NAVY RADON ASSESSMENT AND MITIGATION PROGRAM GUIDEBOOK FOR NAVAL SHORE INSTALLATIONS

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ABBREVIATIONS AND ACRONYMS

AARST	Association of Radon Scientist and Technologist
ACH	air change per hour
ASD	active soil depressurization
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
ANSI	American National Standards Institute
ATD	alpha track detector
Bq/m^3	Becquerel per cubic meter
BUMED	US Navy Bureau of Medicine and Surgery
CDC	Centers for Disease Control
cm	centimeter
COMNAVFACENGCOM	Commander, Naval Facilities Engineering Systems Command
CRM	continuous radon gas monitor
DHA	Defense Health Agencyt
DoDDS	Department of Defense Dependent Schools
DoDEA	Department of Defense Education Activity
DOE	US Department of Energy
DON	Department of the Navy
EHS	Environmental Health and Safety
EIM	electronic integration monitor
eMH	Enterprise Military Housing Management System
EPA	US Environmental Protection Agency
ER	equilibrium ratio
ERV	energy recovery ventilation
EXWC	Expeditionary Warfare Center
ft	foot
ft^3/min	cubic foot per minute
Ga	gauge
h	hour
h^{-1}	per hour
HASP	health and safety plan
HEPA	high-efficiency particulate air
HQMC	Headquarters US Marine Corps
HVAC	heating, ventilating, and air-conditioning
IRAA	Indoor Radon Abatement Act
iNFADS	Internet Navy Facilities Asset Data Store
L	liter
LLD	lower limit of detection
MERV	minimum efficiency reporting value
MCICOM	Marine Corps Installation Command
MHPI	Military Housing Privatization Initiative

NAVFAC EXWC	Naval Facilities Engineering and Expeditionary Warfare Center
NAVFAC Pacific	Naval Facilities Engineering Systems Command Pacific
NAVRAMP	Navy Radon Assessment and Mitigation Program
NRPP	National Radon Proficiency Program
NRSB	National Radon Safety Board
O&M	operation and maintenance
OPNAV	Office of the Chief of Naval Operations
OSHA	Occupational Safety and Health Administration
pCi	picocurie
pCi/L	picocuries per liter
PPV	public–private venture
QA/QC	quality assurance/quality control
RCP	risk communication plan
RDP	radon decay product
RH	relative humidity
RMP	radon management plan
RPC	radon potential category
RPD	relative percent difference
RRNC	radon-resistant new construction
SAM	supplemental air makeup
SCIF	Sensitive Compartmentalized Information Facility
SMD	submembrane depressurization
SP	shell pressurization
SSD	subslab depressurization
TSCA	Toxic Substances Control Act
UIC	Unit Identification Code
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specification
USMC	US Marine Corps
VIP	Very Important Person
WHO	World Health Organization
WL	working level
WLM	working level month

1. INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

This document explains current radon policy for Navy and Marine Corps personnel in conducting the Navy Radon Assessment and Mitigation Program (NAVRAMP) and provides guidance for the implementation of radon-resistant new construction (RRNC), radon testing, radon mitigation, and radon system maintenance activities within all buildings. In addition, a separate technical manual *(Technical Manual for Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations*, 2021, hereafter referred to as *NAVRAMP Technical Manual*) has also been prepared to provide a more detailed discussion of different aspects of radon (i.e., radon and geology, radon entry into structures, exposure risks, risk communication, radon measurement, latest testing and mitigation standards, mitigation diagnostics, and mitigation). The *NAVRAMP Technical Manual,* has been provided to serve as an initial reference for installation personnel involved with NAVRAMP implementation and is suitable for both internal and public dissemination as circumstances dictate. It is important to note that the *NAVRAMP Technical Manual* is a condensed, technical document that reflects current radon industry practices and may not always match NAVRAMP requirements. The primary reason for these differences is the simple fact that current industry standards are written to address radon issues in single homes, public schools, or apartment complexes where retesting or follow-up can easily be performed and are considered routine. This is not always true at naval installations, where thousands of devices or hundreds of mitigation systems may be installed in a single project. The implementation instructions contained within this guidebook rely heavily on lessons learned from past Navy and Marine Corps radon testing surveys and mitigation projects, with emphasis given to reaching a defensible testing conclusion and subsequent corrective action implementation within the shortest time. Therefore, NAVRAMP data quality objectives for both testing and mitigation need to be and are much higher than those currently being utilized in the private sector.

1.2 DOCUMENT APPLICABILITY

This document is provided as the primary reference and implementation guide for all Navy and Marine Corps radon projects conducted in all types of residential (family and unaccompanied housing) and shore facilities. It is important to note that radon sampling and mitigation approaches within buildings are generally based on either a residential or commercial construction practice (i.e., a house vs. a public school or other large building). This can lead to confusion, particularly in unaccompanied housing, where the building population at an installation could consist of converted use family housing units and traditional-style barracks, which would necessitate drastically different testing and mitigation approaches depending on the construction characteristics of the building. For the purposes of this document, unless otherwise indicated, the term *unaccompanied housing unit* or *unaccompanied housing* applies to both converted use former family housing buildings and buildings built to commercial practice (i.e., traditional style barracks). In addition, the term *nonresidential building* includes lodges, temporary lodging

facilities, transient quarters, and unaccompanied housing buildings built using commercial practice. In addition, use of the terms *building* and *room* apply to both family and unaccompanied housing and nonresidential structures. This document is applicable to all Naval Installations worldwide and replaces and supersedes *Navy Radon Assessment and Mitigation Program Guidance Document for Navy Family Housing* (US Navy 2002) and *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations* (US Navy 2015, 2016 and 2017). Public Private Venture (PPV) housing units privatized under the Military Housing Privatization Initiative (MHPI) are not subject to NAVRAMP but are subject to applicable Federal, State and local laws (*Radon Testing and Monitoring of Privatized Military Housing Procedures*, dated 4 August 2020). However, responsibility requirements for MHPI projects are included in this document.

It is important to note that in 2012, EPA initiated a voluntary consensus-based standards initiative with the radon industry (https://www.epa.gov/radon/radon-standards-practice). The subsequent standards produced by this partnership have superseded and consequently replaced the previous EPA standards and guidance documents. Throughout this guidebook references are made to these superseded EPA documents to provide background information and provide proper context for past NAVRAMP testing and mitigation projects. Therefore, to ensure that all future NAVRAMP projects are consistent with the most recent standards and Navy radon policy, it is recommended that all statement of work, request for proposal, performance work statements and similar types of documents reference the most recent standards and this document. A list of all current and relevant ANSI/AARST standards has been included in the Reference Section of this document and can be viewed or purchased on-line at https://standards.aarst.org/ .

1.3 DOCUMENT ORGANIZATION

The document is organized as follows.

Chapter 1: Introduction

- General overview of radon (Section 1.4)
- Suggested installation starting point (Flowchart 1)

Chapter 2: Overview of radon regulations and Navy/Marine Corps radon policy and implementation guidance

- Regulation (Section 1.5)
- Navy radon policy (Section 2.1)
- Marine Corps radon policy (Section 2.2)
- NAVRAMP implementation strategies
  - Radon testing (Sections 2.4 to 2.6)
  - Required NAVRAMP testing status actions for all Navy and Marine Corps installations worldwide (Section 2.7)

Chapter 3: Guidance and instructions for performing radon testing within family and unaccompanied housing and nonresidential buildings (which, for the purposes of this

guidebook, includes lodges, temporary lodging facilities, and dormitories and transient quarters)

- Radon testing device selection and procedures (Section 3.2.1 to 3.2.8)
- Measurement and data set validation procedures (Sections 3.3 and 3.4)
- Testing contractor qualifications (Section 3.6)
- Considerations in performing the radon testing in house (Section 3.6.1)

Chapter 4: Guidance and instructions for performing radon mitigation within family and unaccompanied housing and nonresidential buildings.

- Navy and Marine Corps requirements for radon mitigation systems (Sections 4.1 and 4.2)
- Required maintenance of radon mitigation systems (Section 4.4)
- Mitigation contractor requirements (Section 4.2.9)
- Considerations in performing radon mitigation in house (Section 4.2.9.1)
- Design considerations for incorporating radon-resistant features in new construction (Section 4.3)

Appendix A: Navy's Data Collection Reporting Template for Nonresidential Buildings \
Appendix B: Navy's Data Collection Reporting Template for Family Housing and Unaccompanied Housing
Appendix C: Radon Management Plan Templates
Appendix D: Radon Information Handouts and Radon Risk Communication Template

Flowchart 1 provides a suggested initial starting point for the installation in the use of this guidebook.

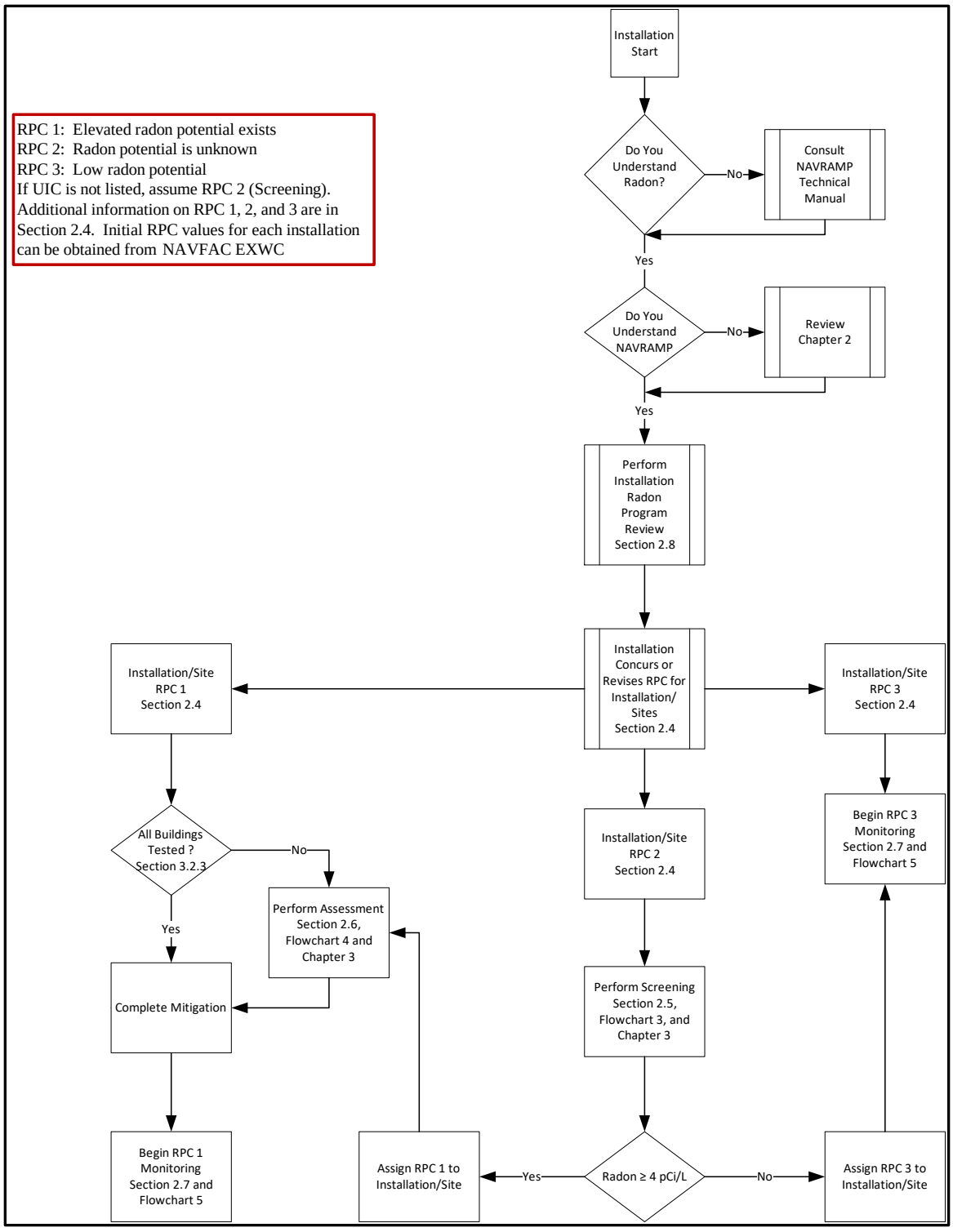
1.3.1 Updates and Changes From 2017 Edition

Most of the changes in this version of the NAVRAMP guidebook were for clarification purposes and where applicable, to reflect changes in the private sector radon testing, mitigation and radon resistant new construction standards. There were no significant policy changes. The following summarizes the significant changes and updates in this document:

- Sections 2.4 and 2.5: The Tier System for prioritizing buildings to test was updated.
- Section 3.2.4.3: Testing approaches and options for Sensitive Compartmented Information Facility (SCIF) buildings and rooms has been updated.
- Section 3.2.4.3: Testing requirements for temporary buildings has been defined.
- Section 3.2.9: Test Types have been better defined and updated.
- Sections 3.3.1-3.3.6: Quality Assurance and Quality Control requirements have been changed to better reflect the overall program's needs.
- Section 4.2: Mitigation specifications have been updated to reflect recent changes in private sector mitigation standards.

- Section 4.3: Radon Resistant New Construction (RRNC) specifications have been updated to reflect recent changes in the private section RRNC standards.
- Section 4.4: Operation and Maintenance requirements for radon mitigation systems have been expanded and updated.
- Appendix B: Master database reporting and format requirements for family and unaccompanied housing has changed.
- Master database reporting requirement for all USMC radon testing is now required to be sent to HQMC/MCICOM GF-Environmental.

In addition to these changes and updates, a technical manual (*NAVRAMP Technical Manual*, May 3. 2023) has been prepared to provide more in-depth information about radon, radon testing, mitigation, and RRNC. This manual was designed specifically to complement this guidebook and should be utilized as a primary reference when performing NAVRAMP implementation at an installation. However, this technical manual augments but does not replace *Considerations in Performing Radon Mitigation Under NAVRAMP*, September 19, 2017.



Flowchart 1. Suggested installation starting point for initial use of the document.

1.4 OVERVIEW OF RADON

Radon is a naturally occurring, odorless, colorless radioactive gas that is released from rock, soil, and water as part of the natural decay of uranium. Although radon levels in outdoor air pose a relatively low threat to human health, indoors, radon can accumulate to dangerous levels. Radon exposure represents about 37% of the annual radiation dose for a typical US citizen (Stanford University 2015). As a result, exposure to indoor radon is the second leading cause of lung cancer in the United States and the number one cause among nonsmokers (EPA, 2016). The EPA estimates that radon causes more than 20,000 lung cancer deaths in the United States each year. Only smoking causes more lung cancer deaths. (EPA 2013, US Surgeon General 1989, BEIR 1998, 1999). Since the precursors of radon (i.e., uranium and thorium) are found to some extent in virtually all soil and rock formations worldwide, varying concentrations of radon gas in soil can be found as well (Krusky, 2003). Given the right combination of radon soil gas concentration, soil permeability, suitable entry pathways, and low indoor ventilation rates, virtually every building in the world has some risk potential for elevated radon (WHO 2009). Therefore, unlike the risks associated with lead-based paint or asbestos, the risk from radon exposure can never be removed—it can only be managed by taking appropriate measures. The only way to avoid the lung cancer risk from radon exposure is to test and, if appropriate, mitigate. If mitigation is required, diligence in the form of inspection, maintenance, and periodic retesting is essential to ensure long-term risk reduction.

Although elevated indoor radon levels can come from water supplies or building materials, in most cases, the radon source is from the soil under or immediately surrounding the building (EPA 2012). The reason is that radon is chemically inert (it does not interact with other substances), so it can usually move unhindered through 1–2 meters of soil. Once in contact with building components in soil (e.g., slab, foundation, wall, crawlspace), it can easily enter into the building through cracks or openings and in some cases, diffuse through pores in concrete masonry units or even through solid concrete. It is important to note that after radon enters the building, many factors influence its retention. Building design, usage, air change rate (a measure of the ventilation rate within a building), occupancy pattern, building shell pressure (buildings under negative pressure typically enhance radon entry from the underlying soil), and type and operational patterns of a building's heating, ventilation, and air-conditioning (HVAC) system have all been shown to influence radon levels within a building (EPA April 1994a). Because none of these building factors, including the radon soil gas concentrations under the building, can be accurately measured or estimated, the only way to know for sure if radon is present at unacceptable levels is to test (EPA 2012).

Indoor radon measurements are relatively simple to perform and are essential to assess radon concentration in a building. Performing radon testing is typically not disruptive to the occupants (the most common types of detectors emit no noise or odors) and usually take only a few minutes per testing location to install. However, radon concentrations within a building do vary from day to day because of episodic weather patterns (i.e., wind, and rain) and can vary significantly from season to season. Because the risk to radon exposure is based on an annualized dose, both the EPA (EPA 2012) and the World Health

Organization (WHO) (WHO 2009) recommend that the radon testing be performed for as long as practical to ensure a representative measurement.

In single-family homes and small nonresidential buildings (e.g., <2,000 ft. ^{2}), one testing location on the lowest occupied level of the building typically is sufficient to determine whether elevated radon levels are present. Regarding which room to test, studies have shown that most of the time the radon levels do not vary significantly from room to room on the same level in these types of structures. However, testing in a centrally located area or room away from outside doors or windows usually gives the most representative results (EPA May 1993, ANSI/AARST MAH-2019). Unlike in the smaller structures, radon levels within large buildings (e.g., >2000 ft^2) such as public schools and nonresidential buildings can and do vary significantly from room to room. In fact, most of the time when elevated radon levels are found in a large building, it is typically limited to only a few rooms and the rest have acceptable levels. The primary reasons are the differences in building structure and construction techniques, occupancy patterns, and HVAC operation (WHO 2009). In multi-family housing (e.g., duplexes, townhouses, flats, low, mid- and high-rise apartments), radon testing has found that radon levels also vary significantly from housing unit to housing unit within the same building. To address this problem, EPA and the American Association of Radon Scientist and Technologist (AARST) and the American National Standards Institute (ANSI) recommend that all ground-contact rooms in a large building be tested (EPA July 1993 and ANSI/AARST MALB-2014, Rev. 1/21) and all ground-contact units in a multifamily housing building be tested (ANSI/AARST MAMF-2017 REV. 1/21).

In the United States, radon is measured in picocuries per liter of air (pCi/L). EPA and the Centers for Disease Control and Prevention recommend that corrective actions be taken at 4 pCi/L or higher as soon as possible to lower the lifetime risks of radon-induced lung cancer (EPA 2012). In addition, EPA also recommends that corrective actions be considered for radon levels between 2 pCi/L and 3.9 pCi/L (EPA 2013).

EPA divides radon mitigation into two basic categories: passive and active ventilation and/or remediation systems (EPA August 1988). Passive mitigation is defined as a nonmechanical means of radon abatement or control. Examples include sealing cracks in contact with soil, balancing an existing mechanical system, or increasing the natural ventilation rate of the building substructure (i.e., crawlspace). Active mitigation entails the use of mechanical means, such as a fan or blower, to control radon entry into the inhabited space and can be grouped into two categories: pre-entry and post-entry mitigation. Pre-entry mitigation is a technique that retards radon entry into the building. Common examples of this type are shell pressurization (SP) and active soil depressurization (ASD); these include subslab depressurization (SSD) for buildings with slabs and sub-membrane depressurization (SMD) for buildings with crawlspaces. Post-entry mitigation involves the treatment of the radon-laden air inside the room or building. Examples are energy recovery ventilation (ERV) and supplemental air mitigation (SAM). The selection of the most appropriate mitigation method for a building depends on many factors, the most common being building design and usage, installation and long-term operation costs, and aesthetics. To assist with the selection of a mitigation method, EPA recommends that diagnostics

(scientific tests that help with the selection of the most appropriate mitigation method) be performed (EPA April 1994a). After mitigation system installation, it is imperative that the system be routinely inspected and maintained, and the building retested periodically (EPA April 1994b) to ensure that effective radon control is still occurring.

For proposed new construction, EPA ANSI/AARST recommends (EPA June 1994, ANSI/AARST CCAH-2020, ANSI/AARST RRNC-2020) that RRNC techniques be considered for all buildings located within areas of known elevated radon potential. Briefly, RRNC entails placing a radon soil gas piping collection network in the subslab aggregate bed before pouring the concrete slab (Section 4.3). The piping network is in turn connected to a vent riser, which passively exhausts the collected radon above the building, or stubbed out and capped in a convenient location in case it is needed later. If later testing finds elevated radon levels, this piping network can be made active with the installation of a fan on the vent riser.

1.5 INDOOR RADON ABATEMENT ACT OF 1988

In recognition of the public health hazard presented by indoor radon, the US Congress passed the *Indoor Radon Abatement Act of 1988,* and the President signed it into law. IRAA, part of Title III of the *Toxic Substances Control Act of 1988,* declares the national goal to be "that the air within buildings in the United States should be as free of radon as the ambient air outside the buildings" (Public Law 100-551, 1988). In addition, IRAA stipulates that the head of each federal agency that manages a building will design a study to assess the extent of radon contamination in buildings within its jurisdiction and submit that study to EPA. However, unlike the case for other indoor environmental hazards (e.g., lead-based paint, asbestos), IRAA did not require that any corrective action be taken. With respect to other federal laws, the Occupational Safety and Health Administration regulates radon only at privately owned and operated nuclear facilities under 29 CFR 1910 (CFR 1996). However, for all other types of buildings, at the federal level, radon is still considered a voluntary, nonregulated program.

At the state level, many states (e.g., Illinois, Pennsylvania, and New Jersey) have strict laws requiring that homes be tested and that radon test results be disclosed to the prospective homebuyer, and some require radon levels to be reduced to acceptable levels prior to closing. In addition, a number of states (e.g., Pennsylvania, New Jersey, Nebraska, and Rhode Island) have strict laws requiring that the company performing radon services (e.g., testing and mitigation) be licensed within that state. However, at this time, the federal government has not relinquished primacy (i.e., jurisdictional control) to the states for radon.

The *Safe Drinking Water Act* (Public Law 104-102, 1996) directed EPA to make available a multimedia mitigation program to address radon risks in indoor air and from drinking water. However, subsequent health risk studies conducted by EPA (https://archive.epa.gov/water/archive/web/pdf/radon-proposed-consumer-fact-sheet.pdf) found that by far, the greatest danger was from the release of radon gas into the indoor environment by typical water usage (e.g., heating water, cooking, showering), not by

ingestion (for every 10,000 pCi/L in water typically 1 pCi/L in air is released indoors). As a result, in 1999 EPA offered the states and federal agencies the opportunity to develop enhanced radon programs to address the health risks from radon in indoor air without necessarily having to test water supplies for radon (EPA 1999). Currently, EPA is encouraging states and sister agencies to adopt this option because it is the most cost-effective way to achieve the greatest radon risk reduction.

In 2011, EPA (See *NAVRAMP Technical Manual*, Appendix A) provided the Navy with clarifications of past EPA protocols and guidelines and made some new recommendations with respect to the management of radon. Recognizing that elevated radon levels are a highly localized phenomenon, meaning that radon concentrations can vary significantly from building to building, EPA's overall position is biased toward testing every building at all naval installations (i.e., screening is no longer a best practice). In addition, EPA also made the following points:

1. Family housing should be retested every 5 years and large buildings after every mechanical adjustment (e.g., HVAC systems).
2. EPA reemphasizes that mitigated buildings need to be retested at least every 2 years.
3. New residential construction should be tested before occupancy.
4. Radon action levels in the workplace are the same as those recommended in family housing (i.e., ≥4 pCi/L).
5. High-efficiency particulate air (HEPA) filtration is not recommended as a mitigation method.
6. Preconstruction radon predictions (i.e., soil flux measurements) and the use of radon test data from neighboring areas should not be considered substitutes for radon testing after construction has been completed.
7. RRNC practices are recommended for all new construction within EPA Radon Zones 1 and 2 (EPA 2015; map is included in the *NAVRAMP Technical Manual* Section 1.2.1).

1.6 BACKGROUND OF THE NAVY RADON ASSESSMENT AND MITIGATION PROGRAM

In response to IRAA, the US Department of the Navy (DON), with concurrence from the Commandant of the Marine Corps, tasked the Commander, Naval Facilities Engineering Systems Command (COMNAVFACENGCOM) to identify naval installations worldwide with elevated radon potential and take corrective action. As a result, COMNAVFACENGCOM created NAVRAMP, the goals of which are to

- Identify potential hazards to Navy and Marine Corps personnel from exposure to naturally occurring radon gas,
- Prioritize corrective actions, and
- Coordinate these actions with the Budget Submitting Offices.

DON Message R 191631Z, dated January 1989, authorized the formation of NAVRAMP with the stated purpose of finding and mitigating all Navy and Marine-occupied structures with confirmed elevated levels of radon. When the program was initiated, dedicated funding was provided to enable completion of program objectives via a centrally managed approach. This funding was subsequently eliminated, and the program funding transitioned to being reimbursable and project specific.

Since the inception of NAVRAMP, the stated overall objective has been to test all Navy and Marine Corps installations worldwide using a sampling protocol that would ensure an overall 95% statistical confidence that no single building would have elevated radon potential. By its conclusion as a centrally funded and managed program in 1994, approximately 31,000 radon measurements had been performed in family housing and 50,000 measurements performed within unaccompanied housing and nonresidential buildings. From those studies, the elevated radon potential of most Navy and Marine Corps installations worldwide was estimated. As the program shifted from a centralized, worldwide screening program to an ongoing facility environmental program, implementation inconsistencies were noted, and lessons learned were not being communicated to other naval installations. With these considerations in mind, COMNAVFACENGCOM has developed and updated implementation strategies to facilitate radon testing at the naval installation level as required under Chapter 25-3.2.b (4) (Periodic Reevaluation and Revision of NAVRAMP) of OPNAV M-5090.1 (US Navy 2021). Therefore, the implementation guidance provided in this guidebook should be considered an extension of the primary policy requirements for full implementation of NAVRAMP at all Navy and Marine Corps installations.

1.7 FAMILY HOUSING VS. NONRESIDENTIAL BUILDINGS

The term building in this document applies to structures built to both the residential construction standard and all other types of buildings. To the best extent possible all radon guidance, methods and procedures for testing, mitigation and operation and maintenance has been standardized. Noted exceptions are listed in Table 1.

Table 1. Guidance differences between family housing and nonresidential buildings

Item	Family Housing	Nonresidential Buildings
Screening (Section 2.4)	Test all testable family housing units	Test all Tier 1 and 2 buildings and all buildings constructed after 2003 (Section 2.4)
Testing approach	Test in one location in each housing unit (Section 3.2.7)	Test all occupied are readily occupiable rooms in ground contact (Section 3.2.4)
Monitoring Testing (Section 2.6)	1. Retest all testable family housing every 5-years regardless of elevated radon potential (Section 2.6) 2. Retest all mitigated family housing units every 2-3 years (Section 2.4).	1. Per EPA recommendations, retest all testable buildings every 5-years at installations/sites with known elevated radon potential (Section 2.6) 2. Retest all mitigated nonresidential rooms every 2-3 years (Section 2.6)

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2. NAVY AND MARINE CORPS POLICY AND GUIDELINES

2.1 US NAVY RADON POLICY

The current Navy Radon Policy established in Chapter 25, Section 3.2 of OPNAV M-5090.1 (US Navy 2021) provides the framework for the implementation of the radon program within the Navy. Briefly, it does the following:

1. Instructs all Navy installations to implement NAVRAMP worldwide.
2. Establishes 4 pCi/L as the action level for both residential and occupational radon exposures.
3. Limits radon testing to occupied buildings.
4. Requires periodic inspections and preventive maintenance as appropriate on mitigation systems and periodic retesting of rooms or buildings with mitigation systems to ensure the systems are operating properly to reduce building radon levels below 4 pCi/L. In addition, retesting within these buildings is required, if the structures have been significantly modified, to ensure levels are still below 4 pCi/L.
5. Requires, where applicable, that radon-resistant features be incorporated into new building construction.
6. Requires installations to evaluate all existing and new lease agreements to ensure that Navy occupants are afforded the same protection from elevated levels of radon as those that are in Navy-owned buildings.
7. Requires US Navy Bureau of Medicine and Surgery (BUMED) to assist COMNAVFACENGCOM in areas of radon public health assessment and risk communication and evaluate the appropriateness of radon action levels and mitigation schedules for Navy installations.

Chapter 25, Section 3.2 of OPNAV M-5090.1 (US Navy 2021) divides radon testing into three phases:

1. **Screening.** Screening requires a statistically significant sample of structures (minimum 95 percent confidence that no more than one room has the potential for elevated radon), mainly family housing. Included in the selection of buildings should be all medical treatment facilities, bachelor quarters, schools, childcare centers, and brigs. A "screening" becomes an "assessment" if the minimum statistically significant number of buildings (31 buildings per installation or 31 housing units per housing area) is equal to or greater than the total number of occupied buildings. Radon testing within these selected structures must be conducted using the appropriate EPA testing protocols as described in *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installation.* Under normal circumstances, screening is performed only once, and therefore should not be considered a recurring requirement.

2. **Assessment.** If, during the screening process, elevated radon levels are detected and confirmed at or above the 4 pCi/L action level, then the installation must test all ground-contact family housing units and all occupied and occupiable testable buildings at the installation for radon using the appropriate testing protocol as described in the NAVRAMP implementation guidance, *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installation.* This requirement applies even to buildings where initial screening showed the radon level was below the EPA-recommended action level.

3. **Monitoring.** Where elevated radon levels have been detected, radon testing should be performed every 5 years for all buildings, including those where mitigation systems have been installed. Where no elevated radon levels were found during screening, testing must be performed in all new construction and acquisitions, within all occupied and occupiable testable buildings constructed after 2003, and in all priority structures (e.g., medical treatment facilities, bachelor quarters, schools, childcare centers, brigs) if they were not tested previously.

With respect to mitigation, OPNAV M-5090.1 (US Navy 2021) states that "Activities must install and maintain a mitigation system in buildings determined to have indoor radon levels with validated monitoring results above the EPA-recommended action level of 4 pCi/L to reduce radon levels below 4 pCi/L and must schedule mitigation steps conforming" to the priority scheme in Table 2.

Table 2. NAVRAMP corrective action timeline. [a, b]

Radon level (pCi/L)	Action
0 to <4	No action required
4 to <20	Mitigation within 2 years
20 to <200	Mitigation within 6 months
≥200	Mitigation within 3 weeks

[a] The schedule for corrective action (i.e., the mitigation clock) should be based upon the testing report date. In cases where confirmation is required, mitigation should be based upon the testing report date of the initial test.

[b] Corrective action schedule is based on recommendations made by the US Navy Bureau of Medicine and Surgery (February 2000).

For installations in which elevated radon potential is known or suspected, OPNAV M-5090.1 (US Navy 2021) states that "Installations must incorporate appropriate radon-resistant new construction (RRNC) techniques into the design and construction phases of new buildings or significant modifications to existing buildings (where necessary due to applicable regulatory requirements, historical data, and geological conditions at the location) to prevent indoor radon levels from exceeding the EPA-recommended action level of ≥ pCi/L."

Overseas Navy and Marine Corps installations may be required to meet the country-specific Environmental Governing Standards prepared by the Department of Defense (DoD) Environmental Executive Agent based on the host nation's environmental requirements and the Overseas Environmental Baseline Guidance Document.

Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC) maintains a central radon data management system containing results for radon testing conducted per NAVRAMP implementation guidance (this document). Installations are responsible and shall maintain records of all NAVRAMP testing data and mitigation projects and shall provide nonresidential testing data (including lodges and inns) to NAVFAC EXWC within 90 days of the acceptance of the radon testing report (Section 3.5). Appendix A provides the template for radon data submission.

For Navy family housing including unaccompanied permanent party buildings and dormitories (does not include lodges or inns) radon data results must be submitted to the Enterprise Military Housing Management System (eMH) within 90 days of the acceptance of the radon testing report (Section 3.5). Appendix B provides the template for radon data submission.

The Navy radon policies in this section have been reviewed and incorporated within NAVRAMP. Therefore, any reference to NAVRAMP within this document should be considered synonymous with the policies listed in Chapter 25, Section 3.2 of OPNAV M-5090.1 (US Navy 2021).

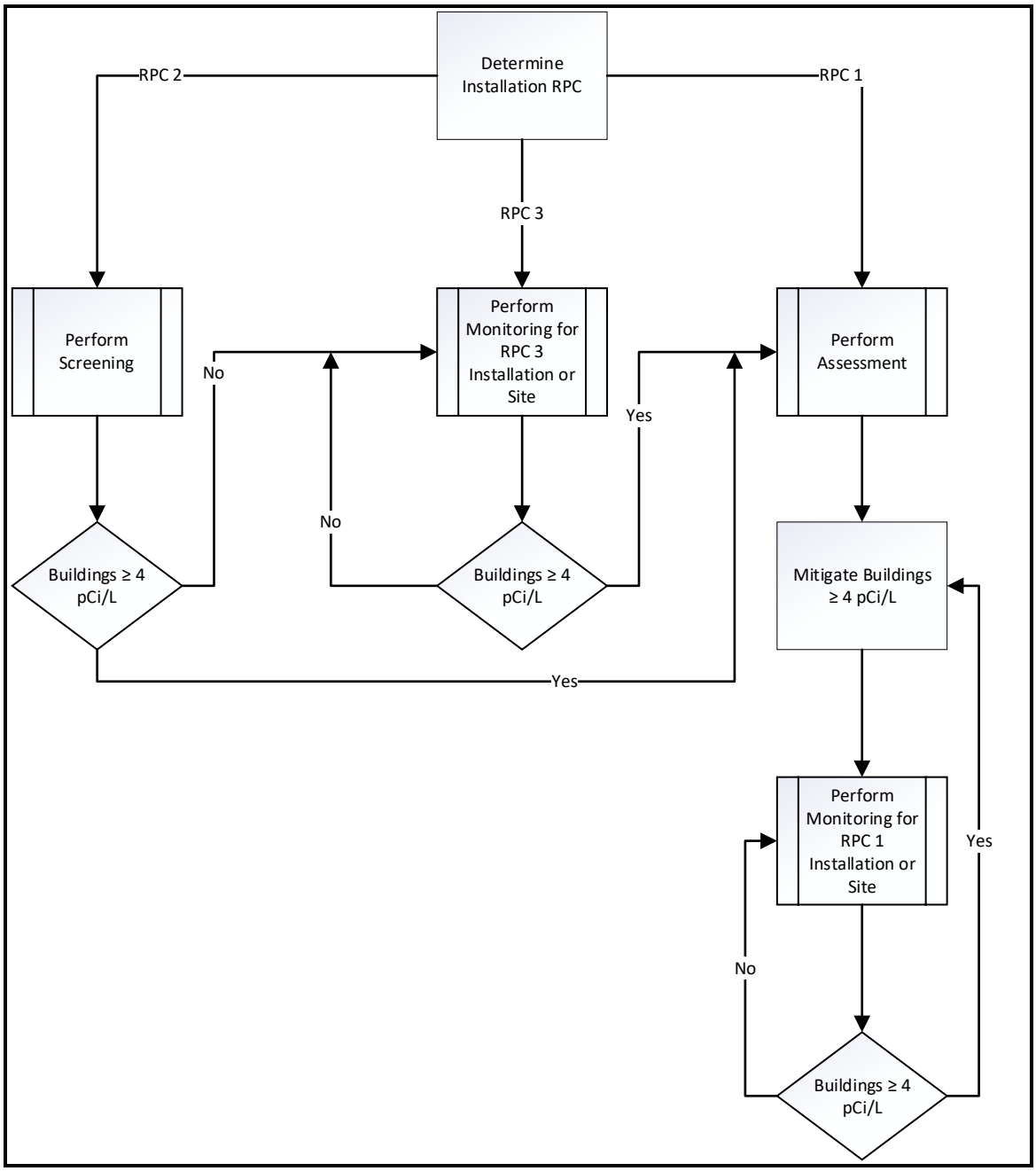
2.2 US MARINE CORPS RADON POLICY

Marine Corps policy is established under Volume 6, Chapter 3 of US Marine Corps MCO 5090.2, *Environmental Compliance and Protection Manual* (US Marine Corps 2018). Briefly, the policy states that all Marine Corps installations must implement all phases of NAVRAMP and incorporate radon-resistant designs in new construction where required by site data showing historical levels of elevated radon, geological conditions, or regulatory requirements. Installations are responsible and shall maintain records of all NAVRAMP testing data and mitigation projects and shall provide testing data to HQMC/MCICOM GF-Environmental. Data submission guidance to be provided upon request.

2.3 NAVRAMP RADON POTENTIAL CATEGORIES

Because to some extent, radon gas is found in all soils and geological formations worldwide, the potential for elevated indoor radon levels is always present at any installation. Therefore, regardless of the radon potential in a specific area, EPA recommends periodic retesting (ie., monitoring) to ensure that the indoor radon levels are still at a safe level (see Appendix A of *NAVRAMP Technical Manual*). The testing phases listed in Section 2.1 outline a phased approach in which all installations undergo initial screening or assessment to determine its elevated radon potential. At the conclusion of these testing phases, the installation is transitioned into an ongoing monitoring phase in which additional testing is performed to ensure that radon levels are still below 4 pCi/L (Flowchart 2). Because the monitoring needs for each installation will depend on the likelihood and frequency of finding elevated radon levels, COMNAVFACENGCOM performed a comprehensive review of all Navy and Marine Corps residential and nonresidential radon data reported from 1989 through May 2015. In addition to the data review, installation radon program technical leads were also consulted to ascertain a better understanding of what worked and, more importantly, what did not work during previous radon testing projects. From this, it was determined that a programmatic ranking system was needed to better define the NAVRAMP requirements at the installation level and that additional implementation options were needed for installations with multiple sites (Section 2.3.1). The NAVRAMP Radon Potential Categories (RPCs) are:

- RPC 1: One or more valid, confirmed radon results ≥4 pCi/L in family or unaccompanied housing or a nonresidential room was present at the installation.
- RPC 2: Based on past and present radon policies, insufficient data exists to project the current radon potential for family and unaccompanied housing and nonresidential buildings at the installation (this would also include lodges, and transient quarters).
- RPC 3: Sufficient radon data (including family and unaccompanied housing data) exists to conclude that the installation has a low radon potential.



Flowchart 2. Overview of the NAVRAMP testing and mitigation phases.

Using all historical residential and nonresidential radon data on file, and property information obtained from the Internet Navy Facilities Asset Data Store (iNFADS), COMNAVFACENGCOM assigned each Naval and Marine Corps installation with shore facilities an initial RPC. The purpose of these assigned codes was twofold: (1) to identify installations in need of initial screening and assessment and (2) to provide an outline for continual monitoring and other actions based on radon potential (please note that RPC and EPA Radon Map Potential Zones values are not equivalent). Initial RPC designations are considered valid, requiring no further review of the data quality objectives used at the time of testing, prior to September 2017. In addition, by design, the initial RPC designations

are changeable by the installation (Section 2.7) for justifiable reasons. These initial RPCs were published in Appendix B of Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations (US Navy 2015, the previous version of this document) and have since been incorporated into the COMNAVFACENGCOM radon database managed by NAVFAC EXWC and are available upon request. Copies of Marine Corps historical radon results and RPC assignments can be obtained from HQMC/MCICOM GF-Environmental.

It is acknowledged that larger installations may have to perform radon testing in stages. To assist with prioritizing which buildings to test at an installation, the following tier system (highest priority to lowest) has been established:

Tier 1: Includes all testable family and unaccompanied permanent party buildings in addition to medical treatment facilities (e.g., hospitals and medical and dental clinics), dependent schools, child-care centers, youth centers and brigs.

Tier 2: Includes all 24 h manned facilities, such as but not limited to command and communication facilities, fire stations, lodges, inns, dormitories, and security buildings.

Tier 3: Includes all offices and administrative buildings, exchanges, commissary, shops, hangars, recreational facilities (i.e., fitness centers, theaters), warehouses, colleges, universities or other instructional facilities for adults, armories, occupied magazines and other work areas.

Tier 4: Includes buildings which meet the minimum NAVRAMP occupancy requirement of 4 h/day or ≥ 1000 h/year but are not continuously staffed. Examples would include communication or radar equipment buildings, range offices, fuel transfer buildings, engine test facilities, security shacks, generator buildings, and water treatment facilities.

For each RPC, the following specific actions are required under NAVRAMP:

- RPC 1 installation or sites
  - All testable nonresidential buildings, family, and unaccompanied housing units (Section 3.2.3 and 3.2.6) must have been assessed (Section 2.5).
    - Mitigate all buildings with confirmed radon levels ≥4 pCi/L in accordance with the NAVRAMP mitigation timeline (Section 2.1, Table 2).
  - Implement RPC 1 monitoring (Section 2.6.1) at assessment completion.
    - Retest all mitigated nonresidential rooms, family and unaccompanied housing units at least every 2-3 years,
    - Retest all testable nonresidential buildings, family, and unaccompanied housing units after every significant earthquake or severe weather event that would alter the building envelope, or significant modification (e.g., HVAC adjustment or replacement, building envelope modifications) or once every 5 years.

        - Test all new or recently acquired buildings
    - Incorporate RRNC features in all proposed new buildings planned for occupancy.

- RPC 2 installation or sites
    - Test all Tier 1 and 2 buildings at the installation.
    - Complete screening in other nonresidential buildings (Section 2.4).
        - Retest any significantly modified, testable family and unaccompanied housing units.
    - Test all untested testable family housing units and permanent party unaccompanied housing.
    - Based upon the survey findings, assign as appropriate an RPC 1 or RPC 3 designation for the installation or site.

- RPC 3 installation or sites
    - Implement RPC 3 monitoring (Section 2.6.2).
        - Test all previously untested Tier 1 (e.g., testable family housing and unaccompanied permanent party buildings, medical treatment facilities (e.g., hospitals and medical and dental clinics), schools, youth centers, child-care centers, and brigs) and Tier 2 nonresidential buildings.
        - Test all nonresidential buildings constructed after 2003.
            - The rationale for testing all buildings constructed after 2003 is that some energy-saving features (primarily lower volumes of fresh makeup air, and tighter building envelopes) typically incorporated after this time have been shown to increase the probability of finding levels of elevated radon.
        - Test all untested buildings acquired through methods other than construction (i.e., transfer of responsibility or cognizance).
        - Retest all testable family housing units and permanent party unaccompanied housing buildings every 5 years.
            - This requirement does not apply to dormitories (i.e., transient population housing)
        - Perform optional monitoring on selected buildings as circumstances dictate (Section 2.6.2.1).
        - Retesting of Tier 1 and 2 buildings after a significant earthquake or severe weather event that would alter the building envelope or after a significant structural alteration is optional, not mandatory.

Because of the challenges of mitigating a Sensitive Compartmentalized Information Facility (SCIF), RRNC shall be incorporated into all new construction and renovations regardless of RPC.

As was mentioned above, the installation can update the RPC assignments and testing phase at any time for justifiable reasons. It is not necessary to re-evaluate historical data based solely on the revised, extended (1-year) testing protocol established by previous versions of the *Navy Radon Assessment and Mitigation Program Guidebook for Naval*

Shore Installations (2015, 2016 and 2017 versions). The changes in the testing protocol over time do not invalidate the existing data or the established RPCs. Should the installation determine new data concerning expected radon levels are available, Section 2.7 provides a suggested outline for the installation to follow while conducting the review.

2.3.1 Option of Dividing Installations into Sites for RPC Assignments

During the radon data set review, it was recognized that not all installations are the same. Some naval installations may include just a few buildings or housing neighborhoods or unaccompanied housing campuses at a central location, whereas others have hundreds of buildings distributed over thousands of square miles at numerous locations. Thus, the potential exists that a single building with levels of elevated radon at a remote location with respect to the main installation would require the testing of all occupied buildings at the installation. Although doing so is not required for implementing NAVRAMP (i.e., is optional), an installation may find it advantageous if warranted to split a single installation into smaller sites for radon testing and radon program management. The key advantage of this approach is that it would ensure that buildings at sites at the greatest risk from radon would get the required attention, while those with low potential would not be tested or retested unnecessarily. Official site names for the installation can be found in the iNFADS property database.

Valid reasons for creating sites within installation are as follows:

1. Geology varies from location to location; hence, the radon potential could vary as well throughout the installation.
2. Building types vary at the installation. It is not unusual for a naval installation to have distinctly different types of buildings grouped within certain areas of the installation (e.g., shipyards usually have different types of buildings from naval magazines, and the two are usually not intermingled) or a historical district.
3. Administrative reasons may exist in cases of joint basing, for buildings under the jurisdiction of a separate command for which funding or jurisdictional issues may arise, or in cases in which NAVRAMP qualifying leased or international use buildings are involved (Section 2.8).
4. A single building or collection of buildings, or a family housing neighborhood, or an unaccompanied housing campus may not be within the traditional footprint of the installation (i.e., it may be located some distance away).
5. A single building or few buildings (atypical buildings) at the installation may have a unique construction style or specialized application (e.g., silos, telecommunication facilities with underground cable vaults, underground facilities, armories, magazines, or other types of atypical structures) that has resulted in elevated radon levels.

If the site option is used, the installation shall assign the most appropriate RPC to each site and implement any required actions for the respective RPC (e.g., complete screening for an RPC 2 site or implement monitoring for an RPC 3 site). The reasons and/or rationale for dividing the installation into sites shall also be documented in the installation Radon

Management Plan (RMP; see Section 2.9 and Appendix C). For administrative purposes, if one or more RPC 1 sites are present, then the installation RPC will remain RPC 1. However, for installations with combinations of RPC 2 and RPC 3 sites should be assigned the most representative RPC for the installation. For example, if 8 of 10 sites are RPC 3 and 2 are RPC 2, the installation should pick RPC 3 as the most representative for the installation (screening would still need to be completed at the RPC 2 site in this example).

In cases where only one specific building or building type at a site or installation has levels of elevated radon (e.g., an atypical building, see valid reason 5 above), it may be excluded from the installation or site RPC classification to more accurately represent the true radon potential at the site or installation. The reason or rationale for using the atypical exception must be documented in the RMP and the atypical building will still need to be managed as an RPC 1 structure (i.e., retesting will be required in the future).

The site option shall not be used to circumvent future or current radon testing requirements. For example, if a group of buildings located on a single iFADS site were tested and no elevated radon was found, they cannot be grouped into an RPC 3 site designation if one or more non-atypical buildings (see valid reason 5 above) at the same site had elevated radon levels. In addition, a building or part of a building cannot be subdivided into a site and assigned different RPC designations.

2.3.2 Unaccompanied Housing Testing Tier Rationale

As was noted in Section 2.3, unaccompanied housing (i.e., barracks) is divided into two testing tiers, Tier 1 and 2. The primary rationale being that residents within permanent party unaccompanied housing are typically there for 1-3 years whereas residents of dormitories (housing used for training and transient personnel) are present for only a few weeks or months. Therefore, the potential cumulative exposure to radon within permanent party unaccompanied housing would be similar to residents in family housing and would require retesting every 5 years regardless of the RPC assignment. However, designating dormitories as a Tier 2 building does not exclude them from being considered for radon testing, it only puts them on par with other transient lodging and inn buildings at the installation (Tier 2) and excludes them from the automatic 5-year retest.

2.4 RADON SCREENING

The objective of screening (Section 2.1) is to reach a defensible testing conclusion using a statistically significant sample of nonresidential structures (i.e., a minimum of 95% confidence that no more than one nonresidential room has the potential for elevated radon levels). At the conclusion of the screening, the installation or site (if applicable) would be designated as either RPC 1 (known elevated radon potential) or RPC 3 (low radon potential) and further action taken as required (Section 2.6). Under normal circumstances, an entire installation or site (if applicable) should be screened only once; screening should not be considered a recurring requirement. Therefore, this section applies only to RPC 2 (Section 2.3) installations or sites.

Radon studies (*NAVRAMP Technical Manual* Section 1.3.3) have found that unlike in family housing, in which room-to-room radon levels are reasonably consistent within the unit, radon levels within large buildings may have significant room-to-room variation. Analysis of Navy and Marine Corps radon data in which all rooms in a building were sampled has confirmed this observation. Further analysis of data collected within individual large buildings has also shown that most of the time, the room(s) identified with elevated radon levels would not have been predicted based on the data distribution collected from other rooms within the building. Therefore, statistical sampling of randomly selected rooms or by selection by other means within a large building would not provide a defensible confidence interval (i.e., 95% confidence interval that all rooms in the building are <4 pCi/L). In addition, within Naval Shore facilities (excluding family housing), studies have shown that buildings vary in size from 1 to over 200 rooms. This level of variation could potentially lead to a case in which a statistically significant number of buildings selected for screening would not offer a comparable and defensible statistical confidence if the total number of testable rooms (see Section 3.2.4) within the population were considered. For these reasons, and to be consistent with EPA and ANSI testing guidelines (EPA July 1993, ANSI/AARST MALB-2014, Rev. 1/21), in buildings selected for screening, the testing of all ground-contact, occupied, or easily occupiable rooms is required under NAVRAMP. Additional information on radon testing, data validation, and other testing considerations is presented in Chapter 3.

In family housing, consistent with EPA and ANSI/AARST (MAH-2019 and MAMF-2017 REV. 1/21) recommendations residential testing recommendations, under NAVRAMP, all testable family and permanent party unaccompanied housing units should be tested regardless of the installations or site's radon potential (i.e., only assessment [see Section 2.5] should be performed in family and permanent party housing). In addition, all family housing and permanent party unaccompanied housing buildings are required to be retested every 5-years regardless of the known radon potential (Section 2.3).

2.4.1 Radon Screening Sampling Considerations in Nonresidential Buildings

The primary advantage of screening vs. assessment (testing all buildings) is the presumption of significant cost savings. Although analysis of past screening projects within the Navy and Marine Corps has demonstrated cost savings at large installations (e.g., >3,000 rooms), the total cost savings for screening at medium or small installations (e.g., <3,000 rooms) has been brought into question. In a screening project, a significant amount of effort must be invested in both the planning and the data analysis portions of the project. Whereas the conclusions in an assessment are mostly self-evident (all buildings are tested, and no extrapolation is needed for potential rooms ≥4 pCi/L), a proper screening project requires a representative sampling of all types of buildings and a good geographical distribution at the installation or site (geology, hence radon potential, can vary significantly in small areas). Once testing is completed, calculations must be made to ensure that the 95% confidence interval was met and, in some cases (Section 2.4.2), statistical modeling is performed to estimate the number of rooms ≥4 pCi/L. The costs for these planning and data analysis efforts may in some cases exceed the actual costs of simply testing all of the buildings. Therefore, during the planning stages, total costs (planning, field testing, data

analysis, and reporting) for statistical screening vs. assessment should be compiled and the best overall value for the Navy or Marine Corps selected.

The number of testable nonresidential buildings (Section 3.2.3) proposed for screening at the installation or site is a consideration as well. Under NAVRAMP (Section 2.1), if the number of nonresidential buildings is ≤31, all should be tested. Using average historical sample densities in past radon surveys in the Navy and Marine Corps (i.e., average rooms per nonresidential building), 31 buildings equate to around 500 to 700 rooms. However, cost analysis of projects of this size has found no significant increase in costs for assessment for projects of up to 1,000 rooms or about 45 buildings. Therefore, it is recommended that if ≥32 buildings are present, but there are <1,000 testable rooms (Section 3.2.4) present, assessment be performed in lieu of screening. An important consideration may be a need for expediency due to potential health concerns or funding cycles for radon testing. In some cases, planning (i.e., the selection of the best method for screening and ultimately the selection of the buildings to test) may take several months to complete, in addition to the time for data analysis after the testing has been completed. Therefore, in these cases, assessment—which has a shorter life cycle compared with screening (typically 3 to 6 months less)—may be the more appropriate choice.

Another consideration is the probability that screening will find elevated radon potential (recall that all buildings will need to be tested if the screening finds one room or housing unit with confirmed levels of elevated radon). In that case, all the remaining buildings would need to be tested, making it necessary to accrue costs for another round of mobilization/demobilization. Therefore, in the initial planning stages of screening, an attempt should be made to ascertain the radon potential of the site or installation from US or host government sources (this would also include Navy, Marine Corps, and other DoD data collected in or near the installation) and past radon surveys at the installation. For naval installations located within the United States or its territories, radon potential information can be obtained online at https://www.epa.gov/radon/epa-map-radon-zones, *NAVRAMP Technical Manual* Section 1.2.1 or from the EPA regional radon point of contact. For overseas locations, the applicable counterpart within the host government should be consulted. If it can be determined via these governmental or other reliable data sources that the installation or site is located within an area of known elevated radon potential (i.e., the installation or site is located within an EPA Radon Zone 1 or 2, (see *NAVRAMP Technical Manual* Section 1.2.1), then assessment (testing of all occupied buildings) is recommended over screening.

If the site option is used, it should not be considered unusual for some sites to be selected for screening while others are selected for assessment. Therefore, if doing so is desirable because of cost or other logistical considerations, the entire installation can be tested over several years based on the testing needs of each site (e.g., performing site screening in years 1–2 and site assessments in years 2–3).

In summary, all installations or sites (if applicable) are required to undergo initial screening. Included in this testing must be all Tier 1 and 2 buildings (Section 2.3).

However, assessment in lieu of screening of an installation or site should be considered when

- the number of testable nonresidential buildings is ≤31, or
- the total number of testable nonresidential rooms is <1,000, or
- reliable data sources have indicated that the installation or site is within an area of known elevated radon potential (i.e., EPA Radon Zone 1 or 2 or the equivalent), or
- because of logistical or other considerations, the cost of screening is comparable to that of assessment.

For buildings constructed after the screening phase has been completed, testing is required prior to occupancy or within 5-years.

2.4.2 Statistical Screening Implementation in Nonresidential Buildings

For an RPC 2 installation or site, if none of the above criteria apply that would warrant assessment (i.e., ≤31 nonresidential buildings or <1,000 nonresidential rooms, or known elevated radon potential in the area), then screening should be performed. The following steps are provided as a guide.

Step 1: Estimation of Overall Population Size

In preparation for executing a statistical screening project, a list of all potentially testable buildings (excluding those planned for demolition within the next 2 years) should be prepared, including an estimate of the number of testable rooms per nonresidential building (Section 3.2.4). The list shall also include NAVRAMP-qualifying leased buildings and international agreement buildings (Section 2.8). If applicable, these buildings then should be grouped into their respective sites. If the site option is used, the total number of testable buildings (Section 3.2.3) should be counted and the number of rooms summed. If the total number of testable buildings per site is ≤31 or <1,000 rooms, then all buildings at that site shall be tested and removed from further screening consideration.

Step 2: Identification of Priority Buildings to Test

The primary usage of each building should be reviewed, each building placed in one of the following classifications, and the number of testable rooms (Section 3.2.4) in each tier totaled.

Tier 1: Includes all testable family and unaccompanied housing buildings in addition to medical treatment facilities (i.e., hospitals and medical and dental clinics), dependent schools, child-care centers, youth centers and brigs.

- Although family and unaccompanied housing units are included in Tier 1, the number of units tested during installation screening does not count toward the required testing minimums for nonresidential buildings.

Tier 2: Includes all 24 h manned facilities, such as but not limited to command and communication facilities, fire stations, lodges, inns, dormitories (i.e., transient housing) and security buildings.

Tier 3: Includes all offices and administrative buildings, exchanges, commissary, shops, recreational facilities (i.e., fitness centers, theaters), warehouses, colleges, universities or other instructional facilities for adults and other work areas.

Tier 4: Includes buildings which meet the minimum NAVRAMP occupancy requirement of 4 h/day or ≥ 1000 h/year but are not continuously staffed. Examples would include communication or radar equipment buildings, range offices, fuel transfer buildings, engine test facilities, security shacks, generator buildings, and water treatment facilities.

Step 3: Selection of a Screening Option

Many statistical models are available for estimating sample size. However, it is difficult for most of those models to establish statistical confidence as the number of potential positive results in a population approaches 1 or 0 (DOE 1990). Therefore, the following options are proposed for installation or site screening to achieve the minimal 95% confidence interval that no more than one room contains levels of elevated radon within the population. However, as discussed earlier, estimated costs for full assessment (i.e., testing of all buildings) should be collected as well to ensure that the best overall value for the Navy and Marine Corps is being obtained.

Screening Option 1: Fixed Sample Density

In this approach, a fixed sample density (i.e., percentage of rooms to test) of sufficient magnitude is used to ensure a 95% confidence interval, assuming a low frequency of elevated radon levels (i.e., 1%). In this approach, no special mathematical or computer skills are required for data analysis. For this option, the selected detectors (Section 3.2.2) must have ≤15% measurement error (accuracy and precision information is available from the manufacturer), and testing must be 1 year in duration (under NAVRAMP, any radon test between 335 and 395 days in duration is considered a 1-year test). To ensure adequate sample density, a minimum of 80% of the total testable nonresidential rooms at the installation or at each site shall be tested for radon (this does not include family and unaccompanied housing in which radon sampling is performed in all testable units). All Tier 1 and 2 buildings will be included, with the remaining balance made up of Tier 3 followed by Tier 4 buildings. Exceeding the 80% minimum to include entire buildings for testing to make up the balance is permitted. Testing all Tier 4 buildings is also recommended (these buildings cannot be included in the 80%) because of the higher-than-expected frequency of elevated radon levels found in such buildings in other studies. In addition, installation maps should be consulted to ensure good spatial coverage. If required, additional buildings above the prescribed minimum may be added in some areas to ensure adequate coverage.

At the conclusion of the survey (assuming that all data quality objectives of the survey are met; see Section 3.5), RPCs (RPC 1 or 3) can be assigned to the installation or sites (if applicable) based on the highest single average radon result (i.e., RPC 3 if the highest single average result is <4 pCi/L and RPC 1 if the highest single average result is ≥4 pCi/L).

Option 2: Enhanced Statistical Method

This approach takes advantage of the fact that a superior-quality radon data set (i.e., ≥175 results) collected at a site or installation usually (i.e., 90% of the time) follows a known statistical distribution (lognormal, normal, or exponential). Taking advantage of this fact can significantly reduce the total number of tests required to achieve a 95% confidence level (DOE 1990). However, during data analysis, advanced computer and statistical skills are required to generate the dataset curves for the installation or each site (if applicable) used to estimate the number of rooms ≥4 pCi/L. As a result, the cost per measurement for this approach is sometimes higher than for screening option 1 or for assessment. Therefore, this option should be considered for use only at larger installations or at sites with >3,000 rooms.

