Alpha Monitoring and Control for Radiation Protection Technicians

Estimated Time to Complete: 1.0 Hour

Revision 1.00
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It Could Happen

During work on primary system piping at a nuclear plant not too far away, workers were milling the ends of components in preparation for welding.

The area was set up for the work. Engineering controls were in place, the milling tool was in an enclosure, and this work had been completed at the other unit without incident.

Air samples taken during the first 24 hours of work identified particulate airborne activity from cobalt-60, so a tent was built around the work area.

This job resulted in sixty workers receiving greater than 200 mrem, including one worker who received 1.6 rem as a result of alpha uptakes.

It Did Happen

Throughout this course, when you see this button, click it for more information regarding the event just described. *Try it now*. (Note: This is required content)

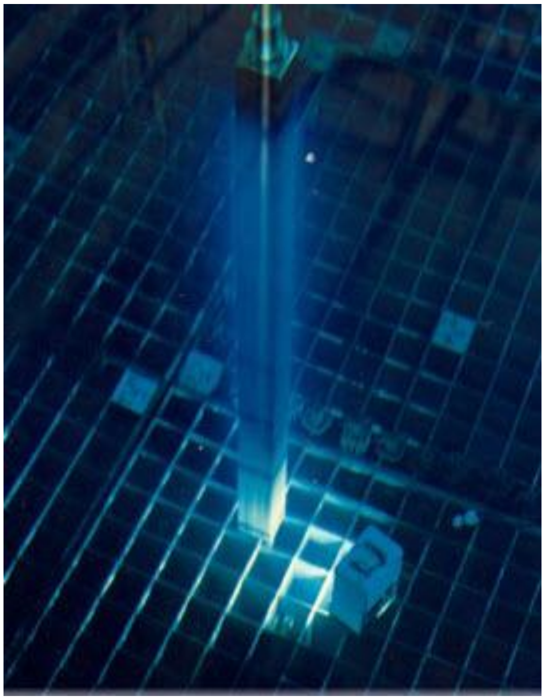
So, what went wrong?

As you go through this course, you will find answers to this question. At the end of the course, you will understand the causes and contributing factors associated with this event.

Throughout this course, when you see this button, Look for more information regarding the event just described. in the outlined boxes

Information in this box will show how the displayed information relates to the event you just read about.

Introduction



Fuel assembly being moved

Every nuclear plant has alpha, even those who "haven't had" fuel failures. In the past, the criteria for fuel failures allowed for a small number of fuel rod leaks. Although the threshold for fuel failures, by definition, was not reached, alpha particles were distributed throughout the primary systems. How much alpha does your plant have?

Your role as a radiation protection technician is critical to identifying alpha hazards, planning for work in areas where alpha contamination or airborne radioactivity exists, and implementing best practices for control of the hazard and protection of the worker.

There will be site-specific guidance on how to implement the alpha monitoring program at your site.

Main Menu

The EPRI publication, *Alpha Monitoring and Control Guidelines for Operating Nuclear Power Stations, Revision 2*, provides a risk-informed approach to alpha monitoring and control.

This course, in addition to any site-specific training, will prepare radiation protection technicians for implementing appropriate alpha controls.

Choose a topic below to begin. You must complete all sections in order to complete the course.

Fundamentals of Alpha	Defining and Monitoring	Work Controls	When Things Happen	Checking your Knowledge

Fundamentals of Alpha

Representation of fuel assembly with fuel pellets

The primary source of alpha emitters is from fuel pin cladding defects. It is important to know the complete history of fuel failures at your site. Remember, early fuel cladding failures may not have met the strict definition of "fuel failure" at the time.

Any time work is done on primary systems and components, assume alpha is present and monitor appropriately.

Fundamentals of Alpha

Alpha contamination survey instrument

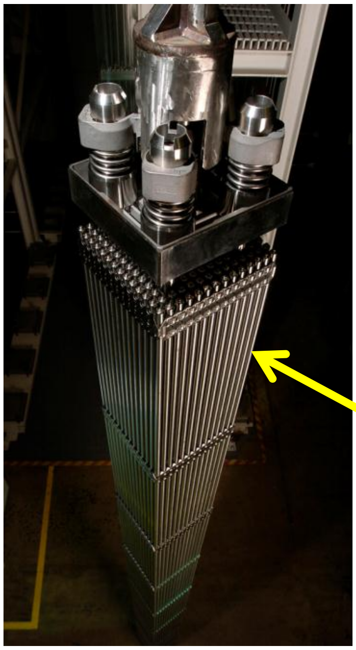
The internal dose from alpha is 1,000-10,000 times the dose from the same beta-gamma activity.

Detection of significant levels of alpha activity can be more difficult than detection of beta-gamma and requires special instrumentation. This is because alpha is easily attenuated.

Assume alpha may be present although the levels may be too low to detect.

Fuel Defects

Short-Term Impact



Fuel assembly

Fuel pin defect

Plants with fuel cladding defects or events involving fuel in the reactor usually have higher radiation, contamination, and/or airborne radioactivity levels as a result.

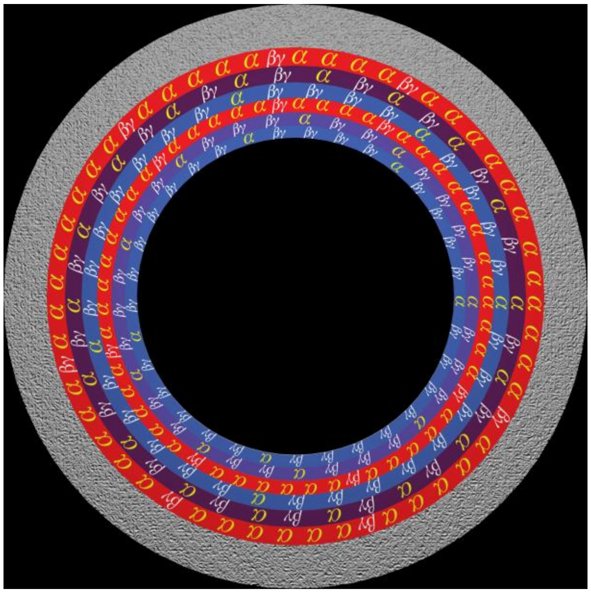
High levels of beta-gamma activity may hide alpha activity in oxide layers or loose in the system.

