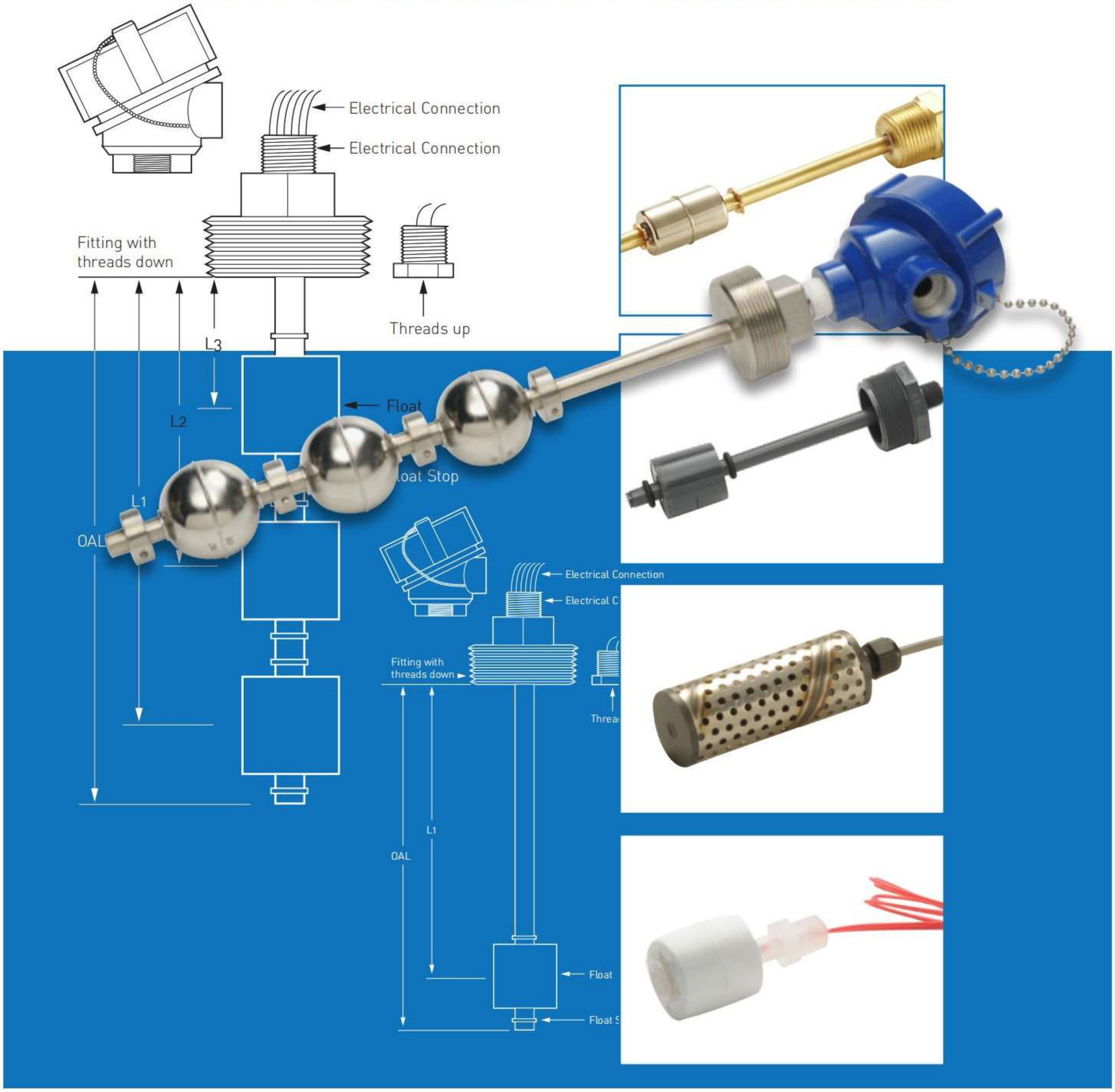
Rochester Sensors

The Ultimate Guide to Float Level Sensors:

How to Select a Float Switch



How to select custom liquid level float sensors

There are many variables that go into selecting the best float switch or continuous level sensor design for a given application. When properly designed, installed and maintained, a float switch or continuous level sensor can be expected to last millions of cycles.

