ARE THE NATIONAL ELECTRICAL CODE

AND THE

NATIONAL ELECTRICAL SAFETY CODE

HAZARDOUS TO YOUR HEALTH?

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Abstract – The National Electrical Code and the National Electrical Safety Code are contributing to the shocking of Americans. The required wiring practices of the two codes encourages the flow of continuous, uncontrolled current over the earth, metallic piping, building steel, etc. This uncontrolled flow of current has resulted in unsafe electrical shocks to humans. This uncontrolled stray current may have resulted in fatalities. Utilities' distribution transformer connections contribute to the flow of stray uncontrolled continuous current. The methods of preventing such stray current will be discussed. A case of a swimming pool shocking the bathers is examined.

Index Terms -- Electric shocks, Ground current, National Electrical Code, National Electrical Safety Code, Neutral blockers, Stray current, Uncontrolled current.

I. INTRODUCTION

From a non-scientific survey taken at a technical conference, 80% of the industrial and commercial electrical engineers were not aware that the utility distribution transformers' primary neutral is connected to the secondary neutral terminal. This connection allows the flow of continuous, uncontrolled electric current to flow over the earth, metallic piping, building steel, etc. and through showers, swimming pools and other similar items.

This paper will cover some basics such as Ohms and Kirchoff's Laws, parallel circuits and the resistance of the human body to electric current. A detail discussion of a swimming pool, without any under water lights or other electrical devices, that is shocking bathers will be discussed. The response of the local utility to this shocking problem is documented.

II. OHMS AND KIRCHOFF'S LAWS

It will be useful in analyzing the results of the tests conducted to review these two laws of electricity.

A. Ohm's Law.

Ohm's Law states that current multiplied by resistance (or in the case of an alternating current, circuit impedance) equals the voltage across the resistance.

One must measure more than just the voltage, such as the resistance or impedance, to make a statement about the amount of current that is flowing. Similarly, if the current is measured along with the voltage, then the resistance or impedance can be calculated.

$$R \text{ or } Z = \frac{V}{I} \qquad (1)$$

Where: I = Current
R = Resistance
V = Voltage
Z = Impedance

Measurement of only one of the three quantities will not reveal anything about the other two.

B. Kirchoff's Law.

Kirchoff's Law states that the algebraic sum of the currents toward any point in a network is zero. In other words, the sum of all currents flowing into a node will equal the sum of all currents flowing out of the node.

Electric current cannot vanish or be absorbed. If part of the electric current flowing from a generator enters the earth, it must come out at some point. One could think of this as conservation of energy. The earth is not a sponge that can absorb current.

C. Parallel Circuits.

When an electrical problem develops, one of the solutions usually offered is the installation of bonding jumpers across the offending points. The installation of a bonding jumper will only hide the problem, not solve it. In some cases, the addition of a bonding jumper may not be the best response. This can easily be shown using the partial circuit in Figure 1.

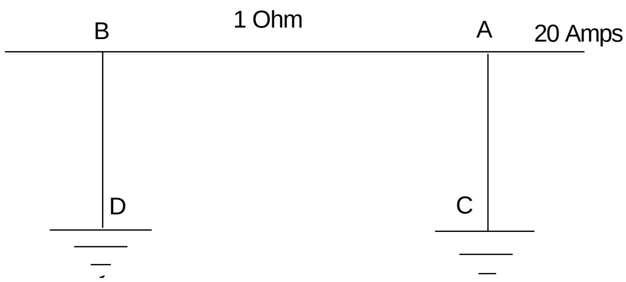

Figure 1.
Parallel Circuit and Current Flow

Refer to Table 1 to see how the current magnitude changes when the resistance between nodes C and D is changed. If a bonding jumper is placed between points C and D and the jumper has the same resistance as between points A and B, the current will divide in half. Ten amperes will flow through A to B and through C to D.

No matter how high the resistance is between points C and D, as compared to points A and B, some amount of current flows between points C and D. Compare the current that would flow with 1000 ohms in the circuit with the safe level of current through a human being.

