March 1995

BACKGROUND INFORMATION ON FEMA-REP-21: CONTAMINATION MONITORING STANDARD FOR A PORTAL MONITOR USED FOR RADIOLOGICAL EMERGENCY RESPONSE

FEDERAL EMERGENCY MANAGEMENT AGENCY

March 1995

**BACKGROUND INFORMATION ON FEMA-REP-21:
CONTAMINATION MONITORING STANDARD FOR
A PORTAL MONITOR USED FOR RADIOLOGICAL EMERGENCY RESPONSE**

INTRODUCTION:

The "Contamination Monitoring Standard for a Portal Monitor Used for Emergency Response (FEMA-REP-21)," is only for portal monitors intended for emergency evaluation of individuals (adult or child) potentially contaminated from an airborne plume resulting from a release of beta-gamma emitting radioactive material from a nuclear power plant accident, or from short term exposure to widespread contamination deposited from such airborne radioactive material. The development and use of a portal monitor standard is intended to provide reasonable assurance that risk of skin cancer and other detrimental radiation effects to the skin of the individual from radiation exposure from contamination on the skin and clothing does not exceed guidelines established by the Environmental Protection Agency (EPA 400-R-92-001) regarding adequate protection of public health under emergency conditions.

Although the primary reason for monitoring and decontamination of evacuees is to reduce the risk of radiation effects to the skin, including skin cancer, these actions also reduce the risk of cancer to internal organs that could result from inadvertent ingestion of contamination on skin and/or clothing or from inhalation of contaminated material resuspended from clothing into the air. The Standard does **not** apply to an individual or worker, as defined in 10 CFR 19.3(c), that could be exposed to contamination under controlled conditions such as in a work-place environment.

BACKGROUND INFORMATION:

The Environmental Protection Agency (EPA) published general guidance for emergency response in the "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," EPA400-R-92-001 (PAG Manual). This guidance provides as a general principle that deterministic health effects (those for which there is a dose threshold) should be avoided. It further provides that the risk of delayed health effects (e.g., skin cancer) from contamination should be limited to less than 20 percent of the risk from the principal exposure pathway.

Individuals who have been exposed in areas where inhalation of particulate materials would have warranted evacuation may be contaminated. This contamination may consist of a

combination of "removable" and "fixed" contamination. Since portal monitors cannot differentiate between removable and fixed contamination, they should be sufficiently sensitive for the detection of either type. Fixed contamination will expose the skin for a longer period and will, therefore, be the basis for establishing the minimum detectable level (MDL) for the portal monitor.

Using the general guidance and risk values provided in the PAG Manual, plus other sources, this paper develops health based recommendations on contamination levels that should be considered as action or trigger levels for deciding when the level of skin contamination is of such significance for health effects that decontamination should be undertaken. The MDL used for evaluation of radioactive contamination on an individual must be sufficiently low to **assure** that any undetected radioactive material will not result in unacceptable risks of health effects. The potential health effects for an individual who has been contaminated by an accidentally released airborne plume of radioactive material or exposed to widespread surface contamination deposited from an airborne plume are, acute exudative radiodermatitis, skin ulcers with fibrosis, skin ulceration from a hot particle, or skin cancer.

In addition, skin erythema may occur. However, this is considered to be only a minor radiation effect; not a health effect. This is because it is only a short-term cosmetic effect (similar to sunburn) and should not require medical attention for full recovery.

Skin cancer, a stochastic health effect, has **no dose threshold** and its probability of occurrence is directly proportional to dose to the skin of the whole body of an individual. The other effects, deterministic effects, have **dose thresholds** below which the effects do not occur.

Two types of radiation detection systems are typically used for monitoring of contamination on evacuees: (1) a hand held portable or stationary rate meter with a detector at the end of a flexible cable, and/or (2) a portal monitor that has several radiation detectors fixed within a frame that forms a passageway for the individual being monitored. These two types of systems differ in their practicality for the type of object to be monitored and in their capability to detect radiation coming from a physically small area versus a relatively large dispersed area of contamination.

Tables of recommended surface contamination screening levels are provided in the EPA PAG Manual for measurements taken with **portable survey instruments**. These are not applicable to portal monitors.

