

## A New Approach to Statistical Analysis of Electrical Fire and Classification of Electrical Fire Causes

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**Abstract:** This paper aims at the statistical analysis of electrical fire and classification of electrical fire causes to collect electrical fires data efficiently. Electrical fire statistics are produced to monitor the number and characteristics of fires attended by fire fighters, including the causes and effects of fire so that action can be taken to reduce the human and financial cost of fire. Electrical fires make up the majority of fires in Korea (including nearly 30% of total fires according to recent figures). The incorrect and biased knowledge for electrical fires changed the classification of certain types of fires, from non-electrical to electrical. It is convenient and required to develop the standardized form that makes, in the assessment of the cause of electrical fires, the fire fighters directly ticking the appropriate box on the fire report form or making an assessment of a text description. Therefore, it is highly recommended to develop electrical fire cause classification and electrical fire assessment on the fire statistics in order to categorize and assess electrical fires exactly. In this paper newly developed electrical fire cause classification structure, which is well-defined hierarchical structure so that there are not any relationship or overlap between cause categories, is suggested. Also fire statistics systems of foreign countries are introduced and compared.

**Key words:** statistical analysis, classification of electrical fire causes, electrical fire statistics

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### 1. Introduction

In order to know what we know about electrical fires, electrical fire data should be collected and analyzed by a statistical approach. Although the statistics can be done by some tests in laboratories, laboratory tests don't explain what causes the largest number of fires or how often fire kills people. Therefore, collection of real-world data sources for electrical fire analysis is required. For last several decades with the achievement of fast economic development, the fire caused by electricity occupies nearly 30 percent of overall fire incidents as of the year of 2006 in Korea and is not decreased in spite of much times and efforts. Electrical fires are of common occurrence all over the world, causing severe damages to valuable things and loss of human lives. Short circuits and arcing faults are one of the major causes of these fires. [1-2]. Electrical fire statistics are produced to monitor the number and characteristics of fires attended by fire fighters. Electrical fire statistics are used in making operational

decisions, policy development and in promoting public awareness about the dangers of electrical fire. The timely collection of electrical fire statistics contributes to achieve above-mentioned aim. Therefore required is researches for electrical fire statistics system which can produce recent statistic figure results with high reliability. Electrical fire statistics are produced to monitor the number and characteristics of fires attended by fire fighters, including the causes and effects of fire so that action can be taken to reduce the human and financial cost of fire. Most of what we know about a country's fire experience, both in the United States and elsewhere, is based on reports filed by a fire officer. These reports are a small fraction of their responsibilities, but the data provided are critical to policy makers, regulators, life safety educators, inventors, the media, and others.

In developing the electrical fire statistics system, needed is the classification of electrical fire cause which can be used in assessing electrical causes in the fire site [3-4].

In this paper, newly developed electrical fire cause classification structure, which is well-defined hierarchi-

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cal structure so that there are no relationship or overlap between electrical fire cause categories is suggested. Also fire statistics systems of foreign countries are introduced and compared.

## 2. Electrical Fire Data Collection

The primary reason for analyzing fire data typically collected in fire departments is that analysis gives insight into fire problems, which in turn can affect operations in the department.

### 2.1 Domestic

Fire fighters in fire departments collect fire data and report their fires directly to a national government office, National Emergency Management Agency (NEMA). Standardized and efficient cause classification system is not exist, but new cause classification system for fire statistics is under preparation by NEMA[5].

### 2.2 Foreign countries

- USA : The National Fire Incident Reporting System(NFIRS) is structured efficiently. Local fire departments collect data on each incident. This incident is then reported to the state fire agencies, then finally to federal government, which is a three-tiered system and they all play critical roles in collecting fire data on NFIRS form. Usually, the State Fire Marshal's office in each NFIRS State has the responsibility for collecting data from its fire departments, and merges all reports onto a database. The statewide database then is forwarded electronically to the National Fire Data Center(NFDC) at the U.S. Fire Administration (USFA)[6].

- Canada : In Canada, as in the USA, the system is three-tiered. Local fire departments report their data to the provinces. However, the provinces report the totals, not the incidents themselves, to the Association of Canadian Fire Marshals and Fire Commissioners.

- United Kingdom : Fire brigades (departments) in the United Kingdom report their fires directly to the Home Office in London. The federal government manages these databases. However, the government does not collect dollar loss information; that task is left to the insurance industry.

- Japan : Fire departments in Japan also report their fires directly to a national government office.

## 3. Cause Classification and Statistic Analysis for Electrical Fires

The persons responsible for reporting the data should

be trained and capable of investigating a fire to determine the origin, cause, and circumstances of the fire. Their determinations become the data used by the system. Weaknesses here can undermine the validity of the data and of any analyses performed on the data.

The fire department should have certain standards that apply to all its record-keeping operations. Such standards will help make the data more uniform from report to report and application to application. Standardization aids all users of the data, makes analysis more accurate, and is essential if data is to be automated. Better data come from fire fighters who see, use, and understand the compiled statistics. The data analyzed and completed by fire fighters will have high quality if the cause classification will be reasonably categorized.

