CP4-ND-1003 FRev. 3	**TITLE**: Nondestructive Assay Scans	**Page 1 of 16**

DOCUMENT CATEGORY: ☒ Technical

LEVEL OF USE: ☒ Reference Level ☐ Continuous Use

FUNCTIONAL AREA: Nondestructive Assay (NDA) **SUBJECT MATTER AREA:** NDA Operations	**SUBJECT MATTER EXPERT**: Brent Montgomery, NDA SME
NUCLEAR SAFETY REVIEW DOCUMENTATION: FRNP-24-0658-S	**APPROVED BY/DATE** (Signature on file): Tyler Coriell, NDA Manager, 11/21/2024
REQUIRED REVIEW DATE (or expiration date for temporary change): 11/21/2032	**EFFECTIVE DATE**: 11/25/2024

REVISION/CHANGE LOG

Revision/Change Letter	Description of Changes	Pages Affected	Date of Revision/Change
FR0	Initial FRNP release	All	10/20/17
FR1	Update references and post calibration activities. Updated performer. Removed forms. Updated NCS stamps.	3-8, 11	12/5/17
FR1A	Remove references to NCSA 310-011. Add NCSE to definitions	3, 4, 8, 10	4/17/19
FR1B	Added NCSE CAS-101 to source references, commitments, stamps on steps 6.2 and 6.3.2, and the stamp in the definitions. Updated Steps 6.2.5-6.2.10. Updated use and source references. Updated prerequisites.	3-8, 10, 11	8/19/19
FR2	Added Use Reference. Completed 3 yr. required review. Replaced NCSAs with applicable NCSEs.	1-10	9/8/2020
FR2A	Periodic Review has been completed with no changes identified in procedure technical content. Nonintent change to correct Approver and dates has been incorporated per CP3-NS-2001. Date for review cycle has been reset.	All	8/26/2021

REVISION/CHANGE LOG			
Revision/Change Letter	Description of Changes	Pages Affected	Date of Revision/Change
FR2B	Updated Scope, Use and Source References, Precautions, and Prerequisites. Updated NOTE above 6.2. steps 6.2.2, 6.2.3, and 6.4.1 Removed step 6.3.13 and 6.4.9. Updated form CP4-ND-1003-F01. Updated acronyms	4-10	1/11/2023
FR3	Update procedure with information from newly developed method. Added new form -F09.	All	11/21/2024

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE

1.1 Purpose

The Paducah Gaseous Diffusion Plant contractor's Quality System for Nondestructive Assay (QSNDA) Plan (CP2-ND-1001) requires that the nondestructive assay (NDA) program requirements shall be incorporated into the implementing procedures to ensure a quality program as well as ensuring the requirements for valid and defensible data. This procedure provides support for the NDA scanning of process gas piping, equipment, or other waste related items and components in the process buildings for the purpose of detecting deposits of uranium bearing compounds. It will develop a data assisted approach to characterization by ensuring that sufficient information is provided to the user in order to enable duplication of requested measurements.

1.2 Scope

This procedure is applicable to routine deposit scans of equipment which are **NOT** covered by a more specialized procedure. NDA scans are normally performed on items where depleted, normal, and enriched UF_6, UO_2F_2, UF_4, and other uranium bearing compounds are contained. Scanning is a qualitative measurement.

2.0 REFERENCES

2.1 Use References

- CP3-RP-1302, *Radioactive Source Control*
- CP4-ND-1000, *Nondestructive Assay Quality Implementation*
- CP4-ND-1010*, Administration of Nondestructive Assay Sources*
- CP4-ND-1013, *Control of Nondestructive Assay Equipment*
- CP4-ND-1014, *Nondestructive Assay Data Flow and Review Process*

2.2 Source References

- CP2-ND-1001, *Quality System for Nondestructive Assay Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*
- CP3-NM-3005, *Measurements*
- CP5-ND-2500, *Method Manual for Qualitative Sodium Iodide Scans*
- JHA-7807, *JHA (Job Hazard Analysis) for NDA Setup and Field Work*
- R.H. Augustson, T.D. Reilly, *Fundamentals of Passive Nondestructive Assay of Fissionable Material*, LA-5651-M Manual, Los Alamos National Laboratories, September 1974.
- T.D. Reilly, N. Ensslin, H. Smith Jr., S. Kreiner, *Passive Nondestructive Assay of Nuclear Materials*, Office of Standards Development: U.S. Nuclear Regulatory Commission, NUREG/CR-5550, March 1991.