This means although alpha may be present, it may be attenuated and not detectable.

This means appropriate alpha monitoring methods should be used.

Fuel Defects

Long-Term Impact



Cross-Section of Primary Piping

In the referenced OE, the plant had fuel failures 25 years ago.

Close

Most alpha emitters are long lived *(for example, Americium 241 with a half-life of 432 years)* and will not be removed by decay. The beta-gamma to alpha ratio will decrease over time as the beta-gamma decays and the alpha remains.

As the beta-gamma hazard decreases, actions to protect workers from the beta-gamma hazard may not be adequate to protect them from the alpha hazard.

ALI and DAC for Long Lived Isotopes

Although alpha emitting nuclides are not encountered as often as beta-gamma, smaller amounts create significant radiological hazards and can result in significant dose to workers.

Radionuclide	ALI Ingestion (µCi)	ALI Inhalation (µCi)	DAC (µCi/ml)
Cs-137	1E+2	2E+2	6E-8
Co-60	2E+2	3E+1	1E-8
Sr/Y-90	3E+1	4E+0	2E-9
I-131	3E+1	5E+1	2E-8
Pu-238	9E-1	7E-3	3E-12
Pu239/240	8E-1	6E-3	3E-12
Am-241	8E-1	6E-3	3E-12
Cm-242	3E+1	3E-1	1E-10
Cm-243/244	1E+0	9E-3	4E-12

This graphic shows orders of magnitude between ALI and DAC values
for alpha emitters (shaded in yellow) and beta-gamma emitters (circled).

This is why alpha contamination has a more restrictive Derived Air Concentration (DAC) and Annual Limit on Intake (ALI). Careful monitoring of work areas is required when alpha is present.

In the referenced OE, the reactor had been shut down for 10 years. Beta-gamma contamination levels were <20,000 dpm/100cm2 but the alpha contamination was not monitored.

Close

Knowledge Check

Which of the following systems would be most likely to present an alpha radiation hazard? *Click on your choice.*

Primary System

Service Water System

Cooling Tower Makeup System

Component Cooling Water System

That’s correct. All systems associated with the fuel (primary systems) are most likely to contain an alpha hazard.

Fundamentals of Alpha Summary

- Alpha emitting nuclides are mostly associated with nuclear fuel and the primary systems most closely associated with it.

- The internal dose from alpha is 1,000-10,000 times the dose from the same activity of beta-gamma emitting radionuclides.

- Detection of significant levels of alpha activity can be more difficult than detection of beta-gamma because alpha is easily attenuated.

- Monitoring for alpha requires special instrumentation.

Characterization of Source Term

Characterization of the alpha source term at a nuclear power plant includes:

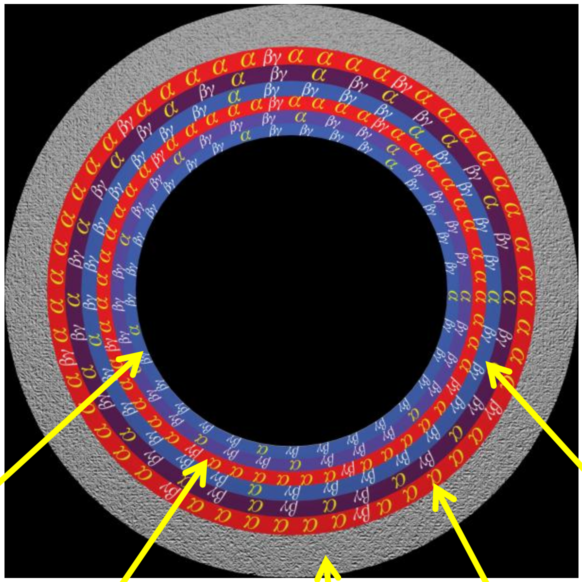
- Knowing the history of fuel cladding defects to identify transuranic activity in oxide layers of primary system components or associated systems
- Determining the distribution of alpha-emitting radionuclides in loose surface contamination or airborne activity, when detected
  NOTE: *If you find alpha on smears, keep them for further analysis. Don't throw them away.*
- Calculating beta-gamma to alpha ratios in loose contamination or in airborne activity
- Identifying alpha contamination levels in plant areas and systems

Oxide buildup on old component

Oxide layers in piping and components are relatively fixed, but can be disturbed by work activities. If work will disturb the oxide layer, smears taken before work began are no longer valid. Job coverage smears should be taken to verify actual work conditions.

EPRI guidelines recommend plants assume fuel failure since past practice has been to allow for a small percentage of fuel leaks prior to calling an event "fuel failure."

This exaggerated graphic shows the buildup of oxide layers inside primary system piping over time.



Cross-Section of Primary Piping

What Does Characterization Tell You?

Level II Posting

Typically, the action levels and job controls to protect the worker from the beta-gamma hazard are sufficient to also protect the worker from the alpha hazard.

Characterization is a starting point for alpha control. However, the assumption that the alpha hazard is properly identified and controlled is challenged when the activity ratio is low (i.e., the concentration of alpha is higher).

the relative abundance of alpha compared to beta-gamma contamination as determined with a frisker, ion chamber, counter or gamma spectroscopy.

$$\text{Activity ratio} = \beta\gamma \div \alpha$$

Activity Ratio

Activity ratios are significant to determine whether radiological work controls are appropriate and are defined as:

Activity Ratio = $\beta\gamma \div \alpha$

as determined with a frisker, ion chamber, counter, or gamma spectroscopy.

