



Trusted radiation protection.

940-3MS

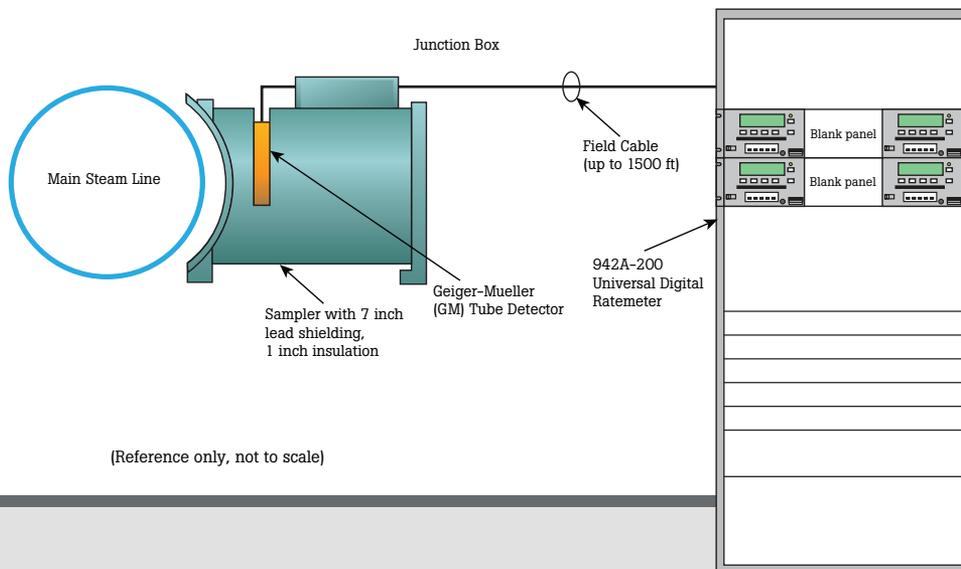
Main Steam Fission Product Monitor

Regulatory Guide 1.97 requires operating pressurized water reactors (PWRs) to monitor the effluent released from steam generator safety relief or atmospheric dump valves for gamma emitting nuclides over the range of $1.0E-1$ to $1.0E+3$ $\mu\text{Ci/cc}$. This is normally accomplished by monitoring the main steam lines for fission products with a shielded, gamma sensitive detector. In the event of a failure of the reactor fuel cladding, radioactive fission products are released into the reactor coolant. If there is primary to secondary system leakage, these fission products will be present in the main steam lines. The 940-3MS monitor will detect the presence of these fission products in the main steam lines. The system may also be used in conjunction with a 940-3N to measure the ^{16}N activity in the main steam lines.

System description

The 940-3MS monitor consists of a field mounted detector shield, a GM gamma detector, a preamplifier and an electrical junction box for each steam line. A remote, control room located, universal digital ratemeter (UDR) provides the detector high voltages and DC operating voltages, processes the detector output, performs

limit checks, generates analog output signals and displays the net fission product activity for each detector. Because of the stability of the GM detector over the operating temperature of the monitor, automatic gain stabilization of the detector output is not required. Where additional system features are required, the 960 Digital Process Radiation Controller may be supplied in lieu of the UDR.



Key features

- 4 Pi lead shield
- Stable, fixed gain GM detector
- Detector output standardized via range calibration
- Integral preamplifier capable driving 1,500 feet of cable
- Microprocessor controlled
- Seismically and environmentally qualified
- Detector anti-jam circuit
- Fission product detection and/or ^{16}N



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Shield

A 841-7, "adjacent to the line" or "on-line" shield assembly, with 7 inches of 4 pi virgin lead shielding is provided. The face of the shield is designed to match the diameter of the main steam line, which affects its overall size and weight. The shield is designed to mount on a platform or pedestal, adjacent to the main steam line. The purpose of the shielding is to reduce the induced background due to the low energy fission products present in the steam line, thereby increasing the monitor sensitivity. Because of the small size of the GM detector, it is inserted into the shield through a stainless steel tube welded to the shield frame. A "seal grip" type adaptor is used to seal the detector entry port and prevent moisture from damaging the detector. The detector tube intersects a viewing port that positions the GM detector to view the main steam line directly. The distance between the detector and the main steam line is established based on the expected fission product activity and the response of the GM tube detector. The shield also provides a convenient location to mount the detector junction box. The shield should be located to reduce potential interference that may result from other steam lines in the area. Where required, thermal insulation may be installed between the steam line and the shield to reduce the temperature at the detector. A radioactive check source is installed in the shield weldment to verify detector operation and its ability to respond to gamma radiation.

