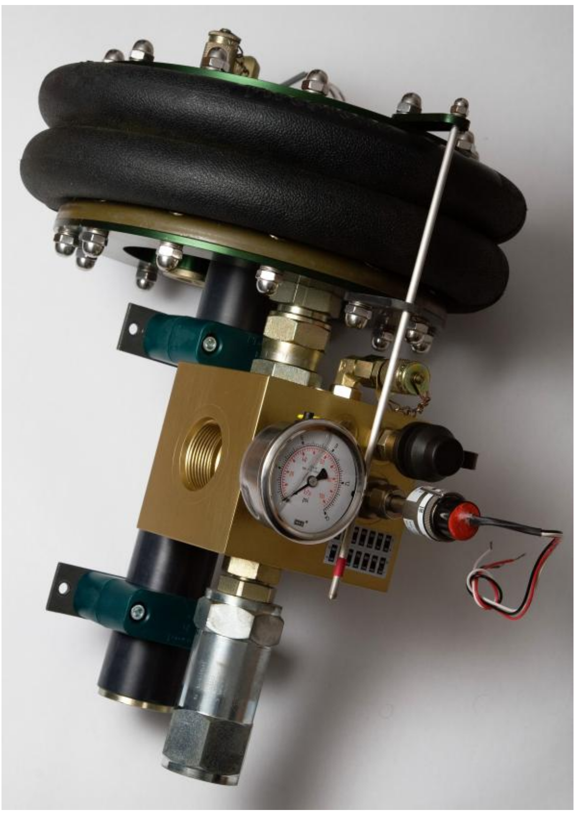
Possible configurations

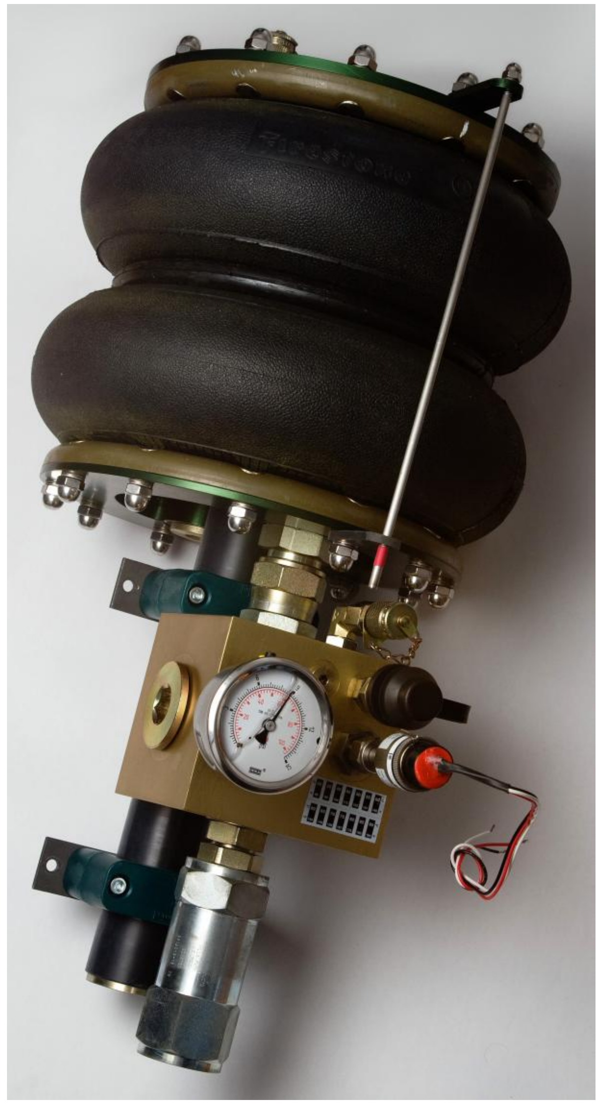
VVR400

VVR400-R

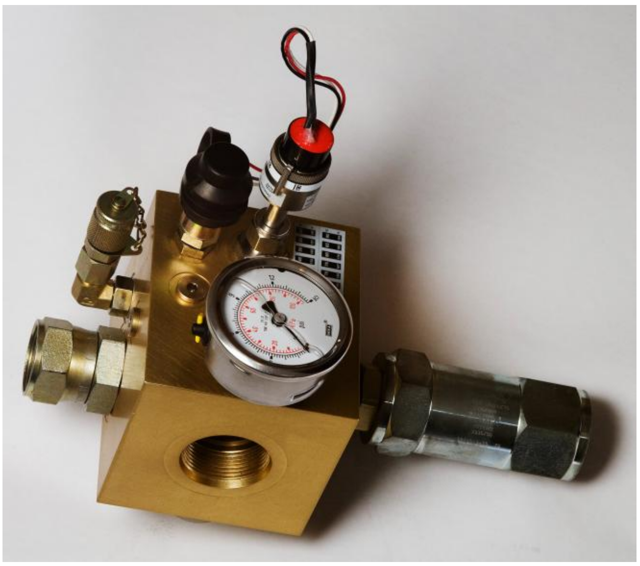
VVR400-IM-S20

Air bleed valve & low level switch



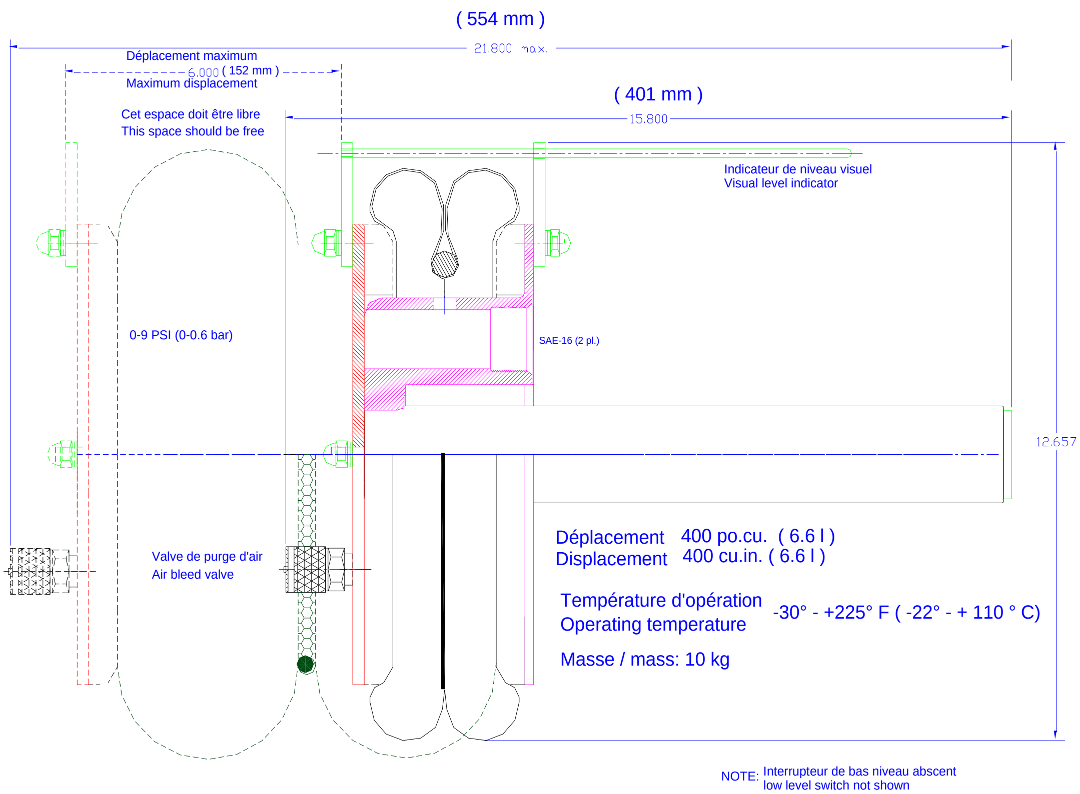


Instrumentation bloc (optional)



Drawings & specifications