The activity ratio determines the "alpha level" for work area characterization.

Contrary to current thinking about contamination (where higher contamination levels represent greater hazard), it is important to note that the **higher the activity ratio, the lower the alpha hazard**.

Activity Ratio ($\beta\gamma/\alpha$)	LEVEL I AREAS (Minimal)	LEVEL II AREAS (Significant)	LEVEL III AREAS (Elevated)
	>30,000	30,000 - 300	<300

In the referenced OE, the actual activity ratios found in the contamination on equipment and components that had been shut down for an extended period differed largely from those commonly found at the plant. This contributed to the poor assumptions about the potential for the alpha contamination on the old system.

Depending on the area classification, there are recommended minimum actions for monitoring alpha.
Each of the highlighted areas is explained in more detail below.

Activity Ratio (BG/A)	Level I Areas (Minimal) >30,000	Level II Areas (Significant) 30,000 - 300	Level III Areas (Elevated) <300
% dose from alpha in inhaled material	< 10	10-90	>90
DAC Fraction Ratio (a/bg)	<0.1	0.1-10	>10

In Level I Areas where alpha contamination is expected to be minor, verify by alpha counting representative smears (number and location) for areas or components with >100,000 dpm/100cm² .

If any of these smears show alpha contamination levels >100 dpm/100 cm^2, additional smears need to be counted to determine the magnitude and extent of the alpha contamination in the area.

Air samples greater than 1 DAC should be counted for alpha or use CAMs.

In Level II Areas, count representative smears for alpha activity when the beta-gamma contamination exceeds 20,000 dpm/100 cm^2, or when loose contamination levels may change.

If any of these smears show alpha contamination levels >100 dpm/100 cm^2, additional smears need to be counted to determine the magnitude and extent of the alpha contamination in the area.

Air samples >than the beta-gamma DAC fraction action level should be counted for alpha or use CAMs which can detect alpha.

In Level III Areas, a sufficient number of smears should be alpha counted to adequately evaluate the magnitude and extent of the alpha contamination.

All air samples should be counted for alpha, or use Continuous Air Monitors (CAMs) capable of direct alpha activity measurements at 0.3 DAC.

Percent Dose
In an area where loose contamination has a beta-gamma to alpha ratio of >30,000:1 (a Level I area), the primary hazard is beta-gamma.

In a Level II area, the alpha hazard can range between 10% and 90% of the dose, if inhaled. For level II areas, the relative radiological hazard contributed by alpha can be quantified. For example:

Level II Activity Ratio	Percentage Hazard due to Alpha
30,000	10%
3,000	50%
300	90%

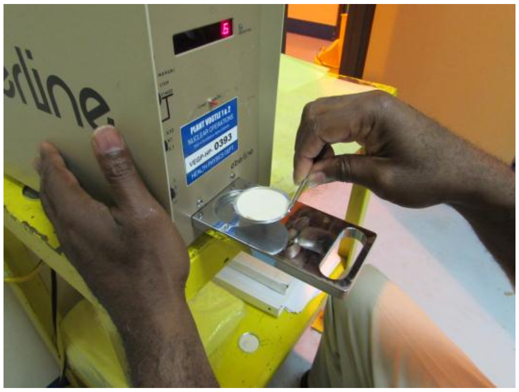
The lower the activity ratio, the higher the relative radiological hazard contributed by alpha contamination. depending on the actual ratio within this category, the main radiological hazard may be alpha or beta-gamma

In an area where loose contamination has a beta-gamma to alpha ratio of <300:1 (a Level III area), the primary hazard is alpha.

Dac Fraction Ratio
Analysis of air sample data can also provide additional support to the classification through comparison with the DAC fraction ratio shown here.

The activity ratio is used only for the purposes of identifying the relative alpha hazard of loose contamination in an area compared with beta-gamma. ***This classification alone does not determine work controls***. The actual activity ratio for the job at hand and many other factors such as wet work, tools used, etc., determine the work controls.

An Example of Classification



Counting smears with a scaler

When taking a contamination survey in a Level I alpha area, the general contamination levels in the area are between 10,000 and 20,000dpm/100cm^2 beta-gamma.

However, you find 150,000 dpm/100cm^2 beta-gamma on a valve bonnet.   According to the EPRI guideline, you count the smear for alpha contamination and find 50 dpm/100 cm^2 alpha.   This will result in an activity ratio of 3,000.

From the previous table, the area would now be a Level II area and additional smears would be warranted.   It's important to note that based on this ratio, 50% of the radiological hazard will be from alpha.

Notify RP supervision of your survey results.

Operating Experience-Another Example

In 2011, disassembly of a low pressure safety injection (LPSI) pump impeller, contamination survey results showed levels of 40,000 dpm/100cm^2 beta-gamma and 500 dpm/100cm^2 alpha. Both of these levels were within the limits of the RWP for the job. (RP did not recognize the *80:1 activity ratio*, which would have required Level III controls).

During the next shift, work on the impeller in another area (already a level III area due to other work) resulted in beta gamma contamination levels of 100,000 dpm/100cm^2 and alpha levels of 2,083 dpm/100cm^2. RP did not recognize the alpha levels were above the RWP limits, nor did they recognize the *48:1 activity ratio*.

Lapel air sample results from the previous shift revealed 24 DAC alpha. However, work continued until the RP manager was notified of radiological data near the end of the shift.

The RP manager issued a formal stop work order for the LPSI pump work.

Reference: OE 33431

Action Levels

Hand-held alpha contamination monitor

The levels of loose surface contamination used to determine the classification, the type of work being performed and the nature of the contamination (oily, wet, dry, etc.) are used to predict potential airborne radioactivity levels and prescribe appropriate work controls.

