Use of Automatic Disconnects on Residential Electric Service Drops

in the St. Joseph Missouri Fire Department

Fire Prevention Program

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: ____

Abstract

The problem is that the St. Joseph Missouri Fire Department jurisdiction experienced ice storms that set in motion a sequence of events that resulted in structure fires at the electrical service entry point. The purpose of this research was to examine the requirements of an automatic electrical disconnect device for residential service drops. A descriptive research method was used to answer the following questions. What is the definition and purpose of an automatic electrical disconnect? What are the requirements of other organizations concerning the use of an automatic electrical disconnect? How would an automatic electrical disconnect be applied to a residential electrical service? What are the conditions and circumstances under which an automatic electrical disconnect would operate?

Procedures included literature review of accident prevention theory. A review of St. Joseph Fire Department alarm reports was conducted in addition to a survey of company officers and shift commanders. Interviews were conducted with representatives from an electrical component manufacturer and utility companies. Internet searches were examined for technical requirements and restrictions.

The results revealed that at least one engineering innovation, Storm-Safe® by Homac, was available to address electrical service fires caused by ice storms. This device met the technical requirements of organizations and has been on the market since mid-summer of 2007. Storm-Safe® appeared to meet the theoretical criteria in accident prevention.

Recommendations were that the St. Joseph Fire Department revise alarm reporting procedures, and take a lead role in engaging the community. Government and Business partnerships including the St. Joseph Fire Department, Kansas City Power and Light, Thomas

and Betts Corporation, and neighborhood groups need to explore the possibility of installing Storm-Safe®, or a similar device, on a test basis.

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Introduction

St. Joseph has experienced several ice storms each year. Severe ice storms cause tree limbs to break, falling on electrical service drops. This pulls the mast with weather head from the structure usually along with the meter and meter base. This failure causes fires in the wall near the meter base connection. St. Joseph experienced a severe ice storm December 10, 2007, resulting in 46 calls for power line down, 27 calls for arcing shorted electrical equipment, and 10 building fires. The problem is that residential structure fires are started by energized electrical service wires during ice storms.

The purpose of this research is to examine the requirements of an automatic electrical disconnect for residential service drops in the St. Joseph Missouri Fire Department's jurisdiction. This research will use a descriptive method and attempt to answer the following questions:

- What is the definition and purpose of an automatic electrical disconnect?
- What are the requirements of other organizations concerning the use of automatic electrical disconnects?
- How would an automatic disconnect be applied to a residential electrical service?
- What are the conditions and circumstances under which an automatic electrical disconnect would operate?

Background and Significance

St. Joseph lies in the northwest corner of Missouri along the Kansas border, approximately 50 miles north of Kansas City. The city encompasses 44 square miles and, according to United States Census estimates for 2005-2007 (2000), is home to 73,476 residents. The St. Joseph Fire Department has 134 personnel with 124 in suppression, 4 in prevention, 2 in training, 2 in maintenance, and 2 in administration. The fire department staffs seven engine companies, two truck companies, one light rescue company and one brush truck, on a 24-hour/48-hour shift rotation. St. Joseph has a combined dispatch center for police, fire, and county sheriff. Four dispatchers are on duty to take emergency calls, routine calls, monitor incidents, initiate documentation, and dispatch responders.

Because of St. Joseph's location and climate, the city is subject to numerous ice storms each winter. Heidorn (2001) described the conditions required for an ice storm to occur. A moist warm air mass collides with a cold front and a wedge of warm air is centered in a vertical column of air. As the moist warm air rises into the cooler air, the moisture freezes into crystals forming snowflakes. Now too heavy to stay aloft, the snow falls back through the warm air, melting into rain. As the raindrops continue to fall, they enter the bottom layer of cold air, super-cooling the rain drops. These water droplets are below 32° F but remain a liquid until striking an object. Difficulties in measuring the temperatures in a vertical column make the prediction of ice storms challenging.

Recent ice storms in St. Joseph date 11/29/06, 12/1/07, and 12/10/07. A disaster declaration was issued for the ice storm of 12/10/07. An ice storm declaration was also issued for St. Joseph in 1994. In December of 2008, ice was in the forecast for 7 days. An appreciable amount of ice did accumulate on the evening of December 18^{th} and on December 26^{th}.

The accumulation of ice on overhead electrical services and surrounding trees sets the stage for a sequence of events which has resulted in several structure fires, and has the potential for starting hundreds of fires during severe ice storm events. Overhead service drops, that portion of wire with connectors between the closest utility pole and the structure, become overstressed due to the additional weight of ice. Nearby trees, also laden with ice, snap and fall striking these already stressed service drops, many times causing a collapse. This collapse results in the insulated anchor being pulled from the structure along with the weather head, mast, and meter with meter base. Energized electrical lines become damaged at the juncture between the external meter base and the internal service panel, initiating combustion in the wall of the residence.

Figure 1

Figure 1 is a photograph representing the customer's side of a residential service drop. This installation is less than one year old and replaced a similar configuration that was destroyed by a high wind event. At the lower left of Figure 1, is the meter with a glass cover. It is mounted in a square metal box called a meter base, which is fastened to the structure. Coming up from the meter base is a metal conduit called a mast, which is fastened to the wood exterior. Fastened at the top of the mast is a weather head. The wires exit the weather head and at a point near the top center of the photograph, the wires are connected to the electrical supply wires. Near the top right corner of this photo is an insulated anchor screwed in at the corner of the residence. It is this anchor that holds the tension and weight of the wires.

This research is significant because of the potential damage from fires during an ice storm event. St. Joseph has thousands of residential electric customers with overhead service drops. The three shift commanders reported a total of six residential structure fires started by collapsed energized service drops during the December 10, 2007 ice storm. Energized power lines between the structure and the utility pole collapsed to the ground, which endangered bystanders and responders. Physical damage due to the weather head, mast and meter base being torn from the structure, required significant time to repair, which resulted in lengthened power restoration time. Power restoration time was significant because the ice storm in December 2007 was followed by several inches of snow and a week of single digit temperatures.

Also of significance is that the timing of these structure fires occurred during a period of work overload for responders. Fire units were overwhelmed with requests for medical assistance due to falls, vehicle collisions, and calls to other structure fires started by improper alternative heating. The number of responding units to structure fires was less than normal as fire units were busy at other calls. Alarm reports indicated that the St. Joseph Fire Department responded to 280 calls for service in the first 60 hours of the December 10th, 2007 ice storm event. Personnel that did respond were exhausted from prior calls for service. Just the act of walking was hazardous due to ice-covered surfaces.

