This Health Hazard Evaluation (HHE) report and any recommendations made herein are for the specific facility evaluated and may not be universally applicable. Any recommendations made are not to be considered as final statements of NIOSH policy or of any agency or individual involved. Additional HHE reports are available at http://www.cdc.gov/niosh/hhe/reports

HETA 91-0337-2466
OCTOBER 1994
ALUMINUM COMPANY OF AMERICA
BADIN, NORTH CAROLINA

NIOSH INVESTIGATORS:
C. Eugene Moss
Don Booher

I. SUMMARY

On July 7-9, 1992, the National Institute for Occupational Safety and Health (NIOSH) conducted an investigation at the Aluminum Company of America (ALCOA) aluminum reduction plant located in Badin, North Carolina. This investigation was performed in response to a confidential employee request which NIOSH received on August 2, 1991, for evaluation of occupational exposure to magnetic fields in the potrooms.

Static magnetic field (SMF) and sub-radiofrequency electric and magnetic field (SRE/MF) measurements were made at various locations inside the four potrooms at ALCOA-Badin under normal work conditions over two shifts. Measured SMF levels were as high as 760 gauss (G) at workers' locations but the occupational SMF time-weighted average (TWA) was estimated between 125 and 150 G. The SMF levels did not exceed the American Conference of Governmental Industrial Hygienists (ACGIH) TWA Threshold Limit Value (TLV) of 600 G.

SRE/MF levels measured at the ALCOA-Badin facility ranged from 1 to 5 Volts per meter (V/m) and 0.3 to 3108 milligauss (mG) while levels of SRE/MF near the buss bars in all potrooms ranged from 2 to 4 V/m and 5 to 25 mG. While it was not possible to precisely determine the dominant electromagnetic field (EMF) frequency (ies) emitted, preliminary evaluations suggest mixed frequencies associated with rectifier ripple and power frequency components plus harmonies. None of the measured fields exceeded ACGIH TWA TLVs of 25,000 V/m or 10 G.

Based on the data collected in this evaluation, NIOSH investigators concluded the following: (1) both SMF and SRE/MFs were found to exist in the potroom; (2) risers were the dominant SMF exposure source at the facility; (3) levels of both SMF and SRE/MFs did not exceed present occupational standards; and (4) electricians and electrical workers are the one occupational group that are exposed to both SMF and SRE/MFs.

KEYWORDS: SIC 3334 (Primary Production of Aluminum), Aluminum, Potroom, Static Magnetic Fields, Extremely Low Frequency Fields.

II. INTRODUCTION

On August 2. 1991, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from workers at the Aluminum Company of America (ALCOA) aluminum reduction plant located in Badin, North Carolina for a health hazard evaluation (HHE). The employees were concerned with electromagnetic field (EMF) exposures in the potroom areas. On July 7-9, 1992, NIOSH investigators visited the facility and measured static magnetic fields (SMFs) and sub-radiofrequency electric and magnetic fields (SRE/MFs) in the potrooms.

III. BACKGROUND

The Badin facility has two production lines composed of 248 pots distributed over four potrooms. At the time of the evaluation, the facility employed about 680 workers over three shifts, with approximate 125 workers assigned to jobs in the potrooms on a full time basis. Workers are represented by the United Steel Workers, AFL-CIO Local 303. The facility was originally built in 1917, re-built in 1960, and has been owned by ALCOA for about 50 years. The electric current used to produce aluminum at Badin can be as high as 174,000 amperes (A) direct current (DC). There are four buildings that contain the potlines. Buildings 201, 202, 203, and 204 are designated in this report as potrooms 1, 2, 3, and 4, respectively. Figure 1 shows the general layout of the facility.

Each potroom is about 2100 feet long and houses 62 pots. Each pot contains 24 anodes (12 on each side of a pot). There are a total of 8640 anodes at the facility. At high temperatures, the anodes are slowly consumed and require replacement every 22 days.

IV. EVALUATION DESIGN AND METHODS

Measurements of occupational levels of SMFs and SRE/MFs found in the potroom areas of the ALCOA-Badin facility were designed to survey worker exposures to EMF during performance of work tasks in the aluminum reduction facility. While little information is available about EMF levels produced in aluminum reduction plants, it is reasonable to assume that potroom workers can be exposed to both static magnetic fields (SMFs) created by DC at typical 30-130 kiloamperes (kA) levels used in electrolytic cells, as well as from time-varying fields related to rectified currents (i.e., "AC ripple") from the incoming alternating current (AC). These AC fields are designated in this report as SRE/MFs.

