English version

ULTIMHEAT® MUSEUM

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Technology of components used in heating.

Chapter 15

Introduction to pressure switches technology

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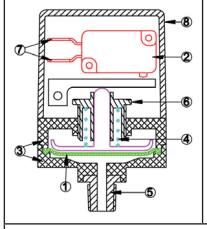
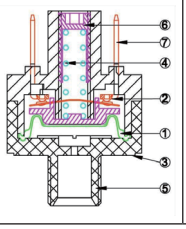
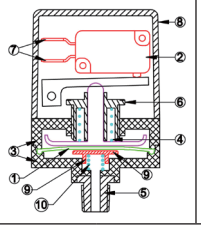
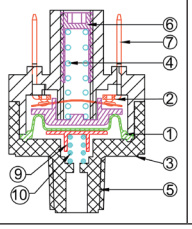
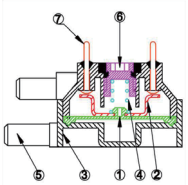
A
Operating principle

The pressure switches are made to the flexible elastomeric membrane technology. The pressure applied deforms the membrane which then actuates an electrical contact. A counter-pressure system, which force is provided either by the contact system itself or by a spring, is applied to the membrane to adjust the set point.

Positive pressure, snap action type	Positive pressure, creep action type	Negative pressure, snap action type	Negative pressure, creep action type	Differential pressure switch, creep action type
				

1: Membrane
2: Electrical switch
3: Pressurized body
4: Back pressure spring
5: Pressure inlet
6: Adjustment system
7: Electrical connection
8: Protection housing (Option)
9: Spring cap (negative pressure only)
10: Spring (negative pressure only)

B
Description of the different parts

1: The membrane

- The membrane area: to a given pressure, the larger the membrane area, the greater the force with which the membrane pushes the contact system.
- The membrane flexibility: it is essential for the realization of switches that are measuring low pressures below 0.1 MPa (1 bar). Elastomers used must be flexible and resilient. In general, the lower the pressure to be, the more flexible the membrane must be for fine for good sensitivity.
- The membrane thickness: the thin membranes cannot withstand high pressures. The thickness of the membrane will be optimized to give the best sensitivity while resisting the maximum pressure to which it may be subjected in operation. The maximum pressure limit can vary from 0.05 MPa to 1 MPa depending on the models and thicknesses.
- The temperature resistance of the membrane:

Compared to metal diaphragms, elastomeric membrane have the advantage of flexibility, allowing the use for low pressure measurements. Elastomers are still limited by their temperature (usually not more than 85 ° C in constant temperature), although it is possible, under certain conditions to use silicone membranes that offer greater thermal resistances (up to 125 ° C or more).

- The chemical resistance of the membrane:

The type of elastomer must be compatible with the nature of the fluid or liquid with which the membrane comes into contact. In addition, it must not harden or crack over time. The gas or liquids in contact with the membrane can have a corrosive or destructive effect on short, medium or long term on it, eg ozone, chlorine and its compounds, bromine and its compounds. The chemical composition of the membrane and how it is vulcanized or molded are the parameters that will influence this resistance.

- Contact with drinking water:

In some applications, when the float is in contact with drinking water, health standards are added, which regulate the chemical composition. The highest standards known, that are used as a normative reference in many countries are those issued by the FDA (Food and Drug Administration, USA) and the WRC (water research council, GB). These standards provide particularly maximum permissible surface in contact with water and the maximum temperature at which the plastic may be exposed without harmful compounds are released into the water. The WRC also tests elastomers to ensure that they do not facilitate the spread of bacteria.

- The number of membranes: some countries and safety standards require two membranes, especially for applications where the switch is in contact with water or people can be immersed. This solution is available in most products however it reduces the accuracy of the pressure switches.

2: Electrical contacts

A certain force is required to actuate the electrical contact device. It can range from a few grams for systems with creep action contacts, to several hundred grams for snap action micro-switches.

In general, the force required to operate an electrical contact increases with its electrical rating.

Creep action contacts

In apparatus slow breaking both sides deviate slowly at speeds of the order of 1/10 mm per second.

In the normal atmosphere, then occurs when the contacts are close together, an electrical arc.

The length of this arc is a function of voltage.

For voltages up to 24V DC or 110V AC, the duration of this arc is short, less than 0.1s.

