Sauna Works
Clearlight Infrared Sauna Heater
AC ELF EMF Testing and Mitigation Analysis Report

Document History:

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1.0	September 14, 2016	JR & PZ	SC	LV	Initial Submittal

Vitatech Electromagnetics Review and Acceptance Status This decal is to be used for submitted documents requiring acceptance by Vitatech Electromagnetics.		
☐	Code 1.	All electromagnetic interference are within acceptable levels.
☐	Code 2.	AC 60 Hz magnetic flux density levels are within acceptable levels.
☐	Code 3.	Static and Quasi-static DC levels are within acceptable levels.
☐	Code 4.	Radio Frequency Power flux density levels and/or electric field strengths are within acceptable levels.
Review/Accepted by: (signature)		
Print Name:	Lou Vitale	Date: 09/14/2016
Acceptance by Vitatech Electromagnetics does not relieve the designer/supplier from full compliance with their contractual obligations and does not constitute Vitatech Electromagnetics approval of design, details, calculations, analyses, test methods or materials developed or selected by the designer/supplier.		

Contents

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September 14, 2016

Mr. Andy Kaps
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San Francisco, CA 94115
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Subject: AC ELF EMF EMC Manetic Field Testing for Sauna Works/Clearlight Infrared Saunas

Dear Mr. Kaps,

Vitatech Electromagnetics, LLC (Vitatech) was commissioned by Sauna Works/Clearlight Infrared Sauna to perform comprehensive AC ELF EMF EMC and electric field (electromagnetic compatibility) testing for a 600 watt 240 V infrared sauna heater at our office in Virginia. Vitatech operated the heater under normal electrical load at its regular "ON/OFF" settings to identify the peak magnetic field emmision level emitted from the heater per full-compliance testing. In addition to the normal magnetic and electric field testing at the common power frequency of 60 Hz, Vitatech measured the AC ELF magnetic field emanating from the sauna heaters from 12 Hz to 50 kHz as spot readings to ensure low-level magnetic flux density levels at the harmonic frequencies as well. The testing was performed on Thursday, September 8, 2016 by EMF Engineers John Robie and Pengcheng Zhang.

Executive Summary

The results of the electromagnetic compatibility testing indicate that the sauna heater tested emitted very low electromagnetic fields (EMF) and meet all known federal, state, and industry standards. Vitatech recommends 10 mG or less for long term human exposure to electromagnetic fields (EMF). Additionally, the peak electric field strength levels recorded for the sauna heater is within ICNIRP's recommended 4,167 V/m human health exposure limit for the general public and fully complies with Vitatech's recommended exposure threshold.

AC ELF Electromagnetic Interference (EMI)

Electromagnetic induction occurs when time-varying AC magnetic fields couple with any conductive object including wires, electronic equipment and people, thereby inducing circulating currents and voltages. In unshielded (susceptible) electronic equipment (computer monitors, video projectors, computers, televisions, LANs, diagnostic instruments, magnetic media, etc.) and signal cables (audio, video, telephone, data), electromagnetic induction generates electromagnetic interference (EMI), which is manifested as visible screen jitter in displays, hum in analog telephone/audio equipment, lost sync in video equipment and data errors in magnetic media or digital signal cables.

Magnetic flux density susceptibility can be specified in one of three terms: B_{rms}, $B_{\text{peak-to-peak}}$ ($B_{\text{p-p}}$) and B_{peak} (B_{p}) according to Equation 1 below:

$$B_{\text{rms}} = \frac{B_{\text{p-p}}}{2\sqrt{2}} = \frac{B_{\text{p}}}{\sqrt{2}} \ . \qquad (1)$$

Purpose

The objective of the AC ELF EMF testing services performed for the sauna heater was to identify the peak magnetic flux density levels emanating from the sauna heater under normal ON and OFF settings and compare the recorded data with both current federal/state/industry standards and Vitatech's 10 mG RMS recommended long-term human health exposure as presented in *Exhibit A, Recommended 50/60 Hz Magnetic Field Human Exposure & EMI Immunity Standards (July 2015).* It should be noted that all recorded time-varying 60 Hz magnetic flux density levels within this report are presented in peak-to-peak units of mG (milligauss) in the B_x, B_y, and B_z axes, then converted to B_r resultant RMS (root-mean-square) units. All electric field strength levels are presented in isotropic V/m (volt-per-meter) units, which is similar to the B_r resultant for magnetic fields.

AC ELF Magnetic Flux Density Site Assessments & Conclusions

Vitatech recorded mapped and spot-reading AC ELF magnetic flux density levels as a set of data plots to ascertain the magnetic field emission profile of the Clearlight 600 watt 240 volt sauna heater. Note that all AC magnetic flux density levels were recorded in units of milligauss RMS (root-mean-square). In addition to magnetic field measurements, electric field measurements were also taken on the sauna heater to evaluate its electric field emission profile. A detailed assessment of the recorded magnetic flux density data is presented as a series of graphics, see attached Figure #1 through Figure #15. A detailed assessment of the electric field data is presented as a series of graphics, see attached Figure #16 through Figure #19. Lastly, decay models of the magnetic field in different directions are presented in Figure #20.

Figure Descriptions

Figure #1 - Experimental Setup

Figure #1 presents the experimental setup for the magnetic flux density measurements of the 600 watt 240 V Clearlight infrared sauna heater. The sauna heater is secured to unistrut, thereby attached to the fork of a forklift using chains. The sauna heater remains level throughout the experiment. By utilizing the hydraulic system of the forklift, the height of the sauna heater relative to ground level can be adjusted. A FieldStar 1000 Triaxial Gaussmeter is secured to the bottom of a mapping wheel. Magnetic flux density is measured within a $14' \times 20'$ box surrounding the sauna heater.

Figure #2 - Background AC ELF Magnetic Flux Density Levels

Figure #2 presents the background magnetic flux density levels of the experiment environment measured as the 600 watt 240 V sauna heater is turned OFF (disconnected). Data is presented as a contour map of isolines. Elevated fields are present on the right ($+x$ direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the 60 Hz electrical panel has little to no effect on the magnetic flux density levels within close proximity to the center point of the sauna heater. Additionally, note that the emission of the 60 Hz electrical panel may vary (isolines extending further away or contracting closer to the source) based on electrical current load of the panel at the time.

Figure #3 - AC ELF Magnetic Flux Density Levels at 3 Ft Elevation

Figure #3 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 3 feet above ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right ($+x$ direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #4 - AC ELF Magnetic Flux Density Levels at 1m Elevation

Figure #4 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 1 meter above ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right (+x direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #5 - AC ELF Magnetic Flux Density Levels at 4 Ft Elevation

Figure #5 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 4 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right (+x direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the emission profile of the electrical panel here extends much further away than the background measurement. No EMI threats were found.

Figure #6 - AC ELF Magnetic Flux Density Levels at 5 Ft Elevation

Figure #6 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 5 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right (+x direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the emission profile of the electrical panel here extends much further away than the background measurement. No EMI threats were found.

Figure #7 - AC ELF Magnetic Flux Density Levels at 6 Ft Elevation

Figure #7 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 6 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right (+x direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #8 - AC ELF Magnetic Flux Density Levels at 7 Ft Elevation

Figure #8 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 7 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right (+x direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #9 - AC ELF Magnetic Flux Density Levels at 8 Ft Elevation

Figure #9 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 8 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right ($+x$ direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the emission profile of the electrical panel here extends much further away than the background measurement. No EMI threats were found.

Figure #10 - AC ELF Magnetic Flux Density Levels at 9 Ft Elevation

Figure #10 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 9 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right ($+x$ direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #11 - AC ELF Magnetic Flux Density Levels at 10 Ft Elevation

Figure #7 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 6 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right ($+x$ direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #12 - AC ELF Magnetic Flux Density Levels at 11 Ft Elevation

Figure #12 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 11 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right ($+x$ direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #13 - AC ELF Magnetic Flux Density Levels at 12 Ft Elevation

Figure #13 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 12 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right ($+x$ direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #14 - AC ELF Magnetic Flux Density Levels at 13 Ft Elevation

Figure #14 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 13 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right ($+x$ direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #15 - AC ELF Magnetic Flux Density Levels at 14 Ft Elevation

Figure #15 presents the magnetic flux density levels measured as the 600 watt 240 V sauna heater is turned ON (connected) and elevated 14 feet from ground level. Data is presented as a contour map of isolines. Similar to the background emission, elevated fields are present on the right ($+x$ direction) portion of the contour map, primarily due to a 60 Hz electrical panel near the experimental setup. All magnetic flux density level measurements were below 0.5 mG, which is well below Vitatech's recommended human health threshold of 10 mG. Note that the magnetic flux density levels within close proximity to the sauna heater are little to none. No EMI threats were found.

Figure #16 - Baseline Electric Field Spot Measurement

Figure #16 presents the background electric field levels of the testing environment recorded with a MEDA ARA Electromagnetic Analyzer PMM. The peak electric field level recorded was 3.8735 V/m at 58.6 Hz.

Figure #17 - Electric Field Spot Measurement at $Z = 1$ m and $X = 0$ m

Figure #17 presents the electric field levels recorded with a MEDA ARA Electromagnetic Analyzer PMM directly 1 m below the 600 watt 240 volt sauna heater as it is turned ON (connected). The peak electric field level recorded was 17.167 V/m at 58.6 Hz. Vitatech recommends a human health exposure limit of 4,167 V/m for 60 Hz electric field, which is compliant with the ICNIRP electric field standard for the general public. The recorded peak electric field level was well below Vitatech's recommended value.

Figure #18 - Electric Field Spot Measurement at $Z = 1$ m and $X = 1$ m

Figure #18 presents the electric field levels recorded with a MEDA ARA Electromagnetic Analyzer PMM 1 m below and 1 m in front of the 600 watt 240 volt sauna heater as it is turned ON (connected). The peak electric field level recorded was 3.8391 V/m at 58.6 Hz. Vitatech recommends a human health exposure limit of 4,167 V/m for 60 Hz electric field, which is compliant with the ICNIRP electric field standard for the general public. The recorded peak electric field level was well below Vitatech's recommended value.

Figure #19 - Electric Field Spot Measurement at $Z = 1$ m and $X = 2$ m

Figure #19 presents the electric field levels recorded with a MEDA ARA Electromagnetic Analyzer PMM 1 m below and 2 m in front of the 600 watt 240 volt sauna heater as it is turned ON (connected). The peak electric field level recorded was 4.1356 V/m at 58.6 Hz. Vitatech recommends a human health exposure limit of 4,167 V/m for 60 Hz electric field, which is compliant with the ICNIRP electric field standard for the general public. The recorded peak electric field level was well below Vitatech's recommended value.

Figure #20 - Decay Models

Figure #20 presents the magnetic flux density emission profiles along the x, y, and z axis of the sauna heater emission. Magnetic flux density levels were measured as spot readings at points along each axis using the FieldStar 1000 Triaxial Gaussmeter. Data taken along the x, y and z directions all demonstrated good fit to a power decay model. Along the x axis, the magnetic flux density levels (in mG) decays at a rate of 0.9568 with respect to separation distance (in inches); along the y axis, the magnetic flux density levels (in mG) decays at a rate of 1.3104 with respect to separation distance (in inches); and along the z axis, the magnetic flux density levels (in mG) decays at a rate of 1.3010 with respect to separation distance (in inches).

Conclusions

It was found that at a separation distance of 3-4 feet the magnetic field levels produced by the Clearlight 600 watt 240 volt sauna heater drop to 0.0 mG (below the detection resolution of the FieldStar 1000 Triaxial Gaussmeter), which fully complies with Vitatech's recommended long-term human health exposure threshold recommendation of 10 mG. In addition, the sauna heater demonstrates excellent magnetic field decay rate along the x, y, and z directions.

