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2014.7.5000(Z)

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Basics of Float-Type Level Switches

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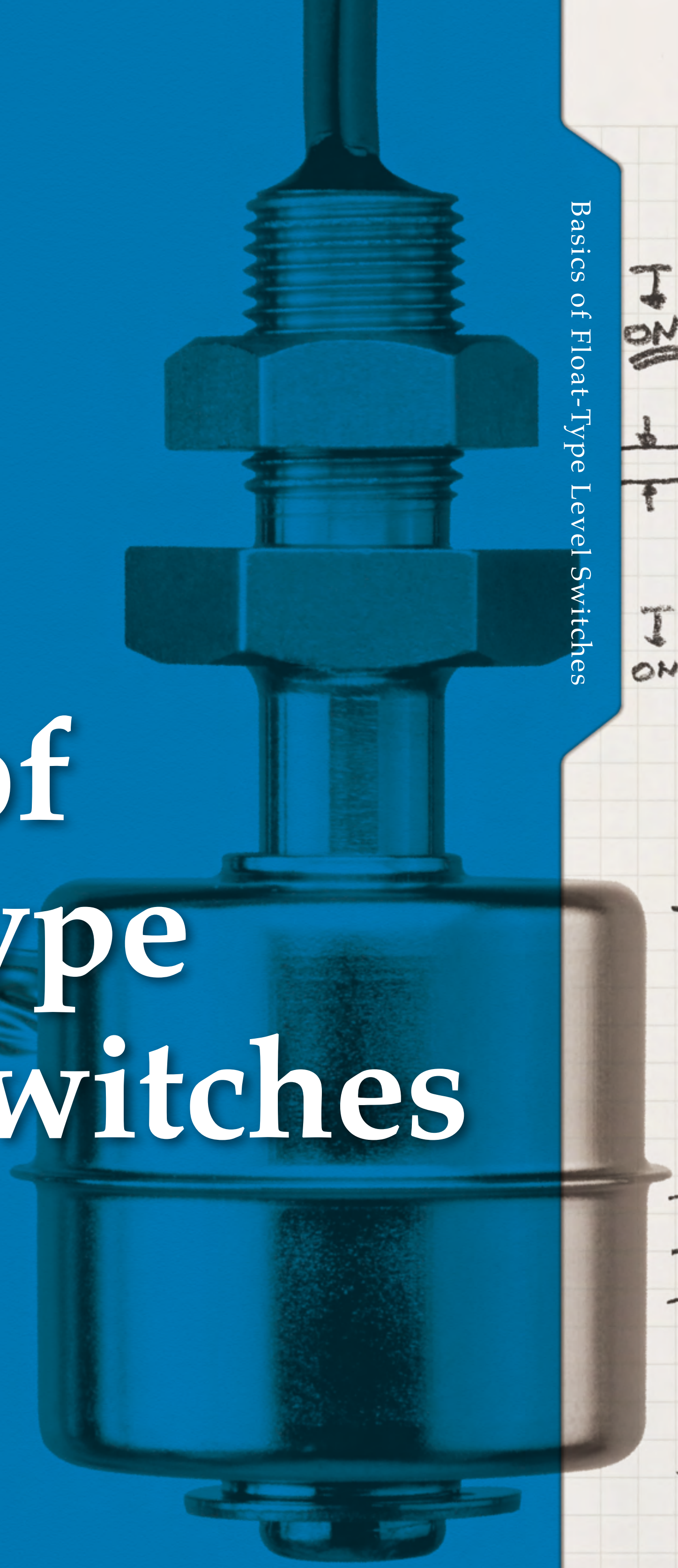

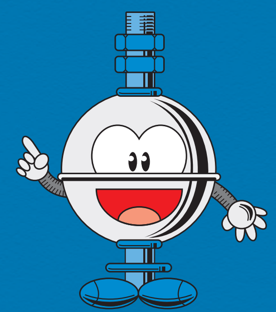

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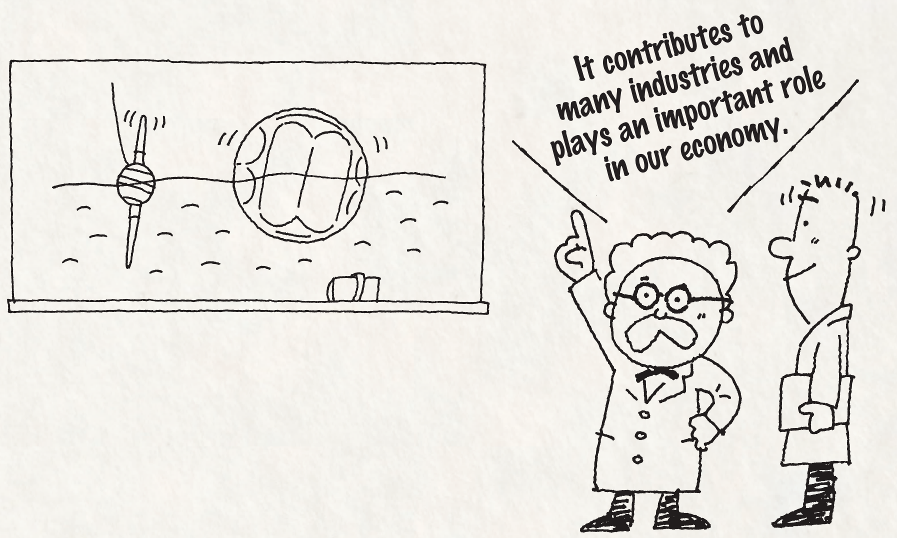
Float-type level switches are indispensable in a variety of industrial applications.

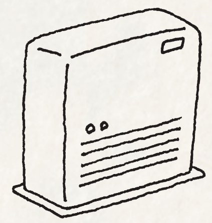
A sensor is a device that converts various physical phenomena or changes in such phenomena into signals and data for output. The many types of sensors available are used to monitor position, pressure, temperature, humidity, and level of a liquid surface. In this article, we will restrict our focus to the sensors that detect the level of a liquid and explain the float-type level switch.

This type of sensor, which precisely detects and measures the amount of liquid inside a container or the like, is generally referred to in short as a "float switch."

As a usage example, when the liquid level in the container rises and the liquid level exceeds the standard (or vice versa), it causes the level switch to contact (detection), triggering a beep sound and activating a control unit. In other words, it has an important control function.



Typical applications of the float-type level switches

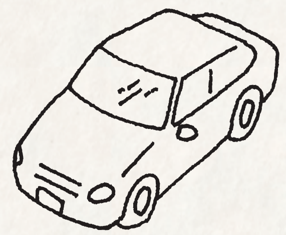


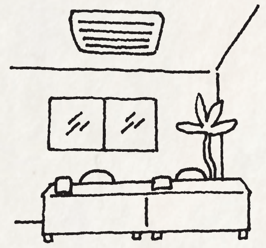
Kerosene heaters

Shuts off the combustion pump and triggers a lamp and buzzer when the kerosene is depleted.

Motor vehicles

Illuminates a warning lamp on the instrument panel when the brake fluid runs low.



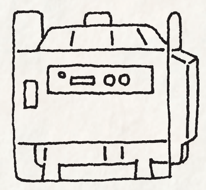


Commercial-duty air conditioners

Turns on a pump to drain the water when the drain pan of a ceiling-recessed air conditioner is full.

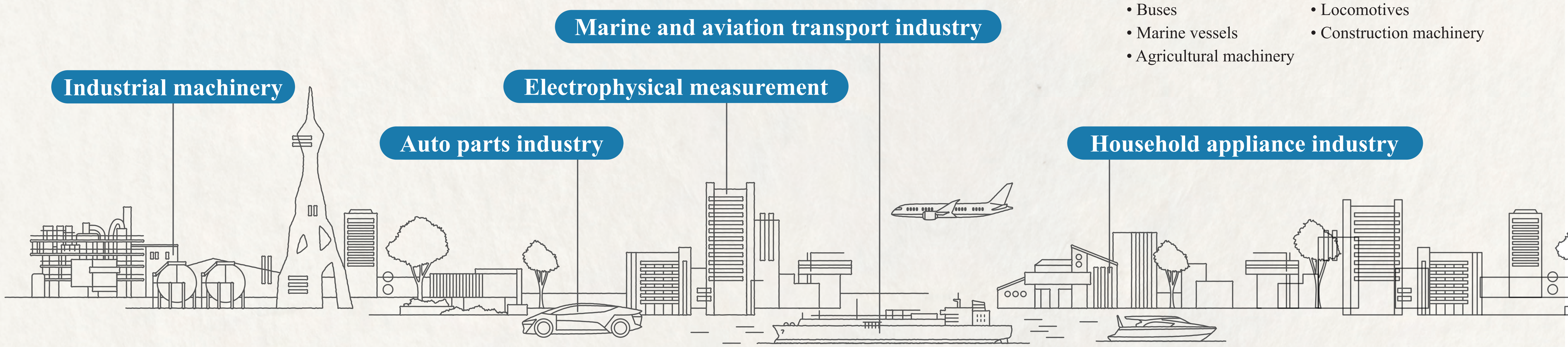
General-purpose engine

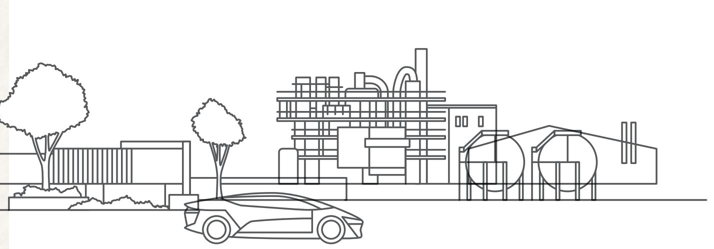
Lights a lamp and shuts down the engine when the oil level is low in a general-purpose engine used for the generator of a food stall or outdoor facility.



Other applications

- Heated toilet seats
- Car wash machinery
- Diesel equipment
- Buses
- Marine vessels
- Agricultural machinery
- Machine tool lubricant
- Fast photo developing machines
- Trucks
- Locomotives
- Construction machinery





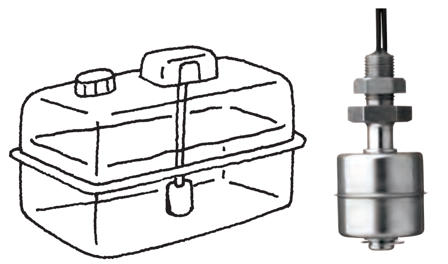
Contents

Riko’s float-type level switch flexibly accommodates the movement of specific liquids.

As liquid flows, the float rises and falls, enabling the float-type level switch to detect the liquid level (as a liquid surface) as the reed switch inside the main unit cycles between ON and OFF status from the magnetic force of the magnet contained in the float.

