Applications of

Hydraulic & Pneumatics

By: Alireza Safikhani

Air Compressors & Distribution System

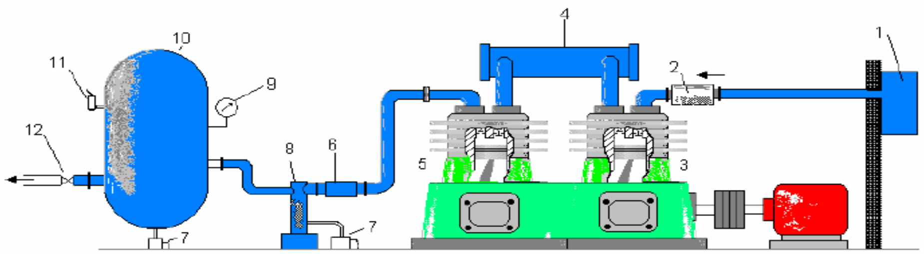
- When air is compressed it rises dramatically in temperature
- The natural water vapour content of air (relative humidity) is concentrated and carried through the compression process as a vapour in the high temperature
- As the air cools water condenses out making freshly compressed air very wet
- Solid particles will also be present, these can consist of fragments of burnt compressor lubricating oil and airborne dust inhaled by the compressor
- Preparation of compressed air consists of reducing temperature, removing water and solids, controlling pressure and in many cases adding lubricant

Condition of Air

- For the continuing performance of control systems and working elements, it is necessary to guarantee that the air supply is:
- at the required pressure,
- dry
- clean

Components of air Preparation

- The equipment to be considered in the generation and preparation of air include:
  - Inlet filter
  - Air compressor
  - Air reservoir
  - Air dryer
  - Air filter with water separator
  - Pressure regulator
  - Air lubricator as required
  - Drainage points
  - ...



2 STAGE RECIPROCATING COMPRESSOR

Figure 1

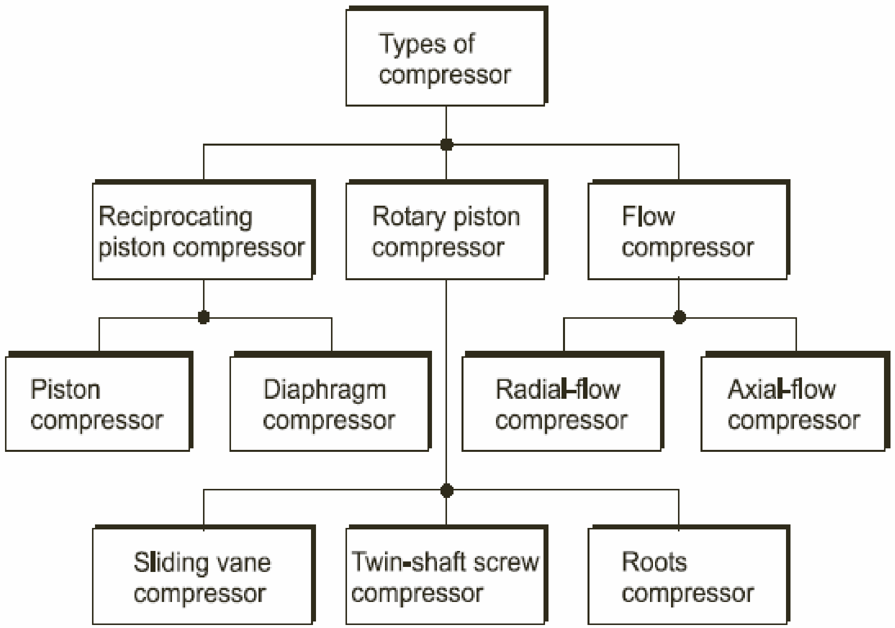
1. Induction box and silencer on outside of building with course screen.
2. Induction filter.
3. Low pressure stage.
4. Intercooler.
5. High pressure stage.
6. Silencer.
7. Drain trap.
8. After cooler
9. Pressure gauge.
10. Air receiver.
11. Safety pressure relief valve.
12. Stop valve

Pressure level

- As a rule, pneumatic components are designed for a maximum operating pressure of 800 to 1000 kPa (8-10 bar). Practical experience has shown, however, that approximately 600 kPa (6 bar) should be used for economic operation.
- Pressure losses of between 10 and 50 kPa (0.1 and 0.5 bar) must be expected due to the restrictions, bends, leaks and pipe-runs, depending on the size of the piping system and the method of layout.
- The compressor's system should provide at least 650 to 700 kPa (6.5 to 7 bar) for a desired operating pressure level of 600 kPa (6 bar).

Compressor Selection

- the various types of compressors available and selection of appropriate Compressor is dependent upon quantity of air, pressure, quality and cleanliness and how dry the air should be.
- There are varying levels of these criteria depending on the type of compressor.



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types of regulation

- In order to adapt the delivery quantity of the compressor to the fluctuating demand, it is necessary to regulate the compressor. The delivery quantity is regulated between the adjustable limits for maximum and minimum pressure.
- There are a number of different types of regulation:
  - Idling regulation
    - Relief regulation
    - Shut-off regulation
    - Claw regulation
  - Part-load control Speed adjustment
  - Suction throttle control
  - Intermittent control

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types of regulation

- Relief regulation: the compressor operates against a pressure relief valve. When the set pressure is reached, the pressure-relief valve opens and the air is exhausted to atmosphere. A non-return valve prevents the emptying of the tank. This type of regulator is only used for very small installations.
- Shut-off regulation: the suction side is shut off. The compressor cannot take in air. This type of regulation is mainly used in the case of rotary piston compressors.
- Claw regulation: With larger piston compressors, claw regulation is used. A claw holds the suction valve open; the compressor cannot compress any air.
- Speed adjustment: the speed of the drive motor of the compressor is controlled dependent on the pressure reached.
- Suction throttle control: control is effected by means of a restrictor in the suction connection of the compressor.
- Intermittent control: With this type of control, the compressor assumes the operational conditions 'full load' and 'normal'. The drive motor of the compressor is switched off when Pmax is reached, and switched on when Pmin is reached.

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Pressure producing plant

- Compressor sizes range from less than 1 l/s with little or no preparation equipment, to multiple compressor plant installations generating hundreds of cubic meters per hour
- Sizes are defined as follows:
  - Small compressors are up to 40 litres per sec and input of no more than 15 kW.
  - Medium compressors are between 40 and 300 litres per second and input of between 15 and 100 kW.
  - Large compressors anything above the medium limit.

