WHITE PAPER

Choosing the Right Teslameter

When choosing a teslameter or gaussmeter for your magnetic field measurement application, keep in mind that all probes and teslameters are not created equal, and every solution on the market will have a place in someone's scenario. The challenge is determining what your particular criteria are and deciphering manufacturer marketing details to uncover the nuggets of truth that are important in your setup. This document aims to demystify this process by offering generalized details of the various aspects of a teslameter with an example decision flowchart illustrating how you might makethis decision.

What To Look For

Hardware features

Accuracy: While teslameters offer accurate measurements at an affordable price, some discrepancies between devices do exist. A reduced level of accuracy might suffice for some users but not for others, depending on the application.

Accuracy is usually specified as a percent of reading and a percent of range. This value tells you how much error you should expect to see in your measurement.

Example scenario:

A measurement accuracy is specified as 1% of reading +0.1% of range on a particular teslameter/gaussmeter.

Measuring a 100 mT (1 kG) field would likely result in the following accuracy, assuming the teslameter is set to the fairly common 350 mT (3.5 kG) range.

1% of 100 mT + 0.1% of 350 mT = 1.35 mT (13.5 G)

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The most challenging aspect of comparing this parameter between different manufacturers is trying to figure out how this specification value was derived. Things to look out for:

- Time frame — determine if this a 1-year or 1-minute specification.
- Confidence level — there is a big difference between "typical" and "95% confidence level."
- Accuracy value in probe performance — it's easy to get a high accuracy voltage measurement from the teslameter, but it's much harder to accurately characterize the performance of the magnetic sensor in the probe.

Field magnitude range: The different ranges in a teslameter tell the story about the instrument's measurement strengths. First, make sure the instrument has a measurement range high enough to measure your highest expected field. For example, if you think that you might need to measure 2 T fields, a teslameter with a range of 3.5 T would be necessary. Also, make sure the range options have enough granularity to accommodate your smallest signals. It is generally considered good practice to select a range such that the measured signal is at least 10% of the range value to maintain good accuracy and resolution.

Probe selection: The more probe types and sizes available, the wider range of testing you can conduct. Be aware that there is a major difference between teslameters when it comes to number of axes:

- A single-axis instrument can only connect to a single-axis (transverse or axial) probe.
- A 3-axis instrument can measure vector fields and is usually also capable of supporting single-axis probes, making this the most flexible choice.

Beyond these major differences, several additional probe parameters mean that many product selection choices will revolve around the probes. These are, after all, the part of the instrument you'll interact with the most:

- Active area size — This is the area where measurement occurs, and field values are averaged over this area. Having a small active area results in more accurate measurement and improved spatial resolution.
- Stem dimensions — Length, width, diameter, etc. All these parameters can be customized to suit your application. Be aware of trade-offs, though. The longest, thinnest probe possible usually is much more expensive and extremely fragile.
- Handle — How do you want to interact with the probe? Many options exist on the market, from various handheld options to solutions that make it easy to mount the probe to secondary hardware. Just keep in mind that repeatable measurements require repeatable probe positioning.

Still not sure which probe to choose? Check out Lake Shore's **Hall Probe Selection Guide.**

- Connectivity — This is a tricky one. Some manufacturers integrate teslameter circuitry directly into the probe, with the probe connecting to a PC or tablet via USB. This has several pros and cons that would require more explanation, but beyond performance differences, this solution effectively requires you to purchase a whole new teslameter every time you buy a new probe. If purchasing just a single probe, these integrated solutions can be more economical and more compact, but as soon as a second probe is required, a standalone teslameter with detachable probes becomes the better choice due to the reduced price of individual probes.

Temperature compensation: Every Hall sensing element has some form of temperature dependence due to the materials that make up the sensors. More advanced teslameters perform this compensation automatically to improve accuracy through the integration of a temperature sensor in the Hall sensor itself.

Ease of use: If many members of your team need to conduct magnetic measurements, simplicity is key to ensuring easy adoption and accurate results. For more advanced teslameters, look for an instrument with a modern, easy-to-use interface. For simple instruments, navigating the options with a logical assortment of buttons could be preferable. Either way, don't wait until after you buy your product to discover it offers a nightmarish user experience. You will pay for it with lost productivity and botched measurements.

