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LESSONS LEARNED FROM A NUREG-0737 REVIEW OF HIGH-RANGE EFFLUENT MONITORS AND SAMPLERS

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ABSTRACT

Shortly after the onset of the accident on 3/28/79 at Unit 2 of the Three Mile Island Nuclear Power Station, the upper range capabilities of its real-time monitors for gaseous, radioiodine and particulate effluents to the atmosphere were exceeded. Subsequently, the NRC required extended range gaseous effluent monitors and an improved capability for the obtaining of frequent samples of radioiodines and particulates at the concentrations that would be anticipated in effluent streams under accident conditions (NUREG-0578, NUREG-0660, NUREG-0737, Items II.F.1-1 + II.F.1-2).

In 1983 an on-site post-implementation review of their installation and operation was initiated by the NRC Region I. The results from nineteen such reviews indicate that the licensees have adopted a variety of approaches to meet the NRC's requirements ranging from the installation of completely new commercial modules to improvised additions to existing monitors and samplers. Some advantages and drawbacks of these various approaches are summarized.

I. INTRODUCTION

As evident from a 1971 survey, concern for the adequacy of the installed effluent monitors at commercial nuclear power reactors preceded the accident at the Three Mile Island Nuclear Power Station (TMI) on March 28, 1979 by almost a decade.[1] Subsequently, criteria for extended range monitors for radiogases, radioiodines and radioparticulates were developed in a follow-up study by Battelle Northwest Laboratories.[2] In 1974 these criteria were incorporated in a proposed ANSI Standard,[3] which was finalized and published in 1978.[4]

In 1977, the U.S. Nuclear Regulatory Commission (NRC) issued Revision 1 to its Regulatory Guide 1.97 which incorporated the criteria of the ANSI standard by reference.[5] At that time, the NRC indicated its intention to implement the guide for all nuclear power plant applications then currently under review and at all operating reactors. The scope for the latter was to be determined by the NRC Staff on a case by case basis.

Only limited progress in this implementation, which had not extended to the TMI reactors, had been made at the time of the TMI accident in 1979. During it and shortly after major fuel cladding damage occurred (at about two hours after its onset), the concentrations of radiogases in the plant effluent stream exceeded the upper range of the installed gaseous effluent monitors.[6] The upper range capability of the installed radioparticulate and radioiodine monitors was also exceeded at about the same time, due to the background from the extraordinary concentration of radiogases. The subsequent retrieval of stack effluent particulate and radioiodine samples for analysis was impeded by the high radiation fields at the location where they were installed.

In its evaluation of this aspect at the accident, the TMI-2 Lessons Learned Task Force observed that at the time of the accident only 20% of the then operating plants had monitors that would have stayed on scale under the TMI accident conditions.[7] They also observed that potential releases from postulated accidents could be several orders of magnitude larger than encountered at TMI. The Task Force recommended the prompt adoption, in its entirety, of the then recently published ANSI Standard on emergency instrumentation, except that they adjudged that real-time monitors for large concentrations of particulates and radioiodines were not practical.

An action plan, incorporating these and other recommendations of the Task Force was subsequently adopted by the Commission in mid-1980.[8] Clarification of the plan, known as NUREG-0737, was provided later in that same year.[9] Its basic requirements with regard to noble gas effluent monitors are contained in its Section II.F.1., Attachment 1, from which Table I is excerpted. The requirements for the sampling and analysis of particulates and radioiodines in plant effluents are contained in Section II.F.1, Attachment 2, from which Table II is excerpted. An implementation date of January 1, 1982 was specified for both II.F.1-1 and II.F.1-2.

Responsibility for the post-implementation review of these selected NUREG-0737 items was assigned by the NRC Office of Inspection and Enforcement to the NRC's regional offices. In mid-1983, the NRC's Region I contracted with the Safety and Environmental Protection Division of Brookhaven National Laboratory for technical assistance in the performance of these reviews. Each has required the identification, acquisition and documentation of the licensee's commitments, clarifications, schedules and orders. A subsequent on-site inspection included physical verification and validation of the installation and operability of equipment, as well as verification of the adequency of the licensee's procedures and of the qualification and training of licensee's personnel.

At the present time, on-site reviews have been completed at the rate of about one per month for nineteen of the twenty licensee sites in Region I, which currently contains a total of twenty-five operating reactors. They are located in four of the New England states: New York, New Jersey, Pennsylvania and Maryland.

II. APPROACH

Before the on-site reviews commenced, the individual elements that should be included in the overall review effort were considered in a Management Oversight and Readiness Tree (MORT). A portion of it is shown in Figure 1.

Following this, a specific set of instructions and/or questions related to each review component was prepared. These included such sub-categories as design, monitoring system, procedures, structures, hardware and support services, readout and recording, personnel and training. An example for the monitoring system is shown in Table III.

III. FINDINGS

A summary of the installed high-range noble gas monitors, according to their location (on-line or off-line), type of detector, and vendor is shown in Table IV. It is evident that the Region I licensees have chosen a variety of approaches to comply with the requirements of Item II.F.1-1. The typical Boiling Water Reactor (BWR) contained either one monitored release point under accident conditions, the unit vent, or a second monitored release point for the standby gas treatment system as shown in Figure 2 (for the Shoreham Nuclear Power Station). The Pressurized Water Reactors (PWR) were more variable from one monitored unit vent and a main steam line monitor found at Millstone 2, to the three monitored vents and steam relief monitor at the Beaver Valley Station, as shown in Figure 3.

Two licensees installed on-line monitors, using ion chambers in or immediately adjacent to stacks or ducts, while seventeen installed off-line monitors. Of the latter, five installed "gas only" high-range monitors as additions to their pre-existing low-range monitors. A schematic of such a monitor which utilizes an ion chamber, is shown in Figure 4. Twelve licensees installed commercially available integrated monitors with modules for both monitoring and sampling. A block diagram of one (the General Atomics WRGM) is shown in Figure 5 and a view of another (the Kaman KDGM-HR) in Figure 6.

These installations have also incorporated a variety of approaches to the problem of achieving the required full-range sensitivity. Typically, three overlapping-range detectors have been provided, as shown in Figure 7 (for the General Atomics WRGM). In order to achieve the upper limit of 10^5 uCi/cm^3 (^{133}Xe equivalent), most of these monitors are designed so that that a limited volume of gas is viewed by their high-range detectors, compared to that viewed by their mid- or low-range detectors. An example, for the enhanced high-range detector of the Kaman HRH, is shown in Figure 8.

Although Item II.F.1-1 was not specific on calibration of noble gas monitors up to the required upper range, the NRC has provided some guidance.[10] It recognized the problem of the availability of suitable noble gases, i.e. ^{133}Xe, at sufficient concentrations and of their utilization by licensees if they were available. Therefore, the Staff recommended that a one-time "type" calibration in the laboratory over the intended range be performed and that the transfer procedure of ANSI N323-1978 be utilized in conjunction with solid sources at appropriate energies for on-site calibrations.

