VITATECH
ELECTROMAGNETICS

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In 1994 Vitatech Electromagnetics, LLC designed a multi-substrate AC ELF Magnetic Shield for DASNY with multiple layers of silicon-iron steel, seam welded aluminum plates, and annealed 75% nickel-iron alloy sheets to attenuate the elevated and high magnetic fields at the Borough of Manhattan Community College (BMCC) from 720 mG RMS peak to 5.2 mG RMS on floor where children would play / sit when used as a day-care center. Read story and see drawing layout.

ELF EMF Contour Survey - Community College In New York City, NY

An actual ELF EMF contour survey, performed on 17 August 1994 at the Community College in New York City, is presented to illustrate the problems associated with transformers, network protectors, high current secondary feeders, and main electrical rooms located near occupied areas. Very high magnetic field levels between 35-150 mG were measured (waist height) by a faculty member in the college fitness center and two adjoining areas (wrestling room and offices) located above four transformers, four network protectors, and the main electrical room. Furthermore, two issues were of concern to the college administration and New York State Dormitory Authority (DASNY) -- recent illness (cancer) of a faculty member who occupied an exposed office for more than ten years, and the dual use of this space as a day care center for faculty, staff and students. The results of the ELF EMF contour survey and dosimetric measurements collected the following month are presented in this section for discussion. This is a very abridged version of the final report.

Site Description

Four underground primary 13.8 KV three-phase feeders terminate in four 2000 kVA transformers located in separate, street-ventilated vaults operating at 60% capacity. High current secondary 460/265 volt feeders (typically 750-1,500 amps/phase) exit from the transformers and connect to the four network protectors in secured adjacent vaults. Each network protector transfers power to a switchgear panel in the main electrical room via an overhead service busway (five feet from the floor above). The four main switchgear panels are rated at 4000 amps each and supply five building busway risers. On the next floor, directly above, is the fitness center (refer to ***Figure #1*** on page 13 for a superimposed diagram). Adjacent to the fitness center on either side is the wrestling room and several offices. The fitness center and wrestling room are open areas 40 feet wide by 50 feet long, joined by a common wall. Finally, this is a large academic building over 800,000 ft^2.

Survey Instrument-FieldStar 1000 Gaussmeter

All magnetic field (actually magnetic flux density) measurements were recorded with a triple-axis *FieldStar 1000* gaussmeter, which is sold by the Dexsil Corporation (203-288-3509). The *FieldStar 1000* is a *high-end* programmable gaussmeter capable of spot, contour, and dosimetric measurements. When collecting contour path data, a nonmetallic survey wheel is attached to the FieldStar 1000 gaussmeter and the unit is programmed to record mapped magnetic flux density data at selected intervals. The FieldStar 1000 is exactly 1 meter (39.37 inches) above the ground with the survey wheel attached. Along each path, the distance is automatically logged by the survey wheel with the relative direction entered on the keyboard. After completing the contour path survey, magnetic flux density data with distance and directional information is uploaded to a 486 PC computer and processed by the FieldStar graphics software (Windows version 1.0) into detailed plots. Plots normally display a record number, DOS file name, time/date stamp, ID path number, and the following *statistical data* defined below:

Peak - maximum magnetic field (flux) value measured in group.
Mean - arithmetic average of all magnetic field (flux) values collected.
Standard deviation - calculated using the formula below:

$$S = \sqrt{\frac{(\sum (B - \overline{B})^2}{(N - 1)}}$$

where B is the magnetic field (flux) and N is the number of samples

Median, L5 and L95 - calculated by first dividing the data set range into 1000 equal bins, then assigning each data point to a bin as the data is plotted. After the data has been assigned to bins, the number of points in each of the bins is summed beginning at zero. When the total number of points in the sum reaches 5% of the total, the mid-point of that bin is labeled **L95** or the magnetic field value above which the data is 95% of the time. Continuing the sum until 50% of the total is reached, the mid-point of that bin is then the **median**. When the sum reaches 95% of the total number of points in the data set, the mid-point of this bin is then **L5**, or the level above which the magnetic field value is 5% of time.

Cum Exp - cumulative exposure calculated for dosimetric (timed) data, which is the area under the field versus time curve.

Contour ELF EMF Survey

Within the main electrical room (refer to ***Figure #1*** on page 13), the magnetic field levels were 15-50 mG along the walkway and greater than 500-2,000 mG on the switchgear and main distribution panel surfaces. There were no elevated magnetic field levels measured near the water service from plumbing currents or from the underground primary feeders in the street: unable to check the building grounding system for excess currents. Finally, seven contour surveys were recorded at the community college; only the first contour survey of the fitness center is examined and discussed.

Map Plot, *Figure #1* on page 13, shows the recorded contour survey path superimposed over a scaled architectural drawing with the transformers, network protectors, and main electrical room below. The contour survey begins at the **Start** point, follows the solid black line marked with letters A-I at the turns, and stops at the **End** point. In order to avoid several piles of stacked mats in the corner, the initial survey path made a quick turn at point A. Data (in milligauss-mG) was recorded at one-foot intervals along the contour path. *Statistical data* is presented under the title, and the 111 peak spot is marked over network protector #4.

Profile Plot, *Figure #2* on page 13, presents recorded (calculated) R_{rms} resultant magnetic field levels as a function of path distance with positional letter marks referenced to the map plot on ***Figure #1***. Over the transformers, the magnetic field levels are below 50-mG, then increase to 90-mG above the transformer secondary feeders and network protectors. Levels peak at 111-mG over network protector #4 that feeds switchgear SWB3. The levels diminish to 65-mG above the overhead busway service feeders that supply switchgears SWB4, SWB2, and SWB1. Except above switchgear SWB3, which is over 40-mG, the other three switchgear panels are below 25-mG. All other levels emanating from the main electrical room are below 10-mG.

3-D Contour Plot, *Figure #3* on page 13, depicts a three-dimensional graphic where the resultant

R_{rms} magnetic field levels are vertically plotted as a function of the horizontally mapped coordinates. This is a visually informative graphic that vividly shows the 111-mG *peak spot* located over network protector #4. In the back of the fitness center near the hallway, the magnetic field levels over most of the electrical room, except for switchgear SWB3, are low compared to the transformers, secondary feeders, network protectors, and service busways.