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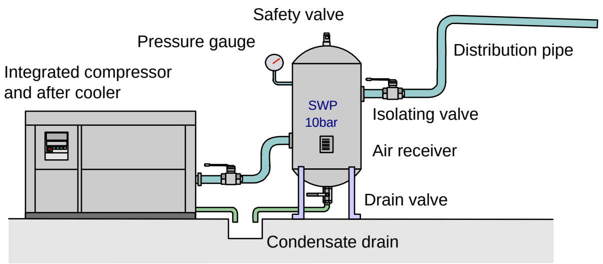
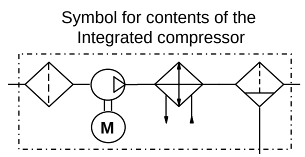
Compressor installation

- Typical medium size compressor installation
- Integrated compressor unit including inlet filter, electrically driven compressor, after cooler and water separator
- Air receiver to smooth demand surges, and provide additional cooling and water collection





Compressor siting

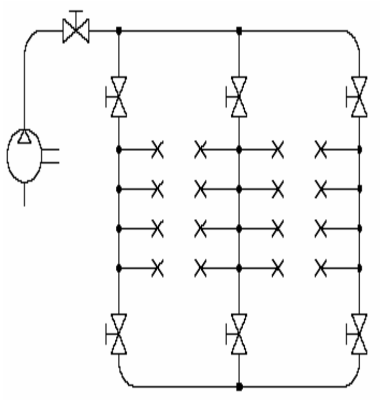
- High temperatures are produced when air is compressed, efficient cooling is important
- Compressor house well ventilated located on an outside north facing wall
- Inlet filter to inhale only clean dry air, keep away from:
  - fumes from parked vehicle with engine running
  - solvent fumes from paint plant or store
- Avoid locations where the air may have a high humidity such as above a pond, river or canal
- Avoid locations where wind eddies whip up dust, grit and litter
- An intake on the factory roof must be protected from the weather and emissions from ducting and chimneys

Distribution

- Ring main installation
- Dead leg with a drip leg drain on each corner to collect and remove water
- Pipes slope to each corner
- Take off drops connected to the top of the main pipe to avoid water pick up
- FRL units before each application

Distribution

- For ease of maintenance, repair or extension of the network without interfering with the overall air supply, it is advisable to sub-divide the network into individual sections.
- Branches with T-pieces and manifolds with plug-in couplings make this possible. It is advisable to fit the branch lines with standard ball valves or shut off valves.



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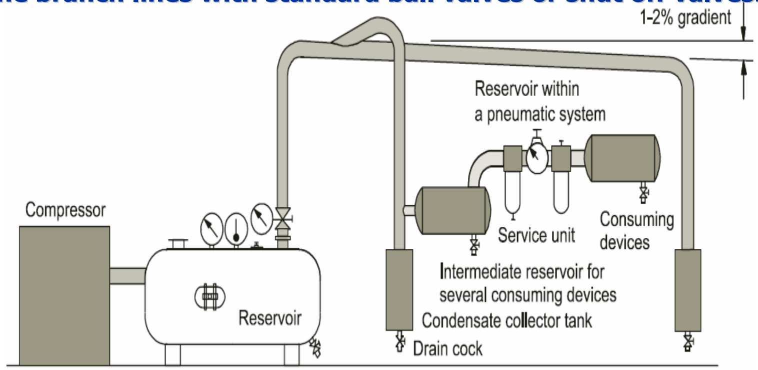

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Reservoirs

- configured downstream of a compressor to stabilise compressed air.
- compensates the pressure fluctuations when the compressed air is taken from the system.
- If the pressure drops below a certain value, the compressor will compensate until the set higher value is reached again.
- the compressor does not need to operate continuously. The large surface area of the reservoir cools the air. Thus, a portion of the moisture in the air is separated directly from the reservoir as water, which has to be regularly drained via a drain cock.

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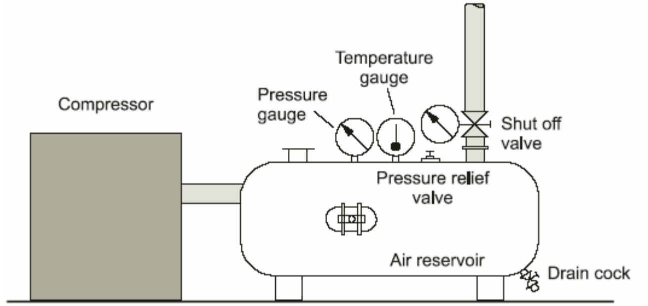
size of a compressed air reservoir

- Delivery volume of the compressor
- Air consumption for the applications
- Network size (any additional requirements)
- Type of compressor cycle regulation
- Permissible pressure drop in the supply network



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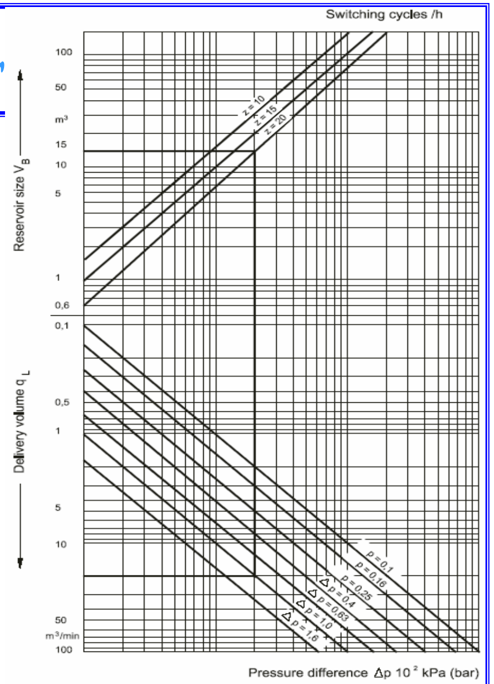
Volume of a reservoir

- Delivery volume q L = 20 m3/min
- Switching cycles per hour z = 20 1/h
- Differential pressure Δp = 1 bar
- Result: Reservoir size VB = 15 m3



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Air dryers

- The service life of pneumatic systems is considerably reduced if excessive moisture is carried through the air system to the components.
- Therefore it is important to fit the necessary air drying equipment to reduce the moisture content to a level which suits the application and the components used.
- There are three auxiliary methods of reducing the moisture content in air:
  - Low temperature drying
  - Adsorption drying
  - Absorption drying

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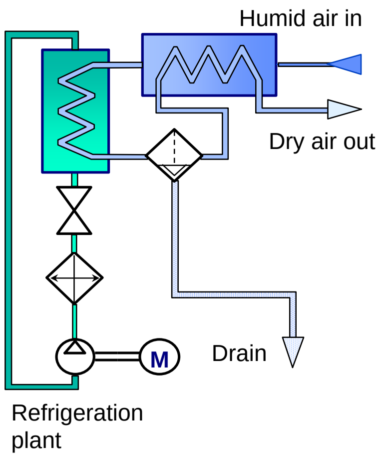
Low temperature drier

- Humid air enters the first heat exchanger where it is cooled by the dry air going out
- The air enters the second heat exchanger where it is refrigerated. It is cooled to temperatures between + 2 and + 5 °C
- The condensate is collected and drained away
- As the dry refrigerated air leaves it is warmed by the incoming humid air



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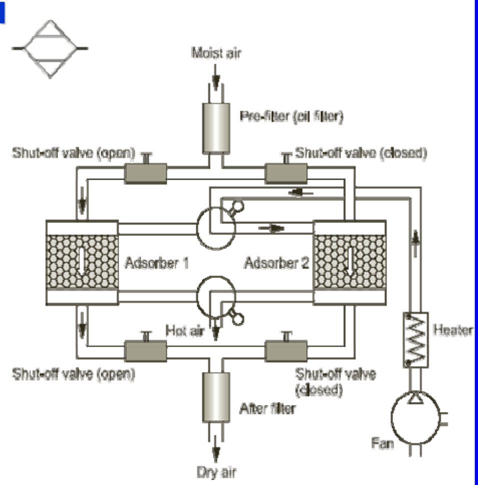
Adsorption dryers

- Adsorption: water is deposited on the surface of solids.
- The drying agent is a granular material (gel) consisting almost entirely of silicon dioxide.
- Usually two tanks are used. When the gel in one tank is saturated, the air flow is switched to the dry, second tank and the first tank is regenerated by hot-air drying.
- The lowest equivalent dew points (down to – 90 °C) can be achieved by means of adsorption drying.



