VICTOREEN
A Fluke Brand

Trusted radiation protection.

Technical Data

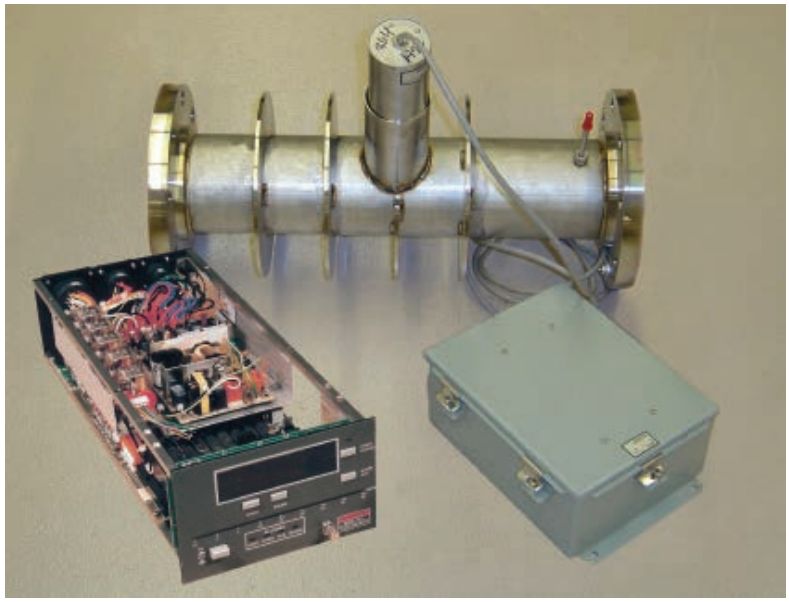
940-4FP

Condenser Air Ejector Discharge Fission Product Monitor

Regulatory Guide 1.97 requires the measurement of noble gasses in the condenser air removal system of pressurized water reactors (PWRs) for detection and assessment of potential radioactive releases. The 940-4FP Condenser Air Ejector Discharge Fission Product Monitor is required to operate over a range of 1 x 10^{-6} to 1 x 10^{5} µCi/cc.

In addition, current regulatory requirements necessitate operating PWRs to monitor the steam generator primary to secondary system leakage. This may be accomplished by monitoring the condenser air ejector discharge (CAED), main steam lines or the steam generator blowdown (SGB) for fission and/or activation products. 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 CAED or condenser off-gas.

The 940-4FP monitor, when configured with beta scintillation detectors, will detect the presence of these fission products to the levels required by Regulatory Guide 1.97. By configuring the monitor with a gamma scintillation detector and utilizing the guidance provided in EPRI TR-104788-1, the fission product activity may be used to determine a primary to secondary leak rate as low as 1 gallon per day (GPD).



Key features

- Optional four pi lead shield available
- NaI (Tl) scintillation detector
- Optional integral LED check source
- Integral preamplifier capable of driving 1,500 feet of cable
- Microprocessor controlled
- Seismically and environmentally qualified
- Detector anti-jam circuit
- CPM to GPD leakage conversion

System description, regulatory guide 1.97 monitor

When used with an accident range noble gas detector, the 940-4FP consists of an in-line field mounted detector shield, one gamma and one beta scintillation detector and an electrical junction box. A remote, control room located, Model 942A Universal Digital Ratemeter (UDR) provides the detector high voltage and DC operating voltages, processes the detector output, performs limit checks, generates analog output signals and displays the net detector count rate or fission product activity for each detector. Where additional system features are required, the 960 Digital Process Radiation Controller may be supplied in lieu of the UDR.

Shield spool piece:

An in-line spool piece and shield assembly, with up to 4 inches of 4 pi virgin lead shielding is provided. The spool piece is designed to mount directly into the CAED discharge line. The spool piece is manufactured from 300 series stainless steel, with standard raised face pipe flanges. A 300 series stainless steel removable well is bolted into the spool piece to position the detector in the effluent to maximize sensitivity and to permit detector removal without violating the integrity of the process pressure boundry. The spool piece and shield may be designed for either vertical or horizontal installation. To support the weight of the shield, a pedestal or other support structure is required. The purpose of the shielding is to reduce the induced background, enhancing the response to the low energy fission products present in the CAED and increasing monitor sensitivity. Detector installation and replacement is accomplished via removable lead caps, located on the top of the shield. Process drain and vent valves, which may also be used to inject a calibration gas, and a pressure transmitter are also provided. The shield provides a convenient location to mount the detector junction boxes. The spool piece is designed to match the diameter of the CAED line.