For higher voltages, the arc lasts much longer, producing premature fusion of the contact, and many radio interference.

This is why it is not recommended, despite the mechanical advantages (simplicity, low cost, high precision) to use this contact in 230V networks to control multiple cycling applications.

Their disadvantages:	Their advantages:
- Do not allow to cut high amperages due to the large arcs (and the radio interference which are the consequence) that occur between the contacts when they are in close proximity to each other. As electric arcs increase with voltage, they are generally not used for voltages above 24V.	- Inexpensive
- There are no slow break pressure switches with a changeover contact, they are usually designed to close the contact when the pressure rises (normally open contact NO), but some models are available with a contact which opens with increasing pressure (normally close contact, NC).	- Low operating force allowing the use for low pressure values.
	- Low differential values between high and low pressure switching levels.
	- Easy and inexpensive making of gold-plated contacts for use in low voltage.

Snap action contacts

On snap action switches, the contact opening speed is around 1m per second (100,.000 faster).

The contact spacing reaches 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 micro switch is particularly suitable for devices operating at 240 or 400 V.

Their disadvantages:	Their advantages:
- Expensive	- High ratings in 110 and 230V, up to 30A.
- Large actuating force limiting their use in low pressure or requesting the use of large diameter membranes	- NO, NC or SPDT contacts
Large differential travel on the switch, affecting the accuracy of pressure control and providing important distance in high and low pressure switching levels.	- Snap action contacts do not generate EMC

Silver contacts, gold plated contacts

The contact of a micro-switch wears by micro vaporization at each open and close cycle. This wear is proportional to the strength and duration of the electric arc.

The most common contact material is pure or alloyed silver. This material was chosen because it is the best conductor of heat and electricity known.

Its thermal conductivity quickly evacuates the temperature peak occurring during

these cycles.
Its very good electrical conductivity provides very low contact resistance, usually less than 3 milli-ohms.
However it oxidizes and is gradually covered with a thin layer of silver oxide, which is not electrically conductive.
This layer is easily vaporized when the switch is used in common household voltages (240V, 300V). However, when used in low voltage (less than 12V) and very low currents (a few milli-amps), and less than 800mW, the contact opening arc is no longer sufficient to vaporize the silver oxide layer. The solution is to plate the contact with a thin layer of gold (said gold flash) 3 to 5 microns thick, to ensure its protection.

Comparison of contact materials and plating

Silver and silver alloys	Gold plated silver
High electrical rating, mandatory use for electrical rating higher than 1A 250VAC	Cannot be used on voltages lower than 0.1 millivolt, because the contact resistance is too high.
Oxidize and the contact resistance increases with time if they are used to cut electrical rating less than 20V and 100 mA	The use on voltages higher than 30V and / or with currents above 100 mA causes vaporization of the gold flash protection. Then contact behaves like a standard silver contact
Cannot be used in oxidizing atmosphere	If the load is less than 30 mV and 10 mA, there is no change in the contact resistance and the electrical life becomes very important (except atmospheric contamination by hydrocarbon)

3: The pressurized body (pressure chambers)
The pressurized body consists of two half-shells which enclose a membrane. It must meet several constraints.

Pressure resistance:
The design must allow these shells to withstand the maximum pressure at which the switch will be submitted. If the switch is subjected to a pressure greater than the pressure for which it was designed, the body will deform or break.

