EL 98-005

EL 98-005

KC/SW

CH/MB-Commerce

EL 98-005

DOCKET NO.

In the Matter of

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE

file file

Public Utilities Commission of the State of South Dakota

DATE		DESCRIPTION
3/6	98	Received;
3/19	98	Response from Lincoln-Union;
3/23	98	Response from Douglas L. Kuper;
4/1	98	Docketed;
4/28	98	Order Finding Probable Cause and Notice Requiring Answer;
5/20	98	Answer of Lincoln-Union;
6/16	98	Received copies of Circuit Court documents;
7/17	98	Motion to Dismiss;
8/3	98	Brief in Support of Motion to Dismiss;
8/3	98	Brief in Support Not to Dismiss Complaint;
8/14	98	Order Denying Motion to Dismiss;
8/17	98	Request for Staff Onsite Inspection and Mediation;
8/19	98	Response to Onsite Inspection;
8/31	98	Order for and Notice of Hearing and Setting Prehearing Deadlines;
11/24	98	Order for and Notice of Prehearing Conference and Hearing;
12/2	98	Lincoln-Union's Response to Order for and Notice of Prehearing Conference;
12/2	98	Motion for Notice of Slip of Mann Pro Deposit of Sector for Dismiss;
12/2	98	Motion to Limit Testimony;
12/2	98	Requests for Admissions;
12/2	98	Final Report of the Science Advisors to the Mann Pro;
12/30	98	Order Dismissing Complaint and Closing Docket;
12/30	98	Docket Closed;
5/18	99	Amended Order Dismissing Complaint and Closing Docket;
5/18	99	Docket Closed.

EL98-005
Received

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

500 E Capitol, State Capitol Building, Pierre SD 57501

COMPLAINT

Complainant(s): (Persons filing the complaint)		Respondent(s): (Persons or Company complained against)	
Name	Douglas L. Kuper	Contact Person	Manager
Address	2810 N. 41st Ave	Company	Lincoln-Union Elec Co
City, State Zip	Canton S.D. 57030	Address	P.O. Box 500
Home Phone	605-987-2267	City, State, Zip	Beresford SD 57004
Work Phone	605-987-5621	Work Phone	1-800-952-4668
Cellular Phone		Cellular Phone	
Fax #		Fax #	

If the Complainant is represented by an attorney, please list the attorney's name, address, telephone number and bar number below: (If Complainant is not represented by an attorney, please leave blank.)

Cargill

These are the facts giving rise to my complaint:

The complaint is against the City of the Lincoln-Union Electric Co. in regards to the City Park and the Swimming Pool. The Lincoln-Union Electric Co. is leasing a portion of the City Park and the Swimming Pool from the City of Canton. The Lincoln-Union Electric Co. is charging the City of Canton for the electricity that is used at the Swimming Pool. The Lincoln-Union Electric Co. is also charging the City of Canton for the electricity that is used at the Park

RESOLUTION REQUEST

I ask that the Public Utilities Commission grant the following relief. (What do you think the Commission should do to solve this problem?)

I would like the company to make their bills more clear so that the customer can see how much they have used and how much they owe. I would like the bill to show a graph of how much energy I have used over the past 12 months.

Note: Please attach any additional pages, if necessary.

VERIFICATION

Complainant's signature must be witnessed by a notary public.

Complainant's Signature

3-2-92
Date

State of South Dakota)
) ss
County of Lincoln)

On this 2nd day of March, 1992, before me personally came and appeared [illegible], known to me to be the individual described herein and who executed the foregoing instrument, and who duly acknowledged to me that he/she executed same for the purpose therein contained.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

Notary Public

My commission expires: [illegible]

page 2

operations continue when the lines
are fix to handle the loads. My
family and I also wish to have in
our home free of shocks from the power
Co. My main concern through these
court cases was to get the public school
and recover some of the lineblock losses
due to death, etc. which part of it has
been done. I guess I must need some
kind of order from the PUC to get the
lines fix so I may continue our operations.
This problem of Stray Voltage from Lincoln
-Union is being felt by other members or
Dairy producers on this system and is a
large concern to all of us. Even one of the
board members on the Coop has the same problem
as I do and has been found to be the Coop's
problem of current looking off of the down grounds
along the line. I do have an attorney
but wish to represent myself if
representation is needed. This case has
been filed if any information is needed
please feel free to contact me. I will do
my best to get it for whom it may concern.
I can only hope and pray that this
problem be corrected.

Very sincerely
Douglas L. Piper

FAX TRANSMISSION

To: Brad Schardin	From : Kelly Hoag
Company :	Company : South Dakota PUC
Fax Number : 8-1-605-334-1964	Fax Number : 1-605-773-3809
Date : 3/11/08 Time : 9:12:18	Pages including cover page : 4

Message:

We have received the following formal complaint from Douglas K. Hager. Commission policy allows a 48-hour period in which the parties may attempt an informal agreement without Commission action.

Please review this information and respond to Steve Wegman in our offices by Friday, March 14th at noon, if such an informal resolution has been reached. If we do not hear from Mr. Wegman or Lincoln-Union by Friday noon, we will assume that no agreement was reached. The issue will then be docketed and scheduled for a Commission meeting.

If you have any questions, please do not hesitate to contact us.

THIS COMMUNICATION IS INTENDED ONLY FOR THE USE OF THE INDIVIDUAL OR ENTITY TO WHOM IT IS ADDRESSED AND MAY CONTAIN INFORMATION THAT IS PRIVILEGED, CONFIDENTIAL AND EXEMPT FROM DISCLOSURE UNDER APPLICABLE LAW. If the reader of this message is not the intended recipient or the employee or agent responsible for delivering the communication to the intended recipient, you are hereby notified that any dissemination, use or copying of this communication is prohibited.

South Dakota Public Utilities Commission
State Capitol Building, Pierre SD 57501
Telephone: (605) 773-3201 Fax: (605) 773-3809

Lincoln-Union Electric Company

P.O. Box 105
Alcester, SD 57001-0105
Tel.: (605) 934-1961 or (605) 313-2859 Sioux Falls
Fax: (605) 934-1964

RECEIVED
[illegible]
[illegible]

March 18, 1998

Mr. Steve Wegman
South Dakota Public Utilities Commission
500 E. Capitol
State Capitol Building
Pierre, SD 57501

Dear Mr. Wegman

We received the formal complaint filed by Douglas L. Kuper with the South Dakota Public Utilities Commission (PUC) on March 2, 1998, in our office via fax on March 11, 1998. That original notification indicated that you needed a response by March 13, 1998, which was extended by the PUC until March 18, 1998. We hope that this letter provides you with an overview of Lincoln-Union Electric Company's (Lincoln-Union) position on Mr. Kuper's written complaint.

Lincoln-Union, through its employees Tim Chance and Todd Nelson, has worked extensively with Mr. Kuper over the years performing numerous neutral to earth/stray voltage investigations and analyses. Based on our records, over 60 visits to Mr. Kuper's farm have been performed over the last several years in which we have worked with him and openly provided him with copies of our tests and additional information and materials. Most of these tests were performed prior to Mr. Kuper's filing a court case against Lincoln-Union in 1993. Copies of the original trial exhibits, and most recent retrial, can be obtained at the Lincoln County Courthouse, Clerk of Courts, in Canton, SD (see file #93-153). Kuper vs. Lincoln-Union 1996 SD 140, 557 NW 2d 768 the Supreme Court ruling should provide extensive information in this matter.

Mr. Kuper apparently feels the problem persists pertaining to neutral to earth/stray voltage. Based on the tests performed by Lincoln-Union employees, outside consultants (those hired by Lincoln-Union and Mr. Kuper), numerous engineers, and other individuals, [illegible] would violate accepted industry standards. Tests performed on Lincoln-Union's primary distribution system also indicated normal operating conditions in relation to loading, grounding, and voltage requirements. Mr. David H. DeVries, P.E., Lincoln-Union's consulting electrical engineer from DeWild Grant Reckert and Associates of Rock

Rapids, IA, has provided some additional comments pertaining to Lincoln-Union's electrical distribution system and particularly the line serving Mr. Kuper. A copy of his comments is attached for your review, and I'm sure Mr. DeVries would be willing to visit with you about any questions you may have on his material. Based on our own tests, tests of independent investigators, and Mr. DeVries' analysis, we believe that Lincoln-Union is providing Mr. Kuper with high quality and adequate electric service. We also believe that our lines meet or exceed the standards and requirements established for the electric utility industry.

Proper grounding of Lincoln-Union's electrical system is a requirement of the National Electric Safety Code (NESC). Mr. Kuper indicated that "until the ground wire along the power co. lines where cut did we see any relief." It is important to note that cutting of Lincoln-Union's grounds is a direct violation of the NESC and was done without Lincoln-Union's knowledge or approval thereby causing unnecessary risks to Lincoln-Union employees and the electric distribution system as a whole. This action contradicts the recent Minnesota Public Utility Commission Field Study which indicates that there has been no evidence provided that the NESC requirement of grounding the primary electrical system in any way creates or causes neutral to earth/stray voltage problems in a dairy barn. The Wisconsin PUC has also gone to the extent of encouraging more grounds on the primary electric system than the NESC requirements.

On March 10, 11, and 12, 1998, Todd Nelson, Lincoln-Union's electrician, attended another Stray Voltage Investigator's Training Course in which the theory of "ground or earth currents" was discussed at length in relation to the field study performed in Minnesota. A Minnesota PUC study indicated that the 60 hertz frequency travels about 1,500 feet below the surface of the earth, and because of the magnetic field and capacitance of the line, it follows the line back to its source. To the best of our knowledge, this is the most recent information available on the concern stated by Mr. Kuper pertaining to the NESC grounding requirements. Lincoln-Union did suggest that Mr. Kuper upgrade his dairy barn's electrical service to meet the most current National Electric Code (NEC). Mr. Kuper took that advice and had an electrician make up to changes in his dairy barn. Lincoln-Union has not done extensive investigation on Mr. Kuper's residence. We believe that any qualified advice we would be able to make [illegible] what Mr. Kuper may be feeling in the [illegible] or [illegible].

The management, employees, and directors of Lincoln-Union believe that throughout our testing for Mr. Kuper and the evaluation of our electrical system, we are, have, and continue to provide the adequate electrical service for Mr. Kuper to perform his dairy operations and to live in his home. We would be willing to share the records of

materials accumulated relative to the tests and evaluations that were performed or those completed by outside independent consultants all indicating no problematic voltages on Mr. Kuper's farm.

We continue to train our employees on the most current issues relative to the topic of neutral to earth/stray voltage such as the recent Madison, WI, seminar cited earlier. We also continue to work with all of our 4000 plus members on issues relative to their needs and the operation of their Electric Cooperative.

It is Lincoln-Union's position that Mr. Kuper's complaint is without any merit and therefore no docket should be opened and the matter dismissed. Please feel free to give me a call if you have any questions.

Thanks in advance for your consideration of this issue and be assured that we will cooperate in every way possible and that the efforts of Lincoln-Union and our employees are to provide quality electric service to all of our members.

Sincerely yours,

Brad Schardin

Brad Schardin
Manager

BJS:ria

Attachment

cc: Douglas L. Kuper
Lincoln-Union Board Members
Doug Eidahl - Director of Government Policy & Legal Affairs, SDREA
John Gubbrud, Project Attorney, Lincoln-Union
David H. DeVries, Project Engineer

DeWild Grant Reckert and Associates Company
Consulting Engineers

March 16, 1998

Mr. Brad Schardin, General Manager
Lincoln-Union Electric Company
P.O. Box 105
Alcester, SD 57001-0105

RE: PUC Complaint Dated 3-2-98
DGR File No. 400998.6

Dear Mr. Schardin:

This letter is our response to the PUC complaint filed by Douglas L. Enger on March 6, 1998.

During the past twenty (20) years DGR Engineers (DGR) has done the engineering for Lincoln-Union Electric Company (LU). Some of the tasks DGR has accomplished for LU are as follows:

- Long Range Planning (10 - 20 years)
- Short Term Planning (2 - 5 years)
- Sectionalizing System Design
- Circuit Design
- Reliability Analysis
- Work Order Certification (Construction Inspection)

In general, LU has a well maintained rural distribution system which offers delivery of power and energy from nine (9) substations owned and operated by East River Power Cooperation (ERPC). The distribution system is operated at a nominal voltage of 12.47 grd wye/7.2 kV, 3-Ø, 4-wire. The system is classified as a multi-grounded, solidly grounded system. Primary voltage regulation is limited to 5.0 volts on a 120 volt base in accordance with RUS and ANSI guidelines.

The reliability goal of the system is to keep the average outage hours per customer under 3 hours per year. This goal has been achieved in all of the last six (6) years. The entire system has been modeled during each short term planning session and construction is proposed to alleviate any excessive voltage drops or excessive line loadings.

March 16, 1998
Mr. Brad Schardin
Page Two

Specifically, the complainant is served on a single-phase line which taps the north 3-Ø circuit out of the Davis substation. The 1-Ø tap line is constructed using a basic RUS "A1" structure, #4 ACSR Phase and Neutral conductors, and the neutral is grounded a minimum of four (4) times per mile in accordance with the NESC. From the latest model, the maximum load on the 1-Ø tap is 8.5 amperes or 61.2 kVA. #4 ACSR has a maximum ampacity of 112 amperes. From a thermal loading stand point the 1-Ø tap in question is loaded to 7½% of its capacity. Actual ammeter readings taken on the 1-Ø tap during the summer of 1998 correlate the model. The maximum voltage drops from the Davis substation to the complainant's location is 2.3 volts on a 120 volt base. This is excellent service and certainly does not support the notion of line replacement or up-grade.

I personally made some random readings of the primary neutral to remote ground potentials in the summer of 1997. I found no unusually high readings in the vicinity of the complainant. Most readings were in the 0.3 VAC or lower range. This is quite normal on a multi-grounded system and indicates to me that the primary system is operating as designed.

In summary, I would like to address three of the complainant's requests for relief:

1. "Heavier line" - The existing line is loaded to less than 10% of its thermal capacity and maintains voltage regulations of 2.3 volts at peak. There is no engineering reason to install larger conductor on the 1-Ø tap line feeding the complainant.

2. "3-Ø line" - Construction of a 3-Ø line to serve a 60 kVA, 1-Ø load is ridiculous.

3. "Covered wires" - "Covered" or insulated conductors either underground or overhead will have the same NESC requirements that the system's neutral be grounded at least four (4) times per mile.

Very truly yours,

DEWILD GRANT RECKERT
& ASSOCIATES COMPANY

David H. DeVries, P.E.
Vice President

DDV/dvc

G:\01000-[illegible]

RECEIVED
MAR 2 [illegible]
SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

(1)

3-22-98

Dear Mr. Weyman

I received the letter or response from Lincoln Union Elect. and would like to respond to their answers if possible.

I have worked hand in hand with the Chance and Todd Nelson and enjoyed working with them very much. Although none of us knew much about [illegible] at the time we started that's probably the [illegible] for all the tests we did learn [illegible] I do believe there is over 60 farm visits and when we did finally find where the current was coming from I was told by Mr. Chance I was [illegible] to pay for Lincoln Union's problems [illegible] I thought was unrealist and I hired an attorney at that time as I am a member of the [illegible].

Based on the tests performed by Lincoln Union employees outside consultants [illegible] engineers and other individuals there were problems on these lines. For instance Mr. Bob [illegible] the authors of the [illegible] Book testified in the first [illegible] that he would be concerned with [illegible]



(2)

of a volt on a dairy farm or herd and that
[illegible] would be a problematic problem.
Once again I am not an attorney or engineer
est. Just a farmer with a problem not
related to my operation or career. Mr
Bodman traveled and showed problematic
levels of current entering my barn from
the [illegible] or Lincoln Union line. I used
Mr Bodman's equipment in the last trail
and a neighbors meter that showed very
high levels of current coming from the
Lincoln Union lines these are all recorded
on file with the case and also a videotape
at the end of the last trail which show
very high voltages in the barn when
[illegible] outside side or conditions are wet.
I used the same equipment that
Lincoln Union Engineer Mr Schultz used
he had the same readings I did which
showed up on the videotape which I took
on his last farm visit to my place prior
to the last trail. My tests and Mr
Schultz's where all done with the same
equipment [illegible].

(3)

I have no reason to doubt Mr. DeVries. But you should know that Faith Lutheran Church is not the only church that has been [illegible] No problem. Our agreement is: Sunday 2:00-3:00 p.m. that is the time during which we are open. Simply because we would like to have [illegible] Though there is not a problem, we would rather not have it. Again, please [illegible] some volunteers on the days you plan to open. Any questions, please call me. Thank you.

Dear Mr. Gordon, I would like to [illegible] Your application [illegible] Your application [illegible] Please [illegible] Please [illegible] Please

(5)

I believe Mr. Bodman and Dr. Dallas have found the reasons why I am feeling shocks in the bathtub and shower. Due to fact that Linda Lincoln down ground are leaking more than is adequate current into the ground surrounding my house.

I guess I would and still do question the evaluation of the electrical system that provides current to my farm and surrounding drusies on the system due to the lack of updating. For instants holds holding the neutral wire instead of insulators. Which when the system was designed was adequate. But no longer is due to the unbalanced system leading to my farm. No tests were done on leading to the farm other than my own when the line is under a load by the mean times around 4:00 P.M. to 5:00 P.M. Which my tests and Mr. Bodman agrees the line is leaking to much current.

In summary to Mr. DeVries summary

(1) There is no tests done by the Linda Lincoln or Mr. DeVries when a load [illegible] load it already shows and unbalance [illegible]

(6)

records indicate that. Which can be fixed.

(2) Is it so ridiculous to want a safe environment for livestock and ourselves.

(3) It doesn't say they have to be in a waterway or in a waterdable do they.

Once again Lincoln Union needs not to forget the members that have made the system work and not only concentrate on the new areas of potential development. I truly have and want to continue to work with there or Lincoln Union to solve their existing voltage problem to my farm! It can be fixed and should be. Not a power struggle of who's right and wrong. Thank-you for your consideration.

Sincerely
Douglas L. Kuper
Date 3-22-98

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	ORDER FINDING PROBABLE CAUSE AND NOTICE REQUIRING ANSWER EL98-035

On March 6, 1998, the Public Utilities Commission (Commission) received a complaint from Douglas L. Kuper, Lennox, South Dakota (Complainant) against Lincoln-Union Electric Company (Lincoln-Union) regarding stray voltage. In the complaint, Complainant states that Lincoln-Union "has been and still is negligent in fixing the stray voltage that has ruined my dairy herd and livestock operation. It has been found to be coming from the down grounds on the poles and is leaving or crossing my farm. By this expert engineers and a physics professor have found the problem to be Lincoln-Union's through numerous tests and also by myself. It has also been felt on our bodies when taking a shower or bath." Mr. Kuper is requesting the Commission to order Lincoln-Union to update the system.

Pursuant to ARSD 20:10:01:03.01 and 20:10:01:03, if a complaint cannot be settled informally, formal action, the Commission shall determine if the complaint shows probable cause of an unlawful or unreasonable act, rate, practice or omission to go forward with the complaint.

On April 9, 1998, at its regularly scheduled meeting, the Commission considered the matter along with comments from Complainant and Lincoln-Union.

The Commission has jurisdiction over this matter pursuant to SDCL 49-34A and ARSD 20:10:01:03.01 and 20:10:01:03. The Commission votes to find probable cause (Commissioner Burg, dissenting). It is therefore

ORDERED, that probable cause has been found in this matter and that the complaint shall be forwarded to Lincoln-Union and Lincoln-Union shall file with the Commission its answer in writing within twenty (20) days of service of this order. It is further

ORDERED, that Lincoln-Union provide to the Commission copies of any pleadings, stipulations, or judgments that were filed in the prior circuit court cases involving this matter.

Dated at Pierre, South Dakota, this 21st day of April, 1998.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, by facsimile or by first class mail, in properly addressed envelopes, with charges prepaid thereon.

By Kristie Fiegen

Date 4/21/98

(OFFICIAL SEAL)

BY ORDER OF THE COMMISSION:

JAMES A. BURG, Chairman, dissenting

PAM NELSON, Commissioner

DUSTIN M. JOHNSON, Commissioner

BECK, CHRISTENSEN, GUBBRUD & HAUGLAND

ATTORNEYS AT LAW

O. G. BECK, DEC.
(1932 - 1950)

JOHN D. GUBBRUD*
CHARLES B. HAUGLAND*

DAVID A. STUART, ASSOCIATE*

WAYNE W. CHRISTENSEN
OF COUNSEL

*LICENSED IN IOWA AND SOUTH DAKOTA

REPLY TO: ALCESTER

May 15, 1998

South Dakota Public Utilities Commission
500 E. Capitol
State Capitol Building
Pierre, South Dakota 57501

Re: File No. EL98-025

Dear Gentlemen:

Enclosed is the Answer of Lincoln Union Electric Company in the above-entitled matter.

Respectfully submitted,

John D. Gubbrud
Beck, Attorney for
Lincoln Union Electric Company

JDG/jas
enc.
pc: Brad Schardin, Manager

RECEIVED

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	)	FILE NO. EL 98-[illegible] ANSWER OF LINCOLN-UNION

COMES NOW, Lincoln-Union Electric Company hereinafter for convenience referred to as "Lincoln-Union" for Answer to above Complaint states as follows:

1.

INCORPORATION BY REFERENCE

Reference is hereby made to a letter filed with the Commission by Manager, Brad Schardin, dated March 18, 1998, whereby Lincoln-Union Electric provided various information, data and proofs indicating that all data obtained by various independent consultants have all concluded that there are no problematic voltages on the Kuper's farm, by this reference such letter is incorporated into and made a part of this Answer as if restated and reallaged and is attached as Exhibit "1".

1.1

TESTING

The Court record clearly shows that Lincoln-Union has worked with the Kuper's over the years performing numerous neutral-to-earth stray voltage tests, investigations and analyses.

The Court record clearly shows various outside consultants, engineers and others have conducted tests and investigations and analyses with no indications of problematic voltage on the Kuper farm which would violate industry standards.

These tests were performed on Lincoln-Union's primary distribution system, indicated normal conditions relating to loading, grounding and voltage requirements.

1.2

TRAINING

The Court record clearly shows that Lincoln-Union employees training and outside consultants and engineers all have the requisite training and experience to perform such testing and make a professional analyses of data obtained.

1.3

NATIONAL ELECTRIC SERVICE CODE (NESC)

The Court record clearly shows that Lincoln-Union's primary electrical service to the Kuper's farmstead, including grounding, is in compliance with the applicable National Electric Service Code (NESC);

That there are no new facts meriting further study or expense.

2.

COVENANT OF COOPERATION

If the Commission would like specific documents, Lincoln-Union is willing to provide them within reasonable limits;

Lincoln-Union will cooperate in every way possible with the Commission in any investigation;

Lincoln-Union is confident that the Commission will find the same conclusions of other independent consultants: that the quality of electric service provided by Lincoln-Union meets or exceed all industry standards, existing laws, rules, regulations and codes presently applicable to this electric service.

Lincoln-Union stands ready to assist in numbers, including the Kuper's regarding any future service problems that may arise;

Lincoln-Union has extensively tested and re-tested the Kuper claims in the Complaint and have found that no problem exists with the electric service provided by Lincoln-Union;

As to the shocks in the house, any competent electrician can check out and remedy that situation on the secondary wiring system in the residence.

3.

RES JUDICATA

The matter complained of has been decided by the South Dakota Supreme Court Case, Kuper vs. Lincoln-Union, 1996 SD 145, [illegible] and the entire thereof refer to records in File Number [illegible] in the Clerk of Court's Office in Lincoln County Courthouse in Canton, South Dakota.

This matter has had two (2) jury trials, the second judgment has been entered, satisfaction in full and appeal time has expired. There are no new issues raised in the Complaint

filed with the Commission.

4.

LINCOLN COUNTY COURT FILE

The Clerk of Courts of Lincoln County, South Dakota advises they can only release Circuit Court files to a licensed attorney, or directly to the Commission upon appropriate Order of the Commission served upon the Clerk of Courts, with arrangement for payment of shipping costs to Pierre and satisfactory assurances of return of Court file when business of the Commission is concluded.

The sheer volume of the case file exceeds capacity of the Clerk of Courts to copy such records (it consists more than nine (9) boxes). It is now a clio of Court file that can be accessed by the Commission for review upon request of the Commission.

5.

JURISDICTION OF COMMISSION/SEPARATION OF POWERS

Due to prior judicial determination having been made as hereinabove set forth, the Commission is without jurisdiction to further consider the issues raised in the Complaint due to legal doctrine of separation of powers, in that the executive branch of government cannot vary a determination made by the judicial branch of government; therefore, this Complaint should be dismissed.

6.

COMMISSIONS OWN DETERMINATION ON JURISDICTION

In the alternative, the Commission by its own rules and regulations may determine, based upon the Court records therein, that it is without jurisdiction or protocol and dismiss on their own motion.

Dated at Alcester, South Dakota, this 19th day of May, 1998.

Lincoln Union Electric Company

By [signature]

c/John D. Gubbrud, Project Attorney
of Bank, Christensen, Gubbrud & Hingland
P. O. Box 97
Alcester, South Dakota 57001
Ph. 605/934-2143

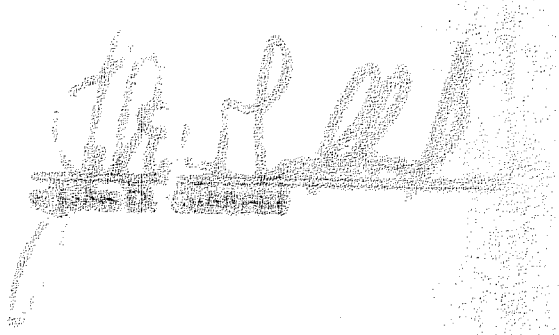
CERTIFICATE OF SERVICE

The undersigned certifies that the foregoing instrument was served upon all parties to the above cause by depositing a copy thereof in the U. S. Mail, postage prepaid, in envelopes addressed to the following:

Douglas L. Kaper
23106 457th Avenue
Lennox, South Dakota 57039

Public Utilities Commission
Capitol Building
Pierre, South Dakota 57501

as disclosed on the pleadings on May 18, 1992.



BECK, CHRISTENSEN, GUBBRUD & HAUGLAND

ATTORNEYS AT LAW

O. G. BECK, DEC
(1932 - 1990)

JOHN D. GUBBRUD*
CHARLES B. HAUGLAND*

DAVID A. STUART, ASSOCIATE*

WAYNE W. CHRISTENSEN
OF COUNSEL

*LICENSED IN IOWA AND SOUTH DAKOTA

REPLY TO: ALCESTER

May 19, 1998

RECEIVED

South Dakota Public Utilities Commission
500 E. Capitol
State Capitol Building
Pierre, South Dakota 57501

Re: File No. EL98-005

Dear Gentlemen:

Enclosed is the attachment marked Exhibit "I" to the Answer of Lincoln-Union Electric Company in the above case matter. Due to an inadvertent error on the part of this office this exhibit was unintentionally omitted from the Answer filed and sent to all interested parties on May 18, 1998.

Respectfully submitted,

John D. Gubbrud
Project Attorney for
Lincoln-Union Electric Company

JDG/jas
enc.
pc: Brad Schardin, Manager

Lincoln-Union Electric Company

P.O. Box 105
Alcester, SD 57001-0175
Tel.: (605) 934-1961 or (800) 333-2859 SD only
Fax: (605) 934-1964

March 18, 1998

Mr. Steve Wegman
South Dakota Public Utilities Commission
500 E. Capitol
State Capitol Building
Pierre, SD 57501

Dear Mr. Wegman:

We received the formal complaint filed by Douglas L. Kuper with the South Dakota Public Utilities Commission (PUC) on March 2, 1998, in our office via fax on March 11, 1998. That original notification indicated that you needed a response by March 13, 1998, which was extended by the PUC until March 18, 1998. We hope that this letter provides you with an overview of Lincoln-Union Electric Company's (Lincoln-Union) position on Mr. Kuper's written complaint.

Lincoln-Union, through its employees Tim Chance and Todd Nelson, has worked extensively with Mr. Kuper over the years performing numerous neutral to earth/stray voltage investigations and analyses. Based on our records, over 60 visits to Mr. Kuper's farm have been performed over the last several years in which we have worked with him and openly provided him with copies of our tests and additional information and materials. Most of these tests were performed prior to Mr. Kuper's filing a court case against Lincoln-Union in 1993. Copies of the original trial exhibits, and most recent retrial, can be obtained at the Lincoln County Courthouse, Clerk of Courts, in Canton, SD (see file #93-155). Kuper vs. Lincoln-Union 1995 SD 145, 557 NW 2d 748 for Supreme Court ruling should provide extensive information in this matter.

Mr. Kuper apparently feels the problem persists pertaining to neutral to earth/stray voltage. Based on the tests performed by Lincoln-Union employees, outside consultants (those hired by Lincoln-Union and Mr. Kuper), numerous engineers, and other individuals, there were no indications of problematic voltages on Mr. Kuper's farm which would violate accepted industry standards. Tests performed on Lincoln-Union's primary distribution system also indicated normal operating conditions in relation to loading, grounding, and voltage requirements. Mr. David H. DeVries, P.E., Lincoln-Union's consulting electrical engineer from DeWild Grant Reckert and Associates of Rock

materials accumulated relative to the tests and evaluations that were performed or those completed by outside independent consultants all indicating no problematic voltages on Mr. Kuper's farm.

We continue to train our employees on the most current issues relative to the topic of neutral to earth/stray voltage such as the recent Madison, WI, seminar cited earlier. We also continue to work with all of our 4000 plus members on issues relative to their needs and the operation of their Electric Cooperative.

It is Lincoln-Union's position that Mr. Kuper's complaint is without any merit and therefore no docket should be opened and the matter dismissed. Please feel free to give me a call if you have any questions.

Thanks in advance for your consideration of this issue and be assured that we will cooperate in every way possible and that the efforts of Lincoln-Union and our employees are to provide quality electric service to all of our members.

Sincerely yours,

Brad Schardin

Brad Schardin
Manager

BJS ria

Attachment

cc: Douglas L. Kuper
Lincoln-Union Board Members
Doug Eidahl - Director of Government Policy & Legal Affairs, EDEA
John Gubbrud, Project Attorney, Lincoln-Union
David H. DeVries, Project Engineer

DeWild Grant Reckert and Associates Company
Consulting Engineers

March 16, 1998

Mr. Brad Schardin, General Manager
Lincoln-Union Electric Company
P.O. Box 105
Alcester, SD 57001-0105

RE: PUC Complaint Dated 3-3-98
DGR File No. 400993.6

Dear Mr. Schardin:

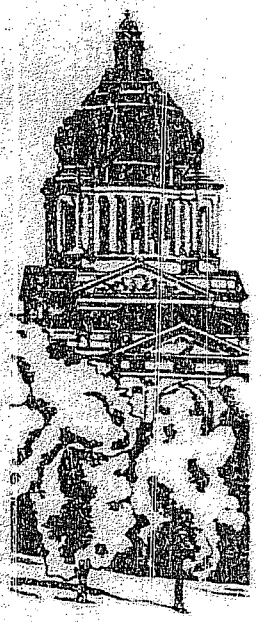
This letter is our response to the PUC complaint filed by Douglas L. Kuper on March 3, 1998.

During the past twenty (20) years DGR Engineering (DGR) has done the engineering for Lincoln-Union Electric Company (LU). Some of the tasks DGR has accomplished for LU are as follows:

- Long Range Planning (10 - 20 years)
- Short Term Planning (3 - 5 years)
- Sectionalizing System Design
- Circuit Design
- Reliability Analysis
- Work Order Certification (Construction Inspection)

In general, LU has a well maintained rural distribution system which uses delivery of power and energy from nine (9) substations owned and operated by East River Power Cooperative (ERPC). The distribution system is operated at a nominal voltage of 12.47 grd wye/7.2 kV, 3-ø, 4-wire. The system is classified as a multi-grounded, solidly grounded system. Primary voltage regulation is limited to 8.0 volts on a 120 volt base in accordance with RUS and ANSI guidelines.

The reliability goal of the system is to keep the average outage hours per consumer under 3 hours per year. This goal has been achieved in all of the last ten (10) years. The entire system has been modeled during each short term planning session and consideration is given to eliminate any excessive voltage drops or excessive line loadings.



South Dakota Public Utilities Commission

State Capitol Building, 500 East Capitol Avenue, Pierre, South Dakota 57501-5070

June 9, 1998

Mr. John D. Gubbrud
Attorney at Law
Beck, Christensen, Gubbrud & Haugland
P. O. Box 97
Alcester, SD 57001

Re: In the Matter of the Complaint of Douglas L. Kuper against Lincoln-Union Electric Company PUC Docket EL98-005

Dear Mr. Gubbrud:

The Commission is in receipt of the Answer which you have filed on behalf of Lincoln-Union Electric Company. In its Order Finding Probable Cause and Notice Requiring Answer dated April 28, 1998, the Commission ordered that Lincoln-Union provide copies of pleadings, stipulations or judgments from the Circuit Court case. In paragraph 4 of your Answer you make reference to the Court record and its voluminous nature. At this point in time, the Commission does not need the entire Court record as it may contain evidentiary matters which may be subject to admission into evidence before the Commission in a contested case proceeding.

Specifically, what the Commission requires Lincoln-Union to provide under its Order are the copies of the following documents:

1. Complaint
2. Answer
3. Stipulation for Settlement
4. Judgment

In asking for copies of these specific documents, I realize that there may be attachments to these but the basic Court documents which the Commission wishes to review are those which framed the issues before the Court and those which led to the final resolution of the case.

If you could provide copies of these Court documents at your earliest convenience, that would be most helpful. Thank you.

Very truly yours,

Camron Hoseck
Acting Commission Counsel

cc: Mr. Douglas L. Kuper
Ms. Karen E. Cremer

Capitol Office
Telephone (605)773-3201
FAX (605)773-3809

Transportation/
Warehouse Division
Telephone (605)773-5280
FAX (605)773-3225

Consumer Hotline
1-800-332-1782

TTY Through
Relay South Dakota
1-800-877-1113

Internet
bills@pucstate.sd.us

Jim Burg
Chairman
Pam Nelson
Vice-Chairman
Laska Schoenfelder
Commissioner

William Bullard Jr.
Executive Director

Edward E. Anderson
Harlan Best
Martin C. Bettmann
Charlie Bolle
Sue Cichos
Karen E. Cremer
Marlette Fischbach
Shirleen Fugitt
Lewis Hammond
Katie Hartford
Leni Healy
Camron Hoseck
Dave Jacobson
Bob Knadle
Delaine Kolbo
Jeffrey P. Lorensen
Terry Norum
Gregory A. Rislov
Tammi Stangohr
Steven M. Wegman
Rolayne Ailts Wiest

EL 98-035

LAW OFFICES

Lynn, Jackson, Shultz & Lebrun, P.C.

Sioux Falls Office
William E. Day, Jr.
Lee A. Magnuson
Jon C. Sogn
R. Alan Peterson
David L. Nadolski
Daniel R. Fritz*
Amy Heinrich Arndt
Todd D. Epp**

*Also Admitted in Minnesota
**Also Admitted in Kansas

Kelton S. Lynn
(1946-1974)
Horace R. Jackson
(1961-1987)

US Bank Building
141 N. Main Avenue
P.O. Box 1920 • Sioux Falls, SD 57101-3020
605-332-5999
Fax 605-332-4249
E-Mail ljlawsf@lynnjackson.com

First National Bank Building
6th Floor • 909 St. Joseph
PO Box 8250 • Rapid City, SD 57709-8250
605-342-2592
Fax 605-342-5185
E-Mail ljlawrc@lynnjackson.com

Member of Lex Mundi
A Global Association of 125 Independent Law Firms

REPLY TO: Sioux Falls 605-332-5999

June 12, 1998

Mr. Camron Hoseck
Acting Commission Counsel
SD Public Utilities Commission
State Capitol Building
500 East Capitol Avenue
Pierre, SD 57501-5070

RECEIVED
JUN 15 1998
SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

RE: In the Matter of the Complaint of Douglas Kuper

Dear Mr. Hoseck:

Pursuant to your June 9, 1998, letter and the request of Lincoln Union Electric Company, the following documents are enclosed:

1. Amended Complaint;
2. Answer and Crossclaim Against Defendant Alvin Bowman, d/b/a Bowman Electric;
3. Instructions to the Jury;
4. Special Verdict Form;
5. Judgment;
6. Order; and
7. Complete Satisfaction of Judgment.

Your letter requests a Stipulation for Settlement. There was no Stipulation for Settlement. In lieu of that request, I have enclosed a copy of the Instructions to the Jury and the Special Verdict Form for your identification of issues decided.

If you have any questions or concerns about this submission, please let me know.

Sincerely,

LYNN, JACKSON, SHULTZ & LEBRUN, P.C.

R. Alan Peterson

RAP/cjd

Enclosure

cc: Mr. Brad Shardine (w/encl.)
Mr. John D. Gubbrud (w/encl.)

INDEX TO PLEADINGS

1. Amended Complaint
2. Answer and Crossclaim Against Defendant Alvin Bossman, d/b/a Bossman Electric (Answer of Lincoln-Union Electric)
3. Instructions to the Jury
4. Special Verdict Form
5. Judgment (to Plaintiffs)
6. Order (of Judgment of Costs to Lincoln-Union Electric)
7. Complete Satisfaction of Judgment (Satisfactions of Judgment among parties)

STATE OF SOUTH DAKOTA)
: SS
COUNTY OF LINCOLN)

IN CIRCUIT COURT

FIRST JUDICIAL CIRCUIT

* * * \

5. That Defendant Lincoln-Union Electric Company is a public utility with rights to sell electrical power at the location of Plaintiffs' farm, including Plaintiffs' dairy barn, located in Lincoln County, South Dakota. That at all times material hereto Plaintiffs maintained a business relationship with Defendant whereby Plaintiffs purchased and Defendant Lincoln-Union Electric Company supplied electrical power to the Plaintiffs' farm.

6. That Plaintiffs began farming in 1975 in Lincoln County, South Dakota, and commenced a dairy operation approximately in the spring of 1985.

7. That since Plaintiffs have commenced their dairy operation they have experienced extensive problems with their dairy herd. Plaintiffs' dairy herd has experienced severe problems with mastitis, causing the quantity of Plaintiffs' milk production to significantly decline. Problems associated with mastitis have also affected the quality of Plaintiffs' milk production.

8. That, between May of 1992 and June of 1993, the Plaintiffs had approximately fifteen cows experience abortions or still-births. That, over the years, Plaintiffs lost approximately 100 head of calves over, and above the normal death loss that they would have expected to have experienced.

9. That the Plaintiffs have been or will be required to prematurely dispose of 217 cows, while a normal cull rate for the Plaintiffs' herd would have been 77 cows. In addition, six cows belonging to the Plaintiffs have died.

10. That the Plaintiffs have incurred additional and continuing veterinary expenses in an attempt to treat their dairy cows for mastitis.