Detector

The detector is an 843-251 Series GM tube gamma detector. The detector is provided with a 6 ft cable with a triax connector for termination in an 843-252 Junction Box. The GM detector is housed in a phenolic tube to reduce the potential for damage during handling. The 843-252 Junction Box includes a pulse shaping and cable driving preamplifier. In addition, the junction box provides a method to interconnect the detector to the control room cable. Because the GM detector operates on a limited plateau, manufacturing differences between detectors can have a significant effect on detector response. To accommodate these differences, each GM detector is subjected to a primary calibration to determine a unique correction factor. By applying the detector unique

correction factor to the counts per minute (CPM) to $\mu\text{Ci/cc}$ conversion constant, the variations between detectors are eliminated. Secondary standard solid source sets and a standard field calibration fixture are available for on-site re-calibrations.

Universal digital ratemeter

The 942A Universal Digital Ratemeter is provided to process the detector output and to display the fission product activity reading in units of CPM or microcuries per cubic centimeter ($\mu\text{Ci/cc}$). In operation, the detector output is monitored by the UDR located in the control room. A 942-200-80 Serial Communication Module provides monitor status and historical data via a serial port for use by the plant computer or a laptop PC.

The $\mu\text{Ci/cc}$ calculation is a measurement of the radioactivity seen by the detector. The equation for the radioactive concentration is:

$$\mu\text{Ci/cc} = (\text{CPM} - \text{CPMBKRD}) \times \text{Ka}$$

where:

| | |
|-----------------------------|--|
| $\mu\text{Ci/cc}$ | Concentration, μCi per cubic centimeter |
| CPM | detector output, counts per minute. This is the average of the 60 previous counts per second values, updated once per second |
| CPM_{BKRD} | background subtract setpoint, current in CPM |
| Ka CPM to $\mu\text{Ci/cc}$ | constant setpoint. Ka is the isotope conversion constant for the detector/sampler geometry, and is defined as the inverse of the isotopic efficiency (i.e., 1/effeciency) stated on the sensitivity data sheet |



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Technical specifications

The firmware in the UDR includes the ability to enter the following monitor specific set points:

- Warn Alarm
- High Alarm
- Fail Alarm
- Overrange Limit
- Detector Dead time
- Background Subtract
- Detector Conversion Constant
- Calibrate Timer
- Analog Full Scale
- Analog Low Scale

The display is updated once per minute, and is the result of the sum of the last 60, one second values. Longer counting times, up to 20 minutes, are available through use of the statistical accuracy jumper options provided on the UDR. As an option, a second UDR and gamma scintillation detector may be provided for monitoring ¹⁶N present in the main steam line. The detector output signal is electrically connected to the second UDR and adjusted to monitor the 6.1 MeV ¹⁶N photon. In this configuration, both fission products and ¹⁶N in the main steam are independently monitored, using the same detector shield.

Shield, 841-7 (typical, 36 inch Ø steam line)

Dimensions (*h x w x d*)
17.25 in x 14.75 in x 20.0 in
(43.81 cm x 37.46 cm x 50.8 cm)

Weight
1,200 lb (544.31 kg), approx.

Construction
0.25 inch thick welded steel frame backfilled with 7 inches of lead shielding

Detector, 843-251

Low range

843-251A Saint-Gobain G1320
Efficiency

- ¹³³Xe 1.1E+07 CPM/μCi/cc
- ⁸⁵Kr 4.3E+06 CPM/μCi/cc

Mid range

843-251B Saint-Gobain G1310
Efficiency

- ¹³³Xe 1.1E+04 CPM/μCi/cc
- ⁸⁵Kr 8.1E+02 CPM/μCi/cc

High range

843-251C Saint-Gobain G1300
Efficiency

- ¹³³Xe 3.7E+03 CPM/μCi/cc
- ⁸⁵Kr 2.5E+02 CPM/μCi/cc

Housing

Phenolic tube

Bias source

Natural uranium, ²³⁸U

Operating voltage

550 V dc to 575 V dc (nominal),
700 V dc (maximum)

Pulse polarity

Negative (-)

