

PERUNDING

Persatuan



Association of Consulting Engineers Malaysia

www.acem.com.my

Conventional and Unconventional
Lightning Air Terminals



ASSOCIATION OF CONSULTING ENGINEERS MALAYSIA
63-2 & 65-2, Medan Setia 1
Damansara Heights,
50490 Kuala Lumpur
Tel: 03-2095 0031/0079/0158 Fax: 03-2095 3499
E-mail: sec@acem.com.my



PERSATUAN JURUTERA PERUNDING MALAYSIA

Load Test on Instrumented 600mm Diameter Bored Pile
in the City Centre of Kuala Lumpur

Conventional and Unconventional Lightning Air Terminals: An Update

HARTONO Zainal Abidin, BSc, MIEEE and ROBIAH Ibrahim, BSc, MIEEE

1. Introduction

The lightning protection systems (LPS) used in this country and around the world is basically divided into two types:

- a) Conventional or standard LPS i.e. that which comply with the technical standards/codes of practice
- b) Unconventional or non-standard LPS i.e. those that do not comply with the standards/codes

The air terminals associated with the conventional LPS is the Franklin rod while those associated with the unconventional LPS are the so-called "active" air terminals e.g. the early streamer emission (ESE) and the charge transfer system (CTS).

In the last decade, the conventional LPS have been validated in a number of studies conducted by lightning protection experts around the world. On the other hand, similar studies have discredited the un-conventional LPS and this has led to their rejection by various scientific and standards organizations. In 2005, the International Conference on Lightning Protection (ICLP) issued a warning that the use of the unconventional LPS presents a danger to the end users. Nevertheless, the local vendors and proponents of the unconventional LPS were not deterred by these events and continued to market their dangerous products to the public and even invented a new one.

This article is a follow-up on the paper presented by the authors during the lightning protection forum organized by ACEM in January 2004. Readers can download the paper from the Lightning Safety Alliance website (www.lightningsafetyalliance.org).

2. Lightning protection standards

The recognized lightning protection standards frequently applied in Malaysia are the MS-IEC 61024 (Malaysian/IEC), BS6651 (United Kingdom), NFPA780 (USA), AS/NZS 1768 (Australia/New Zealand), and CP33 (Singapore). These standards are regularly updated to incorporate the new findings on lightning protection researches.

In addition to the above, the vendors of the unconventional LPS have introduced/proposed their own "product standards" such as the French NFC 17-102. These so-called "standards" have already been rejected by the scientific organizations in their country of origin.

2.1 AS/NZS 1768

Work to revise this standard commenced in the late 1990s and the new interim standard, AS/NZS 1768(Int) 2003, was published in December 2003. The existing methods for positioning the air terminals, namely the Protection Angle Method (PAM), the Rolling Sphere Method (RSM) and the Faraday Cage Method (FCM), are still retained.

The standard also incorporates a new air terminal positioning method that is based on observations of lightning induced damages in Malaysia. The description of this new method is as follows:

"Field data of damage caused by lightning flashes terminating on structures (See Appendix G, Refs 2 & 3) identify the parts that are vulnerable to strikes. The most vulnerable, associated with over 90% of observed lightning damage, are nearly always located on upper parts of structure, such as:

- (a) pointed apex roofs, spires and protrusions;
- (b) gable roof ridge ends; and
- (c) outer roof corners.

Other areas of vulnerability, in decreasing order, are:

- (d) the exposed edges of horizontal roofs, and the slanting and horizontal edge of gable roofs (<10%);
- (e) lower horizontal edges and vertical edges on outer-sides just below corners (<5%);
- (f) flat surfaces near points and corners (<3%); and
- (g) intruding surfaces and other surfaces, particularly flat surfaces (<1%)."

To maximize the probability of intercepting the lightning strikes, the air terminals must be positioned according to the above high-risk locations.

2.2 New IEC standard, IEC 62305

Work on the revised standard commenced in the late 1990s and it was finally published in February 2006 to replace the IEC 61024. The new standard is divided into four parts:

- a) IEC 62305-1: General Principles
- b) IEC 62305-2: Risk Management
- c) IEC 62305-3: Physical damage to structures and life hazard
- d) IEC 62305-4: Electrical and electronic systems within structures

In the IEC 62305-3, the PAM, RSM and FCM methods for positioning the air terminals are also retained. In addition, a new paragraph on air terminal positioning, which is similar to that found in the AS/NZS 1768(Int):2003 above has been added.

The IEC 62305 is currently in the process of being evaluated by the SIRIM Working Group on Lightning Protection to replace the MS-IEC 61024.