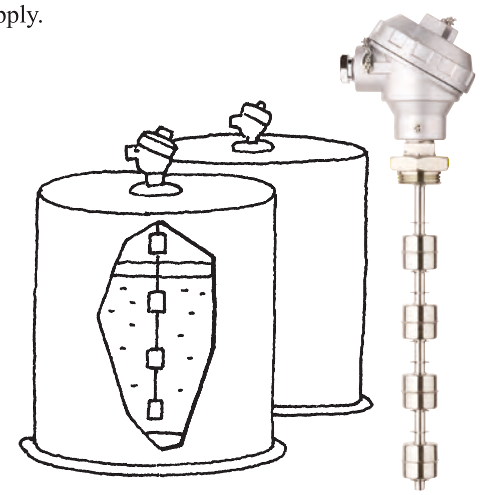
General Applications

Detection of a liquid quantity and control of an electric system



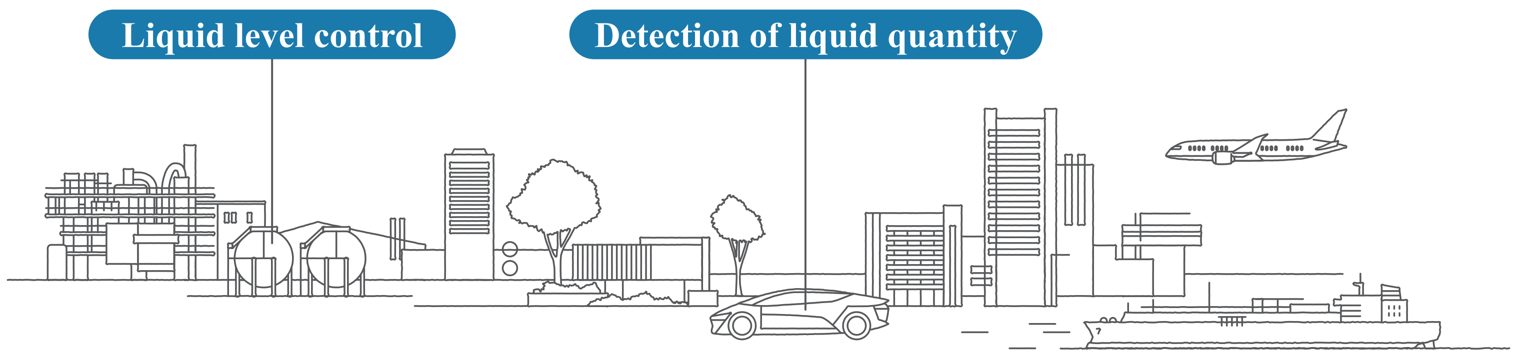
Generally, an alarm triggers a lamp or buzzer from the electrical signal generated when the float switch detects that the liquid in a tank is depleted or replenished.
This approach is used in many control systems that actuate or turn off a motor or heater by closing or opening a power supply.

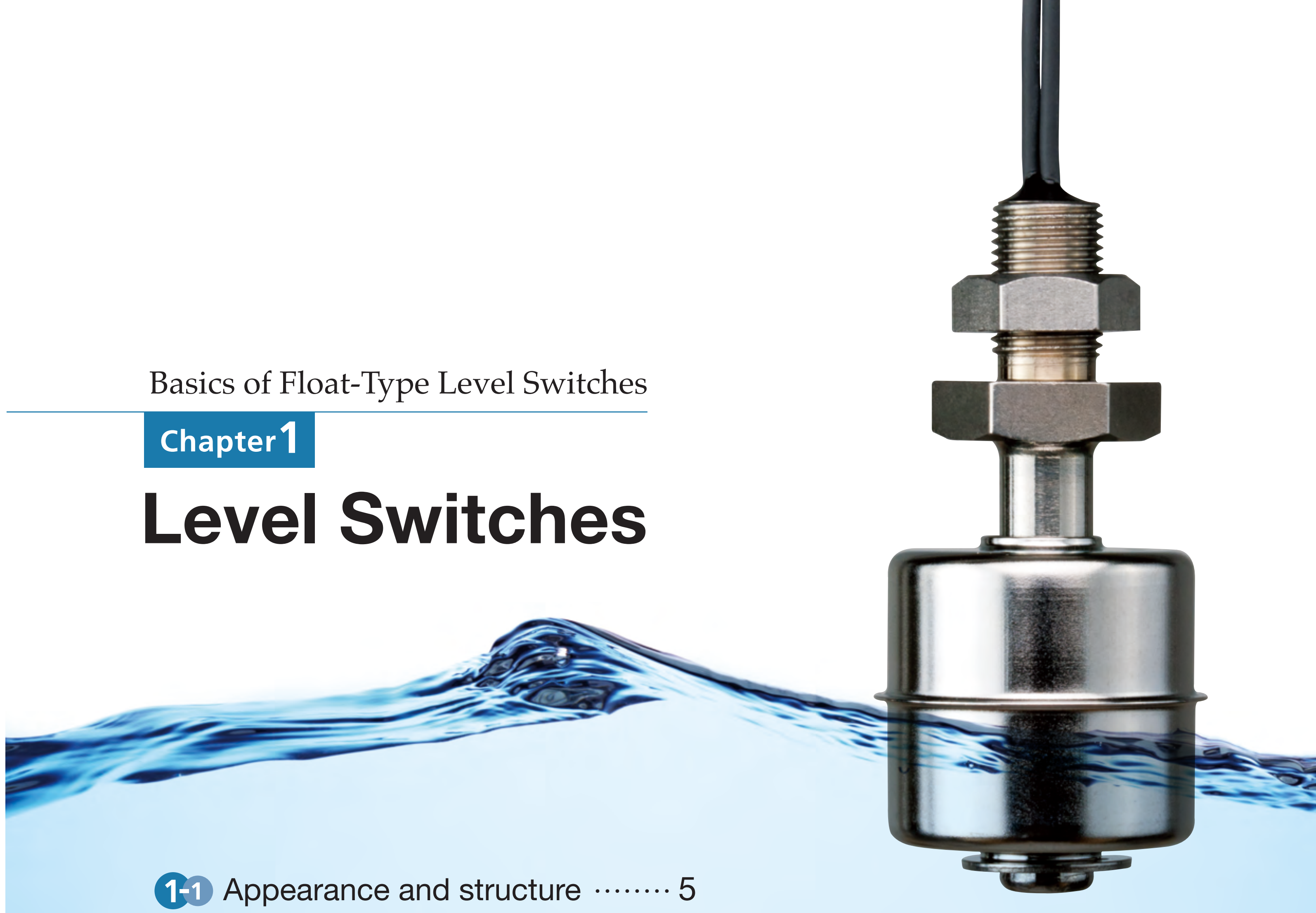
Widely used in liquid level control



The float-type level switches are available with one, two or three contact points, allowing you to select the most suitable for a particular application.
All models are used for control of a liquid level and can be used in various industrial plants, unmanned flexible manufacturing systems, space heating and cooling units, washing devices, and various medical applications for the health-care profession.

Let’s read a basic introduction to float-type level switches.





Basics of Float-Type Level Switches

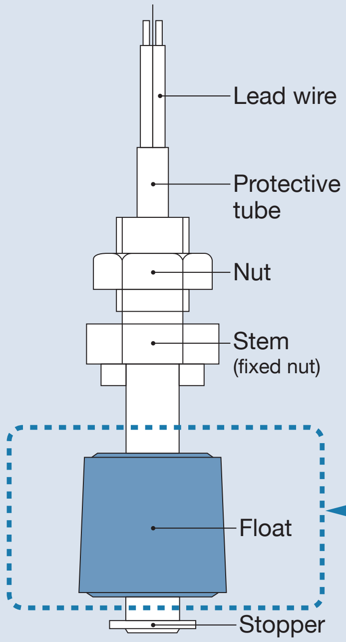
Chapter 1

Level Switches

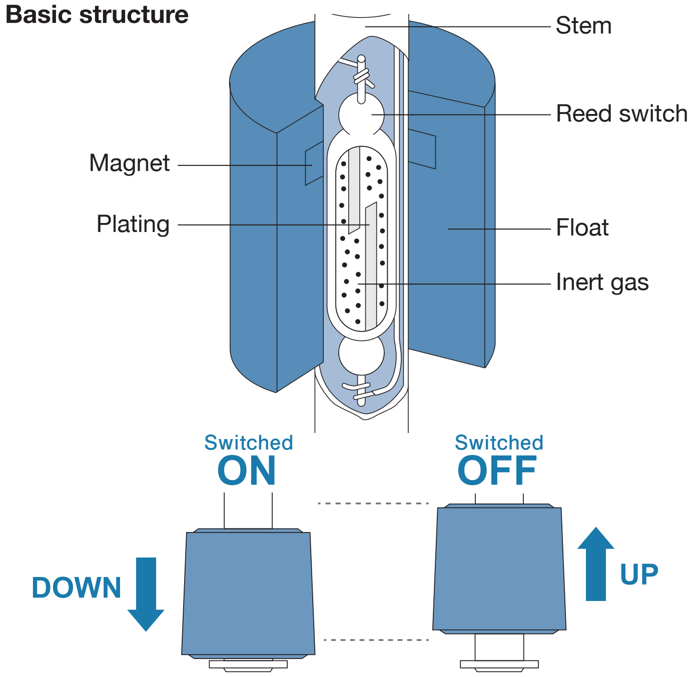
1-1 Appearance and structure

Here, using the example of a Type MFS 17 Level Switch, we explain the name and structure of each part. As outlined in the figure below, as the float falls, it has the status of "switched ON." Likewise, as the float rises, it has the status of "switched OFF."

■ Outline view and nomenclature



■ Basic structure



■ Typical models


MFS17-A


MFS17-B


MFS17-C

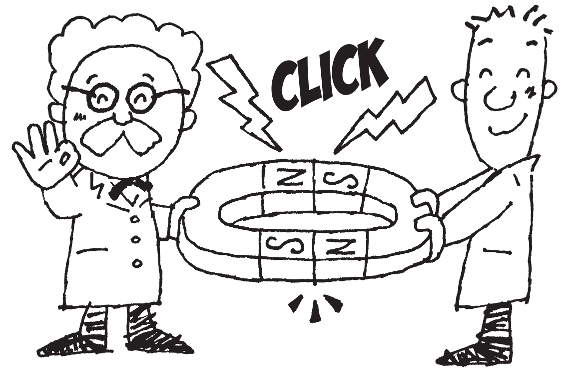

MFS17-D

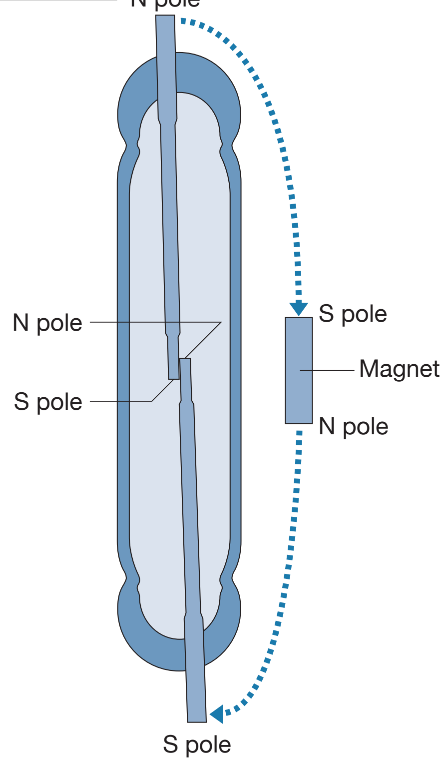
1-2 Features of the level switch

1. The simple mechanism is relatively trouble-free.
2. The compact design requires little space.
3. The highly reliable reed switch contacts have a high repeated accuracy and long service life.
4. No adjustment after installation is required, and little maintenance is needed.
5. The float-type configuration accommodates non-conductive liquids.
6. The stable design exhibits little irregularity of movement.
7. It is lower-priced than other types.

