# Conventional and Un-conventional Lightning Air Terminals: An Overview

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## Synopsis

***The un-conventional lightning protection air terminals (AT) have been around since the invention of the lightning rod by Benjamin Franklin in the 18th century. However they had never been proven theoretically and practically by their proponents.***

***The current un-conventional ATs, such as the lightning eliminators, the radioactive lightning rods and the early streamer devices, were introduced since the 1970s and they too had never been proven. Although they do not comply with the then and existing lightning protection standards, they were used on many projects in Malaysia and around the world.***

***This paper reviews the development of the current un-conventional ATs and their evaluation based on theory, laboratory and field studies. The paper also discusses the standards proposed for the un-conventional ATs in the last decade. The paper also takes a look at the developments in Malaysia in terms of standards implementation and LPS studies conducted by a local university.***

### 1.0 Introduction

Lightning is a natural hazard that is more prevalent in the tropical region than elsewhere. In Malaysia, the average number of thunderstorm days[1] per year is between 79 (Kudat) and 202 (Bayan Lepas) according to information provided by the Malaysian Meteorological Service. This figure is very high when we compare it against the temperate countries like Britain where there is only between 10 and 20 thunderstorm days per year.

Consequently, the damages and casualties as a result of direct lightning strikes are much higher in the tropics. Hence there is a vital need for protection against direct lightning strikes. This protection comes in the form of a lightning protection system (LPS).

The LPS used in this country and around the world are basically divided into two types:

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

While the sale and use of the standard LPS is legal since it complies with the national and/or international standards and has been scientifically proven to provide safety to the users, the sale of the non-standard LPS did not.

### 1.1 Lightning protection standards

Like many electrical products in the market, a LPS is required to comply with the technical standards set by the IEC or by the respective national standards body (eg. SIRIM). When

[1] Hartono, Z. A. and Robiah, I., "Thunderstorm day and ground flash density in Malaysia", National Power Engineering Conference (PECon2003), Bangi, December 2003.

such a system complies with the recommendations set in the standard, it is known as a standard LPS.

The lightning protection standard is usually developed by a technical committee comprising of academics, experts and industry practitioners who are knowledgeable in the field and are responsible for ensuring that the LPS to are scientifically validated and proven. Hence by complying with the standard, the consumer (eg. property owner) will be assured that the LPS installed will provide a meaningful and effective protection against the hazards of lightning.

The existing lightning protection standards that are sometimes referred to in Malaysia are the IEC-61024 (International), BS6651 (United Kingdom), NFPA780 (USA), AS/NZS 1768 (Australia & New Zealand), and CP33 (Singapore).

The first Malaysian lightning protection standard was the MS939 which was developed in 1984. It has since been replaced by the IEC standard, the IEC 61024, in 2001 and is now known as the MS-IEC 61024.

### 1.2 Standard Lightning Protection System

The main component of the standard LPS is the conventional air terminal (a.k.a. Franklin rod) that was invented by Benjamin Franklin around 1750. After more than 250 years in existence, the Franklin rod is still in use throughout the world and it has recently been scientifically validated in two major studies conducted by the AGU[2], a reputable international scientific organisation, and the Federal Interagency Lightning Protection User Group[3], a technical body representing the United States government.

The Franklin rod is a passive device i.e. it serves as a sacrificial device when the lightning strikes it rather than the building. In a typical building, several of these Franklin rods are installed at various locations on the roof that are likely to be struck by lightning. In this way, the lightning will have a high probability of striking the Franklin rods instead of the roof. Therefore, the building is considered protected from direct lightning strikes.

The other components of the standard LPS are the down conductor and the earth terminal. The function of the down conductor is to channel the lightning current safely from the Franklin rod to the earth terminal. The function of the earth terminal is to safely dissipate the large lightning current into the ground effectively.

A locally manufactured Franklin rod costs around RM30.00 each or less while an imported version may cost up to twice as much. The Franklin rod is not protected by a patent.

[2] Report of the Committee on Atmospheric and Space Electricity (CASE) of the American Geophysical Union on the Scientific Basis for Traditional Lightning Protection Systems (http://CASE.AGU.org/NFPAreport.pdf)

[3] "**The Basis of Conventional Lightning Protection Technology**, *A review of the scientific development of conventional lightning protection technologies and standards*", Report of the Federal Interagency Lightning Protection User Group, June 2001. (http://www.lightningsafety.com/nlsi_lhm/conventionalLPT.pdf)

The typical conventional air terminal or Franklin rod (arrowed) which had been installed on the roof of a building. It can either have a sharp or blunt tip (preferred).

### 1.3 Non-standard Lightning Protection System

In the 1970s, two types of unconventional air terminals had been commercially re-invented[4] and introduced in the world market. They are the lightning prevention air terminal and the lightning attracting air terminal.

Only one un-conventional air terminal is usually installed centrally on the roof of a building such as a bungalow or a high-rise apartment block. However, for buildings with a larger roof area, two or more un-conventional air terminals may be installed and they are normally spaced at some distance apart from one another.

As their names imply, the lightning prevention air terminal is claimed to be able to prevent lightning from occurring and hence protect the building. On the other hand, the lightning attracting air terminal is claimed to be able to attract the lightning to it (and hence away from the building) in order to protect the building that it was installed on.

In reality, the inventors of these un-conventional air terminals have never been able to provide any scientific basis for their invention. None of the “scientific papers” that they have published in the last 30 years have been independently verified by the scientific community.

In addition to this, these inventors have never been able to provide any independently validated proof that their inventions work. However, they have provided plenty of anecdotal (i.e. hearsay) evidence which had been obtained from “satisfied customers”.

For these reasons, these inventors and manufacturers have not been able to get their un-conventional air terminals approved by the standards bodies. Hence the LPS that used

[4] It is important to realize that the non-standard lightning air terminals had been invented by others earlier in the 20th century and had been disproved.

these un-conventional air terminals have been classified as non-standard LPS by academics, scientists and the various standards bodies around the world.

An unconventional air terminal may cost between RM4,000 to RM10,000 each and all of them seemed to be foreign made. Each unconventional air terminal is protected by a patent held by the respective foreign manufacturer. A more detailed description of these systems is given in sections 2 and 3.

The non-standard LPS are usually easier and cheaper to install when compared to the conventional system but the protection that it provides is very limited i.e. equivalent to that of a single Franklin rod! Hence these vendors had to rely on some very creative marketing to sell their non-scientific and unproven products.

The above picture shows the damaged concrete roof corner (circled) caused by a direct lightning strike. This college building was installed with an unconventional air terminal (arrowed). Debris from such damages is a hazard to people and cars who may be loitering just below the corner at the time of the incident. More than 80% of buildings in Kuala Lumpur that have been installed with the un-conventional air terminals have at least one of this lightning strike damage features on them.

### 1.4 Consequence of using the non-standard LPS

It is conservatively estimated that at least RM5.0 million is been lost annually by the nation through the purchase of these unconventional air terminals alone. If collateral damages as a result of direct strikes (such as building damages, fires and damaged electronic systems) are added into the equation, the figure could very well be ten times the above amount.

In addition to this loss, human lives have been put at risk when the building installed with the non-standard LPS had been struck and damaged by lightning. A clear example of this risk is the school hostel in Subang Jaya that was struck and severely damaged by lightning in August 2002.


An external view of the lightning damaged hostel of the religious school in Subang Jaya. If the lightning had struck on an occupied dormitory room a few hours later, the possibility of injuries (and even deaths) among the students could not be avoided.


A French-made ESE air terminal (circled) was installed on the roof of the adjacent building (Asrama A) which is about 20m from the lightning strike damage. According to the vendor's product description, this device provides coverage of about 50m radius i.e. to "protect" both blocks A and B. This failure is just another example that the sophisticated lightning protection system does not work.

The Subang Jaya school complex of about half a dozen buildings was installed with three lightning attracting air terminals that is claimed to have protection coverage of about 50 m

each. The lightning strike and resultant fire shows a serious breach of safety had occurred which have a potential to cause injury and loss of life.

We have studied many incidences of lightning strikes to schools and other educational institutions over the last ten years. The study shows that when the standard LPS had been designed and installed properly i.e. when many conventional air terminals have been installed on the roof, the damage to the roof is minimal. However, when the system had not been designed or installed correctly, the damage is more severe.

Since the un-conventional air terminal is only installed at the centre of the roof, the edges of the roof are regarded as unprotected. Hence the damage is usually severe when lightning struck these parts.

The un-conventional air terminal had been used in the universities since the 1970s but they have recently appeared in the schools, junior colleges and matriculation colleges within the last few years. We have alerted this matter in the media in 2001 but it seemed that it had been ignored since more new schools have been installed with these non-standard systems since then.

The incident at the school in Subang Jaya in August 2002 is proof that the un-conventional air terminal is unproven. More incidences of this kind can be expected in the future and may probably cause more losses than just a fire.

Hundreds of school, college and university buildings throughout the country have been installed with these non-standard systems. They have also been installed on hundreds of other public buildings (such as hospitals, public apartments and government offices) and thousands of privately owned buildings such as homes, condominiums, hotels, shopping complexes, offices and factories.

Since this country has up to 50 times more thunderstorm days than some western countries (such as the UK), it is important that the government realise that these non-standard LPS are a serious hazard to property and life. Hence, the sooner action is taken to stop this technical scam for good, the better it will be for public safety and the nation's economy.

## 2.0 The lightning attracting systems

The initial lightning attracting system came in the form of the radioactive air terminal in the 1970s and the later system came in the form of the Early Streamer Emission (ESE) air terminal in the late 1980s

The principle behind the lightning attracting system lay in the existence of the upward streamer (a.k.a. upward leader). It is a naturally occurring low current electrical discharge phenomenon that exists when a lightning bolt is about to occur in the immediate vicinity.

The lightning bolt starts initially with another phenomenon known as a downward leader, an current electrical discharge that moves down from the thundercloud. As the downward leader nears the surface of the earth, it increases the electric field in the immediate area below it and this cause the emergence of upward streamers from various objects on the earth's surface (eg. lightning rods, trees, buildings, TV antennae, people etc.).

One of these upward streamers will make a connection with the downward leader and a resultant high current lightning bolt will occur along the connected leader-streamer path.