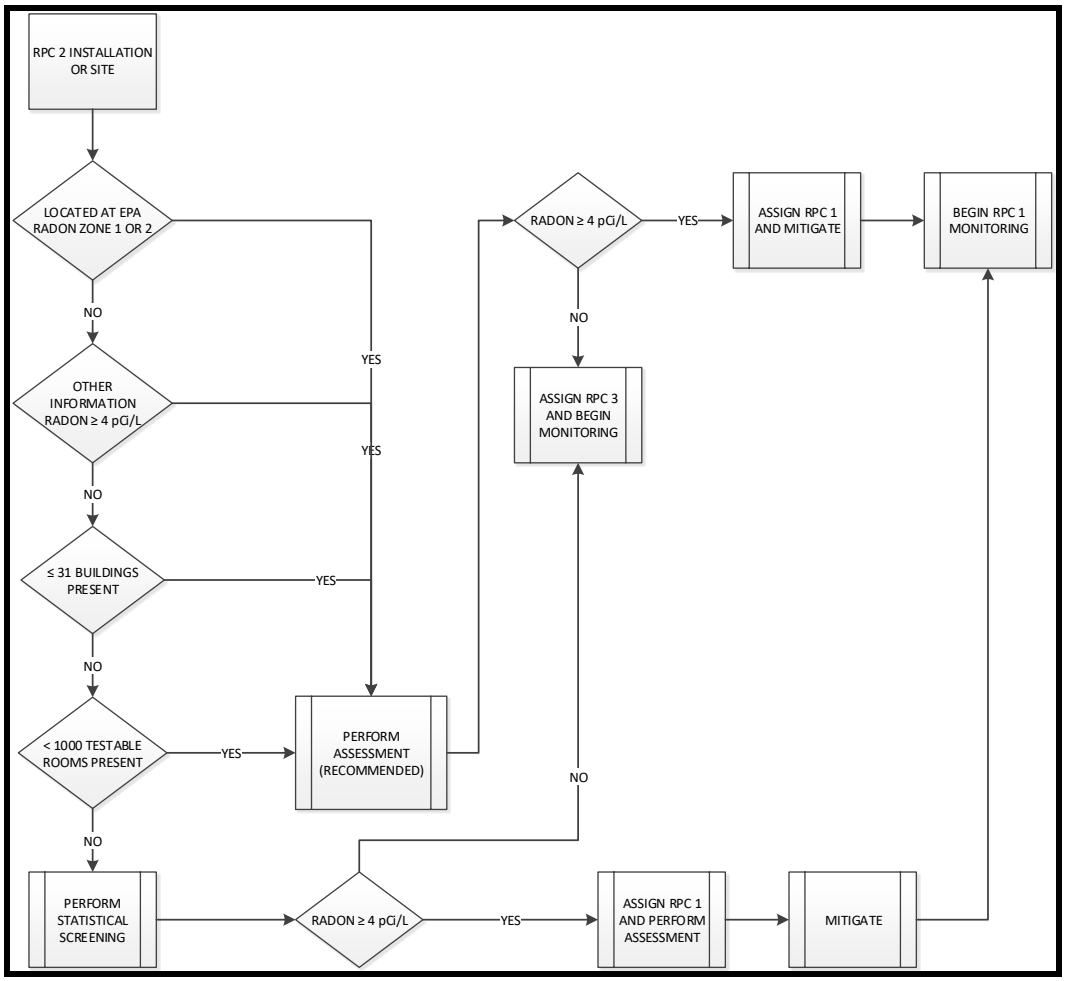
For this option, the selected detectors (Section 3.2.2) must have ≤15% measurement error (accuracy and precision information is available from the manufacturer) with no upper limits on the number of blanks and spike detectors (Section 3.3.1). In addition, the duration of the survey must be 1 year (under NAVRAMP, any radon test between 335 and 395 days in duration is considered a 1-year test). Furthermore, all the sampling at the installation or each site should be performed within the same time period (i.e., detector placement and retrieval cannot be spread out over several months or years).

Sampling of at least 33% of the total testable rooms (Section 3.2.4) at the installation or site (excluding Tier 4) is required. However, because of detector accuracy and precision considerations, an accredited, professional statistician (i.e., American Statistical Association accreditation or equivalent) should review the proposed sample density to ensure that the proper minimum number of rooms are tested. Family housing unit radon results cannot be used in lieu of testing of nonresidential rooms for this required testing minimum.

All Tier 1 and 2 buildings (excluding family housing, which is addressed separately) shall be included, with the remaining balance made up of Tier 3 followed by Tier 4 buildings. Testing all Tier 4 buildings is also recommended (although they should not be included in the model) because of the higher-than-expected frequency of elevated radon levels found in other studies. In addition, installation maps should be consulted to ensure good spatial coverage. If required, additional buildings may be added in some areas to ensure adequate coverage.

After the data have been collected and validated (Section 3.5), a simple inspection is used to verify that all results are <4 pCi/L. If valid data are found to be ≥4 pCi/L, the installation or site is assigned an RPC 1. Assessment designation and actions are taken as appropriate

(Section 2.5). However, if all results are <4 pCi/L, then the results will need to be analyzed by an accredited, professional statistician using nonlinear regression models (as a minimum, lognormal, normal, and exponential) to determine the best fit for the data distribution. Using the best curve fit for the installation or site, estimate the number of rooms ≥4 pCi/L assuming a 95% confidence interval. If the number of rooms estimated is fewer than one, then the installation or site is assigned an RPC 3 designation. However, if one or more rooms are projected to be ≥4 pCi/L, then the remaining buildings at the installation or site should be tested before the final RPC assignment. An overview of the screening phase for nonresidential buildings is shown in Flowchart 3.



Flowchart 3. Overview of screening phase for nonresidential buildings.

2.5 RADON ASSESSMENT

Simply stated, the purpose of the radon assessment is to test all testable buildings (e.g., family and unaccompanied housing units and nonresidential rooms; Section 3.2.3 and Section 3.2.4), including applicable leased and international use agreement buildings (Section 2.8) at the installation or site. Previously tested family housing units and nonresidential buildings with complete, validated radon results can be omitted from the assessment testing provided they have been tested within the past 5-years. The only

exception to this requirement is buildings proposed for demolition within the next 2 years. Within buildings proposed for significant modification (see definition of significantly modified) that would coincide with the radon testing, the testing should be deferred until after completion. The completion of a radon assessment is mandatory for all RPC 1 installation or sites. In addition, RPC 2 installations or sites may be included in assessments under specific circumstances (i.e., ≤31 nonresidential buildings or < 1,000 rooms, or known elevated radon potential in the area, or cost considerations if the assessment costs are comparable to those of screening). In preparation for the assessment, a dated list of all testable buildings needs to be compiled, including the estimated number of testable rooms per nonresidential building (Section 3.2.4) and the number of testable family and unaccompanied housing units. Nonresidential buildings previously tested may be excluded from the proposed assessment, provided all testable rooms (Section 3.2.4) in the building have valid radon test data and the testing was performed within the last 5 years. The same also applies for individual, testable family and unaccompanied housing units. However, consideration should be given to retesting nonresidential buildings and family and unaccompanied housing units if they have been significantly modified or if they have been damaged by events such as earthquakes or storms since the previous radon test. If these buildings or any other testable buildings cannot be included in the assessment survey, then they will need to be tested later under radon monitoring (Section 2.6).

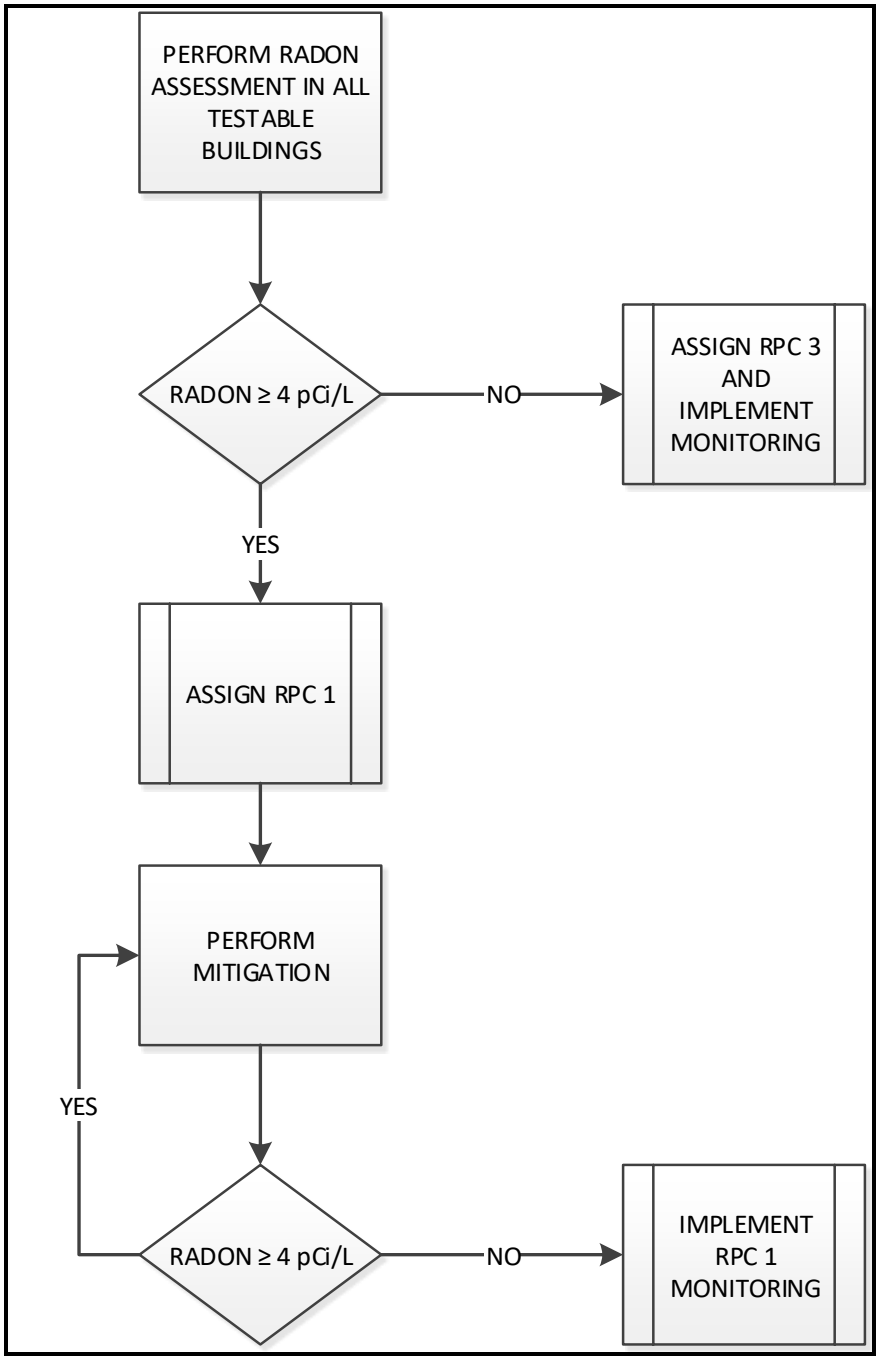
Unlike certain types of screening in which all the testing (i.e., detector placement and retrieval) needs to be performed during the same time period, assessment testing at an installation or site can be performed over extended time periods (e.g., months or years) if needed, provided the minimal testing duration requirements are met (Section 3.2.1).

For assessment testing, the selected detectors (Section 3.2.2) must have ≤25% measurement error (accuracy and precision information is available from the manufacturer), and long-term exposure (i.e., >90 days, with 1 year preferred) is recommended. However, under certain circumstances, short-term testing (2 to 90 days) can be used under very stringent testing conditions (Section 3.2.1).

If the assessment is being performed at an RPC 2 installation or site, at the conclusion of the testing (assuming all data quality objectives of the survey are met; see Section 3.5), the appropriate RPC (RPC 1 or 3) is assigned to the installation or site (if applicable) based on the highest single average radon result (e.g., RPC 3 monitoring if the highest single average result is <4 pCi/L and RPC 1 monitoring if the highest single average result is ≥4 pCi/L). Future action is taken as required based on the assigned RPC (Section 2.3).

By design, under normal circumstances, an RPC 1 installation or site is assessed only once followed by any required radon mitigation. Once the assessment phase has been completed, the installation or site transitions to the monitoring phase (Section 2.6) in which additional testing is performed and actions are taken to ensure that radon levels are maintained <4 pCi/L for all buildings. However, in cases where most of the buildings have been tested, and in particular where mitigation has already occurred, consideration should be given to transitioning to the monitoring phase, with emphasis given to testing the remaining buildings.

Flowchart 4 provides an overview of the assessment phase. Additional information on radon testing, data validation, and other testing considerations is presented in Chapter 3.



Flowchart 4. Overview of the assessment phase.

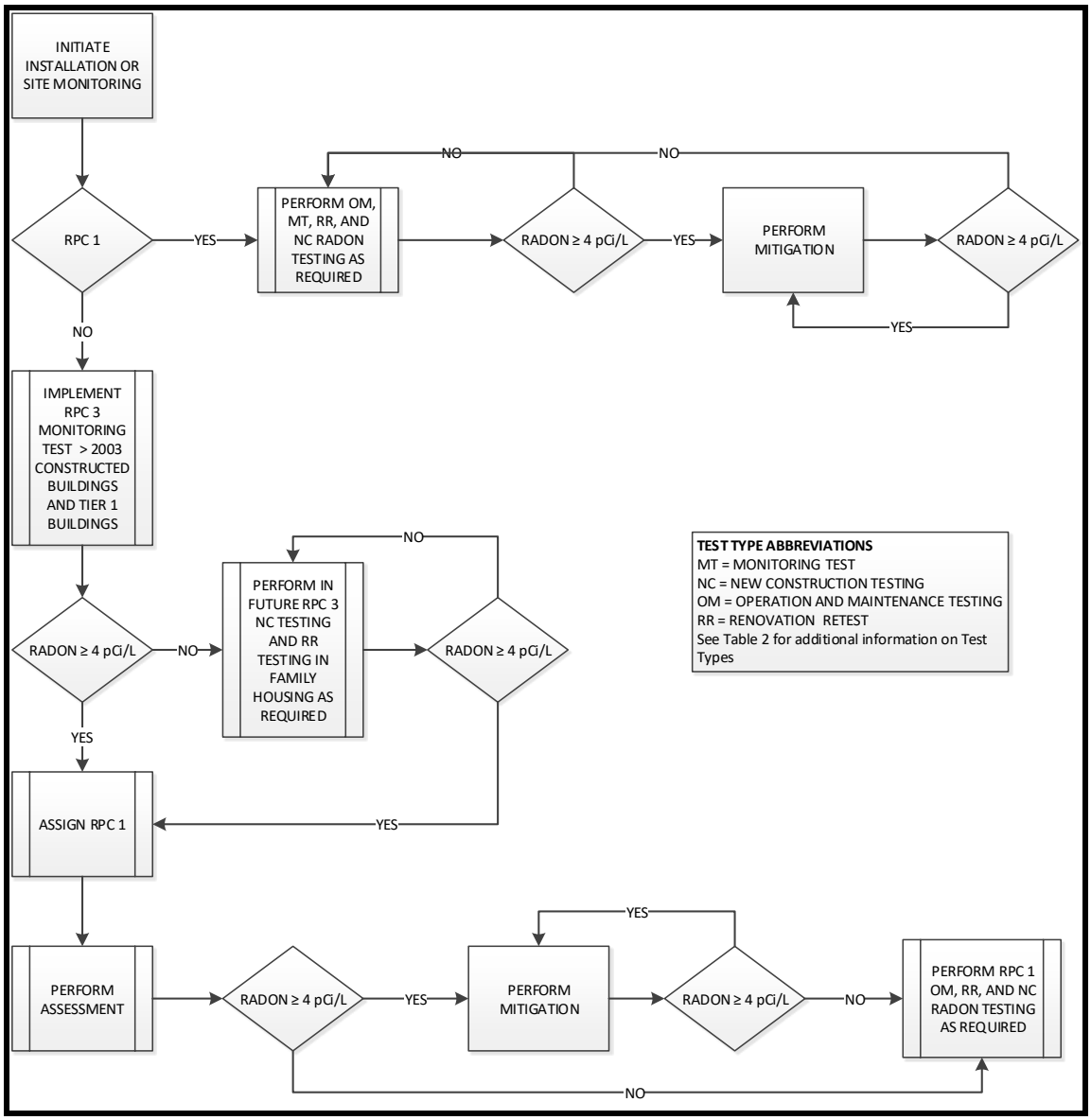
2.6 RADON MONITORING

Once and installation has successfully completed screening or assessment, it is transitioned into an on-going monitoring phase (Section 2.6). Installations which were screened and were found to have no elevated radon potential are automatically placed into the monitoring phase and assigned an RPC 3 monitoring designation. However, those that are known to have elevated radon potential and that have successfully completed assessment are designated RPC 1 monitoring. Because the radon potentials are different (i.e., one has known elevated radon potential and the other does not), each of these monitoring subcategories (i.e., RPC 1 and RPC 3) has its own specific testing requirements (Sections 2.6.1 and 2.6.2, respectively). It is important to note that sites may be moved into the monitoring phase as soon as testing is complete, regardless of what phase other sites are in.

For monitoring testing, the selected detectors (Section 3.2.2) must have ≤25% measurement error (accuracy and precision information is available from the manufacturer), and testing can be either short-term (i.e., <90 days) or long-term exposure (i.e., >90 days). Unless otherwise specified, radon testing within individual testable buildings shall be performed in all testable rooms (Section 3.2.4) with the noted exception of diagnostic, postmitigation, and operations and maintenance (O&M) testing (see Section 3.2.9, Table 4, for descriptions of test types).

For RPC 3 sites, reassignment to RPC 1 is required if monitoring determines elevated radon potential at the site (ie., valid, confirmed radon results ≥4 pCi/L). Similar to testing in the screening and assessment phases, all testable rooms are tested in the building (excluding diagnostic, postmitigation, and O&M testing, see Section 3.2.1, Section 3.2.9 Table 4). Flowchart 5 provides an overview of the monitoring phase.

Unlike certain types of screening, in which all testing needs to be performed during the same time period, monitoring testing at an installation or site can be implemented by testing individual nonresidential buildings, family housing units, or unaccompanied housing buildings on an as-needed basis. Alternatively, it can also be performed over several years for a larger number of nonresidential buildings, family housing units, or unaccompanied housing buildings.



Flowchart 5. Overview of the monitoring phase.

2.6.1 Types of Monitoring at RPC 1 Installations or Sites

Because elevated radon potential is known to be present at an RPC 1 monitoring installation or site(s), periodic monitoring is mandated for all buildings as follows.

- Perform radon assessment (Section 2.5) in any untested, testable family and unaccompanied housing units and nonresidential buildings.
- Perform renovation retesting in all testable family and unaccompanied housing units and nonresidential buildings
  - after every renovation (e.g., weatherization, whole building replacement, addition),
  - after every HVAC modification or replacement,

    - after damage by any event such as an earthquake or storm that would alter the building envelope, **or**
    - simply retest during the next monitoring cycle (see last bullet).
- In buildings with mitigation systems, retest the affected nonresidential rooms (i.e., those that were identified as having levels of elevated radon and mitigated) and family and unaccompanied housing units at least every 2-3 years.
- Test all newly acquired buildings before or within 5 years of occupancy.
- Retest all family housing, unaccompanied housing and nonresidential buildings every 5 years.

2.6.2 Types of Monitoring at RPC 3 Installations or Sites

Because screening has indicated that low radon potential exists at an RPC 3 monitoring installation or site(s), the testing requirements are not as extensive as those at RPC 1 monitoring installations or sites. At an RPC 3 monitoring installation or site, the following actions are required:

- Ensure that all buildings (e.g., all testable family, permanent party unaccompanied housing buildings and unaccompanied housing units, medical treatment facilities (e.g., hospitals and medical and dental clinics), dependent schools, child-care centers, youth centers and brigs), and Tier 2 Buildings have been tested for radon.
- Test all untested buildings acquired through methods other than construction (e.g., through transfer of responsibility or cognizance) since the last radon survey was performed or 2003, whichever is most recent.
- Retest all testable family housing units and permanent party unaccompanied housing buildings every 5 years.
- Perform optional monitoring (see below) in selected buildings as needed.

2.6.2.1 Optional Monitoring at an RPC 3 Site or Installation

At RPC 3 monitoring installations or sites, retesting in significantly modified nonresidential buildings and training unaccompanied housing dormitory buildings is not required. However, in recognition of the fact that radon is dynamic, optional (i.e., not required) radon testing may be performed as part of an expanded monitoring program at RPC 3 installations or sites as specific circumstances as defined by the installation dictate. Examples for expanding the radon monitoring program at the installation would include, but would not be limited to, the following circumstances:

1. An existing building or group of buildings was significantly modified in such a way that they are different from the general building population at the installation.
2. Medical, health or command concerns exist about the indoor air quality within an existing building or buildings.
3. The radon data for selected buildings is >5 years old and there are reasons to suspect that the results are no longer representative of the previous indoor radon concentration. Examples would include replacement of mechanical systems,

implementation of HVAC energy setbacks, building envelope upgrade, and whole building renovation

2.7 INSTALLATION REVIEW OF NAVRAMP TESTING STATUS

As was discussed in Section 2.3, COMNAVFACENGCOM assigned all installations with shore facilities an initial RPC. In making the initial assignments, all valid, historical, and current radon data on file were used (residential and nonresidential collected from 1989 through May 2015). Also taken into consideration was the overall sample density at the installation and within particular types of buildings based on information provided in iNFADS (e.g., did an installation test a minimum of 31 buildings or at least 31 units per neighborhood, see Section 2.1, 2.4, and 2.5). Consequently, it is not necessary to re-evaluate historical data based on solely on the revised, extended (1-year) testing protocol established by previous versions of the Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations (2015, 2016 and 2017 versions). The changes in the testing protocol does not invalidate the existing data or the established RPCs.

The RPCs (Section 2.3) are

RPC 1: One or more valid, confirmed radon results ≥4 pCi/L in family or unaccompanied housing or a nonresidential room was present at the installation.

RPC 2: Based on past and present radon policies, insufficient data exist to project the current radon potential for family and unaccompanied housing and nonresidential buildings at the installation (this would also include lodges, and transient quarters).

RPC 3: Sufficient radon data (including family and unaccompanied housing data) exist to conclude that the installation has a low radon potential.

It is also important to note that the RPC (a unique term developed by COMNAVFACENGCOM for NAVRAMP) is not related to the EPA radon map potential zones (https://www.epa.gov/radon/epa-map-radon-zones), which are similarly numbered. RPCs are assigned based on actual Navy/Marine Corps radon test data collected at the installation. The EPA radon map zones are based on limited data collected over large geographical areas and lack the resolution needed for Navy and Marine Corps monitoring applications. However, the EPA Zone designation may be used as a justification to skip installation screening and perform assessment if the installation is located in an EPA Zone 1 or Zone 2 area or its host nation's equivalent.

In the initial part of the installation review, a decision needs to be made whether to implement NAVRAMP as an installation-wide program or as a series of sites (Section 2.3.1). This decision need not be based solely on distance and geological and structure details but can also be based on potential health concerns (i.e., was this area sampled sufficiently) and administrative issues [i.e., a different DoD agency in a joint base–type arrangement, qualifying leased and international use agreement buildings (Section 2.8)]. In addition, from a program management perspective, sites are managed akin to "mini-

installations" with their own RPCs, testing requirements, and schedules (Section 2.4 to 2.6). Therefore, the use of this option may provide the installation greater flexibility in getting more buildings into the monitoring phase (Section 2.6) in the shortest period of time.

After the site issue has been decided, the next step is to confirm or revise the installation RPC value and, if applicable, assign values to individual sites. The following are suggested steps.

- Consult all the radon data on file for the installation (data for family and unaccompanied housing and nonresidential data can be combined and used).
- If needed, consult the building inventory information in iNFADs.
- Identify any testable family housing and unaccompanied housing buildings in need of initial or renovation retesting.
    a. These family housing units, permanent party unaccompanied housing buildings and unaccompanied housing buildings will need to be tested regardless of the final RPC assignment.
- In cases where only screening has been performed, consult installation maps to ensure that the testing had an adequate footprint.
- If the initial RPC is RPC 1, verify that the results ≥4 pCi/L were valid (Section 3.4) and were not collected in atypical buildings.
- If the initial RPC is RPC 2, using the data on file (there may be additional data that were not on file during the review), determine if screening has been completed (Section 2.4).
- If the initial RPC is RPC 3, verify that sufficient screening was performed.
- Assign updated RPCs as appropriate based upon your review.
- Document these findings and conclusions in the installation RMP (Section 2.9) or in a memo to file.

Examples and rationales for appropriate installation RPC changes at an installation without elevated radon potential would include, but are not limited to, the following.

1. Changing an RPC 3 to an RPC 2
    a. The screening data were insufficient to arrive at a defensible testing conclusion at this installation.
    b. The screening data were collected at a different site or location from this installation.
    c. The screening data were not collected at this installation or unit identification code (UIC)
    d. The screening data are outdated, and the buildings screened are no longer representative of the types of buildings at the installation.
2. Changing an RPC 2 to an RPC 3
    a. Additional valid radon test data that were not included in the COMNAVFACENGCOM database were identified and are sufficient to arrive at a defensible testing conclusion at this installation.

b. Screening was performed successfully (Section 2.4) and no levels of elevated radon were found.

It is also important to note that radon mitigation of one or more buildings at an installation or site does not reduce the radon potential for all other buildings (i.e., mitigating a building does not alter the geological potential, it only controls the radon levels in that particular housing unit, building or room). Also, the greater the number of elevated radon results, the greater the likelihood that the installation or site contains elevated radon levels. In these cases, radon assessment (Section 2.5) or if applicable radon monitoring (Section 2.6) should be performed and the appropriate RPC assigned at the conclusion of these surveys.

Unlike the previous examples for RPC 2 and 3 installations, changing an RPC 1 installation to an RPC 2 or RPC 3 needs to be more specific and defensible, since elevated radon results have already been reported. Therefore, the installation must review the radon data more closely and make a determination based on reportable and documental facts (Section 2.9). Options for existing family and unaccompanied permanent party housing or nonresidential buildings at the installation include:

1. Examine the data set quality factor (DSQF, Section 3.5) for the project associated with the measurement.
    a. This information can be obtained from NAVFAC EXWC or from HQMC/MCICOM GF-Environmental.
    b. Data collected in a former Navy or Marine Corps family housing area that has since been privatized cannot be disqualified unless the neighborhood could be considered a separate site (Section 2.3.1).
    c. DSQF 1 collocated, duplicate data with acceptable precision (Section 3.3.2) are considered valid. Confirmation or follow-up testing is not required.
2. If the DSQF is 4, then the result can be ignored and the new RPC assigned.
    a. This RPC change and reason must be documented in the installation radon management plan (Section 2.9).
3. If the DSQF is 2 or 3, then a confirmation or follow-up measurement (Section 3.2.9.4) should be performed.
    a. If the confirmation measurement fails to confirm the elevated result, then perform a follow-up measurement
    b. If the follow-up result is < 4 pCi/L, then the previous result can be ignored, and a new RPC assigned.
        i. This measurement must be documented in the installation radon management plan and NAVFAC EXWC or HQMC/MCICOM GF-Environmental informed so that the appropriate error code can be assigned in the COMNAVFACENGCOM or USMC master radon database.
    c. If the confirmation or follow-up result is ≥ 4 pCi/L then the RPC remains unchanged.
        i. The corrective action timeline (Section 2.1, Table 2) should be based upon the confirmation or follow-up radon test result.

4. Perform radon screening (Section 2.4), assessment (Section 2.5), or radon monitoring (Section 2.6) as applicable.
    a. Based upon the findings, assign the most appropriate RPC value.

In cases where the room or housing unit cannot have confirmation or follow-up testing (e.g., demolished, no longer under Navy or Marine Corps control) screening (Section 2.4), assessment (Section 2.5) or monitoring testing (Section 2.6) at the installation should be performed. Based upon the findings, assign most appropriate RPC value.

For installations that have been tested since 2015 using the current NAVRAMP testing protocol (Section 3.2), the likelihood of a collocated duplicate, validated, elevated radon result with a DSQF 1 being in error is very small. Therefore, the elevated radon potential for the installation or site has been established. Available options for changing the RPC 1 designation to an RPC 2 or 3 under this specific circumstance would be:

1. The elevated result in question was collected within an atypical type room or building (Section 2.3.1). In this case, the building would still be managed as an RPC 1 site, but the overall installation or site RPC could be changed. This conclusion needs to be included in the installation radon management plan (Section 2.9).
    a) It is important to note that a room cannot be considered as a site.
2. The elevated radon test period included a period of nonstandard test condition (e.g., HVAC out of service, HVAC operating at reduced fresh-air capacity or under repair, or building had a structural renovation). Consult Tables 8 and 9 to determine the potential impact on the measurement.
    a) If the duration of the nonstandard test condition is insufficient to lower the result to < 4 pCi/L, the RPC remains unchanged.
    b) If the duration of the nonstandard test condition is sufficient to raise the result to ≥ 4 pCi/L, then perform confirmation testing (Section 3.2.9.3) in the entire building (all testable rooms) once the building's HVAC has been restored to normal operation or the structural renovation has been completed. This confirmation measurement needs to be of equal or longer test duration and if < 1 year in duration, performed during the season that the original measurement was performed.

        - If the confirmation measurement fails to confirm the elevated result, then perform a follow-up measurement
        - If the follow-up test result is < 4 pCi/L, then the previous result can be ignored, and a new RPC assigned.
            - This finding must be documented in the installation radon management plan and NAVFAC EXWC or HQMC/MCICOM GF-Environmental informed so that the appropriate error code can be assigned in the COMNAVFACENGCOM master database.
        - If the confirmation or follow-up result is ≥ 4 pCi/L then the RPC remains unchanged.

- The corrective action timeline (Section 2.1, Table 2) should be based upon the confirmation or follow-up radon test result.

The next step in the installation review is to determine the most appropriate NAVRAMP testing phase (Section 2.1) for the installation or site(s). As was illustrated in Flowchart 2, the objective of NAVRAMP is to transition all naval installations worldwide into the monitoring phase of the program (Section 2.6). Doing so requires that screening and assessment (if applicable) be completed. However, all RPC 3 installations or sites are by default already considered to be in the monitoring phase. Therefore, the only required action is to implement RPC 3 monitoring as needed (Section 2.6.2). Likewise, RPC 2 installation or sites are by default considered to be in the screening phase. Therefore, screening (Section 2.4) must be completed, and, if required, assessment (Section 2.5) before the monitoring phase can be implemented. However, RPC 1 installations or sites can be either in the assessment testing phase, meaning that most of the buildings still require testing, or the monitoring phase, which means that most if not all of the testing has been completed. However, in cases in which only a few buildings remain to be tested, particularly where mitigation has already occurred, consideration should be given to transitioning to the monitoring phase with emphasis given to testing the remaining untested buildings.

In evaluating past family housing and permanent party unaccompanied housing buildings radon studies at the installation, consideration should be given to the fact that the test data on file, may be ≥ 20 years and no longer representative of the current housing population. This is particularly true in family housing, where significant renovations usually occur every 10 to 20 years and first-hand knowledge of or documentation for these renovations may not be readily available. Therefore, during the installation review, a determination needs to be made whether all testable family housing units and permanent party unaccompanied housing buildings have been tested and whether the data on file are current (i.e., whether renovations have been performed since the last radon test). Although renovation retesting is not a requirement for training unaccompanied housing dormitory buildings and nonresidential buildings at an RPC 3 site or installation, it is an ongoing requirement for all testable family housing units and permanent party unaccompanied housing buildings (i.e., retest every 5-years).

2.8 IMPLEMENTATION OF NAVRAMP WITHIN LEASED BUILDINGS

Navy (Chapter 25, Section 3.2. Section C of OPNAV M-5090.1 [US Navy 2021]) and Marine Corps policy (MCO 5090.2 [US Marine Corps 2018]) affords the same protection from radon exposure to Navy or Marine Corps personnel (includes military, civilian, and dependents) who are occupying testable buildings that are not Navy or Marine Corps owned. In consultation with appropriate legal counsel, installations must evaluate all current and future lease agreements to determine who has the main responsibility for radon testing and mitigation (if applicable). This requirement also applies to buildings used at overseas facilities under international use agreements. If it is determined that the Navy or Marine Corps is responsible, then those buildings shall be tested and mitigated in

accordance with all applicable NAVRAMP requirements. If it is determined that the lessor or host government is responsible, then the installation shall work with these parties to ensure that the buildings are tested and mitigated if required. If the responsibility cannot be determined, then the lease or agreement shall be renegotiated to empower the Navy or Marine Corps to implement NAVRAMP within these buildings. With respect to the construction of new buildings for long-term leases (e.g., leases, limited partnerships, and international use agreements), the naval installation shall consider the incorporation of RRNC features (Section 4.3) if the Navy or Marine Corps will be responsible for implementing NAVRAMP after construction has been completed.

For naval installations located at a non-Department of the Navy Joint Base, it should be determined if the host is following their respective service radon program. If not, then the installation should consult higher headquarters for further instruction.

2.9 RADON MANAGEMENT PLAN

All installations regardless of radon potential shall develop and sustain an RMP. The primary purpose of an installation RMP is to serve as the primary document of the oversight mechanism for the entire radon program. RMP templates for each RPC scenario are included as Appendix C. In addition, the document serves as a major means of maintaining program credibility and provides a quick reference for those who are new to or outside of the radon program at the installation. The RMP shall be reviewed and updated every 5 years or as needed to ensure that the information within the document is current.

The following minimal outline is provided to facilitate RMP development; however, additional information or topics may be added by the installation as needed for further clarity.

Section 1: Introduction

- Date finalized
- Name and title of the preparer
- RMP coverage (i.e., all buildings, plus housing)
- Name and title of radon technical lead at the installation
- Suggested optional subsection: overview of roles and responsibilities for potential team members, for example
    - Installation maintenance (periodic inspections, maintenance and repair of mitigation systems)
    - Installation medical authority (to assist with health questions)
    - Engineering design (new construction)
    - Contracting (new construction)
    - Safety and Occupational Health (SOH)
    - Legal and or public affairs (for release of radon data)
- Suggested optional subsection identifying possible stakeholders
    - Family housing (government owned or privatized)
    - Permanent party unaccompanied housing (government owned or privatized)
    - DoD Dependents Schools (DoDDS) or DoD Education Installation (DoDEA)

- Representatives of non-Navy or non–Marine Corps tenants at the installation

Section 2: Radon Data Analysis

- Brief overview of past radon surveys at the installation
  - Summary of radon surveys at the installation (i.e., number of buildings, rooms tested, number of housing units tested by neighborhood, highest results)
- Overall testing conclusions
  - Overall installation RPC
    - If site option is used—
      - RPC 1 if one site has elevated radon
      - RPC 2 if one site has not been screened
      - RPC 3 if all sites have been screened and no elevated radon levels were detected
  - Site RPCs (if applicable)
    - Include a brief rationale for each site
    - Document in detail the rationale for changing the initially assigned RPC for the installation.
  - List of any leased or international use buildings at installation (Section 2.8)
    - Document who is responsible for testing and mitigation
  - List of atypical buildings (if applicable)
    - Include a brief justification for each atypical building
- A command-approved procedural plan for the release of radon results to stakeholders
- Upload to appropriate database the current radon survey results (see Appendix A and B)

Section 3: Mitigation

- List of mitigation systems by type of mitigation, room, and building at the installation

Section 4: Projects or Items Needing to be Addressed during the Next 5 Years

- List all projects that are required or proposed to meet NAVRAMP (funded and unfunded) over the next 5 years

Appendix:

- A list of all testable buildings and estimated or known testable rooms
  - If all buildings and or family housing units have been tested, then use the building testing or neighborhood testing summary table provided in the radon testing report (Section 3.5).
- A list of all non-testable buildings including reason (e.g., not enclosed, proposed for demolition, not occupied, not a building etc...)
- Documentation that all current survey radon data have been uploaded to appropriate database (see Appendix A and B).

It is quite possible that this document has not anticipated every conceivable technical, financial, or political issue that may arise during implementation of the NAVRAMP at an installation. In these cases, the problems or issues shall be documented in RMP.

2.10 HEALTH RISK COMMUNICATION

Under existing federal law (OSHA Hazard Communication Standard, 29 CFR 1910.1200 [CFR 2012]), military personnel, civil service employees, and contractors have the right to know the results of radon testing within their respective workplaces or residences. It is therefore in the Navy's and Marine Corps' best interest to be open and transparent about radon testing (see example handout in Appendix D). Prior to the initiation of radon testing, each installation shall develop a risk communication plan (RCP) (see example RCP Guidance Template in Appendix D) and include it in the RMP (if applicable). The purpose of this RCP is to ensure that all stakeholders are informed and understand the installation's purpose for initiating radon testing, what the process is, and what to expect in terms of sharing results and other actions that may be necessary based on those results. This plan should include the procedures for the release of current survey data but also any historical data on file at the installation upon request by legitimate stakeholders. In the early stages of developing a risk communication plan, typically one or more of the following are consulted:

- Command authorities
- Installation medical office
- Public affairs office
- Installation legal office

Examples of stakeholders are

- Occupants of the buildings
- Family and unaccompanied housing residents
- DoDDS and DoDEA personnel (if dependent schools are involved)
- Installation medical support staff who are involved in primary care

Examples of methods by which to release the information include but are not limited to

- Notices for building managers or family housing directors to distribute or post
- Written notices or data summaries for family and unaccompanied housing residents (.pdf format)
- Websites, social media outlets, email, or a radon hotline
- Town meetings or building-specific meetings
- Base newspaper, all-hands emails, social media

Another type of data dissemination that should be addressed in the RCP are requests through proper channels (e.g., higher headquarters, installation command, or public affairs office) from state, local, federal agencies, or host government officials; educational and research institutions; and news organizations.

3. NAVRAMP RADON TESTING PROCEDURES

3.1 OVERVIEW OF RADON TESTING PROCEDURES

In the development of the current NAVRAMP testing protocol, considerable effort was expended to develop a testing protocol that arrives at a defensible testing conclusion in the shortest time and with the least inconvenience to naval housing residents and others at the installation. The primary driver was that risk reduction from radon exposures begins after corrective action has been successfully applied. Also, considerable effort was invested in determining the intent of specific EPA and industry standard requirements. Doing so included discussions with EPA (see Appendix A of *NAVRAMP Technical Manual*) and industry subject matter experts and an in-depth review of hundreds of thousands of historical NAVRAMP test results.

The primary reason for differences between EPA and NAVRAMP is simply that historical EPA protocols and current industry standards are written to address radon issues in single homes, public schools, or apartment complexes, where retesting or follow-up can easily be performed and is considered accepted practice. During a 15-year period, EPA published about 25 radon guidance and protocol documents that address topic-specific radon testing issues in homes and public schools. However, EPA never published guidance or protocols for conducting mass surveys (i.e., hundreds or thousands of tests in a short period of time) within family housing or a population of large buildings. This absence of mass survey guidance has in some cases resulted in selected statements being pulled from different EPA protocols and applied out of proper context. For example, in family housing, EPA has published two distinctly different testing protocols, one for real estate transactions and one for informed consumer testing. In the real estate protocol, a single, short-term, collocated measurement is sufficient to reach a testing conclusion, whereas in the informed consumer testing protocol, retesting over several time intervals is encouraged before reaching a defensible testing conclusion. However, neither protocol was developed with the intent of applying it in mass surveys, and both conflict with EPA risk communication statements that the need for corrective action should be based on the estimated annualized radon dose.

The use or need for quality assurance and quality control (QA/QC) is another area often misrepresented and misunderstood by the private sector. Although EPA provided recommended QA/QC guidance to federal agencies in 1988, this information was never disseminated to the public at large. Therefore, in some circles, there is the misconception that spikes, blanks, and duplicate detectors are not recommended by EPA for mass surveys. Under NAVRAMP, these QA/QC detectors play the traditional role—determining background, accuracy, and precision; and it is acknowledged that these characteristics can be estimated using fewer detectors. However, a review of historical risk communication within the Navy has determined that the most common area of concern for occupants is the risk posed by radon in areas testing in the 3.5 to 3.9 pCi/L range within which mitigation is not performed. In the absence of sufficient QA/QC data, the installation is limited to using the ±25% industry standard (this information is readily available on the internet), which means that any result ≥3.2 pCi/L could potentially require corrective action.

However, the enhanced NAVRAMP QA/QC requirements generate the information needed to better define the measurement uncertainty range and provide a more realistic risk estimate to the occupants.

Furthermore, historically within naval homes and rooms found to be ≥4 pCi/L, a primary concern expressed by occupants is almost always the timeline for corrective action. In cases when retesting is required (i.e., only one detector was used for the initial measurement), the delay in taking corrective action sometimes results in added stress for all parties involved, particularly in seasonal locations where retesting may have to be delayed for up to 6 months and the follow-up results not available for potentially 1 year. However, a review of all long-term, collocated duplicate NAVRAMP test results found that 98% of the time, retesting is not required if the two results have acceptable precision. Therefore, in cases where long-term collocated duplicates are used, mitigation can proceed months or in some cases years sooner with a high level of confidence that elevated radon levels are present.

Finally, installation personnel involved with NAVRAMP implementation typically are not seasoned radon professionals adept in the particular nuances of radon testing. In addition, few are likely to be experienced statisticians. If the NAVRAMP QA/QC requirements are applied, data set validation is greatly simplified. Although these validation methods differ from those recommended by EPA and private industry for single-event testing, they have been 100% successful in identifying problem mass survey data sets and can be performed by a radon novice using standard worksheet software on a desktop computer.

In conclusion, the NAVRAMP testing protocols are different from EPA and private industry standards because the technical demands of mass surveys and funding cycles within the Department of the Navy require them to be. Because risk reduction begins with the installation of the mitigation system, there is an indispensable requirement to get it right the first time and without delay.

3.1.1 Basis of the NAVRAMP Nonresidential Testing Protocol

At the inception of NAVRAMP, the stated overall objective was to screen all naval installations worldwide using a sampling protocol that would ensure an overall 95% statistical confidence that no single facility would have elevated radon potential. Since that time, the focus has shifted from an installation screening program to an ongoing environmental program in which the primary focus is the individual building. Because most radon testing in the United States is performed in single-family housing, EPA has focused considerable effort on the development of residential testing protocols. The underlying premise in these protocols is that the resident is genuinely motivated by either health concerns or the desire to sell a house and will do what is required to achieve a defensible testing conclusion. Consequently, the ability to perform a successful short-term radon measurement under the prescribed closed-building conditions (Section 3.2.1) presumably is simplified (for short-term tests of <4 days, closed-building conditions must be initiated at least 12 h before the placement of the detectors and maintained for the duration of the test). With respect to nonresidential buildings, the only available EPA

guidance document, *Radon Measurement in Schools* (EPA July 1993), does not adequately address the reality of testing a large population of buildings using its multiple measurement strategy. Consequently, in consultation with EPA and other subject matter experts, the Navy developed its own large building sampling protocol that blends applicable portions of the following EPA documents into a testing protocol:

- *A Citizen's Guide to Radon* (EPA 2012)
- *Home Buyer's and Seller's Guide to Radon* (EPA 2006)
- *Radon Measurement in Schools Revised Edition* (EPA July 1993)
- *Technical Support Document for the 1992 Citizen's Guide to Radon* (EPA May 1992)
- *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA July 1992)

It is important to note that in 2012, EPA initiated a voluntary consensus-based standards initiative with the radon industry (https://www.epa.gov/radon/radon-standards-practice). The subsequent standards produced by this partnership have superseded and consequently replaced the previous EPA standards and guidance documents. Consequently, for this version of the guidebook a comprehensive review was performed and where applicable changes were made to the NAVRAMP testing protocol. Therefore, for testing standards references to be utilized in a statement of work, requests for proposal, performance work statements and similar types of documents use this document and consult the list in Table 3. These standards can be viewed or purchased on-line at https://standards.aarst.org/ .

Table 3. Current radon testing standards

Standard Name	Standard Number	Applicability
Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes	ANSI/AARST MAH-2019	This standard of practice specifies minimum requirements and general guidance for measuring radon concentrations in single-family residences. This standard applies to testing structures whether conducted for real estate or non-real-estate purposes. The purpose of test protocols is to consistently produce, to the extent possible, reliable and repeatable radon measurements. Radon measurements are conducted to determine if radon mitigation is necessary in order to protect current and future occupants.
Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily Buildings	ANSI/AARST MAMF-2017 Rev. 1/21	This standard of practice specifies procedures and minimum requirements when measuring radon concentrations in shared structures, or portions of shared structures, used for residential, non-residential or mixed-use purposes to determine if radon mitigation is necessary to protect current and future occupants.
Protocol for Conducting Measurements of Radon and Radon Decay Products in Schools and Large Buildings *The 2014 version of this document is referenced in UFGS-31-21-13.	ANSI/AARST MALB-2014, Rev. 1/21	This standard of practice specifies procedures and minimum requirements when measuring radon concentrations in shared structures, or portions of shared structures, used for residential, non-residential or mixed-use purposes to determine if radon mitigation is necessary to protect current and future occupants.

3.1.2 Basis of the NAVRAMP Family Housing Testing Protocol

Although EPA and ANSI/AARST have established standards for testing single-detached and multifamily housing (ANSI/AARST MAH-2019 and ANSI/AARST MAMF-2017 REV. 1/21), those standards were designed to address testing in single units, or with a single apartment/condominium complex in mind. Therefore, those protocols rely heavily on the ability to retest in the event of questionable or single elevated results (this is the same approach that EPA recommended in its testing protocols). In the private sector,

performing the retest is usually not a problem because most of the testing is short-term and performed by a local testing company. Therefore, testing a single home or group of homes two or more times would not be particularly demanding or difficult logistically.

A critical review of past NAVRAMP testing projects (1988–2001) in family housing, which followed the EPA residential testing protocols, identified implementation and execution problems because of the number of units tested and their locations. For example, the need to perform the EPA-recommended confirmation testing prolonged the time lag between the initial discovery of a potential radon problem in a family housing unit and mitigation, in some cases by years (e.g., funding issues for retesting, logistics of retesting, and so on). However, as noted in the review, most of these problems would be eliminated if a defensible testing conclusion could be reached using one testing event as opposed to two or more. The primary benefit would be that risk reduction (i.e., mitigation) could begin sooner and in most cases at a reduced total survey cost.

Although the NAVRAMP family housing testing guidelines mirror EPA and ANSI/AARST protocols (i.e., same preferred testing locations in the home, and same testing conditions), there are some key differences. For example, NAVRAMP

- Recommends testing for one year and has higher QA/QC requirements (duplicates, spikes and blanks)
- Does not require upper floor testing in low-, mid- or high-rise apartment buildings (it is optional) (Section 3.2.6)
- Allows for uncertified Navy and Marine Corps civilian and military personnel (not contractors, see Section 3.6) to perform radon testing
- Has a data validation process that is better suited for larger (i.e., >100 measurements) testing projects.

3.2 NAVRAMP TESTING PROTOCOL

The following testing procedures apply to all radon measurements performed within Navy and Marine Corps–owned, leased, and international agreement buildings and for all testing phases (e.g., screening, assessment, and monitoring). Unless otherwise indicated, the NAVRAMP testing requirements (e.g., device selection, methods and procedures, QA/QC) for all types of buildings are identical; however, the sample density (i.e., number of sampling locations per building) differs based on the type of construction (i.e., residential or commercial construction principle). Briefly, for family housing, typically only one sample location per testable family housing unit will be required. However, for nonresidential buildings (i.e., buildings built to a commercial principle), radon sampling will be required in each ground-contact, occupied, or readily occupiable room (see *NAVRAMP Technical Manual* Chapter 3). If unsure about which construction principle a particular building is, consult with installation facilities and plans or simply sample every testable room.

During the planning stages of any nonresidential radon survey (e.g., screening, assessment, or monitoring), one of the more challenging tasks is estimating the number of testable

rooms within each testable, nonresidential building. For small or medium-size radon surveys, consulting one or more of the following can provide an estimate that is usually very close to the number of testable rooms:

- Building plans (current as built plans)
- Building emergency evacuation plans
- Radon, asbestos or lead-based-paint sampling reports

If these resources are not readily available, then one or more of the following can also be performed:

- Conduct a building walk through
- Contact the building manager
- Review (if applicable) the scope of the installation janitorial services contract (sometimes the number of occupied rooms per building are included)

For medium and large nonresidential radon surveys, generating an estimate of testable rooms by individual buildings is very time consuming. However, in reality, all that is needed is a representative estimate of the total number of potentially testable rooms for the entire proposed survey. Taking this approach, as opposed to consulting plans or reports or the other suggestions mentioned, can significantly reduce the time required for the estimation step. Based on historical radon surveys at naval installations worldwide in which 500 to 4000 rooms were tested, the following process will usually provide a suitable estimate of the total number of testable rooms for the proposed survey (e.g., within ±15 %). Before performing this task, it is recommended that Sections 3.2.4 and 3.2.5 be consulted.

1. Create a spreadsheet containing a list of proposed testable building numbers, building names, ground-floor square footage (this value can be found in iNFADS), and estimated testable rooms.
2. In the estimated testable room column, insert the quotient of ground floor ft^2 divided by 900 ft^2.
3. Round up to 1 for all rooms with estimated rooms <1.
4. For buildings in which ground-contact area is not available, insert the value 12 (average sample density per building at naval installations).
5. Sum the estimated testable rooms column. This value is the total number of estimated rooms for the proposed survey.

To further refine the number of estimated rooms found above, selected types of buildings (see below) will need to be reviewed and the estimated room value potentially revised. If the value appears reasonable, then revision is not required. However, if the number appears to be low or excessive, then consider the following:

- Unaccompanied housing, schools, child development centers, teen centers, and after-school age childcare buildings typically will have a higher overall sample density (i.e., more sample locations per ground contact area), so the estimate will need to be revised upward in most cases. The best value for these types of buildings is one sample location for every 700 ft^2.

- Because of the sizes of the rooms, large warehouses, exchanges, and commissaries (e.g., > 50,000 ft^2) will have a lower overall sample density (i.e., typically one sample location for every 1500–5000 ft^2); therefore, the initially estimated number of rooms will be high. For these large buildings, a default value of 50 testable rooms can be used.
- Because the bays in aircraft hangers are open most of the time during normal occupancy hours (i.e., not testable), only the offices, shops, breakrooms, and the like will be tested. Therefore, a default value of 20 testable rooms can be used in most cases if the estimated number appears excessive.

Note that the number of testable rooms for each individual building is an estimate, not an exact number. During actual detector placement, some buildings will have more testing locations and others will have less. In addition, during detector placement, it is not unusual to identify other testable buildings that were not included on the original list and others that cannot be tested at this time (e.g., proposed or current renovations, mechanical replacements, and so on). However, over the entire population of sampled buildings, these discrepancies tend to offset each other.

With respect to radon testing in unaccompanied housing, inns, lodges and temporary lodging facilities, because of the diversity in construction, during the project planning phases, a decision is needed as to which testing protocol (i.e., family housing or nonresidential protocol) is the most applicable based on the construction principle. For example, if the buildings were originally constructed for use as family housing (i.e., residential construction standard), then the family housing testing protocol would apply (i.e., one sampling location per unit). This would include buildings originally constructed as single or multifamily housing or as low-, mid-, and high-rise towers that are currently being used for other purposes. For unaccompanied housing within buildings constructed using a commercial principle (e.g., 4-story, 160 room, 60,000 ft^2), the nonresidential testing protocol (i.e., one sample location for each ground-contract testable room, Section 3.2.4) shall be used. See Section 3.2.4.1 for additional information for these types of unaccompanied housing buildings.

3.2.1 When to Test, Testing Duration and Closed Building Conditions

Numerous studies have shown that indoor radon levels have not only day-to-day variation but also exhibit season-to-season variation. Consistent with EPA recommendations, under NAVRAMP, a 1-year test (tests ranging in duration from 335 to 395 days are considered 1-year tests) is required for all types of screening measurements (Section 2.4) and is the preferred method for assessment (Section 2.5) and periodic monitoring (Section 2.6) measurements. Testing for 1-year does not require any special considerations (i.e., can be placed at any time of the year) and should be conducted during normal or lived in conditions. However, for radon testing of < 1 year duration, consideration must be given to the extent that the building may be open throughout the year. For example, at northern locations it is not uncommon to find buildings with no air-conditioning. Therefore, during the summer months, these buildings are typically open during occupied periods. All radon

potential being equal, the summer radon levels would be significantly lower than those in the winter months. At installations that experience seasons (i.e., fall, winter, spring, and summer) there is sometimes a 1 month or more transition period during the changeover between heating and cooling configurations. During these transition periods it is not uncommon for occupants to open windows and doors for additional ventilation and comfort making close building conditions difficult to maintain. With these considerations in mind, long-term radon testing of < 1 year duration should only be performed during the time period that the building is most closed. However, if that is unavoidable, then the test period shall contain no more than one HVAC transition period. In some cases, a 90-to-120-day test performed during normal closed building conditions may be preferable over a 180-day test that includes a HVAC transition period.

Under closed-building conditions, all windows are kept closed and doors and other openings are only opened for normal entrances and exits. For all short-term tests (i.e., radon test between 2 to < 90 days) the following criteria must be followed:

- For radon tests between 2 to < 4 days, closed building conditions are applied 12 h prior to the initiation of the radon test and shall be maintained for entire test period.
- For radon tests between 4 to < 90 days, closed building conditions should be maintained for the duration of the test period.
- Closed building conditions for long-term radon tests of < 1 year duration are recommended.

Although under NAVRAMP a 1-year test is preferred, followed by long-term testing conducted during the season(s) that the building is most closed, allowances are made in the sampling protocol for short-term testing (2-90 day). In cases of possible health concerns, limited time, or financial considerations, or at sites or installations at which significant elevated radon potential has been demonstrated (e.g., historical, validated radon data have identified rooms ≥20 pCi/L or the installation or site is RPC 1), short-term measurements (2–90 days) can be used for assessment and for all periodic monitoring measurements provided that specific conditions are met during the entire test period (see also Section 3.4.6):

1. Closed-building conditions are observed.
    a. For short-term tests of <4 days, closed building conditions must be initiated at least 12 h before the placement of the detectors and maintained for the duration of the testing period.
2. For short-term tests of ≥ 4 days but < 90 days closed building conditions 12 h prior to the test are recommended (not required) but should be maintained for the entire test period.
3. HVAC operation is normal.
4. Testing is not performed during abnormal weather conditions.

If one of these conditions was not met, then the short-term test data should be disqualified and the building retested. Validated short-term measurements that do meet these criteria

are termed "representative" and are considered suitable for further evaluation (Section 3.4.6).

It is also important to note that testing for >1 year (e.g., 1.5 years) does not enhance or improve the quality of the long-term radon measurement. The sole intent of a 1-year test is to integrate the day-to-day and seasonal variations in radon concentrations found within most buildings to afford a good representation of the annual average (the risk upon which radon exposure is based). Extending the sample period of a 1-year test for more than 30 days (i.e., >395 days) may bias the result (higher or lower) and could impact the overall measurement confidence. Also, alpha track detectors (ATD) radon detectors do have a shelf-life. For most ATD detectors it is 2 to 3 years from the date of manufacture. Although some (not all) laboratories will analyze and report expired detectors with the expiration warning, the survey's overall accuracy and precision will decrease because of aging effects on the ATD chip.

During the radon sampling period, it is possible that a building may undergo some type of renovation. For short-term tests, retesting is typically the best option if the proposed renovation is going to affect the building's ventilation rate. However, for long-term tests, prior to the renovation, a decision is needed whether to retrieve the radon detectors. For buildings undergoing short-duration renovation projects in which the building would typically not be open for more than a few days or so (e.g., painting, installing new furniture, replacement of existing flooring) little to no action may be required. For example, if the building is being painted, simply have the painters take the detectors down and place them on a chair or desk in the room being sampled, or on an inverted 5-gal paint bucket. After the paint has dried, simply replace the detectors in the same location. It is important for all these types of minor renovations that the detectors stay in the room the entire time. However, for more significant modifications (e.g., HVAC replacement, replacement windows and doors, alterations to the buildings structural components) the detectors do need to be retrieved and returned to the laboratory for analysis within the manufacturer's recommended holding times. Retesting of the building after significant modification would be required if these changes may have had an impact on the building's ventilation rate.

3.2.2 Radon Detector Selection

The selection of the most appropriate radon detector for a particular application depends on many factors, such as the type of radon test, the cost of the device, the highest expected radon result, and the logistics of getting the detector analyzed. For testing in Navy and Marine Corps buildings, four types of detectors are approved for short-term measurements (short-term alpha track detectors [ATD], charcoal, electret, and continuous radon gas monitor [CRM]) and two types of detectors for long-term measurements (long-term ATD and electret). It is important to note that NAVRAMP guidance does not specify a particular detector manufacturer but does require that the following technical specifications be met:

- The detectors and analysis laboratory must be National Radon Proficiency Program (NRPP) or National Radon Safety Board (NRSB) approved.

- The CRM must be NRPP or NRSB listed and the testing technical certified for the specific CRM being used.
- The detectors or CRM must be used in accordance with the manufacturer's, NRPP, and NRSB published specifications.
- The data collected must meet minimum NAVRAMP data quality objectives.
- The detector should have an upper reportable limit of at least 30 pCi/L for the projected exposure period.

All detectors used for screening must have ≤15% measurement error, whereas all other detectors (for assessment and monitoring) must have ≤25% (accuracy and precision information is available from the manufacturer). Gas detectors measuring radon concentrations in international units (Bq/m^3) are allowed provided the laboratory or the Radon Testing Analysts (Section 3.6) converts the results into pCi/L before reporting (1 pCi/L = 37 Bq/m^3).

Another consideration in the selection of the detectors is overall suitability. Most radon detectors are designed for typical indoor environments and have published lower and upper temperature and humidity limits. Testing outside these limits will result in poor data quality and in some cases, will be invalidated by the manufacturer (note that not all manufacturers do so). Maximum testing duration is another consideration. Some detectors have extremely short exposure periods (e.g., 2–3 days) which, if exceeded, invalidate the radon measurements. Others (electrets, ATDs) have upper reportable limits because of technological or calibration issues (similar to overexposing a photo). In addition, some detectors have short holding times (the time elapsed between retrieval and analysis of the detectors) which, if exceeded, would invalidate a radon measurement. Therefore, obtaining this information from the manufacturer and examining return shipment options should be a prerequisite in the planning stages of any survey, and testing duration should be adjusted accordingly.

Although EPA, NRPP, and NRSB protocols allow for the reporting of radon results in either picocuries per liter (pCi/L), becquerel per cubic meter (Bq/m^3), or working level months (WLM), uncertainties in particulate concentrations (a key assumption in WLM measurements) within Navy and Marine Corps buildings make using WLM difficult. Therefore, only testing methods that measure radon gas concentration directly in picocuries per liter are permitted. For additional information on WLM see *NAVRAMP Technical Manual* Section 3.4.6. To avoid confusion in this document and the technical manual, the acronym CRM and EIM applies only to radon monitors which measure radon gas concentrations in air.

Within the past few years, electronic integration radon gas monitors (EIMs) have become commercially available. and accredited by NRSB. Most of these EIMs sell for $1000 to $5000 per device and have been found to be both accurate and reliable. However, some models sell for <$300/device and have demonstrated reasonable accuracy after a 1- to 2-week exposure period. The disadvantage with some of these low-cost EIMs is that they have not been accredited by NRPP or NRSB. But evaluation by the Navy has determined that these low-cost EIMs are suitable for nonreportable, diagnostic measurements with an

exposure period of ≥2 weeks' duration. It is important to note that these test results are for internal use and planning purposes only and cannot be publicly disseminated or incorporated into the NAVRAMP master database. But they can be used by the installation for reference and directional purposes in accessing the urgency of radon testing or mitigation at a particular location.