A minimum guide to assist with determining the extent of alpha monitoring required based on the classification of the area is included as an attachment at the end of this lesson.

Conduct alpha contamination and airborne activity monitoring as necessary ***according to station procedures***.

Knowledge Check

Your pre-job survey indicates 60,000 dpm/100 cm2 beta gamma and 20 dpm/100 cm2 alpha.   What is the beta-gamma to alpha ratio?   *Click on your choice.*

3000

300

3.30

33,000

That’s correct.   60,000 divided by 20 is 3000.   Also, a ratio of 3000 means that alpha contributes 50 per cent of the dose to the individual.

Which level classification would this area be? *Click on your choice.*

Level II

Level I

Level III

That’s correct.   Level II has a wide range of 30,000-300 for activity ratios.   It is important to remember that because of this wide range, alpha activity can account for between 10% and 90% of worker dose.

Knowledge Check

Which of the following has the most potential for significant alpha hazard?
Click on your choice.

Level II with activity ratio of 350 and < 0.3 DAC

Level I with activity ratio of 35,000 and <0.3 DAC

Level II with activity ratio of 20,000 and <0.3 DAC

Level I with 0.3 DAC

That's correct. Level II areas represent significant alpha hazards. The lower the ratio in level II, the more significant the alpha hazard.

Defining and Monitoring Alpha Hazards - Summary

In this section, you have covered the following information:

- Assume alpha is present for primary system work, and plan work accordingly.

- Oxide layer build up on primary system internals can attenuate long lived alpha hazards

- Characterizing alpha hazards includes:
  - knowing the history of fuel cladding defects
  - understanding the distribution of alpha emitting radionuclides in loose surface contamination or airborne activity
  - calculating activity ratios in loose contamination or in airborne activity
  - identifying alpha contamination levels in plant areas and systems.

- The activity ratio is determined using the following equation: $\beta\gamma \div \alpha$

- The activity ratio determines the alpha level for site characterization. It is important to note that the higher the activity ratio, the lower the alpha hazard.
  - Level I (Minimal hazard) >30,000
  - Level II (Significant hazard) 30,000-300
  - Level III (Elevated hazard) <300

- Contamination and airborne survey requirements are defined by the alpha action levels.
- Work controls will be assigned according to the work being done, the RWP, and/or the ALARA job plan.

Operating Experience

After insulation removal from primary component piping during a refueling outage, an old leak was discovered. Before work began, the area was decontaminated using generic industrial cleaner.

The decontamination effort had apparently removed the surface oxide layer, revealing underlying alpha contamination.

	Pre-decon contamination levels (dpm/100cm^2)	Post-decon contamination levels dpm/100cm^2
	60,000	22,000
	43	104

Work Controls in Alpha Areas

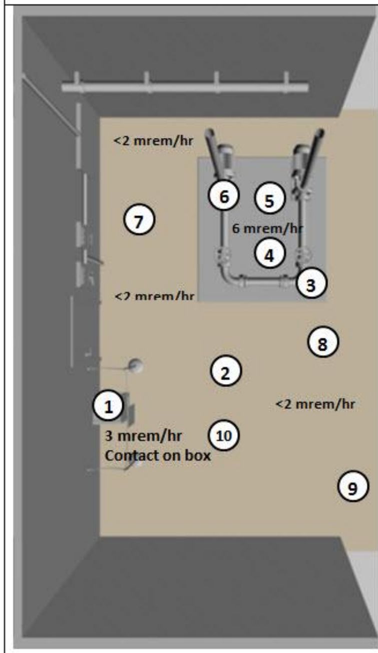
Hepa ventilation used as engineering work controls

Work controls are used so that each job can be completed efficiently with minimal overall radiological risk and keeping total effective dose equivalent (TEDE) ALARA.

Ideally, work should be planned to avoid the risk from alpha contamination. When this is not feasible, engineering controls should be considered to contain the alpha hazard.

Risk Assessment

Survey: 10594 Page 1
Location: Unit 1 LPSI



Smear Data (DPM/cm²)

#	Beta/ Gamma	Alpha
1	15k	30
2	5k	<20
3	70k	30
4	3k	<20
5	2k	<20
6	6k	<20
7	<1k	<20
8	<1k	<20
9	<1k	<20
10	<1k	<20

Survey Data

Unit:	1
Building:	SEB
Elevation:	368
Room:	LPSI
Survey Date:	09/30/14
Survey Time:	0600
RWP:	14-0002
Surveyed By:	Ima Tech
Reviewed By:	I.N. Charge

NOTE: Smear 1 on top of box posted as alpha level III

Example of Survey containing alpha activity

When planning work on primary system components, a risk assessment should begin by assuming alpha is present. Pre-job surveys should not only consider the contamination levels, but also the work environment.

For example, an area with 100 dpm/100cm² alpha contained in dirt or dust may pose a greater threat to worker exposure than 3,000 dpm/100cm² alpha contained in an oily film.

Work controls should be based on a number of factors, not solely the classification of the work area (Level I, II or III). ALARA reviews, RWPs, and work order planning should always address the presence of alpha.

Risk Assessment

Work spaces often contain physical or environmental limitations

Also, evaluate alpha hazards when receiving contaminated equipment from another site or a vendor and when removing equipment from long term radioactive materials storage areas.

In addition to the most recent alpha characterization (Level I, II, or III), technicians should:

- review relevant job history files
- have a working knowledge of the task being performed
- understand the methods being used to accomplish the task
- have knowledge of the physical characteristics and limitations of the work area

Re-Suspension of Alpha Contamination

Grinding can disturb oxide layers

Grinding, welding, decontamination, sanding, cutting, the use of volatile chemicals on primary systems are examples.

Close

Operating experience has also shown that alpha contamination might be shielded by dirt, dust or corrosion, and activity levels could be higher below the surface.

