Improper Fuse Wire Replacement, and Possible Association with Commercial Fires

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Abstract- The rewirable fuse or cutout is widely used in Bangladesh and elsewhere, in spite of the very real danger of improper replacement of fuse wires. To assess the problem, a preliminary survey of buildings, electrical shops, and electricians were conducted. The majority of buildings and retail establishments were found to use fuse wires. Electricians were found to use copper of arbitrary thicknesses as fuses, and were unaware of the existence of specialized fuse wires. Every year, there are numerous fires in the garments and other industries, causing hundreds of deaths. As the vast majority of these fires are of electrical origin, the evidence is strong that improper fuse wiring may have been the cause of the fires. The number of smaller fires which do not make it to the news is likely to be orders of magnitude greater than the publicized fires. Even when the origin is not electrical, insulation failures may cause secondary electrical fires, that may cause the fire to spread rapidly to the rest of the building, making it hard to extinguish.

Index Term-- Fuse, wire, cutout, industry, fires.

I. INTRODUCTION

With the improvement in circuit breaker technology over the last few decades [1, 2, 3, 4], there has been a worldwide decline in the use of fuse wires and cutouts. The decline in fuse wires has been slow to catch on in Bangladesh and developing countries, where it still has wide applications for domestic, commercial, and industrial applications.

Although the rewirable fuse is not permitted in new constructions, it’s popularity continues because of it’s low cost, and lack of people’s awareness of its dangers. The danger lies in the popular practice of copper strands being used as fuse wires. In addition, the thickness of copper used is chosen arbitrarily depending on the load. The existence of specialized fuse wires is almost unknown by almost everyone, responsible for changing fuse wires.

Recently there have been hundreds of deaths in garments factories and other industrial fires [5, 6]. Most of these fires have been identified to be of electrical origin. As improper fuse wire replacement is widely practiced, it is quite reasonable to assume that inappropriate electrical protection, or fuses, may have been the cause behind many of these industrial fires.

1. 1. Past Research

Since fuses are being rapidly replaced by circuit breakers for domestic and commercial applications, less research is being conducted on them [7, 8, 9, 10]. Although human causes have been identified behind many electrical accidents [11], very little is available in the literature on inappropriate fuse wire replacement. Research on fuses has continued for high voltages [12, 13, 14], and more specialized applications [15, 16, 17, 18].

II. FUSE WIRES IN INDUSTRY AND RESIDENCE

For household and industrial protection in Bangladesh, the most common device is the semi-enclosed or rewirable cutout fuse (figure 1) [2]. Made of white ceramic, the carrier holds the fuse wire, and can be plugged into the ceramic base. When needed, the melted fuse wire is to be replaced by specialized fuse wire of the appropriate rating.

Fig. 1. Rewireable Cutout with 0.74 mm copper wire as used by Dhaka "Electrician" for "Room with AC"
A less common fuse is the type that is included on the wall panel with switches for lights and fans (figure 2). It is seen that the copper wire used as fuse wiring is abnormally thick (with the finger as reference). Not only will it be slow to melt in case of a fault, it creates a false sense of security, which will make it unlikely to have further protection at the apartment and building mains.

The main issue with rewireable fuses is the inappropriate replacement of wires. Specialized fuse wires normally have low melting points, quite unlike the copper wires widely used in Bangladesh. The melting point of copper is 1083°C, compared to the much lower melting points of fuse wire. Also the current carrying capacity of the wires cannot be well standardized, as they are dependent on positioning inside the fuse carrier and base.

The survey of electrical shops done here revealed that fuse wires were not found in local electrical shops.

### III. Fuses and Circuit Breakers

In much of the world, the rewireable cutout fuse is not permitted in new constructions. However, they are still widely found in older installations in the much of the world, including UK [3,4]. Fuse wires commercially available at present, are shown (figure 3). The fact that rewireable cutouts are still widely manufactured in China, indicates that there is a large worldwide market for them. In North America, rewireable cutout fuses (for 110 V) were replaced decades ago by circuit breakers.

#### Bangladesh and Developed Countries

Rewireable fuses are normally not permitted for new constructions in Bangladesh [19], having been replaced by circuit breakers. However, this study found that they continue to be sold and used widely. The following preliminary surveys on buildings, electrical shops, and electricians were conducted.

#### 3.1 Survey of Shops

10 shops in various parts of Dhaka were surveyed (Table I). 90% of them were found to carry the rewireable cutout, indicating the continuing popularity of this device. No shop was aware of the existence of specialized fuse wires. According to one source [18], fuse wire is found only in scientific shops in Bangladesh.