Graphic shows (1) downward leader descending from cloud (left picture); (2) upward streamers emerging from lightning rods and tree (middle picture); and (3) leader-streamer connection (right picture).
Source: Uman, M. A. and Rakov, V. A., "**A Critical Review of Non-conventional Approaches to Lightning Protection**", Bulletin of the American Meteorological Society, December 2002.
(http://plaza.ufl.edu/rakov/Uman&Rakov%20(2000).pdf)

In the lightning attracting system, their inventors claimed that their air terminals can generate these upward streamers earlier than other natural objects on the ground can (hence the term "early streamer" was introduced in the early 1990s). To generate the upward streamers, the inventors initially used radioactive materials but these were replaced with other methods when the use of the radioactive materials was banned by governments worldwide.

These artificially generated upward streamers were claimed to be able to make a connection with the downward leader before any other naturally occurring streamers were able to do so, thus "attracting" the lightning flash to the air terminal instead of to the building. In this way, their inventors claimed that the lightning attracting air terminal protects the building on which it is installed.

### 2.1 Radioactive air terminals

The various types of radioactive air terminals were constructed like the Franklin air terminal except that they had radioactive isotopes added to the terminal. The radioactive

isotopes were claimed to be able to ionise the terminal which can assist in the launch of the streamers.

In this method, the inventors claimed that the radioactive air terminal can attract lightning up to 100 m away, hence providing large protection coverage of about the same radial distance. Therefore, only one centrally located radioactive air terminal is required to protect a large building as compared to the dozens of Franklin rods in a standard LPS.

However, these claims were disproved in 1985 when some academics from Australia and Singapore conducted a study of buildings that had been installed with the radioactive lightning rods. In that study[5] that was conducted in Singapore several buildings were found to have been struck and damaged by lightning within the claimed protection radius of the radioactive air terminal.

At the same time, the radioactive air terminals were also found to be hazardous since the radioactive material can disintegrate in the weather and can enter the human body through the food chain or through inhaling radioactive dust in the air. Consequently, the use of the radioactive air terminal was banned worldwide in 1987. However, they were immediately succeeded by a new generation lightning attracting air terminal, the ESE air terminal.

# Government bans import, sale of these lightning rods

New Straits Times Wed 28th June 1989

By ROMLI IBRAHIM

KUALA LUMPUR, Tues. — The Government has banned, with immediate effect, the further import and sale of lightning rods containing radioactive material.

Present users, however, are allowed to retain such rods but are advised to register with the Atomic Energy Licensing Board.

The Government has also allowed the continued use of smoke detectors (ICSD or ionisation chamber smoke detector) containing radioactive matter as the radioactive content in these devices is too small and, therefore, quite harmless.

Announcing this today, the executive secretary of the board, Encik Kasbun Kamat, said: "We have found that such lightning rods have no extra advantages over the conventional ones."

Some people think that such lightning rods are more effective because of their radioactive content.

## Tall buildings

"That is not so. Such lightning rods are not superior to the conventional ones."

He said countries like the Unites States, Sweden, France, Australia and Argentina, which had produced the radioactive rods, had imposed a ban on their use.

The board also decided to impose the ban because of the problem of disposal that would arise with the wider use of the radioactive rods.

"The Government wants to ensure that Malaysia will not become a dumping ground for radioactive rods."

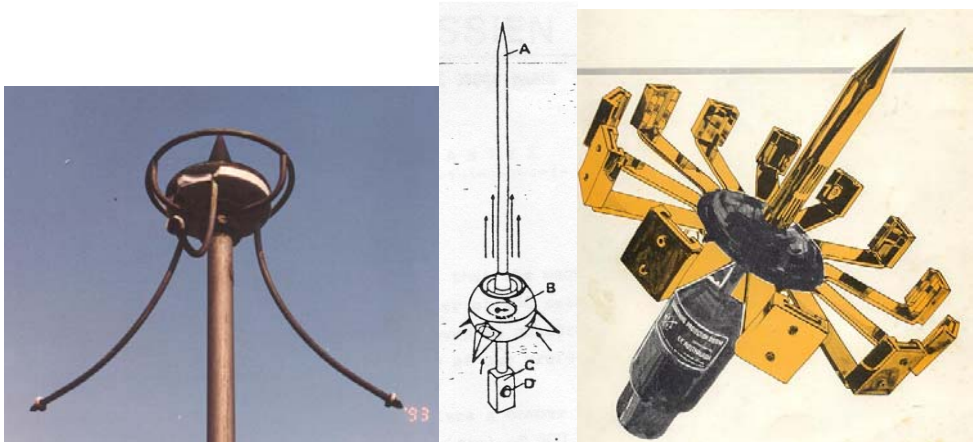
There are now about 50 radioactive rods in

A lightning rod containing radioactive material.

The ban on the radioactive lightning rods that took effect in June 1989.

In Malaysia, the radioactive air terminal was introduced in the 1970s and its import and sale was banned in 1989. However, the use of the radioactive air terminal was still allowed by the government if the user obtained a license from the proper authority. Until today, hundreds of these radioactive air terminals can still be found on many buildings throughout the country and some of them have been replaced by the ESE air terminal.

[5] Darveniza, M., Mackerras, D., and Liew, A. C., "**Standard and Non-standard Lightning Protection Methods**", Journal of Electrical and Electronics Engineering, Australia, 1987.




Some of the radioactive air terminals used in Malaysia. There are about a half dozen variety still in use throughout the country.
Left to right: Preventor (France), Preventor (UK) and EF33 (Australia).

### 2.2 Early Streamer Emission (ESE) air terminals

When the radioactive air terminals were banned worldwide, the manufacturers rapidly introduced new air terminals which used non-radioactive means to launch the streamers. (The popular acronym ESE was only introduced a few years later in the early 1990s.)

The ESE air terminal made use of proprietary designed metal enclosures around the ordinary lightning rods to create the ionisation that can generate the artificial streamers earlier than the natural ones. Different manufacturers will provide different shaped enclosures to distinguish their branded products. However, they all claimed that their air terminals can launch the streamers much earlier that the natural streamers, thus achieving the same kind of protection for the buildings that were provided by the radioactive air terminals.

While scientists do not dispute that the various proprietary ESE air terminals can launch the streamers earlier, by a few micro seconds, they however do not agree to the speed of the streamer that was used by the ESE manufacturers in their calculation of the streamer length. While scientists have observed that the streamer speed is between $10^4$ and $10^5$ $ms^{-1}$, the ESE manufacturers have arbitrary used a value of $10^6$ $ms^{-1}$ i.e. at least 10 times faster than that observed.

Hence, while scientists claimed that the artificially generated streamers cannot be longer than a few meters only through observations in the laboratory, the manufacturers had claimed that the streamers had a length of between 50 to 100 meters (i.e. 10 times longer!) in their marketing brochures. In this way, the ESE vendors can claim that only one centrally located ESE air terminal is needed to protect an entire building.

Several independent scientific studies have shown that the ESE air terminals failed to capture lightning in the laboratories. They also failed to capture natural lightning when tested[6] at the mountain top research laboratory in New Mexico, USA. In Malaysia, our

[6] C.B. Moore, G.D. Aulich, and W. Rison, "**Measurements of Lightning Rod Responses to Nearby Strikes**", Geophysical Research Letters, Vol. 27, No. 10, pp. 1487-1490, May 15, 2000

photographic studies[7] have shown that the ESE air terminals failed to protect many buildings from being struck by lightning.

Some of the ESE air terminals that are commonly used in Malaysia. There are more than a dozen different types in use in the country. All these proprietary designs claimed to produce early streamers but it has been proven that they cannot protect the buildings from being struck by lightning.
Top (L to R): Dynasphere (Australia), Prevectron (France), EF (Swiss).
Bottom (L to R): St. Elmo (France), Pulsar (France), St. Elmo (Italy), DAT Controler (Spain) and Paratonerre (France).

In Malaysia, the ESE air terminals were introduced in the late 1980s i.e. as soon as the radioactive LPS were banned. The ESE air terminals are the most common non-conventional air terminals used in the country. They are mainly made in Australia, France, Italy, Switzerland and Spain.

[7] Uman, M. A. and Rakov, V. A., "**A Critical Review of Non-conventional Approaches to Lightning Protection**", Bulletin of the American Meteorological Society, December 2002, pg. 1817 (http://plaza.ufl.edu/rakov/Uman&Rakov%20(2000).pdf)

## 3.0 The lightning elimination systems

There are two basic types of lightning elimination (i.e. prevention) systems in the market. One is claimed by its vendor to be able to eliminate lightning strikes while the other is claimed to be able to drastically reduce the magnitude of the lightning strike current.

### 3.1 The Dissipative Array System (DAS)[8]

The DAS was invented in 1973 and was claimed to be able to prevent lightning from striking the facility it was installed on. However, the claim was short lived since American scientists who were called in by the US government to investigate the claims were able to photograph several lightning bolts striking on the DAS itself.

The failures of the DAS can be found in a book[9] on lightning protection that was published in 1977. In spite of this, the DAS is still being sold in the US market since its prohibition would have been a violation of the American constitution.

Since the inventor of the DAS still claimed that the air terminal can prevent lightning strikes, other scientists and engineers have examined his claim and found them to be false. Due to the adverse publicity on the DAS terminology, the inventor had introduced a new concept to describe his invention in the 1990s and named it as the Charge Transfer System (CTS). However, other studies[10] revealed that the DAS and CTS systems could not prevent lightning strikes.

In 2001, the inventor had applied for a proposed standard for the CTS from the IEEE[11], an international organisation well known for their technical standards in electrical and electronic technology. However, due to the absence of any scientific theory for the invention, the proposed standard had stalled but the vendors still continued to sell the system worldwide with the claim that an IEEE standard is being developed.

The DAS/CTS was introduced into Malaysia in the early 1990s and a number of them had been sold to large corporations such as Petronas and Tenaga Nasional Berhad.

