English version

ULTIMHEAT® MUSEUM

Jacques Jumeau

Technology of components used in heating.

Chapter 16

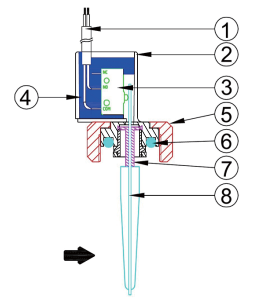
Introduction to the flow switches technology

1st edition 2012/10/30

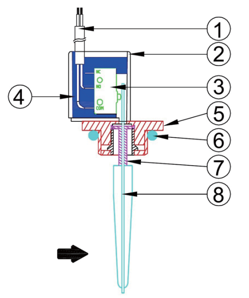
Fonctionnement

Paddle and micro-switch types

In the "in line" types, <u>only a part of the flow</u>, function of the ratio between the pipe section and the paddle surface actuates the flow switch.



1: Cable
2: Body
3: Microswitch
4: Resin filling
5: ¾" Loose nut or ½" male thread
6: Fitting gasket
7: Paddle gasket
8: Paddle



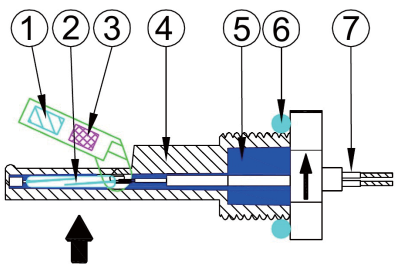
1: Cable
2: Body
3: Microswitch
4: Resin filling
5: ¾" Loose nut or ½" male thread
6: Fitting gasket
7: Paddle gasket
8: Paddle

Operating Principle

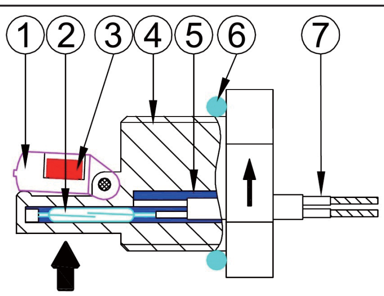
In the paddle and switch flowswitches, the paddle is pushed by the water flow and actuates a microswitch . The seal between the paddle and the electric part is made by a Santoprene elastomeric gasket. Set point calibration value is given mainly by the paddle length and its the surface, the microswitch actuating force , the pipe diameter. As in all paddle flow switches, due to the weight of the paddle, the setting will vary slightly according to the mounting position (horizontal or vertical, and in the latter case, flow inlet direction from top to bottom or from bottom to top).
During assembly it is important to check that the paddle is correctly oriented in the flow direction and that no friction or obstacle hinder its movement. Therefore it is better to focus on devices with ¾" union nut mounting , or clips and O-ring assembly (type Ultimheat Snap-in), which allow easy aorientation djustment , unlike models with fixed thread.
The temperature and pressure withstanding values, as well as resistance to chemical products are limited by the paddle gasket material.
These models have the advantage of high electrical rating, and do not contain magnets, allowing them for use with liquids that may contain magnetic particles.
In the ½" fixed thread types, it is possible to include a built-in temperature sensor: NTC, thermocouple, or Pt100, thus allowing the liquid temperature measurement.

Paddle and reed switch types, gravity back-force

In the "in line" types, <u>only a part of the flow</u>, function of the ratio between the pipe section and the paddle surface actuates the flow switch.



