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Technical Basis for the Use of Alarming Personal Criticality Detectors to Augment Permanent Nuclear Incident Monitor (NIM) Systems in Areas Not Normally Occupied

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Abstract

The technical basis for the use of alarming personal criticality detectors (APCDs) to augment permanent Nuclear Incident Monitor (NIM) Systems in areas not normally occupied is evaluated. All applicable DOE O 420.1A and ANSI/ANS-8.3-1997 criticality alarm system requirements and recommendations are evaluated for applicability to APCDs. Based on this evaluation, design criteria and administrative requirements are presented for APCDs. Siemens EPD/Mk-2 and EPD-N devices are shown to meet the design criteria. A definition of not normally occupied is also presented.

1.0 Introduction

Criticality Accident Alarm Systems (CAAS), designated Nuclear Incident Monitors (NIM) at Savannah River Site, are used to alert personnel in affected areas (12 rad zone) to a criticality accident so that appropriate protective measures can be taken to limit their exposure to radiation. In accordance with DOE O 420.1A[1], which is incorporated into the WSRC S/RID, permanent NIM installations are used to provide coverage for site areas that are within the 12 rad zone of potential criticality accident locations.

DOE O 420.1A also mandates the use of ANSI/ANS-8.3-1997. Criticality Accident Alarm System,[2] which is also incorporated into the WSRC S/RID. ANSI/ANS-8.3-1997, para. 4.4.2 states:

> ***Portable instruments may be used in special situations to augment an installed criticality accident alarm system. Examples of such situations include alarm system maintenance or testing, evacuation drills, activities in areas not normally occupied by personnel, or other special operations. Where portable instruments are used to meet the intent of this standard, the usage shall be evaluated to determine appropriate criteria of this standard. Criteria for use of portable instruments shall be specified in procedures.***

This report specifically deals with augmentation of permanent NIM systems by the use of portable instruments in areas not normally occupied by personnel. That is, in areas defined as "not normally occupied", a portable instrument could be used instead of expanding the permanent NIM system into the area not normally occupied. A **G**roup to **R**ecommend **A**lternatives to **N**IM **D**etectors (GRAND) was formed in early 2003 to examine this specific form of NIM system augmentation. Members included:

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Other situations given as examples in ANSI/ANS-8.3-1997, para. 4.4.2, were not examined by the group and are not dealt with in this report.

The purpose of this document is:

- to establish the technical basis and minimum requirements for Alarming Personal Criticality Detectors (APCD) to be defined as "portable instruments" (as used in ANSI/ANS-8.3-1997) to augment permanent NIM installations in facility areas not normally occupied;
- to define the term "not normally occupied";
- to provide specific APCD design criteria and document how specific APCDs meet the criteria;
- to provide administrative requirements for APCD usage in WSRC facilities;

Subsequent sections of the report deal with each of the aforementioned items.

2.0 Technical Basis & Minimum DOE O 420.1A and ANSI/ANS-8.3-1997 Requirements for APCDs Defined as Portable Instruments

DOE O 420.1A and ANSI/ANS-8.3-1997 requirements were reviewed for applicability for the use of APCDs as portable instruments as used in ANSI/ANS-8.3-1997, para. 4.4.2. Based on the review, compliance with all applicable requirements for portable criticality accident alarm systems is demonstrated. The review results are used in Section 4.0 of this report to establish APCD design criteria and to document how Siemens EPD/MK2 and EPD-N devices meet the criteria. The review results are also used in Section 5.0 to establish administrative requirements for APCD usage as portable instruments in areas not normally occupied in SRS Facilities.

Criticality accident alarm system requirements contained within DOE O 420.1A and ANSI/ANS-8.3-1997 are compiled in Table 1 and reviewed for their applicability to the use of APCDs as portable instruments. The first column of Table 1, labeled “Source”, identifies the source document of each requirement. Column 2, labeled “Section”, shows the section of the source document in which each requirement is located. Column 3 labeled “Requirement/Recommendation” contains each definition, requirement (shall), recommendation (should), and permission statement (may) from DOE O 420.1A and ANSI/ANS-8.3-1997 that is applicable to a criticality accident alarm systems in general. Each definition, requirement, recommendation and permission statement is reviewed in column 4 labeled “APCD Requirement Applicability” for applicability to APCD usage as portable instruments. Columns 5 and 6, labeled “D” and “Ad” respectively, designates specific definitions, requirements, recommendations or permission statements as **D**esign or **Ad**ministrative requirements for APCDs used as portable instruments in areas not normally occupied. Column 7 contains the appropriate design criterion or administrative requirement statement as it pertains to APCDs.

Table 1. Requirements and APCD Applicability

Source	Section	Requirement / Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	1	Where a criticality accident may lead to an excessive radiation dose, it is important to provide a means of alerting personnel and a procedure for their prompt evacuation, or other protective actions to limit their exposure.	This statement is an introduction to discuss the purpose of the standard. While applicable, it does not contain specific requirements for the use of APCD as portable instruments in areas not normally occupied by personnel.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	2, part 1	This standard is applicable to all operations involving fissionable materials in which inadvertent criticality can occur and cause personnel to receive unacceptable exposure to radiation.	This is a general scope statement and is applicable to APCDs used to augment NIMs in areas not normally occupied. While applicable, it does not contain specific requirements.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	2, part 2	This standard is not applicable to detection of criticality events where no excessive exposure to personnel is credible, nor to nuclear reactors or critical experiments. This standard does not include details of administrative actions or of emergency response actions that occur after alarm activation.	This statement discusses the general scope of the standard, is applicable to facilities in which APCDs are used to augment NIMs in areas not normally occupied, but does not contain any requirements. An explicit definition for "excessive exposure" is not provided, therefore it is presumed that "excessive exposure" and "excessive radiation dose" are equivalent (i.e., 12 rad in free air).	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	3.2, part 1	The word "**shall**" is used to denote a requirement, the word "**should**" is used to denote a recommendation, and the word "**may**" to denote permission, neither a requirement nor a recommendation.	This statement discusses the general scope of the standard, is applicable to APCDs used to augment NIMs in areas not normally occupied, but does not contain any requirements. Each "shall", "should", and "may" annotations are provided in this table and examined for their applicability and influence on the use of APCDs to augment NIMs.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	3.2, part 2	To conform with this standard, all operations shall be performed in accordance with its requirements but not necessarily its recommendations.	This statement discusses the general scope of the standard, is applicable to APCDs, but does not contain any requirements. Each "shall", "should", and "may" annotations are provided in this table and examined for their applicability on the use of APCDs to augment NIMs.	N/A	N/A	N/A
DOE O 420.1A	4.3.3.c	All recommendations in the ANSI/ANS standards (ANSI/ANS-8.3) **shall** be addressed. When recommendations are not implemented, justification **shall** be documented in a manner described in the Implementation Plan.	This requirement is applicable to APCDs used to augment NIMs. Recommendations are either implemented or justification is provided in this document. Each specific recommendation associated with ANSI/ANS-8.3-1997 is individually addressed in this document.	N/A	N/A	N/A