Ohms	Current	
C – D	A - B	C – D
1	10.	10.
10	18.182	1.818
100	19.802	0.198
1000	19.980	0.020

Table 1
Parallel Circuit Current Flow as a Function of Resistance

D. Response of the Human body to Electric Currents and Voltages.

The human body is very sensitive to electric currents. Voltage can be thought of as pressure. To force current through the human body, a pressure, i.e., voltage, is required. A voltage of approximately 35 volts will penetrate the first layer of dead, dry skin, where the majority of the resistance occurs. Figure 2 shows the typical resistance values for the human body.

If the human body is wet or the skin is freshly cut, the majority of the resistance is lacking. Less voltage may be required and/or more current may be forced through the human body.

Chart 1 lists the values for current that will cause the human body to react. The majority of people can feel 0.003 to 0.004 amperes.

III. THE CASE OF THE SHOCKING SWIMMING POOL

The details of this case are revealed in the same order as they were found. Take note of all the information presented as this case has not been “adjudicated”. The dispute has not been resolved to the author’s satisfaction and you may have the key to resolving this problem.

In late June a manager of an apartment complex converted into condominiums relate a shocking problem with the community swimming pool. (See Figure 3.) The past three years there had been sporadic complaints of persons receiving electric shocks while in the swimming pool. It was the start of the summer and complaints were beginning again.

A. Free Advice.

The following free advice was offered.

1. Obtain an electrician to check the swimming pool’s service entrance wiring, grounding electrode(s), pump motors, etc.. After obtaining assurances that the wiring meets the National Electrical Code (NEC),

2. Contact the local utility and request their help. If the local utility fails to resolve the problem,

3. Write to the Public Utility or Service Commission outlining the problem and what steps have been taken and the lack of results.

The client proceeded through the above steps. The local utility troubleman visited the site. He could not find anything wrong and proceeded to closeout the trouble ticket.

It was now the second week of July and the hottest week of the year was about to begin. On Monday evening swimmers were receiving shocks and reported them to the lifeguard. This was reported to the condominium management.

The utility was called again on Tuesday morning. An engineer, on his way home that night stopped about 4:00 P.M. and made some measurements with a voltmeter. The reference point was a rod driven out in the parking lot. Finding nothing, he left.

At 6:30 P.M. on this sweltering evening, with the temperatures hovering around 95 plus degrees, severe electric shocks were again reported. If the swimmer had a fresh cut or abrasion, or open his/her mouth while in the pool and had metallic fillings in his/her teeth, an electric current was felt. From reports, shocks were received while immersed in the pool. It was not clear if shocks were received as they touched the metallic ladder as they climbed out of the pool or not. The pool was closed.

A frantic call was received early the next morning from the manager. The client was assured action would be taken to get to the bottom the shocking swimming pool.

Arrangements were made with the utility to have a troubleman and an engineer at the pool on Thursday morning about 9:30 A.M. At 8:00 A.M., an electrician was at the site.

B.. Pool Inspection.

The pool panel was inspected. After first turning off the electric power, all the neutral conductors were removed from the bus bar. All the branch breakers were opened and the insulation resistance of the neutrals was checked. All the circuits checked out. No neutrals were faulted to earth-ground.

The pool circulating pumps were in a pit with sides that extended above the grade. Inside were two pumps, one for the main pool and the other for the kiddies' pool. A ground rod had been driven in the pit and the pumps were connected to the rod.

From the ground rod in the pump pit a bare ground wire extended out to the pool side ladder. There was a bolted connection to the ladder. The metallic chain link fence was connected to the ground wire.

The pool was devoid of any underwater lights. Other than the pump pit with the two motors, there were no other electric devices in or around the pool. The pool had been built in the 1970s. Until three years ago there had been no problems associated with the pool. The last few years complaints of swimmers receiving electric shocks began

C. The Utilities' Electrical Installation.

The troubleman and the engineer arrived. It was the same engineer that had stopped on his way home Tuesday night. We will refer to him as Engineer No. 1. This troubleman was the same one that had visited the site earlier, had found nothing, and had closed the trouble ticket.

They were brought up to date on the tests conducted that morning before they arrived. The layout of the electrical equipment was reviewed. Figure 3 shows the ten buildings surrounding the pool. Every two buildings are feed from an underground transformer. There are five transformers for the ten buildings.