1: Paddle
2: Reed switch
3: Magnet
4: Body
5: Resin filling
6: Gasket (on models with cylindrical thread)
7: Cable



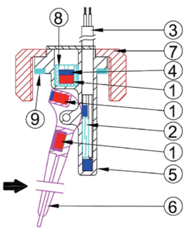
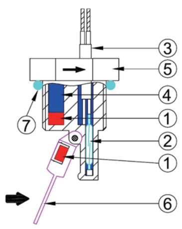
1: Paddle
2: Reed switch
3: Magnet
4: Body
5: Resin filling
6: Gasket (on models with cylindrical thread)
7: Cable

Operating Principle

In the gravity pull-back paddle flow switches, when the upstraem flow pushes against the paddle, the paddle swings away. This changes the position of the magnet in relation to the reed contact and thus activates the contact. As soon as the flow decrease or is interrupted, the paddle moves back to its starting position, and reed switch comes back to its starting contact position. The force necessary to push the paddle is provided by the magnets repelling each other. Our fixed setting paddle switches use only two magnets, and our adjustable setting types have one extra magnet use for repelling force adjustment. This system has no communication or gasket between the paddle and the electrical part. No metal parts are in contact with the liquid, with the exception of some models with a titanium axis. Therefore they are particularly suitable for applications on aggressive liquids, swimming pool water, sea water, or chloration or bromisation equipment. Most models can be used on pipes from 20 to 100 mm diameter, by using an adapted length paddle. Set point calibration value is given mainly by the paddle length and surface, the diameter of the pipe, and, in adjustable versions by the position of the magnet position adjusting screw. As in all paddle flow switches range, due to the weight of the paddle, the setting will vary slightly according to the mounting position (horizontal or vertical, and in the latter case, flow inlet direction from top to bottom or from bottom to top).
During assembly it is important to check that the paddle is correctly oriented in the flow direction and that no friction or obstacle hinder its movement. As the paddle is magnetic, the circuit must be free of all magnetic particles. The low electrical rating of the reed switches limit their use in pilot circuits or electronic circuits.

Paddle and reed switch types, magnetic pull-force, slim design

In the paddle types, only a part of the flow, function of the ratio between the pipe section and the paddle surface, actuates the flow switch.

3 magnets, factory adjustable set point type, smallest external foot print		2 magnets fixed setting, the lowest foot print	
	1: Magnets 2: Reed switch 3: Cable 4: Resin filling 5: Body 6: Paddle 7: 3/4"BSPP plastic Nut 8: Adjustment screw 9: Fitting gasket		1: Magnets 2: Reed switch 3: Wires or cable 4: Resin filling 5: Body with ½" thread 6: Paddle 7: Fitting gasket

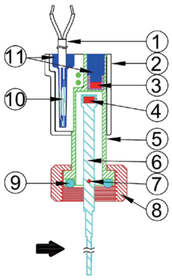
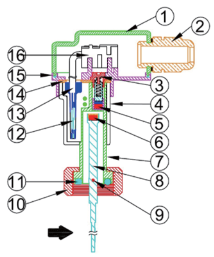
Operating Principle

In the paddle and reed switch types, with magnetic pull-force and slim design, the flow pushes against the paddle, the paddle swings away and the reed switch contact closes. As soon as the flow decrease or is interrupted, the paddle is pulled back by the magnet to its starting position, and reed switch contact opens. The fixed setting paddle switches with slim design use only two magnets, but the adjustable setting types have one extra magnet used for force adjustment. This system has no communication or gasket between the paddle and the electrical part. No metal parts are in contact with the liquid, with the exception of some models with a titanium axis. Therefore they are particularly suitable for applications on aggressive liquids, swimming pool water, sea water, or chloration or bromisation equipment. Most models can be used on pipes from 20 to 100 mm diameter, by using an adapted length paddle. Set point calibration value is given mainly by the paddle length and surface, the diameter of the pipe, and, in adjustable versions by the position of the adjusting screw. As in all paddle flow switches range, due to the weight of the paddle,the setting will vary slightly according to the mounting position (horizontal or vertical, and in the latter case, flow inlet direction from top to bottom or from bottom to top).
During assembly it is important to check that the paddle is correctly oriented in the flow direction and that no friction or obstacle hinder its movement. Therefore it is better to focus on devices with ¾" union nut mounting, or clips and O-ring

assembly (type Ultimheat Snap-in), which allow easy aorientation djustment, unlike models with fixed thread.
As the paddle is magnetic, the circuit must be free of all magnetic particles. The low power rating of the reed switches limit their use in pilot or electronic circuits.