Source	Section	Requirement / Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	3.3, part 1	Definition: **criticality accident** The release of energy as a result of accidental production of a self-sustaining or divergent neutron chain reaction.	This definition is applicable to APCDs used to augment NIMs, but does not contain specific requirements.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	3.3, part 2	Definition: **excessive radiation dose** Any dose to personnel corresponding to an absorbed dose from neutrons and gamma rays equal to or greater than 0.12 Gy (12 rad) in free air.	This definition is applicable to APCDs used to augment NIMs, but does not contain specific requirements. The 12 rad boundary is determined for a postulated criticality accident corresponding to the maximum fission yield. This boundary is not determined by this document.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	3.3, part 3	Definition: **minimum accident of concern** The smallest accident, in terms of fission yield and dose rate, that a criticality alarm system is required to detect.	This definition is applicable to APCDs used to augment NIMs in areas not normally occupied, but only in a limited sense. The minimum accident of concern in terms of fission yield and translated into a constant dose rate is important to fixed NIM detectors that cover a large area. However, APCDs are worn on the individual and are only required to cover the individual. By setting the APCD cumulative dose alarm only high enough above background to prevent false alarms, it will (by definition) detect what amounts to a minimum accident of concern.	N/A	Ad	The APCD cumulative dose alarm shall be set high enough to avoid false alarms while retaining the capability to detect unsafe doses to workers
ANSI/ANS-8.3 (1997)	4.1.1	Installation of an alarm system implies a nontrivial risk of criticality. Where alarm systems are installed, emergency procedures **shall** be maintained.	This requirement is applicable to installed NIM systems and indirectly to APCDs. Since APCDs are only used to augment installed NIM systems in areas not normally occupied, emergency procedures will be maintained because of the regular installed NIM system	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	4.1.2	Process equipment used in areas from which immediate evacuation is required **should** be so designed that leaving the equipment will not introduce significant risk.	This recommendation was reviewed during the 5480.24 compliance assessment performed in 1993. No process equipment was identified at that time that would result in significant risk if left unattended due to immediate facility evacuation, and no new equipment has been introduced since that time that would change the 1993 assessment; hence this requirement is not applicable to APCDs.	N/A	N/A	N/A

Source	Section	Requirement / Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
DOE O 420.1A	4.3.3.c	ANSI/ANS-8.3-1986, paragraph 4.1.2, the second sentence of which becomes for this Order, "Where alarm systems are installed, emergency plans **shall** be maintained."	This requirement was addressed in ANSI/ANS-8.3-1997, Section 4.1.1, above.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	4.1.3, part 1	The purpose of an alarm system is to reduce risk to personnel.	This "purpose" statement is applicable to APCDs, but does not contain specific requirements.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	4.1.3, part 2	Evaluation of the overall risk **should** recognize that hazards may result from false alarms and subsequent sudden interruption of operations and relocation of personnel.	This recommendation is applicable to APCDs used to augment NIM systems in areas not normally occupied. The APCD alarm setpoints for dose and dose rate must be established in a manner that minimizes false alarms. The APCD itself must also resist other causes of false alarms such as radio frequency or electrostatic interference.	N/A	Ad	The APCD alarm setpoints should be set sufficiently above background to minimize false alarms.
				D	N/A	APCD should resist radio frequency or electrostatic interference.
ANSI/ANS-8.3 (1997)	4.2.1, part 1	The need for criticality alarm systems **shall** be evaluated for all activities in which the inventory of fissionable materials in individual unrelated areas exceeds 700 g of U-235, 500 g of U-233, 450 g of Pu-239, or 450 g of any combination of these three isotopes.	The mass values cited in paragraph 4.2.1 of ANSI/ANS-8.3-1997 are treated under DOE O 420.1A with additional specifications. Refer to the requirements of Section 4.3.3.e of DOE O 420.1A, below. If a criticality accident alarm system is needed, an APCD may be used in areas not normally occupied to augment the regular NIM system.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	4.2.1, part 2	For operations involving significant quantities of other fissionable isotopes, this evaluation **shall** be made whenever quantities exceed the subcritical mass limits specified in American National Standard Nuclear Criticality Control of Special Actinide Elements, ANSI/ANS-8.15-1981 (R1995).	The mass values cited in paragraph 4.2.1 of ANSI/ANS-8.3-1997 are applicable under DOE O 420.1A with additional specifications. If a criticality accident alarm system is needed, an APCD may be used in areas not normally occupied to augment the regular NIM system.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	4.2.1, part 3	Also, this evaluation **shall** be made for all processes in which neutron moderators or reflectors more effective than water are present, or unique material configurations exist such that critical mass requirements may be less than the typical subcritical mass limits noted above.	Paragraph 4.2.1 of ANSI/ANS-8.3-1997 is applicable under DOE O 420.1A with additional specifications. If a criticality accident alarm system is needed because moderators more effective than water are in use, an APCD may be used in areas not normally occupied to augment the regular NIM system.	N/A	N/A	N/A

Source	Section	Requirement / Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	4.2.1, part 4	For this evaluation, individual areas **may** be considered unrelated when the boundaries between the areas are such that there can be no uncontrolled transfer of materials between areas, the minimum separation between material in adjacent areas is 10 cm, and the areal density of fissile material averaged over each individual area is less than 50 g/m^2. This stipulation is applicable only to the three specific isotopes noted above (U-235, U-233 and Pu-239).	Paragraph 4.2.1 part 4 of ANSI/ANS-8.3-1997 is applicable under DOE O 420.1A with additional specifications. Refer to the requirements of Section 4.3.3.e of DOE O 420.1A, below. If a criticality accident alarm system is needed, an APCD may be used in areas not normally occupied to augment the regular NIM system.	N/A	N/A	N/A
DOE O 420.1A	4.3.3.e	The requirements in ANSI/ANS-8.3-1986 relating to the needs for an alarm system (paragraphs 4.2.1 and 4.2.2), **are not applicable** to this Order. For the purpose of this Order, Criticality Accident Alarm Systems (CAS) and Criticality Detection Systems (CDS) **shall** be required as follows: In what follows, 10^{-6} per year is used as a measure of credibility, and does not mean that probabilistic risk assessment (PRA) has to be performed. Reasonable grounds for incredibility **may be presented** on the basis of commonly accepted engineering judgment.	This DOE O 420.1A requirement is applicable to APCDs used to augment NIMs in areas not normally occupied, but no specific requirements for APCDs are required.	N/A	N/A	N/A

