King of the bin: Rotary paddle point level indicator

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A point level indicator indicates a material's presence or absence in a vessel, typically at a high or low point. Some of the point level indicator's most common applications are maintaining a predetermined material level in a vessel, preventing vessel overflow, and indicating plugging in a conveyor or pneumatic conveying line. This article looks at one indicator type — the rotary paddle point level indicator — whose simple electromechanical design, low cost, and other advantages make it one of today's most popular point level indicators.

Detecting the level of dry bulk materials at specific points in bins, silos, and other vessels can be a challenge. Factors like your material's bulk density, dielectric constant (the material's ability to hold an electrical charge), particle size, moisture content, and flowability — as well as changes in these characteristics — often limit which point level indicators can perform well in your application. Process and environmental factors like the vessel's internal temperature and pressure and your application's ambient temperature can also affect your choice of point level indicator.

You'll need to consider these factors when choosing from among the most common point level indicators — rotary paddle, RF (radio frequency) capacitance, vibrating element (that is, *rod* or *tuning fork*), diaphragm pressure-sensitive switch, and tilt switch. All except one, that is. The rotary paddle point level indicator is the only one of these essentially unaffected by material, process, or environmental factors. [***Editor's note:*** See the later section "For further reading" for more information on other point level indicators.]

The rotary paddle point level indicator (sometimes called a *paddlewheel level indicator*) not only can operate reliably in virtually any application, but is inexpensive, making it the king of point level indicators for dry bulk material applications. In fact, over 50,000 of these units are placed in service in North America each year, according to industry estimates.

How it works

The standard rotary paddle point level indicator consists of a rotating paddle and a power pack, as shown in Figure 1. The unit is installed through the vessel wall, with the rotating paddle protruding into the vessel and the power pack mounted outside it. The paddle is mounted at the end of a drive shaft that typically extends from the bottom of the power pack enclosure. Usually equipped with three or four vanes, the paddle is located where it can contact the material in the vessel. The power pack houses the indicator's guts: a drive-motor-and-gearbox assembly, one or two output switches, and field electrical terminations for the incoming power supply and output wiring.

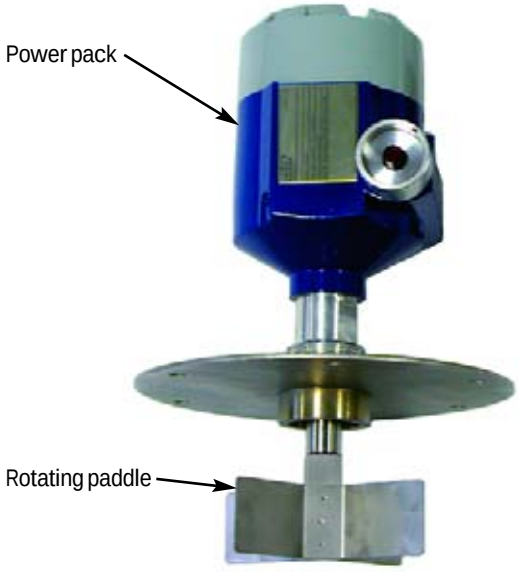
The rotary paddle point level indicator's operating principle is extremely simple: When no material is present at the paddle, it rotates freely. When material is present, the paddle stops rotating, which activates the power pack's output switch (or switches) and indicates the material's presence.

This allows the level indicator to detect high or low levels of material in vessels in a wide range of industries, including plastics, chemical, grain, feed, food, concrete, mining, and many others.

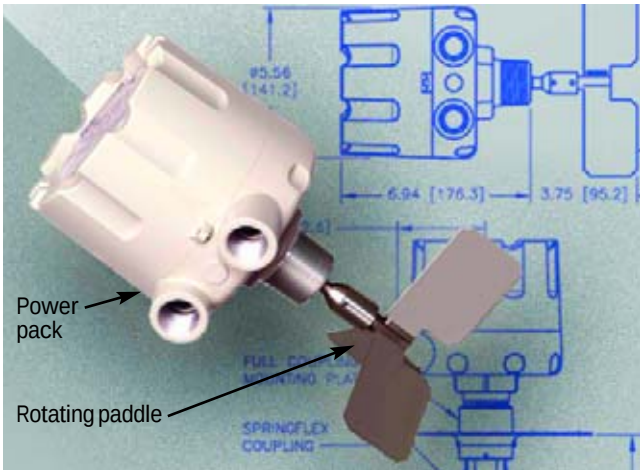
More about the power pack. The power pack is typically mounted with a 1¼-inch NPT process connection. The drive-motor-and-gearbox assembly inside the power pack is attached to the drive shaft. A process seal located at the point where the drive shaft exits the enclosure keeps particles out while allowing the drive shaft to rotate freely. The power pack's removable cover allows access to the components inside the enclosure. The enclosure can have one or two conduit entrances. (Two entrances are sometimes required to meet industry standards for separating power and control output wires.)