Thirty-six different data sets were recorded that measured SMF under different occupational conditions. The number of measurements per data set varied considerably since different parameters were investigated at different locations and times. The number of measurements per data set ranged from as low as two to as high as 40, with the average being approximately 14. All SMF measurements were collected in this evaluation using an orthogonal sensing probe. This method was used since it would detect magnetic flux in

all directions and the resultant value would be of more occupational significance than just data obtained from one direction. Measurements were taken along all potlines, at different distances from the potlines, on top of the catwalk between pots, underneath the pots during clean-out sessions, above the pots, at the end and middle of each potroom, in the switch yard, and near the rectifiers. The following equipment was used to document levels of EMFs produced at the ALCOA-Badin facility:

Sub-radiofrequency Electric and Magnetic Fields

A Holaday Industries, Inc. model HI-3602 ELF Sensor, connected to a HI-3600 survey meter, was used to document both the magnitude of SRE/MFs and the electrical frequency (as well as the waveforms) produced by such fields.
The sub-radiofrequency electric fields (SREF) can be measured either in volts per meter (V/m) or kilovolts per meter (kV/m). The sub-radiofrequency magnetic fields (SRMF) can be expressed in units of milligauss (mG).

SRMF measurements were made with the EMDEX II exposure system, developed by Enertech Consultants, under project sponsorship of the Electric Power Research Institute, Inc. The EMDEX II is a programmable data-acquisition meter which measures the orthogonal vector components of the magnetic field through its internal sensors. Measurements can be made in the instantaneous read or storage mode. The system was designed to measure, record, and analyze power frequency SRMF in units of mG in the frequency range from 30 to 800 Hertz (Hz).

Static Magnetic Fields

A GMW model DTM-132-DS magnetic field system was used to measure SMF in this evaluation. This system has three separate digital tesla meters, packaged in a small cabinet, which is separated from three single axis probes (GMW model LPT-130-30) mounted orthogonally in a specially designed probe by a 20 meter (m) nylon cable. The special designed probe was always held by the NIOSH investigators in the same orientation for all measurements made in this evaluation. Each of the single axis probes is capable of reading up to a maximum of 3000 gauss (G) with a resolution of 0.5 G. The portable system is battery operated and can be recharged in four hours. Background SMF levels were documented with the probe outside of the building and at distances greatly removed from the potrooms. A small round magnet (2.5 centimeters [cm] diameter) was used to check source for field calibration purposes.

In addition, a limited number of area measurements were made with the Holaday monitors at selected work locations inside the facility. All measurements were made during daylight hours at waist height. Where possible, at least two readings were taken at each measurement site with the Holaday monitors and the average reading recorded.

All equipment used to document exposure to electric and magnetic fields had been calibrated within six months use either by NIOSH or their respective manufacturer.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed without experiencing adverse health effects. It is, however, important to note that not all exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity situation.

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects, even if the occupational exposures are controlled at the level set by the evaluation criteria. Finally, evaluation criteria may change over the years as new information about chemical and physical agents become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH criteria documents and recommendations, (2) the American Conference of Governmental Industrial Hygienists (ACGIH's) Threshold Limit Values (TLV), and (3) the U.S. Department of Labor (OSHA) occupational health standards. The OSHA standards are may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational diseases. In evaluating the exposure levels and the recommendations for reducing these levels found in these reports, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

At present there is limited information from OSHA on exposure criteria for workers exposed to physical agents. Criteria for physical agents not covered by OSHA come from either ACGIH, NIOSH, or in some cases from consensus standards promulgated by the American National Standards Institute (ANSI).

A. Static Magnetic Fields[1-4]

In general, there are two conditions for SMF exposures which need to be understood. Exposures can occur either from a steady or time-varying field exposure. In a steady magnetic field the flux does not change with time and will not cause current to flow in a fixed object. In a time-varying field the magnetic flux passing through a surface changes with time and can induce an electrical current flow in conductive objects. Both types of fields create different biological effects.