3.0 COMMITMENTS

- NCSE 120, *Equipment Removal, Handling, and Storage*
- NCSE CAS-101, *00 and 000 Cascade Facilities*
- NCSE GEN-01, *General Limits Used at the Paducah Gaseous Diffusion Plant*

4.0 PRECAUTIONS AND LIMITATIONS

4.1 Precautions

4.1.1 **When** handling the detectors, **then** care shall be taken. Although the detectors are field rugged, they should **NOT** incur significant impacts.

4.1.2 As low as reasonably achievable (ALARA) principles shall be practiced to minimize personnel exposure to ionizing radiation.

4.1.3 Pinch points should be avoided when handling the detectors.

4.1.4 **When** handling radiation sources including Working Reference Material (WRM), **then** CP3-RP-1302, *Radioactive Source Control*, shall be followed to ensure ALARA practices are followed **and** CP4-ND-1010, *Administration of Nondestructive Assay Sources*, shall be followed to ensure source control.

4.1.5 All applicable Rad Worker Permits must be read and signed prior to handling sources and standards.

4.1.6 CP4-ND-1013, *Control of Nondestructive Assay Equipment*, must be referenced prior to performing minor maintenance or repair.

4.1.7 Electrical shock should be avoided by inspecting connections prior to use.

4.1.8 All precautions should be taken when performing work using an aerial lift.

4.1.9 **When** performing NaI scans using a ladder, **then** follow all precautions including maintaining three points of contact, ensuring the ladder is within the inspection date, and ensuring all training has been completed.

4.2 Limitations

4.2.1 Detectors with 2x2 or 3x3 crystals shall be used.

4.2.2 The detector must remain as close to on contact as possible with the measurement item while scanning readings are collected.

4.2.3 The lead collimation/shielding shall be configured so that the detector face is flush with the collimator or recessed the minimum amount possible.

4.2.4 The maximum scan rate shall **NOT** exceed 2” per second.

4.2.5 Systems with different enrichment **CANNOT** be grouped like for like for comparative purposes.

4.2.6 Items with differing wall thickness **CANNOT** be grouped like for like for comparative purposes.

4.2.7 A background must be obtained without the influence of adjacent equipment adding to the count rate unless it is also in the background of the item measured

4.2.8 Large deposits which are significantly self-shielding must **NOT** be utilized for absolute comparison to other deposits.

5.0 PREREQUISITES

Ensure the following test equipment, tools, and supplies are available, as needed:

- Assigned normalization source.
- The quality control (QC) source used for source calibration checks on the detector in use.
- Personal protective equipment for the task.
- Hand-held 2x2 Sodium Iodide (NaI) scintillation detector probe and assigned rate meter.
- Hand-held 3x3 NaI scintillation detector probe and assigned rate meter.
- Appropriate length interface cable and connections for NaI detector.
- Distance measurement equipment (measuring tape, distance pole, or other measuring device).
- NDA field drawings, when available (attached to CP4-ND-1003-F01, *NaI Scan Field Sheet).*
- CP4-ND-1003-F01 or equivalent form.
- Source holder/spacer for detector in use.

6.0 INSTRUCTIONS

6.1 Calibration and Performance Check

NOTE:

The NaI detectors and meters are calibrated annually, at a minimum, by the manufacturer, qualified vendor, or qualified company personnel.