The two transformers that supply power to Buildings A, B, C and D have a common feeder. This underground feeder is feed from York Road and is referred to as Circuit #5, Phase C.

Buildings E and F have an underground transformer that feeds the pool in addition to the buildings. On the same underground feeder as Building E and F are Buildings G and H. This circuit is Circuit #6, Phase B. This underground feeder is feed from a street behind the complex at the opposite end of the complex as the feeder for Buildings A, B, C, and D.

The final two buildings, J and K are feed from a third underground feeder, Circuit #6, Phase C. This underground feeder also originates from the street behind the complex.

Both circuits, Circuits # 5 and #6 originate from the same substation. Naturally the two phases, Phase B and C are also from the same substation

D. The Shocking Revelation.

It was midmorning on Thursday, July 17, the hottest day of the year thus far. The temperature this week had been in the nineties. It was approaching the high nineties and air conditioners had been left on in anticipation of the owners returning to a cool apartment that evening as they had been earlier in the week.

A request was made of the utility troubleshooter to measure the current flowing in the circuit that supplied power to Buildings A, B, C, and D, Circuit #5, Phase C. At the terminal pole, he measured 32 amperes flowing on the phase conductor. When asked to measure the return, neutral conductor, the request was treated as a strange request. The return current flow was 19 amperes.

This missing current was treated as normal. It was not unusual to have 41 percent of the continuous return current flowing uncontrolled over other conductive materials such as metallic water pipes, metallic gas pipes, earth and who knows where?

E. Utility Transformer Connection

It usually comes as a shock to electrical engineers not involved with utilities that the utilities actually solidly connect the primary return side of the distribution transformers to the secondary side neutral connection. See figure 4. The primary return, neutral terminal, PN is connected to the secondary neutral terminal, SN.

This connection of the primary to secondary is made in pole mounted, pad mounted or underground distribution transformers. This connection allows primary current to flow over the secondary neutral-ground conductor. The secondary neutral-ground conductor is grounded, earthed at the transformer, sometimes at the meter and required by the NEC to be connected to earth at the service entrance.

In addition, since the neutral is connected to all the equipment ground connections at the service entrance panel, primary current is now permitted to flow over the equipment ground circuit. Now that we know that a parallel circuit always has some amount of current in all parallel paths, do you want this primary return current flowing uncontrolled over the equipment grounding circuit?

F. The Tests.

With the arrival of the second troubleman, the two began testing the service to the pool. Connections were checked. Grounding was checked and re-checked. A load bank was applied to the swimming pool panel and no problems with conductor capacity were found. The amount of secondary current flowing into the pool panel equaled the amount of current returning to the service. There were no deficiencies in the pool panel or the feeder to the panel.

The underground primary cables were operating at 13.2 kV. They had been installed in the 70s. The trend at that time was to use bare concentric conductors. The construction consisted of the conductor having the standard semi-conducting insulation extruded over the conductors, then a layer of insulation, followed by another layer of semi-conducting insulation. Over this last layer of semi-conducting insulation bare copper conductors are spiraled.

The size of the copper conductors depends on the ampacity of the primary conductor. Number 14 AWG or larger were used. The cable lacks any outer protective jacket. This construction saved the utilities millions of dollars. However, there was no control of return current as the return current could flow through the earth. Many thought that the low impedance of the copper would "prevent" any stray current from flowing over the earth. As was pointed out above, this would be a parallel path and there would always be some current flowing through the earth.

Over the years the bare outer return conductors would corrode, become damaged and deteriorate resulting in an open circuit. Under those conditions, more uncontrolled current would be forced out over the earth, metallic water and gas piping and other conductive paths.

G. Testing Bare Concentric Neutral Conductors.

Test equipment was obtained to test the viability of the bare concentric copper neutral return conductors on the direct buried 15 kV cable. The two sections of underground cable supplying the pool transformer were tested. The section between Buildings G & H to the terminal pole, Circuit #6, Phase B was found questionable. The instrument indicated the bare concentric neutral strands had limited current carrying capacity.

A temporary bare stranded aluminum conductor was connected in parallel and draped across the trees to the terminal pole. Current measurements were made at the terminal pole.

