DOE/HTGR--87-025

HFD-43006

FIRE DETECTION AND ALARM SUBSYSTEM DESIGN DESCRIPTION

4 x 350 MW(t) MODULAR HTGR PLANT

DISCLAIMER

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Author/Contractor

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LIST OF ACRONYMS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CDS	Component Design Specifications
CPU	Central Processing Unit
DOE	Department of Energy
ICD	Interface Control Documents
IEEE	Institute of Electrical and Electronics Engineers
NFPA	National Fire Protection Association
NSSS	Nuclear Steam Supply System
OPDS	Overall Plant Design Specification
SDD	System Design Description
SSDD	Subsystem Design Description
UL	Underwriters Laboratories

LIST OF DEFINITIONS

Alarm	A signal for attracting attention to some abnormal condition
Annunciator	A visual signal device consisting of a number of pilot lights or drops, each one indicating the condition that exists or had existed in an associated circuit, and is labeled accordingly.
Ionization smoke detector	A device which has a small amount of radioactive material which ionizes the air in the sensing chamber, thus rendering it conductive and permitting a current flow through the air between two charged electrodes.
Multiplex	To interleave or simultaneously transmit two or more messages on a single channel.
Photoelectric smoke detector	A photoelectric relay and light source arranged to detect the presence of more than a predetermined amount of smoke in the air.
Thermal (heat) detector	A device which detects abnormally high temperature or rate of temperature rise to initiate a fire alarm.
Ultraviolet flame detector	A device whose sensing element is responsive to radiant energy outside of the range of human vision (below approximately 4000 angstroms).

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PREFACE

The objectives of the HTGR plant project are to produce safe, economical power. Supporting these objectives are four major goals and their associated plant states, identified as follows:

1. Maintain Safe Plant Operation

    1.1 Maintain Safe Energy Production
    1.2 Maintain Safe Plant Shutdown
    1.3 Maintain Safe Plant Refueling
    1.4 Maintain Safe Plant Startup/Shutdown

2. Maintain Plant Protection (in the event that plant operation cannot be maintained in the normal operating envelope)

    2.1 Protect the Capability to Maintain Safe Energy Production
    2.2 Protect the Capability to Maintain Safe Plant Shutdown
    2.3 Protect the Capability to Maintain Safe Plant Refueling
    2.4 Protect the Capability to Maintain Safe Plant Startup/Shutdown

3. Maintain Control of Radionuclide Release (in the low probability event of failure to maintain plant protection)

    3.1 Control Radiation
    3.2 Control Personnel Access

4. Maintain Emergency Preparedness (in the extremely low probability of failure to maintain control of release of radionuclides)

The Overall Plant Design Specification (OPDS) is the top-level technical document for the HTGR plant. The OPDS (based on owner requirements and regulatory requirements) establishes the overall performance, functional, institutional, interface, operational, safety, maintenance, inspection and decommissioning requirements for design of the plant.

In response to the OPDS, a series of low tier documents, System Design Descriptions (SDDs), Subsystem Design Descriptions (SSDDs), Buildings and Structures Design Descriptions (BSSDs), Component Design Specifications (CDSs), and Interface Control Documents (ICDs), describe and control the individual designs. Traceability from plant-level requirements to equipment-level requirements is maintained throughout this hierarchy of design documents.

SUMMARY

Fire Detection and Alarm is an early warning system used to detect and report the presence of a fire within the plant. It detects, annunciates, and records plant-wide fire alarms, subsystem trouble, and fire console operator actions.

SECTION 1

SUBSYSTEM FUNCTIONS AND DESIGN REQUIREMENTS

1.1 SUBSYSTEM FUNCTIONS

The function of Fire Detection and Alarm is to detect and annunciate the presence and location of combustion by-products or presence of fire within the plant. However, the Fire Detection and Alarm provides annunciation only, and does not initiate any fire suppression systems. Fire suppression is provided by the Plant Fire Protection System (SSDD HFD-49004).

1.2 SUBSYSTEM DESIGN REQUIREMENTS

1.2.1 Subsystem Configuration and Essential Features Requirements

Fire Detection and Alarm shall be a stand-alone system designed for independent and reliable operation. This subsystem shall be configured such that no single event or failure to any component or cable will degrade the operation of the subsystem.

