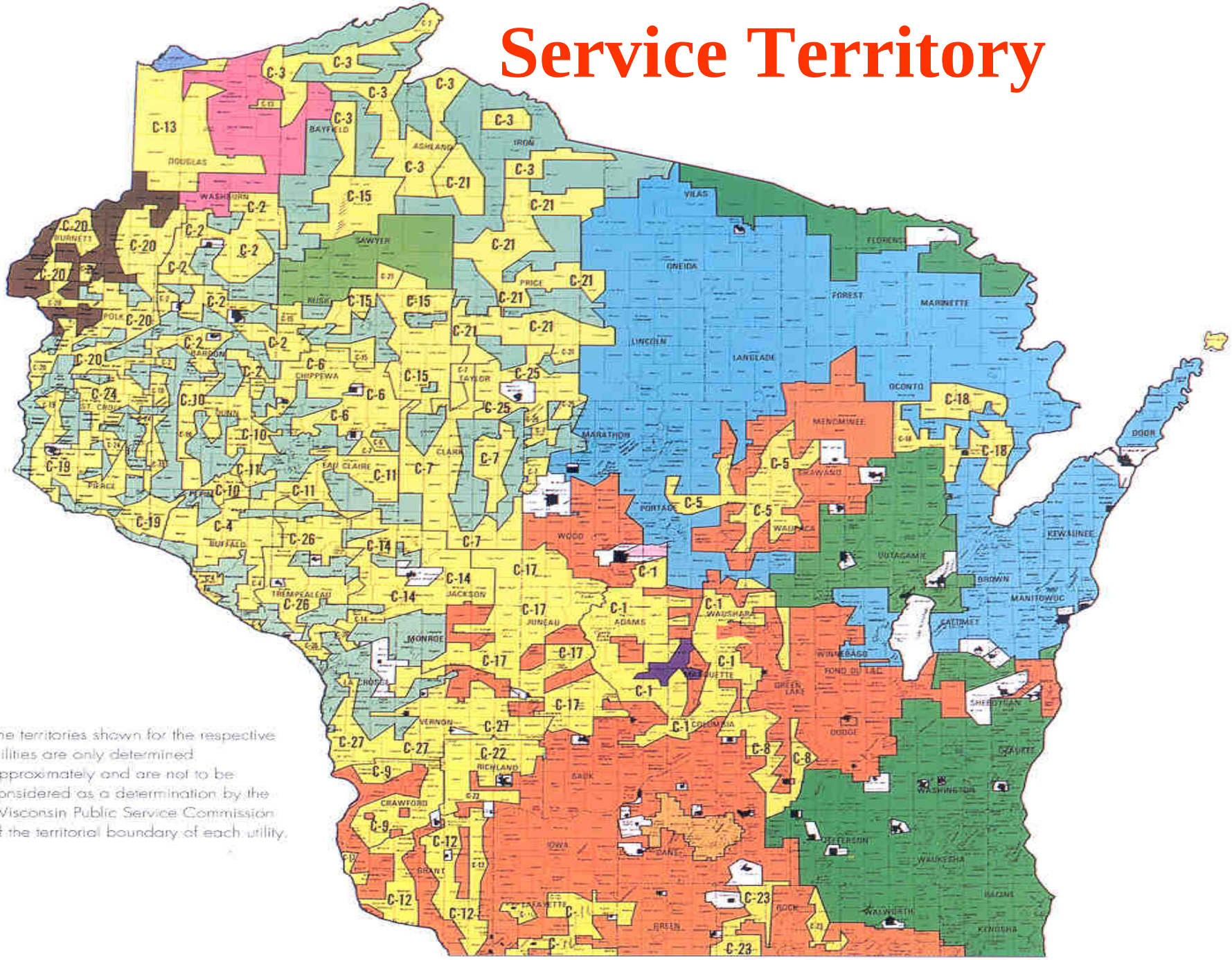
Mark Cook
OEB 2007

General Manager

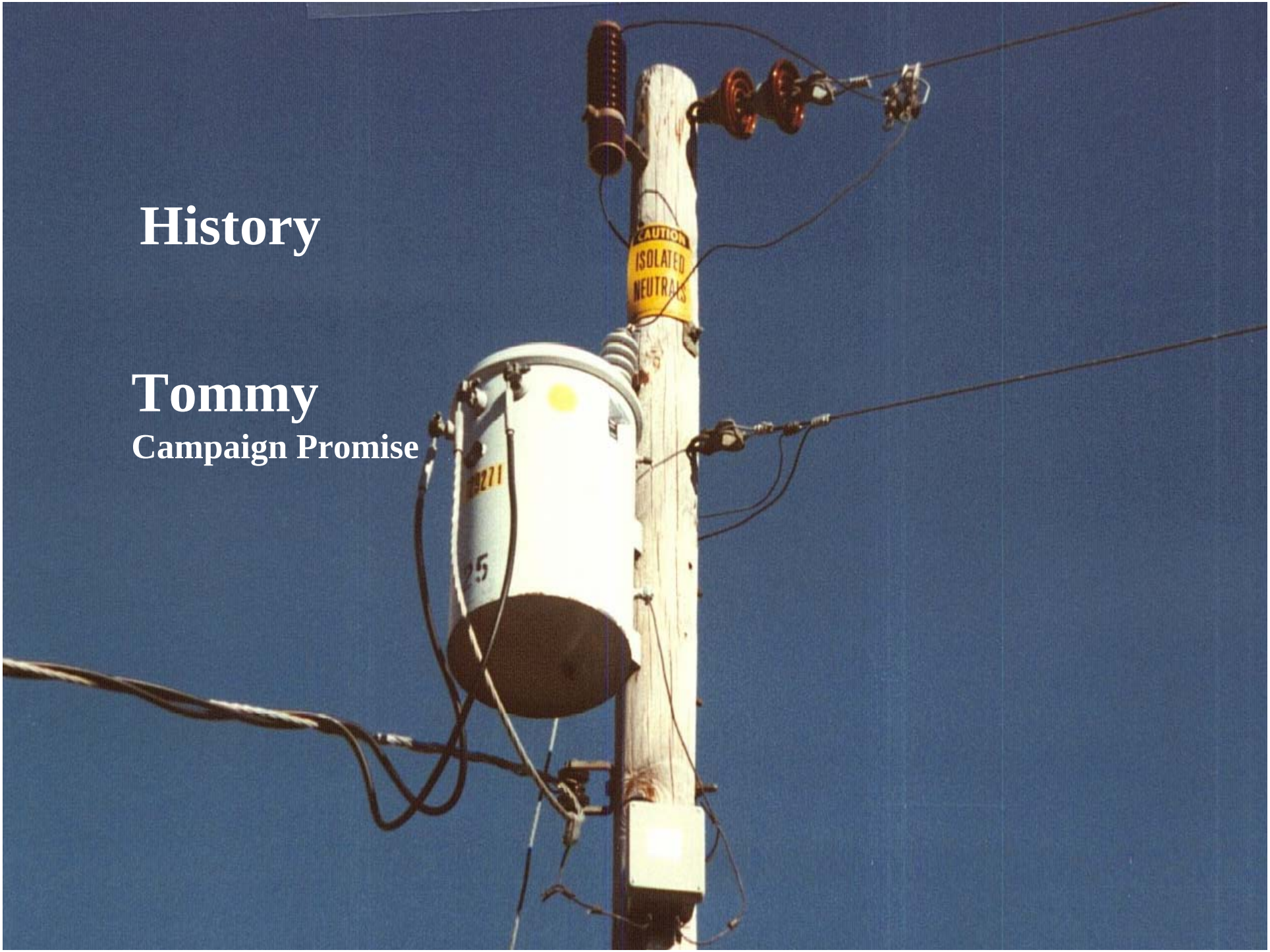
Public Service Commission of Wisconsin

Service Territory



The territories shown for the respective utilities are only determined approximately and are not to be considered as a determination by the Wisconsin Public Service Commission of the territorial boundary of each utility.

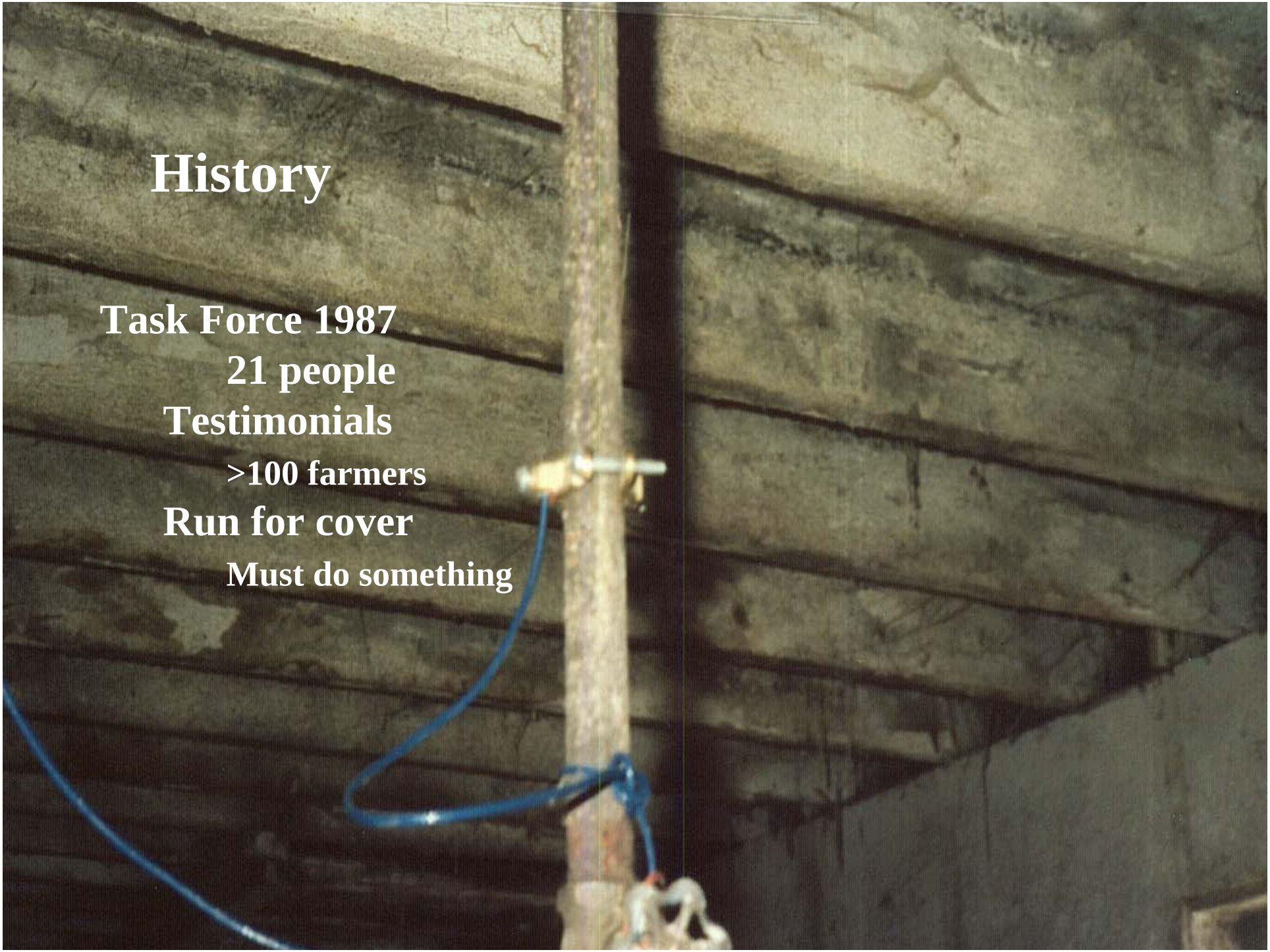

History
$ 1.1 million
Daggett
vs
WEPCO



History

Tommy

Campaign Promise



History

Task Force 1987

21 people

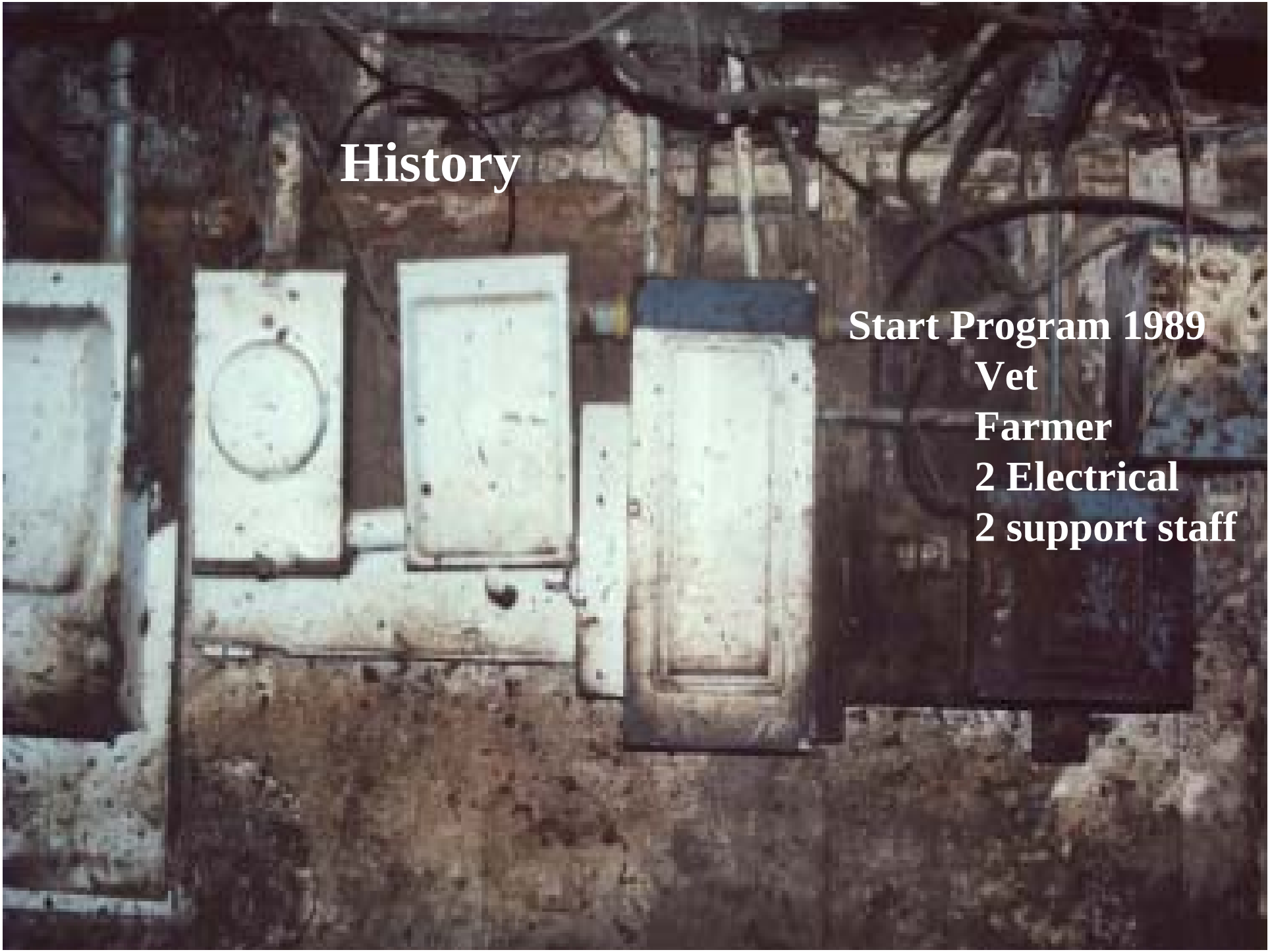
Testimonials

>100 farmers

Run for cover

Must do something


History
Nine farm study 1988
Selection of farms
Staffing (SVAT free)
Standardized Protocol
Investigations
Report to TT
SV Concern, Yes!



History

Start Program 1989

Vet

Farmer

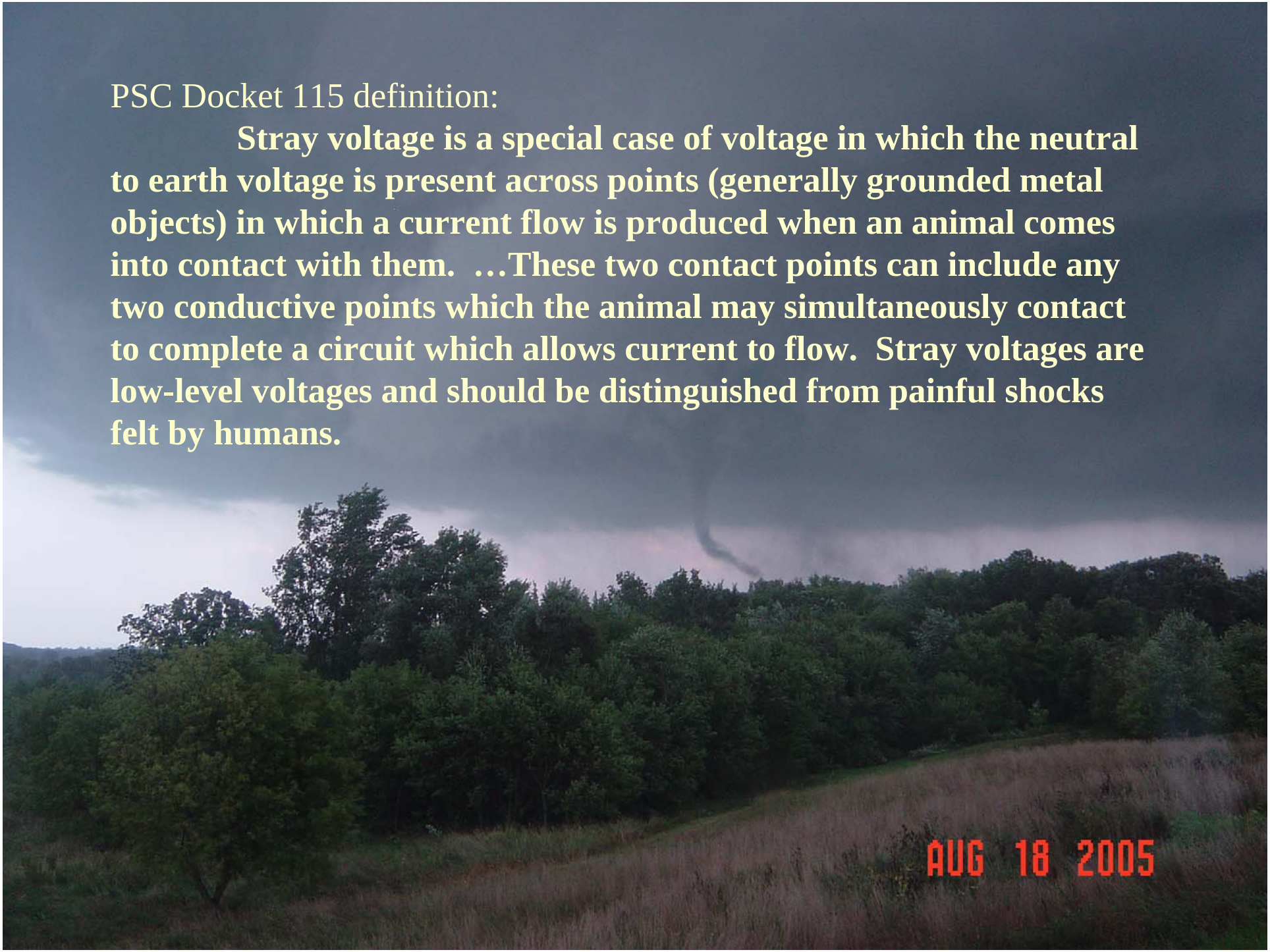
2 Electrical

2 support staff


Open PSCW Docket 106
Hearings (statewide)
Orders Issued 1990

Order points

1. **Research**
2. **State LOC**
3. **Set Policy and Procedures**
4. **Produce Standardized Testing**
5. **Cooperweld**
6. **Isolation**
7. **Who Pays?**
8. **Mitigation, Ownership?**
9. **Staff Testing, *Authority***
10. **Motor starting**
11. **Special needs**
12. **Mitigate on farm for off farm?**



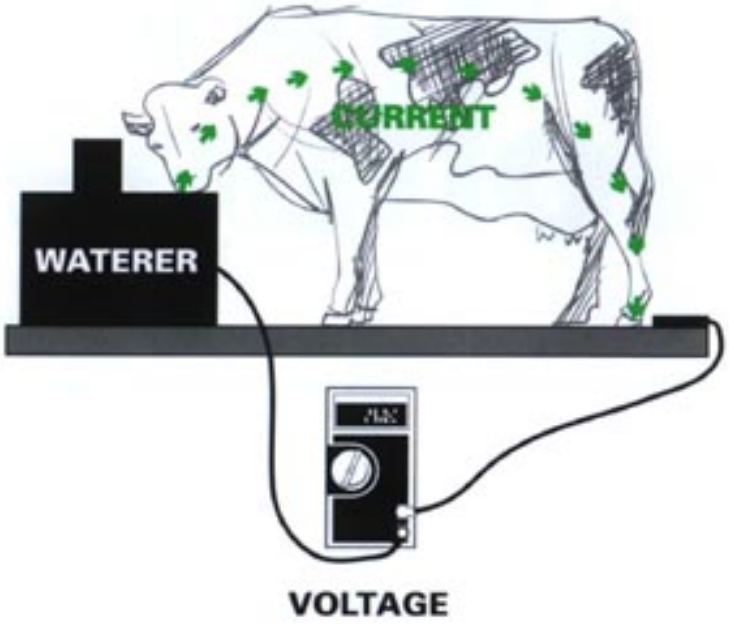
PSC Docket 115 definition:

Stray voltage is a special case of voltage in which the neutral to earth voltage is present across points (generally grounded metal objects) in which a current flow is produced when an animal comes into contact with them. …These two contact points can include any two conductive points which the animal may simultaneously contact to complete a circuit which allows current to flow. Stray voltages are low-level voltages and should be distinguished from painful shocks felt by humans.

Stray Voltage (SV)

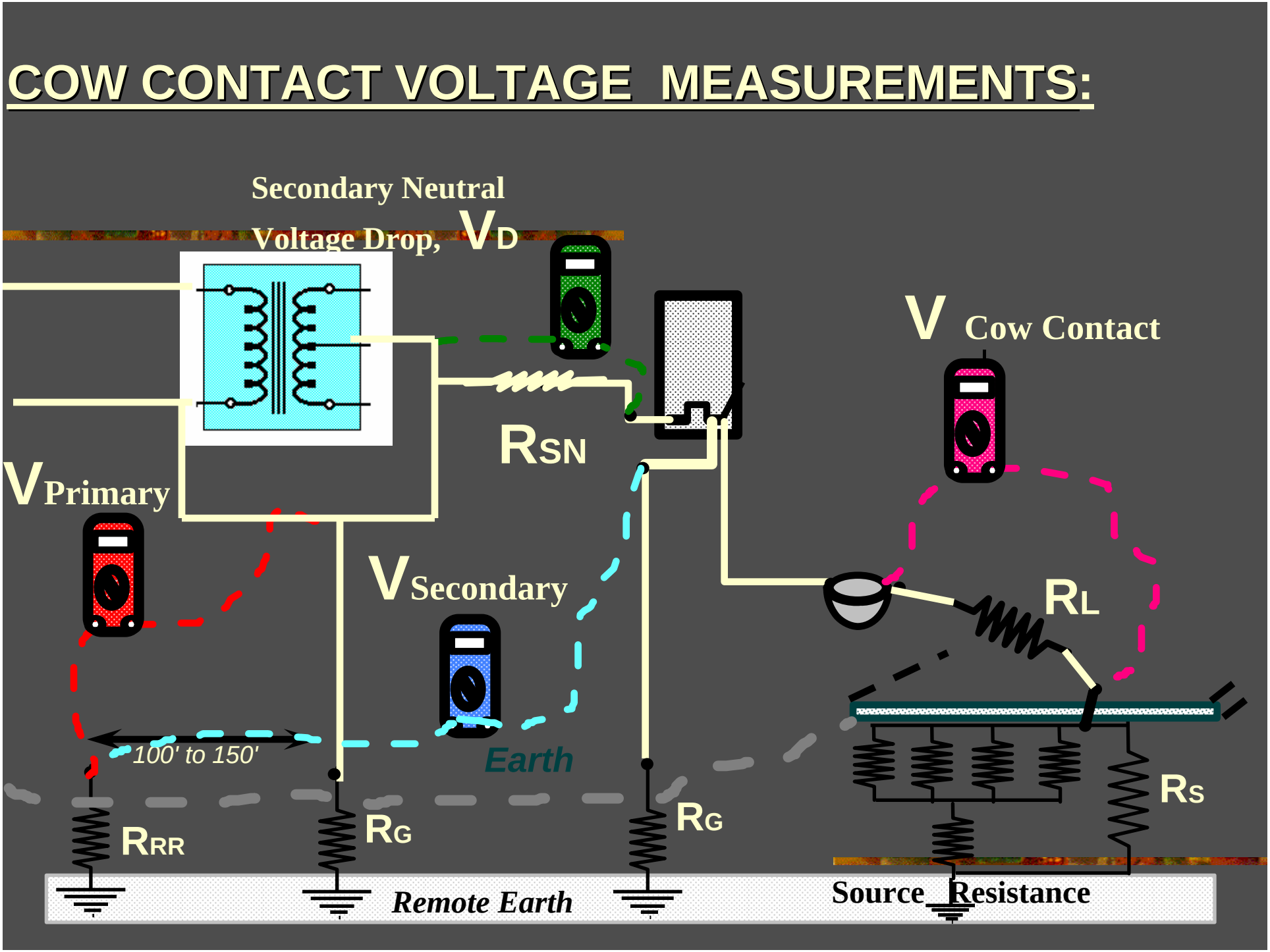
- Special case of Neutral to Earth Voltage (NEV)
- 2 points simultaneously contacted by a cow
- Steady-state 60 Hz
- Level of concern is 2 mA
  - 1 mA or 0.5 volt from utility
- Not damage level
- SV is not debilitating shock or electrocution

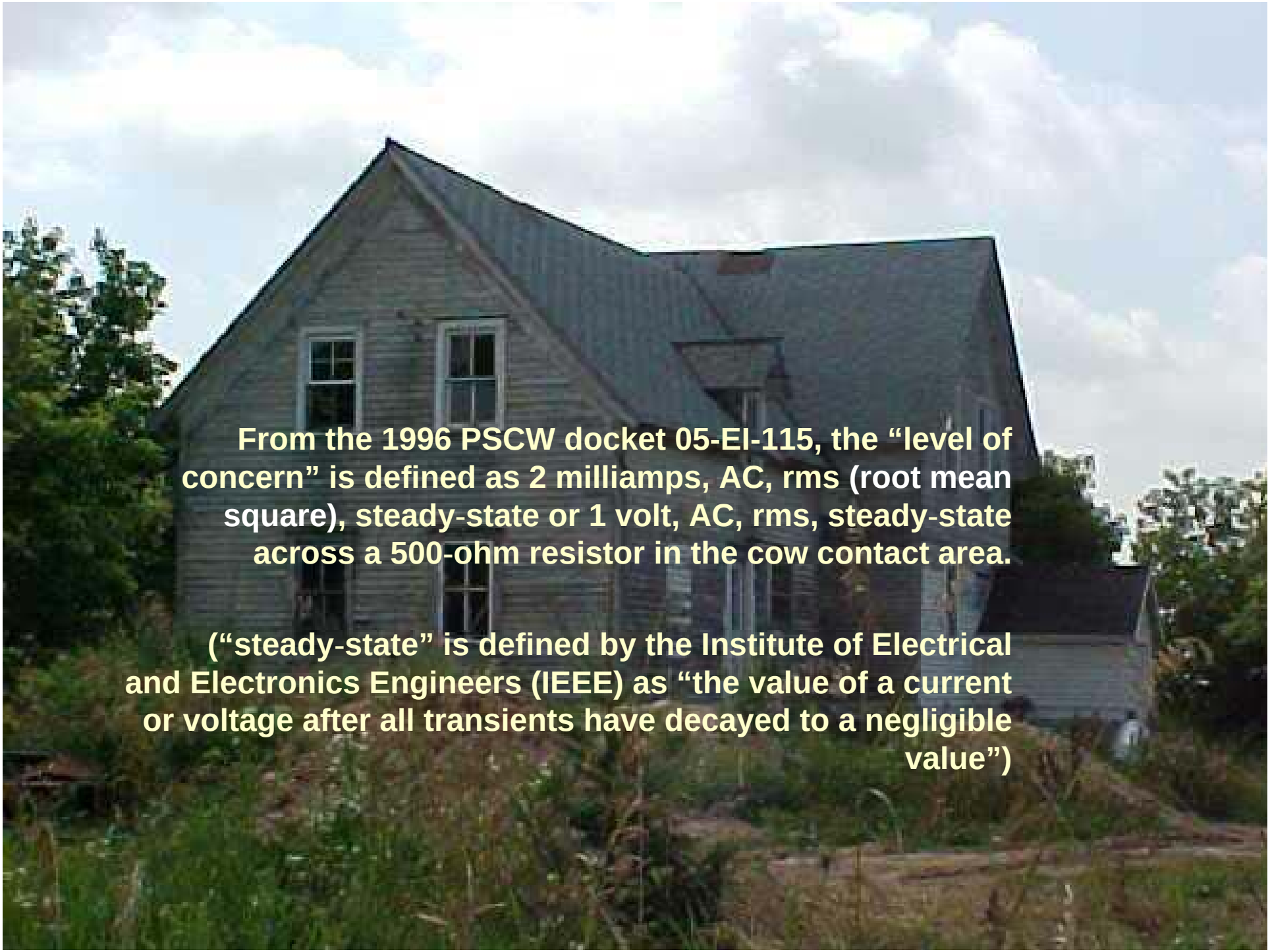
CURRENT = (VOLTAGE) / (RESISTANCE)