Phase Conductor	42 Amperes
Concentric Neutral	12
Temporary Neutral	10
Unaccounted for	20 Amperes

There were five sections of 15 kV cables feeding the total complex. Only two sections were tested. It was requested of the utility company to test the other three sections for continuity of the bare concentric neutral. Three sections out of five were defective.

At this period, the utility was very cooperative. They initiated a project to replace four of the five sections in underground duct. The replacement cable used had an outer jacket. No more bare concentric copper neutral in direct contact with the earth. Most utilities have discontinued the use of the bare concentric neutral cable. In fact, there may be only one manufacturer left that still produces that type cable.

H. Timing of Shocks versus Electrical Demand.

There were no records of the date or time the previous electric shocks occurred. Vague memories, but the shocks always occurred during hot weather. During hot weather in the location under investigation, the electrical demand increases. The amount of stray, uncontrolled continuous current would be a function of the amount of current the transformers drew.

Several members did recall the electrical shocks in the previous years occurred during the hot weather. The utility declined to give out the load profile for this year. However, the interchange had the information on their web site. One could easily assume the load profile would be approximately the same for the utilities that made up the interchange. The day the first electrical shocks were reported this year was on a near record setting day for the electrical load of the interchange system.

This would explain why one did not feel an electrical shock every day; it was a function of the electrical load and the resultant leakage of the stray, uncontrolled continuous current.

I. Requests Made of the Utility.

Some would say the requests for changes to the utility electrical system were more like demands. The first request was for the utility to test all the sections of underground cable for the condition of the bare concentric neutral. This they did.

A request was made to replace all the bare underground cable with jacketed cable. Only four of the five sections of cable were replaced. Since a section of roadway would have to be crossed, the utility declined to replace that section. This was the section supplying the pool area. Since the roadway was to be re-paved the following year the final section was replaced. The utility exceeded the request by installing underground duct for all five sections of new cable.

The next request of the utility was to install an inexpensive electrical device used on farms to protect cows from electric shock. It was requested the utility install, in the underground transformer vaults, an $ 850.00 neutral blocker between the primary neutral transformer winding and the secondary neutral winding.

J. Neutral Blocker.

Neutral blockers are similar to a lightning arrester. It is placed between the primary neutral of a distribution transformer and the secondary neutral connection. See Figure 4, PN and SN terminals. The utilities connect the primary neutral to the secondary neutral. This connection allows stray, uncontrolled continuous current to flow over metallic piping, building steel, earth, etc. By installing a neutral blocker, the primary return current is prevented from flowing over the multiple connection to earth that are part of the NEC requirements.

Neutral blockers are normally used on distribution transformers serving dairy farms to eliminate the shocking potential generated by the flow of uncontrolled current over the dairy barns metallic equipment and the earth.

The utility would not even consider this option. One wondered if cows were considered a higher priority than humans were when it came to preventing electrical shocks?

K. Pool Grounding.

The pool remained closed for the rest of the summer. By now, two utility engineers were on the case. At every meeting, they concentrated on inspecting the pool grounding system. No matter how the conversation would be directed to the stray, uncontrolled flow of electric current over and through the earth, the pool grounding would be regurgitated.

Only in the last four years was there a problem with electric shocks. The pool grounding system was buried in concrete. Measurements made from several points did not show any problems. However, the pool grounding system became a major stumbling point. Finally in desperation, it was recommended to test the grounding system and the condominium association agreed.

All test prior to this were made with a volt meter or an ohmmeter, separately, never together or at the same time. An extensive testing procedure was devised. On a warm day in November the testing took place lasting for over two hours.

Not only would a ground resistance meter be used, but also at the same time the voltage would be read and the current measured.

The pool panel ground bus had be checked by the utility troublemen and had no deficiencies. It was selected as one main test point. The pool panel was located in the lower, right side of Building F.

The ground rod driven in the pump pit was selected as the second major measuring point. Finally, since the utility likes to drive a rod in the middle of the parking lot and make measurements from it, a third main point was selected. It would be a ground test rod driven in the grass plot along the parking lot. It was located 1/3 of the way between Building F and Building B.