2.3 French ESE “standard”, NFC 17-102

This “standard” was published in 1995 by GIMELEC, the association of French ESE manufacturers, in order to standardize the manufacture, test and installation of the ESE air terminals. The “standard” has been copied by other non-French ESE manufacturers e.g. Spain.

The NFC 17-102 was criticized in 2002 in a report [1] by the French scientific agency, INERIS, for non-implementation by the ESE manufacturers. Although the manufacturers have agreed to revise the document, no action has been taken so far. Hence the ESE air terminals now in use worldwide have not only failed to comply with the recognized national/international standards but they also failed to comply with the manufacturers’ own standard.

2.4 Proposed standard for the CTS system

Between 1989 and 2005, the inventor of the CTS made five applications to the NFPA to include the CTS in the NFPA780 standard. All the applications were rejected because the inventor could not provide the required scientific theory to support the CTS. The latest rejection [2] was made by the NFPA in 2005.

2.5 Proposed standard for the Collection Volume Method (CVM)

The CVM is a proprietary method for positioning the Dynasphere® air terminal, an active air terminal developed in Australia. This method was included in the appendix of the AS/NZS 1768:1991 for information only. However, it was applied in many countries for the installation of the Dynasphere® air terminals. The CVM was also re-named as the Field Intensification Method (FIM) in 2002.

Field data collected in Malaysia over ten years on the application of the CVM/FIM failed to prove that the method is valid for air terminal positioning since most of the buildings that used the method had been struck and damaged by lightning. Consequently, the CVM/FIM was deleted from the AS/NZS 1768(Int):2003.

The CVM/FIM was also rejected by the NFPA [3] in 2004 for the same reasons.

3. Legality of advertising the ESE air terminal

Following the rejection of the ESE technology by the NFPA in 2000, several American ESE vendors brought the matter to court alleging “unfair trading practices” on the part of their opponents. However, after lightning experts were called in to testify on the workings of the ESE technology, the court issued a judgement [4] prohibiting the ESE vendors from claiming that their product can provide a protection zone that is much bigger than that of the Franklin rod. The court had decided that the claims made by the ESE vendors constituted false advertising and violated the US Lanham Act.

4. Unconventional LPS and Public Safety

In September 2005, the ICLP issued a warning [5] that the use of the unconventional LPS posed a danger to the end user and general public. The warning highlighted the studies of ESE air terminal failures under real lightning conditions conducted in the USA and Malaysia. Following this warning, ACEM had issued an advisory (Ref: ACEM/sec/2005/13 dated October 27, 2005) to all its members to stop using the unconventional LPS.

The following cases highlight the recent failures of the ESE air terminals in Malaysia:

4.1 Residential buildings

The ESE air terminals are being used by some home developers to protect detached houses and low rise apartment blocks. However, the cases below show that the claimed enhanced zone of protection of the ESE air terminals had failed to prevent lightning from striking these buildings, either singular or in a cluster.

Case 1: Cluster application failure



Fig. 1: The damaged roof of a house that was struck by lightning.



Fig. 2: Close-up view of the ESE air terminal (arrowed) on the adjacent house.

Lightning struck the roof of a house which is adjacent to another house that had been installed with an ESE air terminal. The roof was partially burnt as a result of the strike. This case shows that the ESE air terminal is not capable of protecting clustered small buildings.

Case 2: Single application failure



Fig. 3: The fire damaged top floor of a house that was struck by lightning.



Fig. 4: Close-up view of the ESE air terminal on the roof (arrowed).

Lightning struck the roof of a house which had been installed with an ESE air terminal. The roof and upper floor were badly burnt as a result of the lightning strike. This case shows that the ESE air terminal is not capable of protecting small buildings like a detached house.

4.2 Putrajaya Mosque

The minaret of the mosque, completed in 1998, is a slim 116 m high structure that was installed with a single ESE air terminal on the apex. According to the RSM, the sides of the minaret from about 50 m and above are exposed to lightning strikes and require protection.

The protection provided by the ESE air terminal, according to the NFC 17-102 "standard", should be at its best since the diameter of the minaret is less than 10 m. However, in 2005, lightning struck the side of the minaret about 30 m below the apex. This clearly shows that the claimed enhanced zone of protection for the ESE air terminal is non-existent.