NDA Analyst and/or Technician

6.1.1 Ensure the instrument has been calibrated.

NOTES:

Normalization is **NOT** required for a detector system utilized for single event or item testing. For example, scanning an item in support of a neutron quantification does **NOT** require a detector to belong to a family of detectors. Normalization supports multiple detectors which are utilized for comparative data.

A set of detector systems is established as a family.

The normalization process is performed over multiple days and using multiple data points to take into account uncertainty associated with variable daily conditions. The source holder should be rotated so that each direction (N, S, E, W) is accounted for.

6.1.2 Perform normalization measurements.

A. Obtain the assigned source for normalization **and** designated source holder.

B. Take a minimum of 30 data points **and** record all measurement details on CP4-ND-1003-F09, *NaI Normalization/QC Measurements*.

NDA Analyst

C. Evaluate the normalization measurements to ensure they meet one of the following limitations listed below:

1. Individual results (single net counts per minute) fall within 5% of the mean of the group of detectors.

OR

2. A single detector standard deviation based on 30 point initial setup falls within 2% of the average standard deviation of all detectors.

NOTE:

The establishment of QC limits is performed over multiple days to take into account uncertainty associated with variable daily conditions.

The source holder should be moved and positioned in such a way that represents a variety of background locations.

A total of 32 data points should be taken as a best practice.

NDA Analyst and/or Technician

6.1.3 Perform the following steps to establish QC limits:

A. Obtain the QC check source **and** source holder assigned to the instrument.

B. Take a minimum of 30 data points **and** record all measurement details on CP4-ND-1003-F09.

NDA Analyst

C. Enter the QC data points into the appropriate control chart **and** establish control limits according to CP4-ND-1000, *Nondestructive Assay Quality Implementation*.

NOTE:

Areas of very high background such as in the immediate area of a deposit or near large waste storage areas should be avoided when possible **and** avoided when conducting instrument performance checks. Instrument performance checks are preformed prior to and at the completion of a batch.

6.2 Instrument Performance Check

6.2.1 Perform a 1-minute area background count using Scaler or Count mode.

6.2.2 Align the source with the center of the detector face using the appropriate source holder or spacer for the detector in use **and** perform a 1-minute count.

6.2.3 Compute the measured net counts value, document on CP4-ND-1003-F01, or other appropriate data sheet, **and** compare to the established control limits.

6.2.4 **If** net value is within the **2** sigma limit, **then** source calibration check is complete and acceptable**.**

6.2.5 Continue with the measurement.

6.2.6 **If** the net value is outside the **3** sigma limit, **then** refer to CP4-ND-1000, *Nondestructive Assay Quality Implementation*, for the appropriate response.

6.2.7 **If** the net value is outside the 2 sigma limit but within the 3 sigma limit, **then** repeat steps **6.2.1** through **6.2.4** two additional times.

6.2.8 **If** the two additional source calibration checks are within the **2** sigma limit, **then** source calibration check is complete and acceptable.

6.2.9 **If** one of the additional source calibration checks is outside the **2** sigma limit, **then** refer to CP4-ND-1000 for guidance in resolving unacceptable instrument performance checks.

6.3 Uranium Scans of Unit and Cell Bypasses and Drops for Process Buildings or Other Process Gas Equipment

NDA Analyst and/or Technician

6.3.1 Obtain a normalized detector.

6.3.2 Perform an instrument performance check prior to each measurement batch according to section **6.2**.

6.3.3 Measure the area background holding the detector perpendicular to the body at shoulder level or approximately 6 feet from the floor in all 4 cardinal directions, parallel to the body facing the floor, and then the ceiling **and** record on the field drawing or other appropriate form.

6.3.4 Scan the length of the component at a rate of speed that does **NOT** exceed 2 inches per second to enable proper detection of deposits and document count rates on the field drawing or other appropriate form.

6.3.5 Select one item or subset of pipe, at random from the batch to use for the replicate measurement **and** perform **steps 6.3.3 and 6.3.4**.