Exposure to SMFs has been linked to slight increases in blood pressures, alternation in operation of artificial cardiac pacemakers, movement of implanted metal objects, rotation of sickle cells, influencing length of circadian cycle, and attractiveness of metal objects. Many scientists believe that the effect of SMFs are very subtle and may not represent a particularly hazardous exposure. There have been no official occupational health limits set for SMFs. The Stanford Linear Accelerator Center proposed, in 1971, values of 2000 to 20,000 G, depending on time and exposure area of body, for an upper limit based on lack of complaints. In 1979, the Department of Energy, established a level of 20,000 G. The only other limit for this type of exposure had been proposed by ACGIH in 1987. The TLV for SMF states "Routine occupational exposures should not exceed 600 G whole body or 6000 G to the extremities on a daily, time-weighted average basis. A flux density of 20,000 G is recommended as a ceiling value."

B. Sub-Radiofrequency Electric and Magnetic Fields

At the present time there are no OSHA or NIOSH exposure criteria for SRE/MF but the ACGIH has published TLVs for both SREFs and SRMFs.[1] The SRMF TLV states routine occupational exposure should not exceed:

$$\text{SRMF (in mT)} = 60/f$$

where f is the frequency in hertz. One millitesla (mT) equals 10 Gauss. Conversely, the SREF TLV states occupational exposures should not exceed a field strength of 25 kV/m from 0 to 100 Hz. For frequencies in the range of 100 Hz to 4 kilohertz (kHz), the TLV is given by:

$$\text{SREF (in V/m)} = 2.5 \times 10^6/f$$

where f is the frequency in hertz. A value of 625 V/m is the exposure limit for frequencies from 4 kHz to 30 kHz.

This means, for example, at 60 Hz, which is classified as extremely low frequency (ELF), the SREF TLV is 25,000 V/m and the SRMF TLV is 1 mT or 10,000 mG.

The basis of the SREF TLV is to minimize occupational hazards arising from spark discharge and contact current situations. The SRMF TLV addresses induction of magnetophosphenes in the visual system and production of induced currents in the body. Prevention of cancer is not a basis for either of these TLVs since exposure has not been conclusively linked to cancer.

VI. RESULTS

Results for this evaluation are presented in one of three major categories: SMF, SRE/MFs, or other findings.

A. Static Magnetic Fields

1. SMF levels as a function of location along the potlines

In a series of preliminary measurements made at ALCOA-Badin it was demonstrated that:

a. SMF levels, measured along the walkway in front of the pots, were about 25% higher at the pot center line than at steps leading up to the raised platform between the two pots.

b. SMF levels were measured at 92 centimeters (cm) above the floor, a probe to pot distance of 15 cm, and at every 61 cm horizontally across pot 312. The result of these measurements is shown in Figure 2 and suggests that two maximum points are located midway between the pot's center line and its edges. These results have occupational significance since workers write messages on the pot walls at these locations.

Using the results reported in (a) and (b) above it was decided to take SMF measurements along the potline as indicated in Figure 3A at approximately 15 cm from the buss bar and at a probe height of 92 cm. The SMF levels measured in this manner in one of the potrooms is shown in Figure 3B. The relatively repetitive nature of the results are apparent in Figure 3B. The dotted line in Figure 3B indicates the average or mean value of 190 G for all measurements taken along the potline in front of randomly selected pots in potroom 1 at locations shown in Figure 3A. Figure 4 shows the same data taken in all the potrooms, as well as the average value associated with the pots measured. Location f (at the steps) give the lowest SMF levels measured in this manner, while locations b and d produce maximum indications as suggested from the results shown in Figure 2. Of interest is the observation that SMF levels taken in this manner appeared to be higher in potroom 4. Since special attention was paid to calibration and re-adjustment of the measurement equipment, the explanation for these higher levels is not apparent.

Some selected SMF measurements were also performed on both sides (tap and duct) of a given potroom at the same pot to probe distance. The results obtained in this limited effort indicate little difference in SMF levels from one side or the other. This finding was in keeping with a previous NIOSH evaluation of another aluminum reduction plant.[5]

2. *SMF levels as a function of distance from the potlines*

   Measurements were made on three randomly selected pots (243, 244, and 231) to determine the SMF levels at varying distances from the potline. All measurements were taken with the GMW instrument probe positioned in a tripod 107 cm from the ground. The results of these measurements were fitted to a third order polynomial and are shown in Figure 5. Figure 5 shows the results of two measurements denoted positions 2 and 4. These positions are the locations found in Figure 2 and reflect the place where maximum occupational exposure would occur at distances away from the potline. Several confirming checks were made at other pots in different potrooms that verified Figure 5. These confirming check measurements all agreed to within ±15%.