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
DOE O 420.1A	4.3.3.e (1)	In those facilities where the mass of fissionable material exceeds the limits established in paragraph 4.2.1 of ANSI/ANS-8.3 and the probability of a criticality accident is greater than 10^{-6} per year (as documented in a DOE-approved Safety Analysis Report (SAR) or in the supporting analysis for an SAR), a CAS [Criticality Alarm System] conforming to ANSI/ANS-8.3 **shall** be provided to cover occupied areas in which the expected dose exceeds 12 rads in free air, where a CAS is defined to include a criticality accident detection device and a personnel evacuation alarm.	This DOE O 420.1A requirement is applicable to APCDs used to augment NIMs in areas not normally occupied, but no specific requirements for APCDs are required. APCDs used to augment NIM systems in areas not normally occupied conform to ANSI/ANS-8.3-1997.	N/A	N/A	N/A
DOE O 420.1A	4.3.3.e (2)	In those facilities where the mass of fissionable material exceeds the limits established in paragraph 4.2.1 of ANSI/ANS-8.3 and the probability of criticality accident is greater than 10^{-6} per year (as documented in a DOE-approved Safety Analysis Report (SAR) or in the supporting analysis for an SAR), but there are no occupied areas in which the expected dose exceeds 12 rads in free air, a CDS [Criticality Detection System] **shall** be provided, where a CDS is defined to be an appropriate criticality accident detection device but without an immediate evacuation alarm. The CDS response time should be sufficient to allow for appropriate process-related mitigation and recovery actions. DOE Elements shall ensure that appropriate response guidance to minimize personnel exposure shall be provided by the contractor.	This DOE O 420.1A requirement is not applicable to APCDs used to augment NIMs in areas not normally occupied. Thus, the APCD functions as an alarm system, not a CDS.	N/A	N/A	N/A

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
DOE O 420.1A	4.3.3.e (3)	In those facilities where the mass of fissionable material exceeds the limits established in paragraph 4.2.1 of ANSI/ANS-8.3, but a criticality accident is determined to be impossible due to the physical form of the fissionable material, or the probability of occurrence is determined to be less than 10^{-6} per year (as documented in a DOE-approved Safety Analysis Report (SAR) or in the supporting analysis for an SAR, or in other appropriate documentation), neither a CAS nor a CDS is required. Neither a CAS nor a CDS is required for fissionable material during shipment when packaged in approved shipping containers, or when packaged in approved shipping containers awaiting transport provided that no other operation involving fissionable material not so packaged is permitted on the shipping dock or in the shipment area.	This DOE O 420.1A statement is not applicable to APCDs. If a NIM system is not necessary, APCD use is not necessary.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	4.2.2, part 1	A criticality alarm system meeting the requirements of this standard **shall** be installed in areas where personnel would be subject to an excessive radiation dose.	Paragraph 4.2.2 of ANSI/ANS-8.3-1997 is not applicable under DOE O 420.1A. Refer to the requirements of Section 4.3.3.e of DOE O 420.1A instead.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	4.2.2, part 2	For this purpose, the maximum fission yield integrated over the duration of the accident **may** be assumed not to exceed 2.0×10^{19} fissions. The basis for a different maximum fission yield **shall** be documented.	Paragraph 4.2.2 of ANSI/ANS-8.3-1997 is not applicable under DOE O 420.1A. However, this permission and requirement statement provides a reasonable basis for evaluating the need for a NIM, and hence APCDs used to augment NIMs. There are no specific requirements relative to APCDs. Determination of the maximum fission yield and corresponding 12 rad boundary defines the area where personnel may be subject to an excessive radiation dose.	N/A	N/A	N/A

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	4.2.2, part 3	If criticality accidents of lesser magnitude than the minimum accident of concern given in 5.6 (ANSI/ANS-8.3-1997) are of concern, then other detection methods (e.g., audible personnel dosimetry) **should** be considered. These other detection methods are not considered as criticality accident alarm systems and are not covered by this standard.	Paragraph 4.2.2 of ANSI/ANS-8.3-1997 is not applicable under DOE O 420.1A. APCDs will function as alarm systems. As explained in ANSI/ANS-8.3-1997, para. 3.3, part 3, above, the cumulative dose alarm will be set low enough to detect what amounts to the minimum accident of concern to workers.	N/A	N/A	N/A
DOE O 420.1A	4.3.3.e (4)	If a criticality accident is possible wherein a slow (i.e. quasistatic) increase in reactivity could occur leading from subcriticality to supercriticality to self-shutdown without setting off emplaced criticality alarms, then a CAS might not be adequate for protection against the consequences of such an accident.	This DOE O 420.1A statement is applicable to APCD usage in areas not normally occupied, if an APCD is used in an area subject to a slow criticality event. A slow criticality accident would lead to higher than expected dose over time in an area not normally occupied. APCD must be capable of alarming on total dose.	D	N/A	The APCD must be capable of alarming on total dose.
DOE O 420.1A	4.3.3.e (4) (continued)	To aid in protecting workers against the consequences of slow criticality accidents in facilities where analysis has shown that slow criticality accidents are credible, CASs **should** be supplemented by warning devices such as audible personnel dosimeters (e.g. pocket chirpers/flashers, or their equivalents), area radiation monitors, area dosimeters, or integrating CASs. If these devices are used solely as criticality warning devices in accordance with this Section, the calibration provisions required for personal protection do not apply (10CFR835, 401(b)).	This DOE O 420.1A recommendation is applicable to APCDs in areas not normally occupied since APCDs are used as alarm systems. However, an APCD will alarm on cumulative dose (as well as dose rate); therefore it meets the requirement. Since an APCD will be used as an alarm device (i.e., just like a NIM) and not as a warning device, the statement regarding calibration is not applicable.	D		The APCD must be capable of alarming on total dose.
					Ad	Normal Radcon calibration procedures applicable to electronic personal dosimeters will be applied to APCDs.

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	4.3.1, part 1	Criticality alarm signals **shall** be for prompt evacuation or other protective actions.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. APCDs provide a local alarm signal to the wearer. Upon APCD alarm, prompt evacuation will be required.	D	N/A	APCDs shall provide a signal to the individual carrying the instrument that is recognizable as one that requires prompt evacuation.
				N/A	Ad	Facilities/projects utilizing APCDs shall have an approved training program/procedure on APCD use.
				N/A	Ad	Personnel wearing APCDs shall be trained in their use and in evacuation.
				N/A	Ad	If protective actions in addition to evacuation are necessary, they also shall be specified in training.
ANSI/ANS-8.3 (1997)	4.3.1, part 2	The criticality alarm signals **should** be uniform throughout the system.	This recommendation is applicable to APCDs used to augment NIM systems in areas not normally occupied. However, by design, the APCDs provide a local audio signal to the wearer different than installed NIM units. Personnel training on the APCD alarm sound must be provided.	D	N/A	APCDs shall provide a signal to the individual carrying the instrument that is recognizable as a criticality alarm requiring prompt evacuation.
				N/A	Ad	Personnel wearing APCDs shall be trained in their use.

