Faster, Stronger, More Precise: An Overview of Magnetic Markers and Magnetic Location in Utility Marking

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It is the premise of this paper that magnetic location is an extremely efficient utility locating technology, especially when used in conjunction with magnetic markers. Firms and agencies that implement magnetic location and magnetic marker utility marking schemes are likely to find and mark subsurface utilities more quickly and accurately, and will suffer less damage to underground assets.

The majority of utility location—performed by utility companies, municipalities, or location subcontractors—is accomplished by means of electromagnetic locators. That is, handheld locators are used to trace current in underground lines. If the line in question is itself carrying current (i.e., if it is an electric line) then that current can be read directly. Otherwise, current must be introduced by a transmitter; either electrical leads must be connected, or current must be induced from a short distance away. Where the line is metal, e.g. metal pipe for gas or water, the line itself can carry current. And if the line is non-conductive, such as HDPE or PVC water lines, current can only be introduced if the line is equipped with a tracer wire.

But ‘majority’ is not the same as ‘all’; some utility location is done by means of ground penetrating radar and magnetic location is still routinely used.

Magnetic location is very fast because it requires less setup time compared to electromagnetic location. Operators can simply turn on a magnetic locator and go to work; they don’t have to set up a transmitter or find ways to induce current. Magnetic location is also less susceptible to mistakes. Since transmitter-introduced current can ‘bleed’ to nearby lines, operators using electromagnetic locators can become confused and follow the wrong lines; this rarely happens with magnetic location.

Magnetic location will never entirely replace electromagnetic location; the advantages of current-based location—traces all kinds of line, non-dependence on ferrous or magnetic markers, accurate when performed by skilled personnel—are substantial. But the ratio of magnetic to electromagnetic location can be greatly increased, with real advantages. And in some situations, such as when tracing non-metallic lines with nonexistent or broken tracer wires, magnetic location is far superior.

Advantages of Magnetic Markers and Magnetic Locators
As stated, magnetic location used in combination with magnetic markers is an extremely effective solution. Here are some reasons why:

• Easier to Find: Magnetic locators are good at finding ferrous (iron-containing) material underground. And they are very good at finding magnets underground. Compared to, say, a piece of rebar or a steel survey monument, the signal generated by a magnet is stronger and more precise, and can be detected from farther away. This means that magnetic markers can be buried more deeply than ferrous markers, so they are less susceptible to vandalism and/or accidental disturbance. A study by Schonstedt Instrument Company, using their GA-72Cd magnetic locator to detect Berntsen International’s DEEP1 magnetic markers, found that the
DEEP1 markers gave a clear reading **even when buried six feet deep**. The study further found that, when buried two feet deep, the DEEP1 markers gave *maximum* readings on the GA-72Cd.

Also, the **signal from a magnet is ‘tighter’ and more consistent**—the edges are more tightly defined, and experienced operators are better able to estimate depth and horizontal location. This makes magnetic markers easier to distinguish from underground ‘junk’ such as old pipe or rebar, railroad spikes, car parts, and other discarded ferrous material. It is hard to confuse the relatively weaker and more diffuse signal from junk with the strong, tight signal from a magnet. And, when dug up, magnetic markers are easy to definitely identify;
pipe or rebar markers are relatively ambiguous, because they could be junk or used for things like fence anchors.

**Better for Non-Ferrous Lines:** For obvious reasons, magnetic markers are very useful when used in conjunction with non-ferrous lines like PVC water pipes: since the line itself is not detectable by magnetic (or electromagnetic) locators, ferrous or magnetic markers *have* to be deployed to make magnetic detection possible. But magnetic markers are also useful for a *non*-obvious reason: they are generally more reliable than the tracer wires often used to make electromagnetic location of non-conducting lines possible. That is, non-conducting lines are often equipped with wires that are attached externally as the line is laid, and location operators use these wires to transmit current along otherwise non-conductive lines so that electromagnetic locators can be used. But tracer wire is unreliable for several reasons. Since they are external to the line, and relatively fragile, they can break and be useless. And because they require special treatment at line joints, installation can be tedious and breaks are common at joints.

By contrast, magnetic markers are easy to set and last indefinitely—magnetic flux does not weaken significantly over time:

> "A freshly magnetized permanent magnet will lose a minor percentage of its flux, as a function of time. It has been shown that, if one plots flux loss linearly against time logarithmically, an essentially straight line results." - Magnetic Materials Producers Association

In other words, magnets do lose a bit of flux soon after creation, but this loss quickly stabilizes and slows to virtually nothing by the time magnets are used. So those using good quality magnetic markers don’t have to be concerned about flux loss in the ground—magnetic loss at 100,000 hours (11.4 years) can be essentially zero. Also, magnetic markers are durable physically, function well in extreme temperatures (some models are rated for use from -76ºF to 662ºF), and resist corrosion.

**Case Study—Marquette, Michigan**

Marquette, Michigan has a population of about 20,000, and is the nation’s fifth snowiest city. Utility location can be difficult, especially location of water and sewer lines. “We own the water and sewer networks,” explains Marquette Utility Locator Dan Beerman, “And most of the lines are HDPE (high-density polyethylene) without trace wires.”