Ice storms will continue to be a part of St. Joseph's future, presenting the same problems as they have in the past. Damage significant enough to have federal disaster declarations and severe enough to initiate combustion in multiple structures deserves scrutiny.

The United States Fire Administration has, as one of five objectives, to promote within communities a comprehensive, multi-hazard risk-reduction plan led by the fire service organization (USFA, 2008). This research should provide direction for the St. Joseph Fire Department Prevention Division, and the City of St. Joseph Emergency Management Director, in mitigation planning for ice storms. Implementation of an automatic electrical disconnect installation program would meet one strategy of the National Fire Academy course Strategies for

Community Risk Reduction. This strategy is to focus on reducing fire risk in the local community (USFA, 2008).

Literature Review

Weather conditions converged that were conducive to an ice storm event, which set in motion a sequence of events that led to structure fires started by electric service drop failures. Event sequencing analysis has been used in the medical field for accident and injury prevention. Harriss (2004), reported on the domino theory of accident causation. While the report stated that there are various domino theories, the report focused on the work of H.W. Heinrich. This theory of scientific analysis dates back to 1931, however it is still being used. Heinrich (1959), likened this sequence of events to five dominos, each placed on end and positioned so that when the first domino fell, it would in turn, strike the next until the injury occurred. Theoretically, the removal a domino would result in injury prevention.

The fifth domino in this theory represented the injury. The fourth domino represented the accident. The third domino represented the accident or mechanical/physical hazard. Heinrich believed it is this third domino that is the pivotal domino that needed to be addressed for accident prevention.

Heinrich claimed that identifying the cause and possible solutions is pointless unless an intervention plan is implemented. In several places in Heinrich's work, he emphasized the use of engineering revision and that this remedy should be considered first. "Foolproof the task mechanically when possible and then proceed with control of personal unsafe action" (Heinrich, 1959, p. 73).

This axiom was also shared by Haddon (USFA, 2008), that held there should be a paradigm shift away from education as the first and foremost intervention method. Haddon wrote that changes in the environment, combined with multi-strategic interventions, needed to be emphasized. Hadden believed that injury is the result of an agent or energy applied to a host in an amount or rate in excess of that host's ability to safely absorb. Events that preceded the injury were described as phases. Haddon (1973), offered ten countermeasures as brainstorming tools, to assist policymakers in analysis and management of hazards that precipitated injury.

The first seven countermeasures focused on the agent or energy. The last three countermeasures dealt with host resistance, damage detection and repair. The first three countermeasures were applicable to this research. The first was to prevent the creation of the hazard. The second was to reduce the amount of the hazard. The third was to prevent the release of the hazard.

Kirtley (2008), like Haddon and Heinrich, espoused engineering modifications as a method of risk reduction. Engineering is one of Kirtley's five E's, which also include education, enforcement, emergency response, and economic incentives. These five E's represent mitigation strategies, and the more strategies employed, the more likely that mitigation will be successful. The passive nature, no action required by the resident, of revised engineering is a key element for successful engineering mitigation. Equally important as the five E's is community engagement. Vitally important is the engagement of those stakeholders exposed to the negative impact of the risk.

Heinrich questioned whose responsibility is accident prevention and held that it rested primarily with supervisors and managers. Kirtley claimed that the Fire Department's role should include an all-hazards approach to accident prevention.

After an explanation of the purpose of this research to a Kansas City Power & Light representative, this author interviewed KCP&L Electrical Engineer Scott Pemberton. Mr. Pemberton has thirteen years experience as an electrical engineer. Eight have been with AMEREN Power Corporation in the St. Louis, Missouri area, followed by five years experience with Aquila, now owned and operated by KCP&L. Most of Mr. Pemberton's experience has dealt with substations, but he was present and is well aware of the issues surrounding the St. Joseph 2007 ice storm disaster. Mr. Pemberton provided the specifications for present installation requirements on residential electric service. He provided requirements that would be placed on an automatic electrical disconnect device and insight into a utility companies concerns about such a device. Mr. Pemberton offered additional avenues for this researcher to follow for more information.

Requirements for electrical equipment, conductors, connectors and devices can often be found in regulatory codes like the National Electric Code (NEC). The NEC does not address the equipment provided by the electric utility company. Codes, and the authority to adopt codes, falls to the local political jurisdiction.

Enforcement, one of the five E's in Kirtley's work, is accomplished with the authority the State of Missouri has given local governments to adopt by reference, fire and building codes. Missouri Revised Statute (State of Missouri) 67.280 gives the City of St. Joseph the authority to adopt and enforce technical codes. The 2004 National Electric Code has been adopted by the City of St. Joseph, but the NEC addresses criteria inward from the service mast only, not for equipment from the mast to the electric supply source.

RsMo (Missouri Revised Statute) 67.1832.1 stated that political subdivisions would consent and authorize public right-of-way to do business with public utilities. This statute further stated "…provided that no political subdivision shall require any conditions that are inconsistent with the rules and regulations of the Federal Energy Regulatory Commission, United states Department of Transportation, Federal Communications Commission or the Missouri public service commission." The City of St. Joseph does not have the legal jurisdiction to require KCP&L to add engineering innovations to be installed on electrical service drops.

RsMo 386.310 however, granted the Public Service Commission of the State of Missouri the power to require the use of appropriate safety devices to promote the safety of its employees, customers and the public. An electrical safety device required by the Public Service Commission would meet the requirements under RsMo 67.1832 in the preceding paragraph and address the specification issue.

Homac (2007), a division of Thomas & Betts Incorporated, has developed and patented a product called Storm-Safe®. This product is designed to fasten to the utility pole, providing an electrical service drop connection with a leak link. Should for any reason, the stress on the service drop exceeds 500 pounds, Storm-Safe® will activate. This will allow the service drop to fall from the pole de-energized. Storm-Safe® is available in a 750-pound activation version and both are available in a single or multiple service configuration.

Thomas & Betts Products Manager Marc Salerno was interviewed by telephone. He explained why Storm-Safe® was developed and how it is applied to the electrical service drop. Marc detailed information concerning technical requirements and test results. This interview included information about how and when Storm-Safe® would operate and the ease of power restoration.

With a well-defined problem, this literature review started with current references in the accident and injury prevention field, in an effort to apply scientific method to the prevention analysis. Current sources, Harriss (2004) and USFA (2008) based their work on theories presented decades ago by Heinrich (1959) and Haddon (1973). Phases, event sequencing, and the domino theory all indicated that intervention at a point prior to the accident would prevent the injury. Intervention strategies offered by Heinrich (1959), and Kirtley (2008), favored the use of engineering, although it was to be combined with other mitigation strategies.

