

A Few Thoughts On The Fluxgate Compass

By Captain Bernie Weiss

Last year, *WindCheck* published my article describing how to determine whether your boat's magnetic compass is accurate (see *WindCheck*, October '04, pages 13-14). The article went on to describe how, if the magnetic compass required adjustment, corrections can easily be accomplished using readily available tools such as a GPS receiver, local navigation aids, and a stainless-steel screwdriver. I emphasized that for accuracy in steering and navigating, every boat should have at least one magnetic compass, and every magnetic compass should be corrected to minimize or eliminate deviation due to local magnetic influences such as the boat's engine.

Prompted by that publication, readers of *WindCheck* - - as well as others - - have asked me to address a related subject, the fluxgate compass.

Some basic science

Whereas the conventional magnetic compass has been a standard navigational and steering instrument for hundreds of years, the fluxgate compass was not invented until 1982 (by KVH Industries).

The term "fluxgate" has its origins in geology and physics, geodynamism, geo-magnetism, and magnetic flux. We learned in our high school science classes that the Earth generates its own magnetic field with its own internal dynamo. Most of us remember that at its core, our planet is a vast sea of molten iron, a dense fluid more than six times the volume of the moon. The molten iron, in ceaseless motion attributable to the spinning of the Earth and other influences, creates a fluctuating electro-magnetic field that radiates out to the Earth's crust and beyond. This magnetic field is polarized, and its North Pole is detectable by both the standard magnetic compass as well as the fluxgate compass.

That's right. The fluxgate compass is indeed a magnetic compass -- but it's an electro-magnetic compass. The typical fluxgate is a simple device that employs a microprocessor and two small donut shaped coils of wire around two bars of a ferrite alloy such as iron and nickel. These components, enclosed in a plastic housing, represent the sensing unit. Applying a signal to one wire will result in a voltage in the other wire. The signal undergoes a phase shift due to the Earth's magnetic field; the phase shift is indicative of the coil angle relative to the magnetic North Pole, and the result is displayed digitally as the orientation of the compass. In other words, when charged with electricity, the wire coils sense the horizontal component of the Earth's magnetic field, and they sense angular changes in the field as the compass moves with the boat.

So instead of a round marked card that moves within its binnacle - - the familiar face of a traditional magnetic compass - - the fluxgate compass uses a stationary electronic sensor mounted below deck on the boat's longitudinal axis (or parallel to it), preferably near the pitch/roll center of the vessel. The sensor detects minute changes in electrical voltage caused by a deflection of its North/South orientation. In other



words, it "senses" its position relative to the Earth's magnetic poles and reports it, via hundreds of readings per second, to a microprocessor. This device averages the readings to arrive at an accurate and steady electronic signal. The signal is

instantly dispatched to one or more digital displays at the steering station(s), and to autopilots and other instruments.

Advantages of a fluxgate compass

The advantages of this mechanism over a standard magnetic compass are that the fluxgate system senses changes in the boat's heading instantly, computes the digitized heading data instantly as it changes, and displays the changing data at multiple on-board locations instantly using repeaters. A "real time" display of this sort is a great aid for racing sailors when beating to weather, primed for the next lift or header.

The digitized fluxgate compass headings can also be fed to other on-board instruments, such as autopilots for accurate steering adjustments as the boat's heading changes. The fluxgate digital data output is usually NMEA standard, compatible with virtually any onboard navigation, radar, autopilot, or plotting system.

Many fluxgate compasses are equipped with rate gyros, an accessory. Whereas the basic fluxgate provides a directional reference that's stable over the long term, the rate gyro adds short-term corrections for acceleration and roll-induced heading errors, improving compass performance and accuracy. Despite this, some fluxgate compasses are afflicted with inertial errors under extreme conditions, such as when the vessel is turning sharply or being tossed about by rough seas.

Some fluxgate compasses can provide true headings in addition to magnetic headings. True headings require interfacing with an accessory GPS receiver in order to determine and correct for magnetic variation at a particular location. Variation in our region, Long Island Sound, is approximately 14-15 degrees West, but elsewhere, it's different, and the accessory GPS receiver will automatically correct for changes in variation as the boat moves from region to region. Of course, the variation corrections can also be entered manually, but in this case, one must remember to change the variation when moving to another region.

Magnetic deviation - - heading errors caused mainly by ferrous metals in close proximity to the fluxgate compass - - can be automatically corrected by swinging the boat. This will also minimize spurious readings and eliminate other external influences on the fluxgate.