From each of the main three ground points, test points were selected. Points around the pool such as the ladder sockets, water in the pool, center of the kiddies pool, the corners and center of the fence, etc. A total of 38 readings were taken. See Table 2.

The procedure was sent to the utility company for their comments. They declined to comment, since they felt if they commented it would infer the utility condoned and agreed to the testing and therefore would have to pay for it. The two utility engineers observed and helped with the testing. One sensitive ammeter was loaned to us.

The procedure was to test between the two points with the voltmeter first. Then the current flowing between the two points was recorded. Then the ground resistance meter was connected and the resistance measured.

The fence was chain link and no special grounding connections had been made to it. It was difficult to obtain a good connection. The values did change while we watched. We went through taking the voltage and current reading. Then we took the resistance readings. Correlation between the reading was poor.

With the exception of a ladder socket in the pool, the resistance between points was acceptable except the utility still focused on the pool grounding as the problem.

L. Testing with a Pseudo Body.

Several months later in March utility Engineer No. 2 presented a unique idea. He took an empty water cooler bottle, wedged a copper piece of metal into the neck and allowed it to extend down into the water. A wire was connected to this piece of metal. This device was floated in the empty pool simulating a person.

As the "body" floated around the pool the voltage from the float to various points in and around the pool were measured. The readings varied from 30 mV to 350 mV.

Later, after the test with the bottle, a thought occurred that since it was reported that people were receiving electric shocks while in the pool a pseudo floating body would have been better. A "body" made up of two floating water bottles with the metal strips two meters apart would have simulated a person floating in the water. Then the voltage across the "body" could have been measured and the current through the "body" recorded.

M. Summary of Stray, Uncontrolled Current.

Previously Circuit #5, Phase C and Circuit #6, Phase B current had been recorded during the summer. After four out of five underground cables had been replaced, currents reading were recorded. However, no longer was there a load available to record since the summer heat had subsided.

Table 3 is a compilation of the current readings taken at various times. The letters shown on the top row are for reference. Where letters appear on the second row, they indicate the mathematical function for that column.

On the average over 40% of the return current is flowing over the earth, metallic water and gas pipes, building steel, etc. This is acceptable practice with utilities. There is no violation of the National Electrical Safety Code (NESC). Only a very few are concern with the uncontrolled flow of stray current over the earth.

N. Utility Hard Ball.

As spring approached, the condominium members voiced concern that the pool would not be ready for opening day. Pressure was placed on the utility through a lawyer hired by the condominium association. Letters were written to the CEO of the utility from the tenants.

The utility reacted by reorganizing. Engineer No. 2 was let go and the next level of upper management replaced.

A meeting between the utility, condominium association officers and the author was held. Two new engineers and the new manager appear for the utility.

The utility's position was that they had replaced all the cable and now the facility was as it was back in the 70s. They gave the association a letter stating the utility's electrical system was satisfactory and there should be no concern.

When the subject of stray current was brought to the table, the utility stated it was not debatable and the subject would not be discussed. When asked if they would supply readings of the phase and neutral return current for each of the circuits, the answer was a definite NO.

O. The Following Summer.

The pool was re-opened. A form was prepared for the lifeguard to fill out should anyone report any electrical shocks. The summer lacked any series of heat scorching days that lasted for three or four days straight. The summer failed to produce any reported incidents.

IV. EXAMINATION OF THE FINDINGS

With the data collected, it is time to examine the findings to see if a solution to resolving the electrical shocks in the swimming pool can be reached.

A. The National Electrical Safety Code.

One must be careful to analyze the whole National Electrical Safety Code (NESC) with regards to the subject of grounding. This paper will touch on only the salient points.

The NESC requires: "On multi-grounded systems, the primary and secondary neutrals should be interconnected. . ." Industrial facilities do not interconnect the primary and secondary neutrals of transformers. There are no adverse results. However, separate neutral and ground conductors are used.

In addition, the NESC permits the combining of the neutral and the ground conductor. (Rule 97D2) Some NEC Making Panels have eliminated this dangerous practice. The NESC requires the neutral-ground conductor to be grounded four times per 1.6 km (mile). (Rule 97C) In addition, the neutral-ground conductor must be earthed at each transformer and lightning arrester.