Engineering alternatives, in relationship to an automatic electric service drop disconnect, led to conversations with utility delivery representatives, research and development electrical engineers, a private sector electrical component manufacturer, and an independent testing laboratory representative.

Procedures

In an effort to document the scope of this problem, a computer query of St. Joseph fire alarm reports between December 10th and December 16th, 2007 was processed. The results were then filtered to show only those calls for lines down, arcing electrical equipment, and structure fires. A poll of the St. Joseph Fire Department's three shift commanders, which respond to all structure fires on their respective shifts, was taken on November 7th, 2008. Two questions were asked: How many structure fires did you respond to during the ice storm event December 10 through December 16, 2007, that were started by the meter base being pulled from the structure? At those fires, how serious was the fire damage?

A poll was taken of St. Joseph Fire Department's Captains, on November 6th and 7th, 2007. Two shifts at Fire Headquarters for meetings were asked: To the best of your recollection, on the calls you responded to for lines down and arcing electrical equipment, what percentage involved problems with the electrical service drop at residences? The remaining shift Captains were asked the same question by telephone December 23rd, 2008. There are eleven Captains per shift for a total of 33 Captains.

The definition of automatic electrical service disconnect was found by referencing one word at a time in Webster's New World Dictionary (Guralnik, 1980). The purpose for this device is found in the literature review of prevention theory and in the interview of Marc Salerno.

The requirements of other organizations to use an automatic electric service disconnect were addressed in the interview of Electrical Engineer Scott Pemberton with KCP&L. Scott's concerns were mirrored by those concerns of Tom Jones, Electrical Engineer of the research and development department with American Electric Power.

This device must have the potential to prevent the ignition at the end of the event sequence. Groundwork from the medical field in accident and injury prevention was presented and applied to the event sequence during an ice storm that had resulted in structure fires. Literature review in both the medical field and fire prevention field, revealed exactly where a disconnect device would fit in the overall scheme of electric service delivery and fire prevention during ice storm events.

Implementation strategies, other than engineering innovations, are not part of this research. Application of a disconnect device must not conflict with safety codes or state statues. A brief overview of state statutes was offered to cover jurisdictional authority to regulate an electrical utility. This author relied on the expert opinion of electrical engineers concerning possible requirements and conflicts in regard to the National Electric Safety Code.

To search for the requirements of a device that would serve as an automatic electrical service disconnect, this author interviewed Electrical Engineer Scott Pemberton with the local electric utility company, Kansas City Power and Light. This two-hour interview started at 10:00 the morning of September 29, 2008, in the KCP&L offices located at 613 Atchison St., St. Joseph, Missouri. Scott Pemberton holds a Bachelors of Electrical Engineering Degree from the University of Missouri, and is a registered Professional Engineer. He has worked in the electric power delivery industry for thirteen years, the most recent five of those years in St. Joseph. Questions asked were: Approximately how many residential customers does KCP&L have in St. Joseph and, what percentage do you estimate have overhead service? This question was asked to help determine the size of the potential problem. What are the material specifications for a typical overhead service drop at a residence? This question was asked to acquire technical requirements for a disconnect used in this application. Do you know of any device that would allow for a complete sever of the overhead service drop when struck by a falling limb? This question was asked to find the existence of device so this author could review technical specifications. The next four questions were asked to ascertain what requirements an automatic electrical disconnect needed to meet that were not technical in nature, that applied to a local application, and addressed motivational requirements. What concerns do you have about the use of such a device? What minimum requirements would a hypothetical device have, that would enable KCP&L to consider installation? To your knowledge, is there any safety code that would prohibit the use of a service-disconnecting device? What would be the advantages and disadvantages for KCP&L to use an automatic disconnect device on service drops? If you were researching such a device, where would you look for information? This question was asked to assist this author to delve into a foreign discipline.

The Pemberton interview led to Internet searches of electrical component manufacturers' catalogues. The interview also resulted with leads to Tom Jones and Steve Early, both electrical engineers in the research and development department of American Electric Power (AEP), based in Ohio. This company provides power in eleven states and has over five million customers. Because of its size and the climates in which AEP provides electric power, Mr. Pemberton of KCP&L believed the research and development of AEP would be the most knowledgeable in this area of research.

Tom Jones is the Corporate Technology Development Manager with American Electric Power. In a telephone conversation with Mr. Jones on October 16th, 2008 at 2:00 pm, the following questions were asked: What devices are available for automatic electric service disconnect on residential overhead services? What concerns do you have about the use of such a device?

KCP&L and AEP representatives were not aware of any device available to automatically disconnect an overhead electric service drop and an Internet search showed no results. This author started design work and solicited assistance from the Technology Department at Missouri Western State University (MWSU). Dr. Varma at MWSU was excited about the project and offered their assistance with specifications and testing. This early in the design work, Dr. Varma, the Technology Department Chair, suggested that another search for an existing device should be performed at a large electrical component distributor.

A trip on October 8, 2008, to Kritz-Davis, a large electrical equipment distributor in St. Joseph, revealed that Jason Barnes in utility sales did have knowledge of a single device designed for residential application. Jason provided the web address for Homac, the suppliers of Storm-Safe®. Jason also provided printed material from the web site and followed-up the next day with an email to this author concerning package pricing information. After unsuccessful attempts to telephone and email Homac using the information on the web page, Jason provided the name and phone number of his supplier, Marilyn Miller.

Marilyn explained that the firm Thomas & Betts now owns Homac. Marilyn also provided the contact Mr. Dwayne Ginn, who in turn provided the contact Mr. Marc Salerno, the Product Manager at Thomas & Betts. In a telephone interview December 10, 2008, Mr. Salerno was asked the following questions. What is the application of Storm-Safe® on residential service drops? This question was asked to ascertain that Storm-Safe® design was appropriate for this research. What are the technical specifications for Storm-Safe® and do these specifications meet national electrical requirements? This question was asked to compare Storm-Safe® with the requirements of other organizations. Under what circumstances would Storm-Safe® operate? This question was asked to analyze the functionality of Storm-Safe® in relationship to the ice storm problem in St. Joseph. Marc promised to mail a computer disc containing test data files, testing materials, testing procedures, test specifications, a field test video, and a Power Point® presentation. This author requested written permission to reprint the test data supplied on the computer disc. The disc arrived December 16, 2008, and an email granting permission to reprint test data was received January 20, 2009.