<table>
<thead>
<tr>
<th>Shop</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Kcp</td>
<td>Kcp</td>
<td>Gls</td>
<td>Mdr</td>
<td>Kct</td>
<td>Kct</td>
</tr>
<tr>
<td>Had cutouts?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Had CBs?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Had fuse wires?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

CB = Circuit Breakers, Kcp = Kalachandpur, Kct = Kachukhet, Gls = Gulshan, Mdr = Mohammadpur

#### 3.2 Survey of Buildings

A preliminary survey was conducted on about 10 buildings (Table II), most of which were residential (with some offices, but no factories). About 80% were found to carry cutouts at least at the building mains or at individual apartments. The newer buildings used circuit breakers. Many buildings had transitioned to circuit breakers at the mains board. Rewireable fuses at a building mains have been shown in figure 4.

<table>
<thead>
<tr>
<th>Building</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>5</td>
<td>30</td>
<td>26</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Location</td>
<td>Dhm</td>
<td>Lal</td>
<td>Mpr</td>
<td>Bdh</td>
<td>Fmg</td>
</tr>
<tr>
<td>Bldg mains</td>
<td>Fuse</td>
<td>F+CB</td>
<td>Fuse</td>
<td>CB</td>
<td>CB</td>
</tr>
<tr>
<td>Aptmts</td>
<td>Fuse</td>
<td>Fuse</td>
<td>Fuse</td>
<td>CB</td>
<td>CB</td>
</tr>
</tbody>
</table>

F = Fuse, CB = Circuit Breakers, Dhm = Dhanmondi Lal = Lalmatia, Mpr = Mirpur
Large commercial units such as garments and other factories were not included in this survey, as their electrical boards were not readily accessible for inspection. However, according to all the trends, it is expected that fuses are being widely used in commercial installations also. Numerous retail shops were visited, and most were found to carry fuse/fuses at their mains. A fuse at an iron inside a shop has been shown (figure 5).

### IV. SURVEY OF ELECTRICIANS

Fuse wire replacement is commonly done by electricians, or anyone who claims knowledge on the subject. Electricians are entrusted to replace fuse wires for factories and commercial establishments.

Of the 6 or so "electricians" surveyed, all used copper wire as fuse, and were unaware of the existence of specialized fuse wires. Two thirds recommended using a single 0.8 mm copper strand for a room with an AC. The remaining suggested using 2-3 hair-thin strands of copper for the same purpose. There is obviously lack of consistency in this practice. Such protection is unlikely to be adequate, and can be the subject of further investigation.

When a fuse blows frequently, the response of the attending electrician may be to use more copper as fuse wire, rather than investigate the cause of the malfunction (with dangerous consequences).

#### 4.1 Certification of Electricians

Although improper electrical work carries far-reaching or even fatal consequences, there is very little effective regulation of electricians in Bangladesh. In comparison, most electricians in the developed world, strictly enforces certification and licensing of electricians.

In the absence of enforcement of regulations by the Bangladeshi government, most practicing electricians have very little formal education or training in the field. In practice, employees of electrical retail shops move on to become practicing electricians. The dangers of 220V (compared to 110 V in other countries) is readily apparent. Needless to say, faulty electrical work by electricians cause numerous fires and fatalities every year.

### V. GARMENTS AND INDUSTRIAL FIRES IN BANGLADESH

In recent years, there have hundreds of deaths in garments and industrial fires in Bangladesh [5,6]. An internet search resulted in about 6 industrial fires, of which apparently all were of electrical origin. Two were in textile factories, and the remaining four were in garments industries. In many cases, flammable material placed close to the electrical fire helped fuel the flames. Further details about fires are seldom available, considering bureaucratic hurdles.

#### Garments Factory Fire, Dec. 14, 2010

A recent incident here is cited as an example. About 25 people were killed and 45 injured in a clothes factory fire in the Ashulia region [19]. According to the police, “an electrical fault was the likely cause of the fire.” According to this newspaper report, “fires caused by short circuits and sub-standard electrical wiring are common in Bangladeshi garment factories.”

Four other fires between the years 2000 – 2006 have been described below (Table III).