Detector:

Two detectors are provided with this Regulatory Guide 1.97 Monitor: 943-36 Gamma and 943-27 Beta Scintillation Detectors. The 943-36 detector utilizes a 1.5 inch diameter by 1 inch thick NaI (TI) scintillation crustal coupled to a 2 inch diameter, 10 stage photomultiplier tube. The detector includes a pulse shaping and cable driving preamplifier. It is provided with an 8 foot cable with a "MS" type connector for termination in a 844-211 Junction Box. The junction box also provides a method to interconnect the detector to the control room cable. Secondary standard solid source sets and a standard field calibration fixture are available for on-site re-calibrations.

The 943-27 detector utilizes a 0.0002 inch thick titanium end window, a 1.125 inch diameter by 0.005 inch thick calcium fluoride plastic scintillation crystal coupled to a 1.125 inch diameter by 0.125 inch thick quartz light pipe and a 1.0 inch diameter photomultiplier tube. To operate over the extended range required, the detector is operated in the current, vs. pulse, output mode. The detector is supplied with a 943-227-15 "smart" Digital Preamplifier. The preamplifier contains a microprocessor controlled electrometer, which converts the detector current output (approximately 4 x 10^{-12} A/µCi/cc) into a digital value, and transmits the value to the readout device via a serial data port. The detector is provided with integral high voltage and signal cables. Each cable is 6 feet long, and terminates on mating connectors in the preamplifier enclosure. The preamplifier enclosure contains the electrometer circuit board and the communications circuit board and also provides a method to interconnect the detector to the control room cable. Secondary standard solid source sets, which slide directly onto the detector body, are available for on-site re-calibrations.

System description, leak rate monitor

When used with a steam generator leak rate detector, the 940-4FP consists of an in-line field mounted detector shield, a gamma scintillation detector and an electrical junction box. A remote, control room located, 942A Universal Digital Ratemeter (UDR) provides the detector high voltage and DC operating voltages, processes the detector output, performs limit checks, generates analog output signals and displays the net detector count rate (i.e. the steam generator fission product leakage) for the detector. Where additional system features are required, the 960 Digital Process Radiation Controller may be supplied in lieu of the UDR.

Shield spool piece:

An in-line spool piece and shield assembly, with up to 4 inches of 4 pi virgin lead shielding is provided. The spool piece is designed to mount directly into the CAED discharge line. The spool piece is manufactured from 300 series stainless steel with standard raised face pipe flanges. A 300 series stainless steel well is welded into the spool piece to position the detector in the effluent to maximize sensitivity and to permit detector removal without violating the integrity of the process pressure boundry. The spool piece and shield may be designed for either vertical or horizontal installation. To support the weight of the shield, a pedestal or other support structure is required. To simplify installation, the shield may be provided in sections, for installation on the spool piece in the field. The purpose of the shielding is to reduce the induced background, enhancing the response to the low energy fission products present in the CAED and increasing monitor sensitivity. Detector installation and replacement is accomplished via an access port in the shielding, located on the top of the shield. The shield provides a convenient location to mount the detector junction box. The spool piece is designed to match the diameter of the CAED line.

Detector:

The detector supplied 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 2 inch diameter, 10 stage photomultiplier tube. The detector includes a pulse shaping and cable driving preamplifier. The 943-36L detector includes provisions for an LED (light emitting diode) 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 a "MS" type connector for termination in a 844-211 or 844- 211LS Junction Box. In addition to providing a method to interconnect the detector to the control room cable, the 844-211LS Junction Box includes the LED driving circuitry for the 943-36L detector. Secondary standard solid source sets and a standard field calibration fixture are available for on-site re-calibrations. Based on the guidance provided by EPRI TR-104788-1, the counts per minute (CPM) received from the detector may be converted directly into leakage, in gallons per day.

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

$$CPM_{net} = (CPM\ CPM_{BKRD}) \times Ka)$$

where:		net detector output, counts per minute
	CPMnet	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}	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

VICTOREEN
A Fluke Brand
Trusted radiation protection.

System Description, Universal Digital Ratemeter

The 942A Universal Digital Ratemeter (UDR) is used to process the detector output and display the reading in units of CPM. In operation, the detector output will be monitored by the UDR located in the control room. A 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 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

Shield, 940-442GH (typical, 4 inch Ø CAED line)

Dimensions *(l x w x h)*
64.5 in x 18.6 in x 24.1 in (163.8 cm x 47.2 cm x 61.2 cm)

Well thickness
.06 inch thick end window

Spool piece
4 inch Ø, schedule 40, type 40S stainless steel pipe

Process connection
3 inch, 150 lb weld neck flanges; 2, .5 inch drain/vent ports

Weight
1,500 lb (681 kg) approx.