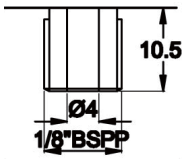
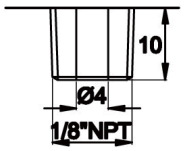
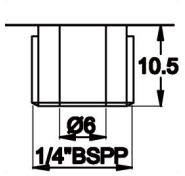
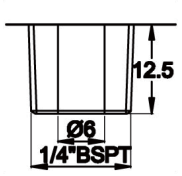
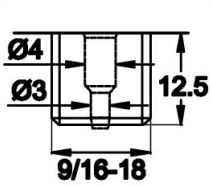
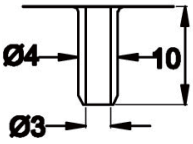
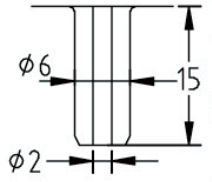
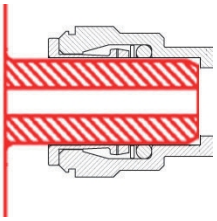
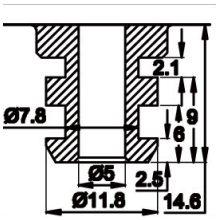
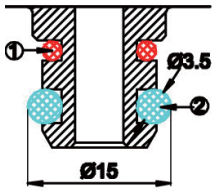
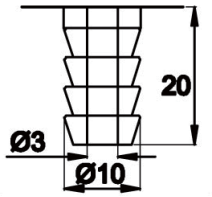
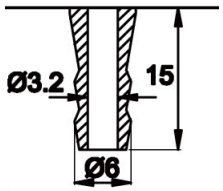
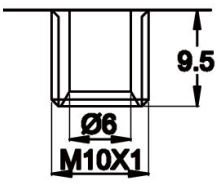
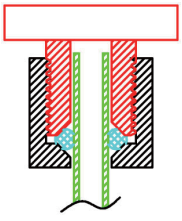
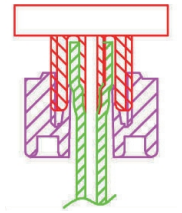
Temperature resistance: the pressurized bodies of pressure switches are made of plastic. Plastic strengths decrease with temperature. Any abnormal temperature rise, out of specified limits will result in a decrease in pressure resistance.

Use in contact with drinking water: when plastic is in contact with drinking water, sanitation standards require that plastic does not release harmful chemicals into the water. The standards and accepted concentrations differ by country, but all give a maximum operating temperature of plastic materials related to temperature. If an application requires compliance of these standards, it is necessary to provide the standard to be met and the maximum water temperature at which the switch will be submitted.

Corrosion: Some disinfectants chemicals, such as ozone and chlorine compounds used in swimming pools and whirlpools can damage some plastics. It is necessary to inform us if such conditions are encountered in the application, so that the choice of the plastic parts in contact is made wisely. In some slow-break switches, especially differential pressure switches for air, the electrical contacts are in contact with the fluid in the pressure chamber where they are located. Thus these contacts are in the presence of air from the pressure source to be measured, and therefore may be oxidized or corroded by the latter. It is important in these applications, to provide information on the quality of the air which pressure is measured.

4: The back pressure spring
We always make the back pressure spring in stainless steel to withstand various environmental media encountered in applications.
When a switch is subjected to a pressure greater than that for which it was designed, the back pressure spring, or the contact mechanism will be subjected to high stresses that can cause a permanent deformation and thus, result in the set point change of the device.

5: The pressure inlet
The connection can be done according to several basic systems.

Description	Drawing	
	Cylindrical	Conical
By a plastic thread. The most common are M10 x 1 1/8 NPT, 1/8 BSPT, 1/8 BSPP, 1/4 NPT, 1/4 BSPT, 1/4 BSPP. This system is frequently used to control pressure of liquids.	 Parallel thread	 Taped thread
	Cylindrical	Conical
By a metallic thread. The most common are M10 x 1 1/8 NPT, 1/8 BSPT, 1/8 BSPP, 1/4 NPT, 1/4 BSPT, 1/4 BSPP. This system is frequently used to control pressure of liquids.	 Parallel thread	 Taped thread
By a fluted or smooth spout for 6x3mm flexible tubes and other diameters. This system is frequently used to control air pressure or vacuum, and for pneumatic remote controls. This solution must be used for low pressure, less than 250 mBars.		
By a smooth spout dia. 6 mm for "Push in" fittings (ISO14743)		
By quick assembly tip without thread, with O-ring seal. This system is widely used in mass production applications in water heaters, boilers and appliances (1: retaining clips, 2 O-ring)		
By a barbed spout for flexible PVC tubes. This system is frequently used to control pressure or air in pneumatic control systems. Pressure limited to 500mbar.		
With a threaded spout, with O-Ring gasket compressed by a nut on a soft or hard tube.		
With a smooth spout for 6x3mm flexible tubes and clamping nut. This solution is used in air switch tubing. Maximum pressure 1 Bar (0.1 MPa)		

6: The adjustment system

Adjusting a pressure switch is made by a force opposed to the movement of the membrane actuating the electrical contact system. This force is produced by a spring which is more or less compressed depending on the setting value to obtain. There are three possible settings:

Description	Drawing
- Fixed setting: there is no adjustment possible, as the force is provided by a calibrated spring which is not reachable. This type of control is inexpensive, but with quite large setting tolerances. It is suitable for mass production.	
- Sealed setting: the setting is provided by a screw which compresses the spring more or less. After adjustment, the screw is factory sealed. This type of setting is accurate but not accessible by the user.	
- Unsealed setting: the end user can change the set point value of the point by himself, with a screw, a dial or a knob. This type of setting is for advanced users.	