Float switches and continuous level sensors come in many styles, sizes, materials and offer many options. This guide provides a step by step process to assist in selecting the best design for your float switch or continuous level sensor application.

Begin by considering the answers to the following questions.

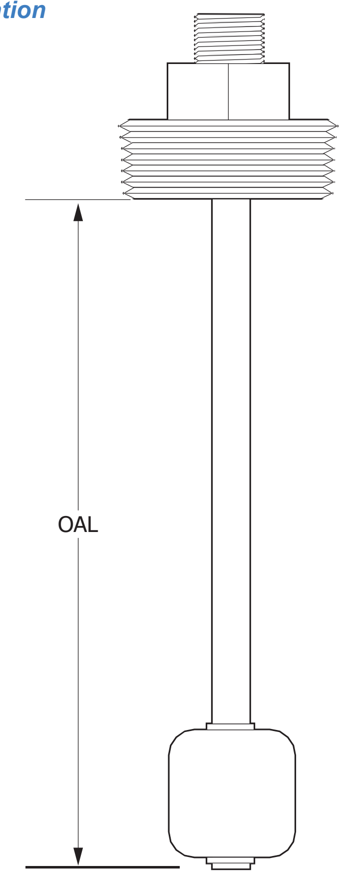
What is the desired operation?

Initially, it is important to consider the function the float switch or liquid level sensor is to perform. For example, does your system require analog output for continuous level monitoring or a switch output for high level alarm, low level alarm or to turn a pump on or off?

Continuous level: If you require continuous level monitoring, check your control to see what type of input is required. Two common analog signals are 4-20mA and 0-5 VDC. Next, measure your tank to determine the range of measurement required. Continuous level sensors require a minimum upper deadband, a measuring range and a lower deadband. Deadband is an area where the sensor is not able to provide a reading. The standard minimum deadband is typically 1" for both the upper and the lower deadbands. However, if less deadband is required, certain considerations can be made to get closer to your application's requirements. The overall length of your sensor as measured from the face of the fitting to the end of the stem must be calculated to ensure the sensor will fit into your tank.

The standard overall length (OAL) is the measurement between the bottom of the fitting and the end of the sensor stem. The OAL is typically automatically calculated based on the Level 1 (L1) dimension. Special OAL's can easily be accommodated. See OAL Illustration.

OAL Illustration



Float switch output: If you require a sensor with switch outputs, determine how many individual switch points you need to accomplish your functional requirements. Measure your tank to determine each switch point location. Take into consideration that the base of each sensor's fitting, the inside face nearest the floats (See Figure 1), is the reference point for all measurements. The industry standard is to determine the desired “Normal” switch operation for each switch when the tank is empty (aka when the floats are away from the fitting). Single pole single throw (SPST) switches should be defined as either normally open (NO), which means the switch is open, or off, when the float is not floating, or normally closed (NC), which means the switch is closed, or on, when the float is not floating. Alternatively, single pole double throw (SPDT) switches are an option for providing both NO and NC switch operation. Note that the complexity and sensor costs increase with SPDT selection.

What fluid type will you be measuring?

Most float switches and level sensors are designed to work in a variety of environments, but some are specifically designed with only one or two applications in mind. Knowing what you’re looking for will ensure the best selections are made for your application. Keep in mind that products can be made to meet your specific application requirements.

Specific gravity

One of the main considerations when choosing a float switch is the specific gravity (sg) of your liquid. To make sure the float will function properly in the application – that it will actually float in your liquid – the specific gravity of the liquid must be greater than the float’s specific gravity at the maximum temperature of the application. Specific gravities of floats typically range from 0.45 to 0.93, depending on size and the material they are made of. In some applications, it is desirable to have a float that sinks in one fluid, such as oil or diesel fuel (0.7sg to 0.9sg), and floats in another, such as water (1.0sg). This is occasionally referred to as an interface float and has a specific gravity of 0.93. Custom specific gravity values are available in certain float materials.

