PHASE II CHECK SHEETS

As a result of the Public Service Commission of Wisconsin (PSCW) order in docket **05-EI-115,** this set of forms was developed by the PSCW Rural Electric Power Services (REPS) staff and constitute the Phase II check sheets. The Phase II check sheets are a guide for documenting follow-up stray voltage investigations and need to be completed prior to a REPS investigation. For these tests, bonding between the secondary neutral and the water line metal structures is required, unless the specific situation found on the farm impedes the bonding. Specific additional tests devised by the testing entity may also be conducted without bonding to replicate as-found conditions. Certain conditions and/or restrictions by the farm operator may make it necessary to modify or eliminate some of the Phase II tests. This can only be addressed on a case-by-case basis by the testing entity.

There are five forms with corresponding instruction sheets:

1. Main/Load Box Test form and instruction sheet
2. Secondary Neutral Voltage Drop Test form and instruction sheet
3. Signature Test form and instruction sheet
4. Primary Profile Test form / instruction sheet
5. "24 Hour" Test Data Summary form / instruction sheet

The format and content of the forms meets the requirements of the PSCW. This testing may not be needed on every investigation by a utility, but **is** required prior to a REPS team investigation and when the customer has requested and will be given isolation-on-demand (IOD) pursuant to docket 05-EI-115. All data shall be recorded and filed electronically to the REPS office upon request.

The **Main Data/Load Box** test form has a general information collection section on the first sheet and provides a section to record before- and after-test source resistance data and calculations. Before- and after-test source resistance testing should be performed when the set-up of cow contact measurement equipment has been completed and again after the Phase II testing has been concluded. The bottom section of the first side has an area for a voltage ratio calculation to be performed *only if* the K-factor calculated on the reverse side of the form results in a number greater than 50%. The form's second sheet provides an area for the required data generated during the load box test. This entire section will need to be repeated for a farm which *is found* in an isolated condition to record data when the farm is temporarily not isolated (i.e. the first set of data is for the isolated condition and a second complete set of data should be recorded for a non-isolated condition). Remember to leave the farm in the as-found condition upon leaving after all testing has been completed.

The **Secondary Neutral Voltage Drop** test form provides space for recording test data from several locations. The first should be from the transformer pole to the main disconnect pole even if this distance is short, to ensure that there is no significant voltage drop due to resistive neutral connections. Secondary service drops from the main disconnect to each of the major buildings on the farm must be tested individually in the manner described by the instruction sheet.

The **Signature Test** form is used to record motor start/stop characteristics or other heavy load start/stop characteristics for each major building on the farm. The data should be recorded by an automatic data logger set to record at least the following channels**: primary neutral to reference voltage** (Vp), **secondary neutral to reference voltage** (Vs), **voltage between the primary neutral and secondary neutral** (Vps) and, lastly, **cow contact voltage,** (Vcc). The digital timepiece used to record the various start and stop times on the form *must* be synchronized to the second with the clock of the data logger to ensure proper interpretation of the data.

The **Primary Profile** test form records the current and resistance of each pole that has a primary ground for approximately 10 poles on either side of the tap pole to the farm, if possible. If the farm is an end of line customer, test the poles for 20 grounded poles back towards the substation, if possible or until the three phase tap is reached. Use ohm's law (V=I*R) to calculate the primary neutral voltage at each pole site. Note all additions and modifications to the pole being tested such as if it has an attached transformer, tap, capacitor bank, telephone pad, etc. Also note any degraded conditions or damage to the pole and or grounding system.

The **"24 Hour" test data summary** form is designed to summarize the data recorded during the "24 hour" test, which collects data from a minimum of the following four points: **Vp**, **Vs** **Vps** and **Vcc**. The data reported consists of the total events in the cow contact area that exceed pre-defined limits. For the first cow contact reporting category, the minimum level is 1 Volt rms. For the second category, the level is 3 Volts peak rms minimum. The last one is for transients lasting 130 microseconds to 16.67 milliseconds and being 10 Volts peak minimum.

PSC SV Database specifications (Phase I & II) and interpretations

Column	Col. Name	Data Type	Width	Example	Interpretation
A	RECORD_I	INTEGER	10	**1258**	Provided by PSC as they are filed. Leave blank.
B	UTILITY	TEXT	4	**Z**	Coded by PSC. Leave blank.
C	VISITDAT	DATE/TIME	10	**12/31/2002**	First day of investigation.[1]
D	LOCATION	TEXT	4	**NW**	By county – check reference table attached.
E	DISTSUBS	SINGLE	8	**12.7**	Circuit miles from farm to substation. One decimal position allowed.
F	GROUNDS_	INTEGER	8	**13**	Average grounds per mile between farm and substation[2]. No decimal point, round to nearest whole number.
G	END_LINE	TEXT	4	**N**	Yes/No following PSC 'eol' definition.[3]
H	PRIM_VOL	INTEGER	8	**14400**	In Volts, not kV. E.g. 2400, 4800, 7200, 14400, etc.
I	PHASCNDC	TEXT	15	**1/0 ACSR**	Predominant conductor leading to farm transformer. Use no # sign for 1/0 & larger, use # sign for #1 and smaller + material: ASCR, CW, steel, CU, URG, AL, etc.
J	NEUTCNDC	TEXT	15	**#2 ACSR**	Ditto.
K	OHM/MI	DOUBLE	8	**0.88**	PSC supplies this number from table look-up, leave blank.
L	FEEDR_PH	INTEGER	8	**3**	The phase configuration at the point of the farm's tap. E.g. 1 or 3.
M	TRANSFOR	SINGLE	8	**37.5**	kVA rating of transformer(s) serving farm, one decimal point allowed.
N	MEASVLTD	DOUBLE	8	**0.98**	Main barn panel SNVD test. 2 decimal points allowed - use std 10-15 amp load.
O	CALCVLTD	DOUBLE	8	**0.76**	Calculated SNVD from distance & material from test of col. N. 2 decimal points allowed.
P	SECND_PH	INTEGER	8	**1**	The phase configuration of the farm's transformer.[4]
Q	SRCE_RES	INTEGER	8	**144**	Rsource on set-up to nearest Ohm. Should rarely be > 500 Ohms.
R	SHUNTRES	INTEGER	8	**516**	Actual measured shunt value to nearest Ohm.
S	PRIMARYN	DOUBLE	8	**1.45**	Ditto from same test as CCA_VOLT.
T	SECNDRYN	DOUBLE	8	**1.37**	Ditto from same test as CCA_VOLT.
U	CCA_VOLT	DOUBLE	8	**0.51**	Worst case steady state, rms value from 24-hr test or load box test.
V	CCA_CURR	DOUBLE	8	**0.99**	Calculated from CCA_VOLT and SHUNTRES or leave blank (PSC will do).
W	NONFARMS	TEXT	4	**Y**	Yes/No where Y = load box test found an off-farm source > 1 mA in cow contact, else N.
X	ASF_EPP	TEXT	4	**N**	Y/N where Y=As-found effective EQ plane, else N.
Y	ASF_EGS	TEXT	4	**N**	Y/N where Y=As-found EGS actively working, else N.
Z	ASF_ISOT	TEXT	4	**N**	Y/N where Y=As-found Isolation transformer installed, else N.
AA	AST_4WIR	TEXT	4	**Y**	Y/N where Y=As-found 4 wire system properly installed, else N.
AB	ONF_GROU	TEXT	4	**Y**	Y/N where Y=Recommended on-farm grounding/bonding improvements, else N.
AC	ONF_EPP	TEXT	4	**N**	Y/N where Y=Recommended on-farm EQ plane installation (retrofit) , else N.
AD	ONF_EGS	TEXT	4	**N**	Y/N where Y=Recommended on-farm EGS installation, else N.
AE	ONF_ISOT	TEXT	4	**N**	Y/N where Y=Recommended on-farm isolation xfmr installation, else N.
AF	ONF_4WIR	TEXT	4	**N**	Y/N where Y=Recommended on-farm 4-wire system installation for barn, else N.
AG	ONF_NEUC	TEXT	4	**Y**	Y/N where Y=Recommended on-farm larger or less resistive neutral conductor system, else N.
AH	ONF_BAL1	TEXT	4	**Y**	Y/N where Y=Recommended on-farm balance of 120 v. sides, else N.
AI	ONF_OTHE	TEXT	15		Any other on-farm mitigations, usually blank.
AJ	OFF_GROU	TEXT	4	**Y**	Y/N where Y=Recommended off-farm grounding/bonding improvements, except counterpoise, else N.
AK	OFF_NEUC	TEXT	4	**Y**	Y/N where Y=Recommended off-farm increase neut. Conductor size, reduce resistance of neutral cond. System (split-bolt removal) , else N.
AL	OFF_RBUI	TEXT	4	**N**	Y/N where Y=Recommended off-farm distribution rebuild, else N.
AM	OFF_BURY	TEXT	4	**N**	Y/N where Y=Recommended off-farm bury counterpoise system, else N.
AN	OFF_BALA	TEXT	4	**N**	Y/N where Y=Recommended off-farm balance loads on 3-phase system, else N.
AO	OFF_OTHE	TEXT	15		Any other off-farm mitigations, usually blank.
AP	NEUTISOL	TEXT	4	**N**	Y/N where Y=Neutral isolator device installed as-found, excluding isolation transformer, else N.
AQ	FENCEROK	TEXT	4	**Y**	Y/N where Y = fencer/trainer correctly installed with no transients of concern found using oscilloscope, else N.
AR	MILKSTAN	TEXT	4	**Y**	Y/N where Y=Stanchions present, else N.
AS	MILKPIPE	TEXT	4	**Y**	Y/N where Y=Milk line present, else N.
AT	ELECTPUL	TEXT	4	**Y**	Y/N where Y=electric pulsation and N= pneumatic pulsation.
AU	HERDSIZE	INTEGER	8	**415**	Average number of animals in-milk on date of test.
AV	TESTPROG	TEXT	8	**AMPI**	Type of test protocol.[5]
AW	MILKPROD	INTEGER	8	**31266**	RHA milk production in pounds on day of SV test or last known record. Convert other measures (#/day) to this number.
AX	SCC_THOU	INTEGER	8	**168**	SCC (x1000) on day of SV test or last known record.
AY	LB_PNREF	DOUBLE	8	**1.89**	Phase II[6]: LB Hi, farm off
AZ	LB_SNREF	DOUBLE	8	**1.76**	Phase II: LB Hi, farm off