11. That, in May of 1992, at the suggestion of Lincoln-Union Electric Company, the Plaintiffs attempted to eliminate the stray voltage problems they were experiencing by rewiring their dairy barn. Plaintiffs employed Defendant Alvin Boesen, d/b/a Boesen Electric, to rewire, in a safe and workmanlike manner, all electric wiring in the Plaintiffs' dairy barn. That in May of 1992, said Defendant did in fact rewire the electric wiring in Plaintiffs' dairy barn.

12. That the Plaintiffs' problems with stray voltage continued and, in fact, became worse after the barn was rewired.

13. That Plaintiffs' excessive problems with stray voltage were known to Defendants Alvin Boesen, d/b/a Boesen Electric, and Lincoln-Union Electric Company, and Defendant Lincoln-Union Electric Company's agents, servants, and employees acting in the scope of their employment, or such conditions existed for such a period of time that Defendants, by the use of ordinary care and diligence, could and should have known of such conditions.

14. That, as a public utility, Defendant Lincoln-Union Electric Company is obligated and has a duty to properly and safely supply electrical power to customers located within the area where electrical power is supplied by said Defendant.

15. Defendant Lincoln-Union Electric Company was negligent in, among other things, but not limited to, the following:

(1) failing to properly install, construct, maintain, operate, repair, and inspect the electrical distribution system that supplies electricity to Plaintiffs' farm;

(2) failing to properly control the stray voltage in its electrical distribution system;

(3) failing to prevent stray voltage from entering the Plaintiffs' property;

(4) failing to warn the Plaintiffs of the existence of and hazards presented by stray voltage;

(5) failing to comply with National Electric Safety Code standards;

(6) using the earth to return current to the substation and failing to warn the Plaintiffs of any potential adverse effects of such use; and

(7) failing to exercise ordinary and reasonable care under all of the circumstances.

16. That Defendant Alvin Bossman, d/b/a Bossman Electric, was negligent in, among other things, but not limited to, the following: failing to properly install and inspect electrical wiring in the Plaintiffs' dairy barn, and failing to comply with National Electric Safety Code standards.

17. As a proximate result of the Defendants' negligence, the Plaintiffs have suffered and continue to suffer severe losses with respect to their dairy operation. The Plaintiffs have suffered and continue to suffer financial losses including, but not limited to, losses in the quantity and quality of milk production, breeding problems, losses in calves, the loss of dairy cows, and veterinary expenses, in the approximate amount of Five Hundred Thousand Dollars ($500,000.00).

18. As a proximate result of the negligence of Lincoln-Union Electric Company, the Plaintiffs have suffered and continue to suffer damages in the form of a great decrease in the value of the real estate upon which the farm they own is located.

Count Two: Nuisance

Plaintiffs reallege and incorporate by this reference the allegations set forth in all preceding paragraphs of this Complaint.

19. That Defendant Lincoln-Union Electric Company, by subjecting Plaintiffs' dairy operation to the detrimental effects of stray voltage originating from its electrical distribution system, has created a condition which injures or endangers the comfort, repose, health, and safety of the Plaintiffs and their property. This condition has and continues to substantially and unreasonably interfere with the Plaintiffs' free and unrestricted use and enjoyment of their property, and as such, Defendant's conduct constitutes a nuisance.

20. That as a direct and proximate result of the aforementioned allegation, Plaintiffs sustained and continue to sustain injuries and damages as set forth in Count One, paragraphs 17 and 18.

Count Three: Trespass

Plaintiffs reallege and incorporate by this reference the allegations set forth in all preceding paragraphs of this Complaint.

21. That Defendant Lincoln-Union Electric Company, without the consent or knowledge of Plaintiffs, has caused or permitted electricity to run through the ground at Plaintiffs' farm, using

the ground of Plaintiffs' farm as a part of Defendant Lincoln-Union Electric Company's electrical circuit.

22. That Defendant Lincoln-Union Electric Company's actions in sending electricity through the ground of Plaintiffs' land and its use of Plaintiffs' ground as a part of its electrical circuit has created a condition which injures and endangers the Plaintiffs' livestock and decreases the value of Plaintiffs' dairy operation, real estate, and other property.

23. That Defendant Lincoln-Union Electric Company's actions in sending electricity through the ground of Plaintiffs' land and its use of Plaintiffs' land as a part of its electrical circuit has interfered, and continues to interfere, with the rights of Plaintiffs, and such action and use of Plaintiffs' land has constituted, and continues to constitute, a trespass upon Plaintiffs' property by Defendant Lincoln-Union Electric Company.

24. That as a direct and proximate result of the aforementioned allegation, Plaintiffs sustained and continue to sustain injuries and damages as set forth in Count One, paragraphs 17 and 18.

WHEREFORE, the Plaintiffs demand judgment against the Defendants jointly and severally in the approximate amount of Five Hundred Thousand Dollars ($500,000.00), together with interest, and their costs and disbursements herein, and against Lincoln-Union Electric Company for damage to the Plaintiffs' real estate, together with such further relief as the Court may deem appropriate.

Dated at Sioux Falls, South Dakota, this _____ day of January, 1995.

[redacted]

[redacted]
Michael J. Schaffer
310 South Main Avenue
P.O. Box 1030
Sioux Falls, SD 57101-1030
(605)336-2885
Attorneys for Plaintiffs

[redacted]

Plaintiffs demand trial by jury on all issues of fact.

[redacted]

STATE OF SOUTH DAKOTA)
: SS
COUNTY OF LINCOLN)

IN CIRCUIT COURT

FIRST JUDICIAL CIRCUIT

* * * \

CERTIFICATE OF SERVICE

The undersigned, one of the attorneys for Plaintiffs, hereby certifies that a true and correct copy of the foregoing "Notice of Hearing" was served by mail upon:

Thomas G. Fritz
Lynn, Jackson, Shultz & Lebrun, P.C.
P.O. Box 8250
Rapid City, SD 57709-8250
and
Charles R. Kennedy
Kennedy & Nervig
P. O. Box 647
Wadena, Minnesota 56482-0647
Attorneys for Defendant Lincoln-Union Electric Company

Richard J. Helsper
Helsper and Rasmussen, P.C.
P. O. Box 198
Brookings, South Dakota 57006
Attorneys for Defendant Alvin Bosman d/b/a Bosman Electric

on this 20th day of January, 1993.

STATE OF SOUTH DAKOTA) :SS
COUNTY OF LINCOLN)

IN CIRCUIT COURT

FIRST JUDICIAL CIRCUIT

* *

DOUGLAS L. KUPER and PEGGY D. KUPER,	*	CIV 93-
Plaintiffs,	*	
vs.	*	ANSWER AND CROSSCLAIM AGAINST DEFENDANT ALVIN BOSSMAN d/b/a BOSSMAN ELECTRIC
LINCOLN-UNION ELECTRIC COMPANY and ALVIN BOSSMAN d/b/a BOSSMAN ELECTRIC,	*	
Defendants.	*	

* *

Defendant Lincoln-Union Electric Company, for its Answer to the Complaint of the Plaintiffs, states as follows:

I.

The Complaint of the Plaintiffs fails to state a claim or cause of action upon which relief can be granted.

II.

This Defendant admits paragraphs 1, 2, 3, and 4 of the Complaint, except the allegation in paragraph 3 that this Defendant is a public utility. Lincoln-Union Electric Company is a rural electric cooperative.

III.

This Defendant admits paragraph 5 except that it provides electricity only up to the meter. Once the electricity passes through the meter it becomes the property of the Plaintiffs.

IV.

This Defendant does not have sufficient information to admit or deny paragraphs 7, 8, 9, 10, 11, 12, or 13 and puts the Plaintiffs to the strict proof thereof. With respect to paragraph 11, the Defendant admits that it did suggest to Plaintiffs that they rewire their barn.

V.

This Defendant admits paragraph 14 and asserts that it did properly and safely supply electrical power to its customers within its service territory.

VI.

This Defendant denies paragraph 15 of Plaintiff's Complaint.

VII.

This Defendant does not have sufficient information to admit or deny paragraph 16.

VIII.

This Defendant denies paragraphs 17, 18, and 19.

IX.

This Defendant denies that it was negligent in any manner in providing electricity to Plaintiffs or in any other means to have been negligent as alleged by Plaintiffs.

X.

This Defendant denies that any stray voltage problems allegedly suffered by Plaintiffs were caused by its equipment or negligence, and further asserts that it has taken steps which have made it physically impossible for such alleged stray voltage to be

coming from its equipment or supply lines.

XI.

That as an affirmative defense, Plaintiff assumed the risk of the damages alleged in their Complaint and were contributorily negligent to a degree more than slight in the causation of their alleged damages, thus barring Plaintiffs' recovery from this Defendant as a matter of law.

XII.

That as a further affirmative defense, Plaintiffs failed to mitigate their damages as required by law.

CROSSCLAIM AGAINST DEFENDANT ALVIN BOSSMAN

Defendant Lincoln-Union Electric Company, for its Crossclaim against the Defendant Alvin Bossman, states and alleges:

I.

That if the Plaintiffs are allowed to recover against this Defendant, which right of recovery is specifically denied, this Defendant is entitled to indemnity from the Defendant Alvin Bossman in that if this Defendant is liable to the Plaintiffs in this action, such liability can only arise by operation of law and not by reason of any fault or negligence on the part of this Defendant. In the alternative, the same could only arise by reason of the acts and omissions on the part of the Defendant Alvin Bossman, this Defendant only being passively involved herein, and as a result thereof, the defense of this action on the part of this Defendant is hereby tendered to Defendant Alvin Bossman. In the event that this tender of defense is not accepted by Defendant Alvin Bossman,

said Defendant is liable to this Defendant for this Defendant's costs, expenses and attorney's fees incurred in the defense of Plaintiffs' claim herein.

II.

That if this Defendant was in any degree at fault, which said fault is specifically denied, such fault was so slight in comparison with the negligence of Defendant Alvin Bossman as to render inequitable an equal distribution between this Defendant and Defendant Alvin Bossman by equal contribution. The relative degrees of fault, if any, of this Defendant and of Defendant Alvin Bossman should be considered in determining the pro rata shares of any liability to Plaintiffs.

WHEREFORE, this Defendant prays for judgment herein as follows:

1. That the Complaint of the Plaintiffs against this Defendant be dismissed upon its merits and this Defendant have its costs and expenses herein;

2. That this Defendant be awarded full indemnification from the Defendant Alvin Bossman for any recovery obtained by the Plaintiffs herein against this Defendant, including this Defendant's costs, expenses and attorneys fees.

3. That if this Defendant be found to have contributed in any way to the alleged damages of the Plaintiffs, that the proportionate or relative degrees of fault, if any, of this Defendant and of Defendant Alvin Bossman be determined and this Defendants right to contribution under the provisions of law be

determined.

4. That this Defendant recover its costs and disbursements.

Dated this 10 day of September, 1993.

LYNN, JACKSON, SHULTZ & LEBRUN, P.C.

R. Alan Peterson
First Bank Building - 6th Floor
141 North Main Avenue
P.O. Box 1920
Sioux Falls SD 57101-3020
Telephone (605) 332-5999

DEMAND IS HEREBY MADE FOR TRIAL OF ALL ISSUES HEREIN BY A JURY

CERTIFICATE OF SERVICE

I hereby certify that on the 10 day of September, 1993, I sent to:

Mr. Michael J. Schaffer
Davenport, Evans, Hurwitz & Smith
513 South Main Avenue
P.O. Box 1030
Sioux Falls, SD 57101-1030

Mr. Richard J. Helsper
Erickson, Helsper & Rasmussen, P.C.
806 22nd Avenue South
P.O. Box 198
Brookings, SD 57006

by first class mail, postage prepaid, a true and correct copy of ANSWER AND CROSSCLAIM AGAINST DEFENDANT ALVIN BOSSMAN d/b/a BOSSMAN ELECTRIC relative to the above-entitled matter.

R. Alan Peterson

STATE OF SOUTH DAKOTA)
: SS
COUNTY OF LINCOLN)

IN CIRCUIT COURT

FIRST JUDICIAL CIRCUIT

DOUGLAS L. KUPER and
PEGGY D. KUPER,

Plaintiffs,

vs.

LINCOLN-UNION ELECTRIC
COMPANY,

Defendant.

CIV. 91-155

INSTRUCTIONS TO
THE JURY

LADIES AND GENTLEMEN OF THE JURY:

This is a civil case brought by Douglas L. Kuper and Peggy D. Kuper, who are considered plaintiffs, against Lincoln-Union Electric Company, who is considered the defendant.

The plaintiffs allege that the defendant Lincoln-Union Electric Company was negligent and that such negligence directly and proximately caused the plaintiffs to suffer harm and loss on their dairy farm, as a result of stray voltage problems.

The defendant denies the allegations and alleges that the plaintiffs were contributorily negligent. The defendant further alleges that the plaintiffs failed to mitigate their damages.

FILED

INSTRUCTION NO. 1

It is vital to the administration of justice that each of you as members of the jury faithfully perform your duties as jurors. You should carefully and honestly consider this case with due regard for the rights and interests of the respective parties. Neither sympathy nor prejudice should influence you. Your verdict must be based on evidence and not upon speculation, guess, or conjecture.

INSTRUCTION NO. 3

The law that applies to this case is contained in these instructions, and it is your duty to follow them. You must consider these instructions as a whole and not single out one instruction to the exclusion of the others.

INSTRUCTION NO. 3

The fact that one of the parties to this action is an electric cooperative is immaterial. In the eyes of the law, an electric cooperative is an individual party to the lawsuit and all parties are entitled to the same impartial treatment.

INSTRUCTION NO. 4

It is your duty as a jury to determine the facts, and you must do this from the evidence that has been produced here in open court. This consists of the testimony of the witnesses and the exhibits which have been received. This evidence is governed by various rules of law. Under these rules, it has been my duty as judge to rule on the admissibility of the evidence from time to time. You must not concern yourselves with the reasons for these rulings, and you must not consider any exhibit which was not received in evidence or any testimony which has been ordered stricken. Such things you must put out of your mind.

INSTRUCTION NO. 5

"Evidence" includes testimony of witnesses, documents, and other things received as exhibits as well as any facts that may have been stipulated to.

Statements, arguments, questions, and comments by the attorneys are not to be considered evidence. An attorney has a right to object to the introduction of certain evidence and the asking of certain questions when that attorney believes something is improper. You should not be influenced by the objection. If I sustain an objection to a question, you must ignore the question and must not try to guess what the answer might have been. If I strike from the record certain testimony or tell you to disregard it, that testimony is not evidence, and you must not consider it. Anything you see or hear about this case outside this courtroom is not evidence. Therefore, your decision must be based upon the evidence that will be presented here in open court.

INSTRUCTION NO. 4

There are, generally speaking, two types of evidence by which a jury may properly find the truth as to the facts of a case. One is direct evidence, such as the testimony of an eyewitness. The other is indirect or circumstantial evidence, the proof of a chain of circumstances pointing to the existence or non-existence of certain facts.

As a general rule, the law makes no distinction between direct and circumstantial evidence, but simply requires that the jury find the facts in accordance with the preponderance of all the evidence in the case, both direct and circumstantial.

INSTRUCTION NO. 2

When evidence of facts and circumstances is offered as a basis for an inference to be drawn therefrom as to a fact in issue, it is known as circumstantial evidence. If there is a conflict in the evidence as to such facts and circumstances, it is for the jury to determine such conflict under the [illegible] instructions. On the basis of such facts and circumstances as are found by the jury, it is for the jury to determine therefrom such inference or inferences as may reasonably be drawn without resort to guess, speculation or conjecture. When the jury considers only one inference relative to the disputed fact question to reasonably be drawn, such inference may be determined by the jury to be supported by circumstantial evidence. When however the jury considers that two or more different and conflicting inferences can reasonably be drawn from such facts and circumstances, it is for the jury to determine which, if any, such differing and conflicting inferences is probably correct as against any and all other inferences, and any fact which supports an inference so determined to be supported by the circumstantial evidence. If, however, the jury determines that there is no reasonable inference which is probably correct as against any and all other reasonable inferences, then no inference may be treated as established by such evidence.

Instruction No. 8

In weighing the evidence in this case, you have a right to consider the common knowledge possessed by all of you, together with the ordinary experiences and observations in your daily affairs of life.

INSTRUCTION NO. 2

You are the sole judges of all questions of fact and the credibility of the witnesses and the weight to give to their testimony. In deciding what testimony to believe, you may consider the witnesses' ability and opportunity to observe, their memories, their manner while testifying, any apparent interest, bias or prejudice, and the reasonableness of the testimony in light of all the evidence in the case.

INSTRUCTION NO. 12

A witness may qualify as an expert and give an opinion on a matter at issue if the witness has special knowledge, skill, experience, training, and education in a particular science, profession, or occupation. In deciding the weight to give to the opinion, you should consider the expert's qualifications and credibility and the reasons for the opinion. You are not bound by the opinion; therefore, if you should conclude the reasons for the opinion are unsound, or that other evidence outweighs the opinion, you may disregard the opinion entirely.

INSTRUCTION NO. 11

The credibility of a witness may be attacked by introducing evidence that on some former occasion he made a statement or acted in a manner inconsistent with his testimony in this case on a matter material to the issues. Evidence of this kind may be considered by you in connection with all the other facts and circumstances in evidence in deciding the weight to be given to the testimony of that witness.

INSTRUCTION NO. 12

If you believe that any witness testifying in this case has knowingly sworn falsely to any material matter in this case, then you may reject all of the testimony of the witness.

INSTRUCTION NO. 13

In civil actions, the party who asserts the affirmative of an issue must prove that issue by a preponderance of the evidence.

By a preponderance of the evidence is meant such evidence as, when weighed with that opposed to it, has more convincing force and from which it results that the greater probability of truth lies therein. In the event that the evidence is evenly balanced so that you are unable to say that the evidence on either side of an issue preponderates, that is, has the greater convincing force, then your finding upon the issue must be against the party who had the burden of proving it. In this action, the plaintiffs have the burden of proving the following issues: that the defendant Lincoln-Union Electric Company was negligent and that such negligence proximately caused the plaintiffs to suffer damages. The defendant has the burden of proving the plaintiffs were contributorily negligent and that such contributory negligence proximately caused the damages that the plaintiffs suffered, and the defendant Lincoln-Union Electric Company has the burden of proving that the plaintiffs failed to mitigate their damages.

In determining whether or not an issue has been proved by a preponderance of the evidence, you should consider all of the evidence bearing upon that issue, regardless of who produced it.

INSTRUCTION NO. 14

By a preponderance of the evidence is meant the greater weight of the evidence, but this is not necessarily determined by the greater number of witnesses testifying to any fact or state of facts. It means that the evidence on the part of the party having the burden of proof must have greater weight in your opinion and be more convincing than that opposed to it.

INSTRUCTION NO. 12

Under the law as applied to the present case, every person is responsible for injury to the person or property of another, caused by such person's want of ordinary care or skill, subject to the defense of contributory negligence. When used in these instructions, negligence means want of such ordinary care or skill. Such want of ordinary care or skill exists when there is a failure to do that which a reasonably prudent person would do or when there is done that which a reasonably prudent person would not do; this in each instance in the same or similar circumstances as existed in connection with the conduct which is under consideration.

INSTRUCTION NO. 16

The distribution of electrical energy is a highly dangerous activity, and anyone doing so is under a duty to exercise ordinary and reasonable care under all the circumstances to prevent injury to persons and property. This requires care commensurate with the danger involved consistent with the practical operation of the business.

INSTRUCTION NO. 12

The mere fact that an accident happened and the parties sustained damages because of such accident, in and of itself, does not give rise to an inference that the accident was caused by anyone.

INSTRUCTION NO. 14

In such actions as this, and except as otherwise stated in these instructions, a claimant for damages cannot recover if he was himself contributorily negligent. Such contributory negligence exists when such claimant was himself negligent as negligence has been defined in another instruction, and when such negligence of the claimant, combined with the negligence of another or other, caused the claimed losses. Therefore, even if the jury should find such claimant himself negligent, he would not be contributorily negligent unless the jury should also find that if it had not been for such claimant's negligence the claimed losses would not have happened.

INSTRUCTION NO. 19

More than one person may be responsible for causing injury to another. If you find that the defendant was negligent and that the defendant's negligence was a proximate cause of the plaintiffs' injury, it is not a defense that some third person, not a party to this action, was partly responsible.

INSTRUCTION NO. [redacted]

When the expression "proximate cause" is used, it means an immediate cause of any injury, which, in natural or probable sequence, produces the injury complained of. Without the proximate cause, the injury would not occur. The proximate cause need not be the only cause, nor the last or nearest cause. It is sufficient if it concurs with some other cause acting at the same time, which in combination with it causes the injury.

For proximate cause to exist, you must find that the harm suffered was a foreseeable consequence of the act complained of.

INSTRUCTION NO. 21

When deciding whether the defendant could have reasonably foreseen or anticipated that stray voltage would injure the plaintiffs' dairy herd, you should consider the defendant's past experience and the practice of others in similar circumstances. However, the law fixes duties for breach of which damages may be allowed and the person upon whom a duty is imposed may not relieve himself or liability by proof that he and others similarly situated have never performed the duty imposed upon them.

Instruction No. 23

Lincoln-Union's responsibility in furnishing electricity to the Plaintiffs ends where Lincoln-Union's primary distribution line reaches the meter pole in the banquet. The meter pole is the termination of the primary line.

The Plaintiffs are responsible for the wiring and care and control of the electrical service on the secondary side. However, if you find that Lincoln-Union rendered service to the Plaintiffs by working on the secondary side, then Lincoln-Union is subject to liability for any harm proximately caused by Lincoln-Union's failure to exercise reasonable care in performing those services for the Plaintiffs.

INSTRUCTION NO. 23

The National Electrical Safety Code requires that all electrical distribution lines be grounded for public safety.

INSTRUCTION NO. 23

Rural electric cooperatives are specifically authorized by statute in South Dakota. They are required to construct, operate, and maintain their electrical distribution lines in accordance with the provisions of the National Electrical Safety Code which has been adopted in South Dakota.

INSTRUCTION NO. 24

Neutral-to-earth voltage is a natural phenomena associated with power distribution systems and therefore "caused" by the mere use of electricity. Stray voltage is not the same thing. Rather, neutral-to-earth voltage is only correctly termed stray voltage when it appears in an animal environment at a magnitude that is problematic to animals.

If you decide for the plaintiffs on the question of liability, as described elsewhere in these instructions, you must then fix the amount of money which will reasonably and fairly compensate them for any loss or harm suffered and proved by the evidence to have been proximately caused by the defendant.

Whether any of these elements or damages have been proved by the evidence is for you to determine. You should make that based on evidence and not upon speculation, guesswork or conjecture.

Instruction No. 24

If you find the plaintiff contributorily negligent, as elsewhere in these instructions defined, the plaintiff may still recover if you find that such contributory negligence of the plaintiff was slight in comparison with the negligence of the defendant.

In determining a question of comparative negligence, you must make a two-step inquiry:

1) Whether the plaintiff and the defendant are negligent, as elsewhere in these instructions defined; and

2) If both are found to be negligent, whether the plaintiff's negligence is slight in comparison with the defendant's negligence.

In determining this second question, you must make a direct comparison between the conduct of the plaintiff and the defendant, and not to the conduct of an ordinary reasonable person. The term "slight" means whether the plaintiff's negligence is small in degree in comparison with the defendant's negligence.

If you find that the plaintiff is contributorily negligent but under the rule just stated the plaintiff is still entitled to recover, then the damages to be awarded to the plaintiff must be reduced in proportion to amount of the plaintiff's contributory negligence.

INSTRUCTION NO. 27

In fixing the amount of money which will reasonably and fairly compensate the plaintiffs, you are instructed that an injured person must exercise reasonable diligence to avoid loss or to minimise the consequence of the injury. Any damages resulting from failure to exercise such care cannot be recovered.

INSTRUCTION NO. 24

The measure of damages to personal property such as livestock is the difference between the fair market value of the property immediately before the occurrence and its fair market value after the occurrence.

INSTRUCTION NO. [illegible]

When you have retired to your jury room, you will appoint one of your number as foreman.

When the same 10 of your members have agreed upon the right of the plaintiffs to recover damages, and upon the amount of the damages allowed, if any, or when 10 of your members have agreed that the plaintiffs should not be allowed any damages, that will be the verdict of the jury.

You will be provided with a copy of these instructions, which you will return into Court with your verdict and the exhibits in this case.

If it becomes necessary during your deliberations to communicate with the Court, you may send a note by the bailiff. But, bear in mind that this jury is not to reveal to the Court or any person how the jury stands, numerically or otherwise, until after you have reached a verdict and reported the same into Court.

When you have agreed upon a verdict and have completed, dated, and your foreman has signed the verdict form, you will at report to the bailiff whereupon you will be conducted into Court where your verdict will be received.

Dated this 27th day of October, 1997.

BY THE COURT.

[illegible]
Circuit Court Judge

STATE OF SOUTH DAKOTA)
: SS
COUNTY OF LINCOLN)

IN CIRCUIT COURT
FIRST JUDICIAL CIRCUIT

* * * \

1988	$
1989	$
1990	$
1991	$
1992	$
1993	$
1994	$
1995	$
1996	$
1997	$

$87,145

Dated this 27 day of October, 1997.

[signature]

Petitioner

FILED

[illegible]

[illegible]

STATE OF SOUTH DAKOTA)
: SS
COUNTY OF LINCOLN)

IN CIRCUIT COURT

FIRST JUDICIAL CIRCUIT

* * * \

Dated this 31st day of October, 1997.

BY THE COURT:

Kathleen K. Caldwell
Circuit Court Judge

ATTEST:

Vivian Fossum
Clerk

By Theresa J. Leucht
Deputy

(SEAL)

FILED
NOV 01 1997
Vivian Fossum
Clerk of Court
By _____ Deputy

STATE OF SOUTH DAKOTA)
:SS
COUNTY OF LINCOLN)

IN CIRCUIT COURT
FIRST JUDICIAL CIRCUIT

****

DOUGLAS L. KUPER and
PEGGY D. KUPER,

Plaintiffs,

vs.

LINCOLN-UNION ELECTRIC
COMPANY,

Defendant.

CIV. 93-155

ORDER

****

Defendant has moved for taxation of disbursements pursuant to SDCL 15-17-55 as a prevailing party, as the first trial was reversed upon appeal. Upon consideration of the application and the file as a whole in this matter, the Court orders as follows:

1. Good cause has been shown to extend the time for consideration of the application of costs;

2. Allowable costs from Mr. Kennedy's application of costs on behalf of the Defendant are $6,299.50; and

3. Allowable costs from Mr. Peterson's application of costs on behalf of the Defendant are $7,338.97.

Dated this 21st day of January, 1998.

BY THE COURT:

[signature]
BATHLEEN E. CALLAHAN
Circuit Court Judge

ATTEST:
Vivian Fossum, Clerk
By [signature] Deputy

FILED
JAN 27 1998
[signature]
CLERK OF COURTS

STATE OF SOUTH DAKOTA)
:SS
COUNTY OF LINCOLN)

IN CIRCUIT COURT
FIRST JUDICIAL CIRCUIT

DOUGLAS L. KUPER and PEGGY D. KUPER, Plaintiffs, vs. LINCOLN-UNION ELECTRIC COMPANY, Defendant.	Civ. 93-155 COMPLETE SATISFACTION OF JUDGMENT

The undersigned, Douglas L. Kuper and Peggy D. Kuper, Plaintiffs in the above-captioned action, do hereby acknowledge full satisfaction of that certain Judgment of the Lincoln County Court, Civ. No. 93-155, dated October 11, 1993, including all costs and accrued interest rendered against the above-named Defendant in the above-entitled action. Judgment in this action was filed and entered on November 3, 1993, in the office of the Clerk of the above-named Court. The Order allowing costs was entered by the Court on January 21, 1994, and filed in the office of the Clerk of the above-named Court on January 21, 1994.

Dated this 27 day of January, 1994.

Douglas L. Kuper

Peggy D. Kuper

STATE OF SOUTH DAKOTA)
:SS
COUNTY OF Turner)

On this 21th day of March, 1998, before me, the undersigned officer, personally appeared DOUGLAS L. KUPER and PEGGY D. KUPER, known to me or satisfactorily proven to be the persons whose names are subscribed to the within instrument and acknowledged that they executed the same for the purposes therein contained.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

(Seal)

NOTARY PUBLIC - SOUTH DAKOTA
My Commission Expires:

FILED
APR 03 1998

STATE OF SOUTH DAKOTA)
:ss
COUNTY OF LINCOLN)

IN CIRCUIT COURT

FIRST JUDICIAL CIRCUIT

***

STATE OF SOUTH DAKOTA)
:SS
COUNTY OF MINNEHAHA)

On this 18th day of March, 1998, before me, the undersigned officer, personally appeared R. ALAN PETERSON, known to me or satisfactorily proven to be the person whose name is subscribed to the within instrument and acknowledged that he executed the same for the purposes therein contained.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

MARGARET J. GERTSEMA
NOTARY PUBLIC
SOUTH DAKOTA

(Seal)

Margaret J. Gertsema
NOTARY PUBLIC - SOUTH DAKOTA
My Commission Expires: [illegible]

FILED
MAR 23 1998
[illegible]
CLERK OF COURTS
By _____ Deputy

STATE OF SOUTH DAKOTA)
:SS
COUNTY OF LINCOLN)

IN CIRCUIT COURT

FIRST JUDICIAL CIRCUIT

DOUGLAS L. KUPER and
PEGGY D. KUPER,

Plaintiffs,

vs.

LINCOLN-UNION ELECTRIC
COMPANY,

Defendant.

CIV. 93-155

COMPLETE
SATISFACTION OF JUDGMENT

The undersigned, R. Alan Peterson, of Lynn, Jackson, Shultz & Lebrun, P.C., one of the attorneys for Lincoln-Union Electric Company, does hereby acknowledge full satisfaction of that certain Judgment evidenced by the Order of the Lincoln County Court, Civ. No. 93-155, dated January 21, 1998, including satisfaction of all accrued interest entered against the above-named Plaintiffs in the above-entitled action.

Dated this 18 day of March, 1998.

LYNN, JACKSON, SHULTZ & LEBRUN, P.C.

By: _____
R. Alan Peterson
Attorneys for Defendant
P.O. Box 1920
Sioux Falls, SD 57101-1920
Telephone: (605) 332-5999

STATE OF SOUTH DAKOTA)
:SS
COUNTY OF MINNEHAHA)

On this 15th day of March, 1993, before me, the undersigned officer, personally appeared R. ALAN PETERSON, known to me or satisfactorily proven to be the person whose name is subscribed to the within instrument and acknowledged that he executed the same for the purposes therein contained.

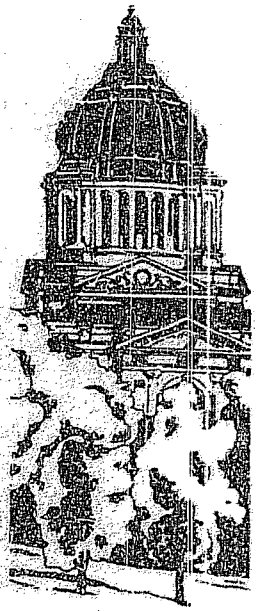
IN WITNESS WHEREOF, I hereunto set my hand and official seal.

MARGARET J. GREITZMAN
NOTARY PUBLIC
SOUTH DAKOTA

(Seal)

NOTARY PUBLIC - SOUTH DAKOTA
My Commission Expires: [illegible]

FILED
MAR 21 1993
CLERK OF COURTS



South Dakota Public Utilities Commission

State Capitol Building, 500 East Capitol Avenue, Pierre, South Dakota 57501-5070

July 8, 1998

Mr. Douglas L. Kuper
28106 467th Avenue
Lennox, SD 57039

Mr. John D. Gubbrud
Attorney at Law
Beck, Christensen, Gubbrud & Haugland
P. O. Box 97
Alcester, SD 57001

Ms. Karen Cremer
Staff Attorney
South Dakota Public Utilities Commission
500 East Capitol
Pierre, SD 57501

RE: In the Matter of the Complaint of Douglas L. Kuper
v. Lincoln-Union Electric Company
PUC Docket EL98-005

Dear Mr. Kuper and Counsel

This will confirm telephone conversations I have recently had with Mr. Kuper and Mr. Gubbrud and an in-person conversation with Ms. Cremer with regard to scheduling this matter

Within ten days of this letter, please let me know an approximate amount of time you will need to prepare for a hearing on this complaint. The Commission wants to give the parties and staff adequate time to prepare while not, at the same time, letting this matter lapse. Accordingly, on behalf of the Commission I am asking for this approximation

Secondly the Commission would encourage the parties to mediate this matter should they voluntarily agree to do so. If there is an interest in mediation, the Commission will make available a facility and mediator to do this. Neither the Commissioners nor I and other Commission support staff would be able to participate in the mediation process; however, should the parties wish to mediate, this process will be given every opportunity. Please let me know if there is a desire to use this process and to use Commission personnel to act as a mediator. I will relay such a request to appropriate personnel here

Capitol Office
Telephone (605)773-3201
FAX (605)773-3809

Transportation/
Warehouse Division
Telephone (605)773-5280
FAX (605)773-3225

Consumer Hotline
1-800-332-1782

TTY Through
Relay South Dakota
1-800-877-1113

Internet
billie@puc.state.sd.us

Jim Burg
Chairman
Pam Nelson
Vice-Chairman
Laska Schoenfelder
Commissioner

William Bullard Jr
Executive Director

Edward R. Anderson
Harlan Best
Martin C. Bettmann
Charlie Bolte
Sue Cichos
Karen E. Cremer
Marlette Fischbach
Shirleen Fugit
Lewis Hammond
Katie Hartford
Leni Healy
Camren Hoseck
Dave Jacobson
Bob Knadle
Delaine Kolbo
Jeffrey P. Lorenzen
Terry Norris
Gregory A. Rislov
Tammi Stangohr
Steven M. Wegman
Rolayne Ailts Wurst

Please bear in mind that insofar as scheduling is concerned, the Commission will set a hearing time and mediation may take place up to the time of the hearing. If mediation fails, then the hearing will proceed.

I look forward to your suggestions as to when you would be ready for a hearing and if you are interested in a mediation session.

Very truly yours,

Camron Hoseck
Acting Commission Counsel

BECK, CHRISTENSEN, GUBBRUD & HAUGLAND

ATTORNEYS AT LAW

O. G. BECK, DEC.
(1932 - 1990)

JOHN D. GUBBRUD*
CHARLES B. HAUGLAND*

DAVID A. STUART, ASSOCIATE*

WAYNE W. CHRISTENSEN
OF COUNSEL

*LICENSED IN IOWA AND SOUTH DAKOTA

REPLY TO: ALCESTER

July 16, 1998

RECEIVED

JUL 17 1998

SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

South Dakota Public Utilities Commission
500 E. Capitol
State Capitol Building
Pierre, South Dakota 57501

Re: In the Matter of the Complaint of Douglas L. Kuper v. Lincoln-Union Electric Company

Dear Gentlemen:

Enclosed is the Motion to Dismiss in the above entitled matter with ten (10) copies thereof per PUC rules. We respectfully request the opportunity to appear and present an oral argument and possible additional evidence in support of the Motion to Dismiss the Complaint.

Respectfully submitted,

BECK, CHRISTENSEN, GUBBRUD & HAUGLAND

John D. Gubbrud
Project Attorney for
Lincoln-Union Electric Company

JDG/jas
enc.
pc: Douglas Kuper

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	FILE NO. EL 98-035 MOTION TO DISMISS

COMES NOW, Lincoln-Union Electric Company and hereby presents its Motion to Dismiss the Complaint of Douglas Kuper for the following reasons:

1.

SUMMARY OF RELIEF SOUGHT BY COMPLAINT

A summary of the Complaint of Douglas L. Kuper is that Lincoln Union upgrade the line to his farm to a 3 phase electric service, requiring over 2¼ miles of re-build line at the estimated cost of over $90,000.00 or in the alternative, the Complaint wants a heavier conductor and new poles which would be located farther from his house at an estimated additional cost of approximately $35,000.00 for single phase construction.

2.

INCORPORATION BY REFERENCE

Reference is hereby made to a letter filed with the Commission by Manager, Brad Schardin, dated March 18, 1998, and Answer of Lincoln-Union Electric whereby Lincoln-Union Electric Company provided various information, data and proofs indicating that all tests conducted by various independent consultants have all concluded that there are no problematic voltages on the Kuper farm and the Project Engineer contends Lincoln-Union facilities are "well within the distribution system" (see letter from DeWild Grant Reckert and Associates, dated March 13, 1998 filed herein) whereby he states, "there is no engineering reason to install a larger conductor" or a 3 phase line for a single phase load is "ridiculous".

3.

TESTING

The Circuit Court record clearly shows that Lincoln Union has worked with the Kuper's over the years performing numerous neutral-to-earth stray voltage tests, investigations

and analyses;

The Circuit Court record clearly shows various outside consultants, engineers and others have conducted tests and investigations and analyses with no indications of problematic voltage on the Kuper farm which would violate industry standards;

Tests were performed on Lincoln-Union's primary distribution system, all indicated normal conditions relating to loading, grounding and voltage requirements.

4.

TRAINING

The Circuit Court record clearly shows that Lincoln-Union employees, outside consultants and engineers all have the requisite training and experience to perform such testing and make a professional analyses of data obtained.

5.

NATIONAL ELECTRIC SERVICE CODE (NESC)

The Circuit Court record clearly shows that Lincoln-Union's primary electrical service to the Kuper's farmstead, including grounding, is in compliance with the applicable National Electric Service Code (NESC).

6.

NO NEW FACTS

That there are no new facts meriting further study, investigation or expense.

7.

RES JUDICATA (MATTER SETTLED BY JUDGMENT)

7.1 The matters on which the Complainant bases his Complaint were previously tried and adjudicated in the Circuit Court action of Kuper v. Lincoln-Union, File No. 98155 duly filed in Lincoln County Circuit Court.

7.2 A final judgment had been made and entered into about a year ago, the appeal time has expired; the judgment for the Complainant has been paid as further shown from the records and files herein.

7.3 The parties in such prior action are the identical persons who are in the present proceeding and the matters raised in the Complaint with the Commission are the same matters at issue in the litigated case.

7.4 The Commission has adequate records and files from such prior litigation and

dismiss the Complaint with prejudice.

8.

DIVISION OF POWERS

8.1 That due to the prior judicial determination having been made, the Commission is without jurisdiction to further consider the issues re-raised by the Complaint due to the legal doctrine of division of powers of government (Article II - South Dakota Constitution), in that the executive branch of government cannot re-try a determination made by the judicial branch of the government; therefore the Complaint should be dismissed.

THEREFORE, Lincoln-Union respectfully presents this Motion to Dismiss and requests the Commission to set a time and place for hearing on this Motion to Dismiss before any other scheduling or proceeding is initiated; Lincoln-Union Electric requests the opportunity to be heard and possibly present other evidence or argument to support this Motion to Dismiss.

Dated at Alcester, South Dakota, this 16th day of July, 1998.