Paddle and reed switch types, magnetic back-force, long design

In the paddle types, <u>only a part of the flow</u>, function of the ratio between the pipe section and the paddle surface, actuates the flow switch.

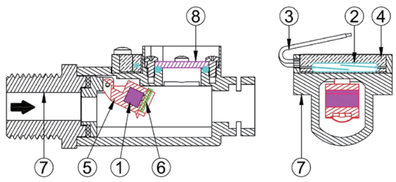
2 magnets fixed setting, external mechanism		2 magnets adjustable setting, external mechanism	
	1: Cable 2: Cover 3: Magnet 4: Magnet 5: Body 6: Paddle 7: Titanium axis 8: 3/4"BSPP plastic loose nut 9: Fitting gasket 10: Reed switch 11: Resin filling		1: Connection box cover 2: Connector or cable gland 3: Adjustment screw and dial 4: Body cover 5: Magnet 6: Magnet 7: Body 8: Paddle 9: Titanium axis 10: ¾ BSPP nickel plated brass Nut 11: Fitting gasket 12: Reed switch 13: Wires 14: Resin filling 15: Connection box frame 16: Connection block

Operating Principle

In the paddle and reed switch types, with magnetic pull-force and long design, the flow pushes against the paddle, the paddle swings away and the reed switch contact closes. As soon as the flow decrease or is interrupted, the paddle is pulled back by the magnet to its starting position, and reed switch contact opens. This system has no communication or gasket between the paddle and the electrical part. No metal parts are in contact with the liquid, with the exception of some models with a titanium axis. Therefore they are particularly suitable for applications on aggressive liquids, swimming pool water, sea water, or chloration or bromisation equipment. Most models can be used on pipes from 20 to 100 mm diameter, by using an adapted length paddle. Set point calibration value is given mainly by the paddle length and surface, the diameter of the pipe, and, in adjustable versions, by the position of the adjusting screw. As in all paddle flow switches range, due to the weight of the paddle,the setting will vary slightly according to the mounting position (horizontal or vertical, and in the latter case, flow inlet direction from top to bottom or from bottom to top).
During assembly it is important to check that the paddle is correctly oriented in the flow direction and that no friction or obstacle hinder its movement. As the paddle is magnetic, the circuit must be free of all magnetic particles. The low power rating of the reed switches limit their use in pilot or electronic circuits.

Hinged flap and reed switch types

In the hinged flap types, <u>100% of the flow</u> goes throw the flow switch

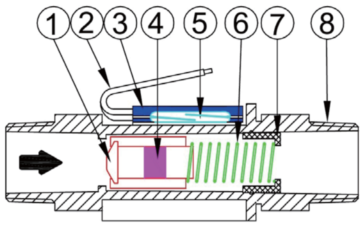
	1: Magnet 2: Reed switch 3: Wires or cable 4: Resin filling 5: Flap 6: Adjustment weight 7: Body 8: Auxiliary plate for triac or other components

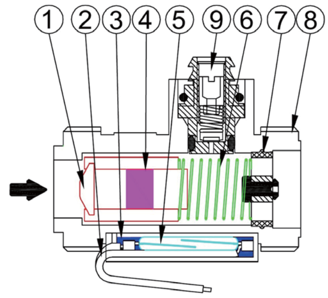
Operating Principle

In "In line" flap reed flow switches, the hinged flap is moved by the water flow and closes a reed switch contact. There is no sealing problem between the liquid and electrical side, because the two are completely separated. When the flow stops or decreases, the magnetic flap returns to its original position by its own weight (vertical position and bottom water inlet are required). The detection set point value is given by a variable mass lodged in the flap. This solution is suitable for small diameter pipes and wall mounting instant water heaters. As the flap is magnetized, the circuit must be free of all magnetic particles. These devices include a location for mounting an auxiliary system: water cooled triac heat exchanger, pressure switch, disc thermostat or temperature sensor. The low power rating of the reed switches limit their use in pilot or electronic circuits.

