Report of Frank Martin, Ph.D.
June 15, 2007

I performed a statistician's critical examination of papers relied upon by various defense experts and several other papers that were not reviewed by such experts and not considered by them. I looked for appropriateness of the analysis of data gathered in the various articles and validity of conclusions reached by authors.

The papers reviewed are:

1. Effects of Neutral to Earth Voltage on Behavior, Production and Water Intake in Dairy Cattle, Aneshansley, Gorewit, Luddington, Pellerin, and Xin, (Paper # 87-3034, ASAE, 1987. This presentation contains powerful data showing statistically significant drops in the slopes of the lactation curves as voltage increases, with one volt being significantly different from 0 volts. This correlates with the conclusion of the authors that drinking behavior was strongly negatively influenced by increased voltages. The authors chose not to analyze the phenomenon of steeper slopes of the lactation curves and reached a conclusion contrary to the data. This presentation by Aneshansley subsequently appeared in the Journal of Dairy Science as AC Voltages on Water Bowls of: Effects on Lactating Holsteins, 1989 J. Dairy Sci. 72:2184-2192. Trial 1 is the same study as the 1987 Aneshansley study above. The authors chose to use a crude definition of response in reporting trial 1 that dampened their ability to observe effects. Trial 2 shows a very definite dose response to .5 volt and higher in Figure 5. Figure 5 shows a very well defined response curve to increasing voltage, with onset of sensitivity occurring as low as .5 volt. This is a powerful illustration of cow sensitivity to voltages as low as .5 volt.
2. Effect of Neutral Isolation on Milk Production and Herd Health, Dairy Update, Issue 80 (July 1987) Appleman, Gustafson, Brennan and Cloud; and Production Record Analysis of Dairy Herd Response to Neutral Isolation, ASAE Paper # 87-3039 (1987), Appleman, Gustafson and Brennan. This is a large field study using records of the highest available quality. The authors found immediate increased milk production response to isolation of dairy herds from the primary neutral of the utility. It is error to dismiss this conclusion because the causal mechanism (cows are responsive to low currents and low voltages) is well understood. Erdreich had this field study but failed to acknowledge it in her analysis of field studies in ¶¶ 46-49 of her report. This study shows the effect of an intervention, similar to what occurs in human medical trials, and shows an undeniable response to the intervention in the form of a marked increase in milk production.
3. Stray Voltage Problems with Dairy Cows, Cloud, Appleman, and Gustafson University of Minnesota Extension Service Publication, NCR Publication # 125. This is not a study and contains no data from which any conclusions can be reached.
4. Dairy Cow and Human Sensitivity to Sort Duration, 60 Hertz Currents, Currence, Steevens, Winter, Dick, and Krause, Volume 6, page 349-353, Applied Engineering in Agriculture, 1990. Sensitivity curves are presented showing a

broad range of sensitivities with responses occurring at 2 mA RMS. The whole herd is responding at 4 mA. However, it is probable that cows were detecting the one cycle current durations before they exhibited a physical reaction. There is no correlation shown between milk production and any threshold, whether that be lower or greater than 2 mA.

