04-2-1998

Service Centre
IntegraL Energy Seven Hills
Panel Cubicles Fire Tests
Substation Electrical
Local Applications
Fire Extinguishing Aerosol System
Pyrotechnically Generated

PYROGEN
1. PURPOSE OF TESTS

This series of tests were to demonstrate the ability of PyroGen fire protection system to adequately extinguish fires that could occur within a typical substation electrical panel cubicles. Tests were conducted on request of Integral Energy Network Substation Assets Branch at Integral Energy Seven Hills Service Centre in anticipation that a suitable solution to the current fire protection problem at the Transmission and Zone Substations could be identified from the tests.

All of the tests were carried out on the 4th of February 1998 and were witnessed by:

INTEGRAL PERSONNEL:

Mr. Steven Parker
Mr. Stephen Quinn
Mr. Jim Hickey
Mr. Noel Mahon
Mr. Ray Thelebic
Mr. Ian Thomson

BHP PERSONNEL:

Mr. Ray Raikko
Mr. Rick Louttit

ASSET PROTECTION PERSONNEL:

Mr. Ray McManus
Mr. Stephen Sinclair

AES INTERNATIONAL:

Dr. Julia Berezovsky
Mr. Sergei Jokov
when used in an enclosed risk area.
expected equipment. Like all solid flooding agents, Pyrogen aerosol is most effective
including those involving flammable liquids and gases, combustible solids, oils and
Pyrogen aerosol is suitable for the protection of a variety of potential fire hazards.

Any milling, aerosol that has settled can easily be brushed, blown or washed away.
As Pyrogen aerosol stays in suspension, it would be removed from the protected area by

Pyrogen aerosol is non-conductive and non-corrosive.
Pyrogen aerosol is white, gas-like medium that is close in density to air.

Pyrogen works.

composition, it requires no pressurized cylinders, and therefore, no complicated design and
As Pyrogen aerosol is self-generated upon ignition of the solid aerosol-generated

the protected zone.

aerosol. The aerosol propels itself through the nozzle and out of the delivery nozzle into
aerosol. The aerosol propels itself through the nozzle and out of the delivery nozzle to produce the fire extinguishing

Electrical or thermal initiation of a Pyrogen generator triggers a chemical reaction of

- a delivery nozzle,
- a chemical coalescer, and
- a block of aerosol-generated composition,
- an electric ignition device.

Pyrogen MFG generator contains four main elements:

electrically connected to most types of fire control panels, manual or automatic.

Pyrogen has no global atmospheric environmental impact and does not require any
1301, gas like distribution and long holding times.

extinguishing concentration, which is more than three times lower than that for Halon
class of suppressants. It has the lowest known amount commercially available agents
Pyrogen - Pyrogenically Generated Fire Extinguishing Aerosol - belongs to a new

2.4 Product Description

2. Pyrogen
Prevent formation of aerosol from suspended particles by reducing or eliminating the concentration of aerosol particles in the air. This can be achieved by physically removing particles from the air through filtering, or by chemical means such as adding reactants that chemically react with the aerosol particles to form a precipitate or a product that is removed from the air.

Primary methods of aerosol formation are:
1. Physical or mechanical processes, such as grinding, cutting, or spraying.
2. Chemical processes, such as condensation, evaporation, or reaction with other substances.
3. Biological processes, such as spore formation or bacterial growth.
4. Radiative processes, such as heat or light exposure.

Aerosol formation is influenced by factors such as particle size, concentration, and type of aerosol.

2.2 Extinguishing mechanism

Prevent formation of aerosol from suspended particles by reducing or eliminating the concentration of aerosol particles in the air. This can be achieved by physically removing particles from the air through filtering, or by chemical means such as adding reactants that chemically react with the aerosol particles to form a precipitate or a product that is removed from the air.

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Immediately after discharge the generators can be hot.

End plate nozzle, within 0.3-0.5 meters from the nozzle the temperature does not exceed 75°C.
The other potential hazard is a high temperature (250-350°C) of Pyrogen aerosol at the

Induced exposure to Pyrogen aerosol should always be avoided.