### 3.1 Domestic

The data on electrical fires that were not reported to fire departments is not calculated in electrical fire numbers of fire statistics. Consequently, fires that are handled by individuals will not be counted. Fig. 1 illustrates how fires in Korea protected by municipal fire departments are or are not captured in the data.

If the fire department responded but did not complete a report, and not sent forward to the government, it will not become part of the statistics. If a fire report has a serious or fatal error or inconsistency, it will also be excluded from the statistics.

The fire statistics in Korea is published mainly by Ministry of Government Administration and Home every year by 2005. From 2006, National Emergency Management Agency(NEMA) has charge in publishing fire statistics reports. Fires are classified into 11 classes by locations which fires occur originally, 7 classes by causes which fires are ignited. Among them, electrical fires which are ignited by electricity or electrical appliances, are consist of 9 categories, or leakage current,

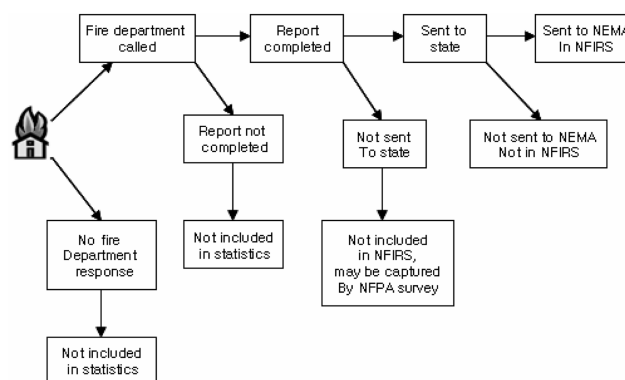


Fig. 1. Data included in fire statistics

**Table 1.** Cause classification for fire statistics

Electrical factors	Leakage current, Disconnection, Shorted- turn, Overload, Short circuit(poor contact, insulation deterioration, damage, tracking and unconfirmed)
Mechanic factors	Over heating, Oil leakage, Auto control failure, Manual control failure, Poor maintenance, Decrepitude, Backfire
Gas leakage	Gas leakage(explosion)
Chemical factors	Chemical explosion, Contact with water proof substance, Chemical ignition, Spontaneous combustion, etc.
Traffic accident	Traffic accident
Negligence	Cigarette, Cooking, Playing with fire, Welding: Cutting, Firecracker, etc.
Natural factors	Natural disaster, Magnifier effect

disconnection, shorted-turn, overload, short circuit by poor contact, insulation deterioration, damage and tracking. The details are shown in the following table 1. In order to set up fire statistics which can produce valuable information, new fire statistics system is under preparation by NEMA.

### 3.2 Foreign countries

#### 3.2.1 USA

The NFIRS began over 25 years ago with the aim of collecting and analyzing data on fires from departments across the country. More than 14,000 fire departments in 42 States now report their fires and injuries to NFIRS. Version 5.0 of NFIRS consists of 11 separate modules in which fire departments can report any type of incident that they respond to. Among of them, if the incident is a fire, the fire module(Module 2) is completed. This includes property details, cause of ignition, human factors, equipment involved, and other information. If it is a structure fire, Module 3(structure fire) is complete. This include such things as structure type, main floor size, fire origin, presence of detectors and automatic extinguishment equipment, and other data. The cause classification for electrical fire statistics in the NFIRS consists of Heat Source, Equipment involved in Ignition, Factors Contributing to ignition and Cause of ignition, based on the NFPA 901[7]. Standard Classifications for Incident Reporting and Fire Protection Data, shown in Table 2.

#### 3.2.2 Japan

Japan, also fire officers and firefighters at the fire

**Table 2.** Cause classification for electrical fire statistics in the NFIRS

Cause of ignition	Intentional, Unintentional, Failure of equipment or heat source, Act of nature, Cause under investigation, Cause undetermined after investigation
Human factors contributing to ignition	Asleep, Possibly impaired by alcohol or drugs, Unattended person, Possibly mentally disabled, Physically disabled, Multiple persons involved, Age was a factor
Heat source	<b>Operating equipment</b> , Spark, ember or flame from operating equipment, Radiated, conducted heat from operating equipment, Electrical arcing, Heat from powered equipment, other, <b>Heat Sources, Other</b>
Factors contributing to ignition	<b>Electrical failure, Malfunction</b> , Water-caused short-circuit arc, Short-circuit arc from mechanical damage, Short-circuit arc from defective, worn insulation, Unspecified short-circuit arc, Arc from faulty contact, broken conductor, Arc, spark from operating equipment, Fluorescent light ballast, Other, <b>Factors contributing to ignition, other</b>
Equipment involved in ignition	<b>Electrical Distribution, Lighting &amp; power transfer</b> , Electrical wiring, other, Electrical power line, <b>Equipment involved in ignition, other</b>

department provide the basis for investigating fire incidents and collecting fire data. Without their efforts, the fire statistics will not completed. By completing a fire report, a fire officer does three important things. First, he or she is making a legal public record that documents the incident. Second, the fire officer's report provides information to senior officers and fire department managers so that they are kept informed about what is happening within their areas of responsibility. This allows them to evaluate the performance of their units at the incident and to talk intelligently about the incident to the media and others. A standardized format is required before statistics can be extracted to meet the statistics purpose. Japan has their own statistics system and codes, fire officers use the system to document incidents simultaneously by collecting and providing data on the time of the incident[8-9]. The cause classification for electrical fire statistics in the Japanese system consists of Form of ignited material, Equipment involved in ignition and Cause of ignition, shown in Table 3.

