CRITICALITY ACCIDENT ALARM SYSTEM

CAAS-3S™

Criticality Accident Alarm System

The Next Generation System for Facility Safety

FEATURES

- Neutron-only, gamma-only or combined detection capability
- Completely redundant architecture at all system levels
- Response time less than 300 ms per criticality standards
- Multiple zone coverage - 10 zones with 2 out of 3, or 8 zones with 2 out of 4 voting logic
- Continuous state-of-health monitoring on each detector
- Remote supervision
- Qualified under real criticality situations at CALIBAN and PROSPERO reactors of the French Atomic Energy Commission (CEA)
- Complies with the IEC 60860 (2014), ISO 7753 (1987) and ANSI/ANS-8.3 (1997)
- Designed to comply with SIL2 IEC 61511-1

KEY BENEFITS

- Low false alarm rates
- Negligible operational interruption
- Low maintenance requirements and minimal facility downtime
- Adaptability to various accidents, shielding, legacy installations and regulations through both gamma and neutron detection
- Post-accident monitoring capabilities

APPLICATIONS

- Fuel Cycle Facilities including enrichment, fabrication, and reprocessing
- Research & Military applications
- Waste & Storage applications

DESCRIPTION

DEPENDABILITY

The CAAS-3S is a next generation system based on operational excellence established over forty years. The new design is based on the highly reliable analog signal chain used in the probe design for the previous EDAC-2 and later EDAC-21 products which have had successful safety records and very low false alarm rates. This new system addresses the next several decades of facility operation.

RANGE OF COVERAGE SCENARIOS

Detection capabilities include gamma-only, neutron-only, and combined neutron + gamma probes to cover all types of installations and criticality excursions

Use of scintillation technology and ruggedized electronic components provides very high-reliability and allows accident and post-accident monitoring of dose rate

SAFETY

The system is designed to meet SIL2 IEC61511, with full redundancy of the safety channel from probe to alarm output

Tested and proven to detect a criticality event and trigger alarms under seismic conditions

KEY DESIGN CRITERIA

- Reliability
- Response time
- Fault/Failure warning
- Seismic tolerance
- Minimization of false alarms

SERVICE

- A range of service options are available to support the system operation over multiple decades

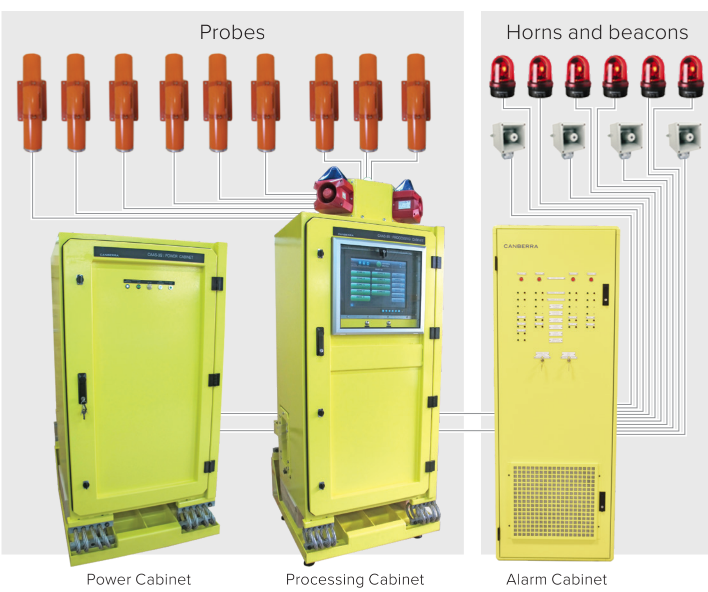
FLEXIBILITY

- Probes can be installed up to 1000 meters from the processing cabinet
- Multiple processing cabinets can be networked securely
- New zones can be added to an existing system without interrupting existing operational zones
- Testing and maintenance of a zone can be accomplished without operational interruption of other zones

SYSTEM OVERVIEW

The CAAS-3S is a criticality accident alarm system (CAAS) as defined by the relevant industry standards. The system is designed to monitor areas where a potential criticality excursion could take place and alarm rapidly for the prompt evacuation of personnel in the event of a criticality accident.

The system can simultaneously monitor multiple zones within a building or across a facility with multiple buildings. The detection probes should be located in areas where personnel would be exposed to an excessive radiation dose (as defined by standards).