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	4.3.1, part 3	The signals **shal**l be distinctive from other signals or alarms that require a response different from that necessary in the event of a criticality accident.	This requirement is applicable to APCDs used to augment NIMs. APCDs provide a local alarm signal to the wearer that is distinctive from non-NIM signals that may be present in the work area.	D	N/A	APCDs shall provide a signal to the individual carrying the instrument that is recognizable as criticality alarm requiring prompt evacuation.
				N/A	Ad	Personnel wearing APCDs shall be trained in their use.
				N/A	Ad	Personnel shall be capable of distinguishing the APCD alarm from other alarms.
ANSI/ANS-8.3 (1997)	4.3.2	The signal generators **shall** be automatically and promptly actuated upon detection of a criticality accident.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. Tests shall confirm that APCDs alarm promptly in dose rate and cumulative dose modes.	D	N/A	APCDs shall be tested to alarm promptly and automatically to a simulated criticality accident
ANSI/ANS-8.3 (1997)	4.3.3, part 1	After actuation, the signal generators **shall** continue to function as required by emergency procedures, even if the radiation falls below the alarm point.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied, but only in a limited sense. The continuous alarm signal generation function is for regular NIMs to alert personnel in the area of the alarm signal and to help preclude inadvertent entry of personnel into a building shortly after the onset of an accident. By maintaining the alarm condition, all personnel (by training and evacuation procedures) are kept at a safe distance until the source of the alarm is confirmed. APCDs are local units worn only by personnel in areas not normally occupied. Therefore, the APCD must alarm long enough to clearly alert the user of the alarm condition. Upon APCD alarm, personnel will be trained to immediately evacuate the area not normally occupied and then contact the appropriate control room. The control room can then order any other emergency actions	D	N/A	APCDs shall provide a signal to the individual carrying the instrument that is sufficiently long to get their attention
				N/A	Ad	Personnel wearing APCDs shall be trained in their use, including the need and method to contact the appropriate control room after evacuation.
				N/A	Ad	All individuals entering an area not normally occupied shall be equipped with an APCD. If only one person enters such area, that person shall be equipped with two APCDs

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	4.3.3, part 2	Manual resets, with limited access, **should** be provided outside areas that require evacuation.	This recommendation is not applicable to APCD, but is for the remote re-setting of fixed instruments.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	4.3.4	A means for manual activation of the alarm **may** be provided.	This permission statement is not applicable to APCDs, but is for fixed instrument testing purposes.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	4.3.5	For all occupied areas where personnel protective action is required in the event of criticality accident detection, the number and placement of criticality alarm signal generators **shall** be such that the signals are adequate to notify personnel promptly throughout those areas.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. When APCDs are used to augment NIMs in areas not normally occupied, each individual within the required coverage area will be required to wear an APCD. Additionally, APCD users will be required and trained to contact the appropriate control room after evacuation. The control room can then notify all necessary personnel.	N/A	Ad	All individuals entering an area not normally occupied shall be equipped with an APCD. If only one person enters such area, that person shall be equipped with two APCDs
				N/A	Ad	APCD users shall contact the appropriate control room after evacuation so that the event is logged and other emergency actions taken as necessary.
ANSI/ANS-8.3 (1997)	4.3.6	The audio generators **should** produce an overall sound pressure level of at least 75 dB, but not less than 10 dB above the maximum ambient noise level typical of each area for which audio coverage is to be provided.	This recommendation is applicable to APCDs in a limited sense. APCDs are worn by individuals, Therefore, general area sound pressure levels are not applicable. The APCD audio alarm must be loud enough to be heard by the person wearing the APCD.	D	N/A	The APCD audio alarm shall be loud enough to be heard by the individual wearing the device.

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	4.3.7	Because excessive noise levels can be injurious to personnel, the audio generators **should** not produce an A-weighted sound level in excess of 115 dB at the ear of an individual.	This recommendation is applicable to APCDs in the sense that the audio alarm should not cause hearing damage.	D	N/A	APCD audio generator sound level should not be loud enough to cause hearing damage.
ANSI/ANS-8.3 (1997)	4.3.8	In areas with very high audio background or mandatory hearing protection, visual signals or other alarm means **should** be considered.	This recommendation is applicable to APCDs used to augment NIMs in area not normally occupied. If APCDs are used in areas of such high background noise that the alarm cannot adequately be heard, they should be equipped with an earpiece or vibration alarm.	N/A	Ad	When using APCDs in high noise areas, they should be equipped with earpieces or vibration alarms.
				D	N/A	APCDs should include the ability to use earpieces or provide vibrations alarms.
ANSI/ANS-8.3 (1997)	4.4.1, part 1	Consideration **shall** be given to the avoidance of false alarms. This **may** be accomplished by providing reliable single detector channels or by requiring concurrent response of two or more detectors to initiate the alarm.	This requirement is applicable to APCDs used to augment NIMS in areas not normally occupied. Alarm setpoints shall be chosen to minimize false alarms. If APCDs include pre-alarms, they should be disabled.	N/A	Ad	The APCD alarm setpoint should be set sufficiently above background to minimize false alarms.
				N/A	Ad	APCD pre-alarms, if provided, should be disabled.
ANSI/ANS-8.3 (1997)	4.4.1, part 2	In redundant systems, failure of any single channel **shall** not prevent compliance with the detection criterion specified in 5.6.	This requirement is applicable to APCDs used to augment NIMs, but only in a limited sense. APCDs are not redundant systems; however, the intent of the standard is met by requiring a minimum of 2 APCDs in any area not normally occupied.	N/A	Ad	All individuals entering an area not normally occupied shall be equipped with an APCD. If only one person enters such area, that person shall be equipped with two APCDs
ANSI/ANS-8.3 (1997)	4.4.2, part 1	Portable instruments **may** be used in special situations to augment an installed criticality accident alarm system. Examples of such situations include alarm system maintenance or testing, evacuation drills, activities in areas not normally occupied by personnel, or other special operations.	This permission allows the use of APCDs for special situations and is applicable to APCDs. This document provides the technical basis to allow APCDs to specifically augment NIMs in areas not normally occupied.	N/A	Ad	Documentation (this report) will be prepared to justify the use of APCDs to augment NIMs in areas not normally occupied.
ANSI/ANS-8.3 (1997)	4.4.2, part 2	Where portable instruments are used to meet the intent of this standard, the usage **shall** be evaluated to determine appropriate criteria of this standard.	This requirement allows the use of APCDs for specific situations. This document provides the technical basis for using APCDs to augment NIMs in areas not normally occupied and identifies the criteria appropriate for such use.	N/A	Ad	Documentation (this report) will be prepared to justify the use of APCDs to augment NIMs in areas not normally occupied.