LINCOLN-UNION ELECTRIC COMPANY

By: _____
John D. Cadwell, Power Attorney
of Beck, Christensen, Cadwell & Haugland
P. O. Box 97
Alcester, South Dakota 57001
Ph. 605-934-2142

CERTIFICATE OF SERVICE

The undersigned certifies that the foregoing instrument was served upon all parties to the above cause by depositing a copy thereof in the U. S. Mail, postage prepaid, in envelopes addressed to the following:

Douglas L. Kuper
28106 467th Avenue
Lennox, South Dakota 57039

Public Utilities Commission
Capitol Building
Pierre, South Dakota 57501

on this 16th day of July, 1998.

_____
/s/John D. Cadwell

DeWild Grant Reckert and Associates Company
Consulting Engineers

March 16, 1998

Mr. Brad Schardin, General Manager
Lincoln-Union Electric Company
P.O. Box 105
Alcester, SD 57001-0105

RE: PUC Complaint Dated 3-2-98
DGR File No. 400998.6

Dear Mr. Schardin:

This letter is our response to the PUC complaint filed by Douglas L. Kuper on March 2, 1998.

During the past twenty (20) years DGR Engineers (DGR) has done the engineering for Lincoln-Union Electric Company (LU). Some of the tasks DGR has accomplished for LU are as follows:

- Long Range Planning (10 - 20 years)
- Short Term Planning (2 - 3 years)
- Sectionalizing System Design
- Circuit Design
- Reliability Analysis
- Work Order Certification (Construction Inspection)

In general, LU has a well maintained rural distribution system which takes delivery of power and energy from nine (9) substations owned and operated by East River Power Cooperative (ERPC). The distribution system is operated at a nominal voltage of 12.47 grd y/7.2 kV, 3-Ø, 4-wire. The system is classified as a multi-grounded, utility grounded system. Primary voltage regulation is limited to 8.0 volts on a 120 volt base in accordance with RUS and ANSI guidelines.

The reliability goal of the system is to keep the average outage hours per consumer under 3 hours per year. This goal has been achieved in all of the last ten (10) years. The entire system has been modeled during each short term planning session and construction is proposed to alleviate any excessive voltage drops or excessive line loadings.

Specifically, the complainant is served on a single-phase line which taps the north 3-Ø circuit out of the Davis substation. The 1-Ø tap line is constructed using a basic RUS "A1" structure, #4 ACSR Phase and Neutral conductors, and the neutral is grounded a minimum of four (4) times per mile in accordance with the NESC. From the latest model, the maximum load on the 1-Ø tap is 8.5 amperes or 61.2 kVA. #4 ACSR has a maximum ampacity of 112 amperes. From a thermal loading stand point the 1-Ø tap in question is loaded to 7½ % of its capacity. Actual ammeter readings taken on the 1-Ø tap during the summer of 1998 corroborate the model. The maximum voltage drops from the Davis substation to the complainant's location is 2.3 volts on a 120 volt base. This is excellent service and certainly does not support the notion of line replacement or up-grade.

I personally made some random readings of the primary neutral to remote ground potentials in the summer of 1997. I found no unusually high readings in the vicinity of the complainant. Most readings were in the 0.3 VAC or lower range. This is quite normal on a multi-grounded system and indicates to me that the primary system is operating as designed.

In summary, I would like to address three of the complainant's requests for relief:

1. "Heavier line" - The existing line is loaded to less than 10% of its thermal capacity and maintains voltage regulations of 2.3 volts at peak. There is no engineering reason to install larger conductor on the 1-Ø tap line feeding the complainant.

2. "3-Ø line" - Construction of a 3-Ø line to serve a 60 kVA, 1-Ø load is ridiculous.

3. "Covered wires" - "Covered" or insulated conductors either underground or overhead still have the same NESC requirements that the system's neutral be grounded at least four (4) times per mile.

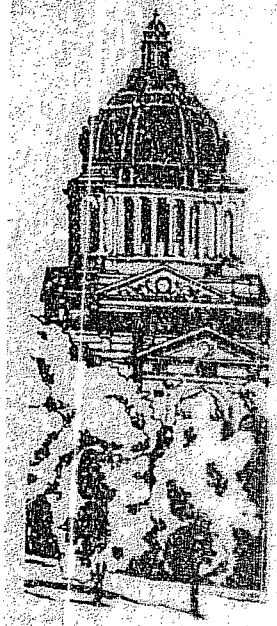
Very truly yours,

DEWILD GRANT RECKERT
& ASSOCIATES COMPANY

David H. DeVries, P.E.
Vice President

DDV/dvt

O:\04\009\098\001.LTR



South Dakota
Public Utilities Commission

State Capitol Building, 500 East Capitol Avenue, Pierre, South Dakota 57501-5070

July 20, 1998

Mr. William Bullard, Jr.
Public Utilities Commission
500 East Capitol
Pierre, SD 57501

RE: In the Matter of the Complaint filed by Douglas L. Kuper, Lennox, SD
EL98-005

Dear Mr. Bullard:

On July 8, 1998, Acting Commission Counsel Camron Hoseck requested that the parties and Staff inform the Commission of the approximate amount of time that would be needed to prepare for a hearing on this complaint. On July 17, 1998 Lincoln-Union Electric Company filed a Motion to Dismiss scheduled to be heard by the Commission on July 23, 1998. Once the Commission has filed its decision on the motion to dismiss, Staff will be in a better position to decide the amount of time needed to prepare for the hearing.

Sincerely,

Karen E. Cremer

Karen E. Cremer
Staff Attorney

cc: Mr. Douglas L. Kuper
Mr. John D. Gubbrud

Capitol Office
Telephone (605)773-3201
FAX (605)773-3809

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Warehouse Division
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Chairman
Pam Nelson
Vice-Chairman
Laska Schoenfelder
Commissioner

William Bullard Jr.
Executive Director

Edward R. Anderson
Harlan Best
Martin C. Bettmann
Charlie Bolle
Sue Cichos
Karen E. Cremer
Marlette Frohbach
Shirleen Fugitt
Lewis Hammond
Katie Hartford
Lori Healy
Camron Hoseck
Dave Jacobson
Bob Knadle
Delaine Kolbo
Jeffrey P. Lorenson
Terry Norton
Gregory A. Risley
Tammi Stangohr
Steven M. Wegman
Rolayne Ailts West

BECK, CHRISTENSEN, GUBBRUD & HAUGLAND

ATTORNEYS AT LAW

O. S. BECK, 1932 - 1968

JOHN D. GUBBRUD*
CHARLES B. HAUGLAND*

DAVID A. STUART, ASSOCIATE*

WAYNE N. CHRISTENSEN
OF COUNSEL

*LICENSED IN IOWA AND SOUTH DAKOTA

REPLY TO: ALCESTER

July 28, 1982

RECEIVED

AUG 03 1982

South Dakota Public Utilities Commission
500 E. Capitol
State Capitol Building
Pierre, South Dakota 57501

Re: In the Matter of the Complaint of Douglas L. Kuper v. Lincoln-Union Electric Company

Dear Gentlemen:

Enclosed is the Brief in Support of Motion to Dismiss in the above entitled matter with ten (10) copies thereof per PUC rules.

Respectfully submitted,

BECK, CHRISTENSEN, GUBBRUD & HAUGLAND

John D. Gubbrud
Attorneys for
Lincoln-Union Electric Company

JDG/bbs
enc.
pc: Douglas Kuper

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	)))))	FILE NO. EL 98-[illegible] BRIEF IN SUPPORT OF MOTION TO DISMISS

COMES NOW, Lincoln-Union Electric Company (Lincoln-Union) and presents its post hearing brief in support of Motion to Dismiss:

This decision is based upon existing facts and records before the Commission and general legal principals which the Commission is bound to accept as limiting jurisdiction of the Commission.

Synopsis of Hearing:

At telephonic hearing held at 4:00 o'clock p.m., on Thursday, July 23, 1998, the Commission heard arguments on the Motion to Dismiss filed by Lincoln-Union, with both parties appearing and presenting arguments.

Lincoln-Union contends the Motion to Dismiss is in order for the following reasons:

1. **Re Judicata:** The matter is settled by Judgment in Kuper vs. Lincoln-Union, File No. 93-155, in Circuit Court of Lincoln County, South Dakota, a judgment based on negligence verdict of a jury that has been satisfied by Lincoln-Union was not appealed.

2. **No New Facts:** All the facts relating to the Kuper electric service are the same as at the trial. Particularly the Complainant is no longer on the dairy business, thereby the neutral to earth or stray voltage issue in the dairy barn is now a moot issue as it relates to primary electric service to the Complainant's farmstead.

3. **No Creditable Data:** No creditable data or proofs has been submitted by the Complainant to support allegations of continuing voltage problems in the dairy barn or residence of the Complainant.

4. **Separation of Powers:** The legal principal of Separation of Powers provides that the Commission cannot re-raise issues that have been determined on prior judicial

proceedings.

5. **Disputed Proofs** That disputed proofs have been filed by Lincoln-Union that the primary distribution system to the Complainant's electric service delivery point (the meter) meets or exceeds the existing industry standards.

6. **Request for Rebuilding:** That the Complainant's request for rebuilding poles and conductors in a single phase line or a construction of a three phase line or covered wire will result in unnecessary and wasteful expenditures of resources of Lincoln-Union to the detriment of other member consumers of Lincoln-Union.

The Complainant (Kuper) admits that Lincoln-Union has cooperated with him by moving ground wires back from the farmstead at his request; he acknowledges that Lincoln-Union personally have repetitively tested for stray voltage problems and provided other advice and counsel regarding his electric services; the shower shocking phenomena is intermittent more probably an internal wiring problem beyond responsibility of Lincoln-Union, and continuing 1.8 volt reading at cow contact points when electric service is shut off is simply "unbelievable" at best and "grossly exaggerated" contrary to preponderance of the evidence at the trial of such issues as further evidenced in trial transcript and proofs submitted by Lincoln-Union in this matter.

Therefore, Lincoln-Union respectfully requests the Commission to dismiss the Complaint of Douglas L. Kuper, with prejudice.

Dated this 24th day of July, 1998.

Lincoln-Union Electric Company

By: _____

John D. [illegible], Project Attorney
of Beck, Chestnutt, Gubbard & Hoagland
P.O. Box 97
Alcester, South Dakota 57001
Ph. [illegible]

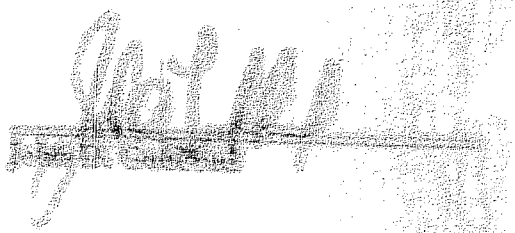
CERTIFICATE OF SERVICE

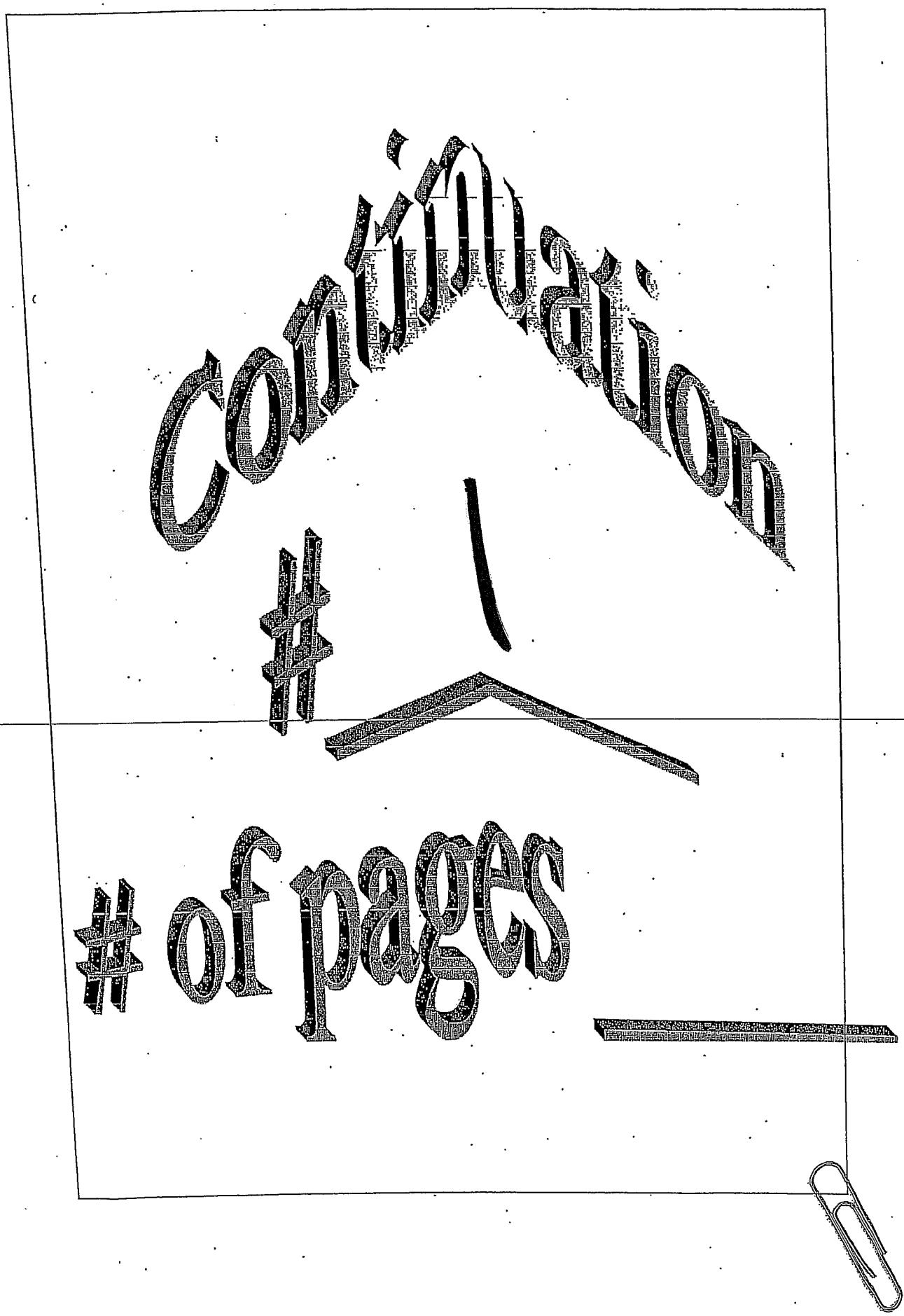
The undersigned certifies that the foregoing instrument was served upon all parties to the above cause by depositing a copy thereof in the U. S. Mail, postage prepaid, in envelopes addressed to the following:

Douglas L. Kuger
2106 467th Avenue
Lemmon, South Dakota 57638

Public Utilities Commission
Capitol Building
Pierre, South Dakota 57501

as disclosed on the pleadings on July 30, 1998.




Confirmation
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of pages

TEL : Aug 03.98 0:17 No.001 P.01

Page 1

Public Utilities Commission

File No. EL 98-005

Brief in Support Not to Dismiss Complaint

(1) I have no dispute that Court Court negligence verdict of the jury has been satisfied. But due to the fact that Lincoln Union Elect hasn't fixed the problem is the dispute.

(2) The fact that we are not in the Dairy at present time is due to the fact that stray Voltage from the Power Co or Lincoln Union is still the problem. For instance on 7-31-98 we tied our 4 H calves in the barn or in the stantions for only a short time and their necks [illegible] swelled up due to the stray Voltage from the or Lincoln Union Elect Co. [illegible] when grooming sheep in barn air could once again feel the tingle present with Electricity off on [illegible] or [illegible] Transformer [illegible] also [illegible]. Also notice little calves don't want to drink water out of Cow water due to schocking with current off on farm. Also water sizing in [illegible] floor

Page 2

Can feel the tingle in my feet while showering 8-2-98! Lincoln Unions own tests show over the years that when it rains out the voltage gets higher at contact points in the [illegible] or when it thaws in the spring.

(3) I guess as far as departure of [illegible] this issue of getting the line fixed really has [illegible] have anything to do with previous judicial [illegible] due to the fact that the [illegible] where not asked to tell [illegible] the or Lincoln Union [illegible] fix the line and feel this question [illegible] to the [illegible] Commission. The jury was asked for damages or losses due to the fact that Lincoln Unions [illegible] voltage was the cause of my [illegible] on my milking herd. Which the [illegible] did find to be the cause in both trials.

(4) Disputed Proofs Once again [illegible] at trial said the line was [illegible] current into the ground and taking a path thrown my farm due to [illegible] old poles no [illegible] or [illegible] splices in the line not [illegible] cables or neutral or [illegible] neutral

at various times due to the high usage at various times which shows up on Lincoln Unions various reports. Out of balance

(5) I still do request rebuilding of the line due to the fact nothing has been done to correct the problem on Lincoln Unions side. It was talked about by Mr Schardin that I cut grounds on the farm and the Power Co. side. The first two grounds that where cut where done by Todd Nelson and Tim Chance at the barn and one of the cattle fountains who are Lincoln Unions employees that where working on the voltage problems in milking barn. By doing the cutting of the grounds it should only relief the stray voltage to the cows. Since Lincoln Union found voltage or stray voltage on their side tests where stopped and I was told I would have to pay for any thing that needed to be done on their side of the utility. The cutting of the grounds and telling over would would have to pay for the Lincoln Unions problems was in around 1993 at that time I went and talked to an attorney. The internal wiring on the farm has been checked by Lincoln Union and also by

pg 4

Mr Bodman and nobody has ever came up with any on the farm problems. Only on Lincoln Unions site has there been and continues to be problems. As to Mr. Gebhard (unbelievable at best and grossly exaggerated) maybe its time for a farm visit or at least know the facts. I don't lie or exaggerate I was not brought up that way. I believe I am still a member of the Coop and ask no more than any other member. This story voltage from Lincoln Union is very unbelievable to animals.

Therefore I respectfully hope that the Commission contains with the Complaint and if possible maybe a farm visit some of the things being talked about might be easier to understand.

Respectfully
Douglas L. Kuper

Dated 8-3-98

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	)))))	ORDER DENYING MOTION TO DISMISS EL98-005

On March 6, 1998, Douglas L. Kuper (Kuper) Lennox, South Dakota, filed a complaint against Lincoln-Union Electric Company (Lincoln-Union), Alcester, South Dakota, regarding stray voltage. In an Order dated April 28, 1998, the Public Utilities Commission (Commission) made a finding of probable cause of an unlawful or unreasonable act, rate, practice or omission by Lincoln-Union. Lincoln-Union filed an Answer dated May 18, 1998. Lincoln-Union by motion dated July 16, 1998, moved to dismiss the complaint of Kuper. A hearing on the motion to dismiss was held by the Commission on July 23, 1998, via teleconference.

The Commission, has jurisdiction in this matter pursuant to SDCL 49-34A-56 and ARSD 20:10:01:08.01 et seq.

On August 4, 1998, at a duly noticed meeting, the Commission, having heard the arguments of counsel for Lincoln-Union and Douglas L. Kuper who represented himself, and being fully advised in these premises, finds that this matter is not barred by res judicata as the Commission may only consider adequacy of service, the allegation of stray voltage is that it is of a continuing nature, and it does not appear that the issues of Kuper's personal inconvenience such as shocks in the shower or bath were previously addressed by the Court (Chairman Burg dissenting). The other grounds raised by Lincoln-Union are without merit. It is hereby

ORDERED that the motion of Lincoln-Union to dismiss this complaint be denied.

Dated at Pierre, South Dakota, this 14th day of August, 1998.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, by facsimile or by first class mail, in properly addressed envelopes, with charges prepaid thereon.

By: Delaine Kolbo

Date: 8/14/98

(OFFICIAL SEAL)

BY ORDER OF THE COMMISSION:

JAMES A. BURG, Chairman, dissenting

PAM NELSON, Commissioner

LASKA SCHOENFELDER, Commissioner

BECK, CHRISTENSEN, GUBBRUD & HAUGLAND

ATTORNEYS AT LAW

O. G. BECK, DEC.
(1932 - 1990)

JOHN D. GUBBRUD*
CHARLES B. HAUGLAND*

DAVID A. STUART, ASSOCIATE*

WAYNE W. CHRISTENSEN
OF COUNSEL

*LICENSED IN IOWA AND SOUTH DAKOTA

REPLY TO: ALCESTER

August 14, 1998

RECEIVED
AUG 17 98
SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

South Dakota Public Utilities Commission
500 E. Capitol
State Capitol Building
Pierre, South Dakota 57501

Re: In the Matter of the Complaint of Douglas L. Kuper v. Lincoln-Union Electric Company

Dear Gentlemen:

Enclosed is the Request for Staff Onsite Inspection and Mediation in the above entitled matter with ten (10) copies thereof per PUC rules.

Respectfully submitted,

BECK, CHRISTENSEN, GUBBRUD & HAUGLAND

John D. Gubbrud
Project Attorney for
Lincoln-Union Electric Company

JDG/jas
enc.
pc: Douglas Kuper

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	FILE NO. EL 98-005 REQUEST FOR STAFF ONSITE INSPECTION AND MEDIATION

COMES NOW, Lincoln-Union Electric Company and respectfully submits the following:

ONSITE INSPECTION

1. That the Commission order the Commission staff to make an onsite inspection of the Complainant's farmstead to investigate the following:

1.1 Determine through field inspection, investigation and testing if there is any electrical service problems or "neutral-to-earth" or "stray voltage" in the dairy facilities that exceed acceptable industry standards while electric service is energized;

1.2 Determine through field inspection, investigation and testing if there is any electrical service problems, "neutral-to-earth" or "stray voltage" in the dairy facilities that exceed acceptable industry standards while electric service is de-energized;

1.3 Determine through field inspection, investigation and testing if there is electric service problems or voltage problems in the residence, particular attention to the shower or bath facilities resulting from Lincoln-Union's distribution of electricity;

1.4 To inspect and evaluate Lincoln-Union's primary electric facilities serving the farmstead and determine if they conform to applicable electric codes;

1.5 To review and make staff comments on Complainant's requests of the Commission to rebuilding or upgrading poles and conductors, providing 3 phase service or underground electric service to the farmstead;

1.6 Make such other inspections, investigations and tests that the staff may be deemed relevant to this matter;

MEDIATION

Upon completion of the staff onsite investigation and report, the parties will meet

for a mediation session of this matter per the Commissions encouragement and that the Commission staff will participate in the mediation process.

SUSPENSION OF OTHER PROCEEDING

That during the time of the staff onsite inspection, preparation of their report and during the mediation process, all other proceedings regarding this matter shall be suspended.

COVENANT OF COOPERATION

Lincoln-Union requests to be present to observe all staff onsite investigations and testings to observe the methodology and instruments used. Lincoln-Union is willing to cooperate with the Commission staff in anyway reasonably possible to facilitate such onsite inspection as Lincoln-Union is confident that the Commission staff will find the same conclusions as other independent consultants have found that the quality of electric service provided by Lincoln-Union meets or exceeds all industry standards, existing law, rules, regulations and codes presently applicable to this electric service.

Dated at Alcester, South Dakota, this 14th day of August, 1998.

LINCOLN-UNION ELECTRIC COMPANY

By: _____

John D. Gubbrud, Project Attorney
of Beck, Christensen, Gubbrud & Haugland
P. O. Box 97
Alcester, South Dakota 57001
Ph: 605/934-2145

CERTIFICATE OF SERVICE

The undersigned certifies that the foregoing instrument was served upon all parties to the above cause by depositing a copy thereof in the U. S. Mail, postage prepaid, in envelopes addressed to the following:

Douglas L. Kuper	Public Utilities Commission
28106 467th Avenue	Capitol Building
Lennox, South Dakota 57039	Pierre, South Dakota 57501

on this 14th day of August, 1998.

_____
John D. Gubbrud

RECEIVED
1992
SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

File No. EL 88-[illegible]

Public Utilities Commission

In response to Onsite Inspection

1. I welcome the commission or the Commission staff for a farm visit [illegible]

1.1 I will be happy to assist staff in barn test. By using Lincoln Union's standards of 0.5 tons of a volt and Mr Gustafson one of the authors of the Red Book which he testified in court that 0.25 volts would be a concern to Dairy Milk Cows or Livestock.

1.2 By de-energizing I am assuming Lincoln Union will shut down the line bringing elect. to my farm. In one of the tests done by Mother Nature it was the only time the current was ever left the barn for example when Lincoln Union unhooked the power line at the end of my farm or driveway the power never left the barn or would one hundredth of a tenth test done by Lincoln Union around June 23 Lincoln Union still thought it was my problem with current unhooked at end of driveway. So I get the line shut down for a good test.

1.3 & 1.4 With the line shut down should pretty much explain itself. for where the stray-voltage is coming from. Would also hope that commission and staff keep in mind weather conditions plays a big part for how much voltage or stray-voltage is getting to the [illegible].

1.5 A neighbor 3 miles west of my place was told by one of the employees that future plans have a three phase running by my place or it wouldn't have been [illegible] to bring it to his place. He will testify to it if necessary.

1.6 Hope that the commission or staff keep in mind that from 5:00 P.M. to 9:00 P.M. is when the line has a load on it. Not off hrs of the day because people in the neighbor hood are gone to work. Which means little use of the line during the day hrs.

Mediation

Delbe happy for Mediation and always have been. Would ask that this be done either at my place or Lincoln Lowe Office. Later part of afternoon [illegible].

Suspension of the Bonneville

I would ask that this not be suspended. Do to the fact of all the tests that have been done which have taken so cool you to do. That relate back to Lincoln Unions problems or lined leaking stray voltage back to my farm. Also because the various weather and load conditions put on the line that show the problems which creates or allows voltage back.

Cooperation:

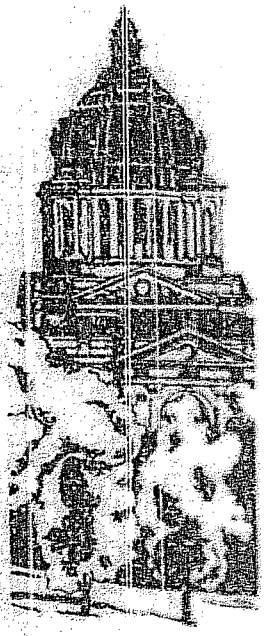
I'd be more than happy to cooperate in any way possible getting larger testing equip. Lined up with the equip that will be needed. I would ask that only one representative from Lincoln-Union help or be present when testing. Because they have before come with so many people I will do hard to keep up with that many people. Or let me know how many are coming with so I can have people available to go with each person to do the testing and where. Also their expectation as why they are coming.

As far as suspension of the Commission does suspend the other proceedings than I feel that I will be asking for damages which have to over 700,000.00 in the last trail. I am not a lawyer or any trying to be one. At this point I have never asked for personal damage for all the inconvenience created by this problem. Having to quit farm feeling my daughter's having to seek employment off the farm. Not being able to sell my farm due to the fact of the shortage. By law also, who would want to once else to go through this problem.

Respectfully submitted
Douglas L. Kuper

Dated 8-17-98

This is my only copy.



South Dakota
Public Utilities Commission

State Capitol Building, 500 East Capitol Avenue, Pierre, South Dakota 57501-5070

August 21, 1998

Mr. Douglas L. Kuper
28106 467th Avenue
Lennox, SD 57039

Re: Kuper Complaint/Lincoln Union Electric
Docket EL98-005

Dear Mr. Kuper:

I noted at the bottom of your letter regarding your response to [illegible] you did not retain a copy for yourself. Therefore, we are enclosing a copy of the letter for your files.

Very truly yours,

Camron Hoseck
Acting Commission Counsel

CH dk
Enc

cc: Mr. John D. Cubbage

Capitol Office
Telephone (605)773-3201
FAX (605)773-3809

Transportation/
Warehouse Division
Telephone (605)773-5280
FAX (605)773-3225

Consumer Hotline
1-800-332-1782

TTY Through
Relay South Dakota
1-800-877-1113

Internet
billb@puc.state.sd.us

Jim Burg
Chairman
Pam Nelson
Vice-Chairman
Laska Schoenfelder
Commissioner

William Bullard Jr.
Executive Director

Edward R. Anderson
Harlan Best
Martin C. Bettmann
Charlie Bolly
Sue Cichos
Karen E. Cremer
Marlene Fischbach
Shelton Fugitt
Lewis Hammond
Kate Hartford
Lori Healy
Cameron Hoseck
Dave Jacobson
Bob Knaefle
Delaine Kolbo
Jeffrey P. Lawson
Terry Nissen
Gregory A. Rislov
Tamani Stangelo
Steven M. Wegman
Rolayne Ashe West

BECK, CHRISTENSEN, GUBBRUD & HAUGLAND

ATTORNEYS AT LAW

O. G. BECK, DEC
(1932 - 1990)

JOHN D. GUBBRUD*
CHARLES B. HAUGLAND*

DAVID A. STUART, ASSOCIATE*

WAYNE M. CHRISTENSEN
OF COUNSEL

*LICENSED IN IOWA AND SOUTH DAKOTA

REPLY TO: ALCESTER

RECEIVED

August 26, 1998

SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

Camron Hoseck
Acting Commission Counsel
Public Utilities Counsel
Public Utilities Commission
500 East Capitol
Pierre, South Dakota 57501

Re: Kuper Complaint/Lincoln-Union Electric Docket EL98-003

Dear Camron:

I appreciated the receipt of the copy of your letter to Mr. Kuper regarding the Complainant's (Kuper) response to Lincoln-Union's Motion for Onsite Staff Inspection and Staff Report prior to any mediation process. Without it we are unaware of the life contour.

The Complainant did not follow the Commission rules by failing to provide Lincoln-Union with a copy of his response.

Kindly provide this office and the Manager of Lincoln-Union with a copy of the Response of Complainant. For the record, I would request that Brad Schenfin, Manager of Lincoln-Union Electric, be included on the service list of parties receiving all notices, pleadings, orders and other correspondences regarding the above matter.

As the Commission procedural rules appear to be relatively vague as to time schedules, response time and the interest of always trying to keep responsive to the Commission's activities in this matter, valuable time is saved by providing both me, as Project Attorney and Lincoln-Union's Manager, with the same information at the same time.

Please advise if you need more information to put Lincoln-Union Electric on the service list.

Thank you in advance for providing the requested information. Please advise when the hearing by the Commission on Lincoln-Union's request for a staff onsite inspection is considered as we want to appear by telephonic appearance while the Motion is being considered. Perhaps we will then be able to provide additional information for the Commission to order such staff action.

It makes sense to me that the Commission staff make an onsite inspection to determine if the Complainant has any factual merit to his position. The staff report may provide some guidelines in any mediation process.

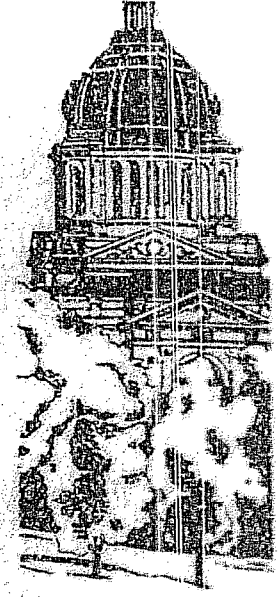
We also need definitive Commission action on the Motion to suspend further action until this Motion is ruled upon. Lincoln-Union is probably already short on the 10 day Order or does filing our Motion automatically suspend the 1-day Order??

Please advise as Lincoln-Union does not want to end up in an embarrassing position through failure to be informed on how your rules run on such matters. I am unable to find anything in the published rules on that point.

Very truly yours,

[illegible]
Project Attorney

JDG/jas
pc: Brad Schardin, Manager
Doug Kuper



South Dakota
Public Utilities Commission
State Capitol Building, 500 East Capitol Avenue, Pierre, South Dakota 57501-6070

August 21, 1998

RECEIVED
AUG 31 1998
SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

Mr. Douglas L. Kuper
28106 487th Avenue
Lennox, SD 57039

Re: Kuper Complaint/Lincoln-Union Electric
Docket EL98-005

Dear Mr. Kuper:

I noted at the bottom of your letter regarding your response to onsite inspection that you did not retain a copy for yourself. Therefore, we are enclosing a copy of that letter for your files.

Very truly yours,

Camron Hoseck
Acting Commission Counsel

CH dk
Enc

cc: Mr. John D. Quaderud

Capitol Office
Telephone (605)773-3201
FAX (605)773-3809

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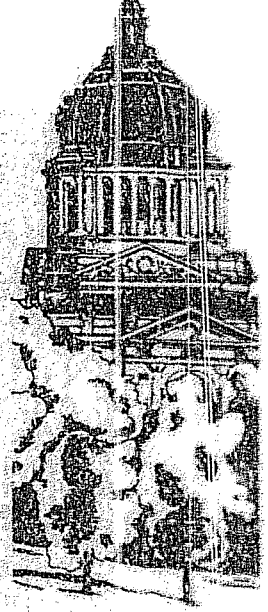
Shirlene Fuqua
Lewis Hammond
Katie Hartford
Lena Healy
Camron Hoseck
Dave Jacobson
Bob Knadle
Delaine Kolbo
Jeffrey P. Lorenzen
Terry Nelson
Gregory A. Rolfe
Tammie Sturgeon
Steven M. Wegman
Roxanne Wilke Ward



South Dakota Public Utilities Commission

State Capitol Building, 500 East Capitol Avenue, Pierre, South Dakota 57501-5070

August 31, 1998

Mr. John D. Gubbrud
Attorney at Law
Beck, Christensen, Gubbrud & Haugland
P. O. Box 97
Alcester, SD 57001

Re: In the Matter of the Complaint of Douglas L. Kuper
against Lincoln-Union Electric Company
PUC Docket EL98-005

Dear Mr. Gubbrud:

As requested, enclosed you will find a copy of Mr. Kuper's response to [illegible] inspection

Very truly yours,

Camron Hoseck
Acting Commission Counsel

cc: Mr. Brad Schardin
Enc

Capitol Office
Telephone (605)773-3201
FAX (605)773-3809

Transportation/
Warehouse Division
Telephone (605)773-5280
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Shirleen Fugitt
Lewis Hammond
Katie Hartford
Lori Healy
Camron Hoseck
Dave Jacobson
Bob Knadle
Delaine Kolbo
Jeffrey P. Lorenson
Terry Nolan
Gregory A. Kirkor
Tammi Stangole
Steven M. Wegman
Rolayne Ailts Wiest

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	ORDER FOR AND NOTICE OF HEARING AND SETTING A PROCEDURAL SCHEDULE EL98-005

On March 6, 1998, the South Dakota Public Utilities Commission (Commission) received a complaint from Douglas L. Kuper (Kuper), Lennox, South Dakota, against Lincoln-Union Electric Company (Lincoln-Union) regarding stray voltage. In an Order dated April 28, 1998, the Commission made a finding of probable cause of an unlawful or unreasonable act, rate, practice or omission by Lincoln-Union. Lincoln-Union filed an Answer dated May 18, 1998. Lincoln-Union by motion dated July 16, 1998, moved to dismiss the complaint of Kuper. A hearing on the motion to dismiss was held by the Commission on July 23, 1998, via teleconference. On August 4, 1998, the Commission voted to deny the motion to dismiss, Commissioner Burg dissenting. An Order to that effect was entered on August 14, 1998.

The Commission has jurisdiction over this matter pursuant to SDCL Chapter 1-26, 49-34A-58, and ARSD 20:10:08.01 et seq.

The issue at the hearing is whether Lincoln-Union has committed an unlawful or unreasonable act, rate, practice or omission.

A hearing shall be held commencing at 1:30 P.M., on Tuesday, December 15, 1998, and continuing through December 18, 1998, at the County Commissioner Room, County Administration Building, located at 415 North Dakota Avenue, Sioux Falls, South Dakota. It shall be an adversary proceeding conducted pursuant to SDCL Chapter 1-26. All parties have the right to be present and to be represented by an attorney. These rights and other due process rights shall be forfeited if not exercised at the hearing. If you or your representative fail to appear at the time and place set for the hearing, the Final Decision will be based solely on the testimony and evidence provided, if any, during the hearings or a Final Decision may be issued by default pursuant to SDCL 1-26-22. After the hearing the Commission will consider all evidence and testimony that was presented at the hearing. The Commission will then enter Findings of Fact, Conclusions of Law, and a Final Decision regarding this matter. The Commission's decision may be appealed by the parties to the state Circuit Court and the state Supreme Court as provided by law. It is therefore

ORDERED that a hearing shall be held at the time and place specified above on the issue of whether Lincoln-Union committed an unlawful or unreasonable act, rate, practice or omission.

Lincoln-Union has requested that the Commission order its staff to make an onsite inspection of Kuper's farmstead and to investigate certain electric issues. The Commission will not enter such an order, however. Commission staff operates independent of the Commission and is free to do such inspections, tests or other discovery work it wishes and the Commission defers to its staff as to what staff deems necessary.

Lincoln-Union has requested mediation between itself and Kuper. The Commission encourages the parties to mediate and suggests that if the parties wish to do so and want a mediator from the staff of the Commission, that they contact William Bullard, Jr. the Executive Director who, without participation from the Commission or its advisory staff, will arrange for a mediator.

Pursuant to the Americans with Disabilities Act, this hearing is being held in a physically accessible location. Please contact the Public Utilities Commission at 1-800-332-1782 at least 48 hours prior to the hearing if you have special needs so arrangements can be made to accommodate you.

Dated at Pierre, South Dakota, this 31 day of August, 1998.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, by facsimile or by first class mail, in properly addressed envelopes, with charges prepaid thereon.

By: Delores Kolbo

Date: 8/31/98

(OFFICIAL SEAL)

BY ORDER OF THE COMMISSION:
Commissioners Burg, Nelson and Schoenfelder

WILLIAM BULLARD, JR.
Executive Director

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	)))))	ORDER FOR AND NOTICE OF PREHEARING CONFERENCE AND HEARING EL98-005

On March 6, 1998, the Public Utilities Commission (Commission) received a Complaint from Douglas L. Kuper (Kuper), Lennox, South Dakota, against Lincoln-Union Electric Company (Lincoln-Union) regarding stray voltage. This matter has been set for hearing commencing at 1:30 P.M., on Tuesday, December 15, 1998, and continuing through December 18, 1998, at the County Commissioner Room, County Administration Building, 415 North Dakota Avenue, Sioux Falls, South Dakota. The Order and Notice for this hearing is dated August 31, 1998.

In order to facilitate the parties (which includes Commission staff for purposes of this Order) and the Commission in conducting an orderly hearing, a prehearing conference will be held on Friday, December 4, 1998, at 10:00 A.M. This prehearing conference will be conducted via a telephone conference call. Parties should call (605) 773-6140 to initiate participation in the conference. Should parties wish to attend the conference in person, they may do so by appearing in the Conference Room of the Public Utilities Commission, 500 East Capitol, Pierre, South Dakota.

Parties should be prepared to discuss or act upon the following matters:

1. names of attorneys representing the parties;
2. names of witnesses each party intends to call at the hearing;
3. an approximation of the amount of time each witness will need for direct testimony and the order of calling witnesses;
4. prehearing motions; parties should make all of their prehearing motions at the prehearing conference; parties may make such motions in writing prior to the time of the prehearing conference;
5. such other matters as the parties or Commission advisory counsel deem necessary to facilitate the hearing.