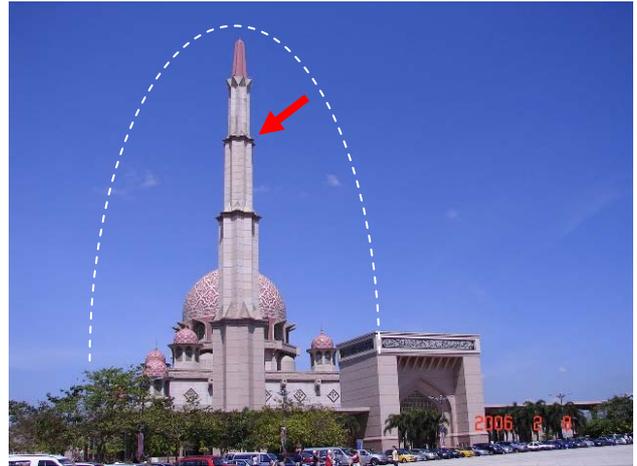


Fig. 5: Minaret of Putrajaya Mosque. The claimed protection zone is shown by the dotted line while the lightning strike location is shown by the arrow.



Fig. 6: An ESE air terminal on the apex of the minaret (arrowed).



Fig. 7: Close-up view of the lightning damaged section of the minaret (arrowed).

The failure of the ESE air terminal to protect the minaret explains why normal buildings are always struck by lightning on the upper corners and edges. This is due to the fact that these locations fall outside the hypothetical ESE protection zone. Installing the ESE air terminals on tall poles also has no effect on enhancing the protection zone.

4.3 Prime Minister Department building, Putrajaya

This large building has been installed with at least five ESE air terminals, one on the apex of the dome and four on ridge ends of the metal roofs below the dome. A photograph of a lightning strike to the dome air terminal was recently captured by a news photographer.

An analysis of the lightning path that terminated on the air terminal shows that the ESE principle is incorrect. If it was correct, then the lightning path would be approximately straight for several tens of meters above air terminal since the streamer would be moving towards the down leader.

The curved path of the lightning stroke just above the air terminal indicates that no streamer was emitted. In addition, no visible streamers were observed from the nearby ESE air terminals on the metal roofs. As already shown in the previous report, a corner of the building next to one of the lower ESE air terminals had been struck by lightning.



Fig. 8: A photograph of lightning striking the ESE air terminal on the Prime Minister Department building. (Photo credit: The Star Publications plc)



Fig. 9: The dotted line represents the hypothetical path of the early streamer according to the ESE hypothesis. (Photo credit: The Star Publications plc)

5. Local studies on the CTS and ESE

Studies in support of the CTS and ESE technologies were made by University of Technology Malaysia (UTM) researchers since 2003. Although they claimed to have found the proof for these technologies, the findings were still inconclusive.

5.1 CTS studies

These studies were made jointly with researchers from Telekom Malaysia Research and Development. The studies by Ramli and Ahmad [6],[7] claimed to have validated the CTS technology based on data obtained from the Malaysian lightning detection network (LDN), lightning video recordings and lightning current measurements made on the CTS air terminals. However, it was found that the erroneous conclusions were made based on misinterpretation of all the three data [8].

5.2 ESE studies

These studies were conducted at the university's high voltage institute, IVAT.

In a study by Ngu and Darus [9], the ESE technology was validated based on observed field data which consist of the number of observed lightning strike damages and selected lightning counter readings. However, the data in this study were found to be similar to the CVM/FIM data submitted by an ESE vendor to Standards Australia. Since the CVM/FIM has been rejected by Standards Australia and the NFPA, the validity of this study is questionable.

In a study by Sidik and Ahmad [10], a new ESE air terminal equipped with a wind-driven electrostatic generator and a palm-sized laser device was invented. They claimed [11] that the laser device is capable of attracting lightning strikes and that the air terminal operates on the CVM principle. They also claimed [12] that their invention need not be installed on the building for protection against direct lightning strikes.

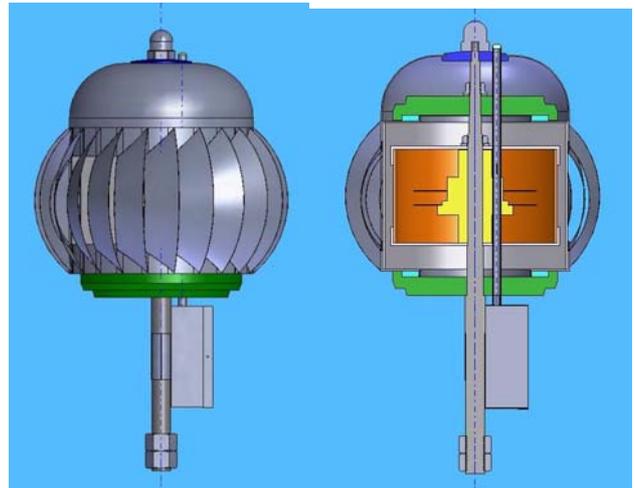


Fig. 10: Side (left) and cross-section (right) views of the UTM invented ESE air terminal. The box-shaped laser device is located below the wind-operated static generator. (Photo credit: UTM)

Several western studies have shown that the laser devices required to ionize very long air paths to create conducting channels for lightning are large and powerful; hence the claim that the palm-sized laser device can produce the same results in the field is doubtful.