The National Electric Energy Testing, Research and Applications Center (NEETRAC) prepared one of the test data files on the computer disc. The document was titled NEETRAC Project #06-208, April 2007, Impact Tests for Homac Storm-Safe® Connectors. Richard Heartlin, from NEETRAC, called this author on December 24,2008, in response to a request to reprint the test documents. Richard stated that the test documents were the property of Homac and permission to reprint them would need to come from Homac.

How the device is applied to the residence is addressed from the Homac web page that was provided by Jason Barnes of Kritz-Davis, the electric component distributor in St. Joseph, Missouri. One of the links on the Homac web page is New Products. Selection of this link shows Storm-Safe® with a link for a detailed installation process.

The conditions and circumstances under which an automatic electric service disconnect would operate is also described on the Homac web page. On Homac's home page is a link for new products. Selecting this link will bring up a Storm-Safe® web page. Included is a field demonstration video link.

Limitations for this research started with a lack of detailed information on the alarm reports preventing an accurate picture of the problem. These alarm reports are only the calls to which the St. Joseph Fire Department responded. During the December 10th, 2007 ice storm event, dispatchers were instructed not to send a fire unit for wires just lying on the ground. Non-arcing wires and wires causing no immediate threat were logged in a book given to Aquila, now owned by KCP&L. That log is unavailable. The phone system in the St. Joseph's 911 Emergency Communications Center at that time had no equipment to record the number of 911 calls that were not answered due to the line being busy. It is a common occurrence, during ice storm events, that all the 911 phone lines coming into the communications center are busy. The number of unanswered calls is unknown. There are an unknown number of residential electrical customers who experienced a service line collapse, and simply called KCP&L themselves.

The searches for an automatic electric service disconnect resulted in only one device being found. With the exception of one outside testing agency, all of the information on Storm-Safe® came from Homac employees, or the Homac web page. There is not a community that has installed a hundred of these devices and recorded the results over several years.

An engineered weak link is not new. Research material is available for bolts designed to shear such as those on fire hydrants and metal utility poles. Material is available on electric breakers and fuses designed to de-energize electrical equipment. By contrast, an electric service drop disconnect is so new that utility company representatives, even those in research and development, are just becoming aware of the device.

Definitions

ANSI – American National Standards Institute

Amp – ampere; the standard unit for measuring the strength of an electric current; the rate of flow of charge in a conductor or conducting medium of one coulomb per second

Coulomb – the meter-kilogram-second unit of electric charge equal in magnitude to the charge of 6.25×10^{18}; charge transported through a conductor by a current of one ampere flowing for one second

NEC – National Electric Code

NEETRAC - National Electric Energy Testing, Research & Applications Center, of the Georgia Institute of Technology

RsMo – Revised Missouri Statute

Volt – the practical mks unit of electromotive force or difference in potential between two points in an electric field that requires one joule of work to move a positive charge of one coulomb from the point of lower potential to a point of higher potential

Results

An automatic electrical disconnect, each word as defined individually by Guralnik (1980), is (a) automatic: moving, operating by itself; (b) electrical: connected to electricity; and (c) disconnect: separate, detach, unplug. An automatic electrical service disconnect device would by definition, operate mechanically without any human action. This device would mechanically unplug electrical conductors used at the service delivery point, de-energizing equipment prior to the point of ignition.

The theoretical purpose of an automatic electrical service disconnect would be to interrupt the sequence of events started by an ice storm breaking trees that fall on service drops. The subsequent failure of residential electrical service mast with weather head has caused fires when energized electrical equipment in the meter base initiated a fire in the nearby wall. An interruption of electrical current would prevent fires initiated by physical damage to service equipment.

Appling the domino theory, an automatic electrical disconnect device would remove a critical domino from the sequence of falling dominos, reducing the number of electrical fires started by electrical delivery equipment failures during ice storm events. This disconnect device would be an engineering innovation used as a mitigation strategy. Using Heinrich’s domino theory, the fifth domino, the injury, would be the fire starting in the wall near the service entrance. The fourth domino, the accident domino, would be the mast and weather head being pulled from its anchors on the structure and collapsing. The third domino, the unsafe act or physical hazard, would represent the well secured energized conductors of the electrical service drop being struck by an ice laden tree limb.

Mr. Pemberton estimated that KCP&L has approximately 45,000 residential customers and that about 60% of those have overhead service drops. The installation of these service drops adhere to the specifications set forth in the National Electrical Safety Code published by the Institute of Electrical and Electronics Engineers. The typical residential service in St. Joseph is for 200 amps, 120/240 volts, using 1/0 aluminum wire using connectors and anchors that are matched to this rating. Two of these three 1/0 wires are insulated. The third wire, also used to hold tension on the service drop, is not insulated and has a steel core. This tension wire fastens securely at one end to the utility pole and the other end to the residence to hold the weight of the wire at a minimum specified distance from the ground. Allowances are made for increases in temperature that cause the wire to expand and sag.

To Mr. Pemberton's knowledge, there is no device available that would de-energize or automatically disconnect a residential service when struck by falling limbs as occurred during St. Joseph's December 2007 ice event. To his knowledge, there is no portion of the National Electric Safety Code that would prevent a disconnect device from being installed provided the device met certain criteria. The device would be required to have a 600-volt rating and carry 125% of the continuous load rating while not exceeding 90° Celsius.

Mr. Pemberton's concerns about using an automatic disconnect device were that it (a) must operate reliably, (b) be consistent in performance, and (c) allow for a complete, not partial, sever of the connection. The benefits of an automatic electrical disconnect would, for the most part, be for the customer. During a large-scale event such as the December 2007 ice storm, the number of calls for KCP&L would remain the same, even with the installation of the device. The same number of limbs would fall, and there would be the same number of service failures to repair. The benefit would be less damage to the structure, weather head, mast and fewer resulting fires. Any time-savings for power restoration or other cost savings would require further research.

A disadvantage, according to Mr. Pemberton, would be the cost of materials and installation. A systematic retrofit based on high hazard areas is interesting but cost estimates impossible because the device is hypothetical. Of interest to Mr. Pemberton and noteworthy was the notion that the number of customers without power could increase with the installation of an automatic electrical disconnect. Certainly, during the ice storm, there were residents with their service drop on the ground with mast and meter base pulled from the structure, that still had power with no resulting fire. There were also occasions were tree limbs fell, brushed the service drop but caused no structural or power failure.