Figure 1

Typical standard rotary paddle point level indicators



Courtesy of ASI Instruments, Houston, Tex. (www.asiinstruments.com).



More about the drive shaft and paddle. The drive shaft is typically supported by one or two bearings to allow for side loads on the shaft and paddle, which can be caused by shifting material in the vessel. Another bearing is typically located where the drive shaft terminates at the drive motor. The paddle's standard design (Figure 1) is suited to 80 to 90 percent of dry bulk materials; other paddle designs are available to handle materials with very high bulk densities or extremely large particles.

More about the drive motor's operation. After the paddle's rotation has been impeded by material, the drive motor in the standard rotary paddle level indicator will stall as it keeps trying to turn the paddle. When the paddle can't turn, the drive motor's position inside the power pack enclosure activates the output switch (or switches). The activated switch indicates an alarm condition, and while the drive motor is stalled and material continues to prevent the paddle from turning, the motor's torque maintains this alarm condition. Once the material falls away from the paddle, the drive motor can again turn the paddle freely and the switch resumes its normal state.

How you can use the indicator's output. The rotary paddle point level indicator's output signal can be used in any number of ways, depending on your needs. For instance, the signal can be connected to a PLC or other control system, switch a process motor on or off, turn an alarm signal on or off, or open or shut a valve. Depending on how you wire the indicator in your application, either output signal — the alarm condition or the normal state — can indicate the presence of material (such as to indicate when a vessel is full or a conveyor is plugged) or absence of material (such as to indicate when a vessel is nearly empty).

Factors in the rotary paddle point level indicator's popularity

So what makes the rotary paddle point level indicator king of the bin? After all, it's an electromechanical device, which means that its drive motor and any moving parts may require some maintenance and occasional replacement. In contrast, some other point level indicators, such as RF capacitance and vibrating element units, are solid state, have no moving parts, and generally require less maintenance. Here's a quick look at what's behind the rotary paddle level indicator's success.

Design simplicity. The rotary paddle point level indicator's extremely simple design makes the unit easy to understand and maintain. Because operators and maintenance technicians can see how it works, they're comfortable with it. In fact, the unit's operating principle is so easy to understand that a maintenance technician who's new to the job can look at it and quickly figure out how it works, what's wrong with it, and how to fix it. The simple design also makes the

rotary paddle level indicator very reliable, with the result that most brands carry multiple-year warranties.

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Wide application. The rotary paddle point level indicator can detect the presence of almost any material in almost any vessel. It can be used with materials that have bulk densities from 5 to 100 lb/ft^3 (80 to 1,600 kg/m^3) and particle sizes from microns to large chunks. The level indicator can handle a large range of material moisture contents, any dielectric constant, and typically even different materials after changeovers. The unit can handle all but the most corrosive materials. It works reliably in ambient temperatures up to 200°F (93°C). Internal vessel temperatures up to 300°F (149°C) are no problem for standard rotary paddle level indicator designs, and high-temperature units (in which the power pack is mounted on an extension pipe to remove it from the process heat and, in some cases, is purged with cool air) can handle up to 750°F (399°C). The level indicator works in pressurized vessels up to 30 psi (2 bar), making it suitable for use in vessels that operate briefly at pressures experienced during pneumatic filling.

Low cost. The standard rotary paddle point level indicator has the lowest cost of the point level indicators that can handle the same wide range of applications, including RF capacitance and vibrating element types. The standard rotary paddle level indicator can be had for around $200. The other wide-application units, RF capacitance and vibrating element, cost much more, with the RF units typically 65 to 150 percent more and the vibrating element units about 100 to 225 percent more. While the diaphragm pressure-sensitive unit and tilt switch unit both cost less, these can be used in far fewer applications because of their designs and operating principles. [***Editor's note:*** See cost information on other rotary paddle level indicators in the following section.]

Rotary paddle point level indicators with added capabilities

Now let's take a look at some rotary paddle point level indicators with features that enhance their reliability, service life, and installation and maintenance ease.

Motor shut-off. One problem with the standard rotary paddle point level indicator's stalled-motor condition is that the gearbox sometimes fails when the drive motor torque meets or exceeds the torque level the gearbox can withstand. You can overcome this problem by selecting a rotary paddle level indicator that has a motor equipped with a shut-off device; this device shuts down the motor when material impedes the paddle. By eliminating the stalled-motor condition, the device keeps the motor from running continuously and eliminates the torque produced by the stalled motor, extending the motor's service life and increasing the level indicator's mean time between failures. This type of rotary paddle level indicator costs about the same as a standard unit.