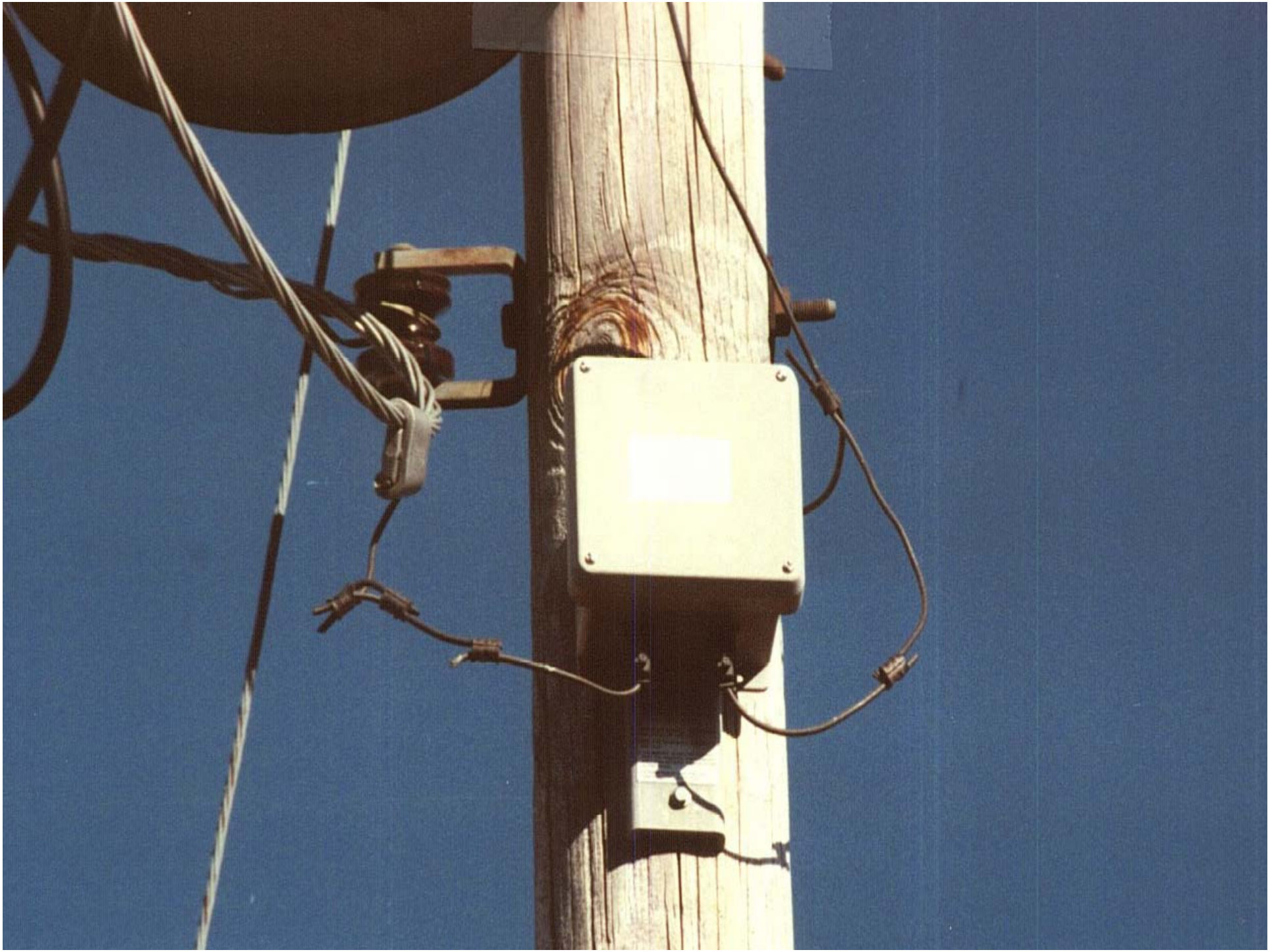
COW RESISTANCE ~ 500 OHMS

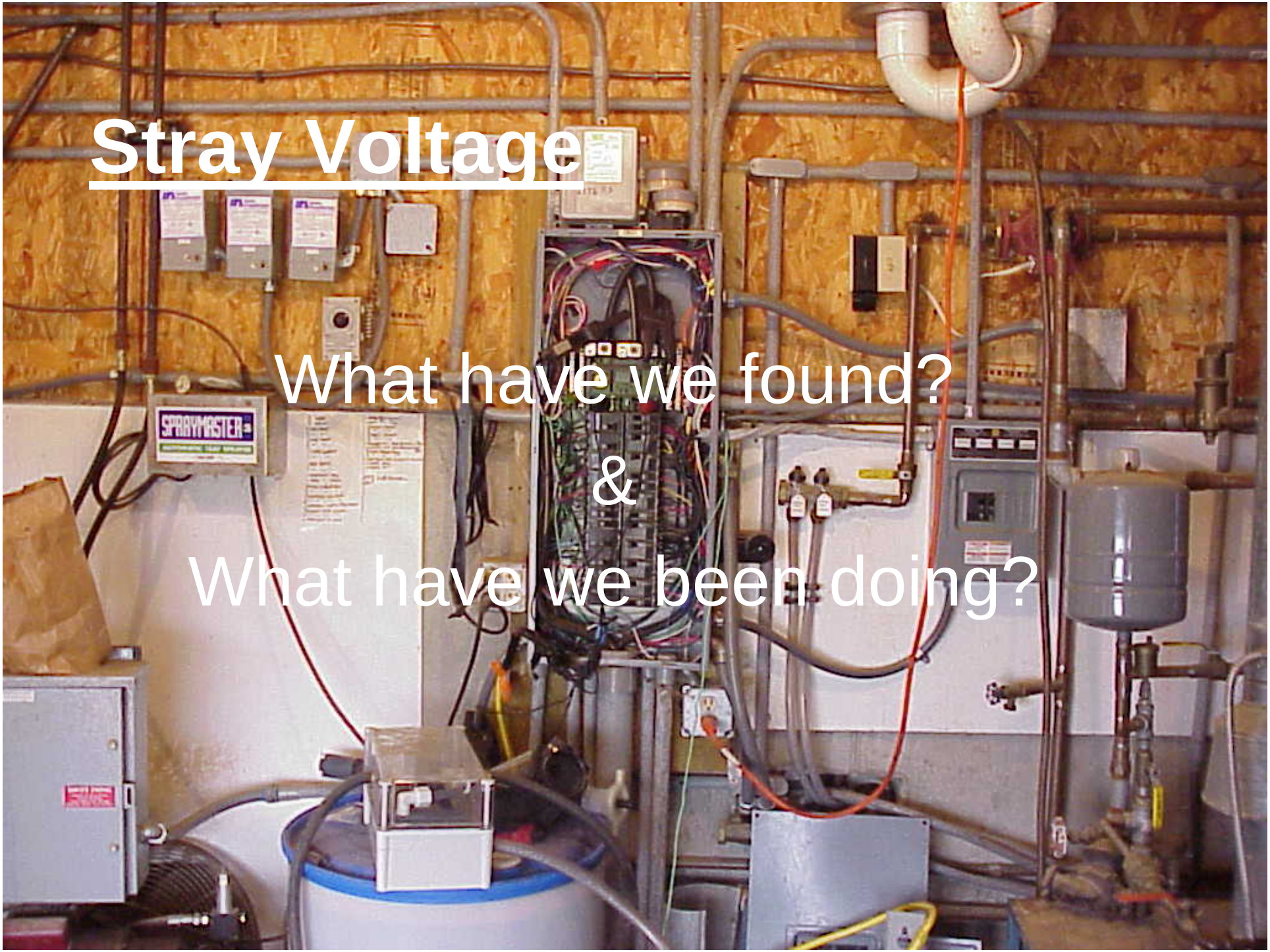
COW CONTACT VOLTAGE MEASUREMENTS:




From the 1996 PSCW docket 05-EI-115, the “level of concern” is defined as 2 milliamps, AC, rms (root mean square), steady-state or 1 volt, AC, rms, steady-state across a 500-ohm resistor in the cow contact area.
(“steady-state” is defined by the Institute of Electrical and Electronics Engineers (IEEE) as “the value of a current or voltage after all transients have decayed to a negligible value”)

- **The State of Wisconsin deems that this level of voltage/current is an amount of electricity where some form of mitigative action is taken on the farmer's behalf, although only some small percentage of cows may actually perceive its presence. The "level of concern" is not a damage level. Instead, it is a very conservative, pre-injury level, below the point where moderate avoidance behavior is likely to occur and well below where a cow's behavior or milk production would be harmed.**





Stray Voltage

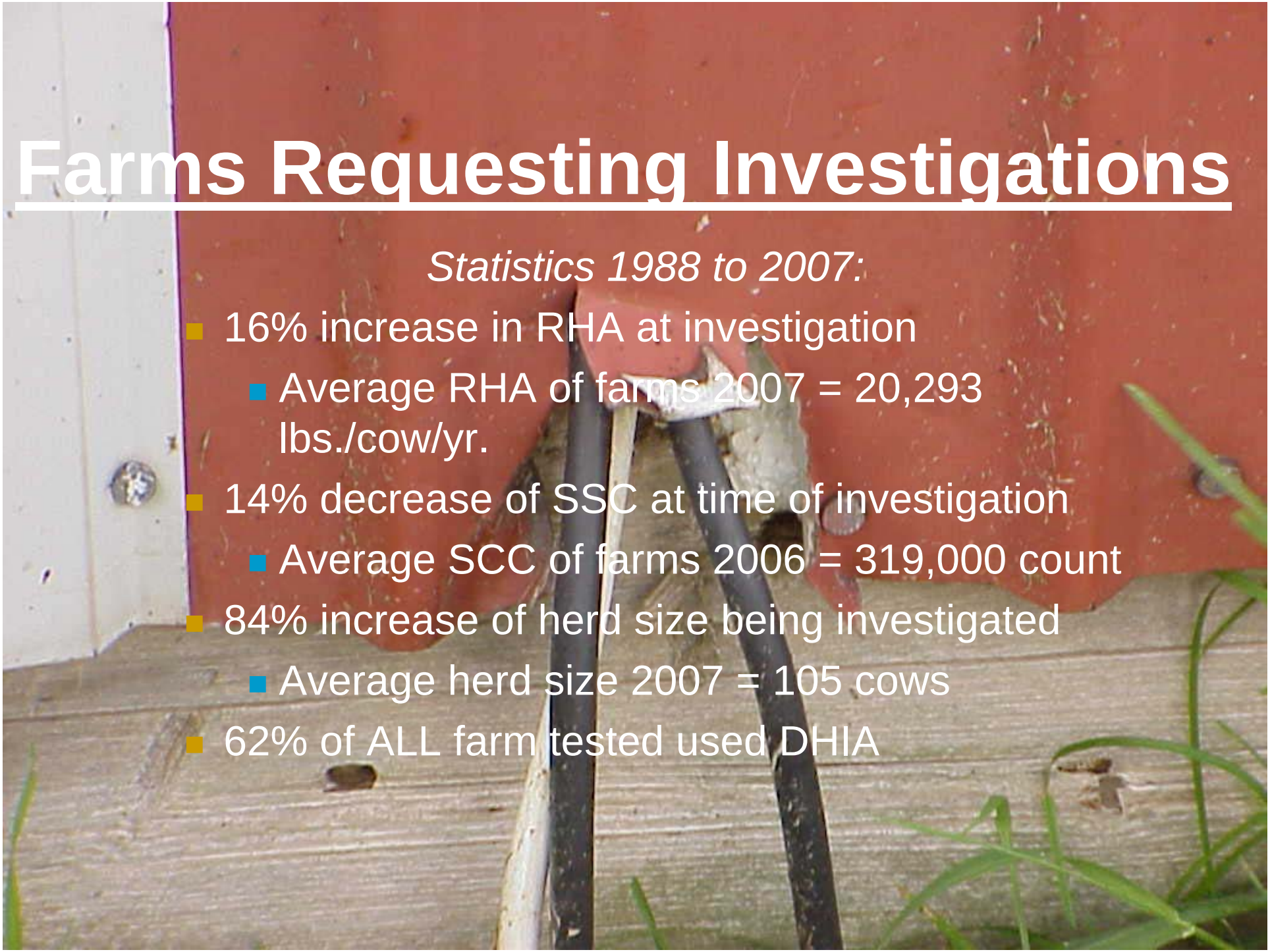
What have we found?

&

What have we been doing?

SV Investigation Database

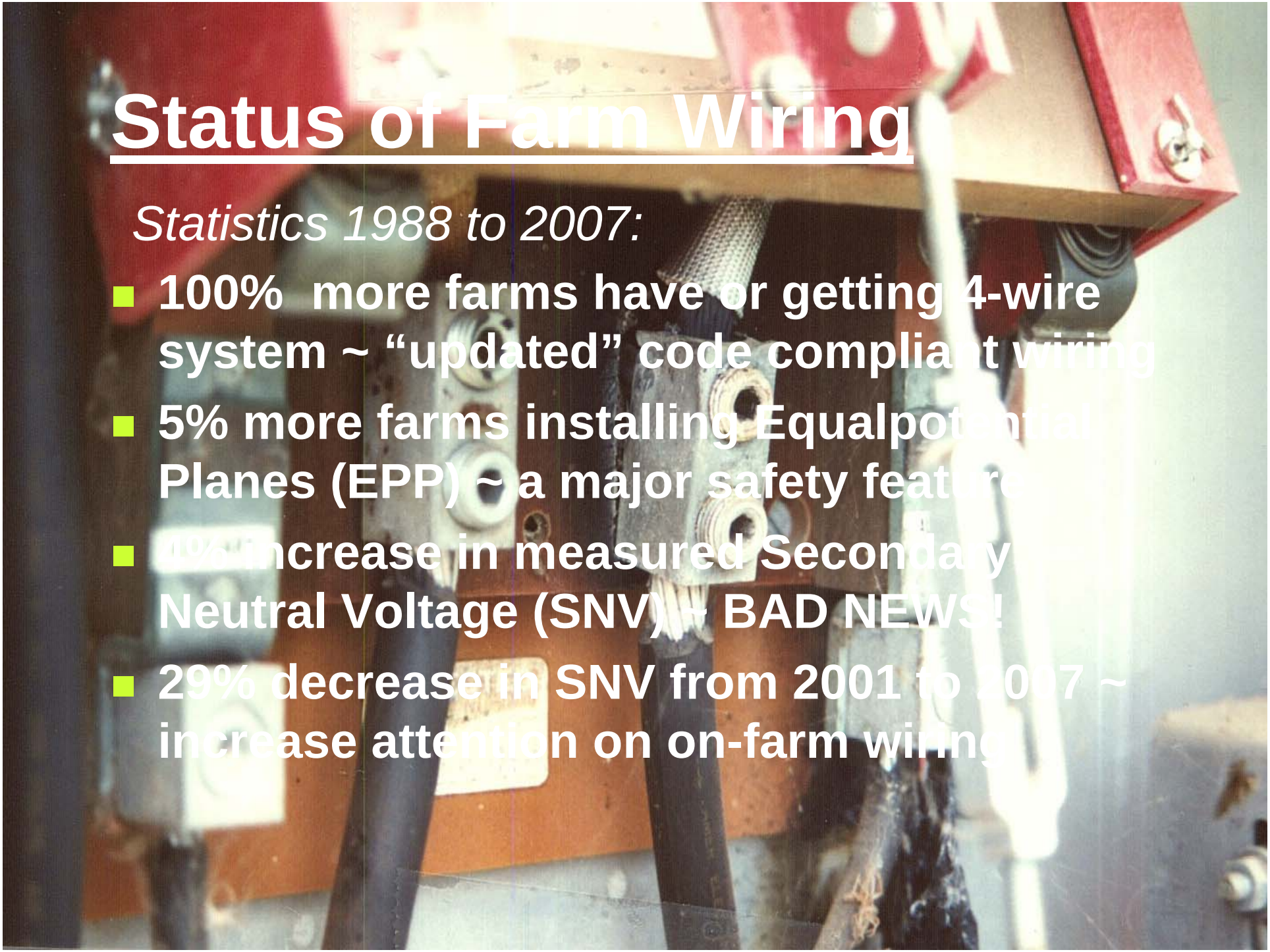
- 8,000 farm investigations in PSC database
  - REPS program and utility investigations
    - 1299
- Reporting required of regulated Investor Owned Utilities (IOUs) and volunteered by Rural Electric Cooperatives (RECs).



Farms Requesting Investigations

Statistics 1988 to 2007:

- 16% increase in RHA at investigation
  - Average RHA of farms 2007 = 20,293 lbs./cow/yr.
- 14% decrease of SSC at time of investigation
  - Average SCC of farms 2006 = 319,000 count
- 84% increase of herd size being investigated
  - Average herd size 2007 = 105 cows
- 62% of ALL farm tested used DHIA



Status of Farm Wiring

Statistics 1988 to 2007:

- **100% more farms have or getting 4-wire system ~ "updated" code compliant wiring**
- **5% more farms installing Equalpotential Planes (EPP) ~ a major safety feature**
- **40% increase in measured Secondary Neutral Voltage (SNV) ~ BAD NEWS!**
- **29% decrease in SNV from 2001 to 2007 ~ increase attention on on-farm wiring**

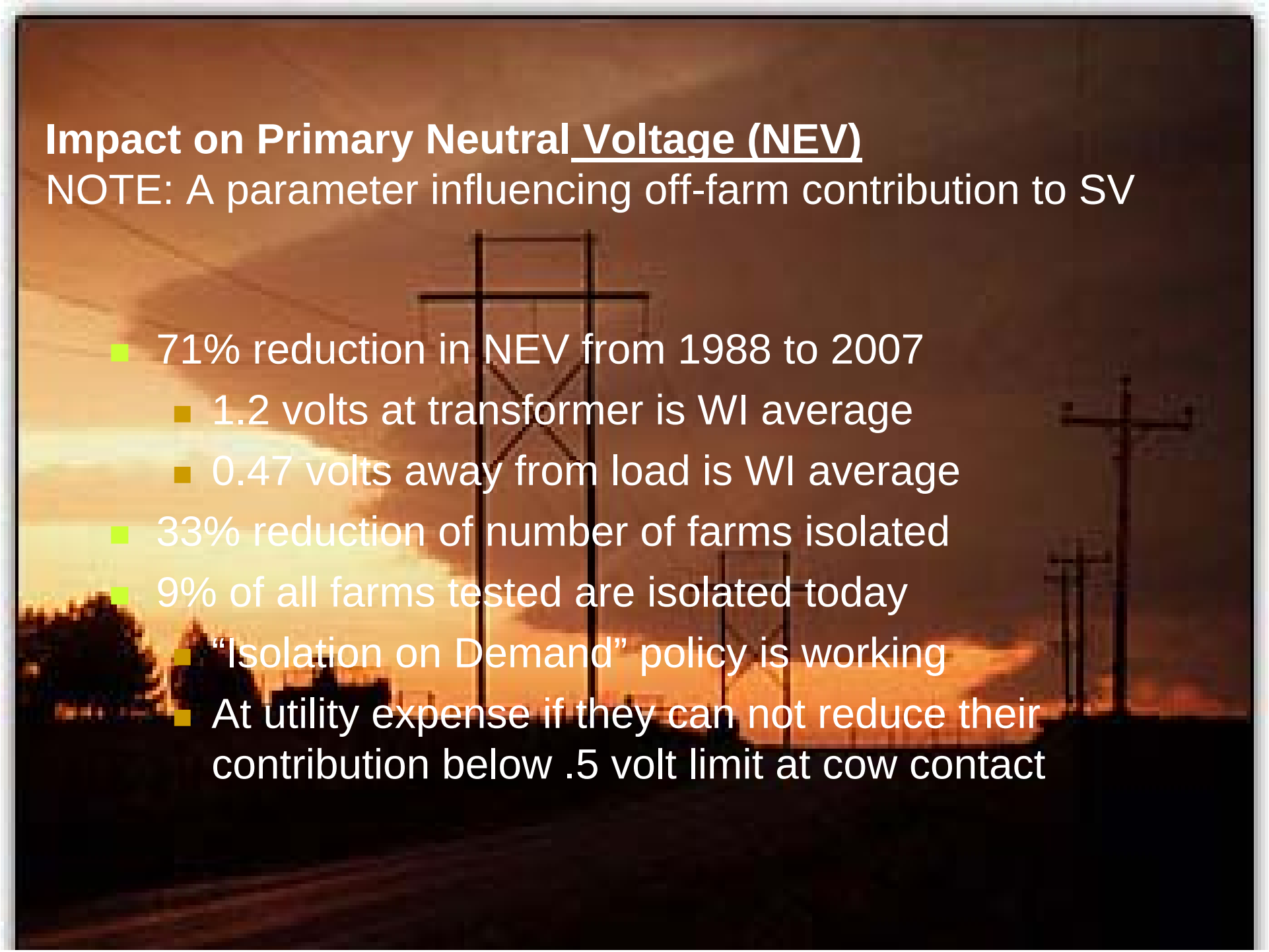
Upgrading Farm Electric & Utility Service

Statistics 1988 to 2007:

- 80% of farms tested getting larger transformers
- 20% of farms are served with 3-phase;
  - voltage conversion programs in place to help more upgrade as becomes feasible.
- 46% reduction of supply conductor resistance per mile
- 39% increase in grounds per mile in place

Upgrading Rural Distribution

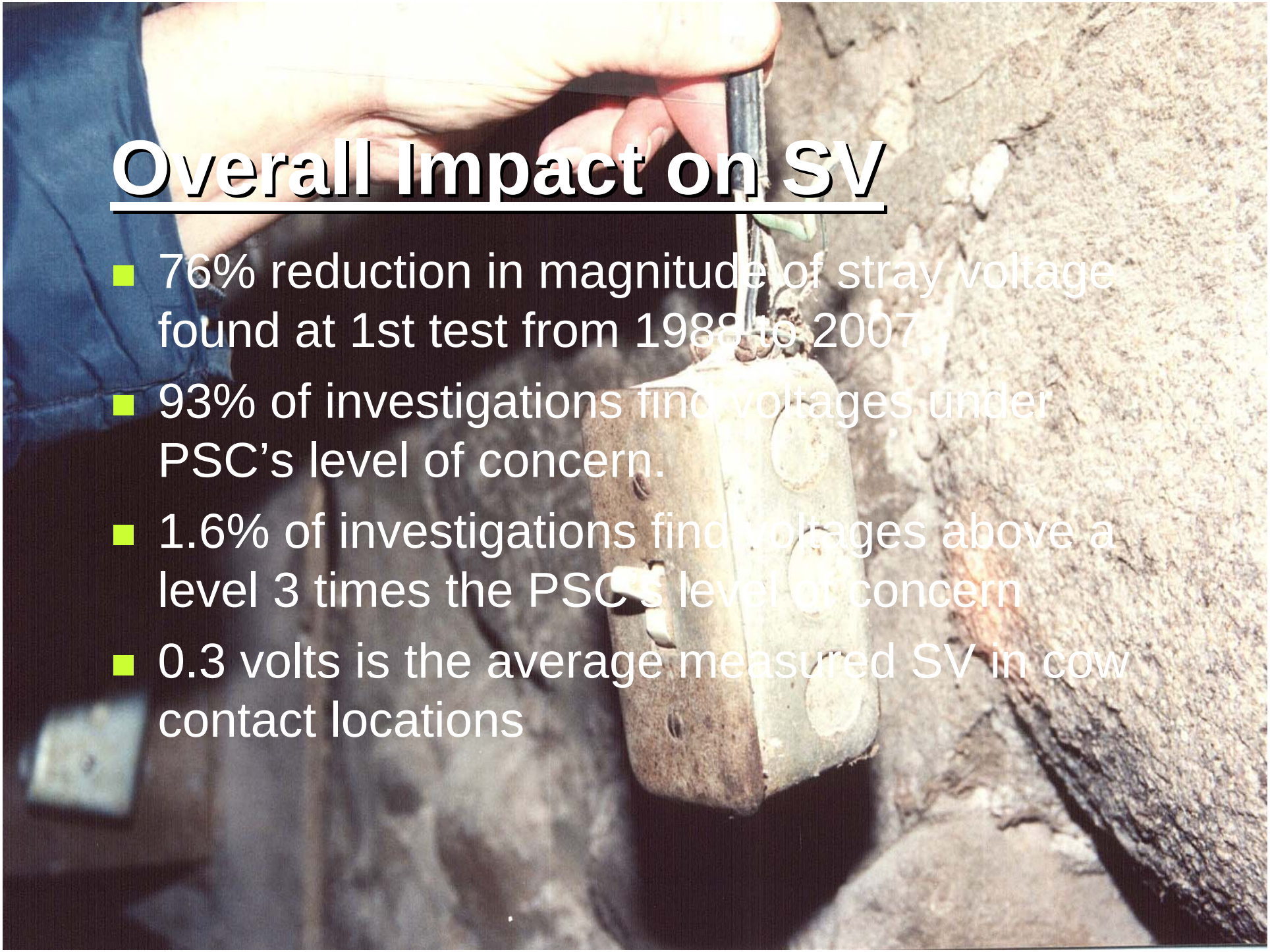
- $1.5 Billion of ratepayers monies spent so far
- Specific initiatives to push system upgrade
  - Split bolt removal program
  - Copperweld conductor inventory reporting
    - 10,400 miles by Investor Owned Utilities
    - Rural Electric Cooperatives now reporting
  - Rural distribution rebuild programs
    - 1,500 miles per year



Impact on Primary Neutral Voltage (NEV)

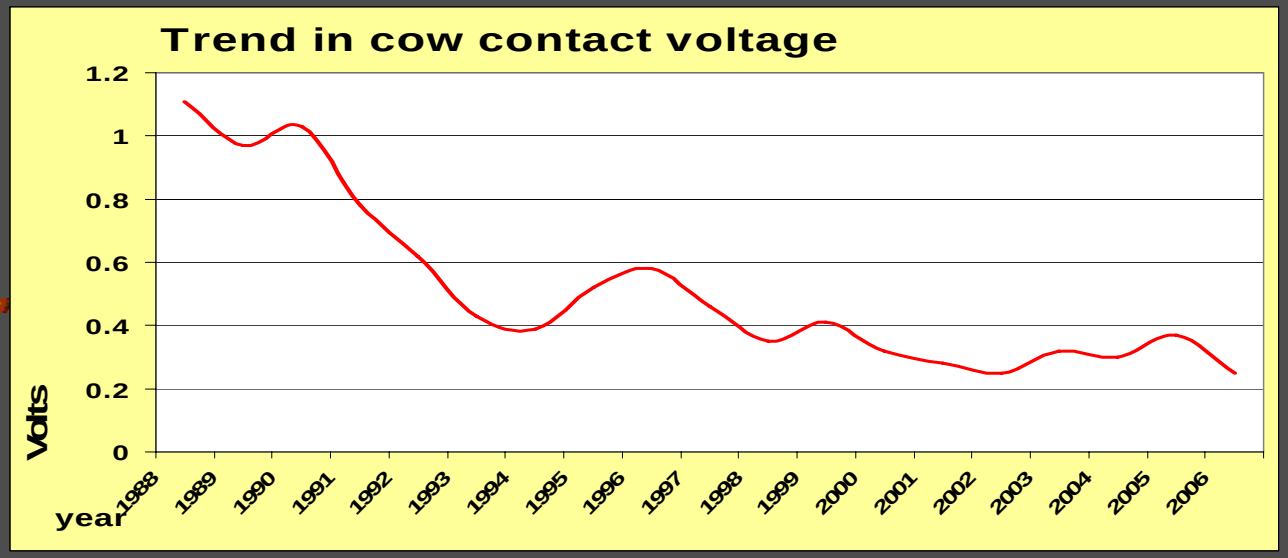
NOTE: A parameter influencing off-farm contribution to SV

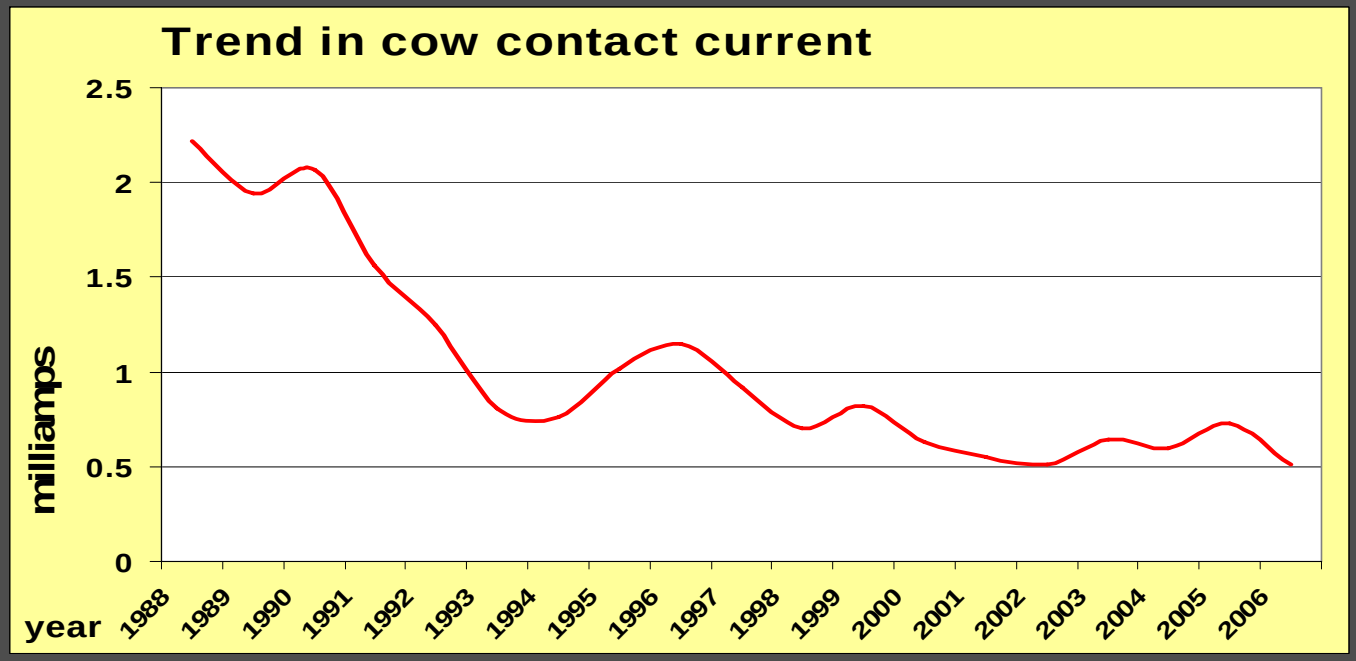
- 71% reduction in NEV from 1988 to 2007
  - 1.2 volts at transformer is WI average
  - 0.47 volts away from load is WI average
- 33% reduction of number of farms isolated
- 9% of all farms tested are isolated today
  - "Isolation on Demand" policy is working
  - At utility expense if they can not reduce their contribution below .5 volt limit at cow contact

