Feedback on the lightning protection of high-risk industrial facilities in France

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Abstract: this paper aims to assess the effectiveness of current legislation in France concerning the lightning protection of industrial facilities classified as presenting a risk to the environment. A satisfaction survey carried out among site managers reveals that many facilities are not yet protected and that damage incurred primarily involves electrical equipment. A draft protection program could be included in the legislation.

Keywords: industrial facilities, risk, effectiveness lightning protection

1. Introduction

Since 1993 French legislation has required that industrial facilities classified as presenting a risk to the environment include lightning protection. In view of the accidents which have occurred over the past ten years, the Ministry of Ecology & Long-term Development has sought to assess the effectiveness of current legislation. GIMELEC & the INERIS have been a pan of the project.

We began by looking for the most common repercussions of lightning incidents using the ARIA data base. We then carried out a survey to measure the satisfaction of people in charge of high-risk facilities.

The results reveal that 80% of damage involves electrical , with 70% involving equipment and 1.2% roofs. It was also shown that owners of protected facilities are totally satisfied. The survey also reveals that 20% of facilities have no protection, despite legal requirements.

This paper outlines the two stages of the project and puts forward new measures which we feel should form an integral part of the legislation.

2. History of lightning accidents

2.1 Accidents caused by lightning

The French Ministry of Ecology & Long-term Development maintains a database of accidents - known as ARIA - containing information primarily on accidents which have or which could have impacted public health or safety, agriculture, or the natural environment.

The accidental incidents logged in ARIA should not be regarded as exhaustive, but available information reveals that over a period of 20 years, 46 lightning-induced accidents resulted in the large-scale deployment of the emergency services.

Although the number of human death is relatively low (1), significant inconvenience is often caused. Table 1 shows that the most commonly encountered risk is fire. The impact on the environment mainly involves atmospheric pollution, with the accidental discharge of chemicals following the failure of a process or toxic smoke during a fire. It can also be seen that financial loss is often significant (16.6%), following either the facility in question being totally destroyed, or a total and long-term shut-down of production.

Repercussions	Effect	Fire	70%
		Explosion	10%
		Electrical fault	33%
	Environmental pollution	Water	3.3%
		Air	10%
		Ground	0%
	Equipment	Low	60%
		Average	20%
		High	16.6%
	Personnel	Inconvenience	16.6%
		Injury	3.3%
		Fatality	3.3%

Table 1: Repercussions of a lightning strike

Lightning protection draft standards [2], [3] define the various types of damage (D) and loss (L). The breakdown of the 46 major accidents reported in France is shown below.

Loss / Damage	L1 Loss of life	L2 Loss of utility	L3 Loss of cultural heritage	L4 Financial loss
D1 Harm to humans or animals	0	0	0	0
P2 Physical damage	3	3	0	23
D3 Failure of electricity or electronic networks	2	3	0	12

Table 2: Number of incidents for each type of damage and loss

Harm caused directly to humans or animals is extremely rare on an industrial facility. Table 2 shows that physical damage and electric failures are the cause of most financial losses.

2.2 Legislation- & standards-based solutions

Protective measures have been implemented to limit the effects of lightning on buildings. Regulations were drawn up in 1987 with French standard NF C 17-100 [4] and in 1995 with NF C 17-102. [5]. However, the lack of compulsory legislation has meant that protection systems have rarely been installed on industrial sites. Following an accident caused by lightning on an industrial facility, a decree was drafted in 1993 requiring that all industrial facilities classified as presenting a risk to the environment be fitted with lightning protection system. Such equipment is compulsory where lightning might, either directly or indirectly, seriously affect the safety of personnel, plant equipment, or the environment. Nearly 50,000 industrial facilities in France are concerned by the legislation.

To comply with legal requirements, all industrial facilities are now fitted with single-rod, Early Streamer Emission rod (ESE) and Meshed cage lightning conductors. Surge arrestors, earthing systems and equipotentiality devices are alsoinstalled.

Ten years after imposing lightning protection on industrial facilities at risk from lightning, the Ministry for Ecology and Long-term Development commissioned a report into the effectiveness of the bill.