As suggested by Table V, most of the vendors appear to have performed only a "one point" primary calibration, utilizing ^{133}Xe and ^{85}Kr. They have then performed a number of transfer calibrations with solid sources with a range of activities and energies, such as ^{109}Cd (0.088MeV), ^{139}Ce (0.165 Mev), ^{51}Cr (0.320 MeV), ^{137}Cs (0.662 Mev) and ^{60}Co (1.17 and 1.33 Mev) to establish the energy response and/or range capability of a given detector.

A summary of the sampling arrangements which have been provided to achieve compliance with Item II.F.1-2 and which have been reviewed to date is shown in Table VI. Again, a variety of approaches is evident. Some licensees (including the five who have utilized "gas only" monitors to comply with Item II.F.1-1) installed independent sampling facilities. One licensee wrote emergency sampling procedures which incorporated pre-existing unshielded routine samplers. Five added additional shielded particulate and iodine sample positions which were connected to an existing low-range sample line, while one added a pre-fabricated multiple sample-position module.

Eleven licensees have installed integrated monitor/samplers which contain micro-processor modules that provide for the automatic or remote collection of a sample at one of three individual sample positions, as also shown in Figure 7. Another licensee located its integrated unit in what would be a high-radiation field during post-accident conditions, so elected to create another more remote sampling station. These integrated monitor samplers typically provide for a much reduced flow of a few hundred cm^3/min, as compared to the customary 1-2 cfm provided for low- and mid-range sampling. This is done in order to limit the total amount of activity that would be collected at concentrations which approach the upper design criterion of 100 uCi/cm^3 for the stipulated 30-minute sampling period.

IV. LESSONS LEARNED

A. HIGH-RANGE NOBLE GAS MONITORS

Oversimplifications in the methods for the conversion of the direct indications of the installed gas monitor, typically in cpm or mR/hr, to effluent concentrations and/or rates of release were among the principal shortcomings encountered in the reviews.

As indicated in Table I, the guidance in NUREG-0737, II.F.1-1 states "Design range values may be expressed in ^{133}Xe equivalent values for monitors employing gamma radiation detectors" (as most do). This concept has not been generally understood or employed by vendors or by the reviewed licensees. In some instances, they have employed uninterpreted actual calibration data for ^{133}Xe or ^{85}Kr to establish detector response, without a recognition of their limitations. The former emits low energy photons, with a mean energy of 0.045 MeV per disintegration. Thus, they may be significantly absorbed in the housing or walls of a detector. In contrast, ^{85}Kr is principally a beta emitter, with accompanying bremstrahlung gamma radiations and a 0.51 MeV photon with a yield of only 0.4%. This is apparent from Figure 9, which illustrates the direct response with distance of Eberline's high-range detector to each of these nuclides. When corrected respectively for absorption and bremstrahlung, the true response of this detector is about midway between the two curves, so using one point from either would lead to a factor of two error. An even greater difference in energy response which is presumably related to the same cause, is shown in Figure 10, which is a calculated response for a Victoreen-847 ion chamber installed adjacent to a duct at the TMI-1 Station.

Beyond this, these uninterpreted calibration data have also been employed to calculate release rates (in uCi/sec), without regard to the variable energy response characteristic of the detector on which they are based and in the geometries in which they were installed. This response characteristic may be close to linear with energy, as shown in Figure 11, for the Kaman KDGM-HR, or may be quite non-linear as shown in Figure 12, for the General Atomics WRGM.

All of the reviewed licensees had installed monitors which in principle met the upper range criterion of 10^5 uCi/cm^3 (see Table 1). However, only two had calibrated the installed high-range monitors on-site at concentrations approaching 10^5 uCi/cm^3. The vendor calibration information supplied by Kaman, as shown in Figure 13, suggested that a test with actual radiogases approaching these concentrations had been performed with ^{133}Xe. However, on the basis of field testing which employed ^{85}Kr it is questionable that this monitor can in fact meet the specified upper range.[11] A similar fall-off at high concentrations was reported by a consultant to a Region I licensee in a field calibration of the high-range detector (SA-9) of the Eberline SPING.

Some licensees recognized the variable energy response of high-range monitors by the provision of corrections in their software for making off-site dose assessments. However, this does not provide guidance for a reactor operator or supervisor who may have to make manual calculations of effluent release rates before skilled post-accident dose assessors are likely to be available.

As indicated in Table V, three licensees selected the Eberline SPING-4 as a high-range monitor for effluent noble gasses. During the reviews, it was ascertained that the micro-processor of this monitor is not radiation hardened, making it doubtful that it would operate reliably in high-radiation fields. However, in one case the monitor was supplemented by the Eberline SA-10 and SA-9 mid- or high-range detectors, for which the sensitive components were remotely located. When the SPING-4 component of this unit senses high-radiation fields, it is isolated from the sample stream, thus increasing its reliability of function throughout an accident sequence.

In several instances, licensees with installed micro-processer controlled high-range gas monitors were found to have a limited number of plant personnel with sufficient training to be able to retrieve data beyond that routinely displayed. Although this ability is not a requirement, these data could be informative in the event of an accident. The review also revealed that several of these monitors had experienced frequent and/or extended down time of their automatic features, apparently due to the failure of their flow sensors.

Except for those with integrated units which function automatically, provision and/or procedures had not been incorporated by licensees for the isolation and/or purging of their low-level gas monitors, should their range be exceeded. Thus their recovery and availablity would be doubtful following an accident as effluent concentrations declined to within the low-range region.

B. SAMPLING AND ANALYSIS OF PLANT EFFLUENTS

The principal deficiency encountered in the review of arrangements for the sampling of radioiodines and particulates was the inability of licensees to document that their sampling systems could collect representative samples. This is particularly so for those with long sampling lines, in which considerable deposition losses of elemental radioiodines could occur even when they were installed in accordance with the design guidance of ANSI N13.1-1969.

The transmission of elemental iodines through long sampling lines has been measured under controlled conditions in the laboratory by Unrein et al.[12] Their studies suggest that it depends upon the relative rates of deposition and resuspension from their walls. Transmission factors greater than 50% were found for 1" sampling lines at flow rates of 2-3 cfm, for injection periods of several hours. However, these studies did not indicate how long it took to reach equilibrim between deposition and resuspension after an initial injection. Only a small fraction (<1%) of the injected elemental iodine was transmitted through the 1/4" sampling line with a 0.06 cfm flow rate as utilized in the General Atomics WRGM, which is shown schematically in Figure 15.