**Table 3.** Cause classification for electrical fire statistics in the Japanese system

Equipment involved in ignition	Heating machine(movable), Heating machine, Electric machinery, Electric equipment, Distribution line and devices, Parts which is apt to leakage, Electrostatic spark, other
Cause of ignition(by progress)	Heat by partly-disconnection, Ground fault, Short circuit, Over-current, Electric spark, Overheating on contacted part, Sparks fly, Insulation deterioration, other
Form of ignited material	Building and furnishing, Contents in building, Ignition material by forest and other fire, Vehicles

## 4. Several Problems and Improvements in Cause Classification

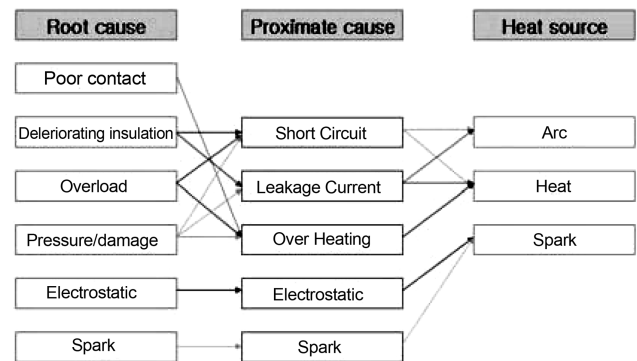
### 4.1 Several problems

One of the most important factors that electrical fires make up the majority of fires in Korea(including nearly 30% of total fires according to recent figures) is that there is not a systematic and standardized classification for electrical fire causes, which makes it possible that the cause of the same fire incident is depend on the fire investigator. In a practical manner, fire departments use generally-recognized systems of cause classification without any categorical definition, but most reports were simply narratives of the incident and actions taken to manage it. Pulling meaningful information or even simple statistics from narratives, however, is an exercise in frustration at the present fire data based on the generally-recognized systems of cause classification.

In order to set up electrical fire statistics which brings meaningful information, it is required to suggest newly developed electrical fire cause classification without any interrelationships between cause categories. Also easy data collection system that the fire fighters can assess the cause of electrical fires by directly ticking the appropriate box on the fire report form or making an assessment of a text description to the exclusion of investigator's subjectivity.

### 4.2 Improvements

• In order to conduct electrical fire statistic analysis more easily, developed is electrical fire data collection system which is a standard format for data collection, enabling aggregation and comparisons across provinces. The standard should be designed to meet the needs of both the people collecting the data and the people who

**Fig. 2.** Electrical fire causes classification

use it. In USA, NFIRS has been widely used since 1980 and has added and dropped data elements at several times in different versions.

• In that fire fighters and fire investigators are assessing the causes of electrical fires, a standardized category for electrical fire cause classification is very critical. Between categories, in case that there are interrelations or overlap, in spite of the same fire sites, the assessed cause of electrical is depend on the fire fighters or fire investigators. However, it is impossible to classify electrical fire causes without any interrelationships between categories since one cause becomes a pre-cause of another cause. For example, overloads make an effect to insulation deterioration, and to leakage, also to shortage, finally to electric spark and arc. Therefore, to cope with the above-mentioned shortcomings, it is reasonable to classify electrical fire causes using twofold structure with root causes and proximate causes which are advanced by root causes. New electrical fire cause classification with well-defined hierarchical structure is suggested by above-mentioned schemes. The suggested cause classification for electrical fire is shown in Fig. 2. It is considered, as root cause, the primary cause which makes heat source, and poor contact, insulation deterioration, overload, mechanically- pressured damage, static electricity and electric spark are included in root cause. As proximate cause, electric shortage, electric leakage, overheat, static electricity and electric spark are included. The hierarchical scheme suggested herein helps ensuring the reliability of electrical fire investigation and statistics.

## 5. Conclusion

This paper aims at the statistical analysis of electrical fire and classification of electrical fire causes to collect electrical fires data efficiently and to make electrical

fire statistics with high reliability.

In this paper newly developed electrical fire cause classification structure, which is well-defined hierarchical structure so that there are not any relationship or overlap between cause categories, was suggested. The suggested electrical fire cause classification structure minimize that non-electrical fires are diagnosed into electrical fires by incorrect and biased knowledge for electrical fires. Therefore it is highly expected that the electrical fire statistics system based on the scheme suggested in this paper can show electrical fire statistics with high reliability, which enable any reasonable prevention measures to be recommended and be set up by electrical fire agency. Also fire statistics systems of foreign countries were introduced and compared. The systems depend on the country, so it is hard to conclude that any system is better than others. The results obtained in this paper will be very helpful for the electrical fire statistics analysis and prevention of electrical fires.

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