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	4.4.2, part 3	Criteria for such use of portable instruments **shall** be specified in procedures.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied.	N/A	Ad	Facilities/Projects shall develop procedures to ensure that the requirements specified in this document are met.
ANSI/ANS-8.3 (1997)	4.4.3	Process areas in which activities will continue during power outages **shall** have emergency power supplies for alarm systems, or such activities **shall** be monitored continuously with portable instruments.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. APCDs are battery powered and not susceptible to facility power outages. In the event of low battery condition, personnel are trained to evacuate the area. Batteries shall be changed or re-charged on a regular basis.	D	N/A	APCDs shall be capable of alerting the user to a low battery condition.
				N/A	Ad	Personnel shall be trained to evacuate the area upon low battery condition.
				N/A	Ad	Batteries shall be changed or re-charged on a regular basis as determined by the life of the battery.
ANSI/ANS-8.3 (1997)	4.4.4	The alarm system **shall** be sufficiently robust as to actuate the alarm signal when exposed to the maximum radiation expected.	This requirement is applicable APCDs used to augment NIMs in areas not normally occupied. Previous testing of various devices has demonstrated that some will not alarm if within a few feet of a criticality accident. Tests shall determine if there is some minimum APCD offset distance from the edge of a criticality accident.	D	N/A	APCDs shall be of a type that has been tested to establish their capability to alarm in radiation fields typical of a criticality accident.
				N/A	Ad	A minimum offset distance from the edge of a criticality accident shall be established as necessary to ensure functionality of the APCD.
				N/A	Ad	All individuals entering an area not normally occupied shall be equipped with an APCD. If only one person enters such area, that person shall be equipped with two APCDs
				N/A	Ad	APCDs shall not be reused after exposure to excessive radiation fields.

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	5.1, part 1	The system **shall** be designed for high reliability.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied.	D	N/A	APCDs shall be of a type that has been tested to establish their capability to alarm in radiation fields typical of a criticality accident.
				NA	Ad	APCDs shall be periodically calibrated and tested to ensure functionality and reliability.
				N/A	Ad	APCDs shall not be reused after exposure to excessive radiation fields.
				N/A	Ad	All individuals entering an area not normally occupied shall be equipped with an APCD. If only one person enters such area, that person shall be equipped with two APCDs
ANSI/ANS-8.3 (1997)	5.1, part 2	The system **should** utilize components that do not require frequent servicing, such as lubrication or cleaning.	This recommendation is applicable to APCDs used to augment NIMs in areas not normally occupied.	D	N/A	APCDs should be of a type that does not require frequent servicing, lubrication, or cleaning.
ANSI/ANS-8.3 (1997)	5.1, part 3	The system **should** be designed to minimize the effects of non-use, deterioration, power surges, and other adverse conditions.	This recommendation is applicable to APCDs used to augment NIMs in areas not normally occupied. Since APCDs are battery powered, power surges are not a problem.	D	N/A	APCDs should be designed to minimize the effects of non-use, deterioration, and other adverse conditions (e.g., RF interference).
				NA	Ad	APCDs shall be calibrated and tested periodically to ensure functionality and reliability.

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	5.1, part 4	The design of the system **should** be as simple as is consistent with the objectives of ensuring reliable actuation of the criticality alarm signal and avoidance of false alarms.	This recommendation is applicable to APCDs used to augment NIMs in areas not normally occupied.	D	N/A	The APCD design should be as simple as is consistent with the objectives of ensuring reliable actuation of the criticality alarm signal and avoidance of false alarms.
ANSI/ANS-8.3 (1997)	5.2, part 1	All components of the system **should** be located or protected to minimize damage in case of fire, explosion, corrosive atmosphere, or other extreme conditions.	This recommendation has limited applicability to APCDs used to augment NIMs in area not normally occupied. An APCD will be worn by personnel and is not expected to survive excessively high temperature, explosion, severe corrosive atmosphere or other extreme conditions. Personnel entering environments involving extreme conditions (e.g., corrosive atmosphere) will wear protective clothing and must wear the APCD in a manner that protects it from such conditions.	N/A	Ad	The APCD shall be worn in a manner that protects it from extreme conditions.
				D	N/A	The APCD should be designed to be durable under normal conditions of use.
ANSI/ANS-8.3 (1997)	5.2, part 2	The system **should** be designed to minimize the potential for failure, including false alarms, due to human error.	This recommendation is applicable to APCDs used to augment NIMs in areas not normally occupied.	D	N/A	APCDs should be designed to minimize the potential for failure, including deactivation and false alarms, due to human error.
				N/A	Ad	Personnel shall be instructed in proper APCD use, available functions, and actions to avoid false alarms.
ANSI/ANS-8.3 (1997)	5.2, part 3	Major system components **should** be labeled.	This recommendation is not applicable to APCDs, but to fixed NIM systems.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	5.3	The system **should** remain operational in the event of seismic shock equivalent to the site-specific design basis earthquake, or to the equivalent value specified by the Uniform Building Code that applies to the structure.	This recommendation is not applicable to APCDs, but to fixed NIM systems. In the event of seismic events, personnel are trained to evacuate facility areas.	N/A	N/A	N/A