The NRC's proposed guidance suggests that the closest approximation to representativeness may be achieved at equilibrium, when deposition and re-entrainment or re-suspension are equal. This could be expected to occur most rapidly in a continuously operated system, rather than one in which flow is initiated only upon the occurrence of higher-range concentrations. The Kaman and the Eberline AXM-1 monitors approximate this in that, upon an indication of abnormal gas concentrations, they isokinetically obtain a small local side-stream flow (of a few hundred cm^3/min) from the low-range monitoring/sampling line, in which a much greater flow (1-2 cfm) is maintained.

From the reviews, it has been apparent that most architect/engineers and licensees have been aware of the need for the heat tracing of sampling lines when they are exposed to "outdoor" conditions. However, it was apparent that many of them have not recognized a similar need for the heat tracing of long indoor horizontal sampling lines in which condensation could occur, especially under the high moisture loads of some accident sequences. In a few reviews condensation was found in the sampling medium of sampling positions.

Although IIF.1-2 calls for continuous sampling, the procedures of four licensees called only for the analysis of a grab sample to be collected post-accident over a short period of time (to limit the amount collected to the capability of their laboratory Ge-Li analysis systems), with no indication in their procedures of how they would evaluate the preceding sample to establish the total amount released from the onset of accident conditions.

In six instances, which included the three SPING-4s, the two SAI RAGEMS and one licensee devised installation, the filter assembly for the collection of particulates and iodines was unshielded. None had conducted an analysis to assure that with such an arrangement, the samples could be collected, retained and transported within the GDC-19 dose limits (5 rem whole body and 75 rem to the extremities). It should be noted that by two successive 1/200 dilutions, the RACEMS should collect only relatively low activity samples under all accident conditions.

All of the licensees had Ag-Zeolite collection media available for sampling under accident conditions. Almost all of the installations provided for isokinetic sampling at normal stack flow rates but only a few could maintain it if large deviations from these flows were to occur under accident conditions. Of those that could not, none had developed correction factors, as called for in Item II.F.1-2.

Only a few licensees had developed adequate procedures for the analysis of "hot" samples, in which the collected activity might considerably exceed the upper limit which could be analyzed by their GeLi counting and analysis systems. Although several had established procedures for counting samples with greater than normal activity in a geometry distant from the detector, only a few would be able to cope with an 85-170 Ci sample of radioiodines collected at a concentration of 100 uCi/cm^3 at flow rates of 1-2 cfm for the stipulated 30-minute sampling period.

VI. COMMENTS AND RECOMMENDATIONS

A wide variety of approaches to the monitoring of noble gasses and the sampling of particulates and radioiodines in high concentrations have been encountered in the nineteen reviews which have been conducted over the past two years.

If the monitoring requirements were solely those for the noble gasses, ion chambers would seem the most straightforward detectors, in view of their simplicity, wide range capability, and linear energy response characteristics. However, they are relatively insensitive and therefore require a large volume of contained gas which is difficult to shield from extraneous radiations, as illustrated by Figure 15. The 0.1"-thick steel wall in which this detector is located has a large absorption for low energy photons, such as those from ^{133}Xe, compared to a much smaller absorption of the higher energy photons from shorter-lived noble gases.

The integrated monitoring/sampling devices which incorporate microprocessor data handling and control accomplish the full range requirements of Item II.F-1.1 by routing the flow to more then one detector, each of which is designed to be sensitive to portions of the full range requirement. This permits the isolation of the low-range detector during periods of high concentrations. It also facilitates the routing of flow to a selected shielded filter assembly at the same time. Their ability to store and to provide a history of release rates over time makes them attractive for both routine and accident monitoring. Additionally, the use of a monitor for every-day purposes adds to its reliability for accident monitoring. If not so utilized, they require regular surveillance and maintenance to assure their availability.

To minimize the ambient post-accident radiation fields, most of the post-accident monitors and/or samples are located at considerable distances from the points of effluent release, thus necessitating long sampling lines (typically 1" x 100-250'). This creates a dilemma between the desirability of maintaining a high flow rate in the sample line so as to minimize deposition losses and the desirability of minizing the amount of collected radioactivity on the sampler. It is solved in some monitors, by the provision of a second stage of isokinetic sampling with a probe situated within the high-flow line close to the sampling head, but with a much smaller flow (a few hundred cm^3/min) through the high-concentration sampler. This seems desirable on the grounds of both convenience in handling and analysis and of ALARA considerations.

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REFERENCES

1. Selby, J.M. and Unruh, C.M., "Technological Consideration in Emergency Instrumentation Preparedness: Phase I - Current Capabilities Survey", BNWL-1552 (Jan. 1971).

2. Selby, J.M. et al, "Technological Considerations in Emergency Instrumentation Preparedness: Phase II-A - Emergency Radiological and Meteorological Instrumentation Criteria for Reactors", BNWL-1635 (May 1972).

3. Wrenn, M.E. (Chair), "Proposed ANSI Standard: Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation", Final Draft ANSI 413/42 WG6 (Aug. 1974).

4. ANSI, "Performance Specification for Reactor Emergency Radiological Monitoring Instrumentation", ANSI N-320-1978 (Dec 1978).

5. USNRC, "Instrumentation for Light-Water Cooled Nuclear Power Plants to Assess Plant Conditions During and Following an Accident", Reg. Guide 1.97, Rev.1, (Aug 1977).

6. USNRC, "Investigation into the March 28, 1979 Three Mile Accident by the Office of Inspection and Enforcement", NUREG-0600 (July 1979).

7. USNRC, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations", NUREG-0578 (July 1979).

8. USNRC, "NRC Action Plan Developed as a Result of the TMI-2 Accident", NUREG-0660 (May 1980).

9. USNRC, "Clarification of TMI Action Plan Requirements", NUREG-0737 (Oct. 1980).

10. D.G. Eisenhut, "Proposed Guidance for Calibration and Surveillence Requirements for Equipment Provided to Meet Item II.F.1 Attachments 1, 2, and 3, NUREG-0737" Memorandum to Regional Administrators (Aug. 16, 1982).

11. D. McClure, "Accident Range Monitor Response", HPS Newsletter, 18:6 pg. 7 (1985).

12. P.J. Unrein et al, "Transmission of Radioiodines Through Sampling Lines", Proceedings of the 18th DOE Nuclear Airborne Waste Management and Air Cleaning Conference, CONF-840806, Vol. 1, p. 98-114 (1985).

TABLE I

HIGH-RANGE NOBLE GAS EFFLUENT MONITORS

REQUIREMENT	Capability to detect and measure concentrations of noble gas fission products in plant gaseous effluents during and following an accident. All potential accident release paths shall be monitored.
PURPOSE	To provide the plant operator and emergency planning agencies with information on plant releases of noble gases during and following an accident.

DESIGN BASIS MAXIMUM RANGE

Design range values may be expressed in Xe-133 equivalent values for monitors employing gamma radiation detectors or in microcuries per cubic centimeter of air at standard temperature and pressure (STP) for monitors employing beta radiation detectors (Note: 1R/hr @1 ft = 6.7 Ci Xe-133 equivalent for point source). Calibrations with a higher energy source are acceptable. The decay of radionuclide noble gases after an accident (i.e., the distribution of noble gases changes) should be taken into account.