The use of a wind-driven static generator means that the streamer generation is only practical on windy days. The CVM claim is unproven since the method had already been discredited and rejected by Standards Australia and the NFPA.

The last claim is also very doubtful since centrally positioned ESE air terminals have repeatedly been shown to be ineffective in protecting buildings from lightning strikes, what more an ESE air terminal that is positioned on one side of a large building.

To avoid a controversy on the status of their ESE invention, the inventors have also claimed [13] that their invention is a conventional air terminal due to the presence of the Franklin rod at the core.

6. Conclusion

Since 2004, no new evidence has been submitted to support the hypotheses behind the unconventional LPS. On the other hand, more evidence has been presented to demonstrate the inefficacy of the unconventional LPS in field applications. The ICLP has issued a warning that the use of the unconventional LPS is dangerous.

The revised national and international lightning protection standards have also included a new air terminal positioning method that will significantly improve the protection of buildings from direct lightning strikes.

Studies conducted by local research institutions in support of the unconventional LPS have also been shown to be inconclusive while a new ESE air terminal developed by a local university is based on discredited and unproven technologies.

7. Acknowledgement

The authors wish to thank The Star Publications PLC for permission to use their award winning photograph of the lightning strike to the Prime Minister Department building.

8. References

- [1] Gruet, P, "Etude des Paratonnerres a Dispositif d'Amorçage: Ministère de l'Amenagement du Territoire et de l'Environnement", INERIS, 2001.
- [2] NFPA Standards Council Decision (Final): D#05-11, January, 2005.
- [3] NFPA Report of the Committee on Lightning Protection, NFPA 780-04-ROC, 2004.

- [4] United States District Court of Arizona, Order No. CV 96-2796-PHX-ROS, dated 9th September 2005.
- [5] WARNING of the ICLP Scientific Committee, September 2005.
http://www.iclp-centre.org/view_news.php?id=45
- [6] Ramli, A., et al, "Analysis of the Effectiveness of Charge Transfer System intended for Lightning Prevention using Lightning Detection System, Lightning Video System and Rogowski Coils", Intl Conference on Lightning and Static Electricity (ICOLSE2003), England, 2003.
- [7] Ramli, A. et al, "The Performance of Charge Transfer System against Lightning Rod at the Communication Towers Analyzed by Using Lightning Video System and Rogowski coils", EMC Zurich Symposium, Switzerland, 2005.
- [8] Hartono, Z. A. and Robiah, I., "A review of studies on Early Streamer Emission and Charge Transfer System conducted in Malaysia", EMC Zurich Symposium, Singapore, 2006.
- [9] Ngu, E. E.. and Darus, A, "A Study on the ESE Lightning Protection System", summary of UTM research project, IVAT website, 2004.
- [10] Sidik, M. A. B. and Ahmad, H., "Study on the ESE Mechanisms aided by Laser Radiation Ionisation Process", summary of UTM research project, IVAT website, 2004.
- [11] Sidik, M. A. B. and Ahmad, H., "Competitive tests between two lightning air terminals", UTM handout distributed at IENA2006 exhibition, Hamburg, 2006.
- [12] Sidik, M. A. B. and Ahmad, H., "A new lightning air terminal for strategic structures using infra-red controller technology", UTM handout distributed at MTE2007 exhibition, Kuala Lumpur, 2007.
- [13] Sidik, M. A. B. and Ahmad, H., "Modernised Lightning Protection System (MLPS) with 5-in-1 Surge Protective Device", UTM handout distributed at IENA2006 exhibition, Hamburg, 2006.

The authors of this paper have been conducting forensic analyses on lightning damaged electronic systems since 1980 and have been conducting research on the effects of lightning strikes to buildings since 1990. They have published over two dozen scientific papers on these subjects in local and foreign conferences and journals. Their research works is highly cited in western scientific journals since 1995 and have been included in the revised Australian and IEC lightning protection standards.

*For more information about the authors, enter "hartono" and "lightning protection" in GOOGLE. They can be contact as follows:
E-mail: hartono@pc.jaring.my
Telephone: 012-3059971*