Dated at Pierre, South Dakota, this 24th day of November, 1998.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, by facsimile or by first class mail, in properly addressed envelopes, with charges prepaid thereon.

By: [signature]

Date: 11/24/98

(OFFICIAL SEAL)

BY ORDER OF THE COMMISSION:
Commissioners Burg, Nelson and Schoenfelder

[signature]

WILLIAM BULLARD, JR.
Executive Director

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REPLY TO: Sioux Falls 605-332-5999

December 1, 1998

Mr. Douglas L. Kuper
Route 4, Box 51
Lennox, SD 57039

RECEIVED
DEC 02 1998
SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

Mr. William Bullard, Jr.
Executive Director
SD Public Utilities Commission
State Capitol Building
500 East Capitol Avenue
Pierre, SD 57501-5070

RE: In the Matter of the Complaint Filed by Douglas L. Kuper, Lennox, South Dakota, Against Lincoln-Union Electric Company Regarding Stray Voltage
Our File No.: 88-131-12

Gentlemen:

Enclosed please find copies of Lincoln-Union Electric Company's Response to Order for and Notice of Prehearing Conference and Hearing EL 98-005, including Motion for Notice of State of Minnesota Public Utilities Commission Report of Scientific Advisors, Motion to Limit Testimony, and Requests for Admissions, which are intended as service by mail upon each of you in the above-entitled matter.

Sincerely,

LYNN, JACKSON, SHULTZ & LEBRUN, P.C.

R. Alan Peterson
RAP/cjd
Enclosure
cc: Mr. John D. Gubbrud (w/encl.)
Mr. Brad Schardin (w/encl.)

RECEIVED
DEC 07 1998
SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE.	*	LINCOLN-UNION ELECTRIC COMPANY'S RESPONSE TO ORDER FOR AND NOTICE OF PREHEARING CONFERENCE AND HEARING EL 98-005

Lincoln-Union Electric Company submits the following in compliance with the Order for and Notice of Prehearing Conference and Hearing, dated November 24, 1998:

1. Names of attorneys representing the parties:

John D. Gubbrud
P.O. Box 97
Alcester, SD 57001
Telephone: (605)934-2140

R. Alan Peterson
Lynn, Jackson, Shultz & Lebrun, P.C.
P.O. Box 1920
Sioux Falls, SD 57101-3020
Telephone: (605)332-5999

Attorneys for Lincoln-Union Electric Company

2. Names of witnesses each party intends to call at the hearing; and

3. An approximation of the amount of time each witness will need for direct testimony and the order of calling witnesses:

Depending upon the nature of the testimony submitted by Douglas Kuper, Lincoln-Union Electric Company may call the following witnesses:

A. Todd Nelson.

Mr. Nelson is a Lincoln-Union Electric Company employee who has been consistently involved in dealing with the complaints of Douglas Kuper. It is anticipated that his direct testimony will take approximately one and one-half hours.

B. Tim Chance.

Mr. Chance is the Director of Operations of Lincoln-Union Electric Company and has been extensively involved in addressing the complaints of Mr. Kuper. Additionally, he is expected to testify as to the adequacy of the metering load balance line construction and other functions of the system. It is anticipated that his direct testimony will require approximately two hours.

C. David DeVries.

Mr. DeVries is the Project Engineer for Lincoln-Union Electric Company. It is anticipated that he will testify as to the design and system requirements of the project, as well as the compliance of the construction to the plan. It is anticipated his direct testimony will require approximately one-half hour.

D. Wes Lane.

Mr. Lane is an independent stray voltage auditor, who is an employee of the Otter Tail Electrical System, Fergus Falls, Minnesota. Mr. Lane was hired by Douglas Kuper to test his farm for stray voltage. He will testify as to the lack of abnormal findings which he found on both the primary and secondary side of the Kuper residence. It is anticipated that his direct testimony will require approximately one-half hour.

E. Matt Schwarz.

Mr. Schwarz is an electrical engineer, who has visited the farm on several occasions as an independent expert. He is expected to testify that the design, operation and maintenance of Lincoln-Union Electric Company's primary distribution system is in compliance with all national, state and local standards, including REA standards and NESC standards, and that the

system functions within the accepted and normal parameters of the industry. It is anticipated that his direct testimony will require approximately one-half hour.

4. Prehearing motions; parties should make all of their prehearing motions at the prehearing conference; parties may make such motions in writing prior to the time of the prehearing conference.

See attached Motions.

Dated this 1 day of December, 1998.

LYNN, JACKSON, SHULTZ & LEBRUN, P.C.

By: _____

R. Alan Peterson
P.O. Box 1920
Sioux Falls, SD 57101-3020

- and -

John D. Gubbrud
P.O. Box 97
Alcester, SD 57001

Attorneys for Lincoln-Union Electric Company

CERTIFICATE OF SERVICE

The undersigned, R. ALAN PETERSON, one of the attorneys for Lincoln-Union Electric Company, hereby certifies that he served a true and correct copy of Lincoln-Union Electric Company's Response to Order for and Notice of Prehearing Conference and Hearing EL 98-005, including Motion for Notice of State of Minnesota Public Utilities Commission Report of

Scientific Advisors, Motion to Limit Testimony, and Requests for Admissions, in the above-referenced matter upon the persons herein next designated by first-class mail, postage prepaid, by mailing a copy of the same thereof to:

Mr. Douglas L. Kuper
Route 4, Box 51
Lennox, SD 57039

and to:

Mr. William Bullard, Jr.
Executive Director
SD Public Utilities Commission
State Capitol Building
500 East Capitol Avenue
Pierre, SD 57501-5070

which addresses are the last addresses of the addressees known to the subscriber.

Dated at Sioux Falls, South Dakota, this 1 day of December, 1998.

R. Alan Peterson

RECEIVED
DEC 07 1998
SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE.	*	FILE NO. EL 98-005 MOTION FOR NOTICE OF STATE OF MINNESOTA PUBLIC UTILITIES COMMISSION REPORT OF SCIENTIFIC ADVISORS

Comes now Lincoln-Union Electric Company and moves for the PUC's judicial notice and admission into evidence of the Final Report of the Science Advisors to the Minnesota Public Utilities Commission, dated July 31, 1998.

A copy of the report is included under separate cover.

In the absence of the Commission's acceptance into evidence of this report by judicial notice, it will be necessary for Lincoln-Union Electric Company to call one or more of the authors of the report to testify as to the background of the report.

Dated this 7 day of December, 1998.

LYNN, JACKSON, SHULTZ & LEBRUN, P.C.

By: _____

R. Alan Peterson
P.O. Box 1920
Sioux Falls, SD 57101-1920

- and -

John D. Oakland
P.O. Box 97
Alcester, SD 57001

Attorneys for Lincoln-Union Electric Company

RECEIVED

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

***

recognized industry standards.

Dated this 1 day of December, 1998.

LYNN, JACKSON, SHULTZ & LEBRON, P.C.

By: _____

R. Alan Peterson
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Attorneys for Lincoln-Union Electric Company

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DEC 01 1998

SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

***

STATE OF MINNESOTA
PUBLIC UTILITIES COMMISSION
121 7th Place East • Suite 350 • St. Paul, Minnesota 55101-2147

RECEIVED
DEC 02 1998
SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

MEMORANDUM

TO: Interested Parties

FROM: Patricia J. Hoben, Ph.D.
Research Director and Liaison to the Science Advisors

DATE: August 5, 1998

SUBJECT: Final Report of the Science Advisors

Attached for your information is a copy of the final report of the Science Advisors to the Minnesota Public Utilities Commission. The report describes the results of the field study carried out in the summer of 1997 and expectations for laboratory research initiated recently. The science advisors also offer final conclusions and recommendations in their report, based on all of the sources of information they assessed since their appointment in December 1994.

The Science Advisors give three findings in their report, which are quoted below:

- "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."

- "At the present time, there is no basis for closing the PUC approved standards by which electric utilities distribute power onto or in the vicinity of individual dairy farms."

- "There are many well-documented non-electrical factors that are known and accepted by the scientific community, and by most farmers as well, to cause dairy cow health and production problems. Among the most noteworthy factors are poor nutrition, poor cow comfort and hygiene, and low or no use of vaccinations and related preventive veterinary practices. These factors should always be addressed by those who want to improve performance of dairy herds."

Additional details on the findings and recommendations are given on pages 25-28 of the report. Please contact Mr. Burl Haar if you have any questions pertaining to the Commission's action on this report. You may contact me directly if you have any questions regarding the report to want additional details on the research addressed in the report. Riley Hendrickson and I both can be reached at The Bakken Library and Museum, (612) 927-6508.

Attachments

START

OF

RETAKE

STATE OF MINNESOTA
PUBLIC UTILITIES COMMISSION
121 7th Place East ★ Suite 350 ★ St. Paul, Minnesota 55101-2147

RECEIVED
DEC 02 1998
SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

MEMORANDUM

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Research Director and Liaison to the Science Advisors

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The Science Advisors give three findings in their report, which are quoted below:

- "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."

- "At the present time, there is no basis for altering the PUC-approved standards by which electric utilities distribute power onto or in the vicinity of individual dairy farms."

- "There are many well-documented non-electrical factors that are known and accepted by the scientific community, and by most farmers as well, to cause dairy cow health and production problems. Among the most noteworthy factors are poor nutrition, poor cow comfort and hygiene, and low or no use of vaccinations and related preventive veterinary practices. These factors should always be addressed by those who want to improve performance of dairy herds."

Additional details on the findings and recommendations are given on pages 37-39 of the report. Please contact Mr. Burl Haar if you have any questions pertaining to the Commission's action on this report. You may contact me directly if you have any questions regarding the report or want additional details on the research addressed in the report. Riley Hendrickson and I have can be reached at The Bakken Library and Museum, (612) 927-6508.

Attachments

END

OF

RETAKE

Final Report of the Science Advisors to the Minnesota Public Utilities Commission:

Research Findings and Recommendations Regarding Claims of Possible Effects of Currents in the Earth on Dairy Cow Health and Milk Production

July 31,1998

Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, Minnesota 55101-2147

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Riley C. Hendrickson
Field Study Coordinator

[1] Alex Furo, Electrical Engineer and Consultant, was a Science Advisor from December 1994 until April 1998.

All findings and recommendations in this report are those of the Science Advisors who worked under contract to the Minnesota Public Utilities Commission, and do not necessarily reflect the views of the Commission.

TABLE OF CONTENTS

		Page
I.	Introduction	6
II.	Mail and Telephone Surveys of Minnesota and Wisconsin Dairy Farmers	7
	A. Mail Survey	7
	1. General Herd Information	8
	2. Clinical Signs of Herd Health Problems	8
	3. Perceived Causes of Herd Health and Production Problems	8
	B. Telephone Survey	8
	C. Conclusions	9
III.	Comparative Field Study of High Health and Productivity (HHP) and Low Health and Productivity (LHP) Dairy Herds on Minnesota Farms	10
	A. Overview	10
	B. Selection of Farms for Evaluation	11
	C. Field Study Process	12
	D. Field Study Results: Confirmation that HHP and LHP Herds are Different	13
	1. Herd Data	13
	2. Individual Cow Data	14
	3. Findings	14
	E. Field Study Results: Analysis of Non-Electrical Parameters	15
	1. Background	15
	2. Findings	15
	F. Field Study Results: Electrical Measurements	16
	1. AC Voltage	16
	2. Transient Voltage	20
	3. AC Magnetic Fields	21
	4. Interaction of AC and DC Magnetic Fields	22
	5. Pulsed Electric Fields from Cow Trainers	23
	G. Field Study Results: Electrical Inspection	24
	1. Hazardous Electrical Conditions	24
	2. Stray Voltage and Magnetic Field Conditions	24
	3. Farm Grounding Impedance and Primary Neutral Impedance	25
	4. Grounding of Submersible Water Pumps and Well Casings	25
	H. General Conclusions: Electrical Inspection	25
	I. General Conclusions: Electrical Measurements	25
	1. AC Voltage	26
	2. Transient Voltage	26

Page

3. AC Magnetic Fields 26
4. Interaction of AC and DC Magnetic Fields 27
5. Pulsed Electric Fields from Cow Trainers 27
6. Conclusions Regarding Sources of Earth Currents 27

J. Statistical Analysis of Possible Associations between HHP or LHP Herds and Selected Electrical and Non-Electrical Factors 28
1. Background 28
2. Findings 29
K. Field Study Conclusions 33
1. Characteristics of HHP and LHP Herds 33
2. Influence of Electrical and Non-Electrical Factors 33
3. Complexity of Possible Influences 33
4. Assessment of Need for a Larger Study 33
5. Choice of Farms 34
6. Value of Study to Individual Farmers 34

IV. Laboratory Studies in Progress 35

A. Part I: Short Term Exposure, Hoof-to-Hoof Sensitivity Testing, and Comparison of Behavioral to Physiological Responses 36
B. Part II: Comparison of Treatments Applied During Milking
C. Part III: Longer-Term Continuous Exposure to Sub-Acute Voltages 36
D. Research Schedule 37

V. Findings and Recommendations to the Minnesota Public Utilities Commission 39

A. General Findings 39
B. Recommendations 39

VI. Bibliography 40

VII. Appendices
A. Definitions of Technical Terms
B. Mail and Telephone Survey Instruments
C. Field Study Protocols
1. Electrical Measurements
2. Electrical Inspection
3. Veterinary Evaluation
D. Laboratory Research Proposal

I. INTRODUCTION

This is the final report of the Science Advisors to the Minnesota Public Utilities Commission (PUC). We are a multidisciplinary group with expertise in the fields of agricultural engineering, animal physiology, biochemistry, electrical engineering, electrochemistry, epidemiology, physics, soil science and veterinary science. The Minnesota Legislature authorized the PUC to establish a committee of science advisors in response to claims by some dairy farmers that electric currents in the earth from electric utility distribution systems are somehow responsible for problems with animal behavior, health and production problems of dairy cows. These claims were advocated by The Electromagnetic Research Foundation (TERF), a group consisting mainly of dairy farmers from Minnesota and Wisconsin. While TERF produced a report including anecdotal evidence, they did not propose a specific mechanism for how currents in the earth might interact directly with dairy cows to cause the problems with dairy production (TERF, 1994). It is important to note that the issues associated with currents in the earth from grounded electric distribution systems are quite different from concerns raised in the 1970's about Minnesota's DC power line and from ongoing controversies related to low frequency fields from overhead AC power lines.

On November 23, 1994 the PUC authorized us to carry out the following tasks:

(1) Review any evidence that might support the proposal that earth currents adversely affect dairy herd health and production.
(2) Determine whether further research in this area is warranted.
(3) Oversee any research proposed to resolve questions related to possible earth current effects.
(4) Provide recommendations to the PUC based on available evidence and the results of any research conducted with funds appropriated under the legislation.

We issued a Progress Report in January 1996 (Minnesota PUC, 1996) in which numerous electrical and related technical terms were defined[2], information from interested parties was reviewed, possible mechanisms of earth and ground current interaction with dairy cattle were hypothesized, and a research plan to address unanswered questions was proposed. We noted then that currents in the earth can only interact with dairy cows through their associated electric fields, magnetic fields and voltages, and that these parameters should be the focus of our analysis, rather than earth currents per se. The Commission approved our research plan in February 1996 and the Minnesota Legislature appropriated additional funding for some of the proposed work in April 1996 and again in April 1997.

This report is based on all of the reviews and analyses we conducted and upon the results of the dairy farm field study for which we served as advisors. Our overall conclusions and recommendations are given in Section V. Section II describes a survey

[2] The "Definitions" section of the 1996 Progress Report is included as Appendix A of this report.

of Minnesota and Wisconsin dairy operators that was designed to obtain information on the specific types of herd health and production problems and to assess the extent to which owners of dairy herds attribute such problems to stray voltage or other causes. Section III describes the results of a field study to assess possible associations between selected electrical and non-electrical parameters and the presence or absence of persistent problems associated with dairy cow health and milk production. Section IV describes laboratory research at the University of Wisconsin that is being funded by the PUC. Detailed descriptions of the field study protocols and the laboratory research design also are appended to this report.

II. MAIL AND TELEPHONE SURVEYS OF MINNESOTA AND WISCONSIN DAIRY FARMERS

Dairy herd owners in Minnesota and Wisconsin were surveyed in late November 1996 in a collaborative effort involving the Agricultural Statistics Services of Minnesota and Wisconsin, the University of Minnesota, the University of Wisconsin, the Department of Public Service of Wisconsin, the Minnesota Public Utilities Commission, the Minnesota Department of Agriculture, the Wisconsin Department of Agriculture, Trade and Consumer Protection, and various organizations representing dairy farmers and electric utilities in the two states. The objectives of the survey were: (1) to collect more comprehensive and valid information than had previously been available on the general health and milk production status of Minnesota and Wisconsin dairy herds and (2) to learn more about perceptions of dairy operators about electrical and non-electrical causes of persistent problems associated with health and production.

A. Mail Survey

The most comprehensive database on dairy herd operations is maintained by the National Agricultural Statistics Service of the U.S. Department of Agriculture. The PUC contracted with the Minnesota Agricultural Statistics Service to conduct mail and telephone surveys using the dairy operator listings in Minnesota and Wisconsin. At the time of the survey (November 1996), there were about 11,000 dairy operations in Minnesota and 25,000 dairy operations in Wisconsin.

Surveys were mailed to a random sample of 2,500 dairy operators, 1,250 from each state's database. Post card reminders and follow-up telephone calls were used to encourage response. Thirty percent (752) of the surveys were completed and returned. The purpose of selecting a random sample of dairy operators was to obtain results that would be representative of the entire population of Minnesota and Wisconsin dairy operations. The random selection method and the number of completed surveys obtained from the initial mailing suggests that the results are representative of the opinions and perceptions of herd owners in the two states.

The results of the mail surveys are as follows:

1. General Herd Information

Responses from dairy herd owners in Minnesota and Wisconsin were similar for almost every parameter addressed in the survey; thus all response data could be averaged for the two states. The average reported herd size (milking and dry cows) was 56, with a range of 10 to 385. Average daily milk production at the time the survey was taken was 52 pounds/cow/day for cows in milk and 42 pounds/cow/day when dry cows were included. From the dairy owners rough estimates, average annual mortality and culling rates for adult cows were calculated at 4.3 percent and 20.6 percent, respectively.

2. Clinical Signs of Herd Health Problems

Herd owners were asked how often each of 22 clinical signs of health or production problems were observed in their herds over the last 12 months. Respondents reported poor heat (estrus) expression, poor conception rate, and mastitis as the most frequently observed signs. Some of the least frequently observed signs were unhealed sores on cows' legs and bodies and various behavioral patterns (e.g., unusual behavior at the drinking cup, nose pressing, and excessive kicking).

Ten percent of all herd owners at the time of the survey thought that cows in their herds have persistent health and/or production problems. These dairy herds tended to have lower milk production rolling herd averages, higher somatic cell counts, and more frequent adverse clinical signs than herds for which no such problems were reported.

3. Perceived Causes of Herd Health and Production Problems

Herd owners were asked their opinions regarding importance of each of 26 factors in causing problems with animal health and/or production problems in their herds. Factors rated as most significant (top one-third) were forage quality, fresh cow performance, cow comfort, heat detection, and animal housing or environment. Factors rated as least significant (bottom one-third), were soil type, quality of outside experts' advice, stray voltage and other electrical phenomena, and chemical contamination of feed or water.

B. Telephone Survey

Each of the herd owners who had completed and returned a mailed survey was contacted by telephone to obtain more detailed information concerning their experience with on-farm investigations of stray voltage and related electrical phenomena. Ninety percent of those who completed and returned the mailed survey also participated in the telephone survey.

Principal findings:

- Thirty percent of the dairy herd owners reported that *at some time* they had a problem with herd health and/or production which they thought was caused mainly by stray voltage or some other electrical phenomena.
- Sixty percent of all dairy herd owners reported that their farms had been tested at least once for stray voltage; 15 percent reported testing for other electrical phenomena, such as magnetic fields, electric fields, EMF, ground currents or earth currents. Of these respondents, about one-half reported that the persons who conducted the tests informed them of stray voltage or other electrical conditions that should be corrected; eighty-seven percent of those with problematic conditions reported that corrective steps had been taken.
- Sixty percent of dairy operators reported that stray voltage testing was performed by employees of electric utilities. Thirty percent of dairy operators reported that electricians conducted such tests. Milk processing field representatives and dairy farm owners were also reported to have conducted stray voltage tests in 10-20 percent of the cases.
- Eighty-seven percent of dairy herd owners in Minnesota and Wisconsin who reported that electrical phenomena were investigated, also reported they were satisfied with both the investigations and attempts to correct stray voltage or other electrical conditions.
- Eight of the 679 owners in Minnesota and Wisconsin who both returned a completed mail survey and answered questions in the telephone survey, indicated that their herds presently had persistent problems with health and production and that they think uncorrected stray voltage or related electrical conditions are having negative effects on the health and production of their dairy herds.

C. Conclusions

The results reported here place dairy farmers' perceptions about stray voltage and related electrical conditions into context with the variety of non-electrical factors that have long been known to be associated with poor herd health and low milk production. From their answers to several of the questions in both the mail and follow up telephone surveys, it is clear that most owners of dairy herds in Minnesota and Wisconsin are much less concerned about stray voltage and other electrical conditions as the source of their unresolved health and production problems than claimed by TERF (TERF, 1994) and by individual dairy farmers who reported to us in public hearings during meetings at the PUC. Most dairy farmers who have had potentially problematic electrical conditions on their farms appear to follow up on them and are generally satisfied with the corrections recommended by electric utility representatives or other farm consultants.

The survey forms used and additional details on findings from the mail and telephone surveys are included in Appendix B.

III. COMPARATIVE FIELD STUDY OF HIGH HEALTH AND PRODUCTIVITY (HHP) AND LOW HEALTH AND PRODUCTIVITY (LHP) DAIRY HERDS ON MINNESOTA DAIRY FARMS

A. Overview

The focus of our charge as advisors to the PUC was to examine the effects, if any, of currents in the earth and related parameters on dairy cows. However, such a mandate could not be fulfilled without also assessing non-electrical factors. It has long been known that certain non-electrical factors can significantly increase problems with cow health and production. Of all the complaints brought to our attention by the PUC or directly by farmers where electric currents in the earth were said to be involved, none showed convincing evidence that non-electrical factors could be ruled out.

In addition, there is little information on the electrical conditions on farms that do not *have* persistent problems with health and production. Further, we could not find any study in which electrical measurement protocols had been used uniformly such that results could be compared from farm to farm. For these reasons, we designed a small field study to assess the effects of both electrical and non-electrical factors on the health and productivity of dairy herds. The study included two different kinds of dairy operations, those with persistent and unresolved health and productivity problems and those without such problems.

The primary objectives of the field study were:

(1) To test the feasibility of implementing protocols to routinely characterize dairy farms that would measure electrical factors, inspect electrical wiring conditions, and assess herd health and productivity.

(2) To determine whether it is possible in a small field study to document associations among specific electrical or non-electrical factors and the health and productivity of dairy herds.

(3) To assess the need for and approach to a larger scale study of potential factors that contribute to poor health and production of dairy herds.

The study did not evaluate on-farm or off-farm sources of electric and magnetic fields and voltages since the first step should be to establish whether the fields or voltages associated with earth and ground currents interact with the cow in the barn to induce health and production problems. Only if such an effect is found would it be appropriate to examine the sources and undertake some kind of mitigation.

The field study was carried out under contract to the PUC by Dr. Ashley Bellhouse and Dr. Will Marsh, both with the Department of Clinical and Population Sciences at the College of Veterinary Medicine, University of Minnesota, at the time of the study.

Dr. Robinson was selected for his expertise in veterinary epidemiology; Dr. Marsh was selected for his expertise in agricultural statistics.

B. Selection of Study Farms for Evaluation

Several approaches to the selection of farms for the field study were considered. One was to select farms directly from the Dairy Herd Improvement Association (DHIA) database, with one group at the high end of production and the other at the low end. This option was not selected because of concerns that the DHIA database may not represent all types of dairy operations in Minnesota. Also, many of the farmers who have raised concerns about earth currents are not members of DHIA. A second option was to survey veterinarians and ask them to identify dairy operations that seem to meet a pre-established set of conditions. This option was not chosen because of potential concerns about bias of the veterinarians and the fact that, in many cases, the serving veterinarians may not visit the farms regularly. The third option, which was chosen by the study directors, was to use responses of dairy herd owners to the mailed surveys since herd owners maintain the most comprehensive information pertaining to their herds.

Several conditions were established for a dairy operation to be a candidate for the field study. The herd owner must have (a) provided a completed response to the mailed survey (367 Minnesota dairy herd operators returned completed surveys); (b) responded to the follow up telephone survey questions (331 Minnesota dairy herd operators responded to the telephone survey); (c) had more than 30 cows in his or her herd; (d) reported conditions for the herd that placed it in either the "high health and productivity" or "low health and productivity" categories within the total population of respondents; and (e) expressed a willingness to cooperate with the on-farm study (over 95 percent of those who could be reached and who met criteria (a-d) agreed to cooperate).

Farms were chosen that were at the two extremes in health and productivity of the available population since such differences between the two groups would be most likely to reveal any meaningful associations between electrical or non-electrical factors. *Our aim was to identify at least 10 farms of each type, since samples of this size - if different enough in type -- may be large enough to provide statistically significant associations, yet small enough to be carried out in a single season by a single research team.*

The high health and productivity (HHP) herds and low health and productivity herds (LHP) were defined as follows: HHP herds were defined as those reported by the owners to have 3 or more of the following conditions: a rolling herd average of 18,000 or above pounds of milk/cow/year; somatic cell counts (SCC) below 250,000 in the last month recorded; cow mortality rates of 0 percent; cow culling rates of 15 percent or lower; and an average score of 1.4 or below on a scale of 1-5 that ranks ownership of each of 26 clinical signs characterizing the herd. Low health and productivity (LHP)

herds were defined as those with 3 or more of the following conditions as reported by the owners: a rolling herd average of 16,000 pounds/cow/year or less; an SCC of 350,000 or above in the last month recorded; a mortality rate of 6.8 percent or higher; a cull rate of 29 percent or higher; and an average score of 2.1 or higher on a scale of 1-5 that ranks severity of each of 26 clinical signs characterizing the herd.

Individual survey responses from the 331 Minnesota dairy operators who completed both the mail and telephone surveys were reviewed to determine which ones met at least 3 of the 5 criteria for HHP or LHP herds. These subgroups were contacted in March and April 1997 to determine whether they would participate in an on-farm field study. The telephone interviews were used to ascertain whether the circumstances on the dairy farm were still the same as reported in the previous November. If so, a visit was scheduled to the farm where one member of the research team met with the owners and reviewed milk production and other records to confirm the information provided in the surveys. Afterward, a total of 15 owners of potentially LHP herds and 15 owners of potentially HHP herds agreed to participate in the field study. Only 9 HHP herds and 10 LHP herds were finally chosen because the others were either borderline in meeting some of the criteria, or lived in geographic regions already represented in the study sample.

C. Field Study Process

The field study was conducted by a research team under contract to the PEC. The team consisted of a veterinarian, a specialist in electrical measurements, an electrical inspector, and two research assistants. One research assistant was responsible for pre-visit interviews and collection of available farm records. The other assistant was the veterinarian and the electrical measurement specialist. These detailed protocols for the 3-4 day site visits by the team are given in Appendix C and for the evaluation of herd health, production and management; and the inspection of the farm wiring and system for measurements of the electrical environment. The protocols were developed with our advice as well as input of staff from the PEC, the Public Service Commission of Wisconsin, the Minnesota Department of Agriculture, and the Wisconsin Department of Agriculture, Trade and Consumer Protection; and representatives of special interest groups including various farm and dairy producer organizations, electric utilities, research universities and others. The field study data was analyzed by Dr. Minch, with assistance from Ms. Doris Mold, also of the College of Veterinary Medicine of the University of Minnesota, and members of the field study research team.

The protocols were tested on two farms before the study of the selected 19 farms began. Data from these two farms were not included in the final analysis. The farm visits were conducted from early June through early October 1997. Members of the 4-person team (i.e., the veterinarian, the electrical inspector, the electrical measurements specialist and the field research assistant) were not made aware of whether a dairy operation was classified in the LHP or HHP herd category, with one exception. After the field data had been collected, the data were analyzed using another designation for

the farms and not the owners name. This "blind" study approach was used to preclude bias in data collection and the analysis.

D. Field Study Results: Confirmation that HHP and LHP Herds are Different

The 19 study farms were widely distributed throughout the state of Minnesota in a pattern that aligns with the known geographic distribution of dairy farms. The farms were concentrated around a line beginning in West-Central Minnesota, roughly following Interstate 94 from Fergus Falls to the Twin Cities, with the line then continuing into the south-east corner of the state. The herds of the 19 study farms ranged from 30 to 125 dairy cows; this range is similar to the herd size distribution of the 10,400 Minnesota dairy operations registered in the database of the Minnesota Agricultural Statistics Service at the time of the surveys were collected. Further, of the 19 study farms, 17 had stanchion and/or tie stall facilities and 2 were parlor facilities. This proportion (9:1) of stanchion and tie stall facilities relative to parlor facilities corresponds to that reported by the total group of respondents to the mailed survey.

The first step in the analysis of results from the field study was to confirm that the two study populations -- HHP and LHP herds -- were indeed different. Since the study farms were selected initially using only data from the survey responses of dairy herd owners, it was necessary to obtain data from owner records, coopery receipts and owner interviews to document that the information on the surveys was valid and up to date.

In this and subsequent analyses, mean values for a variety of descriptive and outcome parameters were derived for each group of herds, HHP and LHP, and then compared. The "P value" for each comparison was determined. The P value is a measure of the statistical association between two measurable parameters. The statistical significance of any correlation analysis increases with the size of the sample. In a small sample such as the 19 or fewer dairy herds in this study, P values can best serve as a screening tool for establishing a ranking among factors that may be of interest when comparing HHP with LHP herds. The lower the P value, the greater the probability that a real association exists. In this study, where the purpose is to identify specific factors that may be associated with certain outcomes, those factors with the lowest P values are of greatest interest.

1. Herd Data

Average rolling herd milk production and somatic cell counts (SCC) were obtained from up to two years of records on the 19 study herds. The mean rolling herd average for all farms was 56 pounds per cow per day, with a minimum of 25.3 pounds per cow per year and a maximum of 78.7 pounds per cow per year for the 3-year period ending in October 1997. The rolling herd average for HHP herds was 67.2 pounds per cow per year and for the LHP herds was 45.9 pounds per cow per year (P = 0.0001). The

mean SCC was lower for HHP herds than LHP herds (319,000 vs. 413,000; P = 0.0994). The mean bacteria count was also lower for the HHP herds: 28,000 vs. 9,000 (P = 0.0896). The owners also were asked to confirm the presence or absence of some of the 26 clinical signs they had reported in the mailed survey. Some of these parameters were later evaluated quantitatively as part of the veterinary protocol during the visit by the research team.

The other 3 parameters that were used initially to identify HHP and LHP herds from the dairy operators' survey data (i.e., annual mortality rate, annual culling rate and average score for clinical signs) were confirmed in interviews with the dairy operator by a member of the research team. However, the differences among the two groups of herds were not very significant. Rough estimates of the mortality rates and culling rates were based on discussions with the owner. According to these estimates, the mean annual culling rate for HHP herds was 34.5 percent and that for LHP herds was 28.3 percent (P = 0.33). HHP herds had an estimated annual death rate of 3.7 percent while the rate in LHP herds was 5.9 percent (P = 0.32).

2. Individual Cow Data

Further characterization of the differences among the two types of herds at the individual cow level was carried out as part of the study protocol. The veterinarian examined a total of 965 adult cows in the 19 herds. Cows in HHP herds were found to be taller (56.26 inches vs. 54.95 inches; P = less than 0.0001), heavier (1,359 vs. 1,305 pounds; P = less than 0.0001) and to have higher body condition scores (3.25 vs. 3.10; P = less than 0.0001) than their counterparts in LHP herds. Cows in the HHP herds were younger (4.23 vs. 4.69 years; P = 0.001), likely due to a younger age at first breeding (14.8 vs. 16.2 months; P = 0.0038), and had shorter inter-calving intervals as indicated by the lower average days in milk (177.6 vs. 196.1; P = 0.0010) at the time of farm visits. There was no difference in lactation number of cows in HHP and LHP herds (2.56 vs. 2.43; P = 0.2887). Individual cow data, although useful for confirming differences among HHP and LHP herds, was not used in subsequent analyses of risk factor associations because statistically, it is not appropriate to compare herd data (19 data points) with individual cow data (over 900 data points).

3. Findings

The above data show that the two groups of field study herds – HHP and LHP – are most clearly distinguished by the measure of pounds of milk produced/cow/day. This is also the most commonly used parameter to characterize overall herd performance in most research. The difference between HHP and LHP herds in mean somatic cell counts is also convincing given the low sample size. The other herd level data collected show various degrees of statistical differences among the two herds. There are also some very significant differences among the two types of herds when data on the individual cow level is used (e.g., height, weight, body condition etc.). After all the

data are considered, there are, indeed, significant differences between HHP and LHP herds.

E. Field Study Results: Analysis of Non-Electrical Parameters

1. Background

Some of the main outcomes cited by farmers who are concerned about possible effects of earth current are reduced milk production, increased somatic cell counts, reduced water consumption and hocks that are swollen or have sores and abrasions. However, there are known causes for these adverse health and production outcomes that are not electrical. These risk factors are described below.

Among the main risk factors for lowered milk production are poor nutrition, high environmental temperature, infectious diseases, milking machine defects and improper handling of cows by those who care for them. Water intake is also important in dairy cows and is primarily determined by 4 factors: dry matter intake, milk production, ambient temperature and sodium intake. Exceptions occur when cows are not able to swallow water because of some physical disability or when the cow cannot reach a water source. Over a period of several days, a cow must consume enough water either through drinking or in forages to maintain a balance in body compartments. A change in water intake can occur whenever one or more of the four major determinants of water needs is altered.

An elevated somatic cell count (SCC) in milk indicates that the mammary gland has an inflammatory condition and is shedding more cells than normal in the milk. Inflammation of the mammary gland can be caused by many factors such as traumatic injury or bacteria that originate in the environment or come from another cow through contamination of milking machine equipment, defective milking equipment or improper milking techniques. Improper nutrition can also lead to deficiencies in the immune system which are often associated with high SCC. In addition, poor environmental conditions such as dirty stalls and muddy pastures can produce high levels of contamination in the teat openings.

A lack of cow comfort and rumen acidosis are the primary causes of swollen hocks, abscesses, sore feet and nose bleeding. Small stalls and lots or no bedding commonly cause increased standing time and sore feet and swollen hocks. Rumen acidosis typically results from feeding high carbohydrate rations that, in addition to the signs listed above, increase the production of lactic acid, cause a secondary mastitis, and reduce rumen motility, feed intake and milk production.

The veterinary management protocol for the study herds on these main types of non-electrical risk factors which have been well-characterized in previous research (1) nutrition, as measured by dry matter intake, net energy, crude protein and fiber, (2) overall cow comfort, which takes into account size and cleanliness of stalls, bedding

levels and types, and ventilation; and (3) vaccination and related disease prevention practices.

2. Findings

Table I summarizes the data collected from the 19 herds on the key risk factors addressed in the veterinary evaluation protocol. The results of statistical analyses comparing these factors among the HHP and LHP herds are summarized in Section III, J.

Table I: Non-Electrical Risk Factor Findings – Range and Mean Values for the 19 Study Herds

Non-Electrical Factor	Range	Mean Value
Nutrition (percent of NRC[3] Recommendation)		
Dry Matter Intake	77.8 to 106.4 percent	97.3 percent
Net Energy	77.3 to 108.3 percent	97.3 percent
Crude Protein	61.5 to 121.4 percent	97.4 percent
Fiber	98.8 to 132.9 percent	134.1 percent
Cow Comfort[4]		
Comfort Score – Cows	1 to 4	2.81
Comfort Score – Heifers	1 to 5	2.36
Rubber Mats	5 of 17 stanchion and tie stall barns	
Stall Size[5]		
Width	40 to 54 inches	45.7 inches
Length	56 to 92 inches	69.2 inches
Vaccinations		
Cows	0 to 8	4.4
Heifers	0 to 8	4.1
(13 types possible)		

[3] NRC: National Research Council

[4] Cow comfort ratings were performed by the veterinarian on the research team using the following scoring system: 1 = clean, dry, well-bedded; good ventilation. 3 = adequate cleanliness, mostly dry, with some stale air. 5 = dirty, wet, with little or no bedding and stagnant air.

[5] Recommended stall sizes (Hutnink, 1990) are at least 45 inches wide and 59 inches long for a 1500 pound cow and 43 inches wide and 56 inches long for a 1500 pound cow.

F. Field Study Results: Electrical Measurements

In our 1996 Progress Report we identified five possible mechanisms by which the various electrical parameters associated with the electrical distribution system that supplies power to dairy farms could conceivably affect dairy cows' behavior, health or milk production (Minnesota PUC, 1996). The purpose of this section is to evaluate these hypotheses with the information now available.

The hypotheses are:

1. *AC Voltage*: Continuous or frequently repeated contact of confined cows to sources of low level stray voltage may result in electric fields inside the cow at levels high enough to produce biological effects without producing observable or measurable behavior modifications.

2. *Transient Voltage*: Current transients may affect a cow through the associated transient stray voltage or through magnetic induction. Examples include 60 Hz transients from motor starting events, and high frequency transients from electrical switching events and from malfunctioning cow trainers and electric fences. The sources of these transients can originate on or off the farm.

3. *AC Magnetic Fields*: Magnetic fields from AC ground current on water lines in the barn may be large enough at the head of a cow to induce biological effects.

4. *Interaction of AC and DC Magnetic Fields*: Exposure of cows to AC magnetic fields from all sources in the barn combined with particular levels of the geomagnetic field may conceivably produce biological effects.

5. *Pulsed Electric Fields*: Pulsed electric fields from sources such as cow trainers may be locally large enough at the cow's back to be sensed by cows.

In the following sub-sections the rationale for each of these hypotheses and is given together with the range of values obtained for each electrical measurement made across the 19 herds. Our conclusions from the electrical measurements and inspection components of the field study are also given. Measures for HHP and LHP herds are compared in Section III, J.

1. <u>AC Voltage</u>

Rationale: This mechanism was proposed because internal body electric fields of 0.01 volt/meter to 0.01 volt/meter have been shown to produce physiological responses in other animals, mostly rodents and small primates. Studies have indicated that internal electric fields within this range are associated with a change in bone formation in the isolated turkey ulna, a decrease in concentrations of metabolites of dopamine and serotonin in cerebrospinal fluid of sheep, and

decreases in testosterone concentrations in rats. Effects such as these can be either adverse, beneficial or neutral, and may be reversible. They are not necessarily applicable to dairy cow health or milk production. However, field strengths in the range of 0.001 volts/meter to 0.01 volts/meter could be induced in the head of a cow (depending on cow and contact electrical resistance), if the cow were exposed to 0.007 to 0.07 volts between water cup and rear hoof. Further, we estimated that a front-to-rear hoof step potential exposure of 0.002 to 0.02 volts would produce such field strengths in the cow's leg muscle tissue.