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	5.4	The system **should** be designed to provide a visible or audible warning signal at some normally occupied location to indicate system malfunction or the loss of primary power.	This recommendation is applicable to APCDs used to augment NIMs in areas not normally occupied. APCDs are worn by the user and are generally equipped with a detector failure, component failure, and low battery condition alarm. APCDs are local and not remote units. When APCDs are used to augment criticality accident alarm systems, each individual within the area will be wearing at least one APCD. A minimum of two APCDs will be required in the area requiring coverage.	D	N/A	APCDs should be designed to provide an indication of system malfunction, including a low battery condition.
				N/A	Ad	APCD users in areas not normally occupied shall be trained to evacuate upon indication of system alarm, system malfunction, or low battery condition.
				N/A	Ad	All individuals entering an area not normally occupied shall be equipped with an APCD. If only one person enters such area, that person shall be equipped with two APCDs.
ANSI/ANS-8.3 (1997)	5.5	The system **shall** be designed to produce the criticality alarm signal within one-half second of detector recognition of a criticality accident.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. APCDs must respond to a step increase in radiation in a time frame similar to that of regular NIM instruments in the annual NIM response test.	N/A	Ad	APCDs must respond to a step increase in radiation in a time frame similar to that of regular NIM instruments in the annual NIM response test.
ANSI/ANS-8.3 (1997)	5.6	Criticality alarm systems **shall** be designed to respond immediately to the minimum accident of concern. For this purpose, in areas where material is handled or processed with only nominal shielding, the minimum accident may be assumed to deliver the equivalent of an absorbed dose rate in free air of 0.2 Gy/min (20 rad/min) at 2 meters from the reacting material. The basis for a different minimum accident of concern shall be documented.	This requirement is applicable in a limited sense to APCDs used to augment NIMs in areas not normally occupied. The minimum accident of concern is used in establishing fixed NIM instrument placement. Since APCDs are worn by an individual, fixed placement consideration is not required. However, the alarm setpoint should be set low enough to detect doses of concern to workers from a criticality accident.	N/A	Ad	APCD alarm setpoints should be set high enough above background to minimize false alarms yet low enough to detect doses of concern from criticality accidents.

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	5.7.1	Criticality alarm systems **shall** be designed so that alarm actuation shall occur as a result of the minimum duration transient. It may be assumed that the minimum duration of the radiation transient is 1 msec.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. Testing shall demonstrate that APCDs are capable of detecting short duration transients (approx. 1 msec).	D	N/A	Test results shall be available to demonstrate that APCDs produce an alarm when exposed to a short duration radiation transient (approx. 1 msec).
ANSI/ANS-8.3 (1997)	5.7.2, part 1	The alarm trip point **should** be set high enough to minimize the probability of an alarm from sources other than criticality.	This recommendation is applicable to APCDs used to augment NIMs in areas not normally occupied.	N/A	Ad	The APCD alarm setpoint should be set sufficiently above background to minimize false alarms.
ANSI/ANS-8.3 (1997)	5.7.2, part 2	The level **shall** be set low enough to detect the minimum accident of concern.	This requirement is applicable in a limited sense to APCDs used to augment NIMs in areas not normally occupied. The minimum accident of concern is used in establishing fixed NIM placement. Since APCDs are worn by the user, fixed placement consideration is not required. However, the alarm setpoint should be set low enough to detect doses of concern from criticality accidents.	N/A	Ad	APCD alarm setpoints should be set high enough above background to minimize false alarms yet low enough to detect doses of concern from criticality accidents.
ANSI/ANS-8.3 (1997)	5.8, part 1	The spacing of detectors **shall** be consistent with the selected alarm trip point and with the detection criterion.	This requirement is not applicable to APCDs. This requirement is applicable to fixed NIM installations.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	5.8, part 2	The location and spacing of detectors **should** be chosen to minimize the effect of shielding by massive equipment or materials. Shielding from low-density materials of construction, such as wood framing, thin interior walls, hollow brick tiles, etc., **may** be disregarded.	This requirement is not applicable to APCDs. This requirement is applicable to fixed NIM installations.	N/A	N/A	N/A

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	6.1	Initial tests, inspections and checks of the system **shall** verify that the fabrication and installation were made in accordance with design plans and specifications.	This requirement is applicable to APCDs. APCDs shall be inspected when received from offsite to ensure that the correct APCD has been received and fabricated correctly.	N/A	Ad	APCDs shall be inspected when received from offsite to ensure that the correct APCD has been received and that it is fabricated correctly.
ANSI/ANS-8.3 (1997)	6.2	Following modifications or repairs, or events that call the system performance into question, there **shall** be tests and inspections adequate to demonstrate system operability.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied.	N/A	Ad	APCDs shall be calibrated and tested prior to being returned to service following any modifications, repairs or events that call the APCD's performance into question.
ANSI/ANS-8.3 (1997)	6.3, part 1	System response to radiation **shall** be measured periodically to confirm continuing instrument performance.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. Periodically tests shall ensure continued instrument performance.	N/A	Ad	APCDs shall be periodically tested to ensure continued instrument response to radiation.
ANSI/ANS-8.3 (1997)	6.3, part 2	The test interval **should** be determined on the basis of experience. In the absence of experience, tests **should** be performed at least monthly.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. APCDs shall be tested monthly unless historical data suggests that less frequent testing is sufficient.	N/A	Ad	APCDs shall be tested monthly unless historical data suggests that less frequent testing is sufficient.
ANSI/ANS-8.3 (1997)	6.3, part 3	Records of tests **shall** be maintained.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied.	N/A	Ad	The records of tests, calibrations and maintenance for each APCD shall be maintained.
ANSI/ANS-8.3 (1997)	6.3, part 4	System designs **may** incorporate self-checking features to automate portions of this testing.	This permission statement is applicable to APCDs used to augment NIMs in areas not normally occupied. APCDs may be equipped with self-checking features such as component testing, low battery condition, etc.	N/A	Ad	APCDs with self-checking features (if applicable) shall be tested periodically in conjunction with other testing.
ANSI/ANS-8.3 (1997)	6.4, part 1	The entire alarm system **shall** be tested periodically.	This requirement is not applicable to APCDs. This requirement is applicable to fixed NIM systems to ensure that all components of the overall system (e.g., remote bells) are functional.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	6.4, part 2	Each signal generator **should** be tested at least annually.	This recommendation is applicable to APCDs used to augment NIMs in areas not normally occupied. APCDs shall be tested at least annually to ensure audible alarm function.	N/A	Ad	APCDs shall be tested at least annually to ensure that the audible alarm is functional.

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	6.4, part 3	Field observations **shall** establish that criticality alarm signals are functional throughout all areas where personnel could be subject to an excessive radiation dose.	This requirement is not applicable to APCDs, but is required for fixed NIM installations instead.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	6.4, part 4	All personnel in affected areas **shall** be notified before testing of the criticality alarm signals.	This requirement is not applicable to APCDs, but is required for fixed NIM installations instead.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	6.5, part 1	When tests reveal inadequate performance, corrective action **shall** be taken without unnecessary delay.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. If an APCD fails any test, recalibration, or if a system fault alarm is received, then it shall not be used until corrective action has been completed and the APCD has passed all necessary tests.	N/A	Ad	If an APCD fails any test, recalibration, or if a system fault alarm is received, then it shall not be used until corrective action has been completed and the APCD has passed all necessary tests.
ANSI/ANS-8.3 (1997)	6.5, part 2	If portable instrument use is required, the criteria of 4.4.2, above, **shall** be met.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. Applicable APCD requirements are presented in this analysis.	N/A	Ad	Applicable APCD requirements are presented in this analysis.
ANSI/ANS-8.3 (1997)	6.6, part 1	Procedures for system testing **shall** minimize both false alarms and inadvertent initiation of emergency response.	This requirement is not applicable to APCDs, but is applicable to fixed NIM installations instead. APCDs are not tested in the field.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	6.6, part 2	The (Test) procedures **shall** also require that the systems be returned to normal operation immediately following tests.	This requirement is not applicable to APCDs, but is applicable to fixed NIM installations instead.	N/A	N/A	N/A
ANSI/ANS-8.3 (1997)	6.7	Records of tests and corrective actions for each system **shall** be maintained.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. This section is applicable in the sense that records of APCD calibration, tests and maintenance shall be maintained.	N/A	Ad	The records of tests, calibrations and maintenance for each APCD shall be maintained.