For additional sources of information, Mr. Pemberton suggested this author contact American Electric Power (AEP). This utility firm supplies electricity in several states and to millions of customers. AEP serves states with a history of ice storms and has an extensive research and development program. Corporate headquarters for AEP is in Ohio. Another source of information he suggested was the manufactures of currently used connectors.

AEP Corporate Technology Development Manager Tom Jones, spoke briefly on the telephone with this author concerning an automatic electric disconnect device. Mr. Jones stated that he was unaware of any device presently available that would prevent the damage associated with energized service drops being torn from the structure by weather events. AEP serves 11 states and has over 5 million customers. Mr. Jones stated that a device that prevented this damage with subsequent fires was definitely needed, and he expressed an interest in assisting with design work. His concerns were with the device being able to carry the electrical duty load, break all three conductors cleanly, and break only when it was supposed to break. Mr. Jones forwarded my request for information to Steve Early, an engineer with AEP more familiar with residential service drop issues. Mr. Early phoned this author the next day with a result he had found with an Internet search.

Kritz-Davis, a local wholesale electric supply dealer in St. Joseph, knew of a device that was designed specifically for the use described in this research. Personnel there provided a printed hard copy and the web page address for Homac (2007). This company has the patent and distributes a device called Storm-Safe®. This is the same device Mr. Early of AEP reported.

Homac's product Storm-Safe® has a configuration for a single, double, or triple service drop application. A pin block designed for plug-in type wire connectors is securely attached to the utility pole. The non-insulated wire is still used for tensioning but is attached to the pole with a link designed to fail at 500 pounds or 750 pounds. The connection at the residential end of the service drop remains unchanged. Storm-Safe® is designed so that when an object such as an ice-laden tree limb strikes the service drop with enough force, 500 pounds of kinetic energy for the 500-pound model, the link on the tension wire fails. As the service drop falls, the wires simply unplug from the pin block on the pole. When the wires reach the ground, they have already been de-energized.

Any force exerted on the Storm-Safe® equipped electric service drop that exceeds the strength of the engineered weak link, would activate Storm-Safe®, and allow the de-energized service drop to fall. Ice storms are not the only event that would cause Storm-Safe® to activate.

Figure 2, used by permission of Thomas & Betts Corporation, copyright 2006/2007, all rights reserved, is a photograph depicting a Storm-Safe® installation with a multiple service drop configuration. Note the hairpin like devices that hold the tension on the service drop.

Figure 2

Each service drop has it's own mechanical breakaway, so if one service drop falls, the remaining service drop stays in service.

Properly installed, Storm-Safe® would mechanically breakaway prior to structural damage and power could be quickly restored. On Homac's web page was found a link for a video demonstration of Storm-Safe® application. Also found on the web page were parts information, installation instructions, and pricing information.

In a telephone interview, Thomas & Betts Product Manager Marc Salerno stated that Storm-Safe® has been on the market about two years. It was designed for residential service drops to breakaway de-energized when a tree falls or due to ice loading. This results in increased safety and prevents the weather head and mast from being ripped from the structure. An added benefit is quick power restoration. Mr. Salerno stated that Storm-Safe® had passed tests to meet the criteria in ANSI C 119.4-2004. Additional tests were performed to ensure that Storm-Safe® would function as designed. Mr. Salerno then mailed to this author a computer disc containing test results that had been performed on the Storm-Safe device. The first was a field test recorded on a brief video. The other tests included load tests, temperature tests, testing procedures, and the test results from an off site laboratory, National Electric Energy Testing, Research & Applications Center (NEETRAC).

NEETRAC is a research center of the Georgia Institute of Technology. Storm-Safe® testing at NEETRAC, project #06-208, centered on the conductors and the pin block into which the conductors are plugged. Testing methods, procedures, instruments and standards used were described. This author spoke with Richard Heartlin of NEETRAC. Mr. Heartlin did confirm that Storm-Safe® passed testing pertaining to ANSI C 119.4-2004. This American National Standards Institute requirement deals with the temperature of conductors while under electrical current load. Test documents have been used by permission of Thomas & Betts Corporation, copyright 2006/2007, all rights reserved, and are located in Appendix A.

The ability of Storm-Safe® to meet these load capacity and temperature requirements was the criteria Electrical Engineer Scott Pemberton of KCP&L spoke of in his interview. These requirements must be satisfied before KCP&L would consider installation in the St. Joseph area.

Alarm report documents indicated that the St. Joseph Fire Department responded to 46 calls for lines down, 27 calls for arcing electrical equipment, and 10 structure fires. A review of each of these alarm reports revealed that no record was made to distinguish between electric service drop problems and all other line down or arcing problems. Nearly all of the officer narrative fields were left blank.

In an attempt to get a more accurate picture of the size of the service drop problem, a poll was taken of the St. Joseph Fire Captains on duty during the December 2007 ice storm. Of the 33 captains, there were 27 responses. This was due to Captains working overtime on more than one shift but giving a response for all days worked. To the question of the calls for line down or arcing equipment, what percentage involved the service drop, the responses were: 35, 25, 40, 75, 60, 75, 60, 50, 40, 70, 20, 10, 2, 40, 50, 60, 10, 50, 35, 3, 85, 5, 5, 70, 25, 50, 80. This is a very wide range of responses. Even by tossing out the high and the low, the average of the remaining responses would not be accurate.

At first glance, the disparity of responses seemed to be attributable to unit response areas. The fire units on the east side of town respond in an area that has relatively more residential services supplied underground. One captain from the east side of St. Joseph told me he ran only two calls of this nature and one involved the service drop, so his answer was 50%. Without knowing the number of calls each captain responded to, the percentage was of little value. The most valuable and accurate information came from the shift commanders. They vividly recalled a total of six structure fires started by service drop failures. Four of these had moderate damage and two sustained major damage. Of these six fires, all were in residential occupancies.

Discussion

Accident and injury prevention can be engaged scientifically using event sequencing analysis (USFA, 2008). Heinrich (1959), used a domino theory and Haddon (1973), called it phases, but they are theoretically similar.

By definition, an automatic electrical disconnect, installed on residential service drops, could de-energize electrical conductors prior to the service entrance. This automatic disconnect is an engineering innovation. Kirtley (2008), and Heinrich (1959), agreed that engineering mitigation, although not to be used solely, should be given a high priority when selecting risk reduction strategies.