Remarkable cellular damage evident of cell death. Effects observed within a week of exposure with very little or no tissue injury due to a rapid dissolution of the highly soluble aerosol particles and not that susceptible to the aerosol interaction were mostly likely due to a compartmentalisation of the

Physiological effects of deep lung penetration is usually a concern for insoluble sub-

Reaction of personnel shall be considered.

Cumulative effect of chemicals as well as high obscuration and associated possible panic provided in reference literature (refer to Pyrogen Toxicity Report). These injuries have been analysed and information on their physiological effects on humans.

Estimation of the above exposure limits is based only on concentration levels of toxins to the eyes.

Prolonged and may cause only moderate local irritation of the upper respiratory tract and

Enclosure being pressurised.

Exposure to a Pyrogen concentration of 100 mg/m³ under conditions of immediately

Pyrogen is intended to be used in normally unoccupied areas only due to the high

2.3 Safety Limits
3.3 Project Installation

The generator was mounted at the center of the enclosure ceiling with a delivery nozzle directed downwards onto the generator.

The generator system consisted of a MAG-3 generator installed in a single panel. The panel was connected to a short circuited CT transformer producing 500-600 Amps.

The loop was approximately 20 cm above the top of a flammable liquid (heptane) tank. The loop was extended in a form of a double loop from the panel's ceiling down the base of the panels. The panels had internal PVC wiring loops to be buried through an additional 8 m cable. The panels had internal PVC wiring loops to be buried through an additional 8 m cable.

3.2 Model Fuses

25-30% of the area of the base and served as a support for a tray with a flammable liquid. The sheet was approximately 10 cm deep, 450 mm wide and 900 mm long, which simulated a cabinet to some extent. The panels were mounted on the ground over a rectangular concrete pit, 450-600 mm high. The panels were made of metal and were included and shielded for the tests.

The fuses and relays have been removed from the panel faces and the resulting holes left single end panel:

<table>
<thead>
<tr>
<th>Left Single End Panel</th>
<th>Central Panel</th>
<th>Right Single End Panel</th>
</tr>
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<tbody>
<tr>
<td>H (H) W x 2 H</td>
<td>0.6 W x 2</td>
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<td>009 mm x 300 mm</td>
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</tbody>
</table>

Following:

The panels are joined together in a non-disassemblable assembly. The panels are as follows:

HIILS 1S to the Seven Hills Service Centre and set up for the tests.

HIILS 1S to the Seven Hills Service Centre and set up for the tests. HIILS 1S has been tested by Intertek Nine. The test has been successful. The panel is a panel.

3.1 Test Enclosure
switchover to enable an on screen time reference
record each test sequence for reference purposes. A clock function was available and
a video camera and thermovision cameras were set up by Test & Instrument Services to

3.2 Recording

activation panel is marked as a "start on pull-down-graphe" of the ON/OFF times and enclosed temperature curves. Pressing of a push button on the
camper to collect data at a rate of 10 times per second and permit the subsequent print
computed to collect data at a rate of 10 times per second and permit the subsequent print

camper to collect data at a rate of 10 times per second and permit the subsequent print

3.2 Instrumentation

Generator

by the name of the name listed would automatically ignite the cord and exhaust the pyrogen
sufficient time would be allowed for the model fire to develop before the heat produced
external cord was pulled through the aeroreal-burnout section was drawn into the exhaust
cone by the external the condensing cord was brought into an-bi-pot with the
the pyrogen generator. Prior to installation a piece of the condensing cord or approximate 1.5
length and property to the aeroreal-burnout element which is a

The internal activation of Pyrogen Generator was achieved automatically via a floor push button

3.4 Pyrogen Activation

activation panel after approximately 30 seconds of pretreatment time.

Electric activation of Pyrogen Generator was achieved manually via a remote push button

were demonstrated.

manual activation allows better control of the conditions, both activation mechanisms
primarily in the exotherm caused by the use of the later. However, since electric

initiated is more involved in thermal activation of Pyrogen via an in-built fire
The test sequence was as follows:

Between the right end and control panel.

In this test the blanking plug was fitted to blend off the perforated metal partition.

4.1 TEST No 1: Right Single End Panel 1 MAG-3 Electric Ignition

4.2 TEST No 2: Control Panel 1 MAG-3 Thermal Ignition
The door was open and the result of extinguishment was observed.

- Holding time of one minute was allowed.