10^5 uCi/cc	Undiluted containment exhaust gases (e.g., PWR reactor building purge, BWR drywell purge through the standby gas treatment system). Undiluted PWR condenser air removal system exhaust.
10^4 uCi/cc	Diluted containment exhaust gases (e.g., > 10:1 dilution, as with auxiliary building exhaust air). BWR reactor building (secondary containment) exhaust air. PWR secondary containment exhaust air.
10^3 uCi/cc	Buildings with systems containing primary coolant or primary coolant offgases (e.g., PWR auxiliary buildings, BWR turbine buildings). PWR steam safety valve discharge, atmospheric steam dump valve discharge.
10^2 uCi/cc	Other release points (e.g., radwaste buildings, fuel handling/storage buildings).

TABLE I (continued)

DESIGN CONSIDERATIONS

Off-line monitoring is acceptable for all ranges of noble gas concentrations.

In-line (induct) sensors are acceptable for 10^2 uCi/cc to 10^5 uCi/cc noble gases. For less than 10^2 uCi/cc, off-line monitoring is recommended.

Upsteam filtration (prefiltering to remove radioactive iodines and particulates) is not required; however, design should consider all alternatives with respect to capability to monitor effluents following an accident.

For external mounted monitors (e.g., PWR main steam line), the thickness of the pipe should be taken into account in accounting for low-energy gamma detection.

REDUNDANCY Not required; monitoring the final release point of several discharge inputs is acceptable.

SPECIFICATIONS

(None) Sampling design criteria per ANSI N13.1.

POWER SUPPLY

Vital instrument bus or dependable backup power supply to normal ac.

CALIBRATION

Calibrate monitors using gamma detectors to Xe-133 equivalent (1 R/hr @ 1 Ft = 6.7 Ci Xe-133 equivalent for point source). Calibrate monitors using beta detectors to Sr-90 or similar long-lived beta isotope of at least 0.2 MeV.

DISPLAY Continuous and recording as equivalent Xe-133 concentrations of uCi/cc of actual noble gases.

QUALIFICATION

The instruments shall provide sufficiently accurate responses to perform the intended function in the environment to which they will be exposed during accidents.

From Ref 9

TABLE II

SAMPLING AND ANALYSIS OR MEASUREMENT OF HIGH-RANGE RADIOIODINE AND PARTICULATE EFFLUENTS IN GASEOUS STREAMS

EQUIPMENT Capability to collect and analyze or measure representative samples of radioactive iodines and particulates in plant gaseous effluents druing and following an accident. The capability to sample and analyze for radioiodine and particulate effluents is not required for PWR secondary main stream safety valve and dump valve discharge lines.

PURPOSE To determine quantitative release of radioiodines and particulates for dose calculation and assessment.

DESIGN BASIS SHIELDING ENVELOPE

10^2 uCi/cc of gaseous radioiodine and particulates, deposited on sampling media; 30 minutes sampling time, average gamma energy (E) of 0.5 MeV.

SAMPLING MEDIA

Iodine > 90% effective absorption for all forms of gaseous iodine.

Particulates > 90% effective retention for .3 micron diameter particles.

SAMPLING CONSIDERATIONS

Representative sampling per ANSI N13.1-1969.

Entrained moisture in effluent stream should not degrade adsorber.

Continuous collection required whenever exhaust flow occurs.

Provisions for limiting occupational dose to personnel incorporated in sampling systems, in sample handling and transport, and in analysis of samples.

ANALYSIS Design of analytical facilities and preparation of analytical procedures shall consider the design basis sample.

Highly radioactive samples may not be compatible with generally accepted analytical procedures; in such cases, measurements of emissive gamma radiations and the use of shielding and distance factors should be considered in design.

TABLE III

EXAMPLE OF REVIEW GUIDE FOR HIGH-RANGE NOBLE GAS EFFLUENT MONITORS (II.F.1-1)

Monitoring System

A. Are monitors located at all effluent pathways and do they meet the following range requirements?

- containment exhaust, undiluted, 10^{-6} to 10^{5} uCi/cc?

- condenser air removal system exhaust, undiluted, 10^{-6} to 10^{5} uCi/cc?

- auxiliary building and others with systems to contining primary coolant or primary collant offgases, 10^{-6} to 10^{3} uCi/cc?

- steam safety valve discharge*, 10^{-6} to 10^{3} uCi/cc?

- atmospheric steam dump valve discharge*, 10^{-6} to 10^{3} uCi/cc?

* Main steam line monitors located upstream of the valves are acceptable, if considerations have been given to account for low energy gammas.

- radwaste building exhaust, 10^{-6} to 10^{2} uCi/cc?

- fuel handling/storage exhaust, 10^{-6} to 10^{2} uCi/cc?

B. Do the ranges of instruments overlap to cover the entire range of effluent from normal (ALARA) through accident conditions?

C. Are the detectors acceptable?

D. Does the sampling system design conform to ANSI N13.1?

E. Is offline monitoring used for detecting less than 10^{2} uCi/cc? (In-line monitoring is acceptable for 10^{2} uCi/cc to 10^{5} uCi/cc)?

F. Can the system detect and measure compositions of noble gases ranging from fresh to 1-day old with an overall system accuracy of less than 2?

TABLE III (continued)

Verify:

1. that noble gas effluent monitors with an upper range capacity of to 10^5 uCi/cc (Xe-133) are installed,
2. that the range extends from normal conditions (ALARA) to 10^5 uCi/cc (Xe-133),
3. that the system provides continous capability during and following an accident,
4. that a design description of the system identifying the specifications in accordance with Table II.F.1-1 is available,
5. that procedures and calculational methods are established,
6. that instrument ranges will overlap to cover the entire range of effluents, from normal thru accident conditions.