An automatic disconnect is a device that is descriptive of Haddon's (1973) countermeasure number three, which is to prevent the release of the hazard. A de-energized electrical conductor that has sustained storm damage represents no fire hazard. Electrical safety devices like fuses and breakers are not new to the electrical industry. An automatic electrical disconnect on residential service drops seems to follow the same path of reasoning and meet the requisites of prevention theory. When questioning electrical component suppliers about the existence of an electrical disconnect for service drops, responses indicated that utility providers go to great lengths to ensure delivery of a reliable, consistent supply of electricity. The connections on service drops need to be very secure.

Heinrich (1959), has stated that the dominos in his theory do not always fall to the end, resulting in an injury. Not every unsafe act results in an accident. As Scott Pemberton pointed out in his interview, not every customer with a collapsed service drop lost power. It was confirmed by St. Joseph Fire Department alarm reports that not every collapsed service drop started a structure fire.

Jack Brown, retired Fire Chief of the St. Joseph Fire Department, related that in 1994, as the result of an ice storm, there was a residential structure completely destroyed by fire. The service drop had collapsed, but the power was already out to that area. When the power was restored, this structure had not been checked for service damage, and a fire ensued. The sequence of events was different than that proposed in this research, however it illustrates how an automatic electric disconnect may be beneficial with a different event sequence. For example, an automatically operated disconnect device would have functioned at high wind events, or even when a tree trimmer exercised poor judgment.

Homac (2007), holds the patent on, and are the suppliers of Storm-Safe®. Information provided by Homac indicated that Storm-Safe® has been designed to address the problem experienced here, in St. Joseph. Mr. Marc Salerno provided test result data and field test video to support Homac's claim of functionality and applicability. This product has been on the market for just under two years, yet according to Mr. Salerno, no community or utility firm has put a hundred or more in service to give Storm-Safe® a real-world test. Without this information, researchers are limited to laboratory tests and staged video clips. Absent from the test data is the ability of Storm-Safe® to function with a significant layer of ice on it.

Storm-Safe® is offered with two choices of breaking strength engineered into the weak link. These choices are 500 pounds and 750 pounds. These breaking strengths would address the concerns of electrical engineers about a squirrel running on the service drop operating the disconnect. These strengths would address the issues surrounding a falling limb just brushing the service drop and activating the Storm-Safe® disconnect.

However, the important strength that should be in question here is the strength of the service mast and weather head in relationship to the strength of the weak link designed into Storm-Safe®. Exactly, how well is the insulated anchor secured to the structure? A porcelain anchor with a lag screw into the residential structure is very typical here in St. Joseph, to hold the tension required to keep the service wire at the required height from the ground.

What the lag screw on the porcelain anchor is screwed into is anything but typical. Sometimes it is screwed into a piece of two-inch dimensional lumber along the eave. Sometimes it is screwed into wooden lap siding with or without sheeting behind the lap siding. Some newer and remodeled homes have vinyl siding with plywood panels behind the vinyl. The wooden members to which the porcelain anchor with lag screw are attached vary in age and condition, resulting in an array of actual holding strength. It would be best if the lag screw were firmly embedded in a stud or other substantial structural member behind the siding, but an inspection from the exterior does not reveal this, making a holding strength determination difficult.

The mast and weather head are fastened to the structure by a clamp held with relatively short screws. When a force is applied strong enough for the porcelain anchor to fail, the mast anchors will almost always also fail. The metal conduit that fastens to the top of the meter base may fail at that juncture, exposing the wires; or the meter base may be pulled from the structure, exposing the wires where they pass through the wall into the interior service panel.

Electrical Engineer Scott Pemberton with KCP&L, previously with Aquila and AMEREN of St. Louis, had no knowledge of Storm-Safe® or any similar device. The same is true of AEP Research and Development Manager Tom Jones, although his associate Steve Early called the next day with results of his Internet search. These individuals represent firms that provide service to a large section of this nation. Being unaware of Storm-Safe® might be due to the fact that Storm-Safe® has only recently been placed on the market.

The lack of knowledge concerning the availability of an automatic electrical disconnect, leaves this author with questions. Why isn't Storm-Safe® more prominent in the marketplace? Why hasn't some community installed some Storm-Safe® devices for evaluation? Could it be that Scott Pemberton's assessment of an automatic disconnect advantages being mostly for the customer be true? And could this customer-only benefit have put a damper on an installation initiative by those utility firms that are aware of the availability of Storm-Safe®? Of what priority is the monetary concern, mentioned by Mr. Pemberton?

For the St. Joseph Fire Department, the implications of these study results are varied. Storm-Safe®, at least in theory, seems to supply one possible solution to a fire problem.

Missouri State Revised Statutes do not give authority to the City of St. Joseph to require an automatic electric disconnect on service drops. The St. Joseph Fire Department Prevention Division will need to focus on the remaining mitigation strategies in Kirtley's (2008) risk reduction work.

Prior to this research, an automatic disconnect on service drops had not been locally considered. This research provides the St. Joseph Fire Department with the background information on the significance of the problem, the theoretical purpose of a disconnect device on residential service drops, and the availability of a device.

Implementation of an installation program would have a potential implication of reducing fire losses in the St. Joseph Fire Department's jurisdiction. The calls for emergency service should decrease and this would be at time when call volume is exceeding the St. Joseph Fire Department's ability to effectively respond. This reduction in calls for service should reduce the number of times responders become exposed to hazardous travel conditions and reduce responder exposure to energized electrical equipment.

Recommendations

To provide a more accurate assessment of the service drop problem, the St. Joseph Fire Departments needs a revision in alarm report documentation. Adding this information to the alarm report narrative will not allow for a query and an easily retrievable set of records. The software program used locally has an alarm report field specifically designed for special studies. Use of this software feature would assist documentation analysis of service drop failures with and without resulting fire. If and when a field test is implemented in the City of St. Joseph, better documentation would provide a more accurate baseline for test analysis.

It is recommended that the St. Joseph Fire Department take the lead role in engaging the community. Results indicated that there is a need for education at every local level including fire personnel, community leaders, utility personnel, and residents. Government-Business partnerships need to be initiated by the St. Joseph Fire Department. A small group of experts from Fire Prevention and KCP&L should meet and discuss the possibility of using Storm-Safe® or a similar product, in a high-risk test area. If such a test is feasible, then Thomas & Betts, the parent company of Homac, should be invited to join the partnership.

Implementation strategies should be on the agenda for partnership participants. KCP&L Engineer Scott Pemberton mentioned a monetary concern. The City of St. Joseph can apply for mitigation grants from state and federal sources. Thomas & Betts has a vested interest in results of large-scale tests, and it would be reasonable for that firm to assist with monetary concerns. Educated residents may choose to bear the costs associated with installation. Future economic incentives may come from insurance companies once an automatic electric disconnect device has a proven risk reduction track record.