3. *SMF levels above the pot superstructure*

   Measurements were made at both ends of pot 34, at a height of 92 cm above the pot superstructure, to estimate SMF levels to crane personnel. The SMF levels were 88 and 60 G. This 92 cm height value was estimated to be the closest position that the crane compartment bottom would come to the top of the superstructure. Such a location might represent a maximum foot exposure to crane personnel during the time when the crane compartment was close to the top of the superstructure, such as during anode replacement.

   In order to confirm the estimated levels in the crane cab, a NIOSH investigator received permission to enter one of the cranes to make SMF measurements. Levels as high as 42 G were measured in the cab when it was approximately 4.6 meters (m) over pots 32 and 33.

4. *SMF at mid-potline cross-over point*

   On all four pot lines, there is a aisle in the middle to allow movement of personnel and equipment. During the course of a day workers will pass through these areas while performing various work tasks and duties. At these mid-pot line areas the pot buss, carrying the DC current, travels 12.2 m under the potroom floor, at a depth of about 91 cm, to the next pot. Measurements were made at waist level at all four cross-over locations at positions shown in Table 1. Workers standing directly over the current path were exposed to levels of 85 to 158 G, and if standing away from the current path and at the center of the area, were exposed to smaller SMF levels ranging from 50 to 110 G.

5. *SMF levels in break-out rooms*

During non-work time periods employees use designated "break-out" rooms for rest and eating. SMF measurements made in the breakroom area were less than 8 G.

6. *SMF levels on elevated pot line platforms and near risers*

Since workers can and do walk up onto the elevated potline platform to perform various job tasks, SMF measurements were made at those different work locations. Workers had to come into contact with risers in their daily work tasks since the risers were situated at some of the elevated platforms. It was very obvious that the presence of high DC current in the risers created very high, localized SMF levels.

Measurements made by NIOSH on the elevated potline platforms at ALCOA-Badin indicated that SMF measurements made close to the anode shield covers along the pot were higher than those further away. Using this information, NIOSH investigators made ankle measurements at anode locations along the width of several pots as an indicator of potential occupational exposure. These measurements were made 15 cm off the elevated platform deck at a position 15 cm in front of each anode shield and at an angle of about 45 degrees. These ankle-level measurements were altered by the presence of the risers. Results are shown in Table 2 and were obtained in all four buildings at the beginning and end of each potline. The SMF values from these eight pots ranged from 77 to 353 G. The impact of the presence of the risers on these measurements is shown in Figure 6 for these same pots.

As shown in Figure 7, measurements made at 15 cm from one side of several risers yielded levels ranging from 311 to 558 G. These levels were approximately the same magnitude on the other side of the riser. In addition, measurements of several risers along different potlines produced results ranging from 344 to 522 G, which are in good agreements with those cited above. The magnetic fields associated with these risers fall off quickly with increasing distance from the riser.

7. *SMF measured underneath pots*

Since there are ALCOA-Badin employees who work in the space underneath pots, a limited number of SMF measurements were made by the NIOSH investigators in this space. Levels ranging from 73 to 760 G were documented, with the highest levels being found near the underground risers.

8. *SMF levels associated with pot shunts*

When performing maintenance on a certain pot, electrical current must either be cut off or reduced to that particular pot in order to permit maintenance workers pot access. One technique used to accomplish this task is to install a cathode block on the selected pot. The establishment of a cathode block permits an electrical shunt to be developed around a number of pots, causing more electrical current to flow on the buss bar than through the pots. One of the disadvantages in this process is that the SMFs levels can be vastly different than what would be normally expected. For example, on a pot in potroom 2 the SMFs measured along the buss bar adjacent to a shunted pot gave levels as high as 400 to 755 G. These values were two to three times higher than those measured at other similar locations in the same potroom. Workers informed the NIOSH investigators they would perceive a stronger magnetic field situation when working around a shunt.

9. *SMF as function of worker's height*

In making several measurements at various plant locations, it was demonstrated that SMF levels measured at a worker's ankle were significantly higher than those at the head position.