Materials

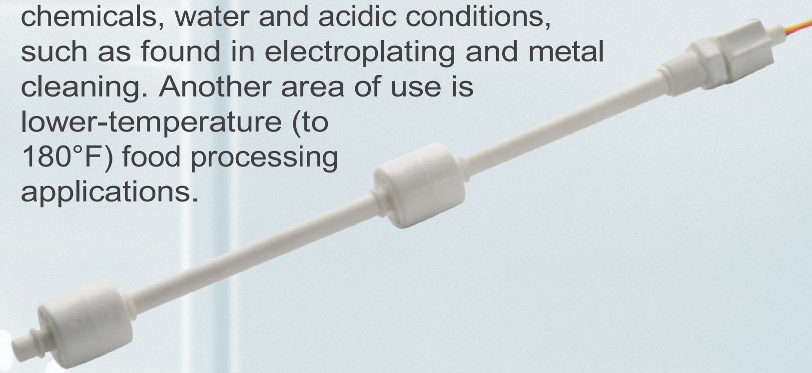
It is also critical to select a float switch that is constructed from the materials that are compatible with the liquids and potential chemical cleaning agents of the particular application. Component damage due to incorrect material selection can ultimately cause failure of a float switch. This is why it’s essential you read the data sheets for each product you’re considering.

Typical float switch materials

Stainless steel: 316 stainless steel is a good material for high-temperature (to 300°F), high-pressure (to 800 psig) and corrosive conditions. It is commonly used in product cleaning and rinsing food processing, medical equipment, hydraulic fluids, fuel oils, heating and cooling equipment. These hollow floats are constructed of thin walled stainless steel.

Buna-Nitrile: Buna-N is a good material to consider for petroleum-based liquids, such as lubricating oils, gasoline and diesel fuels. It is widely used in fluid storage tanks for vehicles, generators, transmissions and hydraulic systems. Other uses are in lubrication, recovery, refining and fuel processing equipment. These solid Buna floats are very light and do not leak.

Polypropylene (PP): Polypropylene is a good material to consider for liquids containing acids and alkalis, detergents, inorganic and organic chemicals, water and acidic conditions, such as found in electroplating and metal cleaning. Another area of use is lower-temperature (to 180°F) food processing applications.



Polypropylene floats also are a good choice for general-purpose applications in commercial or consumer appliances and equipment. The are available both as solid floats (made of foamed polypropylene) as well as hollow floats molded with thin wall polypropylene.

Kynar: This is a good material to consider if harsh chemicals are used in your process. Kynar's solvent-resistant properties make this material a real problem solver for many applications. Its high-purity nature is ideal for food handling and sensitive laboratory or test equipment. The hollow floats are typically molded in 2 pieces and sonically welded together.

Chemical compatibility

Selection of the most suitable materials for a float switch can be made by referring to a Chemical Compatibility table. There are several good chemical compatibility charts available on the internet, for example the Cole-Parmer chemical compatibility database. Simply do a search for "chemical compatibility of 316SS and sulfuric acid," for example. These tables provide a good indication of the suitability of the various float switch materials in a wide range of liquids.
For some process liquids, it may be necessary to obtain a sample float switch to test the compatibility. Keep in mind that products can be manufactured to be compatible with nearly every liquid possible.

Viscous fluids

Liquids with high viscosity do not flow readily, so floats used in viscous liquids should have a rounded shape to eliminate places fluid could accumulate or pool. It is important to ensure that the liquid's changing viscosity (with temperature or drying out or separating) does not interfere with the ability of the float to slide up and down the stem of the sensor.

Fluids with solids or magnetic particles

It is important to determine whether solids, semi-solids or magnetic particles are present in your liquid. If they are, special considerations must be made to prevent these materials from causing problems with the float's movement and/or operation. An alternative design can be engineered so these materials have little to no effect on the float's operation. The trombone float style, for example, has a float attached to an extended arm that, when moved, triggers the switch function. This type of switch is ideal for use in heavy-bodied liquids or in fluids containing metal particles that would otherwise be attracted to a conventional style float.

What is the environment like inside and outside of the tank?

Temperature

Your application's maximum and minimum temperatures must be determined to guide the sensor design selections. For example, 316 stainless steel is ideal for applications with temperatures to 300° F (and greater with special design considerations). On the other hand, polypropylene should only be used when temperatures will be 180°F or lower. Buna-N and nitrile, as well as other common materials, are rated to 180 F° maximum. Temperature extremes can affect the internal switches as well as the epoxy used to seal the end of the sensor.