The St. Joseph Fire Department Fire Prevention Division should maintain a vigilant search for engineering innovations similar to that of Storm-Safe®, to address the local service drop issue. St. Joseph Fire Prevention personnel attend national conferences to discuss needed code revisions. Discussions at these conferences should include the need to address this ice storm, service drop fire problem. In portions of the nation where codes do not apply to electric utilities, as is the case in Missouri, an official appeal to the Public Utility Commission may have some value. Revision of technical codes should follow only after successful testing over a number of years.

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Appendix A

Storm-Safe® Test Data Used by permission of Thomas & Betts Corporation,

ANSI C 119.4-2004 Class 'A' Heat Cycle Data Sheet

Part Tested: SS1 1/0
Date Started: 9/2/2006
Date Completed 10/18/2006
Project #: PD2006-091
Test #: PD2006-091

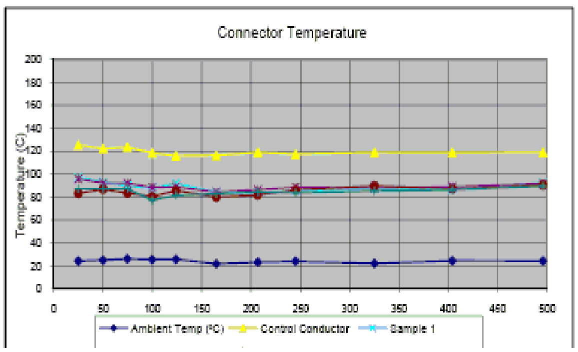
Cable (main): 1/0 Size: 0.398 Type: ACSR Length: 12 in Compound: HM-54
Cable (tap): 1/0 Size: 0.398 Type: ACSR Length: 12 in Wire Brushed: Yes

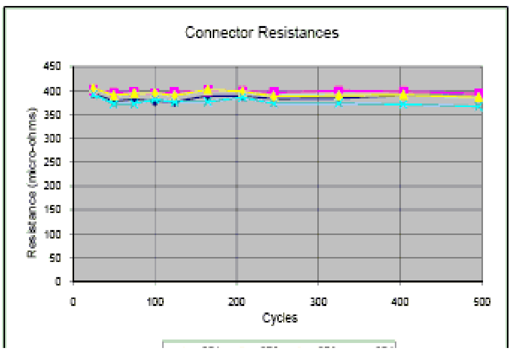
Compression Connector
Crimping Tool: Burndy MD 6
Die # BG Nose
# of Crimps 5

Cycle Period/Current
Current ON Period: 60 min
Current OFF Period 60 min
Test Current (amps) 238

Cycle Number	Ambient Temp (°C)	Current (amps)	Control Conductor	Connector Temperature				Temperature Differential (ΔT)			
				Sample 1	Sample 2	Sample 3	Sample 4	ΔT1	ΔT2	ΔT3	ΔT4
25	24	230	125	97	96	83	87	28	30	42	38
50	25	234	122	93	92	87	87	29	30	35	35
75	26	237	124	90	92	84	87	34	32	40	36
100	26	237	118	88	88	80	77	31	30	38	41
124	26	231	116	92	89	86	81	24	27	30	34
165	22	231	116	84	84	80	83	32	32	36	33
207	23	236	119	84	86	82	84	35	33	37	34
245	24	236	117	85	89	86	84	32	29	31	34
325	22	243	119	88	88	90	85	31	31	29	33
404	24	231	119	87	89	87	86	32	30	31	32
496	24	230	119	92	92	91	90	27	27	28	29
							Average Temperature Differential	30	30	34	35
							Min Acceptable Temperature Differential	20	20	24	25

Cycle Number	Connector Resistance μΩ							
	Connector Resistance (Measured) μΩ				Resistance Corrected to 20°C (μΩ)			
	R1	R2	R3	R4	CR1	CR2	CR3	CR4
25	516	523	507	498	394	402	405	392
50	488	510	494	472	377	396	390	372
75	488	510	494	472	381	396	394	372
100	479	501	490	469	377	393	394	382
124	484	506	492	469	376	396	390	376
165	489	503	498	471	389	400	402	376
207	487	505	496	485	388	399	398	386
245	482	504	491	467	383	395	388	372
325	487	508	498	470	384	399	389	373
404	494	507	496	470	390	397	390	371
496	502	507	495	468	389	394	386	366
				Average Resistance	384	397	393	376
				Min Acceptable Resistance	365	377	374	357
				Max Allowable Resistance	404	417	413	395
				Maxium Resistance	394	402	405	392
				Minimum Resistance	376	393	386	366
				Maxium Deviation +/- 6%	2.2%	0.9%	1.9%	2.6%





Homac Product Development Laboratory
Project Number PD 2006-091

STORM-SAFE® SS1 1/0 Single Service Connector:

ANSI C 119.4 Heat Cycle Test Report

Purpose:

Evaluate the electrical characteristic/performance of the STORM-SAFE SSS 1/0 Service Connectors when tested to ANSI C 119.4-2004 Current Cycling Procedure

Testing Location:

This test was conducted at The Homac Companies, Product Development Labora Bldg 16, Ormond Beach, FL 32174.

Equalizers:

Six, one-inch aluminum equalizers were crimped on the conductor maintai minimum distance of 12- inches from each connector.

Equipment Used:

Test Method:

- Test Method: Class A Current Cycle
- Conductor Size: 1/0 ACSR
- Conductor Stranding: 6/1
- Conductor Material: Aluminum
- Test Current: 238 amps (avg)
- Cycle Time ON: 60 min
- Cycle Time OFF: 60 min
- **Installation Tools: Burndy MD 6 Hand Tool with the BG-Nose Die**

Procedure:

Four Storm-Safe SS1 1/0 Single Service connectors were assembled with 1/0 ACSR as the main and secondary conductors. Each conductor was wired-brushed to re oxidation present and HM-54 oxide inhibiting compound was applied to each cond conductors were wire-brushed again to ensure the HM-54 compound was applied be standing of the conductors.

A small hole was drilled in the center of connector, and a thermocouple was inst thermocouple was placed in the middle of the 1/0 ACSR conductor to serve as the cont

Homac Product Development Laboratory
Project Number PD 2006-091

The Heat Cycle test was controlled by the National Instrument SCXI 1000 Data A System, which controlled the ON/OFF cycles. Temperature readings were taken at the e current ON cycle and resistance measurements were taken at the end of the current O within the intervals specified by ANSI C 119.4.

