

REPORT 943-1 *

**PROTECTION OF SOUND-BROADCASTING STATIONS
AGAINST ATMOSPHERIC ELECTRICITY**

(Question 48/10)

(1982-1986)

1. Introduction

The WARC-79 identified the requirement for the service Study Groups of the CCIR to give consideration to the needs of their services to effect protection of installations against atmospheric electricity, particularly lightning discharges. This Report, relating to sound broadcasting, complements information for the fixed and radio-relay services contained in Reports 861 and 932 respectively.

CCITT Study Group V is currently considering the protection of telecommunication lines and equipment against lightning discharges and the overall subject of lightning protection is under review by IEC Committee TC 81.

2. The lightning process

Lightning discharges occur when the electrostatic potential created by convective charge generation in thunderclouds exceeds the breakdown potential. Discharges may occur from cloud-to-cloud, cloud-to-air or cloud-to-ground. With the cloud-to-ground type, both the discharge itself and the electrostatic stress before and during a storm which can be as great as 5-10 kV/m [Surutka and Veličković, 1973], may cause damage.

As a charged cloud approaches a mast, it induces charges of opposite sign on the sections of the stays. When the cloud is discharged by a lightning stroke to the ground, the field collapses in a time interval of the order of a microsecond. Charges on the stays produce high voltage across the insulators. Voltages as great as 400 kV arise, leading to flashovers and breakdowns. It has been suggested [CCIR, 1982-86a] that arcs caused by static atmospheric electricity represent a greater risk of damage than direct or near lightning strokes.

* The Director, CCIR, is requested to bring this Report to the attention of the IEC.

3. Frequency of incidents

There are marked seasonal, diurnal and geographical variations in the incidence of thunderstorms. Storms tend to occur in the afternoon hours and are least frequent in the post-dawn period. They are most prevalent in the local summer at mid- and high-latitudes, but have little seasonal variation in the tropics. Their incidence is greatest over tropical land masses, but the proportions of cloud-to-cloud and cloud-to-air discharges are also higher in the tropics than at other latitudes.

Current evidence on reported incidents causing damage is scanty, but there is a marked dependence on geographical position and the precise locations of installations. In France, they are appreciably more frequent in the southern part of the country and in high mountainous areas, and in Japan, in the northern part of the country which is subject to heavy snowfalls.

4. Power dependence

Although atmospheric electricity can give rise to problems to domestic receivers, these are minor compared with those occurring at transmitting installations which generally use high masts. High-power installations (with transmitter powers in excess of 10 kW) tend to be more prone than lower-power installations, because the transmitter power is sufficient to maintain an arc discharge across components, once it is initiated, either by a lightning stroke or by wind-borne static. This situation becomes more serious as the power of the transmitters is raised.

5. Locations of flashover points and damage caused

Antennas for LF and MF use include base-fed or loop-fed steel masts which are either self-supporting or guyed with steel ropes divided by insulators into sections shorter than the resonant length. Lightning strikes can cause flashovers between the mast and the ground or on the guy insulators. Moreover, the surges thus created may result in equipment being damaged. Solid-state transmitter circuitry, antenna feed lines and antenna matching-unit capacitors, are particularly vulnerable.

Base insulators are generally ceramic pillars and provided these are shunted by a discharge gap (see § 6.1) damage is rare. For low transmitter powers, stay insulators are invariably of the simple slotted glazed-ceramic egg-type set between interlocking wire loops. Although flashovers occur during lightning storms, no obviously observable mechanical damage or electrical deterioration to antenna performance is noticed in the long term. However, with the sustained discharge arising with high-power transmitters, cracked stay insulators and arc-erosion of stay wires adjacent to insulators may occur.

6. Protection methods

6.1 *Traditional spark gaps*

Base-fed radiators may have discharge gaps permanently fitted to the structure. Generally, the earthed side is connected to the radial ground system through copper conductors. Discharge gaps have a variety of forms, ranging from spheres and cylinders with gaps of less than half the diameter, to rods and loop structures. Gap settings are generous, typically 8-16 mm, to prevent rain droplets from coalescing.

In Japan, judiciously placed spark gaps made of cylindrical hard-carbon electrodes are used. Gap shapes and sizes are optimized as a function of the dominant lightning waveform encountered [CCIR, 1978-82a; NHK, 1982].

6.2 *Non-linear resistances at the guying insulators*

Silicon carbide non-linear resistances of about 1 M Ω at the working RF voltage can be employed at the guy-insulator terminals. These release the static charges on the insulated parts of the gaps, but are often destroyed if lightning strikes the mast directly.

6.3 *Transmitter shut-off*

A lightning detector placed on one of the mast stays may be installed which, when it registers a lightning discharge, momentarily (for about 1 s) causes the transmitter drive to be interrupted. In this way any flashover on a stay insulator is not followed by a power arc; the flashover extinguishes immediately and no damage is caused. The device can be made sensitive to about 5 A which is much less than the current required to cause an arc.

Alternatively, the transmitter may be shut off by measuring the standing-wave ratio at the antenna terminals arising from the arc mismatch.