BA	LB_VCC	DOUBLE		8	**0.57**	Phase II: LB Hi, farm off.
BB	LB_RTOT	DOUBLE		8	**0.28**	Phase II: LB Hi, farm off: calculated Rtotal.
BC	LB_RFRM	DOUBLE		8	**1.45**	Phase II: LB Hi, farm off: calculated Rfarm.
BD	LB_RPRI	DOUBLE		8	**0.37**	Phase II: LB Hi, farm off calculated Rprimary.
BE	LB_KFACT	INTEGER		8	**45**	Phase II: LB Hi, farm off: calculated K-factor.
BF	LB_CRR	INTEGER		8	**62**	Phase II: LB Hi, farm off: calculated Current Return Ratio.
BG	SNVD_CAL	DOUBLE		8	**1.62**	Phase II: SNVD calculated from worst Vcc test below.
BH	SNVD_MES	DOUBLE		8	**1.16**	Phase II: SNVD measured from worst Vcc test below.
BI	SNVD_VCC	DOUBLE		8	**0.33**	Phase II: SNVD Vcc worst one of all NVD tests made.
BJ	PPI1	DOUBLE		8	**11.2**	Phase II: Primary profile[7] measured current in mA, one decimal point allowed.
BK	PPR1	DOUBLE		8	**104**	Phase II: Primary profile measured ground rod resistance in Ohms, no decimal point if over 10 Ohms (use rounding rules). 1 decimal point if less than 10 Ohms.
BL	PPV1	DOUBLE		8	**1.16**	Phase II: Calculated neutral-to-earth voltage in Volts, two decimal points allowed
BM	PPI2	DOUBLE		8	**(etc.)**	Ditto
BN	PPR2	DOUBLE		8		Ditto
BO	PPV2	DOUBLE		8		Ditto
BP	PPI3	DOUBLE		8		Ditto
BQ	PPR3	DOUBLE		8		Ditto
BR	PPV3	DOUBLE		8		Ditto
BS	PPI4	DOUBLE		8		Ditto
BT	PPR4	DOUBLE		8		Ditto
BU	PPV4	DOUBLE		8		Ditto
BV	PPI5	DOUBLE		8		Ditto
BW	PPR5	DOUBLE		8		Ditto
BX	PPV5	DOUBLE		8		Ditto
BY	PPI6	DOUBLE		8		Ditto
BZ	PPR6	DOUBLE		8		Ditto
CA	PPV6	DOUBLE		8		Ditto
CB	PPI7	DOUBLE		8		Ditto
CC	PPR7	DOUBLE		8		Ditto
CD	PPV7	DOUBLE		8		Ditto
CE	PPI8	DOUBLE		8		Ditto
CF	PPR8	DOUBLE		8		Ditto
CG	PPV8	DOUBLE		8		Ditto
CH	PPI9	DOUBLE		8		Ditto
CI	PPR9	DOUBLE		8		Ditto
CJ	PPV9	DOUBLE		8		Ditto
CK	PPI10	DOUBLE		8		Ditto
CL	PPR10	DOUBLE		8		Ditto
CM	PPV10	DOUBLE		8		Ditto
CN	PPI11	DOUBLE		8		Ditto
CO	PPR11	DOUBLE		8		Ditto
CP	PPV11	DOUBLE		8		Ditto
CQ	PPI12	DOUBLE		8		Ditto
CR	PPR12	DOUBLE		8		Ditto
CS	PPV12	DOUBLE		8		Ditto
CT	PPI13	DOUBLE		8		Ditto
CU0	PPR13	DOUBLE		8		Ditto
CV	PPV13	DOUBLE		8		Ditto
CW	PPI14	DOUBLE		8		Ditto
CX	PPR14	DOUBLE		8		Ditto
CY	PPV14	DOUBLE		8		Ditto
CZ	VCCSSGT1	LONG INTEGER		8	**45**	Number of excedances of 1 V. steady state in cow contact during 24-hour test if done by Metrosonics
DA	VCCSSGT3	LONG INTEGER		8	**12**	Number of excedances of 3 V. steady state in cow contact during 24-hour test if done by Metrosonics
DB	VCCTGT10	LONG INTEGER		8	**2**	Number of excedances of 10 V. transients in cow contact during 24-hour test if done by Metrosonics
Overall requirement: Never insert a zero for no data, leave it blank						

Footnotes:

1 – Investigation is a "first time" again if you have not been to the farm in at least 2 years.

2 – Leave this data blank if significant amount of UG makes exact determination of number of grounds/mile difficult.

3 – By definition of the PSCW, a customer is considered end-of-line if s/he is the last customer of a radial feeder or is on a tap at least 1/2 mile from a distribution line going in two different directions from the tap.

4 – 1= single, 2 = open delta, 3 = 3-phase, 4 = mixed 1- and 3-phase on same farm.

5 – Examples: **AMPI, SELF, DHIA, OTHE (meaning other), NON (meaning none), etc.**