Pressure

Is your tank under pressure or vacuum? If so, what is the maximum pressure or vacuum? Different styles of floats and mounting fittings have different pressure ratings. Polypropylene and Buna floats, for example, typically have a pressure rating of about 150 psi. Stainless steel floats, on the other hand, can have pressure ratings of up to 800 psi.

Vibration

Small vibrations typically have no impact on the float sensor's operation. Significant vibration has the potential to interfere with proper float switch operation and may result in erroneous signals. Turbulence can be caused by a vibrating tank, mixer agitation, or liquid swirling around as the tank is filled. Vibration and turbulence can cause erratic sensor operation. There are many design options available to protect sensor operation and reliability in an environment where significant vibration and or liquid turbulence is present.

Sanitary applications or cleaning maintenance

Is your application a sanitary environment and or an application that requires occasional washdown? If so, the sensor should be designed to withstand the rigors of high-temperature, high-pressure caustic washdowns. It is important to identify the cleaning solution used as well as the washdown process. If the end of the sensor where the lead wires exit will be exposed to washdown, then waterproof NEMA 4X housings are a good option to consider.

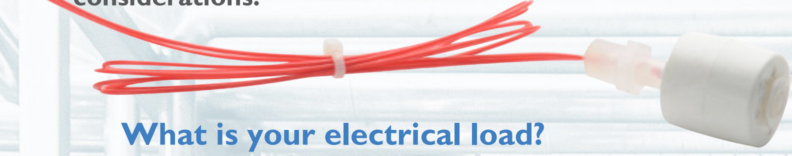
Outdoor locations

For outdoor applications, special attention must be given to the area where the lead wires exit the sensor and the conduit. An integrated outdoor rated NEMA 4X housing is a good option to consider. This option provides space to terminate your wires and protects the inside of the housing from the elements commonly found in outdoor applications.

Hazardous locations

If your area is classified as a hazardous location, the correct device must be selected to ensure proper safety and meet your hazardous location requirements.

For more details regarding sensor selection for hazardous locations, refer to the appendix, "Hazardous location considerations."



What is your electrical load?

Resistive vs. inductive loads

It is important to fully understand the nature of the load that needs to be switched and to ensure that the float switch is capable of handling this load. The electrical ratings most manufacturers provide in their float switch specifications typically are listed for resistive loads. Any loads that are inductive, such as a relay coil or light bulb, will potentially have inrush current and/or flyback power spikes. For these applications, determine the peak inrush current and voltage ratings to decide on the proper float switch rating. Inrush and flyback current often can be 10-50 times or more of the rated operating current. To switch a circuit where the electrical load exceeds the float switches rating, connect the load to an appropriate relay and wire the level sensor to control the relay operation.

Electrical ratings

After the maximum load parameters are determined, the next step is to select a float switch with ratings that will meet your load requirements. Care must be taken so that your load does not exceed any of the maximum parameters of the float switch selected, including maximum wattage, maximum current (amps) and maximum voltage ratings. The most common float switch rating is a 50-watt switch with maximum "do not exceed" parameters of 1 amp, 265 volts and 50 watts. You must know two of these three values to determine if any of the values will be exceeded in your application using the formula Watts=Volts x Amps.

For example, if your process runs on 120 volts and a 50 watt switch is used, it is important to determine the maximum allowable current for this switch.

To calculate this, simply divide the switch's wattage rating by the voltage of your process using the formula Watts/Volts = Current (in amps). The maximum allowable current for this application would be 50/120 = 0.4 amps. In this case, if 120V is used, your load is limited to 0.4 amps (400mA) maximum. If switching an inductive load, the maximum parameters must be based on the inrush current.

Refer to the appendix "Understanding electrical ratings of float switches" for more detail regarding surge protection devices.

Wire

Another step is to consider the type of wire or cable required for your application and the length needed. Common wire sizes for most float switch applications are 18 and 22 gauge. Teflon coated leads are typically standard and are suitable for most applications, however nearly any type of cable can be provided.

How will the sensor be mounted?

The choice of mounting styles that may be suitable for an application will depend on the physical arrangement of the tank, the available mounting positions and whether access is available to the outside or inside of the tank. Make sure the fitting is large enough for the float to fit through the opening if the sensor is to be mounted from the outside top of the tank.

Vertical vs. horizontal mounting

The main sensor mounting orientations are horizontal/side mount and vertical mount. The horizontal/side mount type normally has a threaded fitting, which passes through the sidewall of a tank with a hinged float attached to the stem. Vertical mount types normally have a vertical stem, which is installed through the top or bottom of a tank.