Source	Section	Requirement/Recommendation	APCD Requirement Applicability	D	Ad	APCD Requirement
ANSI/ANS-8.3 (1997)	7.1	Instructions regarding response to criticality alarm signals **shall** be posted at strategic locations within areas requiring alarm coverage.	This requirement is applicable to APCDs used to augment NIMs in areas not normally occupied. However, instructions are typically included in training and documented in procedures	N/A	Ad	Personnel shall be trained in the proper response to APCD alarms. Upon exiting areas not normally occupied, regular facility evacuation routes shall be followed.
ANSI/ANS-8.3 (1997)	7.2	Guidance for training of employees and visitors, and for conduct of criticality alarm drills, is provided in ANSI/ANS-8.19-1996.	This statement is applicable to APCDs used to augment NIMs in areas not normally occupied. Employees and visitors who utilize APCDs shall be trained in their use and in protective actions to be taken upon alarm.	N/A	Ad	Employees and visitors who utilize APCDs shall be trained in their use and in protective actions to be taken upon alarm.

3.0 Definition of Not Normally Occupied

As indicated in Section 1.0, and in compliance with ANSI/ANS-8.3-1997, the objective of this report is to provide a basis for the use of APCDs as portable instruments to augment facility NIM systems in areas not normally occupied by personnel. However, the term "not normally occupied" is not defined in ANSI/ANS-8.3-1997. Therefore, other Standards in which occupancy is a concern were searched for uses of "not normally occupied" and other associated terms.

Several National Fire Protection Association Standards (NFPA) contain information related to "not normally occupied", "occupied", "occupiable stories", and "unmanned space" that may be used to develop a definition of "not normally occupied" applicable to the use of APCDs to augment facility NIM systems. [3] The NFPA 301 definition of "unmanned space" best fits the concept of not normally occupied as intended to be used by WSRC. Such unmanned spaces are only occupied for limited periods, on the order of seven days per year. The "occupiable story" concept in *The Life Safety Code*, NFPA 101, provides similar guidance. Occupiable stories, which are dedicated to mechanical equipment, may require entry about seven days per year to perform maintenance. The inherent assumption for either the unmanned space or the occupiable story is that entry into such areas is infrequent and is of relatively short duration. In addition, the NFPA definition of "occupied" (i.e., > 10 occupants) suggests a general upper limit of occupants for areas designated as not normally occupied (i.e., < 10 occupants).

Using the information above from the NFPA Standards, the Group to Recommend Alternatives to NIM Detectors (see section 1.0) developed the following definition:

> Not Normally Occupied – An area for which entry is controlled and recommended occupancy is limited to 168 hours per year, not to exceed 40 hours per month, and the number of occupants is limited to 10 at any given time. Facility management may request an extension of occupancy time and/or number of occupants, subject to local Criticality Safety Committee concurrence.

The use of APCDs to augment facility NIM systems in areas not normally occupied by personnel shall be subject to the definition above.

4.0 APCD Design Criteria and APCDs That Meet the Criteria

Table 2 contains a compilation of all APCD design criteria identified from the Table 1 analysis. Table 2 also documents the compliance of Siemens EPD/Mk2 and EPD-N devices in meeting the design criteria.

Table 2. APCD Design Criteria and Siemens EPD/Mk2 and EPD-N Compliance

Design Criterion	Siemens EPD/Mk2 and EPD-N Compliance
1. APCDs shall resist radio frequency and electrostatic interference	Yes – Reference 4
2. APCDs shall be capable of alarming on cumulative dose	Yes – Reference 5 & 6
3. APCDs shall provide an audible signal that is recognized as requiring prompt evacuation.	Yes – Reference 5 & 6
4. Documented test results shall demonstrate prompt and automatic APCD alarm response to a simulated criticality accident.	Yes – Reference 7
5. APCDs shall provide a signal to the individual carrying the instrument that is sufficiently long to get their attention.	Yes – See Appendix A

Table 2. APCD Design Criteria and Siemens EPD/Mk2 and EPD-N Compliance	
6. APCD audio alarm shall be loud enough to be heard by the individual wearing the device	Yes – Reference 5, 6, & Appendix A
7. APCD audio alarm sound level should not be loud enough to cause hearing damage.	Yes – Reference 5, 6, & Appendix A
8. APCDs should include the ability to use earpieces or provide vibration alarms.	Yes – Reference 5 & 6
9. APCDs shall be capable of alerting the user to a low battery condition.	Yes – Reference 5 & 6
10. Documented tests shall demonstrate APCD capability to alarm in radiation fields typical of a criticality accident.	Yes - Reference 7
11. APCDs should not require frequent servicing, lubrication, or cleaning.	Yes – Reference 5 & 6; also, Siemens EPDs have been used at SRS for several years. Historical information verifies that these devices do not require frequent servicing, lubrication, or cleaning.
12. APCD design should minimize effects of non-use, deterioration, and other conditions (e.g., RF and electrostatic interference).	Yes – Reference 4; also, Siemens EPDs have been used at SRS for several years. Historical information verifies that these devices are not affected by non-use and have not deteriorated.
13. APCD design should be a simple as is consistent with the objectives of ensuring actuation of the criticality alarm and avoidance of false alarms.	Yes – Reference 5 and 6; also, Siemens EPDs have been used at SRS for several years. Historical information verifies that these devices are simple and straightforward to use.

Table 2 APCD Design Criteria and Siemens EPD/Mk2 and EPD-N Compliance

14. APCDs should be designed to minimize the potential for failure, including deactivation and false alarms, due to human error.	Yes – Reference 5 & 6; also, Siemens EPDs have been used at SRS for several years. Historical information verifies that these devices are designed to resist human failure.
15. APCDs shall provide an indication of system malfunction, including low battery condition.	Yes – Reference 5 & 6
16. Documented test results shall demonstrate that the APCDs produce an alarm when exposed to a short duration radiation transient (approx. 1 msec).	Yes – Reference 7
17. APCDs shall be designed to produce an alarm within 4 seconds of detector recognition of a step increase in dose rate greater than 10% over the setpoint.	Yes – Appendix A

5.0 Administrative Requirements for APCD Use

Table 3 contains a compilation of all APCD design criteria identified from the Table 1 analysis. These administrative requirements must be incorporated into Facility, Radcon, or site-level procedures as appropriate prior to the use of APCDs to augment facility NIM systems in areas not normally occupied.