5. Report of Charles Forster, Phasor Labs, July 31, 2006. The report at page 10 states that the chart set out in the last page of the report "is used to determine when the 5% (5 out of 100) most electrically sensitive cows in a herd can first detect an electrical event." I have been provided with a set of 65 studies that are believed to be those referred to in the Forster report. No data is set out or referred to in these studies which support the conclusion. There is reference to University of Wisconsin testing and "60 other studies", but none of the material that has been provided to me supports the statement made by Mr. Forster. This chart therefore has no scientific support.
6. Effect of Voltages on Cows Over a Complete Lactation. 1. Milk Yield and Composition, 1992 J. Dairy Sci. 75:2719-2725, and Effect of Voltages on Cows over a Complete Lactation. 2. Health and Reproduction, 1992 J. Dairy Sci. 75:2726-2732. The barn notes for this study shows enormous difficulties with the performance and management. The cows selected were not being managed for high production as evidenced by the milk production levels of the cows (for example, I am informed that the Michigan State University RHA at the same time was over 20,000 pounds). Cows were managed by Cornell University personnel with unknown skills, and health variables as a function of management are not set out. Inference from the data collected is not possible because there is no proof that the herd selected for testing was a representative random sample. Thus, extrapolation was used, which has no scientific statistical merit. Cows were kept in the study far below the production level that a commercial dairyman would have dried them off. The results of the study are further compromised by the fact that 25% of the animals were not able to complete the study, mostly related to mastitis. Cows in the various pens were not the same over time. The feeding regimen, including the use of computer feeders, also negatively impacts the value and relevance of the data. The cows reached peaks early, indicating modest condition of the cows. Because of the large amount of variation in the animals, the study had a low power to detect differences. The statistical analysis raises questions because of very small f ratios (e.g. f = .18). This leads me to believe that the authors mis-specified their models and raises doubt as to whether they were able to observe experimental error. As a result of these concerns, I have very low confidence in extrapolating the results of this study.
7. Stray Voltage Effects on Dairy Cattle, New Liskeard College of Agricultural Technology, P. Gumprich, 1992. This study was performed in a tie-stall barn. All animals in the study received the voltage treatment at different times in a 4 week study period. There were 5 cows in 6 groups for 4 periods, providing 120 data points for each experiment. Table 2 presents an analysis showing 144 data points for a single experiment, which does not fit the number of data points collected. As a result, statistical analysis must conclude there. Without resolution of this problem, quoted p values cannot be relied upon. The lack of description of

the calculation of residual effects makes it impossible to interpret the numbers quoted (see, for example R1, R2 and R3 on page 33). One significant conclusion at page 39 supports the opinion set out in item 1 above: "One unusual finding is that the three-period residual affects are often statistically significant. This may mean that the voltage treatment affects the peak and/or rate of decline in the lactation curve rather than having an immediate impact on performance."

8. Behavioral Studies of Dairy Cow Sensitivity to AC and DC Electric Currents, Gustafson, Brennan, and Appleman, Transactions of the ASAE, 0001-2351/65/2805-1680. This study consists of 6 cows. Expanded metal grids were used with resultant lower contact surface. There was a 50% response rate based upon observations of twitch, grimace and flinch at 2 mA or greater for all pathways. The mouth to all hoof pathways was at 2 mA AC where a measurable increase in response was observed.
9. Relationship of Electric Power Quality to Milk Production of Dairy Herds, Hillman, Stetzer, Graham, et al, ASAE Paper number 033116 (2003). This paper represents a field study for 11 farms where farmers believed that a stray voltage problem existed and has two different data sets with nearly identical results. They were fitted regression models, including the number of transients as a predictor. The number of transient events has a negative slope for daily milk production of .028 kg/milk/cow/day per number of transients in both analyses. The authors concluded, among other things that (1) step potentials above .010 Vp (10 mVp) were measured from the floor of milking stalls and in barnyards and affected behavior and milk production in dairy cows in four herds for 535 days, (2) impedance of cows decreases as voltage/current frequency increases, the cows receive higher amperage from higher frequency electrical current, including harmonics than from 60 Hz sinusoidal electrical impulses. This field study contains statistically significant and reliable results.
10. Behavioral Response of Dairy Cows Subjected to Controlled Voltages, Lefcourt, 1982, J. Dairy Sci. 65:672-674. This research establishes that cows have resistances as low as 250 ohms and can respond from less than l mA and voltage of less than .2 volts to 3 mA and .7 volts. It is a small study, but suggests that levels of concern were less than 1mA and .2 volts.
11. Effects of Electrical Voltage/Currents on Farm Animals, How to Detect and Remedy Problems (Red Book), USDA Handbook 696 (1991). Chapter 3 has been reviewed. The graph at page 3-22 has no support in any data presented and merely refers to a "consensus opinion". The basis for the "consensus opinion" is not stated in the report and cannot be verified from any references given in the report. The resulting discussion conflicts with Lefcourt's 1985 study (quoted at page 3-11) that a farmer can, in the short term, take "exceptional care to accommodate behavioral responses" to avoid milk production effects from exposure to voltages. This statement also conflicts with Figure 3-2 at page 3-12 showing a dose behavioral response beginning a .5 volt. This statement also conflicts with the report of Appleman referred to at 3-15 and 3-16 that showed significant response to neutral isolation where criteria was 1 volt or more NEV. The statement that "69% of the herds isolated failed to show a response" is gratuitous and adds nothing to scholarly discussion, raises concern about bias of