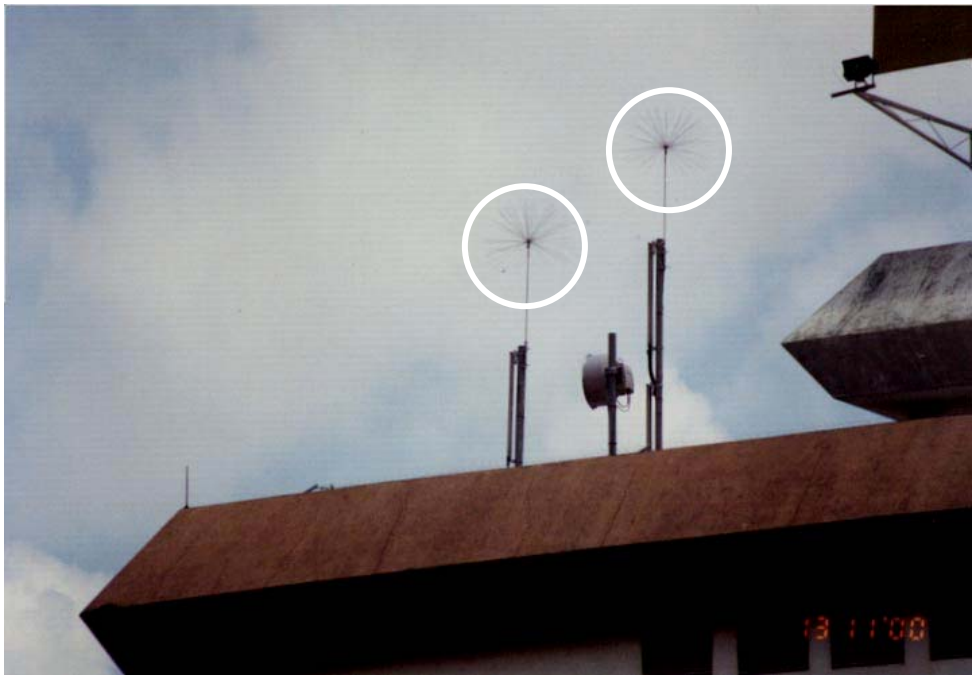
[8] The DAS is one of several lightning protection systems available in Malaysia that claimed to be able to prevent lightning strikes to a building. The DAS is also known as the Charge Transfer System (CTS) in recent years.

[9] "Lightning - Volume 2: Lightning Protection", edited by R. H. Golde, 1977.

[10] To review some of these studies, go to section 5.4 of the Lightning Safety website: http://www.lightningsafety.com/nlsi_lhm.htm

[11] Institution of Electronic and Electrical Engineering (USA), Inc.

A DAS air terminal (circled) installed at a petroleum gas pumping station in Kapar. Similar installations in the USA have been struck by lightning and have been reported in several scientific papers.



Two Spline Ball CTS air terminals (circled) installed on a telephone exchange in Kuala Lumpur. The failure of these terminals have also been reported in scientific papers.

### 3.2 Other lightning elimination air terminals.

Besides the DAS, other lightning prevention air terminals have also been brought into the country in recent years due. They are very much smaller in size and in various shapes. However, they still made similar claims as that of the DAS.

Another form of lightning prevention system installed on camera poles on the highway.

### 3.3 Semiconductor Lightning Eliminator (SLE)

The SLE was invented in China and is claimed by its inventor to be able to reduce the lightning current by 99%, hence making it safe for installation on buildings which contained sensitive electronic systems. In Malaysia, the SLE air terminals were first installed in 2001 at a petrochemical plant on the east coast.

The vendors of the system claimed that the success of the SLE is indicated by the number of “successful” direct strikes that it had intercepted. This number is given by a lightning counter circuit that is attached to the SLE conductor.

However, technical data provided by the local user of this system shows that the claim made by the vendor was unjustified. While risk calculations indicated that the structures on which the SLE can expect an average of less than one direct lightning strike per year, the lightning counter attached to the SLE indicated that it had been struck by between 20 and 30 direct strikes in the first year of operation alone.

Such a figure indicates that the SLE counter is either defective when it comes to counting the number of lightning strikes or it was design to register all surges including lightning. Hence there is still no independent proof that the SLE can work as claimed.

Furthermore, a very recent study[12] by two scientists from the Chinese Academy of Sciences show that the lightning reduction properties of the SLE have not been observed when exposed to rocket triggered lightning.

SLE air terminals (circled) installed on petrochemical processing plants in Trengganu. Their claimed ability to reduce the captured lightning current by 99% has been disproved by scientists from the Chinese Academy of Sciences.

[12] Zhang, Y. and Liu, X. "**Experiment of artificially triggered lightning to lightning rod and Semiconductor Lightning Eliminator**", International Conference on Atmospheric Electricity (ICAE2003), France, June 2003
http://www.atmospheric-electricity.org/icae2003/program/abstracts/wednesday-d.htm#zhang

## 4.0 The scientific controversy surrounding the ESE air terminal

A scientific controversy emerged in the early 1990s when the ESE manufacturers applied to have a standard for their products to make them legal for sale. Without these standards, the sale would be illegal and a breach of the safety regulations in the countries they were sold.

### 4.1 How the controversy started

The French ESE manufacturers were the first to developed their own "product standard" for their air terminal systems, the NFC 17-102[13]. The purpose of this "standard" is to standardise the installation method of the French ESE air terminals rather than to comply with the IEC standard on lightning protection. (France, like Malaysia, is already a member of the IEC and had already subscribed to the IEC standard on lightning protection, the IEC-61024.)

At about the same time, the Australian ESE manufacturer managed to get their LPS "design method", known as the Collection Volume Method (CVM), accepted as an informative appendix[14] of the Australian/New Zealand standard AS/NZS 1768. The manufacturer claimed that their ESE air terminal can protect buildings from lightning if designed and installed according to the CVM method.

Based on the successes of the French and Australian ESE manufacturers, the American ESE manufacturers also proposed a product standard, the NFPA781, to the NFPA and to the IEC. However, the American attempt was short lived as the NFPA and the IEC were, by then, able to conduct a proper study of the ESE terminals before they made their decision on the proposed NFPA781 standard.

### 4.2 The response of standards organisations to the controversy

The following sections describe how the ESE issue was handled by the various foreign standards organisations:

#### 4.2.1 International Electro-technical Commission (1995)

The IEC engaged CIGRE to conduct a study on the ESE since CIGRE had the expertise to do so. CIGRE also has a local presence in this country, the Malaysian National Committee on CIGRE (MNC-CIGRE).

In May 1995, the CIGRE lightning protection review committee rejected the ESE systems based on several scientific studies received from around the world. Among their conclusions were that the claims made for the streamer speed by the ESE manufacturers were higher by at least one order of magnitude.

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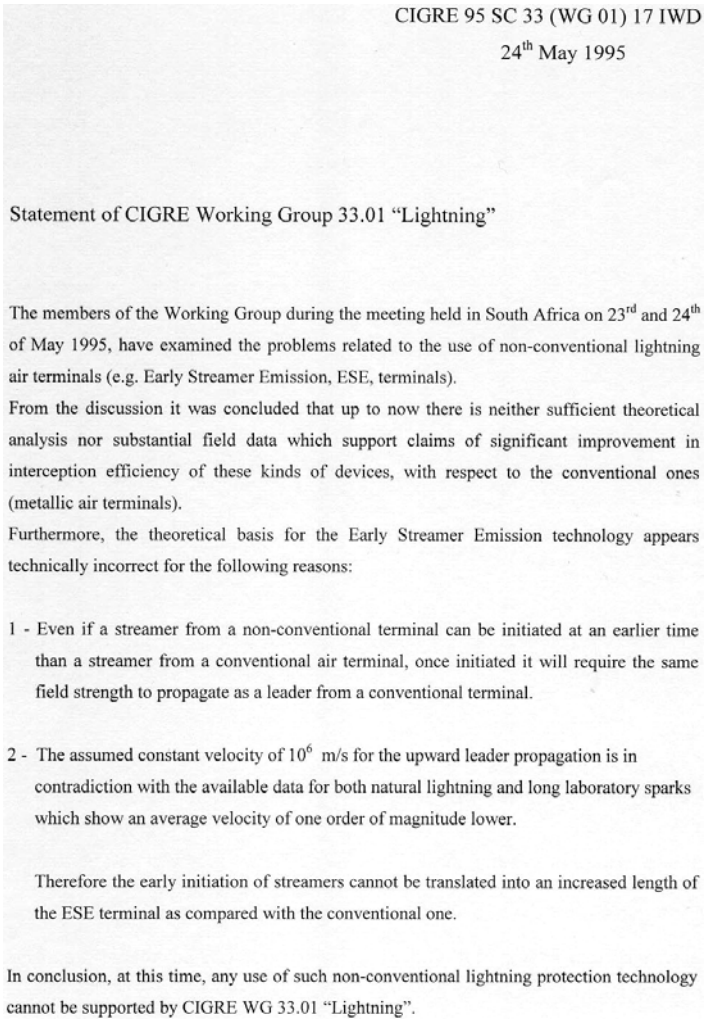
[13] This "product standard" was developed by the ESE manufacturers through their trade association, known as GIMELEC. The standard had not gone through the normal scientific validation process that other standards were put through. See also section 4.2.4.

[14] The standard document is divided into the main body and the appendices. The main body describes the mandatory technical details that must be implemented in order to comply with the standard. The appendices provide additional information that are related to the subject of the standard but is not a part of it. In the AS/NZS 1768 document, the reader is cautioned against using the CVM as a design tool since it had not been validated. However, the ESE vendors never highlight this fact to the unsuspecting potential customer.

This unfounded claim made the length of the artificially generated streamers, and consequently the protection radius of the ESE air terminal, to be at least ten times longer than they actually were.



CIGRE 95 SC 33 (WG 01) 17 IWD

24th May 1995

Statement of CIGRE Working Group 33.01 "Lightning"

The members of the Working Group during the meeting held in South Africa on 23rd and 24th of May 1995, have examined the problems related to the use of non-conventional lightning air terminals (e.g. Early Streamer Emission, ESE, terminals).

From the discussion it was concluded that up to now there is neither sufficient theoretical analysis nor substantial field data which support claims of significant improvement in interception efficiency of these kinds of devices, with respect to the conventional ones (metallic air terminals).

Furthermore, the theoretical basis for the Early Streamer Emission technology appears technically incorrect for the following reasons:

1 - Even if a streamer from a non-conventional terminal can be initiated at an earlier time than a streamer from a conventional air terminal, once initiated it will require the same field strength to propagate as a leader from a conventional terminal.

2 - The assumed constant velocity of $10^6$ m/s for the upward leader propagation is in contradiction with the available data for both natural lightning and long laboratory sparks which show an average velocity of one order of magnitude lower.

Therefore the early initiation of streamers cannot be translated into an increased length of the ESE terminal as compared with the conventional one.

In conclusion, at this time, any use of such non-conventional lightning protection technology cannot be supported by CIGRE WG 33.01 "Lightning".

A copy of this CIGRE document was obtained by SIRIM representatives who had attended an IEC conference in South Africa in 1995.

Furthermore, there was clear evidence from Malaysia to show that the ESE air terminals had failed to protect the buildings. This evidence, in the form of photographs of lightning damaged buildings provided by us, contradicted the claims made by the ESE manufacturers that their systems had worked without any failure. Based on the CIGRE findings, IEC formally rejected the ESE at a standards meeting[15] that was held in South Africa a few months later.