Threads-up versus threads-down

If the sensor is to be mounted from inside the tank and you require a threaded fitting, a threads-up style fitting must be selected and you must make sure you have access to the inside of the tank. If the sensor is to be mounted from outside the tank and you require a threaded fitting, then a threads-down style fitting must be selected and proper size floats must be selected. Be sure that the floats will physically fit through the opening in your tank.

Fittings

Common sensor mounting fitting types are NPT (tapered thread), BSPP (straight thread), SAE threads (straight) and flanges. Quick-connect fittings such as sanitary tri-clamp or camlock fittings are also common for applications where easy access is required for cleaning or testing of the float. Virtually any type of custom fitting can be supplied to meet your specific application requirements.

For more information regarding NPT threading considerations, refer to the appendix, "NPT Connections."

Are there tank restrictions?

Obstructions

It is important that nothing inhibits the movement of the float. Make sure the float sensor has adequate clearance of the tank walls as well as internal tank objects such as baffles, agitators, mixers etc.

Magnetic Field Interference

Ferrous material mounted near the sensor can affect the magnetic field of the senor and interfere with the sensor's operation. Be sure to design the tank fittings for sensor mounting to insure sensor's switch points or measuring ranges are not near ferrous materials or electromagnetic fields.

Tank wall

For thick-walled tanks, or tanks with insulation, make sure the length of the float stem is long enough to reach into the tank so that desired level points are accurately achieved. For thin-walled tanks, make sure that the tank wall is strong enough to support the sensor assembly selected.

Standoff

If the sensor is mounted on a standoff fitting, it is essential to adjust your level points or measuring range to offset the standoff mounting height. The sensor's overall length and the switch point dimensions are relative to the face of the sensors fittings, therefor the difference between the standoff fitting and the inside top of your tank will need to be taken into consideration for accurate sensor readings.

Tall tank height

Tank height must be considered when selecting a float sensor. Custom suspended cable assemblies can be configured to operate on even the tallest tanks and silos. Compression unions can also be utilized for ease of installation and to minimize shipping costs on long length rigid stem float switch assemblies.

Short tank height

If you have a very short tank with very tight switch points, you may want to consider what is commonly called a shared float switch assembly. Using a shared float, near-zero separation switch points can be achieved. This feature often is used on diesel fuel belly tanks, located on power generators where space often is limited and switch points must be very close to each other.

Design details and options

Just about any option you require can be engineered into your float switch. Here are a few of the more common options available along with where and why they are used.

Housings

Virtually any housing or enclosure can be provided to meet your application requirements. For wet or outdoor applications, integrally mounted NEMA 4X waterproof housings are recommended to protect the potted lead wires. For less demanding applications, watertight enclosures such as 3-hole outlet boxes, LB and SLB conduit boxes can be integrally mounted to your float switch for ease of wiring to your system.

Displays

Various digital displays are available to meet both your digital and analog process requirements. These can be mounted either directly to a level sensor or mounted remotely.

Wire, cable, seals

Teflon coated lead wire (24" long) are standard and suitable for most applications. If you need to customize the lead wire on a standard switch, a full range of value-added options are available. Common options are extra-long or short lead lengths; special wire or multi-conductor cable; ungrounded, grounded or shielded cable to eliminate electrical noise; shrink tubing for wire protection, terminations and connectors; cord grips and special sealing materials, such as Viton or Buna-N gaskets and O-rings, for applications where corrosive or caustic chemicals are present.