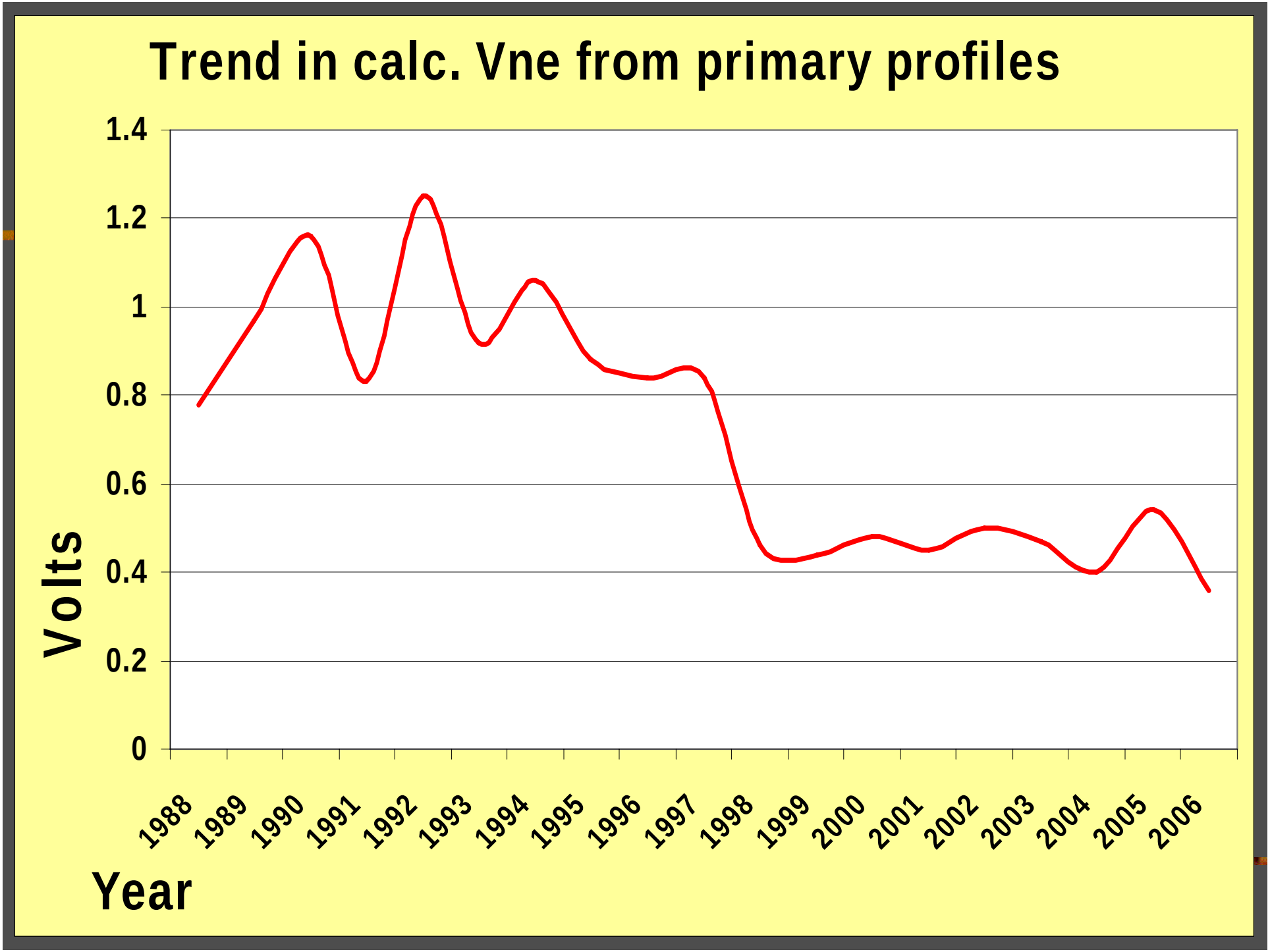


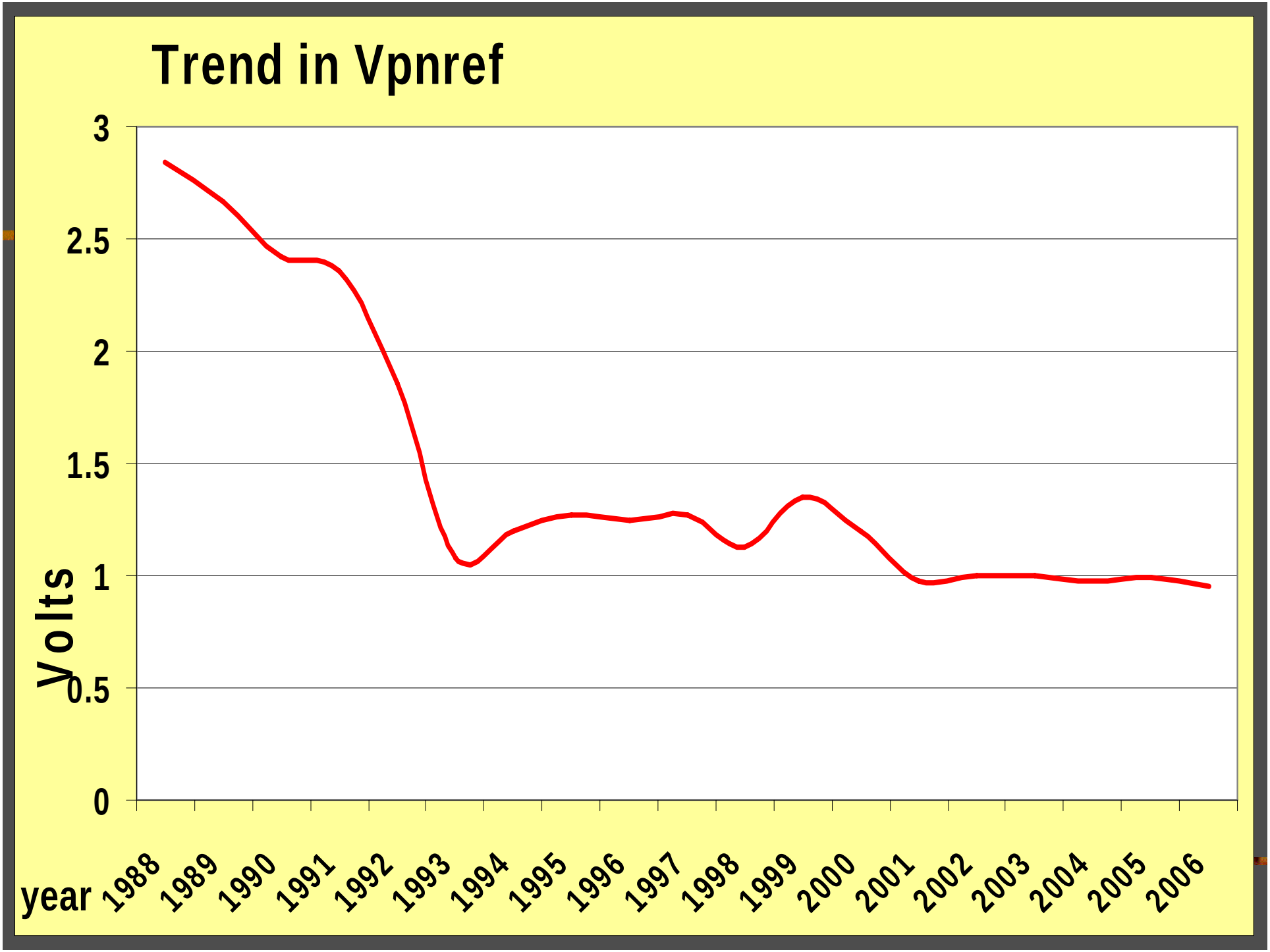
Overall Impact on SV

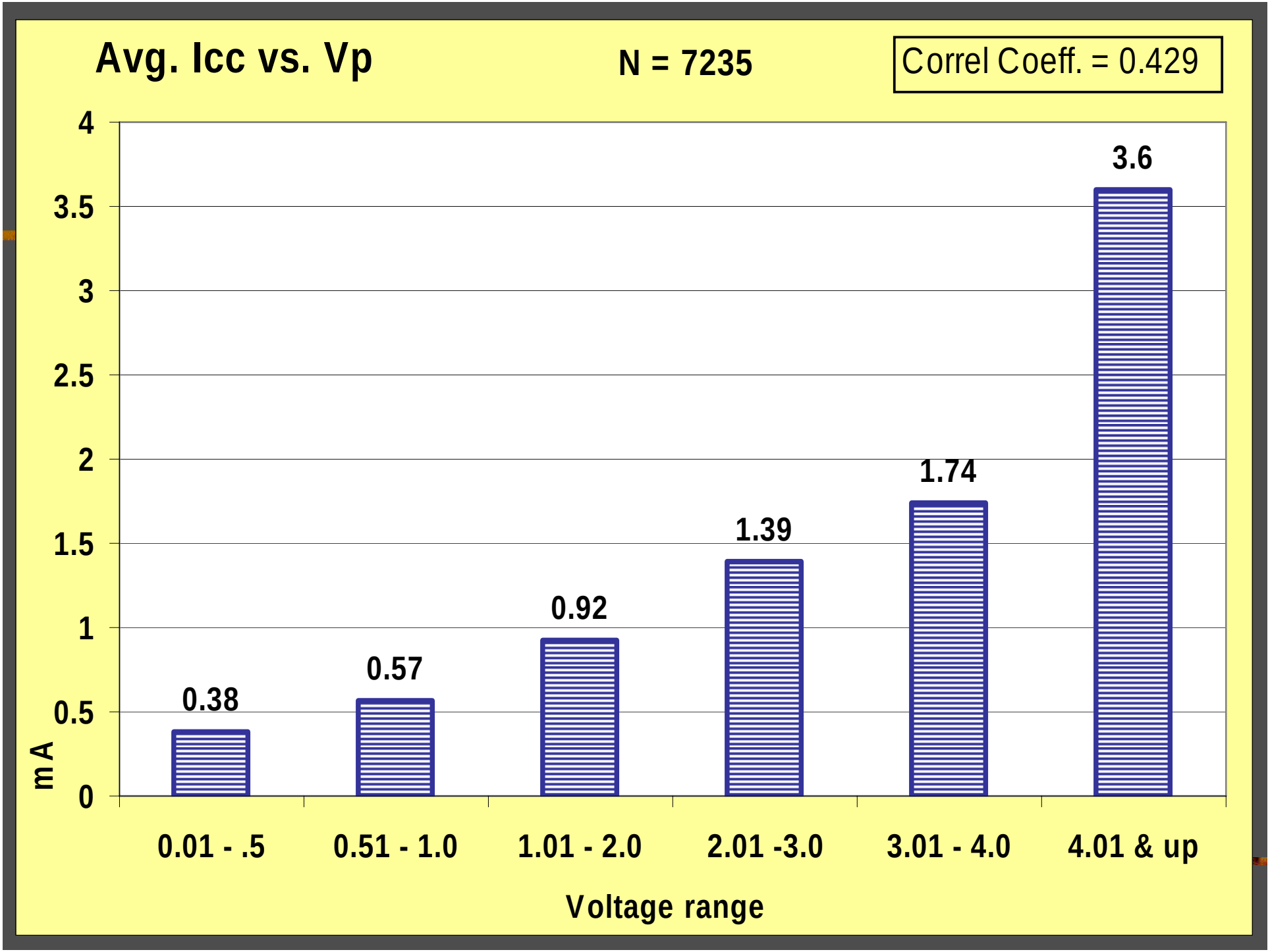
- 76% reduction in magnitude of stray voltage found at 1st test from 1988 to 2007
- 93% of investigations find voltages under PSC's level of concern.
- 1.6% of investigations find voltages above a level 3 times the PSC's level of concern
- 0.3 volts is the average measured SV in cow contact locations


Trend in cow contact voltage
Volts
1.2
1
0.8
0.6
0.4
0.2
0
year
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

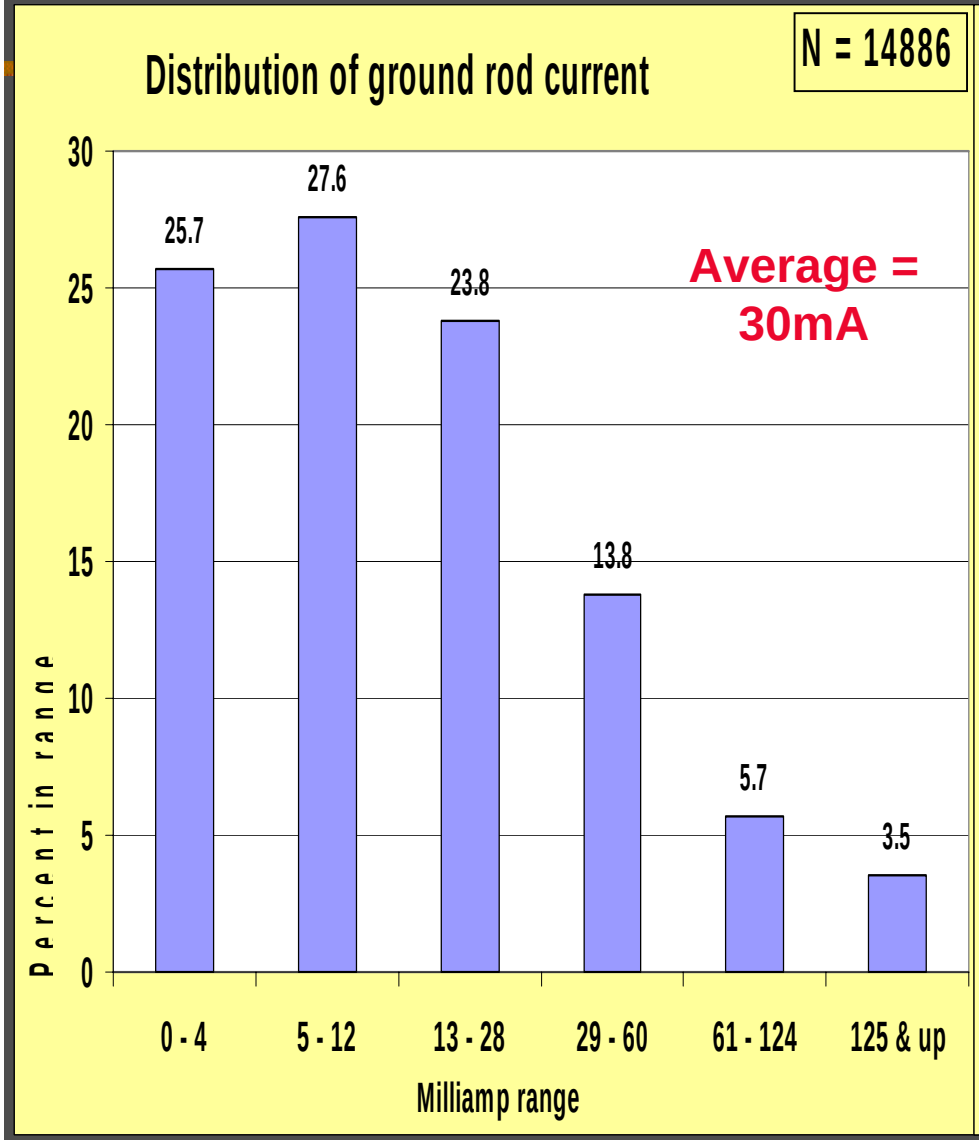

Trend in cow contact current
milliamps
2.5
2
1.5
1
0.5
0
year
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

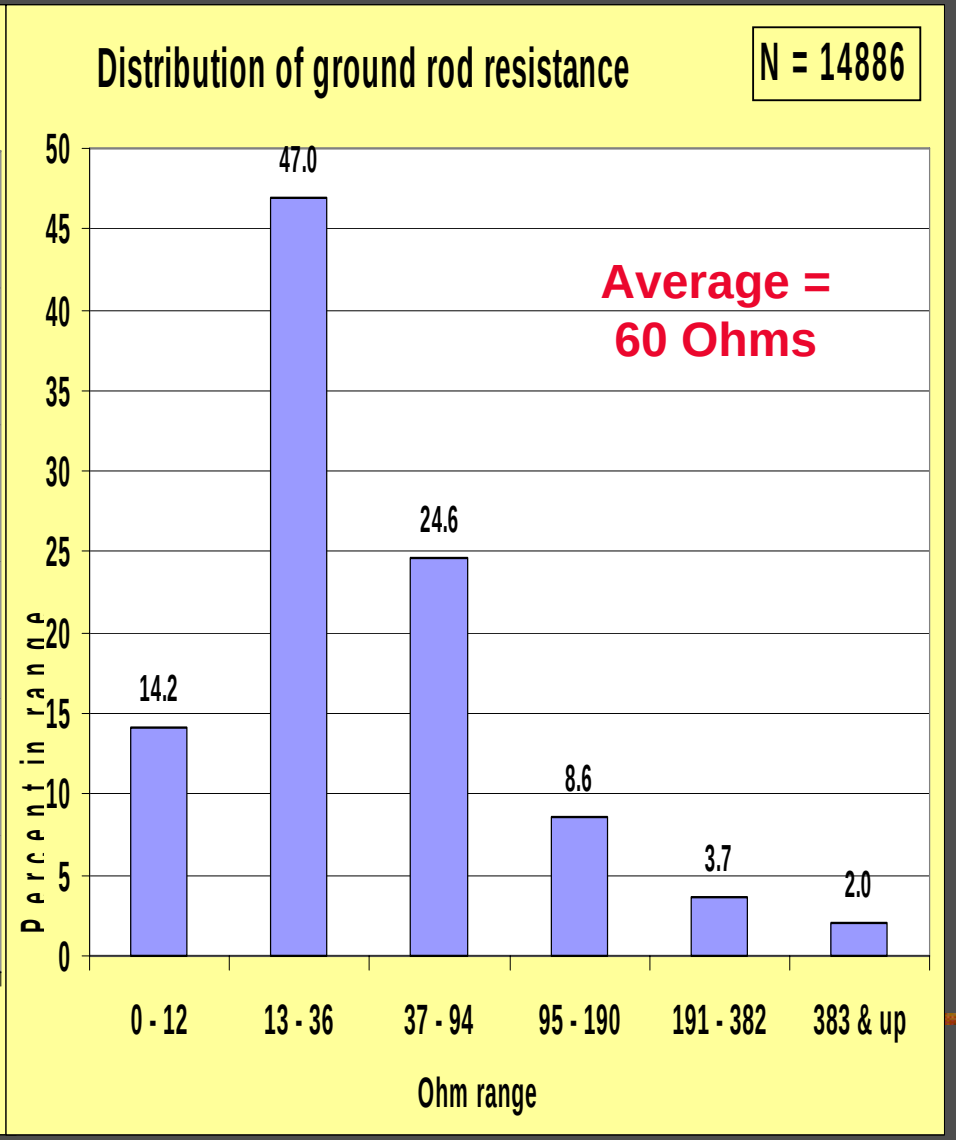

Trend in calc. Vne from primary profiles
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Volts
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Year

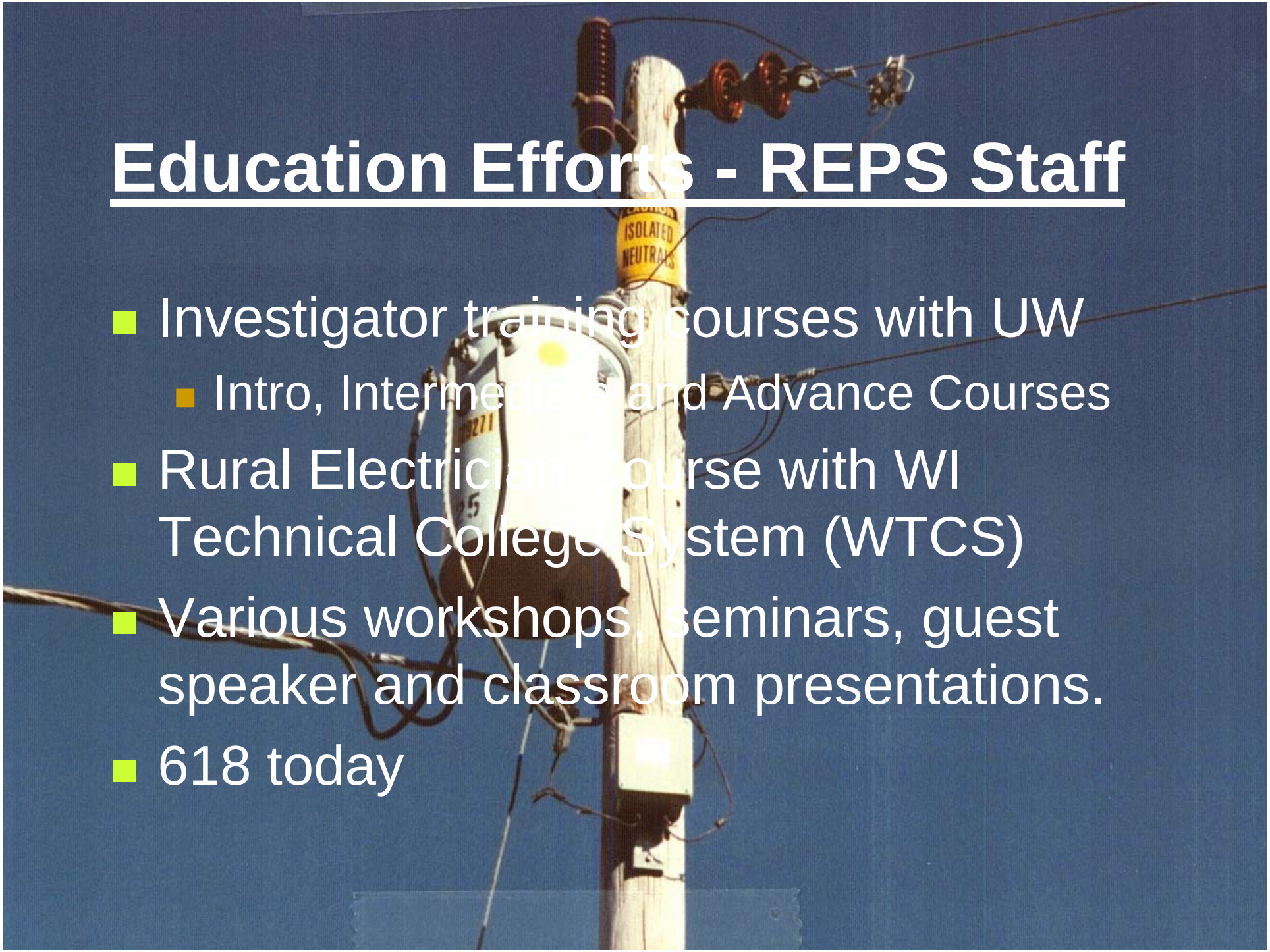

Trend in Vpnref
3
2.5
2
1.5
1
0.5
0
Volts
year
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006


Avg. Icc vs. Vp
N = 7235
Correl Coeff. = 0.429
4
3.5
3
2.5
2
1.5
1
0.5
0
mA
0.38
0.57
0.92
1.39
1.74
3.6
0.01 - .5
0.51 - 1.0
1.01 - 2.0
2.01 -3.0
3.01 - 4.0
4.01 & up
Voltage range

Distribution neutral characteristics SV database: 1988-2006





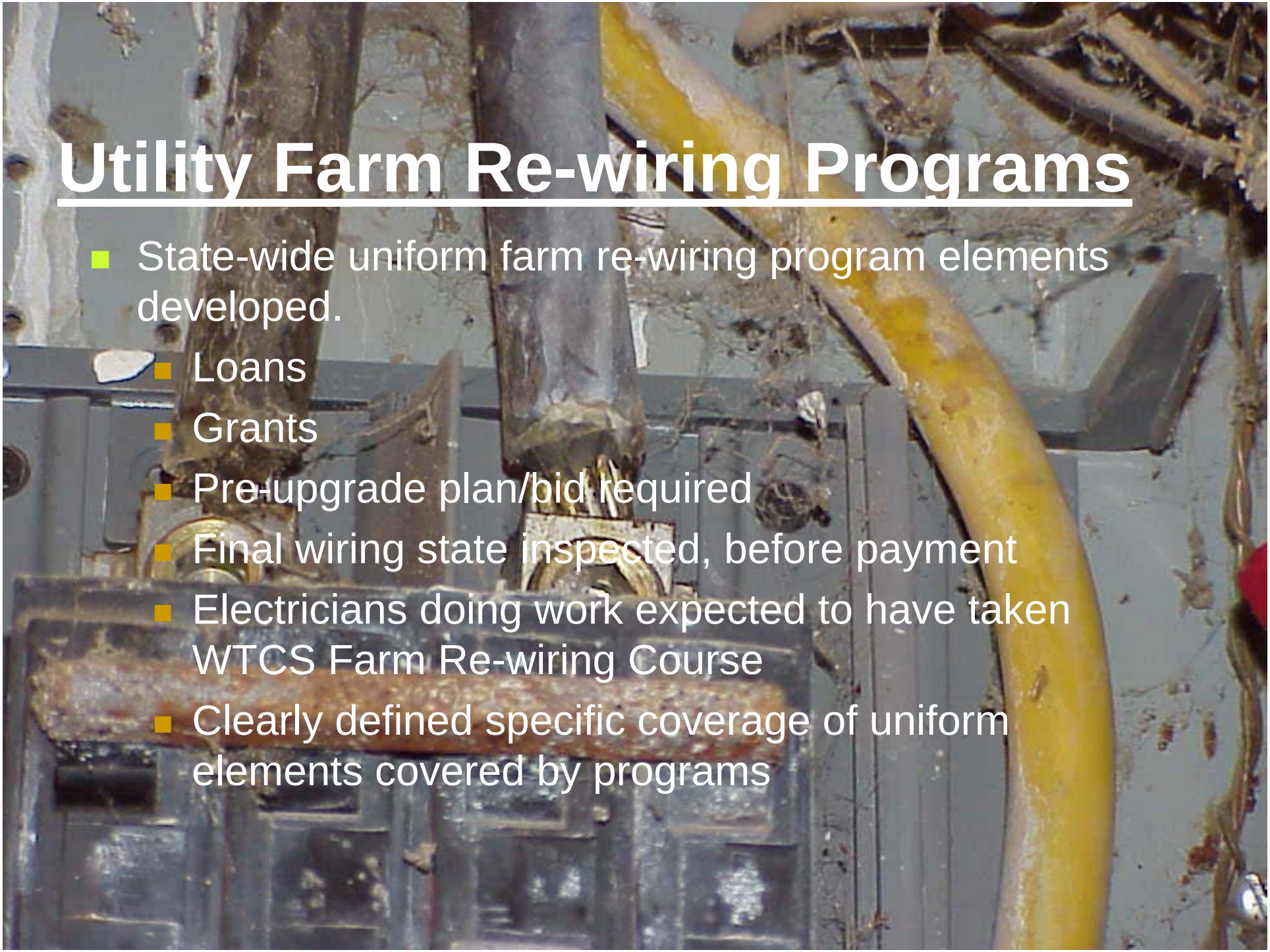


Education Efforts - REPS Staff

- Investigator training courses with UW
  - Intro, Intermediate and Advance Courses
- Rural Electrician Course with WI Technical College System (WTCS)
- Various workshops, seminars, guest speaker and classroom presentations.
- 618 today

Utility Farm Re-wiring Programs

- The dollars used to fund the new Farm Re-wiring Assistance Programs are recovered from rate payers.
- The use of the funds (Investor Owned Utilities) for farm re-wiring requires Commission approval.
- Vested interest in safety, energy conservation and reducing SV on farms in WI.



Utility Farm Re-wiring Programs

- State-wide uniform farm re-wiring program elements developed.
  - Loans
  - Grants
  - Pre-upgrade plan/bid required
  - Final wiring state inspected, before payment
  - Electricians doing work expected to have taken WTCS Farm Re-wiring Course
  - Clearly defined specific coverage of uniform elements covered by programs

Utility Farm Re-wiring Programs

- $9.,800,000.00 as of now
- Utilities with programs:
  - Alliant Energy, Public Service Corp., Rural Electric Cooperatives, We Energies, Xcel Energy

RESEARCH

- Investor Owned Utilities and Cooperatives have contributed $1,500,000 towards SV research
- UW has conducted various research trials looking at specific SV questions with guidance from REPS
- Various formal and informal field studies of specific meters or equipment have been conducted over the years.
- Newly published research reports and news stories are constantly being reviewed.

Policy / Regulatory Must Do!

- Supporting certification of rural electricians
- Supporting inspection of farm wiring
- Control code review
- Facilitate the activities of the issue

DATCP REPS program's Direct Farmer Assistance

- Veterinary Assistance
  - Diagnostic support for dairy farmers facing herd performance issues directly or indirectly associated with concerns over SV
- SV Liaison and Mediation
  - A resource person to help supplement or troubleshoot exchange of information between farmer, utility, PSC and other involved parties.

Veterinary Assistance

- 65-70 farms visits per year, about 40 new cases and others are return visits.
- No lab cost to farmer for diagnostic testing of feed, forage, blood and other factors.
- Effort to involve all service professionals to answer operation and herd questions.
- Most frequent concerns are increased SCC, low milk production and cow losses.

Veterinary Assistance

- The goal is to help farmers regardless of the causes and symptoms of their concerns.
- Continue to educate the farm support profession's (vets, nutritionist, milking equipment dealers, etc.) knowledge of stray voltage and other diagnostic tools or solutions to the common problems observed.

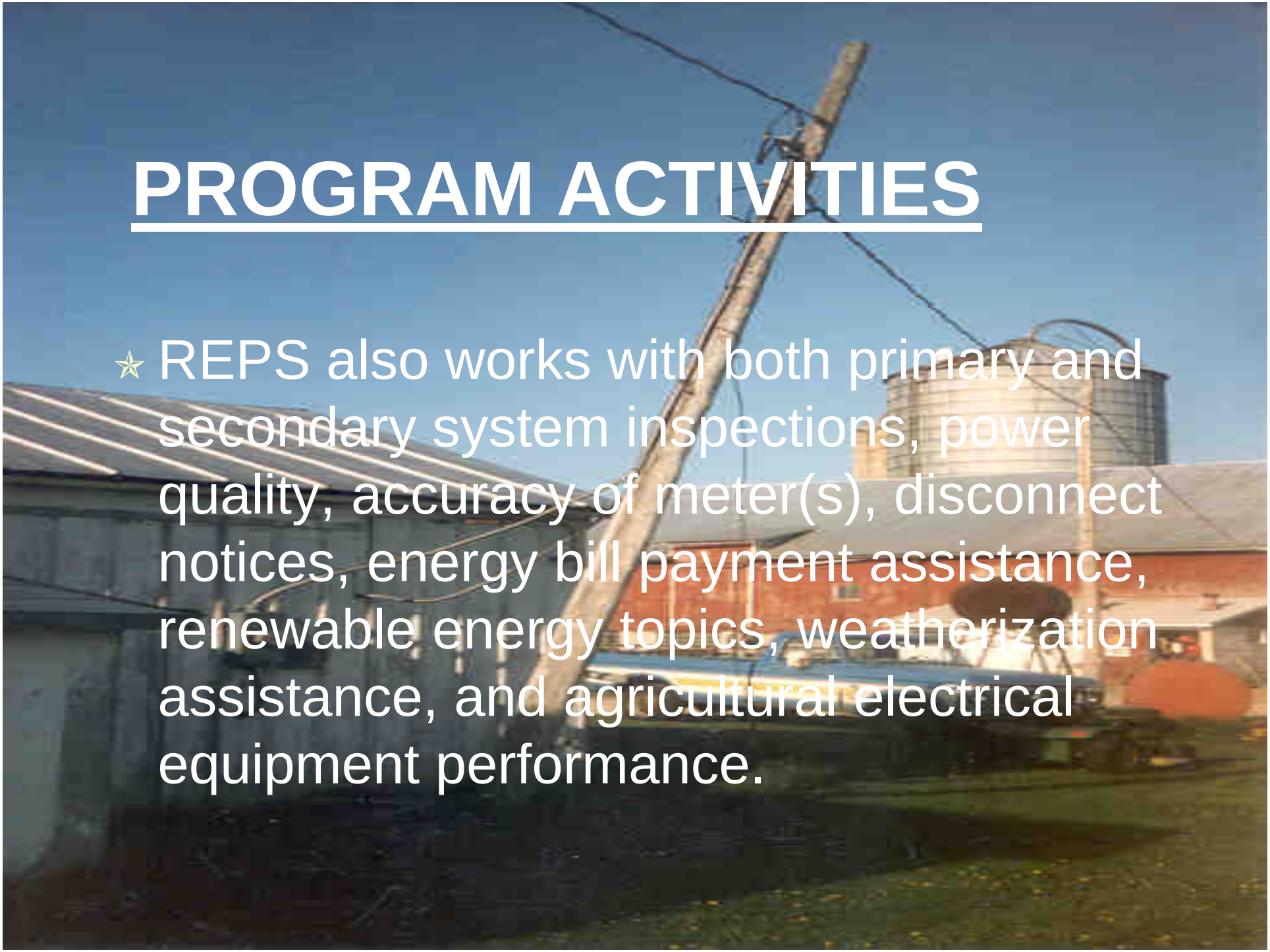
A Veterinarian's Perspective

- There is not a single animal health, production, or behavioral issue or veterinary test that can be used to indicate the presence of stray voltage on a farm.
- Stray voltage is an electrical issue and can only be identified through standardized electrical testing protocols.