3.2.3 Nonresidential Building Testing Requirements

For a building to be considered testable (referred to throughout the document as a "testable nonresidential building"), it must first be enclosed, in ground contact (i.e., slab on grade, crawlspace, basement), occupied or easily occupiable, and not proposed for demolition within the next 2 calendar years. Also included in this category of testable nonresidential buildings are leased and international use agreement buildings for which it has been determined that the Navy or Marine Corps is responsible for the implementation of NAVRAMP (Section 2.8).

Exceptions to these testing requirements are nonresidential buildings proposed for renovation, HVAC replacement, or other projects or installations that would result in the building being more open than in typical usage. Testing for these buildings should be performed after these occurrences have been completed. In addition, purposed constructed buildings that are typically intermittently staffed for < 4 h/day or < 1000 h/year can also be omitted from the testing requirement.

3.2.4 Nonresidential Room Testing Requirements

Within a nonresidential building selected for radon testing (i.e., screening, assessment, and selected types of monitoring; see Sections 2.5–2.7), all ground-contact rooms (wall, floor, or ceiling) over a crawlspace or directly over a basement space not being tested are considered potentially testable rooms or areas. Selected measurement types (Section 3.2.9, Table 4) excluded from this requirement are SSD, ERV, SP, passive postmitigation tests, diagnostic measurements, O&M, replacement for lost or damaged detectors, follow up, and confirmation testing. In these cases, the option exists to test only the individually impacted room or room of interest. However, in nonresidential buildings with centralized HVAC systems where supply or return air adjustments or system rebalancing has been performed, the postmitigation test shall include all testable rooms.

For a nonresidential room or area to be considered for radon testing, it should be in ground or crawlspace contact (wall, floor or ceiling), occupied for ≥4 h/day or ≥ 1000 h/year or readily occupiable (e.g., duty room, duty bunk room, vacant bachelor quarters room, vacant office, or space that could easily be converted without significant modification into occupied or livable space). Examples of a readily occupiable room include built-to-purpose office space which is being used for temporary or overflow storage and vacant rooms in which the furnishings have been removed. It is important to note that detector placement/retrieval during a survey only takes a few minutes in a questionable room. However, if later the room occupancy status changes due to mission of staffing changes

the cost for testing this room would be significantly higher. In cases of doubt, the room should be included in the testing.

In a multi-story building where the ground contact room is not occupied/occupiable, and the room directly above it on the next highest floor is occupied, then that room should be tested. Figs. 1-6 show examples of rooms to test in multi-story nonresidential buildings. In addition, conference rooms, classrooms, and break areas should be included. Occupied service bays (e.g., motor transport buildings, service bays etc.) should be tested only if the bay doors are closed for ≥4 h/day while the space is occupied. Additional nonresidential rooms that could need testing, at the installation's discretion, include ground-contact hallways, stairwells, and other types of common areas. Rooms that should not be tested (unless for diagnostic purposes) include but are not limited to bathrooms, gear lockers, utility closets, dedicated storage rooms, elevator shafts, and unoccupied mechanical, electrical and communication rooms. However, it is important to note that within some buildings rooms that were not purpose built or designed for occupancy can occasionally be found occupied. For example, in mess halls it is not unusual to find an office in the dry or cookware storage room. In older style bachelor quarters, the storage room under the main stairwell is sometimes used as duty bunk room or duty office. If these rooms meet the minimal occupancy requirement, then radon testing would be required.

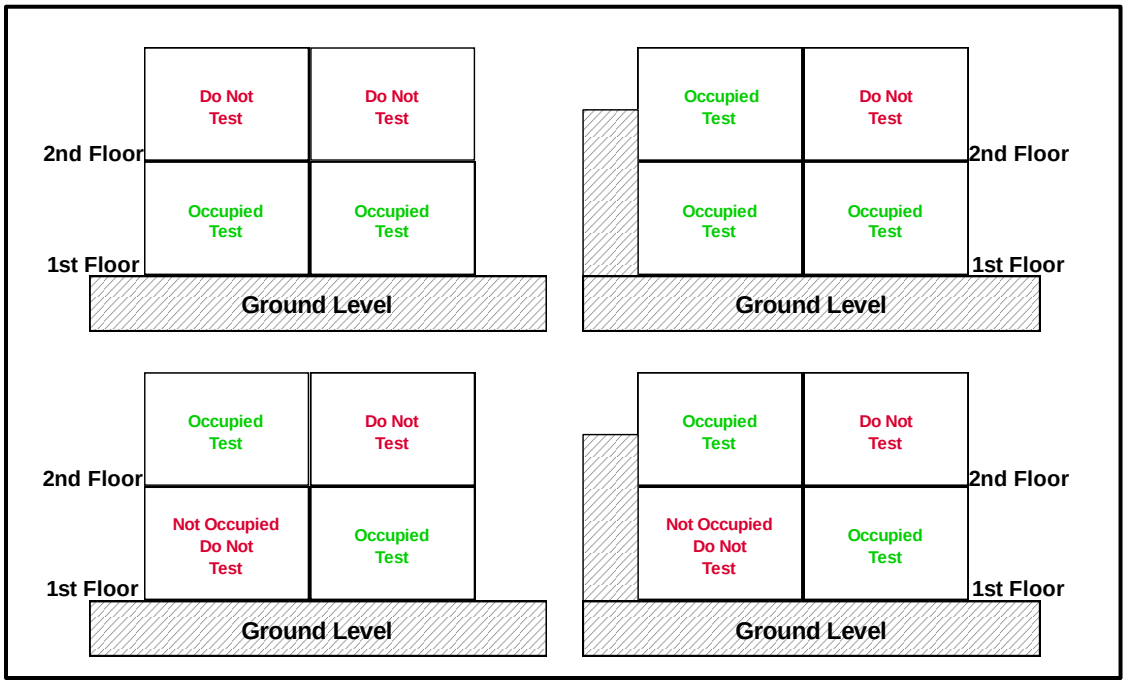


Fig. 1. Examples of which rooms to test in a 2-story nonresidential building.

Fig. 2. Example of testing in a nonresidential building with a simple basement.

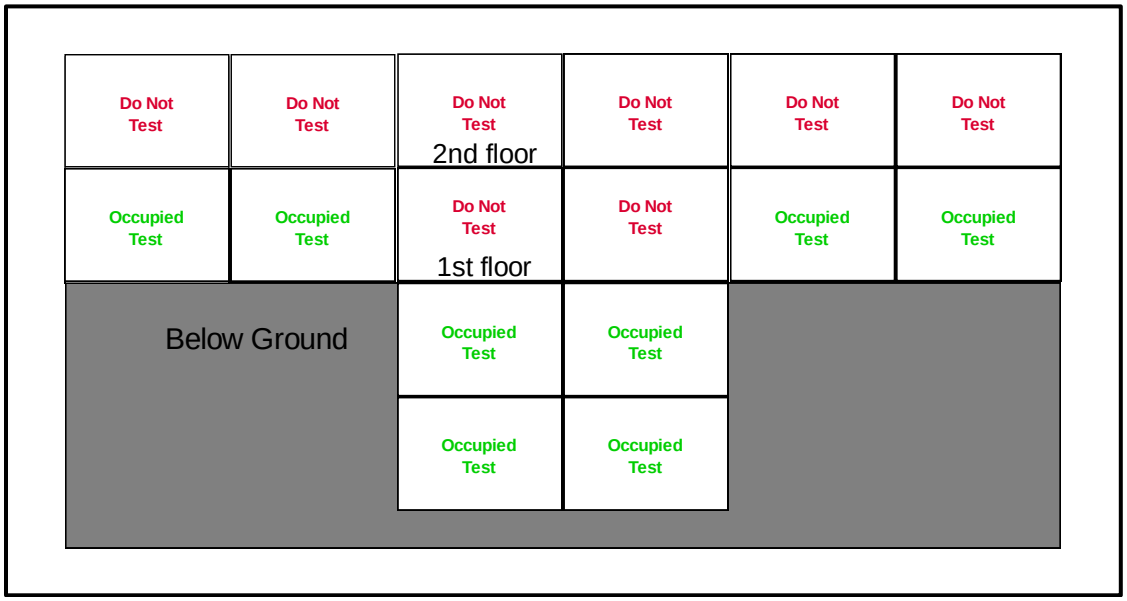


Fig. 3. Example of testing in a nonresidential building with a complex basement.

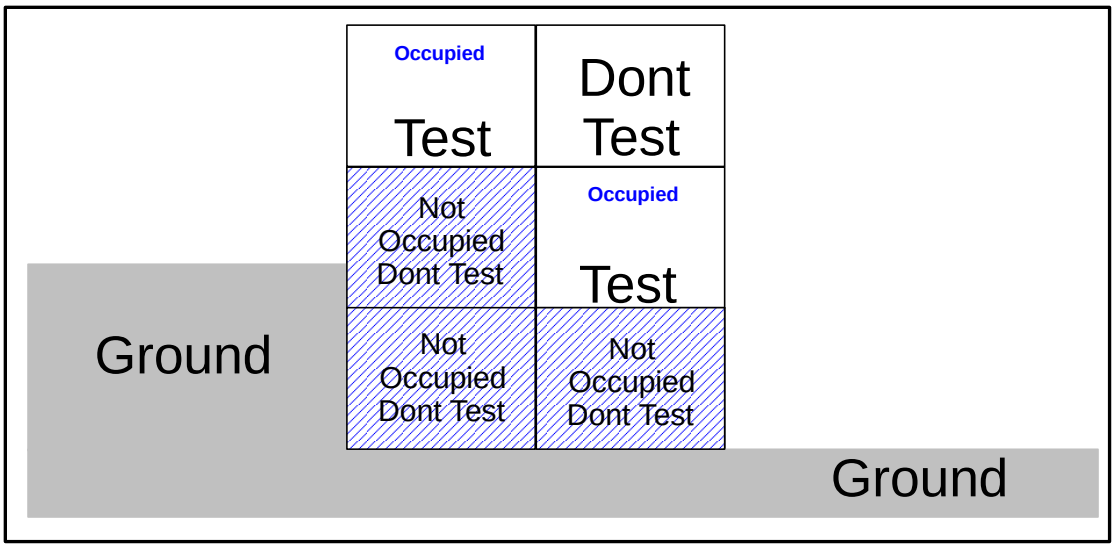


Fig. 4. Examples of where to test if ground contact room is not occupied.

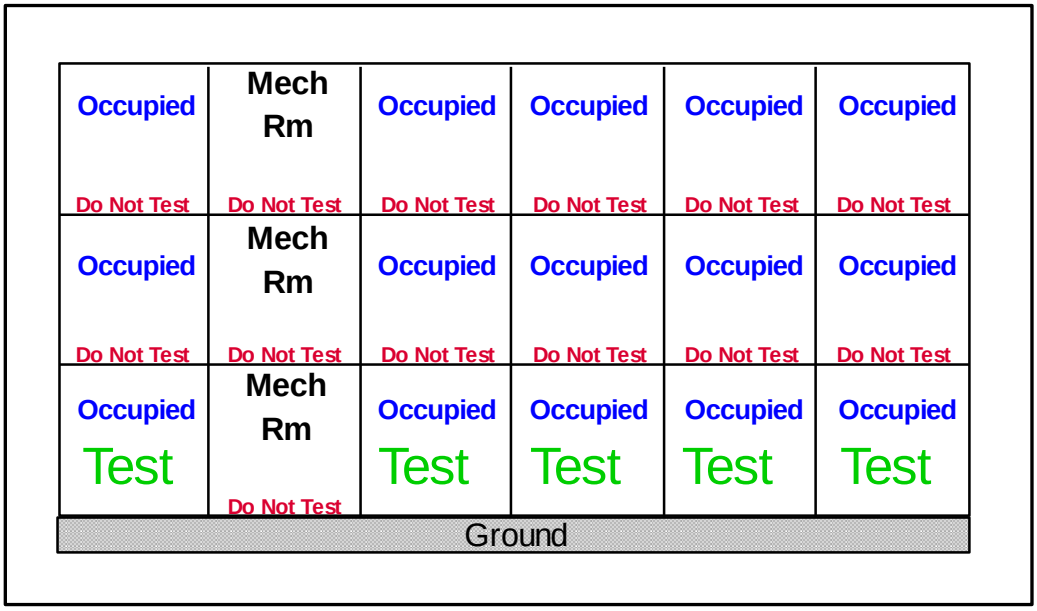


Fig. 5. Example of where to test in a multistory building.

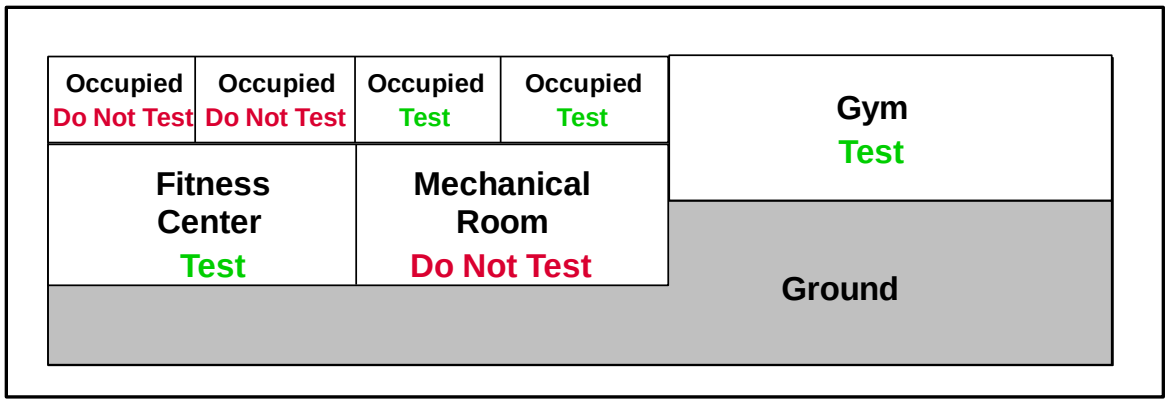


Fig. 6. Example of radon testing in a multi-level fitness center.

Analysis of historical NAVRAMP detector placements has identified certain types of testable, nonresidential rooms that would be disqualified for testing under the EPA guidelines (EPA July 1992 and EPA May 1993). A partial list of these problematic testable nonresidential rooms includes commercial kitchens, breakrooms containing kitchens, shops, laboratories, or armories with high air velocity. Also, a sentry post or small administrative workspace (e.g., offices, reception rooms) with an exterior wall (a wall with one face on the outside of the building) would potentially be not testable if there were strict adherence to maintaining specified distances from windows, outside doors, and supply or return ducts. The basis for EPA concerns over testing within these type rooms is grounded on the known susceptibility of certain types of radon detectors to moisture and above-average air velocity. However, under NAVRAMP, these rooms can be tested using the ATDs, electrets or CRMs because these detectors are less susceptible to the moisture and air velocity concerns. Priority in these cases should be given to selecting a testing location as far from the exterior wall as practical.

3.2.4.1 Radon Testing Within Barracks, Dormitories, Lodges, and VIP Quarters

Because the prevalence and distribution of elevated radon levels within these types of housing facilities (i.e., built to a commercial principle, not a residential one) are identical to those found in nonresidential buildings (*NAVRAMP Technical Manual* Section 3.2.2), radon testing will be required in all testable rooms within the building. However, studies have shown that not every potentially testable room within an unaccompanied housing unit or lodge will need to be tested. The following list provides additional information and exemptions for radon testing in these specific types of buildings with potentially testable, ground-contact rooms:

- Barracks and dormitories
    - Test all testable common areas and other rooms (e.g., duty desk, offices, occupied staff breakroom or office, laundry rooms, and recreation rooms).
    - Do not test main hallways (unless they have gathering or seating areas), bathrooms, unoccupied dedicated storage rooms, gear and locker rooms, unoccupied utility rooms, closets, common shower/locker rooms, or janitor and communication closets.

- Open bay configuration:
  - Select 1 sample location per 2000 ft^2 per bunk room.
- Single room unit (e.g., bedroom and living area are in the same room—sometimes referred to as "studio" configuration):
  - Select one sample location.
- Multiple room unit (e.g., bedrooms separated by a door from a shared common room)
  - Test all bedrooms.
  - Test the common room only if it is configured to have a living room (i.e., large enough to accommodate a sofa, or chairs and TV).
- If the barracks or dormitory is constructed using residential principles (i.e., it was a former housing unit), consult Sections 3.2.6 and 3.2.7.

- Lodges and other temporary lodging facilities:
  - Test all common areas and other occupied/occupiable rooms (e.g., lobby, reservation desk, offices, staff breakroom, laundry rooms, conference and recreational rooms).
  - Do not test main hallways, bathrooms, linen or gear storage closets.
  - Guest room configuration sampling considerations:
    - Single room (e.g., bedroom and living area in the same room, sometimes referred to as a studio room):
      - Select one sample location per guest room.
    - Deluxe or suite room (bedroom[s] are separated by a door from the living area and kitchen):
      - Test only the living room.
  - If the lodge, or temporary lodging facility is constructed using residential principles (i.e., it was a former housing unit), consult Sections 3.2.6 and 3.2.7.

- VIP Quarters
  - If the VIP quarters is constructed using commercial building standards, then test all occupied/occupiable rooms (e.g., living room, bedrooms, office) in the building.
    - Do not test closets, bathrooms, laundry rooms, and pantries.
  - If the VIP quarters is constructed using residential principle (i.e., it was a former housing unit), consult Sections 3.2.6 and 3.2.7.

Figs. 7 and 8 show common configurations for unaccompanied housing units and rooms at lodges and other temporary lodging facilities built to the commercial principle.

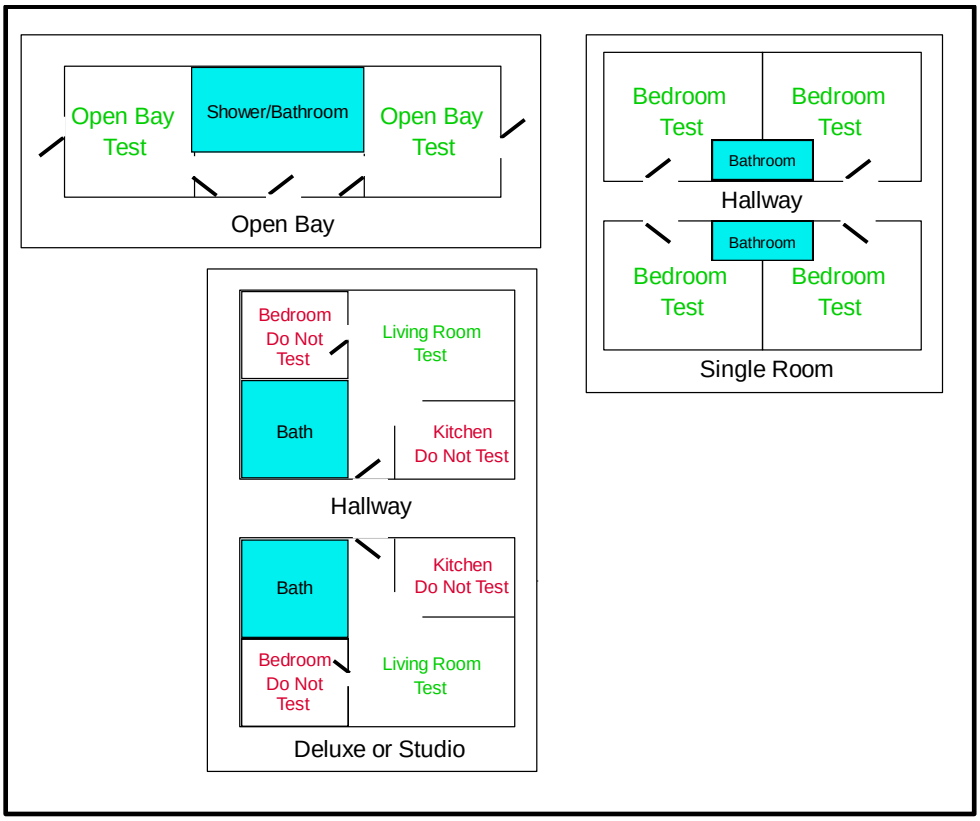


Fig. 7. Examples of single unit and open bay configurations.

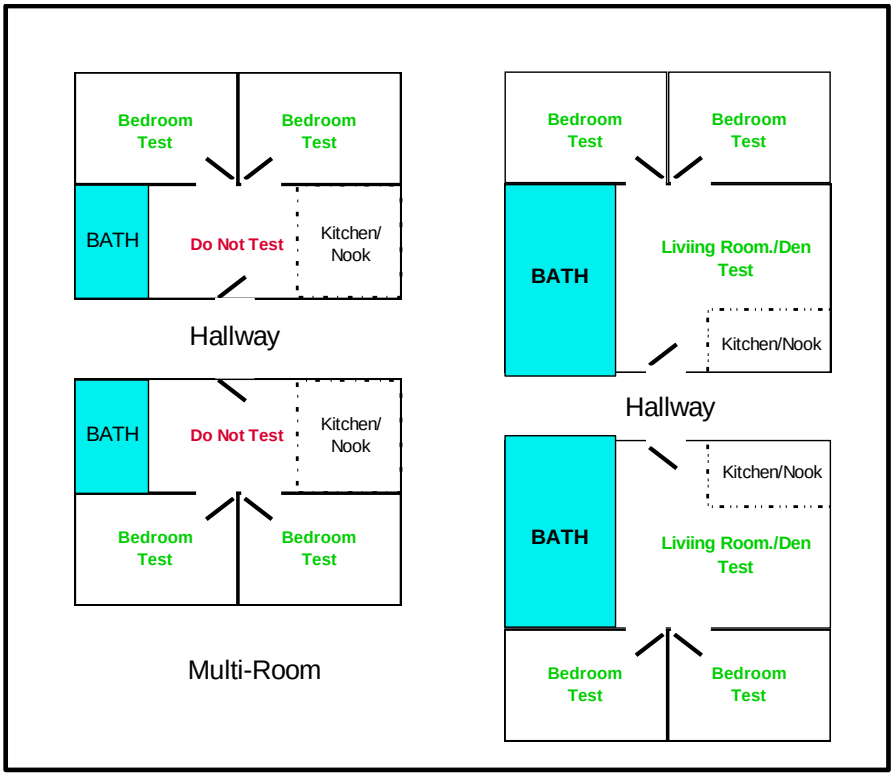


Fig. 8. Examples of multiroom housing unit configurations.

3.2.4.2 Radon Testing in a Sensitive and Secure Rooms or Areas

Within the Navy and Marine Corps there are certain types of rooms in which radon testing may prove difficult to perform. Examples include server farms, telecommunication rooms, simulator training facilities and Sensitive Compartmentalized Information Facility (SCIF). For server, telecommunication and simulator facilities the primary concern is electronic interference. However, if passive detectors (i.e., ATDs, electrets, or charcoal) are being used, with proper explanation and documentation on how the detectors work with prior coordination for access (in some cases only authorized people may be able to enter the room so they will need to place them) radon testing can be performed. It is important to note that for electret detectors exposure to microwaves and similar types of high-level electromagnetic radiation will cause a high bias. Therefore, only ATDs and charcoal detectors should be used in these rooms.

For SCIFs, the primary concerns are the introduction into the room of listening or recording devices and the entry of noncleared personnel. Therefore, time allowances must be made in advance to have the detectors and personnel vetted by the appropriate security authorities. Historically, the use of CRMs or EIM detectors have been more difficult (not impossible) to place than passive detectors and may require approval from at a much higher level (e.g., the approver is not located at the installation). However, passive devices can usually be vetted by local security officer or chief. This vetting process can take days and in some cases months to perform so the process needs to be initiated during the initial planning stages of the testing project to avoid any testing delays. Once the detectors have been vetted, a subset of the detectors or all may need to be disassembled and inspected just prior to placement. This is not a problem for electret detectors, just use caution not to touch the Teflon disk. ATDs can also be disassembled, however white cotton gloves must be worn to ensure that the CR-39 chip is not contaminated with skin oil or lotion. Care must also be taken to put the CR-39 chip back into the holder in the correct orientation since there is a difference on which side is exposed to radon. Charcoal detectors cannot be disassembled. In rare cases, security may request that the detectors be x-rayed or subjected to a CAT scan. In this case only the ATD and charcoal liquid scintillation detectors would be acceptable. Once the device has been properly vetted and cleared, access to the room or area may be limited only to authorized personnel or under escort. Therefore, staff assistance will be required for placement and retrieval.

In cases where permission to test for radon was denied, the documentation should be included in the radon management plan.

3.2.4.3 Radon Testing Within Temporary Buildings

It is not unusual at a naval installation to find occupied, temporary buildings (e.g., office or school trailers, or converted storage containers). In most cases these temporary buildings are in place to provide short-duration work or classroom space while a

permanent structure is being renovated or constructed. To be considered testable, the area under the building must be enclosed (sometimes referred to as under pined) and be in ground contact. The next consideration is the timeline for vacating the buildings. In most cases leased temporary buildings have firm return dates which can be confirmed by the installation contract officer or the rental company. Radon testing is not required for these buildings if the lease expires within the next 5 years. For government owned temporary buildings, the determination of an exact date for vacancy can be more complicated because the current occupants may leave and be replaced with different ones. Also, it is not uncommon for the temporary building to be relocated to another location or installation site. In this case, radon testing should only be performed if the temporary building is going to remain occupied and reside at the current location for the next 5 years.

3.2.5 Number of Sample Locations per Room in a Nonresidential Building

All radon testing using passive detectors shall be performed using 100% collocated duplicate detectors (i.e., two detectors placed side-by-side at the same location). Within a building selected for testing, all occupied or readily occupiable testable rooms shall be tested. Testing within rooms that are < 10,000 ft^2 shall be performed at a frequency of one testing location per 2,000 ft^2 of floor area. For single rooms ≥10,000 ft^2 with a high volume of people usually present (e.g., gymnasiums, commissary or exchange sales rooms), testing locations shall be at an interval of one per 5,000 ft^2 up to a maximum of 50 sampling locations (to the best extent possible, evenly distributed throughout the room). Within rooms with an open floorplan that has movable walls that divide the room into 2 or more sections, testing is required in all sections if the dividers are closed most of the time or during typical occupancy periods. However, if the dividers are used infrequently, select one testing location per 2,000ft^2 of floor area.

For testable rooms ≥ 10,000 ft^2 with a low density of occupants (e.g., warehouse or storage bays) sampling shall be performed at one per 5,000 ft^2 up to a maximum of 5 testing locations per room. Testing locations in these types of rooms should be biased towards areas where the occupants spend most of their time (e.g., counter, desk areas, or break areas). Additional sampling within the less frequently used areas of the room is optional up to a maximum of 5 additional testing locations. In addition, all individual, testable, occupied or readily occupiable rooms within these large rooms shall be tested as independent rooms (i.e., these sampling locations do not count toward the 5 or 50 locations maximum for the large room). Figure 9 shows an example of testing locations within a warehouse bay.

For aircraft hangar bays, fire station and service bays radon testing should not be performed in that room unless the doors are closed for ≥ 4 h/day during normal occupancy periods. If testing is required, they should be placed on an interior facing wall and as far as practical from the hangar or high bay doors and the sampling interval changed to one testing location for every 20,000 ft^2. Figure 10 illustrates possible testing locations in an aircraft hangar. Under no circumstances should the detectors be hung from the hanger bay ceiling by a length of string to place it within the testable range of the floor.

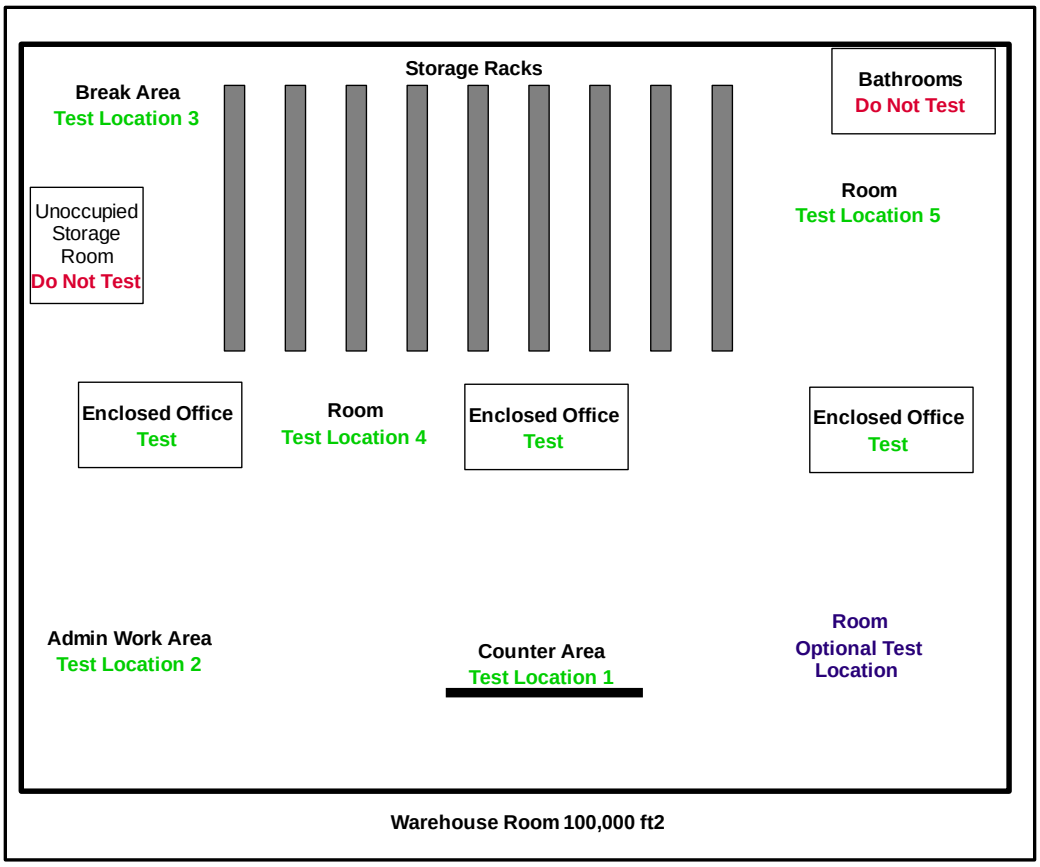


Fig. 9. Example of a testing approach for a warehouse room.

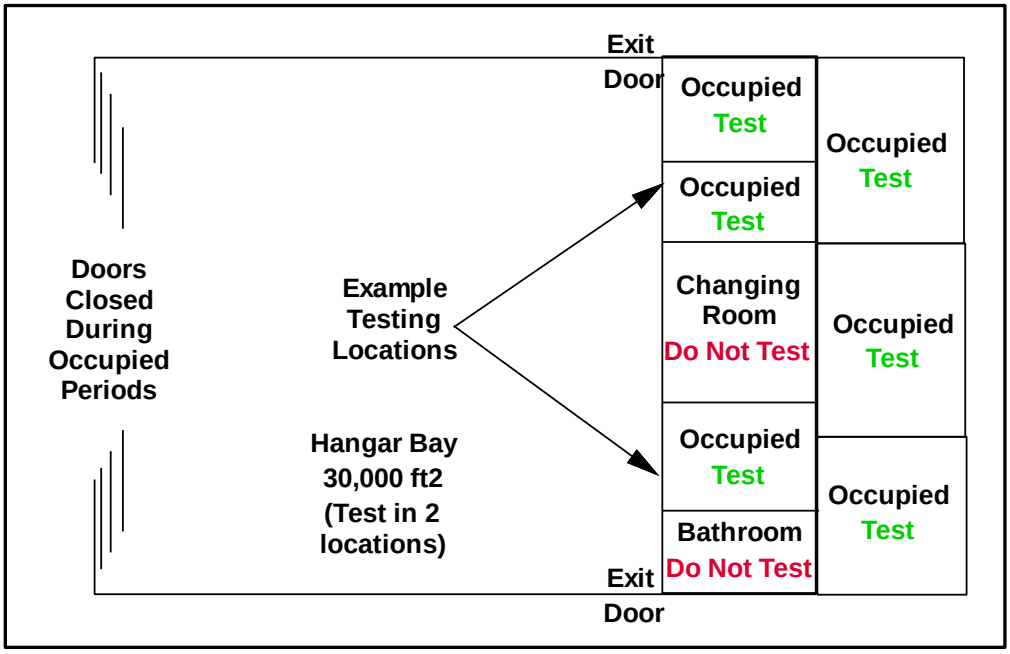


Fig. 10. Example testing locations in an aircraft hangar.

A noted exception to this testing requirement is cases in which family housing buildings (i.e., built to a residential principle) have been converted to other uses (e.g., unaccompanied housing, lodges, transient quarters, offices). In this case, only one centrally located room (i.e., a former living room or hallway) is tested (see Sections 3.2.6 and 3.2.7).

3.2.6 Family Housing Unit Testing Requirements

Navy and Marine Corps family housing units typically are in single-detached, duplex, townhouse, flat, and low-, mid-, and high-rise apartment type buildings. For a family housing unit to be considered testable (referred to herein as a "testable family housing unit") it must be in ground contact (i.e., slab-on-grade, crawlspace, basement), occupied or easily occupiable, and not proposed for demolition within the next 2 calendar years. Consistent with EPA and ANSI/AARST recommendations, NAVRAMP requires that all testable individual family housing units be tested (i.e., screening is not allowed). Also included in this category of testable family housing units are international use agreement family housing for which it has been determined that the Navy or Marine Corps is responsible for the implementation of NAVRAMP (Section 2.8). PPV family housing units privatized under the Military Housing Privatization Initiative (MHPI) are subject to applicable Federal, State, and Local laws and are not subject to NAVRAMP (*Radon Testing and Monitoring of Privatized Military Housing Procedures*, dated 4 August 2020).

Exceptions to these testing requirements are family housing units proposed for renovation, painting, floor covering replacement, kitchen or bathroom replacement, or other projects or installations during the proposed test period that would result in the building's being significantly more open than in typical usage. Testing for these housing units should be deferred until after these modifications have been completed, unless arrangements can be made to keep the windows closed and have doors opened only when required.

It is also not unusual at naval installations to find units that have been taken indefinitely off-line (not available for occupancy) because of reduced demand for family housing or other reasons. Although technically radon testing in these units is not required (the unit is not readily occupiable), if the potential exists that the unit could be brought back on-line, and the unit is in a testable condition (i.e., electrical power is on, heating and air conditioning are operating), then radon testing should be considered. The primary reason is that the cost of testing an off-line, unoccupied unit is significantly less than the cost of testing an occupied one. However, if elevated radon is found in an off-line unit, then mitigation can be deferred until it is ready to be occupied again (if no one is being exposed, there is no risk).

Another family housing testing exception is cases in which units are located on upper floors (i.e., not in ground contact). In most cases, these units are exempt from all NAVRAMP testing requirements (it is recommended that a list of these units be included in the RMP for reference purposes). However, with respect to upper-floor units in low-, mid-, and high-rise towers, recent studies in private sector family housing have found elevated radon levels within housing units not in ground contact, but on upper floors (e.g., 5th and 6th

floors). The cause of the elevated radon level was determined to be a unique combination of low natural ventilation caused by a tight building envelope (also commonly referred to as "building shell"), the absence of fresh air makeup, and slightly above average emanation of radon from concrete (a key ingredient of concrete comes from limestone). However, it is important to note that not all the units in these towers had elevated radon levels, because radon emanation from the concrete was found to be highly variable from sample location to location (concrete is made and poured in batches and, in a large building, cures at different rates, which influences density). Random testing of units in the tower (one unit per floor) also failed in some cases to predict the presence of elevated radon levels in units on that floor. Therefore, in such cases, the only way to know for sure whether elevated radon was present was to test all the units in the tower.

A review of available DoD radon testing data collected within mid- and high-rise towers located in Japan found no evidence of any elevated radon problems caused by the combination of low natural ventilation and elevated radon emanation from concrete. In fact, all ground-contact units were successfully mitigated using ASD mitigation techniques, which would not have been possible it the problem had been caused by the latter. Therefore, under the NAVRAMP, radon testing of upper-floor units in low-, mid-, and high-rise towers is optional and should be considered only if the primary construction material is poured concrete and if one or more of the following are true:

- Little or no (e.g., <75 ft^3/min) fresh air makeup is provided to the individual units.
- Moisture control issues have been noted in the upper-floor units in the tower.
- Residents have complaints about poor indoor air quality (e.g., lingering odors, which are typically referred to as "stuffiness" by the occupants).
- The estimated or measured natural ventilation rate is <0.3 air changes per hour.
- The units are under negative pressure (e.g., [−] 8 Pascal [Pa]) relative to the outdoors with all the unit air exhaust systems on.
- Diagnostics or mitigation of one of more ground-contact units with elevated radon levels in the building has determined that the potential exists for elevated levels of radon in upper-floor units.

If upper-floor testing appears to be warranted, then all family housing units in the tower should be tested.

Another common configuration in mid- and high-rise towers is the absence of ground-floor family housing units. Typically, in this configuration, there are community or meeting rooms and/or storage rooms on the ground-contact floor. These rooms can be tested in lieu of testing the family housing units on lowest residential floor, provided that all rooms in ground contact (including those not occupied) are tested. If this is not possible, then all the family housing units on the lowest residential floor should be tested.

3.2.6.1 Other Considerations in Radon Testing in Family Housing

Radon testing in family housing sometimes presents more challenges than testing in nonresidential buildings. Specifically, it involves residents' concerns regarding the potential health effects of radon exposure on families. For most environmental surveys, an installation subject matter expert (e.g., an environmental or medical professional) is identified in advance to address resident questions and concerns. However, because of the greater interaction between housing staff and residents, there is a high likelihood that residents' questions will be directed toward housing staff. Since most of these questions and concerns are general in nature, it is recommended that housing staff be instructed as to how to provide basic radon risk communication in case questions arise. To assist in this task, a general question-and-answer handout that addresses radon testing and mitigation in family housing is provided in Appendix D.

Another consideration in family housing is determining the best way to get into the home to both place and later retrieve the radon test kits. Although this process takes only a few minutes per unit to perform, at some installations, testing a few hundred units took months to complete. In the past, various methods of placing and retrieving kits have been tried at naval installations worldwide. All were successful, but some methods were much more expensive than others to implement (e.g., five times the cost per unit compared with the least expensive method). In general, options that entailed the radon technician going door to door trying to catch the residents at home, or attempting to contact the resident (e.g., notices, email, and phone) to schedule testing appointments, took the longest and were the most expensive to implement. Although going door to door will usually catch most residents (e.g., 90%) at home after the first five attempts, to get access to the remaining 10% of the units can be very time consuming. The problem with this method is that some residents are gone; others work odd hours; and some do not read or choose not to respond to the notices, phone calls, or emails. Others may feel harassed by all the effort to contact them and complain to Command. The extra effort to access those units typically increases the overall testing cost per unit by one-third to one-half. However, historically, the best option (lowest cost per unit and fewest resident complaints) typically entails the housing inspector, a member of the housing maintenance staff or other authorized housing representative accompanying the radon technician and opening the door if the resident is not at home. An important part of this approach is to provide the residents with a schedule in advance telling them which units will be tested within a given time and date and giving them the option to schedule an appointment. Therefore, in the early planning stages of a family housing radon project, a decision is needed regarding how detectors are going to be placed and retrieved.

3.2.7 Family Housing Unit Room Testing Requirements

A radon detector will be in a family housing unit for 1 year in most cases. Therefore, allowances must be made to accommodate the resident so that the detector is not in the way and, to the extent possible, not in the typical line of sight (out of sight, out of mind). The ideal room for radon testing (in most cases, in family housing, only one testing location per unit is needed) will be in ground contact, centrally located but not enclosed and away from

exterior walls. Examples of typical rooms for radon testing include a central hallway, dining room, or living room. Bathrooms, pantries, and closets should never be used as radon testing locations. Bedrooms can be used for testing locations; however, most residents are uneasy about allowing strangers into their bedrooms. Historically speaking, the most successful testing location in family housing has been in the central hallway, with the detector placed near the doorbell, smoke detector (radon detectors are not susceptible to the low-level radiation emitted by smoke alarms), or electrical breaker panel or near other visually distracting items already present.

To the extent possible, within identical units, technicians should try to place the detectors in the same general location each time. The key advantage of doing so is that during the testing period, maintenance workers, contractors, and new residents can be told where the radon detectors are located and instructed not to disturb them.

In most cases, only one sampling location will be required in a single-family housing unit. However, in some homes (typically command or flag quarters), the size of the unit or floor plan may require two or more sampling locations to ensure that no area of the home has elevated radon levels. Additional testing locations in these homes should be considered if one or more of the following is true:

- The unit has a ground-contact area $\geq$3,000 ft^2.
- The unit has multiple heating and air-conditioning zones that do not share a common air return.
- The unit has isolation doors that separate the common areas (e.g., living room, greeting room) of the home from the private areas (e.g., bedrooms, family den).
- The unit has separate servant or aide quarters.

In family housing units with basements, a decision must be made whether to test the primary living area, the basement, or both. Consistent with EPA and ANSI/AARST, the NAVRAMP testing requirements are that the testing should be performed at the lowest area suitable for occupancy. For example, if the basement is unfinished and unconditioned and is being primarily used for storage or as a laundry, then the testing should be performed on the main floor. However, if the basement contains one or more finished and conditioned rooms, and can be used as a living area (e.g., bedroom, den, or child's playroom), then the basement should be tested rather than the main floor. In uncertain cases, testing of both floors should be considered. For a unit in which the main living area is configured over a garage or storage room that is entirely in ground contact, radon testing should be performed only in the lowest living area.

3.2.8 Selecting a Testing Location within a Room

In selecting a testing location within the room, consideration must also be given to the duration of the radon test and the type of detector being used (Section 3.2.2). For short-duration measurements (e.g., <8 days), the devices (with resident/occupant concurrence) could potentially be placed on desks, credenzas, tables, shelves, or countertops. However, for longer-duration tests (e.g., 8–365 days) the detectors need to be placed in a location

within the room that reduces the probability that the device will be disturbed. Therefore, for these longer-duration tests, allowances must be made to accommodate the resident/occupant so that the detector is not in the way and, to the extent possible, not in the typical line of sight (out of sight, out of mind).

For ATDs and L Chamber E-Perm long-term electrets (LT electrets), studies conducted by the Navy have found no significant differences in reported radon concentration when the detectors were placed flat against the wall vs. hanging from the ceiling at the same height at various distances from the wall sampling location. However, it was noted during this and other studies that detectors hanging from the ceiling were 30% more likely to be lost during the measurement period vs. those that were placed flat on a wall. With these considerations in mind, under NAVRAMP, ATDs and L electret detectors can be placed flat on a wall. In selecting a wall for ATD and L electret detector placement, to the extent possible, an interior wall (a wall having two interior faces) should be given preference.

In general, the following guidelines should be followed to the extent possible:

- Select a testing location that reduces the probability that the device will be disturbed.
- Give preference to an interior wall (a wall having two interior faces) as opposed to an exterior wall (a wall with one face on the outside of the building).
- Do not place the devices within 3 ft of drafts caused by fans or heating, air-conditioning, other ventilation systems or portable fans or air cleaners.
    - In small rooms with supply and return grills that are both within the 3 ft spacing at the proposed testing location, place the detector more towards the return grill.
- Do not place or hang the detectors on smoke detectors, lights, or fire sprinkler fixtures.
- Do not put the detectors inside drawers or cabinets.
- If performing a long-term radon test, do not place the detectors on file cabinets or desks which can be moved or relocated during the test period.
- Place the devices between 2 and 8 ft from the floor, 4 in. from other objects, at least 3 ft from exterior doors (e.g., doors opening to the outdoors) and windows, and 1 ft from an outside or exterior wall (a wall with one face on the outside of the building).
- Place collocated duplicate detectors (i.e., two detectors per test location), within 4 to 6 in. of each other (measured from center to center of the detectors).
    - The only exception for spacing between duplicate detectors is for ATDs and electrets, which can be collocated without any spacing between them.

With respect to placing the detector on an exterior wall, the current ANSI/AARST standards assumed that the wall would be wood framed and covered by sheeting, siding or a brick veneer. These types of exterior walls do leak outdoor air which in turn lowers the measured radon level near the exterior wall. However, if the wall is made of poured concrete or intact concrete block, this problem is very unlikely to occur. Therefore, under NAVRAMP placing detectors on an exterior, poured concrete or intact block walls is allowed however an interior wall location would still be preferred.

In addition to those requirements, all recommendations provided by the device manufacturer should be followed (e.g., do not use in direct sunlight or in areas of high humidity or temperature).

After the detectors are placed, a sticker or placard bearing the following information should be attached either to the detectors or adjacent to them on the wall:

DO NOT DISTURB
RADON TESTING IN PROGRESS
CALL: (contact phone number)

At the time of detector placement, an approved handout containing information about radon, the testing device, and so on should be left with the occupant or resident (an example handout is included in Appendix D).

3.2.9 Radon Test Types

Under NAVRAMP documenting the primary reason for the radon test is also required. To assist with this requirement, 2 letter codes have been provided (Table 4) which are assigned to each individual measurement.

Table 4. NAVRAMP radon measurement testing types and codes.

Type of radon measurement	Testing code	NAVRAMP testing phase	Preferred test type/duration	Description of the test
Screening	SG	Screening (Section 2.4)	Long-term (1 year)	Measurement performed as part of project to determine radon potential at a site or installation
Supplemental screening	SU	Screening (Section 3.2.9.2)	Long-term (1 year)	Measurement used for collecting additional screening data after the survey has been completed and retesting within housing units or rooms/areas in which the detectors were lost or suffered a catastrophic testing event.
Assessment	AS	Assessment (Section 2.5)	Long-term [a] (>90 to ≤365 days)	Measurement performed to identify buildings or rooms, and housing units at a site or installation with elevated radon potential.
Supplemental assessment	SA	Assessment (Section 3.2.9.2)	Long-term [a] (>90 to ≤365 days)	Measurement used for collecting additional assessment data after the survey has been completed and retesting within housing units or rooms/areas in which the detectors were lost or suffered a catastrophic testing event.
Confirmation	CN	All phases (Section 3.2.9.3)	Short-term (2-90 days)	Measurement used to confirm a single elevated radon measurement. If performed more than once the conclusion should be based upon the sequential average (Section 3.4.5)
Follow-up test	FT	All phases (Section 3.2.9.3)	Short-term (2-90 days) or long-term (>90 to ≤365 days)	A retest of the room or building under identical testing conditions as the initial test.
New construction	NC	Monitoring (Section 2.6)	Short-term (2-90 days) or long-term (>90 to ≤365 days)	A radon test performed in a new building before occupancy or within 5 years of acquisition

Table 4 (continued)

Type of radon measurement	Testing code	NAVRAMP Testing Phase	Preferred test type	Description of the test
Significantly modified or HVAC replacement or structural modification retest	RR	Monitoring (Section 2.6)	Short -term (2-90 days) or long-term (>90 to ≤365 days)	A retest of a room or building in which weatherization, whole building replacement, additions, HVAC modification or replacement, or damage by any events such as earthquakes and storms that would alter the building envelope has occurred
Operation and maintenance	OM	Monitoring (Section 3.2.15)	Short-term (2-90 days)	A mitigation performance test is performed at least every 2-3 years within the affected rooms.
Monitoring test	MT	Monitoring (Section 2.6)	Short-term (2-90 days) or long-term (>90 to ≤365 days)	Radon testing performed after the screening and assessment phases have been performed to ensure that levels are <4 pCi/L
Diagnostic measurement	DM	Mitigation (Section 3.2.9.5)	Short-term (2-90 days)	A radon test performed as part of a mitigation diagnostic or under exactly known conditions within a room or building of interest
Postmitigation	PM	Mitigation (Section 3.2.9.4)	Short-term (2-90 days)	Radon test after radon mitigation within the affected rooms

[a] Under certain circumstances (Section 3.2.1), short-term measurements can be substituted for long-term measurements. See also Section 3.5.6.

3.2.9.1 Screening, Assessment, Monitoring and New Construction Measurements

Screening (SG), and assessment (AS) test types are reserved for installation or site wide initial surveys and are used to clearly identify testing phases under the NAVRAMP. Under NAVRAMP, screening is required to be completed during the course of a single survey. However, assessment can be performed over longer time periods for logistical or cost reasons. New construction (NC) test is reserved for the initial radon test of newly constructed building which were not testable during the screening or assessment phases. Screening, assessment and new construction test type designations should only be used once within a given tested building. Subsequent testing in these buildings or rooms should be designed as applicable as confirmation, follow-up, renovation retest, post-mitigation, or operation and maintenance tests. Monitoring testing (MT) is reserved for installation or site wide testing every 5-years and can be used indefinitely.

3.2.9.2 Supplemental Screening and Supplemental Assessment

The supplemental screening and assessment test type is used to designate radon measurements that were performed after the initial screening or assessment was completed. Examples would include buildings that were:

- Not testable because of proposed renovation, ongoing renovations or scheduled for mechanical replacement during the screening or assessment
- Recently acquired (buildings that were not under the installation's control when the screening or assessment was performed)
    - For all newly constructed buildings use the new constructed test type (NC)
- Testable but were omitted for any and all reasons during the screening or assessment
- Tested but a defensible testing conclusion could not be reached (e.g., not all rooms were tested)
- Replacement for lost detectors or measurements with catastrophic errors (Table 5)

3.2.9.3 Confirmation and Follow-Up Measurements

Radon testing in the private sector is divided into two distinct testing protocols. Informed consumer testing (people testing their own house) and real estate testing. Within the informed consumer protocol, confirmation testing is recommended for all short-term radon results $\geq$ 4 pCi/L. If the confirmation test is another short-term test, the testing conclusion is based upon the average of the two tests (see Section 3.4.5). However, if a long-term test is used for the confirmation test, the conclusion is based entirely on the long-term result (EPA402/K-12/002|2016|). In the real estate testing protocol (EPA 402/K-13/002) short-term radon testing was performed using short-term duplicate detectors with the testing conclusion based upon the average of the two results, with no confirmation required. Although it is acknowledged in this testing protocol that the short-term test may not be representative of the annual radon average (See Section 3.2.1), it was concluded that some

health benefit comes from radon mitigation at any radon level and that the new homeowners could easily retest using the informed consumer protocol.

In developing the NAVRAMP testing protocol, it was decided that the testing conclusion had to be right the first time to facilitate any required corrective action. A critical look performed by the Navy and DOE on collocated long-term results ≥ 4 pCi/L determined that the failure rate using long-term collocated duplicate ATD detectors with acceptable measurement precision was extremely small. In most cases where the confirmation test was < 4 pCi/L there had been some changes to the buildings mechanical systems which resulted in the building being pressurized or better ventilated. Error directly attributed to simultaneous detector failure was found to be about one in 10,000 measurements with ATDs. In summary, over 99% of the time the long-term radon measurements are representative of the radon levels exhibited during the exposure period. Therefore, confirmation of a valid collocated duplicate radon result from a validated data set is not required.

Under NAVRAMP confirmation tests should only be used in cases where there is only one elevated radon result (e.g., the collocated duplicate detector was damaged, tampered or lost or the measurement was performed with only one detector). A confirmation test shall be short-term and shall be performed using collocated duplicate detectors placed at the same initial testing location. Testing duration shall be a minimum of 4 days with preference given to measurements lasting up to 30 days using either short-term ATDs or electrets under closed-building conditions (Section 3.2.1). The measurement is considered confirmed if one or more of the following is true:

- The confirmation result is ≥ 4 pCi/L
    - It is not uncommon to compare a long-term and short-term result to find large differences. In all cases the long-term result should be considered more representative of the annual radon average.
- For long-term results being confirmed between 4 to 8 pCi/L confirmation is assumed if the confirmation result is within 50% of the long-term result.
- If the confirmation tests fail, then a follow-up test shall be performed.

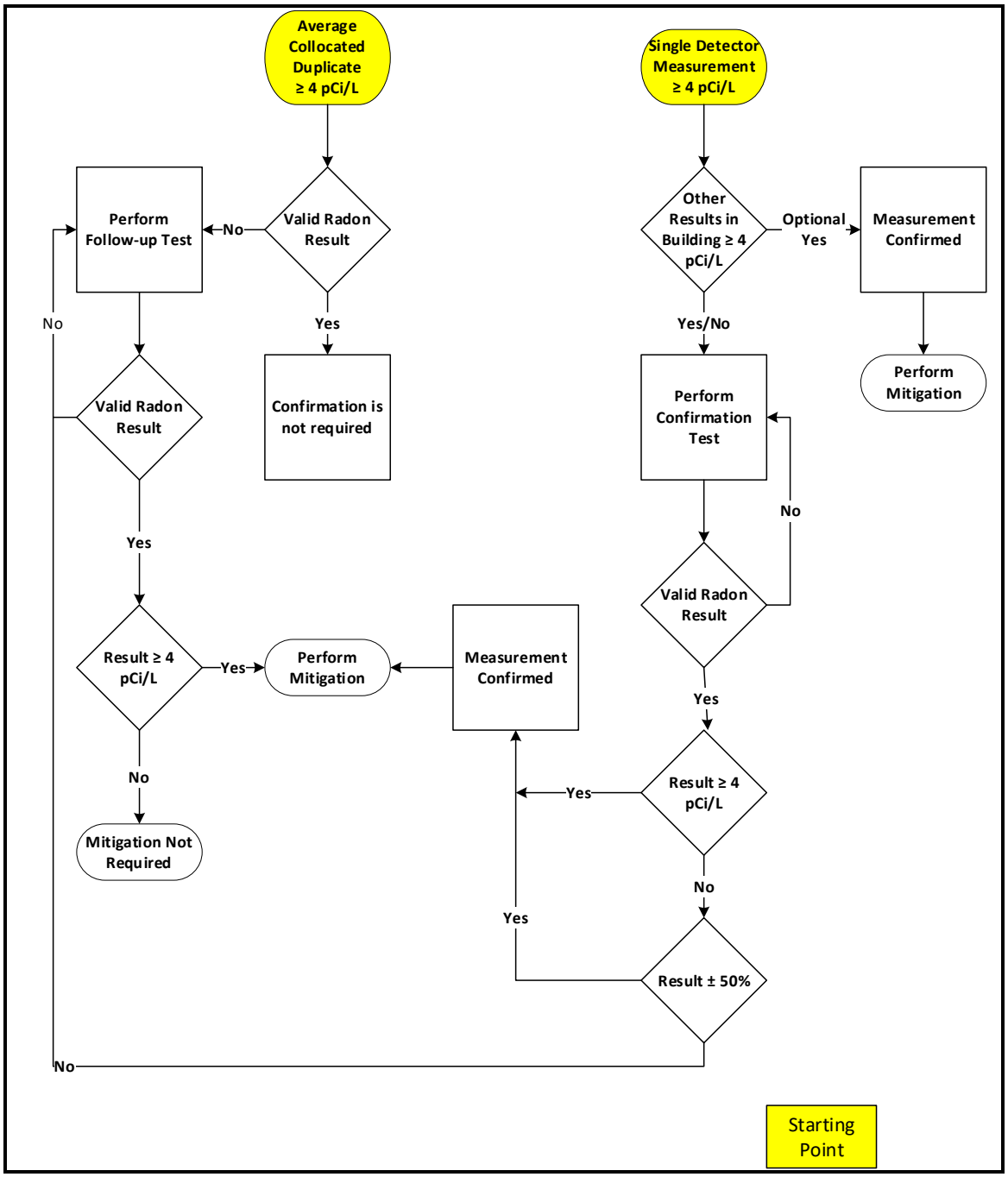
For any given radon measurement, a confirmation test should only be performed once. Therefore, it should only be performed during the most likely season with closed-building conditions (Section 3.2.1). If more than one confirmation test at a given location is performed, the perception of "testing until I find a result that I like" should be avoided at all times. To address this potential concern, if more than one set of short-term confirmation measurements are performed, then they should be treated as sequential duplicates and the conclusion based upon the average of all the confirmation measurements (Section 3.4.5). Flowchart 6 illustrates the confirmation process.

If the initial results are in question, the confirmation test can be omitted and a follow-up test performed. A follow-up test is a radon test performed in the same location, under similar testing conditions and as applicable, identical or typical operation HVAC settings. A follow-up test should only be performed for the following reasons:

- The results failed measurement validation (Section 3.3.2).
    - Under NAVRAMP retesting is allowed for all invalid radon results including those < 4 pCi/L.
- When the short-term confirmation test failed to confirm the presence of elevated radon (see Flowchart 6)
- An event occurred during the test period which invalidated the initial radon result (e.g., HVAC failure, open building, fire, flood etc.)
    - If a renovation, structural modification, or HVAC modification occurred during the test period, perform a renovation retest (Section 3.2.9.6)
- The building or room was tested under nonstandard test conditions (e.g., not meeting closed building conditions, HVAC was not operating under normal operational conditions).

All follow-up testing shall meet the identical testing requirements of the invalidated result. If renovations, structural modification or HVAC repair or replacement are the reason for the results being declared invalid, then a renovation retest shall be performed. Please note that in these cases for nonresidential buildings the entire building shall be retested.

It is important to note that hourly CRM measurements used to determine if the HVAC energy savings operations are responsible for the long-term, elevated radon results are considered as a diagnostic measurement (DM), not a confirmation, or follow-up measurement. Please consult the *NAVRAMP Technical Manual* Sections 3.4.1 and 5.1.9 for more details in conducting these types of measurements.



Flowchart 6. Confirmation and follow-up measurement flowchart.

3.2.9.4 Postmitigation and O&M Measurements

For postmitigation testing, EPA and ANSI/AARST require only that the measurement be performed using an approved device/method and be conducted within 30 days of the mitigation installation). Mitigation success is evident if the measurement is <4 pCi/L. Under NAVRAMP a short-term test performed under closed-building conditions (Section 3.2.1) is sufficient to document a successful mitigation in all residential buildings. However, for non-residential buildings a mechanical setting review is required to determine if the current HVAC settings are appropriate for a short-term measurement. If yes, then a short-term postmitigation test can be performed under closed-building conditions. However, if there are seasonal adjustments, more than one short-term test or a single long-term test may be required to attain a proper mitigation conclusion. The duration of the long-term test can be less than one year provided it is performed within the season with the greatest potential for elevated radon and most likely closed-building conditions. Another option is to perform a diagnostic radon test just prior to the mitigation installation. If the pre-mitigation levels are within 50% of the long-term result or higher and the postmitigation test is < 4 pCi/L then mitigation has been achieved. Similar testing guidance is also provided for O&M testing. However only selected mitigation methods require O&M testing every 2-3 years (Section 4.4).

Under NAVRAMP, these measurements are performed using collocated duplicates (duplicates are not required for CRMs with hourly resolution) every 2-3 years and the results validated by calculating the Relative Percent Difference (RPD, Section 3.3, Eq. 1). The measurement is considered valid if either of the following is true:

- An average RPD of <67% is achieved for average radon results >2 pCi/L and <4 pCi/L.
- An average RPD of <36% is achieved for average radon results ≥4 pCi/L.
- RPD validation is not required if both results are <2 pCi/L.