TABLE IV

SUMMARY OF INSTALLED MID- AND HIGH-RANGE NOBLE GAS MONITORS

No.	Range	Detector	Vendor	Model	Operating Mode	Data Processor	Background Subtraction
On-Line							
2	Mid/High	Ion Chamber	(1) GA (1) Victoreen	RD-2A 847	Continuous	No	No
Off-Line							
Gas Only							
1	Mid/High	Plastic	NMC	GA-270	High Alarm	No	No
1	Mid High	GM Ion Chamber	Victoreen Victoreen	847	Continuous	No	No
3	Mid/High	Ion Chamber	Victoreen	847	Continuous	No	No
Integrated Gas Monitors and Particulate-Iodine Samplers							
5	Mid High	Cd-Te Cd-Te	GA	WRCM	High Alarm	Yes	No
3	Mid High	GM GM	Eberline	SPING-4	Continuous	Yes	Yes
2	Mid High	GM GM	Kaman	KGM-HRH	High Alarm	Yes	No
1	Mid/High	Ge-Li	SAI	RAGEMS	Continuous	Yes	NA
1	Mid High	GM GM	Eberline	AXM-1	High Alarm	Yes	Yes

TABLE V

CONCENTRATIONS FOR VENDOR CALIBRATIONS OF II F.1-1 HIGH RANGE MONITORS

	^{133}Xe Concentrations uCi/cm^3	^{85}Kr Concentrations uCi/cm^3
Eberline		
Mid-Range SPING NGD-1 (SA-13)	0.13	0.47
High-Range SPING AXM-1(SA-14)	0.26	1.47
SA-15, SA-9	1.75	9.98
General Atomics		
Mid/High Range-WRCM	0.65	11.1*
Kaman		
High-Range-HRH	$5x10^4$	

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*Based on calibration data supplied by vendor, as inferred for NBS Reference Date.

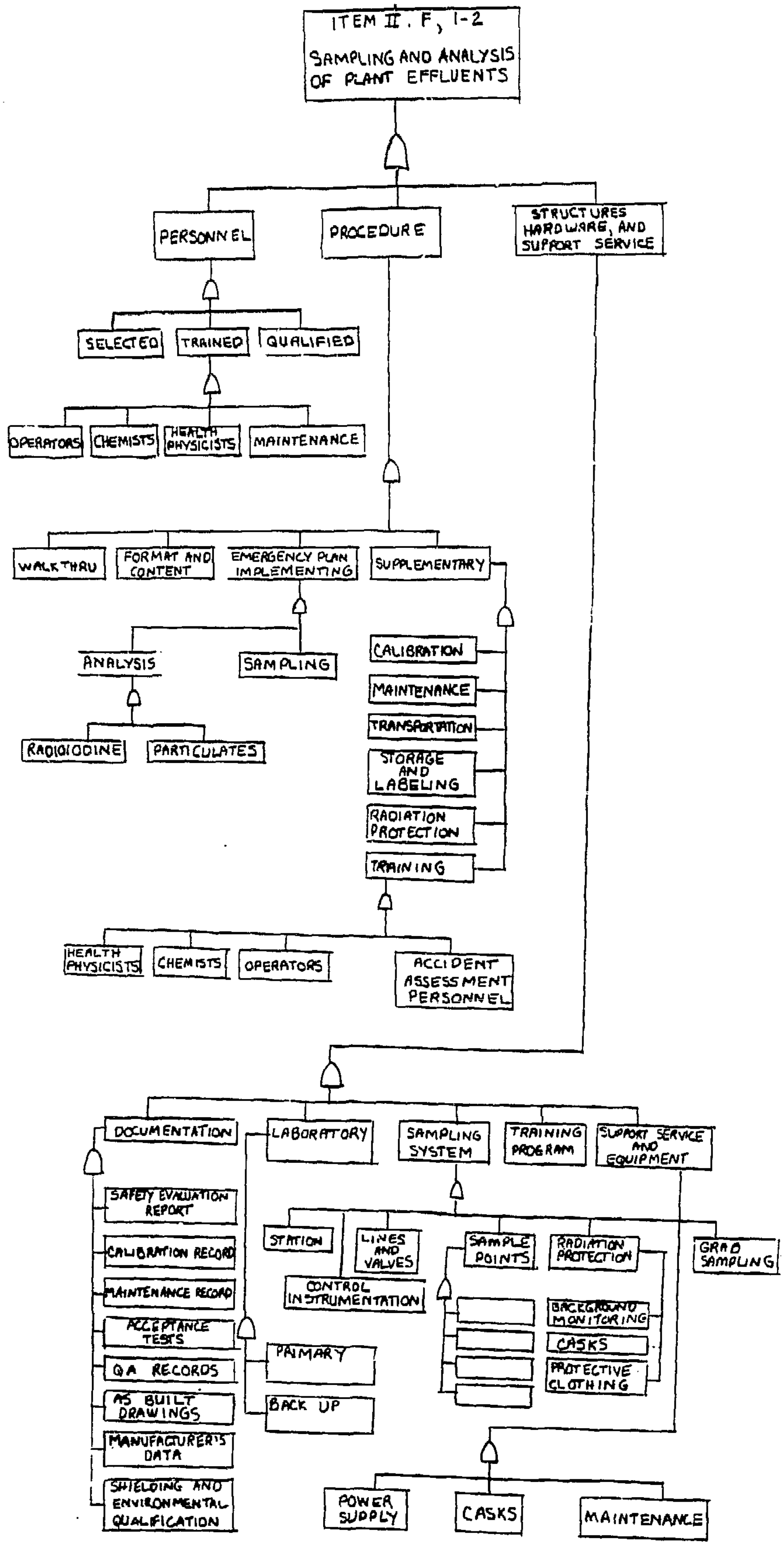
TABLE VI

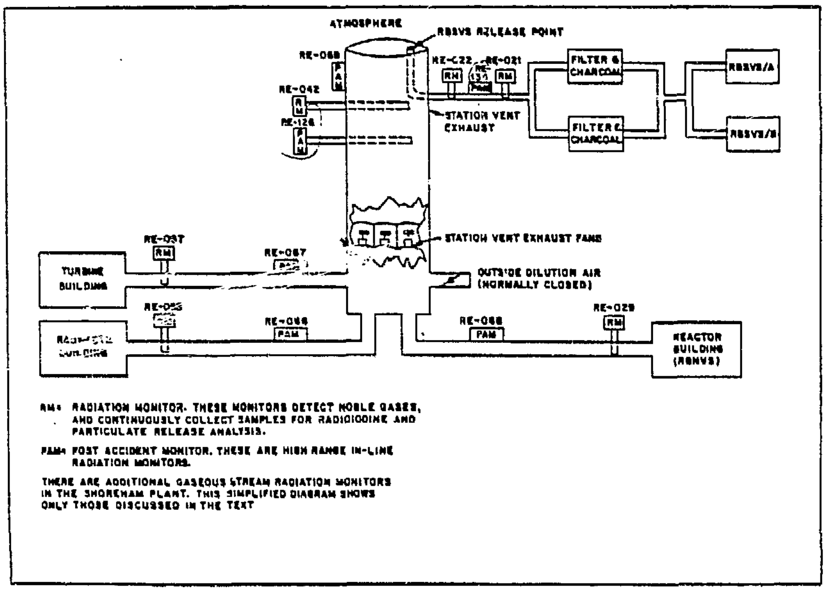
SAMPLING AND ANALYSIS OF PLANT EFFLUENTS, II.F.1-2