Swinging the boat (i.e., calibrating the fluxgate)

Compared to compensating the standard or conventional magnetic steering compass, compensating the fluxgate compass is a breeze.

Calibrating the compass, or "swinging the boat," should be performed upon initial installation, at the beginning of each boating season, and from time to time thereafter if you suspect the compass may no longer be accurate. Calibration takes only a few minutes.

Best results are obtained in calm water, at a speed of 1-2 knots, where there is no other marine traffic in the area. First, power up all the boat's electronics, including the autopilot if you have one. Then turn the boat (manually, using the tiller or wheel) slowly in a wide circle. The 360-degree turn should be completed in about 2-3 minutes. Make this turn at least once to correct gross errors, then once or twice more to correct subtle errors. While turning, the fluxgate will read the difference between the Earth's constant magnetic pull and the magnetic forces on board. The fluxgate software will automatically correct for these deviation errors.

Next, to confirm accuracy, drive the boat slowly along a specific known course, such as a navigation range between two fixed objects. The fluxgate compass display of your heading should align with the known heading as indicated on a chart, chart-plotter, or GPS receiver. If there's a discrepancy, use the data entry keys on the fluxgate to enter corrections (usually, no more than a few degrees plus or minus). To verify accuracy, ride the reciprocal range. Remember to allow for leeway, if any, due to current or wind.

Generally, that's "it," although this procedure may differ slightly depending on the brand and model of your fluxgate. As they say in the military, "RTFM." For example, with some fluxgates, the "FM" suggests driving the boat in a large 360-degree circle at a steady but slow speed. When the circle is completed, a single button is pressed and device's software completes the process. Also, some fluxgate models have an auto-compensation feature: Every time you steer the boat in a circle, even if not part of a formal compensation routine, this type of fluxgate

will verify and improve its compensation; in other words, it auto-adjusts for new distortions in the magnetic field, such as those caused by adding or removing metallic materials, equipment, tools, etc. since the last compensation.

Precautions

Because a fluxgate compass is a carefully engineered and highly sensitive electro-magnetic mechanism, it requires diligence and attention if it is to perform well on your boat. For example, the fluxgate compass sensor should be mounted in an area where stray magnetic fields, such as those generated by electric motors and iron engine blocks, are at a minimum. The sensor should be absolutely clear of electrical interference. That means no cables -- other than its own -- in close proximity to the sensing unit.

(More basic science: Magnetism is created by moving electrical charges, so electricity passing through wires creates a magnetic field. This is true even when the wire is a non-magnetic material, such as copper. For as long as electrical current is present, the magnetic field it creates will be identical to that of a permanent magnet.)

Also, the fluxgate compass requires a reliable source of power. Ideally, the power source is a battery other than the one used for engine starts, because transient voltage drops in the power supply may cause the fluxgate to reset. This may not damage the compass, but it may cause the loss of data, delay in transmission of the data, or some other adverse effect on operation.

Further, to reduce instability and to avoid compass inaccuracies created by the vertical component of the Earth's magnetic field, which is prominent at high latitudes because the magnetic poles are depressed, the fluxgate array must be kept as flat and as horizontal as possible. The objective is to minimize "dip." This is accomplished in a fluxgate by mounting it on gimbals or by using a suspension system with a fluid medium. A fluid medium also dampens fluxgate oscillations, just as it does in a standard magnetic compass.

Conclusion

So, do you really need a fluxgate compass? (Fair warning: This is a trick question.)

Answer: Probably not, unless you're a racing sailor or compulsive navigator who likes to steer a VERY tight compass course. My feeling is that with these few exceptions, boaters in Long Island Sound will get where they're going, and be comfortable doing it, steering plus or minus 5 degrees of their intended course, with an average course made good that's close to the rhumb line. And with that objective in mind, a conventional magnetic card compass suits the need perfectly. A GPS receiver, with or without chart-plotter, also suits that need and obviates the requirement for a fluxgate.

But the fact is, you may already have a fluxgate on your boat without realizing it. Do you have an autopilot? Most are driven by fluxgates. Also, some radars are driven by fluxgates. Some hand-held compasses are mini-fluxgates. Meanwhile, there's a major revolution taking place in the marine electronics industry, in case you haven't noticed, and fluxgates are a big part of that. So take the time to study and learn what the fluxgate compass is all about. ♦

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