(3006.0121.001)

1.2.2 Operational Requirements

Fire Detection and Alarm shall operate on a continuous basis through all plant modes. This subsystem shall be self-monitoring, reporting any subsystem failures as well as the presence of fire or combustion by-products.

(3006.0122.001)

Fire Detection and Alarm equipment shall be designed to reject radio interference from hand-held, two-way communications equipment.

(3006.0122.002)

Fire Detection and Alarm equipment shall not malfunction in the environment of the power station and shall be capable of passing all specified tests.

(3006.0122.002)

1.2.3 Structural Requirements

Fire Detection and Alarm shall be located in both non-seismic Category I and Seismic Category I structures, and shall be seismically supported within Seismic Category I structures.

(3006.0123.001)

1.2.4 Environmental Requirements

Fire Detection and Alarm equipment shall be capable of operating within the normal and abnormal environmental conditions of temperature, pressure, humidity, and radiation for the design life of the equipment, as indicated in Table 1-1.

(3006.0124.001)

1.2.5 Instrumentation and Control Requirements

Fire Detection and Alarm shall provide annunciation (audible or visual) throughout the plant when a fire is detected.

(3006.0125.001)

Visual alert shall be provided outside the fire zone that is in an alarm state.

(3006.0125.002)

All subsystem alarms and abnormal indications are annunciated in the control room and a hard copy record is made.

(3006.0125.003)

1.2.6 Surveillance and In-Service Inspection Requirements

The design of Fire Detection and Alarm shall incorporate, to the greatest degree practicable, those features necessary for status monitoring and implementing in-service inspection functions with the plant in operation.

(3006.0126.001)

The status of all major system components shall be monitored and displayed, and when in-service inspection activities require removal of equipment from service, design features shall be included to minimize the out-of-service time.

(3006.0126.002)

1.2.7 Availability Assurance Requirements

Fire Detection and Alarm shall not be necessary for electrical generation.

(3006.0127.001)

1.2.8 Maintenance Requirements

Fire Detection and Alarm shall be designed to facilitate in-place or on-line maintenance to the greatest degree practicable.

(3006.0128.001)

Fire Detection and Alarm components shall be provided with periodic maintenance consistent with the manufacturer's recommendations. In addition, adequate floor space and maintenance clearances shall be provided around these components to permit in-place maintenance and facilitate dismantling, removal, or replacement of equipment.

(3006.0128.002)

1.2.9 Safety Regulations

Fire Detection and Alarm shall be non-safety related for component design and Non-Seismic Category I for equipment support in non-Class 1E areas, and Seismic Category I for equipment support in Class 1E areas.

(3006.0129.001)

1.2.10 Codes and Standards Requirements

Fire Detection and Alarm shall be designed and constructed in accordance with the regulatory requirements and the industry codes and standards that are

listed in Tables 1-2 and 1-3. Deviations from these requirements may be proposed for review and approval by the Project Office.

(3006.01210.001)

1.2.11 Quality Assurance Requirements

Items designated nonsafety-related are QAL II or QAL III. QAL II items shall come under a quality assurance program which complies with selected basic requirements and supplements of ANSI/ASME NQA-1 and the four additional supplements from NEF2-10, regarding engineering holds, engineering drawing lists, design review, and management assessment which shall be implemented on activities that affect the quality of such items. QAL III items shall come under a quality assurance program which complies with selected basic requirements of NQA-1 and the four additional supplements identified above.

(3006.01211.001)

Subsystem-level documents are assigned the QAL classification that corresponds to the highest QAL of any item in the subsystem. Therefore, this SSDD shall be classified as QAL III.

(3006.01211.002)

1.2.12 Construction Requirements

Fire Detection and Alarm arrangement features shall facilitate the installation, removal, and reinstallation of equipment.

(3006.01212.001)

Fire Detection and Alarm design shall utilize shop, factory, or field fabrication, assembly, or erection as appropriate to minimize erection costs and maintain quality control.

(3006.01212.002)

The design of Fire Detection and Alarm components shall incorporate materials and processes, as required, to meet all packaging, shipping, receiving, storage, handling, construction, and operational functions. Level B and Housekeeping Zone IV is provided from shop fabrication through plant startup.