Results from the 1997 Field Study: The average exposure from water cup to rear hoof was 0.041 volts over 12 hours, 0.051 volts during a high electrical use hour, and 0.026 volts during a low electrical use hour. The average step potential in the stall was 0.006 volt over twelve hours, 0.008 volts during a high electrical use hour, and 0.005 volts during a low electrical use hour. The highest one-hour average cow contact voltage measured on the water line on a single study farm was 0.209 volts. This voltage is less than the 0.5 volts or higher necessary to initiate a behavioral response in dairy cows as presently established in the stray voltage literature. The highest step potential in a study barn stall was 0.047 volts, measured as a one-hour average. The step potentials measured in all of the study farm stalls were 10 to 100 times lower than the established threshold to initiate an observable behavioral response in dairy cows.

However, the measured voltages are high enough to support the low level voltage hypothesis. Twelve of the 17 stanchion and tie stall farms had water cup voltages higher than 0.007 volts (corresponding to an estimated internal electric field on the order of 0.001 volts/meter) as a 12-hour average. Five of 17 farms had water cup to rear hoof voltages higher than 0.07 volts (corresponding to an estimated internal electric field of 0.01 volts/meter). Considering the threshold range for step potentials as defined by the low level voltage hypothesis, the lower end of the estimated range of values for leg muscle tissue (0.002 volts) was exceeded as a 12-hour average on 14 of 17 farms; the higher end of the estimated range (0.02 volts) was exceeded on only one farm. Only the front to rear hoof step potentials measured in the study results in the continuous and longer term exposure required to satisfy the low level voltage hypothesis.

Measured AC earth current densities on 19 dairy farms included the range from 21 to 1139 microamps/meter^2 in the barnyards and from 2 to 184 microamps/meter^2 in the field away from the barn. The AC magnetic fields which result from these earth currents are too low to be measured, and are very much lower than those levels currently of concern in published reports. Therefore, if earth currents induce any kind of physiological response, it must be through the associated step potential across the ground. Measured open circuit step potentials (for a step of 1.5 meters) on these 19 farms ranged from 0.001 to 0.052 volts in the barnyard and from 0.0001 to 0.012 volts in the field. These voltages were all substantially lower when measured across a 500 ohm resistor similar to the electrical resistance of a cow.

These values were measured during a single season. Step potentials vary with soil resistivity which may change with soil moisture and temperature throughout the year. To examine this possibility, a long-term step potential measurement series was carried out at a rural residential site, the characteristics of which insured an adequate test of seasonal variations in earth current. Open circuit step potentials were measured infrequently (every one or two weeks) over a period of 17 months. No discernable pattern related to seasonal changes was evident in the data.

2. Transient Voltage

Rationale: In addition to steady state voltages, cows are exposed to transient voltages. The limited amount of research published on this topic suggests that overt behavioral and some physiological responses to transient voltages are similar to responses to 60 Hertz (Hz) voltages when comparisons are made based on total energy. Thus, since transient voltages have both a magnitude and duration, the shorter the transient duration, the higher must be the voltage to elicit the same behavioral response. Transient voltages found in the barn can be classified as either "60 Hz transients" due to high starting currents drawn by electric motors or "high frequency (HF) transients" which are usually caused by nearby electrical switching events and by malfunctioning electric fence and cow trainer systems.

Results from the 1997 Field Study: Transient voltages between cow contact points were measured using an impedance model of a cow which allowed simultaneous measurement of high and low frequency voltages (Anerhansley et al., 1995), (Stringfellow, et al., 1996). The largest 60 Hz transient voltage occurring between cow contacts on any of the 17 stanchion and tie stall barns in the study was 2.603 volts rms (between water line and rear hoof). This is marginally larger than the single-cycle voltage necessary to cause a behavioral response in 1% of the cows in a herd in another published study (Reinemann et al., 1996). The second-largest 60 Hz transient measured on any farm was 1.533 volts on the water line of another farm. Low frequency step potential transients were usually much smaller than those occurring on the water line. The largest 60 Hz step potential transient detected on any of the farms was 0.148 volts (the largest of seven similar events occurring on this farm in 12 hours).

High frequency (20 kHz to 10 MHz) transient voltages also were detected between cow contacts and recorded. They typically lasted from a few to a few hundred microseconds. Long transients often were composed of several shorter transients and were due to switch contact points bouncing upon closure. The largest water line to rear hoof HF transient had a peak voltage of 1.9 volts. High frequency step potential transients were detected on only two farms: On one farm they were shown to be caused by lightning, and were as large as 0.7 volts peak. On the other farm they were shown to be caused by a faulty cow trainer where the high voltage wire was in contact with barn metalwork; these were as large as 0.9 volts. High frequency transients were detected between the milk line and rear hoof on a number of farms. The largest high frequency transient on a milk line had a peak voltage of 2.48 volts.

In addition, high frequency transient voltages that exceed the 4 volt threshold of the equipment used in the study were measured on the barn neutral bus and referenced to a near (<20 foot) ground stake. On some farms, almost no high frequency transients above the 4 volt threshold were recorded on the neutral, while others had hundreds during a 12-hour period. On three farms, equipment caused neutral high frequency transients to occur every half cycle. These were traced to a kitchen range in two cases, a solid state motor controller for a barn fan, and a countertop air ionizer/purifier. The most common sources of high frequency transients found on farm neutrals, however, were electric fence and cow trainer systems. High frequency transients caused by these devices were detected on the secondary neutral of 14 of the 17 stall barns studied, although they were not always large enough to be recorded (i.e., above the 4 volt threshold) or observed between cow contact points (0.5 volt threshold). These transient voltages were caused by one or more of the following: (1) an energizer grounded to or near the electrical ground on 14 farms, (2) a high voltage wire in contact with barn metalwork or ground on five farms, and (3) a faulty energizer unit on four farms. While sources of transient voltages other than those from electric fences and cow trainers were not characterized in every case, it is well known that they are attenuated with distance due to reactive components in the circuit impedance. Therefore, high frequency transients are usually, but not exclusively, caused by nearby sources.

3. AC Magnetic Fields

Rationale: Cows are confined in stanchion or tie stall barns such that they are close to ground current on water lines, stanchions and other metalwork. The magnetic fields from these currents are not reduced by those from parallel return currents as with most modern electrical wiring. Localized magnetic fields due to ground currents in dairy barns could thus be problematic if they were much larger than about 10 milligauss.

A wide range of magnetic field exposure intensities has been studied in the laboratory. From the data in the literature, there is a general scientific consensus that fields of 1000 milligauss and above produce physiological responses in exposed animals. These effects may or may not adversely affect the health of these animals. Effects in animals below 10 milligauss have not been reported. Only a very few animal studies have been performed using field intensities between 10 and 100 milligauss. Most studies in this range showed no effects. Some studies in the 10 to 100 milligauss range have shown both a reduction in the hormone melatonin in rats and changes in the development of chick embryos, but such changes have not been reported in studies involving humans. Four independent laboratories have found effects in cellular systems (e.g., effects in growth of breast cancer cells in culture) at levels as low as 12 milligauss. Physiological effects have been reported in laboratory studies where animals were exposed to fields between 100 and 500 milligauss. However, results of these studies are mixed; some report field-associated effects and some do not. Effects in animals exposed to this higher range generally have not been independently replicated. In contrast to laboratory animal experiments, evidence in isolated cell systems suggests that only

significant effects with exposures above 100 milligauss. In light of the laboratory study results, data from epidemiological studies are perplexing in that associations between exposures to magnetic fields and adverse health effects in humans have been reported in a fairly large number of studies at levels below 10 milligauss, but above approximately 2 or 3 milligauss. However, firm connections have not been established between such field levels and effects, primarily due to imprecision in assessments of exposure levels. In most human epidemiological studies, it has been difficult to establish both the duration and the intensity of exposure of individuals.

Results from the 1997 Field Study: In each of the 17 stanchion and tie stall barns studied, the 60 Hz magnetic flux density was measured at the cow's head, at the top of the back closest to the overhead water line, and at the base of the tail of each cow. The barn was surveyed during a milking period when barn neutral voltages and ground currents were highest. The barn was also surveyed during an electrically quiet period. Data show that the average exposure of dairy cows in this study was at a fraction of one milligauss. Rarely did exposures exceed several milligauss. The largest single measurement of magnetic flux density on the 17 farms was 9.56 milligauss at the back of a cow; this was caused by an electrical appliance (cow trainer energizer) and disappeared within 1 meter (<0.04 milligauss at the tail of the same cow). These data illustrate that the AC magnetic flux density is commonly highest at the back of each cow (averages across all stalls and farms during milking were 0.44 milligauss at the head, 0.68 milligauss at the back, and 0.39 milligauss at the tail). This is due to proximity of the cow's back to ground current carried by the water line or metal vacuum line to which the barn neutral is bonded.

4. Interaction of AC and DC Magnetic Fields

Rationale: Mechanisms other than Faraday induction have been proposed in the published literature to explain effects attributable to alternating magnetic fields. Several laboratory studies have shown physiological effects that depend upon the simultaneous presence of a DC (static) magnetic field and an AC (alternating) magnetic field of at least one tenth the magnitude of the static field, or above 50 milligauss. Other, more recent studies have indicated effects on cell cultures at 10 milligauss. In addition, laboratory studies are underway to confirm isolated reports that ac magnetic fields at or below 1 milligauss may affect biological systems in the presence of a dc magnetic field.

The magnitude of the DC field determines particular frequencies ("ion cyclotron resonances") at which systems respond. Responses have, for example, been observed in solutions of amino acids. Possible mechanisms to explain these experimental results comprise an active area of research. Other research has established the effect of relatively large, at least 500 milligauss, static and slow varying fields on chemical and biochemical reactions involving free radicals.

Results from the 1997 Field Study: Magnetic fields were examined in detail for one short time period in one stall for each of the 19 of the farms in the field study. Both ac and dc magnetic flux densities were determined for multiple points in the stalls of stanchion or tie stall barns and parlor barns. Then cyclotron resonance conditions for six biologically important ions at 60 Hz were evaluated at each grid point. Resonance (or near resonance) conditions were observed for one or more of the ions to some degree on each farm. The ions K^+ and Mg^{2+} scored the highest when summed across all farms, then, in descending order Cl^-, H^+, Li^+, and Ca^{2+}. However, the single highest alternating magnetic flux density recorded during these measurements was 9.24 milligauss, which is still lower than the lowest field level (12 milligauss) at which physiological effects have been demonstrated in laboratory cell cultures.

5. Pulsed Electric Fields from Cow Trainers

Rationale: Exposure to electric fields in air has been shown to affect biological systems only at magnitudes of several kilovolts/meter. Such fields are found, for example, between a high voltage transmission line and the earth. In a dairy barn, the only source of large electric fields is the cow trainer system. The currents induced in a cow from such high frequency pulsed fields may be strong enough to be sensed. Soreness might be expected with pulsed electric fields larger than 5 to 10 kilovolt/meter.

Results from the 1997 Field Study: For each barn in the field study the peak pulsed electric field was approximated by dividing the cow trainer peak voltage by the average height of the trainer bar above the cows' backs. Average heights of trainer bars ranged from 6.4 centimeters (cm) to 11.2 cm with a mean of 8.1 cm. Peak output voltage ranged from 0.88 kilovolts to 3.0 kilovolts with a mean of 2.0 kilovolts. The calculated average peak electric field varied from 13.9 kilovolts/meter to 43.3 kilovolts/meter with a mean of 25.3 kilovolts/meter. The cow might be able to sense the field at these levels. These field values should be considered to be only representative; higher or lower fields exist as the bar height above the cow changes, as it does often during the day for all cows with normal movements in their stall.

Charge transfer via high frequency conduction is likely to exceed that due to pulsed electric field induction. As noted above, pulses from cow trainer or electric fence were found on the barn neutrals of 14 of the 17 study farms. We estimated that a cow trainer could induce a current in the cow of 0.5 amperes with a duration of resistance x capacitance = 3 nanoseconds, equivalent to a charge transfer of 0.0015 microcoulombs. For comparison, if voltage pulses of 0.1 volt appeared for 100 microseconds between cow contacts, this would result in a charge transfer by conduction of Q = volts x time/resistance = 0.033 microcoulombs, assuming a cow impedance of 300 ohm at a frequency on the order of $1/(100 \cdot 10^{-6}) = 10$ kilohertz. This 'conducted' charge resulting from a nominal, negligible cow contact treatment of 0.1 volts is approximately 20 times the estimated charge transferred via electric field induction.

G. Field Study Results: Electrical Inspection

Farm wiring was inspected to identify conditions that could cause or contribute to the voltage, magnetic field and electric field levels measured in the study. Electrical systems on the farms were evaluated with respect to requirements of the National Electrical Code (NEC) as they apply to secondary grounded neutral electrical systems. The properties of interest were those that may affect (1) neutral-to-earth voltage, (2) voltage relative to earth on equipment connected to equipment grounding conductors, and (3) flow of load current through any path external to the intended circuit conductors.

The electrical inspection of the farms included a preliminary inspection of the premises, a survey of the barn and associated equipment for hazardous electrical conditions, an inspection of the barn and associated equipment for conditions that could produce stray voltages and magnetic fields, a check of the secondary distribution system neutrals and grounding on the farm, an evaluation of the approximate farm grounding impedance and the primary neutral impedance, and a check for grounding of submersible water pumps and well casings. Observations noted during these inspections follow:

1. Hazardous Electrical Conditions

Six farms had line connections supplying main circuit breakers that were severely overheating and in danger of imminent failure. Every farm had one or more pieces of equipment that were not grounded. All but two dairy barns had one or more ungrounded units; some had several. Thirteen had one or more buildings that did not have a grounding electrode as required by the NEC. Interior water piping systems were generally not bonded to the electrical system except through bathroom connections at equipment such as water heaters. Some extensions of service entrances were not bonded (grounded), raising the shock hazard. A number of barns had "temporary" or other makeshift wiring such as extension cords. One farm lacked any connection between the neutral and ground, a condition which could potentially elevate the farm grounding system to 120 V. Many older buildings were wired through original, often bare conductors or conductors with badly deteriorated outer jackets.

2. Stray Voltage and Magnetic Field Conditions

The neutral-to-earth voltage in several barns could have been substantially reduced by balancing 120 volt loads such as lights and fan circuits. One farm had an isolation device at the barn service entrance that was ineffective because of a previously undiscovered bypass in a wiring circuit in the barn. One farm had a bad neutral connection resulting in 5 volts on the neutral in outbuildings and a cattle waterer. Another neutral connection on this farm was worse and would fail eventually. Another farm supplied power to a cattle shed through underground wiring resulting in 3 volts on the neutral with a 10 ampere load. One farm had an open neutral in the feeder to a

machine shed. Two farms had high resistance barn neutrals resulting in elevated neutral-to-earth voltages. In at least three barns, 120 volt loads were improperly supplied from 240 volt circuits that did not contain a neutral, but an equipment ground was present. This produced a flow of current on the grounding conductor that caused elevated ac magnetic fields. Eight barns had more than one service (an accepted practice), resulting in at least one case where interconnections raised the magnetic field level in the barn by 1 to 3 milligauss. Several failing conductor connections occurred because oxide inhibitor was not used when terminating aluminum conductors.

3. Farm Grounding Impedance and Primary Neutral Impedance

Farm grounding impedances ranged from 0.2 to 2.6 ohm with an average of 1.1 ohm. Primary neutral impedances ranged from 0.2 to 1.0 ohm with an average of 0.48 ohm.

4. Grounding of Submersible Water Pumps and Well Casing

Few submersible pumps or well casings were grounded according to NEC requirements. Where grounds were used, grounding impedances were generally about 5 ohm.

H. General Conclusions: Electrical Inspection

The field study indicates that farm wiring is likely to result in hazardous conditions on many Minnesota farms. In many cases farm wiring resulted in elevated neutral-to-earth voltages in the barn. These hazardous conditions appear to be caused by the following factors:

* A substantial amount of wiring was done by the owner, operator, or other persons without electrical training.
* Many code violations were present in work done by electrical contractors.
* Electrical inspectors failed to note or did not require correction of some code violations.
* The wiring in general was not properly maintained or replaced when it became defective.

This situation could be improved by providing information to the users, improving the training of electricians, and by more effective administration of electrical inspection statutes in the state. Also, a re-inspection program, if implemented, could be effective.

I. General Conclusions: Electrical Measurements

The 1997 field study was one vehicle for examining whether certain electrical parameters can be found to be within the range needed for any of the five hypotheses cited above to be relevant. We have used this examination for serving primarily for

further research. For each of the five electrical hypotheses posed in our 1996 progress report, we conclude the following:

1. AC Voltage

The range of average front to rear hoof step potentials of dairy cows in stalls on the 17 farms where the measurement was made was 0.001 volts to 0.047 volts. Using data from published studies on animals other than dairy cows, we have estimated that voltages as low as 0.002 volts could conceivably cause internal electric fields in the cow that are high enough to produce a physiological response. If a physiological response is to occur in dairy cows, it is more likely to be produced by step potential exposures in the stalls rather than outside because (1) step potentials in the stall are larger than outside and (2) step potentials in the stall last longer because of long periods of cow confinement.

No one has proposed a specific physiological response in dairy cows that are exposed to low level voltages (i.e., 1-100 millivolts range). It is not possible to extrapolate directly the research findings from other animal species directly to dairy cows. The various types of physiological responses (e.g., circulating hormones or their metabolites) to electric and magnetic field exposures that have been shown in the published literature to occur in various animals other than dairy cows, are neither equivalent to nor indicative of pathological effects that cause poor health and production in dairy cows. Since it is not possible to extrapolate to dairy cows, we recommend further studies that specifically examine exposure of dairy cows to step potentials lower than those threshold levels already known to elicit behavioral responses.

2. Transient Voltage

Measured magnitudes of transient voltages are lower than would be necessary to elicit a behavioral response in dairy cows according to the most recent laboratory research. Further, data from the field study demonstrate that transient voltages in a dairy barn are most often from nearby sources, a finding which supports previous research.

3. AC Magnetic Fields

Adverse physiological or biological effects of ac magnetic fields at levels in the range of those found in the field study have not been documented in the laboratory (Reinemann et al., 1996, and Burchard et al., 1996). As noted in Section III P. 3, laboratory research on other animals has demonstrated effects caused by ac magnetic fields, but these results involve field strengths generally well above the 10 milligauss measured in this study. No AC magnetic fields were detected away from outside distribution lines; thus, there were no measurable ac magnetic fields associated with electric currents in the earth. These findings indicate that, at this time, further research on effects of AC magnetic fields on dairy cows is not a priority.

4. Interaction of AC and DC Magnetic Fields

Some magnetic resonance conditions were found in the test stall at each of the farms studied. However, even the largest, single ac magnetic flux density measured in the field study was not as large as those used in published laboratory studies where effects have been observed. Because of this large difference, the likelihood is low that cyclotron or ion parametric resonance has affects cows under normal circumstances. Thus, further research on the interaction of AC and DC magnetic fields in dairy cows is not a priority at the present time.

5. Pulsed Electric Fields from Cow Trainers

There does not seem to be a practical need to further study pulses of electric fields from cow trainers. As more farmers expand herd size and adopt free housing for dairy cattle, the need for these devices will be reduced. The likelihood of electrical problems associated with improperly installed or malfunctioning cow trainer systems is high, and the pulsed electric fields from normally operating cow trainers may be large enough to be sensed by the cow. If trainers are perceived to cause problems, farmers can work to improve installation practices or discontinue using them altogether. There are many reasons why even the best installation and maintenance practices can lead to cow problems over time. Intentionally shocking a cow when she strikes her back has been judged not to be justifiable in Sweden.

The findings from the field study support placing the greatest priority on future research that addresses continuous or frequently repeated contact of confined cows to sources of low level voltage which may produce internal electric fields at levels high enough to produce physiological responses. The range of step potentials measured in the test stall on the 17 farms was 1 to 47 millivolts. The prediction in the original hypothesis was that physiological responses might be induced with exposures as low as 2 millivolts. A laboratory investigation of the low voltage hypothesis is warranted and has already been initiated (see Section IV). If additional research funds were to become available, then basic research in the area of magnetic field effects (beneficial, adverse or neutral) would also be useful, particularly because the threshold magnitude of magnetic fields exposure expected to elicit some type of response decreases as more studies are undertaken at progressively lower exposures (i.e., into the 10 milligauss range).

6. Conclusions Regarding Sources of Earth Currents

As noted in section III-A an extensive evaluation of the relative importance of on-farm and off-farm sources of earth currents and related step potentials or magnetic fields was not an objective of the field study, because it was to be established first whether such potentials or fields at the small expected amplitudes could be related to milk production or animal health. Furthermore, the measurements necessary to establish conclusively the sources of currents on the farm would have made the measurements prevent

prohibitively time consuming and expensive. However, in view of concern about earth currents expressed by some farmers and the field study results concerning step potentials and soil resistivity, it is still useful to extract from the available field study data all possible information about source location.

If the source of step potentials is in the barn, one would expect that step potentials should fall off with distance from the barn. Indeed, in most of the study farms step potentials in the stalls were higher than they were in the barnyard and much higher than in the field. All exceptions were in the five barns where rubber mats were used which imposed a high resistance between the floor and the rubber mat standard the animal and across which the step potential was measured. Furthermore, the step potential was always larger in the barnyard than in the field, often by an order of magnitude. The only exceptions were two farms, one where a transmission line was located at 0.1 mile from the farm (potential in the field = 1/2 potential in yard) and the other where a combination of increasing soil resistivity with distance and an overhead transmission line over part of the measurement path led to about equal step potentials in the field and barn yard. These data can suggest that cumulative background earth current density due to off-farm sources is relatively small unless these sources are close to the farm or are extremely strong compared to earth currents from sources such as ground currents flowing to earth on stall pipes. It is well known that step potentials decline as one moves away from ground rods or other grounding electrodes. However, it must be pointed out that multiple grounds, connected directly (or indirectly, i.e. through a close earth path when "isolation" is used) to a primary ground can also concentrate current from distant sources when the potential difference between the ground and the distant source is large enough. The reason for this is that a potential difference between a single "point" (the farm) and a distant distributed source will lead to current concentration at that point. Thus, while data from the field study suggest that in most farms the predominant source of earth current was local, a free exchange of current sources would have required additional measurements. Current from distant sources can also access the farm through the primary/secondary neutral bond on farms that are not isolated.

J. Statistical Analysis of Possible Associations between HHP or LHP Herds and Selected Electrical and Non-Electrical Factors

1. Background

The goal of the field study was to collect data that could be correlated with herds in the HHP and LHP categories. The average values of data associated with each group for a specific factor provide an initial indicator of a possible association between the factor and high or low health and productivity. A factor or variable that shows a possible association may or may not be a cause of the differences that characterize the LHP and HHP herds. The P value for comparing averages indicates the statistical significance that can be attached to the differences in averages. Low P values indicate a high

statistical significance for an association. High P values indicate a low statistical significance. In addition to the statistical comparison of averages of factors for LHP and HHP herds, all factors measured for each of the 19 herds in the field study were combined in a single data set and assessed by a second statistical procedure called Pearson correlation coefficient analysis.

By using these two statistical methods – comparison of averages and correlation coefficient analysis – the relative significance of all the possible risk factors can be assessed. For example, if a comparison of average values for a particular measurement shows a significant difference between LHP and HHP herds, such as $P = 0.04$, the degree of significance is strengthened if the correlation coefficient analysis also gives a low P value (e.g., $P = 0.05$). When the P values are low for both statistical tests, it is more likely that the data will continue to show the same trend even if more data points (i.e., larger sample size) are added. If the P value for the correlation coefficient analysis of a particular variable plotted against pounds of milk/cow/day proves found to be relatively high (e.g., 0.3 or higher), this indicates that there may be some spurious or "outlier" data points that account for the observed "significant" difference in the comparison of averages between LHP and HHP herds.[1]

2. Findings

The results of the statistical analyses are given in Table 8. This table shows that HHP herds were offered more high-energy feed (i.e., dry matter intake and net energy in feedstuffs were greater), were provided with greater cow comfort (i.e., overall losses were higher and cows had larger stalls) and were more likely to have a ventilation program. In addition, HHP cows were exposed to lower electrical voltages between the milk line and cow hoofs, lower average cow potentials, lower soil resistivity in the field, and higher magnetic fields. The Pearson correlation coefficient analysis showed that net energy in feedstuffs, cow ventilation score, cow comfort score and dry matter intake were strongly correlated with milk production. Less strongly correlated with milk production were soil resistivity in the field and average cow potential during low electrical use. Factors that did not correlate well with milk production were soil

[1] The Pearson correlation coefficient analysis was performed to measure the strength and direction of linear associations between pounds of milk/cow/day as the best and all other variables in turn. The different variables tested could have a positive or a negative correlation coefficient. "No," between -1 and +1 (" + " the values indicate that the factor increases with milk/cow/day; " - " the values indicate that the factor decreases with milk/cow/day). The correlation coefficient analysis also yields a "P" value. This P value tests strength of association of the factor with milk/cow/day. It says the probability that the association is unlikely to have occurred by chance. A high P value indicates that the association is likely to have occurred by chance. This is a measure of the strength of the association between the factor and milk/cow/day. If the factor increases by a certain number of units, then milk production should likewise increase. The values closest to +/- 1.0 indicate the strongest correlations between the factor and milk/cow/day.

resistivity in the barnyard, maximum voltages between the milk line and the cow's hoofs, cow comfort scores for calves, magnetic fields, and average voltages between the milk line and cow's hoofs during low electrical use.

The data indicate that good nutrition, cow comfort and a vaccination program are significant factors associated with higher health and productivity. Soil resistivity in the barnyard was not well correlated with milk production. Soil resistivity in the field, while correlated with milk production, may be related to the amount of water, electrolytes, soil fertility and nutritional quality of forages grown in the field, may vary greatly, and from a practical standpoint, may not be easily controlled. Higher soil resistivity also leads to greater dispersion of the earth portion of the unbalanced current underneath the neutral wire of a distribution line (Pender, 1996).

Amounts of feed offered daily to lactating cows varied between 52.0 and 93.6 pounds on an as-fed basis, which corresponds to a range of 36.6 to 13.7 pounds per cow per day on a dry matter basis. On average, cows in HHP herds were given the opportunity to consume more dry matter per head per day than cows in LHP herds (43.8 vs. 44.3 pounds, $P=0.049$). Rations for HHP herds contained more net energy for lactation (36.9 vs. 31.6 percent, $P = 0.0059$) and crude protein (7.8 percent vs. 7.0 percent, $P = 0.1994$).

When compared to published National Research Council standards, rations fed to cows in HHP herds met or exceeded requirements for dry matter intake, net energy for lactation, and crude protein. Conversely, the amount of dry matter offered to cows in LHP herds averaged 2.75 pounds per head per day below NRC recommendations. Consequently, rations for LHP herds contained insufficient energy to support a desirable level of milk production while maintaining body conditions. In order to meet NRC requirements, cows in the LHP herds would, on average, need to be fed 5.7 percent more dry matter, 5.9 percent more crude protein and 7.8 percent more energy per day than was offered to them to adequately meet the nutritional demands of their level of milk production at the time of the site visits. Based on the Acid Detergent Assay (see protocol in Appendix C 3), the amount of fiber in rations fed to lactating cows in all herds studied was well in excess of NRC requirements.

Cows are effectively insulated from milk line voltages because of the high resistance of plastic milk hoses and the air pockets in the milk stream during milking. Cows otherwise do not make contact with the milk line. The maximum voltages between milk line and hoofs measured in the field study represent one 60 Hz transient voltage on each farm, and are too low to produce a behavioral reaction according to the most recent research measuring performance of dairy cows while subjected to these types of transient voltages (Reinemann, 1997). Step potentials were well documented in the stall in each dairy barn. They were 4.2 times higher on average on LHP farms than HHP farms, indicating a possible electrical association. However, the step potential values from measurements made on cows in the HHP herds could have been lower than those for LHP herds simply because of the insulation provided by rubber mats used in

the stalls (i.e., 5 of the 8 HHP herds housed in stanchion or tie stall barns used rubber mats in the cows' stalls; 0 of the 9 LHP herds used rubber mats).

Table II: Low Health and Productivity (LHP) and High Health and Productivity (HHP) Herds Compared by Average (Mean) Scores for Various Factors[7]

	Discrimination Between LHP and HHP Herds			Correlation with Milk/Cow/Day	
Risk Factor	LHP Herds (Avg.)	HHP Herds (Avg.)	P value[8]	Correlation Coefficient (rho)	P value
Use of mats in stalls (17 stanchion and tie stall barns only)	0 of 9	5 of 8	0.0003	Not done	Not Done
Net energy in feed stuffs (percentage)	31.6	36.9	0.0039	0.515	0.0007
Cow vaccination score (13 types of vaccinations possible)	3.1	5.9	0.0039	0.705	0.0005
Comfort score – cows[9]	3.1	2.1	0.0039	-0.772	0.0001
Maximum AC voltage between milk line and cow hoofs	0.63	0.25	0.0039	-0.176	0.4859
Stall length (inches)	64.0	71.7	0.0046	0.488	0.0179
Dry matter intake (pounds/cow/day)	44.3	48.3	0.0046	0.564	0.0042
Soil resistivity in barnyard (ohm-cm)	5060.4	1982.0	0.0056	-0.351	0.1163
Comfort score – calves	1.3	2.4	0.0064	-0.319	0.1562
Soil resistivity in the field (ohm-cm)	9726.4	2554.0	0.0068	-0.434	0.0426
Average step potential, low electrical use (volt)	0.0005	0.0047	0.0073	-0.441	0.0395
Comfort score – heifers	1.3	2.4	0.0078	-0.364	0.1106
Magnetic field at the cow's back during milking (milligauss)	0.35	1.31	0.0079	0.269	0.2183
Average AC volts between milk line and cow hoofs, low electrical use	0.0043	0.0287	0.0083	-0.193	0.4206

[7] Data is ordered from lowest P value for the comparison of averages to highest P value. Herds with both were included for all herd parameters except those indicated.

[8] P value calculations were based on a two sample "T" test for all variables except for use of mats in stalls, for which a chi square test for independent variables was employed.

[9] Cow comfort ratings were performed by the veterinarians on the research team using the following scoring system: 1 = clean, dry, well bedded, good ventilation. 5 = adequate cleanliness, mostly dry, with some stale air. 9 = dirty, wet, with little or no bedding and stagnant air.

K. Field Study Conclusions

1. Characteristics of HHP and LHP Herds

The average milk production (pounds/cow/day) for a two-year period prior to the study was the major difference between HHP and LHP herds. In addition, the herds differed in cow height, weight, body condition, age, calving intervals, etc. Some of these factors used to differentiate among the two productivity groups may themselves influence herd productivity (e.g., average size and weight of cows).

2. Influence of Electrical and Non-Electrical Factors

There is convincing evidence that several of the non-electrical risk factors measured are associated with the LHP herds. The risk factors found to be of greatest importance in LHP herds were lower standards for nutrition, cow comfort and the use of vaccinations to prevent infectious disease. There is a lower association with both step potential during low electrical use times and soil resistivity in the field. Step potentials were in the range of those predicted by the low level voltage hypothesis to induce some kind of physiological response. The use of rubber mats likely contributed to lower step potentials on 5 of the HHP farms; nevertheless, there was a difference between HHP and LHP herds.

3. Complexities of Possible Influences

The field study provides further documentation of how the dairy farm environment represents an extremely complex web of potentially interacting variables that can positively or negatively impact overall productivity. Some of the factors identified with low or high health and productivity in the field study could be possible causes of the conditions. Alternatively, they may be confounders of other factors or indirect effectors (e.g., smaller cows have smaller rumens and smaller appetites which can, in turn impact production of milk; soil resistivity in the field can impact feed and then affect overall nutrition and milk production.). It is important to note, however, that we cannot make definitive statements from this field study about possible "causes" of herd health and productivity problems. This would require conducting experiments that control for one variable at a time. By the same token, a positive result in a controlled laboratory experiment may not necessarily reflect what actually would occur in an on-farm context where the single variable under study would never exist independently of all others.

4. Assessment of Need for a Larger Study

One purpose of the pilot field study was to determine whether a larger scale study (e.g., 50 or more farms) is feasible and warranted. Such a large study is neither practical nor warranted. While there were only 19 herds in this field study, it was possible to identify variables that associate clearly with HHP and LHP herds. Data from this study

can be used effectively to prioritize which electrical variables should be included in any future field or laboratory studies. The low level step potential hypothesis is supported by the data in the field study and this is being pursued in the laboratory (see Section IV). Scaling up the field study to 50 or 100 herds may be prohibitively expensive (at least $500,000); further, statistics from the 19 farm study indicate that more data is unlikely to change the present findings, especially for the non-electrical and electrical factors that show major differences between LHP and HHP herds. In addition, it is desirable to conduct the study in a single season so that seasonal variations would be excluded. In order to conduct a larger study in a single season, multiple research teams would be required; however, such multiple teams would reduce the uniformity of the approach.

5. Choice of Farms

In the design phase of the field study, there were suggestions that the study sample should include more of the 1.2 percent of dairy operators who reported that persistent health and production problems on their farms were caused by stray voltage or related electrical conditions. In fact one such respondent was selected in the initial screening. This dairy owner's herd did meet the study criteria and was included among the 19 farms in the study. We concluded that the perceptions of farmers about the possibility of electrical causes of problems with herd health and production are not sufficiently objective to use as a basis for farm selection. Further, we concluded that a more objective basis for choosing farms was needed, and that it should be based on well-documented outcomes rather than qualitative perceptions of causes. Thus the two groups of study farms in the field study were identified on the basis of outcomes such as milk production.

6. Applications of the Field Study

In addition to future research possibilities, the results of this study can guide individual dairy farmers to prioritize those factors most strongly associated with herd health and production problems on the typical dairy farm. Further, the protocols that were developed in the study can be used to evaluate the factors that are of greatest potential concern. Brief, confidential reports were developed and provided to individual study participants. The veterinarian, the specialist in electrical measurements, and the electrical inspector who collected data on the farms prepared these reports. Dairy operators reported that these summaries were very helpful. The protocols developed for this study and the approach to reporting could easily be adapted for use in investigations by others who want to assist dairy operators.

IV. LABORATORY STUDIES IN PROGRESS

The combined electrical data from the field study indicated that while none of the five electrical hypotheses can be ruled out, only one of them is a priority for research at this time. The hypothesis states that, *Continuous or frequently repeated contact of confined cows to sources of low level stray voltage may result in internal electric fields at levels high enough to produce biological effects.* A laboratory study to test this hypothesis under controlled conditions was proposed by a team led by Dr. Douglas Reinemann, Associate Professor in the Department of Biological Systems Engineering at the University of Wisconsin, Madison. The PUC contracted with Dr. Reinemann and his colleagues to conduct the laboratory study. The research was initiated in May 1998.

The laboratory study has four major objectives:

1) Investigate immune function response to continuously applied, low-level voltage. The presumed pathway of exposure is hoof-hoof step potential.
2) Compare dairy cow sensitivity to voltage applied hoof-hoof with muzzle-hoof pathways.
3) Investigate the relationship between behavioral responses previously observed and other physiological methods of quantifying stressors.
4) Compare responses to low voltage exposure and responses to other stressors.

Three experiments will be conducted to meet these objectives. Two types of voltage and current exposures will be performed as described below. Short-term exposure (from 1 to 10 minutes) will be used for Parts I and II and objectives 2, 3, and 4. Longer-term (2-week) continuous exposure will be used for Part III and objective 1.

A. Part I: Short-Term Exposure, Hoof-to-Hoof Sensitivity Testing, and Comparison of Behavioral to Physiological Responses

Previous methods have relied primarily upon behavioral response as an indication of the sensitivity threshold to electrical exposure. Behavioral responses have also been used by several other researchers to measure the threshold response to voltage exposure. As stated in our 1996 report, "less subjective and more quantitative dairy cow behavioral response indicators and more reliable physiological response indicators are desired in further laboratory studies." Recent studies indicate that behavior and performance are reliable indicators of stress (Hicks et. al., 1998; Turner et. al., 1996). These reports provide evidence that behavioral, endocrine and immune system studies combined with studies on performance criteria, such as fertility, reproduction, weight of newborns, dry matter intake, weight gain, feed conversion, body condition, and milk production are required to fully assess potential harmful impacts of stressors.

Little work has been done to document hoof-hoof exposures, yet this is a common exposure pathway in the field. Short-term experiments involving acute exposures will

be performed to establish the relationship between sensitivity to hoof-hoof and muzzle-hoof pathways.

Four cows each will be tested using the muzzle-hoof pathway and the hoof-hoof pathway. The following day each cow will be tested using the alternate pathway. These tests will establish the threshold behavioral response level for each cow.

The test cows will then be exposed to the hoof-hoof pathway for at least 3 days. Blood samples will be drawn at 15-minute intervals for 1 hour before testing. The main physiological measures will be endocrine response. Each cow will then be exposed to current equal to 50%, 75% and 100% of the sensitivity threshold determined in the first part of the experiment. If no behavioral response is found a fourth level of 150% of the sensitivity threshold will be applied. These voltage exposures will be applied for 5-minute intervals once every hour. Blood sampling will continue at 15-minute intervals throughout the testing and for an additional hour after the last exposure.

B. Part II. Comparison of Treatments Applied during Milking

The treatments for these experiments will be applied in one of the milking stalls during milking. Treatments will be applied over 4 consecutive days using a Latin square design with 8 cows per experiment and 2 cows per treatment group.

The frequency of behaviors such as hoof lifting and kicking during milking have been suggested as measures of cow discomfort during milking. These are likely to be sensitive measures for hoof-to-hoof voltage exposure. The milk letdown reflex is influenced by stresses experienced during milking. Discomfort during milking may decrease both the peak and average milk flow rate during milking, increase the time taken to remove the milk and increase the amount of milk remaining in the udder after machine milking.

The results of these experiments should provide valuable information on the relative effects of voltage exposure and other common stressors in the animal environment such as sub-optimal milking machine performance.

C. Part III: Longer-Term Continuous Exposure to Sub-Acute Voltages

The primary objective of these experiments will be to measure immune and endocrine system responses to continuously applied hoof-to-hoof voltage exposure below the sensitivity threshold of individual cows. The treatments will be applied continuously for a period of 2 weeks. The cows will be exposed to voltage whenever they are in the housing area. The level of voltage exposure will be 1/2 to 1 volt (1 - 2 milliamps). The low level voltage will be cycled on and off on a 10 minute intervals as biological effects previously observed appear to be most pronounced when the exposure is changing with time.

D. Research Schedule

The experimental apparatus has already been assembled and tested. Progress reports will be issued to the Minnesota PUC throughout the study. Experiments will be repeated until a significant response is documented, until there is sufficient statistical evidence to conclude a negative result, or until the end of the contract period (June 30, 1999), whichever comes first. Thus, some experiments may be repeated more or less than others and there may not be time and resources to complete the full schedule. It is estimated that three replicates will be required for each experiment. Dr. Reinemann will forward a final report summarizing all of the experiments completed to the PUC by June 30, 1999.