Hand held **portable survey instruments** are suitable for monitoring an individual (adult, child, or an infant), animal, automobile, or any type of object. This would be the method of choice for someone who, for example, is not ambulatory. Checking for contamination with a portable survey instrument requires a survey of the entire surface area with the beta-sensitive probe held close to the surface being surveyed and the probe moved at a consistent fairly slow rate. With a portable survey instrument, more than a minute may be needed to survey one individual, depending to some extent on the action level (above background) that is used.

A **portal monitor** is specifically designed for monitoring an ambulatory individual, including an adult or child. Because of the sensitivity of these units using several detector tubes, several individuals can be surveyed per minute.

Portal monitors have varying designs with regard to (1) whether the counts are integrated over time or simply presented as the instantaneous count rate and (2) the number of detectors for which the counts are summed to trigger an alarm. Time integration of the counts is an important feature for portal monitors to permit adjustment of the counting time in order to maintain adequate sensitivity to the contamination in increasing levels of background radiation. This feature also increases the overall sensitivity of the portal monitor compared to those that use an instantaneous count rate to trigger an alarm.

The test procedure using one microcurie of cesium-137 at the centerline between the columns of the portal monitor as described in the Standard applies specifically to a portal monitor design that sums the counts from all of the detectors to trigger an alarm. This feature allows the detection of widespread contamination to indicate the potential for the presence of a small spot of highly concentrated contamination that would, by itself, be undetectable but could cause a health effect. Portal monitors that do not sum the counts from all detectors will be less sensitive for the detection of contamination that is widespread and nonuniformly distributed on an individual as assumed for the Standard. Portal monitors that sum the counts from all detectors are, therefore, preferred because if they meet the detectability test of 1 μCi of Cs-137 at the centerline between the columns, they will have sufficient sensitivity to detect either fixed or removable contamination at the level of the Standard.

The Standard is designed to detect contamination at the level of concern for foxed contamination. This level is significantly lower than the level of concern for removable contamination. Therefore, the MDL for contaminated individuals who have not bathed and changed clothes may be designated at a higher threshold than that which is set forth in the Standard. This means that the portal monitors that do not sum the counts and that meet the detectability test, can be assumed to meet the Standard for monitoring

evacuees who have been sent directly to the monitoring center by the responsible off-site response organization (ORO). This is because the contamination on these individuals will be primarily removable.

Other evacuees who have evacuated to locations other than the monitoring centers and have bathed and changed clothes before arriving at the monitoring center should be monitored using a portal monitor that sums the counts or a portable instrument. This is because portal monitors that do not sum counts will not have sufficient sensitivity to detect fixed contamination at the level of the Standard. Individuals who have been decontaminated should be remonitored using a portable instrument instead of any type of portal. This is because portable instruments are more sensitive to small spots of concentrated contamination than portal monitors and they can be used to find the exact location of such spots to support decisions for further actions. The following guidance is intended to aid offsite response organizations in determining the conditions under which different types of portal monitors should be used, along with portal instruments.

MONITORING SITUATION	**APPLICABLE INSTRUMENTS**
Evacuees sent by the ORO directly to the monitoring center	– Portal Monitor that **sums** the counts from all detectors – Portal Monitor that **does not sum** the counts from all detectors – Portable Instrument
Individuals who have evacuated to locations other than the monitoring center and have bathed and changed clothes before arriving at the monitoring center.	– Portal monitor that **sums** the counts from all detectors – Portable Instrument
Individuals who have been monitored with a portal monitor or a portable instrument and have been decontaminated at the monitoring center	– Portable Instrument

BASIS FOR THE STANDARD:

The portal monitor Standard is based on considerations of the potential health risks resulting from contamination on the skin. Radioactive contamination on the skin is more hazardous to an individual than radioactive contamination on the clothing. Thus, for the purpose of deriving this Standard, **all** radioactive contamination on an individual is conservatively assumed to be directly on the skin, i.e., the worst possible situation. In deriving the Standard, each of the radiation effects mentioned in the previous section will be considered separately.