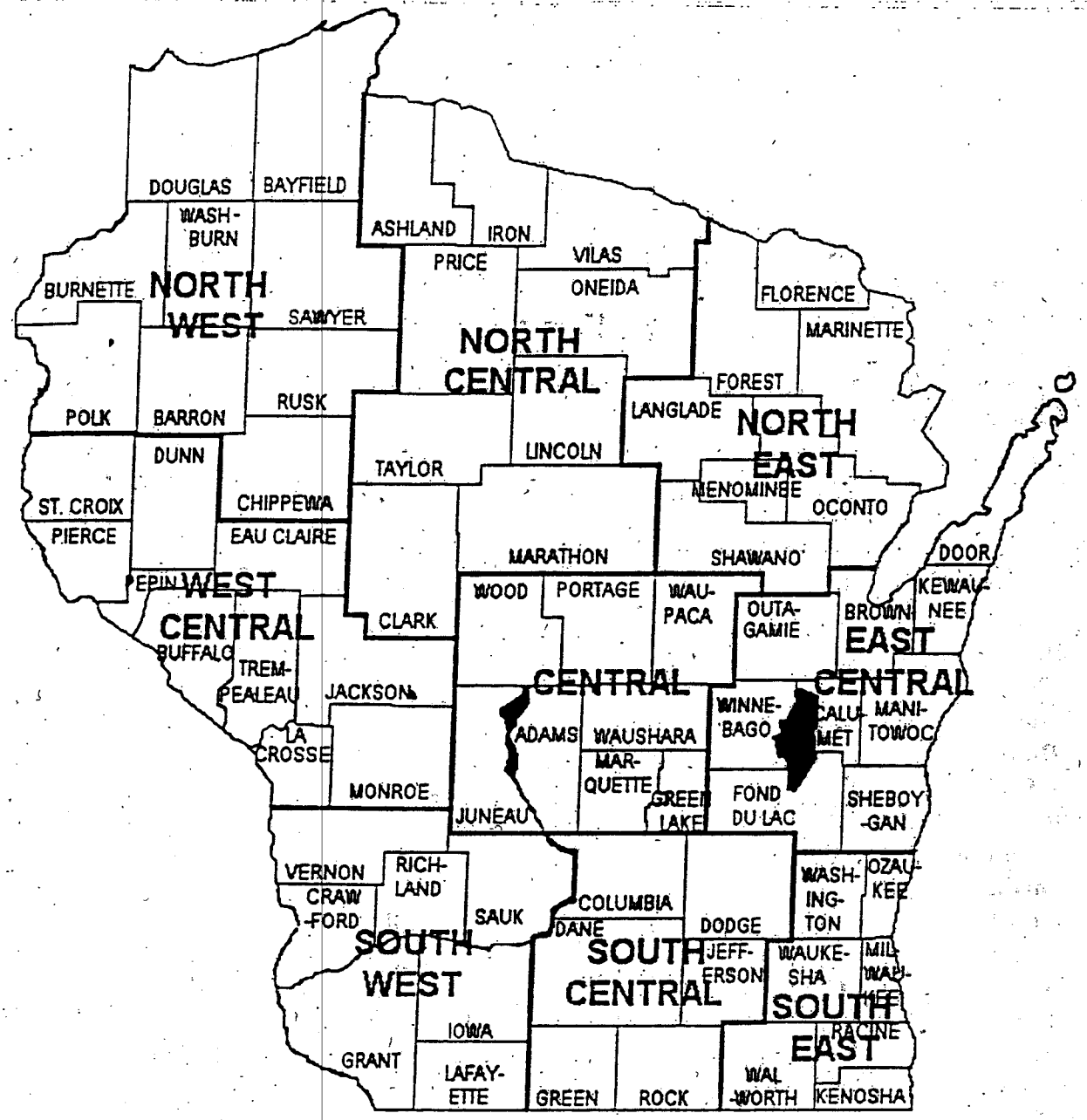
6 – LB test conditions: farm not isolated, water pipe properly bonded if possible, Rs < 500 Ohms.

7 – Primary profile for grounded 10 poles on each side of farm or equivalent during morning or evening milking.

Location area in Wisconsin by county:

County	Location
Adams	C
Ashland	NC
Barron	NW
Bayfield	NW
Brown	EC
Buffalo	WC
Burnett	NW
Calumet	EC
Chippewa	NW
Clark	NC
Columbia	SC
Crawford	SW
Dane	SC
Dodge	SC
Door	EC
Douglas	NW
Dunn	WC
Eau Claire	WC
Florence	NE
Fond du Lac	EC
Forest	NE
Grant	SW
Green	SC
Green Lake	C
Iowa	SW
Iron	NC
Jackson	WC
Jefferson	SC
Juneau	C
Kenosha	SE
Kewaunee	EC
La Crosse	WS
Lafayette	SW
Langlade	NE
Lincoln	NC
Manitowoc	EC

County	Location
Marathon	NC
Marinette	NE
Marquette	C
Menominee	NE
Milwaukee	SE
Monroe	WC
Oconto	NE
Oneida	NC
Outagamie	EC
Ozaukee	SE
Pepin	WC
Pierce	WC
Polk	NW
Portage	C
Price	NC
Racine	SE
Richland	SW
Rock	SC
Rusk	NW
Sauk	SW
Sawyer	NW
Shawano	NE
Sheboygan	EC
St. Croix	WC
Taylor	NC
Trempealeau	WC
Vernon	SW
Vilas	NC
Walworth	SE
Washburn	NW
Washington	SE
Waukesha	SE
Waupaca	C
Waushara	C
Winnebago	EC
Wood	C


DOUGLAS
BAYFIELD
WASH-
BURN
ASHLAND
IRON
PRICE
VILAS
ONEIDA
FLORENCE
MARINETTE
BURNETTE
NORTH
WEST
SAWYER
NORTH
CENTRAL
FOREST
LANGLADE
NORTH
EAST
POLK
BARRON
RUSK
DUNN
TAYLOR
LINCOLN
MENOMINEE
OCONTO
ST. CROIX
CHIPPEWA
PIERCE
EAU CLAIRE
MARATHON
SHAWANO
DOOR
PEPIN
WEST
CENTRAL
WOOD
PORTAGE
WAU-
PACA
OUTA-
GAMIE
BROWN
KEWAU-
NEE
EAST
CENTRAL
CLARK
BUFFALO
TREM-
PEALEAU
JACKSON
CENTRAL
WINNE-
BAGO
CALU-
MET
MANI-
TOWOC
ADAMS
WAUSHARA
LA
CROSSE
MAR-
QUETTE
MONROE
GREEN
LAKE
FOND
DU LAC
SHEBOY
-GAN
JUNEAU
VERNON
RICH-
LAND
WASH-
ING-
TON
OZAU-
KEE
CRAW
-FORD
SAUK
COLUMBIA
DODGE
DANE
SOUTH
WEST
SOUTH
CENTRAL
JEFF-
ERSON
WAUKE-
SHA
MIL-
WAU-
KEE
SOUTH
EAST
RACINE
IOWA
GRANT
LAFAY-
ETTE
GREEN
ROCK
WAL
-WORTH
KENOSHA

APPENDIX B

utility name	Abbr.	type
ADAMS-COLUMBIA ELECTRIC COOP	ACEC	COOP
ALGOMA UTILITY COMMISSION	AUC.	MUNI
ALLIANT ENERGY (WP&L)	WPL	IOU
ARCADIA ELECTRIC UTILITY	AEU	MUNI
ARGYLE UTILITY	AU	MUNI
BANGOR MUNICIPAL UTILITY	BMU	MUNI
BARRON ELECTRIC COOP	BEC	COOP
BARRON LIGHT & WATER COMM.	BLW	MUNI
BAYFIELD ELECTRIC COOP	BAYEC	COOP
BELMONT MUNIC. LIGHT & WATER UTIL.	BMLW	MUNI
BENTON ELECTRIC & WATER UTIL.	BEWU	MUNI
BLACK EARTH ELEC. UTILITIES	BEEU	MUNI
BLACK RIVER FALLS MUNIC. UTILITY	BRFMU	MUNI
BLOOMER ELECTRIC & WATER UTIL.	BLEWU	MUNI
BOSCOBEL UTILITIES	BU	MUNI
BRODHEAD WATER & LIGHT COMM.	BWL	MUNI
CADOTT LIGHT & WATER DEPT.	CLWD	MUNI
CASHTON MUNIC. LIGHT & WATER PLANT	CMLW	MUNI
CEDARBURG LIGHT & WATER COMM.	CLWC	MUNI
CENTRAL WIOSCONSIN ELECTRIC COOP	CWEC	COOP
CENTURIA MUNIC. ELECTRIC UTIL.	CMEU	MUNI
CHIPPEWA VALLEY ELECTRIC COOP	CVEC	COOP
CLARK ELECTRIC COOP	CEC	COOP
CLINTONVILLE WATER & ELECTRIC UTIL.	CWEU	MUNI
COLUMBUS WATER & LIGHT DEPT.	CWLD	MUNI
CONSOLODATED WL&P	CWLP	IOU
CORNELL MUNIC. LIGHTING DEPT.	CMLD	MUNI
CUBA CITY LIGHT & WATER PLANT	CCLW	MUNI
CUMBERLAND MUNIC. UTILITY	CMU	MUNI
DAHLBERG POWER AND LIGHT	DPL	IOU
DUNN ENERGY COOP	DCEC	COOP
EAGLE RIVER LIGHT & WATER DEPT	ERLW	MUNI
EAST CENTRAL ENERGY COOP	ECNEC	COOP
EAU CLAIRE ENERGY COOP	ECEC	COOP
ELKHORN (CITY OF) ELECTRIC DEPT.	EED	MUNI
ELROY ELECTRIC & WATER UTIL.	EEWU	MUNI
EVANSVILLE WATER & LIGHT DEPT.	EWLD	MUNI
FENNIMORE MUNIC. UTILITIES	FMU	MUNI
FLORENCE WATER & LIGHT COMM.	FWLC	MUNI
GRESHAM MUNIC. WATER & ELEC. PLANT	GMWE	MUNI
HARTFORD UTILITY DEPT.	HUD	MUNI
HAZEL GREEN LIGHT & WATER UTIL.	HGLW	MUNI
HEAD OF THE LAKES ELECTRIC COOP	HLEC	COOP
HUSTISFORD UTILITIES	HU	MUNI
JACKSON ELECTRIC COOP	JEC	COOP
JEFFERSON WATER & LIGHT DEPT.	JWLD	MUNI
JUMP RIVER ELECTRIC COOP	JREC	COOP
JUNEAU UTILITY COMM.	JUC	MUNI
KAUKAUNA ELECTRIC & WATER DEPT.	KEWD	MUNI
KIEL UTILITIES	KU	MUNI
LA FARGE MUNIC. UTILITIES	LFMU	MUNI
LAKE MILLS LIGHT & WATER DEPT.	LMLWD	MUNI
LODI MUNIC. LIGHT & WATER PLANT	LMLWP	MUNI
MADISON GAS AND ELECTRIC	MGE	IOU
MANITOWOC PUBLIC UTILITIES	MPU	MUNI
MARSHFIELD ELECTRIC & WATER DEPT.	MEWD	MUNI
MAZOMANIE ELECTRIC UTILITY	MEU	MUNI
MEDFORD ELECTRIC UTILITY	MDEU	MUNI
MENASHA ELECTRIC & WATER UTIL.	MEWU	MUNI