(3006.01212.003)

1.2.13 Decommissioning Requirements

(TBD)

TABLE 1-1

ENVIRONMENTAL CONDITIONS

A. Normal Environment

Temperature, °C(°F)	15.6-40(60-104)
Pressure, psia	Atmospheric
Humidity, percent	20 - 80
Radiation, rad*	(TBD)
Aging, days/yr	(TBD)
Operating cycles	(TBD)

B. Abnormal Environment

Temperature, °C(°F)	48.9(120)
Humidity, percent	10 - 90
Aging, days/yr	(TBD)

NOTES:

* 40 yr total integrated dose (TID)

TABLE 1-2

REGULATORY REQUIREMENTS

Code of Federal Register

10CFR50, Appendix R	Licensing of Production and Utilization Facilities, Fire Protection Program

TABLE 1-3

INDUSTRY CODES AND STANDARDS

National Fire Protection Association

1.	NFPA No. 72D	Proprietary Protective Signaling Systems
2.	NFPA No. 72E	Automatic Fire Detectors

SECTION 2

DESIGN DESCRIPTION

2.1 SUMMARY DESCRIPTION

Fire Detection and Alarm is designed for reliable error-free operation achieved through a redundant design and is designed to the requirements of Subsection 1.2. It provides an alarm response when activated by a fire detector, a failure in the detector's power circuit, or any malfunction which affects the detector's ability to perform properly.

Redundancy is provided by the use of independent transmission cables between remote zone panels and a central processing unit (CPU) located in the Operations Center.

2.2 SUBSYSTEM CONFIGURATION

Fire Detection and Alarm consists of a CPU and remote interface zone panels. A multiplex system is used for communication between the CPU and the remote zone panels, as indicated in Figure 2-1. The remote zone panels receive inputs from various detectors and fire pull stations located in specific fire zone areas throughout the plant.

Various detectors, such as ionization smoke, photoelectric smoke, thermal (heat), and ultraviolet flame type sense the presence of combustion by-products or the presence of fire, and relay a change of state condition to the remote zone panel. Upon receipt of a fire signal from a detector, the zone panel sends a signal to the CPU via the multiplex system. The CPU annunciates the affected fire zone and relates it to the physical location within the plant.

Alarms are provided to alert personnel within the plant to the presence of fire. These alarms are both audible and visual.

Fire pull stations are also located within each fire zone for annual reporting of a fire.

2.3 SUBSYSTEM PERFORMANCE CHARACTERISTICS

Fire Detection and Alarm is operational during all plant operating conditions. In case of loss of ac power, backup generators provide the required power.

2.3.1 Subsystem Operating Modes

Not applicable

2.3.2 Subsystem Steady-State Performance

Not applicable

2.3.3 Subsystem Response to Plant Transients

Not applicable

2.3.4 Subsystem Failure Modes and Effects

The worst case subsystem failure mode is the failure of a fire detection and alarm multiplixer. The effect of this failure would be the inability to monitor fire in the zone that the failed multiplexer services.

2.4 SUBSYSTEM ARRANGEMENT

Fire Detection and Alarm is distributed throughout the plant and arranged so as not to interfere with, nor be interfered by, other systems. Detectors are located according to NFPA 72E. The cabling minimizes the effect of single failures to the balance of the system by providing Class A wiring, as defined in NFPA 72D.

2.5 INSTRUMENTATION AND CONTROL

Fire Detection and Alarm instrumentation and control consists of detectors and annunciators.

Two types of ionization smoke detectors are used to detect products of combustion. In open areas, low voltage detectors with dual ionization chambers capable of detecting products of combustion are used. Standard ionization smoke detectors are used in air ducts.

Photoelectric smoke detectors are also used to detect the products of combustion entering a labyrinth chamber and are set to operate at a density of approximately 1.5 percent per foot.

Thermal (heat) detectors are either rate-compensated electric thermostats or fixed thermostats which measure surrounding air temperature and are set to operate at 140°F.

Annunciation is provided at the CPU console and remotely at the remote zone panels. The alarm at the CPU is locked-in until acknowledged by the operator at the console. In addition to providing an audible signal at the CPU, the location and type of device activating the alarm is automatically recorded via an alarm printer. Report alarms in the fire zone are horns, bells, or lights.