No.	Range	Vendor	Model	Sample Positions	Shielded	Filter Selection	Remarks
Independent Utility Design							
5	-	-	-	1	Yes		(In each instance)
Vendor Design							
1	-	NRC Ind.	MAP-5	3	Yes	Local/remote control	Timed sample
1	-	Kaman	HRH	1	Yes		
Integrated Units							
4	Mid/High	GA	WRGM	3	Yes	Local/remote control	Timed sample
3	Mid/High	Eberline	SPING-4	1	No	Fixed	
2	Mid/High	Kaman	KGM-HRH	3	Yes	Automatic (GM Monitor)	Automatically timed sample
3	All	SAI	RAGEMS	1*	Yes	Automatic	
1	Mid/High	Eberline	AXM-1	1	Yes	Fixed (GM Monitor)	

*The remaining licensee to be reviewed has installed this system

Figure 1


ITEM II. F, 1-2
SAMPLING AND ANALYSIS OF PLANT EFFLUENTS
PERSONNEL
PROCEDURE
STRUCTURES HARDWARE, AND SUPPORT SERVICE
SELECTED
TRAINED
QUALIFIED
OPERATORS
CHEMISTS
HEALTH PHYSICISTS
MAINTENANCE
WALKTHRU
FORMAT AND CONTENT
EMERGENCY PLAN IMPLEMENTING
SUPPLEMENTARY
ANALYSIS
SAMPLING
RADIOIODINE
PARTICULATES
CALIBRATION
MAINTENANCE
TRANSPORTATION
STORAGE AND LABELING
RADIATION PROTECTION
TRAINING
HEALTH PHYSICISTS
CHEMISTS
OPERATORS
ACCIDENT ASSESSMENT PERSONNEL
DOCUMENTATION
LABORATORY
SAMPLING SYSTEM
TRAINING PROGRAM
SUPPORT SERVICE AND EQUIPMENT
SAFETY EVALUATION REPORT
CALIBRATION RECORD
MAINTENANCE RECORD
ACCEPTANCE TESTS
QA RECORDS
AS BUILT DRAWINGS
MANUFACTURER'S DATA
SHIELDING AND ENVIRONMENTAL QUALIFICATION
PRIMARY
BACK UP
STATION
LINES AND VALVES
CONTROL INSTRUMENTATION
SAMPLE POINTS
RADIATION PROTECTION
GRAB SAMPLING
BACKGROUND MONITORING
CASKS
PROTECTIVE CLOTHING
POWER SUPPLY
CASKS
MAINTENANCE



RM= RADIATION MONITOR. THESE MONITORS DETECT NOBLE GASES, AND CONTINUOUSLY COLLECT SAMPLES FOR RADIOIODINE AND PARTICULATE RELEASE ANALYSIS.

PAM= POST ACCIDENT MONITOR. THESE ARE HIGH RANGE IN-LINE RADIATION MONITORS.

THERE ARE ADDITIONAL GASEOUS STREAM RADIATION MONITORS IN THE SHOREHAM PLANT. THIS SIMPLIFIED DIAGRAM SHOWS ONLY THOSE DISCUSSED IN THE TEXT

Figure 2. Gaseous effluent radiation monitors.

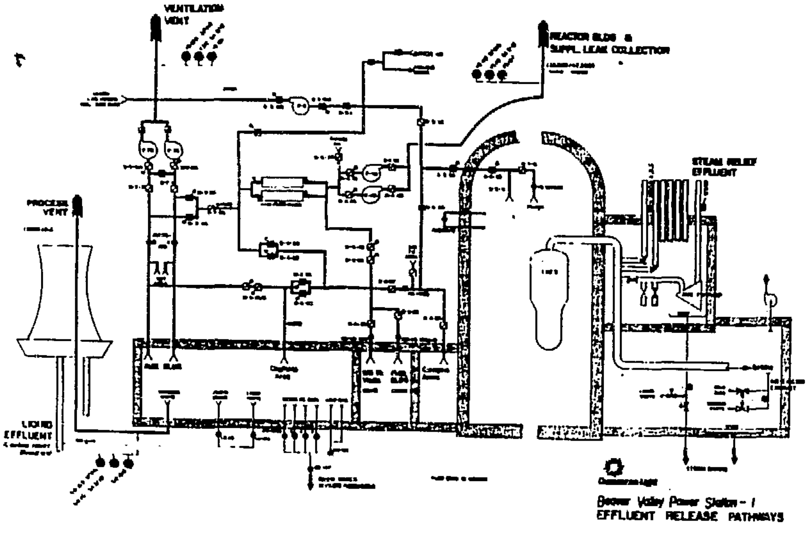


Figure 3. Effluent release pathways.

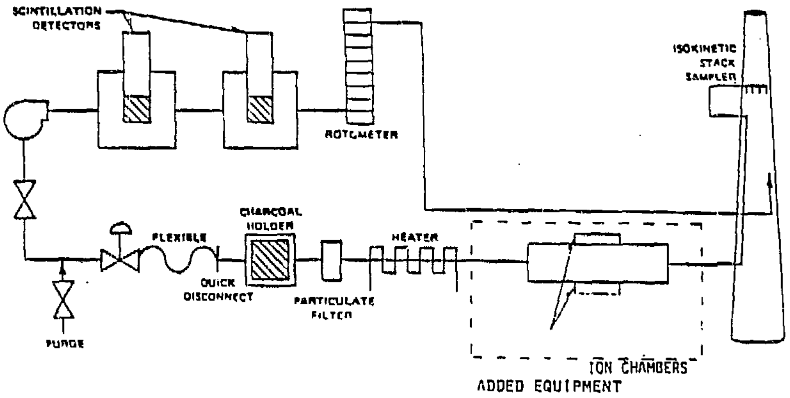
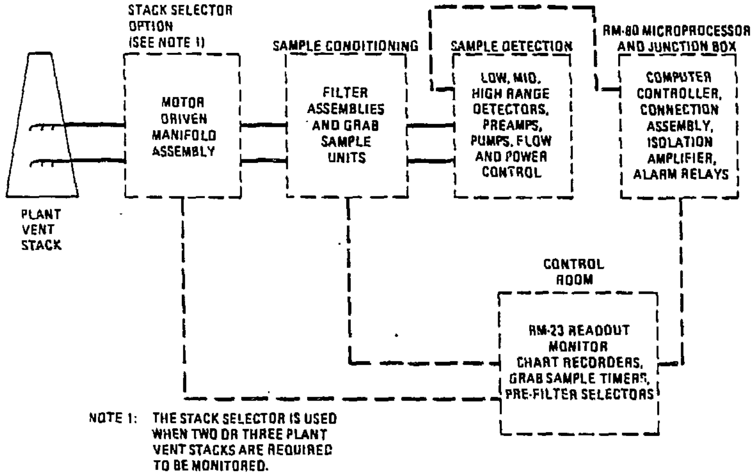
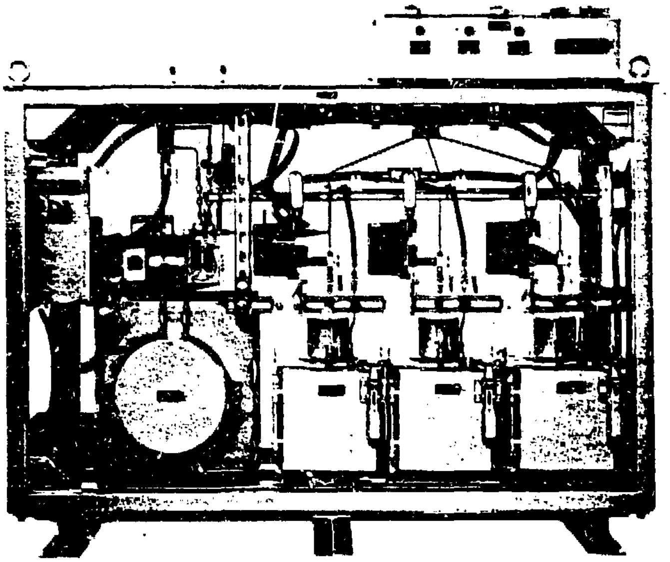