Aggressive surface destructive work can cause re-suspension of contamination by disturbing the oxide layer on the surface of the material/component. If systems are suspected of having alpha contamination indicated by the site characterization and aggressive surface destructive work is to be conducted, fixed alpha contamination should be assumed to be present.

In the referenced OE, preparation of the primary piping required milling and grinding.

Close

Re-Suspension of Alpha Contamination


Grinding and cutting can disturb oxide layers in piping

Aggressive work on plant systems where initial surveys do not show alpha activity should be monitored closely.

Job coverage air samples and smears should be counted to detect any re-suspension of long-lived alpha from oxide layers once work has begun. Periodically re-sample until the work is complete.

Work Planning

Involve work groups in planning for alpha-related work

Planning should be more rigorous for alpha-related work. Consider the following:

- Involving the work group in the planning process
- Reviewing the potential for spreading alpha contamination and the risk this poses to the workers and others in the area.
- Identifying the potential for re-suspension of activity from the surface based on condition of the system (wet/dry), type of work, tools used, or engineering controls.

Most unplanned alpha exposures result from unexpected airborne activity caused by re-suspension that results from a change in job scope not previously reviewed with RP. An example would be using a new tool not evaluated as part of the work plan.

Traditional Work Controls

Traditional work controls often provide worker protection from alpha contamination. Sometimes these controls need to be adjusted or expanded.

Stop Work Controls

Stop work upon:

- Suspected uptake based on contaminated wound
- Alpha levels not covered in RWP/ALARA planning documents or not discussed during the ALARA and pre-job briefings
- When in-progress survey results (i.e. contamination swipes or air samples), change the initial alpha level to a higher level (such as from Level I to Level II)

Materials and Equipment Monitoring

Equipment and materials exiting Level III areas should be properly labeled.

Segregate equipment and materials exposed to a beta-gamma to alpha activity ratio ≤ 50:1 until surveys or assessments are performed to release the items from alpha controls.

Personnel Monitoring

Personnel should be evaluated and surveyed for alpha contamination when exposed to beta-gamma to alpha activity ratios of ≤ 50:1 according to the job work plan.

Because alpha monitoring equipment may not detect very low levels of alpha contamination, frisking needs to be conducted carefully and slowly to properly detect contamination at the lower levels of detection of the equipment.

Radiological Briefings

Briefings should discuss the unique aspect of the alpha hazards and controls for the specific task/work activity as described in the ALARA plan, RWP or work instructions for alpha Level II and III areas. This should include communicating to workers the hold points and stop work expectations.

Radiological Postings

Alpha Level III areas shall be clearly posted to inform workers and radiation protection technicians of this condition.

Posting of areas with a beta-gamma to alpha ratio of ≤ 50:1 shall contain similar words **"alpha frisking/monitoringis required upon exit".**Alpha Level II or alpha Level I areas may be posted at the discretion of the plant.

Alpha Contamination - Air Sampling

Some CAMs are able to monitor alpha activity

To ensure adequate alpha monitoring of the area:

- General area air samples should be sufficient volume and count time to detect 0.3 DAC alpha for posting.
- Personal air samplers are not substitutes for general area alpha airborne monitoring and are not used for posting airborne radioactivity areas.
- Minimize filter loading which may shield the quantity of alpha contamination present.
- Consider additional air samplers such as boundary air samples, air samples outside the immediate work area, or back up GA samplers to verify the integrity of engineering controls, if used.
- If available, alpha continuous air monitors (CAMS) provide early warning to personnel in and around the work area of increased alpha activity.

In the referenced OE, contamination controls were not sufficient to prevent exposure to workers outside the immediate work area.

Personal Air Sampling (Individual Monitoring)

Personal air samplers are used as dosimetric devices

Personal Air Samplers (PAS) used as individual dosimetric devices are preferred for monitoring workers in areas of airborne alpha activity.

PAS should be issued to measure the intake of activity for work in Level III areas.

In Level II areas where aggressive work is being done and/or the ratio of beta-gamma to alpha indicates that alpha may be a significant contributor to the airborne hazard, PAS should be issued.

Verify exceptions with RP supervision and site procedures before not prescribing PAS.

All personal air samples should be counted for alpha activity.

Personal Air Sampling (Individual Monitoring)

Breathing zone air sampler

Air sampling from the breathing zone provides reasonable indications of what the worker has breathed. The location of air samples is important for the evaluation of potential exposure to airborne radionuclides.

A breathing zone air sample is one taken within a 25 cm radius (10”) of the worker's nose and mouth, usually with air sampling filters attached to the collar or lapel.

NOTE: Fixed air samplers are not used for breathing zone samples because they can under or overestimate personal exposures by factors that range from 100 to 1,000.

Personal Air Sampling (Individual Monitoring)

Sites should obtain a lower limit of detection (LLD) of 10 mrem committed effective dose equivalent (CEDE). The results from PAS can be used to determine individual intake and dose from routine work activities.

Whenever a PAS indicates a potential exposure may unexpectedly exceed the screening level of 10 mrem committed effective dose, action should be taken to confirm the extent of exposure.

Where PAS results indicate potential exposures exceed the verification level of 100 mrem committed effective dose, excreta measurements should be used to investigate and determine the alpha intake.

This can be ensured by having adequate background and/or sample count times.

Further, PAS should not be pulled and counted repeatedly during the job. Instead, use grab sampling results to verify air activity.

Alpha Contamination - Radon Interference

Alpha activity on air samples from naturally occurring radon gases can interfere with the initial evaluation of alpha activity from the long-lived alpha emitters of interest. Do not underestimate the presence of long-lived alpha emitters by assuming the presence of naturally occurring decay products.

Delaying the alpha analysis of air samples for 4-hours is sufficient to allow for a significant fraction of the natural radioactivity (radon, thoron decay daughters) to decay. Longer delay times are needed to allow for complete decay.