3.2.9.5 Diagnostic Radon Measurement

Diagnostic radon measurements are used primarily to gain a better understanding of the radon levels within a building or room under known conditions. The most common use of diagnostic measurements is for "cause and effect" type measurements during mitigation diagnostics or mitigation. For example, if it is suspected that the building's exhaust system is causing elevated radon, by turning them off and monitoring the radon levels a clear association or disassociation can be established. Another example of diagnostic measurements is mapping the radon levels within large rooms (e.g., > 10,000 ft^2) in which elevated radon levels were only found in one location. In this example, radon sampling is performed at a location with elevated radon levels on a much smaller scale (e.g., ≤ 2,000 ft2) to map out the area which is ≥ 4 pCi/L. In the example shown in Fig. 11, elevated radon was only found at one testing location in a large room. By testing on a grid using a radon entry pathway instrument with 5-minute resolution (these

instruments are for diagnostic measurements only, not for reportable measurement use) the location of the radon plume was determined. In this case, knowing the extent of the plume determined that only one mitigation system was required.

Diagnostic measurements are also used for:

- Measuring the incremental impact of individual mitigation systems in large or complicated mitigation installation
- Measuring radon levels in within non-testable rooms are areas with the building (e.g., bathrooms, locker rooms, crawlspaces, mechanical, electrical, janitor, and communication closets, and dedicated storage rooms)

It is important to note that these types of diagnostic measurements do not need to be reported to NAVFAC EXWC or HQMC/MCICOM GF-Environmental.

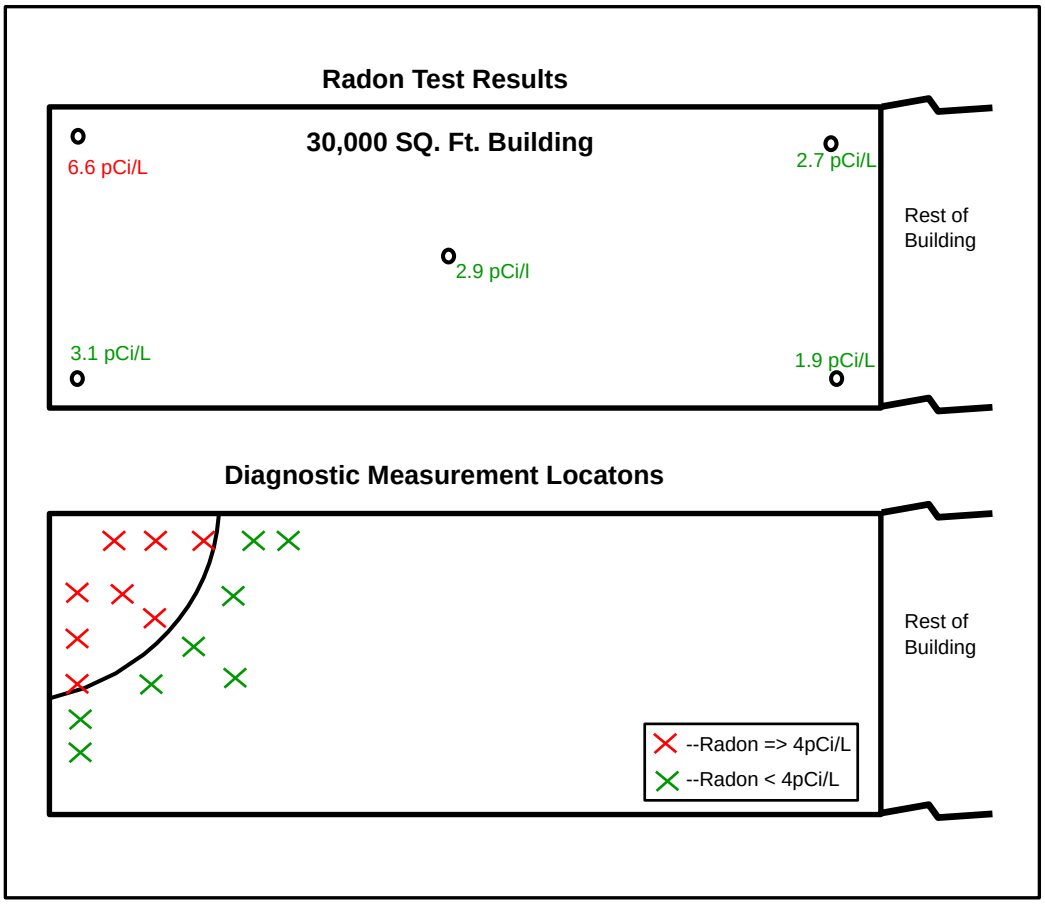


Fig. 11. Example of radon plume mapping in a large room.

Another example would be the use of CRMs with hourly resolution to determine the impact of HVAC energy saving features on radon levels within the building. In this example, the objective is to establish if elevated radon levels are only present within the

building or room during the unoccupied hours. Further discussion on this diagnostic measurement has been included in the *NAVRAMP Technical Manual* Section 5.1.8.

Because diagnostic measurements are considered non-reportable data (informational use only by a radon professional), they do not have to meet any ANSI/AARST or NAVRAMP QA/QC requirements. In addition, there are no minimums for testing duration (e.g., 48 h minimum for all other types of short-term radon tests). However, if the diagnostic measurement was a critical measurement (does not apply to radon entry pathway measurements) used to make a mitigation selection, it should be reported to NAVFAC EXWC or HQMC/MCICOM GF-Environmental along with the postmitigation data.

3.2.9.6 Renovation Retest

Renovation resting (RR) test type is for previously tested buildings which have been significantly modified (see definition) since the last radon test was performed.

3.2.9.7 Other Types of Reportable Radon Measurements

At an installation there is the occasional need to perform a small number of radon tests (e.g., one building or a few housing units) which do not fit into the NAVRAMP phased testing structure or schedule. Typically, these tests are at the request of command or medical authorities or from building occupants or housing residents who have a heightened level of concern over radon. The main problem with this type of request is the sense of urgency and the expectation of a quick answer. If possible, it is recommended that these tests be performed for at least 90-days in duration with a 180-day test preferred. If that is not possible, then short-term tests with duplicate collocated detectors or a single measurement using a calibrated CRM at least 4 days in duration with 7 days duration preferred to be performed under closed building conditions (Section 3.2.1). Because the results of these measurements will be distributed, they must be reported to NAVFAC EXWC or HQMC/MCICOM GF-Environmental. With respect to assigning test types use:

- NC for new construction
- RR if the building has been renovated since the last radon test
- As applicable SU (supplemental screening), SA (supplemental assessment) or MT (monitoring testing) if the building was not under control of the installation during the last scheduled survey or if it was omitted
- MT (monitoring testing) if the building was tested during the last scheduled monitoring test
- OM if the building has been mitigated (this designation supersedes all others if true)

These data must be validated prior to dissemination and depending upon the circumstances, the inclusion of blanks and spikes would be recommended (Section 3.3).

In addition, the reason for the test must also be provided in the comment field (e.g., at the request of medical authorities) of the submitted data for incorporation into the master database. It is important to note that for programmatic reasons, at RPC 1 installations/sites the retested building should be included in the next assessment or monitoring testing.

3.2.10 Testing Documentation for Nonresidential Testing

After the radon detectors have been placed, specific information needs to be recorded on a data sheet. At a minimum, the following information should be collected:

- Placement technician
- Site (if applicable)
- Building number
- Building name
- Detector numbers
- Types of radon detectors (i.e., ATD, electret, CRM)
- Type of radon test (Section 3.2.9 Table 4)
- Date placed
- Time placed (if applicable)
- Room in which placed
- Location placed in the room
- Comments

In addition, rooms that require radon testing but that, for a valid reason, could not be accessed during detector placement should be recorded and the reason documented.

During detector retrieval, the following information should be collected or verified and recorded on the data form:

- Date retrieved
- Time retrieved (if applicable)
- Detector number
- Room and location
- Any evidence of tampering
- Any evidence of significant modification to the building that could have an impact on the radon level
- Whether closed-building conditions (Section 3.2.1) were maintained during the test period (short-term only)

In addition to the information above, in nonresidential testing, it may be advantageous to collect and update building floorplans with the room names used during detector placement and retrieval. Under NAVRAMP, it is required to provide in the testing and final project report an up-to-date floorplan using the testing room names for all buildings whose radon levels were found to be ≥ 4 pCi/L (Section 3.5). However, it is not required (i.e., optional)

to provide in the reports updated floor plans for buildings in which all rooms were < 4 pCi/L.

After the detectors have been retrieved, they should be returned to the manufacturer for analysis and reporting. Because different devices have different field holding times (the time between detector retrieval and analysis), manufacturer recommendations shall be strictly always adhered to. In addition, the QA detectors (blanks and spikes) should be returned at the same time as the field detectors. In surveys in which more than one shipment is required, the QA detectors should be distributed proportionally with each shipment.

3.2.11 Testing Documentation for Family and Unaccompanied Housing

After the radon detectors have been placed, specific information needs to be recorded on a data sheet (Appendix B). At a minimum, the following information should be collected for each detector:

- Placement technician
- Site (if applicable)
- Neighborhood name (if applicable)
- DoD Building Real Property Unique Identifier number (RPUID)
- Unit address (i.e., street number and street or building number as applicable in eMH format)
- Detector numbers
- Types of radon detector (i.e., ATD, electret, CRM)
- Type of radon test (Section 3.2.9 Table 4)
- Date placed
- Time placed (if applicable)
- Room in which placed
- Location placed in the room
- Comments

During detector retrieval, the following information should be collected or verified and recorded on the data form:

- Date retrieved
- Time retrieved (if applicable)
- Detector number
- Room and location
- Any evidence of tampering
- Any evidence of significant modification to the building that could have an impact on the radon level
- Whether closed-building conditions (Section 3.2.1) were maintained during the test period (short-term only)

After the detectors have been retrieved, they should be returned to the manufacturer for analysis and reporting. Because different devices have different field holding times (the time between detector retrieval and analysis), manufacturer recommendations shall be strictly always followed. In addition, the QA detectors (blanks and spikes) should be returned at the same time as the field detectors. In surveys in which more than one shipment is required, the QA detectors should be distributed proportionally with each shipment.

Appendix B includes the Housing Program's data collection/reporting template for capturing radon assessment results. This template should be included as part of a statement of work or performance work statements to ensure the requirements are known before work is awarded. The template spreadsheet worksheet tabs provide guidance/instructions on collection and reporting of radon testing results into the Environmental Health and Safety (EHS) Module of the eMH system. Region/installation Housing Program Office POCs will be able to provide the logistics of securely sending testing results to eMH for upload.

3.2.12 Detector Losses and Missed Rooms

Unfortunately, losses do occur during radon surveys. The longer the testing duration, the greater the losses. Studies have identified the following three major reasons for these losses:

1. An occupant threw the detector away for some reason.
2. Uninformed painters or cleanup crews threw the detector away.
3. The detector fell and was disposed of (10%).
4. CRM and EIM detectors were stolen.

To counter these causes, and reduce detector losses, the following precautions should be taken.

1. Affix warning stickers to the detectors with a local number to call for additional information and provide information handouts during detector placement.
2. Inform contractors and base personnel working in the nonresidential buildings and in family and unaccompanied housing that radon testing is in progress, and the testing devices are not to be disturbed.
3. Place detectors in out-of-the-way locations within the room to ensure that they will not be bumped during the test period and instruct occupants during placement to reattach the detectors if they accidentally fall.

Studies have shown that the implementation of these three precautionary measures will reduce losses by 50%.

If warranted, housing units and rooms in which detectors were lost, and housing units and rooms or buildings that could not be accessed during detector placement, can be retested using either long-term (preferred) or short-term measurement devices. However, short-term testing can be performed only if it can be conducted during closed-building conditions (Section 3.2.1). It is recommended that all nonresidential rooms without radon results be retested within 1 calendar year of the previous survey's retrieval date to ensure measurement consistency. The noted exception is for buildings in which one or more rooms had radon results ≥4 pCi/L. In this case, testing shall be completed as soon as possible so that mitigation planning and implementation can proceed in a timely manner. For all other buildings in which the highest result was <4 pCi/L, retesting in the rooms with missing data should be considered only if losses exceed 20% of the total testable rooms within the building. Detector loss replacement testing in family housing is not as critical and can be performed at any time. However, if elevated radon potential is present in other buildings or family housing units at the installation, loss replacement testing should be performed as soon as is practical.

If retesting is performed after the survey has been completed, the detectors should be assigned a test type (Section 3.2.9 Table 4) as applicable (SU for screening or SA for assessment). For retesting during the monitoring phase, use MT for all retests. If detectors are replaced during the survey and before the initiation of retrieval, then assign as applicable SG, AS, or MT as applicable. In all cases of retesting the initial measurement needs to be reported and assigned the appropriate error code (Table 5).

3.2.13 Testing Errors

During the test period, things may happen that would have an impact on the validity of the radon measurement. Certain types of these events would result in the test's being classified as invalid or nonreportable (commonly referred to as "catastrophic" errors). For example, EPA recommends, as does NAVRAMP, that short-term test data be invalidated if one or more of the following is true:

- Testing was not performed during closed-building conditions (Section 3.2.1).
- HVAC operation during the testing period was not "typical" (e.g., building mechanicals were off or malfunctioning).
- Testing was conducted during periods of abnormal weather conditions.

Typical problems that would invalidate long-term measurements include these:

- Significant modifications to the building or HVAC replacement
- Non-achievement of the minimum manufacturer's recommended exposure time for the detector
- Exceeding the maximum manufacture's recommended exposure time for the detector

Examples of catastrophic errors that would apply to both types of measurements are

- Damage to detectors (e.g., vandalism, water, smoke, paint)
- Device tampering
- Relocation of the detectors to other rooms
- Atypical changes to room pressure and/or ambient indoor temperature

For these types of errors, the result is not reported (i.e., the attempted measurement is documented without the radon result and with the error description listed under comments), and retesting is recommended. However, other types of errors need only be recorded and reviewed to see if the resulting error is significant. Examples of these types of conditional errors are:

- One or both the detectors fell (not significant if both results are <2 pCi/L).
- Placement and/or retrieval dates are missing (not significant if substituting the last placement date and/or the first retrieval date for the project yields results of <2 pCi/L).
- Results exceed the maximum reportable limit

Under NAVRAMP, the term "Anomalous Data" (error code 12) should only be used in cases where an individual measurement in a valid data set failed to meet NAVRAMP precision requirements (Section 3.3.2) or was disqualified by a follow-up test (Section 3.2.9.4).

If those qualifying conditions for the conditional error are true, then the result accompanied with the error may be reported. However, if the qualifying conditions for the error are not met, then retesting is required if one or more rooms in the building has elevated radon levels or if problems were encountered with >20% of the testable rooms. In the case of a family housing unit, then retesting of the unit is required. Table 5 lists common testing error codes and suggested actions to take. A complete list of testing error codes can be obtained from NAVFAC EXWC or HQMC/MCICOM GF-Environmental upon request.

Table 5. Common testing error codes

Error code	Description	Catastrophic error code	Suggested actions
1	No room name provided	Conditional	Investigation, with follow-up test of untested rooms in building if unknown result ≥4 pCi/L No action required for family housing if unit number is known
2	Both dates estimated	No	Confirm or follow-up test if ≥ 4 pCi/L

Table 5 (cont.)

Error code	Description	Catastrophic error code	Suggested actions
3	Placement date estimated	No	Confirm or follow-up test if ≥ 4 pCi/L
4	Retrieval date estimated	No	Confirm or follow-up test if ≥ 4 pCi/L
5	Detector moved in room	Conditional	Retest if new location does not meet NAVRAMP testing location requirements
6	Detector placed but not retrieved	Yes	Retest
7	Damaged	Yes	Retest
8	Detector placed but reported missing	Yes	Retest
9	Tampered	Yes	Retest
10	Insufficient test period	Yes	Retest
11	Mechanical modification during test period	Yes	Retest
12	Anomalous data	Yes	No action. Other testing has already disqualified this result
13	Duplicate not collocated	No	Confirm or follow-up test if ≥ 4 pCi/L
14	Duplicate retrieved on a different date	No	Investigate to confirm retrieval dates were different
15	Retrieved from a different room, location or building	Yes	Retest room in which detectors was moved
16	Renovation or construction was performed during the test period	Yes	Retest room or building as required
17	Detector exceeded upper calibration or exposure limit	No	Mitigation
18	Process loss	Yes	Retest

Table 5 (cont.)

Error code	Description	Catastrophic error code	Suggested actions
19	Fire/flood/wind damage	Yes	Retest
20	Fell down	Conditional	For results ≥4 pCi/L If on the floor for > 25% of the test period confirm or perform follow-up
21	Dirty electret	Yes	Retest
22	Nonstandard condition	Yes	Retest
23	Not retrieved door locked /no key	Yes	Retest if detector cannot be retrieved within exposure limit
24	Not retrieved facility closed or demolished	Yes	No action
25	Placement time estimated	No	Confirm or follow-up test if ≥ 4 pCi/L
26	Retrieval time estimated	No	Confirm or follow-up test if ≥ 4 pCi/L
27	Electret exceeded maximum voltage drop	No	Mitigation
30	Validated measurement	No	No action
32	Working level measurement (WL)	Yes	Retest
33	Refused access	Yes	Retest
35	pCi/L value is greater than reported	No	Mitigation if ≥ 4 pCi/L
36	Measurement or dataset failed validation	Yes	Retest

It is important to note that error code 30 (valid data) is required for all valid radon tests without a testing exception to signify that they have been reviewed and meet NAVRAMP testing requirements.

3.3 TESTING QUALITY ASSURANCE AND QUALITY CONTROL

The objective of radon measurement QA is to ensure that data are scientifically sound and of known precision and accuracy. This is accomplished with project QC using unexposed detectors (blanks), collocated duplicates, and controlled exposures (spikes). Additional elements of QA involve using radon detectors in accordance with manufacturer's instructions and the use of qualified field technicians during detector placement and retrieval (Section 3.6).

As part of these QA programs, procedures for attaining the defined QA objectives and a system for recording and monitoring should be established. Current NRPP and NRSB

QA/QC plan requirements for an accredited company providing radon measurement and laboratory services have been determined adequate for NAVRAMP provided they perform the required NAVRAMP QC (Section 3.3.1). Therefore, there is no requirement for the development of a project QA/QC plan provided the QA/QC requirements in this section are followed. Submittal of the contractors NRPP or NRSB QA/QC plan for review or documentation purposes is optional. However, if a review is required, it should be performed by either the contract officer, contract officer representative (COR) or by a private sector competent person.

In validating and analyzing a data set (defining a data set as a group of measurements performed at the same time using the same devices by the same organization), all testing error exceptions must be noted and reported, and their impact noted in the data report (Section 3.2.13). In addition, the QC measurements shall be permanently linked with the data set to afford independent analysis in the future.

Because, in most NAVRAMP surveys, large number of measurements are performed within a short period of time, plotting daily control charts (*NAVRAMP Technical Manua*l Section 3.3.3) would be of only minimal benefit. Instead, NAVRAMP uses an individual measurement tripwire using the EPA control limits (see the second bullet item, for "duplicates," in the following list). Under NAVRAMP, the QC requirements for all passive radon measurements are the following.

- Blanks: Blanks should be at or below the manufacturer's published lower limit of detection (LLD).
- Duplicates: Collocated detectors in which the average is ≥4 pCi/L should have an RPD of <36% (see Eq. 1). For collocated detectors in which the average measurements are >2 pCi/L and <4 pCi/L, an RPD of <67% is considered acceptable. RPD calculations are not required for duplicate pairs whose average result is < 2 pCi/L.
- Spikes: Spike results should be within ±25% of the known value (Eq. 2).

$$\textbf{Relative percent difference} = \frac{\textbf{(Highest pCi/L – Lowest pCi/L)} \times \textbf{100\%}}{\textbf{Mean}}$$

Equation 1. Relative percent difference
(Quality Assurance Handbook for Air Pollution Measurement Systems: Volume I, EPA 600/9-76-005 [EPA 1984]

$$\textbf{Relative Percent Error} = \frac{\textbf{(Measured Value – Reference Value}\ ^{a}\textbf{)} \times \textbf{100\%}}{\textbf{(Reference Value)}}$$

([a] Reference value can be in either pCi/L-days or pCi/L)

Equation 2. Relative percent error.
Reference: (EPA 1997)

To the best extent possible, the blanks and spikes should be returned to the laboratory at the same time as the field detectors. In addition, they should be intermingled with and undistinguishable from the field detectors.

3.3.1 Passive Measurement Quality Assurance and Quality Control

Before a data set can be reported, it must first be validated to ensure that it meets specific QA requirements. Failure to meet any of the minimum QA requirements will require specific reporting actions and, depending on the severity of the failure, possibly retesting. The following sections detail the requirements, analysis procedures, and corrective actions to be taken if needed. Under NAVRAMP, the level of QC for passive detectors (ATDs, charcoal canisters, and electrets) depends upon the type of testing (i.e., screening, assessment, or monitoring) and the number of locations (i.e., rooms and family housing units, see Sections 3.2.5 and 3.2.7) being tested at a given time. The minimum QC levels follow.

- ≤ 10 testing locations
    - 100% collocated duplicates
    - One blank detector is optional
- 11 to 30 testing locations
    - 100% collocated duplicates
    - One laboratory blank detector
- 31 to 500 testing locations
    - 100% collocated duplicates
    - One laboratory blank detector or 1% of the total testing locations whichever is greater
- > 500 testing locations
    - 100% collocated duplicates
    - Blank detectors:
        - 1% of the total number of locations tested, or up to 30 blanks (2/3 travel blanks, 1/3 laboratory blanks), whichever quantity is less;
    - Spike detectors:
        - 1% of the total number of locations tested or up to 30 spikes, whichever quantity is less; spike concentration of four times the number of days of the projected exposure (e.g., for a 365-day exposure, the spike should be 1460 pCi/L-days which would be equivalent to a 4 pCi/L exposure for 1 year)

For screening using the enhanced statistical method option (Section 2.4.2), there are no upper limits for the number of blanks and spikes.

In all cases in which one or more of the QC requirements are not met, the testing contractor shall first inform the laboratory of the problem(s). If the laboratory can correct the problem, then the corrected results for the data set shall be resubmitted by the laboratory. However, if the laboratory is unwilling or unable to correct the QC problem(s), then the

installation shall perform an in-depth analysis of the impact of the QC failure on the radon measurements. At a minimum, the impact analysis shall address the overall measurement uncertainty at 4 pCi/L and the likelihood of false positive and/or negative measurements. Using these measurement uncertainties, a review of the individual field measurements should be performed and all measurements for which the conclusion (i.e., the need to perform mitigation) is in question should be identified. For these individual measurements, follow-up testing would be required. Individual measurements that are < 4 pCi/L should be documented, and retesting would be at the discretion of the Navy or Marine Corps. It is important to note that EPA and ANSI/AARST testing guidelines do not permit the end user to compensate or correct for laboratory identified QC deficiencies (i.e, blanks or spikes out of compliance) in the survey, these corrections can only be made by the laboratory (see also Section 3.4.1).

3.3.2 Precision Calculations for Passive Detectors

All radon testing currently performed under NAVRAMP using passive radon detectors is performed using 100% collocated duplicates. Each measurement ≥ 2 pCi/L shall have an RPD (Section 3.3, Equation 1) calculated to determine if it meets the following precision requirements:

- An average RPD of <67% is achieved for all average radon results ≥2 pCi/L and <4 pCi/L
- An average RPD of <36% is achieved for all average radon results ≥4 pCi/L
- RPD calculations are not required for average radon test results < 2 pCi/L

All measurements that fall out of their respective control limits shall be investigated to determine if the correct measurement information [e.g., placement and retrieval dates, time if applicable, laboratory result, and applicable testing exception code (Table 5)] has been assigned. If the correct measurement information has been entered then and no testing exception was noted and assigned, then the results should be considered anomalous data (error code of 12, Table 5) and the data considered invalid. Unless the cause of the error can be identified, follow-up testing is recommended in cases where both results are ≥ 4 pCi/L.

For all other measurements that are within their respective RPD ranges and all average radon results < 2 pCi/L which have no testing exceptions, an error code of 30 (validated measurement Table 5) shall be assigned.

The only exception to the ≥ 4 pCi/L RPD limit is for cases in which both radon results are >30 pCi/L. For both technical and business reasons, all commercially available radon measurement devices have upper limits for radon exposure. After those limits are exceeded, precision and accuracy tend to widen and drift, respectively. For example, at one naval installation a room tested 100 and 300 pCi/L (RPD = 100%). Consulting with the detector manufacturer determined that the detectors were only reliable up to 50 pCi/L for this exposure duration. Although the exact radon level was not known, the conclusion that very high radon levels were present was self-evident.

In summary, the device manufacturer should always be consulted when it is suspected that the poor precision is the result of radon levels exceeding the detectors upper limits. In cases where this has been confirmed by the manufacturer, error code 27 (electret) or 35 (ATD or charcoal) shall be assigned. Please note that in cases of high radon concentrations, obtaining a measurement within the NAVRAMP control limits is a secondary concern to expedited mitigation.

3.3.3 Analysis of Passive Detector Blanks

Blanks are radon detectors that are not exposed to room air (i.e., unused) and are used to determine if the field detectors have been contaminated during storage, deployment or during return shipping to the laboratory for analysis. Each detector manufacturer establishes a background (e.g., counts per minute, tracks/mm^2, etc.) for their detector which is then subtracted from each result of the field detectors. If the detector background is higher than expected, then the resulting positive bias could in some cases prompt radon mitigation where it was not required. A high background in a passive detector can be caused by many things, however pre-placement package leakage and detector aging are the most common reasons. Surprisingly, background issues are not a significant problem after detector retrieval if they are packaged and handled properly during detector retrieval and shipped as quickly as possible to the laboratory.

To address these two potential problems the following blanks are used:

- Laboratory blanks: Unused detectors in the original packaging that have been stored in a low radon environment for the duration of the field work.
    - These detectors are used to identify detector ageing issues
- Field blanks: These detectors are unused and left in the original packaging and accompany the field detectors during placement and retrieval. During the placement and retrieval period the detectors are stored in a low radon environment.
    - These detectors are used to identify any ageing or significant bag leakage issues

All blanks for the survey shall be left in the original manufacturer packaging and stored in a conditioned, low-radon environment until needed. The preferred method is to store the blanks within resealable, clean metal cans (e.g., 1 or 5 gal. paint can) with ≥10-50 grams of activated carbon packets (i.e., desi-pak). The cans should also be stored in a conditioned, low radon environment until needed. Upon return of the field detectors, all blank detectors are opened, packed with the field detectors and returned anonymously to the laboratory for analysis and reporting. It is important to note that charcoal detectors and laboratory processed electrets require placement and retrieval dates and times for analysis. The dates and times used should blend in and fall within the range of those used in the survey and match the average exposure period of the survey.

Upon receipt of the blank data, the results will be averaged by individual blank type and as a whole. An acceptable blank result is any measurement below the manufacturer's LLD or ≤ 60 pCi/L-days for a 1-year ATD. For electret-based detectors, an acceptable blank measurement would be any measurement ±3 V from the original measurement. If the blanks results contain a suspected outlier, then perform a student's *t-test* or other appropriate statistical method and exclude if appropriate.

If a high background problem has been observed, then an error assessment must be performed to determine its potential impact. For ATD detectors the results are reported in pCi/L-days. By dividing the average of all blank pCi/L-days results by the average number of days the detectors were exposed the result in pCi/L provides an estimate of the possible positive bias in the survey (Table 6). For electret detectors, if not provided by the laboratory, simply calculate the resulting pCi/L from the average change in voltage using the average number of survey hours or days. Charcoal background results should be reported in pCi/L. To determine the possible background impact for electrets or charcoal, simply average the pCi/L for all blanks.

Table 6. Possible impact of background on ATD detectors.

Average Blank Result (pCi/L-days)	90 Days Exposure Background (pCi/L)	180 Days Exposure Background (pCi/L)	270 Day Exposure Background (pCi/L)	365 Day Exposure Background (pCi/L)
60	0.7	0.3	0.2	0.2
100	1.1	0.6	0.4	0.3
200	2.2	1.1	0.7	0.5
300	3.3	1.7	1.1	0.8
400	4.4	2.2	1.5	1.1
500	5.6	2.8	1.9	1.4

If the positive bias may have resulted in some results exceeding the 4 pCi/L action level (reported results between 4 to 6 pCi/L are the most likely to be impacted), then the manufacturer should be consulted and these results either confirmed or a follow-up test performed prior to taking corrective action.

3.3.4 Analysis of Passive Detector Spikes

Spike detectors are radon test kits exposed to a known dose of radon (i.e., pCi/L-days). The analysis of these detectors provides the statistical certainty that the radon detectors are providing accurate results. Under NAVRAMP, all spikes must be performed in an NRPP or NRSB-accredited chamber or within a US governmental calibration chamber. Currently NRPP recognizes two radon calibration chambers Bowser-Morner (http://bowser-morner.com/) and Kansas State Radon Chamber (https://ksuradonchamber.org/) where NRSB also recognizes Bowser-Morner and TCI Industries (http://radondetek.com/). NAVRAMP requires that the mean spike result (the average of all spike results at a given concentration) be ±25% of the known concentration (Eq. 2). With respect to ordering

spikes from the private accredited chambers, it is highly recommended that contractual arrangements be made with the laboratory before or shortly after the initiation of detector placement. Spikes, if collected before retrieval, shall be stored in resealable, clean metal cans (e.g., 1 gal. paint cans) with ≥10 grams of activated carbon packets (e.g., desi-pak), and the cans shall be stored in a conditioned, low-radon environment until needed.

Each spike shall have its relative percent error (RPE) calculated (Equation 2) and averaged. Acceptance is defined as an average of ≤ 25%.

3.3.5 Continuous Radon Monitor Quality Assurance and Quality Control

At a minimum, all CRMs used under NAVRAMP must measure radon gas concentration directly with hourly resolution, and have ±10% resolution at 2 pCi/L. The device used in the field must have a current manufacturer's calibration certificate and shall be maintained in accordance with manufacturer's specifications. For every tenth radon measurement performed (≥ 48 hr. minimum) on a specific instrument, a duplicate measurement performed with another CRM or an approved electret or charcoal canister shall be performed. The acceptance criterion for the CRM is that the result be within ±25% of the collocated duplicate measurement.

If this condition is not met, then the test should be repeated using either collocated duplicate passive detectors or collocated duplicate CRMs. If the CRM is found to be in error, then all rooms previously tested by the CRM since the last performance check should be retested.

3.3.6 Additional Quality Assurance and Quality Control Checks for Electrets

It is important to note that during the measurement period, electret devices are susceptible to altitude and background gamma radiation. Therefore, the correction factors used by the laboratory in processing the electret radon detectors shall be included with the reported radon results to ensure that the proper values were used in calculating the radon concentration. In addition, studies reviewed and accepted by the Navy have shown that electret readers exhibit significant voltage errors when not being used in an indoor controlled temperature and humidity environment. Therefore, under NAVRAMP, the initial and final surface voltage measurements shall be performed within a controlled temperature and humidity environment between 68 and 75°F and 40 to 60% relative humidity (RH). These conditions must be measured and recorded by the laboratory at least once during each voltage reading session and made available to the Navy upon request.

Another issue with using electrets is dust and lint. The presence of dust or lint on the Teflon disk can result in significantly higher bias yielding an unacceptably high RPD (Section 3.3, Equation 1) for the measurement. Prior to having the initial voltage read, the radon chambers and the electret surfaces should be cleaned by dry compressed air. For exposures in known dusty environments the chamber/electret detector will need to be placed in a paper bag or unsealed plastic bag or inside a manufacturer's special purpose

bag to minimize the dust exposure. Upon detector retrieval, each plunger (S Chamber) and slider (L-OO) chamber shall be inspected and if needed cleaned prior to the detector being deactivated. It is not unusual for 1-3% of the electret detectors to suffer from dust related issues during a survey. Therefore, it is recommended that the duplicate detectors be read sequentially in the laboratory to call immediate attention to potential dust issues. In most duplicate cases where incidental dust is involved one detector will read low (e.g., 1 pCi/L) and the other significantly higher (e.g., 10 pCi/L). A close examination of the electret with the higher result will typically find a small speck of dust or lint present on the electrets Teflon disk. In this case the higher result is not used, assigned an error code of 21 (dirty electret) and the lower result is considered valid (assign error code of 30). In cases where both results are ≥ 4 pCi/L but the RPD is significantly out of range (e.g., low result is 5 pCi/L and the higher result is 25 pCi/L) a dust/lint inspection needs to be performed on both electrets. If dust/lint is found on both electret surfaces, then an error code 21 is assigned to both detectors and a follow-up test is performed. However, if the lower detector is dust free, it should be considered valid data but a confirmation or follow-up must be performed.

3.3.7 Survey QA/QC Timeline

Under NAVRAMP, the number of blanks and spikes are based upon the total number of measurements proposed for a single survey (Section 3.3.1) that for a 1-year exposure period would span an 18–24-month time period beginning with the procurement of the radon detectors. However, at larger naval installations because of logistical or funding concerns, detector placement may have to be performed incrementally over 2 or more years. As a result, the timeline for the total project completion would increase to 3 or more years. Because ATD detectors typically have a 3 year from date of manufacture shelf life (this may vary from manufacturer to manufacturer) field detectors, blanks and spikes that were set aside prior to placement in year 1 of the testing project could potentially be expired when needed. It is therefore recommended for installations performing radon testing over multiple years that detectors only be procured within a few months of proposed usage and that blanks and spikes be set aside for these particular detectors and detectors purchased in each of the following years.

3.4 DATA ANALYSIS

3.4.1 Data Set Validation

When a radon measurement data set is received, the data must be validated before any conclusions are drawn. All deficiencies in the data set need to be documented and corrective actions taken, if warranted. For QA detectors, the following acceptance criteria should be verified:

- The appropriate number of blanks were used (Section 3.3.1), and all blanks are at or below the reported manufacturer's LLD (Section 3.3.3).

- RPD (Section 3.3, Equation 1) calculations (a measure of precision) were performed for all duplicate measurements ≥ 2 pCi/L and meet the requirements listed in Section 3.3.2.
- The appropriate number of spikes were used, were exposed at the correct concentration (Section 3.3.1), and are within ± 25% of the known concentration (Section 3.3.4).

As in any environmental laboratory measurement there is always the possibility of an outlier. This can be true with blanks and spikes. If it is suspected that a result is in outlier, a student's *t-test* or other appropriate statistical method should be used to see if the result in question can be excluded. If appropriate, then the result should be excluded, and spike or blank averages recalculated. All QC issues with blanks and spikes should be addressed with the manufacturer or laboratory prior to analysis of the field test data because of the possibility of having survey results corrected and reissued.

After it has been verified that the blanks and spikes meet NAVRAMP requirements the final step in data set validation can be performed using the following process where both collocated duplicate detectors have an error code of 30 (Section 3.3.2):

1. Average the RPD (Equation 1) for all average results between 2 pCi/L and < 4 pCi/L
    a) Low range is considered validated if the average RPD is < 67%
2. Average the RPD for all average results ≥ 4 pCi/L
    a) High range is considered validated if the average RPD is < 36%
3. Averaging the RPD for results < 2 pCi/L is not required

If the spike, blank and RPD requirements are met, then the data set is considered validated and suitable for reporting. However, if one or both of the RPD precision requirements are not met, then further analysis is required using the following steps:

Average radon measurements >2 pCi/L and <4 pCi/L with RPD ≥67%

- Using student's *t*-test or other appropriate statistical method, eliminate all statistical outliers and recalculate the average RPD.
    - If the average RPD without the statistical outliers is <67%, then the abbreviated data set is considered to have acceptable precision in the lower range.
        - Retesting of the rooms that failed the RPD test is not required.
    - If after the exclusion of the statistical outliers, the average RPD is >67%, then the laboratory should be consulted to see if the problem can be corrected.
        - If the problem cannot be corrected, then retesting shall be considered for all rooms with RPDs ≥67%.

Average radon measurements ≥4 pCi/L with RPD ≥36%

- Using student's *t*-test or other appropriate statistical method, eliminate all statistical outliers and recalculate the average RPD.

    - If the average RPD without the statistical outliers is <36%, then the abbreviated data set is considered to have acceptable precision in the upper range.
        - For the statistical outliers excluded from the RPD analysis, retesting is recommended for results with an arithmetic average ≥4 pCi/L to <20 pCi/L, and not recommended for statistical outliers where both measurements are ≥30 pCi/L.
- If after the exclusion of the statistical outliers, the average RPD is >36%, then the RPD should be recalculated excluding all outliers and measurements in which both radon results are ≥10 pCi/L.
    - If the average RPD is <36%, then the abbreviated data set is considered to have acceptable precision in the upper range.
        - For all results excluded from the ≥ 4 pCi/L RPD analysis, retesting (Section 3.2.9.4) is required.

If the data set with the above exclusions cannot meet their respective RPD requirements, the manufacturer or laboratory shall be consulted to determine if the results can be corrected. If the data cannot be corrected retesting is required for all rooms whose averages were ≥2 pCi/L.

3.4.2 Data Set Quality Factor

Historically, within the Navy and Marine Corps, tens of thousands of individual radon results have survived in one form or another for decades. However, when they are reviewed decades later (Section 2.7), in a significant number of cases, the blank and spike data are incomplete or missing, creating the possibility of having to retest tens of thousands of rooms. To assist future reviewers of the data—who may not have the benefit of process knowledge of a particular survey—at the conclusion of each data set validation, a data set quality factor (DSQF) is assigned. These values will provide future reviewers of the data set some insight into the data set quality and ensure that the validation process need not be repeated. The DSQF values and meanings follow.

- **DSQF 1: Meets NAVRAMP Criteria**
    - The data set meets or exceeds all historical or current NAVRAMP data quality requirements. Data sets with this assignment can be used or cited without further qualifications. However, NAVRAMP confirmation rules for elevated results must be followed as applicable for each measurement before taking corrective action.
- **DSQF 2: Meets EPA or ANSI/AARST Criteria**
    - The data set did not have sufficient blanks or spikes to meet the applicable NAVRAMP requirements in force at that time. However, the data set has at least 10% duplicates, and the duplicates are within the acceptable RPD (Section 3.3, Equation 1) range provided by EPA. Data sets with this assignment can be cited; but in cases in which single radon measurements are ≥4 pCi/L, the result must contain the statement "Pending Confirmation." In addition, before corrective action is taken, all single elevated results must be confirmed. The sole exception is if the elevated measurement was performed using collocated

duplicates and the measurement had an acceptable RPD. In this case, mitigation could proceed without confirmation.

- **DSQF 3: Data Set Quality Is Unknown**
  - The data set has insufficient QC to make a determination. All elevated results, including those with collocated duplicates, must be confirmed before corrective action is taken. All citations of the data ≥4 pCi/L should include the comment "Pending Confirmation."
- **DSQF 4: Unusable Data**
  - The data set has sufficient QC to determine that it does not meet NAVRAMP or EPA data set quality standards. The data set or individual result should not be cited or distributed, and the entire survey should be repeated. In addition, no conclusions should be drawn from the data with respect to the absence or presence of elevated radon levels at the installation or site.

3.4.3 Data Set Completeness

The overall objective of NAVRAMP testing is to test all testable rooms (Section 3.2.4) within a building and all testable family housing units. However, detector losses, inaccessible areas, and other errors will inevitably result in some rooms or homes not having radon data. The necessity of retesting these rooms depends upon many factors, such as the total number of rooms in which data are available, the potential for elevated radon at the installation or site, and the highest result in the building. Within each building tested, a check should also be performed to ensure that all occupied areas required to be tested under NAVRAMP actually were tested (Section 3.2.4). Any areas or rooms that were missed should be documented and reasons provided for their being missed. Under NAVRAMP, retesting of testable rooms with missing data (not the entire building) shall be performed for any building in which a confirmed elevated measurement was found. For all other buildings in which the highest result was <4 pCi/L, retesting in the rooms with missing data should be considered only if losses exceed 20% of the total testable rooms. With respect to family housing, NAVRAMP requires that all testable units must be assessed for radon. Therefore, retesting in cases where detectors were lost or results disqualified must be performed.

3.4.4 Elevated Radon Results

As was stated in Section 3.2.9.4, under NAVRAMP confirmation or follow-up tests are not required for valid collocated duplicate detectors from a validated data set. Mitigation planning and implementation can proceed without additional radon testing. However, prior to reporting final radon results to stakeholders, a review of all radon results shall be performed, and the following information verified for collocated duplicates with an average ≥4 pCi/L:

1. The RPD is < 36% (Section 3.3, Equation 1)
2. A review of the placement and retrieval data sheets agree that the report documents the correct building, room and location or housing unit for the measurement

3. The correct date for placement and retrieval and time if applicable were used in the testing report
4. The results reported by the laboratory are in pCi/L (1 pCi/L = 37 Bq/m^3) and match the results in the testing report
5. There are no testing exceptions which would negate or nullify the elevated radon results (Section 3.2.13)

For rooms tested with a single detector measurement (i.e., only one detector was used or retrieved at that sample location) results ≥4 pCi/L are considered confirmed if one or more of the following is true:

- One or more rooms in the building are ≥4 pCi/L.
- Prior testing in the room has been ≥4 pCi/L.
- The average sequential measurements employing similar test devices for a similar duration in the room is ≥4 pCi/L.

If none of these are true, then confirmation or follow-up test will be required prior to taking corrective action (Section 3.2.9.4).

For both technical and business reasons, all commercially available radon measurement devices have ranges for optimal performance (typically between 2 to 20 pCi/L for most commercially available detectors). Measurements below and above this range typically have higher RPDs and are less accurate. At the low end, this is not an issue since a 0.2 pCi/L and a 1.1 pCi/L clearly indicate that no corrective action is required (RPDs are not required for average radon results < 2 pCi/L). However, at the upper end, depending upon the detector, it is possible to have a collocated duplicate of 25 pCi/L and 40 pCi/L (RPD 67%) that would still qualify as a representative measurement. In this case the laboratory should be consulted to firmly establish the upper limit and consulted as to the most likely average result. If the suspected calibration problem is verified by the manufacturer, both measurements should be coded with error code 17 (Table 5) to indicate that they were collected outside of the calibrated range. Confirmation or follow-up measurements using a different detector or CRM is not required in this case. Obtaining a measurement within the NAVRAMP control limits is a secondary concern to mitigation. However, if the detectors are within the established calibration range and bad results are suspected, then a confirmation or follow up test would be required.

In some cases, the detectors may have been exposed to higher levels of radon than can be accurately reported by the laboratory. (This should not be confused with exceeding the exposure duration of the detector, in which case retesting may be warranted.) Typically, these results are coded by the manufacturer and reported as "measurement exceeds upper limit" or the published result is greater than or equal to some value. Although the conclusion is self-evident (elevated radon levels are present, mitigation is needed), attempts should be made to work with the manufacturer to determine if the result could be over the respective NAVRAMP threshold timelines (Section 2.1, Table 2, i.e. >20 pCi/L or >200 pCi/L). In cases in which the result cannot be bracketed by the manufacturer, mitigation should be performed as soon as practical.

3.4.5 Averaging Sequential Radon Measurements

Under the EPA an ANSI/AARST testing protocol, sequential measurements (sometimes referred to as sequential duplicates) are performed as a means to judge the variability of the indoor radon concentration at different test conditions (e.g., different seasons or HVAC settings). To perform sequential averaging, the results to be averaged must all be from the same category (i.e., all long-term or all short-term). When similar types of radon measurements are averaged, the average of each individual measurement event is calculated first and then the average of these results is calculated. In the example shown in Table 7, over a 1-year period, a room had three short-term testing events, each performed with collocated duplicate detectors. The average result and RPD (Section 3.3, Equation 1) of each measurement event were calculated. Because all the RPDs were within acceptable limits, the overall average of all three measurement events was then calculated. The result, 3.5 pCi/L, indicates that mitigation would not be required in this room. However, if one of the three measurement events had an unacceptable RPD, it would be discarded, the average of the two remaining results would be taken, and a conclusion would be drawn from the result.

Table 7. Sequential testing averaging example.

Measurement	Detector 1 (pCi/L)	Detector 2 (pCi/L)	Average (pCi/L)	RPD (%)
1	3.9	4.5	4.2	14.3
2	2.0	2.4	2.2	18.2
3	3.8	4.3	4.1	12.3
Average			**3.5**	

In some buildings, seasonal HVAC settings may have a direct impact on the radon concentration. Examples include variation in the volume of makeup air, physically turning the HVAC off during transient seasons, and changes in the supply air volume, to name a few. In these cases, a time-weighted-average method can be employed to determine if mitigation is required. For this determination, detailed HVAC operational information is required—specifically, when the changes occur and for what duration—in addition to representative, good-quality radon measurement data collected during these periods. To perform the time-weighted average, the number of days is first estimated for each specific HVAC condition found throughout the year. The individual estimated days are then multiplied by their respective radon results (pCi/L) for this period. The pCi/L-days are then summed and the sum divided by the total number of days (ideally, 360 to 365 days). The result in pCi/L would be an estimate of the annual average for the building (see Table 8 for examples).

In cases where the estimated annual average is ≤2 pCi/L, mitigation is not recommended. For an annual average, ≥4 pCi/L, mitigation should be performed in accordance with the NAVRAMP timeline (Section 2.1, Table 2). However, for estimated results >2 and <4 pCi/L, retesting using a 1-year measurement should be considered.

Table 8. Examples of time-weighted averaging.

Example 1	**Winter (HVAC on)**	**Spring (HVAC off)**	**Summer (HVAC on)**	**Fall (HVAC off)**	**Total**
Number of days	120	60	120	60	360
Radon level (pCi/L)	8.0	1.0	4.0	0.5	N/A
pCi-L-days	960	60	480	30	1530
Average radon level	4.3				
Conclusion	Mitigate				
Example 2	**Winter (HVAC on)**	**Spring (HVAC off)**	**Summer (HVAC on)**	**Fall (HVAC off)**	**Total**
Number of days	180	N/A	180	N/A	360
Radon level (pCi/L)	8.0	N/A	0.1	N/A	N/A
pCi-L-days	1440	N/A	18	N/A	1458
Average radon level	4.1				
Conclusion	Mitigate				
Example 3	**Winter (HVAC on)**	**Spring (HVAC off)**	**Summer (HVAC on)**	**Fall (HVAC off)**	**Total**
Number of days	90	90	90	90	360
Radon level (pCi/L)	6.0	0.5	0.8	0.5	N/A
pCi-L-days	540	45	72	45	702
Average radon level	2.0				
Conclusion	Mitigation is not required, but 1-year testing should be considered				

3.4.6 Analysis of Short-Term Radon Data

Under NAVRAMP, if 1-year tests are not practical, radon tests of >90 days are preferred for assessment and supplemental assessment measurements rather than short-term measurements (2–90 days). However, in cases of possible health concerns, limited time, or financial considerations, or at sites or installations at which significant elevated radon potential has been demonstrated (e.g., historical, validated radon data has identified rooms ≥20 pCi/L or an RPC 1 site or installation), short-term measurements (2–90 days) can be used for assessment and supplemental assessment measurements provided that specific conditions are met during the entire test period (Section 3.2.1).

Unlike long-term tests (91–365 days), short-term measurements can be biased (higher or lower) by episodic and seasonal weather (*NAVRAMP Technical Manual* Section 1.3.1 and

1.3.2). Consequently, extra care must be taken to document periods of heavy rain or high winds during the test period and the HVAC conditions of the building (e.g., is the HVAC operating normally; if applicable, what are the seasonal settings; are there any energy setbacks for nights and weekends). The same precautions also apply to family housing in which residents may not have adhered to ideal closed-building conditions (Section 3.2.1) during the testing period. For these reasons, a validated, elevated short-term result is treated differently under NAVRAMP from a long-term result of similar quality. For example, under NAVRAMP, if an elevated 1-year measurement has been validated and confirmed, mitigation should proceed without additional testing. Conversely, validated and confirmed, representative elevated short-term measurements require a review of the indoor testing conditions and may require additional radon testing before mitigation is considered.

In large buildings, radon levels can be significantly affected (up or down) by the operation of the building's mechanical systems (e.g., HVAC and exhaust blowers). Under the expedited testing protocol, all rooms with validated, confirmed, representative elevated radon levels are treated initially as "rooms of interest," meaning that the possible impact of the building HVAC system should be evaluated before recommending mitigation. Specifically, what needs to be determined is whether any seasonal adjustments were made during the year (e.g., fresh-air dampers opened and closed, heating and cooling cycles turned off for certain times of the year). If any of these has occurred, then the overall potential impact of these adjustments or cycles on the building's ventilation rate needs to be determined. This information can typically be obtained by consulting the installation's HVAC maintenance group or contractor.

In cases where seasonal changes in HVAC condition would not reduce or significantly change the ventilation rate, or in cases where there is no mechanical contribution (e.g., buildings with split systems with no allowance for fresh air, radiator heater/cooling, and so on), Tables 8 and 9 should be consulted to extrapolate the radon levels needed for the remainder of the year to provide an estimated <4 pCi/L/year. Consideration should be given to periods of possible open-building conditions during transition seasons (e.g., spring and fall). For radon results between 4 and 6 pCi/L, or if the extrapolation is uncertain, consideration should be given to performing a short-term test during the opposite season and then doing a time-weighted estimated annual average (Flowchart 7). However, in cases where no significant change in radon concentration is expected, mitigation within the NAVRAMP guidelines should proceed.

However, for cases in which seasonal HVAC fresh-air volume adjustments are made, it should be determined whether the changes might reduce the radon levels either through dilution or pressurizing the building. To determine if retesting is needed, the first step is to estimate the number of days/year on which these HVAC conditions are prevalent. Rounding off to the nearest pCi/L, consult Table 9 to determine what the radon concentration would need to average for the remaining days of the year to average to 3.9 pCi/L. For example, if the initial radon result was 20 pCi/L and the duration of the HVAC condition was 30 days, the radon level would have to average ≤2.5 pCi/L for the remaining 335 days for the integrated annual average to be ≤3.9 pCi/L. In this example, a

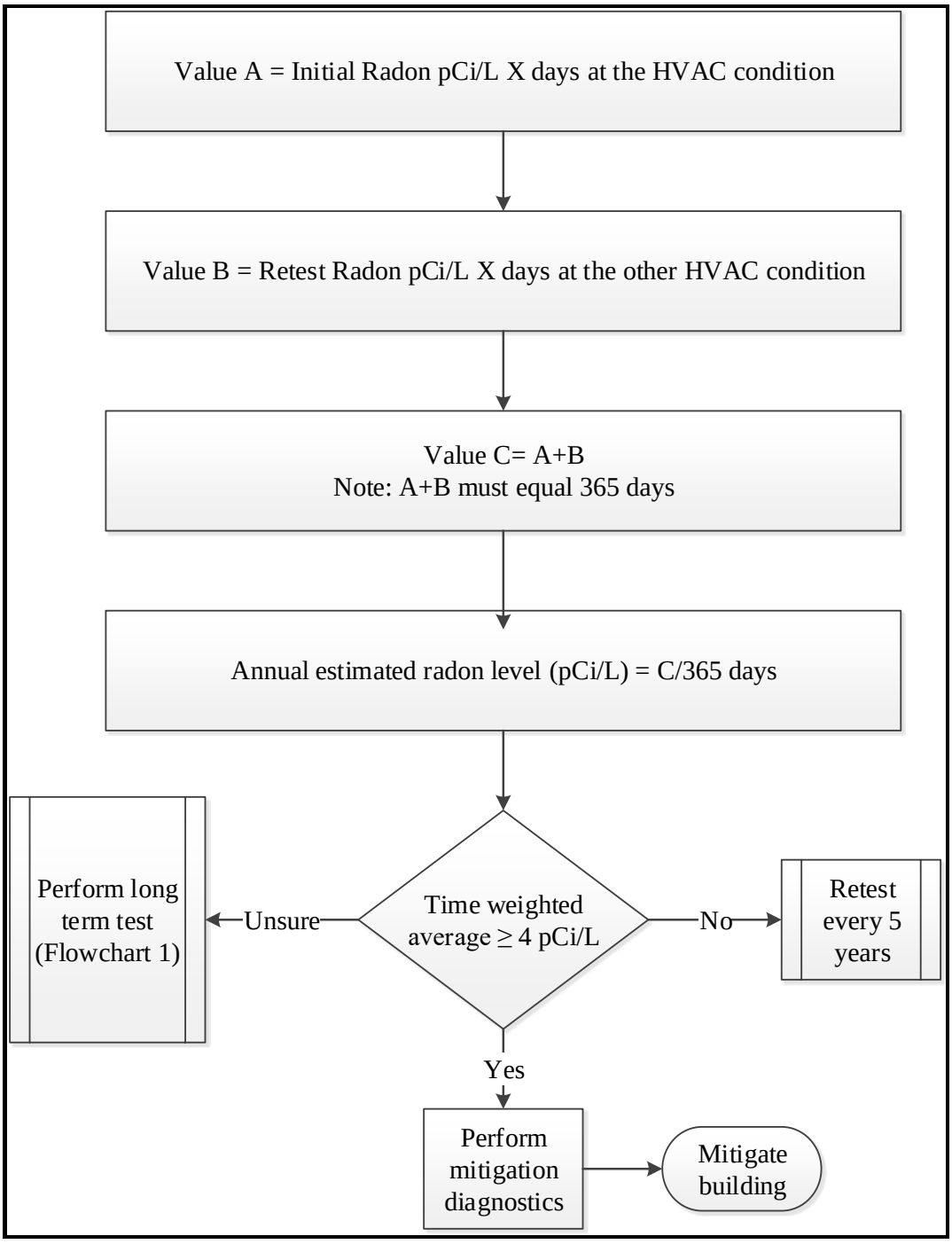
short-term retest during the other HVAC condition would be recommended if the seasonal HVAC changes had the potential to pressurize the building or significantly increase the building ventilation rate. However, in this example, if the duration of the tested HVAC condition was 90 days, mitigation should proceed in accordance with the NAVRAMP recommended guidelines, since negative levels of radon are an impossibility. If a valid and representative retest was performed, then the time weighted average should be calculated using Flowchart 7.

Another option is to perform a series of short-term, diagnostics radon measurements (radon measurements performed during radon mitigation diagnostics under known, precise conditions) at the different fresh-air settings. These measurements can be performed using short-term passive detectors or CRMs, and the data can be processed using a similar time weighted process as illustrated in Flowchart 7.

Table 9. Time-weighted averages to obtain annualized 3.9 pCi/L. [a]

	30 days at HVAC or climate condition	60 days at HVAC or climate condition	90 days at HVAC or climate condition	120 days at HVAC or climate condition	180 days at HVAC or climate condition	270 days at HVAC or climate condition
Initial radon result (pCi/L)	**Average for remaining 335 days (pCi/L)**	**Average for remaining 305 days (pCi/L)**	**Average for remaining 275 days (pCi/L)**	**Average for remaining 245 days (pCi/L)**	**Average for remaining 185 days (pCi/L)**	**Average for remaining 95 days (pCi/L)**
4.0	3.9	3.9	3.9	3.8	3.8	3.6
5.0	3.8	3.7	3.5	3.4	2.8	0.8
6.0	3.7	3.5	3.2	2.9	1.9	–2.1
7.0	3.6	3.3	2.9	2.4	0.9	–4.9
8.0	3.5	3.1	2.6	1.9	–0.1	–7.8
9.0	3.4	2.9	2.2	1.4	–1.1	–10.6
10.0	3.4	2.7	1.9	0.9	–2.0	–13.4
15.0	2.9	1.7	0.3	–1.5	–6.9	–27.7
20.0	2.5	0.7	–1.4	–4.0	–11.8	–41.9
25.0	2.0	–0.3	–3.0	–6.4	–16.6	–56.1
30.0	1.6	–1.2	–4.6	–8.9	–21.5	–70.3
35.0	1.1	–2.2	–6.3	–11.3	–26.4	–84.5
40.0	0.7	–3.2	–7.9	–13.8	–31.2	–98.7
45.0	0.2	–4.2	–9.6	–16.2	–36.1	–112.9
50.0	–0.2	–5.2	–11.2	–18.7	–41.0	–127.1
100.0	–4.7	–15.0	–27.6	–43.2	–89.6	–269.2
200.0	–13.7	–34.7	–60.3	–92.2	–186.9	–553.4

[a] Radon levels < 0.0 pCi/L are an impossibility. The negative values were included for reference purposes only.



Flowchart 7. Estimation of the annual average using two results.

3.4.7 Analysis of Radon Test Data from Other DoD Sources

Recently, as a cost savings measure, DoD combined separate DoD facilities into a common administrative entity to save on both administration and maintenance costs. At naval installations where joint basing has occurred and the Navy or Marine Corps has been designated as the administrative lead (i.e., implementation of NAVRAMP would be required for this population of buildings), a review of all available radon data for the acquired nonresidential buildings and family and unaccompanied housing will be required. Because of differences in the respective DoD radon testing programs, it is very unlikely that the supplied data will meet all the NAVRAMP requirements. Therefore, the data provided will need to be validated (Section 3.4.1) and then assigned a DSQF (Section 3.4.2) before an appropriate RPC can be assigned (Section 2.3). For data set analysis purposes, the provided data set should initially be processed as a separate site (Section 2.3.1) until an appropriate RPC has been determined for this population of buildings. However, if no individual radon test data are available (summary reports, sometimes referred to as circumstantial data, cannot be used), then RPC 2 shall be assigned to the site.

In the initial analysis step, determine if one or more of the following statements are **true** for the provided data set:

- The testing device information (i.e., manufacturer and type of testing device) was not provided or it has been determined that they do not meet the minimal NAVRAMP requirements (Section 3.2.2).
  - Note: WLM or progeny measurements cannot be accepted under NAVRAMP.
- The measurements were **not** collected using the respective services radon testing program guidelines **or** one of the following standards were **not** followed.
  - *Protocols for Radon and Radon Decay Product Measurements in Homes*, (EPA May 1993),
  - *Radon Measurement in Schools* (EPA July 1993),
  - *Protocols for Measuring Radon and Radon Decay Products in School and Large Buildings* (ANSI/AARST MALB-2014, Rev. 1/21), or
- One or more of the following items of information is missing from the provided data set:
  - Detector ID numbers
  - Placement and retrieval dates
  - Building numbers or unit addresses
  - Tested room names
  - Individual radon results for each nonresidential room or housing unit tested

If any of the above statements is **true**, the data set should be assigned DSQF = 4, and the site RPC = 2. However, if the testing devices **do meet** the minimal NAVRAMP testing device requirements, and **at least one** of the testing guidelines listed above, then a review of the available QC data (duplicate, blank and spike results) should be performed and the appropriate DSQF assigned (Section 3.4.2).

For DSQF equal to 2 or 3 (if the data set was assigned a DSQF = 4, assign an RPC = 2 to the site), an RPC 1 is assigned to the site for any confirmed radon results ≥4 pCi/L (Flowchart 7) or if more than one result at the site was found to be ≥4 pCi/L. If confirmation or follow-up testing is required, then the assignment of the RPC should be deferred until the confirmation or follow-up testing has been completed (Section 3.2.9.4). However, in this case, if expediency is desired for the RPC assignment, consideration can be given to other mitigating factors such as the main naval installation or other sites are known RPC 1.

If the data set is validated (i.e., DSQF 2 or 3) but the highest radon result is <4 pCi/L, a determination needs to be made whether sufficient testing has been performed. If at least 25% of the ground-contact occupied rooms at the site were tested, then an RPC 3 designation (Section 2.3) is assigned. However, if <25% of the rooms were tested, then an RPC 2 designation (Section 2.3) shall be applied.