the author, and fails to acknowledge that the problem could still have existed on the herds for which no response was shown. The statement made on page 3-18 that there is an "inability to scientifically establish a direct relationship of stray voltage/current on milk production" raises issues as to orientation of the author, because the causal mechanism is well understood – stray voltage causes problems with dairy cows. This is the same as the "tobacco" defense that there was never scientific proof of a cause between cancer and tobacco – where the epidemiological (observational) studies proved a relationship between smokers and non-smokers – but at the time there was no proof on a cellular level to prove the scientific link. Scientific proof is sufficient where the causal mechanism is present and observational data of the intervention shows the effect. The study set out at item 2 above clearly establishes that there was improvement immediately after the intervention and that was not mere coincidence. I am reliably informed that cow comfort is an important component of milk production. Electric currents are known to cause cows discomfort and avoidance reactions. It is not logical to exclude electric currents from the topic of cow comfort.

12. Final Report of the Science Advisors of the Minnesota Public Utilities Commission, Minnesota Public Utilities Commission, July 31, 1998. This report admits to finding a statistically significant difference between high and low producing herds in Minnesota as a function of stray voltage. According to Polk (2000), these results showed that stray voltage was 4.2 times higher on the low producing farms than the high producing farms. Soil resistivity and voltage was statistically significantly higher on the low production herds. Polk suggested further studies to examine this phenomenon and the effects of long term exposure to low stray voltage levels. On a random sample of 2500 farms, only 30% of the persons responded to the survey, and 90% (679) responded to telephone interviews. Of those, only 8 farmers (1.2%) reported that they believed they had a problem with stray voltage. The report concluded that the *perception* among farmers that stray voltage was a problem on their farms is low. This establishes, at best, that from an epidemiological standpoint, no pandemic exists, but this does little to respond to the farmers with the problem. The next part of the study was a field study. The data was derived from 331 farms that had more than 30 cows that were a subset of the 2500, a subset of the 30% and a subset of the 90% referred to above. Out of a set of 331 qualifiers, the 10 high and 10 low were identified, but only 19 participated. Only 2 were parlor (free stall) facilities and the rest were stanchion. Thus, only two farms were comparable to Siewart's operation. One of those was a high producer and one a low producer. 9 high and 10 low producers were tested. No farms were found with exceptionally high step voltages. Given the fact that the problem has low prevalence, this is not a surprising or revealing result. Moreover, the test was conducted using an impedance model for a cow with a 500 ohm resistor, which conflicts with other research and also with testing on the Siewart dairy establishing lower impedance. Basically, the 19 farms that the field study inspected did not include farms with a step voltage problem, and that is likely due to sample size being too small in the face of low prevalence as reported by the 30% that responded to the survey.