Must do

- Work with non-traditional SV concerns
- Improve quality of on-farm wiring & equipment installation and maintenance
- Improve quality of service by farm and energy service professionals
- Continue maintaining and improving the service provided by the utilities

SV is a ongoing maintenance requirement, not a one-time effort by ALL involved.



PROGRAM ACTIVITIES

- REPS also works with both primary and secondary system inspections, power quality, accuracy of meter(s), disconnect notices, energy bill payment assistance, renewable energy topics, weatherization assistance, and agricultural electrical equipment performance.


Program
Strengths??
* Authority, Authority, Authority
* Ability to work with the best and the worst
* No fear of litigation
* 20 years of experience!
This is very difficult to learn


Program Weaknesses???
Catch all for the junk scientists, and carpetbaggers.
And no other!!!!!!!!

COW CONTACT VOLTAGE

FACTS OF UNIVERSAL LAW

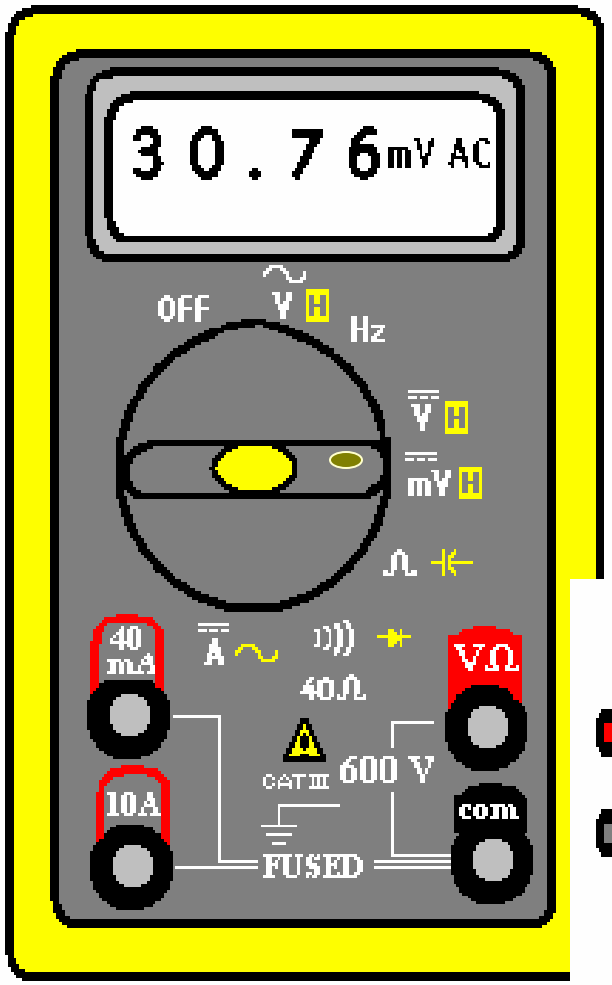
- All currents return to their source.
- All paths have resistance.
- Therefore, some primary and secondary Neutral-to-Earth, as well as cow-contact voltage, will exist.
- These voltages can be reduced, but...
  - By how much?
  - Cost vs. Benefit?

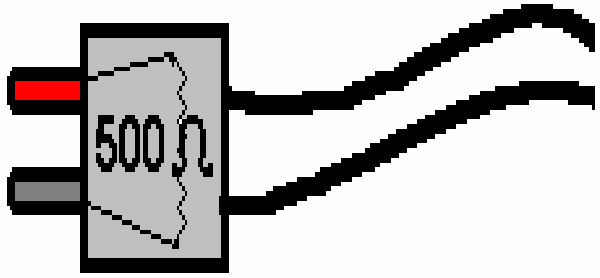
C.C.V. MEASUREMENTS

Measurement Set Up

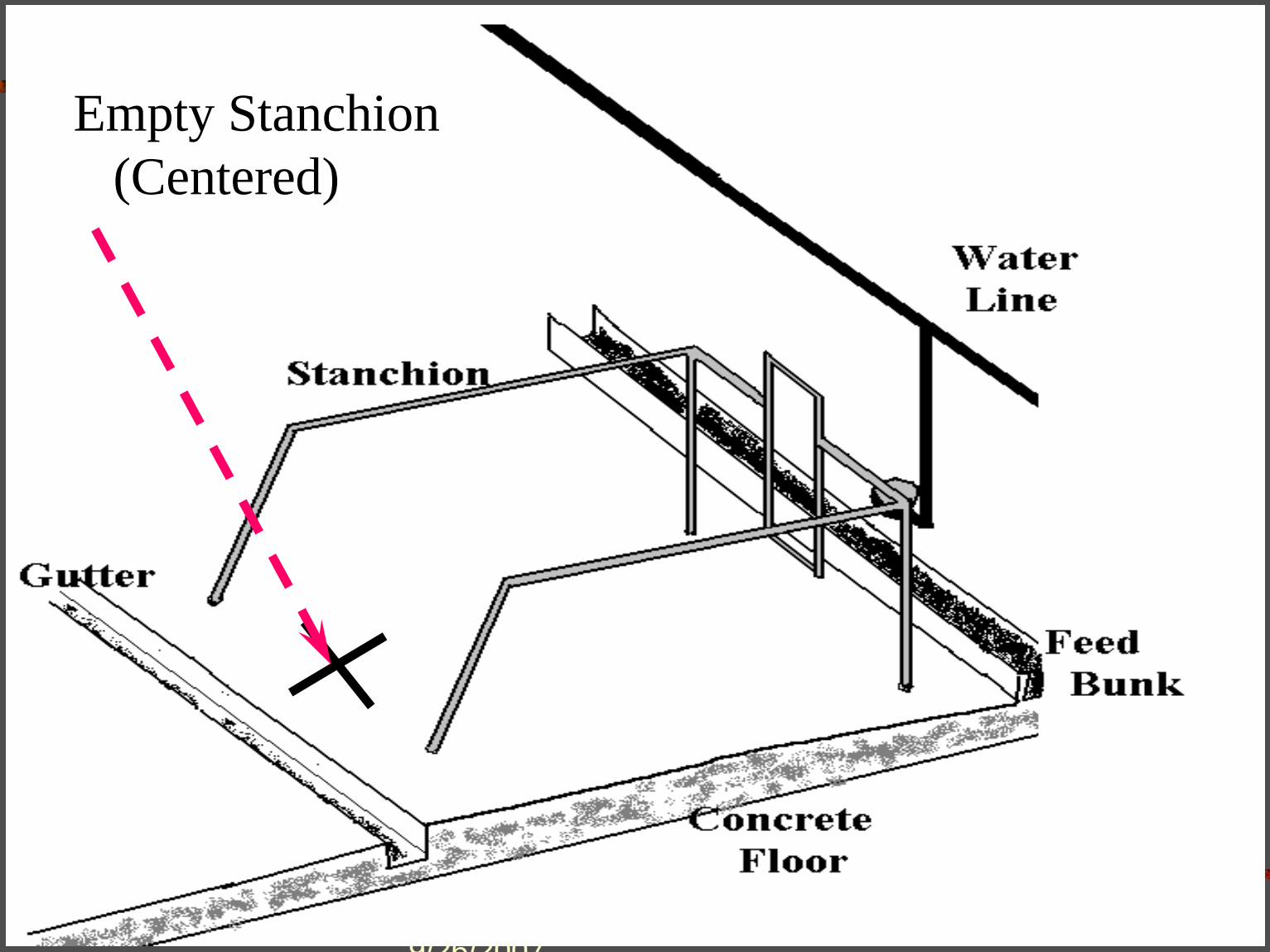
- **A) Cow Contact Points**
- **B) Good Measurements**
- **C) Primary & Secondary Points and Reference Rod Locations**

DIGITAL MULTIMETER



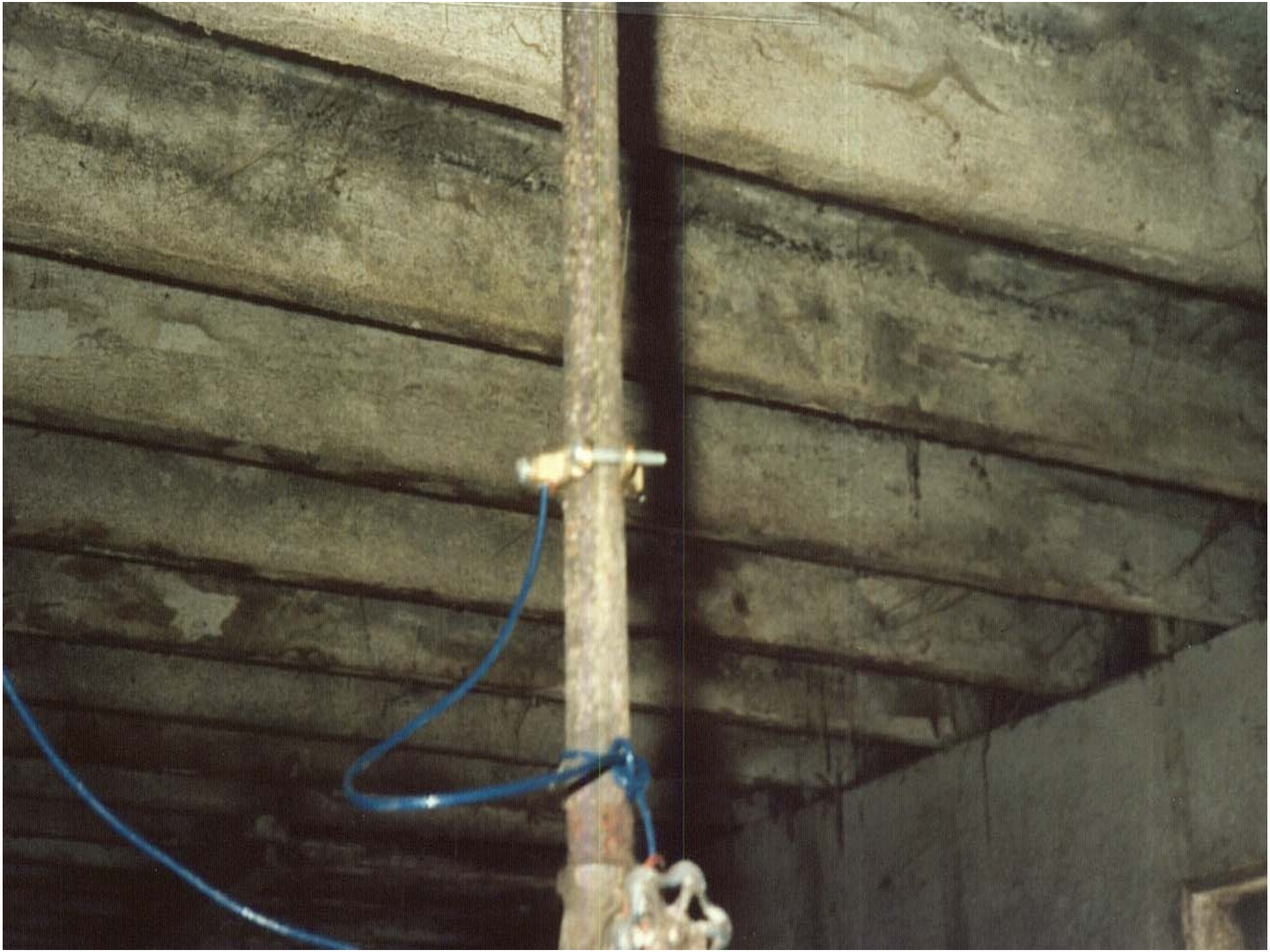


Selecting the site

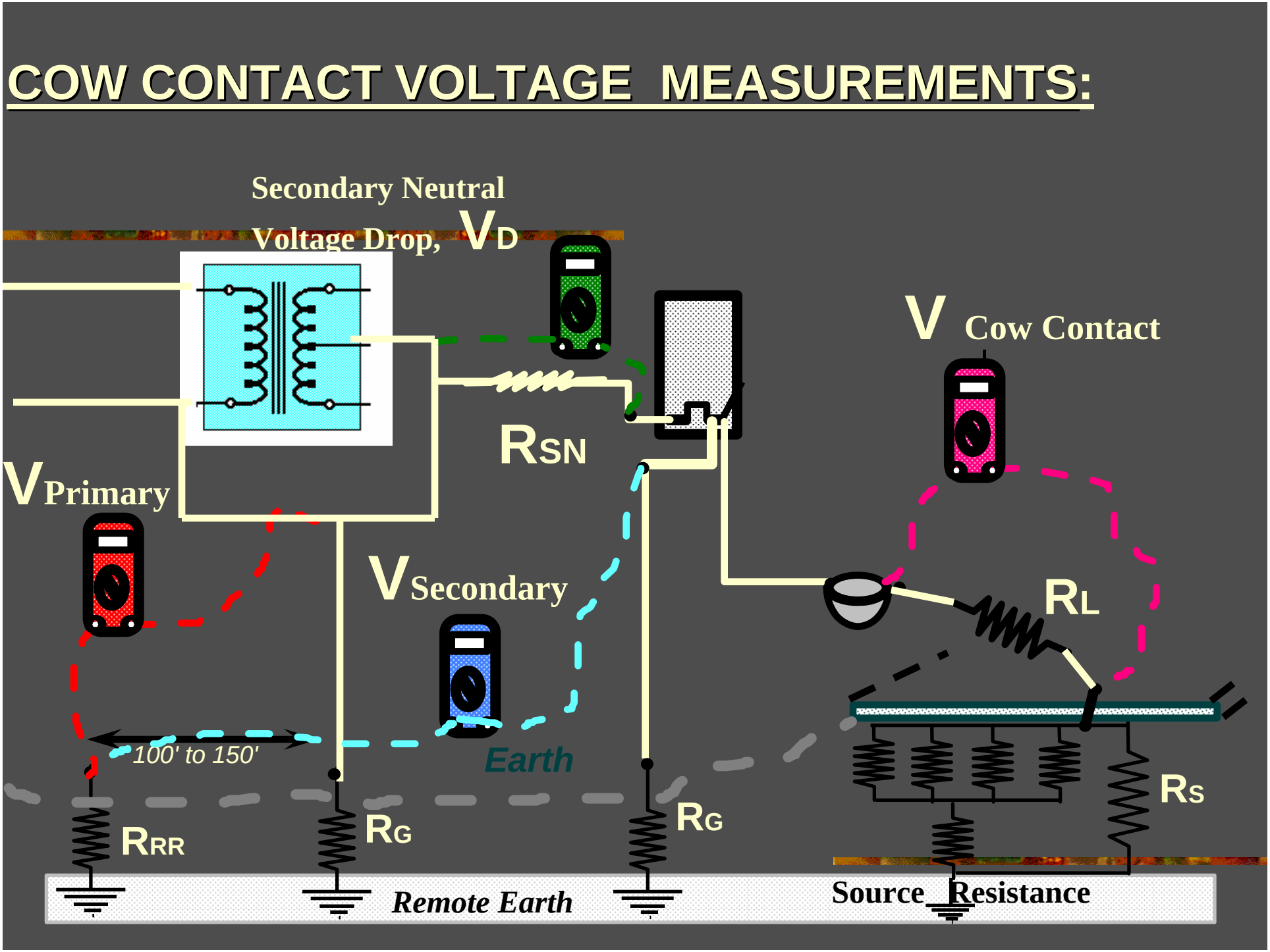


Criteria for Selection

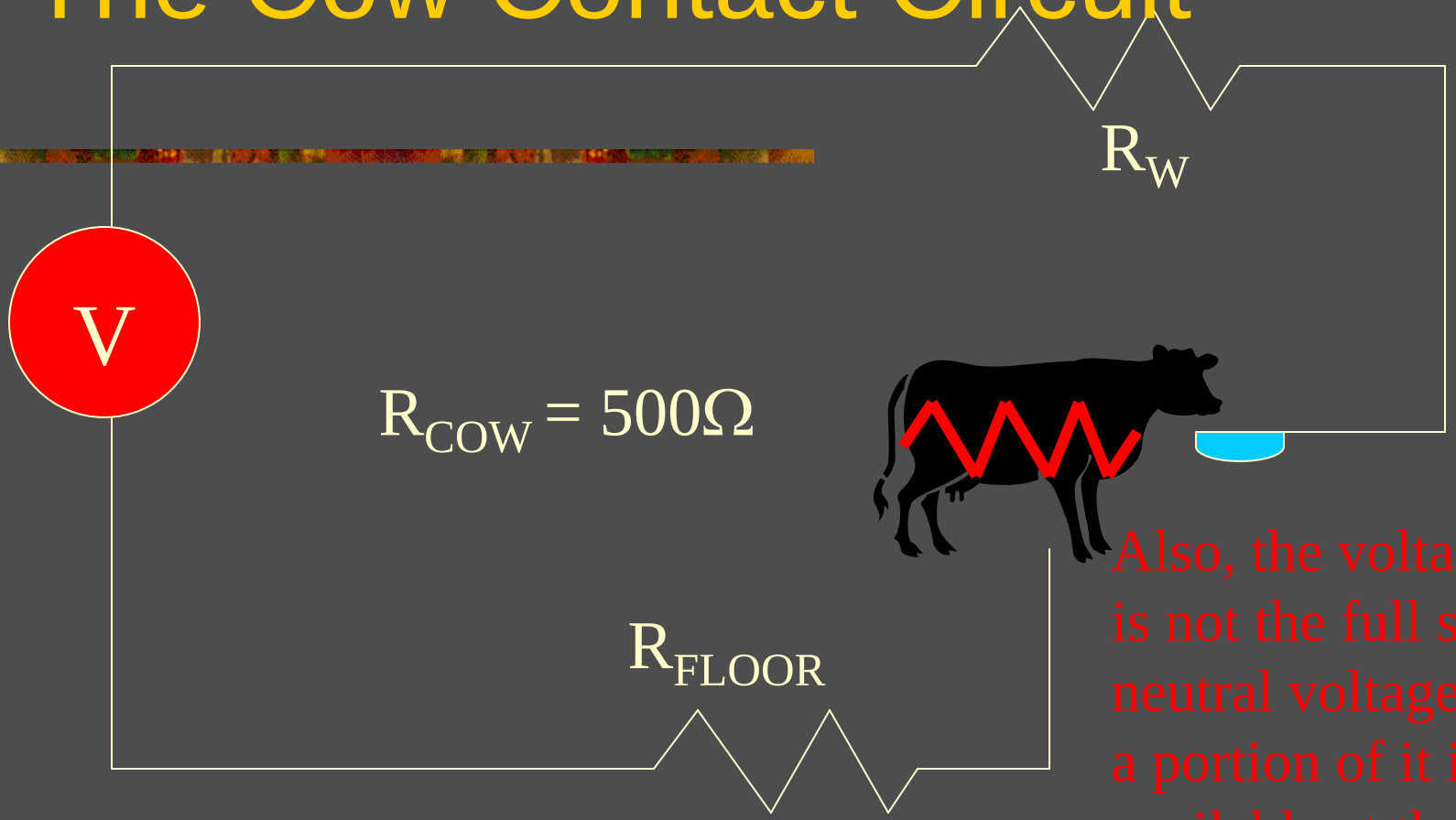
- Highest possible cow contact voltages
- Non-interference by animals
- Animal contact location



COW CONTACT VOLTAGE MEASUREMENTS:



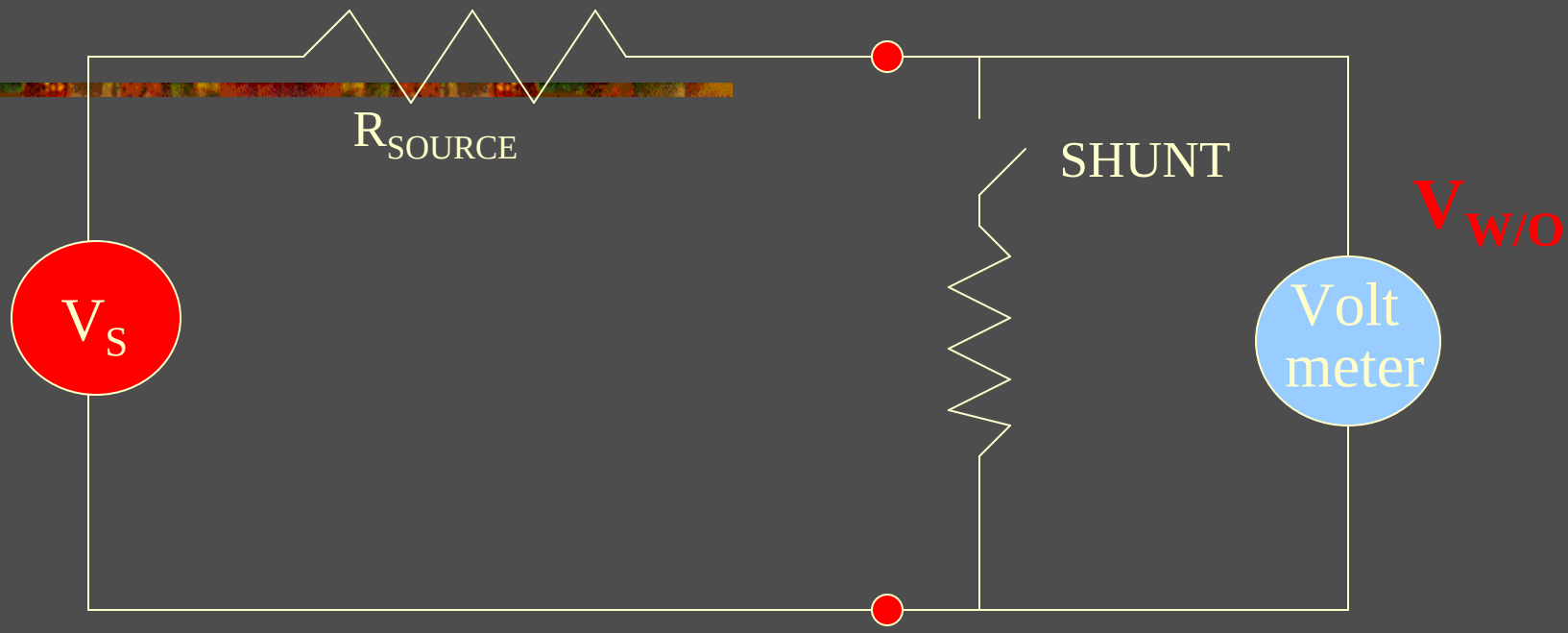
The Cow Contact Circuit



$$R_{SOURCE} = R_W + R_{FLOOR}$$

Also, the voltage source is not the full secondary neutral voltage but only a portion of it is available at the cow contact location. This is due to parallel grounding paths.

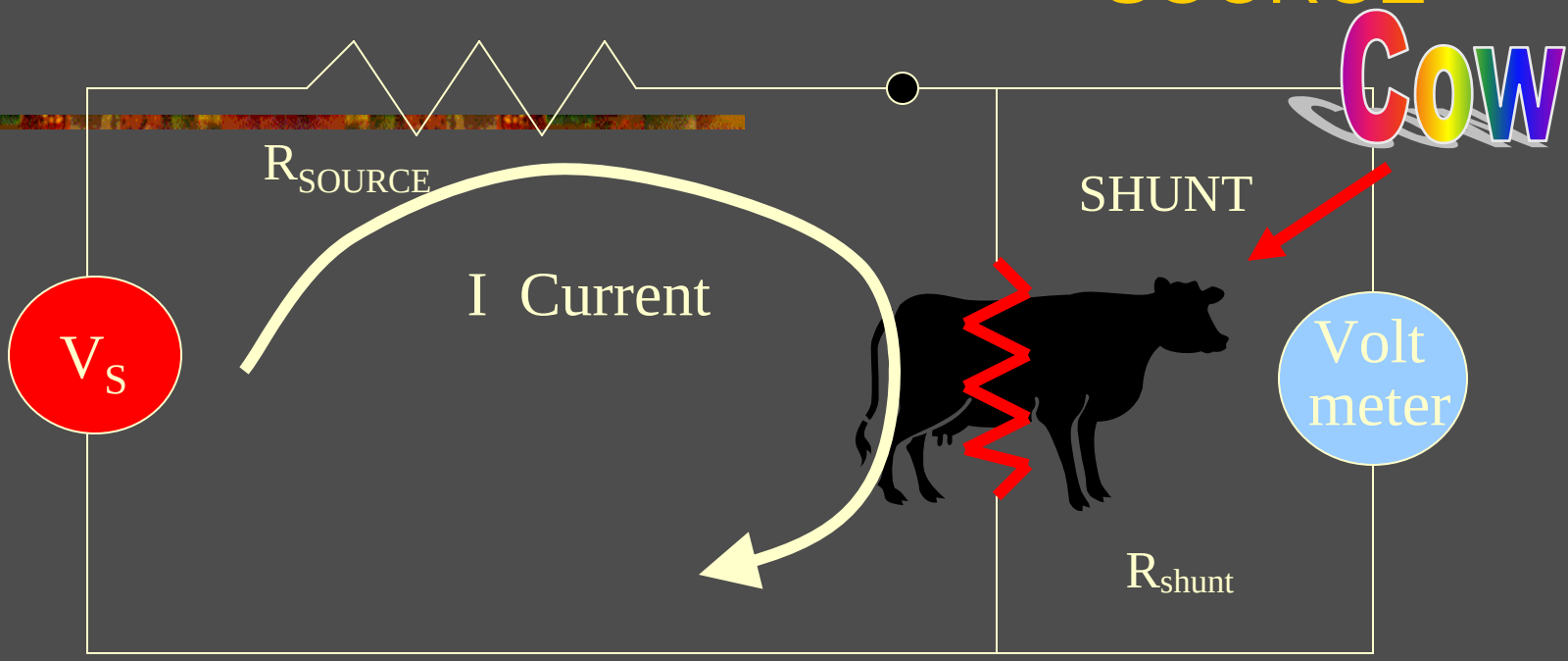
How Do I Measure (R_{SOURCE})?



$V_{W/O\ SHUNT} = V_S$

In an open circuit situation, there is no current flowing in the circuit. Without current, there is no voltage drop in the R_{source}. $V_{w/o\ shunt}$ has to be equal to V_s

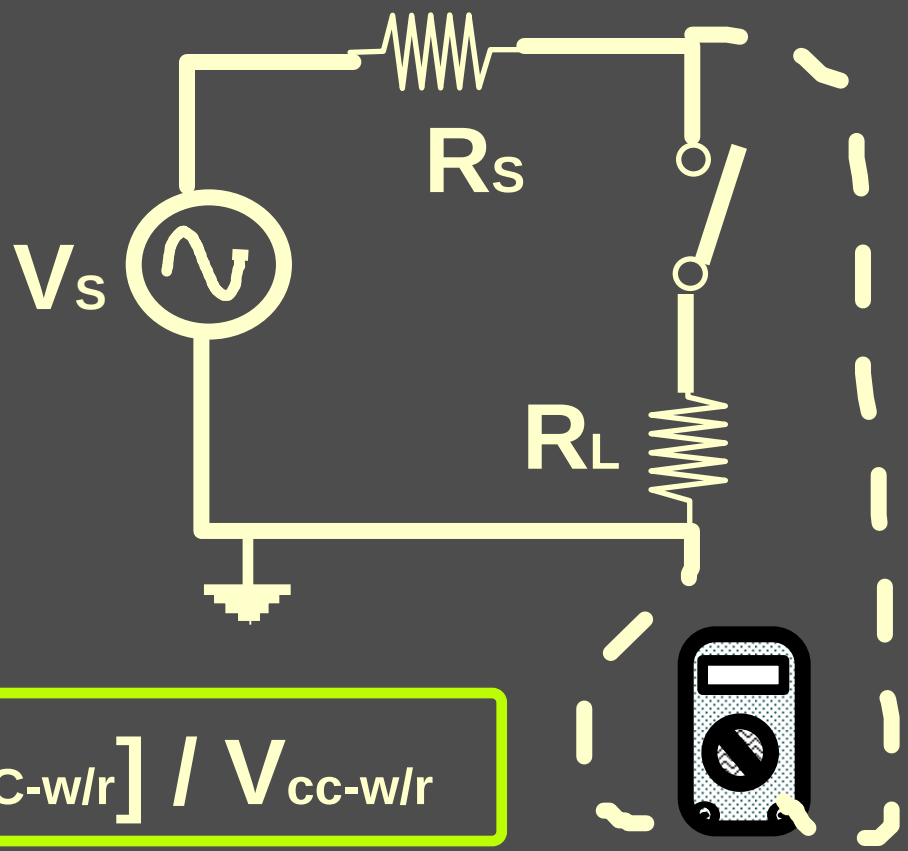
How Do I Measure (R_{SOURCE})?



$$\text{Rsource} = \frac{(\text{Vwo-Vshunt})}{\text{Vshunt}} * \text{Rshunt}$$

Source Resistance Measurement:

- $V_s = V_{cc\text{-}w/o}$
  - Switch open, no shunt load resistor
- $V_{cc\text{-}w/r}$
  - Switch closed, shunt load resistor



$$R_S = R_L * [V_{CC\text{-}w/o} - V_{CC\text{-}w/r}] / V_{cc\text{-}w/r}$$

Sample Data Table:

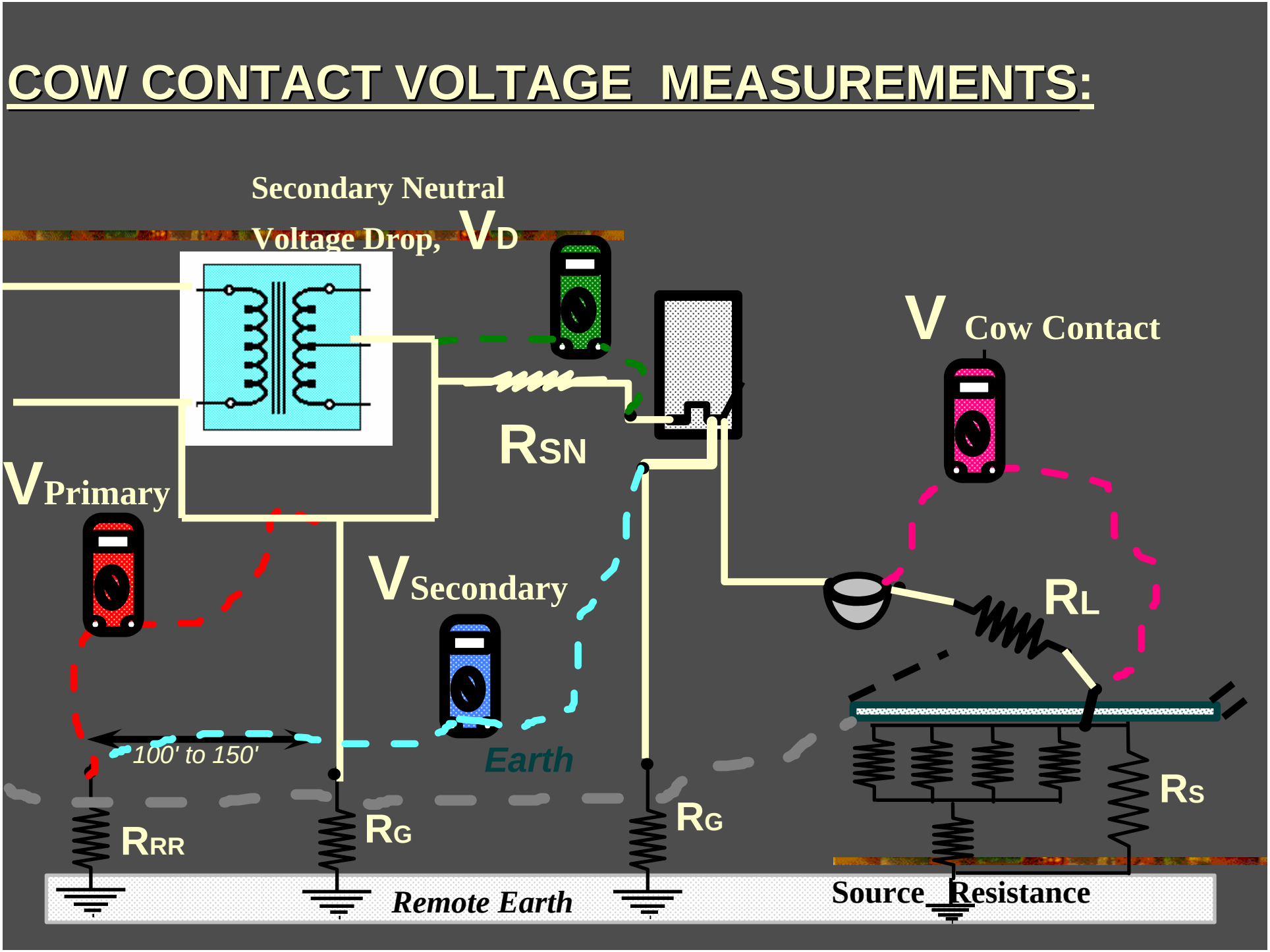
M = Measured Demand

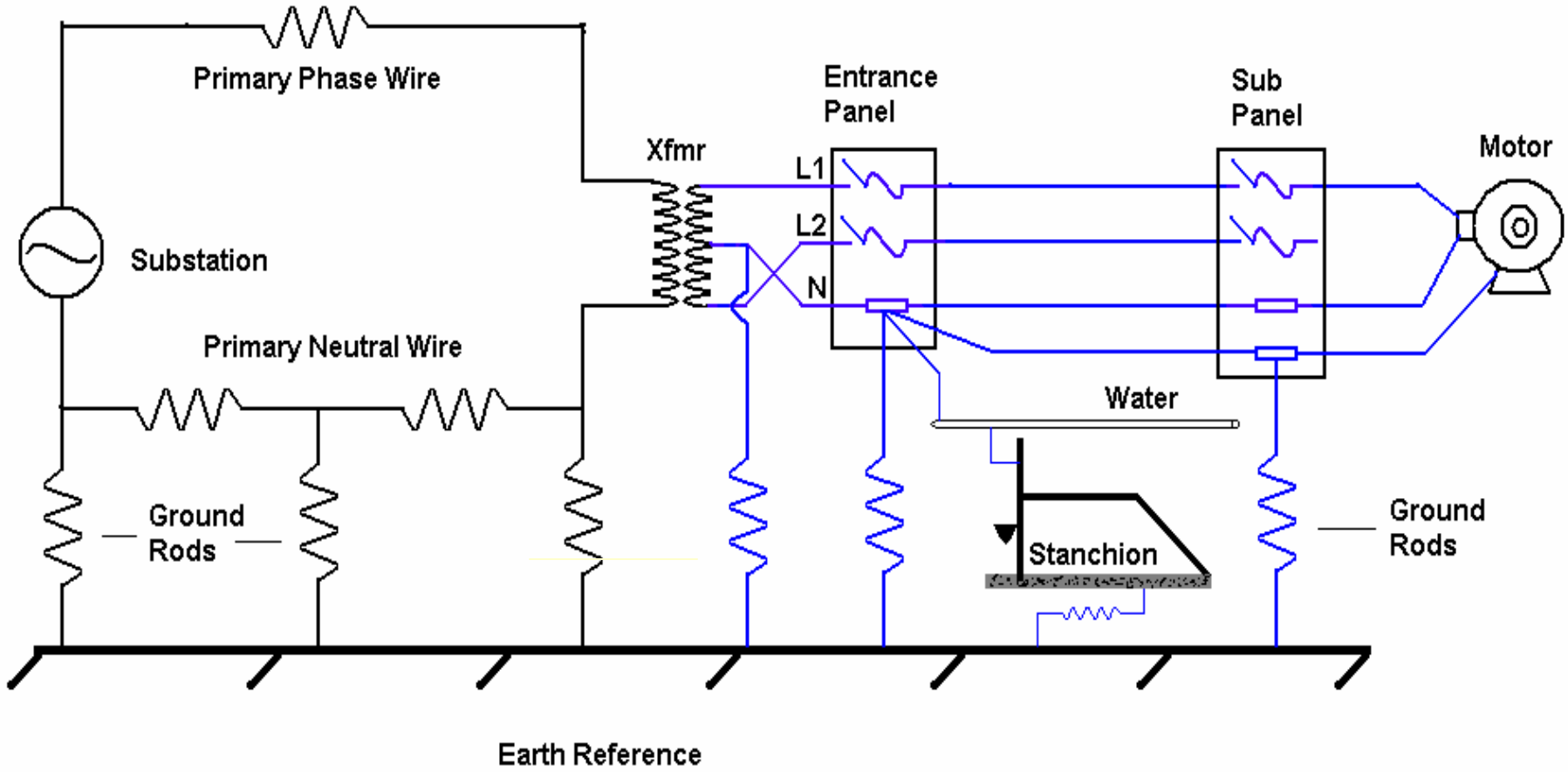
E = Estimated Demand

M E kW :	a.m. p.m.

	Location of Readings in Building of Concern:	V_{WO}	V_{Rsh}	mA
Animal Contacts	Waterline to Rear Hoof Area			
	Pipeline to Rear Hoof Area			
	Stanchion to Rear Hoof Area			
Bonding Tests	Service Entrance Ground to Waterline			****
	Service Entrance Ground to Pipeline			****
	Service Entrance Ground to Stanchion			****
	Service Entrance Ground to Rear Hoof Area			****
	Service Entrance Ground to Remote Ground Rod			****
	Transformer Ground to Remote Ground Rod			****
	Transformer Ground to Service Entrance Ground			****

COW CONTACT VOLTAGE MEASUREMENTS:





Utility & Farm Circuit

1:

M = Measured Demand

E = Estimated Demand

M x E kW : 12	a.m. 5:45 p.m.

	Location of Readings in Building of Concern:	V_{WO}	V_{Rsh}	mA
Animal Contacts	Waterline to Rear Hoof Area	0.75	0.53	
	Pipeline to Rear Hoof Area	0.63	0.21	
	Stanchion to Rear Hoof Area	0.66	0.39	
Bonding Tests	Service Entrance Ground to Waterline	0.08	0.08	****
	Service Entrance Ground to Pipeline	0.42	0.06	****
	Service Entrance Ground to Stanchion	0.10	0.08	****
	Service Entrance Ground to Rear Hoof Area	0.74	0.52	****
	Service Entrance Ground to Remote Ground Rod	1.62	1.38	****
	Transformer Ground to Remote Ground Rod	1.40	1.21	****
	Transformer Ground to Service Entrance Ground	0.22	0.22	****

M = Measured Demand

E = Estimated Demand

M	
X	
E	x a.m.
kW : 12	10.45 p.m.

	Location of Readings in Building of Concern:	V_{WO}	V_{Rsh}	mA
Animal Contacts	Waterline to Rear Hoof Area	**0.76**	**0.51**	**0.001**
	Pipeline to Rear Hoof Area	0.76	0.39	
	Stanchion to Rear Hoof Area	0.76	0.44	
Bonding Tests	Service Entrance Ground to Waterline	0.01	0.01	****
	Service Entrance Ground to Pipeline	0.03	0.03	****
	Service Entrance Ground to Stanchion	0.09	0.09	****
	Service Entrance Ground to Rear Hoof Area	0.76	0.47	****
	Service Entrance Ground to Remote Ground Rod	0.72	0.50	****
	Transformer Ground to Remote Ground Rod	1.54	1.30	****
	Transformer Ground to Service Entrance Ground	0.82	0.82	****

M = Measured Demand

E = Estimated Demand

M x E kW : 16	a.m. 5.55 p.m.

	Location of Readings in Building of Concern:	V_{WO}	V_{Rsh}	mA
Animal Contacts	Waterline to Rear Hoof Area	**1.08**	**0.26**	
	Pipeline to Rear Hoof Area	**0.88**	**0.09**	
	Stanchion to Rear Hoof Area	0.92	0.21	
Bonding Tests	Service Entrance Ground to Waterline	0.02	0.02	****
	Service Entrance Ground to Pipeline	0.09	0.08	****
	Service Entrance Ground to Stanchion	0.10	0.06	****
	Service Entrance Ground to Rear Hoof Area	1.09	0.29	****
	Service Entrance Ground to Remote Ground Rod	2.06	1.77	****
	Transformer Ground to Remote Ground Rod	2.11	1.79	****
	Transformer Ground to Service Entrance Ground	0.05	0.05	****

Example Case #4:

M = Measured Demand

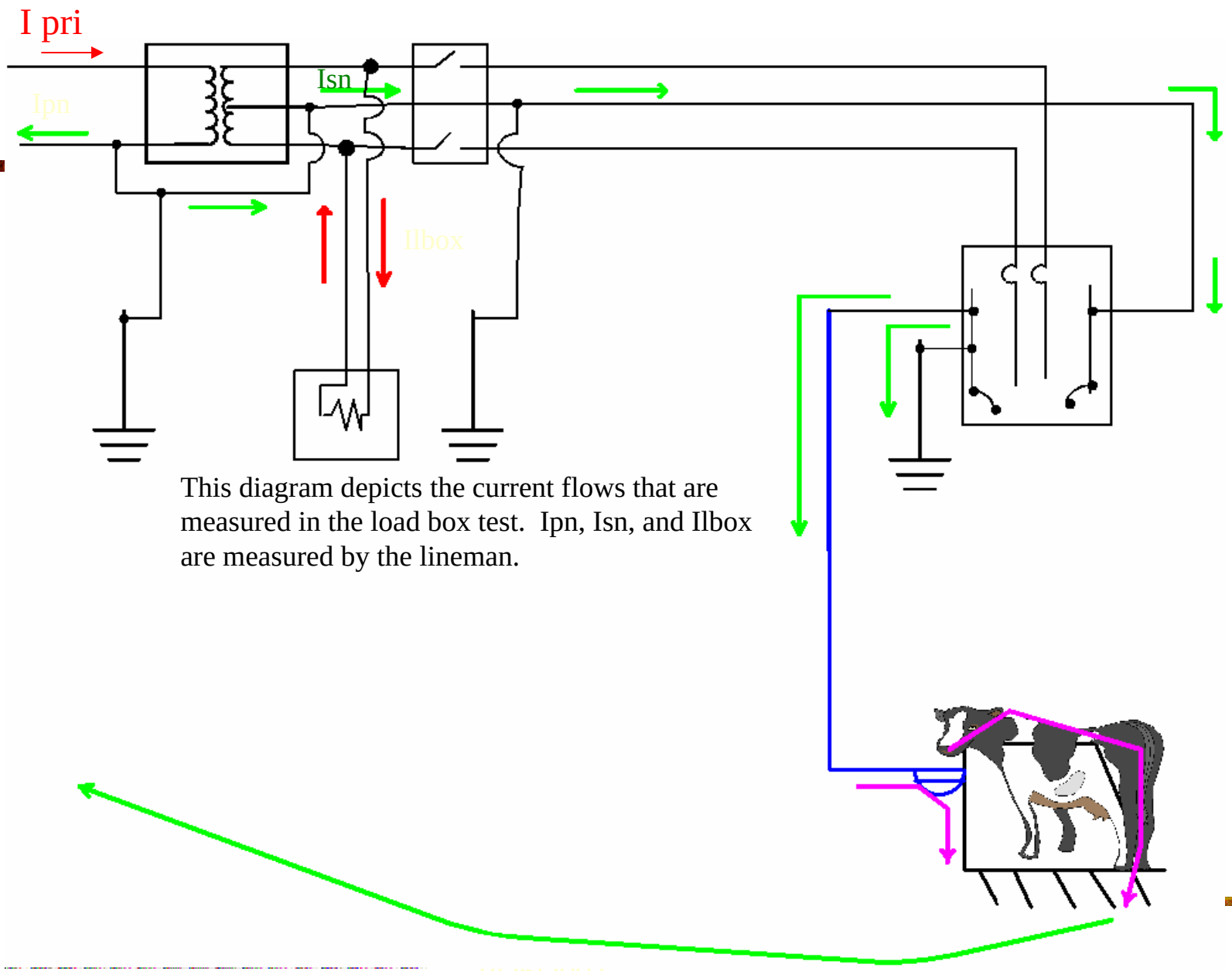
E = Estimated Demand

M x E kW : 12	6:15	a.m. p.m.

	Location of Readings in Building of Concern:	V_{WO}	V_{Rsh}	mA
Animal Contacts	Waterline to Rear Hoof Area	0.53	0.53	
	Pipeline to Rear Hoof Area	0.09	0.003	
	Stanchion to Rear Hoof Area	0.38	0.36	
Bonding Tests	Service Entrance Ground to Waterline	0.02	0.02	****
	Service Entrance Ground to Pipeline	0.00	0.00	****
	Service Entrance Ground to Stanchion	0.02	0.02	****
	Service Entrance Ground to Rear Hoof Area	0.53	0.52	****
	Service Entrance Ground to Remote Ground Rod	1.22	0.97	****
	Transformer Ground to Remote Ground Rod	1.25	0.99	****
	Transformer Ground to Service Entrance Ground	0.09	0.09	****

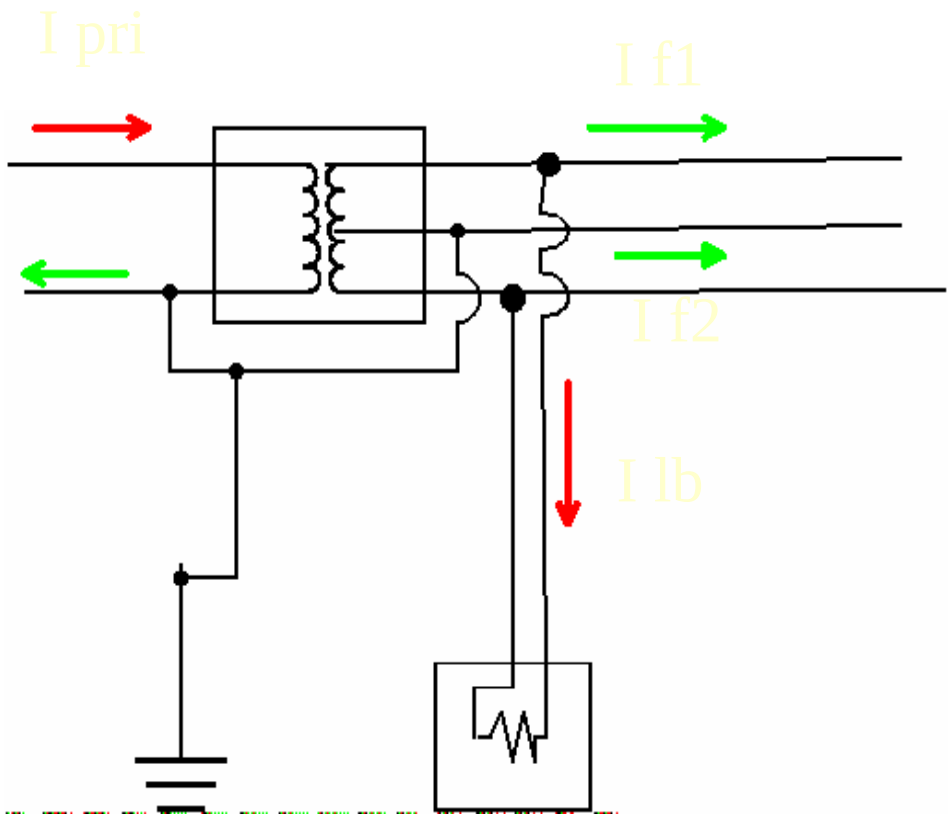
Load Box Test

In Wisconsin, a phase two test includes a test of simply the primary system. This test is accomplished with the use of a 240 volt load box. This 240 volt load is applied at the transformer serving the farm. The farm is completely de-energized. Consequently, any cow contact voltage that is measured in this condition is due to off-farm sources.



This diagram depicts the current flows that are measured in the load box test. Ipn, Isn, and Ilbox are measured by the lineman.

Current Ratio Measurement



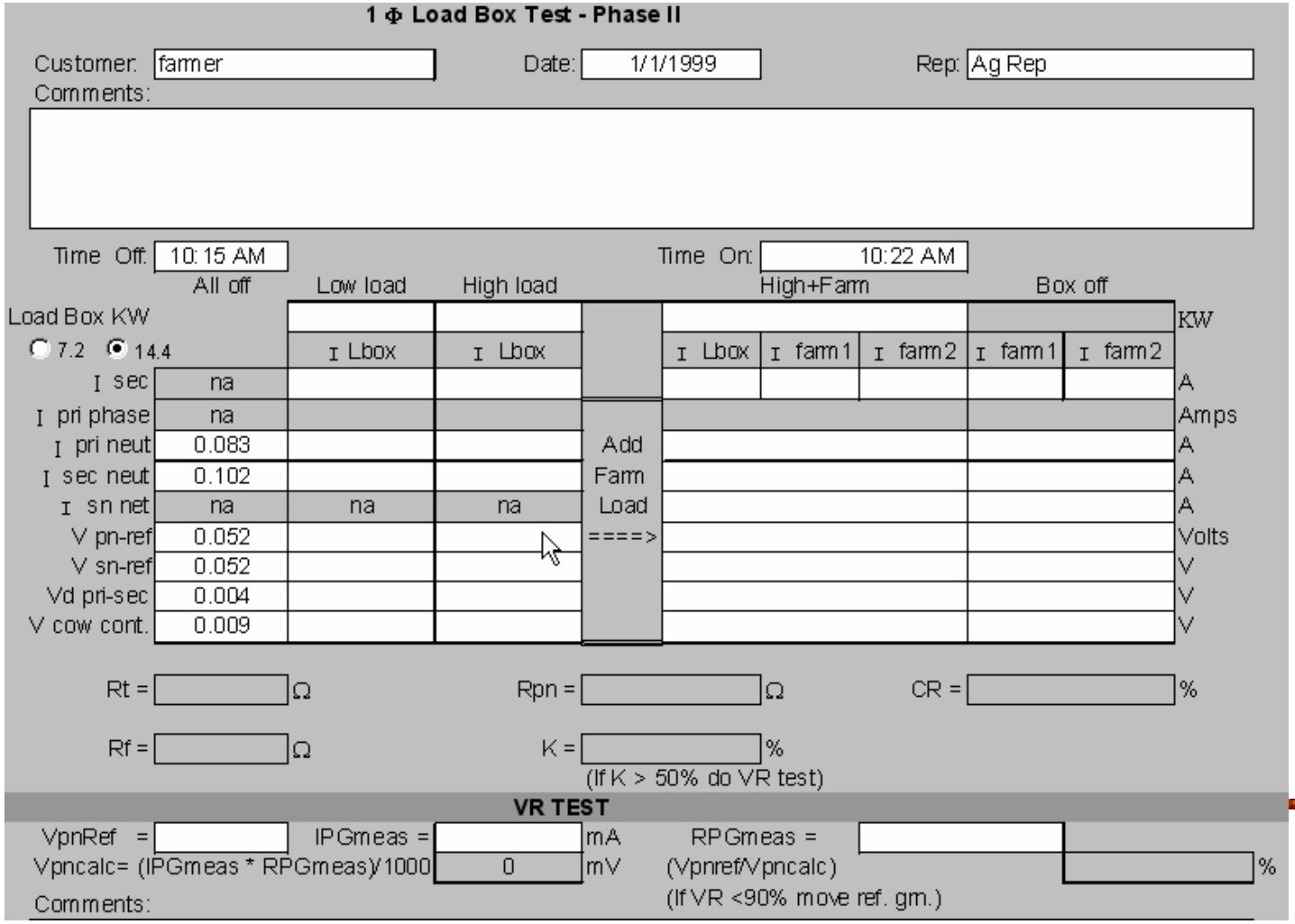
For 14.4 kv

$$I_{pri} = \frac{(I_{f1} + I_{f2})/2 + I_{lb}}{60}$$

For 7.2 kv

$$I_{pri} = \frac{(I_{f1} + I_{f2})/2 + I_{lb}}{30}$$

Load Box OFF



1 Φ Load Box Test - Phase II

Customer: farmer Date: 1/1/1999 Rep: Ag Rep

Comments:

Time Off: 10:15 AM Time On: 10:22 AM

Load Box KW (7.2 / 14.4)	All off	Low load	High load		High+Farm			Box off		
		I Lbox	I Lbox		I Lbox	I farm1	I farm2	I farm1	I farm2	KW
I sec	na									A
I pri phase	na									Amps
I pri neut	0.083			Add Farm Load ====>						A
I sec neut	0.102									A
I sn net	na	na	na							A
V pn-ref	0.052									Volts
V sn-ref	0.052									V
Vd pri-sec	0.004									V
V cow cont.	0.009									V

Rt = Ω Rpn = Ω CR = %

Rf = Ω K = %

(If K > 50% do VR test)

VR TEST

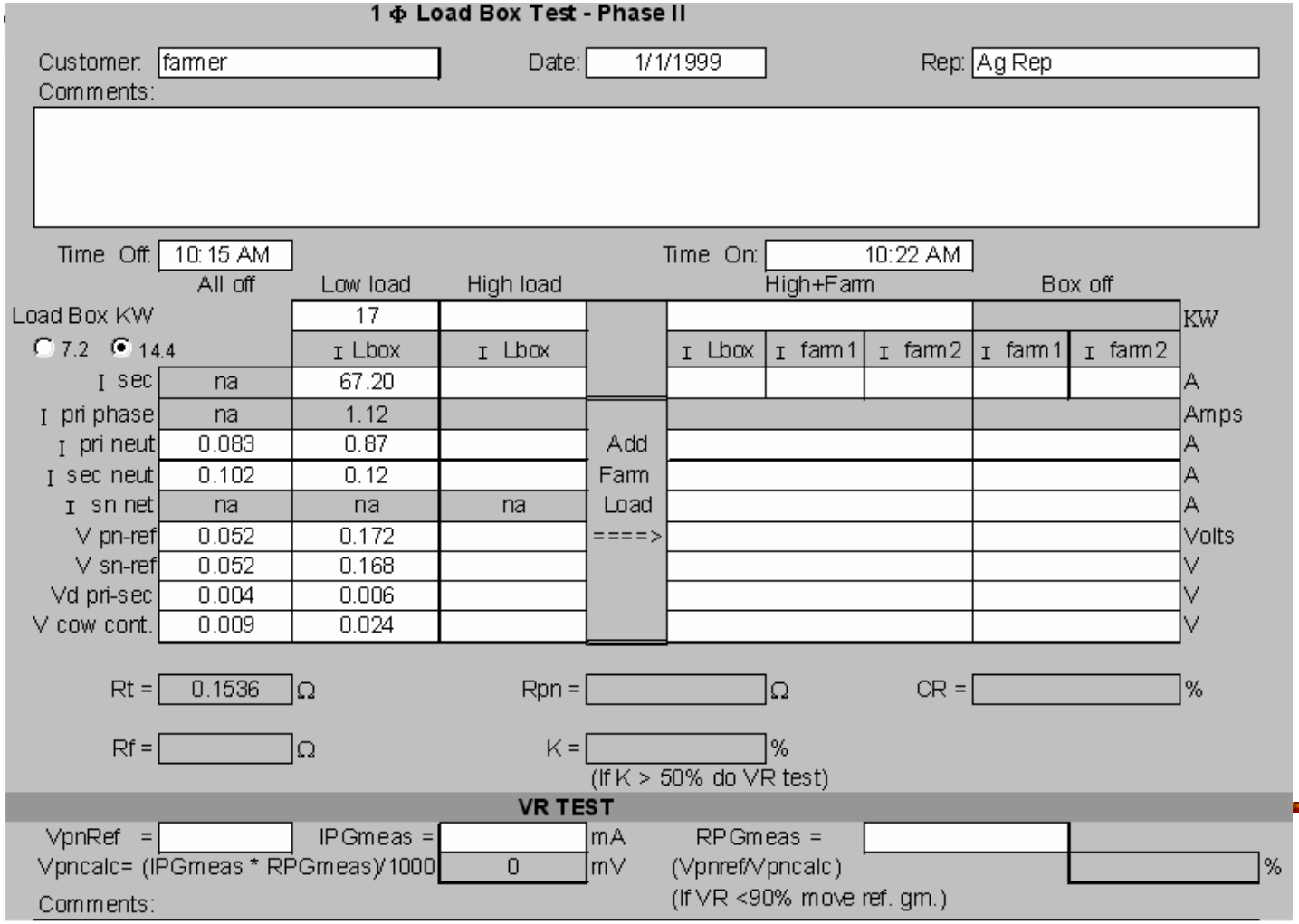
VpnRef = IPGmeas = mA RPGmeas =

Vpncalc= (IPGmeas * RPGmeas)/1000 0 mV (Vpnref/Vpncalc) %

(If VR <90% move ref. gm.)

Comments:

Load Box LOW



1 Φ Load Box Test - Phase II

Customer: farmer Date: 1/1/1999 Rep: Ag Rep

Comments:

Time Off: 10:15 AM Time On: 10:22 AM

Load Box KW: 17 (KW)

7.2 / 14.4

	All off	Low load	High load		High+Farm			Box off		
		I Lbox	I Lbox		I Lbox	I farm1	I farm2	I farm1	I farm2	
I sec	na	67.20								A
I pri phase	na	1.12								Amps
I pri neut	0.083	0.87		Add						A
I sec neut	0.102	0.12		Farm						A
I sn net	na	na	na	Load						A
V pn-ref	0.052	0.172		====>						Volts
V sn-ref	0.052	0.168								V
Vd pri-sec	0.004	0.006								V
V cow cont.	0.009	0.024								V

Rt = 0.1536 Ω Rpn = Ω CR = %

Rf = Ω K = %

(If K > 50% do VR test)

VR TEST

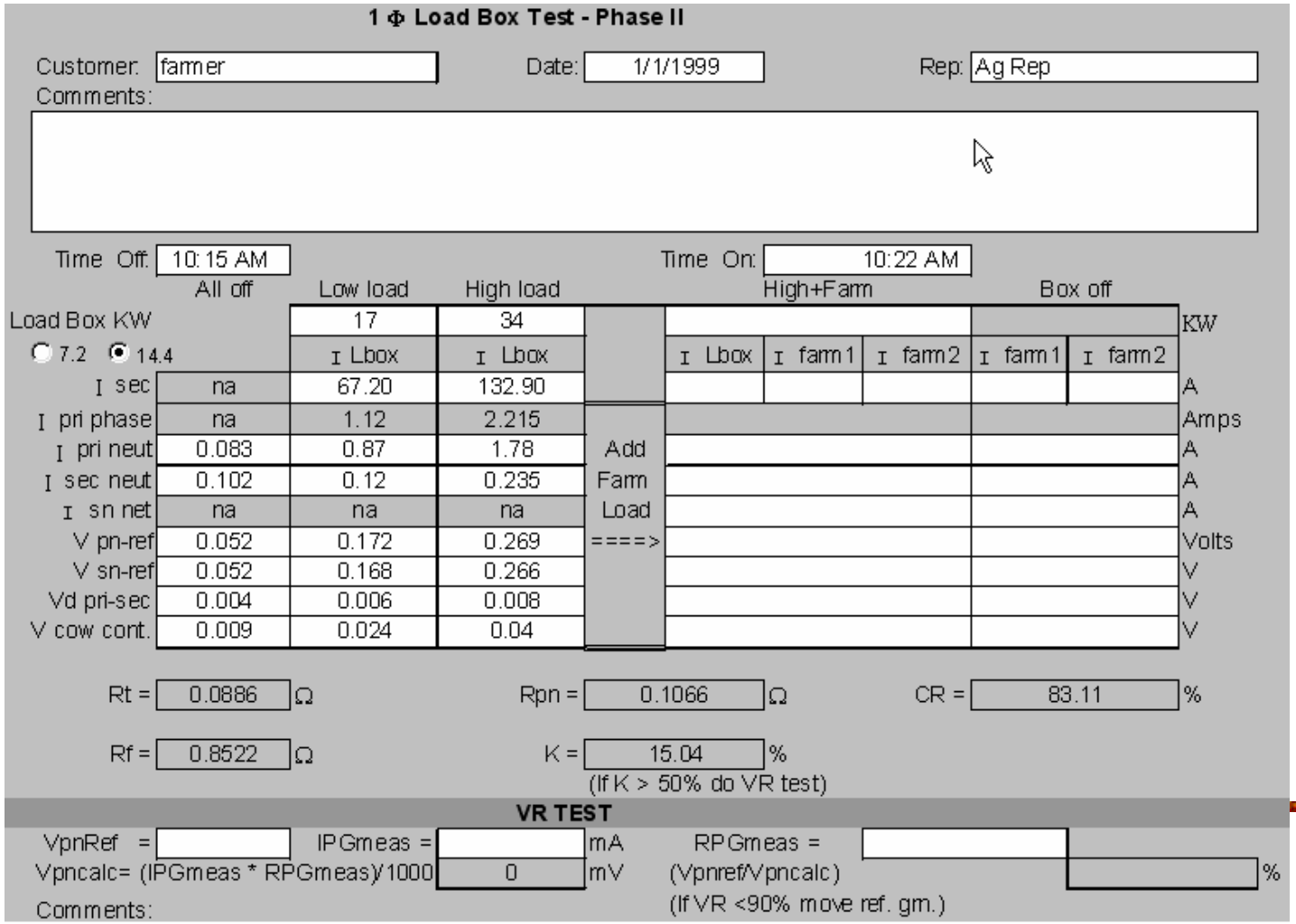
VpnRef = IPGmeas = mA RPGmeas =

Vpncalc= (IPGmeas * RPGmeas)/1000 0 mV (Vpnref/Vpncalc) %

(If VR <90% move ref. gm.)