The electric field measurements taken with the Clearlight 600 watt 240 volt sauna heater switched ON showed peak values at 58.6 Hz. At 1 meter below the sauna heater, a peak of 17.167 V/m was found, which fully complies with the ICNIRP electric field standard for the general public.

Therefore, Vitatech concludes that the Clearlight 600 watt 240 volt sauna heater, not only complies with, but also emits magnetic and electric fields significantly lower than Vitatech's recommended long-term human health EMI exposure limits and can be considered very a low EMI noise heater.

Note: Attachment: Twenty (20) figures – Figure#1 through Figure#20.

This completes the *Clearlight Infrared Sauna Heater AC ELF EMF Testing and Mitigation Analysis Report*. Please call if you have any further questions.

Best regards,

Pengcheng Zhang
Simulation Programmer

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Figure #1
Experimental Setup

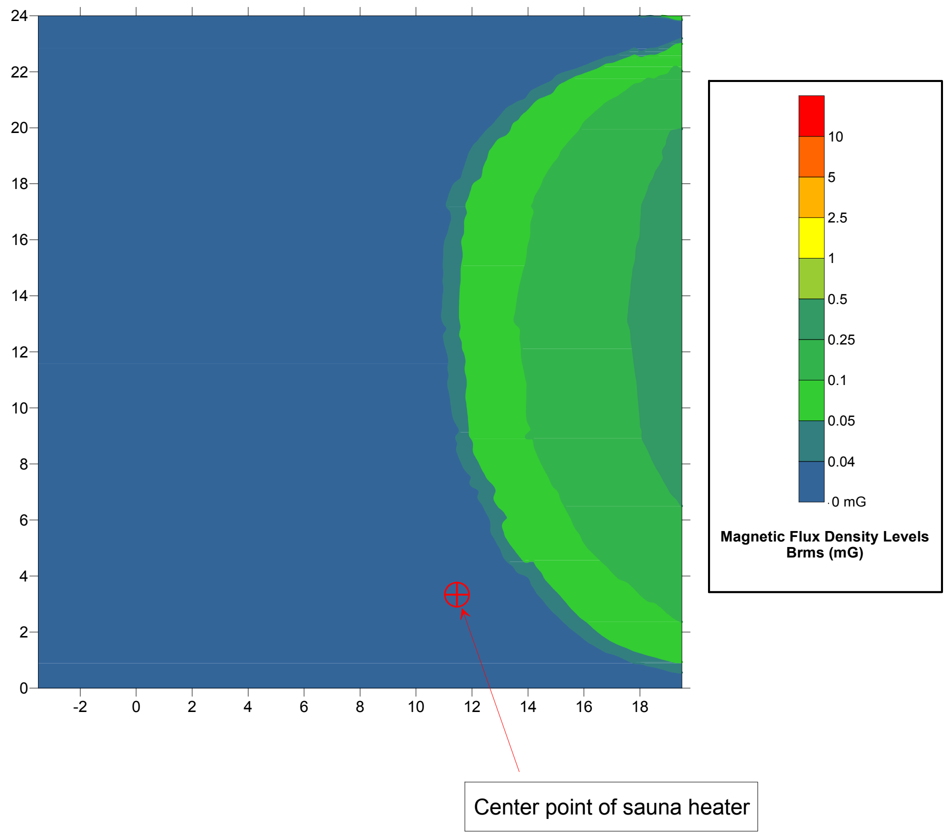
Image #1:
The sauna heater is secured to a forklift using unistrut and chains. The height of the sauna heater is adjusted by raising and lowering the fork.The sauna heater remains level throughout the experiment.

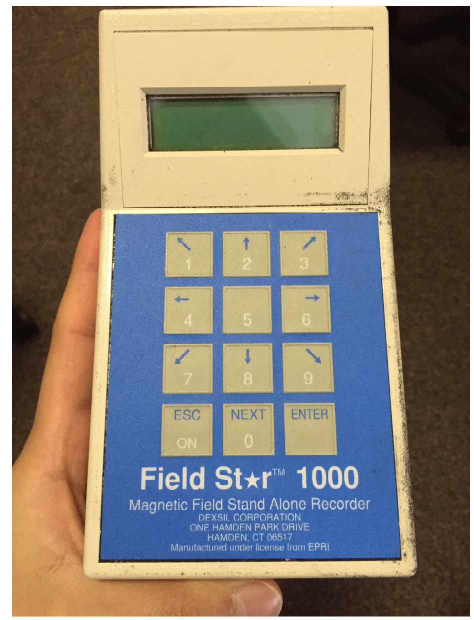
Image #2:
The FieldStar 1000 Triaxial Gaussmeter is secured to the bottom of the mapping wheel. Magnetic flux density measurements are taken every foot from the starting point in a 14' X 20' box. Note that the center point of the sauna heater is located at X = 11' 5" and Y = 3' 8" with respect to the starting point.

Image #3:
The fork of the forklift is raised for height adjustment of the sauna heater. The height of the sauna heater is measured prior to every measurement.