After the initial RPC has been assigned to the site, the installation will need to decide as to whether to continue to manage this population of buildings as a separate site, integrate it into an existing naval site, or incorporate it into the existing population of buildings at the naval installation as a whole. If the decision is made to incorporate these buildings into the existing site, or the entire installation building population, then the RPC for the site or UIC as a whole would apply (Section 2.3) and any additional testing implemented as required (Section 2.3).

3.4.7.1 Analysis of Radon Test Data from Other Sources

Another source of radon data may be the current occupant of a building. Because of the availability and relatively low cost of "do-it-yourself" radon test kits, occupants may be tempted to perform the radon testing themselves. Under no circumstances are these data to be used to draw any testing conclusions. However, this position should not be interpreted as being outright dismissive towards the concerns expressed by the occupant about the test results. If needed, simply arrange for an official retest of the home, building, or room.

3.4.8 Radon Testing Records Management

Under NAVRAMP, all installations are required to maintain a central data management system containing all valid data collected at the installation (this requirement includes current and former Navy/Marine Corps–owned family and unaccompanied housing, and nonresidential buildings that are either owned or leased) that were tested under NAVRAMP. At a minimum, the information on file should contain the information specified in Section 3.5 and can be maintained in either hard copy or electronic format. Consistent with current EPA and BUMED recommendations, all radon test results collected under NAVRAMP shall be kept on file by the installation indefinitely, the rationale being that the manifestation of lung cancer after radon exposure can take decades. However, the installation is not required to maintain radon testing records from PPV housing that were collected by the partnering private company. Section 3061 of the National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2020 (Public Law 116-92) requires that if, as a result of testing, a unit of privatized military housing needs radon mitigation to ensure radon levels are below recommended levels, the landlord providing the housing unit shall submit to the Secretary of the Navy, not later than seven days after the determination of the need for radon mitigation, the mitigation plan for the housing unit. Copies of historical radon results for Navy installations can be obtained from NAVFAC EXWC or for USMC installations from HQMC/MCICOM GF-Environmental.

Any radon testing data collected for nonresidential buildings by the installation shall be submitted to NAVFAC EXWC or HQMC/MCICOM GF-Environmental within 30 calendar days of receiving validated test results for inclusion into the central data repository. Data shall be submitted using the templates provided by NAVFAC EXWC (see Appendix A) or HQMC/MCICOM GF-Environmental. Upon receipt and verification of the import template submission, NAVFAC EXWC or MCICOM shall upload the radon testing data into the central data repository within 30 calendar days.

Any radon testing data collected for family housing and unaccompanied housing by the installation shall be submitted to the EHS Module in the eMH system. Data shall be submitted using the template provided by Commander Navy Installations Housing Program (see Appendix B).

3.4.9 Analysis of Radon Data During Occupied vs. Unoccupied Periods

As an energy saving measure, some nonresidential HVAC units during unoccupied hours (i.e., nights and weekends) operate with reduced ventilation settings. This unoccupied HVAC setting, commonly referred to as energy setback, can in some cases result in significant increases in radon levels within some rooms and in some cases the entire building while the setback is being applied. Passive integrated detectors (Section 3.2.2) cannot distinguish between occupied on unoccupied periods; therefore, the reported radon result is the average for the entire time the detector was exposed. However, CRM measurements can be performed which can distinguish the radon levels hourly providing the opportunity to average the radon levels during occupied hours only (*NAVRAMP Technical Manual* Section 5.1.9). The drawback with this approach is the need to perform simultaneous CRM measurements in all rooms with elevated radon levels for extended periods of times and possibly repeated at different times of the year (ANSI/AARST MALB-2014, Rev. 1/21). In most cases, what can be observed is the radon levels increasing after the setback is initiated and decreasing when the occupied settings are reactivated. Particular attention must be given to the radon levels at the start of the workday. Although the radon level for the occupied hours for the week maybe < 4 pCi/L it is not unusual to find radon levels significantly > 4 pCi/L on Mondays mornings following a weekend setback and to a lesser extent on Tuesdays-Friday mornings (see example in *NAVRAMP Technical Manual* Section 5.1.9). To correct the problem, typically the end of the setback period is moved back several hours thus allowing for more ventilation time prior to occupancy. If this approach is selected as a mitigation measure, it is required that the CRM measurement and subsequent data analysis follow ANSI/AARST *Protocol for Conducting Measurements of Radon and Radon Decay Products in Schools and Large Buildings* (MALB-2014) Rev. 1/21.

3.5 RADON MEASUREMENT REPORTING REQUIREMENTS

Under NAVRAMP, the corrective action schedule (Section 2.1, Table 2) for all validated radon levels ≥4.0 pCi/L begins with the testing report date. In surveys in which elevated radon levels have been measured and validated, it is important for the installation to transition as quickly as possible to mitigation efforts because of health risk and occupant perception. Meeting this objective can sometimes be complicated by the fact that an in-depth, detailed project report can take up to 1 year to draft, review, revise, and finalize. Cognizance of the fact that most radon individual test results are reported by the laboratory within 45 to 60 days of receipt, under NAVRAMP a complete radon testing report shall be provided by the contractor or generated in-house (if the testing was performed by the installation) within 60 days of receipt of all the laboratory results. Within 30 days of receipt of the testing report, the installation shall perform the required validation (Section 3.4) and either accept or reject the survey results. In cases of data set rejection, the installation shall work with the contractor and laboratory to determine if the deficiencies can be legitimately resolved and corrected results provided for installation revalidation. The above-mentioned timelines for testing report generation and validation can be extended as required by the installation as circumstances dictate.

The objective of the testing report is to provide the installation with all the information necessary to validate the survey test data. Once validated, the results from the testing report can then be disseminated as detailed by the RCP (Section 2.10) to stakeholders and other invested parties as final test results and corrective actions initiated if validated elevated radon levels are present.

The testing report as a minimum shall contain the following information:

Testing Report Cover Letter

- **Contractor Information**
  - Company name
  - Address and phone number
  - Contract number
  - General project scope (e.g., perform radon measurement in 100 housing units and 25 selected buildings)
  - Approximate field survey dates (e.g., placement was performed during March/April 2015 and detectors were retrieved during April/May 2016)
  - Any exceptions to the project scope or NAVRAMP testing protocol
  - An attachment with the cover letter shall also contain the names of all staff involved with the testing including NRPP or NRSB testing certification numbers

- **Device information**
  - Manufacturer's name, address, and phone number
  - Device type, device certification code and model number
  - Detectors manufacturer's NRPP and/or NRSB certification number

Survey Result Section

For nonresidential testing, the following information shall be provided for each individual building sample location:

- Report date (can be located in report header)
- Installation name (can be located in report header)
- Site, if applicable
- Building name
- Sample room name or number and testing location within the room
- Type of detector (e.g., ATD, electret, CRM, charcoal)
- Type of radon measurement (e.g., screening, assessment, monitoring, see Section 3.2.9 Table 4)
- Detector identification number
- Duplicate identification number
- Date placed and retrieved
- Time placed and retrieved if measurement is time sensitive

- Detector 1 radon concentration in pCi/L
- Detector 2 (duplicate) radon concentration in pCi/L
- Average radon concentration in pCi/L
- Measurement testing exceptions (e.g., tampered, moved, lost)
- Any comments of merit about that room or testing location

In addition, for each individual building tested, the following summary information shall also be included:

- Total number of placement locations within the building
- Total number of sample locations with test results
- Number of sample locations <4 pCi/L
- Number of sample locations 4 to <20 pCi/L
- Number of sample locations 20 to <200 pCi/L
- Number of sample locations ≥200 pCi/L
- Total number of sample locations ≥4 pCi/L
- Highest measurement in pCi/L
- Any comments of merit about radon sampling in the building

Also included shall be the following building lists by sample location:

- List of testable rooms in which access for detector placement or retrieval could not be performed
- List of rooms in which testing was unsuccessful (e.g., lost, tampered, moved)

For all buildings in which radon levels ≥ 4 pCi/L have been detected the following shall be provided in the appendix section of the testing and final reports:

- A current floorplan labeled with the tested room names
- The average radon result for each room with all results ≥ 4 pCi/L highlighted or colorized
- Submittal of updated floorplans for buildings in which the highest radon result was < 4 pCi/L is optional.

For testing in family housing, the following information shall be submitted by individual family housing unit:

- Report date (can be located in report header)
- Installation name (can be located in report header)
- Site, if applicable
- Neighborhood name (if applicable)
- Unit address (street number, street name, or building number)
- Room sampled and location in the room
- Type of detector (e.g., ATD, electret, CRM, charcoal)

- Type of radon measurement (screening, assessment, monitoring, see Section 3.2.9 Table 4)
- Detector identification number
- Duplicate identification number
- Date placed and retrieved
- Time placed and retrieved if measurement is time sensitive
- Detector 1 radon concentration in pCi/L
- Detector 2 (duplicate) radon concentration in pCi/L
- Average radon concentration in pCi/L
- Measurement testing exceptions (e.g., tampered, moved, lost)
- Any comments of merit about that room or testing location

For each neighborhood tested, a summary listing shall include the following:

- Total number of family housing units with placed detectors
- Total number of family housing units with test results
- Number of units <4 pCi/L
- Number of units 4 to <20 pCi/L
- Number of units 20 to <200 pCi/L
- Number of units ≥200 pCi/L
- Highest family housing unit measurement in pCi/L

Also included shall be the following lists by individual family housing units sorted by neighborhood:

- List of testable family housing units in which access for detector placement or retrieval could not be performed
- List of family housing units in which testing was unsuccessful (e.g., lost, tampered, moved)

Survey Quality Control

For all blanks, the following information shall be provided:

- Detector number
- Blank use (e.g., laboratory or travel blank)
- Results in picocuries per liter-days (pCi/L-days)

The blank results shall be summarized and tabulated as follows:

- Total number of blanks
- Total number of travel blanks
    - Average pCi/L-days for travel blanks
    - Number of travel blanks greater than the manufacturer-reported detector background

    - Any exceptions taken for any suspected outliers
- Total number of laboratory blanks
    - Average pCi/L-days for laboratory blanks
    - Number of laboratory blanks greater than manufacturer reported detector background
    - Any exceptions taken for any suspected outliers

For all spikes, the following information shall be provided:

- Laboratory performing the spikes (laboratory name, address, and phone number)
- Total detector dose in pCi/L-days
- Equivalent spike concentration in pCi/L (chamber dose in pCi/L-days/average number of exposure days in the survey)

For all spike results, the following information shall be provided in tabular form:

- Detector number
- Laboratory reported pCi/L-days
- Relative percent error (Section 3.3.2)

All spike results shall include the following summary information:

- Total number of spikes
- Average relative percent error for all spikes
- Any exceptions taken for any suspected outliers

Included in the submission of the testing report shall be a spreadsheet in the NAVFAC EXWC or HQMC/MCICOM GF-Environmental import format for all the test results collected in the survey. File format and instructions are available from NAVFAC EXWC and from HQMC/MCICOM GF-Environmental.

With respect to nonreportable radon data (Section 3.2.13), the attempted measurement shall be documented in the testing report, but the laboratory result will be left blank or have a placeholder text or symbol (e.g. N/A, *.*, -.- etc.) inserted. To avoid confusion, the numerical value of "0.0" shall never be employed when documenting a nonreportable result. In addition, a comment describing the catastrophic error is also required (e.g., detector was damaged, detector was relocated to another building, HVAC was replaced during sampling period, etc.).

Depending on the survey size and complexity, and the installation's projected reporting needs, in addition to the testing report, a detailed project report may be required. The content of the detailed project report shall include all the information in the testing report plus any other information that the installation requires to document the survey (e.g., building plans, installation maps, local geological conditions etc..).

The prime contractor shall maintain electronic pdf format copies of all data forms, updated floor plans, testing and project reports, laboratory data provided by the vendor, chamber spike results (if applicable) and an electronic copy of the output provided to EXWC or HQMC/MCICOM GF-Environmental for a period of 7-years.

3.5.1 PRE-MITIGATION DIAGNOSTIC SURVEY

At installations where there is a high probability that elevated radon will be detected [e.g., installation is in an EPA Zone 1, 2 or equivalent, RPC 1 designation)] consideration may want to be given (not mandatory) to including in the testing contract the option of a pre-mitigation diagnostic survey. Historically subslab depressurization (SSD) has been the mitigation method of choice at naval installations. However, there can be structural, technical or logistical issues which could complicate or prevent its installation. In addition, in some buildings HVAC or building exhaust issues may need to be corrected before any mitigation method could be considered. Also, within some nonresidential buildings, there may be a HVAC energy setback cycle which could result in significant increases in radon levels during the unoccupied hours. If present, CRM measurements may be needed during the mitigation diagnostic phase to determine the radon levels during occupied hours (*NAVRAMP Technical Manual* Section 5.1.9). Another consideration is the radon testing and mitigation history of the building. For example, if HVAC adjustments were made previously to mitigate room(s) or the building, these settings would need to be checked. Also, if present, a performance check of previously installed mitigation systems would need to be performed as well. In newer buildings there is also the possibility that RRNC was incorporated into the building's design and construction. If present, the location of the riser or vent pipe needs to be documented. A review of the building structural and mechanical plans is in order as well. After these preparations have been performed, a walk-through inspection performed by a radon mitigation analyst (Section 4.2.9) can in most cases determine the best mitigation approaches for a particular room or building and make specific recommendations for mitigation diagnostics (see *NAVRAMP Technical Manual* Section 5.1.1). This information would greatly assist in the drafting of the mitigation request for proposal and budget planning/requests. From a chronology and reporting perspective, it would be best to execute this pre-mitigation diagnostic option after the testing report has been issued so that the findings and recommendations can be included in the final project report.

3.6 RADON TESTING PROVIDER QUALIFICATIONS

For all field placement and retrieval activities, the radon team must be under the supervision of an on-site field supervisor. Qualifications of the field supervisor are:

- Training: Radon measurement training certified by NRPP or NRSB
- Experience: 3 years of documentable radon testing experience
- Certification: Current NRPP or NRSB measurement certification

Personnel other than the on-site field supervisor who are placing and retrieving radon detectors are called "field technicians." Qualifications for the field technician are:

- Training: Radon measurement training certified by NRPP or NRSB
- Experience: 1 year of documentable radon testing experience
- Certification: Current NRPP or NRSB measurement certification

Personnel who perform data analysis, validation, and certification of the radon testing results are called "radon testing analysts." Qualifications for the radon testing analyst are:

- Training: Radon measurement training certified by NRPP or NRSB
- Experience: 5 years of documentable radon testing experience
- Certification: Current NRPP or NRSB measurement certification

Personnel who read electret detectors are called an "analytical service provider." Qualifications for the analytical service provider are:

- Training: Radon measurement training certified by NRPP or NRSB
- Experience: 1 year of documentable electret reading experience using the chamber/electret combination being used in the survey
- Certification: Current NRPP or NRSB measurement certification with analytical services for the chamber/electret combination being used in the survey

Personnel who place, retrieve, download and report radon data from CRMs and EIMs are called "electronic analytical service providers." Qualifications for the electronic analytical service provider are:

- Training: Radon measurement training certified by NRPP or NRSB
- Experience: 1 year of documentable experience using the same make and model of the CRM or EIM being used in the survey.
- Certification: Current NRPP or NRSB measurement certification and listing for the make and model of the CRM or EIM being used in the survey.

Under EPA testing guidelines for implementation of the IRAA, government employees and military personnel may perform the radon testing at their facilities without certification, although accredited radon testing training is recommended. However, installation contractors [e.g., Base Operations Support (BOS), Indefinite Delivery/Indefinite Quantity (IDIQ) or similar] or their subcontractors must meet all the contractor requirements listed above. Under NAVRAMP, if uncertified government employees and military personnel are going to be utilized for radon testing at an installation, the installation must decide if training and certification is required to meet the needs of their radon program. It is important to note that the accredited testing training being offered under the auspices of NRPP or NRSB does not address the logistics and problems which occur during mass surveys. Because of this, to the extent possible, this guidebook has integrated and adapted applicable information which is also included in the accredited training courses to meet the objectives and requirements of NAVRAMP.

3.6.1 Considerations for Performing In-House Radon Testing

Because radon testing at RPC 1 installations/sites will be an on-going program for the foreseeable future, consideration may be given to performing radon testing in-house. Although placing and retrieving radon detectors is straight forward, in larger surveys (e.g., > 1000 rooms or > 100 family housing units) project logistics can result in problems and delays. The following outlines the primary considerations on performing a radon survey in-house.

Detector Selection:

Because electret detectors are reusable, with proper use and planning, they can save money over the long-term. However, under NAVRAMP a current NRPP or NRSB certification is required to read electrets (see analytical service provider, Section 3.6). Therefore, installation staff involved in reading the electrets must take the introduction measurement course, pass the device proficiency test and be listed in order to process and report the radon data. Personnel recertification is required every 2 years while the reader must be recalibrated every year. In addition, electrets must be read in a clean, constant temperature and humidity-controlled environment (Section 3.3.6). Therefore, suitable space must be identified prior to the initiation of the testing project.

Most CRMs and EIMs require manufacturers software to be installed on a computer or tablet to view and download. Depending upon the model, connection is made via WIFI, Bluetooth, thumb drive or a USB cable. However, at most naval installations, getting approval to install the manufacturer's software and make a connection to the instrument to a computer on the network may be difficult or not possible. Optionally, at some installations it has been possible to download the CRMs to an approved off network laptop, or tablet equipped with a working WIFI. Once downloaded, the files can then be transferred via email using public WIFI. If this is not possible, then CRMs or EIMs that can be manually downloaded would be the only option. Another consideration is that all accredited CRMs and EIMs must be calibrated every year (typical cost $100-$300 per device). Instruments that are past the recalibration date cannot be used under NAVRAMP.

For passive detectors that must be returned to a laboratory for analysis, the primary consideration is detector holding time. For CONUS installations with access to multiple overnight or next day shipping services this is typically not a consideration. However, for installations located in foreign countries allowances must be made for export customs from the host nation and import customs into the US. Although the detectors are not hazardous or radioactive, there have been perception problems in the past which resulted in the detectors being held by foreign and US customs for over 30 days.

Another key consideration for long-term passive detectors is how will the detectors be mounted. For example, each of the currently available ATDs attached to the wall differently. Also, the composition, coating and texture of walls at an installation are highly variable as well (e.g., push pins work well for sheetrock, but not as well in concrete masonry).

Staffing:

Under NAVRAMP radon testing can be performed by uncertified government and military personnel. However, the use of uncertified BOS, IDIQ or similar contractors is not (Section 3.6). It is assumed in the discussions below that the in-house radon testing staff are working an 8-h day during typical business hours until the testing has been completed. If that is not achievable, then the timeline will need to be adjusted accordingly. The average placement/retrieval rates listed below are based on historical averages for the entire project.

In testing family housing there are 3 different approaches which have been used historically. The first approach is to go door-to-door and try to catch people at home. If they are not home a door hanger is left for them to call for an appointment. It is important to note that historically, < 5% of the housing occupants will call for an appointment. For those that do not respond to the door hanger request for an appointment a second, third etc... attempts are made until the placement has been completed. The timeline for retrieval is the same. The average success rate per team for a Monday through Friday placement or retrieval is typically 40 units per day on the first pass, 25 units per day on the second pass, and 5 units per day on the third pass and 1 unit per day for ≥ 4 passes. Placement or retrieval rates are 10% higher if performed on Saturday, Sunday or between 5-7 pm during Monday to Friday. The second approach is similar to the first approach, but family housing steps in after 4 or 5 attempts and contacts the occupants and schedules an appointment and/or access under escort. The third approach is to arrange for a family housing escort to allow access to units in which residents are not home. Typically using this option, 75 units per day can be placed or retrieved.

For nonresidential buildings, the average rate per radon team will vary depending upon the type of building being placed. For example, in unaccompanied housing or dependent schools with an escort average about 125 rooms placed or retrieved per day. However, the rate drops to 50 per day for secure/sensitive buildings. For a mixture of building types an average rate of 75 to 100 rooms per day is typical.

Data Management:

NAVRAMP requires that specific information be collected for each testing location (Section 3.2.10 and Section 3.2.11). This information will need to be input into a spreadsheet or Access database for tracking, data validation and ultimately final submittal to NAVFAC EXWC or HQMC/MCICOM GF-Environmental. In addition, each of the passive detector manufacturers has different requirements for detector submittal for analysis and reporting formats. These issues need to be addressed prior to initiation of the project since they will influence how the data will be collected and put into electronic form.

3.7 TESTING CONTRACTOR HEALTH AND SAFETY PLAN

Before any testing project begins, the contractor shall prepare a project health and safety plan. At a minimum, the plan shall list the expected potential hazards to the personnel performing the testing, the workers, and building occupants and the proposed measures to control the hazards. The Health and Safety Plan (HASP) should address hazards as shown in the sample HASP checklist for other clean-up projects, available at https://www.med.navy.mil/Portals/62/Documents/NMFA/NMCPHC/root/Environmental%20Programs/Pages/healthsafety/SSHP-Checklist-Oct-2020.pdf .

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4. NAVRAMP RADON MITIGATION

This chapter provides the NAVRAMP installation specifications for the mitigation systems, RRNC, and mitigation system O&M. Additional information on these topics can be found in the *NAVRAMP Technical Manual* Chapter 6.

It is important to note that in 2012, EPA initiated a voluntary consensus-based standards initiative with the radon industry (https://www.epa.gov/radon/radon-standards-practice). The subsequent standards produced by this partnership have superseded and consequently replaced the previous EPA standards and guidance documents. It is recommended that all statements of work, request for proposal, performance work statements and similar types of documents for radon mitigation reference the most recent ANSI/AARST standards and this document. A list of all current ANSI/AARST mitigation standards has been included in the Reference Section of this document and can be viewed or purchased on-line at https://standards.aarst.org/ .

4.1 NAVRAMP RADON MITIGATION OVERVIEW

A review of all known radon mitigation operations performed from 1993 to 2016 at naval installations worldwide found very few differences between mitigation system selection for family housing and nonresidential buildings. The review determined that 95% of the mitigations performed to date were variations of active soil depressurization (ASD), primarily subslab depressurization (SSD). The remaining 5% (methods are included below) were installed because SSD could not be applied as a stand-alone mitigation method. To ensure that a proper mitigation selection is made, and the system's performance has been optimized, it is highly recommended that mitigation diagnostics (*NAVRAMP Technical Manual* Section 5.1) be performed before mitigation. It is important to note that in addition to SSD mitigation being the most popular mitigation method of choice, it was also determined to be the most reliable and durable. More detailed information on SSD and other mitigation methods has been included in the *NAVRAMP Technical Manual* Chapter 4.

The only mitigation techniques allowed under NAVRAMP are those that prevent radon gas from entering the building or those that dilute the gas by use of supplemental ventilation (see EPA August 1988 and EPA October 1993 for a complete list of mitigation techniques). Mitigation methods using HEPA filtration air cleaners or progeny removal are not allowed under NAVRAMP (see *NAVRAMP Technical Manual* Section 4.3.6 for additional information) and are also prohibited under UFGS-31 21 13 (Section 2.1.1.4 November 2018).

Because of security concerns, radon mitigation in SCIF rooms and buildings can be very challenging. However, with proper planning and execution it can be performed without compromising the security rating of the room. Various options and approaches to radon reductions in SCIF have been provided in the *NAVRAMP Technical Manual* Section 4.5.

The schedule (Section 2.1, Table 2) for corrective action (i.e., the mitigation clock) should generally be based upon the testing report date. In cases in which confirmation or follow-up testing is required or desired, the mitigation schedule should be based upon the original testing report date if the elevated radon measurement has been confirmed. To ensure protection of human health, specific mitigation schedules should be coordinated with command leadership, US Navy Bureau of Medicine and Surgery/Defense Health Agency (BUMED/DHA) personnel, and others as appropriate. See also communication guidance provided in Section 2.10 and Appendix D.

Briefly, NAVRAMP requires the following for all radon mitigation systems and mechanical mitigation approaches:

- The installed mitigation system shall consistently maintain radon levels at <4 pCi/L when operating.
- Each active mitigation system regardless of type shall be equipped with a performance indicator and contact information to report system failure.
    - The noted exceptions are for mechanical repair (Section 4.2.8) and the removal or permanently disabling of exhaust blowers.
- All mitigation installation shall be performed or overseen by qualified personnel (Section 4.2.9).
- All mitigation systems shall be periodically inspected (Section 4.4)
- The incorporation of RRNC features (Section 4.3) in all proposed new construction at RPC 1 installations.

Sections 4.2.1 through 4.2.8 provide NAVRAMP specific requirements by mitigation method.

4.2 RADON MITIGATION SPECIFICATIONS AND REQUIREMENTS

Generally speaking, radon mitigation is divided into two basic categories passive and active ventilation and/or remediation systems (EPA August 1988). Passive mitigation uses nonmechanical measures to control radon entry into the living or occupied space. Typically, this involves the sealing of cracks and slab penetrations or other subslab openings into the living or occupied space. Another method used in new construction entails the installation of a passive stack vent pipe during construction (Section 4.3) which allows radon soil gas to bypass the living or occupied areas and flow directly to the outdoors. Another example of a passive technique is to increase the natural ventilation rate within a crawlspace or other nonconditioned space. The other category, active mitigation, entails using mechanical means, such as a fan or blower, to either dilute or control the entry of radon into the living area. Examples of active mitigation include, but are not limited to, shell pressurization (SP), energy recovery ventilation (ERV), SSD, supplemental air makeup (SAM), and adjustments and repairs to the buildings mechanical systems. For further information on these types of mitigation systems please consult Chapter 4 in the *NAVRAMP Technical Manual*.

Because of the diversity in style and construction of naval installation buildings, a single mitigation approach for all buildings at an installation is highly unlikely. Therefore, building-specific mitigation diagnostics (measurements that assist in the selection of a mitigation system) should be conducted to ensure that a proper mitigation system selection is made. Mitigation method selection criteria always include costs (installation and O&M), probability of success, and direct impact on the building occupants. Other considerations might be:

- Energy consumption
- Security and safety concerns
- Aesthetics
- Noise generation
- Loss of indoor functional space
- Proposed and pending renovations
- Possible impact of mitigation system installation on mission
- Projected remaining lifetime of the building
- Understanding of the occupants' concerns
- Life-cycle cost

As a general rule, because of their long-term cost-effectiveness, passive, SSD, and SAM (nonresidential only) methods should always be considered first. If these methods are not viable, then other mitigation methods (e.g., ERV, SP) should be considered. However, under no circumstances should HEPA systems or other methods that alter the radon decay product equilibrium be used, because their efficacy in reducing risk is uncertain.

Upon completion of a mitigation system installation, postmitigation radon testing shall be performed by the mitigation contractor to ensure that radon levels are <4 pCi/L. All postmitigation testing shall be short term and in accordance with NAVRAMP testing policies, guidelines, and procedures (Section 3.2.9.4). Postmitigation testing shall be performed no sooner than 24 h and no later than 30 days after system activation or, in the case of passive mitigation, completion. Within 30 days of the reporting of the postmitigation test results and at the discretion of the installation, an independent postmitigation test may be performed to verify that radon mitigation has indeed occurred. The extent and frequency of this verification postmitigation testing are at the sole discretion of the installation.

All passive and active ventilation and/or remediation systems (EPA August 1988). mitigation systems should be inspected by either the contract officer, contract officer representative (COR) or by an independent private sector competent person within 30 days of application or installation. Items for inspection are listed below and additional information and expanded detail can be found in the *NAVRAMP Technical Manual*.

4.2.1 Passive Mitigation Specifications and QA

Although simple in concept (e.g., no moving parts), it can in the long term be difficult to inspect passive mitigation measures and ascertain current system performance. NAVRAMP applies the same O&M inspection as for active systems (i.e., periodic inspection every 2-3 years).

In passive sealing, various sealants are applied to cracks, expansion joints, and other potential radon soil gas entry points to reduce radon entry or, ideally, eliminate it entirely. Passive sealing should be attempted as a mitigation means only if the repair would potentially last for >20 years. Therefore, the selection of the most appropriate sealant is critical. According to the American Adhesive and Sealant Council, the choice of a sealant should be based on the type and size of the opening, the opening substrate, the environment in which the sealant would be used, and the potential for deterioration, among other criteria. For most sealants on the market, specification and instruction sheets provided by the manufacturer are a good source of this type of information. In addition, the sealant safety data sheet should be consulted to see if any precautions need to be taken during installation and post-application curing.

In telephone, electrical, communication and server buildings there is typically an underground cable vault where the lines enter the building. These entry pathways cannot be permanently sealed (this includes the use of expansion foam) due to periodic inspection requirements of the wire or cable and the future potential use of the unused pathways. However, they can be sealed with duct seal or putty and the unused ones with tampered conduit cap plugs which can be removed and reapplied as required.

Passive sealing is highly application-specific and thus does not easily fit a standard checklist for post-installation QA. Therefore, a customized QA checklist must be developed for each post-installation inspection and for future O&M checks. Questions that should always be included on the post-installation checklist are:

- Was the use of this sealant appropriate for this application?
- Was the sealant applied according to the manufacturer's instructions?

4.2.2 Shell Pressurization (SP) Specifications and QA

SP, although the oldest and best understood of all radon mitigation methods, should be considered the mitigation method of last resort. To be brief, compared with other forms of radon mitigation, SP has higher maintenance and energy costs and, depending upon the type of SP system installed, may be more expensive to install. SP systems consist of two basic types differentiated by how the required volume of outdoor air is supplied.

A Type 1 SP system uses either an existing or an installed fresh-air damper to supply the fresh air. In this design, the air is conditioned by the building's existing mechanical system before discharge into the building. Therefore, before the SP system is installed, it is necessary to evaluate the current mechanical system and calculate the load to determine if

it could condition the added volume of air (i.e., heat, cool, and dehumidify). If the existing mechanical system lacks the capacity for conditioning the required makeup air, then a Type 2 SP system (an independent mechanical system to condition the outdoor air before it enters the structure) will be required. Load calculations must be performed to ensure that the unit will adequately condition the supply air year around.

Specifications for SP mitigation systems are building- and application-specific—the design for one building will not be readily interchangeable with another. Many considerations go into the design of an SP system to ensure that the current mechanical system(s) can handle the added conditioning load and that the possible increase in humidity would not place the building within the range for inducing mold growth (≥60% RH). Therefore, if SP is selected as the mitigation method, the design will need to be reviewed and approved by a qualified mechanical engineer before the mitigation system is installed. From this final design, a QA checklist can be generated for possible inspection. Examples of typical features and conditions to check after installation are:

1. The quarters, room(s), or building is between (+) 4 and 8 Pa relative to the outdoors.
2. Installed filters have a minimum efficiency reporting value (MERV) rating of 8 or greater (ASHRAE 2007, 52.2-2007) and are accessible.
3. The relative humidity in the housing unit, room(s), or nonresidential building is ≤60% or meets the specific building requirements.
4. Wall penetrations to the exterior are sealed.
5. To the best extent possible, the system meets fresh-air intake requirements of *DoD Minimum Antiterrorism Standards for Buildings* (UFC October 2003, UFC 4-010-01, updated 10 October 2013).

Within 30 days of the mitigation installation, the SP system should be independently inspected to verify that it meets the design requirements and was installed properly. In addition, pressure, temperature, and humidity should be measured in the supply air and in the rooms or building to verify that the tolerances listed in the design were met.

4.2.3 Energy Recovery Ventilation (ERV) Specifications and QA

ERV is a post-entry mitigation technique that reduces the indoor radon concentration by increasing the air exchange in a family housing unit, unaccompanied housing unit, or nonresidential building or room(s). An ERV unit typically consists of two fans, one exhausting a known volume of indoor air and the second bringing in an equal volume. During operation, the two air streams (in separate compartments of the unit) pass over an inter-compartmental heat exchanger (for energy recovery) and a desiccant wheel (for humidity control). Although heat recovery is high for most units (ranging from 60 to 80%), the units are not well suited for use as dehumidifiers in climates with hot, humid summers. Consequently, as part of the mitigation design, it is necessary to evaluate the existing building mechanical system to determine if it can handle the added cooling and heating load and the increase in humidity. If that capability is in question, optional features (available on most commercial units) for conditioning the incoming outdoor air should be included.

The design specifications of all ERV systems for use within naval installation buildings must have been evaluated using either ASHRAE Standard 84-2008 (ASHRAE 2008) or AHRI Standard 1060-2005 (AHRI 2005).

The proposed ERV unit should have a rated capacity of at least 10% above the required cubic feet per minute to allow for some performance degradation between air filter change outs. Also, the supply air volume should be at least 5% greater than the exhaust volume to prevent room depressurization. In addition, on average the unit should recover at least 70% of the conditioned temperature year-round (as determined by either ASHRAE Standard 84-2008 [ASHRAE 2008] or AHRI Standard 1060-2005 [AHRI 2005]). The unit should be equipped with an insect screen and MERV 8 filters (ASHRAE 2007, 52.2-2007). In addition, unit operation should not cause room(s) or the building to exceed 60% RH or the specific building requirements for any extended period of time. In addition, to the best extent possible, the system should meet fresh-air intake requirements of *DoD Minimum Antiterrorism Standards for Buildings* (UFC October 2003, UFC 4-010-01, updated 10 October 2013).

Within 30 days of the ERV installation, the equipment should be independently inspected to verify that the system meets the proposed contract design requirements and was installed properly. In addition, temperature and humidity should be measured in the supply air and in the room(s) or building to verify that the tolerances listed in the design are met.

4.2.4 Supplemental Air Mitigation (SAM) Specifications and QA

SAM is used to correct elevated radon problems in a single, nonresidential room by providing additional forced-air ventilation (*NAVRAMP Technical Manual* Section 4.3.5). Although relatively easy to install and maintain (a typical SAM system consists of a blower, ductwork, and a switch), the technique is not widely employed because of its limited application. For example, the criteria for the room to be mitigated by SAM are that it must

- Have radon levels <20 pCi/L
- Be no larger than 3,500 ft^3
- Have an air change per hour rate of <0.2
- Be located near a large room or common area from which the desired volume of low-radon conditioned air can be withdrawn without a significant risk of depressurization

In addition to these criteria, particular attention must be paid to noise and occupant comfort. Because these systems are usually used in single or double offices, the noise generated by the discharge of the supply air may pose an inadvertent distraction to the occupant(s). Therefore, the supply diffuser, in addition to being aesthetically pleasing, must produce as little noise as possible. Another important consideration is the location of the discharge point. The discharge air velocity from a typical SAM system is comparable to that of a forced-air system. To the best extent possible, the discharge needs to be in a location that would not appreciably increase the air velocity in the primary work area.

Within 30 days of the SAM installation, the system should be independently inspected to verify that it meets the proposed contract design requirements and was installed properly.

4.2.5 Subslab Depressurization (SSD) Specifications and QA

For SSD mitigation systems, the minimum specifications are that the systems comply as applicable with

- *Radon Mitigation Standards for Schools and Large Buildings (RMS-LB-2018) REV. 12/20*
- *Radon Mitigation Standards for Multifamily Buildings*, ANSI/AARST RMS-MF-2018 REV 12/20
- *Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings*, ASTM E2121-13 (ASTM 2013)
    - *This document is referenced in UFGS-31-21-13*
- *Radon Mitigation,* UFGS-31-21-13 (UFGS 2018)

In addition, the following requirements must be met:

1. All electrical work shall meet or exceed the most current National Electrical Code and installation requirements and shall use solid 12 AWG wire.
2. The electrical circuit for the radon fan shall be clearly labeled in the breaker panel.
    a. If more than one SSD fan is present, the label must include the system number
3. All mitigation fans shall be hard-wired unless they are in an attic where corded fans (with cords shorter than 6 ft.) are allowed.
4. A wet location–rated electrical switch shall be located within 6 ft. of the fan unless it is an attic installation where corded fans are permitted.
5. All vent pipes and fittings shall be white 4 in. PVC Schedule 40.
    a. Can be either solid or foam core pipe
6. All pipe strapping will be attached to slotted, 12 Ga channel with a minimum of two fasteners per piece of channel
7. All metal components of the system (e.g., fasteners, pipe straps, channel) shall be stainless steel or be corrosion resistant.
8. All fans shall be rated for exterior use and be designated by the manufacturer for use as radon mitigation fans.
9. Every vent stack discharge shall be covered with a vent cap or critter guard
    a. Side discharge T Caps are allowed at installations where heavy rain is common
    b. Downward directed discharge is not allowed
10. Every system shall have a performance indicator located within 6 ft. of the primary slab penetration point or at the fan. Instructions regarding how to read the indicator and a contact phone number shall be posted adjacent to the indicator.
11. Where applicable, all radon fans shall be covered by a fan cover attached to a fan cover base plate.

12. All SSD systems shall be equipped with a condensation by-pass.
13. All roof mounted fans shall have a fan support stand with a bracket attached above the fan to prevent the fan boot from sagging over time. The fan support stand should be anchored to the roof.
14. On each building, all SSD systems will be assigned a unique system number (i.e. SSD System 1, SP-1, Building Number-1) and have a label affixed near the fan which contains that system number and electrical panel and breaker number.
15. Each SSD system shall be equipped with a U tube or magnehelic to monitor system performance.
    a. Audible alarms as required by current radon industry standards are optional provided periodic system performance checks are performed (Section 4.4).
16. All contractor-requested exceptions to these standards shall be submitted to the installation in writing for consideration at least 2 weeks before the mitigation installation.

Additional information on SSD components and designs has been included in the *NAVRAMP Technical Manual* Section 4.3.2).

Within 30 days of the mitigation installation project, an independent inspection should be performed on a randomly selected section of the radon system to verify that the system meets the proposed design specifications. The frequency of the random checks and the number of systems to verify are at the sole discretion of the installation. An example data form for SSD inspection has been included in the *NAVRAMP Technical Manual* Appendix B.

4.2.6 Submembrane Depressurization

For buildings with crawlspaces in which a submembrane depressurization (SMD) system has been selected as the best mitigation selection, the minimum specifications are that the systems comply as applicable with

- *Radon Mitigation Standards for Schools and Large Buildings (RMS-LB-2018) REV. 12/20*
- *Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings,* ASTM E2121-13 (ASTM 2013)
- *Radon Mitigation,* UFGS-31-21-13 (UFGS 2018)

In addition, the following requirements must be met:

1. A health and safety review shall be conducted prior to the initiation of radon mitigation to determine if confined space permits and precautions are required.
2. All large rocks, sharp objects and debris shall be removed prior to the installation of the membrane.

3. As a minimum the polyethylene or rubber membrane shall be 3 mil thick cross laminated or 6 mil thick. If durability is in question, then 45 or 60 mil EPDM rubber (a polymer composed of ethylene propylene, diene monomer) shall be used.
4. All membrane seams will be overlapped by 12 inches and be sealed with a sealant appropriate for the membrane.
5. In traffic areas the membrane shall be protected with strips of EDPM rubber.
6. The edges of the membrane shall be sealed to the wall of the crawlspace and around support columns to a height of 12 inches. The use of pressure treated boards to more permanently secure the membrane is recommended.
7. All plumbing and other penetrations through the membrane shall be sealed.
8. Geotextile matting or 4-inch minimum perforated pipe tied into the suction point shall be placed under the membrane to help extend the vacuum field.
9. The radon mitigation fan shall not be installed in the crawlspace.
10. All exhaust stacks shall be at a minimum 4 inch, SCH40, solid or foam core PVC pipe.
11. A tee or a purpose-built riser shall be installed under the membrane.
12. Warning labels shall be posted near the entrance of the crawlspace and in visible locations on the membrane. As a minimum all system lettering shall be not less than ¼ in. in height and shall be of a color in contrast to the background color to which the lettering is applied. The label shall state "Radon Reduction System Membrane Do Not Alter or Damage" and whom to contact if the membrane has been damaged.

4.2.7 Limited Access as a Mitigation Method

Under NAVRAMP, radon mitigation should only be considered within buildings, rooms, or housing units that are occupied for ≥4 h per day on average on an annual basis. Therefore, under certain circumstances, it may be advantageous to consider the relocation of the current occupants and converting the space with elevated radon levels into a limited-access area (i.e., if no one is being exposed to the elevated radon levels, there is no health risk). If selected as a mitigation option, this would defer the requirement for mitigation until such a time that normal re-occupancy of the space is required. However, mitigation must be performed prior to the building, room, or housing unit being reoccupied. For example, if a housing unit with elevated radon levels is currently vacant and demand to occupy that style unit is low, the NAVRAMP mitigation can be deferred until such time that the unit may be needed. Another example is within occupied barracks rooms in cases where the occupants could be relocated and the room(s) with elevated radon levels taken out of use. A similar rationale could also potentially be applied to other rooms in other types of buildings at the installation as well. In considering this option, the installation shall consult with a qualified Navy medical health professional to estimate the maximum duration that the room can be entered per year and by whom (i.e., limited access required for maintenance, inspection, removal of items from storage) and to also determine if signage is required. If implemented, the health professional recommendations shall be incorporated into the RMP and the installation shall verify its occupancy status every 2–3 years.

4.2.8 Mechanical Adjustments, Repairs and Modifications as a Mitigation Method

Within the Navy and Marine Corps, nonresidential HVAC units come in all shapes and sizes with practically an infinite combination of features. Therefore, it is extremely difficult to provide detailed specifications for the use of this method for radon control. Ventilation is a balance between intake, exhaust, localized distribution of the conditioned air and energy consumption. If a mechanical issue is causing elevated radon levels, it usually falls into one of the following categories: lack of fresh air, localized imbalanced supply or returns, excessive exhaust or a maintenance issue. A common misconception is that all HVAC units have a reserve capacity which can condition added fresh-air volume or that all fresh-air intakes can always be set at maximum volume. This is not true since oversized units tend to short cycle resulting in broad temperature and humidity excursions, cost more to purchase and to operate. With respect to fresh-air intake duct size there are many designs and technical reasons that it may be oversized (e.g., duct static pressure, noise reduction etc.) that may not be clearly documented in the mechanical drawings. Also, in older buildings it is not uncommon for the HVAC unit to be replaced while keeping the original fresh-air intake duct. Another consideration is the HVAC age. Like other mechanical devices, performance decreases over time. It is not unusual for a 5-year-old HVAC to have a 5% reduction in conditioning with older units significantly more. Therefore, there may be a reason why the volume of fresh-air intake has been reduced. It is important to note that ill planned adjustments made to HVAC units within the DoD and Coast Guard have resulted in mold out breaks, loss of mission critical electronic equipment, severe occupant comfort issues and significant damage to the HVAC. It is highly recommended that both an HVAC engineer and the facility HVAC shop be consulted before any actions are taken.

Another consideration is energy conservation. Over the past 20 years there has been an increase in the number of HVAC units which incorporate energy conservation features. Some of these features can enhance or decrease the radon levels during occupied periods. In certain cases, deactivating or modifying these features can mitigate the room or building but with a loss of energy savings. It is important to note that in some buildings, a private company may have installed new HVAC equipment or electronic controllers to reduce the conditioned air energy consumption. In some cases, the company is reimbursed for the installation based upon the energy savings during a fixed contract period. Deactivation or modification of the equipment would be considered a breach of contract and perhaps subject to legal action. Another complication can be the installation's energy conservation program. In the more stringent cases, command has set mandatory goals for energy reduction. Deactivation in some cases can double the heating and cooling energy consumption for a building. For these reasons, the installation energy conservation office should be consulted prior to any modifications or deactivation of energy saving features. To determine the impact of these energy saving features, hourly, short-term CRM measurements (7 to 14 days in duration are recommended) are commonly used. However, at most naval installations there are different seasonal HVAC settings which may also impact the indoor radon levels. Therefore, CRM measurements may have to be performed during different seasons to fully understand the operational impact of these energy

conservation settings. Additional information on the use and analysis of CRM data has been included in the *NAVRAMP Technical Manual* Sections 3.4.1 and 5.1.9.

In some cases, the elevated radon problem may be linked to a routine maintenance item (e.g., collapsed or blocked duct work, clogged filters), or non-functioning or missing part of the HVAC. Examples include nonfunctioning or purposely blocked fresh-air intake ducts, nonfunctioning control actuators, disabled or nonfunctioning electronic controller components. For these types of problems, the facility maintenance shop should be informed, and arrangements made for its correction. Mechanical repairs to an HVAC unit should never be performed without knowledge and consent of the installation HVAC shop.

It is not uncommon within nonresidential buildings with centralized HVAC units to find localized pressure imbalances within a building. Although restoring the buildings supply and return air to the original design specifications may mitigate a particular room or area within the building, time has shown that long-term mitigation is difficult to maintain.

Duct work location is another possible issue as well. In some buildings the supply and/or return may be under the slab, be in contact with the soil or located in a crawlspace. During HVAC operation, the return air duct will actively draw in radon soil gas. When the HVAC is off, radon soil gas will diffuse into both the supply and return ducts and enter the living space. Passive sealing of the ductwork will work provided it is fully accessible. In most cases however the duct work will need to be permanently isolated and new duct work installed in a different location. If this is required, the HVAC mechanical shop and a HVAC designer consulted prior to implementation.

For nonresidential buildings with existing fresh-air intake ducts, increasing the fresh-air volume to either dilute the radon, pressurize the building to retard its entry, or negate a negative building shell pressure are all potential options. However, as mentioned above, caution must be used not to exceed the conditioning capacity of the HVAC unit. If the unit cannot provide adequate fresh-air conditioning, then a pre-conditioner could be installed on the fresh-air make-up. For this approach, prior to attempting, consultation with the HVAC mechanical shop and an HVAC engineer is required. Temperature and humidity checks need to be performed not only after system activation but also during all seasons to ensure that acceptable indoor environment conditions are being maintained.

For nonresidential buildings under negative shell pressure, a critique of all radon exhaust systems in the building should be performed. It is not uncommon to find that the current exhaust capacity was designed for a function or mission that is no longer being performed. Known examples include but are not limited to:

- Communication and server facilities that were built prior to the introduction of solid-state electronics typically have very high exhaust volumes to control the heat generated by cathode ray and vacuum tubes.
- Older MWR facilities also had high exhaust volumes to remove cigarette smoke.
- Mess halls with non-functioning or undersized air-curtains (this would be considered a maintenance item)

- A former vehicle service bay converted into to cubicle office space

If the investigation determines that the exhaust volume is excessive, then exhaust blower downsizing, or removal should be considered. Consultation with the HVAC mechanical shop, HVAC engineer and the base safety office (if the potential of chemical exposures are involved) prior to exhaust reduction implantation is required.

It is not uncommon to determine that the existing HVAC unit cannot be modified or adjusted to condition the required air volume. In these cases, consideration may be given to the installation of an independent standalone mechanical unit to provide conditioned make-up air for either ventilation or shell pressurization (see Type 2 SP, Section 4.2.2). Other examples include installation of a dedicated outdoor air system (DOAS), or a mini-split heat pump with fresh-air makeup. Sizing and the designs of these units should only be made by a qualified HVAC engineer with installation performed by a qualified HVAC installer. In addition, the installation mechanical shop should be consulted from concept through installation.

In buildings without central ducted, forced air HVAC systems, it is typical to find mini-split or packed terminal heat pump or AC units. The key advantage of these units is that they are very energy efficient and have lower operating costs. Although some of these units are factory equipped with a fresh-air intake and a dehumidification cycle most only provide heating and/or cooling and do not perform any appreciable added dehumidification. To save manufacturing costs, typically only one chassis is built for use with many different types of compressors and other optional features. Therefore, it is not uncommon to find a fresh-air damper, or a knockout for the installation of a fresh-air makeup present in the chassis. The presence of these features should never be interpreted as meaning that the unit has the capacity to condition any volume of outdoor air. Activation of these features should never be performed unless it has been confirmed by the manufacturer that the appropriate compressor has been installed.

With respect to family housing, with the noted exception of tower and certain styles townhouse units which may have a central HVAC, each unit is typically equipped with standalone heating and/or, cooling systems or heat pumps. These systems are typically "right sized" for energy efficiency and occupant comfort. These centralized forced air units are either package or split units and typically are not equipped with fresh-air intakes. With respect to exhaust, most units only contain residential sized exhaust in the bathroom, clothes dryers and a range hood exhaust. Since these tend to be operated intermittently on a as needed basis, it is extremely rare to find a family housing unit that has a consistent negative shell pressure. Therefore, under normal circumstances, mechanical repairs, adjustments, balancing, etc. will not correct elevated radon.

Mechanical mitigation techniques are very application specific and dependent upon many variables. Therefore, the ability to provide a "one size fits all or applies" for an QA check list is impossible. However, the following summarizes the common threads present in all mitigation by building mechanical:

1. The changes would not put the building for any length of time within the range of mold growth (≥ 60% RH).
2. The resulting temperature shall be maintained within the prescribed limits established by the installation for each season or by mission requirements.
3. As a minimum all adjustments, repairs, modifications, setting changes, and alteration shall be reviewed by an HVAC engineer and approved prior to implementation.
4. Always consult the installation mechanical shop prior to any corrective action.
5. If new mechanical equipment is installed, all manuals and/or diagrams and a summary of maintenance requirement shall be provided to the HVAC maintenance shop.
6. All new fresh-air intakes must meet to the best extent possible DoD Minimum Antiterrorism Standards for Buildings (UFC October 2003, UFC 4-010-01, updated 10 October 2013).
7. Installed filters have a minimum efficiency reporting value (MERV) rating of 8 or greater (ASHRAE 2007, 52.2-2007) and are accessible for cleaning or replacement.
8. Where applicable, the installation energy office shall be consulted about any changes that impact on existing energy conservation measures prior to taking any corrective actions.
9. All standalone installation of new mechanical equipment shall only be installed by a qualified HVAC installer.

In older buildings it is not uncommon to find excessive exhaust. In most cases it is legacy of the building's prior use, ventilation requirements at the time of construction, or it was upsized when the original exhaust blower was replaced. The impact of the operation of these exhaust systems can be easily determined using CRM measurements (*NAVRAMP Technical Manual* Section 5.1.9). In cases where exhaust reduction results in radon mitigation, with concurrence of a qualified HVAC engineer, existing exhaust blowers may be removed, downsized or permanently disabled. Like mechanical repair, this type of mitigation approach has shown to be quite durable. Therefore, there is no need for periodic inspection or O&M testing, however monitoring testing of the entire building every 5-years is still recommended by EPA.

Additional technical information about radon mitigation using mechanical adjustments, modifications, repair and exhaust reduction has been provided in the *NAVRAMP Technical Manual* Section 4.3.7.

4.2.9 Radon Mitigation Contractor Qualifications

The mitigation contractor qualifications depend upon the type of radon mitigation method(s) that are going to be used. For all HVAC repairs, adjustments and installations only qualified HVAC engineers or installers should be consulted or used.

For passive and SSD mitigation, the following qualifications would apply:

For all field mitigation diagnostics and installation activities, the radon team must be under the direct supervision of an on-site field supervisor. Qualifications for the field nonresidential or residential mitigation (as applicable) supervisor follow.

- Training: Radon mitigation training accredited by NRPP, or NRSB
- Nonresidential experience: 3 years of documentable radon mitigation experience in nonresidential or other large buildings
- Residential experience: 3 years of documentable radon mitigation experience in residential buildings
- Certification: Current NRPP or NRSB mitigation certification

Personnel other than the on-site field supervisor who are involved in mitigation diagnostics or installation are called field technicians. Qualifications for the lead field technician follow.

- Training: Radon mitigation training accredited by NRPP, or NRSB
- Experience: 1 year of documentable radon mitigation experience
- Certification: Current NRPP or NRSB mitigation certification

Personnel who perform mitigation design are called radon mitigation analysts. Qualifications for the nonresidential or residential (as applicable) radon mitigation analyst follow.

- Training: Radon mitigation training accredited by NRPP, or NRSB
- Nonresidential experience: 5 years of documentable radon mitigation experience in nonresidential or other large buildings
- Residential experience: 5 years of documentable radon mitigation experience in residential buildings
- Certification: Current NRPP or NRSB mitigation certification

However, for all mechanical adjustments, repairs, replacements, SAM, ERV, SP or other mechanical mitigation approaches shall be designed and installed by a licensed mechanical contractor acting independently or under subcontract with the primary mitigation contractor.

4.2.9.1 Considerations in Performing Radon Mitigation In-House

Under EPA guidelines for implementation of the IRAA, government employees and military personnel may perform radon mitigation designs and mitigation at their facilities without accreditation although accredited mitigation training is recommended. Under NAVRAMP, it is left up to the installation to determine what if any radon mitigation training is required to perform the radon mitigation designs or mitigation at their installation. However, mitigation training is highly recommended for personnel whom are involved in the design or oversight of in-house radon mitigation projects. It is important to note that the accredited mitigation training being offered under the auspices of NRPP-

or NRSB is initially biased towards residential SSD mitigation. Nonresidential mitigation is a separate course whose prerequisite is the residential mitigation training class. Although uncertified government employees and military personnel may perform radon mitigation, design and installation, contractors [e.g., Base Operations Support (BOS), Indefinite Delivery/Indefinite Quantity (IDIQ) or similar] or their subcontractors must meet all the mitigation contractor requirements listed above. However, allowable certification exceptions for the BOS or IDIQ contractor would apply for items that are included in the maintenance contract: e.g., mechanical repair, adjustments or maintenance, exhaust downsizing, HVAC replacement.

Another consideration is access to tools and instrumentation. Assuming that the construction skill set is available at the installation, SSD system installs require access to tools that can core either a 5 or 6 in. hole in concrete. Additional power tools are also needed to install the fasteners for pipe strapping and cutting the PVC pipe. For mitigation using and existing HVAC, probes that measure air velocity (hot wire or anemometer probes) and building pressure (micromanometer) are essential. These tools and instruments are typically not found at most naval installations.

4.2.10 Mitigation Contractor Health and Safety Plan

Before any mitigation project begins, the contractor shall prepare a project HASP. At a minimum, the plan shall list the expected potential hazards to the mitigation personnel, workers, and building occupants and the measures to control the hazards. At a minimum, the plan shall list the expected potential hazards to the mitigation personnel, workers, and building occupants and the measures to control the hazards. The HASP should address hazards as shown in the sample HASP checklist for other clean-up projects, available at https://www.med.navy.mil/Portals/62/Documents/NMFA/NMCPHC/root/Environmental%20Programs/Pages/healthsafety/SSHP-Checklist-Oct-2020.pdf

4.2.11 Radon Mitigation Reporting Requirements

For all radon mitigation system installations, the following information must be provided:

1. Navy Contract Number
2. Building number or address
3. General building information (e.g., size, number of stories, year built, type of construction for interior and exterior walls, slab thickness, type and depth of aggregate under the floor, type of roof and composition, etc.)
4. Testing summary and a floor plan with the rooms with elevated radon levels clearly identified.
5. Mitigation diagnostic findings (if applicable)
6. Type of installed mitigation system (e.g., SSD, SP, ERV)
7. Any design assumptions made (e.g., HVAC must operate at current settings)

8. System description (e.g., Type 1 SSD on the exterior of Room 101) with all main components specifications (e.g., mitigation fan or ERV make and model)
9. Owner's manuals and warranty information (if applicable)
10. Location of all radon mitigation system including an eye perfect floor plan with the system(s) locations.
11. Rooms or areas that each system mitigates
12. Mitigation system photos (before and after installation)
13. Electrical panel and breaker number for each mitigation system
14. Pre and Post radon mitigation results including spike and blank results if applicable
15. Installer's name and NRPP or NRSB certification number
16. Installation date (month/year)
17. All maintenance requirements (e.g., changing filters, rebalancing the system)
18. Any know system limitations (e.g., SSD system will not control radon levels if the building drops below -8 Pa)

4.3 RADON-RESISTANT NEW CONSTRUCTION REQUIREMENTS

As was discussed in Section 2.3, RRNC is required for all new construction at RPC 1 installations or sites and within the construction of new, long-term lease buildings (e.g., leases, limited partnerships, and international use agreements; see Section 2.8) in which the Navy/Marine Corps will be responsible for NAVRAMP implementation. Regardless of the RPC, RRNC is also required in all newly constructed or renovated buildings with a SCIF. It is important to note that in 2012, EPA initiated a voluntary consensus-based standards initiative with the radon industry (https://www.epa.gov/radon/radon-standards-practice). The subsequent standards produced by this partnership have superseded and consequently replaced the previous EPA standards and guidance documents. Therefore, for RRNC standards references please consult the list in Table 10. These standards can be viewed or purchased on-line at https://standards.aarst.org/ .

It is important to note that the incorporation of RRNC features into a building's construction does not mean that the building is "Radon Proof". Buildings equipped with RRNC features still must be tested as required along with other buildings which do not have RRNC. The objective of this section is to provide general guidance which will make future mitigation projects less expensive, more predictable with an enhanced probability of success.

4.3.1 RRNC Basic Design Features

As a minimum NAVRAMP requires that the following design features be incorporated into all RRNC designs:

1. Stone aggregate shall be not less than 4 in. in depth (6 to 8 in. is preferred) and meets ASTM C33 requirements for size numbers 5, 6, 56, or 57.
    - For best results use stone aggregate with a high percentage of ¾ in. stone with < 5% fines.
    - If possible, the aggregate bed under the slab shall not be compacted.

- If stone aggregate is not available, sand and the use of geotextile matting may be substituted (see *NAVRAMP Technical Manual* Section 7.3 for design details).
    - The stone or sand layer shall be covered by a minimum 6 mil or 3-mil cross-laminated vapor barrier with seams overlapped by 12 in.
        - The intent of the vapor barrier is to prevent the concrete from infiltrating the gas permeable layer.

2. One riser should be installed for every 4,500 ft^2 of slab area for a 4 in. riser and 10,000 ft^2 of slab area for a 6 in. riser.
    - All risers shall be solid or foam core SCH 40 PVC.
3. The system performance indicator shall be in an accessible and visible location and provide the vacuum in either inches of water column (WC) or Pascals (Pa).
    - Audible alarms for SSD system failure are not required under NAVRAMP (see *NAVRAMP Technical Manual* Section 4.3.2).

Table 10. RRNC current standards

Standard Name	Standard Number	Applicability
Rough-In of Radon Control Components in New Construction Of 1 & 2 Family Dwellings and Townhouses	ANSI/AARST RRNC-2020	Provides minimum requirements for the rough-in of radon control system components in new dwelling units under construction.
Reducing Radon in New Construction of 1 & 2 Family Dwellings And Townhouses	ANSI/AARST CCAH-2020	Provides minimum requirements for the rough-in of radon control system components in new dwelling units under construction.
Soil Gas Control Systems in New Construction of Buildings	ANSI/AARST CC-1000-2018	Provides minimum requirements for the construction of any building intended for human occupancy, except for 1 and 2 family dwellings. It provides general guidance for reducing soil gas entry into existing homes in order to mitigate occupant exposures to certain hazardous soil gases, including radon gas, chemical vapors and other hazardous gases.