Alpha Contamination - Compensating for Radon Interference

In order to compensate for the decay of the short-lived radon progeny, the *background or half-life methods, or the use of gamma spectroscopy, and portable alpha counters.*

While these methods can validate that radon daughters are present, they may not be adequate to validate if there is (or is not) long lived radioactivity present.

The "Background Method" requires 2 air samples. One sample taken before work activities begin is the background, and a second air sample during the work.
(NOTE: These samples should be taken using the same type air sampler and same volume)

The "Half-life Method" compensates for radon by counting a single job coverage air sample twice. The first alpha scaler count starts > 4 hours after the end of sample collection to ensure the contribution from 222Rn is negligible. The second alpha scaler count is performed approximately 18 hours after the first count. Use the following calculation when using this method.

$$A_{LL} = \frac{\left(A_{t_2} - A_{t_1} e^{-\lambda \Delta t}\right)}{\left(1 - e^{-\lambda \Delta t}\right)}$$

where:

A_{LL} - long-lived alpha activity

A_{t_2} - Activity at time 2

A_{t_1} - Activity at time 1

Δt - time between the 1st and 2nd count (same units as the inverse of λ)

λ – radiological decay constant for $^{212}Pb = \frac{\ln(2)}{10.64\ hr} = 0.0651\ he^{-1}$

Make sure the decay times for the background and job coverage air samples are the same. (Decay time is the time between the *end of sample collection* and the *start of an alpha scaler count*.

Gamma spectroscopy will see Am_{241} but it won't see other alpha emitters. Just because you don't see Am_{241} you can't rule out the presence of alpha.

Many sites use portable alpha counters with the capability of discriminating between both radon and thoron and their daughters from transuranic and fission product materials. Portable alpha counters are the preferred because of their ability to determine the presence of long-lived alpha nuclides.

The methods to discriminate naturally occurring radioactivity interference will be defined through site specific guidance.

Knowledge Check

The half-life method compensates for radon by counting a single air sample twice. The first alpha scaler count starts approximately _________ after collection and the second alpha scaler count is performed ________ hours after the first count. *Click on your choice.*

4 hours, 18 hours

2 hours, 6 hours

3 hours, 8 hours

6 hours, 24 hours

That's correct. Four hours is sufficient for decay of a significant fraction of naturally occurring radon and it's daughters.

Work Controls - Summary

- A graded approach to risk assessment to identify the radiological hazards of the work activity should be conducted prior to initiating the work.

- Include work group planning and determine the potential for re-suspension of alpha activity at the work site

- Traditional work controls such as stop work controls, material and personnel monitoring, and radiological briefings and postings often need to be adjusted or expanded due to alpha hazards. Additional work controls may include:
  - Use of glove bags, localized use of HEPA units, frequent taking of smears, specific hold points during work progression for alpha monitoring, etc.

- Considerations for job coverage air sampling in the work area include:
  - Sufficient sample volume/count time to detect 0.3 DAC alpha
  - Prevent filter loading due to dust or debris
  - Radon (short-lived activity) compensation

- Alpha activity on air samples from naturally occurring radon gases can interfere with the initial evaluation of long-lived alpha activity. To compensate for decay of the short-lived radon progeny, the *background* and the *half-life* methods may be used.

- PAS should be issued as dosimetric devices to measure the intake of activity for work in Level III areas.

- Aggressive work in Alpha Level II areas can contribute significantly to the alpha hazard. Alpha can contribute up to 90% of total dose in Level II areas.

- Exceptions to use of PAS should be approved by RP supervison. The use of PAS is not a substitute for general area alpha airborne monitoring. PAS should not be used for posting purposes.

- Alpha Level III areas shall be posted to inform workers and RP technicians of this condition. Posting for areas with activity ratios of $\leq$ 50:1 shall contain similar words that "**alpha frisking/monitoring is required upon exit".**

Internal Exposure Pathways

Loose or re-suspended contamination can be an internal dose hazard because you can *inhale it* (breathe it in). This is the most common way radioactive material enters the body.

However, radioactive material can also enter your body through *ingestion* (eating, drinking, chewing) or *absorption* (absorbing through the skin), through *open wounds or sores.*

Radioactive material can enter the body and result in radiation exposure to internal organs.

Operating Experience

Workers removing items for disposal from the spent fuel pool (SFP) removed a start-up source holder which was not included in the SFP inventory. Radiological surveys indicated relatively low gamma dose rates. However no neutron survey was completed to verify a neutron source was not present.

A small section of the source holder was cut out to remove a 2 R/hr hotspot. Controls and survey methods for beta-gamma contamination were used, but no alpha surveys were completed.

The cut-out was completed, the work area decontaminated, and the workers cleared the RCA without personnel contamination alarms.

Air samples counted the following shift showed negligible beta-gamma airborne concentrations. However, Am-241 was detected. Am-241 was not included in the automatic MPC calculations since it was a nuclide not normally seen at the station and was not questioned by count room personnel. This resulted in high alpha airborne concentrations going unnoticed.

Additional follow-up area contamination surveys were completed because of the previous day high contamination work and discovered extensive alpha contamination spread throughout the work area, step-off pad, most of the refuel floor and overhead crane.

Several workers were subjected to extensive bioassay monitoring with a health physics technician receiving a minor uptake of Am-241.

Contributing causes to this event included:

- An accurate inventory of the spent fuel pool was not available and the source inventory was deficient (the source was received in 1978 and never added to the inventory).
- Insufficient radiological surveys completed due to non-conservative decision-making and proceeding with work in the face of unexpected and unknown radiological hazards.
- Plant procedures and processes did not sufficiently address potential contamination from transuranic elements.