The CAAS-3S offers the following significant design features:

- Five detection capabilities through gamma and neutron detection and different sensitivities.
- The neutron and/or gamma detection head and the electronic alert logic module reside in the probe. Continuous state of health monitoring of the scintillator detector is achieved by using a light-emitting-diode with a feedback circuit. This feedback circuit checks the functionality of the entire system (through the full signal chain to alarm), and any electronic inconsistency is communicated back to the control unit (Processing Cabinet).
- The probe architecture is composed of an analog and digital chain. The analog chain comprises the gamma/neutron sensor module, amplifier, test alert, power, and alert signal generators. The analog chain is SIL2 qualified. It is based on the proven EDAC probe design. The digital chain is FPGA based with auto-testing capabilities and accident follow-up, storage of the probe parameters (including calibration), temperature sensing values, and a watch-dog functionality to determine the health of the digital electronics.
- The alert logic in each probe is sensitive to both criticality excursion scenarios: the “prompt-critical” metal system and the “slow-cooker” non-metal accident.
- Redundancy is built in to the system throughout the entire signal chain. Each control unit has a redundant backup with automatic failover.
- The power supplies are provided with battery backup to maintain detection capabilities in the event of a power outage.
- The system is completely autonomous.
- On-board software enables state of health, logged data, testing, and alarm functions to be monitored from the control room.
- Remote network monitoring (guard stations, shift supervisor) is available as an option.

SYSTEM ARCHITECTURE

The CAAS-3S consists of the detection probes, central processing unit, power supply unit, and alarm unit.

Probes

- The neutron and/or gamma detectors use state of the art scintillation plastic and signal-processing electronics.
- Probe calibration is verified through measurement at the factory prior to delivery.
- The detector response is linear between the dose rates of 1 mGy/hr (100 mRad/hr) and 10 Gy/hr (1000 Rad/hr).
- The probe has been tested to an exposure of 1000 Gy/hr (10^5 rad/hr) and shown to continue to operate as expected without saturation.
- Self-Test capabilities provided through the integrated LED can be programmed to run daily or weekly.
- Detection probes can be located at a distance of 1000 m (~3300 ft) from the processing cabinet

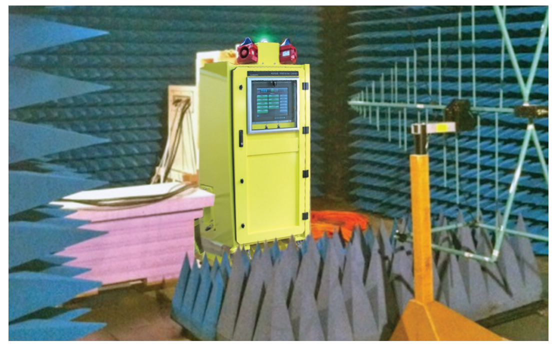
CAAS-3S- Gamma and/or Neutron Probe

Probe Type	Alarm Threshold ($cGy \cdot h^{-1}$ or $Rad \cdot h^{-1}$)	Sensitivity $V/(cGy \cdot h^{-1})$ or $V/(Rad \cdot h^{-1})$	Detection Range in Open Air† (m)
Gamma Only	0.05	20	270
Neutron Only	0.1	10	120
Neutron Only (High Sensitivity)	0.008	63	400
Gamma + Neutron	2	0.5	55
Gamma + Neutron (high Sensitivity)	0.1	10	230

Probe Thresholds, Sensitivities, and approximate detection ranges. † This is the approximate detection range to detect the Minimum Accident of Concern (20 rad in 2 minutes at 2 m) in open air. The number quoted is in open air so that the impact of attenuation of walls and other structures must be taken into account for the actual detection range. These numbers can be used for initial placement estimations, but are not a substitute for regulatory proof.