4. To allow for easy access for fan installation and future maintenance, provisions for 3-4 ft clearance must be made for fan mountings in attic locations.
5. The electrical outlet, junction or switch box for the radon fan should be located within 6 ft. of the proposed mitigation fan location.
6. All electrical circuit breakers associated with the RRNC shall be labeled Radon System and contain the system number if applicable.
7. All floor penetrations and gaps shall be sealed in accordance with Unified Facilities Criteria (UFC) 3-490-04A (UFC May 2003) or consistent with the standards listed in Table 10.
8. Unless capped, all venting of the radon pipe shall be outdoors (i.e., not left open in the building or attic), at least 10 ft above grade, 1 ft above the roof, and at least 4 ft above structural openings, and no less than 10 ft from other horizontal openings.
    - All open vent pipes shall be equipped with a rodent/insect screen not smaller than ½ in. mesh.
9. RRNC design plans (Section 4.3.6) must contain as a minimum the specifications for all parts required for activation (e.g., radon fan, and performance indicator type) and the proposed location of the radon fan and performance indicator.

Under NAVRAMP, the installation has the option to choose a mitigation ready or a mitigation rough-in RRNC system. A mitigation ready system only requires the installation of a radon fan and a performance indicator for activation whereas the mitigation rough-in system may require (in addition to the fan and performance indicator) the installation of additional pipe and a roof penetration (if applicable). If the design criteria listed above is met, both options will have a high probability of success if activation is required. Furthermore, it is not a requirement under NAVRAMP for all RRNC system designs to be an active passive stack (see *NAVRAMP Technical Manual* Chapter 7) upon completion as required in the historical and current RRNC standards. To the best extent possible, the standards listed in Table 10 shall be followed for the design of all RRNC systems in the Navy and Marine Corps. Noted design exceptions and rationale to these standards follow.

4.3.2 RRNC Vent Piping Routing Considerations

Under NAVRAMP it is not required to route the vent pipe through the interior of living space to an egress on the roof. Whereas it is acknowledged that passive stack venting of radon soil gas does reduce the indoor radon levels, the need to activate systems and maintain them in the future is also a consideration. Most interior vent pipe runs require the fan to be mounted in an attic or on the roof (radon fans cannot be mounted in or below occupied spaces). Therefore, attic or roof access is required to install the fan and to perform system inspections and future fan replacements. To perform these tasks ladders or a high lift will be required and depending on the circumstances, a fall protection plan. On the other hand, if the vent pipe is mounted on the exterior of the building the fan can be mounted at waist height (35 to 45 in. above grade) negating the need for ladders or a high lift for fan installation and replacement. In addition, all roof penetrations have the potential

to leak. Exterior pipe runs do not need to penetrate the roof thus eliminating the potential for water leaks in the future if system activation is never required.

If the interior or exterior vent pipe is routed from under the floor or from the soil gas collection plenum to above the roofline (see Item 8 in Section 4.3.1) it is considered a mitigation ready design. However, if the pipe does not extend above the roofline and is capped, it would be considered a mitigation rough-in design. It is important to note that in all mitigation rough-in designs the vent pipe must be capped and exposed (e.g., not buried below grade or under the slab) and of sufficient length (minimum of 4 in.) to allow for the installation of additional pipe if activation is required.

4.3.3 Vent Pipe Specification

All vent pipe shall be either solid or foam core 4 or 6 in. SCH 40 PVC pipe (see ASTM D4396 – 15 and shall comply with ASTM D2665, F891, or F1488. All fittings used in the vent pipe shall be SCH 40 PVC and compatible with the pipe. The joint surfaces for PVC plastic pipe and fittings are to be solvent welded (ASTM D 2564) and prepared with a primer (ASTM F 656).

4.3.4 Soil Gas Collection Plenum Specification

The soil gas collection plenum pipe shall be either 4 or 6 in. of either corrugated, perforated polypropylene or perforated SCH 20 or 40 PVC. The piping shall be placed in a trench that is a minimum of 8 in. wider and 4 in. deeper than the outer diameter of the pipe. The pipe shall be backfilled and covered with clean aggregate (See Item 1 Section 4.3.1). All fittings and connections made to the pipe shall be compatible with the piping material. Sand or soil should never be used as backfill material.

4.3.5 Slab Sealing Specifications

All gaps/joints and all floor slab penetrations must be sealed to prevent air leakage into the building (Table 10, ASTM E1465-08a [ASTM 2008, withdrawn in 2017], or UFC 3-490-04A, inactive with no replacement [UFC May 2003]). Gaps can be filled with polyethylene backer rod or comparable filler material as required and sealed with polyurethane caulk or other types of elastomeric sealant. Caulks and sealants shall be applied according to the manufacturer's instructions. All penetrations into the building exterior should be inspected to ensure they are watertight.

4.3.6 Design Specification for Radon Fan Assembly

For all mitigation-ready and mitigation rough-in installations, designs and specifications shall be provided for the installation of the radon fan in the As Built drawings. In addition, the proposed fan shall be installed in a vertical section of the vent stack pipe and in a vertical orientation to prevent condensed water and precipitation from accumulating in the fan. As a minimum, the design shall contain:

- The proposed fan location and type of fan
- The proposed electrical hook-up and wiring specification including breaker and panel number
- The location and type of the system performance indicator
- Any additional hardware needed for fan activation

4.3.7 Labeling of System

System components shall be labeled as specified in ANSI/AARST CCAH 2020 and ANSI/AARST RRNC-2020 for all passive stack and mitigation-ready options. This would include but not be limited to labels that identify the vent piping as part of a radon reduction system in visible, inside walls and attics. As a minimum all system lettering shall be not less than ¼ in. in height and shall be of a color in contrast to the background color to which the lettering is applied. The label shall state "Radon Reduction System" and if applicable a unique system identification number. Optional information may include the installers name and certification number, date installed and the contract number. At the proposed fan location, a label shall state "Location of Radon Fan" along with the system number, electrical panel and circuit number. In the electrical panel, the circuit breaker shall be labeled Radon Fan and shall include the system number.

In addition, a label or placard stating the building contains an RRNC system shall be permanently placed in a visible, eye level location in the mechanical room. If the building does not have a mechanical room, it can be placed in a janitor closet, electrical or communication closet, or a bathroom. As a minimum the label shall be at least 4 in. height and width and shall have a color in contrast to the background color to which the lettering is applied. The label shall state "RRNC System Information", which method for RRNC was used (see Section 4.3.1) and the location of the riser and/or stub outs and include recommended mitigation fans for each system if activation is required.

4.3.8 RRNC Performance Verification

After the concrete floor has been poured and adequate time allowed for curing, it is recommended that a performance check be performed on the vent pipe network to confirm that the expected coverage with the proposed fan was met. Briefly to perform the test, the proposed mitigation fan is temporarily installed on the riser, activated (not hard wired) and the resultant vacuum measured at the most distance points of the subslab vent pipe grid. These test holes must be uniquely numbered and identified on an eye-perfect or to scale floor or foundation plan. The differential pressure for each test hole (typically 3/8 in.) is then recorded on a data form or on the building floor or foundation plan. The minimum acceptable vacuum would be -2 Pa or -0.008 WC. In cases where the minimum is not met, a higher flow or suction fan should be tried and the vacuum remeasured. If the minimum vacuum cannot be established, then additional test holes will be required to locate the -2 Pa or -0.008 WC contour. The graphic contour on a floor or foundation plan or the distance of the radius of influence from the suction point shall then be provided in the As Built drawings (Section 4.3.12). Additional information on this procedure has been included in the *NAVRAMP Technical Manual* Section 7.3.9.

4.3.9 Radon Testing within an RRNC Building

Upon building completion or within 5 years of occupancy, an initial radon gas test shall be performed as specified in accordance with the NAVRAMP testing protocol for new construction. However, because of potential time and contractual issues, radon testing may have to be performed just prior to building acceptance. In this case, it is required that all the building mechanicals must be fully operational and configured as per design specifications for the duration of the test. Because of the potential time restraints, short-term testing using the NAVRAMP testing protocol would be permissible.

4.3.9.1 RRNC System Activation Prior to Occupancy

If radon testing finds rooms within the building ≥4.0 pCi/L, then the mitigation fan and any remaining vent pipe should be installed per design and activated by a certified radon mitigator. Upon completion of fan installation and activation, postmitigation testing (Section 3.2.9.4) shall be performed no sooner than 24 h after fan activation to ensure that radon levels in occupiable spaces are <4.0 pCi/L. All short-term testing shall be performed under closed-building conditions (Section 3.2.1). In addition, all mechanical equipment that will be operating during normal human occupancy (normally, exhaust blowers and central heating and air-conditioning system operating in a typical fashion) should be operating at least 24 h before an initial radon test is conducted. If an elevated radon level is still present, the contract officer or COR should be consulted for further instruction.

4.3.10 RRNC Inspection Requirements

Prior to the soil gas collection plenum being backfilled, the piping should be inspected and corrected for any defects. Prior to the slab being poured all connections from the soil gas collection plenum to the riser shall be inspected and corrected for any defects.

There are no requirements to perform periodic inspections on RRNC system after construction has been completed. However, if the system is activated, it becomes an SSD system and thus needs to have periodic performance and detailed inspections performed (See Section 4.4). It is important to note that within buildings with multiple risers, only those that are activated require inspection.

4.3.11 Radon-Resistant New Construction Designer Contractor Qualifications

For all RRNC designs, the designer shall have as a minimum:

- Training: Radon mitigation training certified by NRPP, or NRSB
- Experience: 5 years of documentable radon mitigation and RRNC experience
- Certification: Current NRPP or NRSB certification

Personnel responsible for the installation, oversight, or activation of the RRNC system shall have as a minimum:

- Training: Radon mitigation training certified by NRPP, or NRSB
- Experience: 1 year of documentable radon mitigation experience
- Certification: Current NRPP or NRSB certification

4.3.12 RRNC Installation Reporting Requirements

All final RRNC designs and specifications shall be documented on separate, dedicated sheets in the final As Built building drawings. As a minimum it shall contain:

- To scale drawings of
  - Soil gas collection plenum
    - If more than one vent pipe riser is present, they shall each be assigned an easy-to-follow identifier (e.g., Riser 1, Riser 2 etc.)
  - Cross section of the soil gas collection plenum trench
  - Cross section of the soil gas collection plenum and radon vent pipe (i.e., suction pit details)
  - Plumbing plan for the vent pipe riser from the suction point to the exhaust location including proposed fan location and electrical service
  - If applicable, roof flashing details for the vent pipe
- In the notes section the following shall be documented:
  - Declaration if the installed RRNC system is a mitigation ready or a mitigation rough-in installation
  - Specifications for all parts used in the RRNC system if not documented in the drawing including trench backfill and the gas permeable layer aggregate
  - A list and specifications for all parts required to activate the radon mitigation system
  - The electrical panel and breaker number for each proposed fan
  - Section callouts for all slab sealing
  - If applicable the findings of the RRNC performance check (Section 4.3.8)
  - Name of designer and certification number

4.4 O&M OF RADON MITIGATION SYSTEMS

It is a well-established fact that all passive and active radon mitigation systems will eventually fail (e.g., sealant will crack, SSD fans burn out, filters become clogged, drive belts break etc..). To ensure continued mitigation, EPA (EPA 402-R-93-078 [EPA 1994b]) and NAVRAMP recommends that required maintenance, periodic inspections and retesting be performed. However, studies have shown that the specific maintenance requirements and frequency of periodic inspections vary by mitigation type. For example, an SSD mitigation system requires only periodic inspections to ensure that the fan is still operating while SP mitigation systems sometimes require monthly filter cleaning and periodic building shell pressure checks. With respect to active mitigation durability, SSD mitigation has proven to be the most durable (some Navy SSD systems are > 30 years old)

followed by SAM, and ERV. The least durable of all mitigation methods is mechanical adjustments/modifications (Section 4.2.8) where < 50% of the buildings are still mitigated after 5-years (see *NAVRAMP Technical Manual* Section 4.3.7 for additional details). However, it is important to note that the success rate of mechanical repair was > 90% over the same time period.

For SP, SAM, ERV and standalone mechanical mitigation, the key to long-term mitigation is performing the manufacturer and installers prescribed maintenance. However, these requirements will vary by manufacturer and installer. Therefore, for these types of mitigation systems a detailed maintenance section containing plans and specifications, operation manuals, diagrams and required maintenance items shall be provided by the installer for future reference and application.

The following lists the minimum O&M requirements for each type of mitigation system:

- Passive mitigation (caulking, sealing)
    - Perform visual inspection every 2-3 years
        - Repair or replace caulk or sealant as needed
    - Retest building every 5-years per EPA recommendations
- SSD mitigation
    - Perform fan performance check twice per year
        - Replace fan as required
            - Retest mitigated room(s) or areas if a fan with a different performance specification is installed or if the system vacuum has dropped by more than 50% from the installation value
    - Perform detail system inspections check every 2-3 years (see *NAVRAMP Technical Manual* Section 6.2 for details*)*
        - In nonresidential buildings check the building shell pressure
            - If shell pressure has dropped 4 Pa or more since the SSD installation or the last radon test, retest the building
        - Retest the mitigated room(s) or area if the system vacuum has dropped more than 50% from the install value
    - Retest building every 5-years per EPA recommendations
- SAM mitigation
    - Clean or replace intake and exhaust filters as recommended by the mitigation installer
    - Perform fan performance check twice per year
        - Replace blower as required
            - Retest mitigated room(s) or areas if a different fan model is installed or if the capacity of the replacement blower is 10% or lower than the installed blower
    - Perform detail system inspections check every 2-3 years (see *NAVRAMP Technical Manual* Section 6.6 for details)
    - Retest building every 5-years per EPA recommendations

- SP mitigation
    - Clean or replace intake and exhaust filters as recommended by the mitigation installer
    - Perform shell pressure, indoor temperature and humidity check twice per year
        - If required, adjust shell pressure to 4 to 6 Pa or per installer instruction
    - Retest building every 5-years per EPA recommendations
- ERV mitigation
    - Clean or replace intake and exhaust filters and lubrication as recommended by the mitigation installer
    - Perform indoor temperature and humidity check twice per year
        - Check drive belt or drive chain as applicable
        - Adjust intake and exhaust flows as needed to maintain system balance
    - Perform detail system inspection check every 2-3 years (see *NAVRAMP Technical Manual* Section 6.5 for details)
    - Retest building every 5-years per EPA recommendations
- Mechanical adjustments, balance and modification
    - Twice per year verify that no adjustments or tampering has occurred and perform indoor temperature and humidity test and building shell pressure, fresh-air make-up volume if applicable
    - Perform retest of mitigated rooms every 2-3 years
- Mechanical repair, maintenance and permanent exhaust reduction
    - Retest building every 5-years per EPA recommendations
- Standalone mechanical system
    - Twice per year verify that no adjustments or tampering has occurred and perform indoor temperature and humidity test and building shell pressure if applicable
    - Clean or replace intake and exhaust filters as recommended by the mitigation installer
    - Retest building every 5-years per EPA recommendations
- Energy Set Back
    - Twice per year verify that no adjustments have been made to the HVAC controller which would increase the duration of the energy set back.
    - Perform a CRM measurement of 7-to-14-day duration every 2-3 years within the mitigated room or rooms
        - If HVAC settings are seasonal, repeat CRM measurements in applicable seasons.
    - Retest building every 5-years per EPA recommendations
        - Perform a CRM measurement of 7-to-14-day duration within the mitigated room or rooms

Specific details and additional information on O&M inspections of mitigation systems have been included in the *NAVRAMP Technical Manual* Chapter 6.

4.4.1 Qualifications of O&M Contractor

4.4.1.1 Contractor Qualifications for O&M Testing

For all field placement and retrieval activities, the radon team must be under the supervision of an on-site field supervisor. Qualifications of the field supervisor follow.

- Training: Radon testing training certified by NRPP, or NRSB
- Experience: 3 years of documentable radon testing experience
- Certification: Current NRPP or NRSB measurement certification

Personnel other than the on-site field supervisor who are placing and retrieving radon detectors are called field technicians. Qualifications for the field technician follow.

- Training: Radon testing training certified by NRPP, or NRSB
- Experience: 1 year of documentable radon testing experience
- Certification: Current NRPP or NRSB measurement certification

Personnel who perform data analysis, validation, and certification of the radon testing results are called radon testing analysts. Qualifications for the radon testing analyst follow.

- Training: Radon testing training certified by NRPP, or NRSB
- Experience: 5 years of documentable radon testing experience
- Certification: Current NRPP or NRSB measurement certification

4.4.1.2 Contractor Qualifications for O&M Mitigation System Inspection

For all O&M mitigation system inspection activities, the radon team must be under the direct supervision of an on-site field supervisor. Qualifications of the field supervisor follow.

- Training: Radon mitigation training certified by NRPP, or NRSB
- Experience: 5 years of documentable radon mitigation experience
- Certification: Current NRPP or NRSB mitigation certification

Personnel other than the on-site field supervisor who are involved in mitigation diagnostics or installation are called field technicians. Qualifications for the field technician follow.

- Training: Radon mitigation training certified by NRPP, or NRSB
- Experience: 1 year of documentable radon mitigation experience
- Certification: Current NRPP or NRSB mitigation certification

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DEFINITIONS AND TERMS

Abnormal weather: Any type of severe weather (e.g., high wind, heavy rain or snow) that would be considered out of the ordinary while performing a short-term radon test. For long-term tests, examples of severe weather would be hurricanes, tropical cyclones, tropical storms and typhoons.

Assessment: The testing of all testable rooms or family housing units at an installation or site for radon.

Atypical building: A building with unique construction that is different from all other buildings at the installation or site (e.g., underground command bunker).

Barracks: Unaccompanied housing facilities used to house permanent party (sea and shore duty) and mission-essential personnel.

Becquerel per cubic meter (Bq/m^3): The international unit of radon measure. 1 pCi/L = 37 Bq/m^3. See picocuries per liter (pCi/L) definition below.

Blank: A radon detector that is anonymously returned to the laboratory unexposed in order to measure the background of the device as part of NAVRAMP QA/QC.

Building: A structure with a roof and walls, such as a house, dependent school, barrack, aircraft hangar, administration building, armory, warehouse, and so on.

Collocated: Radon test devices are placed within 12 in. of each other during a simultaneous measurement.

Catastrophic Testing Event: Any event that occurred during the test period which would invalidate the measurement. Examples would include lost, damaged or tampered detectors, detectors relocated into another room or building. See Table 5 for a complete list.

Confirmation test: A short-term radon test used to determine if radon levels within a specific housing unit, or building room or location are ≥ 4pCi/L. If the confirmation test fails to confirm the result a follow-up test is required.

Competent Person: A competent person is someone who has acquired through training or experience the knowledge and skills of relevant radon testing, mitigation design, mitigation or radon resistant new construction design and has the appropriate NRSB/NRPP certifications.

Closed-building conditions: During the radon test, the building's windows and exterior doors (e.g., doors leading to the outdoors) are closed except for routine entrances and exits. For short-term tests of <4 days, closed-building conditions must be initiated at least 12 h

prior to the placement of the detectors and maintained for the duration of the test period. For short-term radon tests between 4 and < 90 days initiating closed-building conditions 12 h prior to detector placement is not required but should be maintained for the duration of the test. For test ≥ 90 days to < 1 year, maintaining closed-building conditions is not required but recommended.

Dependent Schools: Nursery schools, kindergartens, primary and secondary schools, for dependent children. Not included are colleges, universities or other instructional facilities for adults.

Dormitories: Unaccompanied housing facilities used to house military students or transient personnel (married or unmarried, enlisted or officer).

Duplicate: Radon measurements that are performed using two radon testing devices at the same time as part of NAVRAMP QA/QC.

Energy setbacks: Any reduction of HVAC fresh air intake or operational settings to reduce energy consumption during unoccupied periods (e.g., evenings, weekends and holidays).

Exterior wall: A wall with one face on the outside of the building.

Family Housing: Housing facilities for members of the Military Services, DoD civilians or DoD-sponsored civilians and dependents that the Navy or Marine Corps owns, leases, obtains by permit, or otherwise acquires. This is also referred to as "government-controlled family housing." This definition does not apply to privatized housing (see definition below).

Follow-up testing: Measurements performed with the same device, at the same location, under similar testing conditions, and if applicable, identical HVAC settings.

HVAC adjustment: Any **c**hanges made to the exhaust, supply, return air or fresh-air makeup volumes which would affect the buildings ventilation air exchange rate or envelope pressure.

High-rise housing building: A family or unaccompanied housing building that is ten or more stories tall as measured above ground from the main building entrance.

Interior wall: A wall having two interior faces.

Karst: Landscape underlain by limestone that has been eroded by dissolution, producing ridges, towers, fissures, sinkholes, and other characteristic landforms.

Laboratory blank: Randomly selected unsealed radon detectors which are stored in a low radon environment for the duration of the survey. At the conclusion of the detector retrieval, they are opened and returned anonymously with the field detectors.

Low-rise housing building: A family or unaccompanied housing building that is less than three stories tall as measured above ground from the main building entrance.

Mechanical adjustment: Any changes made to the HVAC exhaust, supply, return air or fresh-air makeup volumes which would affect the buildings ventilation air exchange rate or envelope pressure.

Mechanical repair: The replacement of a maintenance item or an existing non-functioning part on an HVAC.

Mid-rise housing building: A family or unaccompanied housing building that is less than ten stories tall as measured above ground from the main building entrance.

Mitigation: The corrective action taken in buildings or rooms that have been found to have radon levels ≥4 pCi/L.

Mitigation system: Any system or steps designed to reduce radon concentrations in the indoor air of a building.

Monitoring: Ongoing radon testing performed at an installation or site with known radon potential (low or elevated) which will alert the installation to any future elevated radon problems.

Nonresidential building: Any testable building that is not built to family housing or "residential" construction standards. For the purposes of NAVRAMP and this document, other types of transient, short-term, and long-term residential buildings—such as barracks, dormitories, Navy/Marine Corps lodges, NGIS buildings, and transient quarters—are included in this definition.

Normal building testing conditions: The building is occupied, and the building's mechanical systems (e.g., heating and cooling systems) are operating under typical seasonal conditions.

Occupied: A room or building in which one or more people spend >4 h/day on average or ≥ 1000 hours per year.

Occupiable: A room not currently occupied but that could be occupied easily. Examples are bachelor quarter rooms, vacant offices, or offices currently used as storage rooms that could easily be converted to office space.

One-year test: Under NAVRAMP, any radon test between 335- and 395-days duration is considered a 1-year test.

Picocuries per liter (pCi/L): A common unit of measurement of the concentration of radioactivity in a fluid (liquid or gas). A picocurie per liter corresponds to 0.037 radioactive disintegrations per second in every liter of fluid. For radon testing purposes,

pCi/L is the unit of measure of radon gas. EPA and NAVRAMP have set an action level of 4 pCi/L.

Picocuries per liter per day (pCi/L-day): A measure of the detector dose; 1 pCi/L-day is the dose a detector receives if it is exposed to 1 pCi/L for 1 day.

Privatized Housing: Military family and unaccompanied housing that was acquired or constructed by an eligible entity pursuant to the Military Housing Privatization Initiative (MHPI) legislation (10 USC 2871-2884).

Radon: A colorless, odorless, radioactive gas formed by the decay of uranium. It exists in varying amounts in all soils, rocks, and some groundwater supplies worldwide. Under certain conditions, it can infiltrate into and concentrate to unacceptable levels in buildings.

Radon potential category (RPC): A dynamic category assigned by COMNAVFACENGCOM, based on historical radon testing data to a naval installation or site which designates its potential for having elevated radon levels. The designations are:

RPC 1: One or more valid, confirmed radon results ≥4 pCi/L in family or unaccompanied housing or a nonresidential room was present at the installation.
RPC 2: Based on past and present radon policies, insufficient data exists to project the current radon potential for family and unaccompanied housing and nonresidential buildings at the installation (this would also include lodges, and transient quarters).
RPC 3: Sufficient radon data (including family and unaccompanied housing data) exist to conclude that the installation has a low radon potential.

An installation may change the initially assigned RPC for good reason.

Radon progeny: Radon radioactive decay products that can be breathed into the lungs, where they continue to release radiation as they further decay. Also known as radon decay products or radon daughters.

Representative short-term radon measurement: A short-term radon measurement performed during closed-building conditions; normal HVAC system operation; and typical seasonal weather patterns.

Residential building: Simply put, any structure built to family housing or "residential" construction standards. For the purposes of NAVRAMP and this document, this includes family housing buildings that have been converted to barracks, NGIS, or administrative use.

Retest measurement: A radon measurement performed within housing units, buildings rooms or location in which the previous test was lost or determined to be invalid.

Room of interest: A room with valid test data that indicates the presence of elevated radon levels.

Screening: Radon testing in a representative statistical subset of testable rooms at a site or installation.

Significantly modified or significant modification: A building occupied or to be occupied, altered, or renovated either by changing mechanical systems (e.g., HVAC) or by making modifications (e.g., changing the original number or type of windows, doors, ground slabs, walls) in any manner that significantly changes the air change or flow into and within the building.

Site: The subdivision of an installation into smaller geographical areas based on geology, building types, or remoteness.

Spike: A radon detector exposed at a laboratory to a known radon concentration as part of NAVRAMP QA/QC. When used in conjunction with field testing, spikes measure the accuracy of the survey radon results.

Testable building: A building that is enclosed, occupied/occupiable, in ground contact and not proposed for demolition within the next 2 calendar years.

Testable family housing unit: A family housing unit that is occupied or occupiable and is in ground contact. This also includes family housing units that have been converted to other uses, such as unaccompanied housing, lodges, or other nonresidential uses.

Testable room: An occupied or easily occupiable room in a testable building either in ground contact or over an unoccupied ground contact basement room or crawlspace.

Test type code: A two-letter code assigned to a specific radon measurement to document the reason why the radon test was performed (example: PM = postmitigation).

Tier 1 building: All testable family and unaccompanied housing units, medical treatment facilities (e.g., hospitals, medical and dental clinic), youth centers, dependent schools, child-care centers, and brigs.

Tier 2 buildings: Includes all 24 h manned facilities, such as but not limited to command and communication facilities, fire stations, lodges, and security buildings.

Tier 3 buildings: Includes all offices and administrative buildings, exchanges, commissary, shops, hangars, recreational facilities (i.e., fitness centers, theaters), warehouses, colleges, universities or other instructional facilities for adults, armories, occupied magazines and other work areas.

Tier 4 buildings: Includes buildings which meet the minimum NAVRAMP occupancy requirement of >4 h/day or ≥ 1000 h/year but are not continuously staffed. Examples would

include communication or radar equipment buildings, range offices, fuel transfer buildings, engine test facilities, security shacks, generator buildings, and water treatment facilities.

Travel blank: An unexposed radon detector which travels with the field detectors to and from the site during placement and retrieval. These detectors should remain sealed until they are returned anonymously to the laboratory with the field detectors for analysis. During the field exposure period these detectors should be stored in a low radon environment.

Unaccompanied Housing: Housing facilities for recruits, student, permanent party, and mission-essential unaccompanied personnel, both enlisted and officer.

Unaccompanied housing building: Consists of both residential (converted use family housing units) and buildings built to a commercial principle (i.e.., traditional style barracks). Under NAVRAMP testing guidelines, unaccompanied housing buildings which were constructed using a residential principle (i.e., converted use family housing units) are tested using the NAVRAMP family housing testing protocol (i.e., one testing location per unit). For unaccompanied housing buildings constructed using the commercial principle, the nonresidential testing protocol shall be applied (i.e., the sampling of all testable rooms within the building).

Unaccompanied Housing Unit: An assignable living unit, or apartment, which may be composed of one or more bedrooms, living area, personal storage closets, bathroom(s), and food preparation area. These units can reside in former, converted use family housing units or within nonresidential buildings built to a commercial principle.

Valid radon test or result: A radon test that meets the requirements of NAVRAMP (e.g., type of radon detection device; sampling strategies, procedures, and intervals; QA and QC).

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APPENDIX A: NAVY'S DATA COLLECTION-REPORTING TEMPLATE FOR NONRESIDENTIAL BUILDING

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NAVRAMP Test Data Templates
revised July 2016

Per OPNAVINST 5090 Chapter 25 TSCA, complete templates (1) Project Info, (2) Radon Data and (3) QC (Quality Control) for each radon testing event/project. Email templates to NAVFAC EXWC for inclusion in the Navy Radon Database: genevieve.fanning@navy.mil , 805-982-4855

1. Installation UIC: ?

2. Installation Name: ?

3. Does data include test results for any Site(s) other than "MAIN INSTALLATION" ? (Y/N) ?

Note: For long-term radon program management, it may be advantageous to split an installation or large command into smaller Sites. This management approach is described in Section 2.4.1 of *Navy Radon Assessment and Mitigation Program (NAVRAMP) Guidebook for Naval Shore Installations,* NAVFAC, June 2015. The key advantage of this approach is to ensure buildings at sites with the greatest risk from radon receive the required attention, while those with low potential would not be tested or retested unnecessarily. For example, radon potenial may vary due to differing geology at an annex or detachment, compare with that of the main installation, and it is therefore appropriate to manage the site on its own timeline.

4. Radon Potential Code (RPC) prior to radon sampling project?

Site Name: MAIN INSTALLATION RPC: ?

Second Site Name: [enter "none" if no second site] RPC: ?

Definition (NAVRAMP Guidebook):

RPC 1: installations or sites with known elevated radon potential (e.g., elevated radon has been confirmed in one or more rooms)

RPC 2: installations or sites with unknown radon potential

RPC 3: installations or sites with sufficient screening data that indicate low radon potential

5. RPC as a result of sampling?

Note: An RPC will change at Main Installations or Sites with RPC=2, Assessment phase, to thereby indicate RPC 1 or 3, Monitoring phase, and/or further action.

Site Name: MAIN INSTALLATION RPC: ?

Second Site Name: [enter none if no second site] RPC: ?

6. FEC or Region Point of Contact: [name]

POC E-Mail: [email]

Data submittal date: [mm/dd/yyyy]

additional POC:

Part 2: Radon Data Instructions

Complete template columns A through AA for each radon detector. Do no use commas or quotes in template fields

Non Residential 5 Level Data Hierarchy: UIC/Installation > Site > Bldg Num > Room > Location

Residential 5 Level Data Hierarchy: UIC/Installation > Site > Neighborhood > Address (Street Number + Street Name) > Location

Col	Field Header	Required	Must be in DB Prior to Import	Description	Values
A	UIC	YES		Unit Identification Code: NXXXXX or MXXXXX	Enter the UIC - for example N12345 or M12345; this is the top unique hierarchical key for the identification of an installation or command.
B	Installation or Command Name	YES		The official name of the Installation or command	Use the SNDL (Standard Navy Distribution List) Plain Language Address (PLA) name used for naval messages, available on the DON Issuances website. For example, N61755 is NAVBASE
C	FEC	NO		Name of Facilities Engineering Command	
D	Navy Region	NO		Name of CNIC Regional Command	
E	Site Name	YES		Name of Site	Do not leave blank. Enter "MAIN INSTALLATION" as default value; OR, if there is more than one building at the Installation with the same Building Number, enter a unique Site Name to accommodate the situation. To determine a Site Name, think of what you call where the Building is located (tenant command name such as SRF or NAVMAG). Note, there CANNOT be two Buildings with the same Building Number at the same INSTALLATION and SITE.
F	Building Type	YES		H=Residential N=Non Residential	The database manages data depending on whether it is H or N. Note: BEQ's, BOQ's, and other Billeting type buildings are N (Non Residential); H is for Family Housing only.
G	Building Number	YES, if Non Residential		Building Number	Do not leave blank for Non Residential (leave blank for Residential Housing data).
H	Building Name	NO		Name of Building	For Non Residential buildings only; do not use for Residential housing. Leave blank if unknown
I	Neighborhood	YES, if Residential		Neighborhood	Do not leave blank for Residential; enter Family Housing area name (leave blank for Non Residential buildings).
J	Street Number	YES, if Residential		Street Number	Do not leave blank for Residential; (leave blank for Non Residential buildings).
K	Street Name	YES, if Residential		Street Name	A Street Name must be provided if there is more than one housing unit with the same Street Number, but on different streets.
L	Room	YES		Room Name or Number	Do not leave blank
M	Location within Rm	NO		Description of where a detector was placed	Examples are Wall, Table, Pillar, etc.; leave blank if unknown.
N	Detector ID	YES		Detector ID	Identification number on detector
O	Detector Type	YES	YES	Type of radon testing devices	Code - enter a 3 letter Code from this list only. If a detector type is not in this list, alert the database administrator to add the new detector type prior to import; the imported value must match EXACTLY the value in the database.
				Alpha-Track	ATD
				Charcoal	CHA
				Continuous Monitor	CRM
				Integrating Electronic Monitor	IEM
				Liquid Scintillation	LS
				red l chamber long term ep	LLT
				red s chamber ep	LST
				S-Chamber/Long Term ep	SLT
				Blue Label/S-Chamber ep	SST
				Unknown	UNK

Part 2: Radon Data Instructions (continued)

Manufacturer	YES		Radon test device Manufacturer	A Manufacturer of the Detector Type is required, but does not have to already be listed in the data base; if unknown, enter UNKNOWN.
Date Placed	YES		mm/dd/yyyy	Do not leave blank
Date Retrieved	YES		mm/dd/yyyy	Do not leave blank
Time placed	NO		hh:mm AM/PM	If available; used only with short-term data; leave blank if unknown
Time Retrieved	NO		hh:mm AM/PM	If available; used only with short-term data; leave blank if unknown
pCi/L	YES		picocuries per liter (pCi/L) up to 1 decimal	If values are reported as "<x" (e.g., <0.5), input the numerical value and enter Error Code 34 (pCi/L Value is Less Than Reported) column X; If values are reported as ">x" (e.g., >10.9), input the numerical value and enter Error Code 35 (Value is Greater Than Reported) in the Error Code field. (Does not invalidate data.)
pCi/L-Day	NO		picocuries per liter-day (pCi/L-Day) up to 1 decimal	
Radon Test Type	YES	YES	2 letter code indicating Type of radon test	Code: enter a 2 letter Code from the following list. If another Test Type is required, alert data administrator to add new Test Type to the database prior to import; value must match EXACTLY the value in the database.
			Assessment Confirmation (confirmation) - Measurement used to confirm a single elevated radon measurement	AC
			Assessment (baseline) - Measurement performed to identify buildings or rooms at an installation or site with elevated radon	AS
			Diagnostic Measurement (diagnostic) - A radon test performed as part of a mitigation diagnostic or under exactly known conditions within a room or building of interest	DM
			Follow Up Test (baseline) - A retest of the room where the results are averaged with the pervious radon measurements to reach a conclusion	FT
			Monitoring Test (confirmation) - Radon testing performed after the screening and assessment phases have been performed to ensure that levels are <4 pCi/L (Per Guidebook: RPC 3 monitoring if the highest single average result is <4 pCi/L and RPC 1 monitoring if the highest single average result is ≥4 pCi/L)	MT
			New Construction (baseline) - A radon test performed in a new building before occupancy or within 5 years of acquisition	NC
			Operation and Maintenance (post mit) - A mitigation performance test performed every 2 years within the affected rooms.	OM
			Other (confirmation)	OR
			Post mitigation (post mit) - Radon test after radon mitigation within the affected rooms	PM
			Renovation Retest (baseline) - A retest of a room or building in which weatherization, whole building replacement, additions, HVAC modification or replacement, or damage by any events such as earthquakes and storms that would alter the building envelope has occurred.	RR

Part 2: Radon Data Instructions (continued)

			Supplemental Assessment (baseline) - Measurement repeated as a replacement for lost detectors during assessment	SA
			Screening Confirmation (confirmation) - Measurement used to confirm a single elevated radon measurement	SC
			Screening (baseline) - Measurement performed as part of project to determine radon potential at a site or installation	SG
			Supplemental Screening (baseline) - Measurement repeated as a replacement for lost detectors during screening	SU
Error Code	YES	YES	"Valid" enter 30. However, if there are problems with the data or detector (e.g., missing detector = "8"), select one of the codes from the list that best describes the problem.	Code - choose a numerical Code corresponding to a situation as described; use only these values. If new Error Code is needed, alert the database administrator to add the new Error Code prior to import; the imported value must match EXACTLY the value in the database.
			No Room	1 - Test was conducted in an Unknown Room; does not invalidate data
			Both Dates Estimated	2 - Actual Placement and Retrieval Dates are unknown and were estimated; does not invalidate data
			Placement Date Estimated	3 - Does not invalidate data
			Retrieval Date Estimated	4 - Does not invalidate data
			Detector Moved in Room	5 - The detector was moved within the Room in which it was originally placed; does not invalidate data
			Placed / Not Retrieved	6 - The detector was placed but was never retrieved
			Damaged	7 - Do not use data
			Placed / Reported Missing	8 - Detector(s) are missing at retrieval
			Tampered	9 - Detector was physically tampered with; do not use data
			Insufficient Test Period	10 - Detector was retrieved before proper test period elapsed for that type of test device; do not use data
			Mechanical Modification During Test Period	11 - Does not invalidate data
			Anomalous Data	12 - Data was declared invalid by manufacturer or lab; do not use
			Duplicate not collocated	13 - Duplicate detectors were placed, but at different locations; does not invalidate data
			Duplicate Date Questioned	14 - Does not invalidate data
			Placement / Retrieval Location in Different Room or Building	15 - Do not use data
			Renovation / Construction	16 - Facility was renovated prior to detector retrieval; do not use data
			Detector Exceeded Upper Exposure Limit	17 - Does not invalidate data
			Process Loss	18 - Manufacturer lost data
			Fire/Flood/Wind Damage etc.	19 - Building underwent catastrophic event during testing period; do not use data
			Fell Down	20 - Detector Fell Down but was still located in same general area as placed; does not invalidate data
			Dirty Electret	21 - Do not use data
			Nonstandard Test Condition	22 - Open windows, doors; HVAC off etc.; do not use data
			Not Retrieved Door Locked / No Key	23
			Not Retrieved Facility Closed or Demolished	24
			Placement Time Est	25 - Used only with short-term data if actual Time is unknown; does not invalidate data
			Retrieval Time Est	26 - Used only with short-term data if actual Time is unknown; does not invalidate data
			Electret Exceeded Maximum Voltage	27 - Electret voltage was completed drained due to radon level and not dirt; actual pCi/L value will be higher than the reported value; does not invalidate data
			Valid	30 - No problems or errors were noted to indicate that the test was invalid
			Working Level Measurement	32 - Not an acceptable radon test under NAVRAMP; do not use data

Part 2: Radon Data Instructions (continued)

			Refused Access	33
			pCi/L Value is Less Than Reported	34 - Does not invalidate data
			pCi/l Value is Greater Than Reported	35 - Does not invalidate data
			Individual measurement or data set failed QC	36 - QC Invalid Result
Contractor	YES		Company that placed/retrieved detectors. If in-house, enter NAVY, PWC, FEC, or similar organization name.	
Comments	NO		Comments on the conducted test	Leave blank if no comments
DSQF	YES	YES	Data Set Quality Factor: Determination of Quality of the entire data set based on amount and quality of QC data available	Code - Use only these numerical values
			Meets NAVRAMP Criteria - Data set has sufficient QC data to determine that it meets NAVRAMP	1
			Meets EPA Criteria - Data set has sufficient QC data to determine that it meets EPA, but not NAVRAMP	2
			Unknown - Insufficient QC information to determine the Quality of the Data Set	3
			Unusable Data - Data Set has sufficient QC data to determine that the data should not be used	4

Part 2: Radon Data Template

UIC (required)	Installation or Command Name (reqd)	FEC	Navy Region	Site Name (reqd; enter MAIN INSTALLATION as default)	Building Type (reqd; enter H or N)	Building Number (N reqd)	Building Name	Neighborhood (H reqd)	Street Number (H reqd)	Street Name (H reqd)	Room (reqd)	Location within Rm	Detector ID (reqd)	Detector Type (reqd)	Manufacturer (reqd)	Date Placed (reqd)	Date Retrieved (reqd)	Time Placed (EPerm Only)	Time Retrieved	pCi/L (reqd; may be up to 1 decimal)	pCi/L-Day	Radon Test Type (reqd)	Error Code (reqd)	Contractor (reqd)	Comments	DSQF (reqd)

Part 3: QC Data Instructions

Complete QC Template columns A through Q for each QC radon detector					
Col	**Field Header**	**Required**	**Must be in DB Prior to Import**	**Description**	**Values**
A	Project Name	YES		A "Projects Name" is used to identify testing events and the Quality Control data pertaining to the particular event, such as "Non Residential Testing NAVBASE Guam Oct 2010."	text field
B	Project Begin Date	YES		Enter Project Beginning Date	mm/dd/yyyy
C	Project End Date	YES		Enter Project End Date	mm/dd/yyyy
D	Detector ID	YES		Identification number on detector	
E	Detector Type	YES	YES	Detector Type: type of measurement device used.	Code - enter a 3 letter Code from this list only. If a detector type is not in this list, alert the database administrator to add the new detector type prior to import; the imported value must match EXACTLY the value in the database.
				Alpha-Track	ATD
				Charcoal	CHA
				Continuous Monitor	CRM
				Integrating Electronic Monitor	IEM
				Liquid Scintillation	LS
				red l chamber long term ep	LLT
				red s chamber ep	LST
				S-Chamber/Long Term ep	SLT
				Blue Label/S-Chamber ep	SST
				Unknown	UNK
F	Manufacturer	YES	YES	Manufacturer: The name of the company that manufactured the measurement device, such as PROCHECK, Sylvane, Landauer , RadElec, REM, RTCA, Honeywell, femto-TECH, Beckman, SZARAS, RSSI, Accustar, Unknown, Air Chek, FENTO TECH, or Rad Elec Inc.	text field
G	QCType (Spike or Blank)	YES		"Spike" are detectors that have been sent to a recognized radon chamber to be exposed to a predetermined radon level. These detectors are then included with the field detectors sent for analysis by the manufacturer's lab as a check that the lab analysis results are accurate. "Field Blanks" are used to determine if there has been any additional exposure to the field detectors during shipment. "Lab Blanks" are another check on the laboratory analysis.	Enter "Spike" or "Blank". Note, Blank Type, ("Lab" or "Field") is entered in column M.

Part 3: QC Data Instructions (continued)

H	Chamber Laboratory	Spike Data Only		Enter the name of the Chamber Lab. Under NAVRAMP, all spikes must be performed in an NRPP- or NRSB-accredited chamber or within a US governmental calibration chamber.	text field
I	Chamber Start Date	Spike Data Only		Chamber Start Date: The start date of the exposure at the Chamber Lab.	mm/dd/yyyy
J	Chamber Stop Date	Spike Data Only		Chamber Stop: The stop date of the exposure at the Chamber Lab.	mm/dd/yyyy
K	Chamber pCi/L	Spike Data Only		Chamber pCi/L -the level of exposure in pico-curies/liter of air (pCi/L)	pico-curies/liter of air (pCi/L)
L	Chamber pCi/L-Day	Spike Data Only		Chamber pCi/L-Day -the level of exposure in pico-curies/liter/day (pCi/L-Day). This information pertains only to alpha track type detectors and will not exist for other types of devices. Leave blank if not applicable.	pico-curies/liter/day (pCi/L/D)
M	BlankType (Field or Lab)	Blank Data Only		Enter "Lab" or "Field"	text field
N	Lab pCi/L	Blank Data Only		Lab pCi/L -enter the radon level for the selected detector from the manufacturer's laboratory, if provided. For alpha track type detectors, or if the detector has been used for a BLANK test, PCIL is usually not reported.	
O	Lab pCi/L-Day	Blank Data, alpha-track detectors only		Lab pCi/L-Day -if the QC detector is an alpha track type, enter the pCi/L-Day information, if provided. For BLANK tests, pCi/L-Day is usually the only data provided for alpha track detectors.	
P	Comments				text field
Q	Error Code Description			Enter a code description, such as:	text field
				Valid	
				Anomalous Data	
				Both Dates Estimated	
				Damaged	
				Placement Date Estimated	
				Placement Time Est	
				Retrieval Date Estimated	
				Retrieval Time Est	

Part 3: Project QC data Template

ProjectName	Project Begin Date (mm/dd/yyyy)	Project End Date (mm/dd/yyyy)	Detector ID	Detector Type	Manufacturer	QCType (Spike or Blank)	Chamber Laboratory	Chamber Start Date (mm/dd/yyyy)	Chamber Stop Date (mm/dd/yyyy)	Chamber pCi/L	Chamber pCi/L-Day	BlankType (Field or Lab)	Lab pCi/L	Lab pCi/L-Day	Comments

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APPENDIX B: NAVY'S DATA COLLECTION-REPORTING TEMPLATE FOR FAMILY HOUSING AND UNACCOMPANIED HOUSING

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Relationship of Report Data to eMH Inventory:

The Service/contractor will request, and Housing will provide, the RPUIDs and eMH addresses for all units/properties included in testing scope. Family Housing Radon testing is typically done at the unit level, with reported findings/value for each unit. Radon testing for overseas High Rise and Stairwell Family Housing buildings, and most Unaccompanied Housing buildings, is typically done at the building/structure level; with multiple detectors placed in habitable rooms on the ground floor, with the possibility of other detectors placed on upper floors. Accordingly, there are four Radon data table templates to address different possible Family and Unaccompanied Housing scenarios. Family Housing Unit Results: Identified test results for all units, with report date. Family Housing Building Results: Identified test results associated with Highrise and Stairwell building common areas, outside of assignable units, with building name/number and report date.

Unaccompanied Housing Unit Results: Identified test results for all units, with report date. Unaccompanied Housing Building Results: Identified test results associated with building common areas, outside of assignable units, with building name/number and report date.

The following data templates are intended to provide a uniform/consistent format and terminology for the associated data tables included in Radon reports. On each tab you will see a data input table, with pull-down functionality, where applicable. You will also see a sample table with all the pull-down values displayed.

The columns in these tables represent the information typically included in the respective reports. The texts in these columns represent typical elements/descriptions included in these reports. Using these common templates with the same format, column headings and text options will greatly simplify the eMH import/upload effort; making that data available for EHS Ratings and future Housing management use. (e.g., The wall material in most housing could be described as: Drywall, Wall Board, GYPBD, etc., Without a common/standard text set, the import/upload process could be unmanageable).

Request the Service/contractors provide the following deliverables to eMH for import/upload:

1. An Excel file with ***populated data tables*** for each Radon report, with list of the RPUIDs, eMH addresses included in the report;
2. A .PDF copy of each Radon ***report text***, with list of the RPUIDs and eMH addresses for all units included in the report;
3. A .PDF copy of the Radon report's ***Executive Summary***, with list of the RPUIDs and eMH addresses for all units included in the report;
4. A .PDF copy of the Radon report's ***Resident Report***, if provided, with list of the RPUIDs and eMH addresses for all units included in the report;

"Controlled by: Department of Navy
Controlled by: CNIC N93 eMH PMO
CUI Category: CTI
Distribution Statement: D, 18 November 2021
POC: CNIC N93 eMH PMO"

CUI
Radon Testing Data:

Service/contractor requests RPUIDs and eMH addresses for all units/properties included in Radon testing area. Service/contractor will provide the RPUIDs and eMH addresses, aligned with the Radon test results, for all units and buildings in testing area. EHS saves the Radon data. eMH associates Radon data and report to identified units/properties. Some Radon data is used to calculate EHS Manager Ratings. Other Radon data will be saved for future Housing Information Report (i.e., New resident disclosures, Housing inspections, Re-testing requirements/schedule, etc.).

Housing Radon Testing Samples

Family Housing Unit Radon Result Options

RPUID	Street Number	Street Name	Date Detector Placed	Date Detector Collected	Radon Level (#.## pCi/L)	Report Date
			MM/DD/YYYY	MM/DD/YYYY	Test Results	MM/DD/YYYY

Family Housing Building/High-Rise/Stairwell Radon Result Options (High Rise and Stairwell Buildings Only)

RPUID	Building Name/ Number	Area Tested (Pull Down)	Date Detector Placed	Date Detector Collected	Radon Level (#.## pCi/L)	Report Date
		Entry	MM/DD/YYYY	MM/DD/YYYY	Test Results	MM/DD/YYYY
		FH Office				
		FH Lounge				
		Elevator Lobby				

Unaccompanied Housing Building Radon Result Options

RPUID	Building Name/ Number	Area Tested (Pull Down)	Date Detector Placed	Date Detector Collected	Radon Level (#.## pCi/L)	Report Date
		UH Lobby	MM/DD/YYYY	MM/DD/YYYY	Test Results	MM/DD/YYYY
		UH Office				
		UH Lounge				
		UH Common Laundry				
		UH Storage				
		UH Common Kitchen				

Unaccompanied Housing Unit Radon Result Options

RPUID	Building Name/ Number	Unit Number	Date Detector Collected	Radon Level (#.## pCi/L)	Report Date
			MM/DD/YYYY	Test Results	MM/DD/YYYY

CUI

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Controlled by: CNIC N93 eMH PMO
CUI Category: CTI
Distribution Statement: D, 18 November 2021
POC: CNIC N93 eMH PMO"

Radon Testing Data:

Service/contractor requests RPUIDs and eMH addresses for all units/properties included in Radon testing area.

Service/contractor will provide the RPUIDs and eMH addresses, aligned with the Radon test results, for all units and buildings in testing area.

EHS saves the Radon data.
eMH associates Radon data and report to identified units/properties.
Some Radon data is used to calculate EHS Manager Ratings.
Other Radon data will be saved for future Housing Information Report (i.e., New resident disclosures, Housing inspections, Re-testing requirements/schedule, etc.).

Housing Radon Testing Samples

Family Housing Unit Radon Result Options

RPUID	Street Number	Street Name	Date Detector Placed	Date Detector Collected	Radon Level (#.## pCi/L)	Report Date
			MM/DD/YYYY	MM/DD/YYYY	Test Results	MM/DD/YYYY

Family Housing Building/High-Rise/Stairwell Radon Result Options (High Rise and Stairwell Buildings Only)

RPUID	Building Name/ Number	Area Tested (Pull Down)	Date Detector Placed	Date Detector Collected	Radon Level (#.## pCi/L)	Report Date
		Entry	MM/DD/YYYY	MM/DD/YYYY	Test Results	MM/DD/YYYY
		FH Office				
		FH Lounge				
		Elevator Lobby				

Unaccompanied Housing Building Radon Result Options

RPUID	Building Name/ Number	Area Tested (Pull Down)	Date Detector Placed	Date Detector Collected	Radon Level (#.## pCi/L)	Report Date
		UH Lobby	MM/DD/YYYY	MM/DD/YYYY	Test Results	MM/DD/YYYY
		UH Office				
		UH Lounge				
		UH Common Laundry				
		UH Storage				
		UH Common Kitchen				

Unaccompanied Housing Unit Radon Result Options

RPUID	Building Name/ Number	Unit Number	Date Detector Collected	Radon Level (#.## pCi/L)	Report Date
			MM/DD/YYYY	Test Results	MM/DD/YYYY

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CUI Category: CTI
Distribution Statement: D, 18 November 2021
POC: CNIC N93 eMH PMO

CUI FH Unit Radon Report Results

CUI

	Family Housing Unit Radon Results						
	RPUID	Street Number	Street Name	Date Detector Placed (MM/DD/YYYY)	Date Detector Collected (MM/DD/YYYY)	Radon Level (#.## pCi/L)	Report Date (MM/DD/YYYY)
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Controlled by: Department of Navy
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CUI Category: CTI
Distribution Statement: D, 18 November 2021
POC: CNIC N93 eMH PMO

CUI FH Building Report Results

CUI

	Family Housing Building/High-Rise/Stairwell Radon Results						
	RPUID	Building Name/ Number	Area Tested	Date Detector Placed (MM/DD/YYYY)	Date Detector Collected (MM/DD/YYYY)	Radon Level (#.## pCi/L)	Report Date (MM/DD/YYYY)
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Controlled by: CNIC N93 eMH PMO
CUI Category: CTI
Distribution Statement: D, 18 November 2021
POC: CNIC N93 eMH PMO

CUI UH Building Report Results

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	Unaccompanied Housing Building Radon Results						
	RPUID	Building Name/ Number	Area Tested	Date Detector Placed (MM/DD/YYYY)	Date Detector Collected (MM/DD/YYYY)	Radon Level (#.## pCi/L)	Report Date (MM/DD/YYYY)
1							
2							
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CUI Category: CTI
Distribution Statement: D, 18 November 2021
POC: CNIC N93 eMH PMO

CUI UH Unit Radon Report Results

CUI

	Unaccompanied Housing Unit Radon Results						
	RPUID	Building Name/ Number	Unit Number	Date Detector Placed (MM/DD/YYYY)	Date Detector Collected (MM/DD/YYYY)	Radon Level (#.## pCi/L)	Report Date (MM/DD/YYYY)
1							
2							
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APPENDIX C: RADON MANAGEMENT PLAN TEMPLATES

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HOW TO PREPARE A RADON MANAGEMENT PLAN

Question and Answer Section
30 September 2017

Under the Navy Radon Assessment and Mitigation Program (NAVRAMP), it is required that all installations, regardless of radon potential, develop and sustain a Radon Management Plan (RMP). The primary purpose of an installation RMP is to serve as the primary document of the oversight mechanism for the entire radon control program. In addition, the document serves as a major means of maintaining program credibility and provides a quick reference for those who are new to or outside of the radon program at the installation. The RMP should be reviewed and updated every 5 years or as needed to ensure that the information within the document is current.

What Is a Radon Management Plan and What Is Its Function?

The RMP establishes radon control procedures to include identification (e.g., radon testing), mitigation, and maintenance of radon reduction systems at the installation. It also establishes an installation Radon Management Team (RMT). It also identifies roles and responsibilities of various organizations at each installation to ensure the successful implementation of the NAVRAMP. The intent of the RMP is not to represent the chain of command; the intent is to represent how the radon control program team members may effectively function in relation to other organizations at the installation level. Each member of an installation RMT should review the RMP; understand Environmental Protection Agency (EPA), NAVRAMP, and US Navy radon policies; and provide their respective input on RMP implementation at the installation. It will also be necessary for each RMT member to keep abreast of regulatory, programmatic, or US Navy policy changes. In addition, it is the responsibility of the installation RMT to develop and implement a radon risk communication plan (RCP) as a separate document that complements and supports the RMP.

Who Is Qualified to Write an RMP?

The preparer of the RMP does not need to be a "radon expert" but does need to have basic knowledge about the installation and be familiar with NAVRAMP. At most installations, with a little input from others (e.g., family and unaccompanied housing, Department of Defense Dependents Schools [DoDDS], installation medical authority) the RMP is prepared by the radon program technical lead.

Most of the information needed is readily obtainable from past installation radon reports or other sources such as the COMNAVFACENGCOM radon database and Naval Facilities Assets Data Store (iNFADS) property database. It is recommended that before drafting the RMP, the preparer consult Section 2.9 of *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations*, September 2017.

How Much Detail is Needed in the RMP?

An installation RMP does not need to be a lengthy or highly detailed document. It needs to be only sufficiently comprehensive to document the current radon testing and mitigation status at the installation, list the primary RMT members, and list any proposed plans to meet any NAVRAMP requirements.

What Buildings or Facilities Should Be Included or Covered under the RMP?

Ownership and radon management responsibility of a building at a naval installation sometimes is a complicated issue. It is recommended that the installation real estate or asset manager be consulted before drafting the RMP. In most cases, semi-autonomous tenants such as DoDDS and the Defense Commissary Agency fall under the purview of the installation RMP; however, if they do not, the reason needs to be documented. Another potentially complicated case is the location of other Department of Defense agencies at the installation. A determination needs to be made from the memorandum of understanding if radon is or is not covered under the agreement and documented in the RMP.

Is Privatized Family Housing Covered Under the RMP?

The answer is no, from the standpoint that the installation is responsible for NAVRAMP implementation in privatized family and Unaccompanied Housing inventory (See DoD Memo, *Radon Testing and Monitoring of Privatized Military Housing Procedures* (dated 4 August 2020). However, legal consul should be consulted to determine if the terms of the housing lease agreement require the contractor to implement NAVRAMP or governing country, local or state requirements. If true, then the PPV partners should be consulted to ensure radon is being managed as appropriate. Either finding (i.e., the PPV is responsible for radon or is not) is required to documented in the RMP.

Where Do I Find My Installation Historical Radon Results?

The Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC) and HQMC Marine Corps Installation Command [HQMC/MCICOM GF-Environmental] maintains a central data management system containing results for radon testing. EXWC and MCICOM also has on file the initial Radon Potential Category (RPC) for all naval installations.

Does My Installation Need a Radon Management Team?

The answer to that question depends on many factors unique to the installation. For example, installations involved in active radon assessment or radon mitigation may want to have identified subject matter experts available to help with the risk communication aspects of the project. On the other hand, installations that have completed testing requirements years ago and found no elevated radon issues may need only contact information in case of questions by stakeholders. It is recommended that as a minimum all installations have the following team members:

- Environmental Branch (if different from the radon program technical lead)
- Installation Medical and Preventive Medicine
- Public Affairs Office

- Family housing (if present at the installation and under installation cognizance)
- DoDDS (if present at the installation and under installation cognizance)

At installations with confirmed elevated radon potential and active mitigation systems, including the following representatives on the RMT should be considered, as applicable.

- Design and Engineering
- Facility Engineering
- Staff Judge Advocate

What Are the Responsibilities of Each RMT Member?

Radon Program Technical Lead

The radon program technical lead has the overarching responsibility to coordinate all radon testing, mitigation and maintenance activities at the installation. Briefly, the following are the primary technical lead responsibilities:

- Periodically ascertain the status of radon testing and radon mitigation systems as required by NAVRAMP.
- Set priorities to alleviate deficiencies in the implementation of the RMP.
- Program and budget for radon contractor services, training, and equipment to perform QA activities.
- Oversee radon awareness training, risk communication, and technical services for installation personnel and stakeholders as needed.
- Perform QA activities as needed to ensure that contractors and in-house staff are following NAVRAMP testing and mitigation guidelines.
- Review and provide comments for all renovations and energy upgrade projects for possible impact on radon levels within buildings. In addition, provide comments for all new construction with respect to the incorporation of passive mitigation measures into the design to significantly reduce the presence of elevated radon after construction has been completed.
- Review the installation RMP every 5 years and revise it as needed.
- Maintain a data management system in electronic and written format that tracks and records, in a retrievable manner, all radon survey results and mitigation and all operation and maintenance (O&M) activities.

Installation Design and Engineering

Engineering shall ensure that all design contracts incorporate radon-resistive features consistent with the passive sealing portions of Unified Facilities Criteria (UFC) 3-490-04A (UFC May 2003), the subslab gas collector specifications from ASTM E1465-08a, and NAVRAMP. Engineering shall also coordinate with the radon program technical lead to ensure—before the bidding for a new construction contract, building renovation, or building energy-efficiency upgrade project—that all potential radon concerns are addressed in the design and the proposed design. In addition, during the construction or renovation projects, Engineering shall conduct site inspections to ensure that the proposed radon-resistive measures are being installed according to design and properly.

At the completion of the project, Engineering shall notify the radon program technical lead and list any exceptions to the radon-resistant design plans.

Installation Facility Engineering
Facility Engineering shall designate personnel who shall be responsible for the maintenance and timely repair of all installed radon mitigation systems. These designees or their supervisors shall report to the radon program technical lead periodically the maintenance performed since the last reporting period, any maintenance scheduled or planned for the next reporting period, and a synopsis of any radon mitigation service calls (e.g., at a minimum, the building number, date reported, problem, action taken, and date repaired).