13. Behavioral Studies of Dairy Cattle Sensitivity to Electrical Currents, Norell, Gustafson, Appleman and Overmeier, Transactions, 1983 ASAE 0001-2351/83/2605-1506. Cow resistances for 28 cows were measured, showing mouth to all hooves of 244 ohms at the 10^{th} percentile of the data set. The Siewart cows had even lower resistances, according to testing performed by Neubauer. Figure 4 shows a 20% behavioral response rate at 1.6 mA and a 50% response at 2.6 mA. If the goal of containing stray voltage is 1% of the herd or less, this is clearly not occurring at 1.6 mA, according to this study.
14. Response of Dairy Cattle to Transient Voltages and Magnetic Fields, Reinemann, et al, Transactions ASAE on Industry Applications Vol. 31, No. 4, July/August 1995, pp. 708-14. This is a technical study that demonstrates an approximate 15% response rate at 2 mA, 16-ms, AC transient cow contact voltage repeated every 2 seconds in a 30 second period. This was based upon observed physical reaction. A current of 1.4 mA elicited a response for a transient voltage. The author, at Figure 1, refers to the same graph as set out at page 3-22 of the "Red Book" but provides no further elucidation as to the foundation for or veracity of the chart.
15. Dairy Cow Sensitivity to Short Duration Electrical Currents, Reinemann, et al, Transactions of the ASAE, 42(1): 215-222 (1999). This study demonstrated that minimum threshold for single cycle 60 Hz current was 2.8 mA peak and for 9 cycles was 2.0 mA peak. Reduced to RMS, these numbers are 2.0 mA and 1.4 mA. This article offers no statistical support for the graph appearing on the last page of Forster's report dated July 31, 2006.
16. Milking Performance of Dairy Cows Subjected to Electrical Current and Induced Milking Machine Problems, Reinemann, Rasmussen & LeMire, Transactions of the ASAE, Vol. 45(3): 833-838 (2002). This was a milking machine study showing interactions between milking machine problems and exposure to voltage. There were only 3 study days with 32 cows. 1 mA was applied during the milking on one day out of the three days. The worth of this study is questionable, given observations that effects may be delayed until later in the milking curve.
17. Water, Feed, and Milk Production Response of Dairy Cattle When Exposed to Transient Currents, Reinemann, et al, Transactions of the ASAE, Vol. 48(1): 385-392 (2005). When analyzing the data, the authors mis-identified the experimental unit. The statistical analysis did not identify the experimental error. Therefore, the results are null and void. The P values are uninformative.
18. Review of Literature on the Effect of the Electrical Environment on Farm Animals, Reinemann (December 2005). This is a summary of articles on the general subject noted in the title. It is of little help in determining the statistical validity of the studies set forth.
19. Effects of Continuous Stray Voltage on Health, Growth and Welfare of Fattening Pigs, S. Robert, et al, Can J. Vet. Res. 1991; 55: 371-376. This article deals with exposing pigs to voltage. There is nothing referring to currents or contacts from which any conclusions can be drawn or extrapolation that is of any use relating to dairy cows.
20. Milk Production, Water Consumption, and Somatic Cell Count Responses of Cows Subject to One or Two Volts of Alternating Current, Southwick, et al,

JAVMA, Vol. 201, No. 3, August 1, 1992. This is a case study involving a farm in New York. The controls for cow contact were weak. There is no documentation of the amount of cow contact current the cows were getting, giving low relevance to the data collected. The results are therefore uninformative.