Fitting and stem material

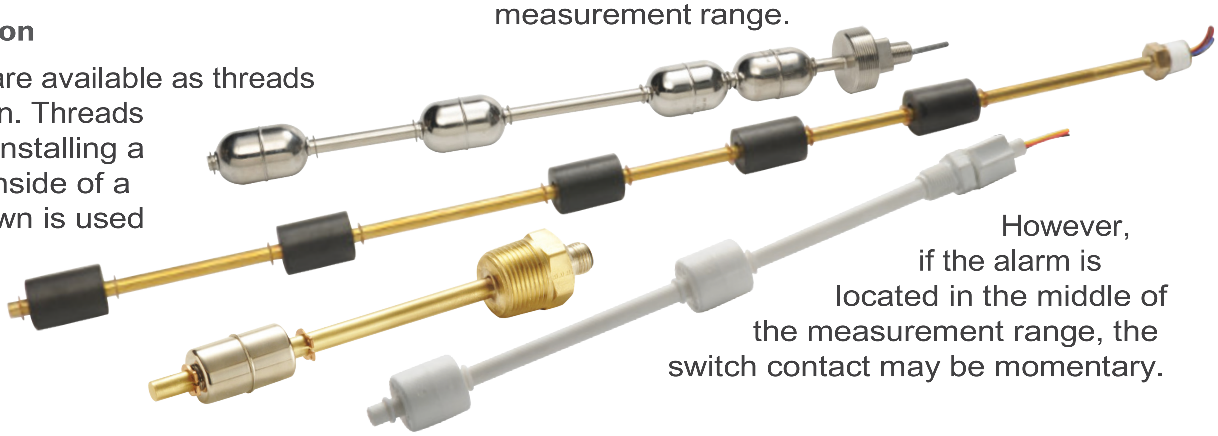
A variety of fitting and stem materials are available, including stainless steel, brass, PVC, polypropylene, Teflon and others. Custom materials can be provided to ensure chemical compatibility with your process.

Fitting types and sizes

Nearly any fitting type and size can be provided. Some of the most common threaded fittings are NPT (tapered thread) in ¼", ½", ¾", 1", 1¼", 1½", 2", 3" and 4" sizes. Metric British Straight Thread (BST) and threaded bulkhead fittings are also common fittings. Common non-threaded fittings are 150 lb. flanges and fittings for quick-access, such as camlock fittings or 316 stainless steel Tri-Clamp sanitary fittings.

Thread orientation

Threaded fittings are available as threads up or threads down. Threads up is used when installing a sensor from the inside of a tank. Threads down is used when installing a sensor from outside the tank.



Float stops

Float stops are used to keep the float in the proper area to insure reliable sensor operation. Retaining rings are standard and suitable for most applications. For applications exposed to high vibration, caustic, corrosive liquids or where adjustability is required, stainless steel set collars may be a better option.

Float materials and specific gravities

Floats can be provided in nearly any material you require. Some of the most common materials of construction are stainless steel, Buna, Polypropylene, Teflon and PVC. The specific gravity of the float determines how it floats in your liquid. The most common float specific gravities (SG) are 0.6 SG and 0.93 SG.

Switch output types and ratings

Switch outputs are available as either single pole single throw (SPST) or single pole double throw (SPDT). SPST output types are the most common and are available with either normally open (NO) or normally closed (NC) contacts. Common switch ratings are 10 watts (500mA, 175 V), 50 watts (1 amp, 265 V) and 100 watts (3 amp, 265 V), with the 50-watt switch being the most commonly used switch. For applications where redundancy is desired, it is possible to build a liquid level float switch with side by side, redundant switches.

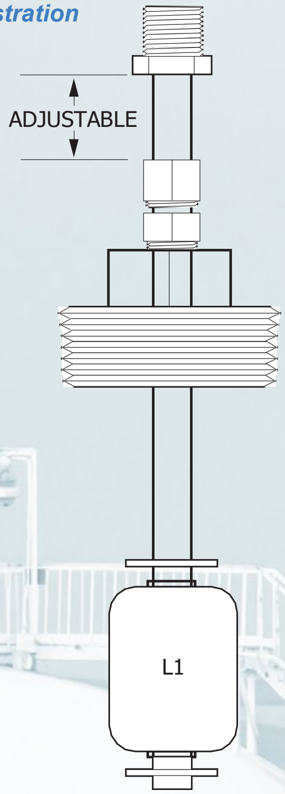
Continuous level alarm output

High and low alarm switch output options are available on continuous level sensors. These alarms can be located above, below or within the measurement range. However, if the alarm is located in the middle of the measurement range, the switch contact may be momentary.

Field adjustable stem length

When accurate positioning of the switch points is critical, a field adjustable stem option may be a good solution. These field adjustable stem lengths can help compensate for the variations in how far the NPT fitting's threads into the tank coupling. It also assists to accommodate variables in the overall tank depth. To obtain precise level measurement a field adjustable stem length option allows the stem length to be adjusted, in the field, to fine tune the exact switch actuation points. This feature is available as fully adjustable, which allows for repeat adjustments (Delrin ferrule), or as fixed adjustability (metal ferrule) which allows for a one-time adjustment. See adjustable illustration.

