



Trusted
radiation
protection.

940-4P

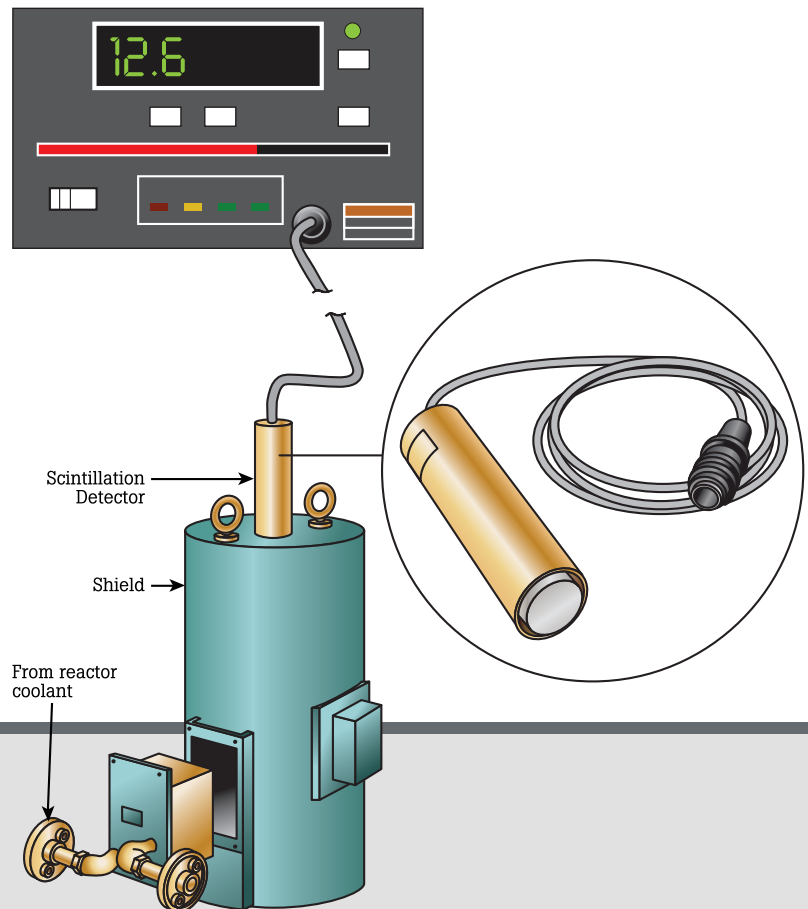
Reactor Coolant Letdown Monitor

The 940-4P Reactor Coolant Letdown Monitor is an effective tool for the measurement of radioactive fission products in the reactor coolant of pressurized water reactors (PWRs) for detection of a breach of a primary barrier for the release of radioactive material, the reactor fuel cladding. The 940-4P is designed to continuously monitor the reactor primary coolant and to operate over a range of 50% to 100 times the plant technical specification limit (typically 1×10^{-6} to 1×10^2 $\mu\text{Ci/cc}$). The sampler is normally located so that the transit time from the reactor coolant to the monitor is approximately two (2) minutes. This will permit the high activity, short-lived activation products, primarily ^{16}N , to decay to insignificant levels. The 940-4P monitor will detect the presence of these fission products to the levels required by Regulatory Guide 1.97.

The 940-4P is an in-line lead-shielded monitor. The sampler consists of an in-line field-mounted sample volume, a

detector shield, a gamma scintillation detector, a check source and an electrical junction box. Two remote, control-room-located 942A Universal Digital Ratemeters (UDRs) provide the detector high voltage and DC operating voltages, process the

detector output, perform limit checks, generate analog output signals and display the net count rate of the detector. Where additional system features are required, the 960 Digital Process Radiation Controller may be supplied in lieu of the UDR.



Key features

- 4 Pi, 5-inch lead shield
- NaI (Tl) scintillation detector
- Gross and single-channel analyzer display
- Optional integral LED check source
- Integral preamplifier capable of driving 1,500 feet of cable
- Lead attenuator for 2.5 decade extended range operation
- Removable sample volume for decontamination
- Seismically and environmentally qualified
- Detector anti-jam circuit



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Sampling assembly

The sampling assembly consists of a 140 cc in-line sample volume welded to two 150 lb or 300 lb raised face flanges that are installed in the reactor coolant letdown system. The sample volume, sample tubing and flanges are manufactured from 300-series stainless steel. The system is designed for operation up to 300 psig. ASME Section IX qualified welders perform all welding. To avoid the expense of ASME Section III certification, suitable isolation valves should be installed upstream of the sample volume. The raised face flanges permit removing the sample volume for decontamination. The sample volume is installed into a lead shield. The shield houses a scintillation detector that views the sample volume. The shield consists of a 0.24 inch thick steel weldment, filled with five inches of 4 Pi lead shielding. The lead shielding surrounds the detector and reduces the response to ambient background radiation. Detector installation and replacement is accomplished via a removable lead cap located on the top of the shield. The shield also includes a lead attenuator to increase the range of the monitor by 2.5 decades. The shield provides a convenient mounting base for a solenoid-operated ¹³⁷Cs check source and the detector junction box. Lifting eyes are provided for transporting and installing the shield. Alternate sampling configurations based on existing in-plant piping arrangements are also available.