Piston and reed switch types

Piston type flow switches place a piston directly <u>in 100% of the flow path</u>.





1: Wires 2: Piston 3: Resin filling 4: Magnet 5: Reed switch 6: Spring 7: Clips 8: Body 9: Overpressure valve (Option)	1: Wires 2: Piston 3: Resin filling 4: Magnet 5: Reed switch 6: Spring 7: Clips 8: Body 9: Overpressure valve (Option)

Operating Principle

Inside "in line" piston and reed type flow switch, the piston, when displaced by the pressure differential from fluid flow, magnetically actuates a reed switch. There is no sealing problem between the liquid and electrical part because the two are completely separated. When the flow stops or decreases, the magnetic piston comes back to its original position by its own weight (vertical installation, water inlet downside), or by a spring (vertical, water inlet upside). The detection set point value is given mainly by the piston shape, its mass and eventually by the spring pull back force. This solution is suitable for small diameter pipes. The piston being magnetized, the circuit must be free of all magnetic particles. The low power rating of the reed switches limit their use in pilot or electronic circuits.

Description of the different parts

The electrical contact system: reed switch or micro-switch.

A certain force is required to actuate the electrical contact device. It can range from a few tenths of grams for systems with reed contacts with a power rating of 10 to 20VA (0.5Amp), to 50 grams for snap action micro-switches with a 5Amp 250V rating.

In general, the force required to operate an electrical contact increases with its electrical rating, and the power available on the detector depends on the paddle, piston or flap characteristics. Most flow switches use reed switches because they are used for detection level in low voltage and low current electronic circuits. This makes possible to design compact devices.

Reed switches

Reed switches are small glass bulbs with a flexible reed strip contact with a breaking capacity of 10 to 70VA, which has the particularity to close in the presence of a magnetic field. These glass bulbs are sealed and filled with argon or under vacuum, therefore they are protected from oxidation.

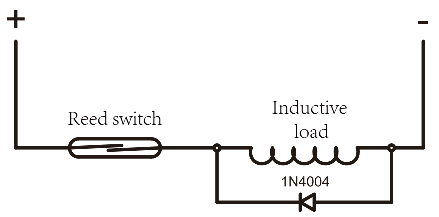
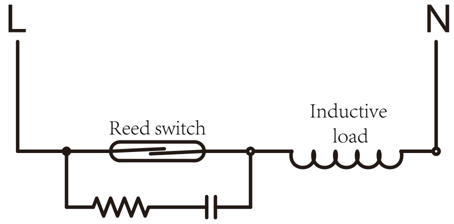
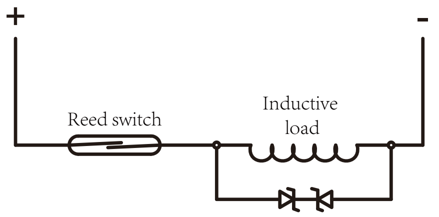
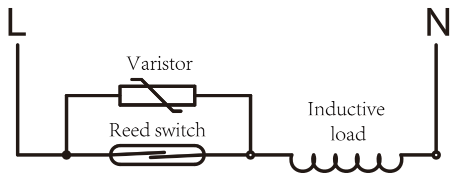
Reed switches applications in flow switches

Suitable	Not suitable
Computer circuits	Small electrical motors, including small DC motors
Programmable logic controllers (PLC's) circuits	Power contactor coils circuits (Unless protected by an arc suppression circuit)
Small relays	Solenoid valves (Unless protected by an arc suppression circuit)
Solid state relays(SSR) trigger circuits	Incandescent lamps

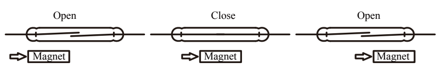
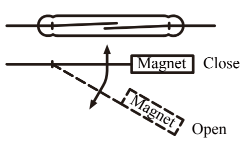
Reed switches contact protection

Switching no load or loads where the voltage is less that 5 Volts @ 10 mA or less, the contacts undergo little or no wear and life times in excess of billions of operations are expected. In the 10 Volt range, higher contact wear will take place. Switching 10 Volts @ 10 mA, life times of 50 million to 200 million operations can be expected.