1-3 Operation principle

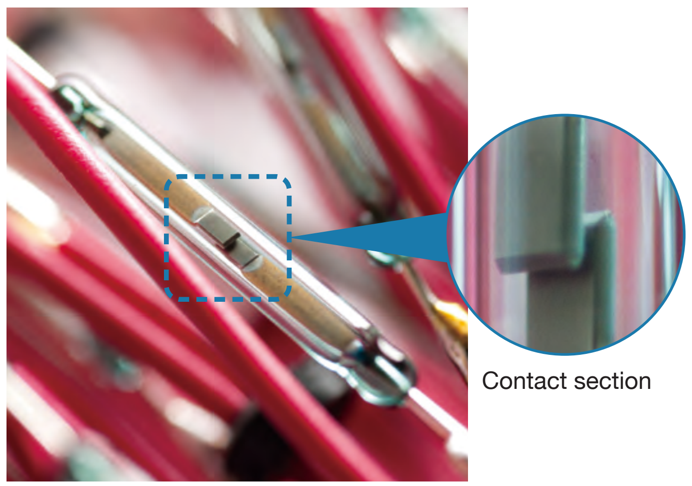
A reed switch is mounted inside the stem of the float. The magnetic field of the N pole and S pole generated by the magnet acts on the reed section of the float, which enters the ON state as a result of magnetic attraction. When the magnet is moved away, the magnetic field is removed and the reeds' elasticity opens the contacts, restoring the OFF state.

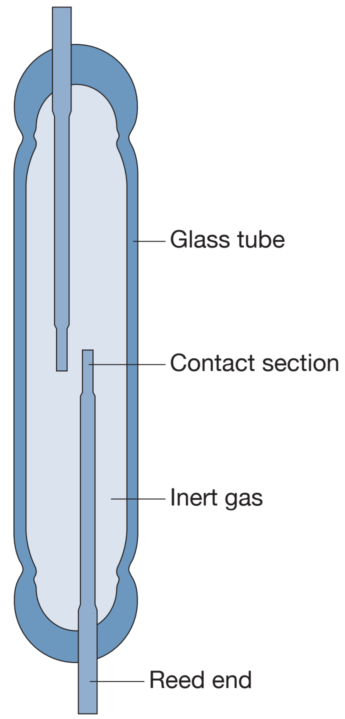




1-4 Structure of the reed switch

As shown in the figure, a reed switch comprises two ferromagnetic reeds enclosed within a glass tube. To prevent oxidation (rust) of the points of contact, the tube is filled with an inert gas (nitrogen) and the surfaces of the points of contact are plated with a noble metal such as rhodium. (In the case of a single reed switch, the contacts are spread apart.)





1-5 Model nomenclature

MFS Series

M	F	S
Miniature	Float	Switch

Base material of product (such as stem and float) is plastic.

RFS Series

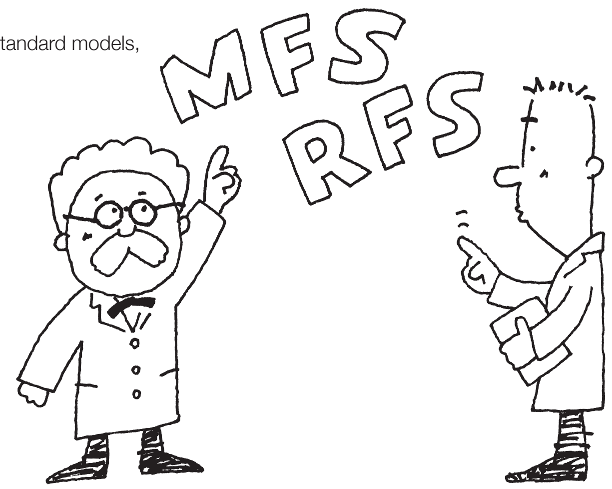
R	F	S
Riko	Float	Switch

Base material of product (such as stem and float) is stainless steel.

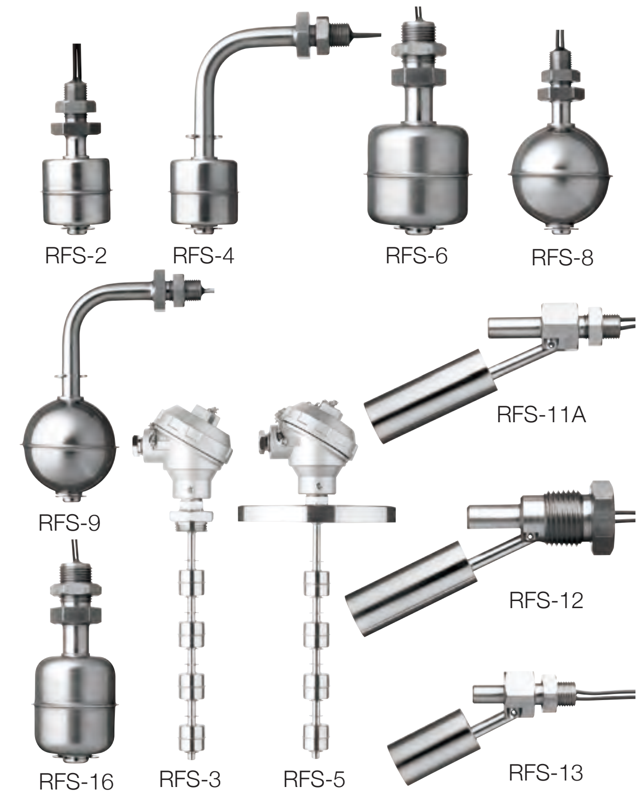
■ Examples of model names

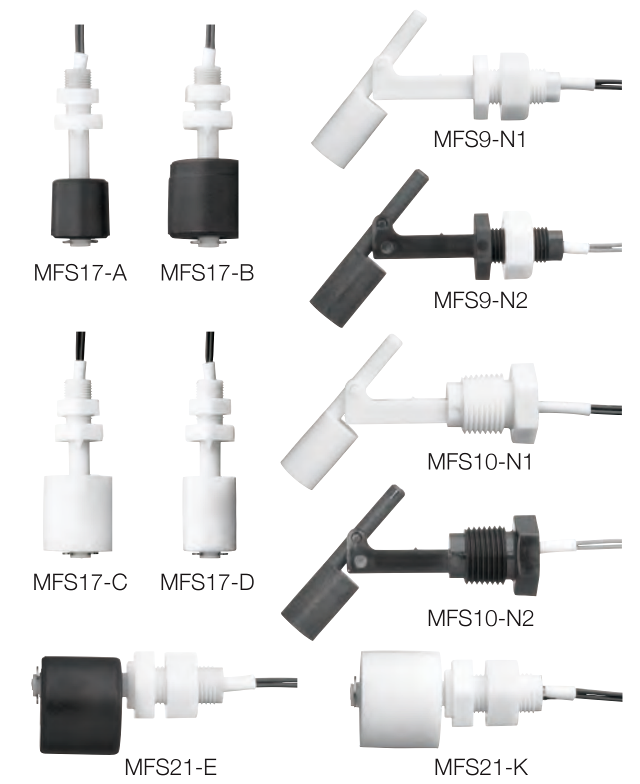
MFS17-A	MFS (base material: plastic), 17 (model, development no.), A (float number). The MFS series includes a float number because in many cases only the float material differs from that of the stem of the same model. In some cases, different materials can have the same shape. 
RFS-2	RFS (base material: stainless steel), 2 (model, development no.) With the RFS series, a model without a stainless steel float is indicated as RFS-2; a model provided with a "B float" is indicated as RFS-2B. 
PVC-2C	Essentially the same as the RFS Series but designed with PVC (polyvinyl chloride) as the base material.
TFS-8	Essentially the same as the RFS Series but with some titanium parts (those in contact with liquid, including the main body, float, and stopper). The "T" indicates titanium.
HFS-2	The HFS Series is unique in indicating "H" for hysteresis. Note: "Hysteresis" refers to models with a level switch requiring a large measurement difference to cause switching between the ON and OFF states (large distance required to switch "ON → OFF" or "OFF → ON").
RFS-12H	The meaning of the "H" suffix in models RFS-11H and RFS-12H is not the same as the "H" prefix in HFS-2, which indicates a heat-shock-resistant type.

Note: Previously, a "-1" or "-2" suffix was appended to model numbers, such as "MFS17-A-1."
The suffix "-1" indicated a model with a maximum switching voltage of 100 V; "-2" indicated a model with a maximum switching voltage of 200 V.
In 2007, maximum switching voltage was unified at 200 V for all such standard models, eliminating the need for the "-1" and "-2" suffixes.

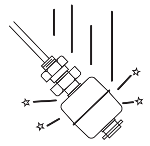
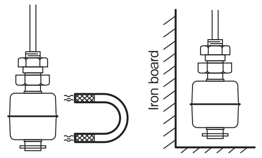
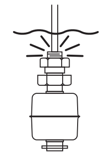
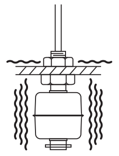
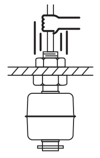
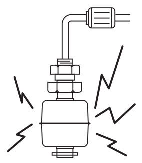
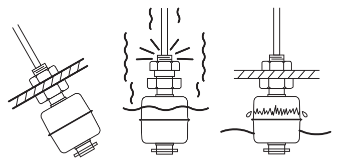


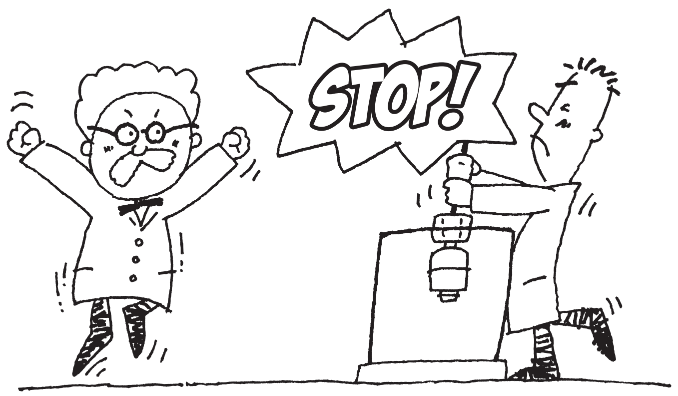
1-6 Features of different models (RFS models contain stainless steel parts; MFS models contain plastic parts)