Figure 4. High-range effluent process radiation monitors.



NOTE 1: THE STACK SELECTOR IS USED WHEN TWO OR THREE PLANT VENT STACKS ARE REQUIRED TO BE MONITORED.

Figure 5. Wide-range gas monitor system block diagram.



HIGH RANGE

Figure 6. Kaman HRH high-range noble gas monitor and sampler.

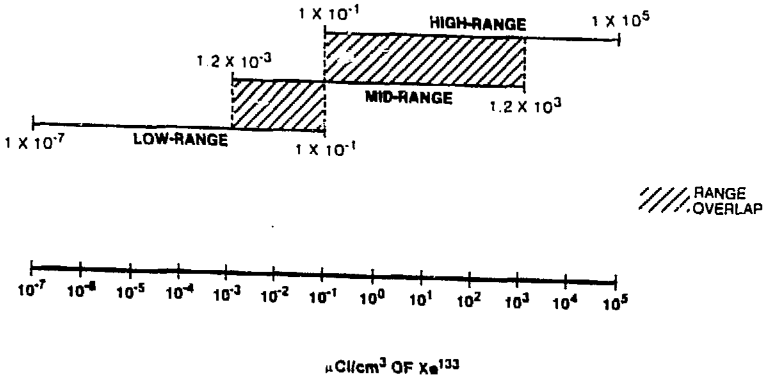


Figure 7. Ranges of General Atomics wide-range gas monitor.

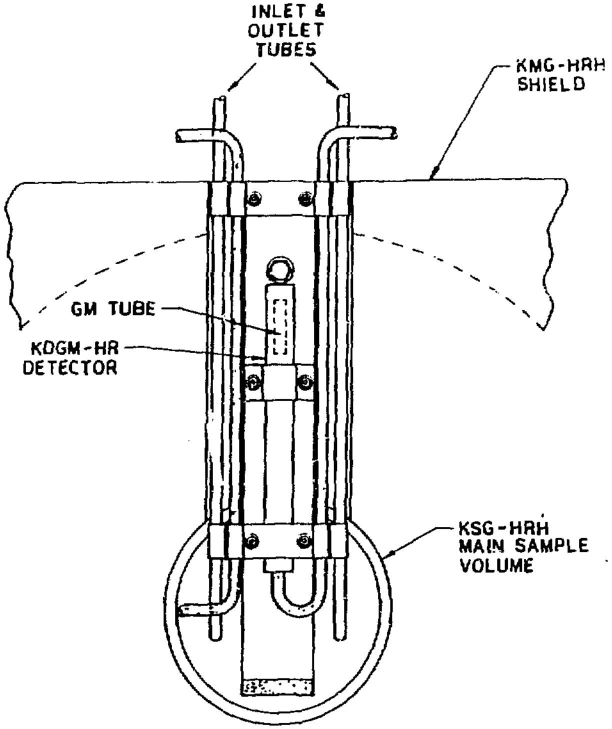


Figure 8. KMG-HRH-Enhanced high-range geometry.

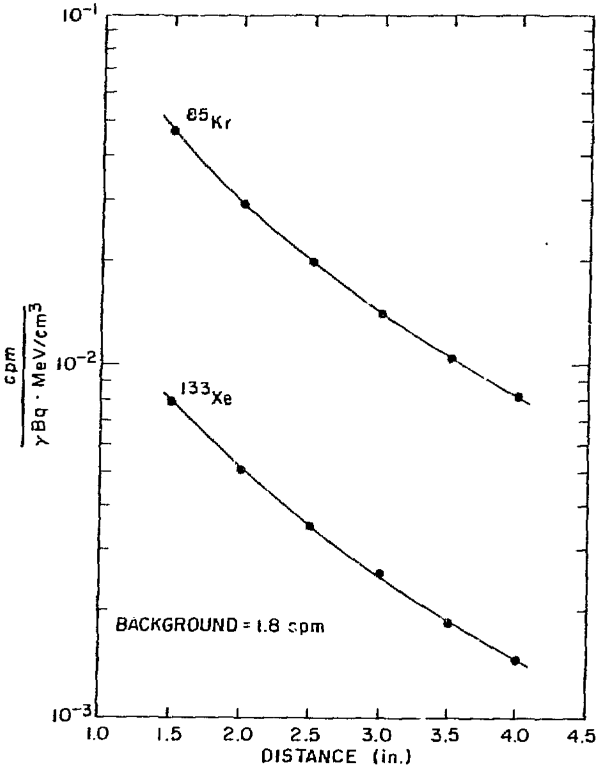


Figure 9. Response of Eberline SA-9 high-range detector to ^{85}Kr and ^{133}Xe.

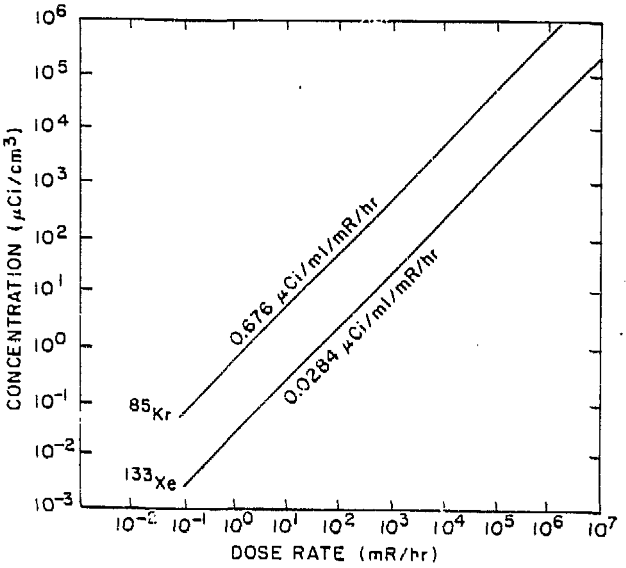


Figure 10. Measured response of a Victoreen Ion Chamber (847-1) installed outboard of a 5" duct and exposed to ^{85}Kr and ^{133}Xe.