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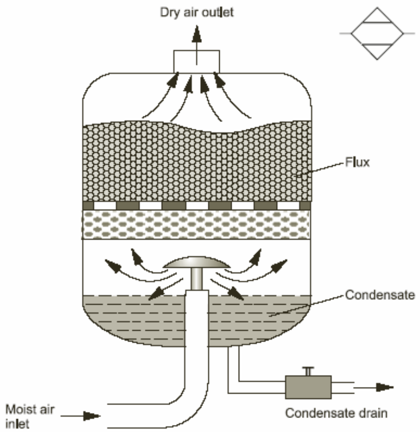
Absorption dryers

- Absorption: A solid or liquid substance bonds a gaseous substance.
- Absorption drying is a purely chemical process.
- Absorption drying is not of major significance in present-day practice, since the operating costs are too high and the efficiency too low for most applications.



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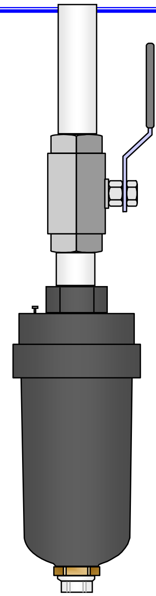
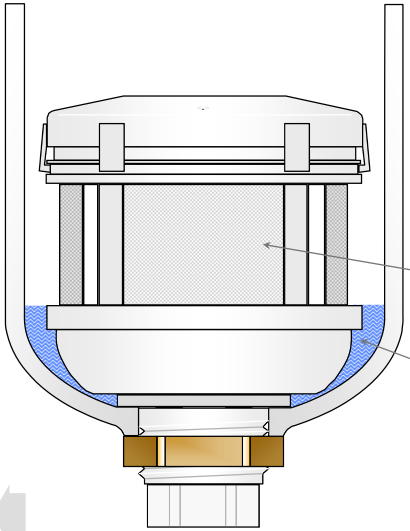
Drip leg drain

- Automatic drain valve for terminating a dead leg
- Water automatically drained when pressure is on, also when shut down
- Fit with an isolating shut off valve for maintenance
- Incorporates a course mesh filter to retain large solid particles
- Built in bleed valve to depressurise the unit prior to maintenance

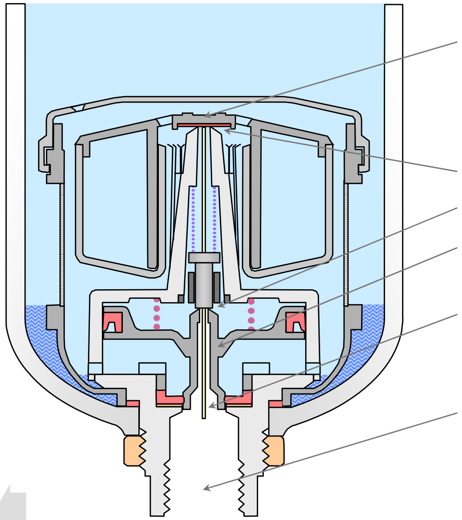


Automatic drain valve



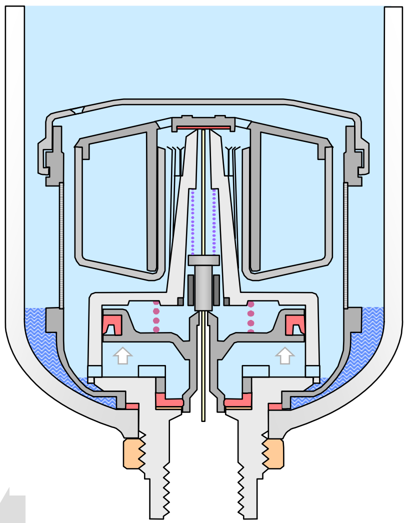
- When water level rises valve opens to eject the water then closes again
- When no pressure, valve opens to drain system
- Unit fits in the bottom of a filter or drip leg drain
- Nylon mesh 500 µm to prevent large solid particles clogging internals
- Dead zone where large particles may settle

Automatic drain valve



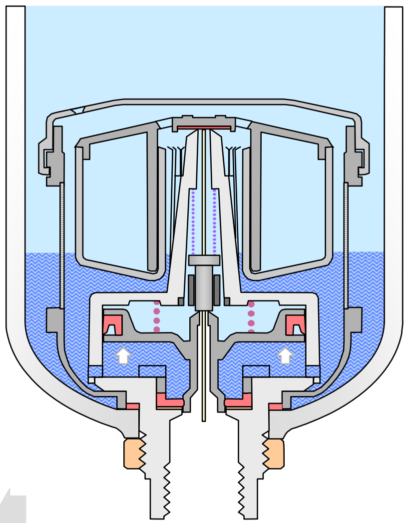
- Float breathable for pressure equalisation, internally splined to prevent rotation
- Air inlet seat
- Air exhaust seat
- Piston and drain valve spool
- Exhaust valve wire can be pushed from below to override and lift the float
- Connection for piping away contaminant

Automatic drain valve



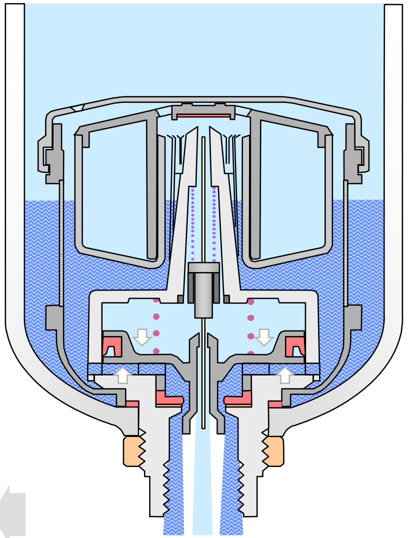
- Pressure first applied to the bowl fully lifts the piston so the drain is closed
- The wire cracks open the float inlet seat until a force balance exists across the piston in the closed position
- Changing bowl pressure, slightly lifts or lowers the piston to adjust the balancing pressure

Automatic drain valve



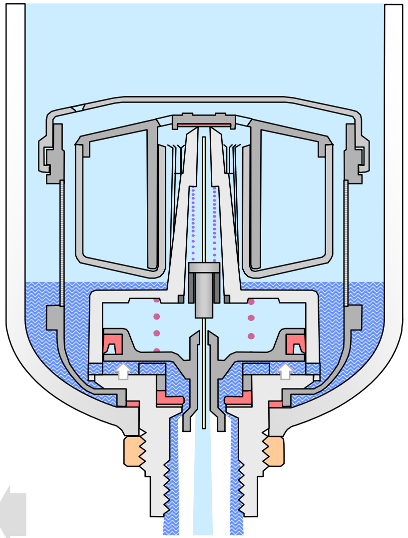
- Water level rises but not enough to lift the float
- Force holding the float down is the pressure differential acting on the float above the inlet seat area
- Water takes on the same pressure as the compressed air in the bowl