Power Cabinet

- Redundant power supplies with automatic fail-over
- Redundant backup batteries ensuring 16 hours of autonomous operation in non-alarming mode and 30 minutes during alarm mode
- Intelligent power management and status monitoring with optional remote monitoring capability
- Power cabinet can be located up to 30 meters from the processing cabinet. (Typical distance 5 meters.)
- Batteries can be changed on the fly without interrupting the global power supply



EMC Tests on the CAAS Cabinets

Alarm Cabinet

- Standard and custom configurations available depending on the site alarm network topography
- Optical fiber or dry contact communications between processing and alarm cabinets
- Optical fiber communication allows multiple alarm cabinets connected on the same loop

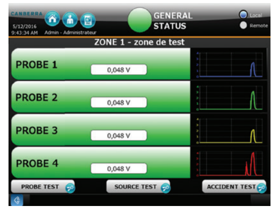
Processing Cabinet

The processing cabinet (control unit) contains a fully redundant set of safety PLCs. Failure of any single board does not affect the capability of the system to detect a criticality accident. Component-level failures are communicated with a local alert message to the local display and an optional remote display.

- The Control Unit:
  - Redundant connections to DC power (from the power supply cabinet), dry contact outputs, and RJ-45 connections to the Ethernet network.
  - Touch-screen front panel display and controls to indicate state-of-health, conduct testing, and annunciate alarms.
  - Set of redundant horns/lights mounted to each control unit.
  - Can simultaneously monitor 10 criticality zones.
  - Multiple control units can be installed on the same network using an optical fiber loop.

Software

- SCADA architecture supervision with a clear separation between safety and non-safety functions
- The software supporting the safety function interacts directly with the SIL3-certified safety PLC
  - The graphical user interface provides visible system status:
    - Green for good status
    - Orange for minor fault: the safety function is not affected (alarms will be issued in case of criticality accident)
    - Red for major fault: the safety function is potentially affected (alarms might not be issued in case of criticality accident)
  - Data status for each probe is also indicated (normal operation, alert, fault). The voting logic defaults to using the remaining probes if one of the probes is in fault status
    - Detector settings (gamma and neutron sensitivity, dose rate threshold)
    - Dose rate history for each detector
    - Power supply status
    - Logbook history of all significant events which have occurred during system operation (emergency, alarm, fault) and the date.
    - The graphical user interface allows the user to perform maintenance actions
    - The user can acknowledge faults and alarms
- User right management ensures that only authorized users can request specified actions



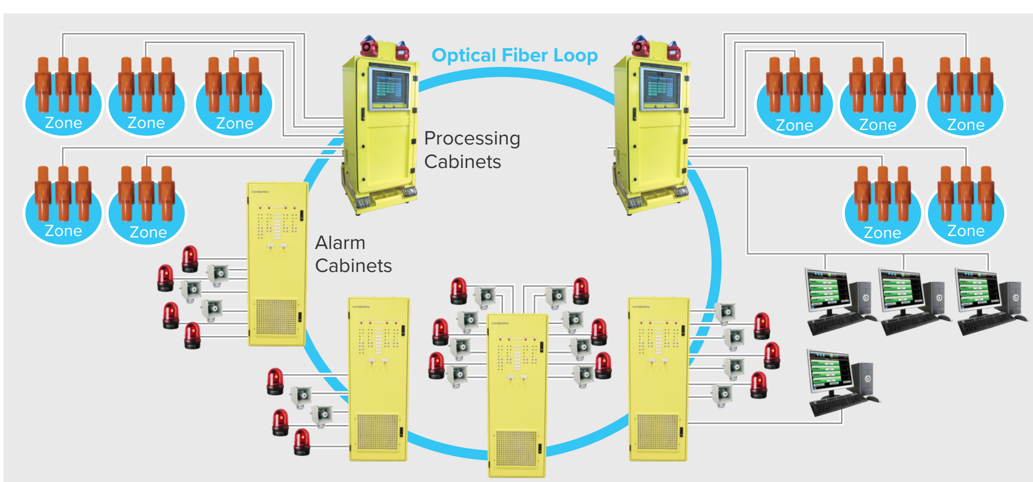
System Status and health state through comprehensive General Status

Red for major fault: the safety function is potentially affected (alarms might not be issued in case of criticality accident)

- The supervision software can be customized to provide other functionality
- An optional remote terminal via ethernet can provide a display identical to the local processing cabinet display.

Network Flexibility

For facilities with more than ten zones, or where separate buildings are required to have local zone control, multiple processing cabinets can be networked together. Alarm cabinets can also be added to the network so that any criticality event in any zone triggers all site alarms. The network is based on a dual optical fiber loop so that the loss of one connection will not impact the alarm network. Software control for multiple systems connected together can be set up in various ways and can be customized to the facility needs.