### 4.2.2 National Fire Protection Association (1995)

[15] This meeting was attended by several participants from Malaysia and the documentation related to this meeting, including the rejection of the ESE, was brought back to SIRIM by the participants. We obtained a copy of this minute from SIRIM in December 1995.

Similar to the French standard, the proposed standard NFPA781 was developed by the ESE manufacturers themselves and submitted to the NFPA. Consequently, the NFPA Standards Council had engaged the NIST[16] to conduct the study.

The NIST came up with an inconclusive finding after conducting an extensive literature research involving more than 300 documents that were available then. During an NFPA Standards Council meeting in August 1995, the NIST and CIGRE findings were discussed and this led the council to reject the proposed ESE standard.

The council had stated[17] that the ESE systems had not met the public safety criteria to allow them to approve the proposed NFPA781 standard for use in the USA.

Among the statements issued by the NFPA Standards Council were:

"Proposed NFPA 781 is based on the assumption that ESE terminals provide a greater zone of protection than conventional terminals. It was undisputed, moreover, that proposed NFPA 781 would permit ESE systems using far fewer terminals and far greater spacing between terminals than in a comparable conventional system installed according to NFPA 780. **Given the absence of reliable evidence that ESE terminals offer an increased zone of protection over that of conventional terminals, it seems clear that a sound technical basis for proposed NFPA 781 has not been demonstrated**."

"Given the current state of knowledge, it does not appear that the type of further research and evaluation recommended by the NIST Report will be available in the short term. In the view of the Council, therefore, continuing standards development activities for ESE systems, would, at present, serve no useful purpose."

Therefore, it can be seen that the ESE still had no scientific basis as of 1995. However, the proposed NFPA781 standard had been used by some ESE vendors and academics to promote the product even after 1995.

### 4.2.3 National Fire Protection Association (2000)

In October 1998, the NFPA Standards Council had announced new study on the ESE air terminals as a settlement of a lawsuit brought by the ESE vendors following the rejection of the proposed NFPA781 standard. A new independent panel, known as the Bryan Panel, reviewed the studies that had been submitted from around the world and they reported their findings to the council in September 1999.

Among the many new studies contained in the Bryan Report[18] that conclusively demonstrated the non-scientific and un-proven status of the ESE air terminals was a study[19] on lightning struck buildings that were submitted by us. Our study contained photographs of the buildings "before" and "after" they were struck by lightning, hence the presence and failure of the ESE air terminal in each case study was indisputable.

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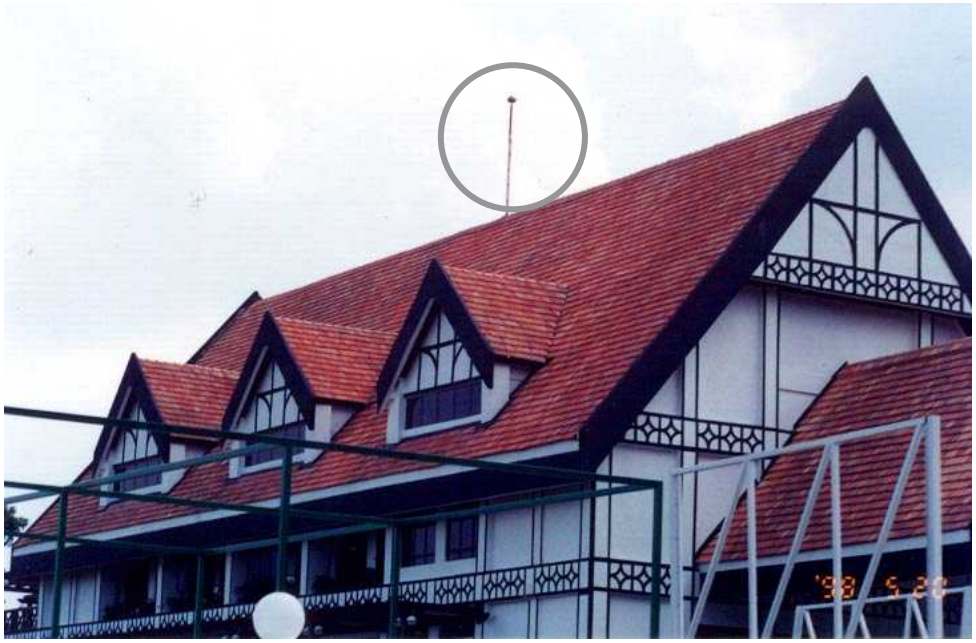
[16] The National Institute of Standards and Technology (NIST) is the leading American scientific body that examines new technology developments.

[17] NFPA Standards Council Decision of July 18, 1995, D #95-26.

[18] Bryan, J. L., Biermann, R. G., and Erickson, G. A., "**Report of the Third Party Independent Evaluation Panel on the Early Streamer Emission Lightning Protection Technology**", report submitted to the NFPA Standards Council, September 1999

[19] Hartono, Z. A., and Robiah, I., "**A Long Term Study on the Performance of Early Streamer Emission Air Terminals in a High Isokeraunic Region**", report submitted to the Third Party Independent Evaluation Panel on the Early Streamer Emission Lightning Protection Technology, National Fire Protection Association (USA), February 1999



This is an example of a recent “before” and “after” lightning strike photograph. The Royal Selangor Club building in Damasara in 1998 soon after it was installed with an ESE air terminal (circled).

The Royal Selangor Club building after it was struck and damaged (circled) by lightning in 2001. This kind of “before” and “after” photographs have provided indisputable proof to the western scientific world that the ESE air terminals are non-scientific and unproven. We have provided dozens of such examples to western scientists since 1995.

In April 2000, the council concluded[20] that there was sufficient new information to show that the ESE air terminals were in fact non-scientific and un-proven in their existing form.

[20] NFPA Standards Council Decision of April 28, 2000, D #00-13.

Hence, the 1995 rejection of the proposed NFPA781 standard for the ESE air terminal was upheld again by the council.

Among the statements issued by the NFPA Standards Council in April 2000 were:

"As indicated above, the Council's previous decision in July 1995 not to issue the proposed NFPA 781 and to discontinue the ESE technical committee project was based on the fact that "given the absence of reliable evidence that ESE terminals offer an increased zone of protection over that of conventional terminals, it seems clear that a sound technical basis for proposed 781 has not been demonstrated." (D #95-26) **Nothing in the record now before the Council has supplied that reliable evidence or has caused the Council, upon its *de novo* reevaluation of the entire matter, to come to a different conclusion**.

In particular, the chief findings of the Bryan Panel Report support the Council's conclusion. Specifically the Panel Report noted that, while ESE air terminals appear to be technically sound in the limited sense that they are generally equivalent to the conventional Franklin Air Terminal in laboratory experiments, the Panel found that **the claims of enhanced areas of protection and the essentials of the grounding system have not been validated**.

Specifically the Panel Report says at page 26:

**The ESE lightning protection technology as currently developed in the installation of complete systems does not appear to be scientifically and technically sound in relation to the claimed areas of protection or the essentials of the grounding system.**

The report adds on page 27:

**There does not appear to be an adequate theoretical basis for the claimed enhanced areas of protection with limited down conductors and grounding system.**

Given these findings, which are, in the view of the Council, supported by the record as a whole, the Council does not believe there is any basis to issue a separate standard, such as proposed NFPA 781, for ESE lightning protection systems or to renew standards development activities aimed at creating such a standard."

This means that the proposed NFPA781 standard still had no scientific basis in April 2000. In addition, there was ample evidence from Malaysia research findings to show that they did not work.

In spite of this, the ESE air terminal was still proposed for the Malaysian lightning protection standard by the UTM led committee at the end of 2000. However, this proposal was rejected by the Industry Standards Council based on our report to them.

### 4.2.4 French "product standard" (2001)

Following the failure of the American ESE manufacturers to secure a standard for their product from the NFPA in 2000, a French government scientific agency, INERIS[21], conducted a detailed study[22] on the French "product standard" and the French-made ESE systems. They found that most of the ESE air terminals had not been tested against the

[21] Institut National de L'Environnement Industriel et des Risques

[22] Gruet, P, "**Etude des Paratonnerres a Dispositif d'Amorcage**:", INERIS, October 2001 (http://www.ineris.fr/recherches/download/PDA.pdf)

French standard NF C 17-102 that were developed by the ESE manufacturers themselves.

An example of a French made ESE air terminal (arrowed) that was installed on the roof of an apartment in Putrajaya. Although the ESE vendor claimed that this air terminal can provide protection coverage for the entire apartment block, lightning had struck and damaged the roof (circled) just below the terminal. The French authorities are very concerned that French products had endangered the public within and outside their country. Perhaps the Malaysian authorities should do the same since this kind of endangerment occurs within their own country.

The translation[23] of the conclusion of the INERIS study is as follows:

"The underlying concept of ESE devices is that they generate upward streamers earlier than done by traditional Franklin rods. According to French Standard NF C 17-102, this time advance is the characteristic parameter of the effectiveness of this equipment, and it can be measured in a high voltage laboratory.

It is necessary to know the propagation velocity of the upward streamer to determine the attraction range of an ESE device. Speeds measured during thunderstorms exhibit wide dispersion (between $10^5$ and $10^6$ m/s). More importantly, the theory behind ESE devices has not been proven.

The study by INERIS revealed the following:

- Some ESE devices cannot be tested in the laboratory even though they are advertised as being in accordance with Standard NF C 17-102.

- Certain models have never been tested to verify that they were capable of withstanding the impact of lightning currents.

[23] Courtesy of Dr. Abdul Mousa of BC Hydro, Canada

- The radius of protection that some manufacturers claim to be based on the provisions of Standard NF C-17-102 has not been verified.
- The superiority of ESE devices compared to the simple Franklin rod, has not been demonstrated.
- The advance triggering time, even if measured under specific conditions, is not sufficient to justify the protection range claimed in the Standard. This is because the used formula rests on hypotheses regarding the propagation velocity of the upward streamer and the adequacy of the energy brought by the downward leader. The ESE approach involves unjustified confidence in the protection range beyond what is warranted by the physics of the problem.

When the results of our review were presented to GIMELEC, the manufacturers promptly offered to revise Standard NF C 17-102. We believe it to be necessary to validate the underlying hypotheses to determine the protective range from the time advance measured

in the laboratory.

Consequently, we recommend that ESE devices built according to Standard NF C 17-102 of 1995 not be used to protect any hazardous installations that can pose a hazard to the environment.