VVR400

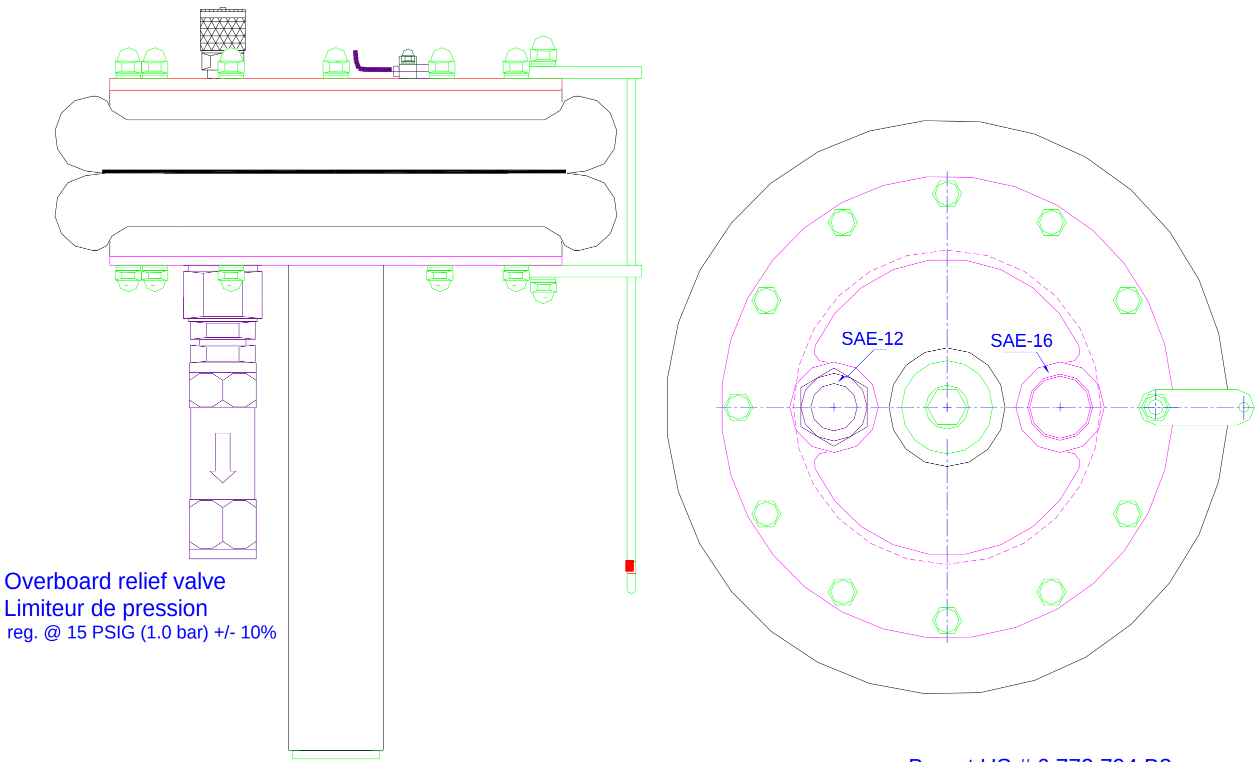


BREVET- PATENT # 6,772,794 B2 Canada : 2 464 829

VVR shown without instrumentation manifold RVV sans le bloc d'instrumentation

VVR400-R

Sobacor inc. 2012



W = 24.3 lb (11kg)

Brevet US # 6,772,794 B2
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