Peer review will be provided by three scientists throughout the course of this research. The review will consist of a site visit to the laboratory in early fall 1998, review of Dr. Reinemann's mid-term report on research progress, and technical review of draft publications as they become available. The study reports and peer reviews will be forwarded to the PUC upon completion.

V. FINDINGS AND RECOMMENDATIONS TO THE MINNESOTA PUBLIC UTILITIES COMMISSION

The findings and recommendations given below take into account our review and analysis of many different sources of information acquired by or provided to us over the four years of our term as advisors to the Minnesota Public Utilities Commission. The primary information sources we have used include:

- Research studies published in the peer-reviewed literature.
- Oral and written reports by concerned dairy farmers.
- Oral and written reports by electric utility company representatives.
- Oral and written reports by other citizens or scientists.
- Information provided by government agency staff with responsibility for matters pertaining to stray voltage and/or dairy cow health and production in Minnesota and Wisconsin.
- Information provided by groups that represent large numbers of dairy farmers such as the Minnesota Farmers Union and the Minnesota Milk Producers Association.
- The 1994 report of The Electromagnetics Research Foundation (TERF) written under contract to the Minnesota Department of Public Service with funds provided under the same legislation that authorized our own work.
- Site visits to Minnesota dairy farms with persistent, unresolved herd behavior, health and/or milk production problems.
- Results of the mailed and telephone surveys of Minnesota and Wisconsin dairy farmers.
- Results of the field study described in this report.

A. General Findings

Based on our analysis of information from the above sources, we have reached the following conclusions:

1. *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.*

2. *At the present time, there is no basis for altering the PUC-approved standards by which electric utilities distribute power onto or in the vicinity of individual dairy farms.*

3. *There are many well-documented non-electrical factors that are known and accepted by the scientific community, and by most farmers as well, to cause dairy cow health and production problems. Among the most noteworthy stressors are poor nutrition, poor cow comfort and hygiene, and low or no use of vaccinations and related preventive veterinary practices. Those who want to improve performance of dairy herds should always address these factors.*

At the present time, there is only one electrical condition that is well documented in the peer-reviewed, published literature to influence adversely cow behavior, health or milk production under specific circumstances. That is cow contact stray voltage. The 10-farm field study did find significant differences between high and low producing herds in the levels of electrical step potentials and soil resistivity in the field. Findings from epidemiological studies (i.e., those that employ field data to examine risks associated with specific factors) and laboratory research are important in uncovering and exploring new ideas about possible biological or physiological effects resulting from the various electrical parameters associated with electric distribution systems. In studies where effects have been established, they have either been potentially adverse, potentially beneficial or potentially neutral to the cell, animal or human system under study. Indeed the scope and direction of current research in this area is in flux and we encourage additional basic research.

There has been some confusion among the general public, politicians and government decision makers about the relationships between currents in the earth and their possible effects on dairy cows versus the possible effects of overhead AC power lines or the high voltage DC power line built in Minnesota and widely debated in the late 1970's. Our analysis has focused only on the question of currents in the earth arising from the grounded AC electric distribution system. This report excludes other types of electrical power distribution systems, such as the DC power line. The 60 Hz magnetic fields that arise from overhead powerlines were recently addressed in the report of an advisory committee to the National Institute of Environmental Health Sciences (NIEHS) that was

in June 1998. The NIEHS committee found a *possible* relationship between low frequency magnetic fields from overhead ac power lines and certain forms of cancer in humans. However, the NIEHS committee findings should not be used to draw conclusions about possible effects on dairy cows from currents in the earth from electric distribution systems.

It is important to note here that there is a difference between what is conceivable or possible and what is likely or probable. For example, the NIEHS committee concluded that there is a "possible" not a "probable" association between the presence of 60 Hz magnetic fields of 2-3 milligauss or higher and childhood leukemia. In the 19-farm field study described in this report, the average AC magnetic fields measured inside the dairy barns were on the order of 0.5 milligauss. Thus *with the present body of evidence, it is our best judgement that magnetic fields from earth currents or any other contributory sources in the dairy barn are not of sufficient levels to cause any health or production problems in dairy cows.*

B. Recommendations

- The Minnesota Public Utilities Commission should advise the Minnesota Departments of Agriculture and Public Service, the Minnesota Board on Electricity, the University of Minnesota, and other agencies with appropriate missions on the need to support training of dairy farmers, utility electric engineers, government agency staff, electrical inspectors, veterinarians, insurers, milk processors and other consultants to dairy farmers. This training should address the importance of collaboration, discussion and evaluation by consultants with varying expertise in simultaneously assessing the potential for both electrical and non-electrical causes of health and production problems.

- The protocols developed for the field study and appended to this report should be given to the Minnesota Department of Agriculture so they can make them available for use by the dairy diagnostic team grants program in the state of Minnesota, as needed.

- Depending on the results of the research on low level step potentials that is now underway in Dr. Reinemann's laboratory, the Minnesota Public Utilities Commission should encourage investigators, including Dr. Reinemann, to pursue additional funds for extending that research, as appropriate.

- Although research on low level step potentials is the priority at this time, if more funds become available for research, attention should be paid to possible effects of magnetic fields on farm animals.

VI. BIBLIOGRAPHY

Anderson LE. Biological effects of extremely low frequency electromagnetic fields: in vivo studies. Am Ind Hyg Assoc J 54, 186-196 (1993).

Anderson LE, and Kaune WT. Electric and magnetic fields at extremely low frequencies: interactions with biological systems. In: Non-ionizing Radiation Protection, WHO Regional Publications European Series No. 25, World Health Organization, Copenhagen (1989).

Aneshansley, DJ, RA Pellerin, JA Throop, DC Ludington. 1995. Holstein cow impedance from muzzle to front, rear and all hooves. Paper No 95-3621, presented at the International Meeting of the American Society of Agricultural Engineers, Chicago IL.

Ayrapetyan SN, Grigorian KV, Avanesian AS, Stambolsian KV. Magnetic fields alter electrical properties of solutions and their physiological effects. Bioelectromagnetics 15:133-142 (1994).

Balaban PM, Bravarenko NI, Kuznetov AN. Influence of a stationary magnetic field on bioelectric properties of snail neurons. Bioelectromagnetics 11:13-23 (1990).

Baxter MR and MacCormack JAD, eds. Farm Animal Housing and Welfare. Commission of the European Communities, Programme of Coordination of Research on Animal Welfare, proceedings of seminar held at Aberdeen, July 28-30 (1982).

Beede DK. Water for dairy cattle. In: Large Dairy Herd Management, eds. Van Horn HH and Wilcox CJ, (Management Services, American Dairy Science Association, 309 W Clark St., Champaign, Il 61820), pp 260-271 (1992).

Blackman CF, JP Blanchard, SG Benane, DE House, and JA Elder. Double blind test of magnetic field effects on neurite outgrowth. Bioelectromagnetics 19: 204-207, (1998).

Blackwell RP. Effects of extremely-low-frequency electric fields on neuronal activity in rat brain. Bioelectromagnetics 7:425-434 (1986).

Bracken TD. An assessment of the electrical environment of dairy farms. A report to the Minnesota/Wisconsin Power Suppliers Group, T. Dan Bracken, Inc., Portland, Oregon (5515 S.E. Milwaukee Ave., Portland, OR 97202) (1986).

Burchard, JF, DH Nguyen, L Richard, E Black. 1990. Biological effects of electric and magnetic fields on productivity of dairy cows. J Dairy Sci 73:1548-1554.

Drommerhausen DJ, Radcliffe DE, Brune DE, Gunter Hd. Electromagnetic conductivity surveys of dairies for groundwater nitrate. J Environmental Quality 24:1083-1091 (1995).

Dawson TW, K Caputa, MA Stuchly. Influence of human model resolution on computed currents induced in organs by 60-Hz magnetic fields. Bioelectromagnetics 18:478-490 (1997).

Dziuk HE. Digestion in the ruminant stomach. In: Duke' Physiology of Domestic Animals, 10th edition. MJ Swenson ed. Cornell University Press, Ithaca NY, 320-339 (1984).

Easley SP, Coelho AM, Rogers WR. Effects of exposure to a 60-kVm, 60-Hz electric field on the social behavior of baboons. Bioelectromagnetics 12, 361-375 (1991).

Feychting M, A Ahlbom, D Savitz. Electromagnetic fields and childhood leukemia. Epidemiology 9:3, pp. 225, 226. (1998).

Fick RJ, Surbrook TC. A review of stray voltage research effects on livestock. Prepared by the Michigan Agricultural Electric Council at Michigan State University, Lansing, MI (1996).

Fitzsimmons RJ, Ryaby JT, Mohan S, Magee FP, Baylink DJ. Combined magnetic fields increase Insulin-Like Growth Factor-II in TE-85 human osteosarcoma bone cell cultures. Endocrinology 136:3100-3106 (1995).

Free MJ, Kaune WT, Phillips RD, Cheng H-C. Endocrinological effects of young 60-Hz electric fields on rats. Bioelectromagnetics 2, 105-121 (1981).

Frey AH, ed. On the nature of electromagnetic field interactions with biological systems. R.G. Landes, Austin (1992).

Friend TH. Behavioral aspects of stress. Symposium, Response of Animals to Stress. J Dairy Science 74, 292-303 (1991).

Frohlich RK, Williams JS, Boland M. A geochemical study of hydraulic hydrocarbon conditions in Aroostook County, Maine. Proceedings, International Conference on Fluid Flow in Fractured Rocks, (Center for Hydrogeology, Georgia State University, Atlanta, GA 30303), 114-134 (1988).

Gilli G, Tofani S, Ferrara A. Evidence for genotoxic effects of extremely ELF magnetic fields. Bioelectrochemistry and Bioenergetics 36:9-13 (1995).

Graham C, Cook MR, Cohen HD, Gerkovich MM. Dose response study of human exposure to 60 Hz electric and magnetic fields. Bioelectromagnetics, 15:447-463 (1994)

Greenwood A,. Electrical Transients in Power Systems, 2nd ed. John Wiley & Sons Inc. (1991).

Gumprich PS, Giesen L. Stray voltage effect on somatic cell count of dairy cows. National Mastitis Council Annual Meeting Proceedings, 83-96 (1993).

Gustafson, RJ, GS Christiansen, and RD Appleman. Electrical resistance of milking system components. Trans. ASAE 26(4):1218-1221. (1983)

Gustafson RJ, Sun Z, Brennan TD. Dairy cow sensitivity to low frequency electrical currents. ASAE Paper No. 88-3522, American Society of Agricultural Engineers, St. Joseph MI (1988).

Hatch EE, MS Linet, RA Kleinerman, RE Tarone, PK Severson, CT Hatasoh, C Haines, WT Kaune, D Friedman, LL Robison, S Wacholder. Association between childhood acute lymphoblastic leukemia and use of electrical appliances during pregnancy and childhood. Epidemiology 9:3, pp 4-13. (1998).

Hicks TA, JJ McGlone, CS Whisnant, HG Kattesh, RL Norman. Behavioral, endocrine, immune, and performance measures for pigs exposed to acute stress. J. Anim. Sci 76:474-483 (1998).

Jenrow KA, Smith C, Liboff AR. Weak ELF fields and regeneration in the planarian Dugesia tigrina. Bioelectromagnetics 16:106-112 (1995).

Kiley-Worthington M. The tail movements of ungulates, canids and felids with particular reference to their causation and function as displays. Behaviour LVI 1-2, pp 69-114 (1975).

Krohn CC. Behavior of dairy cows kept in extensive (loose housing/pasture) or intensive (tie stall) environments. III. Grooming, exploration and abnormal behavior. Applied Animal Behavior Science 42, 73-86 (1994).

Lanzerotti LJ, Gregori GP. Telluric currents: The natural environment and interactions with man-made systems. Studies in Geophysics, The Earth's Electrical Environment, National Academy Press, Washington DC (1986).

Lerchl A, Reiter RJ, Howes KA, Nonaka KO, Stokkan KA. Evidence of an ion cyclotron-resonance effect on pineal melatonin synthesis in vivo. Neuroscience Lett. 124:213-215 (1991).

Liboff AR. Geomagnetic cyclotron resonance in living cells. J Biological Physics 13, 99-102 (1985)

Liburdy RP, TS Sloma, R Sokolic,and P Yaswen. ELF magnetic fields, breast cancer, and melatonin: 60 Hz fields block melatonin oncastic action on ER+ breast cancer cell proliferation. J. Pineal Res. 14: 89-97 (1993).

Lovely RH, Creim JA, Miller DL, Anderson LE. Behavior of rats in a radial arm maze during exposure to magnetic fields: Evidence for effects of magnesium ion resonance. 15th annual meeting Bioelectromagnetics Society, Los Angeles. Abstract E-I-6 (1993).

Lyskov EB, et al. Behavioral effects of ELF magnetic fields probably depend on the DC-component. European Bioelectromagnetics Workshop, Institute of Cellular Biophysics, Puschino, Russia (1995).

McLeod KJ, Rubin CT. Effect of low frequency electric fields on osteogenesis. J Bone & Joint Surgery 74A(6), 920-929 (1992).

McLeod KJ, Lee RC, Ehrlich HP. Frequency dependence of electric field modulation of fibroblast protein synthesis. Science, 236, 1465-1469 (1987).

Miller AB, T To, DA Agnew, C Wall, LM Green. Leukemia following occupational exposure to 60-Hz electric and magnetic fields among Ontario electric utility workers. Am. J. Epidemiology 144:2, pp. 150 (1996).

Minnesota Public Utilities Commission. Request for technical comments on investigations of ground currents and stray voltage on dairy farms, Science Advisors Briefing Book, (Minnesota PUC, 121 7th Place E, Suite 350, St. Paul, MN 55101-2147), December (1994).

Minnesota Public Utilities Commission. Survey to determine the age and condition of electric distribution facilities in Minnesota: Report 1, Analysis of overhead distribution feeder testing data, (Minnesota PUC, 121 7th Place E, Suite 350, St. Paul, MN 55101-2147), May (1995).

Minnesota Public Utilities Commission. Progress report of the science advisors proposed research for evaluating possible electrical causes of poor health and production in dairy cows. Minnesota Public Utilities Commission, 121 7th Place E, Ste. 350, St. Paul, MN 55101. January (1996).

Morisson R, Lewis WH. Grounding and Shielding in Facilities. John Wiley & Sons Inc. (1990).

National Institutes of Environmental Health Sciences, National Institutes of Health. Assessment of Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields. June 1998. www.niehs.nih.gov/emfrapid.

Norden B, Ramel C, eds. Interaction Mechanisms of Low-Level Electromagnetic Fields in Living Systems. Oxford University Press, Oxford (1992).

Nordlund K. Field investigations of laminitis-problem dairy herds. Proceedings of the Mid South Ruminant Nutrition Conference, (Texas Nutrition Council, 17360 Coit Rd., Dallas, TX 75252-6599), 39-46 (1994).

Orr LJ, WR Rogers, HD Smith. Detection thresholds for 60 Hz electric fields by nonhuman primates. Bioelectromagnetics Suppl. 3:23-34 (1992).

Pender, H., McIlwain, K. Electrical Engineers Handbook (pp. 8-10 on distribution of earth current near transmission lines). Third edition. John Wiley and Sons, Inc., New York (1936).

Polk C. Biological effects of low-intensity extremely-low frequency magnetic fields. Workshop on Electromagnetics, Health Care and Health. 17th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Montreal, Canada, September 19-23 (1995).

Polk C, Postow E, eds. CRC Handbook of Biological Effects of Electromagnetic Fields, Second Edition. CRC Press, Boca Raton, Florida (1995).

Polk C, Postow E, eds. CRC Handbook of Biological Effects of Electromagnetic Fields. CRC Press, Boca Raton, Florida (1986).

Reibo I. The influence of restraint on the occurrence of oral stereotypies in dairy cows. Applied Animal Behavior Science 35, 115-123 (1992).

Reinemann DJ, Stetson LE, Langlois ME. Water, feed and milk production responses of dairy cattle exposed to transient currents. Proceedings of International Meeting of ASAE: the Society for Engineering in Agriculture, Food and Biological Systems, Chicago, Illinois, 18-23 June (1995).

Reinemann DJ, Stetson LE, Langlois ME. Effects of frequency and duration on the sensitivity of dairy cows to transient voltages. ASAE Paper No. 94-4527, Atlanta (1994).

Reinemann DJ, Stetson LE, Langlois ME. Response of dairy cattle to transient voltages and magnetic fields. IEEE Transactions on Industry Applications 31:4, 709-714 (1995).

Reinemann, DJ, LE Stetson, JP Reilly, NK Laughlin, S McGuirk, SD LeMire. Dairy cow sensitivity and aversion to short-duration transient currents. Paper No. 96-3087, presented at the 1996 International Meeting of the American Society of Agricultural Engineers, Phoenix AZ (1996).

Reinemann DJ, Stetson LE, Dasho DM, Cook MA. Stray voltage update 97. IEEE Paper No. 97CH36079-D1 presented at the IEEE Rural Electric Power Conference in Minneapolis, MN (1997).

Reinemann DJ, Stetson LE, Reilly JP, Laughlin NK. Behavioral measures of dairy cow sensitivity to short duration electrical currents. Accepted for publication in Transactions of ASAE (1998).

Sastre A, MR Cook, C Graham. Nocturnal exposure to intermittent 60 Hz magnetic fields alters human cardiac rhythm. Bioelectromagnetics 19:98-106 (1998).

Seabrook MF.. Psychological interaction between the milker and the dairy cow. Dairy Systems for the 21st Century, Proceedings of the 3rd International Dairy Housing Conference, Feb 2-5, Orlando, Florida. pp 49-58, (1994).

Seegal RF, Wolpaw JR, Dowman R. Chronic exposure of primates to 60 Hz electric and magnetic fields: II. Neurochemical effects. Bioelectromagnetics 10:289-301 (1989).

Semm P, Schneider T, Vollrath L. Effects of an earth-strength magnetic field on electrical activity of pineal cells. Nature 288:607 (1983).

Smith SD, McLeod BR, Liboff AR. Effects of CR-tuned 60 Hz magnetic fields on sprouting and early growth of Raphanus sativus. Bioelectrochemistry and Bioenergetics 32:67-76 (1993).

Smith SD, McLeod BR, Liboff AR, Cooksey K. Calcium cyclotron resonance and diatom motility. Bioelectromagnetics 8:215-227 (1987).

Stringfellow, MF, DJ Aneshansley, TC Surbrook. Measuring short-duration animal contact voltages and currents. Paper No. 96-3085, presented at the 1996 International Meeting of the American Society of Agricultural Engineers, Phoenix AZ (1996).

Thomas JR, Schrot J, and Liboff AR. Low-intensity magnetic fields alter operant behavior in rats. Bioelectromagnetics 7, 349-357 (1986).

Thompson JM, Stormshak F, Lee JM, Hess DL, Painter L. Contact secretion and growth in ewe lambs chronically exposed to electric and magnetic fields of 60 Hz 500 kV AC transmission line. J. Animal Science 73:3274-3280 (1995).

Turner AI, PH Hemsworth, PE Hughes, AJ Tilbrook. Repeated acute activation of the hypothalamo-pituitary adrenal axis prior to and during estrus did not affect reproductive performance in gilts. Biology of Reproduction 58, pp. 1458-1462 (1998).

USDA, 1991. Effects of electrical voltage/current on farm animals: how to detect and remedy problems. Agricultural Handbook No. 696. A. Lefcourt, Editor, U.S. Government Printing Office (1991).

Weaver JC, Astumian RD. The response of living cells to very weak electric fields: The thermal noise limit. Science 247:459-462 (1990).

Westinghouse Electric Corporation. Electrical Transmission and Distribution Reference Book.

Wilson BW. Chronic exposure to ELF fields may induce depression. Bioelectromagnetics 9:195-205 (1989).

Wilson BW. Evidence for the effect of ELF electromagnetic fields on human pineal gland function. J. Pineal Res. 9:259-269 (1990).

Wisconsin Public Service Commission. Investigation on the commission's own motion concerning stray voltage for electric distribution utilities in Wisconsin: Findings of fact, conclusion of law, and amended order. Madison, Wisconsin, August (1989).

Wisconsin Public Service Commission. Investigation on the commission's own motion into the practices, policies, and procedures of providing electric utility service as it relates to the potential adverse effects on dairy livestock from electromagnetic fields, ground currents, and direct currents associated with that service. Report No. 05-EI-108. Madison, Wisconsin, June (1995).

Walleczek J. Electromagnetic field effects on cells of the immune system: The role of calcium signaling. FASEB J. 6:3177-3185 (1992).

Wolpaw JR, Seegal RS, Doverman K. Chronic exposure of primates to 60-Hz electric and magnetic fields. Bioelectromagnetics 10, 377-388 (1989).

Yost MG, Liburdy RP. Time-varying and static magnetic fields and their combination to alter calcium signal transduction in the lymphocyte. FEBS Lett 296:117-123 (1992).

Zhadin MN, VV Novikoff, FS Barnes, and NF Pergola. Combined action of static and magnetic fields on ionic current in aqueous glutamic acid solution. Bioelectromagnetics 19: 41-45 (1998).

VIII. APPENDICES

A. Definitions[1]

B. Survey Instruments

C. Field Study Protocols

1. Electrical Measurements Protocol

2. Electrical Inspection Protocol

3. Veterinary Evaluation Protocol

D. Laboratory Research Proposal

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[1] Minnesota Public Utilities Commission. *Progress report of the advisory board appointed to assist in evaluating possible electrical causes of poor health and productivity in dairy cows.* Minnesota Public Utilities Commission, 121 7th Place E. Ste. 350, St. Paul, MN 55101. [illegible]

Appendix A: Definitions

It is clear from the information reviewed by the Science Advisors that there is a compelling need to clarify the definitions of the scientific terms commonly used in discussions of stray voltage, earth currents and related issues. The electrical parameters of particular interest can be classified broadly as voltage, current, transient voltage/current, electric fields and magnetic fields. Precise, scientifically sound definitions of these terms are given below to provide clarity to the analysis in this report and to offer a framework for future discussions among the interested parties.

A. Voltage is the electrical potential difference between two points; it is measured in volts. Voltage is commonly classified according to how it changes with time. *Direct current (dc)* voltages change slowly, if at all, with time. *Alternating current (ac)* voltages change polarity periodically. For example, electric power frequency ac voltages change polarity 120 times per second (i.e., have 60 complete cycles per second, each with equal positive and negative parts). Cycles per second are called "Hertz," thus the power frequency in the United States is 60 Hertz (Hz). *Radio frequency voltages* alternate polarity millions of times per second. Voltages may also be *transient*, or rapid, short-lived changes ("spikes").

1. **Stray voltage** is the difference in voltage measured between two surfaces that may be contacted simultaneously by a person or animal (typically less than 10 volts). Sources of ac stray voltage are neutral-to-earth voltages resulting from normal current flow on a resistive neutral system. Stray voltage may be enhanced by poor electrical connections, deteriorated insulation, or faulty equipment. Sources of dc stray voltage are cathodic protection systems, telephone systems, ac power lines, and electrochemical reactions occurring at the surfaces of buried metals. Stray voltage on a farm can exist between two metal objects, between a metal object and the ground, or between two points on the ground. When an animal contacts these two points, it provides a conducting path for current to flow.

2. **Neutral-to-earth voltage (NEV)** is the ac voltage measured between the grounded neutral conductor of an electrical system and the earth. The primary neutral conductor is on the power supplier side of the distribution system and the secondary neutral conductor is on the customer (i.e., farm) side. Utilities may decide to separate the primary and secondary neutral conductors with an isolation device to limit secondary NEV's to on-farm sources.

3. **Step potential/voltage** is the voltage between two points on the earth separated

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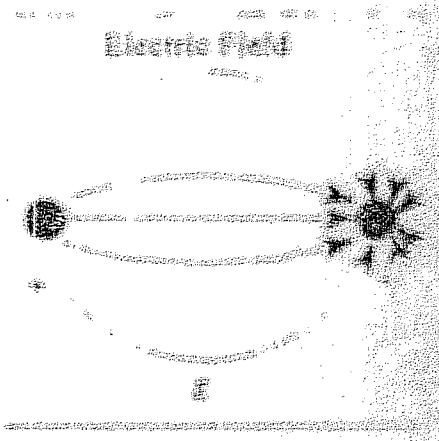
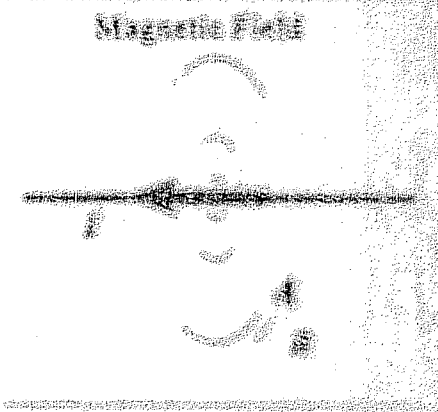
[4] Isolation is separation of all or part of a farmer-of's grounded neutral conductors from the grounded conductor of the distribution system. Several types of isolation devices are used to automatically reconnect them in case of a lightning strike or fault condition.

D. **Electric Fields** originate on electric charges and are detected as forces on (other) electric charges. The direction of the electric field is the direction in which a positive charge would move when acted on by the field. The electric field gives the rate of change in voltage from one point to another, for example in the space between a power line and the earth. The electric field is expressed in terms of volts/meter, and sometimes as volts/centimeter (1.0 V/m = .01 V/cm). Sources of electric field include transmission and distribution lines as well as electrical wiring. The electric fields arising from the power distribution system are predominantly oscillating at 60 Hz. DC electric fields are generated by batteries, dc electric power sources and associated wiring, and by electric charges in the air.



E. **Magnetic Fields** always accompany the passage of electric current, and are detected as forces on moving electric charge. The magnitude of a magnetic field is usually expressed in units of its "flux density," in Tesla, Gauss, or milligauss. One Tesla is equal to 10,000 Gauss and one milligauss (mG) is one thousandth of a Gauss. The magnitude of the dc magnetic field of the earth at mid-latitude is about 0.5 Gauss. The magnetic fields arising from the electric power distribution system are associated predominantly with 60 Hertz (Hz) ac currents. DC magnetic fields are generated by the earth as the geomagnetic field (GMF), by dc currents in electric conductors, and by any other dc current sources.



PLEASE CHECK ALL THAT APPLY TO YOUR OPERATION

- ☐ Stanchions
- ☐ Tie stalls
- ☐ Loose housing
- ☐ Free stalls
- ☐ Flat parlor
- ☐ Elevated (herringbone or parallel) parlor
- ☐ DHIA membership
- ☐ Regular veterinary herd health visits
- ☐ Feed / dairy consultant used
- ☐ Forage testing
- ☐ Own computer used in records
- ☐ Computerized dairy records (Strout, DairyCHAMP, etc.)
- ☐ Computerized farm records
- ☐ Electronic information service (CTH, Internet, etc.)
- ☐ Manual farm business records
- ☐ Farm business/accounting software

1. Today's date (month/day/year): ____/____/____

2. Your position (check one):
   1. ☐ Owner
   2. ☐ Manager
   3. ☐ Employee

3. Location of dairy herd:
   State _____
   County _____
   Township _____

4. How many dairy cows (dry or in milk) were in the herd yesterday? _____

5. How many of those dairy cows were milked yesterday? _____

6. How much milk was produced yesterday? _____

7. What is the current rolling herd average for milk production (check one)?
   1. ☐ Less than 14,000 lbs.
   2. ☐ 14,000 - 15,999 lbs.
   3. ☐ 16,000 - 17,999 lbs.
   4. ☐ 18,000 - 19,999 lbs.
   5. ☐ 20,000 or more lbs.
   6. ☐ Don't know

8. Please indicate your level of satisfaction with the herd's current milk production (circle a number between 1 and 5 on the scale below):

   Extremely Dissatisfied 1 2 3 4 5 Extremely Satisfied

9. What was the bulk tank somatic cell count (SCC) on the latest report from your milk processor (check one)?
   1. ☐ Less than 150,000
   2. ☐ 150,000 - 249,999
   3. ☐ 250,000 - 349,999
   4. ☐ 350,000 - 449,999
   5. ☐ 450,000 or more

10. Please indicate your level of satisfaction with the herd's current somatic cell count (SCC) (circle a number between 1 and 5 on the scale below):

    Extremely Dissatisfied 1 2 3 4 5 Extremely Satisfied

11. How many dairy cows (dry or in milk) were in the herd one year ago? _____

12. During the last 12 months, how many replacement dairy animals (mature heifers or cows) were purchased? _____

13. During the last 12 months, how many adult dairy cows died on the farm? _____

14. During the last 12 months, how many dairy cows were treated or culled for lameness (not including routine foot trimming)? _____

15. During the last 12 months, how many dairy cows were culled for all reasons? _____

1. Have you ever had herd health and production problems that you thought were being caused mainly by stray voltage or other electrical phenomena?

1. _____ Yes 2. _____ No 3. _____ Don't Know (201)

2. Has your farm ever been tested for stray voltage?

1. _____ Yes 2. _____ No 3. _____ Don't Know (202)

3. Has your farm ever been tested for other electrical problems (for example: magnetic fields, electric fields, EMF, ground current, earth current)?

1. _____ Yes 2. _____ No 3. _____ Don't Know (203)

[If respondent answers "Yes" to either question 2 or 3, then go on to question 4. If respondent answers "No" or "Don't Know" to both question 2 AND 3, then go directly to question 10.]

4. When was the most recent test for stray voltage or other electrical phenomena carried out?

_____ (month) _____ (year) (204)

5. Over the last six years, how many different times have you had your farm tested for stray voltage or other electrical phenomena?

_____ (number) (205)

6. Who among the following have been involved in conducting tests for stray voltage or other electrical phenomena on your farm? (Check all that apply.)

1. ____ utility employee (206)
2. ____ government employee or team (207)
3. ____ electrician (208)
4. ____ extension agent (209)
5. ____ veterinarian (210)
6. ____ private consultant (211)
7. ____ yourself (212)
8. ____ other (213) (for example: field man, other farmer, specify: _____ (214)

7. Did any of the persons who conducted tests on your farm ever inform you that there were stray voltage or other electrical conditions on your farm that should be corrected?

1. _____ Yes 2. _____ No 3. _____ Don't Know (215)

8. If yes to #7: Has anything ever been done to try to correct these conditions?

1. _____ Yes 2. _____ No 3. _____ Don't Know (216)

If no or Don't Know to #7: Were corrections made anyway?

1. _____ Yes 2. _____ No 3. _____ Don't Know (217)

9. After all investigations and/or attempts to correct any stray voltage or other electrical conditions on your farm, are you satisfied with the results?

1. _____ Yes 2. _____ No 3. _____ Don't Know (218)

10. At the present time, do you think uncorrected stray voltage or related electrical conditions are having negative effects on the health and/or production of your dairy herd?

1. _____ Yes 2. _____ No 3. _____ Don't Know (219)

Appendix C1: Electrical Measurements Protocol

Dairy Farm Electrical Effects Research Program
Minnesota Public Utilities Commission:
Draft Electrical Measurements Protocol

I. Introduction

An on-farm case/control study was recommended by the Science Advisors to the Minnesota Public Utilities Commission[1] as one element of a field- and laboratory-based research program to expand the base of scientific information on whether and, if so, how man-made or natural sources of electricity can contribute to persistent and unresolved health and production problems in dairy herds. The Science Advisors' research plan outlines a case/control field study in which various electrical and non-electrical parameters would be examined on a sample of dairy farms, first in a pilot study of 20 farms, 10 with persistent and unresolved health and production problems and 10 without such problems. The pilot study would provide an opportunity to (1) test the feasibility of implementing informative electrical measurement, electrical inspection and dairy herd health and production evaluation protocols in relatively short visits to each study farm and (2) assess the need for a larger scale study of potential electrical risk factors. The Science Advisors recommended that if a larger scale study is indicated, a study of 50 or 100 farms would likely be sufficient to determine with some statistical certainty the relative contributions of various possible risk factors, electrical and non-electrical, that could be affecting the health and production of dairy cows.

For the pilot field study, candidate case and control farms will be identified through a mail/telephone survey of a random, statewide sample of dairy farmers and by follow-up site visits to confirm farmer's reports of health and production status of their dairy herds. Once the study sample of 20 farms is identified, the pilot field study would be conducted by a 3-member team consisting of an electrical engineer or electrical measurements specialist, an electrical inspector or contractor, and a veterinarian.

The Science Advisors, project staff and other experts have contributed to the development of an electrical measurements protocol which addresses stray voltage, ground currents, transients, earth currents and other electrical parameters that have been hypothesized to have the potential, under various circumstances, to impact animal health and/or production. The electrical measurements protocol is the subject of this document. The protocols for the on-farm electrical inspection and the dairy herd health and production evaluation, also to be implemented as part of the pilot field study, will be developed by contractors with the advice of the Science Advisors, the Research Director and other project staff and advisors.

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[1]Minnesota Public Utilities Commission. Progress Report of the Science Advisors. Proposed Research for Evaluating Possible Electrical Causes of Poor Health and Production in Dairy Cows. Minnesota PUC, 121 7th Place E, Suite 350, St. Paul MN 55101-2147. January (1996).

V. Measurement Strategy

A number of specific measurements/data were suggested by the Science Advisors which would be reasonable and useful for further refining the understanding of possible effects on dairy cattle of stray voltage, external current and other electrical scenarios. These can be grouped into the following categories:

General Information, including an area map describing the distribution system.

Electrical Environment, including neutral voltages, grounding resistances, cow contact voltages, transient voltages on distribution conductors and in the cow contact area, ac magnetic fields (especially near ground current paths), dc magnetic field in the barn and farmyard, farm electrical load, electrical characteristics of the milking system and cow resistance.

Earth Current Parameters, such as soil resistivity, location of water table, water ion content, earth surface (step) voltages and electrical homogeneity of the barn floor (See Section VII D).

This parameter list is still under development; testing will likely indicate that some of these quantities should be eliminated, altered or replaced by others.

Because Wisconsin has made, and is making, measurements similar to some of the above and has proposed to carry out additional on-farm research, every effort will be made to coordinate measurement methodologies to the extent necessary to combine or compare future data sets.

VI. Measurement Methods

A. GENERAL INFORMATION

1. Area map (2-by-2 miles minimum). Provides locations of earth current sources and preferred paths.

Request a geographic map of the distribution feeder from the serving electric utility. Supplement if necessary, with the following: location of test farm, conductor type and size, all capacitor banks on the circuit (including their status) and, out to ½ mile from the test farm, locations of other electrical services (including phase, type, size, neutral isolation, all primary ground rod and their resistances), distribution lines of other utilities, telephone lines, pipelines and all other conductive large, buried conductors.

stronger source which should be identified if possible.

2. AC ground current and magnetic fields. Record the following quantities separately.

a) AC ground current on metal paths in barn. Possibly may cause locally high magnetic fields near cows (see Hypotheses II-2 and 3); also helps to locate sources of cow contact voltages.

Measure Iac using Swain ammeter (specified in Appendix A) in all grounding electrode conductors (to ground rod and water line, for example) from barn panel neutral bus. Measure Iac in metallic water line, vacuum line and/or milk line at each stall, noting stall where Iac is largest (probably nearest the barn panel).

b) AC magnetic field (Bac). Measurement would indicate ground current flow. If large enough, Bac could affect cow physiology (see Hypotheses II-2 and 3).

Using a Dexsil Magnum 310 milligauss meter (specified in Appendix A):

- Measure Bac in the barnyard noting minimum and maximum values and likely sources.
- Map Bac throughout barn during maximum and minimum electrical use. In stall barns record the value of Bac at approximately 1 m above floor at each stall (or every other stall in large barns) for the following locations: at cow's head, back, rear, and where current-carrying conductors pass closest to cow (if this is a distinctly different point).
- Map Bac (3-dimensions) in stall.
- Record a time series at normal location of cow's head in stall identified above (VII.B.2.a) during maximum electrical use (e.g., during milking).
- Determine 60 Hz harmonic content at same location during milking using milligauss meter with ac output (specified in Appendix A), digital storage oscilloscope, portable computer and harmonic analysis software.

c) DC magnetic field (Bdc). DC field strength appears to determine whether various magnetic field frequencies result in biological effects (see Hypothesis II-3).

Using a Walker Scientific flux-gate magnetometer (specified in Appendix A):

- Measure Bdc outside at a few locations.
- Measure Bdc at a few locations in barn.
- Map Bdc (3-dimensions) in stall, coincident with Bac measurement above.
- Compare outside values with model (GEOMAG/IGRF) predictions available from NOAA.

(described in the next paragraph) Low frequency transients may also be recorded between cow contacts across the hybrid impedance model (low frequency output) using a digital recording oscilloscope to record 60 Hz wavetrains using a sweep speed of 1 second or more.

•High Frequency Transients

- on barn wiring: Using a Dranetz 658 power analyzer (specified in Appendix A) according to manufacturer's recommendations, monitor power quality at the barn service panel using the following channel assignments:

· Channel A = Line voltage [Line 1] to [Neutral] (120 V)
· Channel B = Line voltage [Line 2] to [Neutral] (120 V)
· Channel C = Neutral voltage [Neutral] to [Near (6') Reference]
· Channel D = Neutral current

Format disks as IBM 9-sector, 720K disks (rather than using Dranetz format feature) to allow subsequent computer archiving of data. Use the following setup initially, then adjust items 3 through 7 to limit data capture to a rate such that most of one 24 hour period is recorded per disk:

1 Setup #	A	B	C	D
2 Range	VH	VH	VL	130
3 Hi Lim	126	126	72.4	30.0
4 Lo Lim	114	114	00.0	00.0
5 Sens.	002	002	00.5	05.0
6 Imp.	0025	0025	002.5	002.5
7 Wave	010	010	02.0	3.0
8 Freq.	Sens:0.5	Range: 45-65 Hz		

Print out the following for each channel:

· RMS/Impulse Plot Summary (graph and text)
· Worst impulse events (positive and negative) singly and as multiple channel plots.
· Harmonic distortion analysis on initial waveforms, including the waveform, harmonic graph and harmonic table.
· Multiple channel plots of impulses which are coincident with transient events recorded at cow contact points (as follows).

-Transients at cow contacts: Using a Tektronix digital storage oscilloscope (specified in Appendix A), monitor high frequency transients between cow contacts in the test stall via 100' RG 58C/U coaxial cable using the first channel. Simultaneously monitor

AC current in the earth is accompanied by a step voltage and magnetic field at the surface. Earth current data are required to prove/disprove relevance to dairy herd health and production problems (see Hypotheses II-2, 3, 4 and 5).

1. Location of water table. Strongly affects soil resistivity. Seasonal variations may account for seasonal problems in herd. Map surface water on farm. Measure soil resistivity vs. depth using a soil resistivity meter and 4-point Schlumberger method, locate the depth of the resistivity discontinuity which indicates location of water table.

2. Soil resistivity. Earth current surface voltages are proportional to soil resistivity. Also, there are some reports indicating that earth current rectification may occur where soil resistivity changes abruptly.