Dosimetric Plot, *Figure #4* on page 13**,** displays data collected at the *peak spot* marked on ***Figure #1*** at 1-minute intervals between 20-22 September 1994. Except for a large spike of *unknown origin* that occurred at 3:46 A.M. on Thursday, all other data is rather normal. Maximum levels on the floor occurred as follows: *686-mG* Tuesday at 3:04 P.M.; *712-mG* Wednesday at 1:01 P.M.; and *709-mG* Thursday at 9:04 A.M. *Statistical data* includes 26,475 mG hours of cumulative exposure.

Estimated School-In-Session & Worst-Case Seasonal Peak Load (WCSP)

Since the survey was performed during the August vacation, it was necessary to estimate the *school-in-session* and *worst-case seasonal peak load (WCSP)* from 1-meter above the floor data -- then extrapolate **floor levels** from these estimates. At the *peak spot* in the fitness center, the estimated *WCSP school-in-session* floor and 1-meter levels are 850-mG_{floor} and 185-$mG_{1\text{-meter}}$, respectively. A summary of recorded data is presented in **Table 1** on the next page with estimated (extrapolated) *school-in-session* and *worst-case seasonal peak (WCSP)* ***floor level*** ranges:

Survey Area- Path Data	1-Meter Height Recorded Data 17 August 1994	Estimated School-In-Session Floor Levels	Estimated WCSP[1] School-In-Session Floor Levels
Fitness Center			
Transformers	**20-50 mG**	**130-325 mG**	**150-375 mG**
Transformer secondary feeders	**30-90 mG**	**195-585 mG**	**225-675 mG**
Network protector vaults	**40-111 mG**	**260-722 mG**	**300-833 mG**
Dosimetric: network protector #4 Recorded 20-22 September 1994	**(110 mG) calculated**	**(712 mG) recorded**	**(825 mG) calculated**
Overhead service feeders	**30-100 mG**	**195-650 mG**	**225-750 mG**
Switchgear panels	**10-45 mG**	**65-293 mG**	**75-338 mG**
Distribution panels	**10-20 mG**	**30-60 mG***	**50-100 mG***
Wrestling Room			
Common wall to 25-feet out	**38.9 to 3.0 mG**	**156 to 3.0 mG***	**195 to 3.0 mG***
Offices			
Offices: common wall to hall	**53.8 to 10 mG**	**162 to 30 mG***	**269 to 50 mG***
Hallway Area			
Front-Fitness Center	**3.0-4.5 mG**	**3.0-14 mG***	**3.0-23 mG***

Notes: 1-Worst-case seasonal peak (WCSP)
*-Sources are not directly below, x3-x5 multipliers applied to estimate levels.

Table 1. Contour, Dosimetric & Estimated Magnetic Field Levels

Conclusions & Recommendations

Magnetic field levels in the fitness room, wrestling room, and offices are dependant upon the total building load demand. The college plans to install additional electrically driven chillers in the near future that will increase the seasonal load, and subsequently the magnetic field levels in the affected areas. Therefore, the final conclusions are based upon evaluating the collected data and estimating (and extrapolating) the anticipated *worst-case seasonal peak (WCSP) school-in-session* levels:

1) In the fitness center --
   a) the highest predicted magnetic field levels (883-mG_{floor} and 185-$mG_{1\text{-}meter}$) emanate from the transformer secondary feeders, network protectors, and overhead feeders;
   b) the next highest predicted levels (150-375 mG_{floor} and 33-83 $mG_{1\text{-}meter}$) emanate from the transformers and switchgear panels; and,
   c) the lowest predicted levels (50-100 mG_{floor} and 11-22 $mG_{1\text{-}meter}$) emanate from the distribution panels in the main electrical room.
2) In the wrestling room next to the common wall, the highest predicted magnetic field levels (195-mG_{floor} and 58-$mG_{1\text{-}meter}$) emanate from transformer #1 and network protector #1. The levels diminish to under 3-mG approximately 25 feet away.
3) In the offices next to the common wall, the highest predicted magnetic field levels (269-mG_{floor} and 80-$mG_{1\text{-}meter}$) emanate from transformer #4, network protector #4, and switchgear SWB3. Levels quickly diminish to below 3-mG in the reception area.
4) Hallway (by fitness center) highest predicted levels are below 23-mG_{floor} & 7-$mG_{1\text{-}meter}$.

Final Recommendations:

1) Install a multilayer, three-substrate (silicon-iron, aluminum, and mumetal), rigid magnetic shielding system in the fitness center and one-half of the wrestling room. Refer to **EMF Fundamentals - *Magnetic Field Mitigation*** for more information. Note: The client selected a 3-mG minimum performance criteria at 1-meter above the floor in the fitness center and wrestling room from three proposed magnetic shielding design schemes: 3-mG, 10-mG and 20-mG. The shielding system must attenuate the *WCSP school-in-session* fitness center *peak spot* of 185-$mG_{1\text{-}meter}$ to 3-$mG_{1\text{-}meter}$. This is a very challenging performance objective.
2) Only use the offices for storage (no magnetic shielding) -- absolutely no occupants.

Magnetic Shield Design & Installation & Final Performance

Two multilayer, three-substrate (silicon-iron, aluminum, and mumetal), ELF magnetic shields were designed by VitaTech Engineering, Inc. for the fitness center and half of the wrestling room. The client requested a complete design/build bid package with engineering drawings and complete installation specifications. A local New York City environmental company was awarded the shielding installation contract by competitive bid.

The environmental company had the project management experience and skilled craftsman necessary to comply with the technically demanding installation requirements and specifications. After each substrate was installed on the floors and walls (silicon-iron sheets, aluminum plates, and specially annealed mumetal sheets), VitaTech inspected the workmanship and recorded the magnetic field profile to monitor shielding performance. When the project was completed on 17 August 1995,

an on-site *final performance test* was executed to validate the 3-mG design objective. Coincidentally, the shielding project was completed exactly one-year to the day after the first contour survey. Refer to page 13, ***Figures #5 - #8,*** and the paragraphs below for more information regarding the *final performance test* of the ELF magnetic shields.