B. Extremely Low Frequency Levels

Measurements made with the EMDEX units and the Holaday electric and magnetic fields clearly demonstrated the presence of SRE/MFs in and around the pot lines. These levels typically were on the order of 2 to 4 V/m and 5 to 25 mG. This suggests that the levels of SRMFs near the potline busses are at least three to four orders of magnitude lower than the levels of SMF.

SMF and SRE/MF measurements were made along the entire north wall next to the rectification area. The magnetic field measurements are shown in Figure 8 and indicate that both SMF and SRMF levels were quite similar in spatial distribution along the north wall close to the rectification room, although the SMF levels were about three orders of magnitude higher. The SMFs ranged from 40 to 182 G while the SRE/MFs ranged from 3.1 to 3.3 V/m and 35 to 147 mG, respectively. Additional SRMF measurements were made 1.5 m from the end of each potline and are shown in Table 3. These measurements clearly show that the pots located further away from the rectification room, i.e. at the southern end of the potrooms, generate smaller SRMF levels, by approximately an order of magnitude, than those pots at the northern end.

EMDEX units were worn by three individuals in the rectification area to estimate the magnitude of the SRMFs. The EMDEX data is shown in Table 4 and a representative time-intensity plot is shown in Figure 9. While the maximum levels ranged from 897

to 3108 mG, the average levels were all about 150 mG. It was observed that the standard deviations associated with these averages of the magnetic field were large in magnitude, suggesting a large variance in recorded fields (variable exposure pattern) as a function of the time inside the rectification room. These levels in the rectification room are elevated compared to those levels found near the four potroom buss bars. It should be noted that SMF levels as high as 350 G were also measured at certain locations in the rectification room. It is possible that rapid movement of the EMDEX unit in a high SMF, such as could occur from wearing the unit, may cause it to respond and record an artificial AC signal.

While no electric field measurements were made in the switching yard at ALCOA-Badin for this evaluation, it is anticipated, based on prior NIOSH surveys, that high electric fields exist in this area.

C. Other Findings

Workers can reach the elevated pot locations in the potrooms by walking up small ladders, consisting of four tiers, which are positioned close to every pot and located over the buss bar on both sides of the pots. In general, most of these ladders are rigidly affixed but during the course of the evaluation, it was observed that several ladders were loose and tilted to one side when stepped on by workers.

VII. DISCUSSION AND CONCLUSIONS

A. Static Magnetic Fields

The SMF data obtained in this evaluation demonstrated the following:

1. SMF levels can vary considerably from one pot to another in both the same potroom as well as in different potrooms. The level of SMFs measured at the facility ranged from 5 to 700 G. The lowest occurred immediately outside the potroom entrance while the maximum level occurred underneath one of the pots.

2. The potroom risers appear to be the dominant source of SMF at the facility. This means that work performed at or near the risers, whether above or below the pots, will always produce higher occupational exposure to SMF levels than work away from the risers. The only possible exception to this generalization might be for work performed in the rectification room and around shunted pots.

3. While there are a few locations at ALCOA-Badin that can produce constant SMF levels as high as 600 G, there were no indications that workers exceeded a TWA value of 600 G anywhere in the facility. Workers apparently do not spend 6 to 7 hours per day at locations where there are high SMF levels. This means that occupational exposure to SMF at ALCOA-Badin is below the ACGIH-TLV.

This same conclusion was also reached based on magnetic field measurements performed by ALCOA staff in an in-house report dated July 19, 1991. This report stated that SMF levels in the potrooms varied from 2 to 297 G. Their report also stated that levels near the risers were above the range of the instrument and could not be measured.

Anode replacement operations create a need for potroom workers to be in close proximity to risers (depending on which pot is replaced). It was observed by the NIOSH investigators that the anode replacement operations took about 5 to 10 minutes to complete. Hence, exposure to the higher SMFs at the risers will be of short duration. Furthermore, only a few anode replacement operations occur per day which require workers to be in direct contact with risers.

Higher SMF levels were shown to exist in and around a shunted pot. It is not anticipated that a large number of pots would be shunted at the same time due to productivity factors. However, additional SMF measurements should be made at worker locations around shunted pots to characterize SMF exposures.

4. SMFs tend to drop off rapidly as a function of the distance from their source. This fact is clearly shown in Figure 7 where a reduction factor of at least 50% occurs when moving back from the buss bar a distance of 39 cm.