6.3.6 Perform an instrument performance check upon completion of the measurement batch according to section **6.2**.

6.3.7 Update the appropriate control charts.

6.3.8 Have the background evaluated by a trained NDA Analyst.

NOTE:

A replicate is **NOT** required for scanning associated with quantification measurements or hot spot detection.

6.4 Uranium Scans associated with Quantification Measurements and Hot Spot Detection

NDA Analyst and/or Technician

6.4.1 Obtain a calibrated detector.

6.4.2 Perform an instrument performance check prior to each measurement batch according to section **6.2**.

NCSE 120, CAS-101, GEN-01

6.4.3 **If** performing the scan for use with a quantification measurement for NCS purposes, **then** ensure that each quantification includes an initial and second independent scan.

A. Each scan shall be performed by a different qualified individual.

B. A different instrument shall be used or a performance check shall be performed between the measurements with the same instrument.

C. **If** the same instrument is used, **then** the source performance check shall be performed by a qualified individual other than the person who performed the previous performance check.

6.4.4 Measure the area background holding the detector perpendicular to the body at shoulder level or approximately 6 feet from the floor in all 4 cardinal directions, parallel to the body facing the floor, and then the ceiling and record on the field drawing or other appropriate form.

6.4.5 Scan the component(s) **and** document count rates on the field drawing or other appropriate form.

6.4.6 Perform an instrument performance check upon completion of the measurement batch according to section **6.2**.

6.4.7 Update the appropriate control charts.

6.4.8 Have the background evaluated by a trained NDA Analyst.

7.0 ACCEPTANCE CRITERIA

7.1 For each batch of **20** or fewer measurements performed according to Section 6.3, a replicate measurement of a randomly selected item or subset of pipe is performed.

NOTE:

The value utilized for the replicate analysis will be the highest value obtained during the item scan.

7.2 The Relative Percent Difference (RPD) of the replicated measurement is calculated as follows:

$$\text{RPD} = \frac{|\text{D} - \text{S}|}{\text{S}} * 100\%$$

Where:

S = initial measurement value
D = replicated measurement

7.3 **If** the RPD ≤ 25%, **then** accept the measurement data as valid.

7.4 **If** both values are at background**, then** the replicate **shall** be considered a pass**.**

7.5 **If** the RPD measurement fails, **then** investigate, at a minimum, **and** implement a corrective action plan including creating a Minor Issue report according to CP4-ND-1014.

8.0 POST PERFORMANCE WORK ACTIVITIES

Complete the data review and approval process according to CP4-ND-1014, *Nondestructive Assay Data Flow and Review Process.*

9.0 RECORDS

9.1 Records Generated

The following records may be generated by this procedure:

- CP4-ND-1003-F01, *NaI Scan Field Sheet*, with applicable attachments.
- CP4-ND-1003-F09, *NaI Normalization/QC Measurements*
- Field Drawings

Forms are to be completed in accordance with CP3-OP-0024, *Forms Control*.

9.2 Records Disposition

The records are to be maintained according to CP3-RD-0010, *Records Management Process*.

Appendix A – Acronyms/Definitions

ACRONYMS

ALARA – As Low As Reasonably Achievable

JHA – Job Hazard Analysis

NaI – Sodium Iodide

NCS – Nuclear Criticality Safety

NCSE – Nuclear Criticality Safety Evaluation

NDA – Nondestructive Assay

QC – Quality Control

QSNDA – Quality System for Nondestructive Assay

RPD – Relative Percent Difference

WRM – Working Reference Material

DEFINITIONS

Assay – *(noun)* The amount of ^{235}U contained in uranium, usually measured in weight percent. *(verb)* The quantitative determination of the amount of one or more nuclide(s) of interest in an item, or the result of such a determination.