Comments:

Load Box HIGH



1 Φ Load Box Test - Phase II

Customer: farmer Date: 1/1/1999 Rep: Ag Rep

Comments:

Time Off: 10:15 AM Time On: 10:22 AM

	All off	Low load	High load		High+Farm			Box off		
Load Box KW		17	34							KW
○ 7.2 ◉ 14.4		I Lbox	I Lbox		I Lbox	I farm1	I farm2	I farm1	I farm2	
I sec	na	67.20	132.90							A
I pri phase	na	1.12	2.215							Amps
I pri neut	0.083	0.87	1.78	Add						A
I sec neut	0.102	0.12	0.235	Farm						A
I sn net	na	na	na	Load						A
V pn-ref	0.052	0.172	0.269	====>						Volts
V sn-ref	0.052	0.168	0.266							V
Vd pri-sec	0.004	0.006	0.008							V
V cow cont.	0.009	0.024	0.04							V

Rt = 0.0886 Ω Rpn = 0.1066 Ω CR = 83.11 %

Rf = 0.8522 Ω K = 15.04 %

(If K > 50% do VR test)

VR TEST

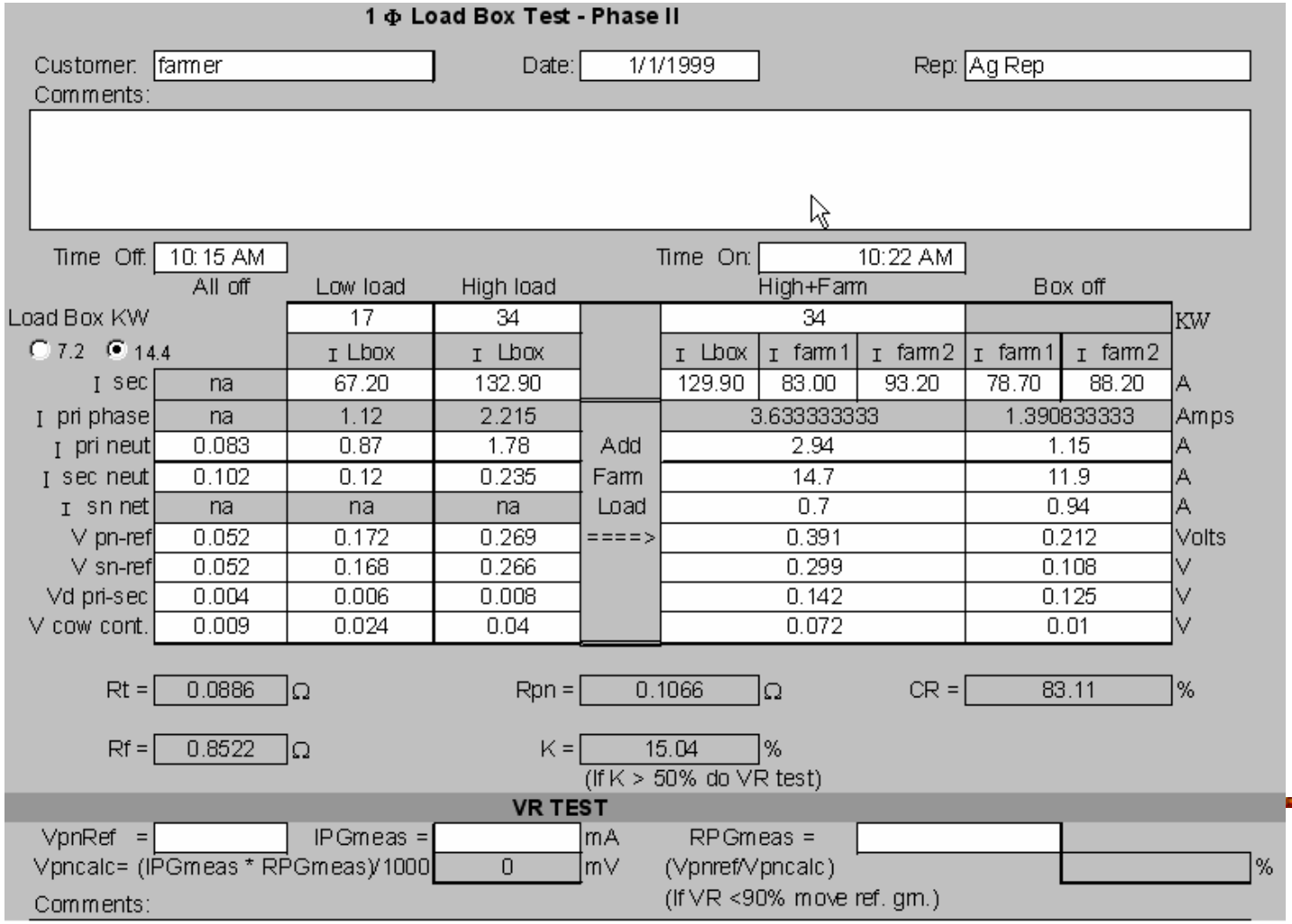
VpnRef = IPGmeas = mA RPGmeas =

Vpncalc= (IPGmeas * RPGmeas)/1000 0 mV (Vpnref/Vpncalc) %

(If VR <90% move ref. gm.)

Comments:

Load Box HIGH + Farm and continuation of Load Box



1 Φ Load Box Test - Phase II

Customer: farmer Date: 1/1/1999 Rep: Ag Rep

Comments:

Time Off: 10:15 AM Time On: 10:22 AM

	All off	Low load	High load		High+Farm			Box off		
Load Box KW		17	34		34					KW
○ 7.2 ◉ 14.4		I Lbox	I Lbox		I Lbox	I farm1	I farm2	I farm1	I farm2	
I sec	na	67.20	132.90		129.90	83.00	93.20	78.70	88.20	A
I pri phase	na	1.12	2.215		3.633333333			1.390833333		Amps
I pri neut	0.083	0.87	1.78	Add	2.94			1.15		A
I sec neut	0.102	0.12	0.235	Farm	14.7			11.9		A
I sn net	na	na	na	Load	0.7			0.94		A
V pn-ref	0.052	0.172	0.269	====>	0.391			0.212		Volts
V sn-ref	0.052	0.168	0.266		0.299			0.108		V
Vd pri-sec	0.004	0.006	0.008		0.142			0.125		V
V cow cont.	0.009	0.024	0.04		0.072			0.01		V

Rt = 0.0886 Ω Rpn = 0.1066 Ω CR = 83.11 %

Rf = 0.8522 Ω K = 15.04 %

(If K > 50% do VR test)

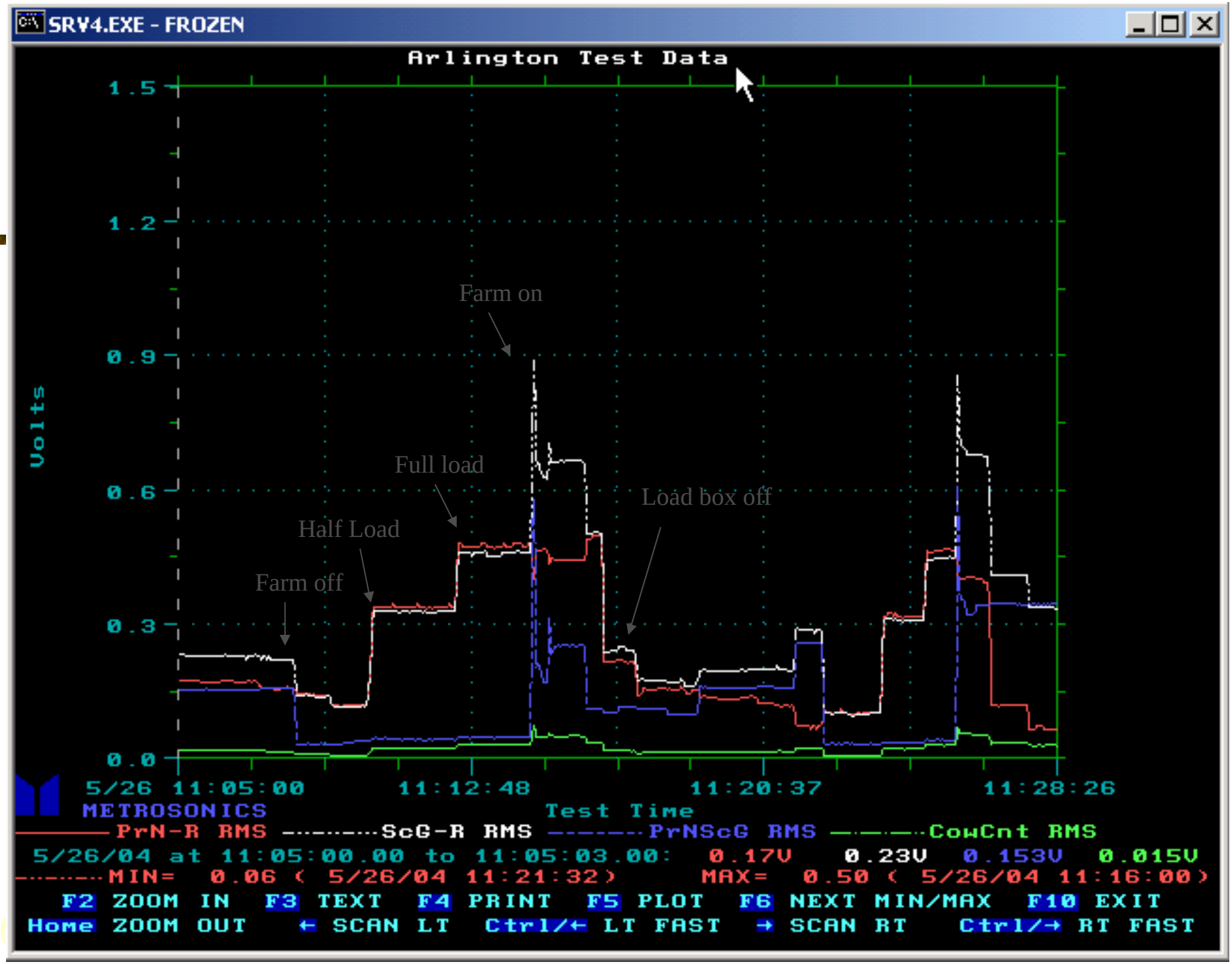
VR TEST

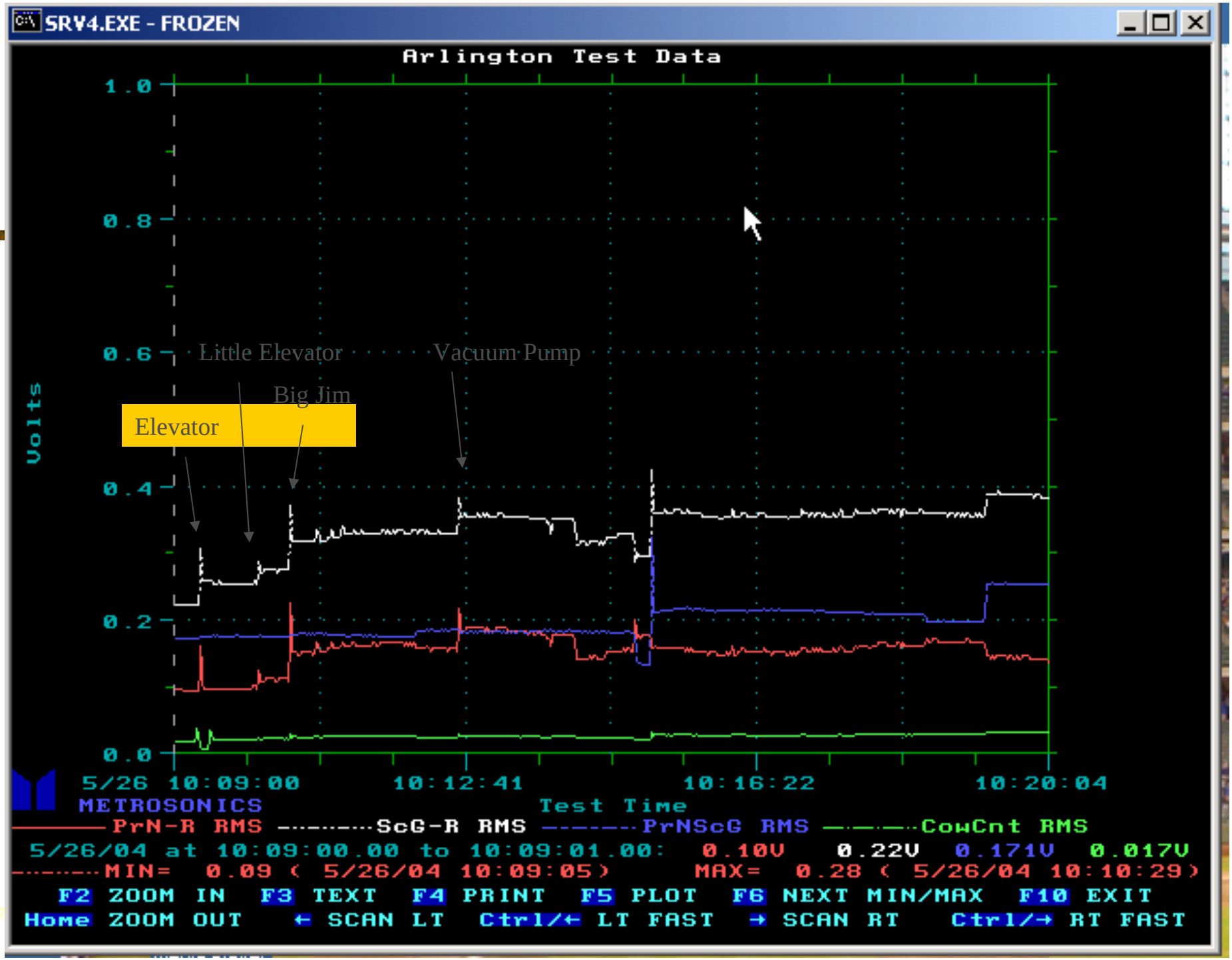
VpnRef = ____ IPGmeas = ____ mA RPGmeas = ____

Vpncalc= (IPGmeas * RPGmeas)/1000 0 mV (Vpnref/Vpncalc) ____ %

(If VR <90% move ref. gm.)

Comments:


SRV4.EXE - FROZEN
Arlington Test Data
1.5
1.2
0.9
0.6
0.3
0.0
Volts
Farm on
Full load
Load box off
Half Load
Farm off
5/26 11:05:00
11:12:48
11:20:37
11:28:26
METROSONICS
Test Time
PrN-R RMS
ScG-R RMS
PrNScG RMS
CowCnt RMS
5/26/04 at 11:05:00.00 to 11:05:03.00: 0.17V 0.23V 0.153V 0.015V
MIN= 0.06 (5/26/04 11:21:32) MAX= 0.50 (5/26/04 11:16:00)
F2 ZOOM IN F3 TEXT F4 PRINT F5 PLOT F6 NEXT MIN/MAX F10 EXIT
Home ZOOM OUT ← SCAN LT Ctrl/← LT FAST → SCAN RT Ctrl/→ RT FAST


SRV4.EXE - FROZEN
Arlington Test Data
1.0
0.8
0.6
0.4
0.2
0.0
Volts
Little Elevator
Vacuum Pump
Big Jim
Elevator
5/26 10:09:00
10:12:41
10:16:22
10:20:04
METROSONICS
Test Time
PrN-R RMS
ScG-R RMS
PrNScG RMS
CowCnt RMS
5/26/04 at 10:09:00.00 to 10:09:01.00: 0.10V 0.22V 0.171V 0.017V
MIN= 0.09 (5/26/04 10:09:05) MAX= 0.28 (5/26/04 10:10:29)
F2 ZOOM IN F3 TEXT F4 PRINT F5 PLOT F6 NEXT MIN/MAX F10 EXIT
Home ZOOM OUT ← SCAN LT Ctrl/← LT FAST → SCAN RT Ctrl/→ RT FAST

Secondary Neutral Voltage Drop Test

- Turn off all services to all buildings
- Then one at a time turn on the service and run a 10 amp load only on each service individually.
- Measure the voltage of the primary to remote, secondary neutral of the panel tested to remote, primary to secondary, cow contact voltage, and the current coming back on THAT PARTICULAR SERVICE WIRE, not necessarily the service wire from the transformer.

Secondary Neutral Voltage Drop Test Form

Stray Voltage Investigation - Phase II
Secondary Neutral Voltage Drop Test

Name: Date: Rep:

	1	2	3	4	5	
Site Location	MlkHse	Grannary	House	Calf Barn	Garage	
Site Location Code	B	D	C	B	D	Units
Sec. Wire Size	# 2 AL	# 4 AL	# 2 AL	# 4 AL	# 2 AL	Ga.
Sec. Length	197	217	212	220	172	Ft.
Res./100'	0.027	0.042	0.027	0.042	0.027	Ohms
Total Res.	0.05319	0.09114	0.05724	0.0924	0.04644	Ohms
Neut. Current						Amps
Calc. Voltage Drop						Volts
Vpnref Load OFF	0.171					Volts
Vpnref Load ON						Volts
Vsnref Load OFF	0.172					Volts
Vsnref Load ON						Volts
Vpn - Vsn Load OFF	0.006					Volts
Vpn - Vsn Load ON						Volts
Actual Meas Vpn-Vsn ON						Volts
Cow Contact OFF	0.0240					Volts
Cow Contact ON						Volts
V Drop Variance						Volts
Actual Serv. Resistance						Ohms

Note that the voltage drop should be .0something

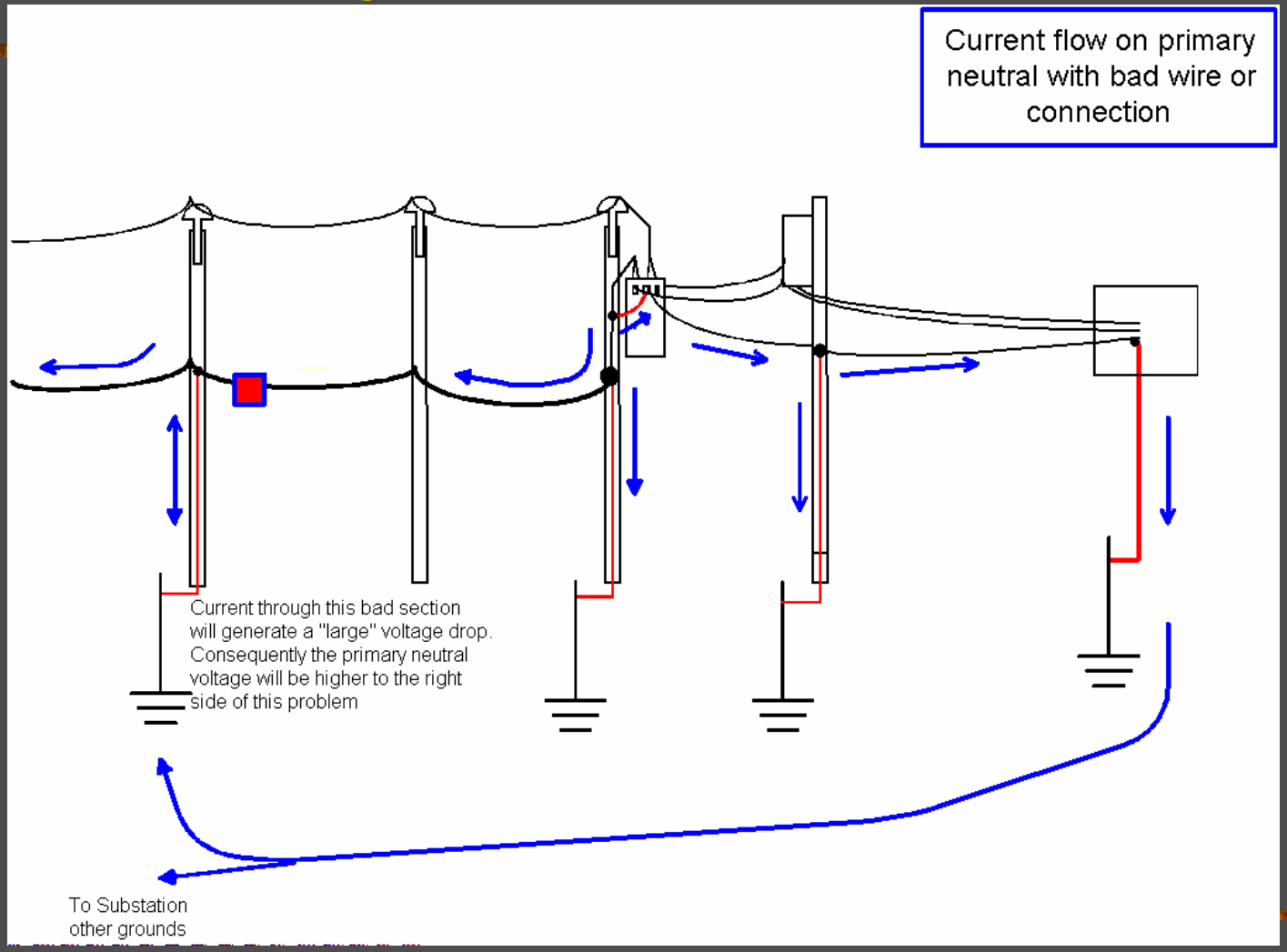
Primary Profile

- In this test we are looking to see the condition of the utility grounding system. We use the AEMC meter, which can measure the resistance of a single ground rod. We measure the resistance of the ground rods and the current through said ground rod. By knowing the resistance of the ground rod and the current through the ground, we can calculate the voltage on the primary neutral, V=I*R

Primary Profile Notes

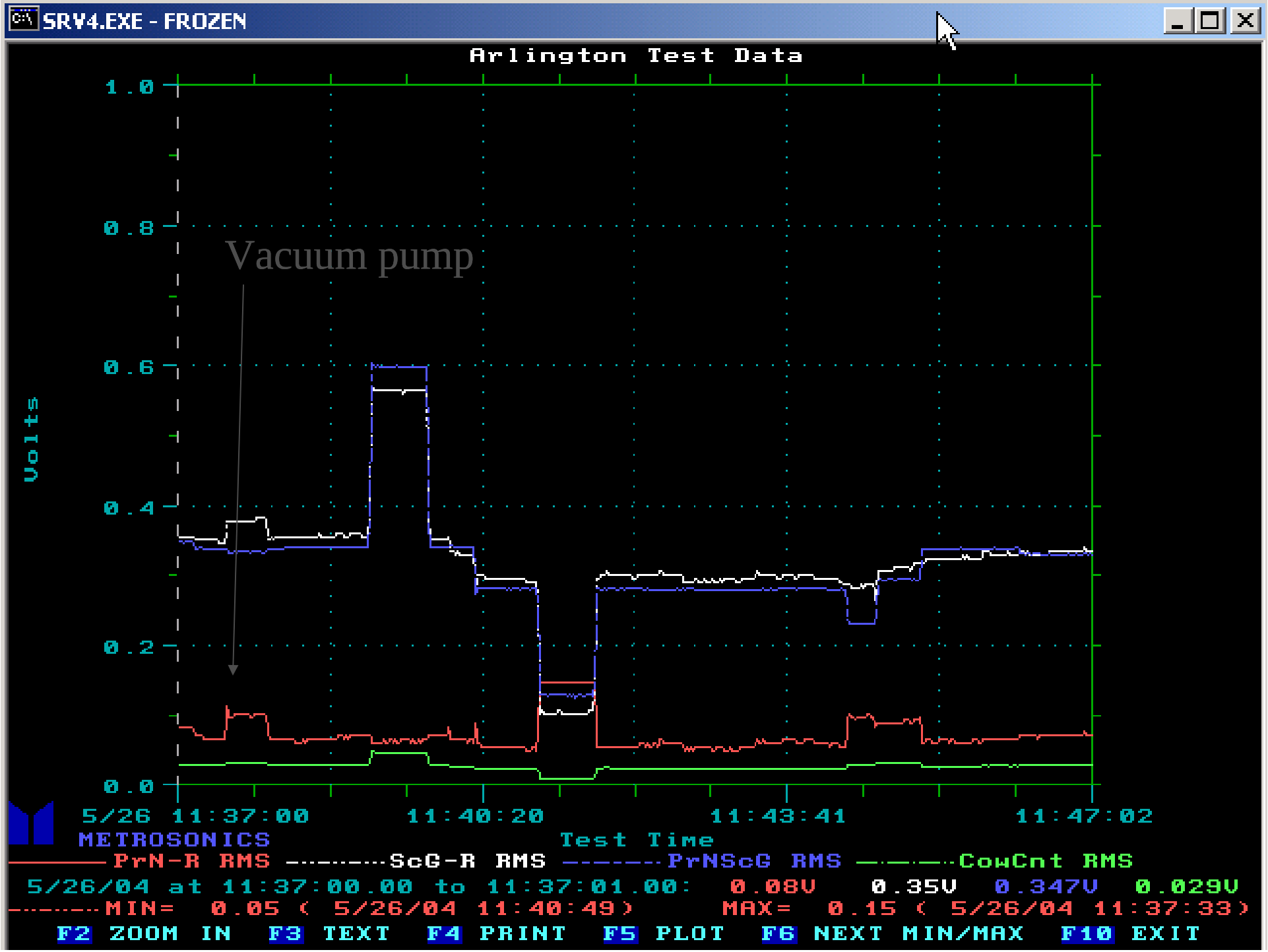
- USE HIGH VOLTAGE GLOVES when working on a pole with a transformer, capacitor setting, recloser or arresters. Again if that connection to ground is loosened up it may be the last good connection and if loosened can potentially energize that ground to line voltage.
- REMEMBER to turn on the load box before you leave for the test. We want that on so that we have a good sized load on the neutral to measure neutral voltage.
- Beacons and flashers on the truck should be turned on and an orange vest can be worn because we are working on the road.

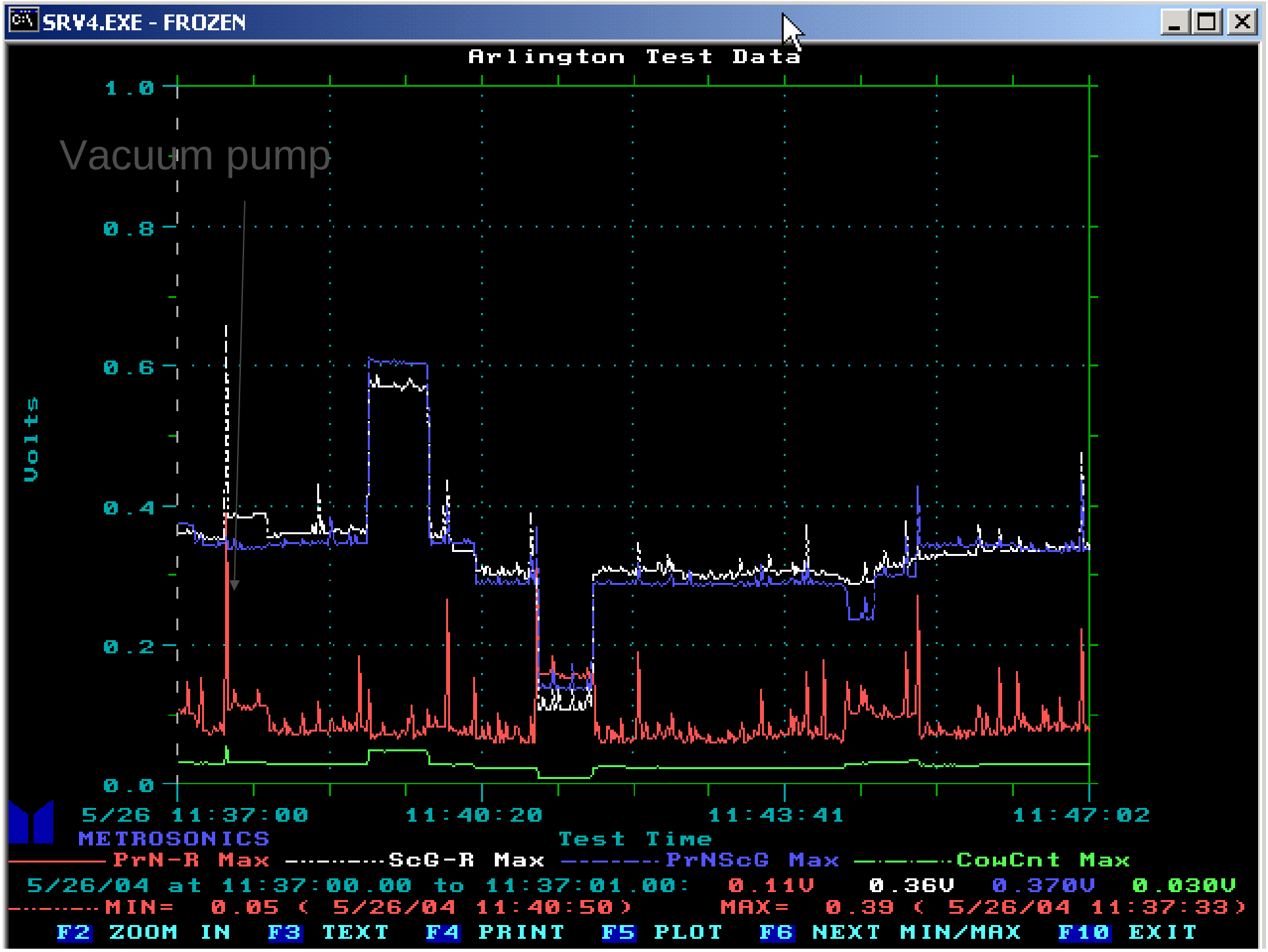
Bad Primary Neutral Connection

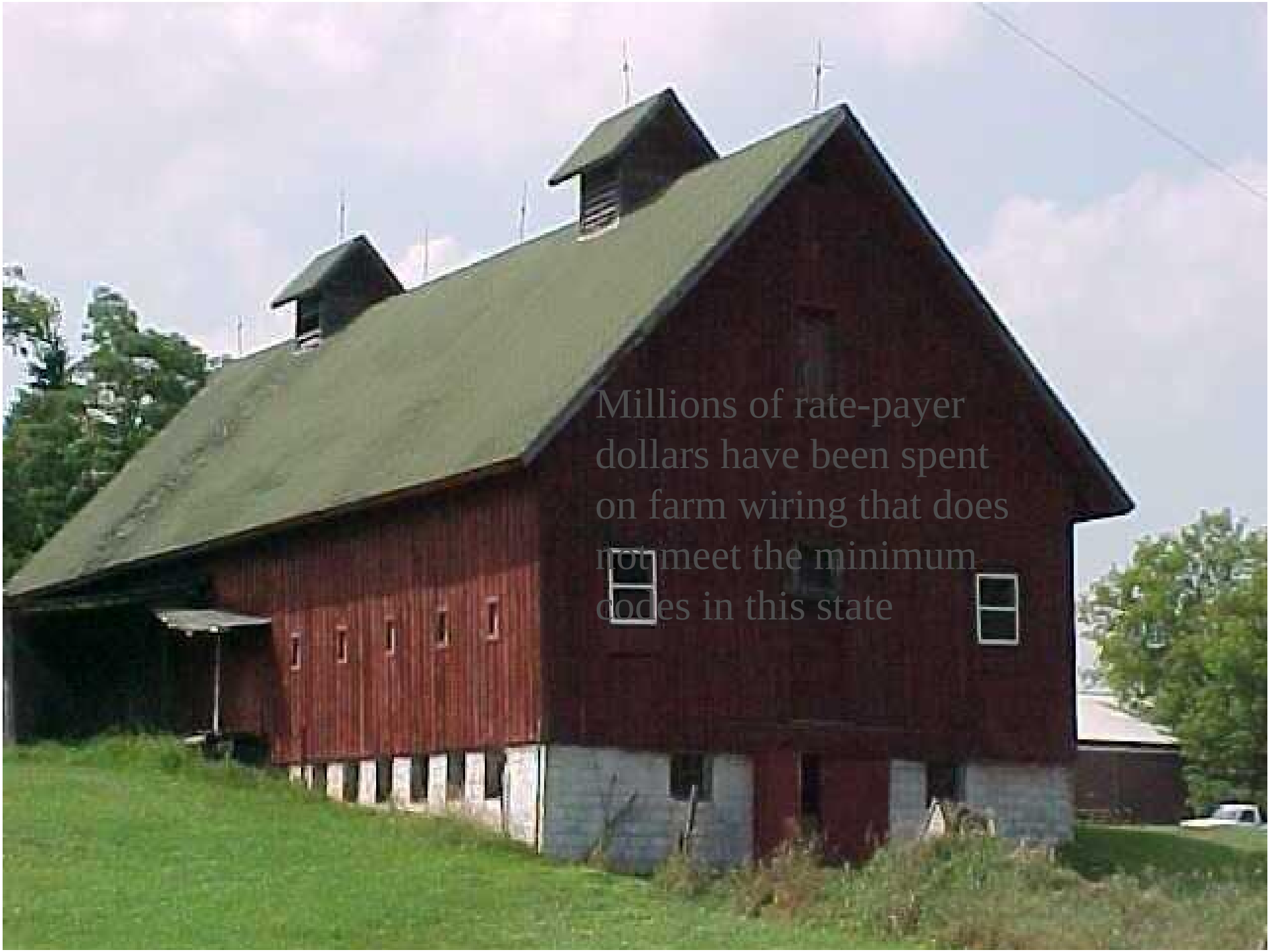


Motor Start Test

We have the farmer start each of his large motors one at a time, noting the time of the start and end times of running. This way we can isolate the one motor that may be having a hard time starting. You will look for large voltage drops when starting or large elevations of the secondary neutral voltages. And as always watch for the cow contact voltages.