Pyrogen generator was manually activated by a remote electric push button.
- The door of the panel was shut.

After a required strength of the fire had been established,
- 20 seconds pre-pump time was allowed to ensure ignition of PVC with thin looms and
- 4-5 seconds later the wire became an open circuit continuing the power.
- 10 seconds later the power was supplied from the transformer to the cable loop.
- Window was ignited.
- Video equipment was set up, recording started.

The test sequence was as follows:

4.1 Test No.4: Central Panel I MAC-3 Electrical Ignition

- The door was open and the result of extinguishment was observed.

- Holding time of one minute was allowed.

Pyrogen generator was heard as it commenced its operation.
- Pyrogen generator was automatically activated by the burning cord. The noise of the panel was quickly shut.
- The noise of the burning cord continued until the fire was heard and the door of the

looms and then a required strength of the fire had been established.
- Approximately 10 seconds pre-pump time was allowed to ensure ignition of PVC with thin
- 4-5 seconds later the wire became an open circuit continuing the power.
- 10 seconds later the power was supplied from the transformer to the cable loop.
- Window was ignited.
- Video equipment was set up, recording started.

The test sequence was as follows:

4.2 Test No.3: Central Panel I MAC-3 Thermal Ignition

- Longer pre-pump time prior to automatic ignition of the cord and operation of pyrogen

generator. The conducting cord was run closer to the ceiling so that it could allow

in the fire were considered insufficient.

Pyrogen operation, as strength of the established fire and involvement of thin looms

Test No.2 was repeated with an attempt to extend 7 seconds pre-pump time prior to
5. TEST RESULTS

The results were evaluated based on the condition of the central panel, the adjacent panels, and the generators installed in those panels. The panels would be activated if the condition of the central panel was not satisfactory or if the condition of the adjacent panels was also unsatisfactory. For panels not activated, the generators were started up in sequence. If the condition of the central panel was satisfactory, the generators were activated. If the condition of the adjacent panels was unsatisfactory, the generators were not activated.

In this test, two panels were removed from both sides of the central panel. The purpose was to establish whether the above conditions of performance would hold. The test was conducted under conditions of continuous loading. The results obtained were used to establish the performance of the panels and panels adjacent to the central panel.
Design factor for PyroGen total flooding applications for class B (flammable liquids) and surface class A (non-smouldering solid materials) fires is 100 g/m³. For smouldering class A fires, such as electrical cables, PyroGen design factor proved to be higher - up to 300 g/m³.

PyroGen application in substation electrical panel cubicles as tested cannot be considered a total flooding application, as base of the panel is not fully open and contains a significant loss of the extinguishant, thus not allowing to establish and maintain its concentration in the protected enclosure. The above application should be considered a local application, where agent is discharged directly onto the identified hazard, and such PyroGen design factors listed for total flooding applications could be used as a guide only.

Successful application of PyroGen in substation electrical panel cubicles as tested was achieved with a single PyroGen generator, providing a design factor of 200 g/m³. The above test results, 1 MAG-3 generator is recommended for a reliable protection of a single cubicle up to 600 mm wide.

Instantaneous extinguishment of hexane and energised cable fires under conditions of open circuit and large area of combustible openings, as well as absence of re-ignition under conditions of extremely short holding time (1 minute compared to accepted 10 minutes for class A fires), clearly indicates that the design methodology, including limitations and installation instructions, provides large safety margin and ensures reliable extinguishment of the above types of fire in a typical substation electrical panel cubicle.

Based on the above test results, 1 MAG-3 generator is recommended for a reliable protection of a single cubicle up to 600 mm wide.

As shown by demonstration tests, a blanket of PyroGen material has been demonstrated to be practical, quick and effective, although additional tests would be required to establish a required response time of the fire conductive cord and its correct installation inside the panel.

Operation of MAG-3 generators is simple. One MAG-3 generator could be either electrical or thermal. Thermal operation via a fire conductive cord has been demonstrated to be reliable, quick and effective, although additional tests would be required to establish a required response time of the fire conductive cord and its correct installation inside the panel.