Automatic drain valve



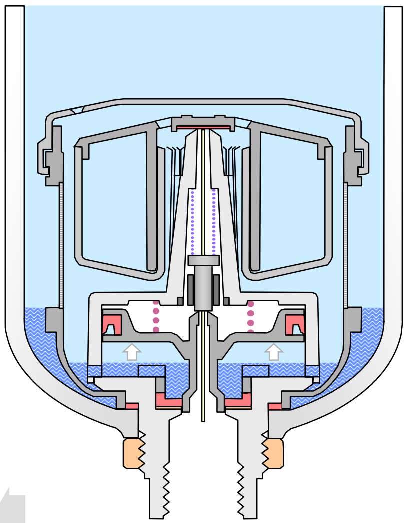
- Water high enough to lift the float
- Air pressure on top of the piston balances the pressure under it
- Spring pushes piston down to open the valve
- Water ejected under pressure
- Exhaust seat open but air enters faster than it can leave so the piston stays open

Automatic drain valve



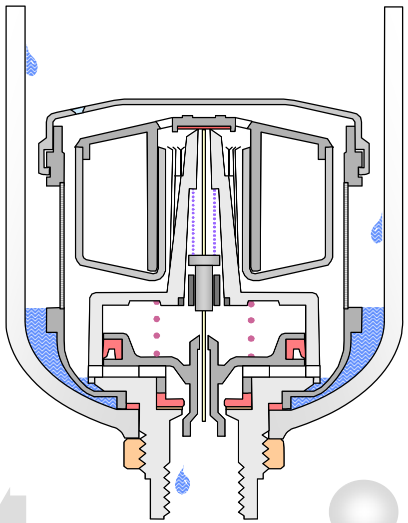
- Float drops and reseals inlet seat
- Water still being ejected as the valve starts to slowly close
- Piston pushed up slowly against air pressure on top of the piston as it escapes through the restricted exhaust seat

Automatic drain valve



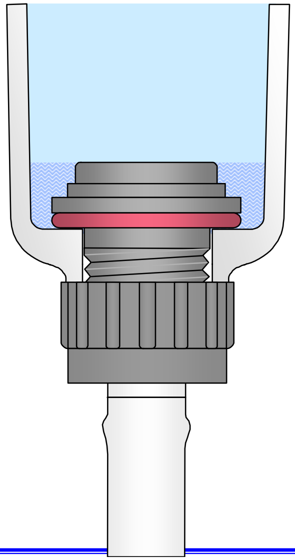
- Piston in the up position fully closing the valve
- The cycle is repeated whenever there is sufficient water to lift the float

Automatic drain valve



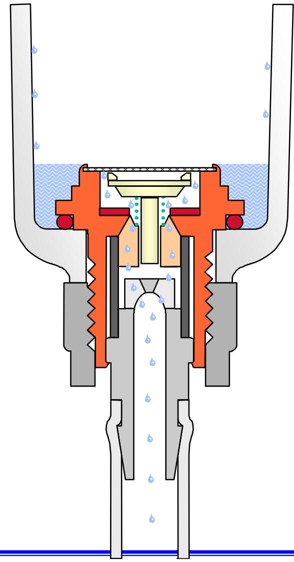
- When system pressure is turned off and exhausted the spring will push the piston down to open the valve
- Any water gradually draining through a depressurised system will be able to pass through the open drain valve

Semi-automatic drain



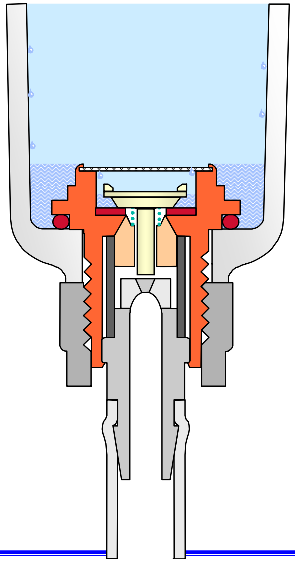
- When the pressure is turned off at the end of the day or at any other time the drain valve will open automatically
- In most applications the normal daily cycle will keep the bowl cleared
- If the bowl needs draining while under pressure this can be achieved manually by pushing up on the pipe connector

Semi-automatic drain



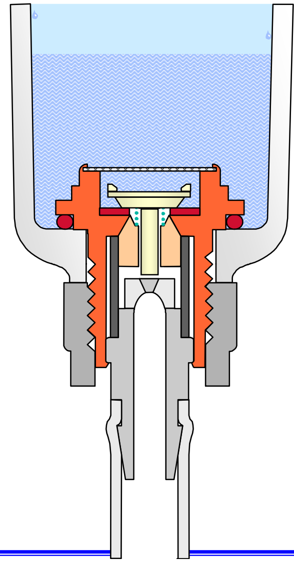
- When air pressure is OFF the valve springs to the open position and draining occurs
- Water contained in the bowl will be cleared

Semi-automatic drain



- When air pressure is ON the valve is pushed closed
- Water will start to build up in the bowl
- If the level becomes too high before the pressure is turned off it can be drained under pressure manually
- Push up on the pipe connector and hold until draining is complete

Semi-automatic drain



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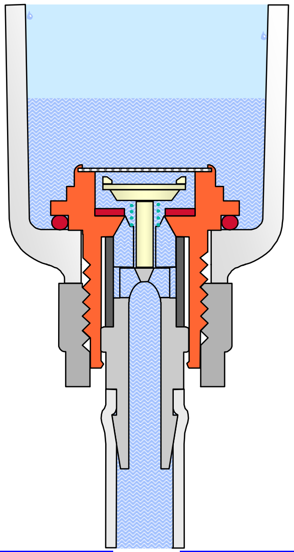

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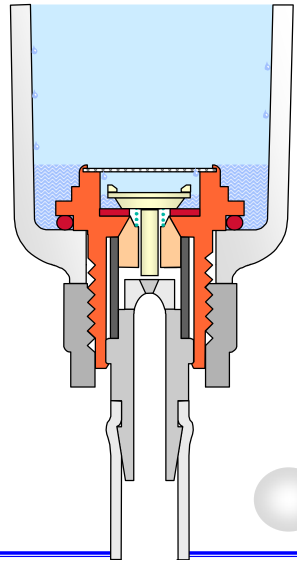

- When air pressure is ON the valve is pushed closed
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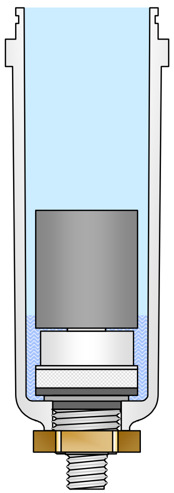
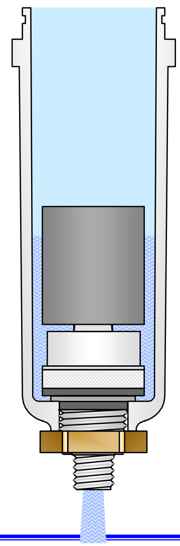
Fully automatic drain valve



- In normal working under pressure, the float will lift when the water level rises
- This causes the valve to open and the water is ejected
- The float falls and the valve closes
- When the pressure is turned off at the end of the day or at any other time the drain valve will open automatically