Plateau length

100 V to 150 V dc

Plateau slope

10 % to 30 % per 100 V

Cable length

6 ft, integral

Connector type

Triax

Environment

- Operating temperature: 32 °F to 122 °F (0 to 50 °C)
- Storage temperature: 32 °F to 122 °F (0 to 50 °C)
- Relative humidity: 0 to 95 %, non-condensing

Dimensions

0.5 in Ø x 2.9 in (l)
(1.27 cm Ø x 7.29 cm)

Weight

4.4 oz (124.74 g), approx.

Preamplifier, 843-252

Power requirements

+ 15 V dc or + 16 V dc

Current requirements

20 mA dc, maximum

Input

- Pulse polarity: Negative (-)
- Impedance: > 100 k-ohms

Output

- Pulse polarity: Negative (-)
- Voltage: 5 V dc, maximum, 50 ohm terminated
- Impedance: 51 ohms

Discriminator

Adjustable, 0 to + 2 V dc
(0.2 V dc normal)

Anti-jam level

Adjustable, 0 to + 3 V dc
(0.9 V to 1.45 V dc typical)

Anti-jam oscillator frequency

50 kHz, approx.

Cable length

1,500 ft drive capability

Max pulse amplitude at maximum cable length

5 V dc

Housing

NEMA 4, weatherproof

Environment

- Operating temperature: 32 °F to 122 °F (0 to 50 °C)
- Storage temperature: 32 °F to 122 °F (0 to 50 °C)
- Relative humidity: 0 to 95 %, non-condensing

Dimensions

8.6 in x 4.2 in x 3.2 in
(21.9 cm x 10.6 cm x 8.1 cm)

Weight

2.4 lb (1.09 kg), approx.

Universal Digital Ratemeter

Main display

5 digits with backlighted radiation units display and floating decimal point. 3 digits plus exponent for data entry/display.

Bargraph display (dynamic range)

3 segments per decade, tricolor, indicating channel status. 10 to 107 CPM.

Alarm indicators

HIGH (red LED), WARN (amber LED), FAIL (red LED) and RANGE (red LED)

Pushbuttons

- Setpoints: HIGH-High Alarm limit, WARN-Warn Alarm limit
- Check source: Activates check source and associated green LED indicator. Momentary non-latching pushbutton operation.
- Alarm acknowledgment: Causes alarm indicators to go to a steady on state after acknowledgment
- Power ON/OFF: Alternate action pushbutton for AC power to unit

Relay outputs (failsafe operation)

- High alarm: One set. DPDT rated 5 A @ 120 V ac (one set 120 V ac powered for use with optional remote alarm)
- Warn alarm: Two sets. DPDT rated 5 A @ 120 V ac
- Fail alarm: Two sets. DPDT rated 5 A @ 120 V ac
- Contact rating for all relays is 5 A @ 28 V dc

High voltage output

1400 V dc max @ 0.5 mA

Analog outputs

4 to 20 mA (2) (500 ohms max) and 0 to 10 V dc (1 k-ohm min), logarithmic. May be scaled for any one decade (min) to the full range of the unit (max).

Alarm acknowledgment input

Optically isolated DC input

Detector accuracy (electronic)

$\pm 1\%$ digit ($\pm 1\%$ of the displayed value), exclusive of the detector energy response

Analog inputs

4, 4 mA to 20 mA

Dimensions (*w x d x h*)

5.64 in x 13.73 in x 3.47 in
(14.33 cm x 34.87 cm x 8.81 cm)

Weight

4 lb (1.8 kg)

Power

120 V ac $\pm 10\%$, 50/60 Hz,
28 W

Heat loading

Approximately 96 BTU/hr

Environmental

- Operating temperature: 32 °F to 122 °F (0 to 50 °C)
- Storage temperature: 32 °F to 122 °F (0 to 50 °C)
- Relative humidity: 0 to 95 %, non-condensing

Mounting

948-1 Rack Chassis, designed to mount 3 UDRs in a 19 inch wide cabinet

Ordering information

Model

940-3MS: Main Steam Fission Product Monitor



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5/2015 3015226c_en

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