3. Feedback

3.1 Satisfaction survey among managers of high-risk facilities

➢ Telephone survey to assess satisfaction levels

One way of measuring the effectiveness of the measures imposed by the legislation is to assess levels of satisfaction among the people in charge of industrial facilities at risk with regard to lightning protection. The market survey agency, IPSOS, was commissioned to report on customer satisfaction [1]. 483 sample surveys were carried out from a database of 1581 sites. All industries located across France were questioned.

To collate as many answers as possible, a telephone survey method was chosen offering total anonymity to the questionee. A pilot survey was carried out in April 2002 with 100 questionnaires to test the relevance of the questionnaire. The remaining 383 questionnaires were then used in June 2002 to give a representative sample of the population concerned. Given the percentage of facilities interviewed, the reliability of the answers is 3.5 %.

The questionnaire focused on the following issues:

- how often the facility was affected by lightning,
- the type of protection equipment installed,
- overall satisfaction with the equipment,
- overall satisfaction with the site's situation (protected or not) with regard to lightning,
- extent of damage, if facility already impacted,
- nature of damage, if facility already impacted,
- downtime caused by damage,
- cost of damage,
- overall satisfaction following damage.

> Results of the telephone survey

How many times has thefacility been struck by lightning?

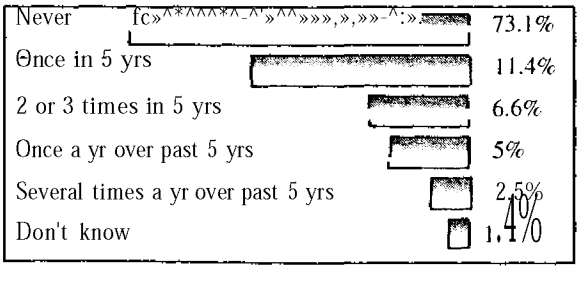


Figure 1: Frequency of lightning strikes

Is thefacility equipped with a lightning protetion system?

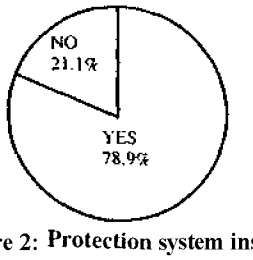


Figure 2: Protection system installed

Whatprotection has been implemented on site?

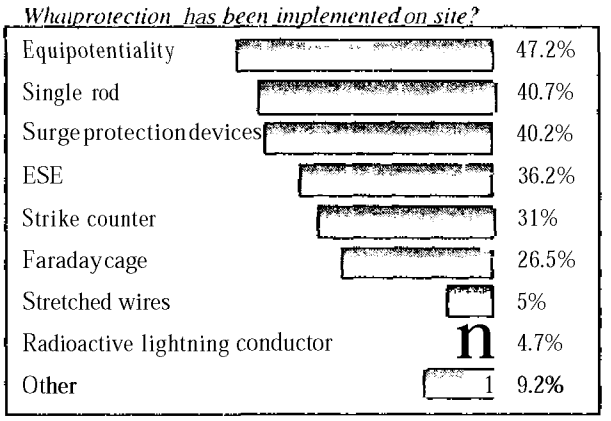


Figure 3: Type of protection

For the 362 protected sites:
How satisfied are you with the situation?

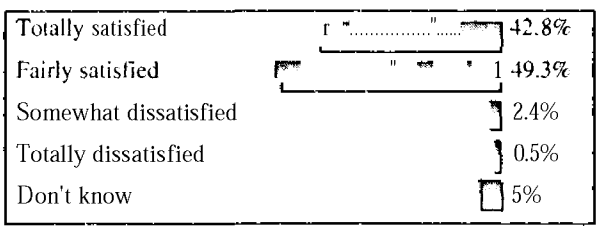


Figure 4: Satisfaction - protected sites

For the 100 unprotected sites:
How satisfied are you with the situation?