A portal monitor will detect contamination only in terms of activity (μCi), not concentration (μCi/cm^2). Therefore, the quantity selected for the MDL is activity in units of μCi.

Dose to skin is the quantity of interest for evaluation of risk. Dose and risk are both proportional to the time-integrated activity (μCi·h) or time-integrated concentration (μCi·h/cm^2). Therefore, in the sections that follow, the time-integrated activity that will produce the dose of concern for each effect is calculated; this number is then divided by the assumed duration of exposure (time) in hours (h) to get the amount of activity needed to produce the dose of concern for each effect.

Deterministic Effects:

Deterministic effects are those for which there is a threshold dose below which the effect does not occur. The deterministic effects from skin contamination are acute exudative radiodermatitis, ulcers with fibrosis, skin ulceration from a hot particle, and skin erythema.

Contaminated Area Assumptions:

Deterministic effects occur only to specific areas of the skin where the dose exceeds the threshold. Contrary to the situation for stochastic (long term) effects, the threshold time-integrated activity that will produce the effect in a particular area is directly proportional to the size of the contaminated area. Since it is necessary to express the Standard in terms of total contamination, as opposed to contamination per unit area, assumptions must be made regarding the size of the highly contaminated area of the skin for each radiation effect (except for ulceration from a hot particle) and the fraction of the total body contamination that is on this area.

For persons contaminated from an airborne plume or from widespread contamination resulting from a plume as previously assumed, it is not credible to assume that all of the contamination on skin and clothing will be confined to a small area of skin with no contamination on other parts of the skin or clothing. Although, it is possible to postulate a rare circumstance where this could occur, the probability of occurrence is believed to be extremely low. It is arbitrarily assumed that the probability is very low that more than 10 percent of the total contamination on a person's skin and clothing will be confined to an a small area of skin.

Acute Exudative Radiodermatitis:

Acute Exudative Radiodermatitis is characterized by inflamed skin with redness, pain, and oozing body fluids. Medical care may be needed. This is the deterministic **health effect** of greatest concern because it occurs at the lowest level of concentrated surface contamination.

Based on information in Appendix B of the EPA PAG Manual, the threshold dose to the skin for acute exudative radiodermatitis is in the range of 1,200 to 2000 rad (as used here, 1 rad = 1 rem). The lower end of the range (1200 rem) is assumed.

The Standard will be expressed in terms of μCi. It is, therefore, necessary to determine the number of μCi that will yield the threshold dose. Since the number of μCi needed is directly proportional to the size of the area of concentrated contamination, it is necessary to identify the size of the area of concern. In keeping with the EPA philosophy of adequate protection of public health under emergency conditions, an area not larger than 0.2 cm^2 (i.e., approximately 0.5 cm diameter circle) is judged to be a limiting size for the rare occurrence of acute exudative radiodermatitis resulting from undetected contamination.

Based on dose conversion factors from EPA 520/1-89-016 "Evaluation of Skin and Ingestion Exposure Pathways," for the mix of radionuclides assumed to be associated with a major reactor accident, the factor to convert skin contamination to skin dose at a skin depth of 7 mg/cm^2, is about 7 rem/h per $\mu Ci/cm^2$ (may also be expressed as 7 rem per $\mu Ci \cdot h/cm^2$). Therefore, if only 10 percent of the total activity is concentrated in a 0.2 cm^2 area, then the threshold MDL of activity on the entire body (skin and clothing)to **avoid** acute exudative radiodermatitis is **340 μCi·h** (i.e., 1200 rem ÷ 7 rem per $\mu Ci \cdot h/cm^2$ x 0.2 cm^2 ÷ 0.1).

Ulceration with Fibrosis:

Ulceration with fibrosis is characterized by an open sore in the skin with pain, pus, redness and swelling. Medical care may be needed.

Based on information in Appendix B of the EPA PAG Manual, ulcers with fibrosis of the skin may occur in the range of 5500 to 7000 rad (as used here, 1 rad = 1 rem). Using the lower end of the range (5500 rem), the threshold level of contamination for **avoiding** ulcers with fibrosis of the skin is 5500/1200 times higher than the threshold for acute exudative radiodermatitis. This is **1560 μCi·h** (i.e., 55/12 x 340 μCi·h).

