Brazil Test Facility

Cachoeira Paulista

Indelec
lightning protection

Cachoeira Paulista was specially built in 1998 in the state of Sao Paulo in Brazil as a dedicated natural and triggered lightning test facility. Construction was carried out on the initiative of INDELEC in partnership with the INPE (Brazilian Space Research Institute) and in collaboration with the University of Toulouse in France, Hydro-Quebec (IREQ) in Canada and the Campinas & San José Dos Campos Universities in Brazil.

2001 saw two further teams of research scientists from France Telecom and their Brazilian counterparts Telebras join the site.

From the outset, INDELEC's teams of scientists and engineers have been conducting a series of tests designed to compare the performance of simple rod with that of early streamer emission lightning conductors. A special instrumented structure was erected to hold the lightning conductors, as well as a full range of measuring equipment, and was then subjected to strikes triggered at high altitude so as to allow the lightning to choose its own natural point of impact.

Aims of the research

Since the very first early streamer emission lightning conductors became available back in the 1980s, INDELEC has always placed considerable importance on proving the effectiveness of its products in the field. To this end, INDELEC forged close scientific and engineering ties with the Atomic Energy Commission (CEA), who invented the triggering of lightning discharges.

Research aims common to all the various test campaigns conducted in Florida, France and Brazil included:

- validation of the PREVECTRON®2's technical operating principal (triggering according to how the electrical field grows $\Delta V/\Delta t$);
- comparative lightning discharge events between simple rod conductors and the PREVECTRON®2;
- measurement of the current of the upward leader emanating from each type of conductor tip;
- a reliability survey of the PREVECTRON®2 by subjecting it to real lightning strikes (similar research is also being carried out by our team of researchers at the Nadachi facility in Japan);
- a demonstration of the precursor upward leader witnessed on the ESELCs, but not on simple rods.

Location of the test facility


Launch platform & conductor masts


Rocket launch tubes


Triggering rocket

Overview of the test facility

The Cachoeira Paulista test facility is located within the INPE compound half-way between Sao Paulo and Rio de Janeiro. This geographical location (22°41.2 S, 44°59.0 W & an altitude of 625m) offers ideal tropical storm conditions.

Two experiments began in 1998:

- construction of an instrumented test facility designed to conduct tests under natural lightning on both a simple tapered rod (r < 1mm), a simple flared rod (r = 15mm) and two PREVECTRON®2;
- a lightning triggering platform fitted out with different types of instrumented air terminals. The discharges are triggered using rockets which trail a length of copper conductor with a Kevlar insulated end section.

When launched in the right electrical fields, the rockets will fly up into the base of the electrically charged storm cloud and cause a "short circuit" with the ground.

A downward leader then moves down the conducting wire, ending its journey to the ground freely and independently.

In addition to the rocket launch tubes, the test platform comprises three lightning conductor tips and is fully instrumented to allow both the low-level currents of the upward leaders and the high-level currents of the actual lightning strikes to be precisely measured.

An electrical field sensor is also attached to one of the masts at the same height as the tips.

To ensure that the measurements taken are reliable and to avoid any electromagnetic distortion due to the variations in the ambient electrical field, all data is sent over fiber optic cable.

Several cameras are also present to help monitor and record both naturally occurring and triggered lightning events.

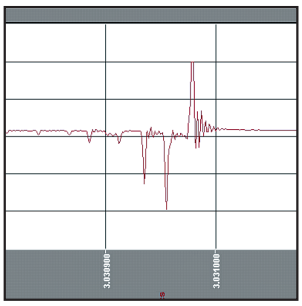
Hydro-Quebec installed a series of automatic cameras which were triggered optically (lightning flash) or electromagnetically (induction loop).

The fastest camera is capable of recording 8000 frames per second.

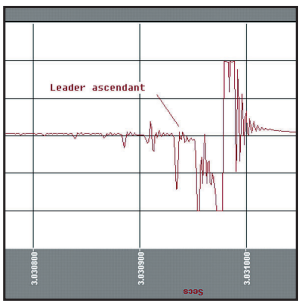
Results 1998 – 2003

For the first time, video footage allowed scientists to see how the upward leader develops from the PREVECTRON®2 while, in identical field conditions and at the same instant, the simple rod exhibited no discernable activity.

In both cases, the flashes were recorded over at least four frames, or 130ms at 30fps. The two images above were captured during naturally occurring, non-triggered lightning conditions and clearly highlight the truth behind the theory that the PREVECTRON®2's ionization system provides for the emission of an early streamer.