When switching inductive loads such as relays, solenoids and transformers, reed switch contacts require protection in order to insure long, dependable life. When current is interrupted, the inductance or electrical inertia of the load generates a large high frequency voltage, which appears across the switch contacts. If the voltage is large enough, it can break down the medium in the gap between them, making a conductive path. This phenomenon is called arcing. Arcing can cause the contacts to burn, weld together or stick .The purpose of protection circuits is to prevent arcing, by shorting this voltage through an alternate path.

<table>
<tr><th>DC load contact protection circuit with diode</th><th>AC load contact protection circuit with R/C circuit</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>A 1N4004 diode is connected cathode-to-positive .The diode does not conduct when the load is energized, but conducts and shorts out the peak transient generated voltage when the switch opens. A resistor can be added in serial with the diode.</td><td>A resistor (R) and capacitor (C) are connected in parallel with the switch.
The capacitor has high impedance at 50/ 60 hertz, and is essentially a short circuit to high frequencies of generated voltages.
Capacitor value: $C = I^2/10$
Resistor value (E= power supply voltage):
$R = E / (10 \cdot I^{(I+50 / E)})$</td></tr>
<tr><th>DC load protection contact with Back to Back Zener diode</th><th>AC load protection contact with Varistor</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>The peak transient voltage that occurs when the switch opens is decreased to a value equal to the back to back Zener diode voltage.
The Zener diode should be sized for a voltage somewhat higher than the circuit source voltage.</td><td>The varistor resistance decrease sharply when voltage reaches its trigger value, and shorts out the peak transient generated voltage when the switch opens. Varistor should be sized for a voltage somewhat higher than the circuit source voltage.</td></tr>
</table>

Magnet displacement and reed switch operation in flow switches

<table>
<tr><th>Piston types</th><th>Paddle and flap types</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>When magnet located inside the piston arrives at the center of the reed switch, the contact closes. Therefore, piston movement is limited to achieve requested operation mode.</td><td>A magnet is located inside the paddle or inside the flap. When it arrives near the reed switch, the contact closes.</td></tr>
</table>

Snap action switches

On snap action switches, contact opening speed is around 1m per second.. The

contacts spacing reach the distance to extinguish the arcing in less than 1/1000 sec. Therefore there is no radio interference, and the contact does not deteriorate. Mechanically, this type of contact, also called " energy storing contact" is much more complicated, expensive, and does not allow such a great control than reed switches.
The snap action microswitch is particularly suitable for devices operating at 240 or 400 V and when high electrical rating is required.

Microswitches vs reed switches in flowswitches

Disadvantages	Advantages
Microswitches are more expensive than reed switch	Microswitches have a higher electrical rating, in 110VAC and 230VAC
Microswitches have a higher operating force, so they need larger paddles	Microswitch are easily made with SPNC, SPNO or change over contacts
Micro-switches have large differential travel, providing large flow differential between contact opening and close	Snap action contacts switches generate very low EMC

Magnets (In reed switch devices)

Selecting a magnet for a flow switch application must take into account the characteristics of the liquid in which it will be immersed, of the temperature at which it will be subjected, of its corrosion resistance, of the magnetic field required to operate the switch and its distance to the reed switches. Ferrite magnets have a good resistance to corrosion, but a very low magnetic power. Neodymium – Iron-Boron magnets contain 60-75% iron (amount is dependent on grade) and are therefore prone to corrosion, but a very big magnetic power. So theses magnets are nickel plated and plastic overmolded.
Bot hf these magnets have a good temperature resistance up to 100°C.