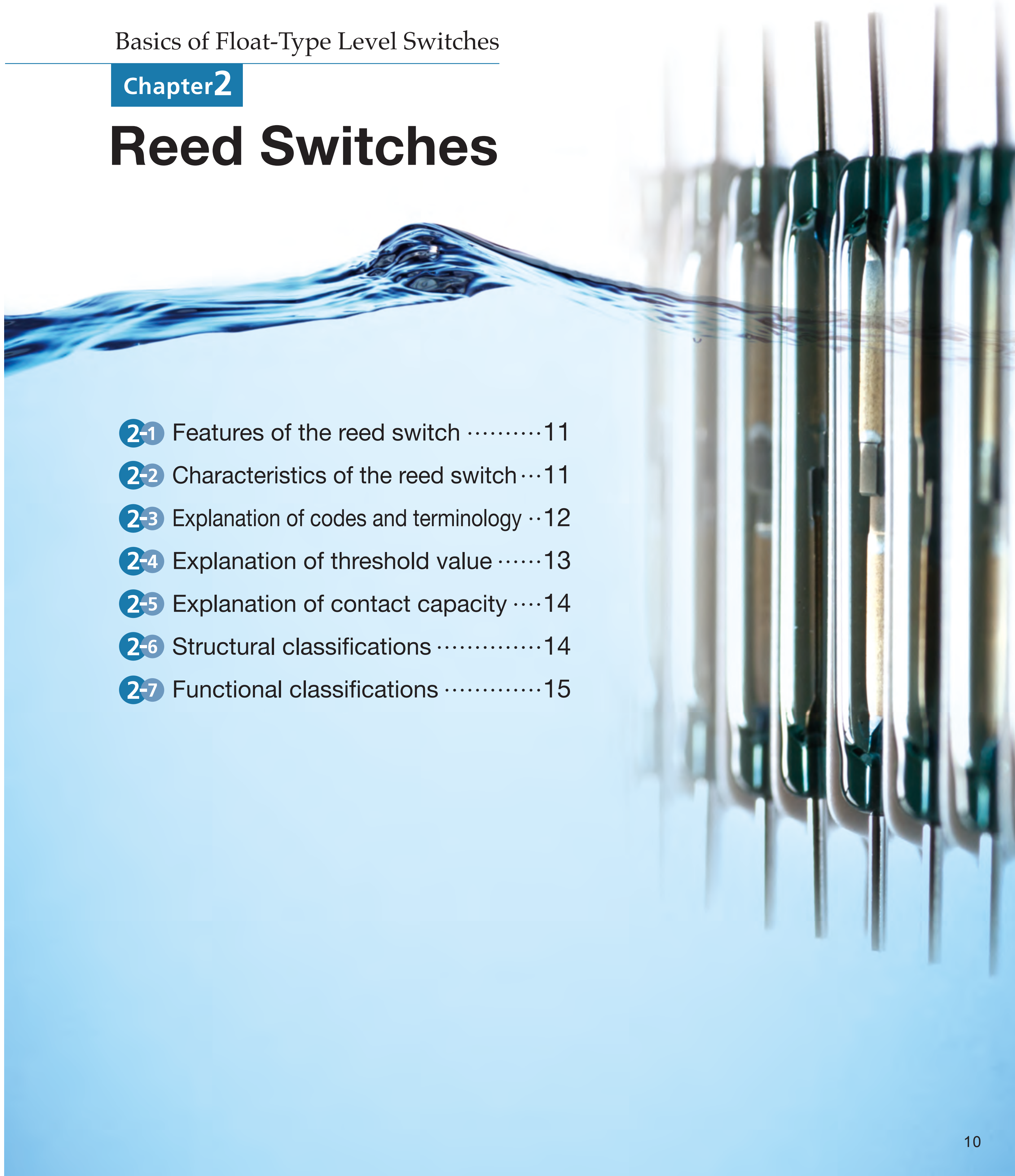
Model Name	Features	Product Examples
RFS-2	Compact	
RFS-3	Direct mounting from top	
RFS-4	Horizontal, L-shaped type	
RFS-5	Flange type	
RFS-6	Heat-resistant type (200°C max)	
RFS-8	Pressure-resistant type (4 MPa max)	
RFS-9	Pressure-resistant/L-shaped type	
RFS-11A	Horizontal, inner mounting	
RFS-11H	RFS-11A heat-resistant specification	
RFS-12	Horizontal, outer mounting	
RFS-12P	RFS-12 with connector	
RFS-12H	RFS-12 heat-resistant specification	
RFS-13	Ultra-compact horizontal/inner mounting	
RFS-14	Ultra-compact horizontal/outer mounting	
RFS-16	Heat-resistant type (200°C max)	
TFS-8	Titanium, heat-and-pressure-resistant specification	

Model Name	Features	Product Examples
MFS17-A	Compact design, oil-compatible	
MFS17-B	Compatible with oil and low specific gravity liquids	
MFS17-C	Compatible with water and chemicals	
MFS17-D	Compact design, compatible with water and chemicals	
MFS21-E	Horizontal, oil-compatible	
MFS21-K	Horizontal, compatible with water and chemicals	
MFS25-J	Compact design, compatible with water and chemicals	
MFS9-N1	Horizontal, inner mounting	
MFS9-N2	Oil-compatible version of MFS9-N1	
MFS10-N1	Horizontal, outer mounting	
MFS10-N2	Oil-compatible version of MFS10-N1	
MFS17-A (Union)	Union specification (Accepts extension rod.)	
MFS17-B (Union)		
MFS17-C (Union)		
MFS17-D (Union)		

1-7 Level switch handling precautions

1	Avoid external shocks.	External shock from a fall or the like can change the behavior of the reed switch, causing it to be permanently "ON" or "OFF."	
2	Keep away from magnetic fields.	The reed switch is activated by the magnetic field generated by a magnet. Any nearby magnetic field can cause a malfunction by triggering a false "ON" or "OFF" state.	
3	Never allow any liquid to penetrate the stopper.	Water or another liquid bypassing the stopper and penetrating the unit can result in a permanent "ON" state. In addition, even a small amount of liquid penetrating poor insulation can result in a short circuit.	
4	Avoid installing in locations subject to strong vibration.	The gap between the contacts of the reed switch is too small to be seen by the naked eye. If the level switch is located in an area subject to vibration, a malfunction can result.	
5	Never pull on the lead line.	In most models, the upper part of the unit is filled only with a molding agent. As a result, subjecting the lead line to excessive pulling force can result in the reed switch becoming dislodged. In some cases, this can result in a short-circuit from breakage of the lead line or tearing of the film.	
6	Provide circuit protection for the contacts.	Install circuit protection to safeguard the contacts if using an electric motor or solenoid valve capable of imparting an inductive load or surge load (inrush current) on the level switch that exceeds the load capacity of the contacts. (Also be cautious about backflow currents in the "OFF" state.)	
7	Other precautions	Using the device under conditions outside the specified values indicated in the catalog, or installing the device in an unstable diagonal orientation, can result in a malfunction or erroneous operation.	





Basics of Float-Type Level Switches

Chapter2

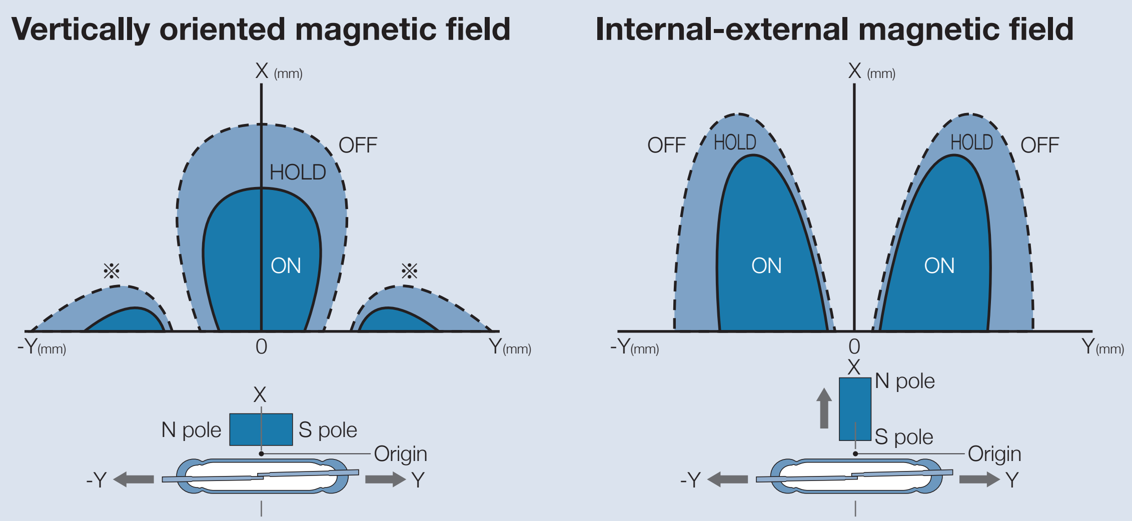
Reed Switches

2-1 Features of the reed switch

1. The contacts are unaffected by the outside atmosphere because they are sealed in a glass tube filled with an inert gas.
2. The small mass of the operating components results in rapid response.
3. The switch is compatible with products incorporating high-frequency transmission because the device circuitry and operation system is constructed with coax cable.
4. The switch features a lightweight and compact design.
5. The contacts offer a longer service life thanks to their superior resistance to wear and corrosion as well as their stable switching operation.
6. It can be configured as an economical proximity switch simply by adding a permanent magnet.

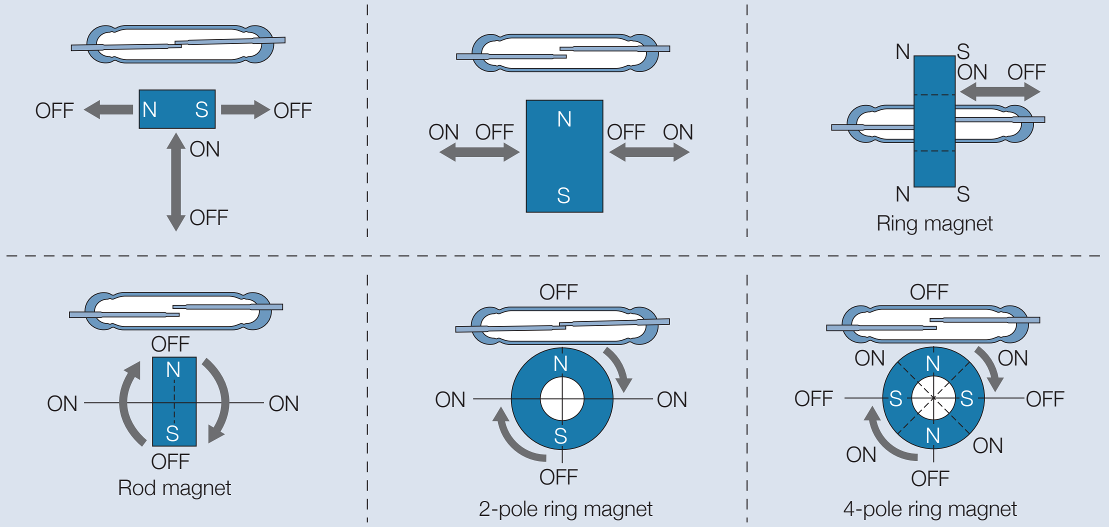
2-2 Characteristics of the reed switch

When constructing a reed switch that operates with a permanent magnet, the characteristics (ON/OFF states) vary with the kinds of reed switch, the threshold value, activation threshold, processing state, and the composition of the permanent magnet as well as its shape and magnetization state. The representative characteristics of the reed switch are shown below.



Notes • When a strong magnet is used, check operation at two or three points.
• Vertically oriented magnetic field and internal-external magnetic field are presented separately on p. 17.