Determine soil resistivity (ρ) on the farm. Compare between wet and dry conditions if testing schedule permits. Using a Vibroground soil resistivity meter (specified in Appendix A) and 4-point Wenner method with 5' electrode separation, map ρ around the barn. Combine resistivity and step voltage data (item 3 below) to determine earth current density around the perimeter of the barn. Note any apparent correlation with location of nearby grounding electrodes.

3. Step Voltage (V_s). Exposure to step voltage is the most likely way earth current might affect cows. V_s (across 500Ω) is the voltage which causes current to flow through cow.

- Using ground probes and Fluke multimeter (specified in Appendix A), map V_s (open circuit and across 500Ω) around perimeter of barn.

- Obtain continuous record of V_s (open circuit) at a point near barn. Drive three 3' ground rods in an L-configuration allowing determination of the N/S and E/W components of V_s. Convert each of the V_s components from Vac to Vdc using converters (specified in Appendix A). Record resulting dc signals using strip chart recorder. Determine source impedance between ground rods using a multimeter and 500 ohm and 1000 ohm shunt resistors.

- Using Tektronix digital storage oscilloscope, computer and Waveteek software, determine harmonic spectrum of surface potential.

4. Electrical homogeneity of concrete floor. Breaks may result in step potentials which are larger than otherwise.

Measure Idc with Fluke multimeter between electrodes 1m apart (attached to shoe heels) on barn floor and charged to 9 Vdc. Calculate nominal resistance of contacts plus concrete path. Map barn floor

Tektronix THS-720 TekScope

Digital storage oscilloscope: battery- or line-powered, two-channel, autoranging, 100MHz bandwith, up to 500MS/s sample rate, 2500 point record length, separate digitizers for each channel, waveform averaging and enveloping with hardware peak detection, real-time digitizing with up to 5-times oversampling, independently isolated channels, cursors and 21 continuously updated automatic measurements, simultaneous oscilloscope and meter operation, advanced pulse and video trigger capability.

Vibroground 4-Point Soil Resistivity and Ground Resistance Tester

Measures soil resistivity from 0 to 1,915,000Ω. Accuracy not affected by earth's resistance and condition, polarization effects, stray AC and DC currents in the earth, or accuracy of meter. Measures soil resistivity using 4-point method, resistance to earth of man-made grounds using 3-point method, and circuit resistance using 2-point method.

Walker Scientific Portable Hand-held Fluxgate Magnetometer FGM-JD1

Single axis DC magnetic field instrument. Battery-powered, best resolution 0.01mG, +/-0.5% absolute accuracy traceable to NIST, 3 FS ranges +/-(20, 200, 2000 mG, noise 0.5 gamma, wide bandwidth 100Hz, analog output +/-2V.

Waveform Manager Pro for Windows, Metratek

Software accessory for digital field service oscilloscopes. Transfers waveforms, data and scope between scope and computer. Here, used to transfer and store transient waveforms at capture, then reset scope trigger. Performs harmonic (and other) analyses on waveforms and provides full Windows support for report writing.

WaveRider Data Acquisition System, EGS, Inc.

Battery and line powered, eight differential inputs, detects and stores peak voltages per power cycle, sample rate > 35/cycle depending on # channels enabled, electrically isolated serial port to 1kV, average data collection rate 70 peaks/s, burst data capture rate one per channel per cycle at 480/s, internal buffer approx 13,000 peaks, channel full scales from 5V to 400V AC peak, channel input impedances from 17.7kΩ to 1.4MΩ, band pass -6dB (50%) voltage for all channels.

Day 3

6 am	Conduct transient recording during milking on CC#2.
7	Record Bac time series in barn during maximum electrical use. Determine Bac harmonic spectrum.
8	Breakfast. Team discussion.
9	Check electrical homogeneity of barn floor.
11	Conduct transient recording during quiet time on CC#2.
12 pm	Read kW-hr meter. Lunch.
1	Measure CC#2 source impedance. Move to CC#3. Measure CC#3 source impedance. Conduct transient recording during quiet time on CC#3.
3	Map step voltages and soil resistivity around perimeter of barn.
5	Conduct transient recording during milking on CC#3.

Day 4

7 am	Breakfast.
8	Shut down all instrument systems and archive data files.
9	Disassemble monitoring systems. Map Bac and Bde in stall. Pack trailer.
12 pm	Read kW-hr meter. Lunch. Team discussion.
1	Deliver trailer to next farm.
2	Travel.
6	Home.

Farm:

Xmas [illegible]

Date	Time Per.	SN min	SN max	SN avg	CC point	CC min	CC max	CC avg	K=CC/SN
					#1				
					#2				
					#3				

[illegible] [illegible]

Date	Time Per.	SN #	SN max	CC point	CC #	CC max
				#1		
				#2		
				#3		

[illegible]

Date	Time Per.	SN min	SN max	SN avg	CC point	CC min	CC max	CC avg	K=CC/SN
					#1				
					#2				
					#3				

[illegible]

Date	Time Per.	SN #	SN max	CC point	CC #	CC max
				#1		
				#2		
				#3		

[illegible]

Date	Time Per.	SN min	SN max	SN avg	CC point	CC min	CC max	CC avg	K=CC/SN
					#1				
					#2				
					#3				

[illegible]

Date	Time Per.	SN #	SN max	CC point	CC #	CC max
				#1		
				#2		
				#3		

Note: SN = Secondary Neutral, barn to Reference
CC#1 =
CC#2 =
CC#3 =

V hf - 2

Farm:

Note:
CC#1 =
CC#2 =
CC#3 =

Cow Contact High Frequency Transients - 1

HF transient counts/30 min

High electrical use:

Date	Start Time	CC point	Trig. Lev.	# Trans.
		#1		
		#2		
		#3		

Low electrical use:

Date	Start Time	CC point	Trig. Lev.	# Trans.
		#1		
		#2		
		#3		

HF transient matches with transients on secondary neutral

CC #1

Date	File Name	Time	CC Dur	Vpk (CC)	Dranetz Disk Name Event #	SN Dur	Vpk (SN)	K=CC/SN

CC #2

Date	File Name	Time	CC Dur	Vpk (CC)	Dranetz Disk Name Event #	SN Dur	Vpk (SN)	K=CC/SN

CC #3

Date	File Name	Time	CC Dur	Vpk (CC)	Dranetz Disk Name Event #	SN Dur	Vpk (SN)	K=CC/SN

Farm: Date: Start Time: End Time:

[redacted] barn, milking

Stall	Head	Back	Tail	Average

Avg

Stall	Head	Back	Tail	Average

Avg

Sketch:

Farm: Date: Start Time:

[redacted] Time Series

Time	Bac	Time	Bac	Time	Bac
0:00		6		12	
0:10					
0:20					
0:30					
0:40					
0:50					
1		7		13	
2		8		14	
3		9		15	
4		10		16	
5		11		17	

Average

Continuation

2

of pages

EL98-005

Earth - 3

Farm: Date: Start Time: End Time:

Homogeneity of barn floor

Stall	Gutter mA	R(Gutter)	Stall mA	R(Stall)	Stall	Gutter mA	R(Gutter)	Stall mA	R(Stall)

If you are concerned about the level listed above, you should report this value to your local electric utility company. They will schedule a stray voltage investigation for your farm and will help you determine the source. Stray voltage has many possible causes which are as likely to be on your farm as off. Stray voltage is a well-understood phenomenon and solutions should be available in all cases, often at little or no expense to you.

Transient Voltage

Transient voltages are very brief electrical events caused by switching, operation of electrical equipment (especially motors), lightning, or by electric cow trainers, fencers and crowd gates. These transient voltages may appear in the barn where cows can access them, just as for stray voltage. Not as much is known about the effects of transient voltages on cows as is known for steady voltages. The research that has been done to date has shown that behavioral responses to transients occur at higher levels than for steady voltages. Briefer transients require higher voltages to produce an effect, which most often is a behavioral response that indicates the cow has sensed and reacted to the transient.

The largest low-frequency transient voltage measured in the test stall was _____ volt measured between _____ and the rear hoof across 500 ohm. It was probably caused by the start-up of an electric motor.

The largest high-frequency transient voltage measured in the test stall was _____ volt measured between _____ and the rear hoof. Research indicates that these fast transients are most often caused by operation of a switch nearby. High frequency transients may also be caused by improperly grounded electric animal control equipment. The regularity of cow trainer transients on cow contacts is easily apparent and is rectified by improving the cow trainer ground. Cow trainer transients (did) (did not) appear at cow contact points in your barn.

Steady and transient voltages were also measured on the barn wiring at the circuit breaker panel. This data record will be used to determine the quality of your electric power and will help to identify sources of transient voltages in the stall.

Magnetic Fields

Magnetic fields are caused by the flow of electric current. Alternating current (ac) produces ac magnetic fields. These fields can be found everywhere to some degree, though they are larger near electrical devices and conductors. In the barn they are produced by florescent lights, wiring, motors and other electrical devices, and the flow of current on metal paths such as water lines, among other things. There is no evidence to date that indicates that ac magnetic fields have any negative effect on cows. Other research has indicated a possible effect on other biological species and material, and magnetic fields may be implicated in some human health concerns. The debate about these effects continues.

neutral conductor on your farm and the neutral conductor on the distribution line are each connected to earth with ground rods and other electrodes at many places. This is done to limit the voltage on the neutral side of wiring. By so doing, this practice also reduces stray voltage to a safe level. Grounding is a safety practice required by the National Electric Safety Code to reduce the impact of faults and lightning strikes on the distribution system. As a consequence, current flows in the earth from the ground rod back to the current source (your transformer on the farm or the electric distribution substation).

Current flowing in the earth cannot have an effect on a cow unless the step voltage between front and rear hooves is large enough (see discussion of ac voltage above). These voltages are believed to be small, or at least smaller than step voltages found in barn stalls due to stray voltage. For this reason, they have not been commonly measured. This lack of data is why our research involves earth current measurements.

Step voltages were measured around the perimeter of your barn. The largest step voltage found outside the barn was _____ volt as measured across 5 feet of earth using a 500 ohm resistor. This compares with _____ volt measured across 5 feet in the test stall, again using a 500 ohm resistor. These comparisons will be used to determine the relative importance of voltages related to earth current in the stray voltage picture.

Other earth current quantities were measured or determined. The soil resistivity was measured around the barn. A soil sample was collected to determine its type and conductivity (ability to conduct electric current). A soil profile is being developed for your geographic location, again to get a more complete understanding of currents in the earth.

Further Information

If you have questions about the above information, you may contact me at the following address:

Riley Hendrickson
MN Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, MN 55101-2147

Data Privacy

This specific electrical data collected on your farm is being provided to you, the dairy operator, alone. No one else will be given this data without your written permission. The only data we will release from this research project will be statistical data that does not allow identification of individual test farms.

Dairy Farm Electrical Effects Research Program
Minnesota Public Utilities Commission
Electrical System Evaluation Protocol

I. Premises

For the purpose of this protocol, neutral-to-earth voltage (NEV) is the ac voltage measured between the grounded neutral conductor of an electrical system and the earth. Stray voltage is a small voltage between conductive surfaces subject to simultaneous contact by dairy cows.

The procedures described below will generally serve as means to evaluate conditions on the utility primary neutral and farm electrical system that may cause or contribute to stray voltage and electromagnetic fields. The values of stray voltage and electromagnetic fields that have been shown or alleged to affect dairy cows have been the subject of many published and sometimes conflicting reports, and are not addressed.

A. Stray Voltage. The predominant source of stray voltage is NEV on conductors which are connected to grounding electrodes at more than one point and interconnected with equipment grounding conductors. Less frequently, the source may be fault, leakage or capacitive current from energized conductors to equipment enclosures, or current flow between the earth and grounding electrodes. Possible sources of stray voltage include:

1. Voltage drop in utility primary neutral conductors interconnected with the farm neutral system
2. Voltage drop in secondary system neutral conductors on the supply side of points where they are bonded to equipment grounding conductors
3. Voltage drop in secondary system neutral conductor connections on the supply side of points where the conductor is bonded to equipment grounding conductors
4. Voltage drop in equipment grounding conductors due to current from conductor faults in the equipment to which the grounding conductor is connected
5. Faults, insulation leakage, or capacitive coupling in ungrounded electrical equipment
6. Improper use of equipment grounding conductors as a circuit conductor for utilization equipment, including the output circuits of equipment such as cow trainers, fencers, and milker pulsators, either directly, or through conductive interconnection with the electrical equipment
7. Improper connection of equipment grounding conductors to grounded circuit conductors on the load side of the disconnecting means for a building or structure
8. Voltage drop across the impedance associated with grounding electrodes due to earth current from faults in ungrounded equipment in contact with the earth, such as pumps
9. Voltage drop across the impedance associated with grounding electrodes due to earth current between grounding electrodes resulting from an open-circuited neutral conductor in the supply circuit to a building with 120-volt load
10. Voltage drop across the impedance associated with grounding electrodes where the electrode is inadvertently connected to an ungrounded circuit conductor, sometimes the result of improper installation or repair of two-wire feeders or services.

B. Electromagnetic Fields. Electromagnetic fields are generated by electromagnetic devices and currents whose instantaneous sum is zero in conductors enclosed in the same raceway or cable and are considered unavoidable without relocation of the offending equipment. Abnormal electromagnetic fields result where conductors of a circuit are not in close proximity, including cases where part

Most farm wiring systems will have Code violations or other defects. The inspector must therefore judge whether the defects observed pose an imminent hazard. Hazards may be corrected prior to the study only where it is clear that such changes will not affect the values to be studied. Where the electrical inspector, in consultation with other team members, determines that such conditions pose an undue risk, the farm should be dropped from the study. If a farm is dropped from the study, the reason shall be discussed with the owner/operator, followed by a written report to the owner/operator reaffirming that decision and the conditions that prompted it.

B. **Inspection and Testing Procedures.** Evaluation of the farm electrical system shall include visual inspection and test procedures to determine conditions that may cause or contribute to stray voltage or abnormally high electromagnetic fields, according to Part IV, below. Where the electrical measurements specialist identifies abnormal parameters, the electrical inspector shall perform any additional inspection services, when requested, to determine the cause. If hazardous conditions are found in the course of inspection and testing, the procedures of the last paragraph of Part III A, above, shall be followed.

C. **Inspection Findings Reported to Owner/Operator.** Although it is not an objective of this study to conduct a complete electrical safety inspection, as a service to the owner/operator, and to avoid possible liability claims, the inspector shall record and report to the owner/operator any observed National Electrical Code violations or system defects that, in his or her judgement, constitute significant risk of fire, shock, personal injury, or premature deterioration of components of the electrical system.

IV. Evaluation Procedures

A. **Documentation of Inspection Procedures.** All electrical inspections findings will be recorded on-site on the standardized electrical inspection forms devised to assure uniform procedures. The inspection record shall include:

1. Date, identifying information for the farm, and names of persons present
2. Name and address of serving electrical utility
3. A checklist of each item evaluated in the inspection
4. A description of any National Electrical Code or National Electrical Safety Code violations or other conditions that the inspector deems to be imminently hazardous or to actually or potentially contribute to stray voltage or electromagnetic fields, including Code references and Code edition where pertinent

B. **Site Electrical Plan.** As an aid to later analysis of the results an evaluation, a rough site plan (need not be to scale) with the following information shall be provided:

1. Identification of the northerly direction and orientation relative to public road
2. The location of poles for utility primary and secondary conductors and farm wiring system
3. The location of the utility distribution transformer
4. The location of the farm service equipment or service point
5. The relative location and identification of farm buildings and structures served with electrical power
6. Location and type of any passive or active primary isolation or neutral-to-earth voltage suppression devices
7. Routing of supply conductors for buildings or structures

structures

7. Impedance of grounding electrodes at the disconnecting means for structures

   A ground-rod resistance tester is the most convenient instrument for measuring electrode impedances if there are other grounding electrodes connected to the neutral system. Another method is to calculate the impedance from the measured grounding electrode current and the voltage between the grounding electrode and a remote reference ground, adding 120-volt load to obtain an accurately measurable voltage when necessary.

8. Grounding / bonding of neutral conductors and equipment grounding conductors at the disconnecting means for a structure

9. Proper grounding of conductive parts of electrical equipment, where required

   Grounding continuity may be conveniently checked by connecting a conductor to the grounding bus of the panelboard, extending it to the supplied equipment, and using an ohmmeter to measure the resistance between the conductor and the equipment enclosure.

10. Proper routing, sizing, and integrity of equipment grounding conductors

11. Installation of equipotential planes and bonding of metal equipment in confinement areas

    Due to the interconnection of many components with equipotential planes, in most cases it is impractical to accurately measure their impedance to ground. The effective grounding impedance of structures so equipped can be roughly determined by disconnecting the load in the building and testing with a ground-rod resistance tester on the neutral (or feeder grounding conductor, if present), or calculating it from the NEV and no-load neutral current.

12. Intentional or accidental grounding connections to circuit neutral conductors on the load side of the disconnecting means for structures

    Neutral grounding connections may be detected by the following methods:

    a. If the equipment is operating, check for current in the equipment grounding conductor, or place the ammeter jaws around both (or all three, if the circuit is three-phase) circuit conductors (but not the equipment grounding conductor) to check for residual current, which would indicate a fault.

    b. If the equipment is not energized, use an ohmmeter to check the resistance between a circuit conductor (on the load side of any controller or switch) and the equipment grounding conductor. The resistance should be at least several hundred thousand ohms. For 120-volt circuits, the neutral must be disconnected before performing this test.

13. Integrity of insulation of ungrounded circuit conductors

14. Correct polarity of two-wire circuits supplying structures - to assure that the ungrounded conductor is not erroneously connected to a grounding electrode

15. Grouping of conductors of the same circuit, including equipment grounding conductors

16. Current-carrying circuit conductors tapped from equipment grounding conductors

D. Summary Reports

A summary report of the conditions revealed by the electrical inspections shall be prepared upon completion of the project.

Appendix B. Proposed Farm Visit Schedule

Day 1

10:00 AM	Arrive. Conduct preliminary survey for unsafe conditions.
11:30	Begin inspection and testing of dairy barn and related facilities
12:30	Lunch break
1:30	Resume inspection and testing of dairy barn and related facilities
2:30	Begin inspect neutral/grounding system of other farm structures
6:00	End activities

Day 2

8:00 AM	Draw site plan
9:00	Perform load tests
10:00	Complete inspection reports - discuss results with other team members
11:30	Depart - unless other team members request further services

Dairy Barn and Associated Electrical Equipment

Building Power Source No. 1

☐ Overhead ☐ Underground

Drop or lateral phase conductors:

☐ Copper ☐ Aluminum

Size _____ Number per phase ____

Drop or lateral neutral conductor(s):

☐ Copper ☐ Aluminum ☐ ACSR

Size _____ Number per phase ____ Length, ft. _____

Entrance phase conductors (if applicable):

Wiring method:

☐ Non-metallic conduit ☐ Metal Conduit ☐ SE Cable

☐ Copper ☐ Aluminum

Size _____ Number per phase ____

Entrance neutral conductor(s) (if applicable):

☐ Copper ☐ Aluminum

Size _____ Number per phase ____ Length, ft. _____

Equipment grounding conductor (if any):

☐ Copper ☐ Aluminum

Size _____ Number per phase ____ Length, ft. _____

Main Disconnect:

☐ Fused switch ☐ Circuit Breaker

Rating in amperes _____

Building Power source No. 2:

☐ Overhead ☐ Underground

Drop or lateral phase conductors:

☐ Copper ☐ Aluminum

Size _____ Number per phase ____

Drop or lateral neutral conductor(s):

☐ Copper ☐ Aluminum ☐ ACSR

Size _____ Number per phase ____ Length, ft. _____

Entrance phase conductors (if applicable):

Wiring method:

☐ Non-metallic conduit ☐ Metal Conduit ☐ SE Cable

☐ Copper ☐ Aluminum

Size _____ Number per phase ____

Entrance neutral conductor(s) (if applicable):

☐ Copper ☐ Aluminum

Size _____ Number per phase ____ Length, ft. _____

Equipment grounding conductor (if any):

☐ Copper ☐ Aluminum

Size _____ Number per phase ____ Length, ft. _____

Main Disconnect (source 2 cont.):

☐ Fused switch ☐ Circuit Breaker

Rating in amperes _____

Source 1 neutral conductor impedances (ohms):

Drop or lateral _____ ohms (wire table values)

Entrance conductors (if any) _____ ohms (wire table)

Total neutral impedance _____ ohms (wire table)

Measured voltage drop at _____ amperes _____ volts

Calculated neutral impedance _____ ohms

Source 2 neutral conductor impedances (ohms):

Drop or lateral _____ ohms (wire table values)

Entrance conductors (if any) _____ ohms (wire table)

Total neutral impedance _____ ohms (wire table)

Measured voltage drop at _____ amperes _____ volts

Calculated neutral impedance _____ ohms

Underground metal water pipe present: ☐ Yes ☐ No

Other underground metal piping, etc. suitable for use as a grounding electrode: _____

Grounding electrodes employed / impedance in ohms:

	Source 1	Source 2
☐ Ground rod	_____	_____
☐ Underground water piping	_____	_____
☐ Well casing	_____	_____
☐ Building steel	_____	_____
☐ Reinforcing steel	_____	_____
Other _____		

Non-electrical equipment bonded to service:

☐ Interior water piping ☐ Milk pipeline ☐ Vacuum line

☐ Building steel ☐ Stanchion/tie stalls metalwork

Other _____

Service bonding jumper installed? ☐ Yes ☐ No

Equipment grounding meets National Electrical Code (NEC) requirements? ☐ Yes ☐ No (see comments)

Equipotential plane installed? ☐ Yes ☐ No

Impedance _____ ohms

Neutral grounding connections or faults that violate NEC?

☐ No ☐ Yes (see comments)

Branch circuit and feeder overcurrent protection meets NEC requirements? ☐ Yes ☐ No (see comments)

Submersible pump(s) grounded? (Yes if checked)

☐ Pump ☐ Casing ☐ No submersible

Location _____ Ohms

Building and Electrical System Layout (not to scale)

Dairy Diagnostics & Assessments Research Program
Minnesota Public Utilities Commission:
Draft Report on Veterinary Farm Study Evaluation

I. Introduction

As part of the ongoing project established by the science advisors to the Minnesota Public Utilities Commission, a team of professionals was assembled. This team consisted of, an electrical inspector, an electrical engineer, and a veterinarian. The purpose of the team was to conduct field assessment and data collection on 20 dairy farms in the State of Minnesota.

In this particular draft, I, Robert J. Schell DVM will summarize the procedures and techniques utilized in the veterinary portion of the protocol of the on farm assessments.

II. Selection of Farms

Along with the potential 20 test farms, there were 2 additional "practice" farm sites selected for conducting protocol testing. These two farms were selected from knowledge of the individual dairymen and were not chosen at random for test procedures but rather as locations for trial runs of the protocols. The results were tabulated to ensure that spreadsheet formulas were correct. The data was not included with the test farms nor evaluated for statistical significance.

The actual test farms were selected from surveys conducted by the Minnesota Agriculture Statistics Service. The minimum number of milk cows had to fall in the 15th percentile of average dairy size in Minnesota. The farm had to milk at least 30 cows.

From this point farms were separated by the following categories:

1. Rolling herd average
2. Somatic Cell Count (SCC)
3. Mortality Rate
4. Cull Rate

Farms were assigned scores based on the above as follows:

1. Rolling herd average; poor-1 or 2, below 16,000 lbs/cow/yr
   good-4 or 5, above 18,000 lbs/cow/yr
2. Somatic Cell Count Score(SCC); poor-4 or 5, SCC 350,000 or >
   good-1 or 2, SCC below 250,000
3. Mortality Rate; poor-80th percentile on mortality rate of 6.8%
   good-20th percentile on mortality rate of 0%
4. Cull Rate; poor-80th percentile on culling rate 29%
   good-20th percentile on culling rate 11.1%

The mean clinical score were broke down as follows:

poor-80th percentile on signs score 2.09
good-20th percentile on signs score 1.36

- monthly protein percentage
- monthly somatic cell count (SCC)
- bacteria counts at the bulk tank

With the above data, time plots could be attained for the individual dairy and compared to its contemporaries.

The collection of this data was often the most difficult to obtain. Due to missing milk receipts and the reporting differences between milk procurement companies. This created a need for the data to be standardized.

The next data obtained from the farm visit was animal profiles. Each animal in the herd was profiled (up to 75 head per herd). The purpose of the profile was to determine if there were physical differences in the animals on a herd basis. Included in this analysis were the following traits.

- Cow ID
- Age
- Lactation number
- Days in milk
- Reproductive status (open, bred, or pregnant)
- If pregnant, days carrying calf
- Height
- Weight
- Body condition score (1-5, with 3 being average)
- Manure consistency score
- Lactating status (none, lactating, or dry)

With the accumulation of this data a herd profile could be calculated and this could be compared herd to herd. These indicators are very useful and used regularly in the field. In addition to these above, every lactating cow was tested with a procedure called the "California Mastitis Test". The test includes the collection of milk from each lactating quarter from the profiled cows. The quarters are sampled into a sample paddle with a uniform amount of milk from each quarter. A test detergent is added to each quarters' sample. A resulting change in color and consistency occurs when the SCC of the quarter is elevated. The quarters were scored 1 through 4, with a score of one showing no change in consistency and a light blue color. A score of four indicates a complete clumping or the production of a gel like mass and a deep purple color. The higher the score the higher the SCC. The purpose of this test was to assess if the SCC in the bulk tank was produced by a few cows with extremely high SCC or a high number of cows with a modest SCC. This information assisted in determining farm recommendations for herd problem work-ups or the removal or treatment of individual animals.

The above listed categories were collected for all of the cattle in the herd. Animals in the lactating stage, as well as, dry cows. Any animal who had not yet had her first calf was considered youngstock and data on these animals was collected in the following health survey. A similar type of accumulation of incidence with a slight variation in categories was used for data collection. The youngstock categories were as follows:

- calf scours (listed as a percentage of incidence in the herd in the last 12 months)
- pneumonia (actual number of treated cases)
- parasites - internal (number of animals in groups that tested fecal positive for any internal parasites)
- parasites - external (number of animals treated for external parasites or mainly "lice")
- pinkeye
- ringworm infections
- warts
- lameness (foot, leg or hip injuries)
- abortions (again 1st, 2nd, or 3rd trimester)

Accumulation of data on the youngstock was the most difficult because the records were the least accurate. Most farms in the study required that I rely upon the dairyman's recollection of incidence from the past twelve months. The ability to accurately recall the information varied by producer.

NUTRITION:

In the area of nutrition, each farms' lactating cow ration was defined and analyzed. All roughage's were analyzed for dry matter content using a digital gram scale and a feed dehydrator. One hundred grams of each feedstuff were placed in the dehydrator and when a constant weight was achieved, the dry matter percentage was recorded. This process usually took approximately 24 hours. If the farmer was using a total mixed ration (TMR) this also was dehydrated to determine dry matter percentage. The dry matter percentages were used to calculate dry matter intake of each animal. The amount of feed fed each animal was weighed by ingredient and then multiplied by the dry matter percentage to give the actual dry matter intake. When this was calculated and all ingredients combined the total dry matter intake was calculated. I used a software program produced at Michigan State University called "Spartan Balancer" as a spreadsheet template and feedstuff library to put together the ration as it was being fed to the cattle. If the dairyman had not previously had his feedstuffs analyzed, a sample of the feed was submitted to an analysis lab. At the lab the results obtained were:

- Dry matter Percentage of the feedstuff
- Crude protein content
- NDF (neutral detergent fiber)
- ADF (acid detergent fiber)
- TDN (total digestible nutrients)
- Insoluble protein

It was also recorded if there was the need for a booster immunization (whether or not this was completed). Also where applicable, the timing of the vaccine was recorded, such as with killed vaccines. The date or dates of the annual vaccination or biannual was recorded. Other vaccines that were given at certain reproductive stages or as a continuous ongoing process where specific animals were vaccinated monthly or weekly were also noted.

The same criteria was used on the youngstock and the completion of the vaccination protocol was submitted. In the youngstock it was also identified if they were vaccinated against brucellosis or "bangs" disease. This is a common practice amongst dairymen.

ENVIRONMENT

The assessment of the environment begins with the basic measurements of the housing facilities of the milk cows. This includes the length, width, and height of the actual building in which the animals are housed. utilizing these dimensions the cubic footage of the building can be calculated. The purpose of the calculation is to determine two things, the amount of air that needs to be exchanged both summer and winter and to determine if the barns are physically large enough to adequately house the cattle in them. It is desirable to have 4 air exchanges per hour in the peak winter (cold) days and 30 air exchanges per hour in the summer. Exhaust fans are designed and calibrated in units called CFM or cubic feet per minute of air exchanged. The information on building dimensions and the calculations for CFM summer and winter are included in the spreadsheet.

The area measured next is probably the single most important to the cow, and that is the dimensions of her individual stall. The desired dimensions in a tie or stanchion barn are 48 inches wide by 72 inches long. I laid out and reported an average stall size for the entire barn. In retrospect a grid should be made of the barn with the stall sizes listed individually, as in many barns the stall sizes varied. This was not a large issue in barns were cows had assigned stalls, but in the majority of the barns this was not the situation. A problem arises when a large cow ends up in a small stall. The outcome is reduced production. If a grid map were made and time permitting a correlation could be made between cow size, stall size, and production in these trial barns.

Animal comfort was analyzed next. This was done on each of the following areas:

- Milking cows
- Maternity pens
- Dry cows
- Springing Heifers
- Breeding age heifers
- 4-13 mo. old calves
- 0-4 mo. old calves

MILKING SYSTEM

Along with collecting data on the dairy cattle and their environment it is also necessary to check the equipment required to harvest milk from the cows. In using standard techniques adopted by the National Mastitis Council, the milking equipment analysis was added to the protocol.

In the analysis of the system various parameters were evaluated including:

- operating vacuum level (inches Hg)
- regulator function test
    - effective reserve with .6 inch vacuum drop
    - manual reserve with .6 inch vacuum drop
        - result equals % regulator function (>90% required to pass, effective reserve divided by manual reserve)
- milk machine drop off test (< .6" vacuum drop in line vacuum w/ 1 machine inserting maximum air)
- pulsator function test on each pulsator
- mono Vs. dual pulsation
- if dual pulsation, then front to rear or side to side
- pulsation rate (beats per minute)
- pulsation ratio, % of each beat in the milk phase Vs rest phase
- milk line size (inches)
- pulsation line size (inches)
- number units
- number of units per milker
- maximum number of milking units per milker
- milk line type: high line or low line

A number of these tests require special instruments to evaluate the milking equipment. A vacuum gauge along with a flow meter are required to conduct all of the regulator tests. A digimat 2000 was used for the pulsator function tests. This piece of equipment digitally measures all of the parameters that pertain to the pulsators (i.e. rate, ratio, all phase breakdowns and degree of fluctuations).

The purpose of testing the milking system was to identify if there was system variability and reasons to suggest limited milk production. In almost every installation we were able to identify some aspect of the milking system that was not operating up to manufacturers specifications.

LIVESTOCK INVENTORY

subtotals

ADULT COWS (have had at least one calf)

lactating _____

dry _____

other _____

total 0

YEARLINGS (> 12 mo. age and not calved)

total 0

YOUNGSTOCK (< 12mo age)

4 to 12 Mo. _____

< 4 Mo old _____

total 0

OTHER

steers _____

bulls _____

beef cattle _____

_____ _____

_____ _____

total 0

total 0

2 HEALTH PROBLEMS: PREVIOUS 12 MONTHS

COWS

OFF FEED/INDIGESTION

FATTY LIVER/COW SYNDROME

UDDER EDEMA

DISPLACED ABOMASUM (LDA & RDA)

MILK FEVER

KETOSIS

MASTITIS (CLINICAL)

MASTITIS (TREATED SUBCLINICAL)

RETAINED PLACENTA

METRITIS OR PYOMETRA

HARDWARE DISEASE

FAILURE TO CONCEIVE (BRED > 3 TIMES)

ASSISTED CALVINGS

LAME CATTLE/ FOOT PROBLEMS

HOCK INJURIES

CHRONIC SCOURS

PNEUMONIA

ABORTIONS:

LESS THAN 3 MO PG

3 TO 6 MO PG

GREATER THAN 6 MO PG

3 COMMON HERD PRACTICES

COWS

A) DRY COW THERAPY PRACTICES

	Y	N
ALL		
NONE		
SELECTIVE		

PRODUCT USED: _____

B) TEAT DIPPING

ALL		
NONE		
SELECTIVE		

PRE DIP		
POST DIP		

PRODUCT USED POST: _____

PRODUCT USED PRE: _____

C) DO YOU WEAR LATEX GLOVES AT MILKING?

DO ALL MILKERS?

4 OTHER HERD HEALTH PRACTICES

A. VETERINARY HERD HEALTH VISITS

	Y	N
weekly		
twice/mo		
monthly		
quarterly		
as needed		
other:_____		

B. CALF RAISING PRACTICES

colostrum at birth from dam		
colostrum at birth thawed from freezer		
nurse on cow w/ no help from dairyman		

milk replacer		
whole fresh milk		
whole discard milk		
% whole fresh_____%discard_____milk rep_____		

age at weaning

< 4 weeks		
4 - 6 weeks		
6 - 8 weeks		
8 - 10 weeks		
> 10 weeks		

MILK RECEIPTS

MONTH	DATE month/year	days/mo	lb milk/mo	# cows milking per day	average # treated cows per day	lb milk/day	# milk/ cow/day
		1					
		2					
		3					
		4					
		5					
		6					
		7					
		8					
		9					
		10					
		11					
		12					
		13					
		14					
		15					
		16					
		17					
		18					
		19					
		20					
		21					
		22					
		23					
		24					

NUTRITIONAL WORKSHEET

RATION GROUP: _____ DATE: _____

feedstuff	lbs. fed	% dry matter	lb. dry matter

comments: _____

VACCINATION Hx

FARM:

YOUNGSTOCK

date	VACCINE	Y	N	BOOSTER Y OR N	MLV/KILLED	VACCINE USED
	BRUCELLOSIS (BANGS)					
	IBR					
	BVD					
	BRSV					
	LEPTO					
	PASTUERELLA					
	CLOSTIDIAL					
	ROTA VIRUS					
	CORONA VIRUS					
	OTHER:					

RUMEN pH READINGS

	ANIMAL ID	pH	DIM
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

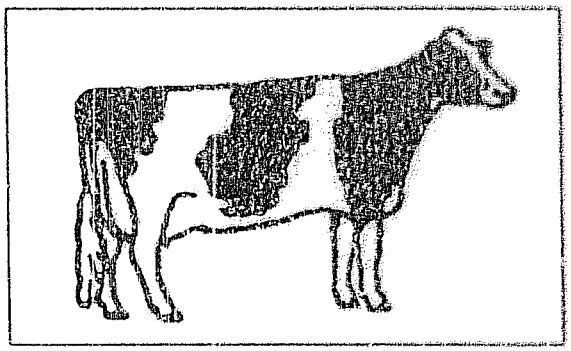
cow comfort continued:

day #	time	# cows standing	total cows in barn	activity in barn ** see note

** should be conducted at a time when there are no people in the barn

% of herd with hock bone lesions

% of herd with pin bone injuries



% of herd with hock injuries

% of herd with knee injuries

other: describe:_____

FARM

LAB RESULTS

BULK TANK SAMPLE ANALYSIS

TYPE OF BACTERIA	YOUR HERD
Strep. ag.	
Staph. aureus (coagulase pos.)	
Non-Ag. Strep.	
Coliforms	
Staph. epi (coagulase neg.)	

FECAL EXAMINATIONS

sample source or animal #	coccidia pos/neg	other pos/neg	type other

OTHER LAB TEST

describe: type test & animal ID	result pos/neg/other

Appendix D: Laboratory Research Proposal

RESEARCH PROPOSAL

SUBMITTED TO THE MINNESOTA PUBLIC UTLITIES COMMISSION

BY Douglas J. Reinemann, Ph.D., Associate Professor, Biological Systems Engineering, University of Wisconsin-Madison
Morten Dam Rasmusssen, Ph.D., Senior Research Scientist, Danish Institute of Agricultural Science, Department of Animal Health and Welfare

Milo C. Wiltbank, Ph.D., Associate Professor of Dairy Science, University of Wisconsin-Madison
Lewis G. Sheffield, Ph.D., Associate Professor, of Dairy Science, University of Wisconsin-Madison.

Jenks Britt, DVM, Associate Professor of Veterinary Medicine, University of Wisconsin-Madison

The proposed study has four major objectives:

Investigate immune function response to continuously applied, low-level voltage. The highest priority question emerging from the science advisors report is the possible adverse effects of continuous exposure to low level voltage and current. The presumed pathway of exposure is hoof-hoof step potential.

Compare dairy cow sensitivity to voltage applied hoof-hoof with muzzle-hoof pathways.

Investigate the relationship between behavioral responses previously observed and other physiological methods of quantifying stressors.

Compare responses to low voltage exposure to other acute stressors.

Three experiments are proposed to meet these objectives. Two types of voltage and current exposures would be performed. Short-term exposure (from 1 to 10 minutes) would be used for Parts I and II and objectives 2, 3, and 4. Longer-term (2-week) continuous exposure would be used for Part III and objective 1.

Part I. Short-term exposure, hoof-hoof sensitivity testing, and comparison of behavioral to physiological responses

Short-term acute exposure experiments will be performed to establish the relationship between sensitivity to hoof-hoof and muzzle-hoof pathways. There has been very little work done to document hoof-hoof exposures yet this is a common exposure pathway in the field. Previous methods have relied primarily upon behavioral response as an indication of the sensitivity threshold to electrical exposure. Behavioral responses have also been used several other researchers to measure the threshold response to voltage exposure. As stated in the science

advisory report, 'less subjective and more quantitative dairy cow behavioral response indicators and more reliable physiological response indicators are desired in further laboratory studies'.

These studies would be done in the same manner as those previously performed at the UW to establish sensitivity to a variety of other electrical exposures. Cows would be exposed to an ascending series of voltage/current exposure via muzzle-hoof and hoof-hoof pathways until a behavioral response is measured. Previous results have indicated that computerized monitoring of animal activity (shift in center of gravity) was highly correlated with human observers measurement of hoof lifting. This computerized monitoring systems will be enhanced with real-time statistical analysis of cow activity indicating change in activity level. Cow activity and hoof lifting is expected to be the most repeatable indicator of perception for hoof-hoof exposure and will be used as the primary behavioral indicator of response.

Four cows will be tested using the muzzle-hoof pathway and four cows using the hoof-hoof pathway. The following day each cow will be tested using the alternate pathway. These tests will establish the behavioral response level for each cow.

The test cows will then be exposed to the hoof-hoof pathway while at least 3 days after sensitivity testing. Blood samples will be drawn at 15-minute intervals for 1 hour before testing. The main physiological measure will be endocrine response. Each cow will then be exposed to current equal to 50%, 75% and 100% of the sensitivity threshold found in the first part of the experiment. If no behavioral response is found a fourth level of 150% of the sensitivity threshold will be applied. These voltage exposures will be applied for 5-minute intervals once every hour. Blood sampling will continue at 15-minute intervals throughout the testing of for an additional hour after the last exposure.