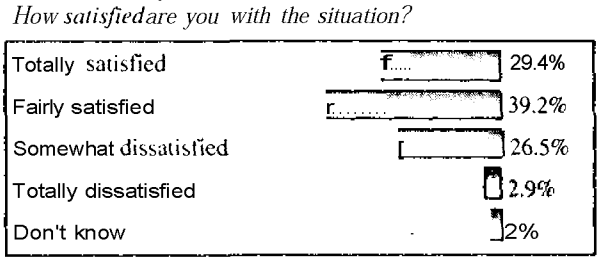


Figure 5: Satisfaction - unprotected sites

What damage has been caused by lightning? (84 answers)

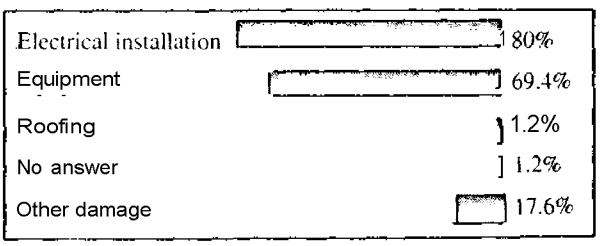


Figure 6: Type of damage caused by lightning

Repercussion ofthe strike on production tS4 answers)

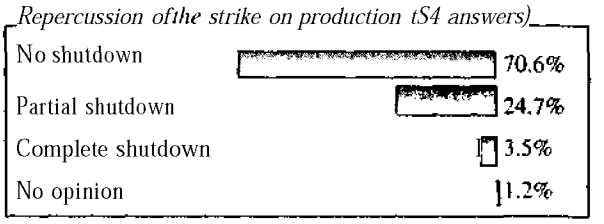


Figure 7: Impact on production

What financial loss *has been caused by lightning? (84 answers)*

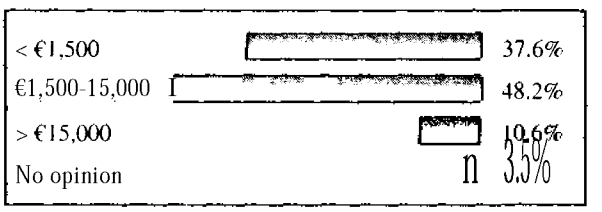
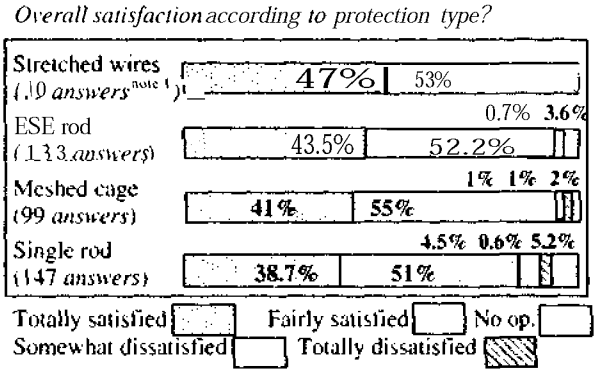


Figure 8: Financial loss following **lightning** strike

Overall satisfaction according to protection type?



Note 1 : Important: low sample rate < 30, results not significant, indicative of slight trends only.

Figure 9: Overall satisfaction according to protection type

3.2 Survey of high-risk facility inspections

The telephone survey was supplemented by an investigation into inspections carried out on high-risk facilities. This highlighted that studies into lightning protection reveal a need tor facilities to he protected in 97% ofcases. Intrinsically protected facilities are rare.

Who conducts the surveys into the protection of the facility?

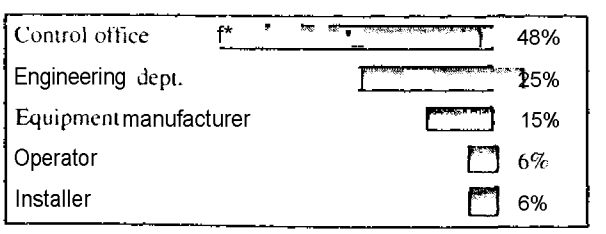


Figure 10: Breakdown of how surveys are carried out

33 Assessment of the impact of current legislation

The results of the survey and additional enquiries indicate that:

- lightning strikes 26.9% of all industrial facilities at least once every 5 years,
- most damage caused by lightning involves site equipment (especially electrical components). Damage to roofing represents just 1.2%,
- only 40% of facilities are protected by surge protection devices,
- sites not fitted with a protection system exhibit levels of dissatisfaction significantly higher than those fitted with a protection system: 30% dissatisfied compared to just 3. The survey also reveals that 25% of protection systems defined in the protection surveys have yet to be installed
- Over 20% of high-risk industrial facilities are unprotected, despite legal requirements;
- Damage to buildings protected by *a* single-rod lightning conductor or an ESE rod is no greater than to those protected by a meshed cage.