Indications of Potential Intake

Contamination monitor alarms should be evaluated for alpha contamination when exiting alpha work areas

Where radiological conditions indicate that a worker may have been exposed to unexpected airborne alpha concentrations or to an unplanned intake of alpha emitting nuclides, an investigation into the extent of exposure should be initiated.

Examples of these conditions include the following:

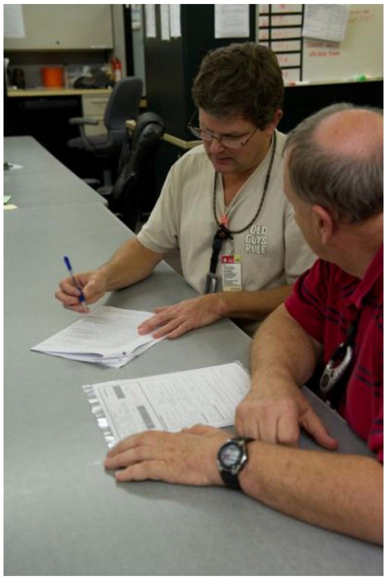
- Facial beta-gamma contamination or a positive nasal swipe of a worker that worked in an area with alpha contamination.
- Personnel beta-gamma contamination monitor alarms without the confirmed presence of external contamination when activity ratios indicate there may be alpha contamination present

Note: site procedures will define the investigative process for potential alpha uptakes.

Other Indications of Potential Intake

- Alpha contamination monitoring results in a work area are higher than expected
- Personnel contamination surveys indicate the presence of alpha contamination on the hands or face
- Personal air sampling results indicate alpha airborne activity
- General air sampling results indicate alpha airborne activity directly or by activity ratios
- A wound sustained in an area or from an item where activity ratios or alpha monitoring indicates the presence or possible presence of alpha contamination
- A person has a positive whole body count following work in a known alpha area

Investigating Potential Intakes



Gather appropriate data for investigating potential uptakes

When investigating for potential alpha uptake, include the following steps:

- Notify RP supervision
- Gather all relevant data concerning the event such as air sample results and contamination levels for workers and the work area, activity ratios and any other related information
- Estimate the potential dose to the worker from the event

Remember, fixed air samplers can underestimate personal exposures by factors that range from 100 to 1,000.

Investigating Potential Intakes

Further individual monitoring can be initiated using a graded approach, depending on the potential dose to the worker as shown in this table. Dose received is recorded in the individual's dose record.

Potential Dose [1]	Definition[8]	Action	Techniques which can be used
> 10 mrem CEDE	Screening Level	Confirm dose by other means	Whole body counting, PAS, or excreta measurements
> 100 mrem CEDE	Verification level	Validity of dose assignment to be confirmed by individual monitoring[2]	Excreta measurements are preferred technique[3]
> 500 mrem CEDE	Investigation level	Individual measurements must be taken to define the dose more accurately	Extensive excreta sampling should be conducted[3]

Individual monitoring requirements based on potential dose
Source: EPRI Alpha Monitoring and Control Guidelines for Operating Nuclear Power Stations, Revision 2

Excreta sampling is used to confirm the magnitude of the intake when the potential dose to the individual cannot properly be determined or remains uncertain.

Excreta sampling consists of samples and follow-up samples of fecal matter and/or urine for analysis.

Excreta Sampling

Excreta samples may be used to determine an intake from alpha emitting nuclides following a suspected exposure. High results on an air sampler or PAS, high alpha contamination monitoring results or from a contaminated wound may indicate potential exposures that exceed the verification level.

Refer to site excreta sampling program for more details and direction.

Whole Body Counting

Whole body counters don't detect alpha contamination

Whole body counting (WBC) is used for estimating a worker’s intake from gamma emitting radionuclides. However, most alpha emitting radionuclides are not accompanied by gamma photon emissions with sufficient energy to be detected by whole body counting.

Depending on the significance of the suspected uptake, alpha can be scaled in to WBC results based on job air sample and smear survey results.

Just because the WBC does not detect alpha contamination it cannot be assumed that it is not there.

Investigating Wounds for Potential Intakes

Even small wounds can result in significant internal exposures resulting from alpha contamination.

Because contamination enters the bloodstream directly through wounds, urinalysis is used to assess the dose.   If someone gets injured while working in a potential or actual alpha area, notify supervision for further action.

When investigating wounds sustained in an area or from an item that is potentially alpha contaminated, monitor the item that caused the wound as well as on the wound itself.

Knowledge Check

Which of the following methods is used to confirm the magnitude of the intake when the potential dose to an individual is uncertain.

excreta sampling

whole body counting

urinalysis

process the individual's TLD

That’s correct.   Excreta sampling is used to confirm the magnitude of the airborne activity intake when the potential dose to the individual cannot properly be determined or remains uncertain.

Individual Monitoring Summary

In this section, you have covered:

- Potential pathways/routes of intake for alpha contamination into the body

- Typical conditions that may indicate an unplanned alpha intake, such as
  - Facial contamination or contamination monitor alarms for workers exiting alpha work areas
  - Air sampling results or activity ratios that indicate presence of alpha

- Steps to take when investigating a potential unplanned alpha intake

- Individual monitoring requirements based on potential dose to the worker

- Whole body counting (WBC)
  - WBC methods are limited for detection of alpha internal contamination because most alpha emitting radionuclides are not accompanied by gamma photon emissions with sufficient energy to be detected by whole body counting.

- Excreta sampling
  - Excreta samples include both urine and fecal samples and may be used to determine an intake from alpha emitting nuclides following a suspected exposure.

Knowledge Check – Scenario

You are the radiation protection technician supporting an outage at a dual unit site. Unit 2 is performing a refuel and maintenance outage.   Unit 1 has been shut down and out of service for 15 years.

Repair is necessary to a radwaste system used to process solid radioactive waste. The Site Engineering group determined that an equivalent replacement valve is available in unit 1, and using that valve will reduce the repair time and cost of purchasing a new valve.