Ulceration from a Hot Particle:

A hot particle is a tiny chemically or physically bound fragment of highly radioactive material. It may be too small to be seen without magnification. A hot particle on the skin could cause a single small ulceration that is treatable as an ordinary thermal burn. If hot particles occur, it is assumed that they will be removed by ordinary bathing. In its Report No. 106, The National Council on Radiation Protection and Measurement (NCRP) recommended a time-integrated activity for exposure to hot particles of 75 μCi·h per particle, which is considered to be a threshold exposure below which ulceration does not occur. Therefore, the minimum detectable level for avoiding ulceration from a single hot particle is **750 μCi·h** (i.e., 75 ÷ 0.1). This assumes that a hot particle would be accompanied by other widespread contamination such that it represents no more than 10 percent of the total activity on a contaminated person.

Skin Erythema:

Skin erythema is a redness of the skin similar to sunburn. It is a visual, temporary, cosmetic, effect but not a significant effect impacting an individual's health at the threshold level of dose and, as such, **requires no medical treatment** for recovery.

The most **conservative** estimate found in the literature (NUREG/CR-4212, p. II-68) of the **threshold dose** below which erythema **does not occur** is 200 rad (as used here, 1 rad = 1 rem). Other references (e.g., the EPA PAG Manual) estimate the threshold to be in the range of 300 to 800 rad (depending on the reference used). Keeping the dose to any portion of the skin to less than 200 to 800 rem will **avoid** skin erythema.

Based on the factor of 7 rem per μCi·h/cm^2 and the range of dose thresholds (200 to 800 rem), a time-integrated concentration in the range of 29 to 114 μCi·h/cm^2 would represent a threshold exposure for erythema, depending on the reference used. Since erythema is **not** considered to be a health effect, a median value (as opposed to a minimum value

as used for health effects) of 70 μCi·h/cm^2 is assumed to be a reasonable threshold value. It is also assumed that a spot of erythema larger than 5 cm^2 (i.e., approximately a 2.5 cm diameter circle) from undetected contamination would be unacceptable. Thus, based on a threshold concentration of 70 μCi·h/cm^2, the minimum detectable level of a portal monitor for preventing skin erythema is **3500 μCi·h** (i.e., 70 μCi·h/cm^2 x 5 cm^2 ÷ 0.1).

Stochastic Effects:

Stochastic effects are those for which there is no threshold dose below which the effect will not occur and the probability of occurrence is directly proportional to the dose received. The stochastic effect of concern from surface contamination on skin and clothing is skin cancer. In this case, a dose to the skin must be selected at a level for which the corresponding increase in risk of skin cancer is within established guidelines.

Based on guidance in the PAG Manual, the health risk from skin contamination should not be allowed to exceed 20 percent of the risk that would warrant evacuation of the public. EPA PAGs limit skin dose to 50 times the numerical 1 rem evacuation PAG, or 50 rem. Twenty percent of 50 rem (10 rem), is, therefore, used as the limiting dose to the skin of the whole body from a single exposure to reduce the risk of skin cancer.

To determine the upper limit for whole body skin contamination, it is necessary to calculate the time-integrated concentration on the skin that would produce a dose of 10 rem. The factor to convert from time-integrated skin contamination to a dose of 10 rem is **1.4 μCi·h/cm^2** (i.e., 10 rem ÷ 7 rem per μCi·h/cm^2).

To determine the time-integrated activity necessary to yield a dose of 10 rem to the skin of the whole body, it is necessary to multiply the time-integrated concentration per square centimeter that will yield a dose of 10 rem times the area of the skin on the whole body (about 18,000 cm^2 for an adult). Although the area of a child's skin would be smaller, the margin of safety in the activity threshold for cancer compared to the activity threshold for the controlling deterministic health effects is so large that no adjustment to the area of the skin is needed. Based on the above data, the threshold level corresponding to adequate protection of the public from skin cancer under emergency conditions is a time-integrated activity of **25,000 μCi·h** (i.e., 1.4 μCi·h/cm^2 x 18,000 cm^2). This is independent of the distribution of the contamination on the skin.