Fully automatic drain valve



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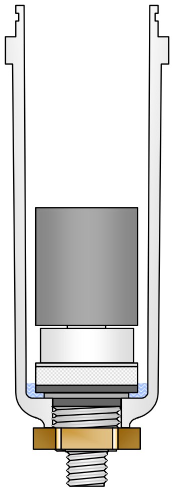
Fully automatic drain valve



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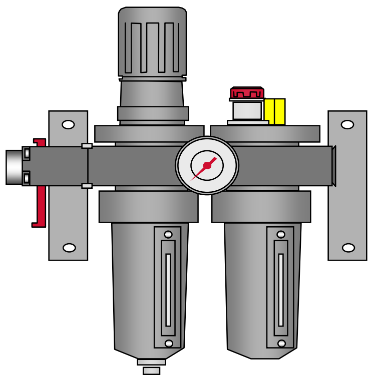
FRL

- FRL stands for filter, regulator and lubricator
- When an FRL unit is referred to, it means a combination of these three devices closely connected together
- They form a unit that will prepare the condition of compressed air just before delivering it to pneumatic equipment or machinery
- This ensures the air supply is clean and dry, the pressure is at the correct level and fine particles of oil are carried in the air to lubricate the wearing parts within valves, cylinders and tools
- A convenient method of combining these components is to use a modular system

FRL

- shown with gauge, shut off valve and wall mounting brackets
- Updated system based on the popular modular yoke with plug in units
- Extensive range of plug in units



Olympian Plus

1. Quick connect yokes
2. Plug in unit
3. Bayonet bowls
4. Prismatic sight glass
5. Captive ‘O’ Rings
6. Tamper resistant cover
7. Pressure switch
8. Soft start/dump
9. Shut off valve 3/2

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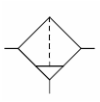
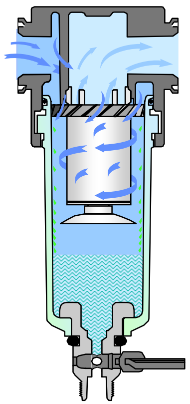
Filter (general principle)





- Separate and collect contaminants
- Angled louvers spin the air as it enters the bowl
- Water droplets and large solid particles spun outwards against bowl and run to the bottom
- Baffle prevents turbulent air splashing water on to the filter element
- Element traps finer solid particles

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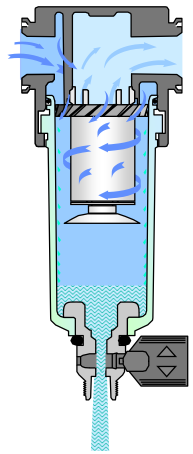
Filter (with manual drain)



- Daily visual inspection is required to ensure the water contaminant level is prevented from rising to a level where it can be drawn through the filter element
- A quarter turn valve allows the contaminant to be ejected under pressure
- Threaded end allows a tube connection for draining to a suitable container

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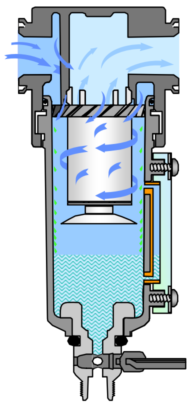
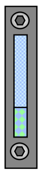
Filter (with metal bowl)





- Refraction grid clearly indicates contaminant level

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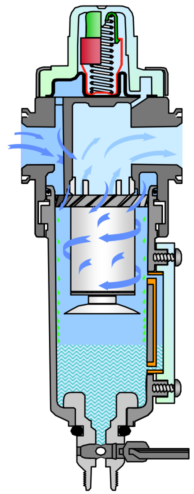
Filter (with service indicator)



- As a filter element becomes clogged the flow decreases
- The developing pressure differential acting on the diaphragm lifts the red sleeve
- The filter element must then be replaced

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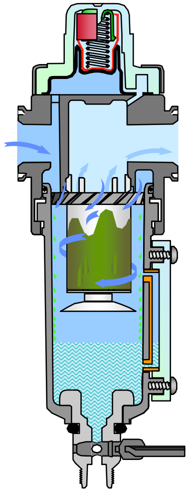
Filter (with service indicator)



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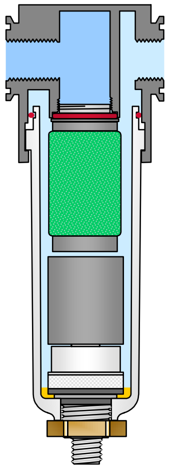
Coalescing filters



- For applications where the air is to be exceptionally clean and free of oil
- For use in food and drug processing, air bearings and paint spraying etc.
- Sub-micrometre particle removal down to 0.01 µm
- Air should be pre-filtered down to 5 µm to prevent short element life due to solid particle build up

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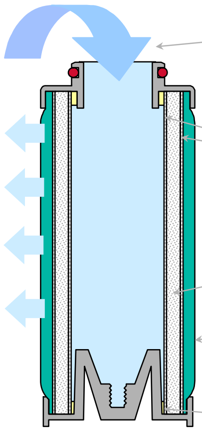
Coalescing filter element



- Air enters the inside of the element and passes through the filter to the outer surface
- Perforated stainless steel supporting formers for up to 10 bar differential
- Filter media: borosilicate glass micro fibre
- Foam sock diffuses air flow to low velocity to prevent oil re-entrainment
- Ends set in resin to seal

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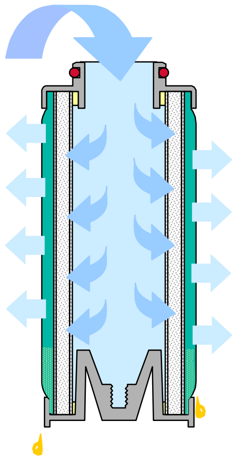
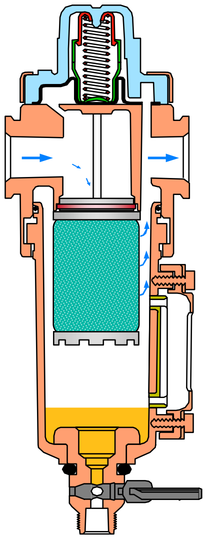
Coalescing filter element



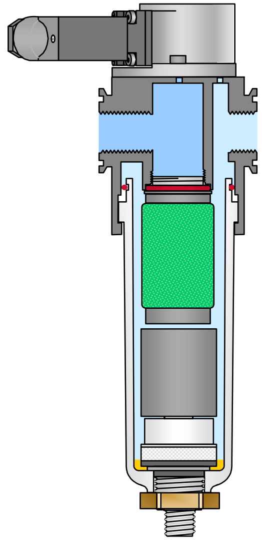
- Oil aerosol particles coalesces (join together) when they contact the element media
- The pathways through the media are so fine and complex that the particles cannot pass through without contact
- Oil soaks and drains to the bottom of the sock where it drips in to the bowl

Coalescing filters



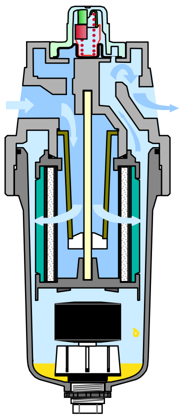
- Flow ratings are lower than equivalent sized standard units e.g. 28 dm3/s compared to 83 dm3/s for G1/2 at 6.3 bar
- Filter area large for rated flow to keep air velocity low and prevent oil re-entrainment
- Standard service life indicator monitors the pressure drop to warn when element requires replacing