Electrical wiring

For reed switches systems, the most common electrical connection is by wires or cable. Given the low electrical rating of reed switches, conductor cross section is generally less than or equal to 0.5 mm^2. If there is no thermal stress or environmental conditions, wires and cables are PVC insulated. Silicone insulation, FEP and Teflon are not recommended because they do not provide hermetic sealing with resin filling and may let in water or moisture inside the product.
Tabs or connector outputs are recommended for large quantities.

Resin filling (For reed switch types)

The resin filling provides two functions
- Mechanically securing the reed in the body, and provide its resistance to tearing (Standards impose a tearing resistance equal to or greater than 10N)
- Main electrical insulation of the electrical contact and wiring. This requires a UL94-VO resin. In some customer applications the insulation class I is insufficient, and the contact system must receive and additional insulation to comply to the requirements of insulation class II.

Mechanical stop of measuring device

The mechanical displacement of the piston or paddle must be limited to remain within the limits of the magnet position detection by the reed switch.

Mechanism body and mounting system

Choice of material:

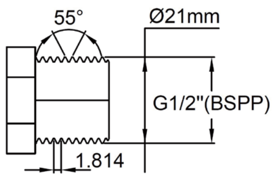
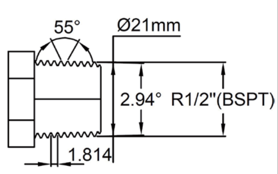
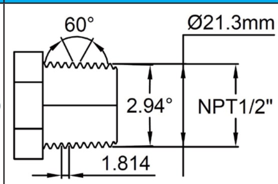
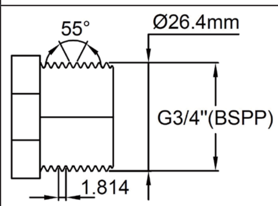
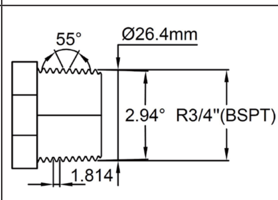
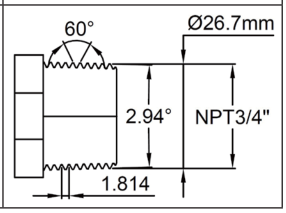
The body of the mechanism provides several functions:
- Device protection against electric shock, water ingress, pressure value, and chemicals. Plastics used for the body are always UL94-VO rated
- The use in potable water systems:
Models intended for use in drinking water are made of plastic and metal parts in contact with water that meets the specifications of the WRC (Water Research Council)
- The flow switch mounting:
This mounting can be secured by NPT or BSPT (Tapered) threads, or BSPP cylindrical threads or metric threads. Tapered threads require sealing on the threads, and the cylindrical threads require sealing by a flat gasket or O-ring.

Metallic parts inside magnetic devices
On flow switches using a magnetic mechanism, liquids containing magnetic particles such as iron filings must be avoided, because these particles will accumulate on the magnet.
It is possible to use a magnetic trap upstream if it is not possible to avoid magnetic flow switches in the final application.

Ingress protection
This protection can have several functions:
- Ingress protection against attacks from the outside environment (rain, dust, shock). Most of our flow switches have their electrical components potted inside an electrical insulation and waterproof resin. Some of them can also be provided with waterproof protection box.
- Protection against the conditions in which the product will be installed in its application.
In most cases, level switches will be integrated by an OEM into a machine or equipment. Then it is this machine or equipment that will ensure protection against water, dust, shock and other contaminants.
- Protection against gas and dust explosive atmospheres: flow switches were not initially designed for use in these environments and therefore may not meet the applicable standards in this field of application.
Overmolded reed switches do not have potential sources of ignition. On special request, they can be subjected to an ignition hazard assessment according to DIN EN 13463-1: 2002. They could be, therefore, not subject to directive 94/9/EC, and used as a simple electrical device for connection to a certified intrinsically safe circuit in accordance with DIN EN 60079-11: 2007.