Installation Medical Authority and Preventive Medicine
For the purpose of having an available in-house radon medical authority, the Chief of Preventive Medicine shall assign personnel who are cognizant with the risks associated with elevated radon exposure. These personnel shall consult with the radon program technical lead as needed to set corrective action priorities and provide answers to questions generated by other medical staff, naval personnel, dependents, and workers. In addition, if requested by the radon program technical lead, the radon medical authority shall meet with concerned parties (e.g., occupants of buildings with elevated radon) and address their exposure concerns.

Installation Public Affairs Office
The Public Affairs Office (PAO) is responsible for interfacing with the news media and general public concerning inquiries about the installation radon testing and mitigation program. For in-house questions (questions asked by workers, military personnel, and dependents), the radon program technical lead may ask the PAO for assistance in disseminating the requested information. This includes but is not limited to:

1. Hosting town meetings to discuss radon concerns with building occupants
2. Releases of radon data to the news media and state or local government
3. Assisting with the public relations aspect of the radon program
4. Ensuring that the key risk communication elements in the RCP are consistent with the RMP

Installation Staff Judge Advocate
The Staff Judge Advocate is to be consulted regarding any liability or regulatory compliance issues relating to radon testing or mitigation. The environmental legal advisor will provide guidance for interpreting federal, state, and local laws, regulations, and guidelines. In addition, the environmental legal advisor will coordinate all requests for monitoring data and inspections by federal, state, and local environmental agencies to determine whether the data is required by applicable law or regulation.

Installation Family Housing
The director of Navy or US Marine Corps –owned family housing shall designate personnel to assist the radon program technical lead with the implementation of radon testing, installation of radon mitigation systems, and O&M of existing radon mitigation systems in family housing. This assistance includes but is not limited to the following:

1. Provide all new arrivals written notification that their prospective quarters have uncorrected elevated radon and, if requested, provide them with alternative quarters.
2. If they have not already been notified in writing, provide radon results to the current residents in quarters with elevated radon.
3. In quarters with radon mitigation systems, provide the new arrivals written instructions on how to ascertain that the mitigation system is operating and a phone number to call for repair.
4. Provide prior notification to residents that radon-related services will be performed in their quarters.
5. Assist in timely access to quarters scheduled for radon-related services if the resident is off-post or unresponsive.
6. As soon as feasible, provide the radon program technical lead a list of homes to be renovated or replaced and proposed new construction.

Installation DoDDS

As a semi-autonomous tenant at a naval installation, the oversight and management of radon issues within the installation dependent schools resides with the DoDDS. However, it is recommended that the Superintendent of Schools at the installation designate personnel to consult with the radon program technical lead on matters dealing with the implementation of radon testing and the installation of radon mitigation systems. In addition, it is also requested that the superintendent or a designee:

1. Provide the radon program technical lead a list of past radon test data to verify that it is current, is complete, and meets NAVRAMP requirements.
2. Provide the radon program technical lead with a list of buildings known to require radon testing or radon mitigation.
3. Provide a list of all radon reduction systems currently installed in dependent schools at the installation.
4. Obtain funding to rectify any deficiencies in testing, mitigation, or O&M of radon mitigation systems.

What is the Difference between an RMP and the Installation Radon RCP?

Briefly, the installation RCP describes the measures that will be used at the installation to keep all stakeholders fully informed of the findings and significance of any past or present radon projects, whereas the RMP outlines the methods and procedures that the installation is employing to meet NAVRAMP. The two documents, although different in function, must complement and support each other to ensure a successful radon program. Under NAVRAMP, the RCP should be either contained or cited in the RMP.

Can the RMP and RCP Team Members Be the Same?

Absolutely.

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OUTLINE AND SUGGESTED WORDING OF A RADON MANAGEMENT PLAN

30 September 2017

The following outline is provided to assist the installation in the preparation of a radon management plan (RMP). Installations are not required to follow this format or outline and may develop their own RMP documents, provided all the elements below are included and addressed.

Section 1: RMP Introduction

- Authorization page
  - Signature of environmental director or command authority to signify that the plan has been reviewed and approved.
- Date finalized
  - The date on which that the document was finalized and went into effect.
    - Note: The RMP needs to be reviewed and updated (if applicable) every 5 years.
- Name and title of the preparer (optional)
  - Required only if the name of title of the preparer is different from the name of the technical lead.
    - If RMP preparation was contracted, it is suggested the following minimal information be included:
      - Company name
      - Name/title of preparer
      - Contact information
- Name and title of radon technical lead at the installation
  - It is recommended that the following information be provided:
    - Name, title, organization, and contact information
- Radon program requirements and other documents
  - It is recommended that the following references or their successors be included in the RMP as applicable:
    - Navy Policy Requirements
      - *Chief of Naval Operations (OPNAV) Environmental Readiness Program Manual*, OPNAV M-5090.1, Chapter 25, Section 3.2, Department of the Navy, 25 June 2021.
  - NAVRAMP implementation guidance
    - *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations*, September 2017.
  - Reference the installation radon RCP
    - Example wording: The RCP is contained in Appendix A of this document, or the RCP for NAS Somewhere is contained in *Radon Risk Communication Plan for NAS Somewhere*, February 2017.
  - Overseas installations may be required to meet the country-specific Final Governing Standards prepared by the Department of Defense (DoD) Environmental Executive Agent based on the host nation's environmental requirements and the Overseas

Environmental Baseline Guidance Document. If it is applicable for radon, include the reference in this section.

- Radon Management Plan coverage
  - Simply state what types of buildings the RMP includes.
    - Wording for simple cases:
      - Example wording: This RMP covers all family housing and other buildings at the installation.
      - Example wording: This RMP covers all buildings at this installation (no family housing is present).
      - Example wording: This RMP covers all buildings at the installation except Naval Hospital Somewhere (radon program is being managed separately by the tenant command).
    - Wording for more complex cases:
      - Example wording: This RMP covers all Navy buildings at the installation with the noted exception of those under US Air Force (USAF) cognizance. Per the MOU Dated 21 February 2016 between the Navy and USAF, all environmental, including radon, is under USAF jurisdictional control.
      - Example wording: This RMP covers all Navy owned/controlled buildings at this installation with the exception of family housing. All family housing at the installation was privatized in July 2005 and implementation of NAVRAMP was included in the agreement. According to the Public Private Venture agreement, Military Housing R US, LLC, is responsible for NAVRAMP implementation within all family housing.
      - Example wording: This RMP covers all Navy-owned and Navy-controlled buildings at the installation. However, family housing was privatized in July 2005 and implementation of NAVRAMP was ***NOT*** included in the agreement. Therefore, it is uncertain at this time who is responsible for NAVRAMP implementation in family housing.
- Radon Management Team members
  - In addition to the radon program technical lead, the following team members are recommended, as circumstances require, for all installations regardless of radon potential:
    - Installation Medical and Preventive Medicine
    - PAO
    - Family housing (if present at the installation and under installation cognizance)
    - DoDDS (if present at the installation and under installation cognizance)
  - Optional team members depending on installation radon potential and circumstances (e.g., radon mitigation systems are present, or elevated radon is present at the installation) would include representatives from:
    - Design and Engineering (if RPC 1 and new construction is proposed)
    - Facility Engineering (if radon systems are present),
    - Staff Judge Advocate and/or
    - Installation maintenance (if radon systems are present)
  - Other possible stakeholders may also need to include representatives of non-Navy tenants at the installation

- Installation description
  - Briefly describe the population of testable buildings (family housing and other buildings) at the installation.
  - If the site option will be used, include a description of each site and a rationale for splitting the installation into sites
    - Example wording: The installation resides on various geological provinces that are located at some distance from the main installation. The sites at the installation are as follows:
      - Main installation: Consists of 50 testable buildings.
      - Support annex: Located about 15 miles NE of Main Installation. Consists of 40 testable buildings and 300 testable family housing units.
      - Munitions area: Located 20 miles SW of Main Installation. Consists of 10 testable buildings and 75 other buildings (primarily bunkers) that do not meet the NAVRAMP occupancy requirements according to CPO Jane Smith.
  - Optional: Include in the appendix of the RMP a list of testable housing and other buildings at the installation.

Section 2: Radon Data Analysis

- Provide a summary of past radon surveys at the installation and indicate where the data are recorded.
  - The testing summary can be stated or tabulated as required for emphasis.
    - If tabulated, it can be in the body of the document or included in the appendix.
    - If multiple testing events have occurred at the installation (e.g., the same building or house was tested several times), use only the most recent screening or assessment result in the summary
      - Example wording: Radon testing was performed during 1992–1993 in 116 housing units and 4 nonresidential buildings (114 rooms). The highest result was 2.9 pCi/L. All data are on file in the COMNAVFACENGCOM radon database.
    - Example optional tables for single site

Summary of radon testing in nonresidential buildings 1992–1993

Building number	Building name	Number rooms tested	Highest result (pCi/L)
1	HQ	37	1.8
2	CDC	12	2.9
3	BEQ	40	2.4
4	Enlisted Club	25	0.5

Summary of radon testing in residential buildings 1992–1993

Neighborhoods	Total testable units	Number of units tested	Highest result (pCi/L)
Senior Officer Housing	10	10	1.1
SNCO Housing	25	23	1.9
Nimitz Housing	100	33	2.8
Jones Housing	200	50	2.8

Summary of radon testing by site 1992–1993

Site name	Number of housing units tested	Number of nonresidential buildings tested	Number of nonresidential rooms tested	Highest radon result (pCi/L)
Main Installation	25	1	37	1.8
Naval Magazine	0	1	40	2.2
Support Site	91	2	37	2.9

    - If the site option is used at the installation, summarize the radon testing history for each site:
        - Example wording: Radon testing was performed during 1997–1998 at the installation. The following table summarizes the testing by site. Data are on file in the COMNAVFACENGCOM radon database and in *Radon Testing Report for NB Somewhere*, March 1999.

- Overall testing conclusions for the installation
    - Based on the available radon data, determine the overall ***installation*** RPC and testing phase.
        - Example wording: Radon testing in 1992–1993 identified three housing units with elevated radon (highest result was 8.8 pCi/L). Currently, about 1/3 of family housing and 5% of testable nonresidential rooms have been tested. Because not all housing and other buildings have been tested, the installation is classified as ***RPC 1 Assessment.***
        - Example wording: Radon testing in 1989–1990 (15 results in a population of 2,500 testable rooms) was insufficient to determine elevated radon potential at the installation. Therefore, the installation is considered ***RPC 2 Screening***.

        - Example wording: Radon testing in 1992–1993 was sufficient to determine the absence of elevated radon potential. Therefore, the installation is considered ***RPC 3 Monitoring*****.**
    - If the site option is used, based on the radon data collected at each site, assign an appropriate RPC and testing phase.
        - Example wording: RPC and testing phases for the four sites within the installation are as follows:
            - **Main Installation:** Radon testing in 1992–1993 was sufficient to determine the absence of elevated radon potential. Therefore, the site is considered ***RPC 3 Monitoring*****.**
            - **Naval Magazine:** No radon testing has been performed at this site. Therefore, the site is considered ***RPC 2 Screening***.
            - **Support Site:** Elevated radon was detected within family housing during the 1992–1993 survey. Since additional testing is required, the site is considered ***RPC 1 Assessment***.
            - **Naval Communication Site:** Radon assessment was performed in all testable buildings and rooms at the site in 2007–2008. A total of 15 rooms were found to have elevated radon. Therefore, the site is considered **RPC 1 Monitoring.**
    - If applicable, list any leased or international-use buildings at installation.
        - Document who is or would be responsible for radon testing and mitigation.
    - List atypical buildings at each site if an exception is being employed.
        - Include a rationale for why the building should be considered atypical.
            - Example wording: Building 5 is part of an underground coastal fort that was constructed in 1888. All other buildings at the installation are above ground.
            - Example wording: Building 6 is the armory and is the only pre-stressed concrete building at the installation. All other buildings are more traditional in construction.
    - Develop a command-approved procedure for the release of radon results to stakeholders.
        - Simply state how the residents or building occupants are going to obtain their radon results.
            - Example wording: Data are distributed using form letters provided by the Public Affairs Officer.
    - Optional: Include a template in the appendix section of the RMP.
        - Example wording: Procedures for release of radon results are detailed in *Radon Risk Communication Plan for NB Somewhere*, January 14, 2014.
    - Based upon the RPC and testing phase selected for the installation or individual sites, insert the applicable NAVRAMP requirements.
        - For example, for an RPC 1 Monitoring installation/site, wording should be as follows:
            - Retest all testable buildings after every 5 years per EPA recommendation, or after every significant earthquake or severe weather event that would alter the building envelope.
            - Test all new or newly acquired buildings and retest significantly modified buildings (e.g., those with heating, ventilation, and air-conditioning [HVAC] adjustment or replacement, or building envelope modifications).

- Retest every 2 years all buildings in which active mitigation systems have been installed.

- State which option the installation plans to use to meet the ongoing testing requirements.
  - Example wording: Retesting requirements will be performed as needed after every significant renovation and HVAC adjustment and earthquake or severe weather event.
  - Example wording: Because of logistical considerations, the installation shall perform the retesting every 5 years instead of after every HVAC adjustment or significant renovation, earthquake, and severe weather event.

Section 3: Radon Mitigation

- Summarize or list all radon mitigation systems present at the installation.
  - The summary can be either in the body of the document or in the appendix.
    - Example wording: There are no mitigation systems at the installation.
    - Example wording: There are 15 subslab depressurization (SSD) systems in family housing and 8 SSDs in nonresidential buildings at the installation. See mitigation details in the Appendix.
    - Example wording: There are eight SSD systems at the installation (see tables below).

Radon mitigation systems in family housing at NB Somewhere

Address	Type system	Number of systems	Installation date
101 Nimitz Loop	SSD	2	April 3, 1997
15 Saipan	SSD	1	April 5, 1997
17 Betel Palm	SSD	1	April 20, 1998

Radon mitigation systems in nonresidential buildings at NB Somewhere

Building number	Building name	Type system	Number of systems	Installation date
1	HQ	SSD	2	April 1, 1995
15A	BEQ	SSD	3	April 1, 1995

- Indicate what the O&M schedule is for the radon mitigation systems.
  - Example wording: O&M inspections are performed on the 18 SSD mitigation systems quarterly.
  - Example wording: Required maintenance on the energy recovery ventilation system is performed every 30 days according to manufacturer recommendations.

- Summarize any outstanding radon mitigation that needs to be performed at the installation.
  - The summary can be in the body of the document or in the appendix.
  - It should include estimated timelines for completion.
    - Example wording: Radon testing in Buildings 101 (BEQ), and 102 (Admin) found eight rooms with elevated radon in 2015 (highest result 12.0 pCi/L). Funding has been requested and mitigation is expected to be completed sometime in FY 2017.
  - Provide reasons why any buildings or housing units that were tested in the past and were found to have elevated radon and that were *never* mitigated, cannot be mitigated now.
    - This can be in the body of the document or in the appendix.
      - Example wording: Radon testing in 1992–93 identified three units (101, 102, and 103 Spruance Circle) as having elevated radon. Those units were demolished in 2002.
      - Example wording: Radon testing in 1995–1996 in Building 619 (BEQ) found elevated radon in four rooms. The building was renovated in 2006 and retesting found all rooms below the action level.
      - Example wording: Building 201 cannot be identified at this installation.

Section 4: Projects or Items to Address during the Next 5 Years

- List or tabulate all projects that are required or proposed under NAVRAMP (funded and unfunded) over the next 5 years.
  - Example wording for an RPC 1 Assessment with some mitigation:
    - Radon testing
      - Perform radon assessment in 300 family housing units.
        - ◊ Funding requested for FY 2017.
      - Perform radon assessment in an estimated 2,000 nonresidential rooms.
        - ◊ Funding requested for FY 2018.
    - Radon mitigation
      - Mitigate two housing units (101 Nimitz and 105 Jones Ave).
        - ◊ Funding requested for FY 2016.
  - Example wording for an RPC 2 screening:
    - Perform radon screening in 100 nonresidential buildings.
      - Method selected is fixed sample density.
      - Funding requested for FY 2017.
  - Example wording for projects that are under development (all RPCs):
    - Perform radon testing in 300 new housing units in Nimitz Heights after construction has been completed in FY 2019.

- Identify any issues that may be in flux, such as Public Private Venture or cognizance issues
  - Example wording: Consult legal and contracts to determine if the housing Public Private Venture company (Military Housing R Us) is responsible for implementation of NAVRAMP.
  - Example wording: Consult with Command and legal about the memorandum of understanding between the US Army and the US Navy to determine whom is responsible for radon program implementation at Camp Smith.

Radon Management Plan for NB Somewhere (NBS)
(Example RPC 1 Assessment)

Section 1: Introduction

- Date finalized: November 9, 2016
- Installation Radon Project Manager:
  John Q. Public
  Environmental Director/N45 Public Works Department (PWD) Somewhere
- Radon Management Plan coverage:
  - All family housing and nonresidential buildings at installation.
- Radon program requirements and other documents
  - **Navy policy requirements**
    - *Chief of Naval Operations (OPNAV) Environmental Readiness Program Manual*, OPNAV M-5090.1, Chapter 25, Section 3.2, Department of the Navy, 25 June 2021.
  - **Navy Radon Assessment and Mitigation Program implementation guidance**
    - *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations*, September 2017.
  - **Risk communication guidance document**
    - *Radon Risk Communication Plan for NB Somewhere*, November 2016.
- Radon Team members and responsibilities

  Radon program technical lead:
  Matthew Smith
  PWD Environmental (Phone XXX-XXXX, m.smith@nbs.mil)

  - Periodically ascertain the status of radon testing and radon mitigation systems at NB Somewhere as required by NAVRAMP.
  - Set priorities to alleviate the deficiencies in the implementation of the RMP.
  - Program and budget for radon contractor services, training, and equipment to perform QA activities.
  - Provide radon awareness training, risk communication, and technical services to installation personnel and stakeholders as needed.
  - Perform QA activities as needed to ensure that contractors and in-house staff are following EPA and NAVRAMP testing and mitigation guidelines.
  - Review and provide comments for all renovations and energy upgrade projects for possible impact on radon levels within buildings. In addition, provide comments for all new construction with respect to the incorporation of passive mitigation measures into the design to significantly reduce the presence of elevated radon after the construction has been completed.
  - Review the installation RMP every 5 years and revise as needed.
  - Maintain a data management system in electronic and written format that tracks and records in a retrievable manner all radon survey results and mitigation and O&M activities.

Public Affairs Office:

Lt. James Jones
(Phone XXX-XXXX, j.jones@nbs.mil)

- Coordinate with Office of Radiation Protection and radon technical lead the release of radon results to stakeholders.
- Host town meetings to discuss radon concerns with building occupants.
- Release radon data to the news media and state or local government.
- Assist with the public relations aspect of the radon program.
- Ensure that the key risk communication elements in the RCP are consistent with the RMP.

Office of Radiation Protection:

Lt. Martin Williams
Commander NBS Hospital Radiation Protection Program
(Phone XXX-XXXX, m.williams@nbs.mil)

- Work with the radon program technical lead to help establish priorities for corrective action where needed.
- Coordinate with the PAO in releasing the radon test results to the stakeholders.
- Provide, as needed, one-on-one medical consulting with concerned stakeholders.

NBS Family Housing:

Martha Cone
Assistant Housing Director NBS
(Phone XXX-XXXX, m.cone@nbs.mil)

- Provide all new arrivals written notification that their prospective quarters have uncorrected elevated radon and, if requested, provide them with alternative quarters.
- If they have not already been notified in writing, provide radon results to the current residents in quarters with elevated radon.
- In quarters with radon mitigation systems, provide the new arrivals written instructions on how to ascertain that the mitigation system is operating and a phone number to call for repair.
- Provide prior notification to residents that radon-related services will be performed in their quarters.
- Assist in timely access to quarters scheduled for radon-related services if the resident is off-post or unresponsive.
- As soon as feasible, provide the radon program technical lead a lists of homes to be renovated or replaced and proposed new construction.

- Installation description
  - Installation consists of five sites with two residing on different geological providences:
    - Naval Base: All mission support and administration buildings, ship yard plus harbor support shops and ship repair facilities, and family housing.
      - Resides in an EPA Radon Map Zone 3

- Docomo Site: Family housing, commissary/exchange, child development center, and dependent schools.
  - Resides in an EPA Radon Map Zone 1
  - Located approximately 15 miles north of NBS

- Sitka Site: Family housing and a site housing office
  - Resides in an EPA Radon Map Zone 1
  - Located approximately 17 miles north from NBS

- Magazine Site
  - Resides in an EPA Radon Map Zone 3
  - Has atypical buildings (converted magazines being used as secure office spaces)
  - Located 8 miles southwest of NBS

- Fuel Site:
  - Resides in an EPA Radon Map Zone 3
  - Located across the bay on peninsula approximately 6 miles NW of NBS

- For the purposes of this document, the installation will be implementing the site option for radon management at the installation.

Section 2: Radon Data Analysis

- Radon testing history at NB Somewhere
  - Naval Base
    - Radon screening 1990–1991 in family housing (33 of 150 units) located on the naval base did not find any elevated radon (highest result 1.0 pCi/L).
    - No nonresidential buildings have been tested at this site.
  - Magazine and Fuel Sites
    - No radon testing has been performed at these sites.
  - Docomo Site
    - Radon assessment in family housing found elevated radon during 1993–94.
      - 333 of the 500 units were successfully tested.
      - Ten units were found to have elevated radon.
      - Highest result was 10.1 pCi/L.
  - Sitka Site
    - Family housing units (75 testable units, constructed in 2001) have never been tested for radon.
  - The housing radon data are on file in the COMNAVFACENGCOM Central Radon Data Base and at the Installation Housing Office Environmental Archives.

- Overall testing conclusion and radon category
  - Because elevated radon has been detected at the installation at the Docomo Site, the overall installation radon category is ***RPC 1 Assessment***. However, since the site

option is being used at the installation, NAVRAMP testing requirements will be implemented as required under each assigned NAVRAMP radon category.

- **Naval Base Site** (RPC 3)
  - Sufficient screening was performed in family housing to determine that the naval base site has low elevated radon potential. Testing requirements are as follows:
    - Test all untested buildings constructed after 2003.
    - Test all Tier 1 and 2 buildings (e.g., hospitals, bachelor's quarters, dependent schools, child-care centers, youth centers and brigs) that have not been tested previously.
    - Retest all family housing every 5 years.

- **Docomo Site** (RPC 1)
  - Perform required nonresidential assessment.
  - Assess all 500 family housing units at the site (all housing underwent significant renovations during 2000–2005).
  - Retest all family housing 5 years after initial assessment.

- **Sitka Site** (RPC 2)
  - Although screening could be performed, it has been decided to perform radon assessment since the site resides on identical geology to Docomo Site.

- **Magazine Site** (RPC 2)
  - Site consists of five occupied buildings plus six magazines converted into occupied office spaces.
    - Test all 11 occupied buildings at the site.
    - Testing of 55 magazines will not be required since they do not meet the 4 h occupancy requirement.

- **Fuel Site** (RPC 2)
  - Site consists of two Navy-owned buildings and four contractor-owned support buildings.
    - Test all Navy-owned buildings at the site.
    - Contractor-owned support buildings will not be included in the testing.

Section 3: Mitigation Systems at Installation

- There are no radon mitigation systems at this installation.
- Radon-resistant new construction would apply only to new buildings at the Docomo site at this time.

Section 4: Projects and Items That Need to Be Addressed

- Nonresidential radon testing
    - **Naval Base Site** (RPC 3 Monitoring)
        - Perform Tier 1 and 2 and post-2003 construction testing.
            - Tier 1
                - Billeting (10 buildings or about 250 rooms)
                - Brig (1 building, 22 rooms)
                - Hospital (2 buildings, 144 rooms)
                - PMO (1 building, 15 rooms)
        - Test post-2003 construction.
            - 14 buildings, approximately 150 rooms
        - Perform 1-year radon tests during FYs 2017 and 2018.
    - **Docomo Site** (RPC 1 Assessment)
        - Test all 17 nonresidential buildings at the site (approximately 789 rooms).
            - Project will include both dependent schools and the child care center.
        - Perform 1-year radon tests during FYs 2016–2017.
    - **Magazine and Fuel Sites** (RPC 2 Screening)
        - Test the 13 buildings (about 100 rooms) at both sites concurrent with the radon testing at the Naval Base in FYs 2017–2018.
- Family housing radon testing
    - Retest all family housing in FYs 2018–2019 in Docomo Housing and Stika Housing Areas.
        - Perform mitigation as needed.

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Radon Management Plan for Naval Station Somewhere (NSS)
(Example RPC 2 Screening)

Section 1: Introduction

- **Date finalized:** November 9, 2016
- Installation Radon Project Manager:
  John Q. Public
  Environmental Director/N45 PWD Somewhere
- Radon Management Plan coverage:
  - All nonresidential buildings at installation.
  - Family housing was privatized in 2003 and is not covered under this document.
    - Responsibility for all radon issues within family housing resides with Military Housing R Us, LLC.
    - Point of contact is John Smith (Lead Housing Inspector, 555-1212)
- Radon Program requirements and other documents
  - **Navy policy requirements**
    - *Chief of Naval Operations (OPNAV) Environmental Readiness Program Manual*, OPNAV M-5090.1, Chapter 25, Section 3.2, Department of the Navy, 25 June 2021.
  - **Navy Radon Assessment and Mitigation Program implementation guidance**
    - *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations*, September 2017
  - **Risk communication guidance document**
    - *Radon Risk Communication Plan for Naval Station Somewhere*, November 2016.

- Radon Team members and responsibilities

Radon Program Technical Lead:
Matthew Smith
PWD Environmental (Phone XXX-XXXX, m.smith@nss.mil)

- Periodically ascertain the status of radon testing and radon mitigation systems at NB Somewhere as required by NAVRAMP.
- Set priorities to alleviate the deficiencies in the implementation of the (RMP.
- Program and budget for radon contractor services, training, and equipment to perform QA activities.
- Provide radon awareness training, risk communication, and technical services to installation personnel and stakeholders as needed.
- Perform QA activities as needed to ensure that contractors and in-house staff are following EPA and NAVRAMP testing and mitigation guidelines.
- Review and provide comments for all renovations and energy upgrade projects for possible impact on radon levels within buildings. In addition, provide comments for all new construction with respect to the incorporation of passive mitigation measures

into the design to significantly reduce the presence of elevated radon after the construction has been completed.
- Review the installation RMP every 5 years and revise as needed.
- Maintain a data management system in electronic and written format that tracks and records in a retrievable manner all radon survey results and mitigation and O&M activities.

Public Affairs Office:

Lt. James Jones
(Phone XXX-XXXX, j.jones@nss.mil)

- Coordinate with Office of Radiation Protection and radon technical lead the release of radon results to stakeholders.
- Host town meetings to discuss radon concerns with building occupants.
- Release radon data to the news media and state or local government.
- Assist with the public relations aspect of the radon program.
- Ensure that the key risk communication elements in the RCP are consistent with the RMP.

Office of Radiation Protection:

Lt. Martin Williams
Commander NBS Hospital Radiation Protection Program
(Phone XXX-XXXX, m.williams@nss.mil)

- Work with the radon program technical lead to help establish priorities for corrective action where needed.
- Coordinate with the PAO in releasing the radon test results to the stakeholders.
- Provide, as needed, one-on-one medical consulting with concerned stakeholders.

Department of Defense Dependents Schools:

Martha Cone
District 7 Superintendent of Schools
(Phone XXX-XXXX, m.cone@nbs.mil)

- Provide the radon program technical lead a list of past radon test data to verify that it is current, is complete, and meets NAVRAMP requirements.
- Provide the radon program technical lead with a list of buildings known to require radon testing or radon mitigation.
- Provide a list of all radon reduction systems currently installed in dependent schools at the installation.
- Obtain funding to rectify any deficiencies in testing, mitigation, or O&M of radon mitigation systems.
- Provide logistical support to radon program technical lead for NAVRAMP implementation in all District 7 dependent schools.
- Coordinate with PAO all requests for radon test results.

- Installation description
  - Installation consists of two sites on different geological providences.
  - Main Installation: All mission support and administration buildings plus airfield support shops and hangers.
    - Resides in an EPA Radon Map Zone 3
  - Support Site: Family housing; morale, welfare, and recreation facilities; public works shops; commissary/exchange; child care; and dependent schools.
    - Resides in an EPA Radon Map Zone 2
  - For the purpose of this document, the installation will be implementing the site option for radon management at the installation.

Section 2: Radon Data Analysis

- Radon testing history at NSS Somewhere
  - A partial radon screening was performed in family housing during 1989–1990.
    - Because of housing renovations during screening, data were obtained from only 9 of 66 units tested.
    - Highest result from housing was 1.9 pCi/L.
  - Radon testing has never been performed within nonresidential buildings at the installation.
  - Radon data are on file in the COMNAVFACENGCOM Central Radon Data Base.
    - A copy of the housing results was provided to Howard Smithson, contact for radon at Military Housing R Us, LLC, via email on June 6, 2015.

- Overall testing conclusion and radon category
  - Because there are insufficient radon data to draw a defensible testing conclusion, the installation is classified as ***RPC 2 Screening***. Therefore, the following testing actions are required under NAVRAMP for non-housing buildings:
    - Complete required nonresidential screening at the installation.
    - At the conclusion of the nonresidential screening, assign the appropriate RPC for each site at the conclusion of the radon screening.
    - All 1,000 testable family housing units were privatized in 2003.
      - Radon testing is currently required in all units.
      - Current responsibility for NAVRAMP implementation is in question.
      - Consultation with Military Housing R Us, LLC, in 2017 has not been successful in determining when or if Military Housing R Us will be implementing NAVRAMP.

Section 3: Mitigation Systems at Installation

- There are no radon mitigation systems at this installation.
- Radon-resistant new construction would not be required at this time.

Section 4: Projects and Items That Need to Be Addressed

- Nonresidential radon testing
  - Conduct and complete nonresidential radon screening at installation.
    - Main installation site consists of about 2,000 testable rooms.
    - Screening option 1: Fixed sample density will be used.
      - All Tier 1 and Tier 2 buildings will be tested.
      - All high-occupancy Tier 3 (e.g., ≥10 occupants/building) will be tested as well.
      - Lower-occupancy Tier 3 and Tier 4 buildings, with the exception of the armory (atypical building), will not be tested for radon.
      - It is estimated that about 1,625 rooms will be screened (81%).
    - Support site consists of about 400 testable rooms in 28 buildings.
      - All buildings will be tested (Assessment) as required by OPNAV.
      - Site also resides in an EPA Radon Map Zone 2.
    - All testing will be 1-year alpha track detectors.
    - Proposed timeline for testing is during FYs 2018 to 2019.
- Family housing radon testing
  - As required under Navy policy (Chapter 25, Section 3.2. Section c of OPNAV M-5090.1 [US Navy 2021]), determine through NAVFAC Contracts and installation legal counsel if Military Housing R Us, LLC, is responsible for implementing NAVRAMP within family housing.

Radon Management Plan for COMFLEACT Somewhere (CFAS)
(Example RPC 1 Monitoring)

Section 1: Introduction

- Date finalized: November 9, 2016
- Installation Radon Project Manager:
  John Q. Public
  Environmental Director/N45 PWD Somewhere
- Radon Management Plan coverage:
  - All family housing and nonresidential buildings
- Radon program requirements and other documents
  - **Navy policy requirements**
    - *Chief of Naval Operations (OPNAV) Environmental Readiness Program Manual*, OPNAV M-5090.1, Chapter 25, Section 3.2, Department of the Navy, 25 June 2021.
  - **Navy Radon Assessment and Mitigation Program implementation guidance**
    - *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations,* September 2017.
  - **Risk communication guidance document**
    - *Radon Risk Communication Plan for COMFLEACT Somewhere,* November 2016.
- Radon Team members and responsibilities

Radon Program Technical Lead:
Matthew Smith
PWD Environmental (Phone XXX-XXXX, m.smith@cfas.mil)

- Periodically ascertain the status of radon testing and radon mitigation systems at COMFLEACT Somewhere as required by NAVRAMP.
- Set priorities to alleviate the deficiencies in the implementation of the RMP.
- Program and budget for radon contractor services, training, and equipment to perform QA activities.
- Provide radon awareness training, risk communication, and technical services to installation personnel and stakeholders as needed.
- Perform QA activities as needed to ensure that contractors and in-house staff are following EPA and NAVRAMP testing, mitigation guidelines.
- Review and provide comments for all renovations and energy upgrade projects for possible impact on radon levels within buildings. In addition, comments will be provided for all new construction with respect to the incorporation of passive mitigation measures into the design to significantly reduce the presence of elevated radon after the construction has been completed.
- Review the installation RMP every 5 years and revise as needed.
- Maintain a data management system in electronic and written format that tracks and records in a retrievable manner all radon survey results and mitigation and O&M activities.

Public Affairs Office:

Lt. James Jones
(Phone XXX-XXXX, j.jones@cfas.mil)

- Coordinate with Office of Radiation Protection and radon technical lead the release of radon results to stakeholders.
- Host town meetings to discuss radon concerns with building occupants.
- Release radon data to the news media and state or local government.
- Assist with the public relations aspect of the radon program.
- Ensure that the key risk communication elements in the RCP are consistent with the RMP.

Office of Radiation Protection:

Lt. Martin Williams
Commander NBS Hospital Radiation Protection Program
(Phone XXX-XXXX, m.williams@cfas.mil)

- Work with the radon program technical lead to help establish priorities for corrective action where needed.
- Coordinate with the PAO in releasing the radon test results to the stakeholders.
- Provide, as needed, one-on-one medical consulting with concerned stakeholders.

Department of Defense Dependents Schools:

Martha Cone
District 11 Superintendent of Schools
(Phone XXX-XXXX, m.cone@cfas.mil)

- Provide the radon program technical lead a list of past radon test data to verify that it is current, complete, and meets NAVRAMP requirements.
- Provide the radon program technical lead with a list of buildings known to require radon testing or radon mitigation.
- Provide a list of all radon reduction systems currently installed in dependent schools at the installation.
- Obtain funding to rectify any deficiencies in testing, mitigation, or O&M of radon mitigation systems.
- Provide logistical support to radon program technical Lead for NAVRAMP implementation in all District 11 schools.
- Coordinate with PAO all requests for radon test results.

CFAS Family Housing:

Sharon Franks
Assistant Housing Director NBS
(Phone XXX-XXXX, s.frank@cfas.mil)

- Provide all new arrivals written notification that their prospective quarters have uncorrected elevated radon and, if requested, provide them with alternative quarters.
- If they have not already been notified in writing, provide radon results to the current residents in quarters with elevated radon.

- In quarters with radon mitigation systems, provide the new arrivals written instructions on how to ascertain that the mitigation system is operating and a phone number to call for repair.
- Provide prior notification to residents that radon-related services will be performed in their quarters.
- Assist in timely access to quarters scheduled for radon-related services if the resident is off-post or unresponsive.
- As soon as feasible, provide the radon program technical lead a list of homes to be renovated or replaced and proposed new construction.

CFAS Public Works Department Maintenance:

CPO Erick Wyatt
Facility Maintenance Chief
(Phone XXX-XXXX, e.wyatt@cfas.mil)

- Perform semi-annual performance checks on all installed radon mitigation systems.
- Repair all mitigation systems as needed.
- Provide required maintenance summary semi-annually to the radon program technical lead.
- Make recommendations for mitigation system improvements to the radon program technical lead.

- Installation description
  - Installation consists of one main site with both nonresidential and family housing.

Section 2: Radon Data Analysis

- Radon testing history at COMFLEACT Somewhere
  - To date, approximately 1,100 radon tests have been performed.
  - All family housing and nonresidential buildings have had the required NAVRAMP screening and assessment testing.
    - Radon testing to date has identified 19 family housing units and 27 nonresidential rooms as having confirmed levels of radon, with the single highest reported result being 9.7 pCi/L.
  - Radon data are reported in *Radon Mitigation Report and Operation and Maintenance Plan for Commander Fleet Activities Somewhere*, August 16, 2006.
- Overall testing conclusion and radon category
  - Because elevated radon has been confirmed and the assessment phase completed, the installation is classified as a ***RPC 1 Monitoring***. Therefore, the following testing actions are required under NAVRAMP for non-housing buildings:
    - Retest all testable family housing units and other buildings after every 5 years, or after every significant earthquake or severe weather event that would alter the building envelope.
    - Test all new or newly acquired buildings and retest significantly modified buildings (e.g., those with HVAC adjustments or replacements or building envelope modifications).

- Retest every 2 years all buildings in which active mitigation systems have been installed.
  - Because of logistical considerations, the installation shall perform the retesting every 5 years instead of after every HVAC adjustment or significant renovation.

Section 3: Mitigation Systems at Installation

- Currently, all family housing units and nonresidential buildings at the installation with elevated radon have been mitigated using subslab depressurization (Tables 1 and 2, respectively).
  - Routine inspections of the systems are performed quarterly.
    - Repairs are performed as needed.
  - The last detailed system inspection was performed in September 2014.

Table 1. Radon mitigation systems in family housing

Unit number	Number of radon mitigation systems
1201-A	2
1201-B	2
1202-B	2
1203-A	2
1203-B	2
1205-B	2
1302-A	2
1303-A	1
1303-B	2
1304-A	1
1304-B	2
1401-A	2
1401-B	2
1402-A	2
1402-B	2
2301-B	2
2303-A	2
2306-A	2
2306-B	2

Table 2. Radon mitigation systems in nonresidential buildings

Building number	System number	Location
706	1	Street side
706	2	Air-conditioning unit side
715	1	Canyon side
715	2	Back side
715	3	Back side middle
715	4	Back, parking side
715	5	Front, parking side
719	1	Left side
719	2	Right side
783	1	Street side
783	2	Housing side
799	1	Street side
799	2	Woods side
115	1	Armory
704	1	Room 1
723	1	Office storage
723	2	Computer center
723	4	Room 2
723	6	Room 4
723	8	Room 6
723	9	Lounge
723	10	Media center
723	11	New classroom
796	1	West side of building
S794	1	Lounge

- Radon-resistant new construction
  - Because of the presence of elevated radon at the installation, radon-resistant new construction features shall be incorporated in all proposed new buildings planned for occupancy.

Section 4: Projects and Items That Need to Be Addressed

- Radon testing
  - Retest within the next 5 years all nonresidential buildings and family housing at the installation.
  - Retest in 2 years (ca. 2019) all buildings and housing units in which active mitigation systems have been installed and retest every 2 years afterward.

- Radon mitigation
  - Currently, no radon mitigation is required at the installation.
- Radon mitigation system repairs
  - Perform the needed repairs identified by the detailed system inspection in September 2014 (*Radon Mitigation System Operations and Maintenance Inspection Report for Commander Fleet Activities Somewhere*, July 15, 2015).

Radon Management Plan for NAF Somewhere (NAFS)
(Example RPC 3 Monitoring)

Section 1: Introduction

- Date finalized: November 9, 2015
- Installation Radon Project Manager:
  John Q. Public
  Environmental Director/N45 PWD Somewhere
- Radon Management Plan prepared by:
  - A&E Services LLC under contract XXXXX-XXXX-XXXXX for Naval Facilities Engineering Command Somewhere
- Radon Management Plan coverage:
  - All nonresidential buildings at installation.
    - There is no family housing at this installation
- Radon program requirements and other documents
  - **Navy policy requirements**
    - *Chief of Naval Operations (OPNAV) Environmental Readiness Program Manual*, OPNAV M-5090.1, Chapter 25, Section 3.2, Department of the Navy, 25 June 2021.
  - **Navy Radon Assessment and Mitigation Program implementation guidance**
    - *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations*, September 2017.
  - **Risk communication guidance document**
    - *Radon Risk Communication Plan for NAF Somewhere*, November 2016.

- Responsibilities of Radon Project Manager
  - Periodically ascertain the status of radon testing and radon mitigation systems at NAF Somewhere as required by NAVRAMP.
  - Set priorities to alleviate the deficiencies in the implementation of the RMP.
  - Program and budget for radon contractor services, training, and equipment to perform QA activities.
  - Provide radon awareness training, risk communication, and technical services to installation personnel and stakeholders as needed.
  - Perform QA activities as needed to ensure that contractors and in-house staff are following EPA and NAVRAMP testing and mitigation guidelines.
  - Review and provide comments for all renovations and energy upgrade projects for possible impact on radon levels within buildings. In addition, provide comments for all new construction with respect to the incorporation of passive mitigation measures into the design to significantly reduce the presence of elevated radon after the construction has been completed.
  - Review the installation RMP every 5 years and revise as needed.
  - Maintain a data management system in electronic and written format that tracks and records in a retrievable manner all radon survey results and mitigation and O&M activities.

Note: At this time, the presence of other formal radon management team members is not required. However, the following installation staff are available for consultation as circumstances dictate.

Public Affairs Office:
Lt. James Jones
(Phone XXX-XXXX, j.jones@nafs.mil)

Office of Radiation Protection:
Lt. Martin Williams
Commander NBS Hospital Radiation Protection Program
(Phone XXX-XXXX, m.williams@nafs.mil)

- Installation description
  - Installation consists of one site
    - There are no dependent schools or family housing at the installation.
  - The site resides in an EPA Radon Map Zone 3
  - According to the state government radon point of contact, the installation resides in an area of the state with very low elevated radon potential.

Section 2: Radon Data Analysis

- Radon testing history at NAF Somewhere
  - Radon assessment was performed in 102 buildings (1,103 rooms) at the installation during 1997–98
    - Radon testing included all current Tier 1 and 2 buildings.
    - Installation assessment was selected over screening at that time because the costs were the same.
    - The highest result was 2.2 pCi/L.
  - Radon data are on file in the COMNAVFACENGCOM Central Radon Data Base and included in *Radon Testing Report for NAF Somewhere*, December 1, 1998.

- Overall testing conclusion and radon category
  - Since radon testing was performed in all testable buildings and rooms during 1997–98 and no elevated radon levels were found, the installation is classified as ***RPC 3 Monitoring***. Therefore, the following testing actions are required under NAVRAMP for nonresidential buildings:
    - Perform radon testing in all buildings constructed after 2003.

Section 3: Mitigation Systems at Installation

- There are no radon mitigation systems at this installation.
- Radon-resistant new construction is not required at this time.

Section 4: Projects and Items That Need To Be Addressed

- Nonresidential radon testing
  - Perform radon testing in the following buildings constructed after 2003:
    - NEX Service Station (6 rooms), morale, welfare, and recreation Recreational Center (15 rooms), 4 assorted administration/support buildings (25 rooms).
    - 1-year radon tests are proposed for years FYs 2018 to 2019.

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REFERENCES

Chief of Naval Operations (OPNAV) Environmental Readiness Program Manual, OPNAV M-5090.1, Chapter 25, Section 3.2, Department of the Navy, 25 June 2021.

Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations, September 2017 (superseded).

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APPENDIX D: RADON INFORMATION HANDOUTS AND RISK COMMUNICATION PLAN GUIDANCE TEMPLATE

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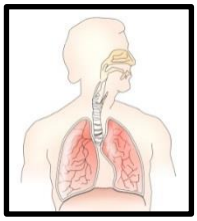
NOTE: This handout is provided as an example and can be used "as is" by simply editing the highlighted areas. However, as circumstances dictate, the handout can be modified in whole or in part by the installation to meet its specific needs, or replaced entirely with an installation-specific handout.

What Is Radon?

Radon is a colorless, odorless, tasteless gas that is produced by the breakdown (radioactive decay) of naturally occurring uranium. Outdoors, radon is harmlessly diluted by the atmosphere. However, in enclosed places like homes and buildings, radon can accumulate to unacceptable levels.

Is There A Health Risk?

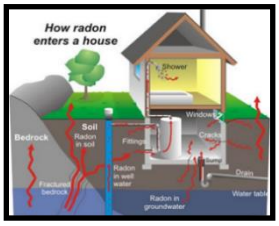


Radon gas decays into radioactive particles that can become trapped in your lungs. As these particles break down further, they release small bursts of energy that can damage lung tissue. Many years of exposure to elevated radon levels can lead to an increased risk of lung cancer.

How Common Is Radon?

The EPA has estimated that 7% of all homes in the United States have radon levels that need corrective action. Indoor elevated radon levels have also been found in almost every country in the world as well. No area in the world is considered radon free.

How Does Radon Enter a Building?



Radon gas comes from uranium in the soil and bedrock. Wherever air and moisture seep in through drains, joints, cracks, and pores in the foundation and exterior walls, radon can enter your building. If the building shell is tight, the radon can become trapped and reach unacceptable levels.

Am I being Exposed to Radon?

The only way to know if elevated radon levels are present is to test.

Why Is the Navy Testing for Radon?

The health of its military personnel, their dependents, and employees is a primary concern of the Navy. When various medical studies showed that radon could be a potential health risk, the Navy developed a program called the Navy Radon Assessment and Mitigation Program (NAVRAMP) to identify and manage radon at all naval installations worldwide.

How Is the Navy Going to Test?

For this radon testing project, the Navy has selected the Alpha Track Radon detector. This detector emits no noise, emits no harmful chemicals, and requires no special attention. It only needs to be left undisturbed. If the detector is moved or falls down during the test period, please return it to its original location and contact the program point of contact listed below.

How Long Will the Test Period Last?

Depending on the local climate, the test could last up to 1 year.

How Soon Will the Navy Fix the Problem?

If a problem is found, the Navy will take corrective action in accordance with NAVRAMP and published US Environmental Protection Agency (EPA) guidelines. Depending on the radon concentration, corrective action will be taken within a few months to a few years.

What Can I Do?

Provide the Navy access to your residence or work place for testing. Leave the radon detectors undisturbed. Inform your local Environmental Office if any issues arise.

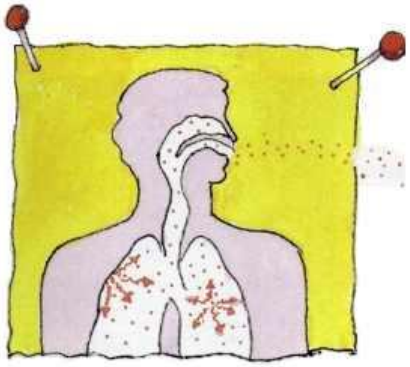
Whom Do I Call For More Information?

For more information about radon, please contact your local Environmental Office at Phone Number.

RADON FACT SHEET FOR FAMILY HOUSING STAFF

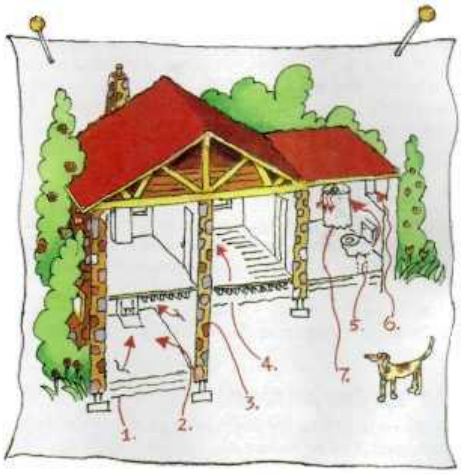
What Is Radon?

Radon is a naturally occurring, odorless, colorless, radioactive gas caused by the breakdown of uranium. Because uranium is found in varying amounts throughout the Earth's crust, detectable quantities of radon have been measured throughout the world. Chemically, radon is inert, meaning that it is harmless. However, when radon undergoes radioactive decay, its subsequent products attach to dust particles that can be inhaled and deposited into the lungs. If the concentration of these radioactive particles is high enough, and if a person is exposed for a long enough period of time, an increased lifetime risk of contracting lung cancer will result. According to the US Environmental Protection Agency (EPA), radon exposure is the number 2 cause of lung cancer in the US population behind smoking. However, EPA states that, if a home with elevated radon levels can be identified and corrective action taken, the lifetime risk for contracting lung cancer for the resident is significantly reduced. This is analogous to the cancer risk reduction observed when someone quits smoking.



How Does Radon Enter a Housing Unit?

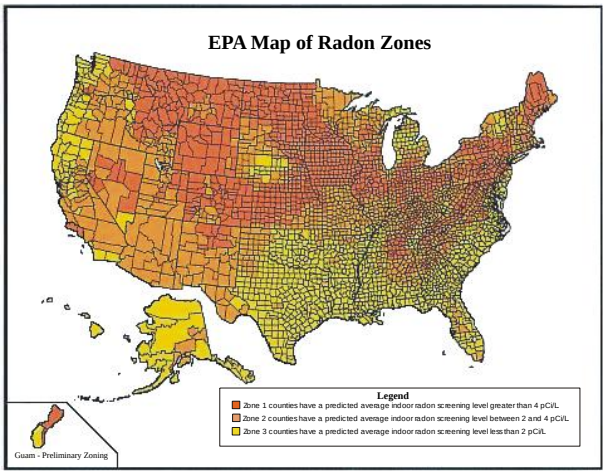
Radon enters a housing unit by migrating from the surrounding soil through holes in the foundation, cracks in concrete slabs and basement cinder blocks, and air spaces around pipes. Radon can also collect in crawl spaces and then flow into living and work areas. Once radon enters the living space, the building shell acts as a trap that collects radon; and under certain conditions radon may build up to unacceptable levels.



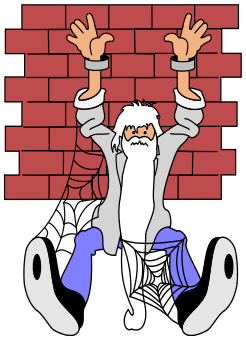
Because radon is naturally occurring, it exists in small concentrations in the air that we breathe. So, unlike other environmental hazards found in family housing (e.g., lead paint and asbestos), radon cannot be permanently removed. However, with the installation and proper maintenance of a radon mitigation system, radon levels can be controlled for the remaining life of the unit.

How Common Are Elevated Radon Levels?

Because radon comes from uranium, which is found naturally in varying amounts throughout the Earth's crust, elevated radon levels have been found in all 50 states of the United States, Guam, Europe, and Asia. Because you cannot see, smell, or taste radon, the only way to know if it is present in a home or other building is to test. Within the United States, EPA estimates that 14% of all homes have elevated radon levels.



Is Radon Regulated?



Radon is not regulated at the federal level. With the noted exception of the *Indoor Radon Abatement Act of 1988* (IRAA), which states only federal agencies assess the extent of radon contamination in buildings within their jurisdiction, there are no requirements. However, the Navy and Marine Corps are concerned about radon exposure in family housing and have developed the Navy Radon Assessment and Mitigation Program (NAVRAMP) to protect military personnel, their dependents, and employees from the health risks associated with radon exposure.

What is the Objective of NAVRAMP in Family Housing?

Simply stated, the objective of the NAVRAMP is to

1. Test all testable Navy and Marine Corps family housing units worldwide
2. Mitigate the homes identified as having levels of elevated radon
3. Retest after every significant renovation for the remaining lifetime of the housing unit

How Do We Test for Radon?

Because radon is odorless, colorless, and tasteless, special monitors and detectors are needed to find it. A detector emits no noise, emits no harmful chemicals, and requires no special attention. It only needs to be left undisturbed. If the detector is moved or falls down during the test period, please return it to its original location.

How Long Will the Radon Testing Last?

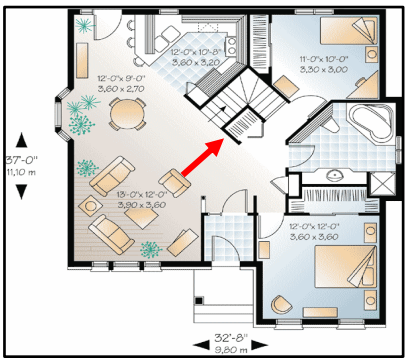
Radon levels in some homes are known to vary significantly from season to season. To ensure all homes with elevated radon levels are identified, NAVRAMP prefers to test for a whole year. However, as circumstances dictate, shorter test periods can be used.

Are Radon Levels the Same for All Housing Units Within a Neighborhood?

No. Because of small differences in construction and in the geology beneath each unit, no two units will have the same radon level. As a matter of fact, even in multifamily housing, sizeable differences may exist between adjacent units. The only way to know a unit's radon level is to test for it. For this reason, NAVRAMP tests **all units** in ground contact.

How Many Testing Locations Are in a Housing Unit?

In most cases, only one sample location is needed in a family housing unit. However, large homes or homes with basements may need two or more locations.



Where Will the Radon Detectors Be Placed?

The radon detectors will be placed 6–8 ft. from the floor, in ground contact, centrally located, but not in an enclosed room. Typical rooms for radon detector placement are a central hallway, living or great room, and dining room. Radon detectors cannot be placed in closets, bathrooms, or pantries.

What Are the Action Levels?

The EPA has established 4 picocuries per liter of air (4 pCi/L) as the radon action level, but EPA currently does not provide a timeline for corrective action. However, the Navy Bureau of Medicine and Surgery (BUMED) has reviewed the risks and has provided acceptable corrective action timelines for NAVRAMP.

NAVRAMP corrective action schedule

Radon levels (pCi/L)	NAVRAMP recommended actions
0 to <4	No action required
4 to <20	Mitigate within 2 years
20 to <200	Mitigate within 6 months
≥200	Mitigate within 3 weeks

How Do You Fix a Home with Elevated Radon Levels?

A variety of proven methods are used to reduce radon in existing homes. In some cases, passive mitigation, which involves the sealing of cracks in floors and walls, may help to reduce radon. However, in most cases, an active form of mitigation will be needed. Typical examples are shell pressurization (SP), subslab depressurization (SSD), and submembrane depressurization (SMD). SP, the oldest radon mitigation method, retards radon entry by mechanically introducing sufficient outdoor air to induce a positive pressure across the slab and into the soil. For buildings with slabs or basements, SSD is a common means of radon control. This method uses a pipe that is inserted through the slab, with a fan connected to the pipe. When the fan is activated, the area beneath the slab (subslab) is depressurized. The resulting depressurization prevents radon entry into the living area by redirecting the subslab radon into the pipe for discharge into the atmosphere, where it is harmlessly diluted. In buildings with crawl spaces, SMD is usually used. A polymeric membrane, such as a plastic sheet, is placed on the floor of the crawl space and a fan is used to depressurize underneath the membrane. The radon is then collected and discharged into the atmosphere away from the building. Post-entry mitigation involves the treatment of the contaminated air inside the building. Energy recovery ventilation involves the exchange of contaminated indoor air with fresh, uncontaminated outdoor air.

Which Radon Reduction Method Is the Best?

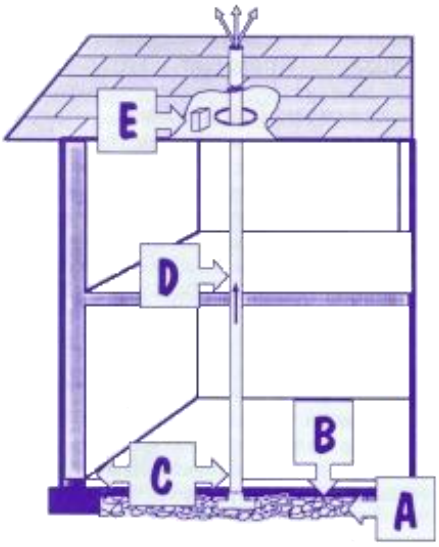
Studies conducted by COMNAVFACENGCOM have found that within Navy Family Housing, SSD would be the most economical radon reductive measure in the long term. However, because of variations in housing types, other radon mitigation methods may be more suitable. To assist in the selection of a mitigation method, a series of scientific tests called “diagnostics” are performed before method mitigation selection and installation.

What Happens after a Radon Mitigation System is Installed?

Radon mitigation does not permanently remove radon from a home; it only maintains it at a more acceptable level. After a system is installed, if it fails, the radon will return to the previous unmitigated levels. Therefore, after the system is installed, a certain level of operation and maintenance (O&M) is required for the remaining lifetime of the unit. The interval for O&M will depend upon the type of mitigation system and will involve inspection by the residents, local maintenance staff, and qualified radon professionals. For all housing with radon mitigation systems installed, NAVRAMP requires periodic inspection and retesting every 2-3 years.

What About New and Replacement Unit Construction?

If you already know you have elevated radon levels at your installation, it is required that you incorporate passive mitigation measures into all new and replacement unit construction. For an average cost of $350 to $500 per unit, you can take the following five simple steps to deter radon from entering your new units:



A. Install a 4-in. layer of clean gravel (½ to ¾ in.) beneath the slab or flooring system.
B. Lay polyethylene sheeting on top of the gravel layer.
C. Seal and caulk all openings in the concrete foundation and floor to reduce soil gas entry into the home.
D. Install a 4-in., SCH 40 PVC pipe (commonly used for plumbing) from the gas-permeable gravel layer through the house to the roof to safely vent radon and other soil gases above the house. Leave the top of the pipe open.
E. Install an electrical junction box in case an electric venting fan is needed later.

These construction techniques will be familiar to your designers and builders. There is no need to hire a special contractor or architect.

Can Renovations Impact the Radon Level Within a Home?

Yes, studies have shown that renovations that reduce the natural ventilation rate of a building (e.g., envelope weatherization) can result in an increase in radon levels. Increased radon levels may also occur when housing units are converted from outdoor heating and air-conditioning units to interior package units. For these reasons, NAVRAMP requires retesting of all renovated family housing units after renovations have been completed.

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RADON RISK COMMUNICATION PLAN GUIDANCE TEMPLATE

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Radon Risk Communication at Navy Installations (Guidance Template)

September 2021

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CONTENTS

Acronyms and Abbreviations

CO	Commanding Officer
DON	Department of the Navy
FAQs	Frequently asked questions and answers
NAVFAC	Naval Facilities Engineering Command
NMCPHC	Navy and Marine Corps Public Health Center
MHPI	Military Housing Privatization Initiative
NDAA	National Defense Authorization Act
OSHA	Occupational Safety and Health Administration
PPV	Public Private Venture
USEPA	U.S. Environmental Protection Agency

1. PURPOSE/STATEMENT OF INTENT

This document is designed to provide Navy Environmental Staff with recommendations for notifying and relaying information regarding radon testing, monitoring and mitigation to Installation personnel and potentially affected occupants of industrial, office, or residential buildings.

This document provides a framework for effective radon risk communication planning, and includes:

- Purpose
- Background
- Objectives of Radon Risk Communication
- Audience and Stakeholders
- Roles and Responsibilities
- Key Messages
- Communication Strategy

This information should be considered when developing an installation specific radon Risk Communication Plan (RCP). It is important to start the risk communication process and develop an RCP prior to radon testing during the planning phase. Note that a more comprehensive RCP will be necessary once radon testing results become available. The objective of the communication plan is to be open and transparent throughout the notification process with all potential stakeholders. The radon Risk Communication Plan should begin by identifying the stakeholders, and then the purpose of the plan to the stakeholders.

Ensuring safety, health, and environmental protection are important to Department of the Navy (DON) officials. Navy environmental staff should use this guidance to assist project teams and Installation officials with communicating plans and results of radon testing or monitoring and potential future actions in a timely and responsible manner.

The purpose is to ensure all stakeholders are informed and understand the purpose for initiating radon testing, what the sampling process is, how long it will take, and what to expect in terms of sharing results and other actions that may be necessary based on those results.