utility name	Abbr.	type
MERRILAN ELEC. LIGHT & WATER DEPT.	MELW	MUNI
MOUNT HOREB UTILITIES	MHU	MUNI
MUSCODA LIGHT & WATER COMM.	MLWC	MUNI
NEW GLARUS MUNIC. LIGHT & WATER WORKS	NGLW	MUNI
NEW HOLSTEIN UTILITIES	NHU	MUNI
NEW LISBON MUNIC. LIGHT & WATER DEPT.	NLLW	MUNI
NEW LONDON UTILITY COMM.	NLUC	MUNI
NEW RICHMOND CITY UTILITIES	NRCU	MUNI
NORTH CENTRAL WISCONSIN ELECTRIC	NCWE	IOU
NORTHWEST WISCONSIN ELECTRIC	NWWE	IOU
OAKDALE ELECTRIC COOP	OEC	COOP
OCONOMOWOC UTILITIES	OU	MUNI
OCONTO ELECTRIC COOP	OCEC	COOP
OCONTO FALLS WATER & LIGHT COMM.	OFWL	MUNI
PARDEEVILLE ELECTRIC COMM.	PVEC	MUNI
PIERCE-PEPIN COOPERATIVE SERVICES	PPEC	COOP
PIONEER POWER AND LIGHT	PPL	IOU
PLYMOUTH UTILITIES	PU	MUNI
POLK-BURNETT ELECTRIC COOP	PBEC	COOP
PRAIRIE DU SAC ELECTRIC DEPARTMENT	PDSE	MUNI
PRICE ELECTRIC COOP	PEC	COOP
PRINCETON LIGHT & WATER DEPT.	PLW	MUNI
REEDSBURG UTILITY COMM.	RUC	MUNI
RICE LAKE UTILITIES	RLU	MUNI
RICHLAND CENTER MUNIC. UTIL.	RCMU	MUNI
RICHLAND ELECTRIC COOP	RECO	COOP
RIVER FALLS MINUC. UTILITY	RFMU	MUNI
RIVERLAND ENERGY COOP	REC	COOP
ROCK COUNTY ELECTRIC COOP	RCEC	COOP
SAUK CITY UTILITIES	SCU	MUNI
SCENIC RIVERS ENERGY COOP	SREC	COOP
SHAWANO MUNIC. UTILITIES	SMU	MUNI
SHEBOYGAN FALLS UTILITIES	SFU	MUNI
SHULLSBURG ELECTRIC UTILITY	SEU	MUNI
SLINGER ELECTRIC UTILITIES	SLEU	MUNI
SPOONER MUNIC. ELECTRIC UTILITY	SMEU	MUNI
ST. CROIX ELECTRIC COOP	SCEC	COOP
STOUGHTON ELEC. WSTWATER & WATER UTIL.	SEWW	MUNI
STRATFORD WATER & ELECTRIC DEPT.	SWED	MUNI
STURGEON BAY UTILITIES	SBU	MUNI
SUN PRAIRIE WATER & LIGHT COMM.	SPWL	MUNI
SUPERIOR POWER LIGHT AND WATER	SPLW	IOU
TAYLOR ELECTRIC COOP	TEC	COOP
TREMPEALEAU MUNIC. ELECTRIC DEPT.	TMED	MUNI
TWO RIVERS WATER & LIGHT DEPT.	TRWL	MUNI
VERNON ELECTRIC COOP	VEC	COOP
VIOLA MUNIC. ELECTRIC UTILITY	VMEU	MUNI
WASHINGTON ISLAND ELECTRIC COOP	WIEC	COOP
WATERLOO WATER & LIGHT COMM.	WLWLC	MUNI
WAUNAKEE WATER & LIGHT COMM.	WNWLC	MUNI
WAUPUN PUBLIC UTILITIES	WPU	MUNI
WESTBY ELECTRIC & WATER UTIL.	WEWU	MUNI
WHITEHALL MUNIC. ELECTRIC UTILITY	WMEU	MUNI
WISCONSIN DELLS WATER & LIGHT COMM.	WDWL	MUNI
WISCONSIN ELEC POWER CO	WEPCO	IOU
WISCONSIN PUBLIC SERVICE CO	WPSC	IOU
WISCONSIN RAPIDS WATER WORKS & LIGHT COMM.	WRWL	MUNI
WONEWOC MUNIC. WATER & LIGHT DEPT.	WMWL	MUNI
XCEL POWER (NSP)	NSP	IOU

STRAY VOLTAGE DATA INPUT FORM INSTRUCTION SHEET

ITEM	EXPLANATION
1	Investigation Date for the starting day of the testing.
2	Circle the proper response when determined: Yes = cow contact steady state RMS voltage exceeds the "level of concern" [over 1.0 Volt AC RMS (2.0 mA) total or over 0.5 Volt AC RMS (1.0 mA) from the primary system].
3	Enter the location of stray voltage found exceeding the level of concern recorded above.
4	Enter the proper region of the state in which the farm test is performed (one of nine regions).
5	Farm Customer Name (i.e. Smith, John or Smithco Farms, John Smith, prop.).
6	Name of person filling out this form.
7	Case number for your tracking system, if applicable.
8	Utility company name (e.g. People's Power Co.).
9	Circle the utility type. (IOU = Investor Owned Utility)
10	Distance to substation in circuit miles. Express to the nearest tenth of a mile.
11	**Average** number of ground rods per mile on the primary system **from the farm to the substation.** Round to the nearest whole number.
12	Circle appropriate box for EOL: An End-of-Line customer is defined as the last one on a radial distribution feeder or the last one served by a tap off the main feeder whose farm is located more than 0.5 mi. from the source distribution facility where it goes in two different directions.
13	Primary voltage phase to ground (e.g. 7200, 14400, etc.). Use Volts, not kV.
14	**Total** farm transformer kVA rating (e.g. 15, 25, 37.5, etc.).
15	Secondary service type: 1=one phase, 2=two phase – open delta, 3=three phase and 4 =mixed phases.
16	Wire gauge and material of primary phase conductor at farm xfmr (e.g. 1/0 ACSR or #8A CW).
17	Repeat for neutral conductor size and material.
18	Circle the proper attribute if it is presently installed and activated on the farm: EPP = Equal-Potential Plane properly installed EGS = Electronic Grounding System, including an Agri-Volt system. 4-WIRE = 4/5-Wire system properly installed on secondary. ISOL XFMR = Isolation Transformer installed. NEUT ISOLATOR = Neutral isolated by an electronic isolating device at the transformer pole. **Use the comment section to record any unusual circumstances about any of these devices (i.e. EGS Installed but not presently working)**
19	Record the farm data for the number of cows presently milking, the Herd Average production level in pounds, note if the farm is on DHIA or equivalent, and the present SCC (x1000) level.
20	Record the shunt resistance and the voltage at cow contact without and with the shunt resistance in place on set-up. Calculate the source resistance according to the formula.
21	Repeat the source resistance measurement prior to teardown of the test equipment.
22	If the K-factor (determined on side two) exceeds 50%, calculate the Voltage Ratio (VR) as follows; use an AEMC to measure the ground rod current and resistance at the transformer pole (as the first choice, unless it is within 30 feet of the main disconnect pole. If it is, use the next available grounded pole back towards the distribution system/substation). Record the ground rod current and the ground rod resistance. Calculate the primary neutral voltage (i.e. $Vpcalc=I_{pole}*R_{pole}$). Use this value along with the measured Vp from the data logger under the same load and farm conditions to calculate and record the VR (VR=Vp/Vpcalc). If the calculated VR value is less than 80%, move the reference rod another 100' farther away from the electrical system under test.

