VICTOREEN
A Fluke Brand

Trusted radiation protection.

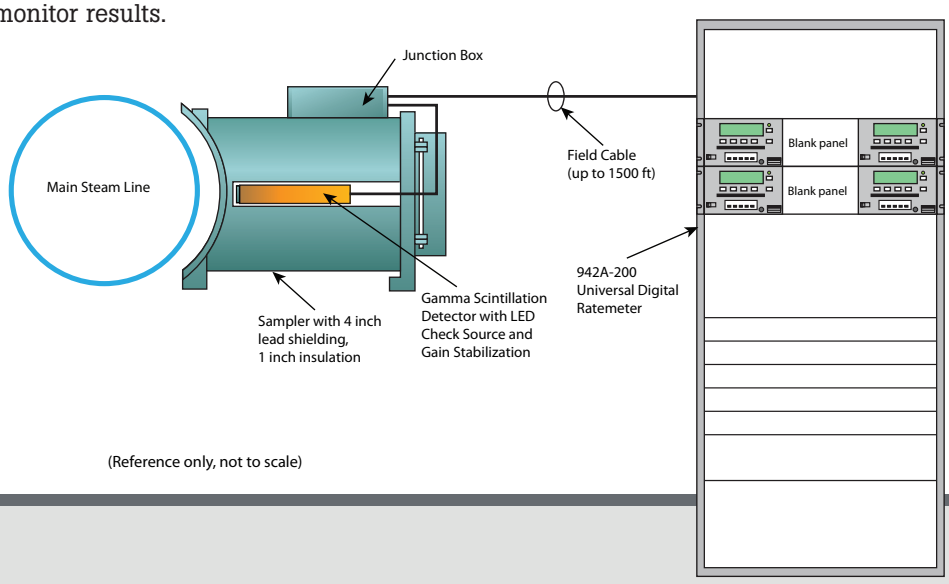
Technical Data

940-3N

Main Steam ^{16}N Monitor

Current regulatory requirements necessitate operating pressurized water reactors (PWRs) to monitor primary to secondary system leakage. This is normally accomplished by monitoring the main steam lines (MSL), condenser air ejector discharge (CAED) and steam generator blowdown (SGB) for fission and/or activation products. During normal reactor operation, the neutron activation of oxygen in the reactor coolant results in the production of significant amounts of the radioactive isotope Nitrogen-16 (^{16}N). The amount of ^{16}N produced is directly proportional to the reactor power level. In the event of primary to secondary system leakage, the ^{16}N will be present in the steam generator. The ^{16}N that migrates into the main steam lines prior to its decay will be detected by the 940-3N ^{16}N monitor. By applying the actual reactor power level and plant-unique primary and secondary system factors to the raw monitor output, the primary to secondary leak rate, in terms of gallons per day, may be calculated. The plant-unique parameters may be adjusted to agree with the actual leak rate determined by the plant chemistry personnel. Because the origin of the leak is unknown, and considering the short half-life of ^{16}N (7.13 seconds) and the complex hydraulic characteristics of the steam generator, monitor sensitivity is dramatically affected by leak location and monitor location. MSL, CAED and SGB monitors are available as backups to support ^{16}N monitor results.

The 940-3N monitor consists of a field-mounted detector shield, a gain-stabilized gamma scintillation detector and an electrical junction box for each steam line. A remote, control-room-located Universal Digital Ratemeter (UDR) provides the detector high voltage (automatically adjusts the high voltage for gain changes), provides DC operating voltages, processes the detector output, performs limit checks, generates analog output signals and displays the ^{16}N value for each



(Reference only, not to scale)

Key features

- 4 Pi lead shield with rear door
- Temperature compensated NaI (Tl) scintillation detector
- Integral preamplifier capable of driving 1,500 feet of cable
- Microprocessor controlled
- Seismically and environmentally qualified
- Detector anti-jam circuit
- Analog input processing
- Single channel analyzer
- Automatic high voltage control
- ^{16}N and/or fission product detection

detector. The UDR is provided with a single-channel analyzer, electrically adjusted to respond to the ^{16}N 6.13 MeV gamma photon. Where additional system features are required, the 960 Digital Process Radiation Controller may be supplied in lieu of the UDR.

Shield

An "adjacent to the line" or "on-line" shield assembly, with 4 inches of 4 pi virgin lead shielding is provided. This shielding reduces the induced background due to the potential for lower energy fission products in the steam line, increasing the monitor sensitivity and range. A hinged rear door simplifies detector installation and replacement. The shield also provides a convenient location to mount the detector junction box. The shield is designed to mount on a platform or pedestal, adjacent to the main steam line. Due to the penetrating power of the 6.13 MeV photon, the shield should be located to reduce interference resulting from other steam lines in the area. Where required, thermal insulation may be installed between the steam line and the shield to prevent thermal shock from damaging the detector crystal. The shield is designed to match the diameter of the main steam line, which affects the actual size and weight of the shield.