5. It is very difficult to accurately estimate an overall TWA for SMF exposures for the following reasons:

   a. Fields vary as a function of distance from the source.
   b. Workers move at random in and around the potroom.
   c. There is limited exposure to risers.
   d. Exposure to different parts of the body as a function of work task.

   However, based on all the data obtained from this evaluation, the above restrictions, and with special attention to Table 1, Table 2, Figures 3B, and 5, the NIOSH investigators have estimated a TWA between 125 and 150 G.

B. Sub-Radiofrequency Fields

The SRE/MF data obtained during this evaluation indicate the following observations:

1. AC fields were clearly shown to exist from both oscilloscope waveforms as well as meter results on potlines in all potrooms at ALCOA-Badin. SRE/MF levels are in the range of 1 to 5 V/m and 5 to 25 mG, respectively. Moreover their presence was documented along the potline busses, at the end of all potlines, along the north wall near the rectification room, and obviously inside the rectification room.

2. Waveform measurements made near the buss bar on several pots verified that these fields were not of the normal 60 Hz sinusoidal form. The NIOSH investigators believe that there are several frequencies present. The main frequencies are probably associated with a combination of rectifier ripple components, 60 Hz power frequency components, and harmonics of these components.

3. All of the documented fields appear to be far below the ACGIH TLVs.

4. It appears that the AC field levels are higher near busses than they are away from the busses. However, the distribution of these fields are rather complicated and additional measurements would be necessary to understand their characteristics.

The NIOSH investigators note that while biological concern due to exposure to EMF at ALCOA-Badin was expressed as one of the reasons for this confidential evaluation, discussion with workers conducted during the evaluation did not reveal any employee reports of actual biological effects or damage.

VIII. RECOMMENDATIONS

The following recommendations may help to improve the work environment at the ALCOA-Badin facility:

1. ALCOA-Badin should consider purchasing appropriate SMF and SRE/MF monitoring instruments for use at the various areas within the facility, especially during service and maintenance activities.

2. The Health and Safety Group should initiate monitoring for levels of SMFs and SRE/MFs produced at various sites within the plant. Additional measurement information may be needed to understand the magnitude of the AC fields.

3. Additional measurements of SMF occupational levels need to be performed for different shunted pot situations.

4. The safety office could consider identifying all areas having SMF levels above 600 G as part of a worker identification process. The ability to post such information will of course be dependent on the purchasing of appropriate instrumentation.

IX. REFERENCES

1. ACGIH [1988]. Threshold limit values (TLV) for chemical substances and physical agents in the workroom environment with intended changes for 1993-94. American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.

2. Technical Brief [1988]. Static Magnetic Fields, Applied Industrial Hygiene V3(1):R/4-R/5.

3. Grandolfo M, Michaelson SM, and Rindl A, editors [1985]. Biological effects and dosimetry of static and ELF electromagnetic fields. Published by Plenum Publishing Corporation, New York, N.Y.

4. Polk C and Postow E, editors [1986]. CRC Handbook of Biological Effects of Electromagnetic Fields. CRC Press, Inc. Boca Raton, Florida.

5. NIOSH [1994]. Health hazard report no. HETA 90-0244-2414. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

X. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared by:	C. Eugene Moss, HP, CSS Health Physicist
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies
Report Typed By:	Ellen E. Blythe Office Automation Assistant