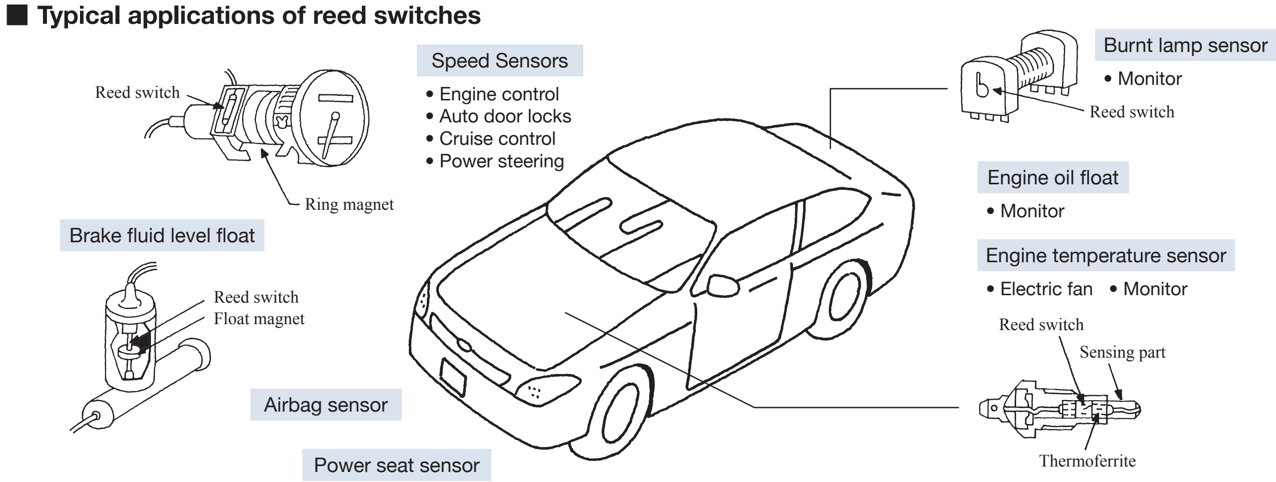
Other examples of activation



2-3 Explanation of codes and terminology

Term	Code	Unit	Explanation
Threshold value	PI	AT	This is the most important characteristic of a reed switch. It is the product of the current value and number of coil turns required to excite the coils and activate the contacts. [This represents the sensitivity of the reed switch; the lower the (numerical) threshold value, the higher the sensitivity.]
Activation threshold	DO	AT	This is a product of the current value and number of coil turns that causes the contacts to enter an activated state through coil excitation. It is correlated with threshold value and represents a secondary value.
Contact resistance threshold	CR	mΩ	This value is the resistance between the terminals when the contacts are closed and includes the conductor resistance.
Breakdown voltage between contacts		V	This is the breakdown voltage between the contacts. A reed switch can be safely operated at this maximum switching voltage; this is also the prescribed transient overvoltage that can be temporarily endured due to a surge on the circuit in use caused by an external factor or other similar phenomena.
Insulation resistance		V	Determined by the insulation resistance between the terminals, this is the resistance value for leakage current of the glass tube of the reed switch and its surface.
Contact capacity		W VA	This is the product of the usable voltage and current of the contacts and is an important value in establishing switching performance. This value must not be exceeded during opening and closing of contacts to ensure their longevity and reliability. The value will be less than the “maximum switching voltage” × “maximum switching current”. When designing, do not exceed the value of the product of the voltage and the electric current applied to the contacts. It is also referred to as the allowable contact power or contact rating.
Maximum switching voltage		V	This is the maximum voltage capable of activating the contacts and the reference voltage for determining performance of contact switching. This is the value that must not be exceeded during opening and closing of contacts to ensure their longevity and reliability. It is also referred to as the rated contact voltage or maximum voltage.
Maximum switching current		A	This is the maximum current capable of activating the contacts and the reference current for determining performance of contact switching. This is the value that must not be exceeded during opening and closing of contacts to ensure their longevity and reliability. It is also referred to as the rated contact current or rated disconnection current.
Maximum activation current		A	As the maximum current value for activating the contacts, this is the current value for activating the contacts in succession without switching the contacts. Exceeding this current value when activating the contacts can compromise their longevity and reliability. It is also referred to as the rated activation current or the maximum contact activation current.
Resonance frequency		Hz	This is a vibration frequency specific to the particular reed switch. Exposure of the reed switch to a nearby vibration of this frequency can cause a malfunction.
Maximum driving frequency		Hz	This is the maximum driving frequency that permits normal opening and closing of a reed switch. Frequencies above this value can interfere with normal opening and closing operation signals in relation to operation time and bounce time.
Operating time	Top	ms	This is the time from application of a voltage to the activation coil until the contacts operate. Unless specified, bounce time is not included in operating time.
Bounce time	Tb	ms	This is the time from application of a voltage to the activation coil to close the contacts until the contacts are completely closed.
Standard coil		Number	This is a dedicated coil used to measure the characteristics of the reed switch. Various types of coils are used.

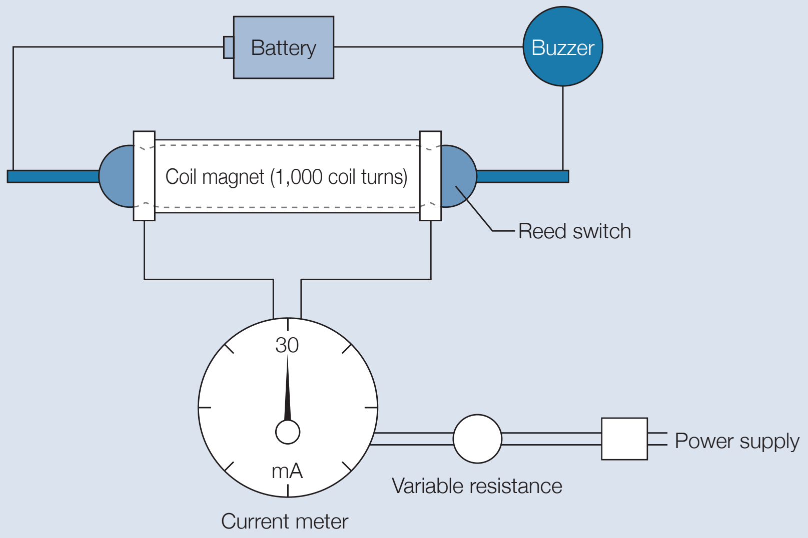
■ Typical applications of reed switches



2-4 Explanation of threshold value

Threshold value (AT)

This is the most important characteristic of a reed switch. It is the product of current value and the number of coil turns necessary to operate the contacts with a coil magnet. It indicates the sensitivity of the reed switch, and the lower the numerical value, the better the sensitivity (ON state achieved with a small magnetic field).



In the above illustration, if the buzzer sounds when the state is 30 mA, "30 mA" is "0.03 A", and

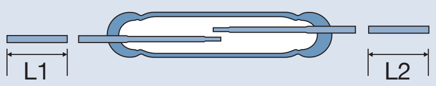
current 0.03 (A) × no. of coil turns 1,000 (T) = 30 (AT),
(amperes) (turns) (ampere turns)

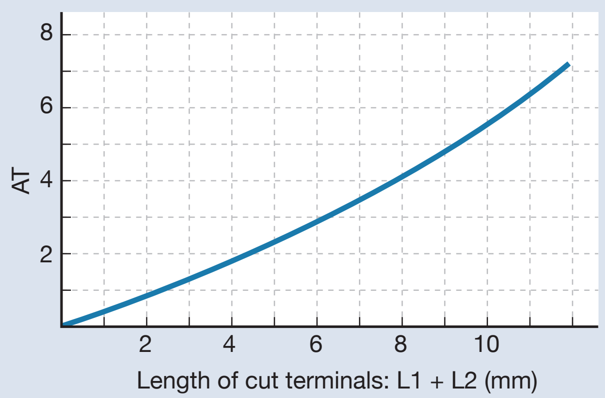
the threshold value of this reed switch is **30 (AT).**

Generally, the threshold value increases as the gap between the contacts increases, and the threshold value decreases as the gap decreases. (However, in cases of strong reed elasticity, the threshold value can be high even with a small gap; the opposite is also true.)

■ Variation in threshold value (example)

- The threshold value changes when the reeds of the reed switch are trimmed.
- As the reed lengths increases, the threshold value increases.





2-5 Explanation of contact capacity

Contact capacity (W, VA)

This is the product of the usable voltage and current of the contacts and is an important value in establishing switching performance. This value must not be exceeded during opening and closing of contacts to ensure their longevity and reliability. The value will be less than the "maximum switching voltage" × "maximum switching current." When designing, do not exceed the value of the product of the voltage and the electric current applied to the contacts.

■ Example with Model MFS17-A

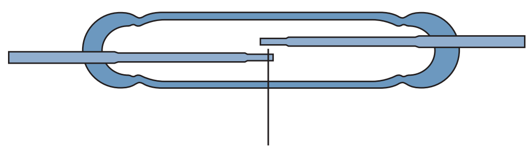
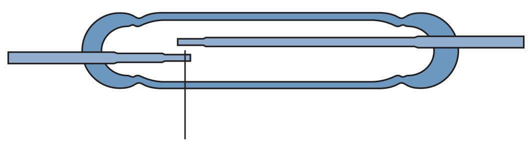
- Maximum switching voltage: 300 V (DC/AC)
- Maximum switching current: 0.5 A (DC/AC)
- Contact capacity: 50 VA (DC/AC)

Maximum switching voltage 300 (V) ×
Maximum switching current 0.5 (A) = 150 (VA)

The numerical value for contact capacity listed in the catalog is "50 VA."
In other words, 150 VA exceeds the contact capacity, so you must lower the voltage (to 100 V max.) or add resistance to control the electric current (to 0.16 A max.).

2-6 Structural classifications

Chapter 1 explains the basic structure of the reed switch. The different types include those in which each of the individual reeds are of different lengths as well as those with different structures and functions such as the types that enclose a set of three reeds.

1	Center type	In this type, the contacts are positioned near the center of the sealed glass.  Contacts are located in the center.
2	Off-center type	Also known as the offset type, this type positions the contacts offset from the center of the sealed glass.  Contacts are offset.

2-7 Functional classifications

The classifications of Types A, B, C introduced here, also commonly used for general switches, are used to classify reed switches by structure.

1	Type A reed switch	The A type reed switch is activated when subjected to a magnetic field, and the normally open circuit is then closed, causing current to flow. It is referred to as a normally open ("make") contact, with two reeds enclosed in a glass tube serving as the open contacts. This is the most common type of reed switch currently being manufactured.
2	Type B reed switch	In contrast to the Type A reed switch, normally the contacts are closed; the contacts open when a magnetic field is applied. This type is also known as a normally closed ("break") contact. Currently, prototypes have been made to demonstrate the feasibility of the theory, but some of the characteristics are inadequate. Therefore, the Type B reed switch has not yet been adopted for practical use.
3	Type C reed switch	This is also known as the transfer contact type (switchover type). When this reed switch is subject to a magnetic field, the contact in the closed state switches to the contact that is open (the circuit is switched over). ■ **Configuration of Type C reed switch contacts** 

Basics of Float-Type Level Switches

Chapter3

Magnets

3-1 Characteristics of ferrite magnets

Ferrite magnets are permanent magnets with stable magnetic characteristics. They are used in applications that do not require a strong magnetic field. They are made primarily from iron oxide (Fe_2O_3), barium carbonate ($BaCO_3$), and strontium carbonate ($SrCO_3$) sintered with powder metallurgy techniques.
These magnets are economical because the so-called iron oxide (also seen as rust occurring on iron) is fire-hardened during manufacture.

3-2 Measurement of magnetic force

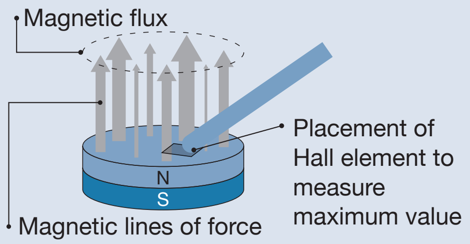
Measurement of the magnetization state (magnetic force) is performed with a gauss meter or flux meter as shown below.

■ Measurement with a gauss meter [measured in gauss (G) units]

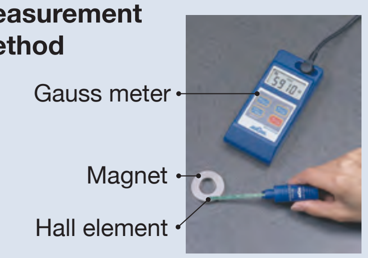
A gauss meter is used to measure the density of the magnetic force lines per unit of area.
The maximum value is measured by placing the measurement area (Hall element) on the surface of the magnet's N pole.

Measurement of magnetic flux density

Magnetic flux density



Measurement method

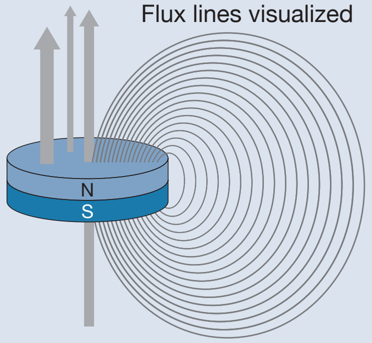


■ Measurement with a flux meter [Measured in Weber (Wb) units]

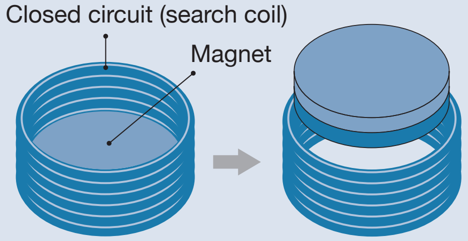
A flux meter is used to measure changes in magnetic flux when a magnet is interlinked with a closed circuit (coil).
It measures the electromotive force required to raise the magnet.