To resolve the question regarding the effectiveness of ESE devices, we suggest two research projects:

a) taking advantage the large number of installed devices and the experience gained from using them to estimate the extent of the protection that they provide,

b) investigating the validity of the underlying theory and the appropriateness of the use of the advance triggering time as a performance criterion."

The INERIS report was published in 2001 and until today the French ESE manufacturers had not been able to comply with the report. This means that the thousands of French made ESE air terminals already in use in Malaysia do not comply with any standard since the French "product standard" NF C 17-102 had been discredited by their own government agency.

In the INERIS report, our study on the ESE failures was also mentioned[24] as a factor in their decision to review the French ESE standard.

### 4.2.5 Draft Australian/New Zealand Standard (2002)

In 1999, the Australian/New Zealand standard for lightning protection, AS/NZS 1768, was put on a review process to update the information based on recent findings. The CVM method for designing the LPS, which was described in the standard, was not a valid method since it was found only in the appendix and not in the main body of the standard document. This status was clearly stated in the standard document but was never explained to the potential buyer by the ESE vendor.

Nevertheless, the CVM has been widely used as a design tool to market the Australian-made ESE air terminals around the world to unsuspecting buyers. This means that the

[24] Gruet, P, "**Etude des Paratonnerres a Dispositif d'Amorcage**", INERIS, October 2001, pp. 30/46.

Australian-made ESE air terminals that are widely used in this country are without compliance to even the Australian standard.

The original CVM method was based on a study conducted by a South African scientist. However, his study was based on measurements to lightning current that were made at the base of a tall observation tower. His study had been proven inaccurate by two researchers at different times, B. Melander (1985) and V. Rakov (2001), who showed that lightning current measurements made at the base of a tower is significantly different from those made at the top[25]. Hence the CVM method was already technically invalid when it was inserted into the AS/NZS 1768 in 1991.

To overcome this problem, the Australian ESE manufacturer had made modifications to the original CVM method and had renamed it to the Field Intensification Method (FIM). To add credence to the CVM/FIM method, a study based on the performance of their ESE air terminals in Malaysia was made by the manufacturer to show that the method was "successful".

However, these reports failed to convince the Australian/New Zealand standards committee when our studies[26],[27] showed that the data contained in the manufacturer's reports were grossly incorrect. Since the CVM/FIM method still had not been proven, it was again inserted into the appendix of the new draft standard[28] that was published for public comments in June 2002.

This means that the CVM/FIM method is still not a valid lightning protection design method as far as the draft AS/NZS 1768 standard is concerned. After more than ten years, the Australian ESE manufacturer is still without any valid theory to support their claims for their CVM/FIM method or for their ESE air terminals.

In Malaysia, more than a thousand Australian-made ESE air terminals had been installed on government buildings, colleges, industrial plants, commercial buildings, condominiums and bungalows.

### 4.3 Selected responses from foreign scientific institutions

In response to the call made by the NFPA in 1998 for new information on the ESE air terminals, dozens of scientists from around the world submitted their findings or comments to the Bryan Panel and to the NFPA Standards Council. The following describes some of the responses of the various institutions to the ESE controversy:

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[25] Mousa, A. M., "**Validity of the Collection Volume Method/Field Intensification Method for the Placement of Lightning Rods on Buildings**", 26th International Conference on Lightning Protection, Krakow – Poland, September 2002.
http://www.power.nstu.ru/conference/ICLP%202002/proceedings/10a04.pdf

[26] Hartono, Z. A. and Robiah, I., "**A review of the Erico survey and analysis of bypasses and raw strike data obtained from the Dynasphere installations in the Klang Valley, Malaysia**" report submitted to the Australian/New Zealand Lightning Protection Committee EL-024, September 2001.

[27] Hartono, Z. A. and Robiah, I., "**An analysis of the data contained in the paper – Field validation of an air terminal placement method**", report submitted to the Australian/New Zealand Lightning Protection Committee EL-024, January 2002.

[28] Draft for Public Comment, Australian/New Zealand Standard, Lightning Protection, (Revision of AS/NZS 1768 - 1991), pp. 163 – Appendix F: Field Intensification Method (Informative).
https://committees.standards.com.au/COMMITTEES/EL-024/C0044/DR02359-PDR.pdf
http://www.standards.co.nz/drafts/dr02359nz.pdf

### 4.3.1 International Conference on Lightning Protection (ICLP)

The ICLP is an international scientific organisation, like CIGRE, that focus on lightning and lightning protection. It has been in existence for more than 50 years and its members consist of the leading lightning scientists of various countries around the world, some of whom are also members of the CIGRE lightning committee.

In response to the legal action on the NFPA by the ESE vendors, the ICLP had issued a joint statement[29] by its members to reject the ESE air terminal on scientific basis. The signatories consist of more than a dozen academics and lightning scientists who are the leaders in the field in their respective countries.

### 4.3.2 National University of Singapore (NUS)

The NUS is recognised as one of the leading lightning research universities in the region. One of its academics, Professor Liew Ah Choy (elelac@nus.edu.sg), was also a co-author of the scientific paper that provided field evidence on the failure of the radioactive lightning air terminals in Singapore in the 1980s.

In his letter to the NFPA in February 1999, Professor Liew had written the following statements:

- "The use of ESE lightning protection systems is not recommended in the Singapore Code of practice for Lightning Protection SS CP 33: 1996, of which I am the Chairman of the Technical Committee. The Building Control Division of the Public Works Department of the Singapore has also much earlier in 1982 banned the use of radioactive lightning protection terminals for installation on its projects submitted after this date. The decision has been based on several and sufficient known failures in their use in the earlier years."

- "Also, the Technical Committee of the Singapore Code cannot see the scientific merit of the remarkable claims made by the ESE systems, i.e. particularly, their much increased range of attraction to a lightning leader."

- "Scientifically, I cannot reconcile the claims with the Law of Physics. None of the vendors/manufacturers of these devices have also been close to attempting to use good Physics to logically explain their claims of the performances."

### 4.3.2 University of Strathclyde (United Kingdom)

This university is also recognised for its research on lightning in Britain. Many of the lecturers in UTM had graduated from this university, including those that supported the non-standard LPS. The researchers, Professor I. D. Chalmers and Dr. W. H. Siew (w.siew@eee.strath.ac.uk), issued a joint statement to the NFPA in February 1999, as follows:

- "The motivation for the study was purely academic. Three years ago, we could find no indisputable scientific evidence in the published literature of learned societies worldwide, to support the claimed performance of ESE lightning protection systems. Today, we are still patiently looking."

[29] "**Scientists Oppose Early Streamer Emission Air Terminals**"
http://www.lightningsafety.com/nlsi_lhm/charge_tranfer_oposition.htm

- "To summarise, we are still not able to find any scientific evidence in the published literature to support the claimed performance of ESE protection systems. Our own study is ongoing and we are hopeful that our understanding of such systems would be enhanced in the next 3 years."

## 5.0 Un-conventional lightning protection system: A technical scam?

In many western scientific institutions, the marketing and sale of the un-conventional LPS is considered un-ethical and a technical scam. The technical scam arises because the vendors of the non-standard LPS had used half truths and outright deception to convince the potential customer that:

- The non-standard LPS had complied with a foreign "product standard" or had been "approved" by the local standards body.
- The use of the non-standard LPS system will provide safety for the user from direct lightning strikes.

Both these claims are totally false as shown in the earlier sections.

The methods used by the vendors in selling their non-standard systems are highly questionable. They have used a number of different techniques with each technique being applied according to the type of potential customer i.e. whether a non-technical layperson or a technical professional.

The methods are briefly described below:

### 5.1 Melville's "Lightning Rod Man" method (http://www.melville.org/lrman.htm)

This refers to the 19th century short story about the devious lightning rod salesman who went from town to town selling lightning rods to the layperson in the USA.

In the story, the method used by the lightning rod salesman is to strike the fear of lightning into the unsuspecting customer by using jargon that the customer does not fully understand. The salesman also portrayed himself as a person who is learned in the science of lightning and belittled the customer when he gets too many inquisitive questions about his product.

A similar method is used by the modern day "lightning rod man" i.e. the non-standard LPS sales engineer. He will use his superior technical knowledge to dupe the potential customer into purchasing the non-standard system. The sales engineer is sometimes aided by a foreign "LPS expert" from the manufacturer if his potential customer is a non-specialist technical professional.

The unethical tactic sometimes involved psychological operations by the foreign "expert" such as branding the potential customer as "backward", "mediocre", "archaic", "old fashioned" etc. if he failed to understand or refused to accept the unconventional LPS. On the contrary, those who succumbed to the deception were praised as "brave", "open minded" etc. as a reward.

For example, an Australian ESE manufacturer even had the following phrase, supposedly made by Albert Einstein, written in the opening pages of its marketing brochures from 1987 to 1995: "**Great spirits have always encountered violent opposition from Mediocre Minds".**

This kind of subtle phrase puts pressure on the potential customer to recognise the non-standard air terminal in order that he avoid being branded as mediocre by the foreign "expert" in front of his colleagues. Such tactics may succeed in making sales but they do not validate the non-standard LPS.

### 5.2 "Success stories" in foreign countries

This "half-truth" tactic is used when the sales engineer meets with the layperson and professionals. He would provide references of "successes" in foreign countries that would be rather difficult for the layperson or professional to verify. At the same time, any evidence of failures that occurred locally will not be mentioned.

For example, one foreign ESE "expert" keeps referring to how the system was successfully used at a satellite ground station in a neighbouring country but refused to mention that the same system had failed to protect dozens of buildings from being struck by lightning in Kuala Lumpur although he already knew about it from our photographs and published works.

This method was also used by the local vendors and some of the academics.

### 5.3 Claims of "on-going research" by the manufacturers

This tactic is normally used when the sales engineer meets with the technical professionals. He would provide information about the research work that was being done by the manufacturer to "verify the effectiveness" of the product.

This information is normally in the form of conference papers submitted by the manufacturers' "experts" and the purpose is to make an impression on the professional about the "scientific nature" of their product. However, the result of the research work was never reported to the customer since the sale had been successful.

Years later, a new "on-going research" program would be publicised to a new set of professionals but no reference was made to the earlier research program. This is because the results of the earlier work was either a failure or was inconclusive to show that the product worked.

For example, a 1987 product brochure of an Australian ESE manufacturer had mentioned of an extensive field testing involving several air terminals that were exposed to lightning at a testing ground in the mountains of New Mexico, USA. However, a 1995 brochure by the same manufacturer made a passing reference about the New Mexico field test plus a similar new field test that was being conducted in Darwin, Australia.