7: The electrical connection

Description	Picture	Description	Picture
Pins for printed circuits		Screw terminals	
Tabs		Lead wires	

8: The protection housing

The protection housing can have two functions:

- Ingress protection against attacks from the outside environment (rain, dust, shock)
- Protection against the conditions in which the product will be installed in its application.

In most cases, pressure 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 usual external environment: These are usually plastic housings providing an IPxx (Protection against the penetration of water and dust, EN 60529 ingress protection) and an IKxx (Protection against shock, EN 50102).

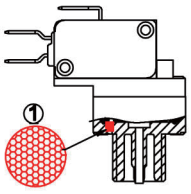
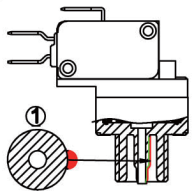
Some pressure switches may receive protection by epoxy resin or polyurethane potting. The pressure switches themselves have an IP00 degree of protection as they are components to be integrated. Some safety standards require a particular degree of protection

- Protection during the welding process: special protections are required if switches are soldered on electronic circuits (pressure switches with pin terminals). The solder flux is corrosive and can penetrate by capillarity and cause the oxidation of the contacts. Their use should be limited to a minimum. Similarly, the duration

and the temperature at which the pressure switch terminals are subject may, if they exceed certain limits, cause melting of the plastic body of the switch and its deterioration or change its set point.

- Protection against gas and dust explosive atmospheres: Ultimheat level switches are not designed for use in these environments and therefore do not meet the applicable standards in this field of application.

C
Air switches and pressure switches, what differences?