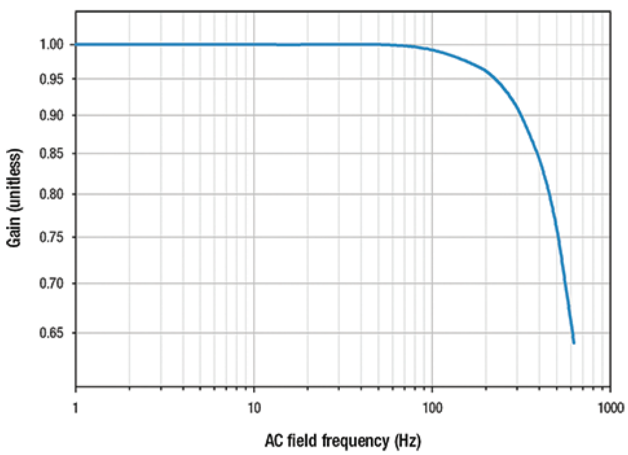
No matter which teslameter you choose, proper technique helps to ensure accurate results. Learn how to prevent mistakes by downloading the whitepaper, **Top 5 Most Common Sources of Error in Magnetic Measurement.**

Teslameter operation features

While many setup options exist, some basic settings common among teslameters include:

AC/DC mode selection: Selecting an appropriate frequency is important for accurate measurements. DC mode is best suited for measuring static or slowly changing fields. AC mode is for measurements where there are periodic or pulsed fields. Ideally, the selected AC frequency should lie on the flat response portion of the instrument frequency response curve:

Teslameter frequency response: AC mode



Beyond simple AC measurement, many teslameters also offer the ability to apply filters to remove unwanted noise from the measurement.

Error correction: Offset errors caused by things like zero field offsets, warm-up time, temperature coefficients, and recalibration intervals are all challenges with measurement instruments. For instance, the Hall probe's sensitivity can vary with temperature. As it increases, the sensitivity typically decreases, which can mean less measurement accuracy. Since these parameters are usually considered features rather than performance specifications, you may have to dig into the product manual to find details on recommended probe zeroing intervals, warm-up times, and recalibration intervals. Be sure to investigate these characteristics before making your product choice. Probe zeroing, warm-up times, and recalibrations are the activities required for accurate measurements, but also apply limitations on how long or when you can take measurements.

- Even at zero field (a probe in a zero gauss chamber, for example) the Hall sensor in the probe generates a small voltage that is interpreted as a field value by the teslameter. Generally, this error is more significant at smaller fields, but can still be noticed with strong permanent magnets. This error is always present and intrinsic to the sensor, but zeroing the probe compensates for the error by characterizing it with the probe in a zero gauss chamber over a period of time, then subtracting the voltage from all future field measurements. If periodically placing the probe in a zero gauss chamber is undesirable, look for teslameters like the Lake Shore F41 or F71 **that automatically and continuously zero the probe, without the need for a zero gauss chamber or even pausing the measurement.**
- Warm-up times and temperature coefficients are performance specifications based on the same principle, measurement circuitry performance changes as it gets warmer or colder. When an instrument is turned on, current flowing through the circuits cause them to warm to temperatures beyond the ambient temperature they were at before being turned on. Teslameters are calibrated when warm, so full accuracy is achieved only when the teslameter is at operating temperature. An extension of this principle is the situation when you are operating the teslameter in an environment outside of the calibration temperature. This is why it is important to uncover the following specifications in relation to your environment:
  - Calibration temperature
  - Temperature range of accuracy — Will the accuracy specifications be valid at any temperature other than the calibration temperature?
  - Temperature coefficient – How will the accuracy shift as your ambient temperature moves away from the calibration temperature? Usually represented as %/°C, this parameter is of critical importance if your measurement environment is in a location without good environment control (HVAC). This is an often-overlooked specification. A common cost reduction tactic for manufacturers is to choose electronic components with poor temperature stability, which has a direct impact on measurement accuracy over temperature.

Hold function: Some teslameters offer a display hold setting that shows the highest reading obtained during the current measurement operation. This is quite valuable when the operator must look away from the front panel display to make including reset instructions, keypad lock/unlock, alarm, pass/fail settings, and other operator instructions can be entered, depending again on the teslameter type.