When questioned about the results of the earlier field test that was conducted in the USA, the sales engineer feigned ignorance about it and the foreign "expert" replied that he would have to check with his research colleagues about the results (in order to avoid answering the question directly).

By 1998, the manufacturer published a paper[30] concerning the work done at the Darwin site and by this time, nothing was mentioned at all about the 8 year long tests at the New Mexico site. The 1998 paper also made no mention that lightning had struck any of the air terminals in the Darwin tests after 3 years of exposure, thus suggesting that the air terminal still could not "attract" lightning.

In another study by American scientists, the Australian ESE air terminal was one of several types of ESE terminals that were subjected to natural lightning tests at their research laboratory in New Mexico. It was reported[31] that none of the ESE air terminals they tested was struck by lightning in the 7 years that they were exposed to

[30] J.R. Gumley, F. D'Alessandro, M.A. Austin, "Experimental arrangements to study lightning attachment characteristics in Northern Australia".

[31] Uman, M. A. and Rakov, V. A., "A Critical Review of Non-conventional Approaches to Lightning Protection", Bulletin of the American Meteorological Society, December 2002, pp. 1817. (http://plaza.ufl.edu/rakov/Uman&Rakov%20(2000).pdf)

thunderstorms at the mountain top testing ground. Only the blunt tipped Franklin rods, which were also installed as part of the experiment, were struck several times while none of the ESE air terminals and the sharp tipped Franklin rods were struck.

This independent study suggests that the ESE air terminals tested did not have the ability to attract lightning as claimed by their manufacturers. However, the ESE sales engineer would ignore all their earlier studies and refer only to the “on-going research” in order to dupe the unsuspecting customer.

This picture shows of one of the New Mexico test sites where several types of ESE (French and Australian air terminals) and conventional air terminals had been exposed to lightning for several years to gauge their effectiveness under natural lightning conditions.
[This picture was obtained from one of the American lightning research websites.]

### 5.4 Lightning strike counters reading

This tactic is a favourite method employed by sales engineers to convince the layperson and technical professional. The ESE air terminal is often equipped with a lightning strike counter in its down conductor circuit. The purpose of the counter is to register the number of “successful” lightning strikes captured by the ESE air terminal.

However, some of these counters had given an exceedingly high count, some as high as 30 strikes in a single year. This figure is used by the sales engineer to impress the unsuspecting potential customer that the air terminal is working very well i.e. “capturing” many lightning bolts.

However, such high counter readings are misleading since the unconventional air terminal can expect an average of only one direct strike per year if its non-scientific claim is true and it is installed on a 100m high building. The high counter reading only showed

that the counter supplied was of low quality i.e. its mechanism had registered other current surges instead of lightning.

Hence the sales engineer is depending on the ignorance of the potential customer to believe the unjustified claims and to make his sale.

### 5.5 Claims for scientific freedom

This tactic is used when the sales engineer is confronted with scientific evidence that his product is a failure. He will appeal to the potential customer by saying that the "advanced research" that they were conducting on the non-standard system should not be "gagged" by academics and scientists.

This kind of appeal may seem reasonable in the early stages of the product life cycle but, after more than a decade of failure to provide even a scientific basis for their product, the sales engineer should have the decency to stop selling the non-standard LPS until he and his colleagues can show indisputable scientific evidence that their product actually works.

### 5.6 Scare tactic and creating doubts

This tactic is used when the sales engineer meets a project engineer that does not have a firm knowledge about the lightning protection system to be used. This situation is commonplace since our experience shows that many project engineers have never seen a lightning protection standards document before and would rely on the vendors for information about lightning protection.

The sales engineer will try to scare the project engineer into buying his product by inducing doubt on the conventional system, such as by suggesting "What if the conventional system does not work?" Such scare tactics, when combined with other dubious methods, sometimes work when the potential customer is new to the subject.

### 5.7 "Approvals" from foreign and local standards bodies

This tactic is used by the sales engineer to convince his potential customer that his product had been "approved". He would show to them the documents from the standards bodies that allegedly provide the approval to his product.

One document, a "certificate of test witnessing" from the BSI[32], was used to convince the customer that the French-made LPS is "approved" by the body. However, a close inspection revealed that the certificate only stated that the test on the product had been carried out in their (BSI) presence. Furthermore, there already was a disclaimer (in fine print) at the bottom of the certificate that the document was not to be taken as an approval for the product.

Another document, a "certificate of testing" from SIRIM was similarly used. However, the document only stated that the product had been certified for testing against an electromagnetic compatibility standard to show that it will not cause any interference with the domestic electronic appliances. The potential customers, who probably have never seen any SIRIM standards document before, would not have known that the document had been misused to deceive them into purchasing the unapproved product.

[32] British Standards Institute.

Another similar document from MINT[33] shows that the non-standard system had been tested and found to be free from any radioactive materials. This document had been used to remove any further doubts that the potential customer may have on the non-standard LPS, especially after the customer have previously been using the banned radioactive LPS.

### 5.8 "VIP" customers

If the above tactics failed, the sales engineer would normally cite the impressive supply record of the product as "proof" that it worked. With an impressive list of VIP users, probably in the hundreds, the layperson and professional can be easily persuaded to purchase the product without many questions.

VIP users in the country include most, if not all, of the royal palaces and government ministry buildings in the capital. However, the most convincing VIP user of them all is SIRIM.

By openly displaying the non-standard LPS on some of their buildings, SIRIM had given these products the veiled "approval" that the vendors desperately needed.

### 5.9 Denial of ESE status

This desperate tactic was made by several ESE manufacturers and sales engineers in recent years in order to mislead the potential customer.

After many years of promoting their product with the acronym "ESE" attached to their product brand name, some of the manufacturers had removed the offending acronym from their new brochures that appeared since the NFPA rejected the ESE again in 2000. They have now substituted the acronym with other acronyms that gave their air terminals an air of "advanced" technology.

### 5.10 Blame Game

This tactic has been used by the manufacturers when they are confronted with evidence of failures during international conferences and meetings. The manufacturers will normally put the blame for the failure on their local vendors, such as for not understanding the correct design method or for incorrectly installing the non-standard system.

However, when the matter was referred to the local vendors later, some of the sales engineers defended themselves by saying that the design was made by the manufacturers since this design was done by software which only the manufacturers had. Alternatively, sales engineers might put the blame on a third party who did the installation.

### 5.11 Poor quality construction material

Most lightning strike damages do not have burnt marks on them. The sales engineer would put the blame for the lightning strike damages on the quality of cement used in the making of the roof structure.

[33] Malaysian Institute of Nuclear Technology.

However, they were unable to cite any report made by the construction industry or by expert civil engineers to support their claim. (They were also reluctant to put their allegations in writing when challenged to do so, perhaps out of fear of being ridiculed by the civil and construction engineering community.)

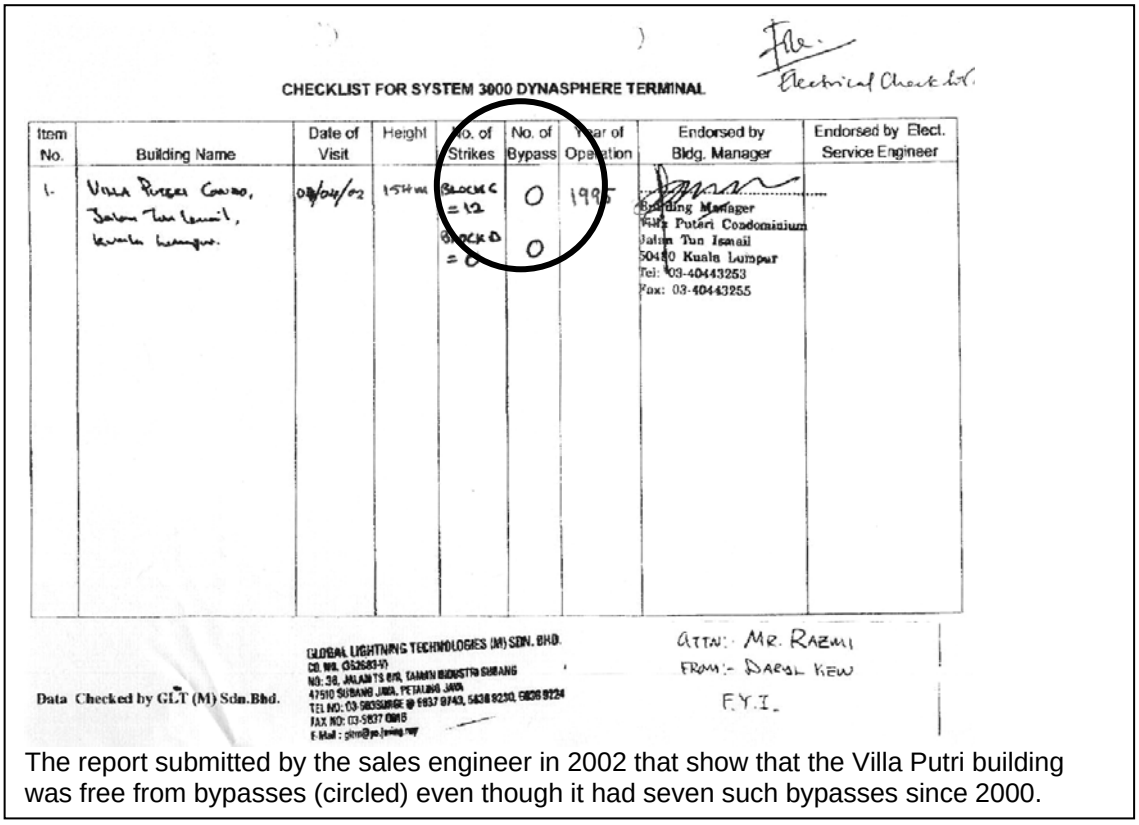
### 5.12 Building defects

Some lightning strike damages (a.k.a. bypasses) occur during a period of heavy rain or at night and this event usually go un-noticed by the building owner if the debris did not cause any secondary damages. Since the customer had no clues as to what had caused the damages at the roof, the sales engineer had taken that opportunity to deny that the building had been struck by lightning and put the blame on simple building defects.

For example, the Villa Putri apartment building had been struck by lightning several times since it was completed in 1995. This building had been the subject of a scientific paper published in 2000 and was known to both the ESE manufacturer and local vendor.