XI. DISTRIBUTION AND AVAILABILITY OF REPORT

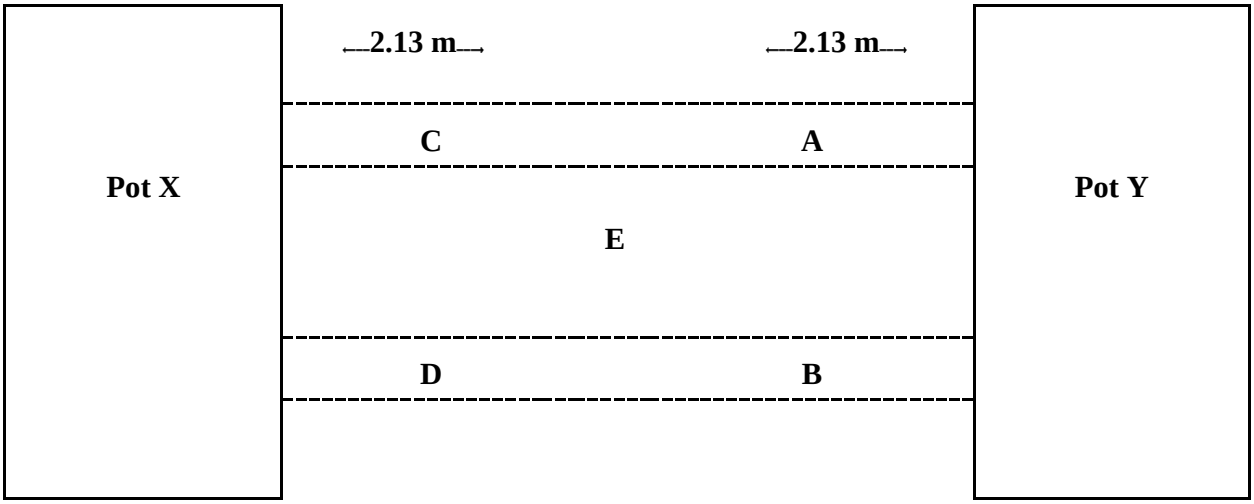
Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, Ohio 45226. To expedite your request, include a self-addressed mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. ALCOA-Badin
2. NIOSH
3. OSHA, Region IV

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1
SMF Levels in Gauss (G) Measured in the Center Aisle Walkway in all Potlines

ALCOA-Badin
Badin, North Carolina
HETA 91-0337



Location	Static Magnetic Field Levels (G)			
	Potroom 1	Potroom 2	Potroom 3	Potroom 4
A	85	149	158	134
B	122	151	152	132
C	158	120	129	152
D	144	134	122	165
E	50	85	75	110
Average	111	126	127	139

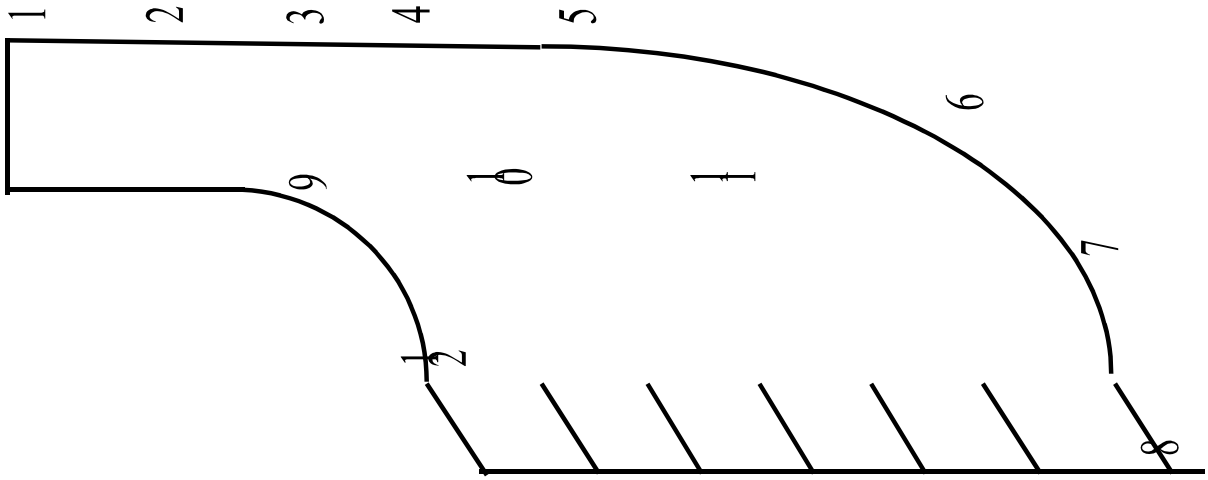
All measurements made at a distance of 1 m from the floor

Table 2
SMF Levels in Gauss at Base of Anode Covers
at First and Last Pots on Each Potline

ALCOA-Badin
Badin, North Carolina
HETA 91-0337

POTROOM 1		POTROOM 2		POTROOM 3		POTROOM 4	
Pot 1	**Pot 62**	**Pot 67**	**Pot 128**	**Pot 201**	**Pot 262***	**Pot 263**	**Pot 324**
96	52	96	88	115	72	120	82
95	65	74	88	71	80	94	82
131	77	122	96	122	118	126	93
246	81	246	97	230	178	256	86
353	90	251	99	305	120	312	92
221	115	160	111	129	71	233	102
127	107	84	112	125	20	156	98
105	106	113	106	120	80	130	104
175	98	220	104	195	144	177	112
308	105	308	103	312	240	266	106
277	120	202	130	252	132	260	107
146	121	118	131	128	60	148	86
77	107	115	113	60	45	74	86
85	106	166	105	114	50	83	60
MAX 353	121	308	131	312	240	312	112
AVG 174	96	163	106	163	101	174	93
MIN 77	52	74	88	60	20	74	60