Table 3. Administrative Requirements for APCD Use
1. APCD cumulative dose alarm shall be set high enough to avoid false alarms while retaining the capability to detect unsafe dose to workers. GRAND recommends that APCD cumulative dose alarm be set a 1 rem.
2. APCD alarm setpoints should be set sufficiently above background to minimize false alarms. GRAND recommends that the dose rate alarm be set a minimum of 30 mr/hr, or 10 %, above expected background, whichever is greater, and the APCD cumulative dose alarm be set a 1 rem.
3. Radcon procedures for calibration of Siemens EPDs used for dose logging shall be applied to Siemens EPD/MK-2 or EPD-N instruments used as APCDs to ensure functionality and reliability. Siemens EPD/MK-2 or EPD-N instruments used as APCDs should be marked in such a way that they can be distinguished from Siemens EPDs used for dose logging.
4. Facilities/projects using APCDs shall have an approved training program/procedure on APCD use.
5. Personnel wearing APCDs shall be trained in their use and in evacuation, including evacuation for instrument malfunction or a low battery condition.
6. If protective actions other than evacuation are necessary, they shall also be specified in training.
7. Personnel shall be capable of distinguishing the APCD alarm from other alarms.
8. Personnel shall be trained and have a means to contact the appropriate control room after evacuation so that the event is logged and other facility emergency actions can be taken as necessary.

Table 3. Administrative Requirements for APCD Use
9. When using APCDs in high noise areas, the APCDs shall be equipped with earpieces and/or vibration alarms.
10. APCD pre-alarms, if provided, should be disabled.
11. Facilities/projects shall develop the necessary procedures to ensure that these administrative requirements are met.
12. Personnel shall be trained to evacuate an area intended for APCD use upon APCD low battery condition or device malfunction.
13. APCD batteries shall be changed or re-charged on a regular basis.
14. A minimum offset distance from the edge of a designated potential criticality accident location (e.g., edge of tank) shall be established to ensure APCD functionality. GRAND recommends a minimum offset distance of 3 meters (10 feet).
15. APCDs shall not be re-used after exposure to excessive radiation fields, such as from a criticality accident or a simulated criticality test.
16. APCDs shall be worn in a manner that protects it from extreme environments (e.g., under protective clothing).
17. Personnel shall be instructed in proper APCD use, available functions, and actions to avoid false alarms.
18. APCDs must respond to a step increase in radiation in a time frame similar to that of regular NIM instruments in the annual NIM response test.
19. APCDs shall be calibrated and tested prior to being returned to service following any modifications, repairs or events that call APCD performance into question.
20. APCDs shall be periodically calibrated and tested to ensure continued appropriate instrument response to radiation. This test requirement and the test requirement in item 21 may be combined at the discretion of the testing organization(s).
21. APCD shall be tested monthly unless historical data suggests that less frequent testing is sufficient.
22. The records of tests, calibrations and maintenance for each APCD shall be maintained.
23. APCDs with self-checking features (if available) shall be tested periodically in conjunction with other testing.
24. APCDs shall be tested at least annually to ensure that the audible alarm is functional.
25. If an APCD fails any test, recalibration, or if a system fault is received, then it shall not be used until corrective action has been completed and the APCD has passed all necessary tests.
26. Upon exiting area not normally occupied in the event of an APCD alarm, regular facility NIM evacuation routes shall be followed.
27. Visitors who use APCDs shall be trained in their use.
28. All personnel entering a not normally occupied 12 rad zone area shall be equipped with an APCD. If only one person enters such area, that person shall be equipped with two APCDs.

6.0 References

1. DOE Order 420.1A, Facility Safety, Att. 2, para. 4.3.2.e, U. S. Department of Energy, 5/20/2002.
2. ANSI/ANS-8.3-1997, Criticality Accident Alarm System, published by the American Nuclear Society, 5/28/1997.
3. WSMS-SAE-M-03-0076, Modified NIM Protection for Areas that are Not Normally Occupied, A. A. Coutts, Washington Safety Management Solutions, 4/21/2003.
4. Evaluation of Siemens Environmental Systems Model Mk-2 Electronic Personal Dosimeter, T. E. Bratvold, Battelle Memorial Institute, July 2001.
5. Siemens Electronic Personal Dosimeter (EPD Mk2) Technical Handbook, 611/HB/4052/000, Siemens Plc., 1999.
6. Siemens Neutron Sensitive Electronic Personal Dosimeter (EPD-N Mk2.0) Technical Handbook, 611/HB/44335/000, Siemens Plc., 9/4/2000.
7. Testing of Siemens Electronic Personal Dosimeters (EPD) in Simulated Criticality Conditions, J. F. Coleman, Siemens Commercial-In-Confidence Paper, 5/25/2000.

APPENDIX A
WSRC Testing of Siemens EPD-N APCDs

Test Details:

Date: 3/11/2003

Personnel Performing Test: J. W. McMahan (Maintenance Engineering, Site NIM Engineer) and T. R. Sullivan (Health Physics Technology)

Purpose of Test:

To test Siemens EPD-N MK 2 instruments to a step increase in dose rate greater than 10 % over the setpoint and observe response time to alarm signal;

To observe duration of audible alarm signal;

To qualitatively observe loudness of alarm signal;

Test Description:

Two Siemens EPD-N Mk 2 instruments with neutron detection capabilities were subjected to a step increase radiation from the Health Physics gamma irradiator. This facility exposes a Cs 137 source in a short time for evaluation of the speed of response a detector system exhibits. Using several repetitive exposures, the two samples responded similarly and repeatably to the source.

The reason for these tests was to evaluate the effect of data processing as described in the vendor literature, which suggested some time might be lost because a sampling scheme with an unacceptably long several second interval was in use to conserve power. However, the time from beginning of exposure to alarm sound was measured and resulted in consistent 2.5 to 3.5 second intervals, proving there was no meaningful sampling influence. The time response of the Siemens EPD-N Mk 2 was determined to be acceptable for personal criticality alarm application.

The audible alarm sounded for several seconds and it was noted that the instrument settings could be easily adjusted such that the alarm could be made to latch (i.e., sound continuously). Thus, the duration of the signal was judged acceptable.

The loudness of the audible alarm was qualitatively judged to be sufficiently loud to alert the wearer, yet without being loud enough to cause hearing damage.