TABLE 2-1

FIRE-DETECTORS

Detector Type	Quantity	Location
Ionization	(TBD)	Reactor Building Reactor Service Building Reactor Auxiliary Building Turbine Building Operations Center Makeup Water Treatment and Auxiliary Boiler Building Radioactive Waste Management Building Meteorological Building
Thermal	(TBD)	Reactor Building Reactor Service Building Reactor Auxiliary Building Helium Storage Building Personnel Services Building Turbine Building Transformer Areas Makeup Water Treatment and Auxiliary Boiler Building Operations Center Hydrogen Storage Area Maintenance Building ECA Warehouse Fire Pumphouse Radioactive Waste Management Building Standby Power Building Fuel Oil Storage Tanks
Ultraviolet	(TBD)	Turbine Building Fire Pumphouse Standby Power Building Fuel Oil Storage Tanks
Photoelectric	(TBD)	Reactor Building Reactor Service Building Reactor Auxiliary Building Radioactive Waste Management Building

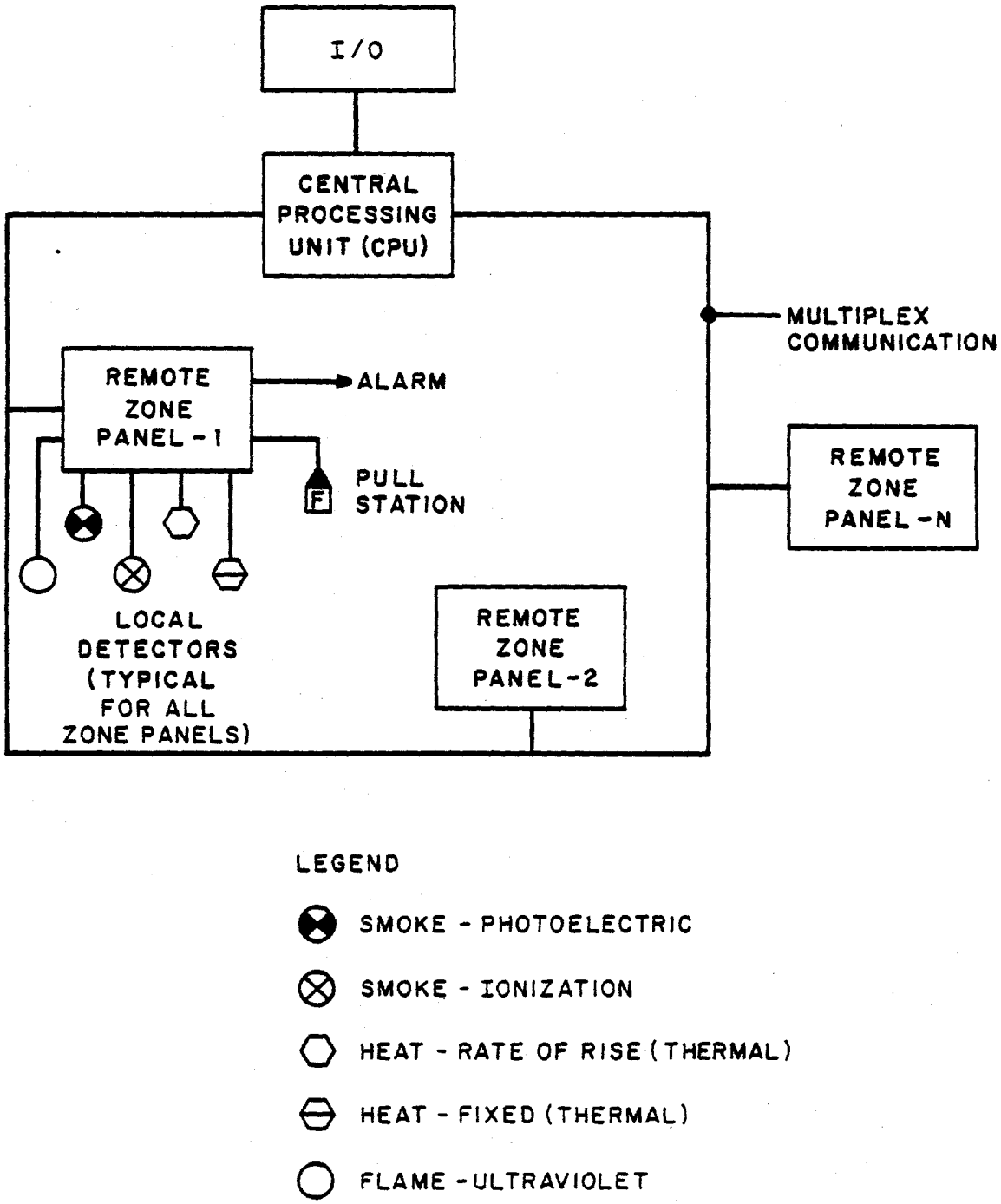

Figure 2-1
FIRE DETECTION AND ALARM
SUBSYSTEM SCHEMATIC

SECTION 4

SUBSYSTEM AND COMPONENT INTERFACES

4.1 SUBSYSTEM INTERFACE REQUIREMENTS

4.1.1 Interface Requirements Imposed on Other Systems

Interface requirements at the system level are presented in Table 4-1 showing the interfacing systems with subsystem identification on which the requirements are imposed, the nature of interface, the interfacing components, and the interface requirements.

4.1.2 Interface Requirements Imposed on Subsystems Within the System

Interface requirements at the subsystem level are presented in Table 4-2 showing the interfacing subsystems within the Miscellaneous Control and Instrumentation Group on which the requirements are imposed, the nature of interface, the interfacing component, and the interface requirements.

4.2 COMPONENT BOUNDARY DEFINITIONS

(TBD)

TABLE 4-1

INTERFACE REQUIREMENTS IMPOSED ON OTHER SYSTEMS

Interfacing Systems (with Subsystem/Identification)	Nature of Interface	Interfacing Component	Interface Requirements
1. Reactor System (10)	No interface	NA	NA
2. Vessel System (11)	No interface	NA	NA
3. Reactor Services Group (20)	No interface	NA	NA
4. Heat Transport System (21)	No interface	NA	NA
5. Miscellaneous Control and Instrumentation Group (30)	See Table 4-2 for interface requirements imposed on subsystems within the Miscellaneous Control and Instrumentation group.		