* Last operator pot on line on day of evaluation
** Measurements made at 15 cm off floor, 15 cm from shield, and at a 45° angle
*** Shaded area reflects locations of risers contributions



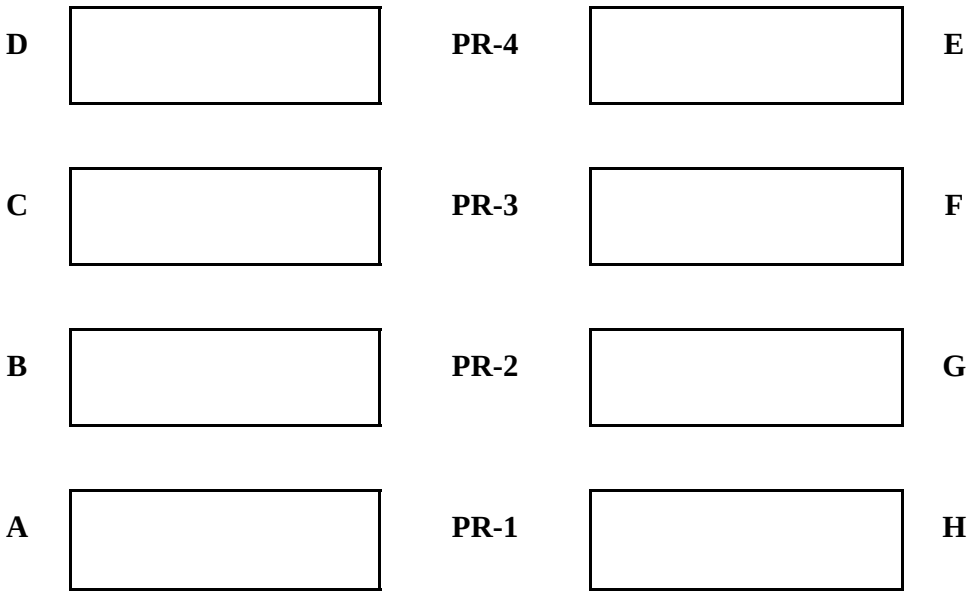
Location	Pot at 311/312*	Pot at 112/113	Pot at 54/55
1	431	463	400
2	451	---	---
3	473	490	469
4	297	463	456
5	311	328	331
6	392	492	333
7	440	---	---
8	486	413	483
9	558	531	410
10	471	---	---
11	340	---	---
12	---	425	446

* Average of both risers except for location 9-12
** Data taken from side facing pot end

Figure 7. Side View of Typical Riser and the Actual SMF Levels Measured at Various Locations on Three Different Risers.

Table 3
SRMF Measurement at Start and Stop Locations in Each Potline

ALCOA-Badin
Badin, North Carolina
HETA 91-0337



Location	SRMF (mG)
A	6
B	4.5
C	3.4
D	2.6
E	29.8
F	27.6
G	29.8
H	23.0

SRMF = Sub-radiofrequency magnetic field
mG = milligauss
PR = Potroom

Table 4
Summary of EMDEX Personnel SRMF Measurements (in mG)
Made at 1.5s Sample Rate Inside Rectification Room

ALCOA-Badin
Badin, North Carolina
HETA 91-0337

Individual	Min.	Max.	Mean	St. Dev.	Geo. Mean	St. Dev.	Median	N	mG-Hr	Fraction Exceeding		
										2 mG	4 mG	10 mG
1	0.3	3108	149	245	14.62	15.71	28.9	1295	80.2	0.9998	0.9997	0.9996
2	0.3	897	155.3	208	16.59	16.98	38.1	1191	77.1	0.9998	0.9997	0.9997
3	0.3	2702	157.5	289	10.35	18.30	3.2	1379	90.5	0.9998	0.9997	0.9997

St. Dev. = Standard deviation
Geo. Mean = Geometric mean
N = Number of data points
mG-Hr = milligauss - hour