However, the sales engineer had succeeded in assuring the customer that the damages were nothing more than building defects and that the ESE air terminals were functioning normally. In 2002, the customer was still receiving reports from the ESE vendor that indicated no bypasses had occurred.

The Villa Putri apartment building in Kuala Lumpur was damaged (arrowed) by lightning at 7 different places on the roof. In spite of this building being a subject in a conference paper in 2000, the sales engineer still informed the building manager in 2002 that the building was free from lightning strike damages. One of the two Australian ESE air terminals can be seen above (circled).



CHECKLIST FOR SYSTEM 3000 DYNASPHERE TERMINAL

File: Electrical Check list

| Item No. | Building Name | Date of Visit | Height | No. of Strikes | No. of Bypass | Year of Operation | Endorsed by Bldg. Manager | Endorsed by Elect. Service Engineer |
|---|---|---|---|---|---|---|---|---|
| 1. | Villa Putri Condo, Jalan Tun Ismail, Kuala Lumpur. | 08/04/02 | 154m | BLOCK C = 12 BLOCK D = 0 | 0 0 | 1995 | Building Manager Villa Putri Condominium Jalan Tun Ismail 50480 Kuala Lumpur Tel: 03-40443253 Fax: 03-40443255 | |

Data Checked by GLT (M) Sdn.Bhd.

GLOBAL LIGHTNING TECHNOLOGIES (M) SDN. BHD.
CO. NO. 653583-H
NO: 38, JALAN TS 6/6, TAMAN INDUSTRI SUBANG
47510 SUBANG JAYA, PETALING JAYA
TEL NO: 03-5635URGE @ 5637 8743, 5638 8230, 5626 9224
FAX NO: 03-5637 0815
E-Mail : glm@po.jaring.my

ATTN: MR. RAZMI
FROM:- DAEGL KEW
F.Y.I.

The report submitted by the sales engineer in 2002 that show that the Villa Putri building was free from bypasses (circled) even though it had seven such bypasses since 2000.

### 5.13 Discrediting scientific works

This method was carried out by the sales engineers around 1998 when UMIST published a high voltage test report that discredited the ESE air terminal. The sales engineers alleged that the experiment was rigged by the academics and that resulted in the ESE air terminal performing poorer than the Franklin rod. However, such tactics failed as other universities and laboratories obtained similar results that discredit the claims made for the ESE air terminals.

Earlier in 1995, the ESE vendors also attempted to discredit our photographs which had been submitted to CIGRE. They had alleged that the buildings had been struck by lightning before the ESE air terminals were installed. However, western academics had defended our photographs since they were familiar with the subject. In 1999, we submitted the "before" and "after" event photographs in our report[34] to the NFPA to show indisputable proof that the ESE air terminals had failed to protect the buildings they were installed on.

Similar attempts were made to discredit our photographs since 1993 and they were more successful at this with the local populace.

[34] Hartono, Z. A., and Robiah, I., "**A Long Term Study on the Performance of Early Streamer Emission Air Terminals in a High Isokeraunic Region**", Report submitted to the Third Party Independent Evaluation Panel on the Early Streamer Emission Lightning Protection Technology, National Fire Protection Association (USA), February 1999

## 6.0 Support for the non-standard LPS in public institutions

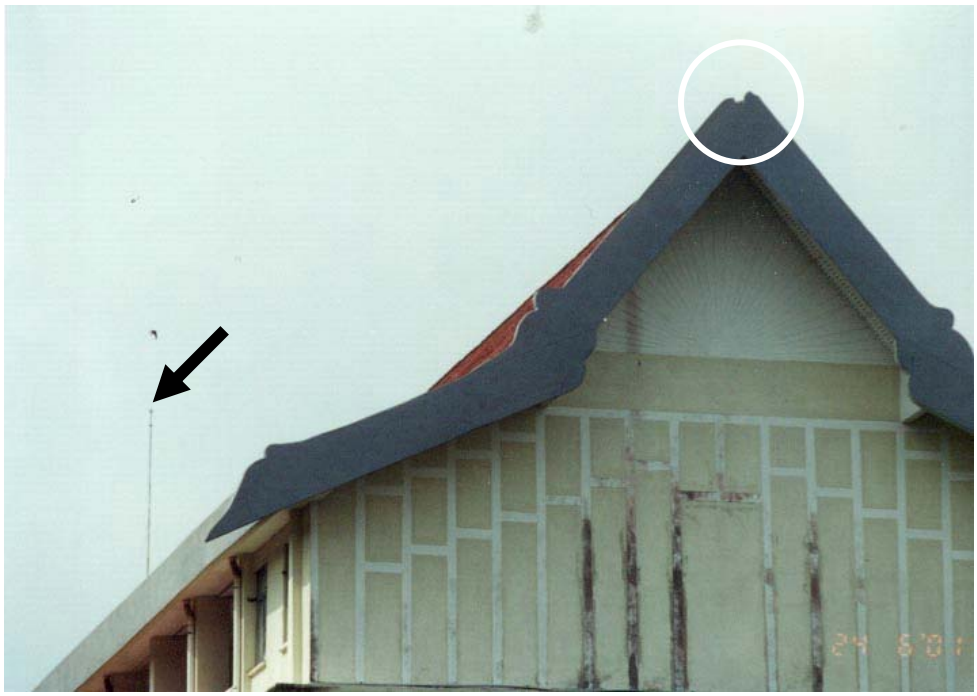
In the advanced western countries, academics, scientists and standards bodies have rejected the use of the non-standard LPS in order to ensure public safety. They have considered the sale of these non-standard systems as nothing but a technical scam whose victims are mostly gullible laypersons.

However, in Malaysia, the situation is different since the early 1990s. The use of the non-standard LPS has been promoted by local non-standard LPS vendors with the support from some academics from UTM who claimed to be lightning experts. In addition to this, SIRIM has been silent on this issue although they have received vital information about the status of the non-standard LPS from their foreign counterparts in 1995. They have also been installing the non-standard LPS on buildings within their premises from the early 1990s to 2001.

This has led to a proliferation of the non-standard LPS usage throughout the country. Thousands of these non-standard systems are now in use and their failure can be clearly seen on many of the buildings that used them. These failures, in the form of damaged concrete roof corners or tiled roofing, are inconspicuous at a glance but can be clearly seen if one were to look at the building carefully.

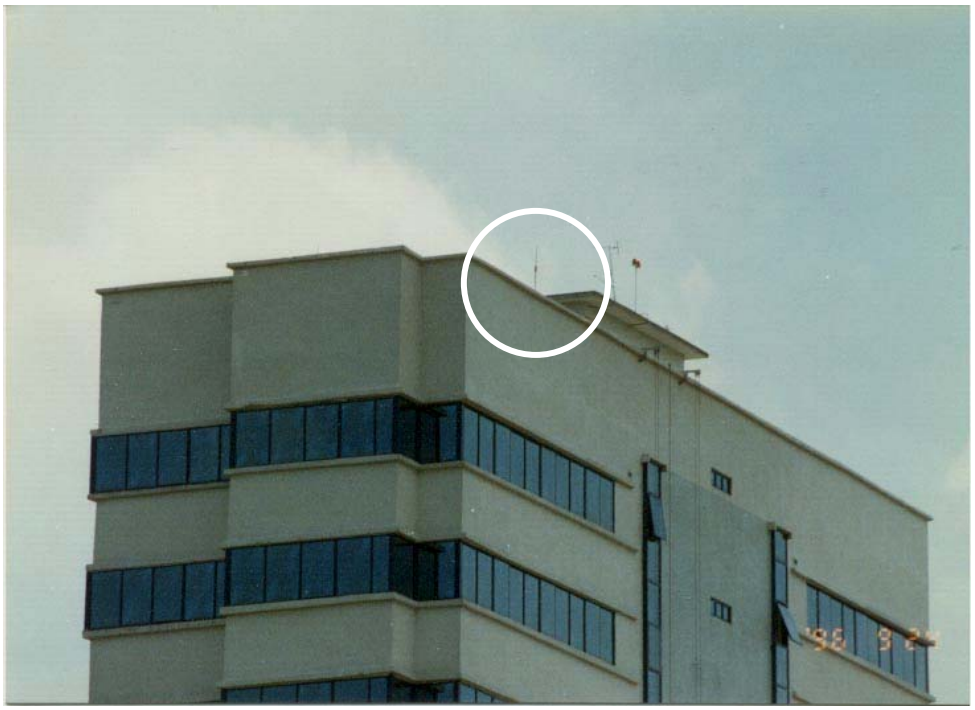
### 6.1 Use of non-standard LPS in UTM and SIRIM

Ironically, some of the buildings in UTM and SIRIM that were installed with the non-standard LPS had also been damaged by lightning in the same way but this did not stop them from installing new ones later on.

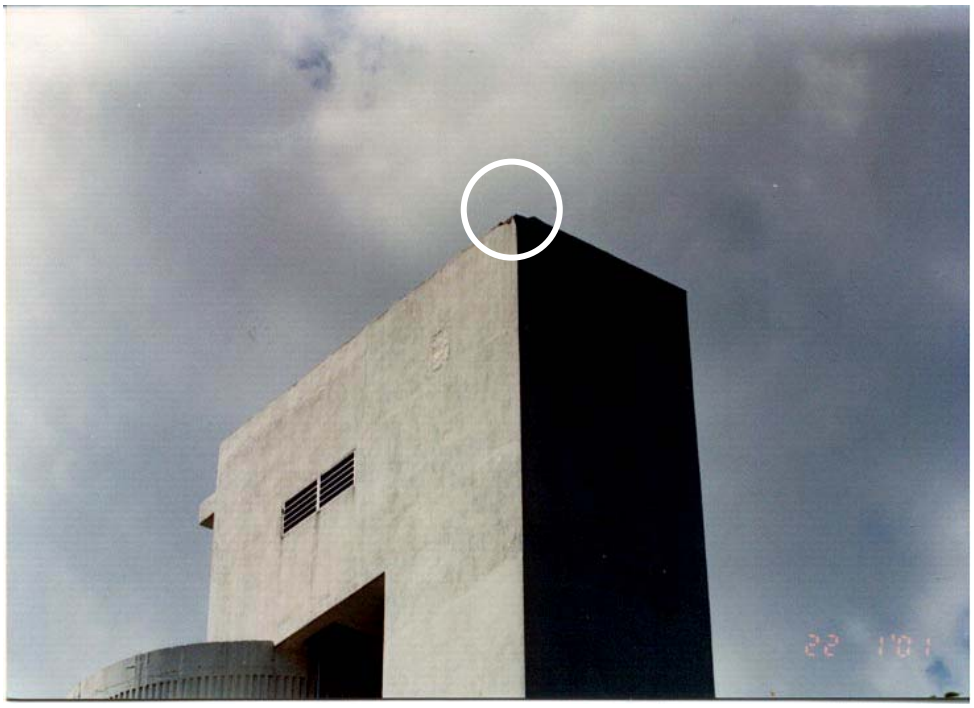


One of the UTM buildings in Skudai that had its façade damaged (circled) by lightning. An undamaged façade would have a sharp pointed apex. Several other similar buildings had been struck also with the damage in varying sizes. Most of the faculty buildings were installed with the ESE air terminals (arrowed).