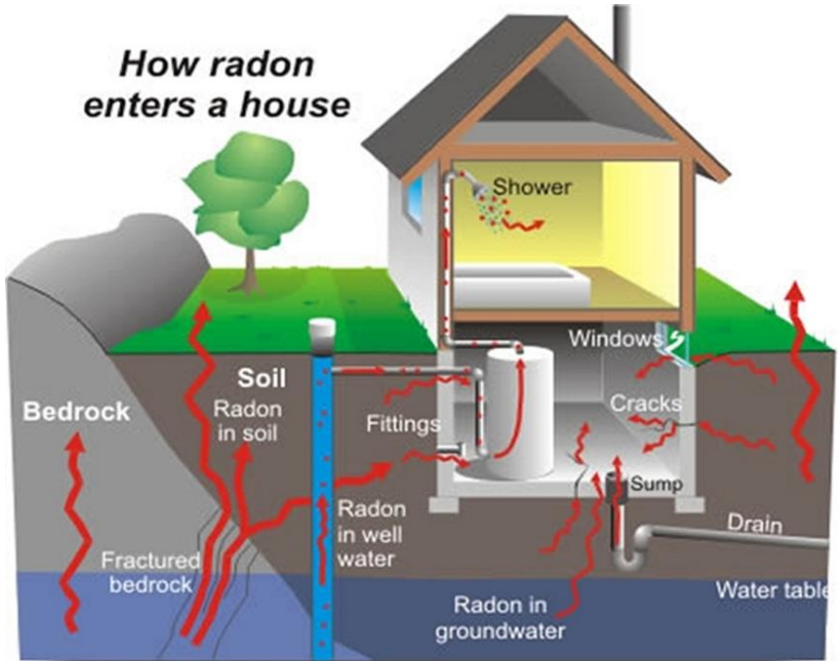
2. BACKGROUND

The Radon RCP should provide general radon background information to the intended audience similar to what is shown below.

Radon is a naturally occurring, odorless, colorless radioactive gas that is released from rock, soil, and water as part of the natural decay of uranium. Radon is a naturally occurring environmental pollutant and is not the result of Navy activities past or present at the installation. Although radon levels in outdoor air pose a relatively low threat to human health, indoors, radon can accumulate to dangerous levels. Exposure to indoor radon is the second leading cause of lung cancer in the United States and the number one cause among nonsmokers. The EPA estimates that radon causes

more than 20,000 lung cancer deaths in the United States each year. Only smoking causes more lung cancer deaths.

Although elevated indoor radon can come from water supplies or building materials, almost always, the problem comes from radon emanation from the soil under or surrounding a building. The reason is that radon is chemically inert (it does not interact with other substances), so it can usually move unhindered through 3 – 6 feet of soil. Once in contact with building components in soil contact (e.g., slab, foundation, wall, crawlspace), it can easily enter into the building through cracks or openings and in some cases, diffuse through pores in concrete masonry units or even through solid concrete. It is important to note that after radon enters the building from the soil, many factors influence its buildup and retention. Building design, usage, air change rate (a measure of the ventilation rate within a building), occupancy pattern, building shell pressure (buildings under negative pressure typically increase radon entry), and type and operational patterns of a building's heating, ventilation, and air-conditioning (HVAC) system have all been shown to affect radon levels within a building. Because none of these building factors, including the radon soil gas concentrations under the building, can be accurately estimated, the only way to know for sure if radon is present at unacceptable levels is to test.



In the United States, radon is measured in picocuries per liter of air (pCi/L). EPA and the Centers for Disease Control and Prevention recommend that corrective actions be taken at 4 pCi/L or higher.

Radon exposure represents about 37% of the annual radiation dose for a typical US citizen. As a result, exposure to indoor radon is the second leading cause of lung cancer in the United States and the number one cause among nonsmokers. Since the precursors of radon (i.e., uranium and thorium) are found to some extent in virtually all soil and rock formations worldwide, varying concentrations of radon gas in soil can be found as well. Given the right combination of radon soil

gas concentration, soil permeability, suitable entry pathways, and low indoor ventilation exchange rates, virtually every building in the world has some risk potential for elevated radon. Therefore, unlike the risks associated with lead-based paint or asbestos, the risk from radon exposure can never be removed—it can only be managed by taking appropriate measures. The only way to reduce the lung cancer risk from radon exposure is to test and, if appropriate, mitigate. If mitigation is required, diligence in the form of inspection, maintenance, and periodic retesting is essential to ensure long-term risk reduction.

3. OBJECTIVES OF RADON RISK COMMUNICATION

Environmental Staff and Installation officials should communicate plans and results of radon investigations in a timely and responsible manner from the outset of the project.

The objective of outreach efforts should be to increase knowledge and understanding of the health effects of radon exposure, the technical aspects of radon and the investigations being conducted including identifying subject matter experts to address questions and concerns commonly asked about health effects from radon exposure. Communication should allow for a two-way exchange of information between potentially affected building occupants and Installation personnel and environmental staff to identify questions and address concerns. This will help avoid potential confusion and misperceptions. It is important that information is conveyed clearly and concisely and that accurate and consistent information is shared with all stakeholders.

4. AUDIENCE AND STAKEHOLDERS

Stakeholder identification is the first step to developing an effective communication strategy. The primary objective of this step is to help ensure that potentially affected individuals or groups are informed and that messages are tailored to their level of knowledge and to specifically address their concerns and issues.

Everyone potentially affected by a radon exposure issue is a stakeholder. This typically includes building occupants as well as those responsible for developing a communication plan and communicating the information. Key personnel to engage may vary Installation to Installation and building to building.

In the plan, identify the primary Points of Contact (POC) for the intended audience. Include the following information for each primary POC: command, name, phone number and email address, role and responsibility regarding the radon testing or mitigation.

Examples of primary POCs include: key radon project team member on the environmental staff, Public Affairs Officer (PAO), Environmental Director, Radon Program Manager, Medical Authority, and the Radiation Health Officer.

Secondary POCs are the people that are typically contacted first by interested parties and may include: housing staff, dependent school principals, building managers, and command occupational safety and health (NAVOSH) officers. The RCP should be given to them and include the Frequently Asked

Questions (FAQs) list and provide contact information for questions which arise that are not included in the list.

The plan should also identify the installation Subject Matter Experts (SME). No matter how detailed and expansive the FAQs list may be, unanticipated questions always arise. A plan on how to address these questions in a timely manner is critical to establishing trust and credibility in the risk communication process.

The Primary Audience for risk communication is those individuals who are immediately impacted by the radon testing and may include:

- Workforce (active duty, civil service, local, national, contractor personnel and families)
- Dependent schools/CDC (staff, students, parents)
- On-installation Support Site residents (family housing, TLA, barracks)
- On-installation residents (NGIS, barracks)

The Secondary Audience is all interested parties and may include the following:

- Military leadership
- U.S. Consulate General
- Host-nation communities
- Unions
- Off-installation residents
- Media/Social
- Federal and State radon regulators
- Congress

A Tertiary Audience is interested in the outcome of the radon testing:

- Former community members
- Stateside audiences
- Other regional U.S. military installations

When developing the site-specific radon Risk Communication Plan, the first step is to identify:

- Chain-of-command responsible for the specific buildings and tenant commands affected. This includes all levels of management from the Installation Commanding Officer (CO) down to first level supervisors and occupants in each potentially affected building
- Installation Environmental Manager
- Installation NAVOSH Manager and PAO
- Environmental counsel
- Local human resources and/or union representatives
- Military Treatment Facility Public Health (Occupational Medicine, Industrial Hygiene) and Radiation Health Officer (local Navy hospital or branch medical clinic)
- For residences, the property occupant is a primary stakeholder and housing office approval is required before conducting any radon-related activities.

Environmental staff and key installation officials must understand their role in communicating radon exposure information to building occupants and other stakeholders. Roles and responsibilities of key personnel and Installation officials include:

- Installation CO – approves RCP and makes risk management decisions regarding building occupants
- Environmental staff and Installation Environmental Manager – provide radon SME support to all stakeholders and coordinate all aspects of investigations and communication efforts.
- Installation NAVOSH Manager– provide workplace safety subject matter expertise
- PAO (Installation and/or NAVFAC) – approves official outreach materials and coordinates media and public communications
- Environmental Counsel – advises Installation CO regarding liabilities and legal implications of risk management decisions
- Local human resources and/or union representatives – provide subject matter expertise for employee rights and coordinate outreach efforts with union employees
- Military Treatment Facility Public Health (Occupational Medicine, Industrial Hygiene) and Radiation Health Officer (local Navy hospital or branch medical clinic) – provide subject matter expertise for communicating potential exposures and health affects

5. KEY MESSAGES

The underlying objective of any risk communication is either to exchange information or convey a message. Developing key messages ensures consistency of information and helps prepare the DON officials to communicate with one voice to stakeholders. Key DON representatives should keep each other informed to ensure key messages remain current and statements or actions are consistent at all times. Good key messages provide a balance between giving people so much data and technical information that they are overwhelmed and oversimplifying information so much that important details are left out.

The first step in developing key messages is to identify information stakeholders typically want to know, information commonly misunderstood, and information the DON should provide. A list of FAQs is included as Appendix B of this document. This list of FAQs has been documented over the years and is based upon actual experiences implementing NAVRAMP at DON installations.

Stakeholders will generally want to know about radon, so providing information to address the following questions will be necessary:

- What is radon?
- Why is a radon investigation being conducted now and why not before now?
- How will the radon investigation affect my daily routine?
- When will the results be available?
- What do the results of the radon study mean?
- Has/will my health be affected by radon?

DON staff should convey the following information to the audience and stakeholders during risk communication for radon testing:

- DON POCs
- Assurance to occupants that their safety is the DON's first priority
- Assurance that the DON will be proactive and take immediate action to protect human

health
- Explanation of technical information
- Transparency of on-going radon planning, results and actions

Effective key messages should be developed using simple sentence structure and everyday language, and should focus on conclusions and actions. Effective key messages include two to three main ideas or themes that are used to address a variety of questions or concerns.

Additional guidance on key message development is available in *Risk Communication Primer Tools and Techniques* [Navy Marine Corps Public Health Center (NMCPHC)], https://www.med.navy.mil/Navy-Marine-Corps-Public-Health-Center/Environmental-Health/Environmental-Programs/Risk-Communication/

Here are examples of some key CORE (TOP-LINE) MESSAGES:

- We are committed to providing a safe and healthful working and living environment for our people.
- Our stringent health, safety and environmental standards help to ensure the well-being of our workforce and families.
- Our mission is to provide effective and efficient support to the warfighter, our civilians, their families, and our contractors and host nationals.

6. COMMUNICATION STRATEGY

The communication strategy identifies how the information will be disseminated to the audience and stakeholders. Don't wait until the last minute to decide how to provide the radon test results. Proactively manage elevated radon in housing, child development center facilities, and dependent schools where elevated radon is found. Team building is essential so consult in advance with installation medical, public affairs, and legal staff to coordinate activity.

Work with the PAO to develop a public affairs posture similar to the following example:

PUBLIC AFFAIRS POSTURE: ACTIVE. Communication will initially take place via installations' existing channels of communication. Direct engagement with external media will be conducted on an RTQ-only basis; however, indirect contact will be made through PAO Notes, installation news publications, and social media postings.

- Installation will inform community members via existing channels of communication (e.g., email, installation newspaper, social media, AFN TV/radio, etc.).
- Installation will inform affected housing residents and tenants of workspaces via face-to-face meetings and letters.
- Community feedback will be closely monitored and assessed for communication strategy refinement.

In addition, the PAO should have a communication strategy to refer people to which covers basic radon information, the public affairs posture, key messaging, any public statement information, FAQs, and a PAO POC list at the installation.

The communication plan should also provide a timeline and strategy for communicating key events as the process develops. The strategy should identify key objectives (i.e. sharing data analysis) and how those objectives will be communicated to the intended audience and stakeholders.

Another part of the communication strategy is to develop Installation Commanding Officer talking points. These talking points should provide a snapshot overview of key information along with some basic background information on radon.

Other items to consider in the communication strategy include: news releases, PAO notes, a sample letter to give residents, a thorough POC list, and the project timeline.

The basic communication process for residential buildings is similar to the process for industrial/occupational buildings, but communicating with residents poses additional challenges because of the following:

- Questions regarding relocation are more likely
- Potentially sensitive populations (children, elderly, sickly, etc.) may be present
- Greater exposure potential (24 hours / day) exists
- For PPV residences, the PPV agreement will require the PPV Limited Liability Company to manage any radon testing and mitigation in accordance with Federal, State, and local radon regulations

When dealing with a residence, the property occupant is a primary stakeholder and housing office approval is required before conducting any radon related activities. In residential areas, it is critical to notify residents anytime activities are occurring in the neighborhood to avoid confusion, fear, and anger. Additional time for coordination and approval should be considered when planning and scheduling radon testing.

If a public meeting is part of the communication strategy, consider hosting an "open-house" style meeting with poster stations manned by subject matter experts instead of the more traditional "town hall" style meeting with formal speakers followed by a public question and answer session.

More information on public meeting formats is *Risk Communication Primer Tools and Techniques* (NMCPHC), https://www.med.navy.mil/Navy-Marine-Corps-Public-Health-Center/Environmental-Health/Environmental-Programs/Risk-Communication/

7. REFERENCES AND RESOURCES

NAVFAC Atlantic and NAVFAC Pacific are available to provide technical support for radon testing and mitigation projects. The NMCPHC is available to provide risk communication, risk assessment, toxicology, and occupational health and industrial hygiene support. Sample Installation RCPs and frequently asked questions (FAQs) are provided as Enclosures 1 and 2 respectively. Enclosure 1 includes a sample installation RCP for development prior to starting radon testing and an example RCP that would be useful prior to the collection of radon detectors and the analysis of testing results.

Additional resources include:

- *WHO Handbook on Indoor Radon A Public Health Perspective* 2009: https://www.who.int/publications/i/item/9789241547673
- EPA Citizens Guide to Radon: https://www.epa.gov/radon/publications-about-radon
- *Navy Radon Assessment and Mitigation Program Guidance Document for Navy Family Housing*, September 10, 2002
- *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations*, June 6, 2015
- *Chief of Naval Operations (OPNAV) Environmental Readiness Program Manual*, OPNAV M-5090.1, Chapter 25, Section 3.2, Department of the Navy, 25 June 2021.

ENCLOSURE 1

Sample Installation Radon Risk Communication Plan(s)

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EXAMPLE
COMMUNICATION PLAN

For use prior to
PLACING
Radon Detectors

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Example Communication Plan – For Use Prior to Placing Radon Detectors
Installation Radon Study
Last Updated: Enter Date

BACKGROUND:

Starting in (enter date), (installation name) will place radon detectors (called alpha-track detectors) in buildings as part of a Navy-wide program to test indoor concentrations of radon gas at its installations. The detectors will be placed in Navy facilities at (list building locations). Per OPNAV 5090.1D (Environmental Readiness Program Manual), Navy installations are required to conduct testing for radon. To complete this, radon detectors are left in place for a one-year time period. Radon testing at (installation) was last conducted in (enter year if applicable and use last two sentences of this section only if historic testing was completed). Because base infrastructure (or other reason) has changed since that time, a new study was initiated.

OBJECTIVES:

To ensure all stakeholders are informed and understand the purpose for initiating radon testing, what the testing process is, and what to expect in terms of sharing results and other actions that may be necessary based on those results.

AUDIENCE:

The Primary Audience for risk communication is those individuals who are immediately impacted by the radon testing and may include:

- Workforce (active duty, civil service, local, national, contractor personnel and families)
- Dependent schools/CDC (staff, students, parents)
- On-installation Support Site residents (family housing, TLA, barracks)
- On-installation residents (NGIS, barracks)

The Secondary Audience is all interested parties and may include the following:

- Military leadership
- U.S. Consulate General
- Host-nation communities
- Unions
- Off-installation residents
- Media/Social media
- Federal and State Radon Regulators
- Congress

A Tertiary Audience is interested in the outcome of the Radon testing:

- Former community members
- Stateside audiences
- Other regional U.S. military installations

STRATEGY:

- (Enter Installation) will inform community members via existing channels of communication (e.g., email, base newspaper, social media, AFN TV/radio, etc.).
- (Enter Installation) will inform affected housing residents and tenants of workspaces via face-to-face meetings and letters.
- Community feedback will be closely monitored and assessed for communication strategy refinement.

ASSUMPTIONS:

- The process for installing radon detectors will have minimal impact on affected community members and facilities.
- Radon detectors will be installed (enter date).
- Radon test results will be inconclusive until the detectors are collected after a one-year period and the data is analyzed. Radon collection to start (enter date) and results are anticipated (enter date).
- The scope and purpose of radon testing at (enter installation) have the potential to generate interest due to (list reason).

PUBLIC AFFAIRS POSTURE: ACTIVE. Communication will initially take place via (enter installation) existing channels of communication. Direct engagement with external media will be conducted on an RTQ-only basis; however, indirect contact will be made through PAO Notes, Base Newspaper, All Hands emails, and social media postings.

CORE (TOP-LINE) MESSAGES:

- We are committed to providing a safe and healthful working and living environment for our people.
- Our stringent health, safety and environmental standards help to ensure the well-being of our workforce and families.
- Our mission is to provide effective and efficient support to the warfighter, our civilians, their families, and our contractors and host nationals.

Appendix A: Public Affairs Guidance
Appendix B: Radon Gas FAQ (for RTQ only)
Appendix C: CO Talking Points
Appendix D: PAO Note
Appendix E: Housing Resident Letter
Appendix F: Primary Points of Contact

APPENDIX A: PUBLIC AFFAIRS GUIDANCE

Public Affairs Guidance
Radon Testing
Last Updated: (Enter Date)

1. Background (not for public release):
1.1 On (enter date) (enter installation) will begin a radon assessment, as part of a Navy-wide program to test indoor concentration levels for radon gas.

1.2 Radon is a colorless, odorless, tasteless gas that is produced by the radioactive decay of naturally occurring uranium and thorium found in soils and rocks such as granite and shale. Radon is present in outdoor air at an average concentration of 0.4 picocuries per liter (pCi/L) in the U.S., and is deemed by the U.S. Environmental Protection Agency (EPA) as relatively harmless at this level. However, radon gas exposure at high concentration levels for extended periods of time can potentially damage lung tissue and lead to an increased risk of lung cancer. Radon can be found at elevated levels in basements and ground level spaces of buildings or homes.

1.3 Per OPNAVINST 5090.1D, Navy installations are required to test for radon. Personnel from the (enter installation) Environmental Division will install detectors (enter date). Once detectors are installed, after the testing period (enter time frame) and analysis of those detectors is completed, mitigation measures will be enacted at rooms and/or facilities found to have radon concentration levels exceeding 4 pCi/L, the EPA and Navy action level.

1.4 Radon testing was previously conducted at (enter installation) in (enter dates if applicable). Because base infrastructure has changed since that time a new study was initiated (Use 1.4 only if historic data is available).

2. Public Affairs Posture:
2.1 The Public Affairs posture for the rollout of radon testing at (enter installation) is ACTIVE.

2.2 (enter installation) CO will inform all tenant commands of the installation of the detectors and again when test results are received via existing channels of communication (e.g., meeting, email, base newspaper, social media, AFN TV/radio, etc.).

2.3 Media questions outside the scope of the public statements should be forwarded to the (enter installation) Public Affairs POC listed in paragraph 7.

3. Key Themes and Messages:
Safe Environment: We are committed to providing a safe and healthful working and living environment for our people.

Precautionary Action: If we identify unsafe working or living conditions, we will address them as quickly as possible.

Low Impact: Personnel from the (enter installation) Environmental Division will install radon detectors with minimal disruption to tenants and community members.

4. Public Statements:
The statements provided in Appendices D-G of the Comm Plan are authorized for release by (enter installation) Public Affairs to community members.

5. Questions and Answers (Media):

*******Note: A historical list of common radon-related questions and answers are addressed as Appendix B of the Communication Plan (See Enclosure 2 of this Radon Risk Communication Plan Guidance Template for a detailed historic list of questions and answers).***

6. Miscellaneous Information:

6.1 Upon (enter installation) release of the public statement, (installation) public affairs organizations are highly encouraged to repurpose the released statement (only) on social media, and AFN TV/radio.

6.2 (Installation) PAO will monitor community feedback during initial phases of the execution plan to assess the need to refine communication and outreach efforts.

7. Points of Contact: (List PAO POCs)
7.1
7.2
7.3

APPENDIX C: CO TALKING POINTS

- Beginning (enter date), we'll begin installation of detectors for a one-year testing period in order to collect data for the naturally occurring gas called radon.
- We're being pro-active with this monitoring and acting out of an abundance of caution.
    - Other Navy installations will complete radon testing in the future.
- Radon detectors – called alpha-track detectors –have been placed in Navy facilities at (list buildings).
- Last time we did this test in (enter installation) was in (enter dates) and the results were (enter results).
    - Support Site did not exist back then and neither did many of the buildings we currently use.
    - Exceedances were found in XX of the XX buildings that were studied in (enter dates). The concentration levels above the EPA action level ranged from XX.X to XX.X picocuries per liter (pCi/L).
    - All locations that had exceedances have been demolished, renovated, or are no longer in use.
- *Bottom line:* This comprehensive radon study for our current facilities is a good thing.
        - It enables us to ensure that we are providing a safe and healthful working and living environment for our people.
- Elevated indoor radon levels can be mitigated by properly ventilating spaces.

Background on radon:

Radon is a gas that is naturally occurring from rocks and soils.

- It's a colorless, odorless, tasteless gas that is produced by the radioactive decay of naturally occurring uranium and thorium found in soils and rocks such as granite and shale.
    - For instance, the uranium (found in soils throughout the world) decays into other elements, one of them being radon gas. The gas molecules work their way up through the soils and rock fissures to escape into our air.
- We breathe small concentrations of it every time we step outdoors, where it is relatively harmless.
    - [Analogy: Drop of water in the ocean.]
- Radon is present in outdoor air but may collect in basements or ground level spaces. Thus, indoor environments are commonly studied to determine whether radon is present at high concentrations.
- Long-term exposure to radon gas at high concentrations can potentially impact health over time.
- Wherever air or moisture seeps into building drains, joints, pores, cracks, foundations or exterior walls, radon levels can increase.

APPENDIX D: PAO NOTE

(Enter Date): (Enter Installation) to Install Indoor Radon Level Detectors
(Enter Installation) will install indoor radon gas detectors, beginning (enter date) as part of an ongoing Navy-wide program. Radon detectors, called alpha-track detectors, will be installed in (list buildings). The detectors will be placed in all basements and ground level indoor spaces inhabited at least four hours daily over the last year. Navy facilities in (enter installation) were last tested in (enter dates); however, the base infrastructure has since changed necessitating completion of a new test. For U.S. Environmental Protection Agency information on radon, go to https://www.epa.gov/radon/publications-about-radon . If you have questions, call the Environmental Office at DSN: (enter DSN – phone number).

APPENDIX E: HOUSING RESIDENT LETTER

Dear Housing Resident,

(Enter installation) is in the process of completing a one-year radon study. (Enter installation) is conducting this study as part of a Navy-wide program to meet U.S. Navy environmental requirements for identifying radon levels at current facilities.

Radon is a gas that is naturally occurring from rocks and soils. It is present in the outdoor air we breathe but may collect in basements or ground level spaces. Indoor environments are commonly studied to determine whether radon is present at high concentrations. Wherever air or moisture seeps into building drains, joints, pores, cracks, foundations or exterior walls, radon levels can increase. Long-term exposure to radon gas at high concentrations can potentially impact health over time. However, the majority of community members are only here for a relatively small portion of their lifetime, reducing the overall health risk. Natural ventilation is the most effective measure you can take to reduce the level of radon in your home. Open two or more windows to create airflow across a room periodically throughout the day.

The only way to know a radon concentration level is to test. Navy facilities in (enter installation) were last tested in (enter dates).

Personnel from the (enter installation) Environmental Division will install radon detectors, called alpha-track detectors, in all ground floor units with minimal disruption to residents. The radon detectors are much smaller than typical smoke detectors (approximately 2 inches in diameter by 1.5 inches in height) and have been placed near ceilings. The detectors will be installed in residences beginning (enter date). Specific dates for affected units will be posted.

Should the detectors fall from their original placement before their removal, please return them to the original location or contact the base's Environmental Office at DSN: (enter DSN – phone number).

The test results will be announced during (enter date). For U.S. Environmental Protection Agency information on radon, go to.
[END]

APPENDIX F: PRIMARY POINTS OF CONTACT

COMMAND	NAME	PHONE NUMBER	EMAIL
PAO			
Environmental Director			
Environmental Radon Program Manager			
NAVHOSP Public Health Director			
NAVHOSP Industrial Hygiene Officer			
NAVHOSP Radiation Health Officer			

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EXAMPLE
COMMUNICATION PLAN

For use prior to
COLLECTING
Radon Detectors

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Example Communication Plan – For Use Prior to Collecting Radon Detectors
Installation Radon Study
Last Updated: Enter Date

BACKGROUND:

Starting in (enter date), (installation name) will collect radon detectors (called alpha-track detectors) that were installed as part of a Navy-wide program to test indoor concentrations of radon gas at its installations. The detectors were placed in Navy facilities at (list building locations). Per OPNAV 5090.1D (Environmental Readiness Program Manual), Navy installations are required to conduct testing for radon. To complete this, radon detectors are left in place for a one-year time period. Radon testing at (installation) was last conducted in (enter year). Because base infrastructure (or other reason) has changed since that time, a new study was initiated.

OBJECTIVES:

To ensure all stakeholders are informed and understand the purpose for initiating radon testing, what the testing process is, and what to expect in terms of sharing results and other actions that may be necessary based on those results.

AUDIENCE:

The Primary Audience for risk communication is those individuals who are immediately impacted by the radon testing and may include:

- Workforce (active duty, civil service, local, national, contractor personnel and families)
- Dependent schools/CDC (staff, students, parents)
- On-installation Support Site residents (family housing, TLA, barracks)
- On-installation residents (NGIS, barracks)

The Secondary Audience is all interested parties and may include the following:

- Military leadership
- U.S. Consulate General
- Host-nation communities
- Unions
- Off-installation residents
- Media/Social media
- Federal and State radon regulators
- Congress

A Tertiary Audience is interested in the outcome of the Radon testing:

- Former community members
- Stateside audiences
- • Other regional U.S. military installations

STRATEGY:

- (Enter Installation) will inform community members via existing channels of communication (e.g., email, base newspaper, social media, AFN TV/radio, etc.).
- (Enter Installation) will inform affected housing residents and tenants of workspaces via face-to-face meetings and letters.
- Community feedback will be closely monitored and assessed for communication strategy refinement.

ASSUMPTIONS:

- The process for installing radon detectors will have minimal impact on affected community members and facilities. Radon detector installation was completed (enter date).
- Radon test results will be inconclusive until the detectors are collected after a one-year period and the data is analyzed. Radon collection to start (enter date) and results are anticipated (enter date).
- The scope and purpose of radon testing at (enter installation) have the potential to generate interest due to (list reason).

PUBLIC AFFAIRS POSTURE: ACTIVE. Communication will initially take place via (enter installation) existing channels of communication. Direct engagement with external media will be conducted on an RTQ-only basis; however, indirect contact will be made through PAO notes, base newspaper, all hands emails, and social media postings.

CORE (TOP-LINE) MESSAGES:

- We are committed to providing a safe and healthful working and living environment for our people.
- Our stringent health, safety and environmental standards help to ensure the well-being of our workforce and families.
- Our mission is to provide effective and efficient support to the warfighter, our civilians, their families, and our contractors and host nationals.

Appendix A: Public Affairs Guidance
Appendix B: Radon Gas FAQ (for RTQ only)
Appendix C: Plan Execution Matrix
Appendix D: CO Talking Points
Appendix E: News Article
Appendix F: PAO Note
Appendix G: Housing Resident Letter
Appendix H: Primary Points of Contact
Appendix I: Example Project Timeline for (enter installation)

APPENDIX A: PUBLIC AFFAIRS GUIDANCE

Public Affairs Guidance
Radon Testing
Last Updated: (Enter Date)

1. Background (not for public release):
1.1 On (enter date) (enter installation) began a radon assessment, as part of a Navy-wide program to test indoor concentration levels for radon gas.

1.2 Radon is a colorless, odorless, tasteless gas that is produced by the radioactive decay of naturally occurring uranium and thorium found in soils and rocks such as granite and shale. Radon is present in outdoor air at an average concentration of 0.4 picocuries per liter (pCi/L) in the U.S., and is deemed by the U.S. Environmental Protection Agency (EPA) as relatively harmless at this level. However, radon gas exposure at high concentration levels for extended periods of time can potentially damage lung tissue and lead to an increased risk of lung cancer. Radon can be found at elevated levels in basements and ground level spaces of buildings or homes.

1.3 Per OPNAVINST 5090.1D, Navy installations are required to test for radon. Personnel from the (enter installation) Environmental Division will collect detectors installed in the (enter date) timeframe. Mitigation measures will be enacted at rooms and/or facilities found to have radon concentration levels exceeding 4 pCi/L, the EPA and Navy action level.

1.4 Radon testing was previously conducted at (enter installation) in (enter dates if applicable). Because base infrastructure has changed since that time a new study was initiated.

2. Public Affairs Posture:
2.1 The Public Affairs posture for the rollout of radon testing at (enter installation) is ACTIVE.

2.2 (enter installation) CO will inform all tenant commands of the collection of the detectors and again when test results are received via a Tenant Commanders' Meeting and via existing channels of communication (e.g., email, base newspaper, social media, AFN TV/radio, etc.).

2.3 Media questions outside the scope of the public statements should be forwarded to the (enter installation) Public Affairs POC listed in paragraph 7.

3. Key Themes and Messages:
Safe Environment: We are committed to providing a safe and healthful working and living environment for our people.

Precautionary Action: If we identify unsafe working or living conditions, we will address them as quickly as possible.

Low Impact: Personnel from the (enter installation) Environmental Division will remove installed radon detectors with minimal disruption to tenants and community members.

4. Public Statements:
The statements provided in Appendices D-G of the Comm Plan are authorized for release by (enter installation) Public Affairs to community members.

5. Questions and Answers (Media):

***********Note: A historical list of common radon-related questions and answers are addressed as Appendix B of the Communication Plan (See Enclosure 2 of this Radon Risk Communication Plan Guidance Template for a detailed historic list of questions and answers).***

6. Miscellaneous Information:

6.1 Upon (enter installation) release of the public statement, (installation) public affairs organizations are highly encouraged to repurpose the released statement (only) on social media, and AFN TV/radio.

6.2 (Installation) PAO will monitor community feedback during initial phases of the execution plan to assess the need to refine communication and outreach efforts.

7. Points of Contact: (List PAO POCs)
7.1
7.2
7.3

APPENDIX C: PLAN EXECUTION

1. Purpose. This communication plan has been developed to identify methods that will be used to reach out to the community audiences in order to achieve the outlined objectives.

2. Sample Matrix:

DATE	EVENT/ACTION	SUPPORTED	SUPPORTING	TARGET AUDIENCE	NOTES
	CO announces collection of radon detectors	CO	Environmental	Tenant Commanders	
	News Article	Installation Name	PAO	Primary	See Appendix E for story shell. Story will be accompanied by detector imagery.
	Mention during CO's radio show.	CO/XO	PAO, AFN	Primary	See Appendix D for radio show talking points. Show may include SME.
	Publication of base note in (newspaper name)	Installation Name	PAO	Primary, Secondary	(Newspaper Name Article) is posted to Facebook.
	Assess community feedback and consider needed communication strategy refinement. Publication of base note in (newspaper name)	CONSA	PAO, Environmental, NAVHOSP, PAO	N/A Primary, Secondary	PAO will assess need for CO/SMEs to focus on issue during a quarterly town hall to be scheduled in (month). (New Article) is posted to Facebook.
	Study results released	CO	PAO, Environmental		
	Assess community feedback and consider needed communication strategy refinement.	CO	PAO, Environmental, NAVHOSP	N/A	PAO will assess need for CO/SMEs to focus on issue during a quarterly town hall to be scheduled in April.
	Study results released	COI	PAO, Environmental		

APPENDIX D: CO TALKING POINTS

- Beginning (enter date), we'll begin collection of radon detectors that have been in place during the last year for data collection of the naturally occurring gas called radon.
- We're being pro-active with this monitoring and acting out of an abundance of caution.
    - Other Navy installations will complete radon testing in the future.
- Radon detectors – called alpha-track detectors –have been placed in Navy facilities at (list buildings).
- Last time we did this test in (enter installation) was in (enter dates) and the results were (enter results).
    - Support Site did not exist back then and neither did many of the buildings we currently use.
    - Exceedances were found in XX of the XX buildings that were studied in (enter dates). The concentration levels above the EPA action level ranged from XX.X to XX.X picocuries per liter (pCi/L).
    - All locations that had exceedances have been demolished, renovated, or are no longer in use.
- *Bottom line:* This comprehensive radon study for our current facilities is a good thing.
        - It enables us to ensure that we are providing a safe and healthful working and living environment for our people.
- Elevated indoor radon levels can be mitigated by properly ventilating spaces.

Background on radon:

Radon is a gas that is naturally occurring from rocks and soils.

- It's a colorless, odorless, tasteless gas that is produced by the radioactive decay of naturally occurring uranium and thorium found in soils and rocks such as granite and shale.
    - For instance, the uranium (found in soils throughout the world) decays into other elements, one of them being radon gas. The gas molecules work their way up through the soils and rock fissures to escape into our air.
- We breathe small concentrations of it every time we step outdoors, where it is relatively harmless.
    - [Analogy: Drop of water in the ocean.]
- Radon is present in outdoor air but may collect in basements or ground level spaces. Thus, indoor environments are commonly studied to determine whether radon is present at high concentrations.
- Long-term exposure to radon gas at high concentrations can potentially impact health over time.
- Wherever air or moisture seeps into building drains, joints, pores, cracks, foundations or exterior walls, radon levels can increase.

APPENDIX E: SAMPLE NEWS ARTICLE

Naval Installation XXXX to Collect Radon Detectors *Naval Installation, Public Affairs Office*

Naval Installation XXXX, will begin collecting radon detectors to complete a one-year test of radon gas concentrations indoors as part of an ongoing Navy-wide program.

Personnel from the Installation's Environmental Division will collect radon detectors installed in Navy facilities at (list host and tenant commands). They have been placed in basements and ground-level indoor spaces inhabited at least four hours daily over the last year.

The radon detectors, called alpha-track detectors, were placed starting at the end of (insert month and year) and finished by (insert month and year).

"In order to account for seasonal changes, radon detectors will be collected in (insert month and year), one year from the time they were installed," said XXXXX, the base environmental director.

Radon is a gas that is naturally occurring from rocks and soils. It is present in outdoor air but may collect in basements or ground level spaces. Indoor environments are commonly studied to determine whether radon is present at high concentrations.

Long-term exposure to radon gas at high concentrations can potentially impact health over time. Testing is the only way to know the indoor radon concentration in a building.

Navy facilities in XXXXX were last tested in (enter dates), but the base infrastructure has since changed necessitating the completion of this new study.

[Proposed] "The last time we tested, (enter command) did not exist and the administrative activities currently here at (enter location) were located in (enter location)," said XXXX. "The Navy's footprint at (enter location) was significantly smaller. Back then, (enter command) main function was to support flight and logistical operations."

[Proposed] "If we find an issue in any of our spaces, we will work to correct it as soon as possible," said XXXX. "Elevated indoor radon levels may be mitigated by adding or adjusting ventilation to spaces or upgrading building foundations."

Results from the study are not expected to be available until (enter date). Naval Installation XXXX will publish the results.

For U.S. Environmental Protection Agency information on radon, go to https://www.epa.gov/radon/publications-about-radon . Call the Environmental Office at DSN: (enter DSN) or (enter phone number) if you have questions.

APPENDIX F: PAO NOTE

(Enter Date): (Enter Installation) to Collect Indoor Radon Level Detectors
(Enter Installation) will collect indoor radon gas detectors, beginning (enter date) as part of an ongoing Navy-wide program. Radon detectors, called alpha-track detectors, will be collected in (list buildings). The detectors have been placed in all basements and ground level indoor spaces inhabited at least four hours daily over the last year. Navy facilities in (enter installation) were last tested in (enter dates); however, the base infrastructure has since changed necessitating completion of a new test. For U.S. Environmental Protection Agency information on radon, go to https://www.epa.gov/radon/publications-about-radon . If you have questions, call the Environmental Office at DSN: (enter DSN – phone number).

APPENDIX G: HOUSING RESIDENT LETTER

Dear Housing Resident,

(Enter installation) is in the process of completing a one-year radon study. (Enter installation) is conducting this study as part of a Navy-wide program to meet U.S. Navy environmental requirements for identifying radon levels at current facilities.

Radon is a gas that is naturally occurring from rocks and soils. It is present in the outdoor air we breathe but may collect in basements or ground level spaces. Indoor environments are commonly studied to determine whether radon is present at high concentrations. Wherever air or moisture seeps into building drains, joints, pores, cracks, foundations or exterior walls, radon levels can increase. Long-term exposure to radon gas at high concentrations can potentially impact health over time. However, the majority of community members are only here for a relatively small portion of their lifetime, reducing the overall health risk. Natural ventilation is the most effective measure you can take to reduce the level of radon in your home. Open two or more windows to create airflow across a room periodically throughout the day.

The only way to know a radon concentration level is to test. Navy facilities in (enter installation) were last tested in (enter dates).

Personnel from the (enter installation) Environmental Division will collect installed radon detectors, called alpha-track detectors, in all ground floor units with minimal disruption to residents. The radon detectors are much smaller than typical smoke detectors (approximately 2 inches in diameter by 1.5 inches in height) and have been placed near ceilings. The detectors will be collected from residences beginning (enter date). Specific dates for affected units will be posted.

Should the detectors fall from their original placement before their removal, please return them to the original location or contact the base's Environmental Office at DSN: (enter DSN – phone number).

The test results will be announced during (enter date). For U.S. Environmental Protection Agency information on radon, go to https://www.epa.gov/radon/publications-about-radon

APPENDIX H: PRIMARY POINTS OF CONTACT

COMMAND	NAME	PHONE NUMBER	EMAIL
PAO			
Environmental Director			
Environmental Radon Program Manager			
NAVHOSP Public Health Director			
NAVHOSP Industrial Hygiene Officer			
NAVHOSP Radiation Health Officer			

APPENDIX I: EXAMPLE PROJECT TIMELINE FOR (Enter Installation) RADON TESTING PROJECT

Date	**Event**	**Who**
March 20XX	PWD discussion	PWO, Environmental, FMD, FEAD, APWO Support Site
March 20XX	Submit timeline to Region	PWO, Environmental
Mid-April 20XX to June	Comm Plan development	Environmental, LANT, PAO, Medical,
June 20XX	Pull detectors and send to analysis laboratory	Environmental, BUMED/DHA staff for Hospital
June to Aug 20XX-resample	If missing in housing-replace-for 3-month abbreviated test	Environmental
Aug 20XX	Medical update	
All dates pushed 3 months if resampling is required		
July 20XX	Engage facilities stakeholders for what ifs	DOD Schools, Real Estate, DECA, Hospital, Gaeta FOS, PWD FMD, Housing
September 20XX	Preliminary data	Radon subject matter expert (Radon SME) will alert Environmental if values above 4 pCi/L
October 20XX	Final results in excel spreadsheet	Radon SME
October 20XX	PAO to post on CNIC website; PAO Notes and Panorama article	PAO
October 20XX	Respond to questions	PWO, Medical
December 20XX	Final report with results and mitigation recommendations	Appropriate Stakeholders

ENCLOSURE 2

Frequently Asked Questions

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Navy Radon Assessment and Mitigation Program
Questions and Answers

Navy Policy and Guidelines

Q: Why is the Navy concerned about radon?
A: The health of its military personnel, civilians, and their families, is a primary concern of the Navy. When various federal and state studies showed that indoor radon could be a health risk, the Navy decided to start a program [Navy Radon Assessment and Mitigation Program (NAVRAMP)] to locate Navy buildings with elevated radon levels and correct and manage the problem as quickly as possible.

Q: What does NAVRAMP stand for?
A: **Nav**y **R**adon **A**ssessment **A**nd **M**itigation **P**rogram

Q: Where is Navy Radon Policy found?
A: The current Navy Radon Policy is established in Chief of Naval Operations (OPNAV) Environmental Readiness Program Manual, OPNAV M-5090.1, Chapter 25, Section 3.2, Department of the Navy, 25 June 2021.

Q: What does Navy radon policy require?
A: Navy radon policy requires that all Navy installations worldwide perform radon testing and, if needed, radon mitigation. If mitigation systems are installed, the policy also requires periodic inspection and preventive maintenance. The policy also requires where applicable that radon-resistant features be incorporated into new construction.

Q: How is the Navy radon program implemented?
A: Chief of Naval Operations (OPNAV) Environmental Readiness Program Manual, OPNAV M-5090.1, Chapter 25, Section 3.2, Department of the Navy, 25 June 2021.
, divides radon testing into three phases:

- Screening: Testing a statistically significant number of buildings determines the elevated radon potential of an installation.
- Assessment: All occupied buildings are tested at an installation with a known elevated radon potential.
- Monitoring: An ongoing testing process is conducted at installations with known elevated radon potential to ensure that buildings with radon mitigation systems are still working properly and that no new, renovated, or previously tested building develops an elevated radon problem in the future.

Q: What are the Navy radon action levels?
A: Consistent with the recommendations made by the Environmental Protection Agency (EPA), the Office of Naval Operations (OPNAV) establishes an annualized average of ≥4 pCi/L as the action level.

Q: If a building is ≥4 pCi/L for part of the year, but <4 pCi/L for the rest of the year, is mitigation required under Navy policy?

A: Consistent with EPA recommendations, the decision to take corrective action (e.g., mitigate) is based upon the annualized (1 year) result. If a 1- year test or data extrapolation finds radon ≥4 pCi/L, then yes. However, if the opposite is true, mitigation would not be required.

Q: What is the Navy policy timeline for corrective action?
A: With close consultation with the US Navy Bureau of Medicine and Surgery, the following corrective action schedule was developed:

Category	**Radon level** (pCi/L)	**Action** [a]
1	0 to <4	No action required
2	4 to <20	Mitigation within 2 years
3	20 to <200	Mitigation within 6 months
4	≥200	Mitigation within 3 weeks

[a] The schedule for corrective action (e.g., the mitigation clock) should be based upon the testing report date. In cases where confirmation is required, mitigation should be based upon the report date of the initial test.

Q: Are there written procedures for radon testing and mitigation within the Navy?
A: As required by OPNAV, Commander Naval Facilities Engineering Command has developed and distributed *Navy Radon Assessment and Mitigation Program Guidebook for Naval Shore Installations*, which addresses every facet of radon testing and mitigation for all shore installation buildings.

Q: Why are the Navy testing procedures slightly different from EPA and other radon industry standards?
A: For the most part, EPA and other industry standards were written to address radon testing within individual homes or small populations of buildings where, in the event of an elevated result, retesting is performed in most cases. However, in large testing populations, retesting can delay the implementation of possible corrective action, in some cases for years. Therefore, to reduce the overall risk to the population, the Navy decided to implement a quality assurance and quality control (QA/QC) program that greatly increases the probability of getting an accurate and defensible testing conclusion with a single set of measurements. Therefore, mitigation, if needed, can proceed without the need of further retesting.

Q: Is elevated radon found only in Navy buildings?
A: Elevated radon is not found just in Navy buildings. Buildings in surrounding civilian communities would have the same geological radon potential. In fact, the Navy reviews data collected by EPA, state and local governments, and host nations to prioritize installation testing worldwide. The EPA Map of Radon zones can be reviewed here: https://www.epa.gov/radon/epa-map-radon-zones

Q: Does NAVRAMP apply to all Navy installations worldwide?

A: Yes, and it also applies to leased buildings.

Q: Is the Navy responsible for radon testing in private-public venture housing, leased or international-use properties?
A: OPNAV affords the same level of protection from radon exposure to Navy personnel (including military, civilian, and dependents) who are occupying testable buildings that are not Navy-owned. However, consultation with appropriate legal counsel should occur first to determine who has the main responsibility for radon testing and mitigation (if applicable).

Q: At my previous assignment, radon was being managed differently. Does the Navy have different policies for each installation?
A: Implementation of NAVRAMP will vary from installation to installation depending upon what testing phase an installation is in (screening, assessment, or monitoring) and whether any elevated radon has been found.

Q: Why is the Navy not testing all the buildings at the installation?
A: Radon sampling at a given installation will depend upon what testing phase the installation is in (screening, assessment, or monitoring). In screening and monitoring at sites with no history of elevated radon, only selected types of buildings are chosen for testing. If elevated radon is found, then all buildings (assessment phase) will be tested for radon.

Q: Does NAVRAMP cover rental or private homes on the economy?
A: No. However, the Navy does encourage personnel who live off-base to test their homes. To find information about Local Radon Zones and State Contact Information, visit: https://www.epa.gov/radon/publications-about-radon

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Radon and Its Health Risks

Q: What is radon?
A: Radon is a colorless, odorless, tasteless gas that is produced by the breakdown (radioactive decay) of naturally occurring uranium found in rock, soil, and water. Outdoors, radon is harmlessly diluted by the atmosphere. However, in enclosed places like homes and buildings, radon can accumulate to unacceptable levels.

Q: How common is radon?
A: The EPA has estimated that nearly 1 out of every 15 homes in the U.S. is estimated to have elevated radon levels. Elevated radon has also been found in almost every country in the world. No area in the world is considered radon-free.

Q: What is the health risk from exposure to radon?
A: Exposure to elevated radon over many years can lead to an increased lifetime risk of contracting lung cancer. Radon is the number one cause of lung cancer among people who do not smoke. It is the second leading cause of lung cancer for people who do smoke. EPA estimates that radon causes more than 20,000 deaths from lung cancer each year in the United States. If you smoke and your home has a high radon level, your risk of lung cancer can increase even more.

Q: Are there any other health risks from exposure to indoor elevated radon other than lung cancer?
A: According to the EPA, there are no other known health risks from exposure to elevated radon in air.

Q: How do radon-induced lung cancer deaths compare with other cancer deaths in the United States?
A: Cigarette smoking is the most common cause of lung cancer. Radon represents a far smaller risk for this disease, but it is the second leading cause of lung cancer in the United States. Scientists estimate that 15,000 to 22,000 lung cancer deaths in the United States each year are related to radon.

Q: How do the lifetime risks from radon exposure compare with other lifetime risks?
A: According to the EPA, if 1,000 people who never smoked were exposed to 4 pCi/L over a lifetime, seven (7) of them would develop lung cancer. This would equal the same risk as dying in a car crash. If 1,000 people who never smoked were exposed to 10 pCi/L over a lifetime, 18 of them would develop lung cancer. This is equal to 20 times the risk of dying in a home fire.

Q: Are there different isotopes of radon, and is the Navy testing for them?
A: There are 33 known natural and manmade isotopes of radon. However, only two natural isotopes (^{220}Rn and ^{222}Rn) have half-lives long enough to enter the indoor

environment, and the long-term devices used by the Navy will detect both. Of those two isotopes, ^{222}Rn is by far the most common.

Q: Am I being exposed to elevated radon?
A: The only way to know if elevated level radon is present in the building is to test.

Q: Is elevated radon found only in family housing?
A: No, in fact Navy studies have shown that the frequency of elevated radon within individual rooms in nonresidential buildings is about the same as in family housing at the installation.

Q: What are the sources of indoor radon?
A: In most cases, radon originates from the soil and rock immediately surrounding or under a building. However, it can also come from groundwater and, in very rare cases (i.e., <1%), from building materials.

Q: How does radon enter a building?
A: Typically, radon gas comes from the soil and rock immediately surrounding or under a building. Wherever air and moisture seep in through drains, joints, cracks, and pores in the foundation and exterior walls, radon can enter as well. If the building shell is tight, the radon cannot escape and it may build to unacceptable levels.

Q: What are the risks from radon in water exposure?
A: According to the Centers for Disease Control, 30 to 1,800 stomach cancer deaths per year in the United States are attributed to the ingestion of radon in water. However, almost all of those deaths are attributed to the use of drinking water from private wells or public water supply systems that use untreated groundwater.

Q: Where can I get additional information on radon?
A: The US EPA has numerous publications available online at https://www.epa.gov/radon/publications-about-radon

Q: Are there laws and regulations for radon?
A: The only federal law is the Indoor Radon Abatement Act of 1988 (IRAA). IRAA declares the national goal to be that the air within buildings in the United States be as free of radon as the ambient air outside the buildings, and it requires each federal agency that manages any buildings to test them for radon. However, IRAA does not stipulate corrective actions be taken. At the local and state level, however, some cities and states require radon testing and mitigation if needed as part of the sale of a home.

Q: Is the Navy responsible for the elevated radon in my home or building?
A: No, radon is naturally occurring. It comes from the soil and geological formations surrounding or under the building.

Q: Do tight building shells enhance indoor radon retention?
A: Yes, studies have shown that the tighter the building shell, the lower the natural ventilation exchange rate, which in turn can increase the rate of radon retention.

Q: What is the radon action level in the United States?
A: The EPA has established 4 pCi/L as the action level in the United States. However, EPA recommends that mitigation be considered for any result ≥2 pCi/L.

Q: Do other countries have different elevated radon action levels?
A: Countries that have established action levels (most have not) vary from 2 to 20 pCi/L. The World Health Organization currently recommends 2.7 pCi/L for developed nations.

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Radon Testing

Q: Why is the Navy testing for radon?
A: The health of its military personnel, their dependents, and Navy employees is a primary concern of the Navy. Because radon is odorless, tasteless, and invisible, the only way to know is to test.

Q: Why is the Navy testing each site at the installation differently?
A: Generally speaking, indoor radon potential can vary because of geology and building type. The Navy protocol recognizes this and allows each installation the flexibility to select the most appropriate testing strategy for each site.

Q: Can indoor radon levels be seasonal?
A: Yes, numerous studies have shown that indoor radon levels can vary significantly as a function of seasonal weather patterns (e.g. rain, snow, prevailing winds, and outdoor temperature). This effect can also be enhanced by certain types of underlying geology (e.g., karst). Also, indoor radon levels can vary significantly over a few hours or days because of changing weather patterns (e.g., rain and wind) as well. For these reasons, the EPA and the Navy recommend that radon testing be performed for as long as possible.

Q: Can indoor radon levels be enhanced by certain types of geology?
A: Yes, studies have shown that buildings constructed over certain types of geology (e.g., karst, lava tubes, layered basalts and volcanic tuff, weathered granite, and coquina) can exhibit enhanced indoor radon levels. Also, in some cases, these enhancements may be totally seasonally dependent on ambient outdoor temperature, wind, or precipitation.

Q: Can Renovations Impact the Radon Level Within a Home or Large Building?
A: Sometimes, EPA and Navy studies have shown that renovations which reduce the natural ventilation rate of a building (e.g. envelope weatherization), can result in an increase in radon levels.

Q: Is radon in water a problem?
A: Elevated radon levels in drinking water are not usually a problem when the water source is surface water or the water is treated. A problem with radon in water is more likely when the water source is groundwater (e.g., a private well or a public water supply system that uses untreated groundwater). However, according to the EPA, because typical water usage readily releases radon into the indoor air, testing for radon in air within the building is a valid substitute for testing for radon in the water supply.

Q: Why is the Navy testing for 1 year?
A: Numerous studies have shown that indoor radon levels can vary significantly from season to season (e.g., up and down) for geological and other reasons. Therefore, testing for shorter periods of time increases the chances that a building that averages ≥4 pCi/L over a year might be missed (e.g., half the year the building is at 2 pCi/L, and the other half of the year the building is at 6 pCi/L).

Q: Why is the Navy testing for less than 1 year?
A: Under certain prescribed circumstances, an installation may elect to perform radon testing for periods of less than one year. For example, at some installations there are no distinct seasons, or previous studies at the installation have shown no significant seasonal dependency.

Q: Why is the Navy installing two detectors at each sample location?
A: One reason is that if elevated radon is found, and the two detectors agree, the elevated result is confirmed and follow-up testing is not required. That means mitigation can be performed sooner. Another reason is that having a large pool of collocated duplicate data greatly enhances the overall precision of the survey.

Q: Are the testing devices used by the Navy accredited?
A: Yes, all devices used for reportable radon test results have been vetted by the National Radon Proficiency Program and/or National Radon Safety Board.

Q: How reliable are the Navy test results?
A: Because of enhanced QA/QC and data validation methods, published Navy results are typically within ±15% in the range of interest (e.g., 3–8 pCi/L) vs. ±25% within the private industry.

Q: All my neighbors have elevated radon; why does my home not have elevated radon?
A: There are no simple or easy answers as to why some homes located on the exact same geology have elevated radon and other identical homes do not. Possible reasons include variations in the micro-geology under the homes, variations in soil compaction during initial construction, undetectable settling of the homes over time, and quite possibly smaller or fewer openings in some slabs. The bottom line is that these types of results are typical and not an unusual occurrence.

Q: Why is the Navy testing every room in nonresidential buildings but only one location in family housing?
A: Within family housing, studies have shown that if a proper location is selected for radon testing, there is little if any variation in radon levels. However, in nonresidential buildings, studies have shown that, most of the time, elevated radon within a large building is limited to one room or a few rooms. The reasons for this vary, but most of the time it is related to the buildings' mechanical systems.

Q: What are the criteria for testing a room in a nonresidential building?
A: The Navy policy is to test all occupied or readily occupiable rooms within a nonresidential building that are routinely occupied for ≥4 hours per day, on average, in a single year. Bathrooms, locker rooms, dedicated storage rooms, janitor closets, and electrical or communication closets are typically not tested because they usually do not meet this criterion.

Q: Why did the Navy select more than one testing location in the main sales area of the commissary and/or exchange?
A: Studies have shown that within rooms larger than 2,000 ft^2, elevated radon could be localized. Therefore, the Navy testing protocol requires more sampling locations within large rooms to address this concern.

Q: EPA, local, state, or host government radon test data indicate a different frequency of elevated radon in the surrounding communities. Why are the Navy results so different?
A: Typically, these estimates are based on residential results collected over a large geographical area (e.g., state or county level) employing a small number of measurements per unit of area. On the other hand, the Navy radon data are collected within a much smaller geographical area, using a much higher sample density per unit of area, and include both residential and nonresidential data. Therefore, some differences are to be expected.

Q: Radon testing was performed at this installation over 20 years ago and no problems were identified. Why are you retesting?
A: Many changes in construction have occurred over the past 20 years. Most notable is that newer building envelopes are much tighter and have a lower natural ventilation rate. Studies have shown that the lower the natural ventilation rate, the greater the chances of having elevated radon. In addition, as buildings age, they tend to settle, creating cracks in the floors and foundations in the process. These cracks may provide openings for radon to enter the building.

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Radon Mitigation

Q: If elevated radon is found, how is the Navy planning to fix it?
A: There are many techniques for reducing radon within a home or workplace. To assist in the selection, radon mitigation diagnostics (scientific tests) are usually performed to assist in the selection process. Since the creation of NAVRAMP in 1988, the Navy has installed thousands of mitigation systems worldwide.

Q: What is the most common mitigation technique in the Navy?
A: Approximately 95% of all mitigation in the Navy has been subslab depressurization (SSD). SSD mitigation uses a pipe inserted through the slab and connected to a fan. When the fan is activated, the area beneath the slab (subslab) is depressurized. The resulting depressurization prevents radon entry into the living area by redirecting the subslab radon into the pipe for discharge into the atmosphere, where it is harmlessly diluted.

Q: Why is SSD mitigation the most common technique in the Navy?
A: SSD is also the most common technique used in the private sector. Studies have shown that SSD systems are by far the most durable mitigation method and require the least maintenance over the long term. Compared with other active mitigation techniques, SSD is also the most energy-efficient.

Q: Other than SSD, are there other types of radon mitigation?
A: Other common active mitigation techniques use increased ventilation (energy recovery ventilation) or use conditioned outdoor air to pressurize the building (shell pressurization). However, these techniques use more energy and require increased maintenance as well.

Q: Do I need to vacate my home or office for mitigation?
A: In most cases, no. However, loud noise and dust generation will occur during mitigation.

Q: How long will mitigation take?
A: In most cases, a system can be installed in a home or office in 4 to 8 hours. However, some of the more challenging installations can take several days.

Q: Do I need to do anything special after the mitigation system is installed?
A: No. However, the most common type of radon mitigation system in the Navy (SSD) has a performance indicator. If you happen to see that the system is not working, please report it so that it can be repaired.

Q: Does the Navy require postmitigation testing?
A: Yes, postmitigation testing is required, and it must meet the same stringent QA/QC criteria as the initial test.

Q: What is RRNC?
A: **R**adon **R**esistant **N**ew **C**onstruction entails the incorporation of various building techniques into new construction which can reduce the indoor radon levels and make the building easier to mitigate if required.

Q: I was told that this building was constructed with radon-resistant features. Why does it now have elevated radon?
A: Incorporation of radon-resistant features into new construction does not make the building "radon-proof." In most cases, it only makes the building easier and less expensive to mitigate. However, some studies do suggest that the frequency of elevated radon is lower within buildings with radon-resistant features, which include vent stacks.

Q: I have elevated radon in my home or office. Does opening the windows and doors in my home or office lower the radon concentration?
A: Over the short term, yes. However, the rate at which radon can build back up to a level of concern varies from building to building (e.g., from a few hours to days). At best, this is a short-term fix.

Q: How will the radon mitigation impact my mission?
A: A key part of mitigation system selection is installing a system with minimal or no impact.

Q: Will the installed mitigation system impact my quality of life?
A: A key part of mitigation system selection is installing a system with minimal or no impact.

Q: How much electrical energy will the mitigation system require?
A: This varies depending on the type of mitigation system selected. However, for most SSD systems installed in the Navy, the range is about 40–60 watts.

Q: In large buildings, can an adjustment of the building mechanical systems (supply, return, and exhaust) mitigate the building?
A: Sometimes. In some cases, the root cause of the elevated radon was found to be an out-of-balance mechanical system. Simple restoration of the mechanicals to the original design specifications fixed the problem. However, each building is different, and mechanical adjustments do not work in all large buildings.

Q: After mitigation, will the Navy perform follow-ups to ensure that the system is still working over time?
A: Yes, the monitoring phase of NAVRAMP requires periodic inspections, including retesting to ensure that the radon levels have not increased to a point of concern.

Questions to Refer to Subject Matter Experts

Q: A family member has had serious health issues since we have been stationed here. Is radon the cause?
A: I am not a medical professional. We recommend you consult your health care provider.

Q: Can I claim this on a VA disability?
A: I am not sure. You need to consult with the VA.

Q: We have worked/lived in this home/office for "X" years. Are we going to get lung cancer?
A: I am not a medical professional. We recommend you consult your health care provider.

Q: Can I sue the Navy over radon exposure?
A: I am not a legal expert; however, you can always consult with the installation's legal counsel.

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Questions for the Installation to Answer

Q: Who is responsible for the implementation of NAVRAMP at the installation?

Q: How are the radon data going to be distributed to the stakeholders?

Q: Why are you testing now, do you know something we do not know?

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