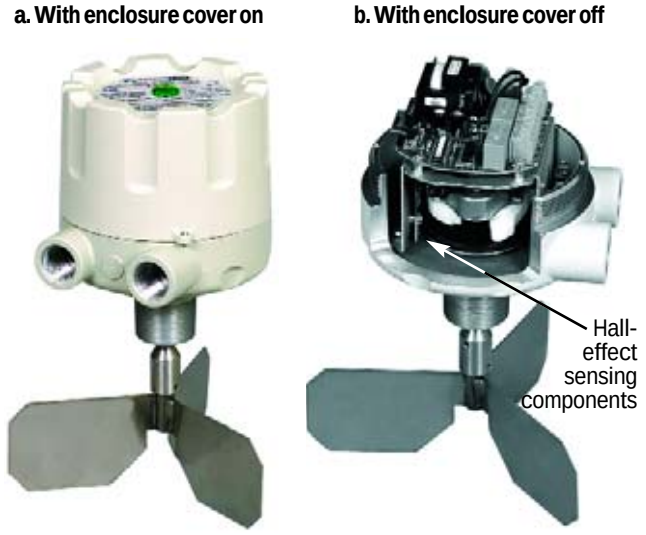
Screw-on enclosure cover. Another difficulty with the standard rotary paddle point level indicator is that the enclosure typically has a bolt-on cover for access to the drive motor and related components. The cover requires from six to eight bolts, and removing, hanging onto, and replacing the bolts when the unit is installed or serviced can be difficult and time-consuming. Failing to fully tighten each bolt can allow dust and moisture into the enclosure, where they can contact the electrical connections and create dangerous conditions in hazardous locations. You can avoid these problems by choosing a rotary paddle level indicator that has an enclosure with a screw-on cover. This cover can be screwed off and on the enclosure in much less time than the bolted cover, speeding installation and service and also improving worker safety in hazardous areas. A rotary paddle point level indicator with a screw-on cover typically doesn't cost more than a standard unit.

Fail-safe mechanism. An important limitation with the standard rotary paddle point level indicator is that if it stops working, the failure may not be apparent until the vessel entirely empties or overfills, interrupting the process and creating cleanup or repair headaches. Selecting a *fail-safe* rotary paddle level indicator can eliminate this problem. The original version of this unit has a fail-safe mechanism that uses optical sensors near the point

This rotary paddle bin level indicator has been mounted on an extension to detect high levels of sand in a bin at a concrete batch plant.

Figure 2

Fail-safe rotary paddle indicator with Hall-effect sensing



where the drive shaft exits the enclosure for detecting shaft rotation. When the sensors detect that the drive shaft isn't turning and the output switch hasn't been activated, another switch is activated. The output from this switch can be used to signal that a failure may exist — hence the term *fail safe*. This fail-safe rotary paddle level indicator costs between $300 and $400. Some fail-safe units are also equipped with LED status lights that locally indicate when the unit has failed. Depending on the model, LED lights can also indicate when power is applied to the unit and when material is present or absent. The lights typically don't add to the unit's cost.

In dusty applications, the optical sensors in some fail-safe rotary paddle point level indicators can become fouled by micron-sized particles that enter through the seal around the drive shaft. To overcome this problem, one version of the fail-safe rotary paddle level indicator[1] uses an enhanced fail-safe technology, called *Hall-effect sensing*, based on magnetic sensing. This unit, shown in Figure 2, detects shaft rotation and switch output activation by detecting the rotation of a magnetic ring on the shaft and a magnetic section on the motor mounting plate, eliminating the problem of fouled optical sensors. The enclosure also has a screw-on cover and two conduit entrances. The unit costs about $300 to $350.

Some selection advice

To select a rotary paddle point level indicator for your application, work with any experienced point level indicator supplier who offers devices with a range of features. The supplier can help you select the best components and configuration for your material and operating conditions, including any added capabilities the point level indicator may require to operate reliably in your environment. If you've experienced failures with rotary paddle level indicators in the past, consider choosing a fail-safe model. By alerting you immediately when a failure occurs, this unit can quickly pay for itself by eliminating downtime, lost material, cleanup labor, and equipment repairs. **PBE**

Reference

1. SafePoint fail-safe rotary paddle point level indicator, available from Monitor Technologies LLC, Elburn, Ill. (www.monitortech.com).

For further reading

Find more information on point level indicators in articles listed under "Level detection" and "Storage" in *Powder and Bulk Engineering*'s comprehensive article index at www.powderbulk.com and in the December 2005 issue.

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