Records show unit 1 had damaged fuel 35 years ago.   The last survey of the replacement valve performed 15 years ago reported loose surface contamination levels of 60,000 dpm/100cm^2 beta-gamma activity and 80 dpm/100cm^2 alpha activity.   No information was available about the internal contamination levels of the replacement valve.

Knowledge Check

Based upon the scenario you just read, all of the following assumptions are correct **except**:

Alpha has decayed significantly after 15 years to non-detectable activity

External alpha contamination is suspect on the valve and insulation

Internal alpha contamination is suspect at potentially higher activity

Beta-gamma activity has decayed significantly after 15 years increasing the alpha risk

That's right. Alpha contamination would still be detectable after 15 years. Most alpha nuclide half lives are very long lived.

Knowledge Check

Radiation protection engineering currently estimates the replacement valve external loose surface contamination levels at 7,000 dpm/100cm2 beta-gamma activity and 100 dpm/100cm2 alpha activity.
The beta-gamma to alpha activity ratio and alpha level classification are:

- 70, Alpha Level III Elevated
- 700, Alpha Level II Significant
- 700, Alpha Level III Significant
- 70, Alpha Level II Elevated

That's right. The activity ratio is <300, so Level III is correct. By definition, Level III poses an elevated risk for alpha hazards.

Knowledge Check

You setup a work area around the valve. Radiation levels are generally 20 mR/hr around the valve and 6 to 7 mR/hr at the work area boundary. You survey the externals of the valve and find loose surface contamination levels at 6,000 dpm/100cm2 beta-gamma activity and 150 dpm/100cm2 alpha activity. You would post the work area as:

All answers are correct

Contaminated area

Level III alpha area

Alpha Frisking/Monitoring Required Upon Exit

Radiation area

That's right. Because the activity ratio for this area is 40, "Alpha Frisking/Monitoring Required Upon Exit" needs to be on the posting along with Level III Alpha, radiation, and contaminated area postings.

Knowledge Check

______________ methods are limited for detection of alpha internal contamination because most alpha emitting radionuclides are not accompanied by gamma photon emissions with sufficient energy to be detected.

Whole Body Counting

Urinalysis

Gamma spectroscopy

Fecal sampling

Correct. Unless the alpha nuclide is accompanied by a gamma photon, whole body counting will not detect it. Excreta monitoring (urinalysis and fecal sampling) are most commonly used for determining alpha uptakes.

Final Thoughts on Significant Event

- The plant had fuel failures 25 years ago. This was not taken into account when assessing the potential alpha risk.
- The unit had been shut down for 10 years. Beta-gamma contamination levels were <20,000 dpm/100cm^2 but the alpha contamination was not monitored.
- Assumptions about the potential for alpha contamination on equipment and components that had been shut down for an extended period were inaccurate.
- The actual activity ratios contained in the contamination on long term out of service equipment and components differed significantly from those commonly found at the plant. This contributed to the flawed assumptions concerning the potential for the presence of alpha contamination.
- Preparation of the primary system components required destructive work (milling and grinding).
- Machining components in preparation for welding activities was similar to work previously done on the other unit which is also being refurbished. Since no radiological problems were detected at that unit, the same controls were used on this unit.
- Contamination controls were not adequate to prevent exposure to workers outside the immediate work area. Workers outside the tented work area were exposed to airborne alpha activity.
- This job resulted in sixty workers in adjacent work areas receiving greater than 200 mrem. One worker received 1.6 rem as a result of alpha uptakes.
-

Remember, it **could** happen...***again***.

Course Summary

There have been several industry events where RP personnel and staff have underestimated the extent of radiological hazard presented by alpha contamination.

You should now have a concept of the fundamentals of alpha radiation including the sources and the controls for protecting workers. Site characterization of the hazard is only one part of protection. Remember the importance of work planning and controls during work activities. Notify supervision if you suspect that beta-gamma work controls may not be sufficient for the protection against the alpha hazard.

Finally, you should understand that all plants have the potential for alpha hazards. Therefore, you should maintain a questioning attitude, conservative decision making, and constant diligence in your job.

Remember, you may be the last line of defense between successful work execution and unanticipated personnel exposure.

Course Objectives

Fundamentals of Alpha Objectives

- Understand the characteristics of alpha and its hazard compared with beta-gamma contamination
- List typical sources of alpha radiation found in nuclear power plants and the challenges associated with its detection

Defining and Monitoring Alpha Hazards

- Describe typical tasks completed by a station to characterize its alpha source term
- Define beta-gamma to alpha ratio and how it is determined
- Explain the classification of plant systems and components and the associated beta-gamma : alpha ratio
- Describe methods for determining alpha nuclide distribution at a facility
- Describe the action levels for alpha monitoring using beta-gamma ratios, contamination survey data, and air sampling results

Work Controls

- Describe work planning controls for alpha as applied to:
    - Risk Assessment
    - Work Planning
    - RWP
    - PPE
- State considerations and rationale for job coverage air sampling in the work area
- Explain how radon can interfere with initial evaluation of alpha activity and measures to compensate for this interference
- Explain the use of personal air samplers as personal dosimetry.
- State exceptions to use of PAS in level II or level III areas
- Discuss field work controls including:
    - Stop work actions
    - Monitoring of personnel and materials
    - PPE
    - Radiological briefings
- Describe posting requirements for Level III alpha areas

Individual Monitoring

- List typical conditions that may indicate an unplanned alpha intake
- Describe the steps to take when investigating a potential unplanned alpha intake
- Recognize individual monitoring requirements based on potential dose, including actions to take and the techniques used for monitoring
- Describe the benefits and limitations for each of the following individual monitoring techniques:

    - PAS
    - WBC
    - Excreta
        - Urine
        - Feces
- Recognize potential pathways/routes of intake for alpha contamination into the body