Map Plot, *Figure #5* on page 13, shows the ***shielded*** fitness center recorded contour survey path superimposed over the transformers, network protectors, and main electrical room below. Data was collected at one-foot intervals, one-meter above the floor, along the path. The *peak spot* over network protector #4 was now only 4.28 mG - it was 111 mG in ***Figure #1***. *Statistical data* is presented under the title of ***Figures #5 - #8***.

Profile Plot, *Figure #6* on page 13, presents the ***shielded*** fitness center R_{rms} resultant magnetic field levels in referenced to the map plot in ***Figure #5***. The ***shielded*** mean (average) level was only 2.96 mG compared to the unshielded 34.5 mG level in ***Figure #2***. Furthermore, the ***shielded*** *peak spot* on the floor was merely 5.2 mG compared to the 720 mG unshielded peak spot in ***Figure #2***. Remarkably, the *peak spot* shielding factor (SF) was -43 dB on the ***shielded*** floor. Slightly elevated levels between 3.2 - 4.2 mG emanated from the ***shielded*** walls (denoted with marker letters A-O) around the perimeter of the room.

3-D Contour Plot, *Figure #7* on page 13, shows a three-dimensional graphic of the ***shielded*** fitness center. The center region of the ***shielded*** fitness center is only 2.5 mG compared to the unshielded (mountainous) center area with peaks between 80 - 111 mG in ***Figure #3***.

3-D Contour Plot, *Figure #8* on page 13, presents a three-dimensional graphic of the ***shielded*** wrestling room. The ***shielded*** mean (average) level was only 1.41 mG compared to the previously unshielded wrestling room 9.25 mG level. Furthermore, the ***shielded*** wrestling room *peak spot* was 3.36 mG (4.1 mG on floor) compared to the unshielded peak spot of 37.6 mG (93.2 mG on floor). Finally, the ***shielded*** *peak spot* shielding factor (SF) was -29 dB floor.

Final Conclusion

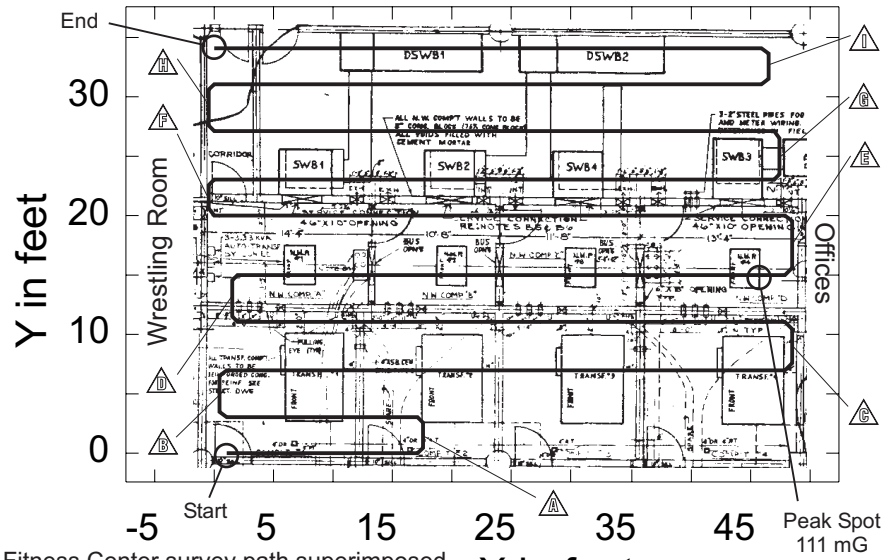
The final design objective of 3-mG (± 1 mG) was verified in both the ***shielded*** fitness center (MEAN of 2.96 mG) and the ***shielded*** wrestling room (MEAN of 1.41 mG). Although the 3-mG objective was achieved, it should be noted this project was difficult and expensive to implement. Furthermore, it demanded the utmost cooperation between the college, VitaTech Engineering, and the construction company. It is more practical and significantly less expensive (nearly half the cost) shielding any room to 6-10 mG, rather than 3-mG, which is the ultimate challenge.

DC & AC ELF Magnetic Shielding Update

VitaTech Engineering, LLC is the only EMF shielding company in the industry that guarantees in writing the final shielding performance (i.e., 0.01 mG, 0.1 mG, 1-mG, 3-mG, 5-mG & 10-mG) under all normal (average and peak) building load conditions. We have installed performance guaranteed DC and AC ELF magnetic shields throughout the United States (visit our www.vitatech.net for more information) and the world.

Map Plot - Community College 8/17/94

PEAK = 111 mG, MEAN = 34.5 mG, STD = 26.7 mG, MEDIAN = 28.3 mG
L5 = 85.3 mG, L95 = 6.2 mG



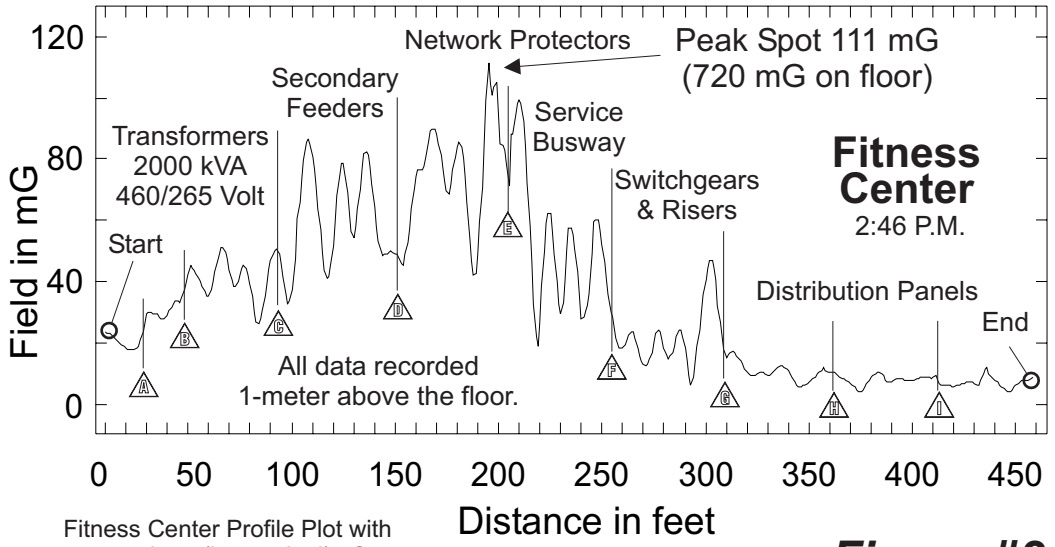
Fitness Center survey path superimposed over transformers, network protectors, feeders, switchgears & distribution panels.