LOAD BOX TEST

Note 1: Testing may be accomplished by use of a single 18 – 25 kW resistive load box or dual section resistive load box totaling 20 - 30 kW. Some calculations are derived from a difference measurement using either the high and low load box settings or the high and off load box settings. A large 240-Volt load can also be used for a quick minimal Load Box test, if all other farm loads can be de-energized at the time of the test.

Note 2: If the farm is found in an isolated condition, the load box test must be performed twice: in a non-isolated condition and in an isolated condition.

ITEM	EXPLANATION
1.	Attach the load box to the secondary side of the transformer. With the load box off, record the time when the farm is turned off at the main disconnect and record the 7 data lines indicated. **Data recorded** is **primary line current** (**I** pri line)*, **primary neutral current** (**I** pri neut), **secondary neutral current** (**I** sec neut), **primary neutral to reference voltage** (V_p), **secondary neutral to reference voltage** (V_s), **the voltage between the primary and secondary neutrals** (Vps) and the **cow contact voltage measured with the 500-Ohm resistor** (V_{cc})
2	Next, turn on one load box, if using a dual type, representing half the available load and record the time and 7 data numbers. Skip this step if using a single load type box.
3	Turn on the second half of the load box, if using a dual type, or turn on the load box, if using a single type and record the time and 7 data numbers.
4	Turn the farm back on via the main disconnect without changing the status of the load box. Record the time and 8 data numbers (include the **net secondary current**, which is a simultaneous measurement of all three secondary feed wires (**I** sec neut net)).
5	Turn off the load box. Record the time and the 8 data numbers.
6	Transfer the appropriate numbers to the formulae and calculate the resultant total apparent neutral system resistance (R_t), the apparent primary neutral system resistance (R_p) and the apparent farm neutral system resistance (R_f).
7	Transfer the appropriate numbers to the formulae and calculate the **K**-factor and the current return ratio, **CR**. Express these last two numbers as percents. If the **K**-factor is larger than 50%, perform the calculation for the voltage ratio, **VR** on bottom of the preceding page.
	Note: Care must be taken when performing this test. If the transformer is located on the distribution system ROW, both line and neutral currents upstream and downstream of the transformer must be recorded as close in time as possible.

*The primary phase current may be calculated by measuring the load box current and dividing by the transformer ratio (i.e. 100amps/30=3.3amps for a 7200 volt system with 240 volt secondary).

STRAY VOLTAGE PHASE II
DATA INPUT FORM

Investigation DATE: _____

Cow Contact above level of concern? Y N If Yes, Cow Contact Location _____

_____ Wisconsin Region: _____

Farm Customer _____ Recorded By : _____

CASE NO:_____ Utility:_____ TYPE: Muni IOU Coop

Miles to Substation: _____ Gnds/Mile: _____ END OF LINE? : Y N

Primary Line Voltage: _____ Primary xfmr KVA: _____ Secondary Phase: 1 2 3 4

Conductor Size & Material at xfmr: Primary Line _____ Primary Neutral _____

EPP?	Y N	
EGS?	Y N	
4-WIRE?	Y N	
ISOL XFMR?	Y N	
NEUT ISOL?	Y N	

HERD SIZE_____ MILK production _____ DHI or equiv.? Y N SCC(X1000)_____

SOURCE RESIST CHECK 1:(set-up) R_{shunt} = [ ] Ω

V_{wo} = _____ V_w = _____ $R_{source} = \frac{(V_{wo} - V_w) \times R_{shunt}}{V_w}$ = [ ] Ω

SOURCE RESIST CHECK 2:(Take-down)

V_{wo} = _____ V_w = _____ $R_{source} = \frac{(V_{wo} - V_w) \times R_{shunt}}{V_w}$ = [ ] Ω

VR TEST (IF REQUIRED): I_{PGmeas} = _____ mA R_{PGmeas} = _____ Ω

$V_{pncalc\ pole\ gnd} = I_{PGmeas} \times R_{PGmeas}$ = _____ mV $VR = \frac{V_{pnref}}{V_{pncalc\ pole\ gnd}}$ = [ ]

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SINGLE PHASE LOAD BOX TEST

	FARM OFF			FARM ON	
TIME:	: :	: :	: :	: :	: :
Condition:	NO LOAD	1 STAGE ON	---------BOTH STAGES ON---------		NO LOAD
Meas $I_{pri\ line}$	A	A	A	A	A
Calc.	A	A	A	A	A
$I_{pri\ neut}$	A	A	A	A	A
$I_{sec\ neut}$	A	A	A	A	A
$I_{sec\ neut\ net}$	---	---	---	A	A
V_{pnref}	V	V	V	V	V
V_{snref}	V	V	V	V	V
$V_{pri/sec}$	V	V	V	V	V
$V_{cow\ cont\ WR}$	V	V	V	V	V

CALCULATIONS:(FARM OFF)

$$R_T = \frac{V_{pnref\ HI} - V_{pnref\ LO}}{I_{pri\ line\ HI} - I_{pri\ line\ LO}} = \_\_\_\_\_$$

$$R_{PN} = \frac{V_{pnref\ HI} - V_{pnref\ LO}}{I_{pri\ neut\ HI} - I_{pri\ neut\ LO}} = \_\_\_\_\_$$

$$R_F = \frac{V_{snref\ HI} - V_{snref\ LO}}{I_{sec\ neut\ HI} - I_{sec\ neut\ LO}} = \_\_\_\_\_$$

$$K = \frac{V_{cow\ cont\ WR\ HI}}{V_{snref\ HI}} = \_\_\_\_\_$$

$$CR = \frac{I_{pri\ neut\ HI}}{I_{pri\ line\ HI}} = \_\_\_\_\_$$

$$I_{Pri\ Line\ (Calc)} = \frac{\text{Load Box Current}}{\text{Transformer Ratio}} = \_\_\_\_\_ =$$

SUMMARY:

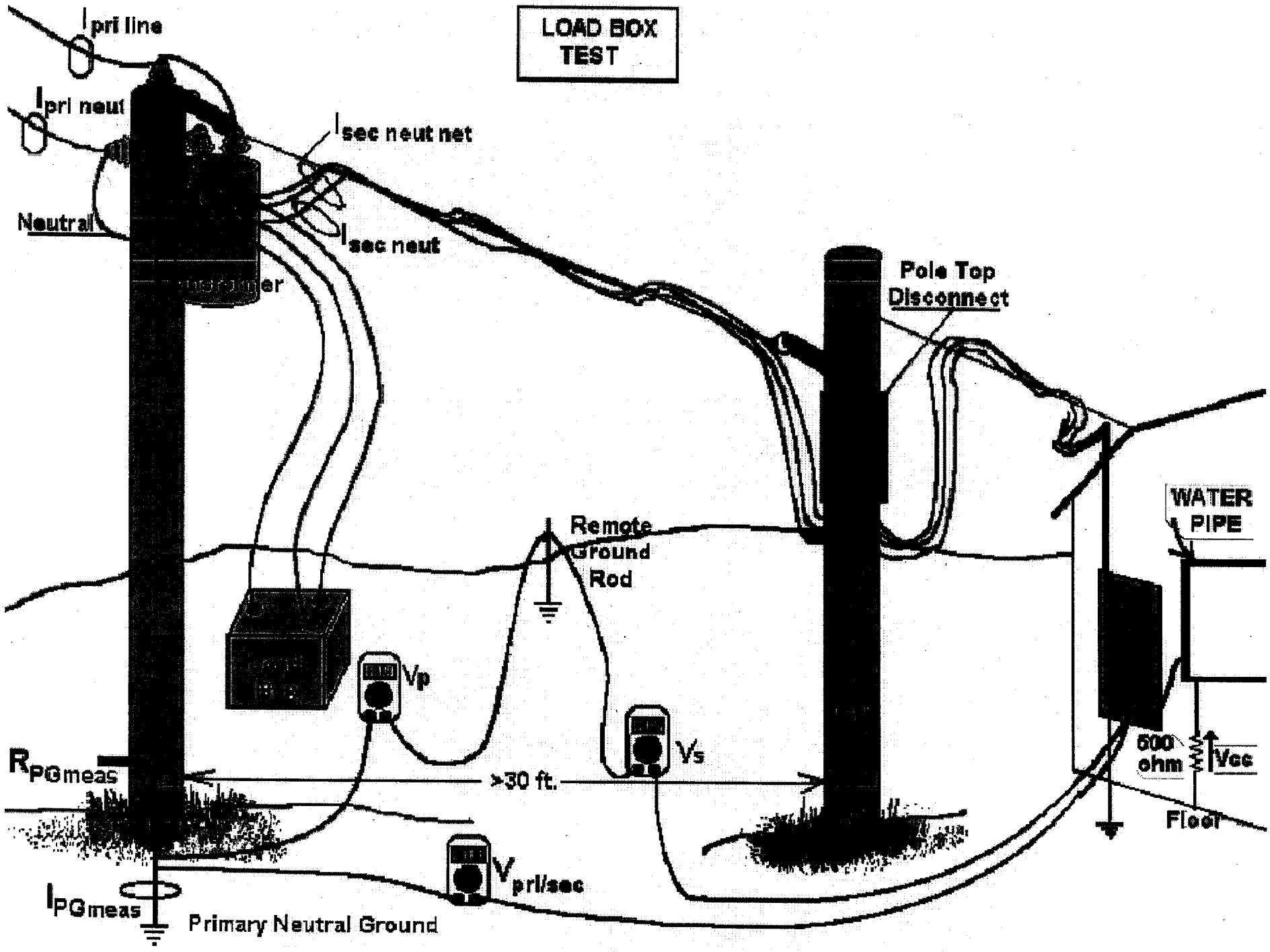
$R_T =$ Ω

$R_{PN} =$ Ω

$R_F =$ Ω

$K =$ %

$CR =$ %


LOAD BOX TEST
I pri line
I pri neut
I sec neut net
Neutral
I sec neut
Pole Top Disconnect
WATER PIPE
Remote Ground Rod
Vp
Vs
>30 ft.
500 ohm
Vcc
Floor
R PGmeas
I PGmeas
V pri/sec
Primary Neutral Ground

SECONDARY NEUTRAL VOLTAGE DROP TEST INSTRUCTIONS

ITEM	EXPLANATION
	(**Set-up:** All farm loads should be turned off via the main breaker in each panel. Energize one panel at a time and select one 120 V. load of at least 10 amps per site for this test or use a paint peeler/hair dryer of 10 A – 15 A. load.)
1	Enter the date of the test.
2	Name/Initials of the person performing the test.
3	Enter the name of the farm customer.
4 - 8	Use these columns to record the designated data for the 5 LARGEST secondary service neutral drops on the farm. PROCEDURE: 1. Measure the number of hundred feet of the neutral line (i.e. 120 ft. = 1.2 C ft.) along with its wire gauge and material. The neutral may contain multiple lengths of different material and gauge wire. Include all that exist (e.g. for a 180-foot drop of two different gauges: 1.2 C ft #2 CU / 0.6 C ft #4 CU) 2. Look up and enter the appropriate Ohms per hundred feet from the table on page 2. Multiply the distance times the Ohms per hundred feet to calculate and record the total resistance of the service neutral. If there are multiple materials and lengths, include all appropriate numbers in the calculation. 3. Enter all LOAD-off condition data. 4. Connect and energize the 120 V. load to the circuit under test. 5. Enter all LOAD-on data. 6. Measure the secondary neutral current for this load device and enter the value in the table. 7. Multiply this current times the total resistance value for the line to record the calculated voltage drop. 8. Then measure the actual voltage drop on this secondary neutral from each end point (i.e. at the **transformer** neutral or the **disconnect** neutral wires feed point to the panel neutral where you have energized the load) and record this value.

The data of the lower section, (Vp, Vs, Vps and Vcc), are those points normally monitored for the load box or 24-hour test.

Note: If the measured value differs from the calculated value by more than 20%, circle it and investigate why this is so.

SECONDARY NEUTRAL VOLTAGE DROP TEST

Test performed by: _____ **DATE:** _____

FARM CUSTOMER NAME: _____

(All other farm loads off. Use one known load per site.)

SITE	1	2	3	4	5	Units
SITE Description:						
A. Secondary Feed Neut. wire gauge/type						———
B. Total FEED LENGTH (Ft/100)						HUNDRED FEET
C .Ω /100 Ft. (From table on pg. 2)						Ω / C ft
D. TOTAL Ω (B times C)						Ω
E. MEASURED NEUT CURRENT						AMPS
F CALCULATED VOLT DROP (D times E)						VOLTS
G MEASURED VOLT DROP (LOAD on-LOAD off)						VOLTS
Vp LOAD off						mVolts
Vp LOAD on						mVolts
Vs LOAD off						mVolts
Vs LOAD on						mVolts
Vps LOAD off						mVolts
Vps LOAD on						mVolts
Vcc LOAD off						mVolts
Vcc LOAD on						mVolts

STANDARD RESISTANCE CHART
(Ohms per 100 feet)

GAUGE	MATERIAL ALUM	COPPER
14	0.42	0.26
12	0.26	0.16
10	0.17	0.10
8	0.11	0.064
6	0.067	0.041
4	0.041	0.026

GAUGE	MATERIAL ALUM	COPPER
2	0.027	0.016
1	0.021	0.013
1/0	0.017	0.010
2/0	0.013	0.008
3/0	0.011	0.006
4/0	0.008	0.005

SIGNATURE TEST INSTRUCTION SHEET

1. Enter the farm customer's name and date.

2. The type of load should be noted. For 120-Volt outlets, use a plug-in hair drier or equivalent to generate about 10 to 15 Amps of load current. For existing farm loads, note type (e.g. barn cleaner, fan, silo unloader, auger, feed conveyor, vacuum pump, etc.).

3. Specify the physical location of load (e.g. barn, calf shed, milk house, northwest corner of feed bunk, etc.).

4. Times are noted for each load energization (turn-on) and de-energization (turn-off). Equipment should be turned on for a period of not less than 10 to 15 seconds. NOTE: Put a check mark to the right of the turn-off column if the equipment WAS FOUND in the ON condition so that the times shown in reverse order MAKE SENSE (first off, and then back on).

5. Repeat for all major 120-Volt and 240-Volt loads and locations as necessary. At the farthest outlet point in the branch circuit, you may elect to use a hair dryer load for maximum drop effect.