SRV4.EXE - FROZEN
Arlington Test Data
1.0
0.8
0.6
0.4
0.2
0.0
Volts
Vacuum pump
5/26 11:37:00
11:40:20
11:43:41
11:47:02
METROSONICS
Test Time
PrN-R RMS
ScG-R RMS
PrNScG RMS
CowCnt RMS
5/26/04 at 11:37:00.00 to 11:37:01.00: 0.08V 0.35V 0.347V 0.029V
MIN= 0.05 (5/26/04 11:40:49)
MAX= 0.15 (5/26/04 11:37:33)
F2 ZOOM IN F3 TEXT F4 PRINT F5 PLOT F6 NEXT MIN/MAX F10 EXIT


SRV4.EXE - FROZEN
Arlington Test Data
Vacuum pump
1.0
0.8
0.6
0.4
0.2
0.0
Volts
5/26 11:37:00
11:40:20
11:43:41
11:47:02
METROSONICS
Test Time
PrN-R Max
ScG-R Max
PrNScG Max
CowCnt Max
5/26/04 at 11:37:00.00 to 11:37:01.00: 0.11V 0.36V 0.370V 0.030V
MIN= 0.05 (5/26/04 11:40:50)
MAX= 0.39 (5/26/04 11:37:33)
F2 ZOOM IN F3 TEXT F4 PRINT F5 PLOT F6 NEXT MIN/MAX F10 EXIT


Millions of rate-payer dollars have been spent on farm wiring that does not meet the minimum codes in this state

State wide uniform farm re-wiring program developed


All dairy farms in Wisconsin
can participate


Loans
Range from $5000 to $14,000
Interest rates from 0% to 4%

Grants

First $1k grant

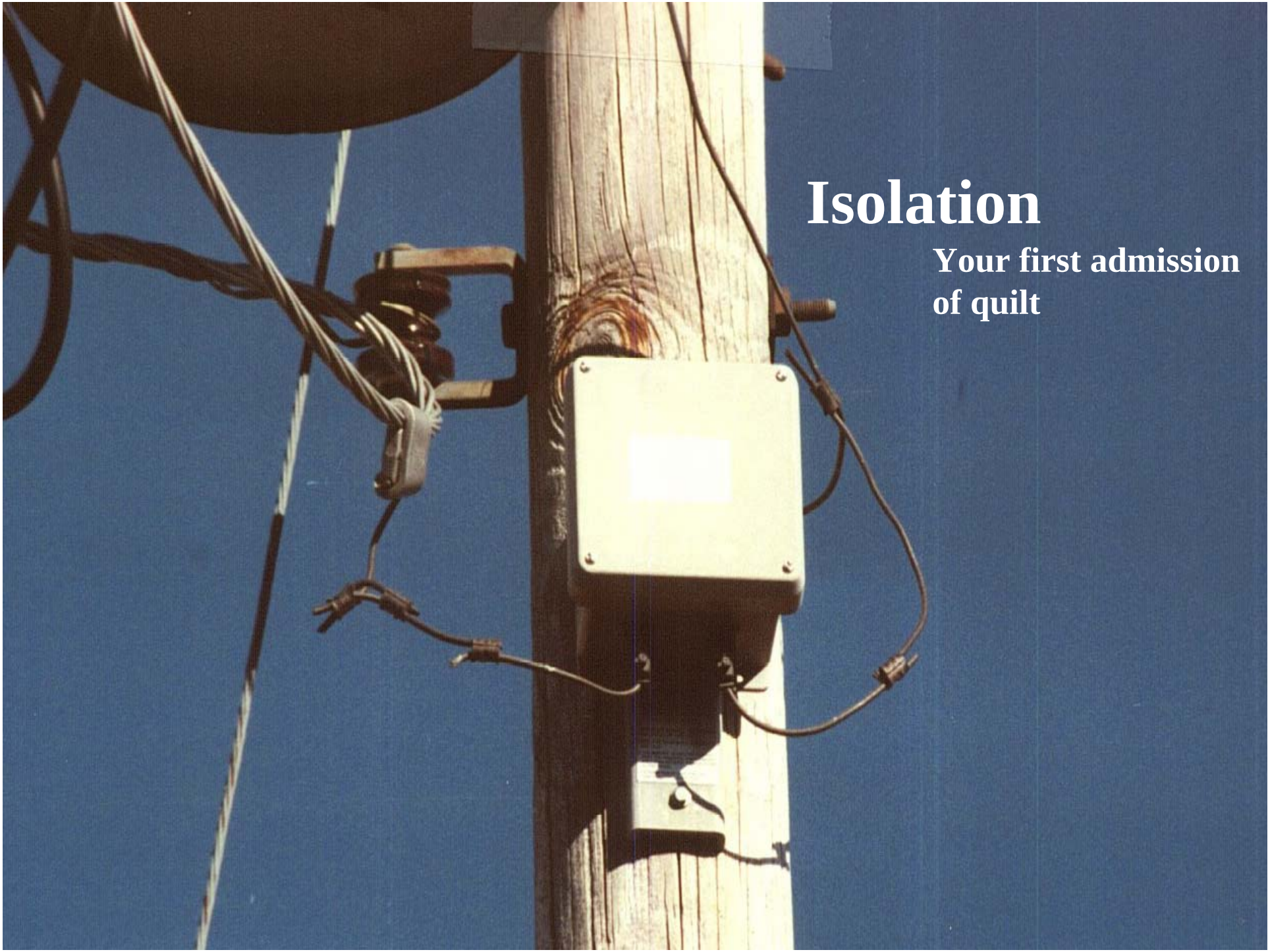
Grants range from $2,500 to $11,000

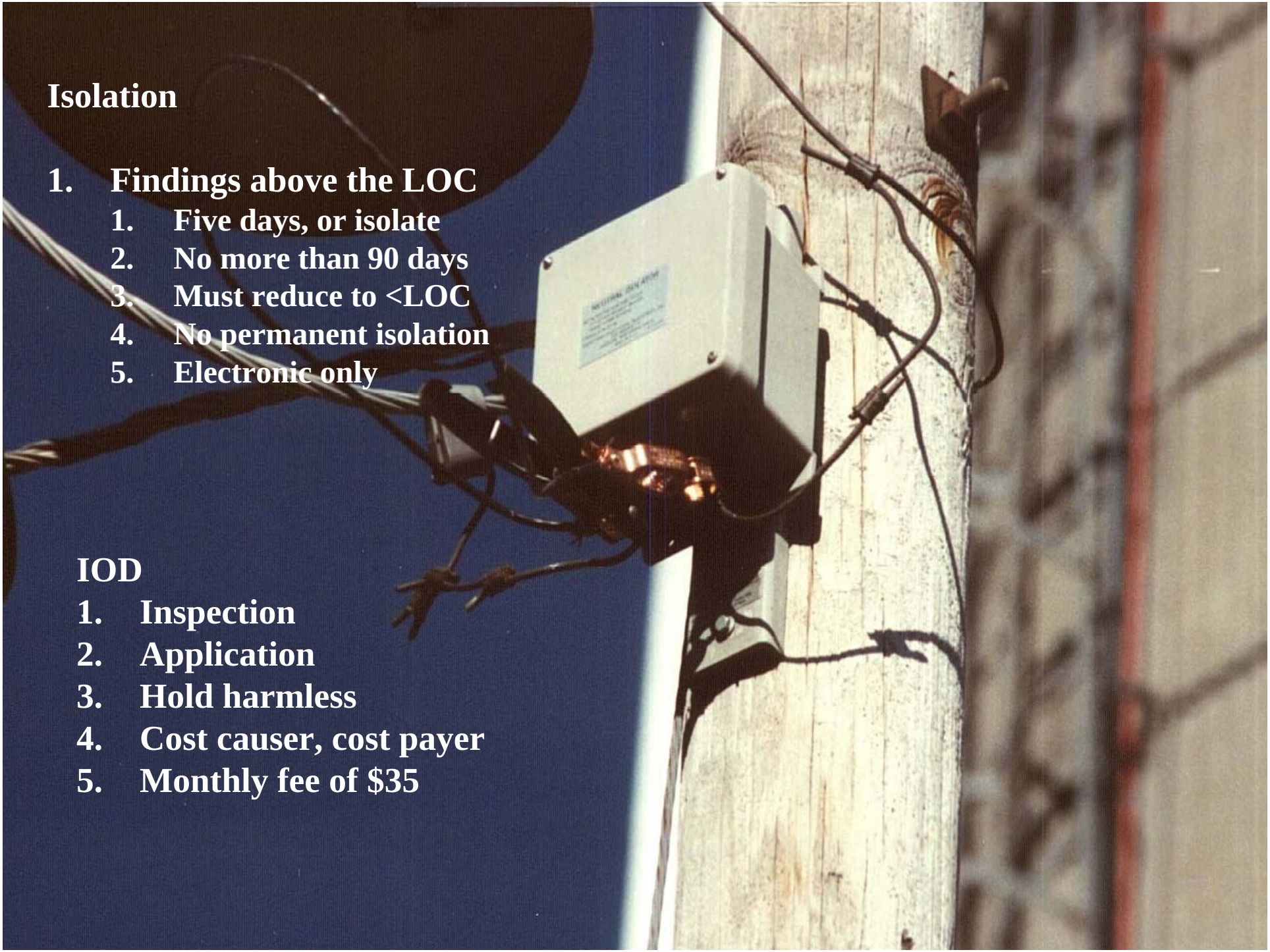
All new wiring must be inspected.

State Inspector paid by $1000 up front grant. No cost to the farmer for inspections


New re-wiring programs are
Conservation driven
Safety
Stray Voltage

mitigation


Isolation
Your first admission
of quilt

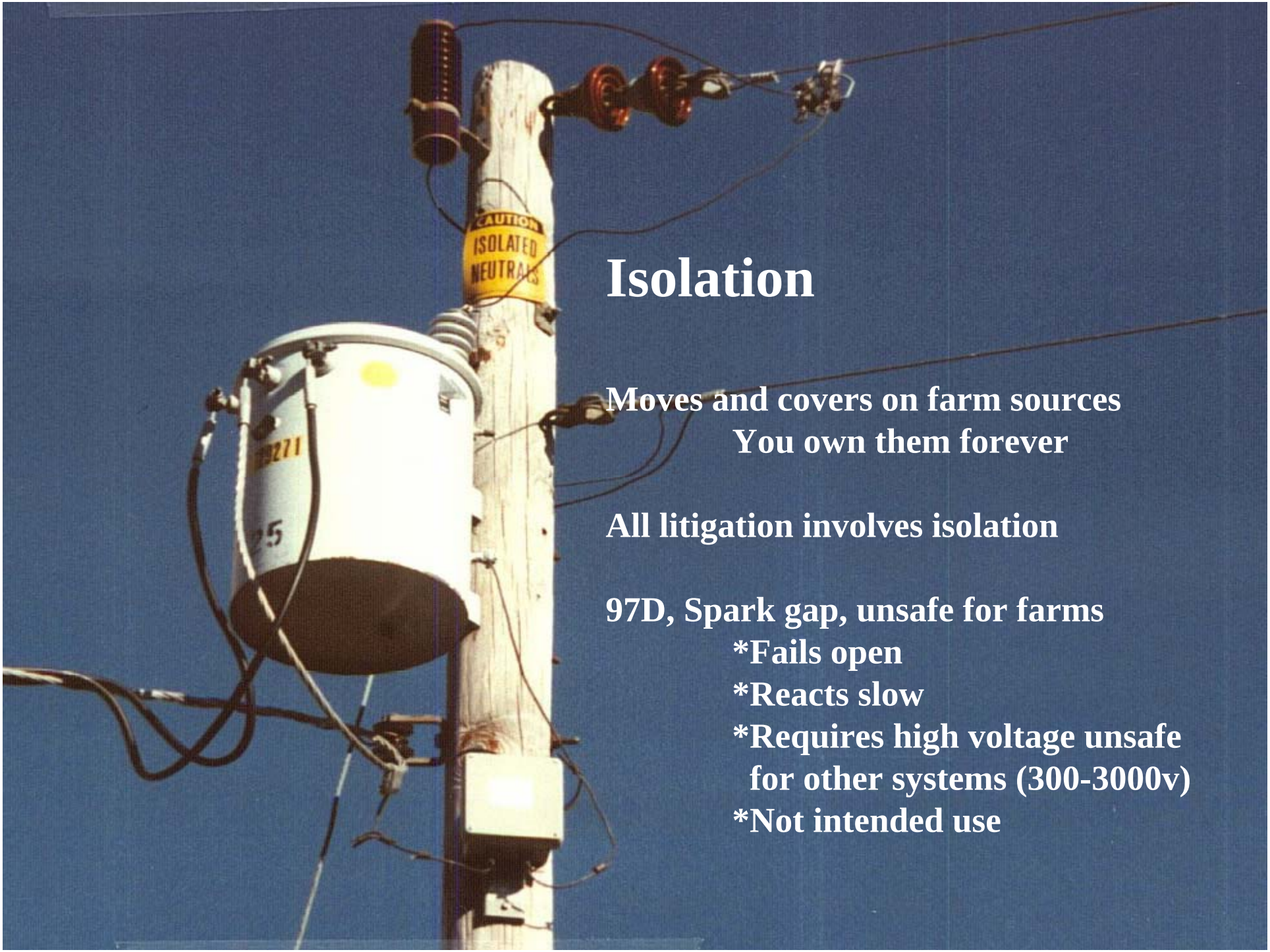


Isolation

1. Findings above the LOC
    1. Five days, or isolate
    2. No more than 90 days
    3. Must reduce to <LOC
    4. No permanent isolation
    5. Electronic only

IOD

1. Inspection
2. Application
3. Hold harmless
4. Cost causer, cost payer
5. Monthly fee of $35

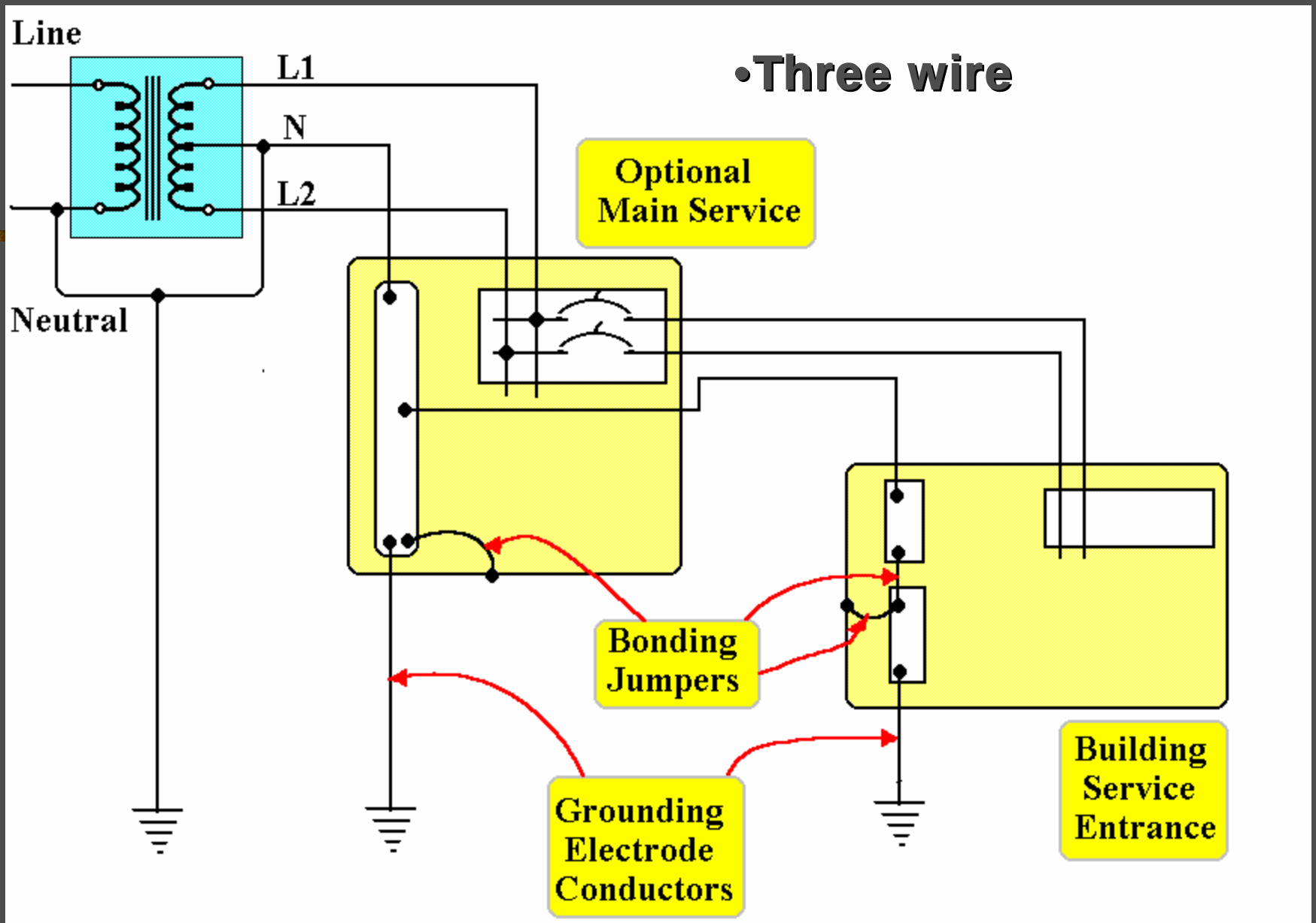


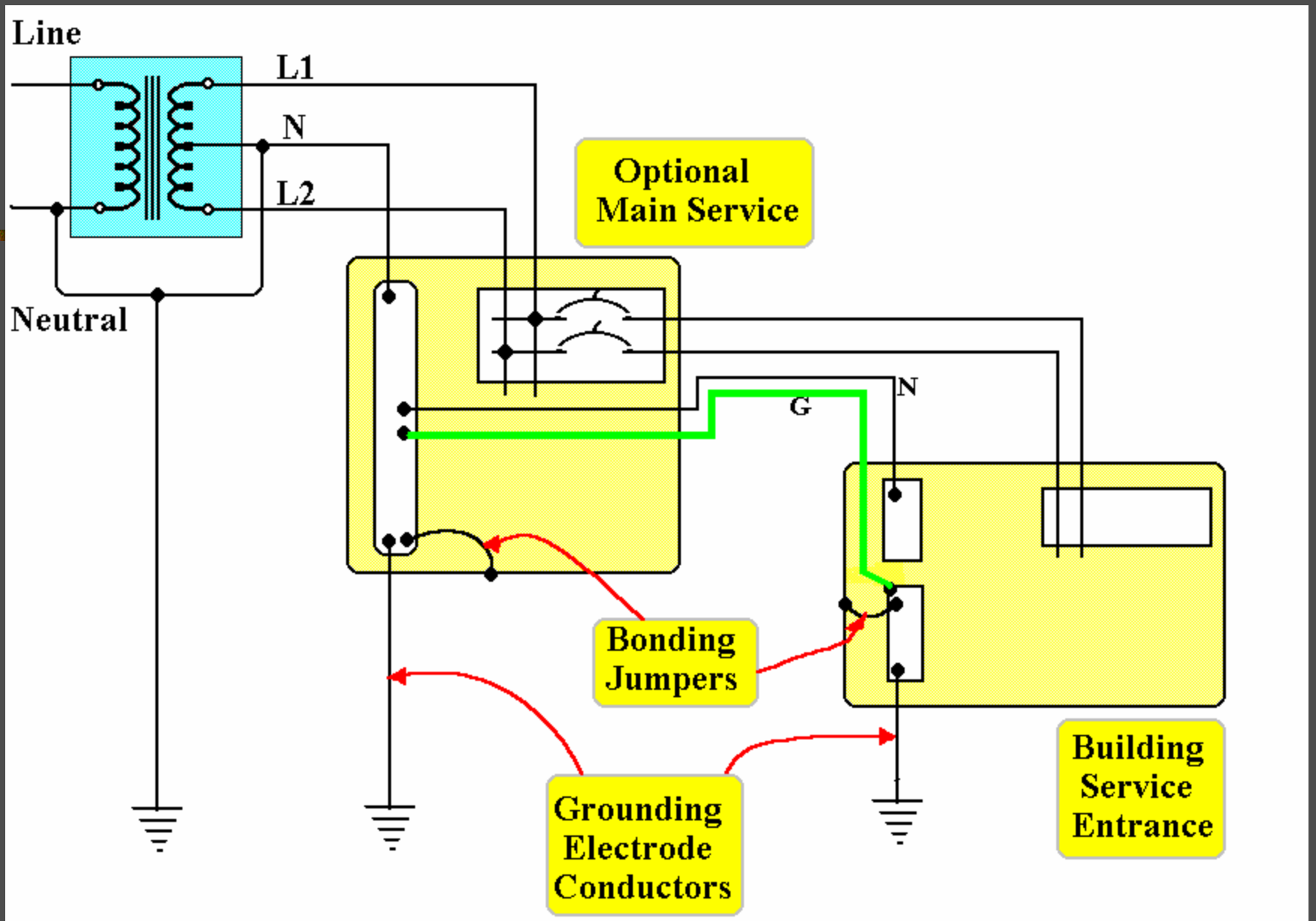
Isolation

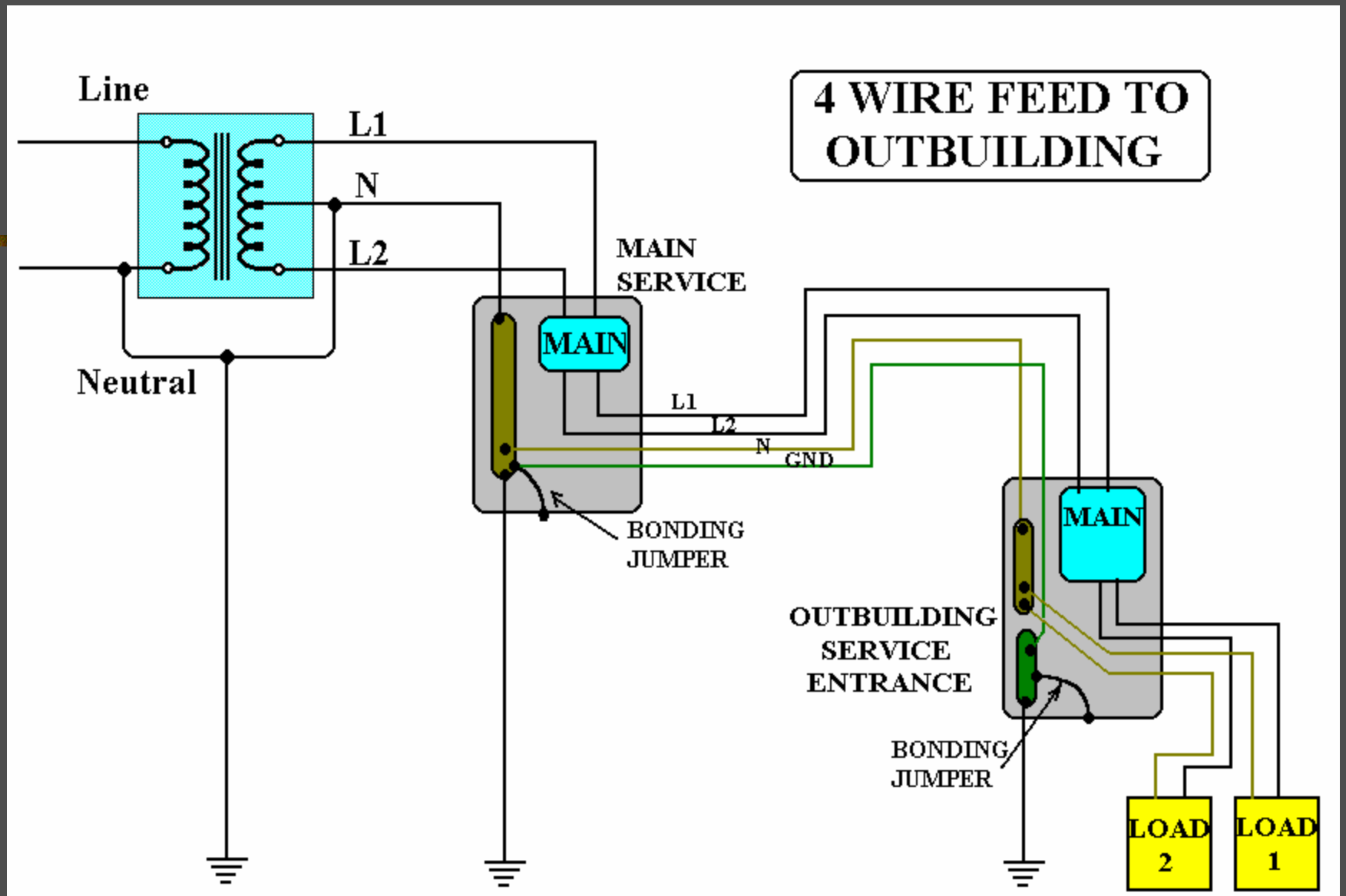
Moves and covers on farm sources
You own them forever

All litigation involves isolation

97D, Spark gap, unsafe for farms
- ***Fails open**
- ***Reacts slow**
- ***Requires high voltage unsafe for other systems (300-3000v)**
- ***Not intended use**


Line
L1
N
L2
Neutral
•Three wire
Optional Main Service
Bonding Jumpers
Grounding Electrode Conductors
Building Service Entrance


Line
L1
N
L2
Neutral
Optional
Main Service
G
N
Bonding
Jumpers
Grounding
Electrode
Conductors
Building
Service
Entrance


4 WIRE FEED TO OUTBUILDING
Line
L1
N
L2
Neutral
MAIN SERVICE
MAIN
L1
L2
N
GND
BONDING JUMPER
MAIN
OUTBUILDING SERVICE ENTRANCE
BONDING JUMPER
LOAD 2
LOAD 1

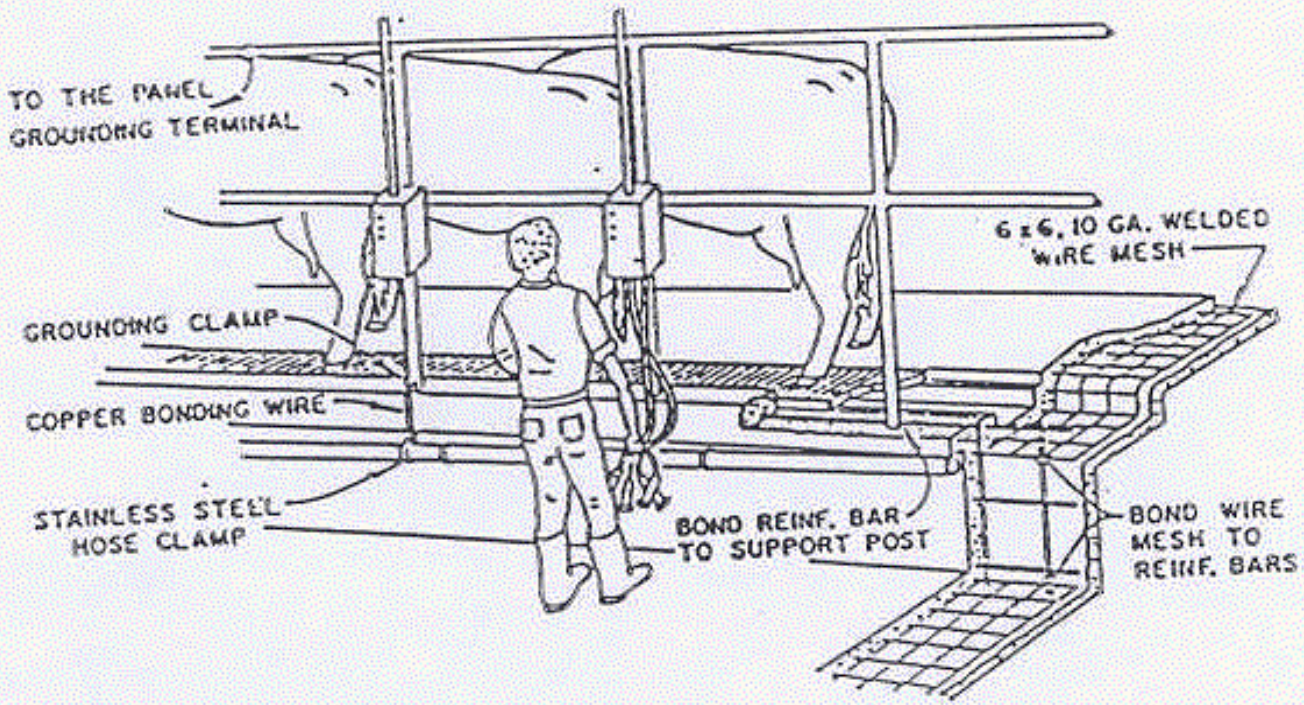
Positives

- Reduces on farm source voltages at cow contact
- Eliminates cyclical 120 volt load problems (no load balance required).
- Reduces amount of secondary neutral current returning through the earth.