Electrical service life indicator



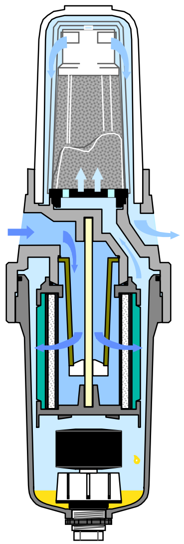
- Ideal for remote indication when filter element requires replacing
- Can be used to give remote visual and audible warning
- For sensitive applications can be used to automatically turn off a machine or process

High efficiency oil removal



- High efficiency coalescing element
- Remaining oil content 0.01 ppm max at + 21°C
- Particle removal down to 0.01 µm
- Air quality to ISO 8573-1 Class 1.7.2 (to accommodate any oil vapour carry-over that may condense out at lower temperatures)

Ultra high efficiency



- Active carbon pack for oil vapour and odour removal
- Warning pink dye activated if oil carries over due to coalescing element failure
- Remaining oil content 0.003 ppm max at + 21°C
- Particle removal down to 0.01 µm
- Air quality to ISO 8573-1 Class 1.7.1

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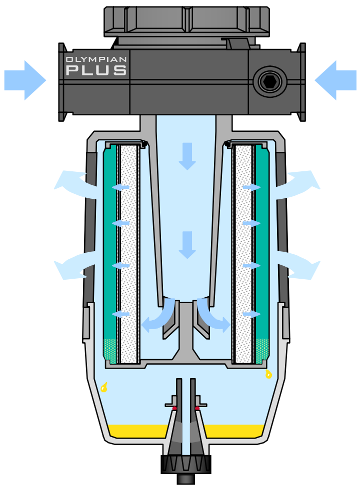
Coalescing silencers



- For the termination of all pneumatic system exhausts
- Removes lubricating oil particles carried over in the exhaust
- Large filter area keeps exhaust velocity low for very low noise
- Piped exhausts can be connected to either end
- Can be gang mounted also with porting blocks

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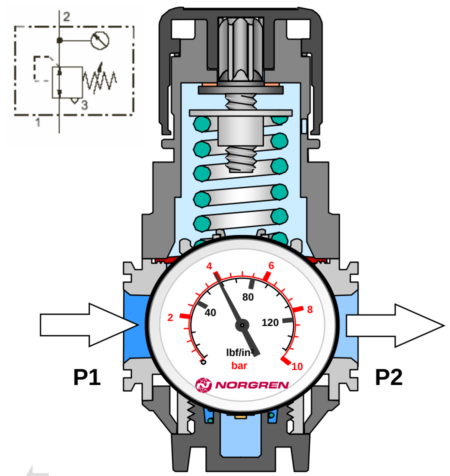
Pressure regulator



- Reduces supply pressure P1 to a suitable working pressure P2
- When there is no flow demand the poppet valve closes to hold the pressure at P2
- Flow demand will open the poppet valve wide enough to satisfy the flow rate at pressure P2
- P2 can be set on a gauge fitted to the regulator

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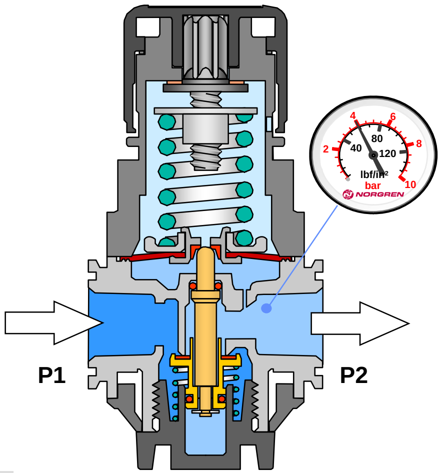
Pressure regulator



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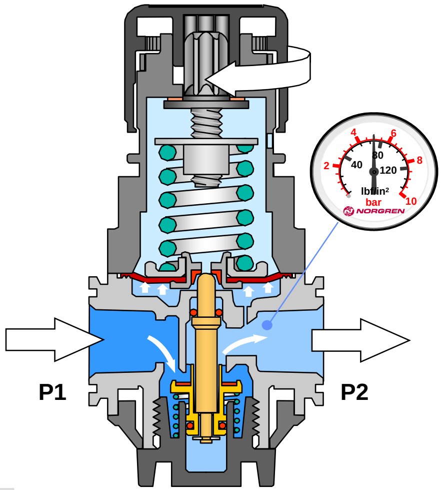
60

Pressure regulator



- To increase pressure P2, pull the adjusting knob up to disengage the locking teeth
- Turn clockwise until new P2 pressure reached
- The higher spring force pushes the valve open
- The rising pressure P2 acts under the diaphragm to balance the spring and allow the valve to close

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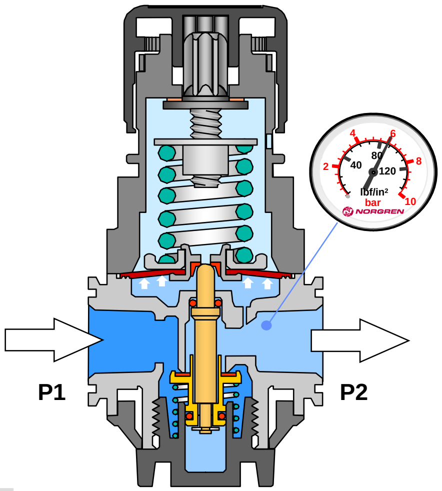
Pressure regulator



- When the desired pressure is reached the force on the diaphragm will fully balance the force on the spring and the valve will close
- Dead end applications are those that are closed ended. The flow demand is intermittent so the system will fill and settle at the set pressure e.g (a single stroke of an actuator)

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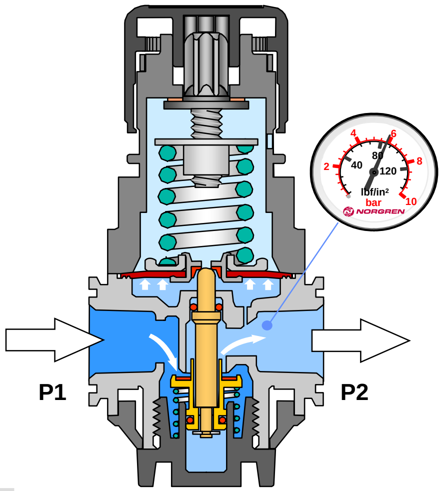
Pressure regulator



- While flow is taking place the valve will be held open wide enough to keep as close to the set pressure as possible for the flow demand
- As the flow rate increases so the pressure under the diaphragm decreases to open the valve wider to maintain the flow close to the set pressure

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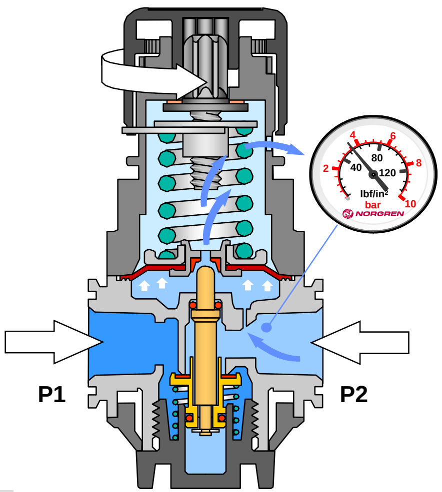
Pressure regulator