Simple rod



PREVECTRON®2 S6.60

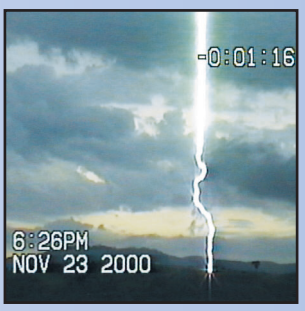
The data collected also allowed the precursor currents at the top of the PREVECTRON®2 lightning rods to be measured and compared with the activity around the simple rod. The graphs above show the shape and amplitude of the current signals for both types of tip. The initial pulses (low-level corona effects with no propagation) appear simultaneously on the PREVECTRON®2 lightning conductor and the simple rod. However, the shape of the current around the PREVECTRON®2 then shows the triggering of an upward leader, which then propagates until the first return stroke appears (induction saturation).

During this time, the similarly sized corona around the simple rod represent its vain attempts to trigger a leader.

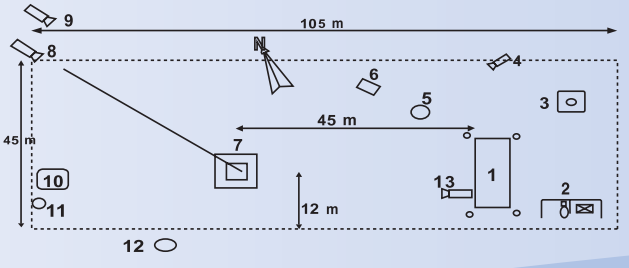
Control station

Inside the control station

LSR-G triggered launch rocket



LRS-A triggered launch rocket



1 > Control station,
2 > Electrical power plant, compressed air supply & fuel tank,
3 > Electrical field sensor (launch sensor),
4 > Hydro-Quebec experiment:
automatic video camera (natural & triggered lightning flashes) 75m away
5 > San Jose Dos Campos University experiment (INPE):
vertical element of the radiated electrical field,
6 > Caminas University (UNICAMP) experiment:
electromagnetic induction in a mesh cage,
7 > INDELEC lightning conductor test & measurement launch platform,
8 > Video camera operated from the control station (1) 50m away
9 > Hydro-Quebec experiment:
automatic video camera (natural & triggered lightning flashes) 800m away,
10 > GPS station (Cachoeira INPE),
11 > Geodesic mark,
12 > Isolated tree,
13 > Hydro-Quebec: video camera (8000 fps).

LRS-A rockets

Speed: 150m/s
Wire length >800m
Conducting wire: 700m
Non-conducting wire (Kevlar): 100m

Two concurrent
downward stepped leaders
(taken from Hydro-Quebec video)

Branched
downward stepped leaders
(taken from Hydro-Quebec video)

In addition to these previously unseen images, the testing carried out under real lightning conditions provided the following results:

A

The PREVECTRON®2's basic operating principle was verified and shown to comply with the positive results obtained previously at Camp Blanding in Florida and Saint Privat d'Allier in France: the PREVECTRON®2's ionization system reacts automatically as soon as any sudden build-up in the electrical field - synonymous with a downward leader - is detected.

B

The data collected during the triggered launches highlights the robust construction of the PREVECTRON®2 lightning conductor, capable of withstanding repeated high-intensity lightning strikes: the average current measured in a lightning strike triggered at Cachoeira Paulista is 27kA (compared to just 13.5kA in Florida over the course of the 1993-94 test campaign at Camp Blanding), with an average of 6 return strokes (greater than 3kA).

C

The scientists were able to collect invaluable tropical storm data over the course of each test campaign, while INDELEC's partners pursued their research projects, involving - among others - the study of electromagnetic interference on overhead telecommunications lines. Video footage taken using high-speed cameras has enabled researchers to collate an unprecedented series of images and other information on the build-up of a lightning strike (see photos of downward stepped leaders taken from video footage).

Conclusion

The Cachoeira Paulista facility in Brazil means INDELEC has been able to pursue its policy of testing its products under real lightning conditions it began in Florida in 1993. These test campaigns provide a host of invaluable information in terms of both fundamental and applied research:

- even today, the uncertainty that shrouds the phenomenon of lightning continues to fascinate the scientific community. INDELEC regularly provides new information collected over the course of each test campaigns, thereby contributing to a better understanding of the lightning phenomenon.
- the campaigns also form an essential part of the company's product development strategy. Testing allows the PREVECTRON®2 range of lightning conductors and accessories to be fully evaluated and developed under real storm conditions.

Indelec
lightning protection

61, Chemin des Postes - 59500 DOUAI France
Tél : + 33 (0)327 944 944 - Fax : + 33 (0)327 944 955
www.indelec.com - e-mail : contact@indelec.com

Ivoi'Art - Lille - 03 28 52 67 54