Figure #2

Background Magnetic Flux Density Data

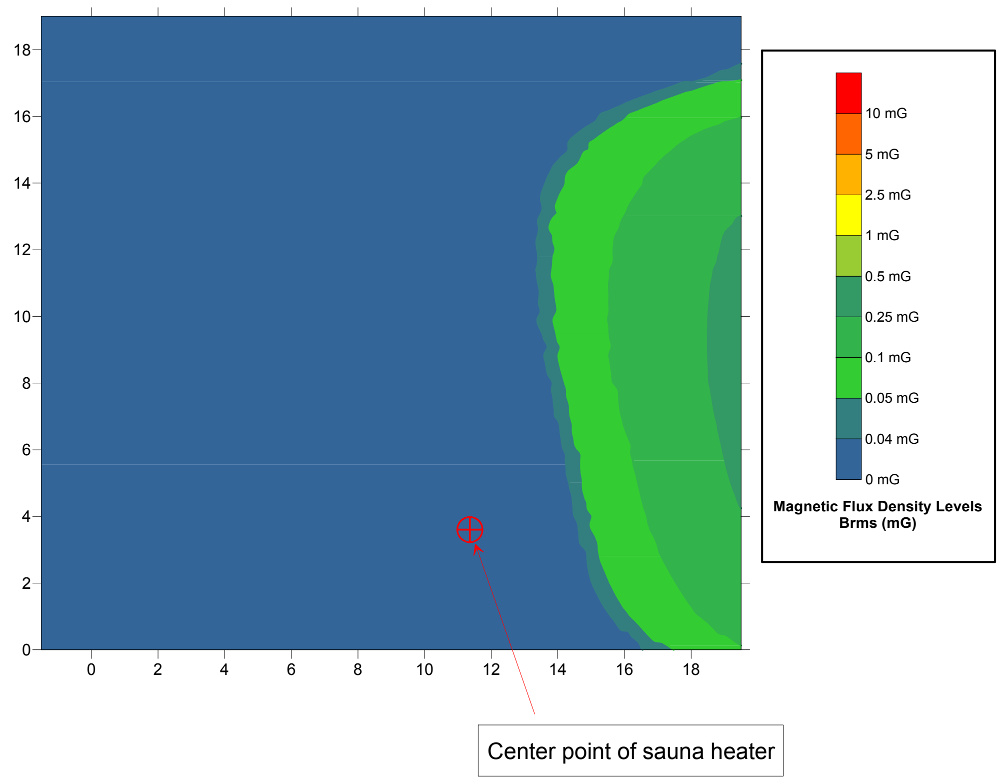


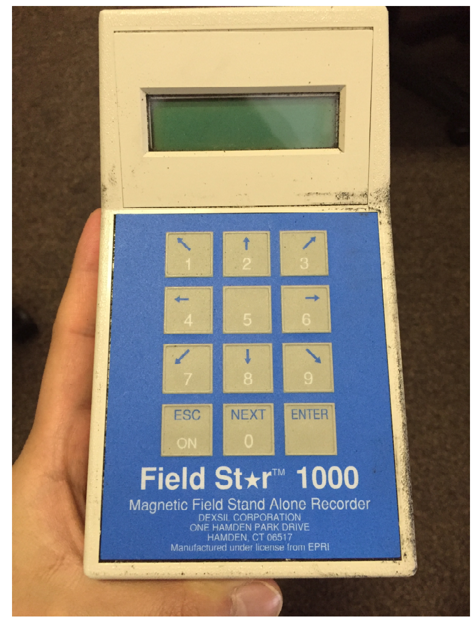


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #3

Magnetic Flux Density Data at 3 Ft Elevation

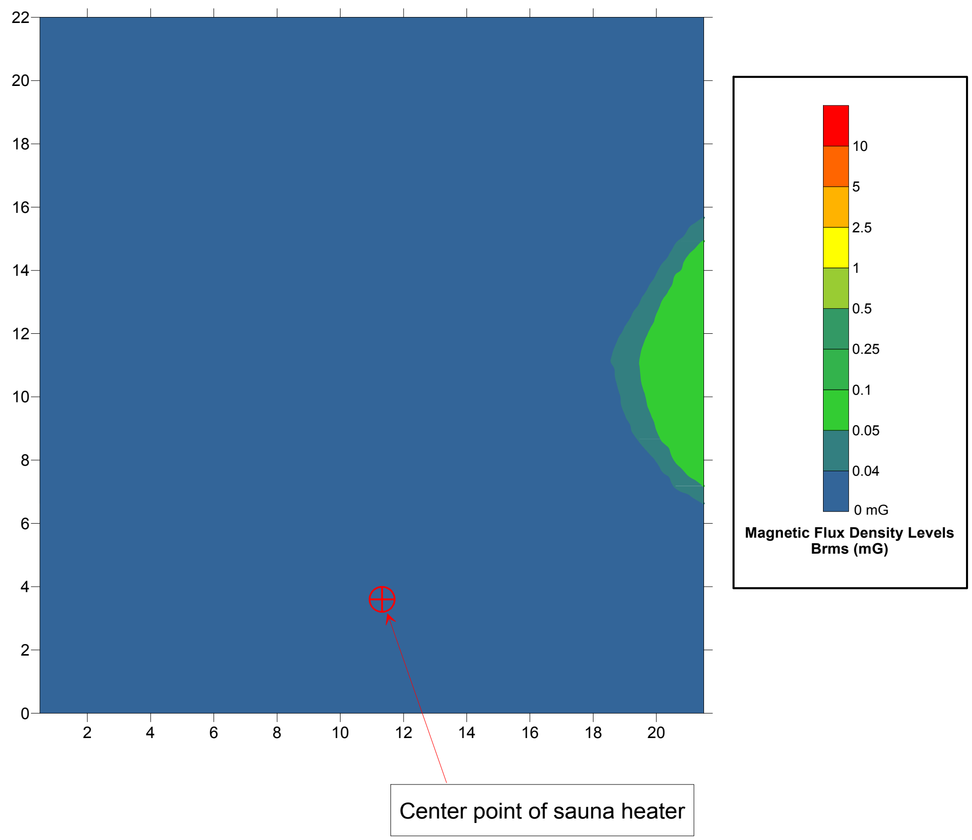


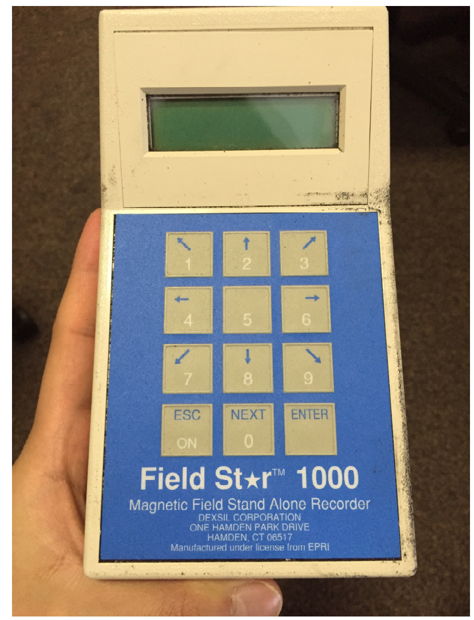


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #4

Magnetic Flux Density Data at 1 m Elevation

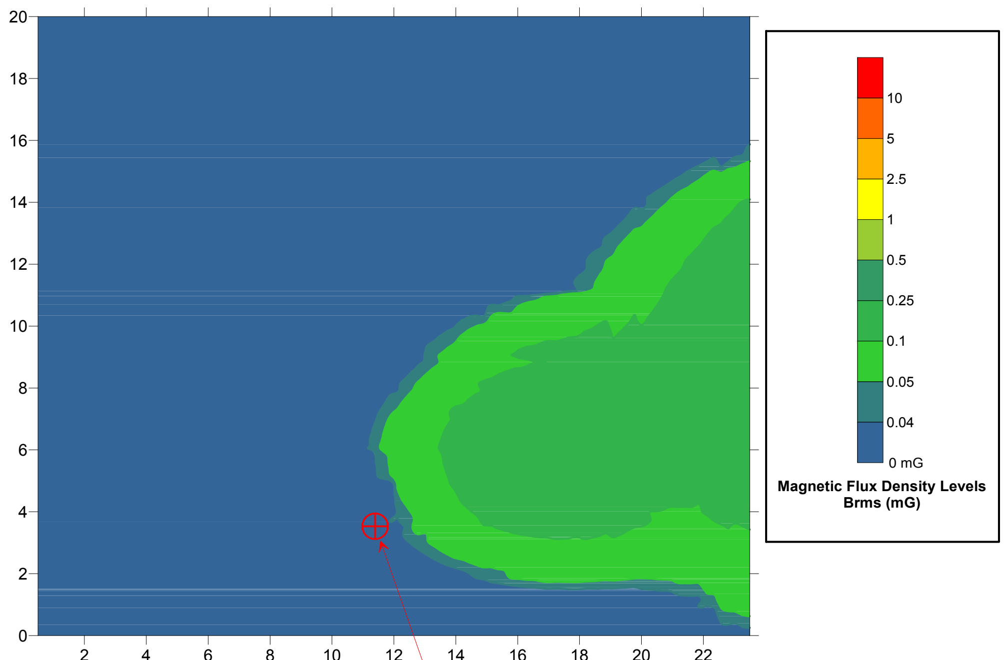




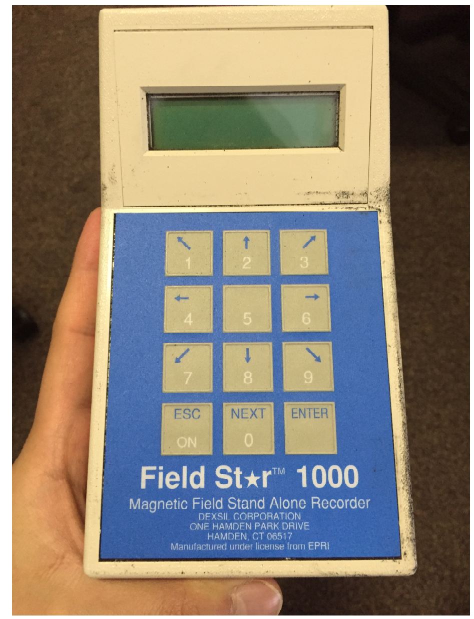
FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #5