Figure #1

VitaTech Engineering, Inc.

Profile Plot - Community College 8/17/94

PEAK = 111 mG, MEAN = 34.5 mG, STD = 26.7 mG, MEDIAN = 28.3 mG
L5 = 85.3 mG, L95 = 6.2 mG



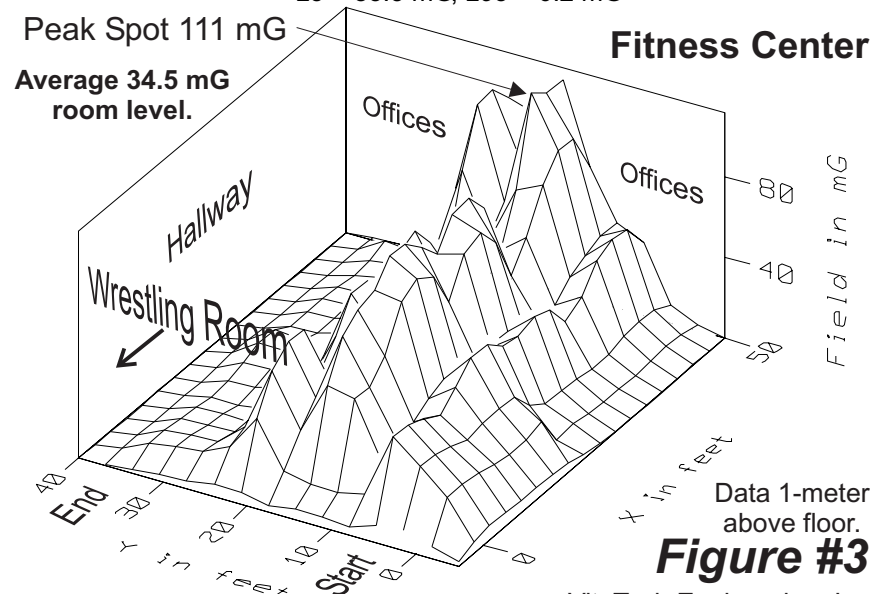
Fitness Center Profile Plot with turn markers (letters A - I). See Figure #1 for exact locations.

Figure #2

VitaTech Engineering, Inc.

3-D Contour Plot - Community College 8/17/94

PEAK = 111 mG, MEAN = 34.5 mG, STD = 26.7 mG, MEDIAN = 28.3 mG
L5 = 85.3 mG, L95 = 6.2 mG



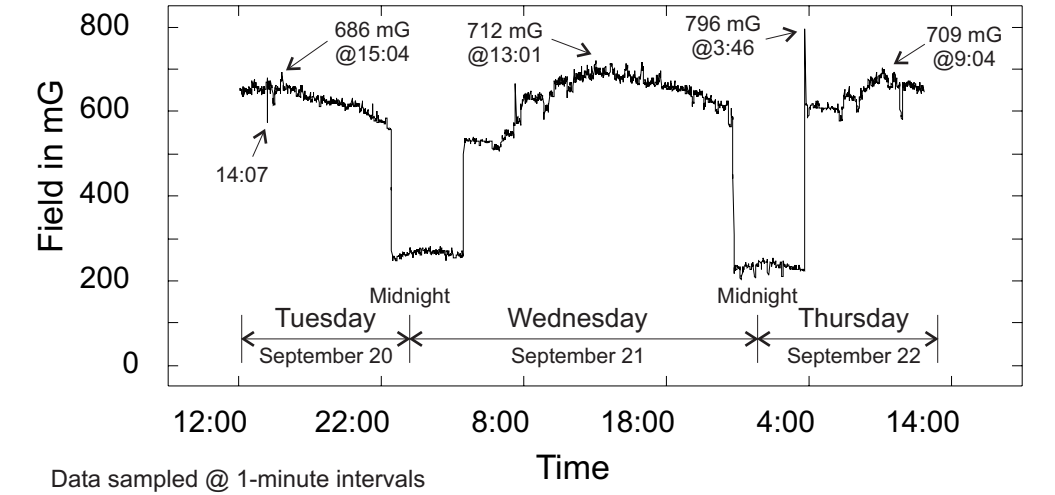
Data 1-meter above floor.

Figure #3

VitaTech Engineering, Inc

Dosimetric Data - Community College 9/20-22/94

PEAK = 796 mG, MEAN = 552 mG, STD = 161 mG, MEDIAN = 624 mG
L5 = 690 mG, L95 = 235 mG, CUM EXP = 26475 mG hr