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SIGNATURE TEST FORM

DATE: _____

Farm Customer: _____

	TYPE OF LOAD (HD=HAIR DRYER)	LOCATION	TIME ON	TIME OFF	(✓)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

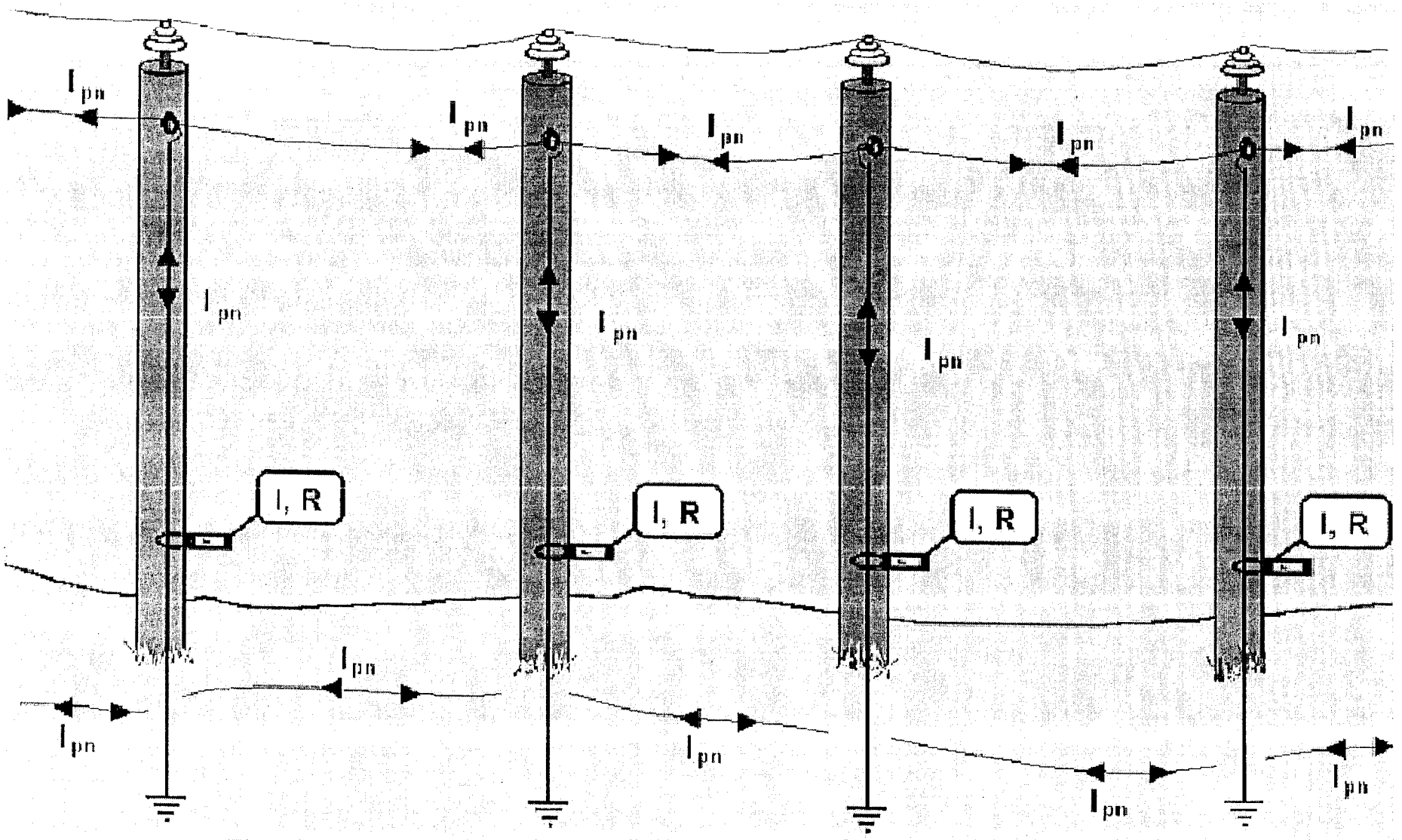
PRIMARY PROFILE REPORT FORM

Customer Name _____ Date _____

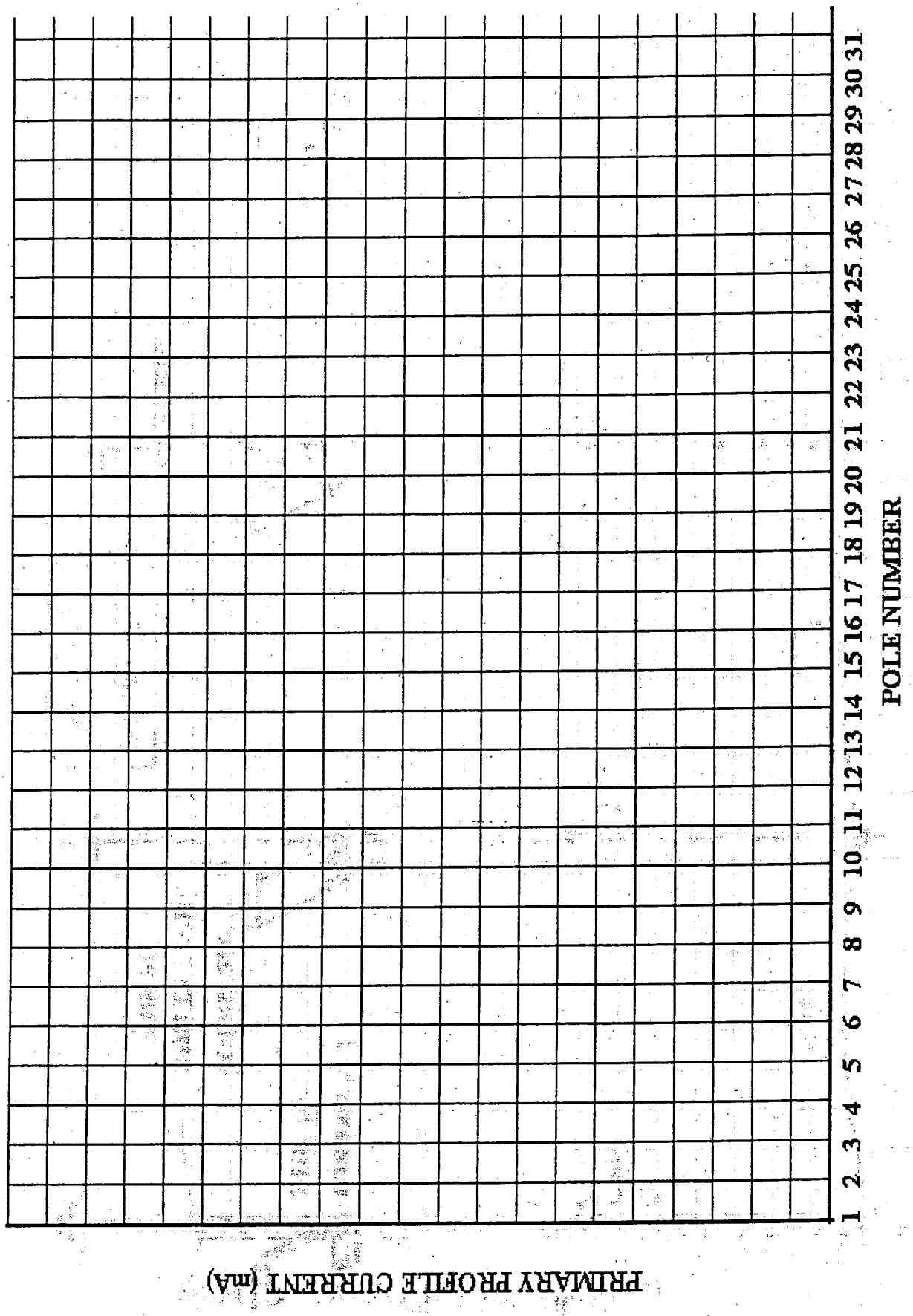
Case # _____ Initials _____

Identify the pole number to be measured. Using an AEMC or equivalent meter, record the ground rod current (Ip) and the ground rod resistance (Rp) of 10 existing primary ground rods on either side of the tap pole, including the farm tap pole, of the farm being tested, if possible. If the farm is an end-of-line customer, test the first 20 grounded poles towards the substation, if possible. Using Ohm's Law, calculate and record the equivalent primary neutral voltage (Vp = Ip*Rp). Remember that milliAmps times Ohms results in milliVolts. Convert answer to Volts. Use the notes section to record the condition of the ground circuit, if damaged or if not to specifications. Also, record any transformers, taps, telephone pads, capacitor banks or any other additions or modifications to the neutral/grounding circuits at this pole.