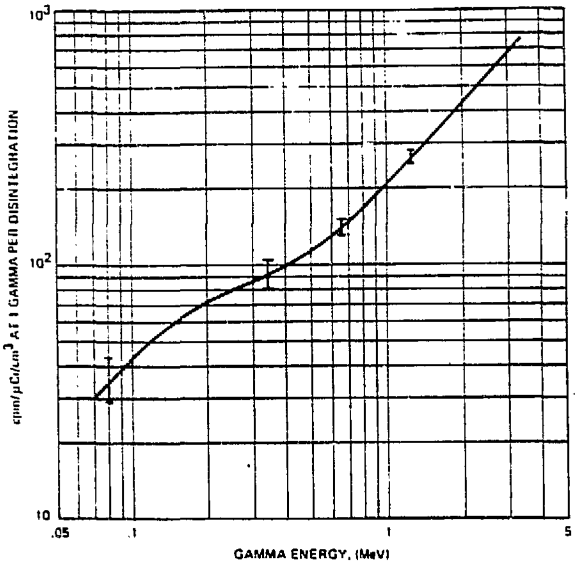


Figure 11. KDGM-HR enhanced detector in KSG-HRH sampler, enhanced high-range position energy dependence characteristic.

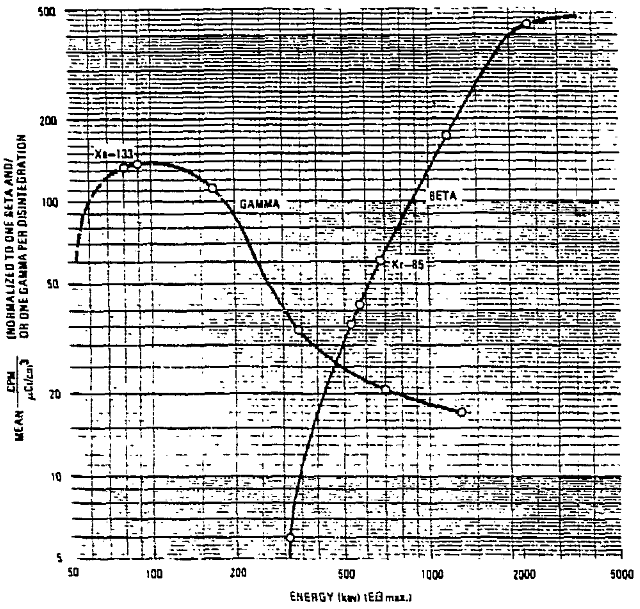


Figure 12. General Atomics wide-range gas monitor RD-72 high-range detector energy response curve.

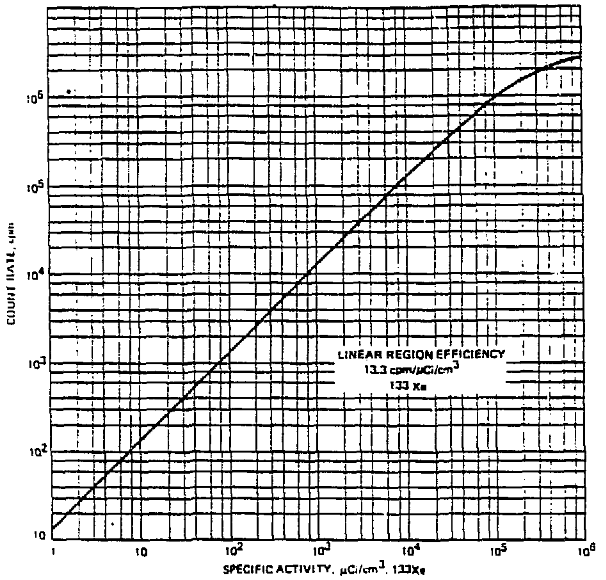


Figure 13. HDGM-HR Enhanced detector in KSG-HRH enhanced high-range position efficiency to Xenon-133.

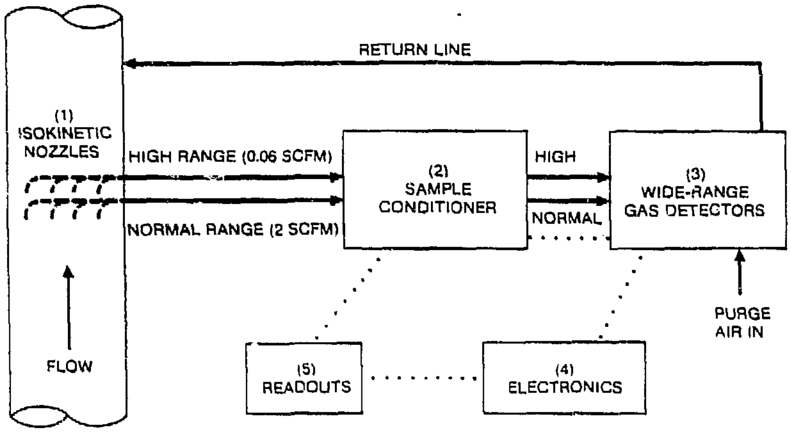


Figure 14. Block diagram, wide-range gas monitor.

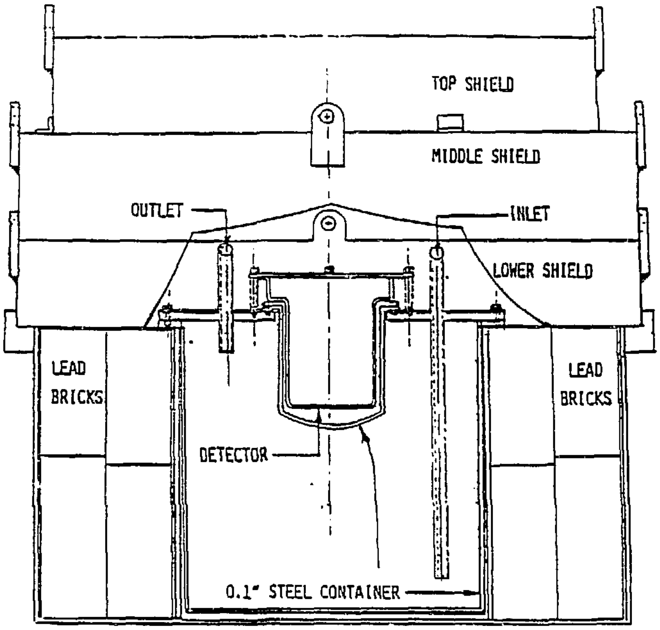


FIgure 15. High-range noble gas monitor.