Magnetic Flux Density Data at 4 Ft Elevation



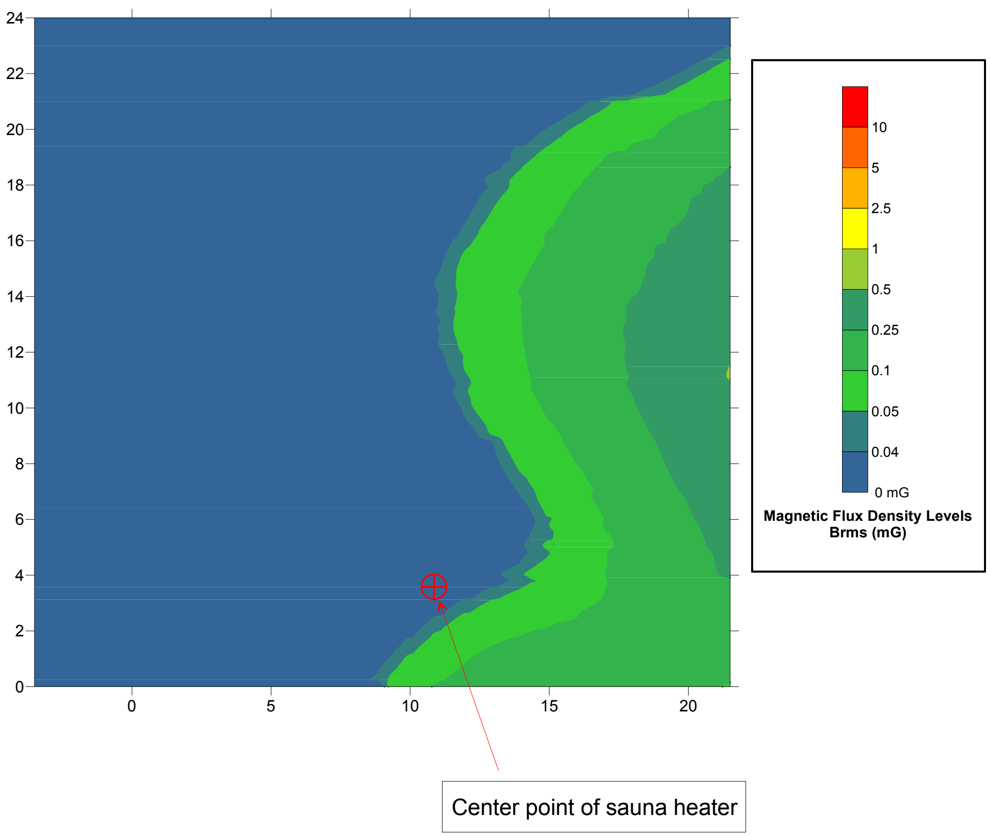
Center point of sauna heater

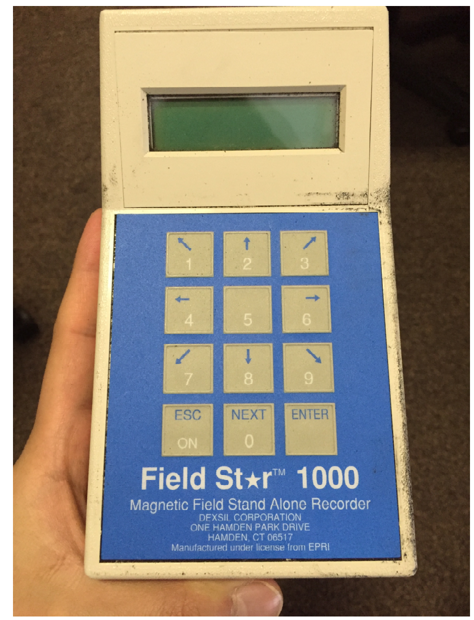


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #6

Magnetic Flux Density Data at 5 Ft Elevation

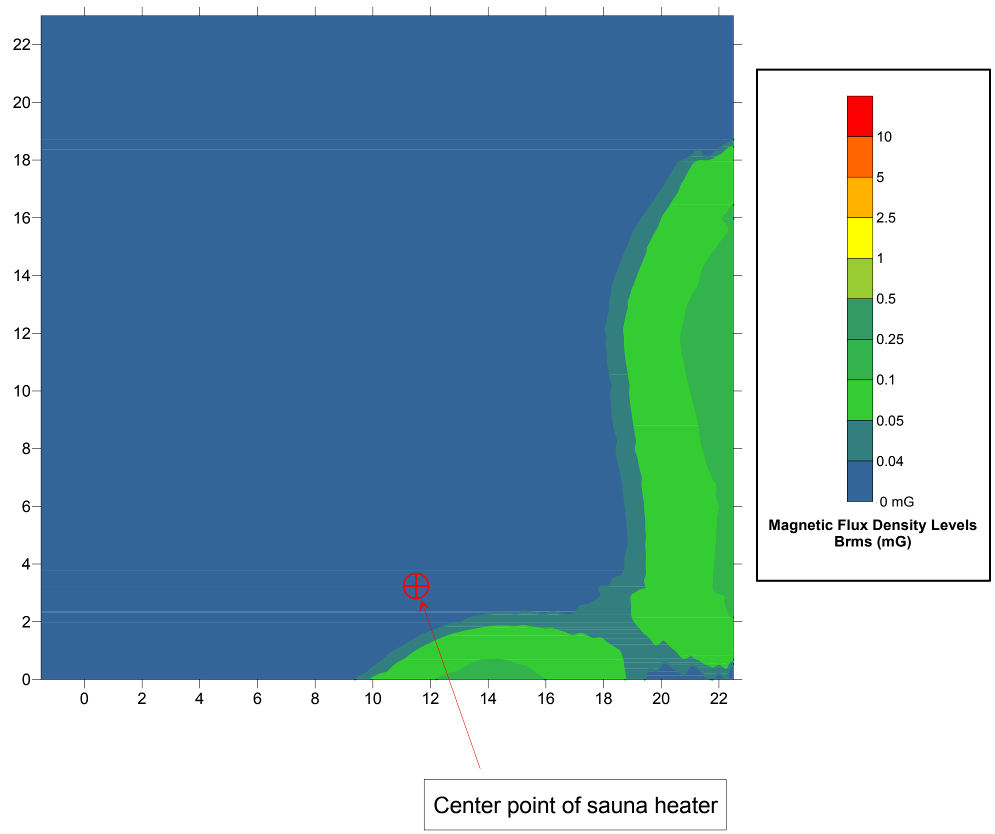


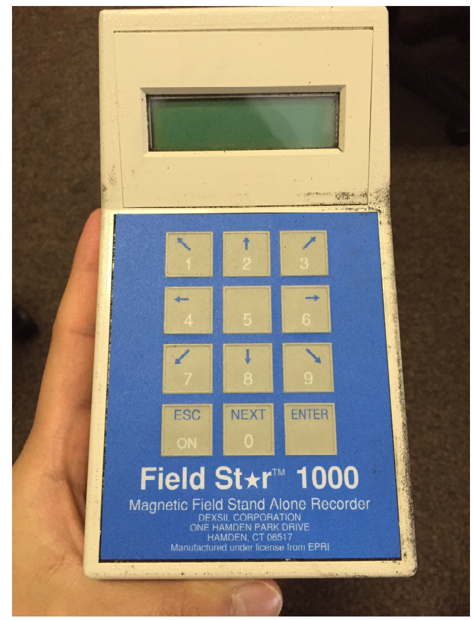


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #7

Magnetic Flux Density Data at 6 Ft Elevation

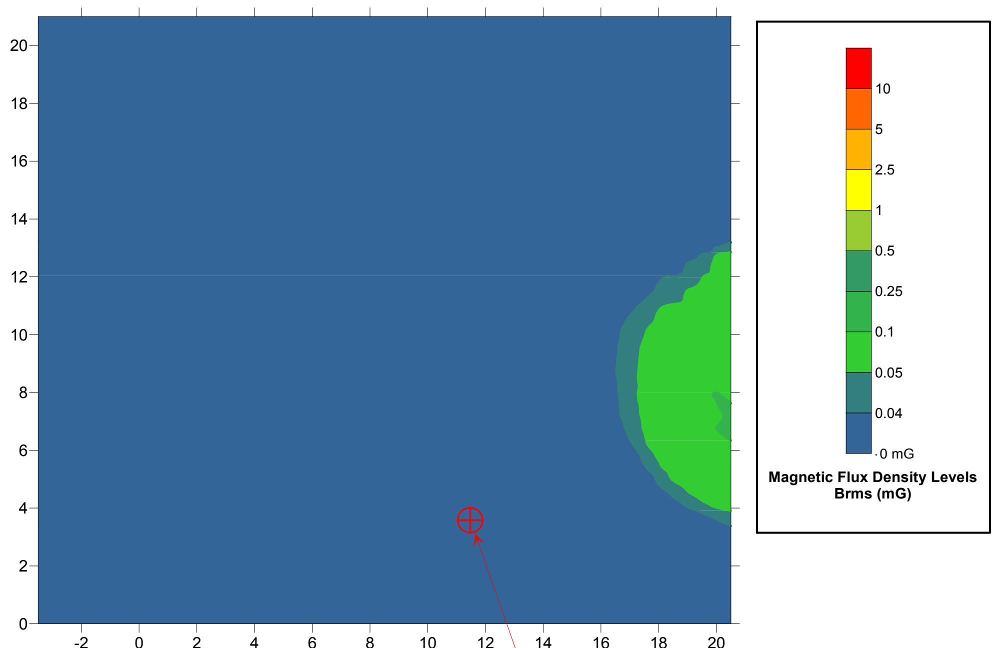




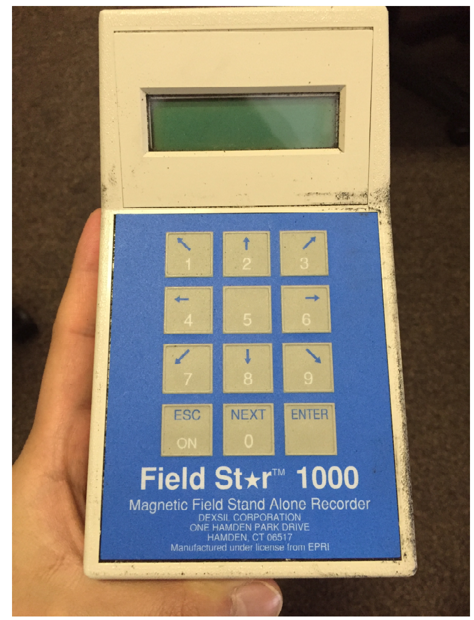
FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #8

