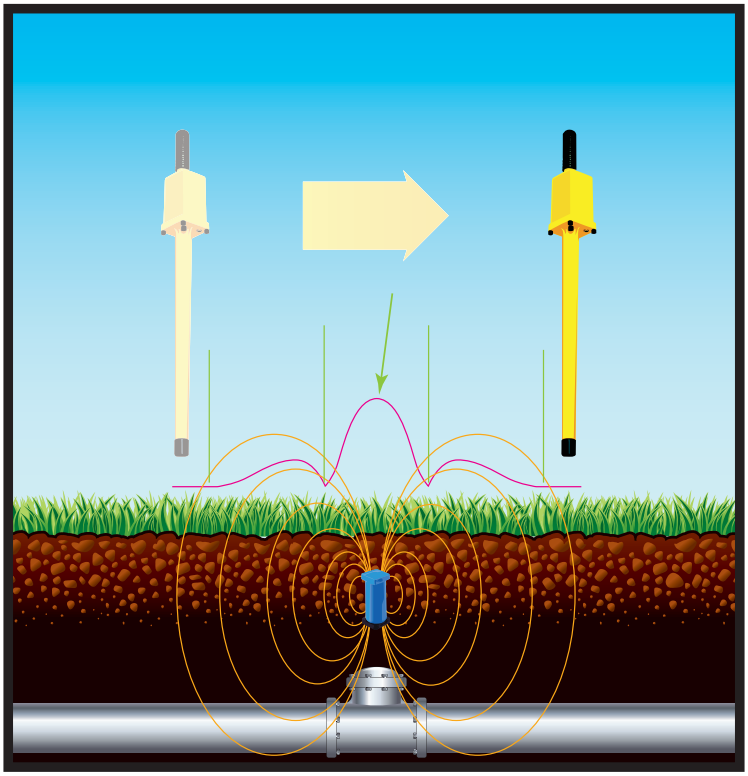
FASTER, STRONGER, MORE PRECISE: AN OVERVIEW OF MAGNETIC MARKERS AND MAGNETIC LOCATION IN UTILITY MARKING



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 DEEP-1 magnetic markers, found that the DEEP-1 markers gave a clear reading **even when buried six feet deep.** The study further found that, when buried two feet deep, the DEEP-1 markers gave maximum readings on the GA-72Cd.

BERNTSEN "DEEP-1 MAGNET" FIELD LAB TEST
USING SCHONSTEDT GA-72 CD MAGNETIC LOCATOR

Note: DEEP-1 magnet buried in traditional play sand (Stage 1, 3, 4, 5, & 6)
Note: Test data is based on GA-72Cd oriented vertically & centered over DEEP-1

Stage 1 test - 6 feet separation between locator and DEEP-1 (D1) - **Buried**

D1 orientation towards locator	72Cd Sensitivity Setting	milligaus indication	# of Segments/Polarity
NEG	LO	none	none
	MED	none	none
	HI	-1.03	7 bars neg
	HI-HI	-0.98	10 bars neg
Neutral (sideways/perpendicular)	LO	none	none
	MED	none	none
	HI	-0.56	4 bars neg
	HI-HI	-0.68	8 bars neg
POS	LO	none	none
	MED	none	none
	HI	none	none
	HI-HI	none	none

Stage 2 test - 2 feet separation between locator and DEEP-1 (D1) - **NOT Buried**