#### Table III: Some industrial fires in Bangladesh

<table>
<thead>
<tr>
<th>Case</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Feb 2006</td>
<td>Aug 2001</td>
<td>Dec 2000</td>
<td>May 2004</td>
</tr>
<tr>
<td>Industry</td>
<td>Textile</td>
<td>Garments</td>
<td>Garments</td>
<td>Garments</td>
</tr>
<tr>
<td>Location</td>
<td>Chittagong</td>
<td>Dhaka</td>
<td>Narsingdi</td>
<td>Dhaka</td>
</tr>
<tr>
<td>Deaths</td>
<td>91</td>
<td>24</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>Cause</td>
<td>&quot;Short Circuit&quot;</td>
<td>&quot;Electrical Board flames&quot;</td>
<td>&quot;Short Circuit&quot;</td>
<td>&quot;Transformer burst&quot;</td>
</tr>
</tbody>
</table>
Clearly, cases A, B, and C are suspect, and it is quite possible that rewireable cutouts may have been the culprit. As circuit breakers are quite reliable, it is quite reasonable to assume that rewireable cut-outs (and not circuit breakers) were used as protection. Case D of transformer explosion may have from harmonics into fluorescent lamps and power electronics, and may not have been preventable by circuit breakers or fuses.

VI. NON-INDUSTRIAL FIRES

Although commercial fires with large casualties make the headlines, smaller domestic fires mostly do not make the news. A good example is the mains board fire in the residence of the author in Lalmatia in 2008. Very likely, the unpublicised cases of improper fuse-related fires are orders of magnitude greater than the fires that make it to the media.

The Nimtoli Blaze

On June 3, 2010, Bangladesh had its worse fire in recent memory, when 6–8 buildings in old Dhaka caught fire, and 121 people lost their lives. Whatever the origins of the fire, it is agreed that two transformers just above the point of origin greatly fuelled the flames. As described below, in case of fire, the fuses may have been unable to detect and stop electrical insulation failures, spreading the fire among the electrical wiring.

During a visit by the author to the site of the tragedy, it was found fuse cutouts had been installed (figure 6) right after the tragedy.

![Fig. 6. The fuse cutouts installed in the central building of the blaze, about two weeks after the Nimtoli blaze](image)

This re-installation of fuse wires in the building illustrates that, even such a high-fatality fire with media exposure was not followed up with appropriate replacement with circuit breakers.

VII. FIRES OF NON-ELECTRICAL ORIGIN

Like in the Nimtoli blaze, the question can be raised about the role of fuses, when there is a non-electrical fire in some other part of the building. In case of a fire, amidst all the heat, the electrical insulation are likely to fail first. This could be the insulation of cables running through a building, or the thin insulation in motors, such as in a fan, refrigerator, or in an air-conditioner. It is clear that faulty fuses will allow fires of non-electrical origin to spread through electrical cables to other parts of the building. It is possible that many of fires of non-electrical caused secondary fires of electrical origin. These secondary fires must have caused the rapid spread of the fire, and greatly impeded the successful extinguishing of the flames.

VII. RECOMMENDATIONS

Some recommendations are made, based on the findings of this paper. As wires of low-melting point, are easy to manufacture, there should be encouragement to manufacture and widely distribute fuse wires. To create mass awareness, a media campaign, with TV, radio, and newspapers, should be conducted to create awareness on the dangers of fuses and replacement with circuit breakers.

There may be an official requirement that fuses be replaced by circuit breakers in all commercial buildings, with immediate effect. Rewireable cutouts in residential units should be replaced within a specified time, say one year. The certification system for electricians should be enforced, so that inappropriate fuse replacement is less likely.

8.1 Further Research:

Further research should be conducted on the interrupting currents when copper is used as a fuse wire. Fires from non-electrical origin can cause electrical insulation failure and secondary electrical fires. As very little data is available, some research conducted should be conducted on this field.

IX. CONCLUSION

This study confirmed that there is widespread and arbitrary use of copper as fuse wires in an underdeveloped country such as Bangladesh. Specialized fuse wires were found to be almost unknown to laymen and electricians. Fuse wiring is a prime suspect as the cause behind many recent devastating garments and industrial fires. Inappropriate fuse wires are likely to have caused hundreds of fires over the years, which did not make it to the news. In case of fires of non-electrical origin, electrical insulation is likely to fail first, causing secondary fires to spread through electrical wiring. Corrective action through media campaigns, and manufacture of fuse wires is recommended. Further research should be conducted on electrical insulation failure causing secondary electrical fires, for fires of non-electrical origin.

REFERENCES

[19] Personal discussions with Kamal Hasan, Eltech Ltd., Gulshan 1, Dhaka, Bangladesh (July 2006).