Duration of Exposure:

Results of all of the above derivations of contamination levels corresponding to acceptable levels of risk or threshold levels are expressed in terms of time-integrated activity (μCi·h). To translate these values into the units of the Standard (μCi), it is necessary to divide by the duration of exposure. Duration of exposure is assumed to be either 36 hours (12 hours before being monitored plus 24 hours after being monitored) for loose contamination (contamination that is removable by washing and changing clothing) and 336 hours (14 days) for fixed contamination (contamination that is not removed by washing and changing clothing).

Twelve hours is the FEMA limit for completion of the monitoring effort, and 24 hours is assumed to be an adequate amount of time for evacuees who have been monitored and found to have no detectable contamination to wash and change clothes. This takes into account the difficulties that evacuees may have in getting access to bathing facilities and in getting non-contaminated clothes. Fourteen (14) days is the approximate time needed for the skin to replace itself by natural processes. It is assumed that all contamination (except for hot particles) may initially include some fraction of radioactive material that is fixed. For hot particles, it is assumed that the same process that combined the radioactive material into particles rendered them unlikely to be attached to or absorbed by the skin. Thus, it is assumed that hot particles will be removed by bathing and changing clothes and that the maximum exposure period will be 36 hours.

DISCUSSION

The derived MDL of activity (μCi) required for a portal monitor for each risk category (condition) and for loose and fixed contamination is shown in Table 1. These were arrived at by dividing the time-integrated level of activity for each risk category by the respective assumed exposure period; 36 hours for loose contamination and 14 days (336 hours) for fixed contamination. Table 1 also shows the maximum size of the area where each condition could occur from undetected activity if (1) the minimum detectable level (MDL) of the portal monitor is as specified in the Table, and (2) 10 percent of the total undetectable activity on the skin and clothing is on that small area.

The assumption that no more than 10 percent of the total activity on a person will be concentrated on a small area of skin is considered to be a conservative assumption. For persons contaminated from a plume or from widespread contamination resulting from deposition from a plume, it is possible, but considered to be highly improbable (except for the case of hot particles), that ten percent of the contamination on an individual could be confined to an area smaller than 5 cm^2 as assumed for avoiding erythema. It is

even more improbable that a smaller area (e.g., 0.2 cm^2 as assumed for acute exudative radiodermatitis and ulceration with fibrosis) would contain 10 percent of the total activity on an individual.

The data in Table 1 show that the controlling effect for the establishment of this Standard is acute exudative radiodermatitis. It also shows that in order to provide reasonable assurance that risk of this effect will not be significant for persons with fixed contamination, the MDL should be one μCi of contamination which has a distribution of ten percent of the activity on a small spot and 90 percent widely distributed on other parts of the skin and clothing. This means that decontamination decisions based on detection of 1 μCi of contamination will provide reasonable assurance that undetected contamination will **not cause** a deterministic health effect over an area larger than 0.2 cm^2 and that **any such effects will be rare**. At this level of detection and decision, protection of the population from acute exudative radiodermatitis will be adequate for emergency response. Maintaining this health effect at an adequate level of protection for emergency response, assures that protection from the other potential health effects will be achieved to an even greater degree. Therefore, **one μCi is chosen as the Standard for the MDL of a portal monitor used for detection of widespread non-uniformly distributed contamination on an individual.**

Based on the Standard of 1 μCi, and the assumptions regarding the distribution of the contamination on the skin and clothing discussed previously, the data in Table 1 show the following:

- The **increased risk of skin cancer is not a significant consideration** with regard to detection of contamination by a portal monitor at the detection level specified.

- The **threshold for skin erythema will be avoided** by a factor of 10 for fixed contamination and by a factor of 90 for loose contamination at the detection level specified.

- **Ulceration from hot particles** (if they should occur) **will not be the leading consideration** for detection of contamination.

- The **threshold for ulcers with fibrosis will be avoided** by a significant margin at the detection level specified.