Magnetic Flux Density Data at 7 Ft Elevation



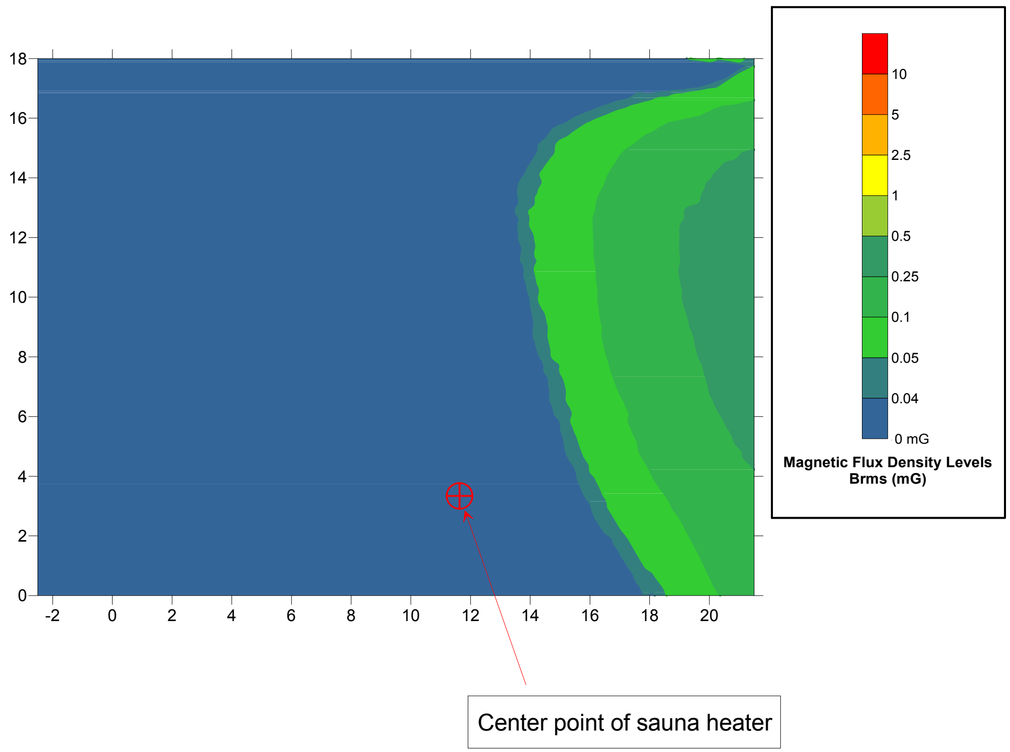
Center point of sauna heater

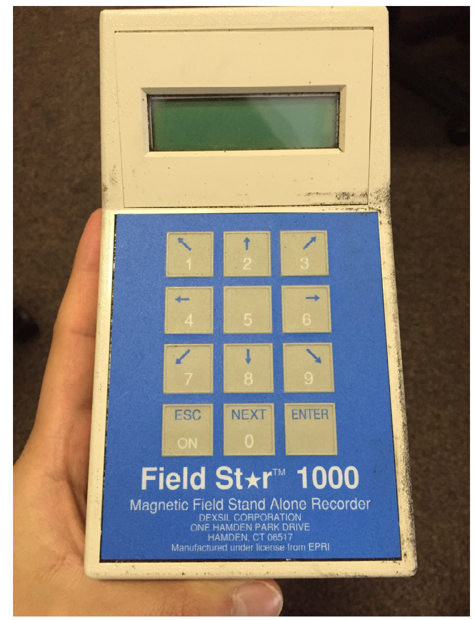


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #9

Magnetic Flux Density Data at 8 Ft Elevation

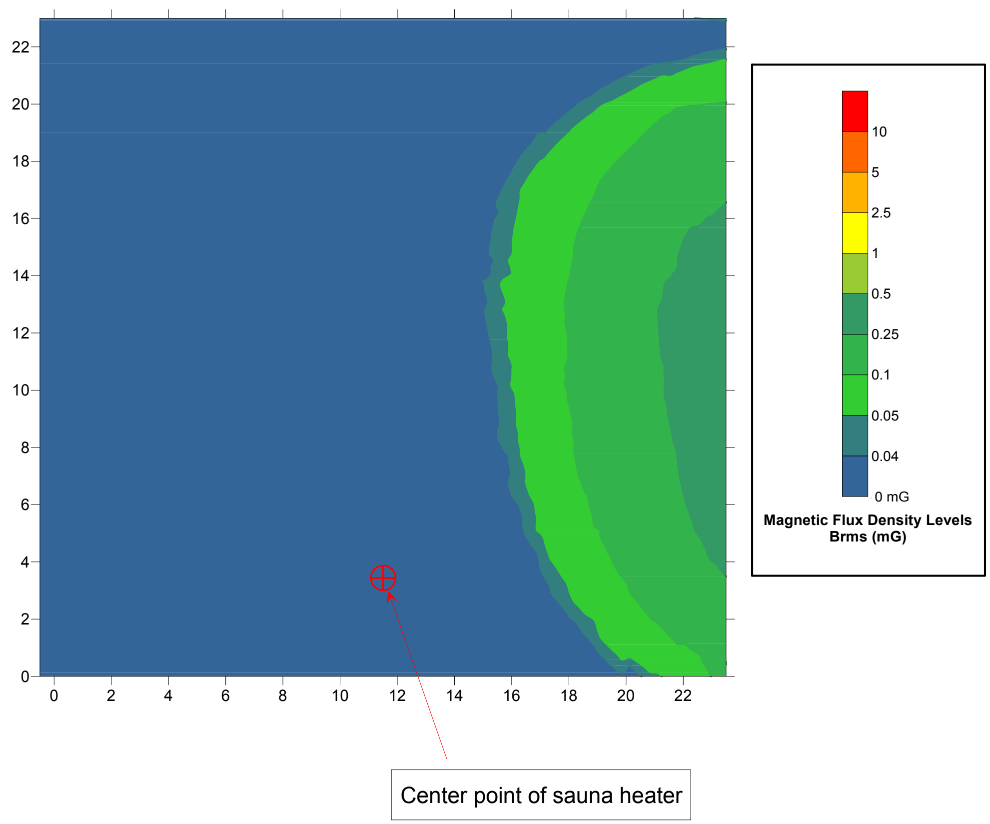


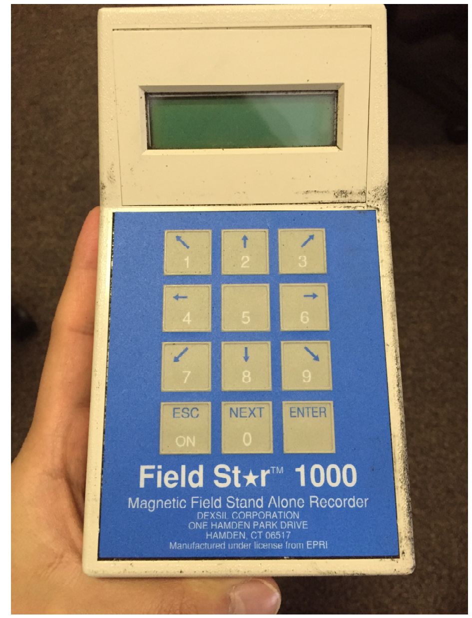


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #10

Magnetic Flux Density Data at 9 Ft Elevation

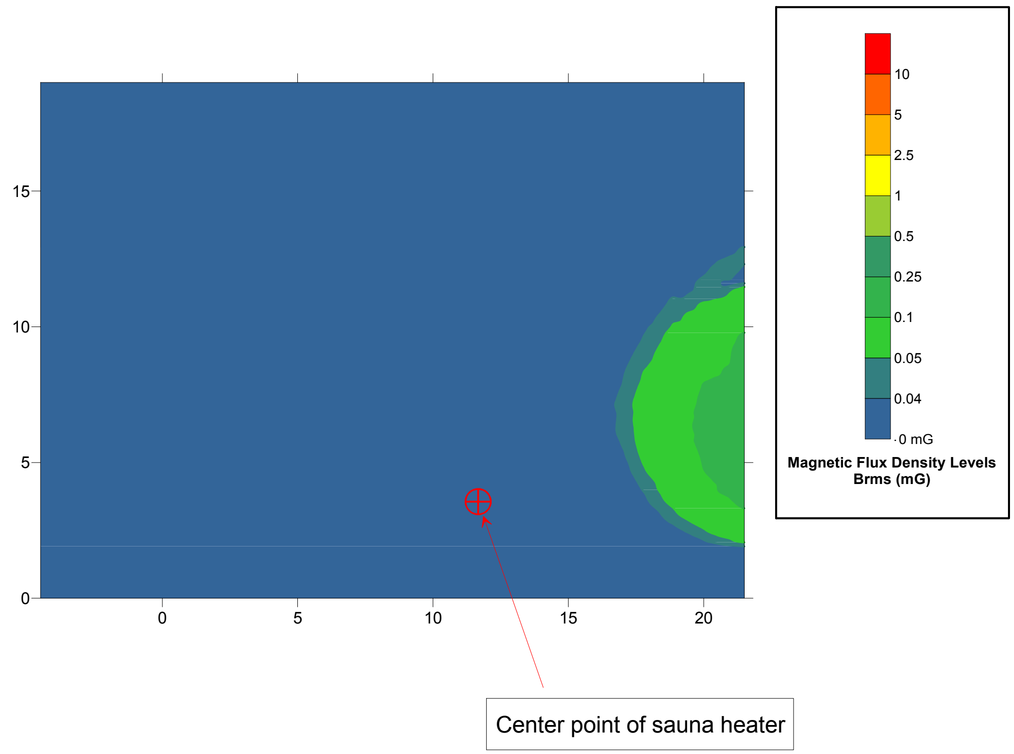


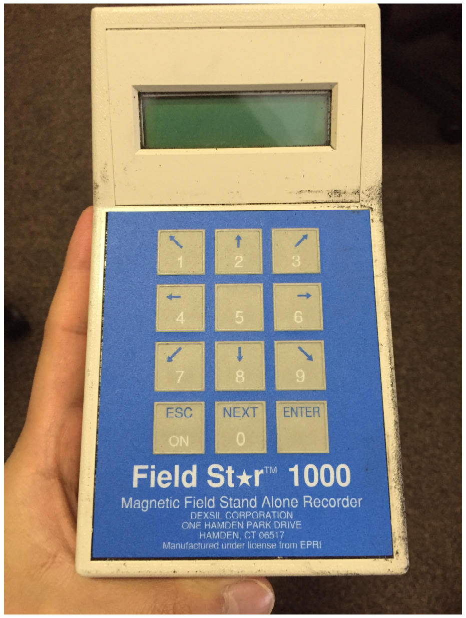


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #11

Magnetic Flux Density Data at 10 Ft Elevation

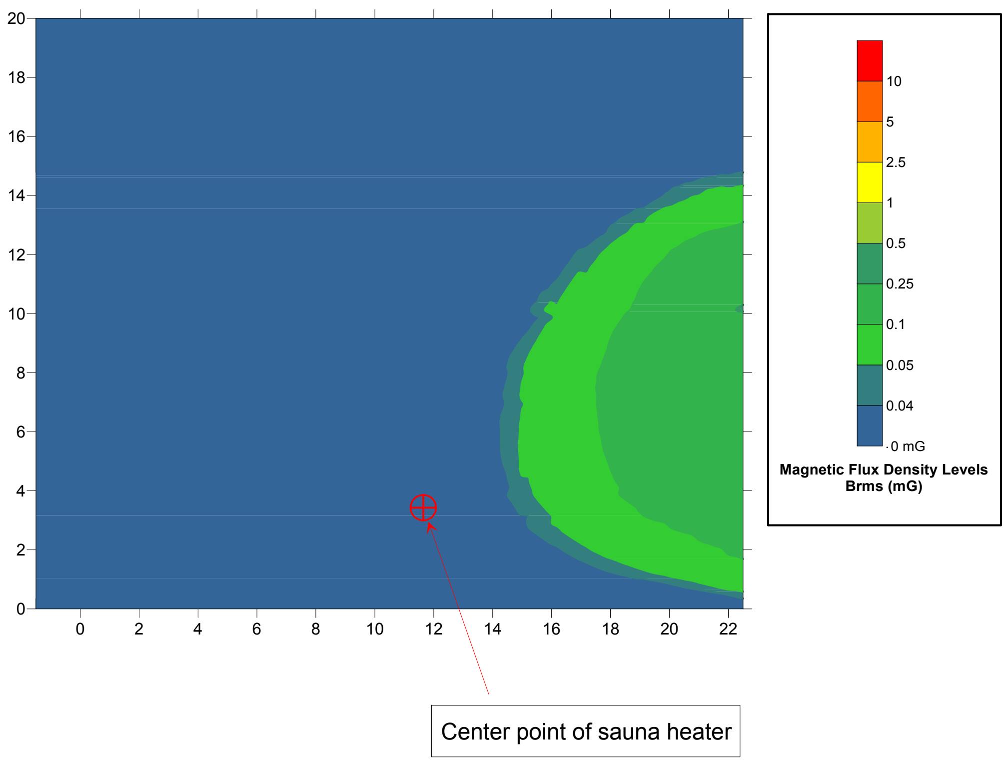


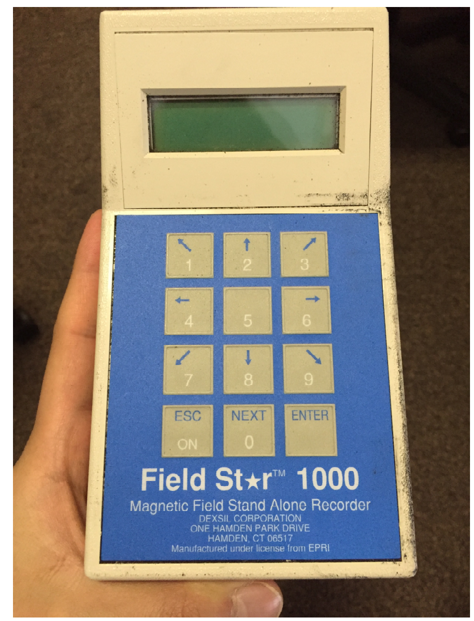


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #12

Magnetic Flux Density Data at 11 Ft Elevation

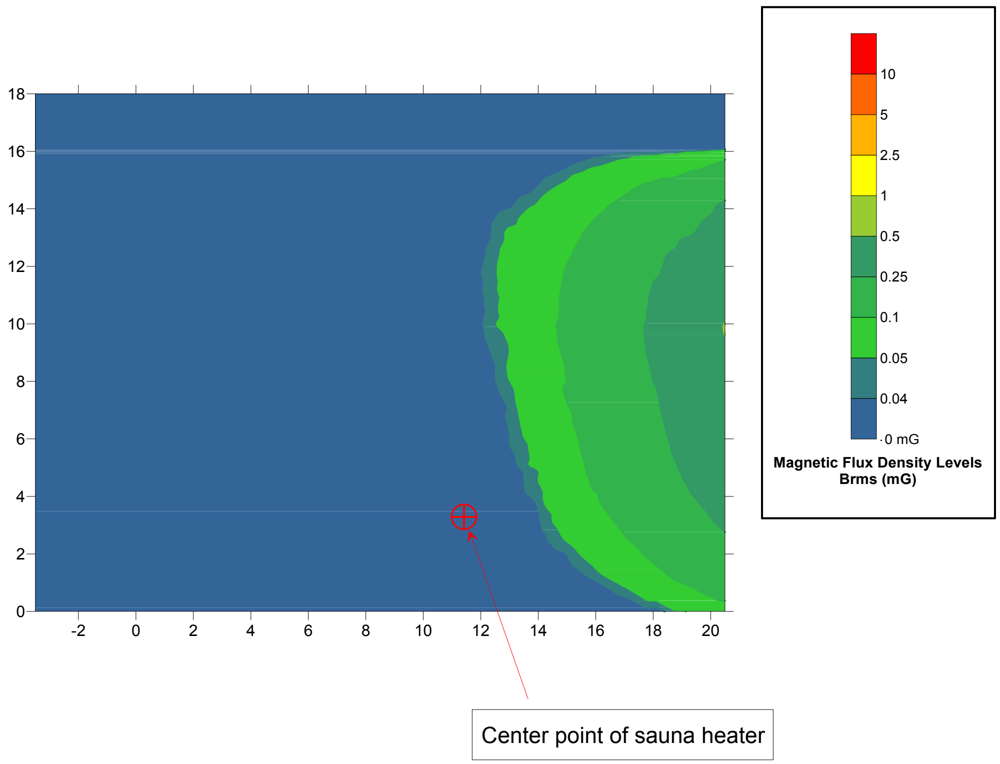


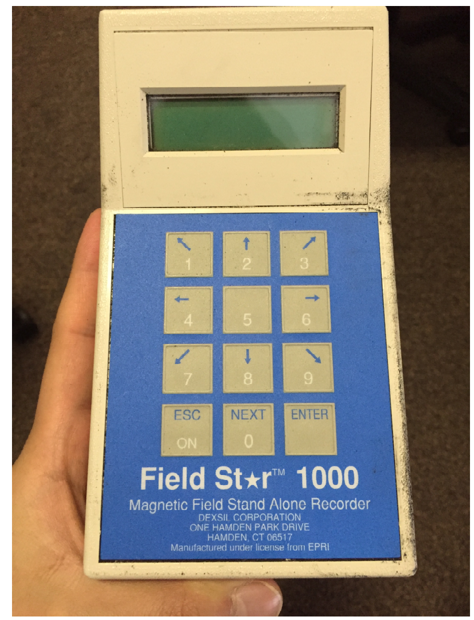


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #13

Magnetic Flux Density Data at 12 Ft Elevation

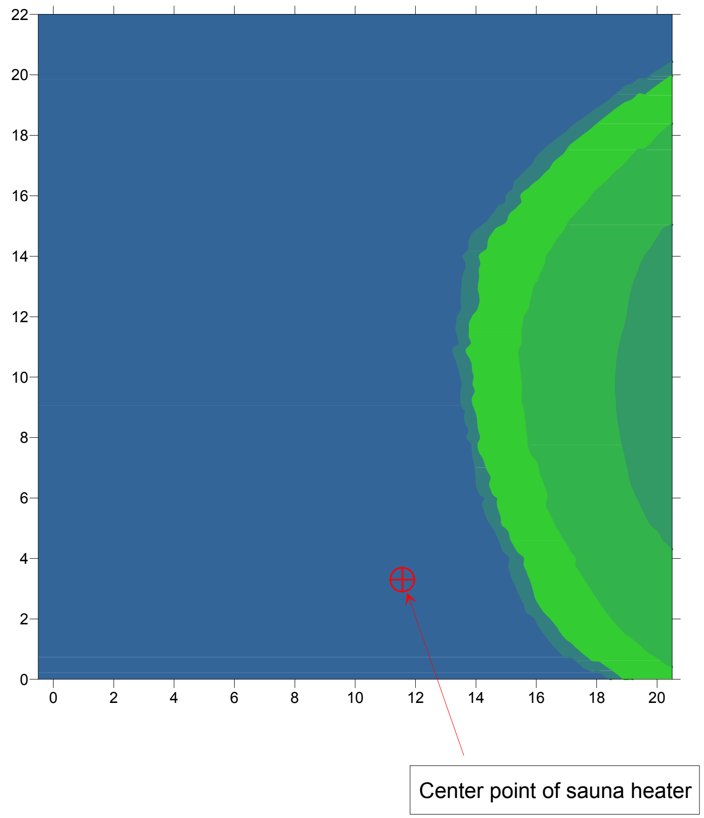


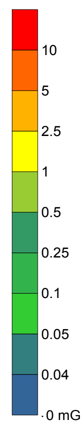


FieldStar 1000 Gaussmeter
used during EMF/EMC Study

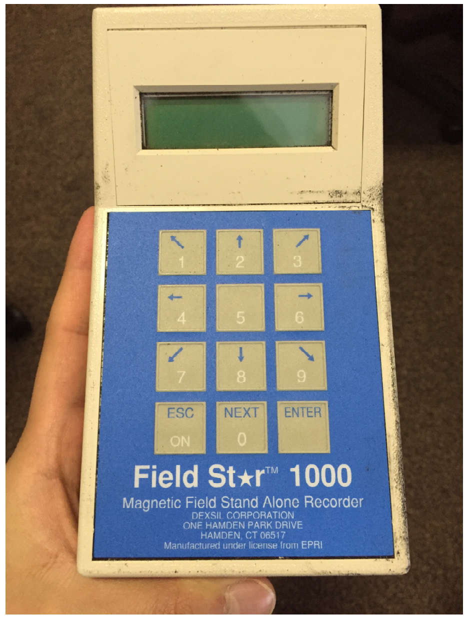
Figure #14

Magnetic Flux Density Data at 13 Ft Elevation





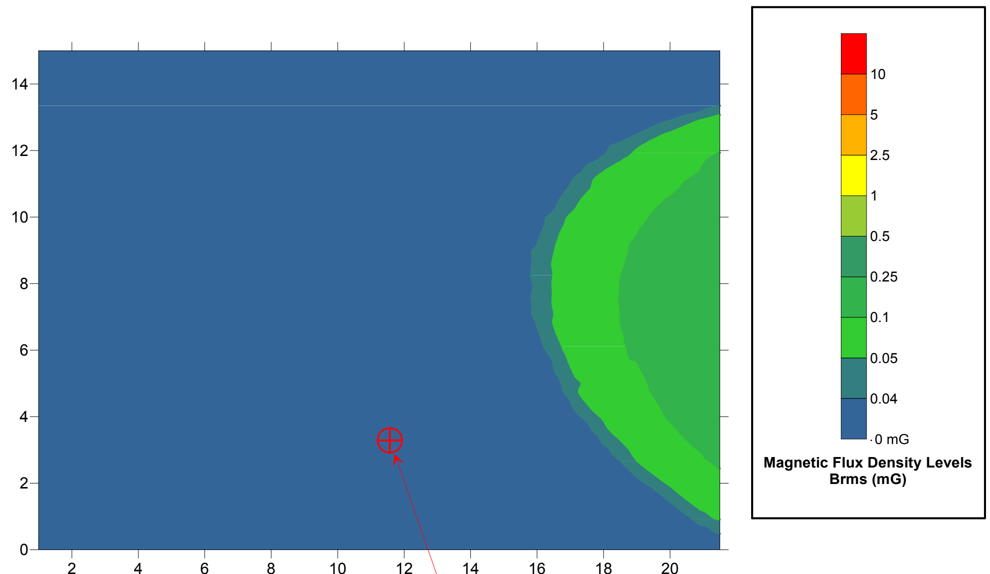
Magnetic Flux Density Levels Brms (mG)