4. New measures for high-risk facilities in France

In light of the feedback on the protection of high-risk facilities, it was decided to amend the legislation governing industrial facilities. The new measures are illustrated in figure 10.

The first step involves **analyzing the lightning risk.** This is based on the use of draft standard IEC 62305-2: *Risk management*. Incident frequency is estimated from storm activity data and the characteristics of the installation concerned. Impact can be assessed from various documents including risk analyses, safety reports and the use of safety equipment.

Protection measures are precisely laid out in a **technical survey** in accordance with the findings of the risk analysis report. Details of Internal & External Lightning Protection System (ILPS & ELPS) are also provided at this point. The characteristics of the surge protection devices and installation diagrams are drawn up. The ground network is evaluated and supplemented if necessary. When prevention is based on a storm warning system, the equipment and associated procedure are also defined.

The protection system is designed and built in line with the specifications in the technical survey. The protection system should be checked for conformity on completion of the work and a simplified check should be carried out each year. Every 5 years a full verification is required; this involves checking all the equipotentialities.

The steps described above should be entrusted to professionals qualified in the field of lightning protection. Companies carrying out these services should be certified by an independent organization on the basis of an organizational diagram and certificates of competence for all persons involved.

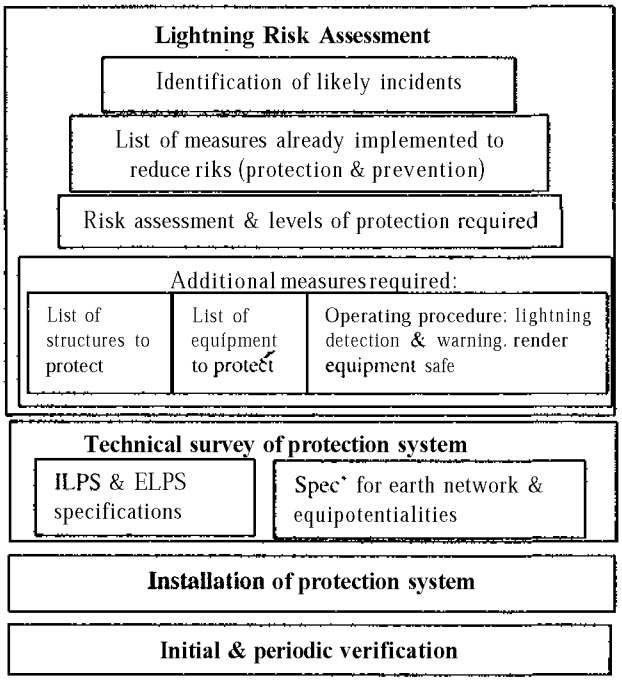


Figure 10: Lightning protection timeline

5. Conclusion

This aim of this paper has been to assess current legislation regarding the protection of industrial facilities at risk from lightning. Our survey reveals that existing protection solutions are satisfactory, but that implementation is not widespread. Given the amount of damage to electrical equipment, surge protection devices should be more widely used.

New measures, in particular risk assessment based on document IEC 62305-2, more frequent verification of protection systems and improved monitoring of the damage caused by lightning should be included in the legislation.

6. Acknowledgements

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7. References

[1] IPSOS: Satisfaction survey «Lightning protection» Questionnaire GIMELEC/INERIS/MEDD 2002
[2] IEC 62305-2, "Risk management". Draft 81/241A/CDV
[3] UTE C 17-100-2, "Gestion du risque", 04.2004.
[4] NF C 17-100 Protection of structures against lightning installation of lightning Protective system 1997
[5] NFC 17-102 Protection of structures and open areas against lightning using early streamer emission air terminals 1995