- The **calculated areas are small** in which 10 percent of the total activity on the skin and clothing would have to be concentrated for any deterministic effects to occur. This indicates that the **probability is very low** for the occurrence of such a distribution of

contamination from exposure to an airborne plume or to widespread deposited radioactive material.

DISCUSSION OF ASSUMPTIONS

Since the risk of fatal cancer from a particular quantity of contamination is much lower than the risk from deterministic effects over a small area, no discussion is needed regarding the effect of assumptions on the risk of fatal cancer. However, changes in assumptions regarding deterministic effects could significantly affect the conclusion on an acceptable minimum detectable level. The following is a discussion of the assumptions:

- **All contamination that is detected is assumed to be on the skin.**

  This is a conservative assumption with regard to health effects to skin since clothing would be exposed to air or surface contamination to the same degree as skin and the dose to skin from unit contamination on clothing will be less than that from unit contamination on skin.

- **No more than 10 percent of the contamination detected by the monitor will be confined to a small area of skin.**

  This assumption can be either liberal or conservative. The nature of the contamination on individuals from exposure to a plume or to contamination deposited from a plume is expected to be generally widespread with higher concentrations in spots that have come in contact with highly contaminated surfaces. Since a portal monitor cannot distinguish a small spot of contamination from more widespread contamination, it is necessary to make an assumption regarding the maximum fraction of the total contamination that would be on a small area. The assumption of 10 percent of the total contamination on an individual being confined to a small area is arbitrary. The probability of occurrence of this distribution is believed to be very low, however, no data are available to estimate a numeric probability. This should result in a very low, but indeterminate, probability of any failure of a portal monitor calibrated to this Standard to detect unshielded contamination on skin and clothing that could cause deterministic health effects. There is a small chance that some contamination will be shielded by body parts (e.g., under the arms) and will not be detected. Risk of skin cancer (a stochastic effect) from skin contamination is not affected by the distribution of the contamination.

- **The assumed distribution of the contamination on the skin and the unit area used for calculating dose to the skin result in a low probability of health effects to the skin.**

  For any detectable level of contamination using a portal monitor, an area can be calculated, which if contaminated to that level for a specified extended period of time, a particular health effect to the skin will occur. Therefore, reducing the size of the assumed area which might get contaminated simply reduces the probability that the effect will occur. The probability of 10 percent or more of the total contamination being concentrated into an area smaller than indicated in Table 1 is indeterminate but is assumed to be extremely remote. This remote chance of occurrence and small area of effect are used in lieu of the principle of keeping the dose below the threshold for deterministic health effects. This Standard strikes a balance between risk of health effects and the potential need to complete screening of large numbers of evacuees for contamination in a short period of time.

- **Threshold values for deterministic health effects were selected as the lower end of ranges of values given in the literature.**

  Except for the case of hot particles, the threshold dose values for specific deterministic health effects vary from one literature source to another. The range of threshold dose values for a particular health effect may vary by up to a factor of 4 depending on the literature reference used. Since erythema is not considered to be a health effect, a median value was used instead of the lowest value as was used for the deterministic health effects. For acute exudative radiodermatitis, the controlling health effect, the threshold dose values in the literature vary from 1200 to 2000 rem. Use of the 1200 rem value introduces the possibility of a small conservatism in the 1 μCi standard.

- **The time period of exposure is assumed to be fourteen (14) days.**

  It has been assumed that persons who have been in areas where evacuation would have been justified based on total effective dose equivalent (TEDE), and who have been monitored and contamination was not detected, will be advised to wash and change clothes at their first opportunity and preferably within 24 hours after being monitored. Since emergency response plans call for completion of the monitoring within about 12 hours of all residents and transients in the plume exposure emergency planning zone arriving at relocation centers, the total duration of exposure to loose contamination is assumed to be 36 hours or less. This appears to be conservative for most evacuees because monitoring,

bathing, and changing clothes will likely take place within about 36 hours. However, these actions may take longer for some evacuees because of the time needed to set up monitoring centers and because of lack of opportunities for them to bathe and/or lack of available uncontaminated clothing. However, this is not a problem since the standard is based on fixed contamination with an exposure time of 14days.