Pressure switch	Air switch
A pressure switch is a pressure control device	**An air switch is a remote control device**
Pressure switches are used to control the pressure of a medium and operate an electrical device. When pressure rises to the set point value, they switch off the equipment or switch on an alarm. Fluid they control can be air or water. There is no barometric or ambient temperature compensation in pressure switches. There are 3 types of pressure switches : **- Positive pressure switches,** **- Negative (vacuum) pressure switches,** **- Differential pressure switches** (pressure difference between 2 pressure ports) There are two types of pressure switches electrical action: **- Pressure control:** they switch off the set point is reached and when pressure goes down under the pressure hysteresis value (also named differential), they automatically switch on again. **- Pressure high limit, with manual reset:** they switch off when the set point is reached and do no automatically switch on when pressure decreases. To restart, it is necessary to manually actuate the reset button **Unique features of pressure switches** **1. Wide range of pressure connection systems:** - Center spout for 1/8" and 1/16" OD soft tubing with 1/4"NPT mounting screw (fits also directly on 1/4" pipes threads) - Center spout for 1/8" and 1/16" OD soft tubing with 9/16-18" mounting screw, 2 flats D slot - Side spout for 1/8" and 1/16" OD soft tubing - 1/8 NPT plastic or metal thread - M10 x 100 plastic or metal thread - M8x 125 metal tread - 1/4 BSPP plastic or metal - Barbed fitting (metal) - 1/4 NPT plastic or Brass or stainless steel, - Snap on with O-ring **2. Easy to handle:** -1 " (25 mm x 25 mm) square shape housing easy to hand screw **3. Riveted switch and mechanism:** - No end customer access to mechanism and unknown changes, **4. Air switches temperature and pressure compensation:** - Located inside the 1/4 NPT thread or beside: no air leak inside the electrical body, means no condensation inside it and no electrical hazard. **5. Worldwide switch approvals:** Most of products are UL(file E246956) and they use UL,CSA,CE, VDE, ENEC approved microswitches in standard. The same model can be used anywhere in the world. **6. Wide range of accessories:** Self-locking stainless steel or common plastic nuts, tubing, hose securing nut, adhesive gaskets, housing. **7. Tough Membrane design:** - No barometric compensation hole in membrane, rejected by some certification laboratories or customer applications, - Most products designed to receive 2 membranes to comply with class II insulation requests in Europe. **8. Lowest market price and adapted solutions:** - 50 years OEM components experience: trained manufacturing organization: we made our first pressure switch in 1945. **9. The world largest air switch range:** PC board types, snap action switches for high voltage and ratings or slow make and break contact for electronic application, silver, gold or copper contacts, 1 switch, 2 switches, 3 switches, 1 or 2 membranes and plenty of pressure connection fittings	An air switch is a wireless control used as an electrically safe remote control to operate motors or pumps or electrical devices. This is a shockproof, explosion proof and waterproof system. The system works on a sealed air displacement principle. It uses an air bellows actuator (air button, foot pedal) joined by tubing to an air switch contained within the equipment or appliance to be switched. As the transmitter button is depressed and released, sealed air is displaced and transmitted through an air hose connected to a pressure sensitive switch, switching the equipment on. Air switches have integrated compensation system (usually a small calibrated leak named bleed hole) to avoid an erratic operation due to internal air volume pressure difference with the ambiance when temperature or barometric pressure changes. Most common applications are in swimming - pools, spas and hot tubs, showers, saunas, plumbing tools, sink erasers, garbage disposals. They switch motors, pumps, lights, blowers or pc board loads. **They exist with two types of actions:** **- Latching (or bistable):** The circuit remains energized until the air transmitter is depressed and released again, switching the equipment off. **- Non-latching (or momentary):** The circuit is energized when the air transmitter is pressed. When the air transmitter is released, it switches off. **Air switches applications:** - When a standard electrical switch is impractical, hazardous or impossible, - To increase safety. An air switch is a safe and convenient on/off remote control for use in wet, humid or watery places As only air is used to switch a distant electrical circuit, it provides full electrical insulation: no risks of electrical shocks, sparks or explosion at the point of actuation. Therefore, it is the best choice for hot tubs, spas, whirlpools and garbage disposals Air switches are also a cost effective solution in some hazardous locations (e.g. explosive vapors such as gasoline or other solvents). - Air switches eliminate spurious switching signals and electrical interferences which can be picked up by cables used on low voltage circuits. - Easy installation: no electrical wiring between air switch and transmitter - Air switches are the most economical solution for short distance remote control. **How to select an air switch:** 1.Select action (latching or non-latching). 2. Select rating, number of switches, contact: depends of what you want to switch (motor, relay, low voltage electronic board). 3. Select sensitivity: the maximum operating distance is linked to length of PVC tubing between air switch and air button, volume of air button. Avoid small volume air button and long tubing. Sensitivity decreases when rating increases. A high rating air switch can only be used with short distance tubing.
	 Air switch with bleed hole on pressure chamber
	 Air switch with bleed hole on air spout

D
Important parameters to select a pressure switch

Accuracy, actuating force and differential are given by membrane surface.
The bigger the surface is, the better the accuracy is, and the lower the differential is. Surface is proportional to the square of diameter. A 45 mm diameter membrane pressure switch will be 4 time more sensitive to pressure than a 22 mm diameter membrane because it will need 4 time less pressure to actuate a mechanism that need the same operating force.
Sensitivity is also given by the membrane hardness, and its thickness. The thinner it is and the softer it is, the more sensitive the pressure switch is. But thin and soft membranes cannot withstand high pressure. Therefore, selecting a device is always a compromise between sensitivity and maximum pressure.

High rating switches need a high force to actuate them. The higher the electrical rating is, the higher the force needed to actuate the contact is. It is very difficult to actuate high rating switches with low pressure and small membrane surface.

The selection of a pressure switch model will therefore take into account:
- The pressure ranges which must be submitted,
- The fluid or liquid to be monitored,
- The type of contact (NO, NC or SPDT),
- The electrical rating (voltage, amperage),
- Whether or not of a setting by the user,
- The use at positive pressure, vacuum or differential,
- Its pressure connection (fitting type),
- The environment (protection against water, dust, shock)
- The temperature at which the membrane is exposed.

For example, a small diameter membrane (25mm) is sufficient to actuate a slow break micro switch at 20 millibars with a 1 ampere rating, but it will take a 45 mm membrane to operate at the same pressure a snap action switch with a 15 amperes rating.