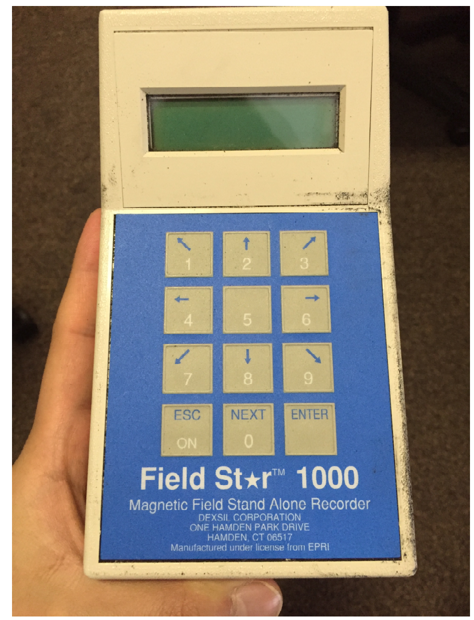
FieldStar 1000 Gaussmeter used during EMF/EMC Study

Figure #15

Magnetic Flux Density Data at 14 Ft Elevation



Center point of sauna heater



FieldStar 1000 Gaussmeter
used during EMF/EMC Study

Figure #16

Electric Field Background Measurement at Z = 1m and X = 2 m (with respect to the center point of the sauna heater)

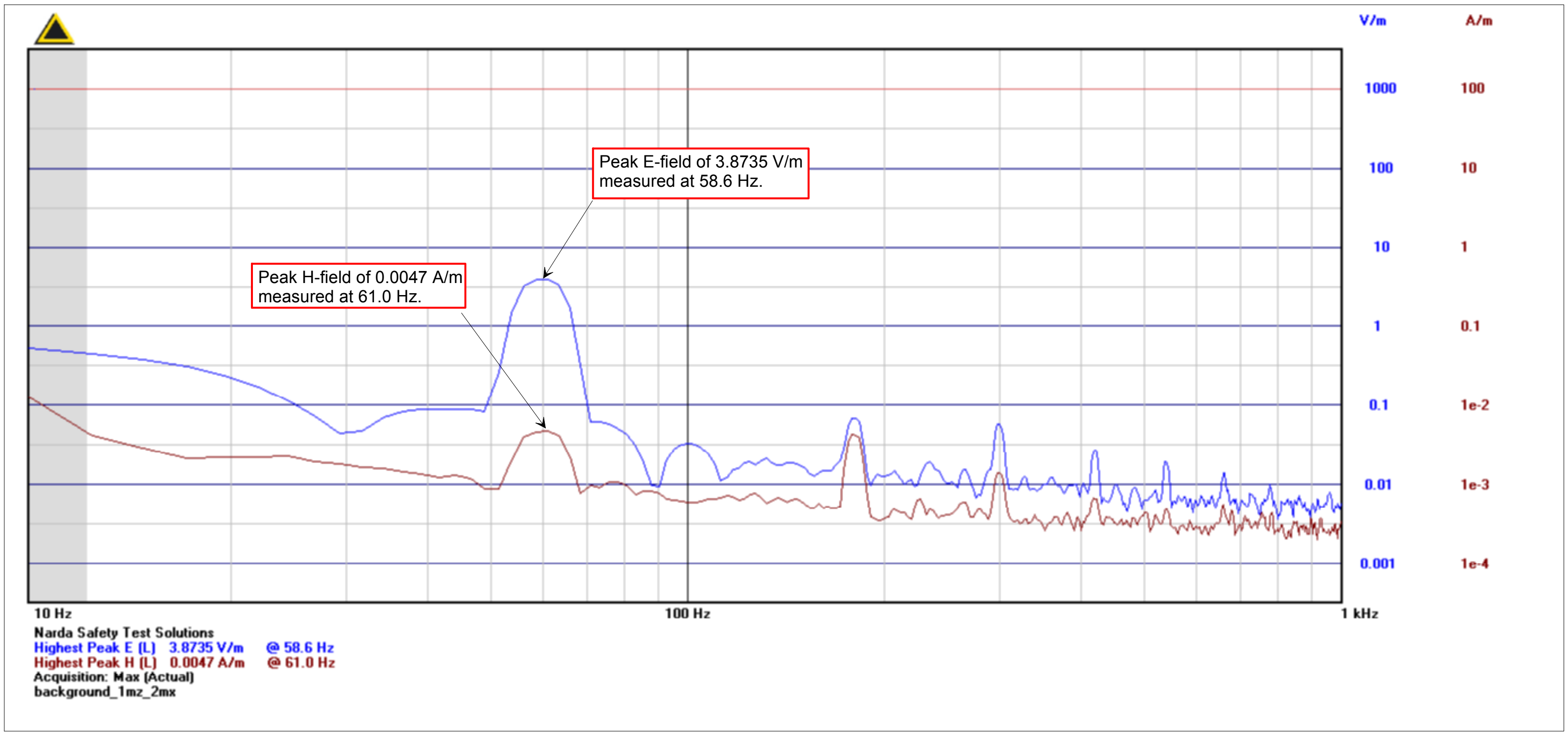


Figure #17

Electric Field Measurement at Z = 1m and X = 0 m (with respect to the center point of the sauna heater)

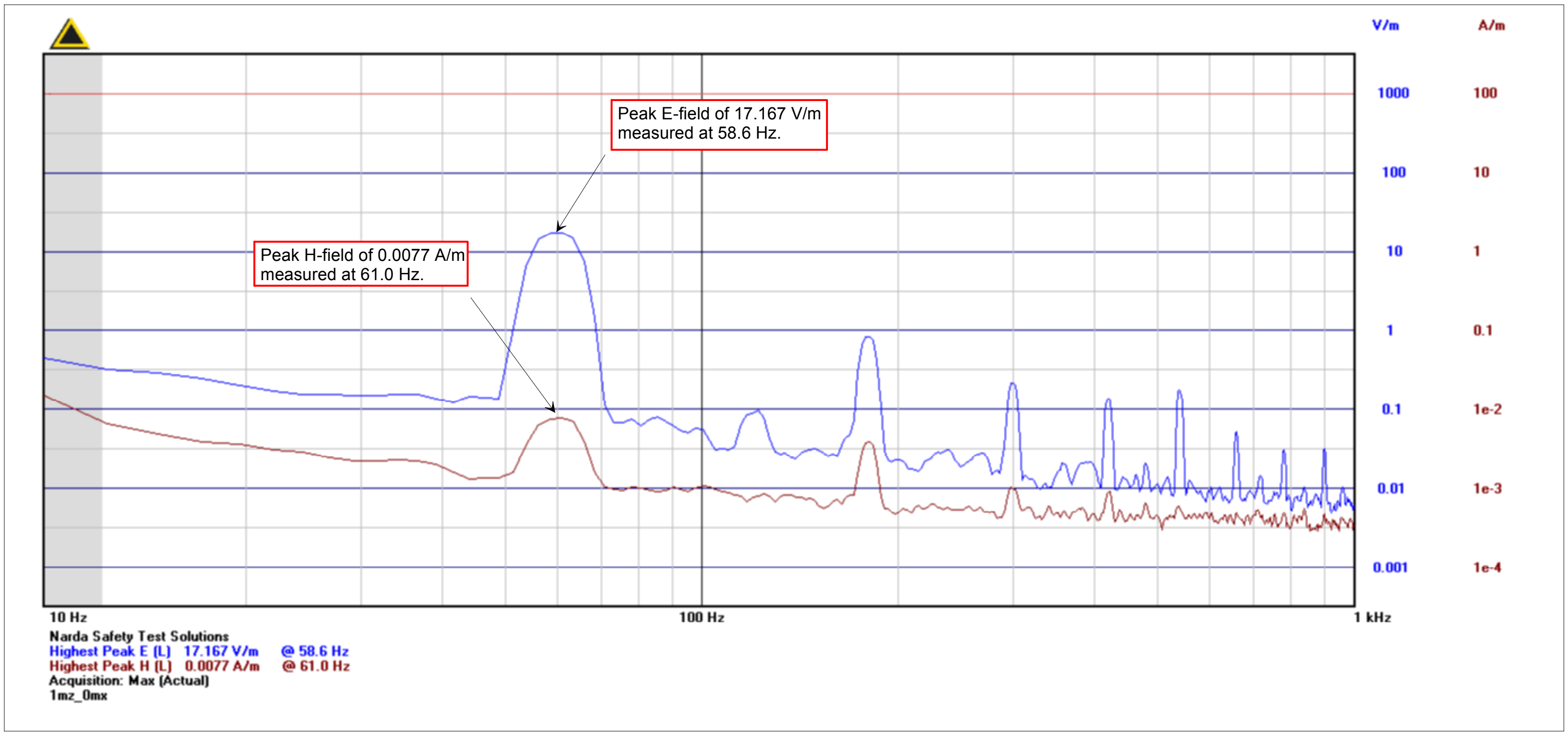


Figure #18

Electric Field Measurement at Z = 1m and X = 1 m (with respect to the center point of the sauna heater)