The assumption of removal of fixed contamination by normal skin replacement within approximately 14 days is a conservative assumption. Since skin replacement is a gradual process (not a step process that happens at the end of 14days), the average contamination level over the period will be much less than the initial level. This effect is also enhanced by radioactive decay of short lived radionuclides. Radioiodines are expected to be the primary source of potential **fixed** contamination if the contamination is directly on the skin, due to the ability of the skin to absorb them. Their half lives range from a few hours to about 8 days. Therefore, the exposure rate would decrease significantly over a 14 day period.

Although none of these separate processes can be predicted accurately, when combined, they will **significantly** reduce the dose to the skin. These factors contribute to conservatism in the analysis.

- **Hot particles are assumed to be removed by washing.**

  The accuracy of this assumption is unknown. However, even if they are not removed by washing but remain until skin replacement in 14 days, they still would not be the controlling exposure pathway. Referring to Table 1, the MDL for hot particles as fixed contamination is not shown. However, the calculated value for total body contamination is 2.3 μCi, which is higher than the 1 μCi chosen for the Standard.

- **Ability to detect one or more cesium-137 sources with a total activity not in excess of one microcurie placed at locations along the centerline between the two columns of a portal monitor may be used to confirm compliance with the standard of one microcurie of widespread non-uniformly distributed contamination on an individual.**

  Although experiments have not been conducted to confirm this assumption, it is believed to be slightly conservative for a portal monitor that sums the counts from all detectors to a single alarm point. The conservatism comes from the fact that, for widespread contamination, the average distance from the various detectors to the contamination would be less than the average distance from the detectors to the centerline. This relationship will vary among portal monitor designs. For example, this is believed to be a liberal

assumption for portal monitors that do not sum the counts from all of the detectors.

Based on the above assumptions, the threshold minimum detectable level for maintaining **risk of radiation effects to the skin, including health effects, within established guidelines is 1 µCi**. Due to the above mentioned conservatisms in this evaluation, the selection of 1 µCi as the standard for the minimum detectable level of a portal monitor will provide an adequate margin of safety for emergency response.

CONCLUSIONS:

The only way for the skin to receive the high dose that is needed to cause health effects from an undetectable amount of radioactive contamination on an individual by a portal monitor that meets the above Standard, would be for a significant fraction of the total radioactive material on the skin and clothing to be concentrated on a small area of skin. If the effects should occur from activity not detected by a portal monitor that meets the Standard, the size of the affected area would be so small as to be of minor or no medical consequence.

An individual who is evaluated for contamination using a portal monitor in accordance with recommendations in this document and one that meets the detectability criterion in the Standard **will have no significant increase in risk of acute exudative radiodermatitis or other health effects** from radiation exposure from undetected contamination on the skin and clothing. During the **early phase** of the emergency, this level of detection **will be adequate** for the screening of **evacuees and emergency workers** for radioactive contamination.

Table 1

DERIVED MINIMUM DETECTABLE LEVELS FOR HEALTH EFFECTS

Condition	Assumed Maximum Acceptable Area[a] of the Condition from Undetected Contamination	Derived Minimum Detectable Level (μCi)			
		Small spot of Contamination		Total Body Contamination	
		loose[b]	fixed[c]	loose[b]	fixed[c]
Acute Exudative Radiodermatitis	0.2 cm 2	0.9	0.1	9	1
Ulceration with Fibrosis	0.2cm2	4.3	0.46	43	4.6
Ulceration from a Hot Particle	N.A.[d]	2.1	N.A.[d,e]	21	N.A.[d,e]
Erythema	5 cm 2	9.7	1.0	97	10
Skin Cancer	N.A.[d]	N.A.[d]	15	700	75

[a] The derived minimum detectable levels are based on 10 percent of the total activity on an individual being confined to an area of this size with 90 percent being widespread on other parts of the skin and clothing.

[b] Loose contamination that is not detected by monitoring is assumed to be removed by bathing within 36 hours after its deposition on the skin.

[c] Fixed contamination is assumed to be removed by natural processes within 336 hours (14 days) after deposition on the skin.

[d] N.A. means not applicable.

[e] Hot particles are assumed to be removable by bathing (i.e., loose contamination).