

WHY GROUND CURRENTS?

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The issue of ground currents as a potential contributor to human and animal health effects has been contested ever since the relationship was first suggested.

Possible associations between ground currents and health have been suggested at least since the 1920s, and the first research report addressing the health effects of ground currents was published in the 1930s (Pohl 1983). The research had been conducted in Germany in the 1920s, by and for medical doctors. From the perspective of modern science, the controversial aspect of this research is the fact that ground currents were measured using dowsing rods. Of course no electronic instruments were available at the time that would have been capable of measuring ground currents.

A 1978 study conducted by Consumers Power Company (Consumers Energy) of Michigan concluded that unbalanced three phase circuits in their system caused electric currents to be carried on natural gas and oil pipelines (Lathrop 1978). This work was one of the first efforts to measure the presence of ground currents from distribution and transmission systems. In this case the concern was for pipeline workers

In 1985 a report was presented to the Minnesota Department of Agriculture and the Minnesota Legislature suggesting that currents entering the ground through the grounding of the electric utility distribution lines were associated with behavioral, health, and production problems on dairy farms. These ground currents from the utility system can thus be considered as one of the sources of stray voltage. Stray voltage has been defined as the 60Hz electric potential between two contact points in the dairy barn, and the floor is normally one of the contact points. Electric currents entering the ground from conditions such as ground faults have long been recognized as a cause for behavioral, health, and production problems on dairy farms. Since the majority of the current on the utility distribution system returns to the substation through the grounding system, there exists a perpetual ground fault (Dahlberg 1985).

In a paper presented at the American Public Power Association Engineering and Operations Workshop in 1989, Eugene Preston discussed ground currents in Austin, Texas. Preston discovered that electric currents on the neutral side of the distribution system in Austin were going through water pipes, the ground, and other conductors in returning to the substation. This condition caused an imbalance between the neutral and the phase wires of the distribution system, and consequently increased the 60 Hz magnetic field exposure for people in Austin. The outcome of this discovery was the development of the current balancing transformer, which forced the return current from the transformer to go to the substation by way of the neutral wire and not through the grounding wire

into the ground (Preston 1989). This transformer is manufactured and marketed by SNC Manufacturing of Oshkosh, Wisconsin.

In 1992 Daniel Hartsell, D.V.M. conducted a farm study in which he assessed possible changes in the health and production of dairy cows when electric current entering the ground on and near the farm was increased. The increase occurred when utility grounding wires were reconnected to ground rods. The study showed that the act of reconnecting the utility's neutral grounding wires on and near the farm had a negative impact on the health and production of the dairy herd (Hartsell, et. al. 1994). One of the findings was a change in blood chemistry, which is indicative of the beginning of the decline of the cows' immune systems. The same farm was the site of a second study in 1993, conducted by the Minnesota Environmental Quality Board (EQB). Similar health and production effects were noted in this study, but they were not considered statistically significant.

The conditions of the Hartsell and the EQB studies were different in two respects. First, in the EQB study the current entering the ground on the grounding wire on the farm ranged between 10 and 25 mA for a period of approximately two months before the beginning of the study and continued until approximately one month after the completion of the measurements. During the time of the Hartsell study, and at all other times, the current entering the ground on the utility grounding wire ranged between 100 and 200 mA. Second, for the EQB study the grounding wire was connected to the ground rod, thus allowing current into the ground, for only 6 days before blood tests and observations were made; in the Hartsell study the grounding wire had been connected to the ground rod for a period of 17 days before final observations and blood tests were made.

John Douglas published a 1993 article in the EPRI Journal summarizing an EPRI nationwide EMF survey of sources of 60 Hz magnetic fields in homes. One of the findings was that electric current in water pipes and other grounding paths may be the largest non-appliance magnetic field source in the home (Douglas 1993). Another report was published in 1993 that expanded on the results of the EPRI survey and provided information on the origin of ground currents (Raloff 1993).

The Allegan Study Group, which included a number of scientists, was organized to study problems in dog kennels. The investigations and research began in the early 1980s and continued into the early 1990s. Because the majority of scientists in the group had experience related to chemistry, their emphasis was searching for chemical causes for the problems. After a number of years of investigation, the scientists were not able to find any chemical present in the dog kennel capable of causing the observed health problems. Through the assistance of dairy farmers in Michigan and an electrical engineer, they finally concluded that ground currents entering the dog kennel were the cause of the problems. When the dogs were moved to a location where no ground currents

were measured, the health problems also ended (Marks, et. al. 1995).