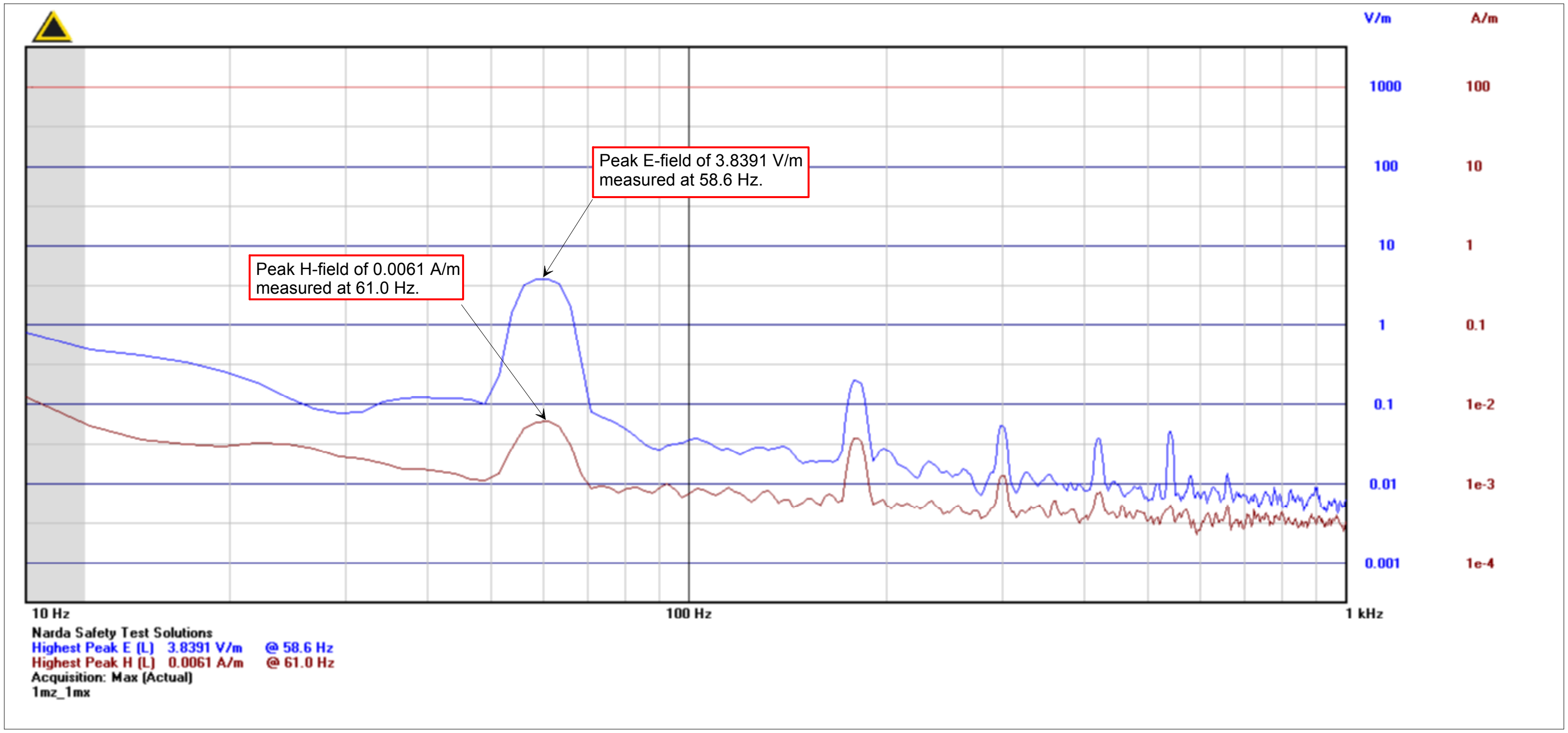


Figure #19

Electric Field Measurement at Z = 1m and X = 2 m (with respect to the center point of the sauna heater)

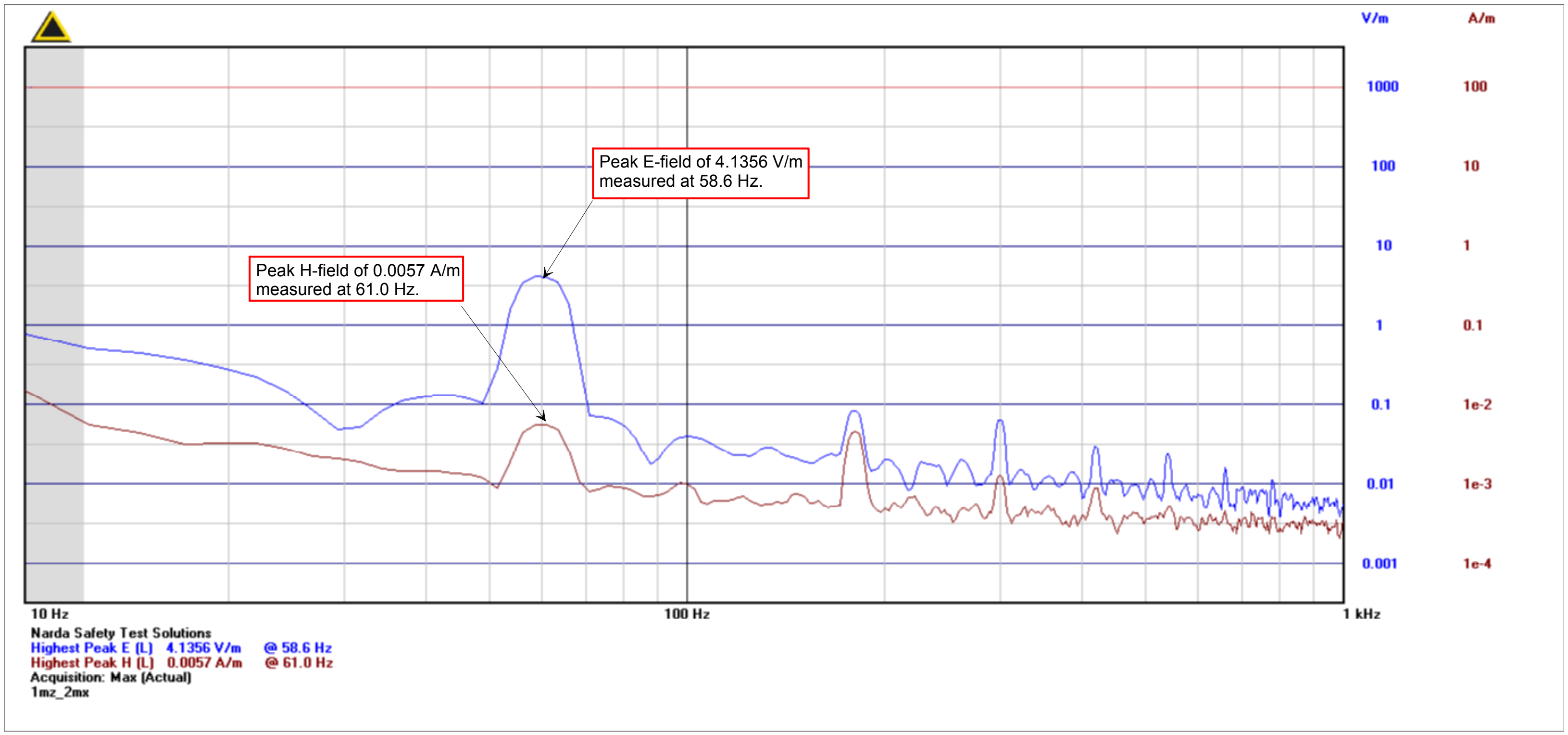
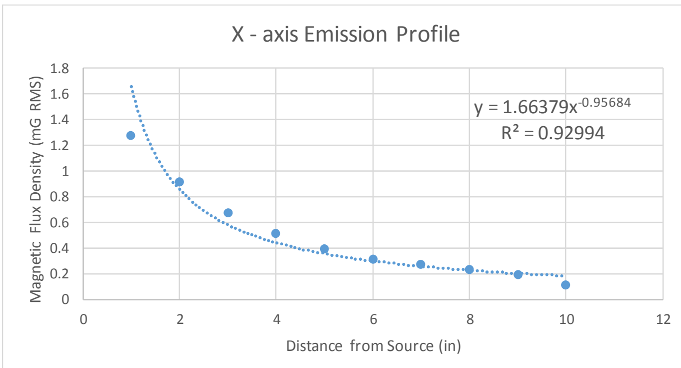
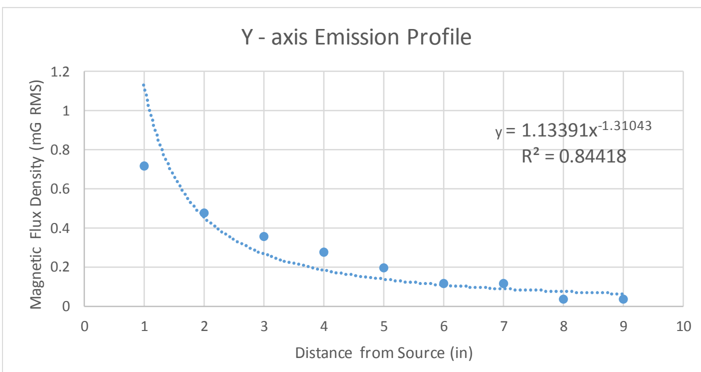
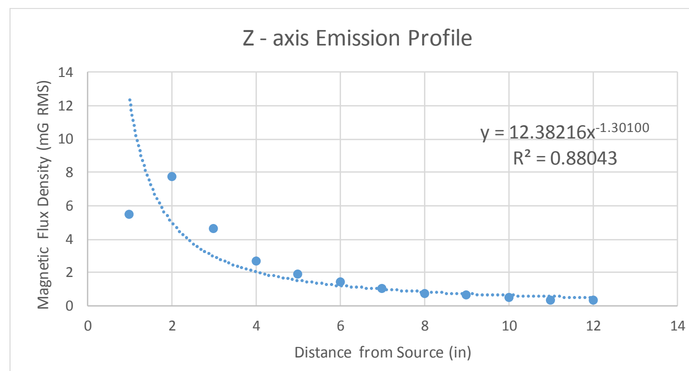


Figure #20

Decay Models







Appendices

Exhibit A

Human Exposure Issues & Electronic Equipment Immunity Standards

The last two (2) decades Vitatech has recommended 1 μT RMS (10 mG RMS) and less (see **AC ELF EMF Health Issues** for details) as the acceptable long-term (6 to 8 hours or more) human exposure standard and EMI immunity threshold for residential, commercial, university, research, and medical occupied areas without EMI sensitive scientific and diagnostic instruments and equipment.

Vitatech recommends applying the appropriate mitigation controls (i.e., magnetic shielding, increased separation distances, etc.) to the extent practicable to achieve acceptable long-term exposure levels to members of the public and occupational workers that are "as low as is reasonably achievable (ALARA) in environments where they must live and/or work for more than eight (8) hours per day with or without their knowledge or consent. However, we do not recommend AC ELF magnetic shielding in transit areas such as sidewalks, lobbies, hallways, parking garages, cafeterias and walkways unless the magnetic field emissions approach 100 μT RMS (1000 mG RMS) which is the 60 Hz EMI magnetic field threshold for implantable medical devices (i.e., pacemakers, defibrillators, insulin pumps, etc.).

The European international 50/60 Hz magnetic field electronic and electrical equipment immunity standard, IEC 61000-6-1.2005-3, Electromagnetic compatibility (EMC) Part 6-1: Generic standards Immunity for residential, commercial and light-industrial environments recommends a maximum of 3 A/m RMS (Level / Class 2) magnetic field strength which converts to 3.77 μT RMS (37.7 mG RMS). Note: multiply A/m by 4π to convert to magnetic flux density. In Europe, UK and other countries around the world except the United States, electronic and electrical equipment must be tested and CE certified to the IEC 61000-4-8 EMC Part 4-8 Testing and measurement techniques Power frequency magnetic field immunity test for residential and commercial locations, industrial installations and power plants and medium and high voltage substations. IEC 61000-4-8 tests and certifies with a CE stamp one of six (6) classifications of Level / Class (1 to x) according to the EMC environmental requirements shown in Table 1 on the next page:

Environment	Magnetic Field Strength (Magnetic FLux Density)
Level/Class 1:	1 A/m (1.26 μT RMS or 12.6 mG RMS)
Level/Class 2:	3 A/m (3.77 μT RMS or 37.7 mG RMS)
Level/Class 3:	10 A/m (12.6 μT RMS or 126 mG RMS)
Level/Class 4:	30 A/m (37.3 μT RMS or 377 mG RMS)
Level/Class 5:	100 A/m (120 μT RMS or 1260 mG RMS)
Level/Class x:	special

Table 1: Test Levels for Continuous Field

Class 1 Environmental level where sensitive device using electron beam can be used.

CRT Monitors, electron microscope, etc., are representative of these devices.

Class 2 Well Protected environment.

The environment is characterized by the following attributes:

- absence of electrical equipment like power transformers that may give rise to lekage fluxes;
- areas not subjected to the influence of H.V. bus-bars.

Household, office, hospital protected areas far away from earth protection conductors, areas of industrial installations and H.V. substations may be representative of this environment.

Class 3 Protected environment

The environment is characterized by the following attributes:

- electrical equipment and cables that may give rise to leakage fluxes or magnetic field;
- proximity of earth conductors of protection systems;
- M.V. circuits and H.V. bus-bars far away (a few hundred metres) from equipment concerned.

Conmercial areas, control building, field of not heavy industrial plants, computer room of H.V. sub-stations may be representative of this environment.