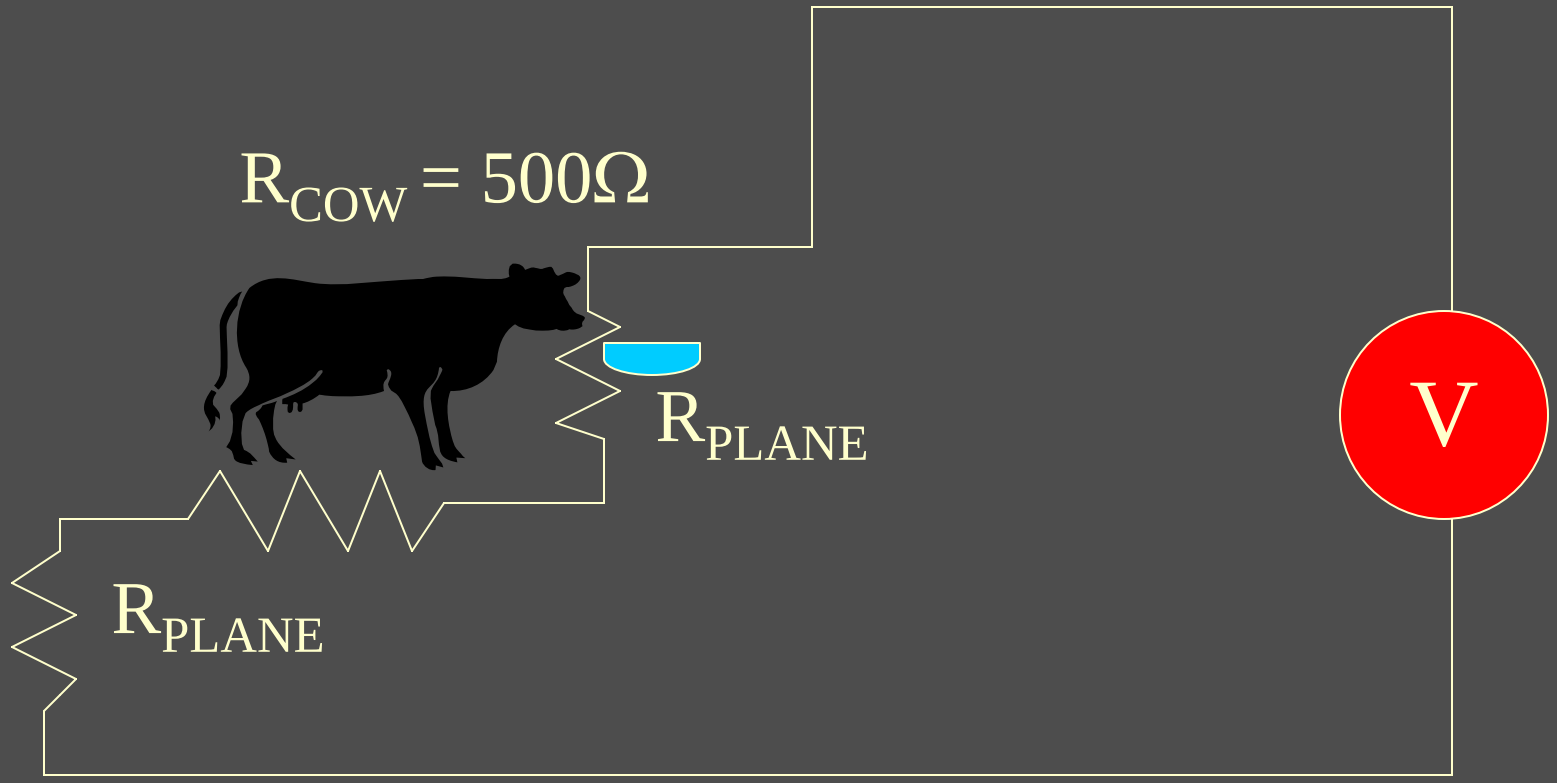
Equipotential Plane

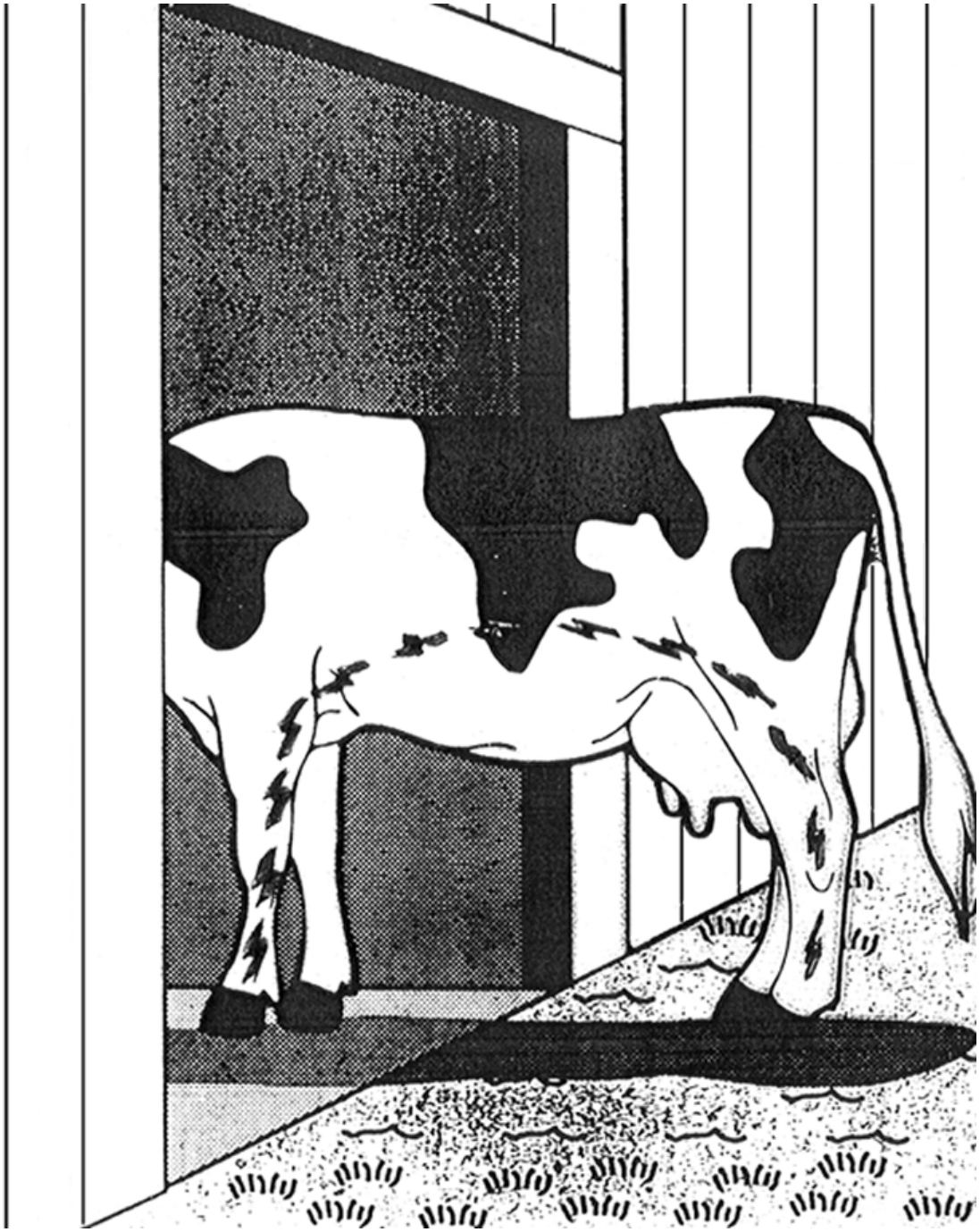
1. Improves personnel/animal safety
2. Relatively inexpensive in new installations
3. Retrofit possible
4. Provides grounding to lower NEV, cow contacts, and transients
5. Reduces motor start effects
6. Include feed bunks and waterers

547-9. Bonding and Equipotential Plane


TO THE PANEL GROUNDING TERMINAL
6 x 6, 10 GA. WELDED WIRE MESH
GROUNDING CLAMP
COPPER BONDING WIRE
STAINLESS STEEL HOSE CLAMP
BOND REINF. BAR TO SUPPORT POST
BOND WIRE MESH TO REINF. BARS

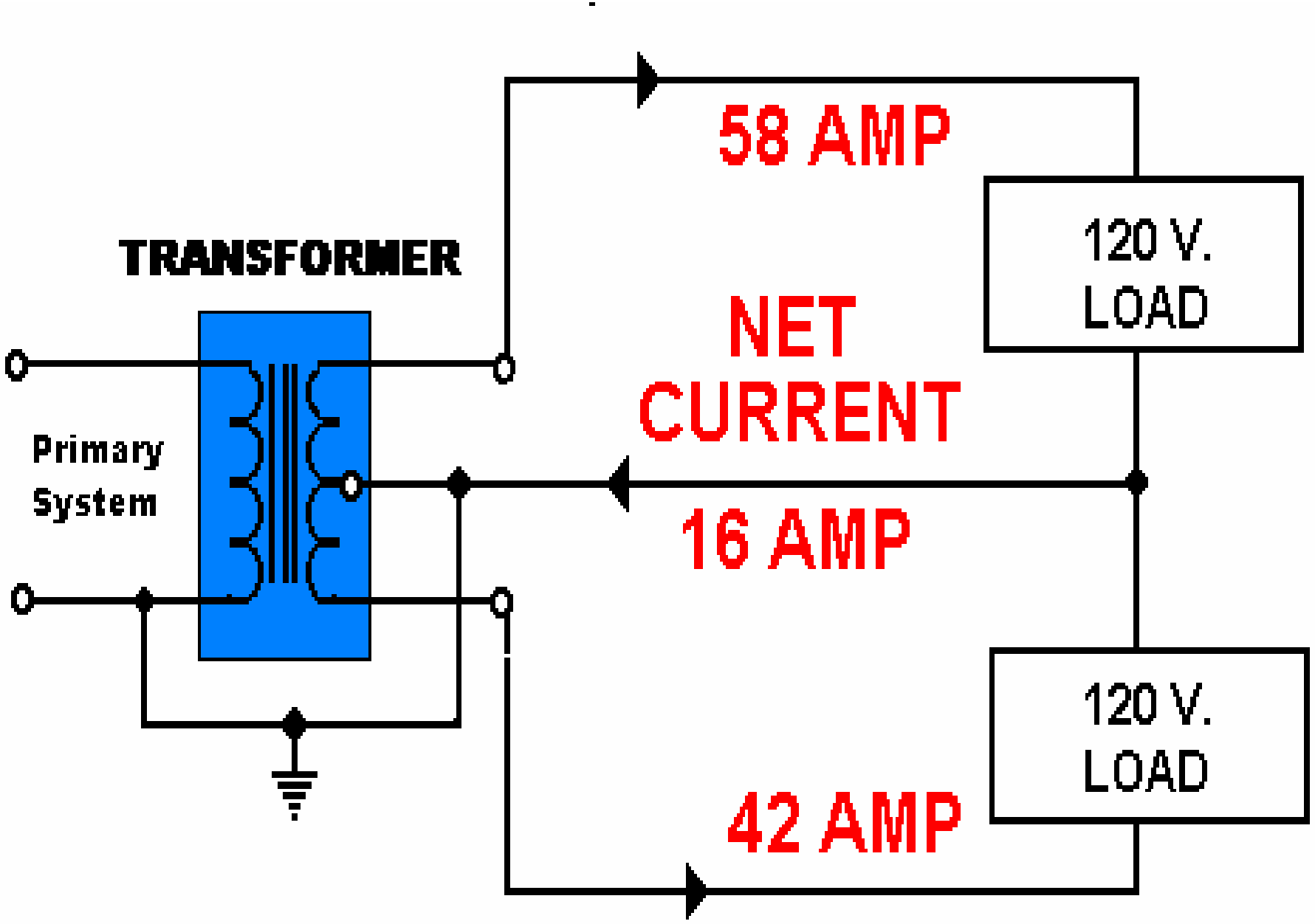
Equipotential Plane

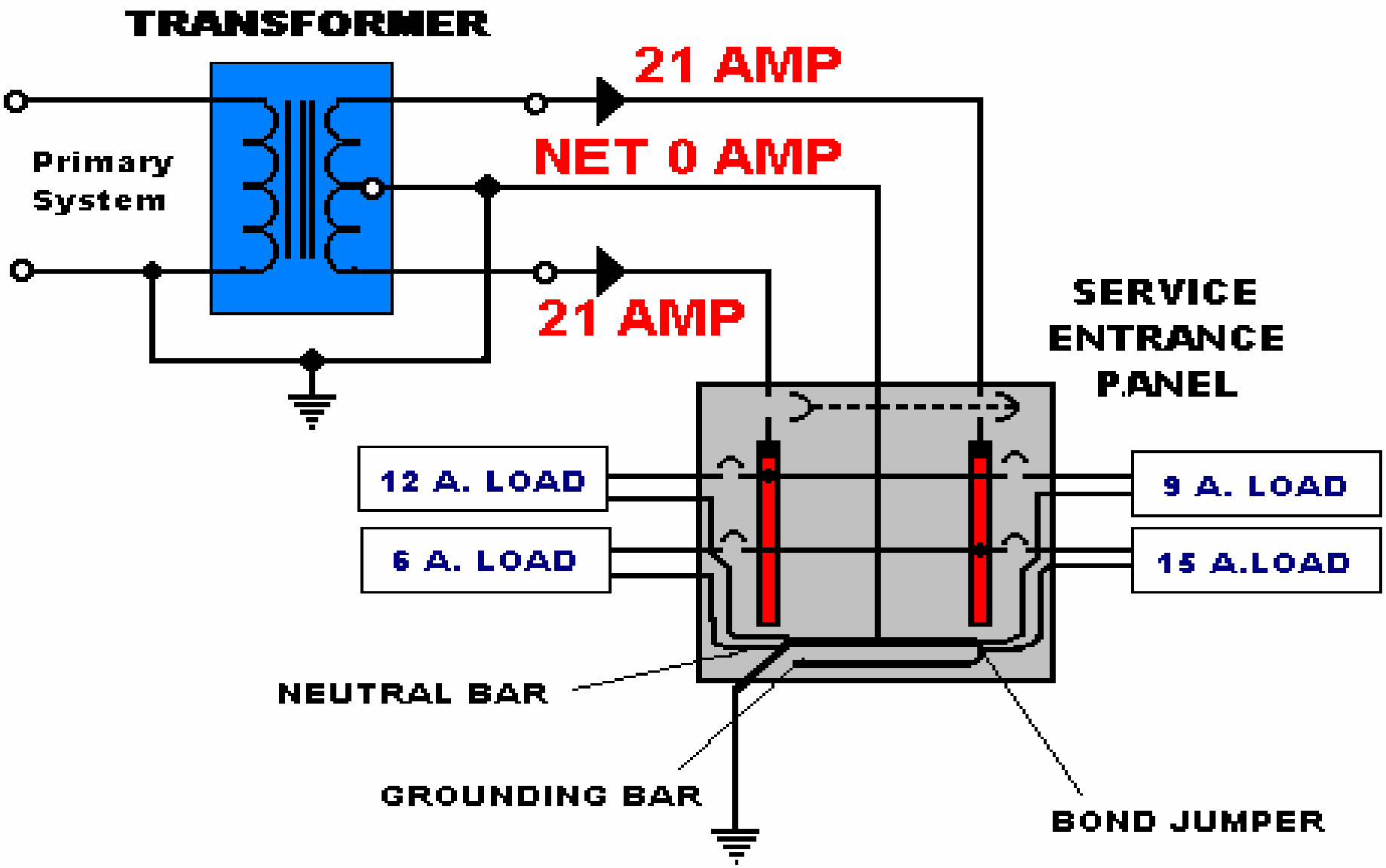




Load balancing

- Balance 120 volt circuits on farm
- Replace 120 volt loads with 240 volt
- Cyclical nature of loads can be a problem (see four-wire system)


TRANSFORMER
Primary System
58 AMP
120 V. LOAD
NET CURRENT
16 AMP
120 V. LOAD
42 AMP


TRANSFORMER
Primary System
21 AMP
NET 0 AMP
21 AMP
SERVICE ENTRANCE PANEL
12 A. LOAD
6 A. LOAD
9 A. LOAD
15 A.LOAD
NEUTRAL BAR
GROUNDING BAR
BOND JUMPER

Electronic Grounding System

EGS (?)

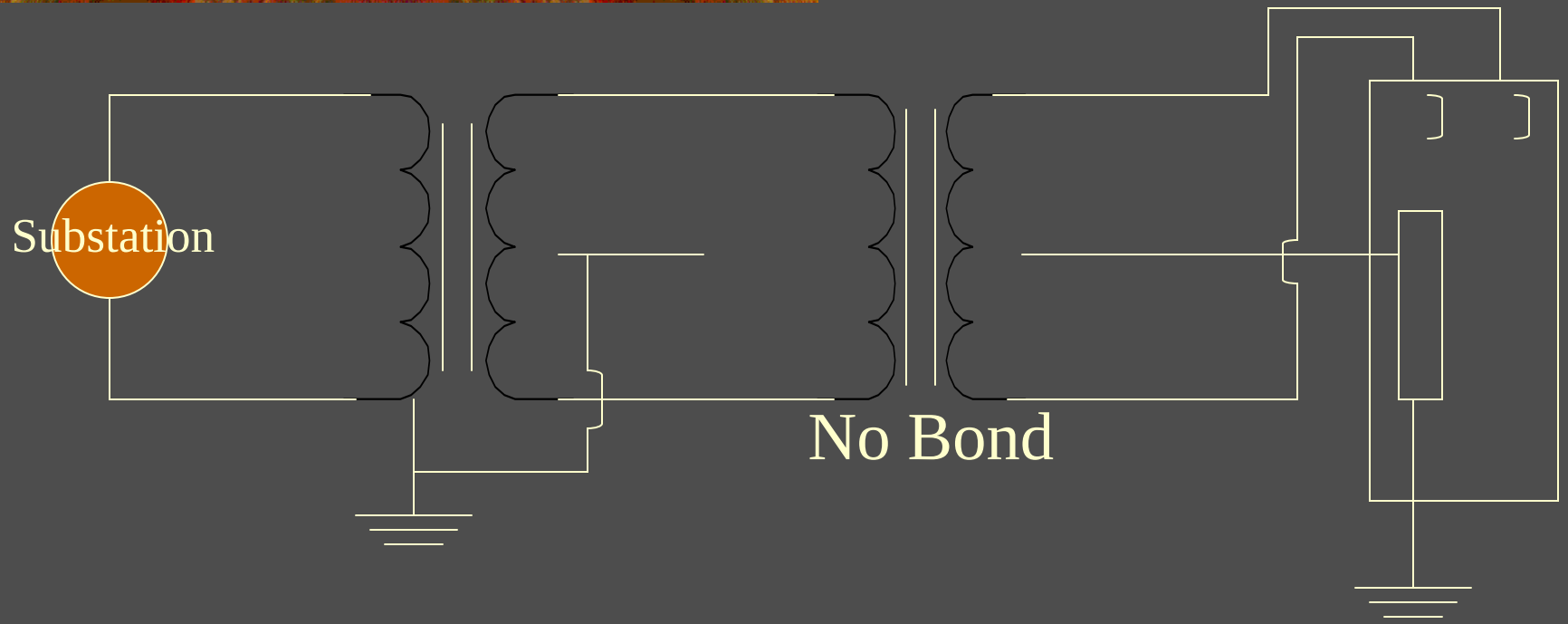
1. Repair service
2. Work well on farms
3. Needs good wiring
4. Agrivolt

ON FARM E.G.S.

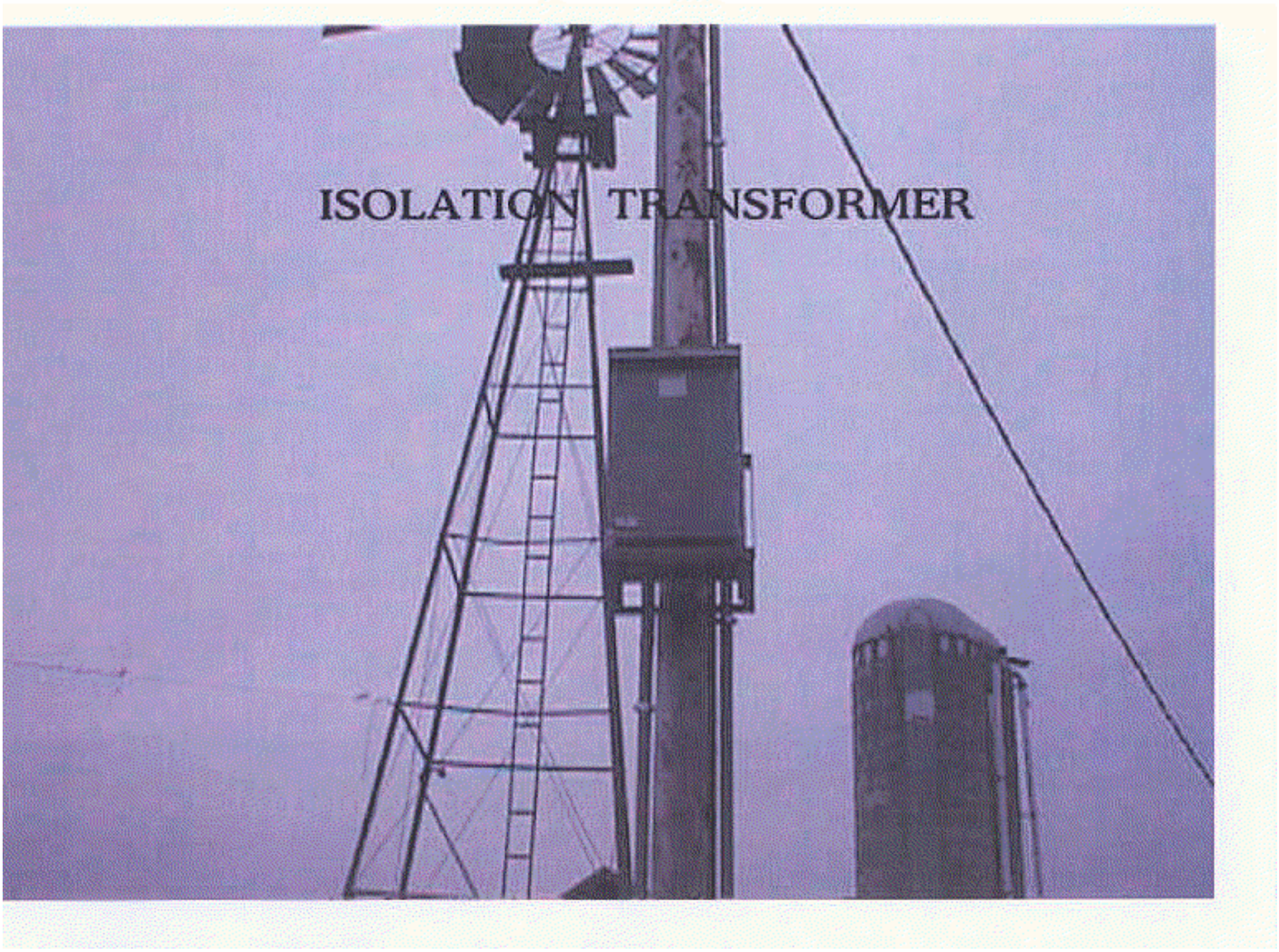
Ungrounded Transformer

1. Expensive (some, very)
2. Code violations and safety concerns common
3. Increases electrical consumption (really!)
4. Raises primary NEV

Isolation Transformer




•Dead cows
Acme Electric


ISOLATION TRANSFORMER


No
over current
protection

What Do We Mean By.....?

- Remote Reference Rod
- Neutral-to-Earth Resistance
- Neutral-to-Earth Voltage
- Ground Current
- Earth Current

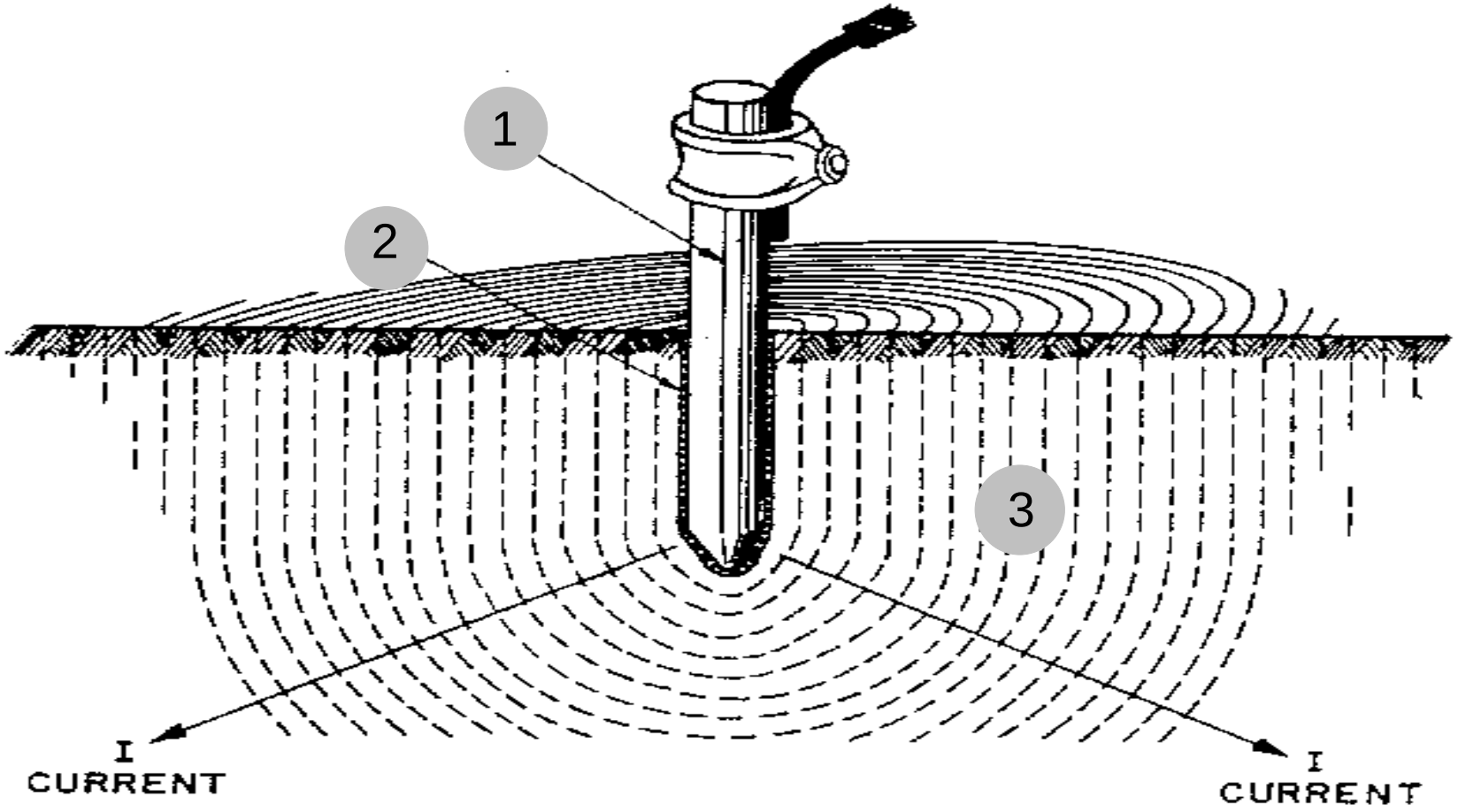
REMOTE REFERENCE ROD

- A reference electrode driven at a location sufficiently distant from existing electrodes so that it is not significantly within the influence of them.

NEUTRAL-TO-EARTH RESISTANCE

- The electrical resistance of all interconnected conductive parallel paths between the neutral conductor at the location being measured and a properly established remote reference.

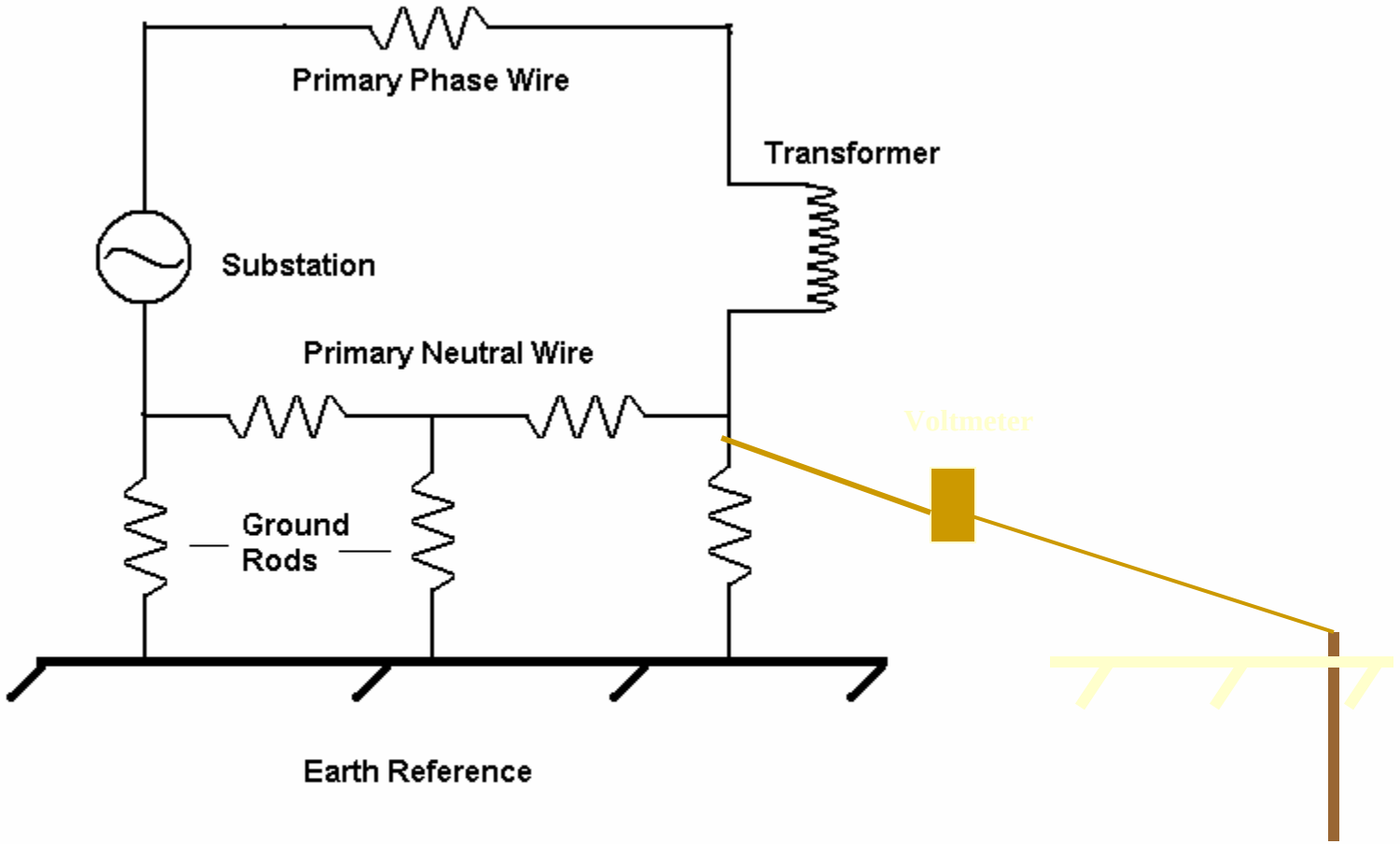
GROUNDING ROD RESISTANCE



1Resistance of the electrode itself and connections to it.
2Contact resistance between the electrode and the soil adjacent to it.
3. Resistance of the surrounding earth.

NEUTRAL-TO-EARTH VOLTAGE (NEV)

- Voltage measured between the neutral conductor and a remote reference rod.
  - The voltage drop across the neutral-to-earth resistance.



The Utility Circuit

GROUND CURRENT

- System return current, either normal or abnormal, that flows on the conductive pathways between the neutral conductor and earth.

EARTH CURRENT

- System return current, either normal or abnormal, that flows in the earth from or to existing electrodes.