Measurement of magnetic flux

Visualization of magnetic flux

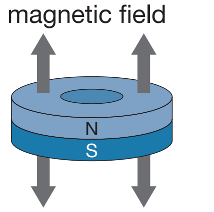


Measurement method

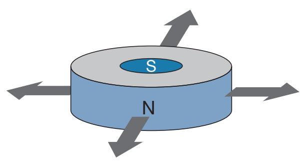


3-3 Examples of orientation of magnetic field

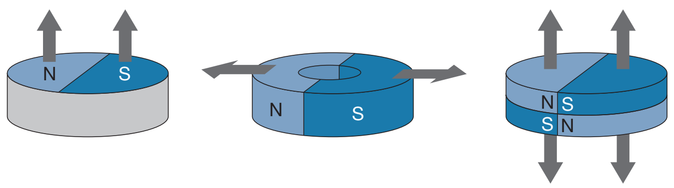
Vertically oriented magnetic field



Internal-external magnetic field



Examples of other orientations of magnetic field



3-4 Application examples of orientation of magnetic field

Vertically oriented magnetic field	This, the most common orientation of a magnetic field, is easy to use when designing and assembling a level switch. Many in-house products use this type.
Internal-external magnetic field	Used especially in level switches, this commonly used type is referred to as a "hysteresis" type.

Note: As shown in section 3-3, various magnetization orientations are available; however, any types other than the above are rarely used for level switches.

3-5 Magnet types and features

Ferrite magnet		In wide use, this magnet offers stable magnetic properties at low cost. The "homolytic" type is magnetized after molding and sintering; the "anisotropic" type is molded and sintered after being magnetized.
Alnico magnet		This type is often used when stable precision is required. It has superior characteristics regarding temperature, but has the disadvantage of being easily demagnetized.
Plastic magnet		This type can be freely molded into even complex thin-walled shapes. It is made by mixing powdered ferrite magnet and rare earth magnet with plastic for molding.
Rubber magnet		Flexible enough to be bent, this magnet is more resistant to breakage and chipping than sintered magnets. It has a wider range of application and is easy to cut, punch and print.
Neodymium magnet		Neodymium magnets provide the highest magnetic energy among existing magnets. It is a molded sintered product made mainly of neodymium, iron and boron. Because it easily oxidizes, it is usually nickel-plated.
Samarium-cobalt magnet		After neodymium magnets, this type offers the best characteristics. It is a molded sintered product made mainly of samarium and cobalt. It is resistant to high temperatures and corrosion. As for disadvantages, it breaks easily.

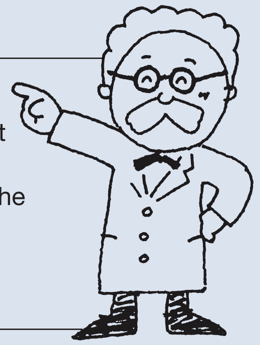
3-6 Changes in magnetic field

Ferrite magnets lose 0.18% of their magnetic force with each degree Celsius increase in temperature.
(Alnico magnets lose 0.02%/°C; neodymium magnets lose 0.1%/°C.)

Example : A 600 gauss magnet at a room temperature of 25°C is raised to a room temperature of 30°C

5°C change (difference between 30°C and 25°C) × 0.18(%) = 0.9, therefore
600 – (600 × 0.9(%)) = 594.6 (gauss)

Magnetic force decreases with temperature rise, but the magnetic force is restored when the room temperature returns to 25°C. Be aware that if the magnet reaches its “Curie point” (temperature at which the magnet loses all magnetic force*), the magnetic force does not return even if temperature falls afterwards. The magnetic becomes demagnetized and the force does not return when it reaches “service temperature” (temperature at which the magnetic force of the magnet is rendered unrestorable**).

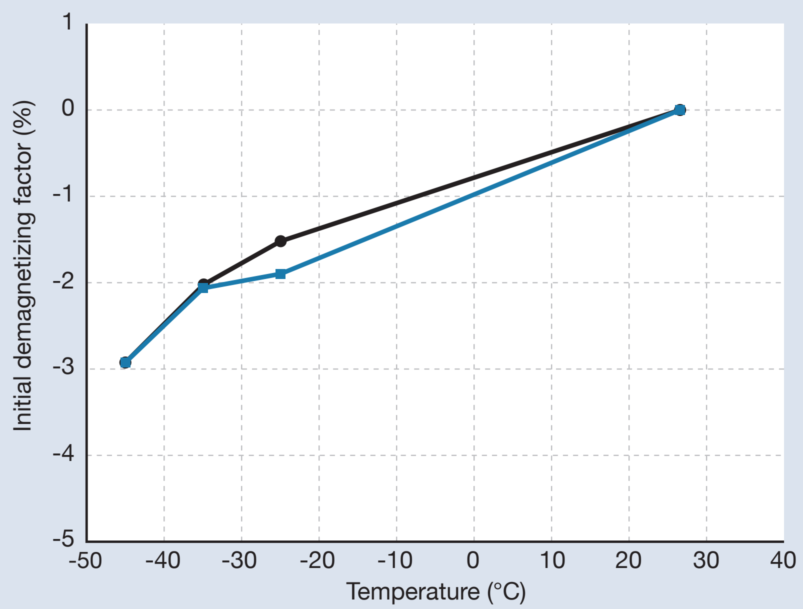


* The “Curie point” of a ferrite magnet is about 450°C to 460°C; for an alnico magnet, it is about 850°C.
**The “service temperature” of a ferrite magnet is about 300°C; for an alnico magnet, it is about 450°C.
As the temperature rises, magnetic force falls, and as the temperature falls, the magnetic force is restored.
It is advisable to remember “service temperature,” the temperature at which the magnet is demagnetized and loses its ability to recover its magnetization.

■ Irreversible low-temperature demagnetization of a homolytic magnet (TF)

If the operating environment is less than the normal temperatures shown in the graph below, the magnet will demagnetize as the temperature falls. This condition is called “irreversible low-temperature demagnetization,” and the magnet will not return to its original state even after the temperature returns to normal.

- Magnet shape: 20 mm dia. × 4 mm
- Measuring temperature: 26.5°C
- Coercivity (HcJ): 3.1 kOe
- Permeance coefficient: 0.6



3-7 Primary magnet manufacturing process

Homolytic ferrite magnet

Composition: barium carbonate (BaO_3), strontium carbonate ($SrCO_3$), iron oxide (Fe_2O_3)

Raw materials & compounding → Calcination → Grinding → Molding → Sintering → Processing → Cleaning → Magnetization → Inspection → Finished product

Alnico magnet

Composition: aluminum (Al), nickel (Ni), cobalt (Co), iron (Fe), copper (Cu)

Raw materials & compounding → Dissolution → Casting/molding → Heat treatment → Aging process → Processing → Magnetization → Inspection → Finished product

Neodymium magnet

Composition: Neodymium (Nd), iron (Fe), boron (B), dysprosium (Dy)

Raw materials & compounding → Dissolution → Grinding → Press molding → Sintering and heat treatment → Processing → Surface treatment → Magnetization → Inspection → Finished product

3-8 Design considerations

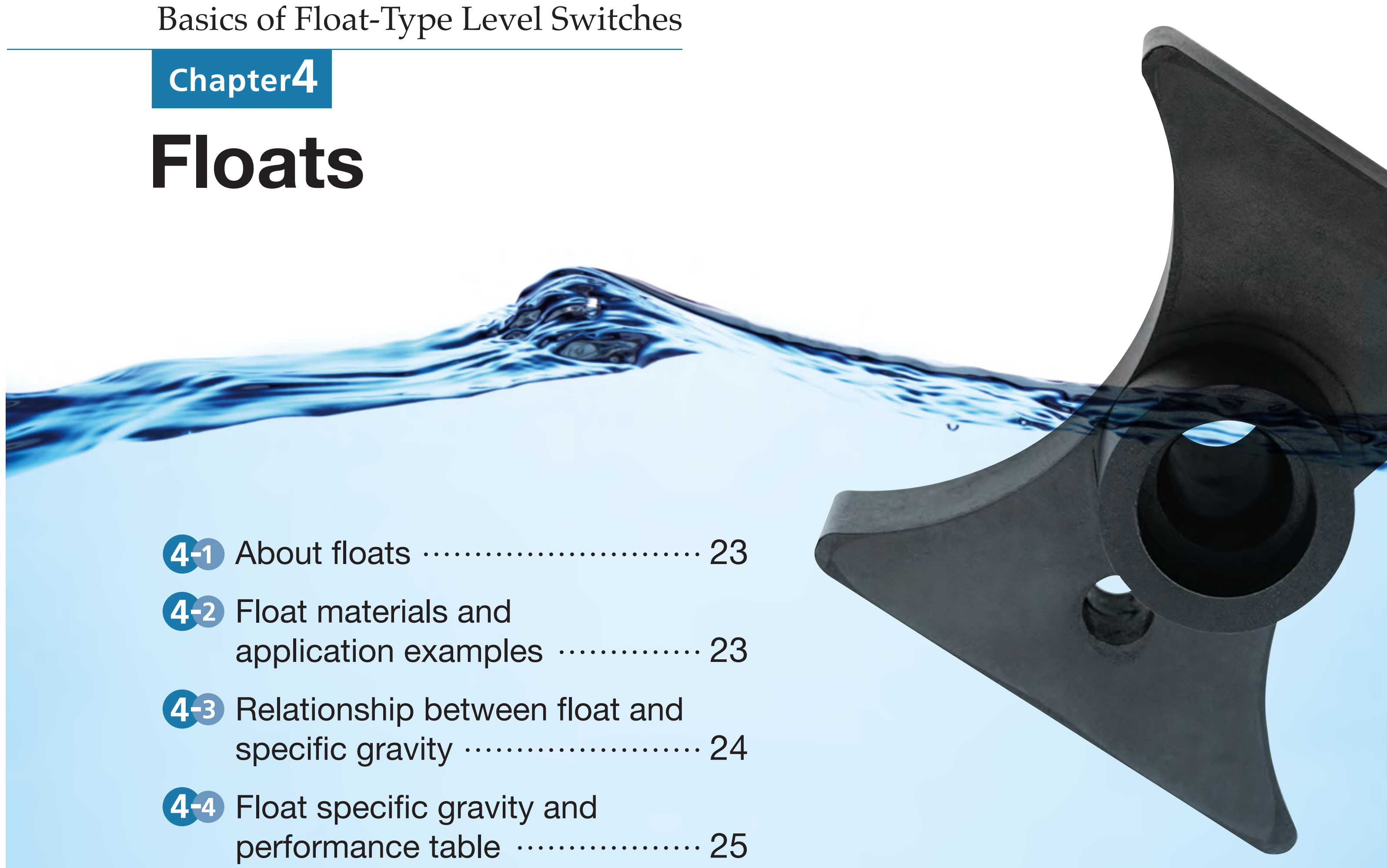
1	Confirm that proper clearance exists between the inner diameter of the magnet (or inner diameter of the float) and the outer diameter of the stem. In some cases, if the clearance does not exceed 1 mm, the float might not move because of the presence of dirt and the like.
2	Confirm that the magnetic force of the magnet is sufficient to move the reed switch. If not, complaints may arise such as “sometimes the switch doesn’t work.”
3	Check the need for hysteresis. Since hysteresis can be as small as 1 mm if the magnetization is vertically oriented, it is necessary to orient the magnetic field to “internal-external magnetization” when hysteresis is required.
4	Check whether the reed switch is operating at three points. If it operates at three points, change to a weaker magnetic force (smaller size) or change the threshold value of the reed switch.
5	Confirm that magnet material is the appropriate type. Determine the magnet material after considering cost and quality.
6	Confirm that the magnet is firmly attached to the float. Confirm that a ring-shaped or rod-shaped magnet has not detached from the float.
7	A thicker magnetic field results in a longer “ON” region. With a larger radial orientation, the “ON” state begins at a position distant from the reed switch contacts.
8	Confirm that the magnet maintains sufficient force to activate the reed switch even at maximum operating temperature.