Compliance with the European directive 2006-42 (Machinery directive):
These flow switches are not a safety component as described in this directive. Their operational safety is only guaranteed when they are used for flow monitoring of liquids, inside the limits given by their data sheets and instruction manual .

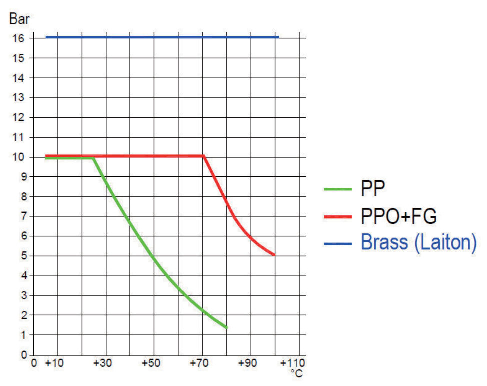
Threads and threaded pipe connections

	G	R	NPT
1/2			
3/4			

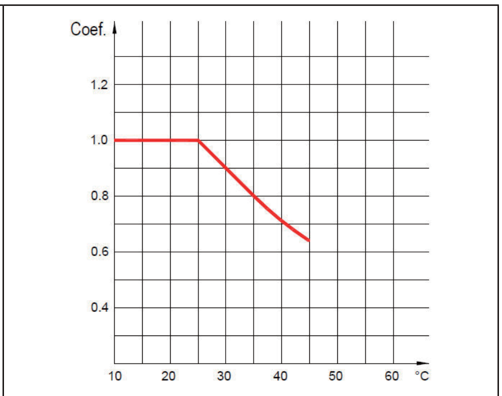
The correspondences between the threads, and they may have different names in different countries and often it is difficult to understand catalogs and plans.
The threads used in flow sensors can be:
- ½" NPT: tapered thread, American standard ANSI B1-20-1.
- ½" BSPT: tapered thread, meet ISO-7-1, DIN2999, BS21, often called " conical gas thread " or " conical gas ", but they may also be described in documents under the abbreviation " Rp " , " R " and in France " conical 15-21 " (for ½"), and "conical 20-27 " (for the ¾").
- ½" BSPP and ¾" BSPP: cylindrical thread, described in ISO 228, DIN259, often called "cylindrical gas thread" or "BSP", as described on the documents under the abbreviation "G", and in France "cylindrical 15-21" (for ½"), and "cylindrical 20-27" (for the ¾").
Male cylindrical threads are mounted in cylindrical female thread, with a flat gasket

or an O-ring seal on a flat seal seat.
The tapered male threads are mounted in cylindrical female threads with a sealant on the pitch.
In tapered threads, there is a strong resemblance between BSPT and NPT in sizes ½" and ¾". For these dimensions only, they have the same pitch, diameters very close, and a slight pitch angle difference (55° and 60°), and this explains why in some cases, and for plastic threads,1/2" NPT male will can fit quite correctly in a BSPP female thread.

PN and temperature resistance



Maximum operating pressure correction on flow switches upon their body material



Maximum operating pressure correction coefficient against temperature on PVC tubes (From EN 1452-2)

The Nominal pressure (PN) is the pressure which is often used in the design of a pipeline. This value is expressed in bar, as the pressure at the temperature of 25°C for which the equipment is able to withstand pressure without failure and with adequate security during a given time. At 25°C the nominal pressure corresponds to the maximum operating pressure (PFA). This pressure varies with temperature and the characteristics of the material used, so great care must took when this concept is used. The main standard is EN 1452-2 for drinking water supply pipes in PVC. This standard provides the correction coefficient of the maximum operating pressure between 20 and 45°C for PVC.