In 1994 the Minnesota Legislature enacted legislation calling for an investigation of the origin of electric currents reaching dairy barns by means of earth paths, and whether or not these currents are adversely affecting dairy cows. They designated the Minnesota Public Utilities Commission (MNPUC) as the lead agency for implementing this investigation.

One of the requirements of the legislation was the appointment of a multidisciplinary team of scientists to oversee the investigation. In 1998, after three and one half years of study, the final report was made available. In that report the authors concluded, "We have not found credible scientific evidence to verify the specific claim that currents in the earth or associated electrical parameters such as voltages, magnetic fields and electric fields, are causes of poor health and milk production in dairy herds" (MNPUC 1998). The Electromagnetics Research Foundation, Inc. (TERF) responded with the observations that the conclusions of the report were not consistent with the data that had been gathered, and that some important aspects of the legislation had never been examined. (TERF, n.d.)

One of the projects of the Science Team was a study of 19 dairy farms, including both farms with low milk production and those with high milk production. Dr. Charles Polk, a member of the Minnesota Science team, reanalyzed the data from the 19-farm study and presented his conclusions in a paper published in 2001. Dr. Polk observed that the step potentials during low electricity use on the farms were 4.2 times higher on average for the low-producing herds than for the high-producing herds. He also observed that the soil resistivity in the field around the farm correlated inversely with milk production. These two observations are consistent with correlating a decrease in milk production with an increase in ground currents, and were the only measurements made on the farms that could have relate ground currents to milk production. Dr. Polk agreed that the PUC study did not produce credible scientific evidence that ground currents cause health and production problems, but he goes on to say, "neither did it find any evidence that currents in the earth from on- or off-farm sources are not the source of the small step voltages which were measured or that these SV's cannot affect cows health" (Polk 2001, 15). He also concluded that, at the present time, neither the research done by the PUC in Minnesota nor that by Reinemann at the University of Wisconsin answers the questions as to whether or how long-term exposure to step potentials above 9 mV can affect the behavior, health, and production of dairy cows. The conflicting conclusions of the science team report with those of one of the scientists on the team leaves the question of effects from ground currents in doubt.

The Minnesota Department of Commerce also commented on the work of the Minnesota Science Team. One of their recommendations is that the PUC adopt a neutral position concerning the conclusions of the final report. As stated in the

Department of Commerce comments, "While there isn't current evidence to verify the claim that ground currents cause poor health and milk production in dairy herds, there also isn't conclusive evidence to prove the contrary" (Beck and Michaud 2000).

Another component of the PUC study was to determine the condition of electrical distribution systems in Minnesota. In one part of that study, electric utilities measured the percentage of neutral current returned to substations as ground current. The average percentage for all the utilities in the State was 59% (Hendrickson, et.al. 1995). From their own measurements, the electric utilities in Minnesota are saying that on the average more than one half of the neutral current returns to substations through the ground as ground currents.

In April 1998 Michigan's Attorney General Frank J. Kelley, filed a complaint against Consumers Energy Company (Consumers). A portion of that complaint is quoted below:

In this complaint the Attorney General respectfully requests an order requiring Consumers to cease and desist from allowing any stray voltage or current flowing from its electric system (poles, lines, substations, and other facilities) into the earth and onto private property, and for an order requiring Consumers to upgrade and improve its distribution system and to operate and maintain this distribution system so as to eliminate all stray voltage or current from flowing from the utility's distribution system into the earth and onto private property.

The Attorney General concluded that these currents were causal to birth defects in dairy cows and livestock (beef cows, swine, horses, chickens, etc.) and other farm animals (cats, dogs, etc.); death of dairy and livestock animals; stillborn and aborted calves; significant reductions in milk production in dairy cows; reduced weight gain and/or failure to achieve proper marketable weight in livestock; lameness in dairy cows and livestock; swelling in legs and open sores on dairy cows and livestock; extremely erratic, unpredictable and uncontrollable behaviors in dairy cows and livestock, causing potential physical injury to both the animal and/or farm personnel; increased incidence of clinical mastitis; incomplete milk outs; and increased stress and agitation of dairy cows and livestock (Kelley 1998).

From 1985 to the present dairy farmers from Minnesota, Wisconsin, and Michigan have gathered information connecting ground currents generated by the electrical utility systems to the behavior, health, and production of their cows and health problems of people living and working on the farms (Dahlberg and Falk 1995). A number of other scientists and electricians, such as Dr. Marty Graham, Dr. Donald Hillman, and David Stetzer, have also concluded that ground currents are a major electrical cause of the health and production problems on dairy farms.