Note: Normally, depending on the service environment, malfunctions will not occur even if the magnetization is 30% lower than its normal level at room temperature. Final confirmation must be performed on-site. However, when designing with a magnet strong enough to overcome predicted demagnetization, confirm with 3-point operation.

Basics of Float-Type Level Switches

Chapter4

Floats



4-1 About floats

A float is one of the most important components of a sensor that detects liquid level.
It floats in a fluid such as water or oil, rising and falling with the changing level of liquid.

4-2 Float materials and application examples

BUNA-N RF-2 (Fully independent foam)	This is foamed by the addition of phenolic resin to NBR (nitrile rubber). Typical applications: Oil, various liquid chemicals	 Made of NBR
SUS304 SUS316 (Internal cavity)	Made of press-molded stainless steel with plasma welding. Typical applications: Oil, various liquid chemicals, high-temperature and high-pressure equipment	 Made of stainless steel
Plastic (mixture of contiguous and self-supporting plastic)	Made of PP (polypropylene) and nylon foamed in a resin mold. Typical applications: Water, various liquid chemicals	 Made of PP (polypropylene)
Wood, cork	Previously, wood and cork were used for floats, but this made it difficult to maintain uniform quality and obtain a stable supply of material. They are not currently used because of quality and cost problems and issues of insertion of sensor magnets.	
PVC (SUS and similar with internal cavity)	PVC (polyvinyl chloride) pipe is processed with PVC glue or PVC weld. Typical applications: Water, various liquid chemicals	
Other types	Products of titanium and fluorine exhibit very good characteristics (including good resistance to high temperature and high pressure). Currently, because of high cost, marketing is difficult and demand is low.	 Made of titanium  Made of fluorine

4-3 Relationship between float and specific gravity

The specific gravity of a substance is the ratio of the weight of a given volume of the substance to the weight of the same volume of water.

Specific gravity = weight/volume (SG = W/V)

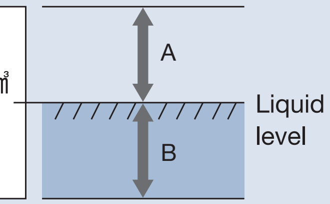
Example: Specific gravity of a float with a weight of 10 g and float volume of 20 (cm³)

10 ÷ 20 = 0.5, so the specific gravity is 0.5

In the above case, the calculation is that half of the float is submerged in water. In addition, at least one-half of the float will be submerged if a float with a specific gravity of 0.5 is placed in a liquid with a specific gravity of 0.8. In other words, the lighter the specific gravity of the liquid, the more the float sinks into the liquid; and the heavier the specific gravity of the liquid, the greater the amount of the float appearing above the surface of the liquid (floating margin). On the other hand, the lighter the specific gravity of the float, the larger the amount of float appearing above the surface of the liquid; and the heavier the specific gravity of the float, the larger the amount of float that is submerged in the liquid.

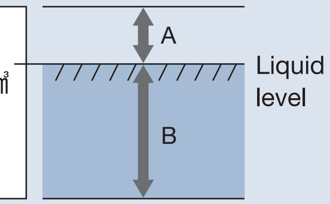
Example 1

Weight: 10 g
Volume: 20 ㎤
Specific gravity: 0.5



Specific gravity of liquid 1.0 (water)
A and B are the same length
(About half the float is in liquid.)

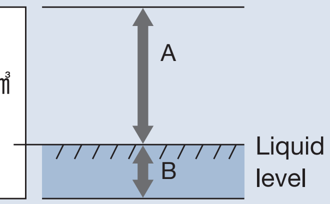
Weight: 10 g
Volume: 20 ㎤
Specific gravity: 0.5



Specific gravity of liquid 0.8 (oil)
B is larger than A.
(More than half of the float is in liquid.)

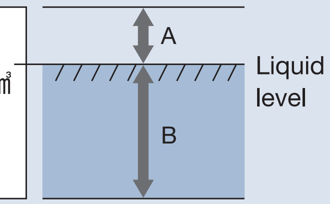
Example 2

Weight: 8 g
Volume: 20 ㎤
Specific gravity: 0.4



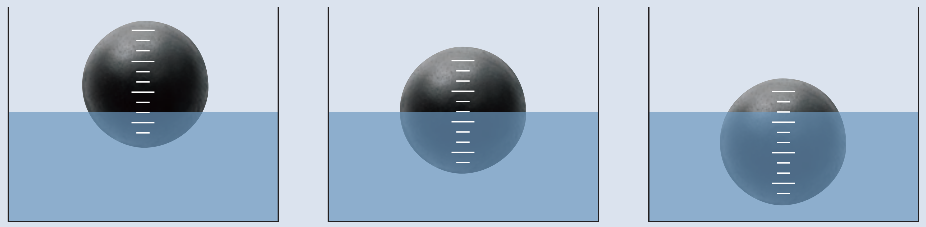
Specific gravity of liquid 1.0 (water)
Specific gravity of the float is light.
(A is larger than B.)

Weight: 12 g
Volume: 20 ㎤
Specific gravity: 0.6



Specific gravity of liquid 1.0 (water)
Specific gravity of the float is heavy.
(B is larger than A.)

Example: "Float is in floating condition" when float is on water.



Specific gravity 0.2 | Specific gravity 0.5 | Specific gravity 0.8

4-4 Float specific gravity and performance table

Float Name		A	B	C	D	E	K	F	J	R1	RFS-2	RFS-6	RFS-8	ϕ51×60L	TFS-8
Volume		4.40	11.60	10.68	5.03	14.96	15.02	4.87	6.15	8.35	11.14	63.64	30.60	87.38	55.60
Weight		3.23	5.42	7.42	3.52	7.77	10.51	3.80	4.00	6.70	7.80	35.00	18.36	39.32	35.55
Specific gravity		0.73	0.47	0.70	0.70	0.52	0.70	0.78	0.65	0.80	0.70	0.55	0.60	0.45	0.64
Pressure (Pa)		0.2M	0.2M	0.2M	0.2M	0.2M	0.2M	0.2M	0.2M	0.2M	1M	1M	4M	1M	5M
Heat resistance (°C)		80	80	80	80	80	80	80	80	80	120	200	120	120	200
Liquid compatibility		Oil	Oil	Water, chemical solutions	Water, chemical solutions	Oil	Water, chemical solutions	Water, chemical solutions	Water, chemical solutions	Water, chemical solutions	Water, chemical solutions	Water, chemical solutions	Water, chemical solutions	Water, chemical solutions	Water, chemical solutions
Dimensions	Outer diameter	ϕ20.0	ϕ26.5	ϕ25.0	ϕ18.0	ϕ31.0	ϕ31.0	ϕ23.5	ϕ24.0	ϕ25.0	ϕ28.0	ϕ50.0	ϕ43.0	ϕ51.0	ϕ51.0
	Inner diameter	ϕ8.5	ϕ9.0	ϕ9.0	ϕ8.0	17×9	17×9	ϕ8.0	ϕ8.0	ϕ9.0	ϕ9.5	ϕ15.5	ϕ10.5	ϕ15.5	ϕ15.0
	Height	20.0	25.0	25.0	25.0	25.0	25.0	14.0	16.5	20.0	27.0	48.0	42.0	61.0	48.0
Composition		N.B.R	N.B.R	P.P	P.P	N.B.R	P.P	P.P	P.P	P.P	SUS	SUS	SUS	SUS	TP340

Note: Floats under columns E and K above are compatible only with horizontal applications; they are not interchangeable.
- Because the above values are the respective maximums, the floats might not be resistant if both temperature and pressure apply concurrently. (Absorbed water can increase the weight, or dents and other deformations can change the volume and specific gravity, etc.)

Example: When the level switches are fabricated with an RFS-6 float, and a dented float is at 200°C and 1 MPa, it is usable in performance but the appearance is poor. If it is at atmospheric pressure, no problem will occur even at 200°C. There is no problem at 1 MPa at normal temperature.

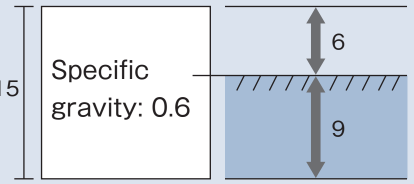
(Unit of pressure resistance: 1 MPa = 10.2 kgf/cm² ≈ 10 kgf/cm²)

4-5 Float specific gravity and liquid level

In level switch design, the product of the float height multiplied by the float specific gravity determines how much of the float is below the water surface (for the purpose of calculation).

Example 1 : with float height of 15 mm and float specific gravity of 0.60

15 mm height × 0.6 specific gravity = 9
9 mm of the float is below the liquid surface. (Water)

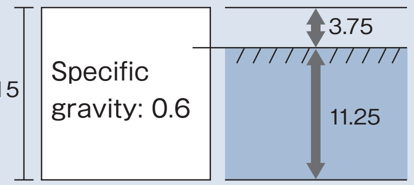


With water (specific gravity: 1.0),
9 mm of float is below water, 6 mm is above.

Example 2 : When using oil of specific gravity of 0.80 with the above float

If the specific gravity of the liquid is not the same as water (1), calculate how much of the float will be below surface by multiplying the float height by its specific gravity and dividing by the specific gravity of the liquid.

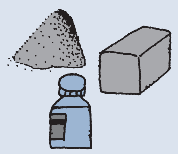
15 mm height × 0.6 specific gravity ÷ 0.8 specific gravity of liquid = 11.25
11.25 mm of the float is below the liquid surface.



With water (specific gravity: 0.8),
11.25 mm of float is below water,
3.75 mm is above.

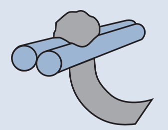
4-6 NBR float manufacturing process

1 Composition



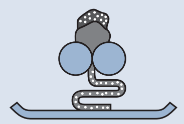
- Test results
- Any other data

2 Basic mixing



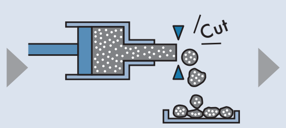
Mooney viscosity

3 Mixed compound



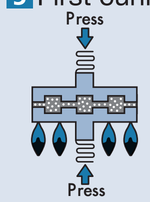
- Rolling process standard chart
- Fully blended state
- Compounding daily

4 Extruding & cutting



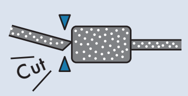
- Work standard chart
- Surface finishing conditions
- Dimensions, weight and shape

5 First curing



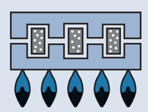
- Confirming temperature and time
- Temperature control of press machine

6 Burr finishing



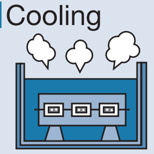
Checking weight for excessive burrs

7 Second curing



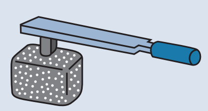
- Confirming temperature and time
- Foaming condition
- Temperature control of press machine

8 Cooling



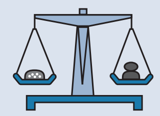
Water temperature control

9 Finishing



- Foaming condition
- Post-mortem visual inspection

10 Inspection

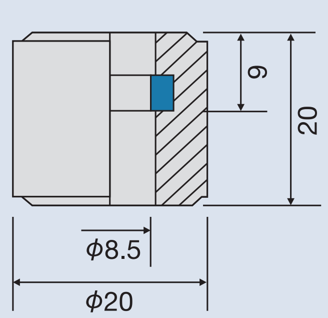


- Weight, appearance and dimensions
- Performance testing

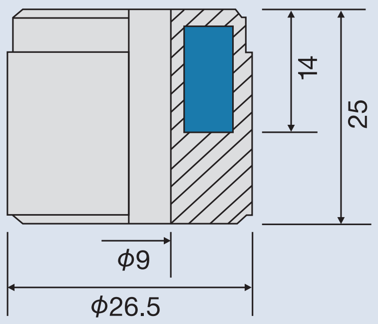
4-7 Internal structure of float

To create a level switch, insert a magnet inside a float by some means.
A float not fitted with a magnet obviously has no magnetic force to function as a level switch to turn a reed switch in the stem ON or OFF.
The magnet is most often mounted not in the center, but on one side, to enable the float to be "reversible" (meaning the direction of operation can be changed). This type is becoming more popular.
(However, not all floats with magnets mounted on one side are reversible, as this is dependent upon the distance between the stoppers.)