6. Plant Protection and Instrumentation System (32)	No interface	NA	NA
7. Fuel Handling, Storage and Shipping System (34)	No interface	NA	NA
8. Plant Control, Data and Instrumentation System (37)	No interface	NA	NA

TABLE 4-1 (continued)

Interfacing Systems (with Subsystem/Identification)	Nature of Interface	Interfacing Component	Interface Requirements
9. Power Conversion Group (50)	No interface	NA	NA
10. Heat Rejection Group (52)	No interface	NA	NA
11. Reactor Cavity Cooling System (56)	No interface	NA	NA
12. Shutdown Cooling System (57)	No interface	NA	NA
13. Building Structures and Building Service Group (70)	See Table 2-1 for interface requirements on Building Services.		
14. Mechanical Services System (90)	No interface	NA	NA
15. Electrical Group (92)			
(Non Class IE UPS)	Provides Power to the Fire Detection and Alarm System	UPS bus	120 V, 60 Hz 1 phase UPS
(Grounding, Lightning, Heat Tracing, and Cathodic Protection)	Provides grounding for equipment	Equipment enclosure	TBD

TABLE 4-2

INTERFACE REQUIREMENTS IMPOSED ON
OTHER SUBSYSTEMS WITHIN THE SYSTEM

Interfacing Systems (with Subsystem/Identification)	Nature of Interface	Interfacing Component	Interface Requirements
Miscellaneous Control And Instrumentation Group (30)			
(NSSS Analytical Instruments)	No interface	NA	NA
(Radiation Monitoring)	No interface	NA	
(Seismic Monitoring)	No interface	NA	NA
(Meteorological Monitoring)	Provides detection	Meteorological Building	TBD
(Security Monitoring)	No interface	NA	TBD

SECTION 9

REFERENCES

1. Gas-Cooled Reactor Associates (GCRA). Utility/User Design Requirements for Modular High Temperature Gas-Cooled Reactor Plant, GCRA-86-002, Rev. 1. GCRA, San Diego, CA, March 1986.

2. GA Technologies, Inc. (GA) et al. Overall Plant Design Specification Modular Hig Temperature Gas-Cooled Reactor, HTGR-86-004, Rev. 1. GA, San Diego, CA, February 1986.

3. GA Technologies, Inc. (GA). NSSS/BOP Interface Requirements for the 4 x 350 MW(t) Modular HTGR Plant, HTGR-86-007, GA, San Diego, CA, April 1986

4. Bechtel National, Inc. (BNI). BNI Input to SWEC on Mechanical Services Group, Letter, GCRA/BEC/81-202, BNI, San Francisco, CA, February 1986.

5. Quality Assurance Requirements, HCP-20801, Rev.1. September 1984.