- This is a relieving regulator to allow pressure to be reduced to a lower setting
- Turn anticlockwise to reduce the spring force
- The higher force under the diaphragm lifts it clear of the valve spindle
- P2 can now exhaust until the diaphragm seals
- Turn clockwise to adjust up to the new pressure

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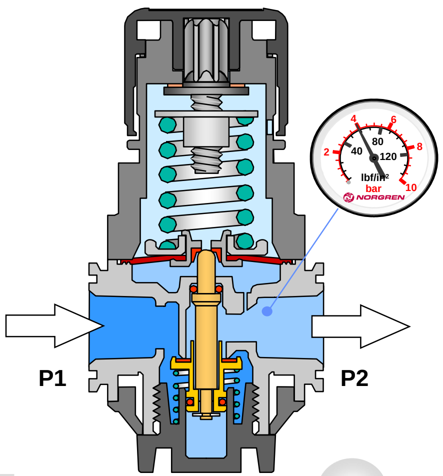
Pressure regulator



- Once the desired setting has been established push down the locking adjusting knob to prevent inadvertent changes

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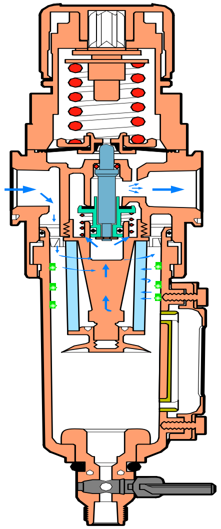
Filter Regulator



- Filter and regulator designed as a single unit
- Air is first filtered then directed to the primary side of the regulator
- Pressure is then reduced to a working value
- Only one unit to install
- Cost saving when compared to two separate units

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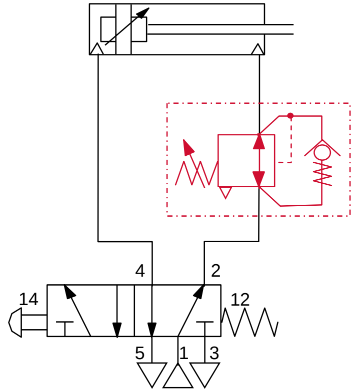
Reverse flow regulator

- For applications where the supply to a regulator is cycled
- The reverse flow pressure regulator features an inbuilt check valve to allow reverse flow
- Illustration shows a reverse flow regulator between cylinder and valve, this allows pressure reduction to the front end of a cylinder



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Lubrication

- For efficient running of pneumatic equipment and long life of seals and wearing surfaces, correct lubrication is essential
- Where non-lube equipment is used it has been pre- lubricated on assembly and will last for the normal life expectancy of that equipment without further lubrication.
  It will not be detrimental however to include this equipment on lubricated air supplies and is likely to result in an extension of the normal life of the equipment
- For the best results light lubrication is applied continuously from an air line lubricator. This is particularly relevant in adverse applications where there may be high speed and high temperature running or where the condition of the compressed air has been poor

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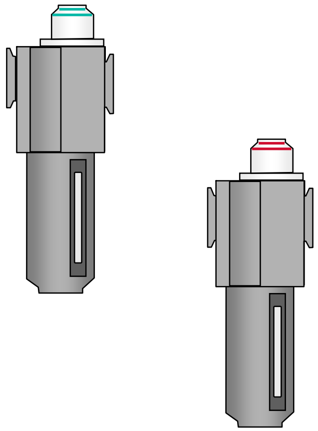
Lubrication

- Valves, actuators and accessories in a typical application can operate at different rates and frequencies and require lubrication rates to match. The airline lubricator provides a very convenient method of satisfying this demand
- In a lubricator, oil drips are atomised and the tiny oil particles form a very fine mist in the air supplying the application
- The amount of oil delivered is automatically adjusted as the air flow changes. The result is constant density lubrication. For any setting the oil particles per cubic meter of air are the same regardless of the flow rate

Lubricators

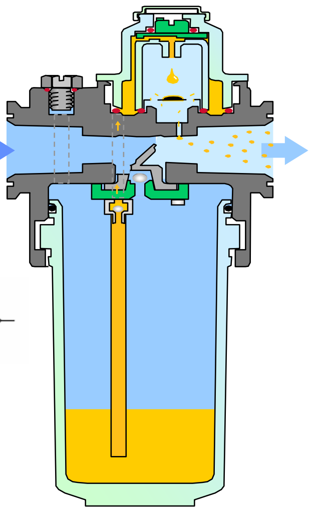


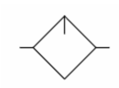
- There are two main types of lubricator
- One is the conventional high delivery Oil Fog series (coded green)
- The other is the unique and more widely used Micro Fog range (coded red)
- Both types are easily adjusted to pre-set the lubrication density

Oil fog lubricators

- All of the oil drips seen through the sight dome enter the air stream and are atomised
- The size range of the oil particles produced are ideally suited to lubricating single items of equipment on medium to short runs of pipe
- The oil particles are carried along with the air flow, and gradually "wet out" to provide adequate lubrication for applications such as nut runners, screwdrivers and other equipment requiring heavier lubrication

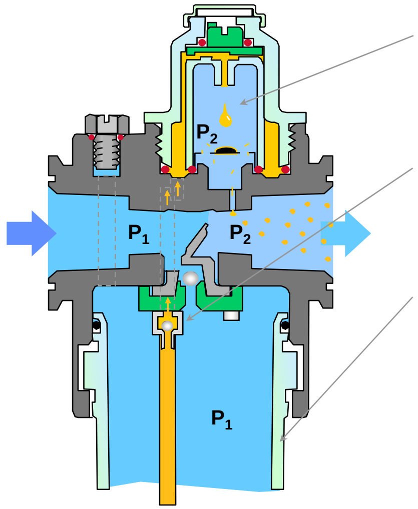
Oil fog lubricator





- For lubricating over short distances where wet-out is required early
- Suited for; air tools, air motors, single large cylinders etc.
- Oil drips are broken up in the main air stream and all particle sizes carried in the air
- Drip rate is adjustable

Oil fog lubricator



- Oil drips visible through the sight dome pushed by the pressure difference between P_1 and P_2
- Syphon tube with check valve to prevent oil drain back when there is no flow taking place
- Transparent polycarbonate bowl to inspect oil level
- Alternative metal bowl with sight glass

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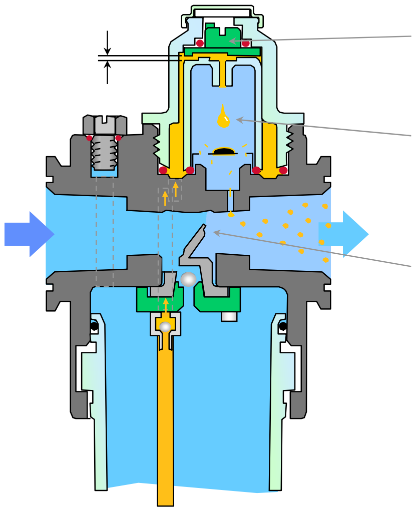
Oil fog lubricator



- Turn the green control to adjust the oil flow restriction
- Observe the drip rate
- Flexible flow sensor, progressively bends flat as the flow increases. This controls the local pressure drop to draw oil drips in proportion to air flow