Adjustable illustration



Combined level and temperature sensing

Thermocouples, thermistors, resistance temperature detectors (RTDs), temperature switches and other sensing devices can be added and as built-in features of the level sensor. Such a combined sensor can reduce costs, minimize SKUs, reduce labor, improve reliability and can eliminate an entry point or use of another fitting on your tank.

For temperature switches, be sure to specify normally open (NO) or normally closed (NC) and the set point in degrees Fahrenheit.

Slosh shields

A slosh shield is a low-cost solution that will protect a float switch from premature failure due to chattering and allow it to perform accurately in environments where intensive agitation or turbulence occurs.

Pipe centering disc

For special applications where the sensor will be mounted in a stand-off pipe or stilling well, a centering disc would be a good option to consider keeping the floats centered in the pipe and ensure proper unrestricted operation.

Suspended cable

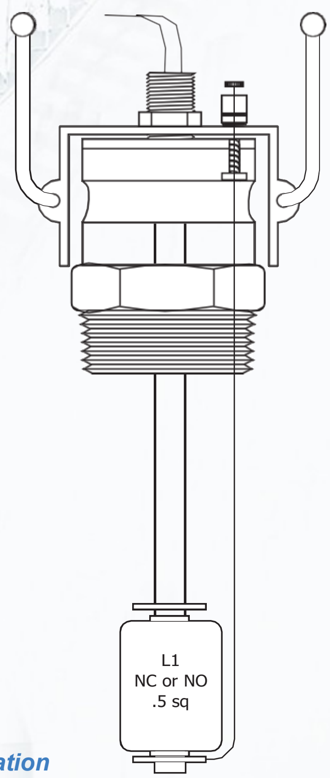
For tall tanks and silos, a suspended cable option can be used to cover a large span providing ease of installation.

Compression unions

Compression unions on stems are available on long length assemblies for ease of installation and to minimize shipping costs.

Float test rod

This option allows for testing of the floats without having to remove the assembly from the tank. As shown on Figure 3, the push/pull test rod is accessible on the top of the sensor's mounting fitting. The remote push/pull rod feature saves time and money wherever scheduled testing of floats is required. See Test rod illustration.

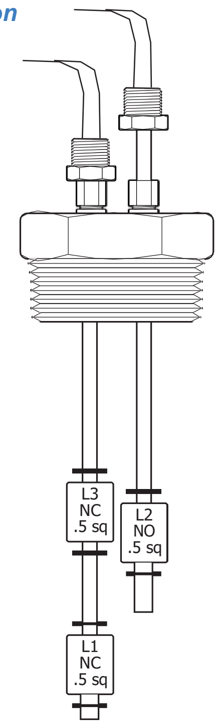


Test rod illustration

Dual stem

Dual stem assemblies are basically two-float stem assemblies incorporated into one fitting. This option is a real problem-solver where limited mounting space exists, or where only one tank fitting is available and multiple or redundant switch points are required. It is most common to build each stem adjustable to fine tune each stems level setting. See Dual Stem illustration.

Dual Stem illustration



Remote float

This design has a remote float attached to an extended arm that, when moved, triggers the switch function. This design is ideal for use in heavy-bodied liquids, liquids containing solids or in liquids containing metal particles that would otherwise be attracted to a conventional style float and cause fouling.

Shared float

This option provides two switch outputs using one shared float. The result is a near-zero float spacing, which is a real problem-solver for applications where tight switch points are required. A shared float can also be used where redundant switch points are required.

Hazardous locations

Intrinsically safe sensors and safety barriers are available for use in areas classified as hazardous locations.

For more details regarding sensor selection for hazardous locations, refer to the appendix, "Hazardous location considerations."

In summary…

There are many choices for monitoring liquid level. Selecting the ideal sensor for an application can be difficult simply due to the number of options available. The challenge is determining the "best" option based on the application and design goals. One shortcut to finding a quick and successful solution is to work with a knowledgeable partner with broad product expertise and good application experience. By choosing to work with a leading sensor company, your design group can reduce risk, optimize resources, and speed development.