In 2006, Marquette began to use DEEP-1 magnetic markers made by Berntsen International. “We use them as needed,” says Beerman, “but especially at sewer cleanouts, which are hard to find otherwise.” Marking sewer cleanouts is a specialized use of magnetic markers, but it illustrates the factors that make magnetic markers so effective for all utility marking.

**Ease of Deployment:** “Our crews carry the markers, and a roll of duct tape of course,” Beerman says, “And whenever a new cleanout is installed, or we dig up an old one, we tape a marker to it.” And markers that are easy to set are more likely to be set. Using the magnets, Beerman doesn’t have to worry about signal strength, and routinely buries markers as deep as 18 inches.

**Easy to Find:** In Marquette, sewer cleanouts and other buried utility features are located by ties to nearby landmarks, like building corners. “This gets us within ten feet,” Beerman says, “From there, it’s easy to use a locator to find a magnet, and when we get a reading we have a strong confidence that we’ve found the cleanout—the magnets give a stronger, tighter signal than pipe or rebar.” And since the magnets are green, in
accordance with American Public Works Association (APWA) guidelines for utility marking, there is no confusion when they are excavated.

**Fast:** Marquette utility locators routinely carry Schonstedt GA-52 magnetic locators. So it usually takes just a few minutes to locate sewer cleanouts or other features marked by magnetic markers—all crew members have to do is check landmarks, turn on a magnetic locator, and sweep a ten-foot radius area. This is much faster than setting up a transmitter and electromagnetic locator.

Beerman is satisfied with the performance of the DEEP-1 markers, and recommends them to other municipalities; “I think they’d be silly if they don’t use them.”

**Features to Look For in an Ideal Magnetic Marker**
Magnetic markers are a good idea in most utility marking situations. But even though they are a relatively uncomplicated technology they can, like any product, be made well or badly. Since, over time, the stakes are high—avoiding just one accidental break will pay for a lot of utility marking—buyers should look for excellent markers. Here are some features to look for in magnetic markers that are useful for underground utility marking:

- **High-Strength, Long Lasting:** The above quoted loss figures describe good quality magnets. Manufacturers should be able to supply similar figures for any marker in their line.

- **Clearly Marked Magnetic Orientation:** For various reasons, the negative and positive magnetic poles of markers should be clearly and consistently marked. For example, on Berntsen DEEP1 markers, the negative pole is always marked with a black cap, while positive poles are match the particular marker’s color coding. This allows placement that, depending on which hemisphere the marker is being placed in, maximizes signal. When placed horizontally, a marker’s magnetic orientation can also be used to distinguish the position of underground features.

- **Made of Good Materials:** For utility use, magnets need to be strong and give a good signal, but not so strong that ordinary handling is dangerous or inconvenient (as can be the case with some rare earth magnets). Buyers should pay attention to magnet composition. Because it combines high magnetic flux, convenience, and value, strontium ferrite is a good example of ideal composition.

- **Color Coded:** The APWA has adopted Uniform Color Codes for utility marking, and it makes sense for any magnetic marking system to adhere to this nationally published scheme.

- **Customizable:** Because underground assets can be complex, those managing said assets will always need to convey a great deal of information to anyone doing locating. Therefore, it should be possible to annotate magnetic markers to assist anyone who uncovers them. For example, markers should accept stamped or permanent ink notes. Ideally, it should be possible to order customized markers that suit existing marking schemes.

- **Relatively Inexpensive:** Because large quantities of magnetic markers will be set in any useful marking protocol, individual markers should not be prohibitively expensive. Put another way, there should be no reluctance to set a marker based on price.

- **Moisture and Corrosion Resistant:** Magnetic utility markers are intended for subsurface use, and need to reliably last for decades. Therefore, manufacturers should be able to state the expected lifetime of a marker,
and they should be able to stand up to the rigors of their intended use. For example, the actual magnets may be encased in tough plastic.

- **Easy to Set:** Since their use generally doesn’t depend on orientation in the ground, and since they are unlikely to drift once buried, setting magnetic markers should be fast and easy, and should not require special equipment.

- **Made by an Established Firm:** Underground assets have active lives of many decades, or even centuries. Therefore, support systems like magnetic markers should be reliably available. Purchasers should evaluate marker suppliers in terms of their stability over time.

**Schonstedt Instrument Company: Making Locating Easier Since 1953**

Erick O. Schonstedt founded Schonstedt Instrument Company in 1953 in order to apply his considerable expertise in magnetometry to practical problems. The company soon developed the first magnetic locator—or 'pin finder'—intended for land surveyors, and now 'Schonstedt' is synonymous with monument location all over the world.

Schonstedt continues to research and develop locators for use by land surveyors and utility location professionals. As part of that research effort, Schonstedt is proud to present original research that furthers the goals of everyone who works to preserve and extend the world's vital infrastructure. After all, if you want to make it better, you have to find it first!

**To learn more about Schonstedt magnetic and utility locators:**
Sales Department  
800-999-8280  
info@schonstedt.com  
[www.schonstedt.com](http://www.schonstedt.com)

**To learn more about Berntsen's DEEP1 markers and other products:**
800.356.7388  
[www.berntsen.com](http://www.berntsen.com)