VERY EARLY FIRE DETECTION FOR HIGH POWER PULSED SYSTEMS

S. Pavis, N. Magnin, E. Carlier, C. Lolliot
CERN, Geneva, Switzerland

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Introduction

CERN's accelerator beam transfer kicker systems employ dipole magnets which are pulsed with hundreds of kV and several kA. These pulses are produced via systems which employ high energy power supplies and associated solid state switching electronics enclosed in equipment racks to protect against high voltages. Under certain fault conditions such as a degrading power component, material fatigue of or damage to a connector or cable causing arcs, short circuits and abnormal heating effects, smouldering and fire can occur, even igniting nearby flammable material (e.g. cable insulation and oil pipes). Building/tunnel smoke and fire detection, due to the lack of propagation of smoke from the cabinet, is often not capable of detecting such fires until they are well established. Underground zones may be inaccessible during accelerator operation, further complicating the detection and identification of fire situations. Such a fire occurred in the AD Horn installation due to a damaged and loose trigger cable for the ignitron causing energy discharge to ground, with the resulting electric arc burning nearby cables and oil hoses.

Fig.1 - Aftermath of Fire in AD Horn Equipment Rack

To mitigate such in-rack fire risk, a more localised and rapid fire detection strategy is needed which can detect an in-rack fire in its incipient stages.

Fire Detection Methods and Considerations

Detection methods considered included Optical and Ionisation point detectors, IR, CO, Heat and ASD (Aspirating Smoke Detection). ASD was chosen based on extremely high sensitivity (up to 100 times more sensitive than point type smoke detectors), option to sample air from the rack entire volume as well as close to key "at risk" components, and the option to mount detection electronics away from potentially EM noisy zones.

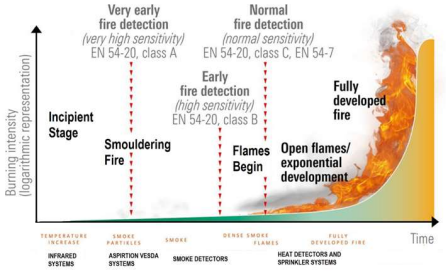

Fig.2 – Stages of a Fire and Detection Technologies

Smoke/Dust Discrimination

By using both blue and infrared light scattering techniques for detection, particle sizes of typical smoke and dust particles such as concrete and cement can be discerned, particularly for particle sizes under 1 µm.

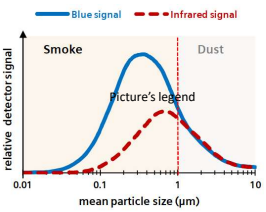

Fig.3 - Blue & Infrared Light Scattering to Differentiate Smoke and Dust Particles

ASD & Sample Pipe Installation

Industrial applications for ASDs use PVC/ ABS sampling pipes. These materials are forbidden for CERN installations (toxic off-gassing when burning, particularly hazardous in underground areas). In this application, aluminium pipes are cut to length using a handheld pipe cutting tool, and then glued to pre-formed bends and elbows using a high strength, room temperature curing adhesive, achieving the necessary routing and tightness very efficiently (no welding needed) .

Two sampling points are installed per rack in case of blockage of one and to distribute air sampling for better overall response. . The ASD is fitted to the end rack (accesible even when HV is on).

Fig.4 – Typical Pipe and ASD Installation

Control System Interfacing

Manufacturers provide s/w tools for flow speed, nozzle size and sensitivity calculations. An intelligent detection algorithm is implemented in the ASD to achieve extremely sensitive detection of smoke particles and excellent discrimination between smoke and dust.
Kicker systems are based on a phased power up approach, passing from "OFF" via "STANDBY" to "ON" (NOMINAL) operational states, achieved via a State Machine implemented in the PLC code with corresponding HMI.

The selected ASD features industrial type interface, with dry contacts connecting to the kicker system in much the same way as any other emergency interlock, stopping the kicker system and removing power from all sub-systems via two main relay contactors. In this way, potential fires are stopped in their tracks at the incipient stages of a smouldering component or an arcing connector, and at the same time alarms are raised at the CERN Control Centre. A 4-20mA output from the ASD is used for remote display and trending of smoke level via an HMI.

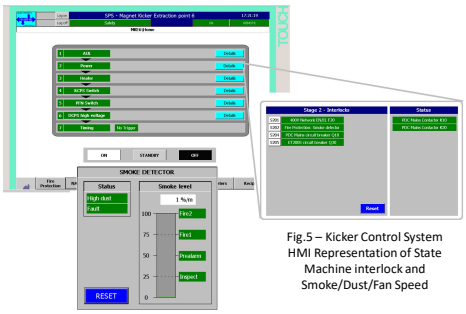

Fig.5 – Kicker Control System HMI Representation of State Machine interlock and Smoke/Dust/Fan Speed

Test and Evaluation Over One Year

No false alarms occurred, but 4 separate fire alarms occurred not caused by an actual fire in a kicker equipment rack:

1. Oil vapour from an open PFN assembly 3m away caused a low-level smoke indication (system was not operational)
2. A small smouldering motor fire in an air conditioning duct in the tunnel air intake
3. A smouldering component in a non-related control rack some 5m away, but with a common floor void for cables
4. A large fire in a neighbouring town, causing smoke clouds to pass over the equipment building (surface installation). The ASDs have 9 levels of sensitivity, of which level 2 (second highest) had been selected. This is now being reduced to level 3.