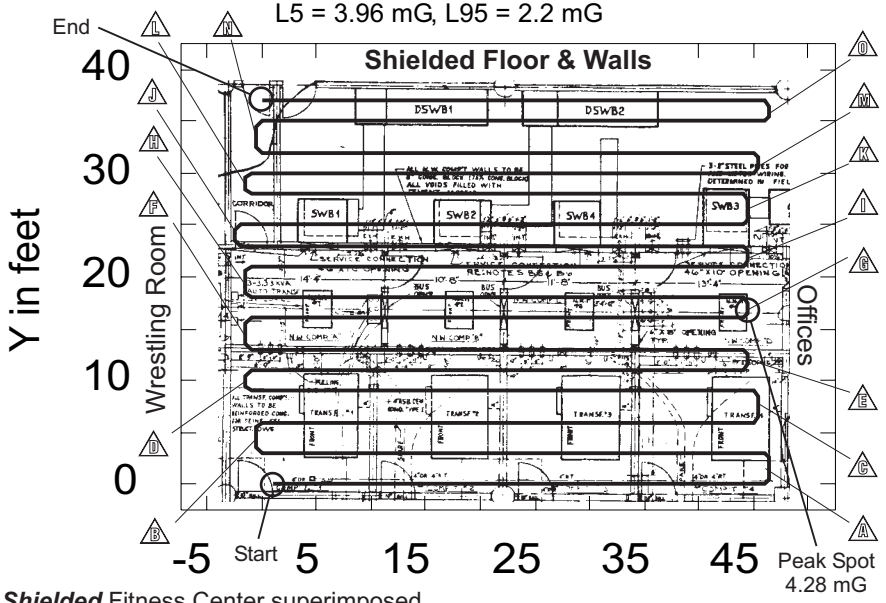
Data sampled @ 1-minute intervals for 48 hours. Gaussmeter placed over "peak spot" in Fitness Center. See Figure #1 for exact location.

Figure #4

VitaTech Engineering, Inc.

Map Plot - Community College 8/17/95

PEAK = 4.28 mG, MEAN = 2.96 mG, STD = .504 mG, MEDIAN = 2.96 mG
L5 = 3.96 mG, L95 = 2.2 mG



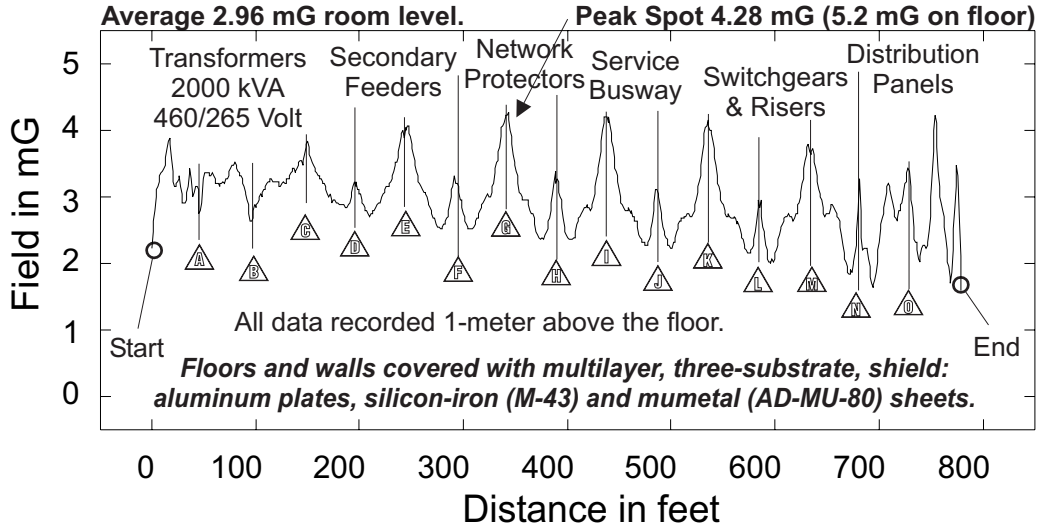
Shielded Fitness Center superimposed over transformers, network protectors, feeders, switchgears & distribution panels.

Figure #5

VitaTech Engineering, Inc.

Profile Plot - Community College 8/17/95

PEAK = 4.28 mG, MEAN = 2.96 mG, STD = .506 mG, MEDIAN = 2.96 mG
L5 = 3.96 mG, L95 = 2.2 mG



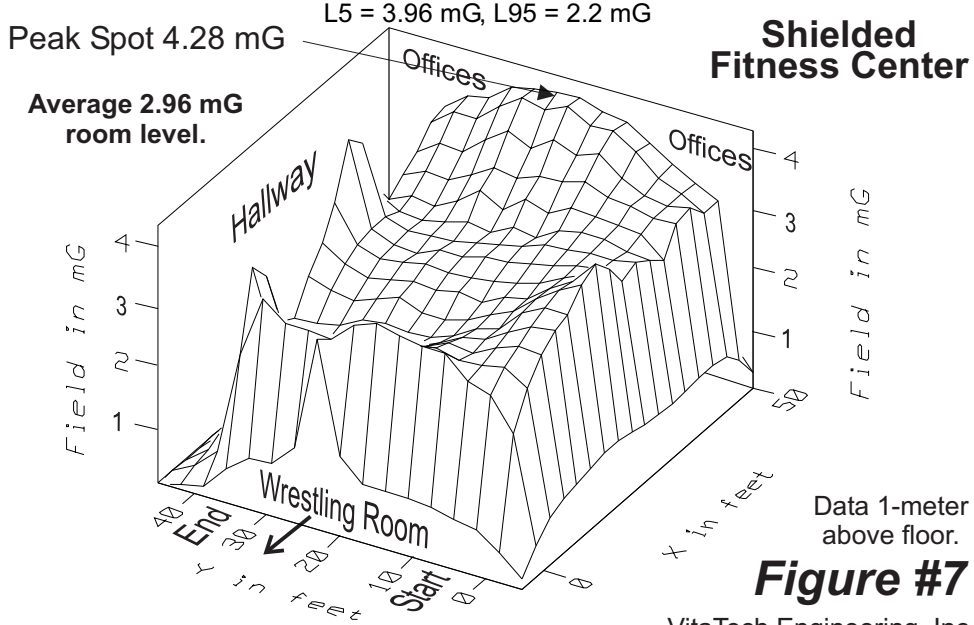
Shielded Fitness Center Profile Plot with markers (note: elevated wall levels). See Figure #5 for exact locations.

Figure #6

VitaTech Engineering, Inc.