Example scenario:

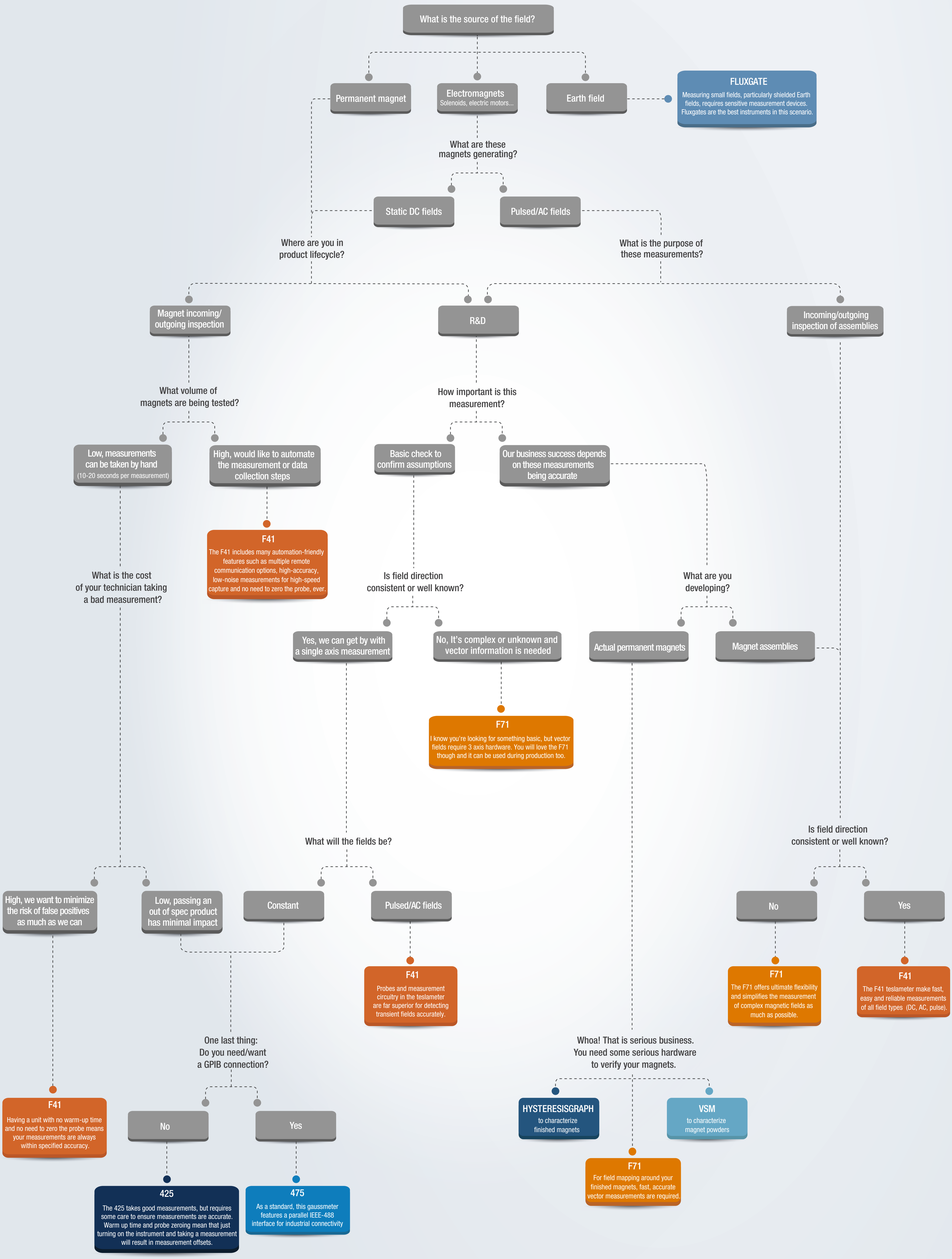
Accuracy = 1% valid at calibration temperature ±3 °C
Instrument calibrated at 24 °C
Temperature coefficient = 0.05%/°C

An instrument operating at an ambient temperature of 10 °C would therefore be operating 11 °C outside of the calibration range and would have an adjusted accuracy of:

1% + 0.05% × 11 = 1.55%

Data logging: The logical next step to taking a field measurement is storing the measurement data. Many methods are available for recording measurements, ranging from pen and paper to internal data storage or remote storage directly on a PC or using a software, for e.g., MeasureLink™. Select a teslameter with a data recording method that suits your application. **Data storage methods may not be obvious and may require reading the product manual or published application notes.** Even so, it's easier to read through these documents before making a purchase rather than trying to figure out how to integrate a teslameter to a system it wasn't designed to connect to. An example of this can be seen on the following page in the decision tree, where an application's need for a GPIB connection makes the Model 475 a logical upgrade from the Model 425.

So... you need to measure the **magnetic field** of something in your manufacturing facility?



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