An ESE air terminal (circled) installed on Building #2 of the SIRIM complex in 1992. Another type of ESE air terminal had also been installed on Building #3.



Another type of ESE air terminal (circled) installed on the new SIRIM head office building in 1996 i.e. nearly a year after the ESE had been rejected by the IEC. This building was struck and slightly damaged by lightning not long after this picture was taken.



The SIRIM Block #8 without the ESE air terminal in January 2001. The building had sustained lightning strike damage (circled) in 1999.

The SIRIM Block #8 with the ESE air terminal (circled) that was installed between January and August 2001. SIRIM still continued to install the ESE air terminals even though the ESE technology had just been dropped from the new Malaysian standard.

### 6.2 Factual errors in lightning protection concepts taught in UTM

These errors were stated in several chapters of the book[35] that was published by UTM in 1998. They cover the basic aspects of lightning protection and revealed the author's lack of understanding on the subject. Below we highlight the critical statements that, if not corrected, will confuse the mainly Malay-speaking engineers, technical professionals, technical students and the general public.

#### 6.2.1 Error in the basic concept of lightning protection

The erroneous concept is found in the following statement:

***"Perlindungan yang diberi oleh pengalir rod berdasarkan prinsip iaitu setiap 'ketua' tertapak yang memasuki zon perlindungan kon akan tertarik kepada pengalir rod tersebut."*** (Page 16 and 96)

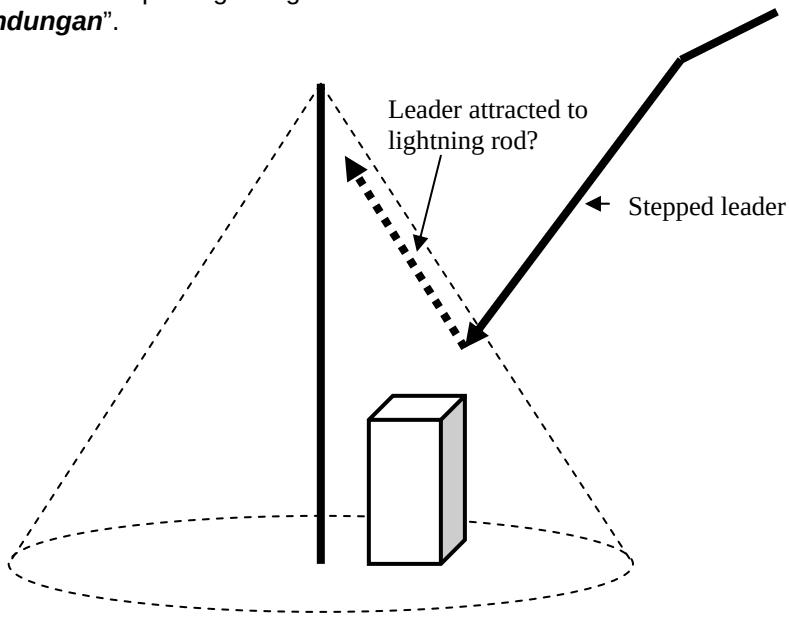
Translation:

**"The protection provided by the rod conductor is based on the principle that every stepped leader that enters the conical protection zone will be attracted to the rod conductor."**

Comments:

This statement is fundamentally wrong since it would mean that the stepped leader, on entering the conical zone of protection, would have to make a drastic change in direction towards the lightning rod which is installed higher up on top of the pole or structure. This would also mean that if a small structure is located within the cone of protection and would be closer to the in-coming stepped leader than the lightning rod, it (the small structure) would be by-passed by the stepped leader in favour of the more distant lightning rod.

The flawed concept of lightning strike mechanism as described in the book "***Kilat dan Perlindungan***".




[35] Ahmad, H., "**Kilat dan Perlindungan**", Penerbitan UTM, 1998.

### 6.2.2. Illogical statements about lightning protection in general

These statements concern general concepts about lightning as well as concepts that are already well established in the technical literature. They seemed to reinforce the popular misconceptions about lightning that are normally found among the ordinary public rather than the seasoned engineer or scientist. They can be found in the opening sentences in Chapter 5 of the book that dealt with structural lightning protection:

***"Zaman dahulu manusia membina tempat perlindungan daripada kayu adalah untuk melindungi rumah dari terbakar dan rosak disebabkan oleh panahan kilat. Kini manusia telah mendirikan rumah dan bangunan dengan sokongan bahan besi, mengakibatkan ia mudah dipanah kilat dan menyebabkan lebih banyak kerosakan."*** (page 49)

Translation:

"**In the past, mankind built shelters from wood in order to protect their homes from fire and damage as a result of lightning strikes. Nowadays, mankind has built homes and buildings with the support of steel components, which led them to be easily struck by lightning and causing more damages**."

Comments:

In many pre-modern societies, wood was the choice of building material since it was cheap and abundant. However, wood is a combustible material when compared to stone, mud or earth i.e. the other common building materials then.

Hence even if it was already known that lightning causes fire and damage, the statement that the choice of wood as a building material "in order to protect their homes from fire and damage" seemed to be illogical. It would be logical for pre-modern societies to have built their homes from stone, mud or earth if they had wanted to avoid the occurrence of fire from lightning strikes.

In the second statement, the use of steel in homes and buildings was described as a reason for those buildings "to be easily struck by lightning and causing more damages". This statement is again illogical and untrue since the presence of steel in a building does not make it any easier for it to be struck by lightning.

It is already well understood for the past few decades that lightning will struck any exposed object within its striking distance, whether it is a steel pole, a tree or a person standing in an open field. This is one reason why some football players were struck by lightning even though there are taller trees and lamp posts at the perimeter of the playing field.

The presence of steel on or in a building actually reduces the severity of damage to the building fabric due to a lightning strike since it is a good conductor of electricity and will divide and dissipate the large return stroke energy into the steel lattice of the building. In many studies on lightning damages to buildings, the presence of the steel re-bars actually limit the damage caused to the outer layers of the building that are made of brick, concrete or plaster.

In fact, Benjamin Franklin had already pointed out, in 1773, that "buildings that have their roof covered with lead or other metal, and spouts of metal continued from the roof into the ground are never hurt by lightning; as whenever it (i.e. lightning) falls on such a building, it

passes in the metal and not in the wall[36]". This shows that even Franklin himself already understood that the presence of metal on a building can prevent or reduce the damaging effects of a direct lightning strike.

### 6.2.3 De-recognition of the conventional air terminal and its effect on the frequency of lightning strikes

The statement to the above effect is found in Section 4.2.1 of the book that concerned (conventional) lightning rod concept and reads as follows:

***"Namun demikian, cara ini tidak lagi diperakui oleh kebanyakan pihak pempiawaian perlindungan kilat kerana prinsip perlindungannya akan menyebabkan sesuatu system yang perlu dilindungi lebih kerap dipanah kilat."*** (page 41)

Translation:

"**Nevertheless, this method is no longer recognised by most lightning protection standards since this protection principle will result in the system to be protected to be struck more frequently by lightning**."

Comments:

The above phrase that alleged that the conventional lightning rod is no longer recognised by most lightning protection standards is false since no standards organisation had de-recognised the conventional air terminal at that time. The succeeding phrase that alleged that the principle of the conventional lightning rod will increase the frequency of lightning strikes is also false since there is no scientific basis to substantiate this allegation. This matter has been covered earlier.

### 6.2.4 Unconventional air terminals as recent advancements of lightning protection methodology

The statement to the above effect is found in Section 4.3 of the book with the title "Advancements in lightning protection systems".

"***4.3 Pembaruan pada alat perlindungan kilat***

***Pelbagai jenis rod penangkap kilat diperkenalkan di pasaran dunia. Namun demikian, ia masih di bawah kategori memperbaiki atau mencegah. Dua jenis rod penangkap kilat yang akan diterangkan ialah Sistem Tatasusunan Pelepasan dan Pendedenyut.***" (page 46)

Translation:

"**Various types of lightning rods have been introduced in the world market. However, they are still categorised under improvement or prevention. Two types of lightning rods that will be described are the *Dissipative Array System* and the *Pulsar***."

The author of the book had alleged that the DAS (a lightning prevention air terminal) and the Pulsar (an ESE air terminal) are "advancements" in lightning protection methods when, in actual fact, these terminals had already been disproved scientifically in 1975 and 1995 respectively.

[36] Schonland, B.F.J. 1964, The Flight of Thunderbolts, pg. 14, 2nd edition, Oxford: Clarendon Press.

It is interesting to note that the description of the working principles of the above air terminals made in the book seemed to have been taken from their manufacturers' "research papers" and product brochures. These working principles have no scientific basis at all and are meant to dupe gullible laypersons who have no scientific and technical background in lightning protection.

## 7. Conclusion

The un-conventional/non-standard LPS have been proven by academics and scientists around the world to be without any scientific basis as far as their claims to provide enhanced protection against lightning is concerned. These studies have been debated and accepted by all national and international standards bodies that produce the lightning protection standard for structures.

The manufacturers of these systems have also failed to provide any independent study that could prove that their products are field proven. This is in spite of the fact that they have been conducting laboratory and field studies around the world for nearly three decades.

In spite of this deficiency, tens of thousands of these systems have been sold worldwide based on the promise of enhanced protection that is supported by the manufacturers' own "research". In this country alone, several thousands of these air terminals have already been installed nationwide since the 1970s at the cost of tens of millions of Ringgit.

The use of the un-conventional air terminals has led to many buildings being damaged by direct lightning strikes. Some of these reported damages were found to be life threatening since they occur in buildings used for mass occupation eg. a school building.

The popularity of the non-standard LPS in Malaysia is partly due to the support given to them by SIRIM and UTM. In the latter case, the standard LPS is taught to the students as an out-dated system while, at the same time, the non-standard system is also taught as "advancement" in the lightning protection methodology.