Endocrine Assays

Secretion of glucocorticoids, such as cortisol, is the classical measure of stress response. This response can be reduced by many conditions that have been identified as biological stressors such as surgery, pain, isolation, physical handling, or psychological stress. Ruminants secrete both of the principal glucocorticoids, cortisol, and corticosterone, in sizable amounts and measurement of either of these should be a good indicator of this aspect of stress response. Subsequent experiment could focus on downstream effect of stress such as effects of particularly stresses on reproductive hormones, reproductive behavior, or other parameters. For this project, it is considered most important to focus on the early mechanisms involved in the stress response so that we can rationally evaluate subsequent biological response.

Cows will be fitted with indwelling jugular catheters to facilitate sample collection prior to beginning experiments. Canulas will be flushed twice daily with heparin. After collection, blood samples will be centrifuged and plasma stored at -20 C until assay.

Samples will assayed by radioimmunoassay or ELISA for cortisol, prolactin, and catecholamines. Cortisol is a standard marker of stress, and changes rapidly in response to stress. It is well known to suppress systemic immune function. Prolactin is also increased during acute stress. In contrast to cortisol, prolactin appears to have a protective effect on immune function, and may ameliorate some of the negative effects of cortisol. Catecholamines are also acutely

released in response to environmental stress.

All of the above assays are straightforward, and the necessary reagents for RIA and ELISA are readily available. These measures typically have coefficients of variation of 25-30%. For replication of 8-10 animals per treatment, this would correspond to detecting a 50-60% change in hormone concentration. The concentrations of the hormones measured typically double (or more) in response to stress, so the experiment should readily detect important differences.

These experiments will test whether direct physiological measures of stress occur at voltage and current levels below those at which behavioral responses can be measured. This would help to clarify the applicability of previously documented behavioral measures of response to voltage and current.

Part II. Comparison of treatments applied during milking

The treatments for these experiments will be applied in one of the milking stalls at the UW Dairy Cattle Research and Instruction facility during milking. Treatments will be applied over 4 consecutive days using a Latin square design with 8 cows per experiment and 2 cows per treatment group. The treatments applied will be:

Control
Hoof-hoof voltage exposure below sensitivity threshold
Milking machine induced stress
Combined low voltage and milking machine stress.

The response measures will be:

Hoof lifting during milking
Average and peak milk flow during milking
Pounds of milk yield
Milking time

Cows will be directed into one of the four milking stalls equipped with the experimental apparatus. Cows not involved with the experiment will be milked in the other 3 milking stalls during the experiment so that 'normal' milking routines will not be interrupted. The order in which cows enter the milking area will be recorded and the time taken for the cow to move from the entrance gate to the parlor into the milking stall will measured. Reluctance to enter the milking stall may provide a measure of carry over effects of treatments. The level of voltage exposure will be 1/2 to 1 volt (1 – 2 milliamp). This is below the level of concern established by previous research and adopted by the State of Wisconsin, Public Service Commision in their stray voltage rule.

Frequency of hoof lifting and kicking during milking have been suggested as measure of cow discomfort during milking. These are likely to be sensitive measures for hoof-hoof voltage exposure. The milk letdown reflex is influenced by stresses experienced during milking. Discomfort during milking may decrease both the peak and average milk flow rate during milking, increase the time taken to remove the milk and increase the amount of milk remaining in the udder after machine milking.

The results of these experiments would provide valuable information on the relative effects voltage exposure and other common stresses in the animal environment such as sub-optimal

milking machine performance.

Part III. Longer-term continuous exposure to sub-acute voltages.

These experiments will be performed using the eight test stalls in the UW research barn housing area. The primary objective of these experiments will be to measure immune function response to continuously applied hoof-hoof voltage exposure below the sensitivity threshold of individual cows. The treatments will be applied continuously for a period of 2 weeks. The cows would be exposed to voltage whenever they are in the housing area. The level of voltage exposure will be 1/2 to 1 volt (1 – 2 milliamp). This is below the level of concern established by previous research and adopted by the State of Wisconsin, Public Service Commision in their stray voltage rule. Cows will be taken to the milking parlor to be milked and then returned to their stall in the housing area twice per day. The low level voltage will be cycled on and off an a 10 minute intervals as biological effects previously observed appear to be most pronounced when the exposure is changing with time.

The treatment groups will be:

Control	(4 cows)
Hoof-hoof exposure below perception	(4 cows)

The response measures will be:

Immune function response indicated below and
Time and pattern of laying
Time to re-enter stall after milking

For the hoof-hoof exposures in the tests stalls in the housing area, the current level and current density in the cow will be reduced when cows are lying. This is due to the higher resistance and larger contact area when lying. Cows must, however, stand to eat and drink. If the voltage/current exposure were perceived as undesirable to the cow, the time and pattern of lying would likely be changed. The time for the cows to reenter the test stalls in the housing area will be used to measure aversion to this treatment.

Immune Function Assays

Blood samples will be collected twice weekly for assessment of immune function. Samples will be collected for one week before exposure and for the two weeks of exposure. Samples will be collected from indwelling jugular canulas as described for hormone sample collection. Immediately after collection, an aliquot will be saved and used for differential cell counts. Remaining blood will be used to collect leukocytes, as previously described (Lohuis et al., 1990). Hypotonic lysis will be used to remove red blood cells, and percoll gradient centrifugation used to enrich target leukocyte populations. Leukocytes will then be used immediately for lymphocyte blastogenesis, antibody production and oxidative burst assays.

For lymphocyte blastogenesis (Lave et al., 1979), cells will be diluted in Fisher's medium and 50 ml containing 10^5 cells plated onto 96-well culture dishes. Dose responses to standard mitogens, including S. aureus, phytohemagglutinin, pokeweed mitogen and concanavalin A will be

determined. Phytohemagglutanin and concanavalin A activate largely T lymphocytes, pokeweed mitogen T and B lymphocytes and S. aureus cells B lymphocytes. After 72 hours, 1 mCi 3H-thymidine will be added, cells incubated an additional 4 hours and cells harvested using a 96-well plate harvester. Incorporation of 3H-thymidine into DNA will then be used as an index of mitogenesis.

To assess immunoglobulin production (Lane et al., 1979), 3x106 cells will be suspended in 300 ml media. Cells will be treated with or without pokeweed mitogen for 5-10 days and immunoglobulin production assessed by ELISA, using antibodies against specific bovine immunoglobulins.

To assess oxidative burst (Trush et al., 1978), chemiluminescence in response to standard activators of macrophage and neutrophil function will be used. Leukocytes (106)will be placed in 0.5 ml phenol red free Dulbecco's Modified Eagle's Medium (DMEM) containing 100 mg/ml luminol. Baseline luminescence will be assessed after 10 minutes incubation. Next, 0 or 10 ng/ml phorbol myristate acetate (PMA) will be added, cells incubated 1 minute and light emission determined again. The difference will be used to estimate PMA-induced chemiluminescence. Specificity will be assessed by measuring superoxide production on randomly selected samples, using reduction of cytochrome c (Badwey et al., 1979) as well as phagocytosis and intracellular killing of opsonized S. aureus (Leijh et al., 1979).

These assays are rapid, relatively inexpensive, routine and provide important initial information on immune system function. Lymphocyte mitogenesis (blastogenesis) is a well-documented response to lectins, and is generally recognized as a useful measure of systemic immune function. Chemiluminescence is widely used as a measure of respiratory burst in phagocytic cells, a key event in phagocytosis and intracellular killing of bacteria. These two measures together will provide important measures of lymphocyte and phagocyte function in response to various treatments.

Obviously, the above measures are not exhaustive. In addition to the proposed measures, a variety of others, such as cytokine expression, response to in vivo antigen challenges or NK cell activity could also be measured. However, the proposed measures represent several of the major immunological processes, and are likely to be altered if systemic immune function is suppressed by the treatments. If these basic measures of immune function are altered, additional studies to determine the mechanisms of alteration in more detail could then be undertaken.

In a recently completed study (unpublished) we used the above measures of bovine immune function, and observed that error variation was 10-15% for most measures. Using 8-10 animals per treatment, this would allow us to detect differences of 15-20%, which is in the range considered physiologically relevant for these measures (see, for example, Kehrli et al., 1989a, b; Weigel et al., 1992).

Because samples cannot be stored for immunology measures, a technician must be available during the times when experiments are in progress. Samples for hormone assays can be stored prior to analysis. A full-time technician will collect samples and perform immediate immune function assays, as well as to perform hormone assays on stored samples when samples are not being collected. Additional hourly labor will e used to assist in sampling and reagent preparation.

SCHEDULE FOR EXPERIMENTS

Part I. Short-term exposure, hoof-hoof sensitivity testing, and comparison of behavioral to physiological responses.

Week 1 — Place 8 cows in housing area Test Stalls
Behavioral sensitivity testing 4 muzzle-hoof, 4 hoof-hoof
Behavioral sensitivity testing 4 hoof-hoof, 4 muzzle-hoof

Week 2 — Fit Canulas for endocrine tests
Ascending voltage series and Endocrine tests, 4 cows per day

Part II. Comparison of treatments applied during milking.

Day 1 — Baseline data with no treatment

Days 2-5 — Randomly assigned treatments, 16 cows tested per day
Each cow to receive all 4 treatments
Treatments = Control, Low Voltage, Milking Stress, combined Low Voltage and milking stress

Part III. Longer-term continuous exposure to sub-acute voltages

Week 1 — No voltage/current exposure
2 blood samples for Immune Assay

Week 2 — Continuous voltage/current exposure
2 blood samples for Immune Assay

Week 3 — Continuous voltage/current exposure
2 blood samples for Immune Assay

The experimental apparatus will be assembled and tested beginning at the start of the contract period. A progress report on the validation of the equipment and test methods will be issued by June, 30 1998. A second progress report will be issued by Dec 31, 1998 documenting results of experiments completed by that date. It is anticipated that at least one replicate of parts I, II and III will be completed by this date. This second report will also indicate any revisions to the protocol and provide a schedule for remaining experiments. Our intention is to repeat the experiments until a significant response is documented, until sufficient statistical power to conclude a negative result, or until the end of the contract period, whichever comes first. Thus, some may be repeated more or less than others and we may not have time and resources to complete the full schedule. It is estimated that 3 replicates will be required for each experiment. A final report will be issued by June 30, 1999 summarizing the results of all studies completed.

ESTIMATED BUDGET

Lab Technician, 14 months	43,550
Research Assistant ½ time for 16 months	32,760
Hourly lab and technical assistance, 1/3 time, 16 months	17,740
Electrical monitoring and hardware, equipment and supplies	18,000
Lab Supplies, Immune and Endocrine Assay materials	19,700
Cow use fee 1500 cow-days	4,500
Travel	2,500
Office supplies, expenses and publishing costs	2,500
Danish Institute of Agricultural Science	
Scientist salary and office support 4.5 months	31,500
Travel	4,500
Total from Minnesota PUC	178,550

REFERENCES

wey, J.A., J.M. Robinson, M.J. Karnovsky and M.L. Karnovsky. 1979. Reduction and excitation of oxygen by phagocytic leukocytes: biochemical and cytochemical techniques. In: Immunological Methods, 3rd Edition. I. Lefkovits and B. Pernis, Eds. New York: Academic Press, pp50.1-50.16.

rli, M.E., Jr., B.J. Nonnecke and J.A. Roth. 1989a. Alterations in bovine peripheral blood neutrophil function during the periparturient period. Amer. J. Vet. Res. 50: 207-214.

rli, M.E., Jr., B.J. Nonnecke and J.A. Roth. 1989b. Alterations in bovine peripheral blood lymphocyte function during the periparturient period. Amer. J. Vet. Res. 50: 215-220.

e, H.C., G. Whalen and A.S. Fauci. 1979. In vitro evaluation of human lymphocyte function. In: Immunological Methods, 3rd Edition. I. Lefkovits and B. Pernis, Eds. New York: Academic Press, pp. 6.1-66.14.

n, P.C.J., R. VanFurth and T.L. VanZwet. 1979. In vitro determination of phagocytosis and intracellular killing by polymorphonuclear and mononuclear phagocytes. In: Immunological Methods, 3rd Edition. I. Lefkovits and B. Pernis, Eds. New York: Academic Press, pp46.1-46.12.

ds, J.A.C.M., Y.H. Schukken, P.A.J. Henricks, R. Heyneman, C. Burvenich, J.M.H. Verheijden, A.S.J.P.A.M. Van Miert and A. Brand. 1990. Preinfection functions of blood polymorphonuclear leukocytes and the outcome of experimental Escherichia coli mastitis in the cow. J. Dairy Sci. 73:342-350.

h, M.A., M.E. Wislen and K. Van Dyke. 1978. The generation of chemiluminescence (CL) by phagocytic cells. Methods Enzymology 57:462-494.

gel, K.A., A.E. Freeman, M.E. Kehrli, Jr., J.R. Thurston and D.H. Kelley. 1992. J. Dairy Sci. 75:1672-1679.

EL98-005

Dated 12-3-1998 Time 4:00 P.M

Dear Mr. Wiegman,

As we have discussed earlier their seems at this time no need to proceed with the Hearing Do to the fact that Lincoln Union is know trying to update the Line around my place and fix some of the things discussed and also that they will report back to you periodically on various reports.

Best regards.
Douglas L. Kuper

Public Utilities Commission

I Douglas A. Kagan, withdraw my complaint against Hawaiian Elect. Co. And the Commission will receive reports from Hawaiian Elect. at various times.

Case No. A-97
Dated 12-4-1998

Sincerely,
Douglas A. Kagan

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	)))))	ORDER DISMISSING COMPLAINT AND CLOSING DOCKET EL98-005

On March 6, 1998, the South Dakota Public Utilities Commission (Commission) received a complaint from Douglas L. Kuper (Kuper), Lennox, South Dakota, against Lincoln-Union Electric Company (Lincoln-Union) regarding stray voltage. In an Order dated April 28, 1998, the Commission made a finding of probable cause of an unlawful or unreasonable act, rate, practice or omission by Lincoln-Union. Lincoln-Union filed an Answer dated May 18, 1998. Lincoln-Union by motion dated July 16, 1998, moved to dismiss the complaint of Kuper. A hearing on the motion to dismiss was held by the Commission on July 23, 1998, via teleconference. On August 4, 1998, the Commission voted to deny the motion to dismiss, Commissioner Burg dissenting. An Order to that effect was entered on August 14, 1998. A prehearing conference was scheduled for December 4, 1998, with the hearing scheduled for December 15, 1998, in Sioux Falls, South Dakota. Prior to the prehearing conference Mr. Kuper faxed a letter to the Commission Staff stating that there was no need to proceed with the hearing. Mr. Kuper was not present for the prehearing conference. The Commission decided to defer the matter to clarify the intent of Mr. Kuper to dismiss the complaint. On December 4, 1998, Mr. Kuper faxed a letter to the Commission stating, "I, Douglas L. Kuper withdraw my complaint against Lincoln-Union Electric Co. That the Commission will receive reports from Lincoln-Union Electric at various times." At its regularly scheduled meeting of December 7, 1998, Mr. Kuper confirmed that he wished to withdraw his complaint and have the Commission dismiss it without prejudice. The Commission voted unanimously to dismiss the complaint without prejudice and close the docket. The Commission also ordered that Staff's final report be filed in the docket and that an ongoing power review continue through the summer of 1999.

The Commission has jurisdiction over this matter pursuant to SDCL Chapter 1-26, 49-34A-58, and ARSD 20:10:01:08.01 et seq. It is therefore

ORDERED that the complaint shall be dismissed without prejudice and the docket will be closed. It is further

ORDERED that Staff's final report be filed in the docket and that an ongoing power review continue through the summer of 1999.

Dated at Pierre, South Dakota, this 30th day of December, 1998.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, by facsimile or by first class mail, in properly addressed envelopes, with charges prepaid thereon.

By: Delaine Kolbo

Date: 12/30/98

(OFFICIAL SEAL)

BY ORDER OF THE COMMISSION:

JAMES A. BURG, Chairman

PAM NELSON, Commissioner

LASKA SCHOENFELDER, Commissioner

Lincoln-Union Electric Company

P.O. Box 105
Alcester, SD 57001-0105
Tel.: (605) 934-1961 or (800) 333-2859 SD only
Fax: (605) 934-1964

February 12, 1999

RECEIVED
FEB 11 1999
SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

Karen Cremer, Staff Attorney
SD Public Utilities Commission
State Capitol
Pierre, SD 57501-5070

Dear Ms. Cremer:

As part of our ongoing monitoring process pertaining to Mr. Douglas L. Kuper's complaint to the South Dakota Public Utilities Commission, File No. EL98-005, we are enclosing the attached information for your review.

These materials are load monitoring data pertaining to Mr. Kuper's electrical distribution line serving his farm (pages 1 & 2) and how that load compares to our entire load on the Davis Substation circuit (pages 3 & 4.) The written explanation on each graph should provide a clear description of what we are monitoring and how it compares to the maximum load carrying capability of these lines. These graphs are a continuance of the previously provided data included on pages 15 through 18 of the Line Maintenance Report sent to Mr. Steven Wegman on December 11, 1998.

If you have any questions on these materials or the data provided to Mr. Wegman and Mr. Kuper dated December 7, 1998, please give me a call.

Sincerely,

Brad Schardin
Manager

Enc.
cc: Douglas L. Kuper

Confirmation

4

of pages

Doug F 2 hrs
Unit #6 40 miles

FORM 24893 TIMECANCE PRESS INC., SHELBYVILLE, IND.
NO. 4 DUFFIN NO. 166-1

INTERRUPTION REPORT

Serial No. _____

Time Reported: 9:00 AM. Reported By: Mrs Harvey Hoffman

Report Received By: Doug F Assigned To: Doug Triest

Time Off: 8:50 AM. Time On: 9:50 AM. Total Time: 1 hr

Location or Area Affected: Davis Sub North circuit B Ø

Number of Members Affected: 69 Consumer Hours Off: 69 hrs.

Cause: Squirrel on top of our pole mount transformer at the location of 18-36-8 shorted the line and tripped our B Ø OCR in the Davis Sub.

Action Taken: I removed the squirrel and reset our B Ø OCR in the Davis Sub.

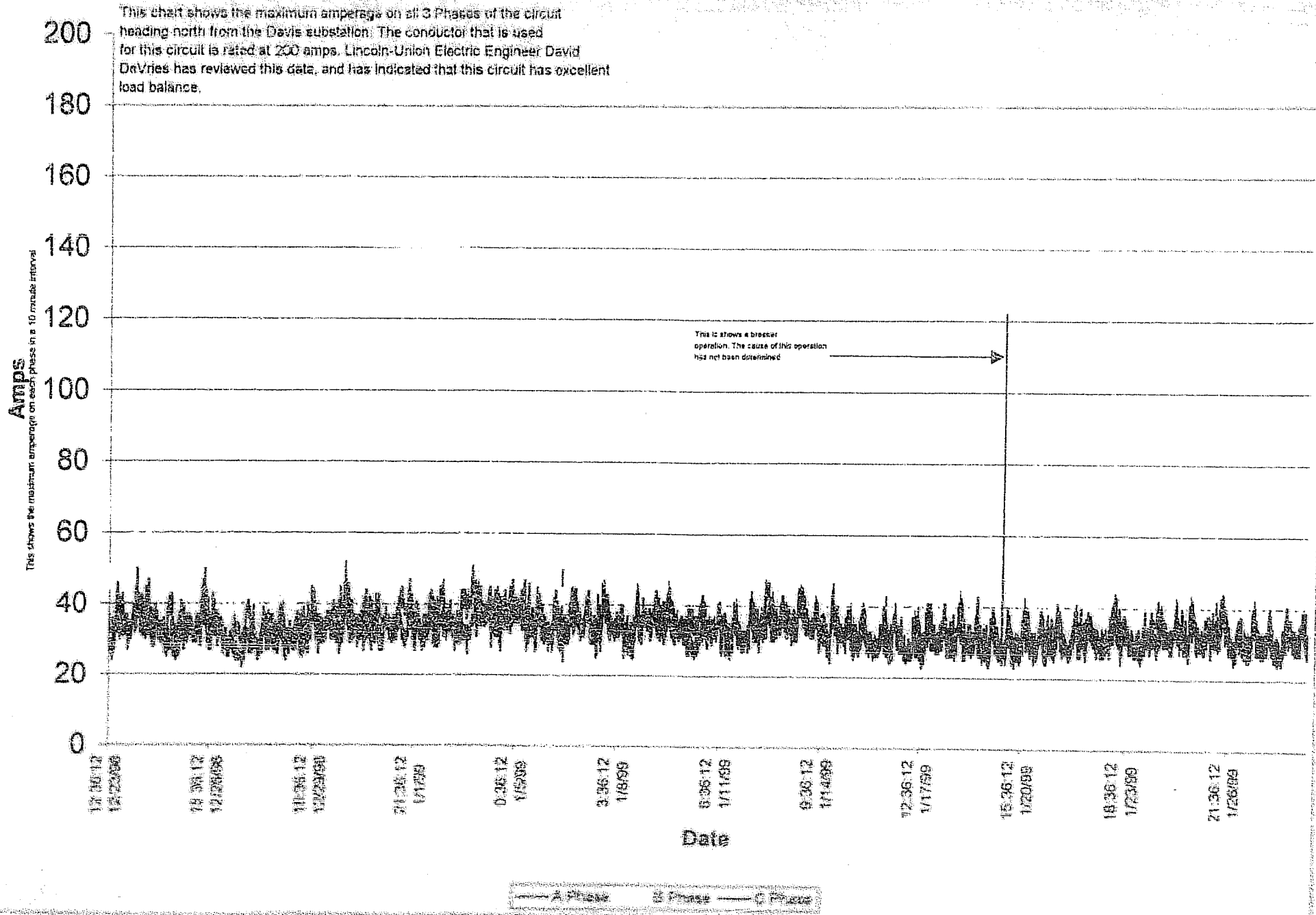
Date: 12-5-98 Signed Doug Triest
Lineman

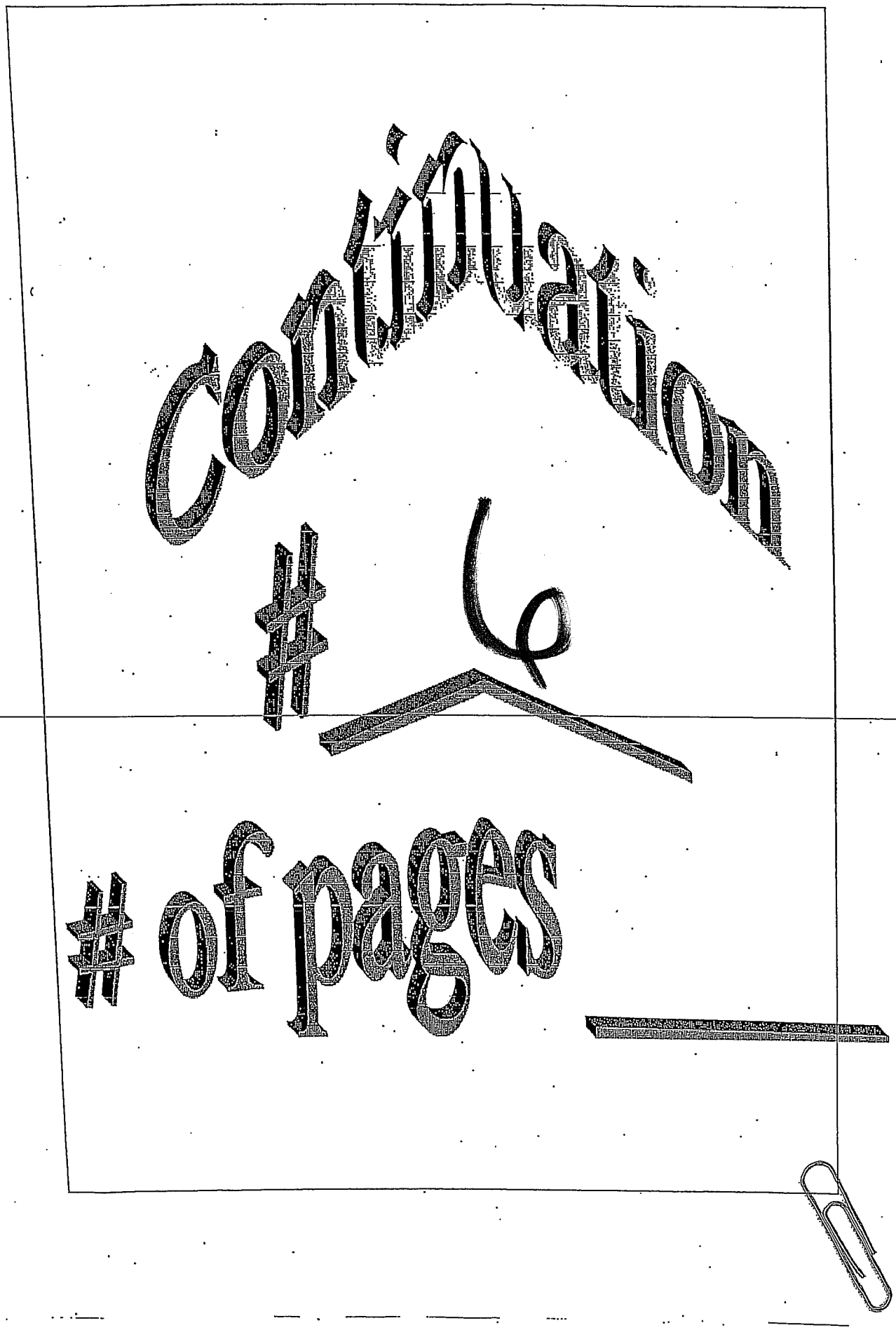
(This form to be completely filled in and turned in to the office for any interruption in service whether pre-arranged or otherwise.)

CONTINUATION

5 -

Davis North Amperage




Confirmation
6
of pages

Lincoln-Union Electric Company

P.O. Box 105
Alcester, SD 57001-0105
Tel: (605) 934-1961 or (800) 333-2859 SD only
Fax: (605) 934-1964

RECEIVED
APR 19 1999
SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

April 14, 1999

Karen Cremer, Staff Attorney
South Dakota Public Utility Commission
State Capitol Building
Pierre, SD 57501-5070

Dear Ms. Cremer:

We have enclosed a copy of our most recent monitoring information pertaining to Mr Douglas L. Kuper's complaint to the South Dakota Public Utilities Commission, File No EL98-005. Based on our conversation today, you indicated that you would contact Mr. Steve Wegman about reviewing these materials and setting up a time to meet with the Commissioners during a regularly scheduled meeting.

The materials enclosed include load monitoring on the primary distribution system serving Mr. Kuper's farm (page 1 and 2) and how that load compares to our entire load on the Davis Substation (page 3). The written explanation on each graph should provide a clear description of what we are monitoring and how it compares to the maximum load carrying capacity of these lines. These graphs are a continuance of the previously submitted data sent to you on February 12, 1999. We were unable to retrieve the Davis Substation data for page 1; but based on that load data to Mr. Kuper's farm, we cannot see any reason for concern out of the Davis Substation.

If you have any questions on these materials or any other data we have provided to you or Mr. Wegman, please give Todd Nelson or me a call.

Sincerely,

Brad Schardin

Brad Schardin
Manager

BJS:ria
Enclosures
cc: Douglas L. Kuper

CONTINUATION

7 -

Amperage on Doug Kuper Tap

This chart shows the maximum amperage on the single phase circuit going from the 3 phase line to Mr. Kuper's farm.
The conductor used for this circuit is rated at 100 amps.

Maximum Amps (B Phase)

This shows the maximum amperage on this circuit in a 10 minute interval.

Amperage on Doug Kuper Tap

This chart shows the maximum amperage on the single phase circuit going from the 3 phase line to Mr. Kuper's farm. The conductors used for this circuit is rated at 100 amps.

Maximum Amps (B-Phase)

This shows the maximum amperage on this circuit in a ten minute interval

Davis North Amperage

This chart shows the maximum amperage on all 3 Phases of the circuit heading north from the Davis substation. The conductor that is used for this circuit is rated at 200 amps.

Amps

This shows the maximum amperage on each phase in a 10 minute interval

200
180
160
140
120
100
80
60
40
20
0

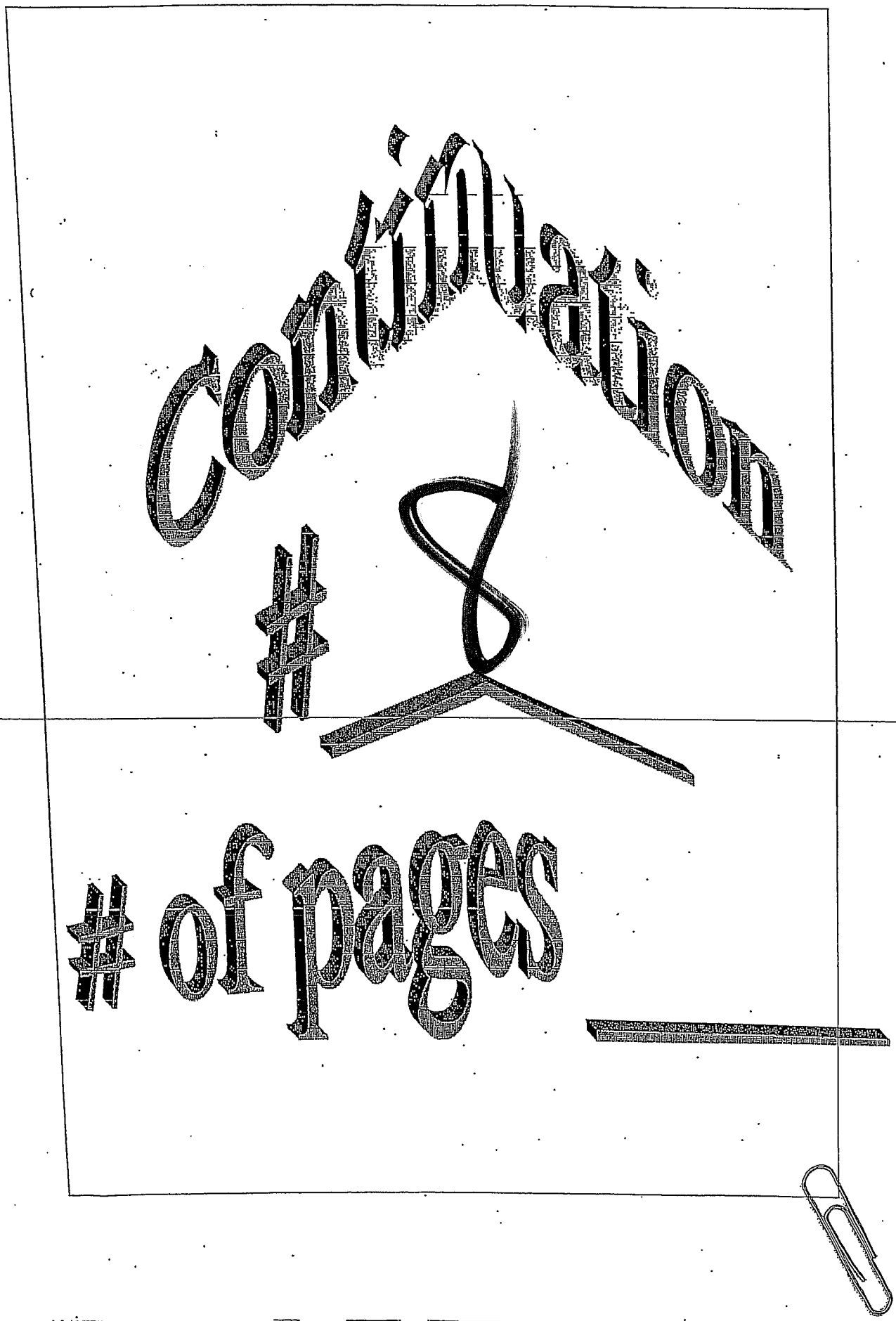
Breaker Operation
(Unknown Cause)

This was an outage
caused by high winds
(Broken Wire)
15:30 4/8/99

12:30:06 3/3/99
23:50:06 3/6/99
11:10:06 3/10/99
22:30:06 3/13/99
9:50:06 3/17/99
21:10:06 3/20/99
8:30:06 3/24/99
19:50:06 3/27/99
7:10:06 3/31/99
18:30:06 4/3/99
5:50:06 4/7/99

Date

A Phase B Phase C Phase


Confirmation
8
of pages

Doug B 1hr
Paul 1hr
#14 30 miles

FORM 24803 TIPPECANOE PRESS INC., SHELBYVILLE, IND.
NO. 1 BULLETIN NO. 164-1

INTERRUPTION REPORT

Serial No. _____

Time Reported: 3:40 pm Reported By: Virgil Roberts

Report Received By: Tim Assigned To: Doug & Paul

Time Off: 3:30 pm Time On: 5:00 pm Total Time: 1½ hr

Location or Area Affected: Davis North BP ocr at 18.76 B

Number of Members Affected: 17 Consumer Hours Off: _____

Cause: Phase brake South of 18-27-L8

Action Taken: Splice wire & re-energized line

Date: 4-8-99 Signed Doug Bentley
Lineman

(This form to be completely filled in and turned in to the office for any interruption in service whether pre-arranged or otherwise.)

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE COMPLAINT FILED BY DOUGLAS L. KUPER, LENNOX, SOUTH DAKOTA, AGAINST LINCOLN-UNION ELECTRIC COMPANY REGARDING STRAY VOLTAGE	)))))	AMENDED ORDER DISMISSING COMPLAINT AND CLOSING DOCKET EL98-005

On March 6, 1998, the South Dakota Public Utilities Commission (Commission) received a complaint from Douglas L. Kuper (Kuper), Lennox, South Dakota, against Lincoln-Union Electric Company (Lincoln-Union) regarding stray voltage. In an Order dated April 28, 1998, the Commission made a finding of probable cause of an unlawful or unreasonable act, rate, practice or omission by Lincoln-Union. Lincoln-Union filed an answer dated May 18, 1998. Lincoln-Union by motion dated July 16, 1998, moved to dismiss the complaint of Kuper. A hearing on the motion to dismiss was held by the Commission on July 23, 1998, via teleconference. On August 4, 1998, the Commission voted to deny the motion to dismiss, Commissioner Burg dissenting. An Order to that effect was entered on August 14, 1998. A prehearing conference was scheduled for December 4, 1998, with the hearing scheduled for December 15, 1998, in Sioux Falls, South Dakota. Prior to the prehearing conference Mr. Kuper faxed a letter to the Commission Staff stating that there was no need to proceed with the hearing. Mr. Kuper was not present for the prehearing conference. The Commission decided to defer the matter to clarify the intent of Mr. Kuper to dismiss the complaint. On December 4, 1998, Mr. Kuper faxed a letter to the Commission stating, "I, Douglas L. Kuper withdraw my complaint against Lincoln-Union Electric Co. That the Commission will receive reports from Lincoln-Union Electric at various times." At its regularly scheduled meeting of December 7, 1998, Mr. Kuper confirmed that he wished to withdraw his complaint and have the Commission dismiss it without prejudice. The Commission voted unanimously to dismiss the complaint without prejudice and close the docket. The Commission also ordered that Staff's final report be filed in the docket and that an ongoing power review continue through the summer of 1999.

On May 12,1999, at a regularly scheduled meeting, the Commission considered reports from Lincoln-Union which were dated February 12, 1999 and April 14, 1999. It also took comments from Lincoln-Union's manager, Brad Schardin, Kuper and the staff analyst Steve Wegman, all of whom were present via teleconference. Following a discussion of the complaint, the Commission voted to amend its December 30, 1998 order dismissing the complaint and closing the docket in two respects: (1) that a final report be filed by Lincoln-Union and (2) that the ongoing power review which was to continue through the summer of 1999 be suspended.

The Commission has jurisdiction over this matter pursuant to SDCL Chapter 1-26, 49-34A-58, and ARSD 20:10:01:08.01, et seq. It is therefore

ORDERED that the December 30, 1998 Order which dismissed the complaint and closed the docket shall be amended as follows:

1. A final report shall be filed with this Commission by Lincoln-Union as to its testing and monitoring efforts in this docket.

2. The ongoing power review which was to continue through the summer of 1999 shall, as of the date of this Amended Order, be suspended.

3. All terms of the Order dismissing this complaint and closing the docket not specifically modified by this amendment shall remain in effect.

Dated at Pierre, South Dakota, this 19th day of May, 1999.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, by facsimile or by first class mail, in properly addressed envelopes, with charges prepaid thereon.

By: Delaine Kolbo

Date: 5/19/99

(OFFICIAL SEAL)

BY ORDER OF THE COMMISSION:

JAMES A. BURG, Chairman

PAM NELSON, Commissioner

LASKA SCHOENFELDER, Commissioner

Lincoln-Union Electric Company

P.O. Box 105
Alcester, SD 57001-0105
Tel.: (605) 934-1961 or (800) 333-2859 SD only
Fax: (605) 934-1964

RECEIVED
MAY 28 1999
SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

May 26, 1999

Karen Cremer, Staff Attorney
South Dakota Public Utility Commission
State Capitol Building
Pierre, SD 57501-5070

Dear Ms. Cremer:

We have enclosed a copy of our most recent monitoring information pertaining to the matter of Douglas L. Kuper, File No. EL98-005. This concludes our testing and monitoring efforts for this docket and is follow up to our prior report sent to you or Mr. Steve Wegman on December 11, 1998, February 12, 1999, and April 14, 1999.

The materials enclosed include the final load monitoring on Lincoln-Union's primary distribution system for April 9, 1999, to May 13, 1999, serving Mr. Kuper's farm (pages 1 & 2) and how that load compares to our entire load on the Davis Substation (pages 3 & 4). The written explanation on each graph should provide a clear description of what we were monitoring and how it compares to the maximum load carrying capacity of these lines. These graphs are a continuance of the previously submitted data noted above and are our final reports. As with all our other reports, we cannot see any reason for or areas of concern relative to our line and substation monitoring tests.

This will be Lincoln-Union's final report to the Commission which supplements all the other reports noted in our opening paragraph. As per the Commissioners' action on May 12, 1999, we have removed our testing equipment and have discontinued our ongoing power review.

If you or the Commission have any questions for us, please feel free to give us a call.

Sincerely,

Brad Schardin
Manager

BJS:ria
enc.
cc: Douglas L. Kuper

CONTINUATION

9

Amperage on Doug Kuper Tap

This chart shows the maximum amperage on the single phase circuit going from the 3 phase line to Mr. Kuper's farm. The conductor used for this circuit is rated at 100 amps.

Amperage on Doug Kuper Tap

This chart shows the maximum amperage on the single phase circuit going from the 3 phase line to Mr. Kuper's farm. The conductor used for this circuit is rated at 100 amps.

This chart is spread out due to only 4 days of recording as compared to 30 days of recording on page 1.

Davis North Amperage

This chart shows the maximum amperage on all 3 Phases of the circuit heading north from the Davis substation. The conductor that is used for this circuit is rated at 200 amps.

Davis North Amperage

This chart shows the maximum amperage on all 3 Phases of the circuit heading north from the Davis substation. The conductor that is used for this circuit is rated at 200 amps.

This chart is spread out due to only 4 days of recording as compared to 30 days of recording on page 3