Detector

The detector is a 943-36 or 943-36L Gamma Scintillation Detector. This detector utilizes a 1.5-inch diameter by 1.0-inch thick NaI (Tl) scintillation crystal coupled to a 1-inch diameter photomultiplier tube. The detector includes a pulse-shaping and cable-driving preamplifier. The 943-36L detector includes provisions for an LED to function as an integral check source. To maximize the integrity and life of the optical couplings, the crystal, light pipe and photomultiplier tube are provided as a sealed, integral assembly. The detector is provided with an 8-foot cable with an "MS" type connector for termination to a 844-211 or 844-211LS Junction Box. In addition to providing a method to connect the detector to the field cable, the 844-211LS Junction Box includes the LED driving circuitry for the 943-36L detector. For applications where temperature variations are expected, the 943-237A Gain Stabilized Gamma Scintillation Detector is available. Secondary solid source sets and a field calibration fixture are available for on-site re-calibrations.

Universal digital ratemeter

Two 942A Universal Digital Ratemeters process the detector output and display the reading in units of counts per minute (CPM). The first UDR operates in the "gross" mode, displaying the total output of the detector. The second UDR is provided with an optional single-channel-analyzer (SCA) circuit board adjusted to display the count rate for a specific control isotope, normally ¹³⁵I. In the SCA mode, an ¹³⁵I sensitivity of 1E-4 µCi/cc may be realized to detect fission product activity at the 1% failed fuel element level. Using the attenuator plug, the range may be extended up to 1E+3 µCi/cc, approximately 30 times higher than the expected activity at the 1% failed fuel level. As an option, a single UDR may be provided with a front-panel-mounted Gross/SCA display select switch. In operation, the detector output is monitored by the UDR located in the control room. An optional 942-200-80 Serial Communication Module is available to provide monitor status and historical data via a serial port, for use by the plant computer or a laptop PC.

The radiation value calculation is a measurement of the average radioactivity seen by the detector. The equation for the radiation value is:

$$CPM_{net} = (CPM - CPM_{BKR D}) \times Ka$$

where:

- CPM_{net} net detector output, counts per minute
- CPM detector output, gross or SCA, counts per minute. This is the average of the 60 previous counts per second values, updated once per second.
- CPM_{BKR D} set point, detector output due to ambient background radiation, counts per minute.
- Ka user-enterable radiation value compensation factor. May be used for sample volume pressure compensation, flow compensation, or engineering units conversion.



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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.

Technical specifications

Sampling assembly

Dimensions

30.5 in (h) x 13 in Ø
(77.5 cm x 33 cm)

Weight

1,300 lb (approximate)

Construction

0.25 in thick weldment

Shielding

5 in, 4 Pi virgin lead

Mounting

4, 0.625 inch Ø mounting holes

Lifting

Two, 1.0 in Ø lifting eyes

Connections

0.5 in, 150 lb raised face flanges

Sample volume

140 cc (approximate)

Attenuator

2 in Ø x 2.5 in (h)

Check source

¹³⁷Cs, 8 µCi, solenoid actuated

Electrical

4 x 6 in, NEMA 4 junction box

Detector access

Removable lead top cover

Detector

Type

Gamma scintillation, pulse mode

Crystal

NaI (Tl)

Dimensions

1.5 in Ø x 1.0 in thick

Construction

Integral crystal, light pipe and photomultiplier tube

Photomultiplier

2 in photocathode, 10 stage

Power requirements

+ 1,000 V dc at 500 µA;
± 15 V dc at 15 mA

Stabilization

Auto temperature compensation, optional

Efficiency, gross

¹³⁵I 7.8E+6 CPM/µCi/cc

Sensitivity

¹³⁵I 2.7E-6 µCi/cc

Efficiency, gross,

with attenuator

¹³⁵I 3.0E+4 CPM/µCi/cc

Sensitivity

¹³⁵I 7.2E-4 µCi/cc

Full range, with attenuator

¹³⁵I 2.7E-6 to 3.2E+2 µCi/cc

Efficiency, gross, 0.5 to 2.0

MeV window

¹³⁵I 2.8E+6 CPM/µCi/cc

Sensitivity

¹³⁵I 7.7E-6 µCi/cc

Efficiency, gross, with attenuator,

0.5 to 2.0 MeV window

¹³⁵I 1.0E+4 CPM/µCi/cc

Sensitivity

¹³⁵I 2.1E-3 µCi/cc

Full range, with attenuator and 0.5 to 2.0 MeV window

¹³⁵I 7.7E-6 to 1.0E+3 µCi/cc

Preamplifier

Integral, 1,500 ft drive capability

Cable

Integral, 8 ft, with "MS" type connector

Rise time

< 250 nanoseconds

Dead time

10 µsec, approximately

Max count rate

1 x 10⁷ CPM

Input impedance

> 50 k-ohms

Coupling

AC

Voltage gain

6.1 V/V

Configuration

Voltage sensitive

Output impedance

50 ohms

Output polarity

Negative (-)

Max pulse height

- 6.0 V dc

Dimensions

9.5 in (l) x 2.5 in Ø
(24.1 cm x 6.4 cm)

Weight

3 lb (1.4 kg) approx.

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

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

Set points: 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 at 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 at 28 V dc
- High voltage output: 1400 V dc max at 0.5 mA
- Analog outputs: 4 mA 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)

± 1 % digit (± 1 % of the displayed value), exclusive of the detector energy response

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 ± 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

940-4P: Reactor Coolant Letdown Monitor

Standard accessories

942A: Universal Digital Ratemeter (2)

943-36 or 943-36L: Gamma Scintillation Detector

Optional accessories

844-211 or 844-211LS: Junction Box

942-200-80: Serial Communications Option Board

943-237-A: Gain Stabilized Gamma Scintillation Detector

943-36H: Gamma Scintillation Detector, High Temperature (up to 150 °F)

960: Digital Process Radiation Controller



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