The service drop or service entrance conductors have the neutral and the ground combined, which contributes to the unsafe continuous flow of stray uncontrolled current over the earth.

From the multiplicity of connections to earth of the neutral and the application of Ohms Law and parallel circuits, excessive current is flowing over the earth.

B. The National Electrical Code.

The National Electrical Code (NEC) requires the service entrance to have the neutral connected to earth. In addition to the secondary connection to earth at the transformer, there may be a connection of the neutral to earth at the meter enclosure. The connection of the equipment ground to the neutral at the service entrance, which in turn is connected to the primary neutral connection at the transformer, allows primary current to flow uncontrolled over the equipment ground conductor.

C. Current Measurements at the Condominium.

The current measurements of the phase and return neutral currents flowing on the three circuits have been documented. Over 40% of the return current is flowing uncontrolled over the earth. How and why is it flowing into the swimming pool needs to be resolved.

D. Function of Temperature.

One would expect in the Northeast United States that the peak electrical load would occur during the summer months. This was confirmed with the comparisons of the summer and fall current readings, see Table 3.

With the increase in temperature, the stray, uncontrolled current would also increase. The human body immersed in conductive water loses its resistance to current flow. The majority of the resistance to the flow of electric current is in the first layer of dead. Dry skin.

When the level of stray current reaches the point where the current flow through the human body is above the level of sensitivity, 0.003 to 0.004 amperes, the person can feel the stray current.

E. Phasing

Buildings A, B, C and D surround the pool. They are connected to phase C.

Buildings J and K are also connected to phase C.

However, Building F and G, H, and E are connected to phase B.

Is it conceivable that the neutral phase C current is flowing into the pool and onto phase B neutral conductor?

Time has not permitted the study of this possibility. In addition, the client no longer is funding any additional studies of the shocking pool situation. The vector solution would make an excellent practical problem for an electrical engineering class to solve.

V. CONCLUSIONS

The unhealthy practice of the National Electrical Safety Code requiring the connection of the primary neutral to the secondary neutral in distribution transformers results in the flow of uncontrolled continuous current over the earth. This flow of uncontrolled current over metallic water and gas piping, building steel and other conductive materials results in electrical shocks to humans and livestock, particularly cows preventing them from discharging their milk, leading to mastitis and then death.

The NESC requirement permitting the combining of the neutral and ground conductor into one conductor and requiring the multiple connections to earth results in stray current flowing uncontrolled over the earth and other conducting materials. The practice of combining two functions into one conductor has saved the utilities millions and millions of dollars. European countries prohibit such practice. A few of the NEC Making Panels have recognized the hazards of this unsafe practice and now require marinas, trailers, ranges and dryers to be wired with separate neutral and ground conductors.

The reluctance of other National Electrical Code Making Panels to continue to accept the concept of allowing the combining of the neutral and the ground functions into one conductor is appalling.

The flow of uncontrolled current can be stopped by the application of solid state, neutral blockers installed between the primary neutral and the secondary neutral connection.

The NESC and the NEC requires the neutral and ground to be combined into one conductor for services to buildings. A proposal to allow, if requested by the owner, separate conductors for each function, was unanimously rejected during the 1999 Code cycle. The NESC also rejected the same proposal and it will be seven years before the NESC is revised in the year 2007.

A letter was sent to the Vice-president of the NFPA-NEC and to the Chair of the NESC requesting a joint meeting to resolve the interface, service problem. It was suggested the joint meeting be held so that the modification suggested by the joint meeting could be incorporated into the 1999 NEC and the 2002 NESC. The idea was rejected by both parties. Pressure should be applied to both the NESC and the NEC for such a meeting.

As for the swimming pool, it is envisioned the electric shocks will occur when the temperature rises to the mid-nineties and remains there for an extended time. Hopefully, the tenants will turn on their electrical appliances, which should result in the current to the transformers increasing to approximately 22 amperes per transformer. At this point, it is expected the swimming pool will have a sufficient amount of stray, uncontrolled continuous current flow that will result in shocks to the bathers.