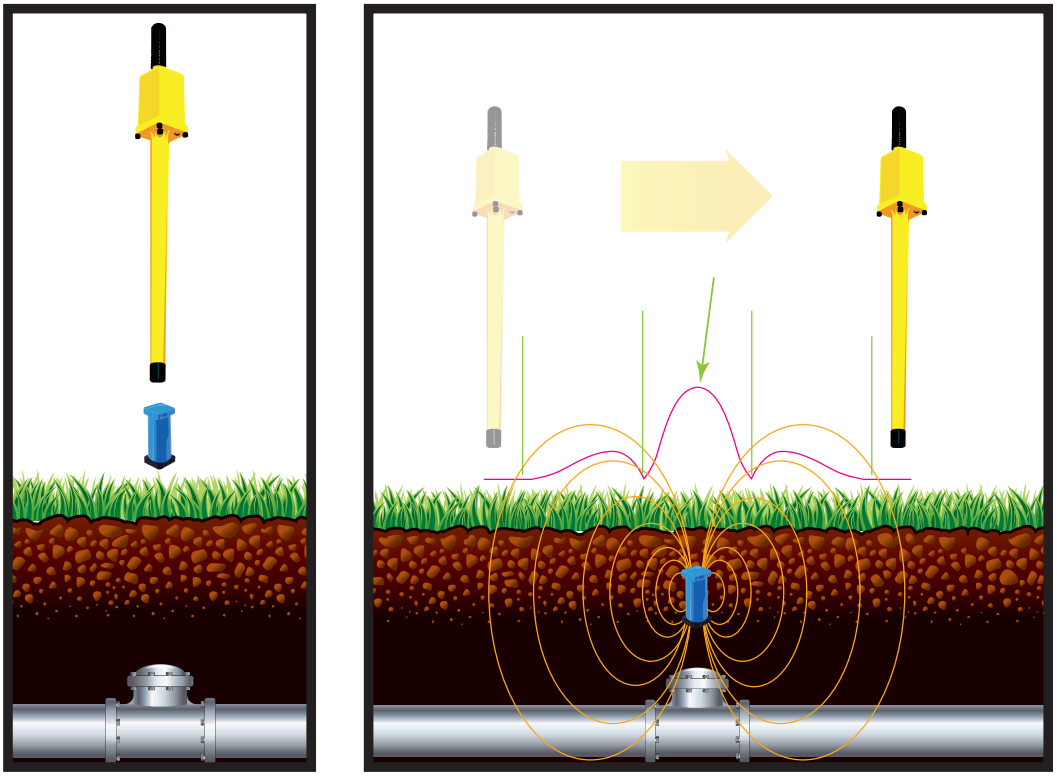
D1 orientation towards locator	72Cd Sensitivity Setting	milligaus indication	# of Segments/Polarity
NEG	LO	-48	5 bars neg
	MED	-36	16 bars neg - max
	HI	-6 max	16 bars neg - max
	HI-HI	-2 max	16 bars neg - max
POS	LO	24	4 bars pos
	MED	25	14 bars pos
	HI	6 max	16 bars pos - max
	HI-HI	2 max	16 bars pos - max

Stage 3 test - 2 feet separation between locator and DEEP-1 (D1) - **Buried**
Note: Wanted to determine if being covered by the sand had diminished magnetic intensity at locator.
The POS end was tested as it had the weakest magnetic field. A slight change at the lower sensitivity was noticed.

D1 orientation towards locator	72Cd Sensitivity Setting	milligaus indication	# of Segments/Polarity
POS	LO	36	4 bars pos
	MED	38	14 bars pos
	HI	6 max	16 bars pos - max
	HI-HI	2 max	16 bars pos - max

Stage 4 test - 2 feet separation between locator and DEEP-1 (D1) - **Buried**
** direct center would almost produce a balanced zero value; these readings are taken at center; the 6" off center both from POS and NEG ends of the magnet.

D1 orientation towards locator	72Cd Sensitivity Setting	milligaus indication	# of Segments/Polarity
Center	LO	none	none
	MED	1.09	3 bars pos
	HI	2.08	11 bars pos
	HI-HI	2 max	16 bars pos - max
POS - 6" off center	LO	15	3 bars pos
	MED	16.4	11 bars pos
	HI	6 max	16 bars pos - max
	HI-HI	2 max	16 bars pos - max
NEG - 6" off center	LO	-11	2 bars neg
	MED	-11.1	10 bars neg
	HI	-6 max	16 bars neg - max
	HI-HI	-2 max	16 bars pos - max



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 previously 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 DEEP-1 markers, the negative pole is always marked with a black cap, while positive poles 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 placement 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 code.

• **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.

BERNTSEN INTERNATIONAL: MARKING THE INFRASTRUCTURE OF THE WORLD

Berntsen International has been making and selling the most complete line of durable infrastructure markers for over 40 years, beginning in 1972 with the invention of the W-1-B magnetic aluminum survey monument, which was lightweight, stable when set, and—because it was metallurgically sound—didn't 'self destruct' in the ground.

Since then, Berntsen has led the way in the infrastructure marking industry with important innovations in self-stabilizing and corrosion-resistant markers, and we were the first to use orbital forging technology—which makes stronger markers in less time—in the monument industry.

In other words, we've been inventing, testing, getting feedback, and reinventing for our entire history as a company, and Berntsen holds several important industry patents. Put simply, no company in the world is better positioned to supply durable magnetic markers to the utility industry. Our commitment to innovation and reinvention of our products is one reason **99.2% of our customers say that our products and service meet or exceed their expectation** (we're still working on the other 0.8%).

We are very serious about the magnetic marking principles described previously. Our DEEP-1 Magnetic Markers are designed and built based on our knowledge of what really works in the construction, survey, and utility industries. We designed them, tested them in the field, then redesigned and retested until we were sure they would meet the needs of our clients and stand up to the challenges of field use. We think that they are far and away the best magnetic markers available—let us prove it to you!

TO SEE HOW YOUR ORGANIZATION COULD BENEFIT FROM THE DEEP-1 MAGNETIC MARKER SYSTEM, CALL US TODAY OR VISIT WWW.BERNTSEN.COM TO VIEW VIDEOS AND LEARN MORE.

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