SPECIFICATIONS

COMPLIANCE

- Meets or exceeds the IEC 60860 (2014), ISO 7753 (1987), ANSI/ANS 8.3 (1997) standards.
- Designed for SIL2 IEC61511
- NRTL and EMC compliant
- NQA-1 compliant
- ROHS compliant

REDUNDANCY

- By parallel:
  - processing circuitry
  - emergency circuitry
  - power supply circuitry
- By safe loop for
  - communication and supervision circuitry
- By redundancy for battery backup
- The system continues to meet the criticality standard criteria even in the event of failure of part of the circuitry.

RELIABILITY

- The CAAS-3S remained fully operational under conditions of a criticality excursion on separate test reactors.
- System is seismically qualified to 5 g
- PFD: 5.7E-3 (SIL-2)
- IP56 for the cabinet
- IP67 for the probe
- AWS D1.1 AWS D1.3, AWS D1.6, AWS D9.1 (American Welding Society) and ASME BPVC Section IX certification

MAINTAINABILITY

- "Hot swappable" design concept allows replacement of components (including probes, safety PLCs and batteries) without powering down the system.
- The local terminal indicates the potential fault location
- Local and remote PC supervision
- Data logging including:
  - Data status for each detector
  - Detector parameters
  - History of events

ALARM INDICATION

- Local audible: configurable multi-tone siren /105 dB at 1 m
- Local visible: Two flashing lights/ 5 joules power
- Redundant Alarm outputs (2x Dry Contacts + 2x Optical Fiber)

POWER

- Low voltage 24 V dc ± 20% (lead acid batteries)
- Low Voltage Power Cabinet: To protect the system against possible failure of the LVPS, lead-acid batteries of the CAAS-3S ensure continuous power supply in accordance with the specified standards.

PHYSICAL

GENERAL CHARACTERISTICS OF THE PROCESSING CABINET

- Dimensions: 912 x 795 x 2132 mm (35.9 x 31.3 x 83.9 in.) (W x D x H)
- Mass: 350 kg (772 lb)
- Mounting: Floor mount
- Environmental Operating conditions:
  - Temperature: -10 °C (14 °F) to +50 °C (122 °F)
  - Humidity: 40% to 90%

GENERAL CHARACTERISTICS OF THE POWER CABINET:

- Dimensions: 912 x 795 x 1584 mm (35.9 x 31.3 x 62.4 in.) (W x D x H)
- Mass: 850 kg (1874 lb)
- Mounting: Floor mount
- Environmental Operating conditions:
  - Temperature: -10 °C (14 °F) to +50 °C (122 °F)
  - Humidity: 40% to 90%
- Low Voltage Power Supply Output – 24 V dc
- Power Supply Input: 110-240 V ac, 50/60 Hz
- Battery Capacity: 2x 360 Ah

PROBE DIMENSIONS

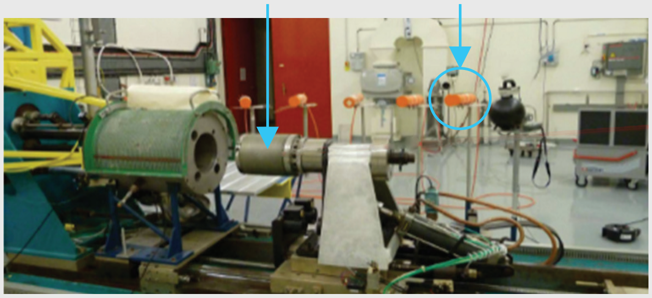
- Length 510 mm (20.1 in.)
- Diameter 100 mm (3.9 in.)
- Mass: 2 kg (4.4 lb)
- Mounting: Wall-mounted specific brackets
- Environmental Operating conditions:
  - Temperature: -10 °C (14 °F) to +50 °C (122 °F)
  - Humidity: 40% to 90%

PROBE CABLE

- Cable between gamma and/or neutron detector and processing cabinet (max. length 1 km).
- Cable characteristics:
  - Radiation resistance 250 kGray
  - Compounds tested accorded to CERN procedure (3.6 kGy/h) and IEC60544 standard

OPTIONS

- Probe placement studies and calculations based on MCNP modeling and known energy response functions
- Remote supervision software with customization options



Test of CAAS-3S probes at the PROSPERO criticality facility (CEA)

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