Detector

The 943-37LS Gamma Scintillation Detector utilizes a 2-inch-diameter by 2-inch-thick NaI (Tl) scintillation crystal coupled to a 2-inch-diameter photomultiplier tube. The detector includes a cable-driving preamplifier and provisions for an LED (light emitting diode) for gain stabilization. To maximize the integrity and life of the optical coupling, the crystal, light pipe and photomultiplier tube are provided as a sealed, integral assembly. The detector is provided with a 5-foot cable with an "MS" type connector for termination to an 844-211LS Junction Box. In addition to providing a method to interconnect the detector to the control room cable, the junction box includes a stable temperature reference and LED driving circuitry. Secondary standard solid source sets and a standard field calibration fixture are available for on-site recalibrations.

Universal digital ratemeter

The 942A UDR processes the detector output and displays the ^{16}N reading in units of counts per minute (CPM) or gallons per day (GPD). In operation, the detector output is monitored by the UDR located in the control room. To provide the required auxiliary functions, various optional modules are factory-installed. The 942-200-80 Serial Communication Port Module provides monitor status and historical data via a serial port for use by the plant computer or a laptop PC. The 942-200-75 Analog Input Module accepts a 4-20 mA input signal representing reactor power. The 942-200-90 Single Channel Analyzer/Americium Regulator Module is used to count the pulses that fall into a 4.5 to 7.5 MeV window, capturing the primary 6.13 MeV ^{16}N photopeak. To prevent changes in temperature or high voltage supply drift

The GPD calculation is a measurement of the radioactivity seen by the detector. The equation for instantaneous GPD is:

$$GPD = GC - (Ba \times Ka) \times (PA/PN) \times Kn$$

where:

GPD	gallons per day
GC	gross concentration, CPM x Ka
CPM	detector output, counts per minute
Ka	GPD to CPM conversion constant set point at normal power. Ka is the isotopic conversion constant for the detector/sampler geometry, and is defined as the inverse of the isotopic efficiency (i.e., 1/efficiency) stated on the sensitivity data sheet.
Ba	background subtract set point, in CPM
PN	normal power, 100 %
PA	actual reactor power (obtained as an analog input)
Kn	other operator or automatically entered constants or variables relating to the GPD calculation (i.e. steam flow, steam generator pressure, steam temperature, steam density, transit time, etc.)

from causing photomultiplier tube gain changes that could shift the detector output pulse out of the 6.13 MeV window, the 942-200-90 also contains a gain stabilization circuit to automatically adjust the detector high voltage. Approximately once every 10 minutes, the 942 UDR actuates the gain stabilization LED through a pulsar circuit located in the 844-211LS Junction Box. The LED output feeds back through the detector signal cable to the 942-200-90 Single Channel Analyzer/ Americium Regulator Module in the UDR. The detector output is compared to an internal reference in the 942-200-90 and the detector high voltage is adjusted as required to agree with the internal reference. If the reference signal cannot be matched within one minute, the detector FAIL alarm is turned on. The gain stabilization LED may also be actuated manually by pressing the UDR Front Panel Check Source pushbutton.

The advantage of this method of gain stabilization over the traditional ^{241}Americium gain stabilization method is that the background count rate that results from the ^{241}Americium is eliminated, providing a greater operating range. The firmware in the UDR allows for the entry of 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
- ^{16}N Delay Factor

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. An optional second UDR may be provided for monitoring fission products present in the main steam line. The detector output signal would be electrically connected to a second UDR, set to monitor fission products in the 80 keV to 2 MeV range. In this configuration, both fission products and ^{16}N in the main steam may be independently monitored using the same detector and shield.

Technical specifications

Shield and J-Box (typical, 36 in Ø steam line)

Dimensions *(h x w x d)*
16 in x 12 in x 26 in
(40.64 cm x 30.48 cm x 66.04 cm)

Weight
800 lb (363 kg) approx.

Detector

Crystal
NaI (Tl), 2 x 2 in

Preamplifier
Integral, 1,500 ft drive capability

Stabilization
Temperature Compensated LED

Efficiency
Approximately 1E7 CPM/µCi/cc, ^{16}N (pending primary isotopic calibration)

Sensitivity
Approximately 1E-6 to 1E-1 µCi/cc, ^{16}N (pending primary isotopic calibration)

Temperature
32 °F to 122 °F (0 °C to 50 °C)
(160 °F to 360 °F optionally available)

Dimensions
10.5 (l) in x 2.5 in Ø
(26.67 cm x 6.35 cm)

Weight
3 lb (1.36 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 10^7 CPM.

Alarm indicators
- HIGH (red LED)
- WARN (amber LED)
- FAIL (red LED)
- 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 @ 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 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

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 ± 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

940-3N: Main Steam ^{16}N Monitor

Standard accessories

844-211LS: Junction Box
942A: Universal Digital Ratemeter
942-200-80: Serial Communication Port Module
942-200-75: Analog Input Module
942-200-90: Single Channel Analyzer/Americium Regulator Module
943-37LS: Gamma Scintillation Detector

Optional accessories

948-1: Rack Chassis

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

5/2015 3029378c_en