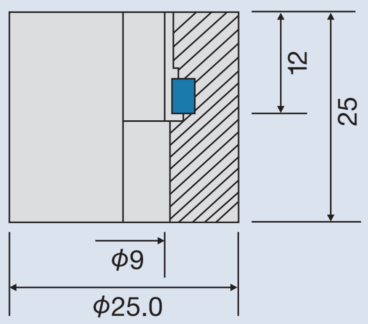
■ **Examples of internal structure of float (the magnet is indicated as ■)**



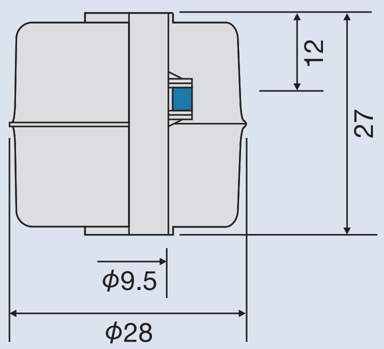
A float



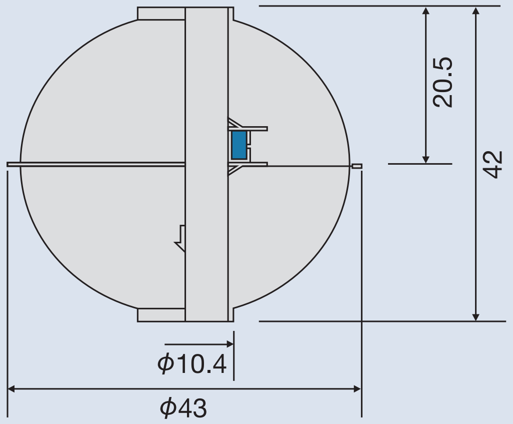
B float



C float

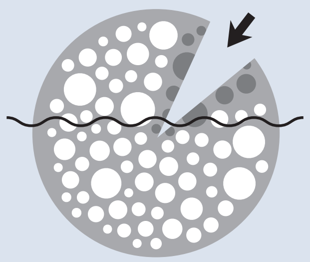


RFS-2 float



RFS-8 float

■ **Structure of RF-2 (NBR float)**

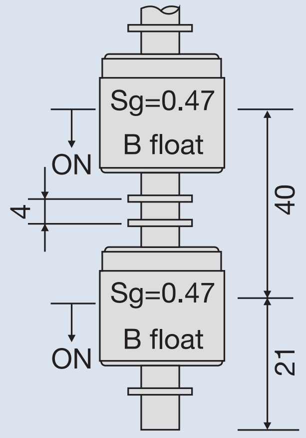


Because the individual air cells are totally enclosed, very little water penetrates. Even if punctured with a through-hole, buoyancy is unaffected and it will not sink.

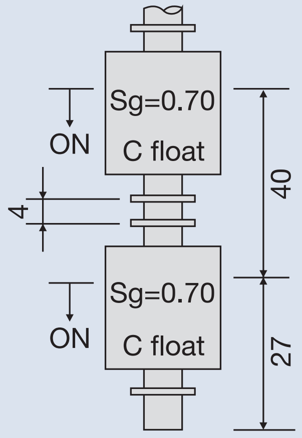
4-8 Multiple float design

In the design of a level switch, a single float presents no problem. But when using two or more floats requiring more than two contact points, allow sufficient operating distance; otherwise, malfunctions will result or the design will be impossible to manufacture.

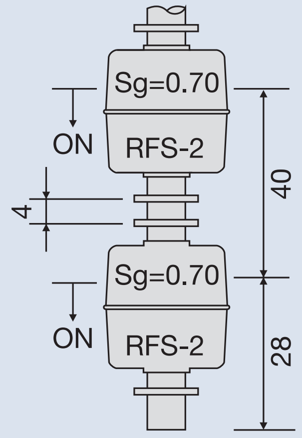
Refer to the following examples when designing your system.



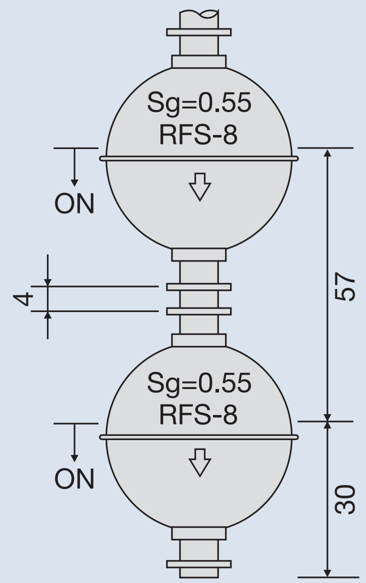
40 mm minimum



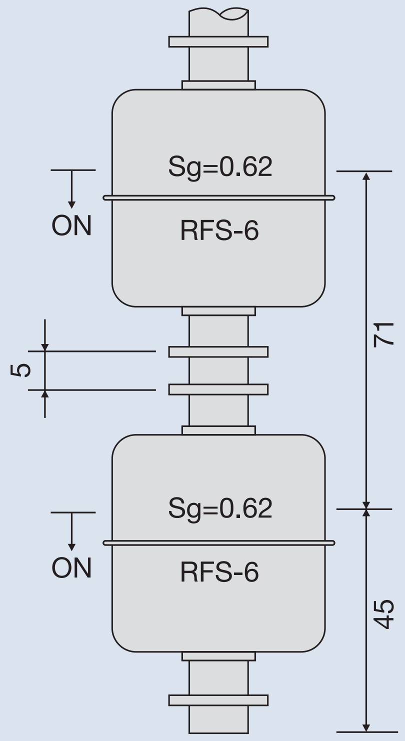
40 mm minimum



40 mm minimum



57 mm minimum



71 mm minimum

Note	All these examples show the same float in the same orientation of operation. Because the operating distance differs with the orientation of operation, be sure to prepare a sample for testing.

4-9 Design considerations

1	Confirm that the clearance (gap) between the internal diameter of the float and the outer diameter of the stem is appropriate. At least 1 mm of clearance is required, as a small amount of dirt or the like can prevent the float from moving.
2	Confirm that the internal diameter of the float can accommodate the stopper. If the internal diameter of the float and external diameter of the stopper are the same, the stopper will bind on the internal diameter of the float as the liquid level rises and falls, and the switch will not operate properly.
3	Confirm whether the distance between the float and the stopper's ON area and OFF area are appropriate. Normally allow a distance of 3–4 mm for the ON side and 4–5 mm for the OFF side.
4	When the operation distance of the float is long, confirm the operation at three points. If the float operates over a long distance (distance from one stopper to the other), use a threshold value without three-point operation when selecting the reed switch.
5	Confirm whether the specific gravity of the liquid is lighter than the specific gravity of the float, and use a float with a specific gravity at least 0.1 less than that of the liquid. For example, assuming a float with a specific gravity of 0.7, the usable liquid must have a specific gravity of at least 0.8 to avoid a malfunction of float movement.
6	Confirm that the materials used for the float material and the stem are compatible. Determine the composition of each component, including the float, in consideration of the service environment. Be sure to avoid situations leading to comments such as "the float is adapted to service, but the stem does not last" or "the stoppers don't last." (Consider not only resistance to liquid but also to temperature and pressure.)
7	Confirm whether the liquid surface is still. In locations where the service environment for the level switch is characterized by an unstable liquid surface, use the hysteresis type (for example, instead of the usual 1 mm distance for operation switchover from OFF to ON or ON to OFF, use around 5 mm); otherwise, the switch will start chattering (rapidly and repeatedly switching between ON and OFF states), leading to breakdown or malfunctions by stressing the reed switch.

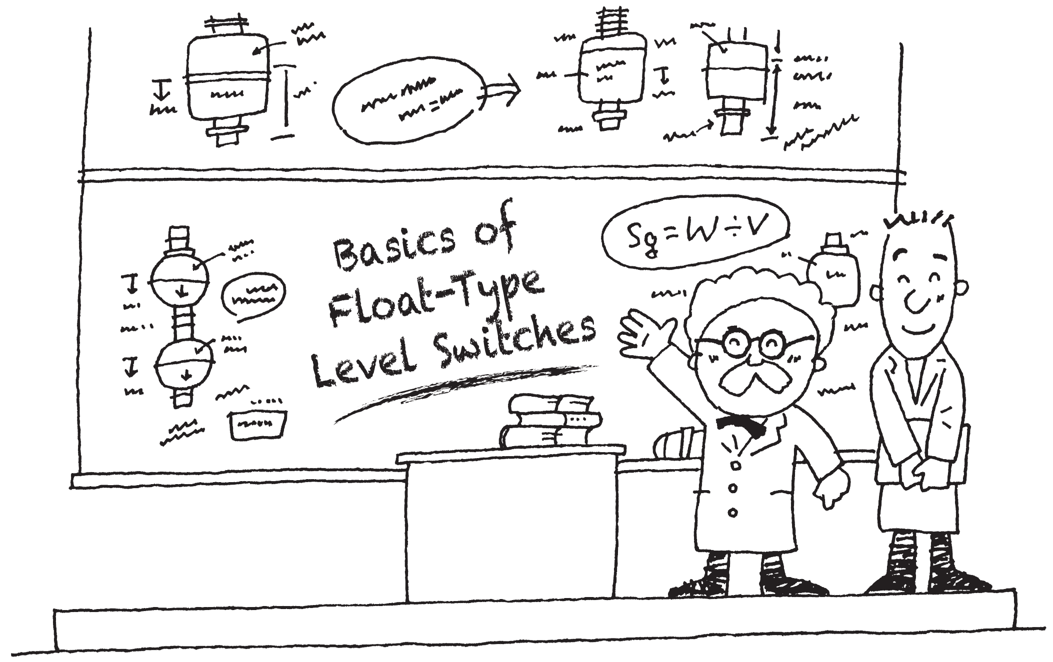
Postscript

As indicated in the title, this book is presented as a general reference containing only basic information. For more information about each component, please refer to the catalogs and other relevant documents.

Note that the contents of this publication are subject to change in the interests of technical progress.

Please utilize this publication as an introductory reference as needed, as it contains limited information about float-type level switches.

Note: All model names, specific gravity values, and information related to operational orientation of level switches and floats in this publication refer to products of Riko Float Technology Co., Ltd. In addition, information on reed switches and magnets has been extracted from the catalogs and websites of the respective manufacturers.



Basics of Float-Type Level Switches

First edition published April 1, 1990.

Seventh edition published May 28, 2014.