If the engineering and public community exert pressure on the NESC and the NEC, this unsafe practice of allowing stray, uncontrolled flow of continuous current over the earth, metallic water and gas piping, building steel and other conductive items, could be eliminated.

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10 A	
9	
8	
7	Severe burns, not fatal unless vital organs burned.
6	
5	
4	______________________________
3	
2	
1 A	
900 mA	
800	Heart stops during shock. May restart if
700	current is removed before death occurs.
600	
500	
400	
300	______________________________
200	
100 mA	
90	Heart fibrillation in 1 to 4 seconds –
80	usually fatal.
70	
60	______________________________
50	
40	Breathing Stops – often fatal.
30	______________________________
20	Cannot let go – Current may increase to
10 mA	fatal level______________________
9	Painful sensation. Individual can let go –
8	___ muscular control is NOT lost. ___________
7	
6	Sensation of shock. Not painful
5	___ GFCI setting. Maximum harmless current
4	intensity
3	______________________________
2	Mild sensation
1 mA	______________________________
900 µA	
800	
700	Imperceptible
600	
500	____ UL Limit for consumer products ________
400	
300	
200	
100 µA	UL Limit for hospital equipment not connected directly to patient

Chart 1
Value of Current Resulting in Human Reaction

Figure 2
Typical Body Resistances

Figure 5
Resistance Test Points and Readings

VITA

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For the next 14 years he was with FMC Corporation in their Engineering Service organization, functioning as an Electrical Engineering Consultant, responsible for providing electrical design of new facilities and consulting service to the total corporation, both chemical and mechanical groups.

He is a registered Professional Engineer. He represents the IEEE on the National Electrical Code Making Panel #14, Hazardous Locations, the Lightning Standard NFPA 780 and is a member of the International Association of Electrical Inspectors. He serves on the National Electrical Safety Code, Grounding Subcommittee.

He has served on many IEEE committees, participated in the color books, and standards groups, including the Standards Board. He is a member of the IEEE USAB COMAR, Committee On Man And Radiation, and Standards Correlating Committee #28, Non-Ionization Radiation. Mr. Zipse received the Standards Medallion for his work in and promoting standards.

He has published many technical papers on such diverse and controversial subjects as Unity Plus Motors, Computers, Neutral to Ground Faults, NEC Wire Tables, Health Effects of Electrical and Magnetic Fields, Measuring Electrical and Magnetic Fields, Lightning Protection Systems: Advantages and Disadvantages and has participated on National Electrical Code panels and in teaching the Code.

For the last five years, he has been President of Zipse Electrical Engineering, a consulting firm.

Figure 4
Transformer Connections

B	C	D	E	F	G	H	I	J	K
				D-E	F/D			I/D	J*F
Readings Thursday, July 17, 1997									
							Assume		
Phase	**Buildings**	**Current**			**Percent**		**Summer Peak Loading**		
	Served	**Phase**	**Neutral**	**Missing**	**UnCtrl**		**Amps**	**F(x)**	**Uncontrolled**
		Amps	Amps	Amps	%		Amps		Amps
C	A, B, C, D	32	19	13	40.6%	Reading Taken 10:30 am	45	1.4	**18.3**
B	E, F, G, H	42	22	20	47.6%	Reading Taken 4:00 pm	45	1.1	**21.4**
C	J, K	0	0	0		No Reading Taken			
	Totals =	74	41	33	**44.6%**				
Readings, Friday, October 3, 1997									
After replacement of 4 out of 5 cables									
							Assume		
Phase	**Buildings**		**Current**		**Percent**		**Summer Peak Loading**		
	Served	**Phase**	**Neutral**	**Missing**	**UnCtrl**		**Amps**	**F(x)**	**Uncontrolled**
		Amps	Amps	Amps	%		Amps		Amps
C	A, B, C, D	8.9	5.3	3.6	40.4%		45	5.1	**18.2**
B	E, F, G, H	8.1	3.4	4.7	58.0%		45	5.6	**26.1**
C	J, K	4.8	3.8	1	20.8%		22.5	4.7	**4.7**
	Totals =	**21.8**	**12.5**	**9.3**	**42.7%**				

Table 3
Compilation of Current Readings