Class 4 Typical industrial environment

The environment is characterized by the following attributes:

- short branch power lines as bus-bars, etc.;
- high power electrical equipment that may give rise to leakage fluxes;
- ground conductors of protection system;
- M.V. circuits and H.V. bus-bars at relative distance (a few tens of metres) from equipment concerned.

Fields of heavy industrial and power plants and the control room of H.V. sub-stations may be representative of this environment.

Class 5 Severe industrial environment

The environment is characterized y the following attributes:

- conductors, bus-bars or M.V., H.V. lines carrying tens of kA;
- ground conductors of the protection system;
- proximity of M.V. and H.V. bus-bars;
- proximity of high power electrical equipment.

Switchyard areas of heavy industrial plants. M.V., H.V. and power stations may be representative of this environment.

Class x Special environment

The minor or major electromagnetic separation of interference sources from equipment circuits, cables, lines, etc., and the quality of the installation may require the use of a higher or lower environmental level than those described above. It should be noted that the equipment lines of a higher level can penetrate a lower severity environment.

The IEC 61000-4-8 Level / Class 2 threshold of 3.77 μT RMS (37.7 mG RMS) is 3.7 times higher than the Vitatech 1 μT RMS (10 mG RMS) level recommended for commercial buildings and long-term occupancy (residential, etc.) in NYC, around the US and in several European countries. CRT monitors would not operate in 3.77 μT RMS (37.7 mG RMS) environments displaying screen jitter (waving back-and- forth); however, in the last decade most CRT monitors have been replaced by LCD monitors which are EMI immune to levels exceeding 100 μT RMS (1000 mG RMS) and does not display screen jitter. But any electronic, computer, control and communications equipment could experience EMI issues at 3.77 μT RMS (37.7 mG RMS) unless there is a CE mark specifying compliance with IEC/EN 61000-4-8 Level 2 EMC standard.

European electronic equipment manufacturers are legally required to test, verify and document compliance to the International IEC/EN EMC standards in the Operators Manual, but U.S. manufactured equipment only requires compliance to the FCC standards for EMI/RFI immunity unless they sell their electronic and electrical products in Europe. *Regardless, Vitatech still recommends 1 μT RMS (10 mG RMS) as a reasonable EMI threshold for electronic and electrical equipment including long-term human exposure based upon the ALARA Principle (Suggestion – Google ALARA).*

AC ELF EMF Health Issues

VitaTech defines AC ELF magnetic flux density emissions according to six orders of magnitude from *low, elevated, high, very high, extremely high* to *potentially hazardous*:

First order of magnitude 0.1 to 0.99 μT (1 to 9.9 mG) as *low*,
Second order of magnitude 1 to 9.9 μT (10 to 99 mG) as *elevated*,
Third order of magnitude 10 to 99.9 μT (100 to 999 mG) as *high*,
Fourth order of magnitude 100 to 999.9 μT (1000 to 9,999 mG) as *very high*,
Fifth order 1000 to 9999.9 μT (10,000 to 99,999 mG) as *extremely high*.
Sixth order 10,000 to 99,999 μT (100,000 to 999,999 mG) as *potentially hazardous*.

Warning: at AC ELF magnetic flux density levels exceeding 5,000 μT (50,000 mG) (10 mA/m^2 induced current density threshold used by WHO, ACGHI, CENELEC, DIN/VDE, NRPG & NCRP), the human body experiences physiological and/or neurological responses because of induced currents within body tissues, organs and neurons. The actual biological effect depends on the magnitude, polarization, proximity and exposure time to *extremely high* and *potentially hazardous* magnetic field sources. Finally, information about *AC ELF EMF Health Issues* and Vitatechs 1 μT (10 mG) recommended long-term human exposure limit are discussed in the next section.

AC ELF Magnetic Field Health Issues, Standards & Guidelines

Currently, there are no Federal standards for AC ELF electric and magnetic field levels. The National Energy Policy Act of 1992 authorized the Secretary of the Department of Energy (DOE) to establish a five-year, $65 million EMF Research and Public Information Dissemination (RAPID) Program to ascertain the effects of ELF EMF on human health, develop magnetic field mitigation technologies, and provide information to the public. In May 1999, the NIEHS Director Kenneth Olden, Ph.D. delivered his final report, *Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*, to Congress that stated the following in the Cover Letter and Executive Summary below:

> *The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and* ***chronic lymphocytic leukemia in occupationally exposed adults... The NIEHS concludes that ELF-EMI exposure cannot be recognized at this time as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard.***

U.S. & International Organizational AC ELF EMF Standards

In 2010 the International Commission on Non-Ionizing Radiation Protection (IRPA/INIRC) increased the 2002 maximum human exposure limit for 50/60 Hz magnetic fields for the general public over 24 hours from 833 mG RMS to 2000 mG RMS and for occupational workers from 4,167 mG to 10,000 mG RMS. Whereas The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a 10,000 mG (10 Gauss) exposure limit over 24 hours for occupational workers, but specifies 1,000 mG (1 Gauss) as a maximum exposure for workers with cardiac pacemakers.

Occupational Safety & Health Administration (OSHA)

Currently no specific OSHA standards address AC ELF (extremely low frequency) magnetic fields and recommended human exposure limits. *"Some epidemiological studies have suggested increased cancer risk associated with magnetic field exposures near electric power lines,* as stated on OSHA website.

New York State Public Service Commission AC ELF EMF Standards

Effective September 1990, the State of New York Public Service Commission (PSC) began a process looking toward the adoption of an interim magnetic field standard for future major electric transmission facilities. The Commission concludes that a prudent approach should be taken that will avoid unnecessary increases in existing levels of magnetic field exposure. Therefore, future transmission circuits shall be designed, constructed and operated such that magnetic fields at the edges of their rights-of-way will not exceed 20 μT (200 mG) when the circuit phase currents are equal to the winter-normal conductor rating. They also established an electric field strength interim standard of 1.6 kV/m electric transmission facilities.

IARC June 2002 Report

In June 2002, the International Agency for Research on Cancer (IARC) issued a 400+ page report formally classifying extremely low frequency magnetic fields as ***possibly carcinogenic to humans*** based on studies of EMF and childhood leukemia. ***This is the first time that a recognized public health organization has formally classified EMF as a possible cause of human cancer***. IARC found that, while selection bias in the childhood leukemia studies could not be ruled out, pooled analyses of data from a number of well-conducted studies show a fairly consistent statistical association between childhood leukemia and power-frequency residential magnetic fields above 0.4 μT (4 mG), with an approximately two-fold increase in risk that is unlikely to be due to chance.

IARC is a branch of the World Health Organization. The IARC classification of EMF was made by a panel of scientists from the U.S. National Institute of Environmental Health Sciences, the U.S. Environmental Protection Agency, the U.K. National Radiological Protection Board, the California Department of Health Services, EPRI, and other institutions around the world.

Switzerlands February 2000 AC ELF Standard

The Swiss Bundersrat in February 2000 set by law an emission control limit of 1 μT (10 mG) from overhead and underground transmission lines, substations, transformer vaults and all electrical power sources.

VitaTechs & NCRP Draft Recommended 10 mG Standard

Section 8.4.1.3 option 3 in the National Council of Radiation Protection and Measurements (NCRP) draft report published in the July/August 1995 issue of *Microwave News* (visit the Microwave News Homepage <www.microwavenews.com> for the entire draft report) recommended the following on the next page:

8.4.1.3 Option 3: *An exposure guideline of 1 μT (10 mG) and 100 V/m: A considerable body of observations has documented bioeffects of fields at these strengths across the gamut from isolated cells to animals, and in man. Although the majority of these reported effects do not fall directly in the category of hazards, many may be regarded as potentially hazardous. Since epidemiological studies point to increased cancer risks at even lower levels, a case can be made for recommending 1 μT (10 mG) and 100 V/m as levels not to be exceeded in prolonged human exposures. Most homes and occupational environments are within these values, but it would be prudent to assume that higher levels may constitute a health risk. In the short term, a safety guideline set at this level would have significant consequences, particularly in occupational settings and close to high voltage transmission and distribution systems, but it is unlikely to disrupt the present pattern of electricity usage. These levels may be exceeded in homes close to transmission lines, distribution lines and transformer substations, in some occupational environments, and for users of devices that operate close to the body, such as hair dryers and electric blankets. From a different perspective, adoption of such a guideline would serve a dual purpose: first, as a vehicle for public instruction on potential health hazards of existing systems that generate fields above these levels, as a basis for "prudent avoidance; and second, as a point of departure in planning for acceptable field levels in future developments in housing, schooling, and the workplace, and in transportation systems, both public and private, that will be increasingly dependent on electric propulsion.*

AC ELF Test Instruments

FieldStar 1000 Gaussmeter – AC ELF Magnetic Flux Density

VitaTech recorded the AC ELF magnetic flux density data using a FieldStar 1000 gaussmeter (Serial Number 31400418, last calibrated on January 21, 2016) with a NIST traceable calibration certificate manufactured by Dexsil Corporation. The FieldStar 1000 has a resolution of 0.04 mG in the 0 – 10 mG range, 1% full-scale accuracy to 1000 mG and a frequency response of 60 Hz (55 – 65 Hz @ 3dB). Three orthogonal powdered-iron core coils are oriented to reduce interference to less than 0.25% over the full dynamic range. The three coils are arranged inside the unit holding horizontal with the display forward: Bx horizontal coil points forward, By horizontal coil points to the right side, and Bz vertical coil points upward. The microprocessor instantly converts the magnetic field to true RMS magnetic flux density (milligauss) readings of each axis (B_x, B_y, B_z) and simultaneously calculates the resultant R_{rms} (root-means-square) vector according to the following formula:

$$R_{rms} = \sqrt{B_x^2 + B_y^2 + B_z^2} \ .$$

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 (1-ft., 5-ft., 10-ft. etc.) intervals. The FieldStar 1000 is exactly 39.37 inches (1 meter) above the ground with the survey wheel attached. Along each path the distance is logged by the survey wheel and the relative direction (turns) entered on the keyboard. Up to 22,000 spot, mapped and timed data points can be stored, each containing three components (B_x, B_y, B_z), event markers and turn information. After completing the path surveys, magnetic flux density data is uploaded and processed. All plots display a title, time/date stamp, ID path number, and the following statistical data (in milligauss) defined below:

Peak – maximum magnetic field (flux) value measured in group.
Mean – arithmetic average of all magnetic field (flux) values collected.

The following is a quick description of the Hatch, Profile and 3-D Contour plots presented in the figures of this report:

Hatch Plot – data is represented by four difference hatch marks (0 mG, 0.25 mG, 1 mG and 5.0 mG thresholds) based on width and color as a function of distance along the survey path that shows 90 and 45 degree turns. Note: the site drawing and all Hatch Plots were scaled in feet to verify actual recorded distances and correct survey locations.

Profile Plot – data shows each recorded component (B_x, B_y, B_z) axis and the resultant (B_r) levels as a function of distance: B_x (red) is the horizontal component parallel to the survey path, B_y (green) is the horizontal component normal (perpendicular) to the survey path, and B_z (blue) is the vertical component with the computed B_r resultant RMS (root-means-square) summation of the three components.

3-D Contour Plot - data is presented along survey with B_r resultant level in the vertical direction using eight (8) color thresholds on a horizontal plane.

Three-Axis Electric & Magnetic Field Measurement EHP-50

Vitatech recorded isotropic electric field strength levels in units of V/m from 10 Hz to 1 kHz with the EHP-50 (S/N 1001) MEDA ARA Electromagnetic Analyzer PMM. The EHP-50 prob has an electric field measurement range of 0.001 V/m - 100 kV/m in each axis (E_x, E_y and E_z) and provides isotropic (E_r resultant) and individual E_x, E_y, and E_z electric field levels in units of V/m. The EHP-50 was connected via a fiber-optic cable and USB to our laptop computer when recording isotropic electric field data during data testing.