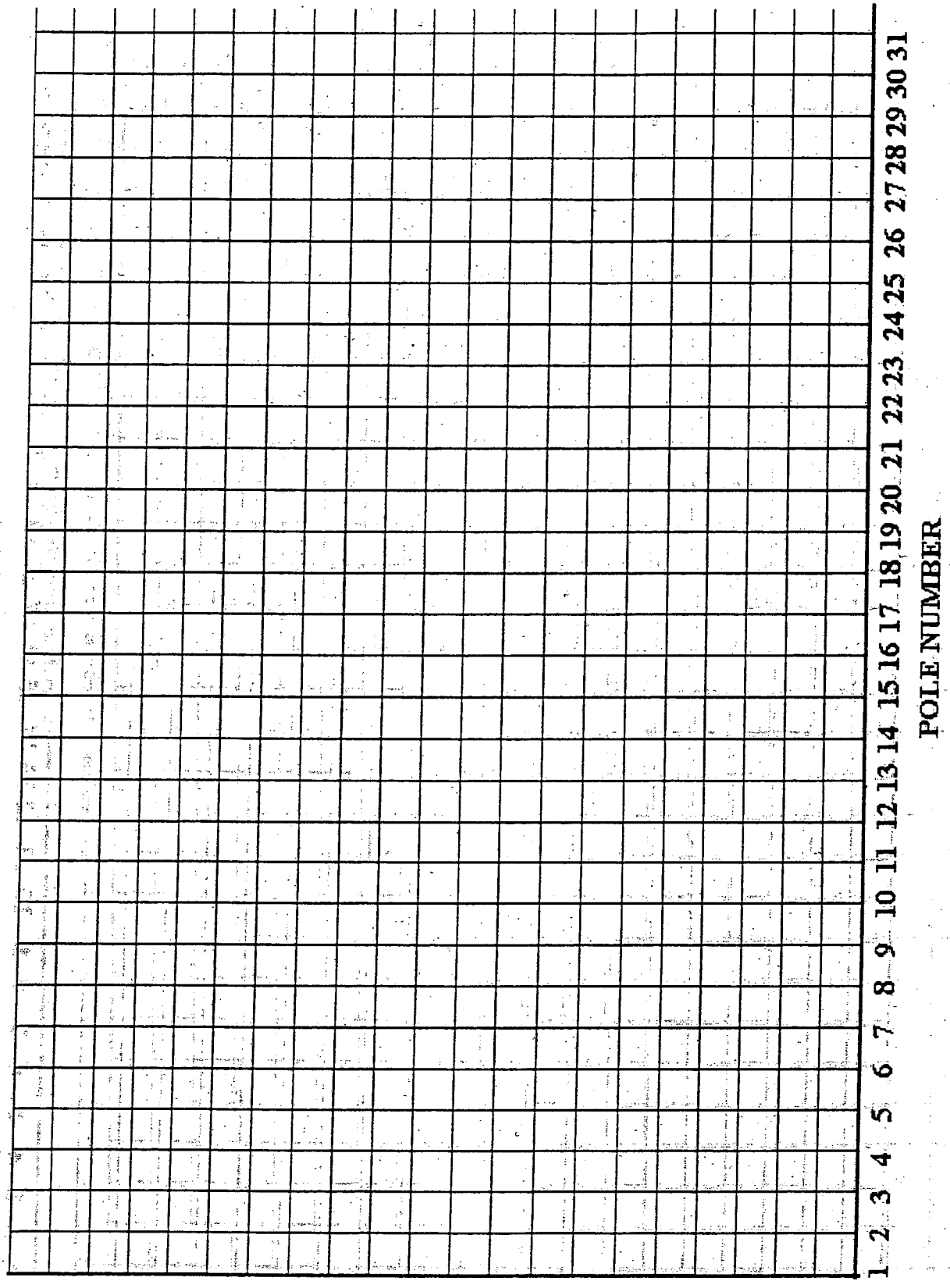
pole #	POLE Identification	Ipn mA	Rp □	Calc Vp Volts	Time	Notes
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						


I pn
I pn
I pn
I pn
I pn
I pn
I pn
I pn
I pn
I pn
I pn
I, R
I, R
I, R
I, R
V =IR
Primary Profile

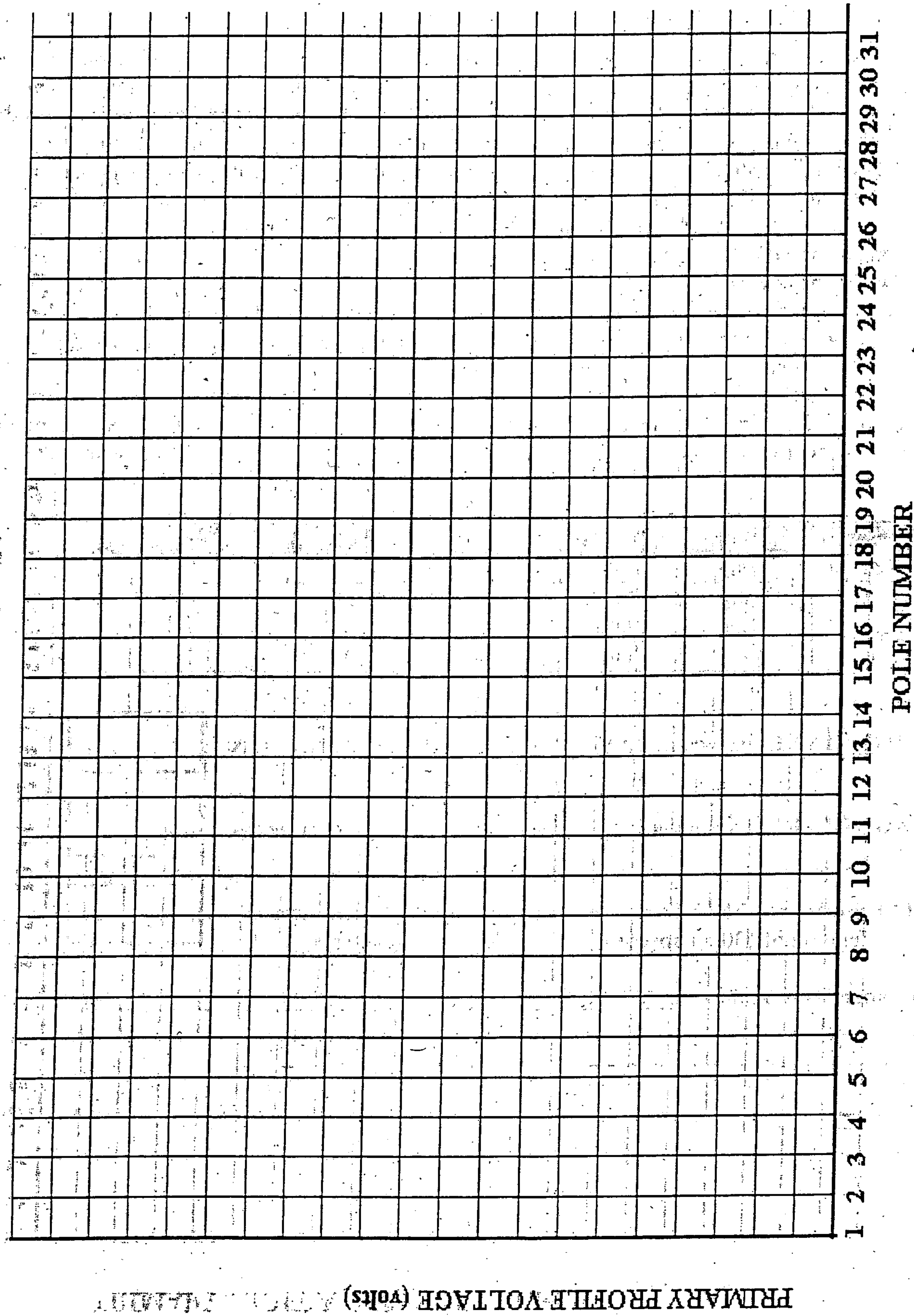
Appendix A-5b



Appendix A-5c



Appendix A-5d



"24 HOUR" TEST DATA REPORT FORM

Farm Customer Name: _____ **Date:** _____

Use this form to report the number of events from the recorded data of the "24 hour" test. This record involves only the voltage in the cow contact area exceeding the limits set below. The duration of the test is nominally 24 hours, but, if short of that time, it should be long enough to include two full milking periods. All cow contact voltage readings are made with a shunt resistance of 500 Ω at the measurement point.

The "24 hour" test should record a minimum of four channels of data: voltage on the primary neutral to remote reference (V_{pn}), voltage on the secondary neutral to remote reference (V_{sn}), voltage between the primary and secondary neutrals (V_{ps}) and the voltage in cow contact area with resistor ($V_{ccw/r}$).

The data recorded is to be analyzed and the following report completed. Record the number of occurrences where the cow contact voltage exceeds 1 Volt RMS from the excedence report. Secondly, record the number of occurrences of the cow contact voltage exceeding a minimum of 3 Volts RMS from the out of limits report. Lastly, record the number of occurrences of the cow contact impulse voltage exceeding a minimum of 10 Volts peak from the out-of-limits report.

It is suggested that a Metrosonics SRV4 unit be used with the following settings: Waveform capture - OFF, Impulse capture - ON, Record min RMS - NO, Record RMS - YES, Record max RMS - YES, Max record time with 4 channels, RMS storage interval - 10 SEC., Channel assignments and settings:

Red	Vpng	ON	OFF	OFF	15V
Black	Vsng	ON	OFF	OFF	15V
Blue	Vps	ON	OFF	OFF	15V
White	Vcc	ON	OFF	ON 3V	10V

1. **VOLTAGE LEVEL:** Exceeding **1.0Vrms MAXIMUM** **Occurrences:** ☐

2. **VOLTAGE LEVEL:** Exceeding **3.0Vrms MAXIMUM** **Occurrences:** ☐

3. **IMPULSE VOLTAGE LEVEL:** Exceeding **10Vpeak MAX** **Occurrences:** ☐
   for a time duration of 130 microseconds to 1 cycle (16.67 msec.) per event.

Additional comments from the test: _____

_____

_____

File No. _____