During the same period that dairy farmers have been experiencing stray voltage problems, groups of scientists have been studying the effects of 60 Hz magnetic fields on human health. Wertheimer and Leeper (1979) brought attention to the potential effects of 60 Hz magnetic fields. Since then many studies have been conducted with mixed results.

In the year 2000 two papers were published that reanalyzed groups of previous studies involving the correlation between childhood leukemia and magnetic fields. One of these is a pooled analysis of nine studies and the other analyzes 12 studies (Ahlbom 2000, Greenland 2000). The Ahlbom analysis revealed no statistical difference between controls and cases for measured magnetic fields below 4 mG, but for measured magnetic fields above 4 mG there was an estimated summary relative risk for leukemia of 2.00 (1.27-3.13), P value = 0.002. For the highest wire code category the estimated relative risk was 1.24 (0.82-1.87). In the Greenland analysis there was no statistically significant association between childhood leukemia and magnetic fields less than 3 mG, but for magnetic fields between 3 and 10 mG the summary odds ratio was 1.7 (95% confidence limits = 1.2, 2.3). The odds ratio estimates comparing high to low wire code configurations varied between 0.7 to 3.0 (homogeneity P = 0.005).

In a study funded by the National Cancer Institute (NCI), Dr. Linet's research team concluded that there was no statistically significant correlation between 60 Hz residential magnetic field levels and acute lymphoblastic leukemia (ALL) in children. The raw data from which the conclusions were drawn consist of a table of measured time weighted average magnetic field levels in residences of ALL cases. The magnetic field levels in the residences of the 624 ALL cases varied continuously from 0.17 mG at the low end to 10.64 mG at the high end (Linet, et.al. 1997).

The results of the NCI study take on a greater significance when examined together with another study by the Electric Power Research Institute (EPRI) in 1993. EPRI made two sets of magnetic field measurements in an effort to develop an understanding of the magnetic field levels in homes throughout the country. One set consisted of spot measurements made in 992 residences and a second set consisted of median combined power line/grounding system measurements in 986 residences. The two sets are quite similar. For both sets of data, 50% of the residences had magnetic fields exceeding 0.5 mG, 25% exceeding 1.0 mG, 10% exceeding 1.7 or 1.8 mG, 5% exceeding 2.5 or 2.6 mG, and 1% exceeding 5.5 or 5.8 mG (EPRI 1993).

If magnetic fields were not a factor in the causing or promoting of the ALL cases, the profiles of magnetic field levels in the NCI study should be similar to those of the EPRI study. In comparing the two, one finds that 50% of the residences in the NCI study had magnetic fields in excess of 0.74 mG, compared with 0.5 mG for the EPRI study. Likewise in the NCI study 25% of the affected homes had

magnetic fields above 1.29 mG, compared with 1.0 mG for the EPRI study; 10% of the affected residences in the NCI study had magnetic fields above 2.31 mG, compared with 1.8 mG in the EPRI study; 5% of the affected residences in the NCI study had magnetic fields above 3.37 mG compared with 2.6 mG for the EPRI study; and finally, 1% of the affected residences in the NCI study had magnetic fields above 5.48 mG, compared with 5.8 for the EPRI study.

These data show a consistent difference between the magnetic fields of residences in general, in the EPRI study, and the residences occupied by ALL victims, in the NCI study. In residences of ALL victims the magnetic fields were consistently higher, except for the highest one percent. This evidence clearly shows an association between the ALL cases and magnetic field levels in the residences.

E. Stanton Maxey, M.D., through a Freedom of Information action, received the raw data from the NCI study in November 2000. With the help of mathematicians he reanalyzed the data and has concluded that the NCI raw data reveals approximately a 3,000,000,000,000 to one probability that elevated 60 Hz magnetic fields are in some manner causal to childhood ALL.

Wertheimer, Savitz, and Leeper published a paper in 1995 that found an association between cancer and conductive plumbing in residences. They found that measurements made in these residences suggest an increased cancer risk for persons who live with elevated magnetic fields from ground currents (Wertheimer, et.al. 1995).

In 2000 a paper was published presenting the results of research conducted under an EPRI contract that considered the role of contact currents in the risk of cancer (Kavet, et. al., 2000). These contact currents are the result of ground currents in the conducting parts of residences and businesses. Among the conclusions of the paper is the statement, "We have identified contact current due to VOC as a factor potentially responsible for the association between residential magnetic fields and childhood leukemia" (p. 549). (VOC is the term used in the report to refer to contact voltage.)

Kavet's paper brings together ground currents and 60 Hz magnetic fields as co-contributors to leukemia in children. It is not surprising to draw this conclusion, since both magnetic fields and contact currents resulting from ground currents increase electric current in the body.

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