Detector, Normal Range, 943-36

Type
Gamma scintillation, pulse mode

Crystal
NaI (Tl)

Size
1.5 in Ø x 1 in thick

Construction
Integral crystal, light pipe and photomultiplier tube

Photomultiplier
2 in photocathode, 10 stage

Power required
- + 1,000 V dc @ 500 uA;
- ± 15 V dc @ 15 mA

Stabilization
Auto temperature compensation, optional

Efficiency, mixed fission products
6.8E+9 CPM/µCi/cc

Sensitivity
2.9E-9 to 1.4E-3 µCi/cc

Efficiency
- ^{133}Xe 3.2E+7 CPM/µCi/cc
- ^{85}Kr 4.3E+6 CPM/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 10^7 CPM

Input impedance
> 50 k-Ω

Coupling
AC

Voltage gain
6.1 V/V

Configuration
Voltage sensitive

Output impedance
50 Ω

Output polarity
Negative (-)

Max pulse height
-6.0 V dc

Dimensions *(l x w)*
9.5 in x 2.5 in (24.1 cm x 6.4 cm)

Weight
3 lb (1.4 kg) approximate

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

VICTOREEN
A Fluke Brand
Trusted radiation protection.

Detector, Extended Range, 943-36

Type
Beta scintillation, current mode

End window
0.0002 inch titanium

Scintillator
Calcium fluoride, CaF2(Eu)

Diameter
1.125 inch

Power required
–500 V dc at 400 µA

Detector output
1.0E–12 A/µCi/cc

Efficiency
- ^{133}Xe 1.02E+03 picoamps/µCi/cc
- ^{85}Kr 3.43E+03 picoamps/µCi/cc

Sensitivity
- ^{133}Xe 1.9E–2 to 1.0E+5 µCi/cc
- ^{85}Kr 5.7E–3 to 3.2E+4 µCi/cc

Cables
Two, Integral, 6 ft cable with connectors

Dimensions *(l x w)*
9.0 in x 2.5 in (22.9 cm x 3.8 cm)

Weight
3 lb (1.4 kg) approx.

Preamplifier, Remote, 943-227-15

Power required
+ 15 V dc, 150 mA

Max output
1.0E+03 mA

Coupling
Capacitive

Output
Serial data, RS-232 based

Cable required
Three, twisted pair with overall shield, 16 AWG

Dimensions *(l x w h)*
4 in x 10 in x 8 in
(10.2 cm x 25.4 cm x 20.3 cm)

Weight
8 lb (3.6 kg) approx.

Environmental
- Operating temperature: 0 to 122 °F (–16 °C to 50 °C)
- Storage temperature: 0 to 122 °F (–16 °C 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 CPM to 10^7 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 mA to 20 mA (2) (500 Ω max) and 0 V dc to 10 V dc (1 k-Ω 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 *(l x w x h)*
13.73 in x 5.64 in x 3.47 in
(34.87 cm x 14.33 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

Leak Rate Monitor Shield, 940-483 (typical, 8 inch Ø CAED line)

Dimensions *(l x w x h)*
24 in x 18.75 in x 17.71 in
(60.9 cm x 47.6 cm x 44.9 cm)

Well thickness
.06 inch thick end window

Spool piece
8 in Ø, schedule 40, type 304 stainless steel pipe

Process connection
8 in, 150 lb, type 304 stainless steel raised face flange

Weight
705 lb (320 kg) approx.

Detector, 943-36

Type
Gamma scintillation, pulse mode

Crystal
NaI (Tl)

Size
1.5 in Ø x 1 in thick

Construction
Integral crystal, light pipe and photomultiplier tube

Photomultiplier
2 in photocathode, 10 stage

Power required
+ 1,000 V dc @ 500 uA;
± 15 V dc @ 15 mA

Stabilization
Auto temperature compensation, optional

Efficiency, mixed fission products
6.8E+9 CPM/µCi/cc

Sensitivity
2.9E-9 to 1.4E-3 µCi/cc

Efficiency
- ^{133}Xe 3.2E+7 CPM/µCi/cc
- ^{85}Kr 4.3E+6 CPM/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 10^7 CPM

Input impedance
> 50 k-Ω

Coupling
AC

Voltage gain
6.1 V/V

Configuration
Voltage sensitive

Output impedance
50 Ω

Output polarity
Negative (-)

Max pulse height
-6.0 V dc

Dimensions *(l x w)*
9.5 in x 2.5 in (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

Ordering information

Model

9404FP: Condenser Air Ejector Discharge Fission Product Monitor (custom configuration required)

VICTOREEN
A Fluke Brand

6045 Cochran Road
Cleveland, OH 44139-3303 U.S.A.

For more information, please contact us at:

Phone: 440-542-3628
Email: Sales@Victoreen.com
Web access: www.victoreen.com