Results:

The temperature data shown on the attached data sheet indicates the temperature differential was above the minimum allowable differential for each co as specified by ANSI C 119.4-2004

The resistance data in the attached data sheet demonstrated that the resistances measurements of all test samples were within the +/- 5% variation s by ANSI C 119.4-2004

By virtue of the attached data sheet, conformance of the STORM-SAFE S connector to the heat cycle requirements of ANSI C 119.4-2004 are met and cert

Tested By:

Sesel H Brown Jr
Laboratory Technician

Approved By:

James L. Zahnen
Sr. Product Development Eng

ANSI C 119.4-2004 Class 'A' Heat Cycle Data Sheet

Testing Information For Bus Assembly 1 and 2

Part Tested:	383 Contact Assy.	**Cable (main):**	350 kcmil	**Size:**	0.641	**Type:** Al	**Length:** 48 in	**Compound:**	HM 53
Date Started:	9/1/2006	**Cable (tap):**	1/0	**Size:**	0.398	**Type:** ACSR	**Length:** 24 in	**Wire Brushed:**	Yes
Date Completed	11/1/2006								
Project #:	PD 2006-090								
Test #:	PD 2006-090								

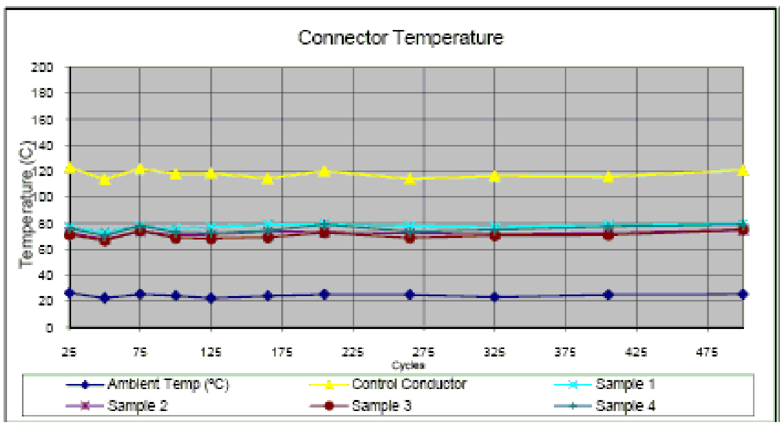
Compression Connector

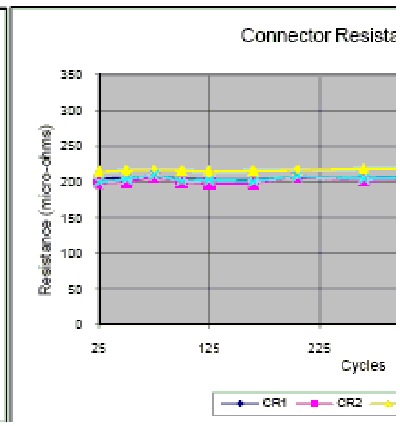
Crimping Tool: Burndy MD 6
Die # BG Nose Die
# of Crimps 5

Cycle Period/Current

Current ON Period: 90 min
Current OFF Period 90 min
Test Current (amps) 600

Cycle Number	Ambient Temp (ºC)	Current (amps)	Control Conductor	Connector Temperature				Temperature Differential (ΔT)				Connector Resistance (Measured) µΩ				Resista
				Sample 1	Sample 2	Sample 3	Sample 4	ΔT1	ΔT2	ΔT3	ΔT4	R1	R2	R3	R4	CR1
25	26	583	123	77	73	71	76	46	50	51	47	251	240	258	244	204
50	22	569	114	73	68	67	70	41	46	47	43	249	238	256	245	205
75	25	574	122	78	74	74	78	44	48	48	44	256	251	263	259	208
100	24	569	118	76	71	69	73	42	47	49	45	251	240	258	244	205
125	22	583	118	77	71	68	73	41	47	50	46	249	238	256	245	203
165	24	569	114	79	73	69	74	35	41	45	40	251	240	258	244	203
205	25	575	120	79	73	73	79	41	47	47	41	255	252	262	257	206
265	25	563	114	78	72	69	73	36	42	45	41	253	244	261	248	205
325	23	568	116	77	72	71	75	39	45	46	41	255	247	263	252	207
405	25	570	116	79	73	71	77	37	43	45	38	256	249	265	253	208
500	25	563	121	80	75	75	79	41	46	46	42	257	249	265	254	207
							Average Temperature Differential	40	46	47	42				Average Resistance	206
							Min Acceptaple Temperature Differential	30	36	37	32				Min Acceptable Resistance	196
															Max Allowable Resistance	216
															Maxium Resistance	208
															Minimum Resistance	203
															Maxium Deviation +/- 5%	1.47%





Paris Jenkins

From:	Paris Jenkins [paris444@yahoo.com]
Sent:	Tuesday, January 20, 2009 10:46 AM
To:	Paris Jenkins Fw: Re: written
Subject:	authorization to reprint

On Mon, 1/19/09, George Trj.antopoulos <George.Triantopoulos@tnb.com wrote:

'from: George Tr.antopoulos <George.Triantopoulos@tnb.com
Subject: Re: written authorization to reprint
To: "Paris Jenkins" <paris4 4<3 0yahoo.com
Date: Monday, January 19, 2009, 4:59 PK Paris, Sorry it took us a little bit to get back to you.
Our legal department does not have any major concerns allowing you to .use this information.
The only request they *have* is that you mark this information with "Used by permission of Thomas & Betts Corporation, copyright 2006/2007. All rights reserved."
Please let me know if you have any other questions.
Thank you for utilizing our products in your research paper.
Hope your paper makes it through the qualification process.
Good Luck!
George

Appendix B

List of contacts for research

Scott Pemberton	KCP&L, St. Joseph, MO
Tom Jones	American Electric Power, OH
Steve Early	American Electric Power, OH
V. K. Varma	Missouri Western State University
Jason Barnes	Kritz-Davis Company, St. Joseph, MO
Marilyn Miller	Thomas & Betts Corporation
Dwayne Ginn	Thomas & Betts Corporation
Marc Salerno	Thomas & Betts Corporation
George Triantopoulos	Thomas & Betts Corporation
Mike Hoelter	Patent Counsel for Thomas & Betts Corporation
Jack Brown	St. Joseph Fire Department Fire Chief (Ret.) MO