3-D Contour Plot - Community College 8/17/95

PEAK = 4.28 mG, MEAN = 2.96 mG, STD = .506 mG, MEDIAN = 2.96 mG
L5 = 3.96 mG, L95 = 2.2 mG



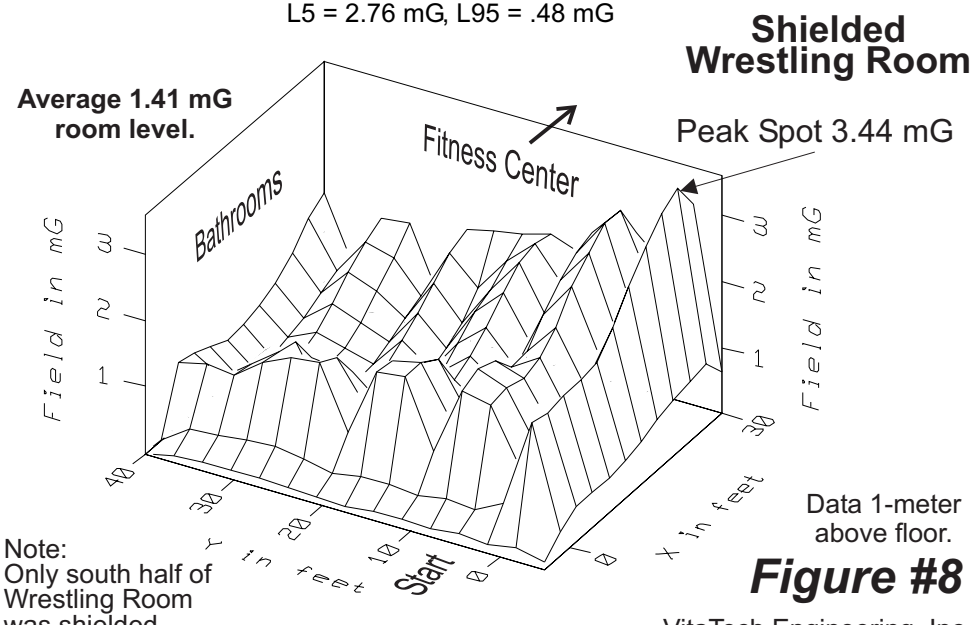
Data 1-meter above floor.

Figure #7

VitaTech Engineering, Inc

3-D Contour Plot - Community College 8/17/95

PEAK = 3.44 mG, MEAN = 1.41 mG, STD = .662 mG, MEDIAN = 1.44 mG
L5 = 2.76 mG, L95 = .48 mG



Data 1-meter above floor.

Note:
Only south half of Wrestling Room was shielded.