Float switch and level sensor selection checklist

Here are the main questions that need to be considered when selecting a float level switch or continuous level float sensor for a particular application.

Liquid parameters

What is the type and concentration of the liquid involved? ______________________________________

What is the specific gravity of the liquid?____________sg

Are solids present in the liquid? ○ Yes ○ No

Will the liquid coat and build up on the float switch? ○ Yes ○ No

Are caustic or corrosive chemicals present? ○ Yes ○ No

If so, what is the concentration?______________%

Is the liquid surface turbulent or is tank vibration present? ○ Yes ○ No

What temperature range will the float switch be exposed to?________° F Max. _______° F Min.

What is the maximum tank pressure/vacuum the float switch will be exposed to?_____________psi/vac

What function is the control to perform (example: keep tank full)? _______________________________

Are switch output, continuous level output, or both required? __________________________________

For switch output applications: What are the switch point locations on the tank (use the base of the sensors fitting as a reference) L1:_____", L2:_____", L3:_____", L4:_____", L5:_____", L6_____", L7_____"

SHOULD WE REFERENCE A DIAGRAM? ○ Yes ○ No

If a switch output is required, do you need SPST or SPDT? ______________

If a SPST, do you need normally open (NO) or normally closed (NC) contacts? _________

For continuous level output applications: What is the measurement range required on the tank?

(use the base of the sensor fitting as a reference)________________________"

Do you need 4-20mA or 0-5VDC analog output? ________________________

Electrical requirements

What will the device be wired to? (example: PLC, relay) ____

What is the maximum voltage of the load?____________VAC (or)_VDC What is the

maximum current draw of the load?_________________________amps

Is the load resistive or inductive? ________________________________

If an inductive load, what is the maximum inrush current?_____________amps

Is the location classified as a Hazardous location? ⭘ Y ⭘ N (see also appendix)

Will the float switch be located indoors or outdoors? ________________________

Are there any approvals required (i.e., UL, CSA)? ⭘ Yes ⭘ No

For more details regarding electrical loads versus ratings regarding sensor selection, refer to the appendix, "Understanding electrical ratings of float switches."

Mechanical component selection

What is the maximum overall length (OAL) allowed to fit into your tank?___________________" max.

Specify an option from each category.

1. The float level sensor will be mounted from the: ⭘ side, ⭘ top, ⭘ bottom of the tank.
2. The sensor will be installed from the ⭘ inside, ⭘ outside of the tank.
3. Select mount fitting and size: ⭘_______" Male NPT, ⭘________" Straight thread, ⭘ 150lb Flange,

   ⭘_______Sanitary Flange, ⭘ Tube, ⭘ Quick Connect Cam Lock Fitting, ⭘ Other _______________

   ____

4. Include a ½" conduit connection? ⭘ No ⭘ Yes

   If yes, select: ⭘ Male or ⭘ Female.

   Check desired construction materials: (other materials available)

   ⭘ Brass, ⭘ Buna-N, ⭘ 304 Stainless, ⭘ 316 Stainless, ⭘ Polypropylene, ⭘ Polyethylene,

   ⭘ CPVC, ⭘ PVC, ⭘ PVDF, ⭘ Kynar, ⭘ Teflon

5. What is the desired float material? ____

6. What is the acceptable maximum size of the float (example: need to fit through mounting hole of .75")_____________".

7. Electrical wiring to each switch will have: ❍ individual wires ❍ a shared common wire

8. Add an electrical junction box? ❍ Yes ❍ No

   If yes, box desired:

   ❍ NEMA 4X waterproof, ❍ LB, ❍ SLB, ❍ 3-hole outlet box, ❍ other

9. Wire leads: ❍ 24" long (std.) ❍ optional length____________"

10. Select desired type of Lead Wire: ❍ PTFE insulated wire ❍ Jacketed cable, ❍ Shielded cable,

    ❍ Other_____________________ ❍ Connector: type desired __________________________

11. Is a display needed? ❍ Yes ❍ No

12. Do you require field-adjustable positioning of the float stem? ❍ Yes ❍ No

13. If so, do you prefer fully adjustable (plastic ferrule) or one-time adjustability? _________________

14. Is a built in temperature sensor desired? ❍ Yes ❍ No

15. Is remote testing of the float switch required? ❍ Yes ❍ No