EM Site A.C. Magnetic Field Sources, Surveys and Solutions Part IV: Survey Data Analysis

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Up to the present waypoint in this series on EM site magnetic fields, we have identified typical sources of time-varying magnetic field intensities, examined salient field characteristics and illustrated correct survey methods. Our goal this month is to analyze data collected at a proposed site and answer the key question of whether or not the candidate site is, as far as magnetic fields go, acceptable for EM use. In the process of analyzing the magnetic field survey data we will define some of the interpretive techniques involved and observe the distinction between localized (a.c. power) and non-localized (geomagnetic) time-varying fields. Finally, we will discuss the implications of EM susceptibility threshold vs. measured field ratios when considering remedial site shielding.

Unambiguous, accurate field survey data is required as a basis for EM site acceptability if analysis of that data is to be the final arbiter of whether a site can be "fixed" or must be abandoned. Interfering magnetic fields which fall below well-defined levels, for example, can often be adequately reduced by shielding the site. Since the alternative option of relocating a proposed (or operating) site may be costly in terms of physical, financial and political tradeoffs, it is obviously important to correctly analyze the magnetic field situation before a final decision is made.

Even at relatively low intensities, a.c. magnetic fields (and slower field variations, in the case of elevator or vehicular geomagnetic modulations) can interfere in subtle ways with EM operations, particularly at sites employing FEG, high resolution and/or low beam energy equipment. In the previous article of this series (Part III, "Survey Instrumentation and Methods", *Microscopy Today*, January/February '96) we reviewed survey data collecting instrumentation and methodology, and there made a careful distinction between magnetic fields related to a.c. power usage as being quite distinct from "quasi-d.c." fields attributable to vehicles moving through the earth's relatively static field. In the following example data set analyses we will accordingly analyze these two field categories separately.

Presuming an urban, large-building setting, we find ourselves armed with two sets of data magnetic field survey work performed in Part III of this series. Let us first consider the "a.c. magnetic field" [ACMF] survey data, Table 1, which is comprised of powerline-related magnetic field

CELL	B_X	B_Y	B_Z	$B_{XY(meas)}$	$B_{XYZ(calc)}$
A	93.3	28.3	178	95.0	204
B	113	53.7	122	116	175
C	122	31.3	181	124	221
D	139	59.4	130	153	201
E	184	50.9	164	195	252
F	158	56.6	139	161	218
@ COLUMN	124	33.9	158	130	204

Table 1. ACMF fluxgate survey data (values in nT, peak-to-peak, at height=1.5m).

values recorded at several points throughout the site. The room is rectangular with a bird's-eye aspect of approximately 3 to 2 and is divided into roughly square cells which are consecutively lettered A, B, C and D, E, F proceeding from left to right and top to bottom. As noted in the previous article, the tabulated values are recorded with the aid of a calibrated tri-axial fluxgate probe and have been verified by comparison with values observed on a hand-held teslameter.

ACMF's may be characterized in two ways. First, they possess interference components which range from 16 Hz (e.g., Scandinavian electrified trains) to 720 Hz (12^{th} harmonic of 60 Hz). Also, significant third-harmonic magnetic field energy at 150/180 Hz is quite common. The second important characteristic of ACMF's is that they are frequently produced by local sources such as transformers, motors and video display monitors. Often, transformers and motors are hidden by walls and/or partitions and are only easily "seen" with the hand-held teslameter. Analysis of "hot spot" data noted during a sweep will indicate if a source is contributing in a significant way to magnetic fields at the proposed EM column location. If so, a marginal site may be salvaged by relocating the offending electrical apparatus further away from the EM site.

In the hypothetical room represented by the above table, peripheral equipment imposes strict limitations on instrument placement — and we can locate the EM column only where the corners of cells A, B, C and D, or cells C, D, E and F touch. Let us assume initially that our EM is a standard non-FEG instrument, and exhibits a typical susceptibility threshold of 250 nTp-p [2.5 mGp-p] in the XY plane and 500+ nTp-p [5.0 mGp-p] in the Z (vertical) axis. Reviewing the above table figures, we observe that we are on fairly safe ground as far as the environmental ACMF fields are concerned. If, on the other hand, we are expecting to operate a FEG-equipped or high-resolution or low eV instrument in that room, some type of shielding will be necessary. Under the B_{XYZ} conditions listed in the final column of Table 1, and with a typical 150 nTp-p [1.5 mGp-p] isotropic interference threshold, such instruments would probably not deliver full resolution specs.

Next, we look at the "quasi-d.c." [QDC] data which we prudently collected (having previously noted that our building is full of exotic equipment and a subway line runs beneath it). As described in our last installment, the initial survey step for QDC fields is to fix a probe near the center of the EM room and manually note all axial field variations occurring in a frequency range of 0 to 1.6 Hz over a period of two minutes or more. That data is tabulated (Table 2) and immediately analyzed

AXIS	LOW uTp-p	HIGH uTp-p	Δ, ABS uTp-p	Δ, REL, %
X	11.08	11.35	0.27	2.4
Y	2.13	2.74	0.61	2.2
Z	15.30	16.20	0.90	5.6

Table 2. Site "QDC" short-term (2 minute) sample data.

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to determine which two axes are to be monitored for a total period of at least 24 hours using a dual-channel chart recorder (ref. Part III). In this case, we have chosen axes Y and Z. With our completed chart (or charts) in hand, the statistics and magnitude of peak-to-peak low-frequency magnetic field variations occurring within any eight minute window (i.e., corresponding to -20 dB with respect to the lowest frequency of interest) are carefully noted. Let us assume here that the relevant peak-to peak QDC variations discerned on the chart are 1.5 μTp-p [15 mGp-p] in the Y axis and 2.5 μTp-p [25 mGp-p] in the Z axis. It is readily apparent that these variations are over an order of magnitude greater than the ACMF EM threshold specs. Worse still, the EM conductive shrouds and UHV containment are relatively ineffective in blocking QDC field variations below 16 Hz, so the EM's exhibit up to 30% more sensitivity to magnetic field variations in this frequency range. All factors considered, our measurements indicate field modulations in the room are approximately 24 times greater than the interference threshold for a FEG instrument! From the standpoint of probable magnetic field interference, this site is clearly unacceptable in its present state for any of the previously mentioned instrument classes.

Nonetheless, since the observed magnetic field variation to EM susceptibility ratio is less than 25, the site may in fact be usable if magnetic shielding is employed. We will discuss that encouraging prospect in the next article of this series.

Questions and/or comments relating to this series are welcomed and may be faxed to the author's attention at Linear Research Associates, Trumansburg, NY (USA) 607-387-7806. ■