21. Improvement in Milk Production and Udder Health Following Correction of Stray Voltage on Computer Feeders, Wilson, Southwick and Kaeser, Agri-Practice, Vol. 17, Nos. 5 & 6, May/June 1996, pages 24-29. This was a case study done by Cornell researchers establishing that isolation resulted in a precipitous jump in RHA and feed consumption. Heifers entering the herd post-isolation out performed heifers in the herd pre-isolation. Voltage averaged 1.05 v for 6 hrs, 54 mins/day, and ranged from .30 v to 2.61 v at the computer feeders. In the milking parlor, the voltages were between .36 and 2.3 volts. Isolation resulted in less than .30 volts in both the parlor and at the computer feeders.
22. Comparison of Dairy Cow Aversion to Continuous and Intermittent Current, Reinemann, Stetson and LeMire, Transactions of the ASAE Vol. 47(4): 1257-1260 (2004). There were two experiments involving 16 cows. Cows were wired to the water bowl and were personalized to individual cow thresholds for aversion, ranging from a low of 2.8 mA and higher. The breed of cows is not set forth. The cows were housed in dry stalls. There were significant delays to drinking when cows were shocked at personalized threshold behavioral reaction current. If the cows react to current, then the herd has problems, including inhibitions to drinking water. There was a bigger effect from pulsing current.
23. The Effects of Ground Currents in Dairy Cows: A Case Study, Hartsell, Dahlberg, Lusty and Scott, The Bovine Practitioner, September 1994, pp. 71-78. This is a reverse case/field study. The power company told the farmer to either hook up the ground or they were going to disconnect him from power. Veterinarians did herd measurements before the ground was re-connected and then 17 days later did further measurements and began getting effects. Before the re-attachment of the ground, the herd was examined and body scored and found to be in good condition. Even one week after re-connection, cows showed rubbed and hairless spots on their hocks and carpal joints. 17 days after hook up, fully one-third of the herd had the same markings that were not present before hook-up. The somatic cell counts (SCC) before hook-up were 141,000. In the pick-up immediately following the connection, the SCC was 758,000 and two weeks later it was 355,000. Water consumption was measured for the week before re-connection. In the week from day after re-connection, water consumption dropped 3 gal/cow/week from the previous week. Blood from a random sample of cows was taken before and after re-connection and there was an increase in lymphocytes and a decrease in monocytes that was statistically significant. It is noteworthy that no other papers have considered condition of the hair and skin on the hocks and carpal joints.
24. Report of J. Patrick Reilly, "Evaluation of data concerning electrical exposure of dairy cows on Siewart farm", October 4, 2006. At pages 3 and 4 of this report, reference is made to Table 1. Reference is made to "median" values for "minimal behavior thresholds" and that the 10^{th} and 50^{th} percentiles are calculated from

published data. The sources referenced have been reviewed. The conclusions reached by the author are invalid. The 10th and 50th percentiles cannot be meaningfully computed for anything except the 120 cow data set. Most of the quoted results are not estimates of population percentile. There appears to be a lack of understanding of population density function. The 120 cow data set (for an unknown breed of dairy cow) shows numbers that were calculated from peak current and converted to RMS continuous. The 120 cow data set was based upon single cycle exposure at 60 Hz and not RMS continuous exposure. As a result, this chart is not capable of providing any useful information about the 10th percentile for minimal behavior thresholds. The studies themselves do provide certain information, but it is improper to bundle them in order to draw median information. It appears from the data presented that thresholds for dairy cattle vary by breed, with Holsteins being the most sensitive and Jerseys being less sensitive.

25. Occurrence of NEV voltage in cow contact area and its relationship to milk production on randomly selected Wisconsin dairy farms: Field Survey. Hendrickson, et al. December 1990. Presentation to ASAE, paper number 903507. Table 2 is suggestive of a relationship between low production and stray voltage in Wisconsin dairy herds. This is a field study and re-analysis of survey data needs to be pursued. The statistical analysis is wrong and permitted conclusions that are likely false.

It is my opinion that Dr. Erdreich did not critically examine her references, which do not support the conclusions she reaches. Therefore, it is error to draw conclusions based upon weight of the evidence she relied upon. At best, the studies cited establish that stray voltage is not a pandemic. Paragraph 68 wrongfully criticizes Dr. Behr's conclusions. Dr. Erdreich has also made no power calculation and the statement in the last sentence of paragraph 68 is pure speculation. The observation made at paragraph 69 is not sound because of small sample size. This reflects placing uncritical faith in the study, which is not warranted and leaves her conclusion without foundation. The studies she refers to in paragraph 70 do not support the conclusion she reaches. I disagree with Dr. Erdreich's conclusions in paragraph 71, as there is available research that establishes concern for exposure below the 2 mA level. See, for example, item 10 above.

It is my opinion that the graph relied upon by Forster in his report has no foundation in the studies I have reviewed. It would be improper to draw conclusions based upon this Table.

It is my opinion that Table 1 in the Reilly report reflects a lack of understanding of population cumulative density functions.

I reserve the right to amend and supplement this report as further evidence and research comes to my attention.