Batch — A measurement batch is a group of items that are analyzed with the same instrument, instrument calibration, and analytical software. Batch size may vary depending on the throughput of the NDA system for the measurement items at hand, but may **NOT** be greater than 20. A batch can also be defined as a grouping of similar measurement items to which a set of QC criteria is applied to demonstrate the acceptability of results. The batch size is specified to be 20 items or less including the subset, such that when one replicate measurement is performed per batch, a minimum 5% check of the data is achieved.

Certified Source – Sources and/or standards for which original certification exists relating them to nationally or internationally (i.e. National Institute of Standards and Technology, New Brunswick Laboratory) accepted standards through an unbroken chain of comparison measurements. The original values for the characteristics of interest (isotopic mass, enrichment, etc.) were documented but periodic re-certification is **NOT** required. These standards **CANNOT** be utilized for calibration unless traceability is current. Typically, these standards are utilized with instrument performance checks for which a relative response, rather than quantitative, is evaluated.

Nondestructive Assay (NDA) – The observation of spontaneous or stimulated nuclear radiations, interpreted to estimate the content of one or more nuclides of interest in the item assayed, without affecting the physical or chemical form of the material.

Appendix A – Acronyms/Definitions (continued)

Normalization – A group or "family" of detectors utilized for generating a set of comparative data will be tested to ensure that they produce results that are **NOT** statistically different for a given measurement. This process ensures that the detectors are **NOT** statistically different. The family of detectors are typically set up with like detector, meter, and shield/collimator.

Qualified Personnel – Person(s) having the necessary training for performing the indicated task.

Replicate – The replicate measurement is acquired by randomly selecting one measurement item from a given batch to be processed through the NDA measurement. The item may be a piece of equipment, a section of pipe or a defined subset of a given pipe. This measurement item or subset is then measured twice within a batch using the same NDA system, software, and acquisition/reduction parameters. The second measurement becomes the replicate that is reported for that batch. The value utilized for the replicate analysis will be the highest value obtained during the item scan.

CP4-ND-1003-F01 – NaI Scan Field Sheet

This is an example form. For useable approved forms, go to: S:\Controlled Documents\Approved Forms

CP4-ND-1003-F01 – NaI Scan Field Sheet

Technician(s):	Date:
System Type: ☐ Normalized 2x2 Handheld NaI ☐ 2x2 Handheld NaI ☐ 3x3 Handheld NaI	
Building/Location:	
Drawing attached? ☐ Yes ☐ No	

QC check			
ID#:	Detector#:	Meter#:	Cal Due Date:
Source ID:			PDP Due Date:

QC Limits:	2σ:	3σ:	Units:
Pre Source:		Post Source:	
Pre Bkg:		Post Bkg:	
Pre Net:		Post Net:	
Pre QC Passed: ☐ Yes ☐ No		Post QC Passed: ☐ Yes ☐ No	
QC entered on control chart? ☐ Yes			

Replicate Information	
Replicate completed? ☐ Yes ☐ N/A	Replicated Component ID:

Comments:

Technician: _____
(Signature/Date)

Analyst Review: _____
(Signature/Date)

CP4-ND-1003-F09 – NaI Normalization/QC Measurements

This is an example form. For useable approved forms, go to: S:\Controlled Documents\Approved Forms

CP4-ND-1003-F09 – NaI Normalization/QC Measurements

Measurement Purpose:	Normalization ☐ Yes	QC Limit Establishment ☐ Yes	
ID#:	Detector#:	Meter#:	Cal Due Date:
Source ID:	Source Holder #:		
Technician(s):	Dates Performed:		

	Date	Direction (N,S,E,W)	Bkg Count	Source Count	Net	Comments
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						

CP4-ND-1003-F09 – NaI Normalization/QC Measurements

This is an example form. For useable approved forms, go to: S:\Controlled Documents\Approved Forms

CP4-ND-1003-F09 – NaI Normalization/QC Measurements

	Date	Direction (N,S,E,W)	Bkg Count	Source Count	Net	Comments
24						
25						
26						
27						
28						
29						
30						
31						
32						

Comments:

Technician (print, sign, date): _____

Analyst (print, sign, date): _____