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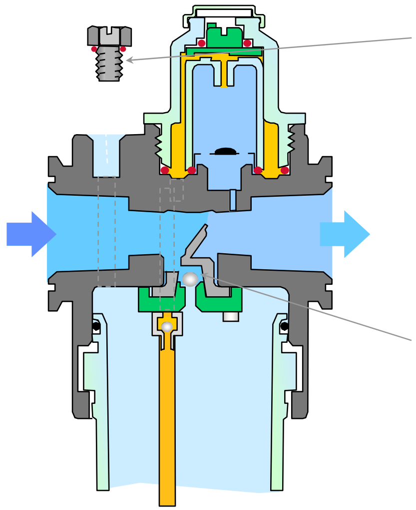
Fill under pressure (oil fog)



- Filler plug with flats to bleed the bowl pressure
- Crack open and wait for pressure to drop then remove the plug
- Remove bowl with simple bayonet action, fill and replace securely
- Replace plug and tighten
- Check valve with small by-pass notch. Flow too low to pressurise bowl when plug removed

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Micro-fog lubricators

- The oil drips seen through the sight dome in this unit are atomised in the bowl, but only a small percentage of the particles produced actually enter the air stream
- Those that do, make up about 10% of the drip rate and are the very smallest ones, so fine they can be likened to thin smoke. The drip rate is 10 times that of the oil fog units for the same oil delivered. Setting the drip rate is 10 times quicker too as there is less time to wait between drips
- Wetting out of these oil particles occur gradually. This allows them to be carried the long distances associated with the maze of pipework, tight turns and fittings that form part of the typical industrial pneumatic system

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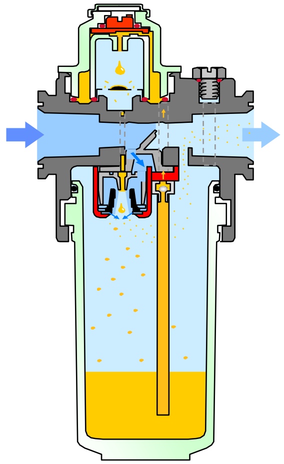
Micro-fog lubricator



- For lubricating over long distances where particles must reach the furthest parts of intricate systems
- Suited to; control circuitry, multiple valve / actuator systems
- Oil drips are atomised in the bowl
- Only the finest 10% of oil particles leave the bowl
- Stay in suspension longer

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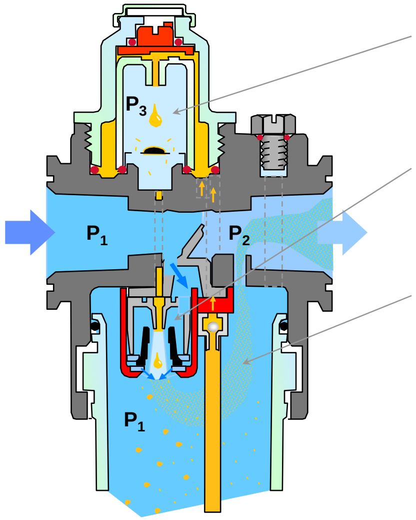
Micro-fog lubricator



- Oil drips visible through the sight dome pushed by the pressure difference between P_1 and P_3
- All drips pass through the atomising head. Pressure drop P_3 created by venturi in atomising head
- Only smallest lightest 10% oil particles can make the tight turn to exit the bowl carried by the pressure drop $P_1 : P_2$

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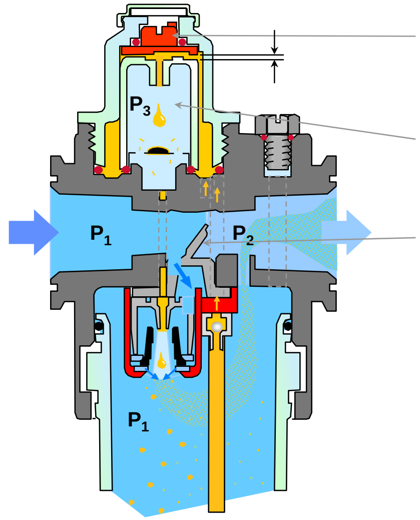
Micro-fog lubricator



- Turn the red control to adjust the oil flow restriction
- Observe the drip rate
- Flexible flow sensor, progressively bends flat as the flow increases. This controls the local pressure drop $P_1 : P_2$ to draw lubricated air from the bowl in proportion to flow

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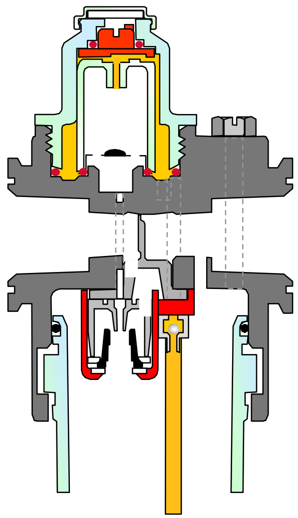
Micro-fog lubricator



- Due to the high flow in to the bowl, a micro-fog cannot be filled under pressure
- First turn off and exhaust the air supply
- Remove the bowl and fill
- Replace bowl securely
- Turn on the air
- To fill under pressure, replace filler plug with a nipple adaptor

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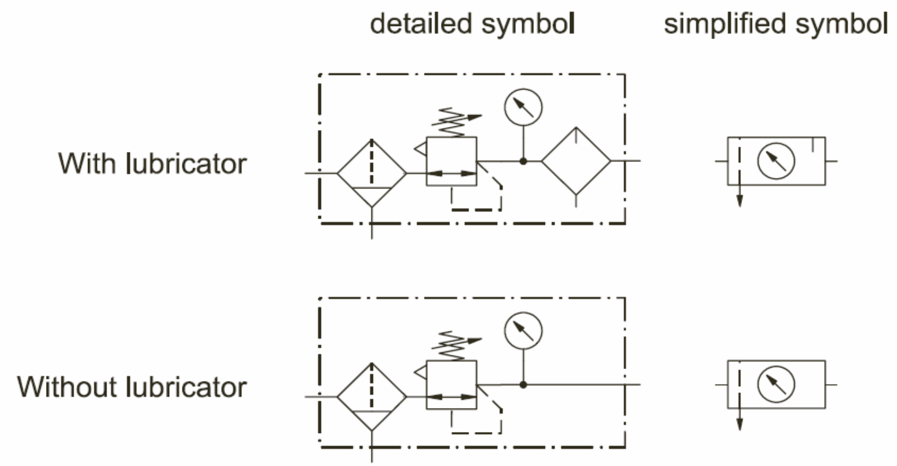
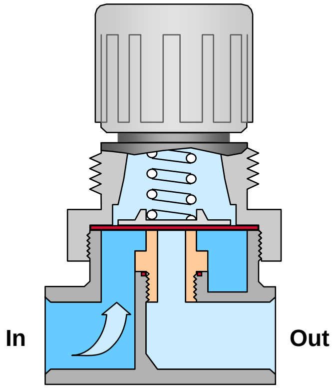
FRL



Relief valve

- Spring force prevents normal air pressure from lifting the diaphragm
- Excessive pressure will lift the diaphragm to open the poppet valve and relieve air to the outlet
- When the pressure drops to the pre-set value again the spring closes the diaphragm poppet



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