Figure #8

VitaTech Engineering, Inc

Before Shield Survey - Fitness Center Taken 8/17/94 ID-A1FS

PEAK = 111 mG, MEAN = 34.5 mG, STD = 26.7 mG, MEDIAN = 28.3 mG
L5 = 85.3 mG, L95 = 6.2 mG

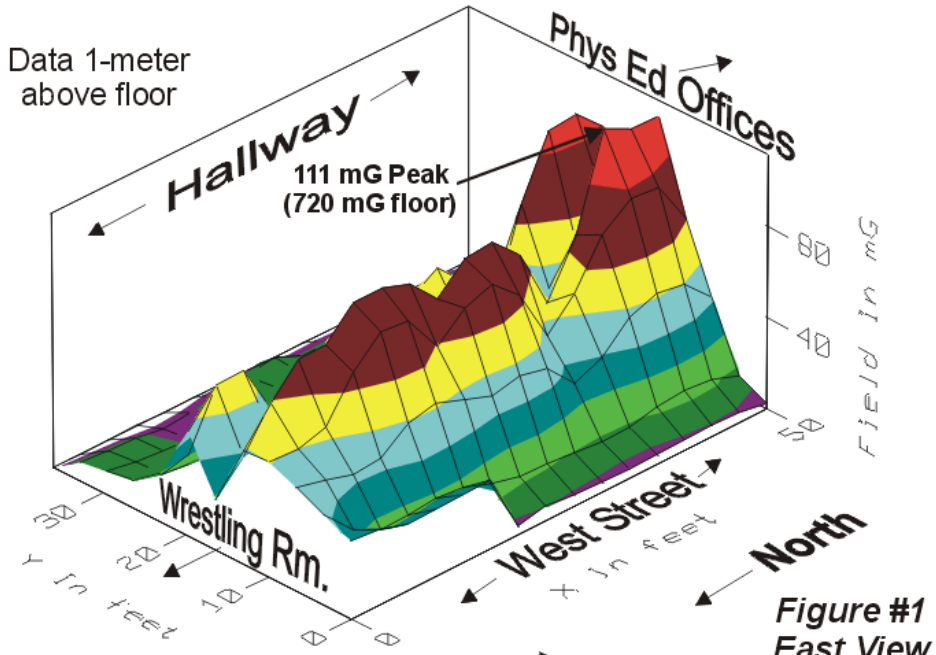


Figure #1 East View

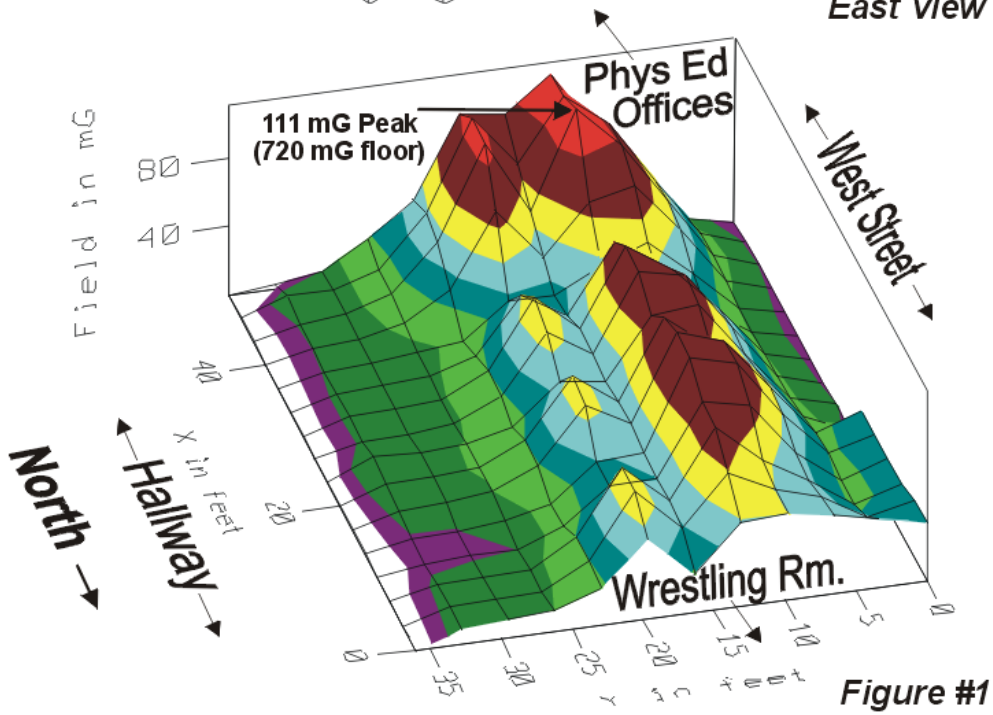


Figure #1 South View

3 < < 6 < < 12 < < 24 < < 36 < < 50 < < 65 < < 90 < (Br in mG)

Final Survey (Silicon-Iron, Aluminum & Mumetal) - Shielded Fitness Center Taken 4/3/96 ID-BMCC FS0

PEAK = 4.44 mG, MEAN = 2.61 mG, STD = .416 mG, MEDIAN = 2.64 mG
L5 = 3.36 mG, L95 = 2.08 mG

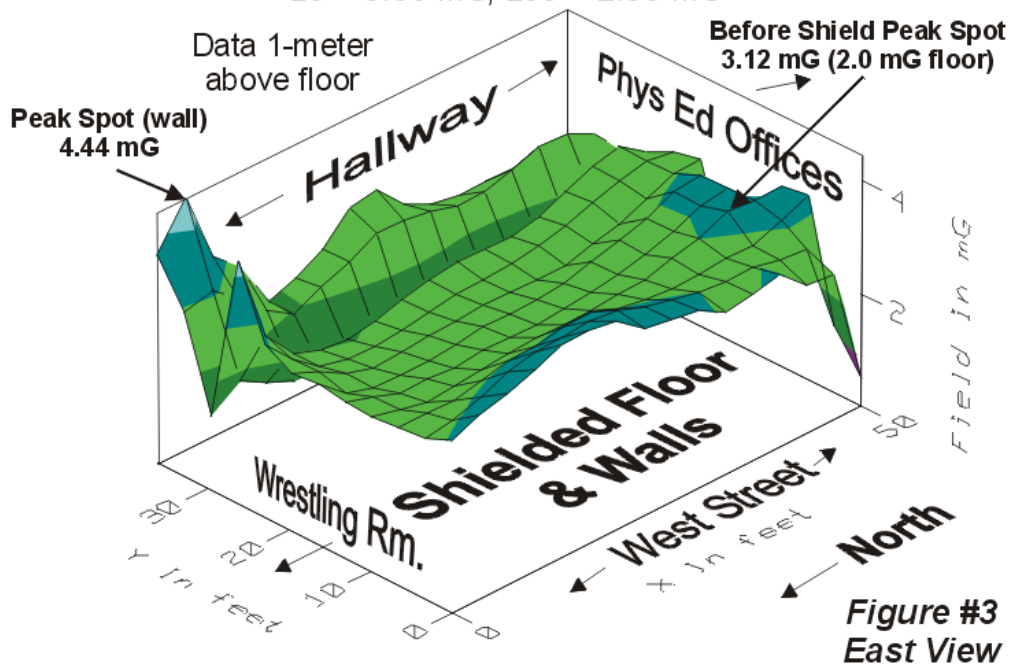


Figure #3 East View

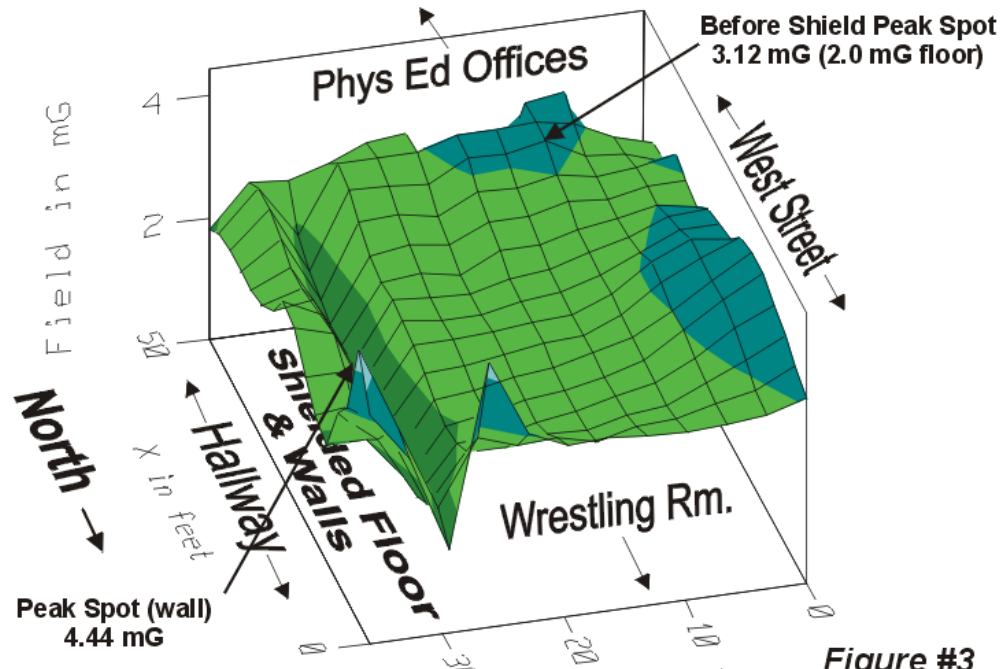


Figure #3 South View

0 < < 1 < < 2 < < 3 < < 4 < < 5 < < 6 < < 7 < (Br in mG)

Demolition/Preparation/Final Treatment

Wrestling Room (N212)

Fitness Center (N211)

Surface Wall D

Surface Wall C

Extension Wall A

Surface Wall A

Site Preparation

1) Remove electrical outlets/circuits from wall marked surface & extension in both rooms.

2) Install two temporary 20 amp suspended outlet boxes from the Fitness Center ceiling for power.

3) Remove from Fitness Center and store in Wrestling Room back area: wall mounted TV's, brackets, control boxes, telephones, clocks, black/cork boards, rubber floor tiles and mirrors.

4) Move existing Fitness Center light switches and circuits to new doorway (temporary until surface wall D is built).

5) Demolish Fitness Center existing windows, frames and two doors. Install double door with frame as shown. Close openings, cover surfaces with gypsum, and paint

6) Remove Extension Wall C heater units and cap-off exposed pipes.

7) Construct & install three Extension Walls A, B & C and four surface walls A, B, C & D as shown. All extension/surface walls are covered with 3/4" interior plywood 4' x 8' sheets.

Control Joints 3/8" high x 1/4" (variable width)
Also install Control Joints at the perimeter wall/floor seams.

Floor Section: 450 sq. ft.

Temporary Storage Area
Fitness Center (stuff)
Construction Materials

Floor Section: 450 sq. ft.

Leave clearance for exit.

Floor Section: 450 sq. ft.

Control Joints 3/8" high x 1/4" (variable width)
Also install Control Joints at the perimeter wall/floor seams.

Floor Section: 450 sq. ft.

THOROFLOW 100 Installation

1) Each room is divided into four 450 sq. ft. sections with control joints as specified by the THOROFLOW 100 instructions. Mix 30 bags of THOROFLOW 100 with 157.5 gallons of THOROFLOW POLYMER ADDITIVE for each section for 3/8" maximum thickness (follow product mixing instructions.) Room temperature during mixing and pouring, finishing, and curing must be near 70 degrees F.

2) Pour into each floor section, screed (level), and finish surface. Care must be taken when pouring on either side of the expansion joint. Do not pour into open expansion channel. Final surface should be flat, smoothe, and clean. Expansion channel must be clean - remove splatter.

3) THOROFLOW 100 drys to accept foot traffic within 12 hours.

Floor Section: 450 sq. ft.

Floor Section: 450 sq. ft.

Finishing Work

1) Install finished gypsum walls over extension and surface walls, dress corners and soffits (top of aluminum and wall extensions) with molding. Fill, sand, and paint the walls, soffits, and molding to match each room color.

2)Install electrical outlets, light switches and circuits in gypsum walls at similar locations before construction.

3)Remove temporary electrical power boxes and circuits.

4) Install wall mounted TV's, brackets, control boxes, telephones, clocks, black/cork boards, mirrors and rubber floor tiles.

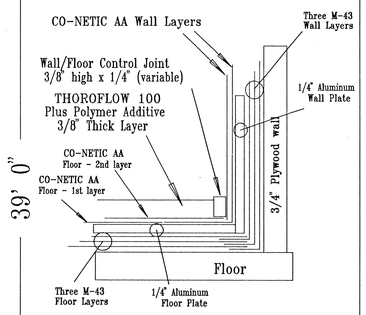
5) Install heater units next to extension wall C in Wrestling Room.

Floor Section: 450 sq. ft.

50' 0"

50' 0"

39' 0"



THOROFLOW 100
Wall/Floor Seam Joints
Installation Diagram

Extension Wall C

Surface Wall B

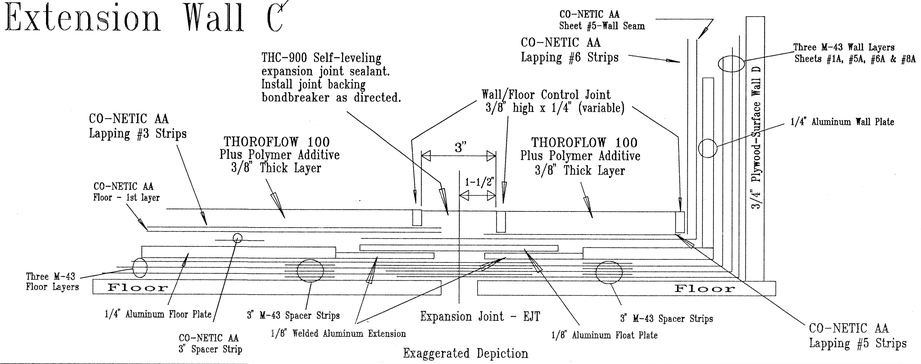
Extension Wall B

THOROFLOW 100 Cement & Expansion Joint Sealant Expansion Joint Installation Diagram

1) Install four 3/8" x 1/4" (variable width) control joints 1-1/2" from either side of the Expansion Joint forming a 3" wide channel as shown. Place 3" wide cut boards (studs) in channel to hold the control joints fixed. The inside channel/control joint seam must be water proof during the THOROFLOW 100 pouring - temporarily caulk along the joint/floor seam with silicon latex sealant.

2) Mix and pour the THOROFLOW 100 as direct in the Wrestling Room: do not permit THOROFLOW 100 intrusion into the expansion joint.

3) After THOROFLOW 100 is cured, remove the wooded 3" channel supports and temporary caulking along the joint/floor seams. Install a joint backing bondbraker (tape) as instructed by the TCH-900 specification, then pour the self leveling THC-900 expansion joint sealant into the open expansion joint channel. Requires 10-12 hours to set.



Exaggerated Depiction

Floor Plan-Demolition/Preparation/Final Treatment		
SCALE:1/4" = 1'	APPROVED BY: Lou Vitale, Chief Engineer	DRAWN BY:LSV
DATE:11/3/94		REVISED:
Borough of Manhattan Community College		
VitaTech Engineering, Inc. 15414 Beachview Drive, Montclair, VA 22026		DRAWING NUMBER EMF-2