NCRP STATEMENT No. 15

RESPIRATORY PROTECTION RECOMMENDATIONS FOR WORKERS AND VOLUNTEERS RESPONDING TO A NUCLEAR INCIDENT OUTSIDE THE AFFECTED AREA

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National Council on Radiation Protection and Measurements

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Executive Summary

After a large-scale nuclear incident (*e.g.*, detonation of a nuclear weapon) a large population may be displaced, and many may be contaminated with radioactive materials. Outside the radioactive fallout zone, staff and volunteers at public shelters, community reception centers (CRCs), or other locations will be providing contamination screening, decontamination, housing, referral, or other types of services. People arriving at these locations may be contaminated with unknown quantities of radioactive material through direct deposition of fallout or resuspension while traveling to these locations. This Statement recommends a tiered approach (Table 1) for respiratory protection (RP) of workers and volunteers who may be at risk of an inhalation or incidental ingestion hazard generated by arrival and movement of potentially contaminated people. A tiered approach is similar in concept to the Crisis Standards of Care established by the National Academy of Medicine for provision of medical care in response to catastrophic disasters such as that caused by natural disasters, terrorist incidents, or pandemics. This approach is practical to implement and incorporates the variability in circumstances and available resources that may be encountered in the early phase of a response by various organizations. This Statement excludes first responders (law enforcement, firefighters, and emergency medical services) and first receivers (staff at hospitals) for whom adequate guidance exists.

Background

After a large-scale nuclear incident (*e.g.*, detonation of a nuclear weapon) a large population will be displaced, and many may potentially be contaminated with radioactive materials by direct deposition of fallout or through resuspension of fallout during transit through contaminated areas once the shelter-in-place period has passed. Workers and volunteers will be involved in assisting the displaced population with evacuation, screening and decontamination at CRCs, mass care at public shelters, and referrals for medical, relocation, and other services outside the affected area.

The magnitude and relative significance of the potential inhalation hazard to which this group of workers may be exposed, as well as the health risks resulting from that exposure, are dependent on many factors including the size of the nuclear detonation, time after detonation, distance from ground zero, and any decontamination (including self-decontamination or change of clothes) which may have taken place prior to people reaching these workers. The scarcity of resources early in the response may make it difficult to ascertain the extent of contamination and significance of such risk to the workers.

After a nuclear detonation, the primary radiation hazard within the Hot Zone or Dangerous Radiation Zone is external radiation (NCRP 2010; FEMA 2022). The fallout reaching the ground surface within the first few hours and in the vicinity of the detonation site is dominated by large-sized, nonrespirable particles, particularly in the case of ground or near surface detonations (Klement 1965; Glasstone and Dolan 1977). In the Hot Zone and Dangerous Radiation Zone, the dose from the inhalation of radioactive materials is a small fraction of the dose from external radiation, even during fallout deposition. Farther from the detonation site, nuclear fallout contains smaller-sized respirable particles at much lower concentrations which take longer to deposit on the ground (Klement 1965; Larson et al. 1966; Hicks 1982; Kocher et al. 2009; Cederwall et al. 1990; Ng et al. 1990). Nonrespirable size particles (larger than 10 μm), while unlikely to deposit in the respiratory tract, may be trapped in the nose and swallowed, resulting in ingestion dose (LeRoy et al. 1966; Ng et al. 1990; Anspaugh et al.

TABLE 1—*Tiered approach to RP for workers*[a] *and volunteers in a nuclear incident with potential for inhalation hazard.*

RP Tier	Inhalation Exposure Mitigation Steps
Conventional RP Capacity	
• Respirator supply is adequate • All workers already included in an RP program	• Make every effort to eliminate need for RP • Implement the organization's RP program • Monitor and document radiological conditions at the facility • Evaluate potential internal dose and implement bioassay as appropriate
Contingency RP Capacity	
• Respirator supply is adequate • Some workers are **not** part of an RP program	• Make every effort to eliminate need for RP • Monitor and document radiological conditions at the facility • Use available respirators even if workers are not fit tested • Implement as many elements of an RP program as possible • Evaluate potential internal dose and implement bioassay as appropriate
Crisis RP Capacity	
• Respirator supply is inadequate or unavailable • Some workers are **not** part of an RP program	• Make every effort to eliminate need for RP • Monitor and document radiological conditions at the facility • Prioritize allocation of available RP to staff with highest potential for exposure • Consider use of face coverings if no respirators are available • Make every effort to implement contingency or conventional capacity. For example: - If face coverings are being used, replace with appropriate respirators as soon as possible • Evaluate potential internal dose and implement bioassay as appropriate

[a]This excludes first responders and first receivers (see text for additional information).

2022; Simon et al. 2022). Evacuated and displaced people could be contaminated by direct deposition or resuspension of ground contamination. If present, this contamination could pose an inhalation or incidental ingestion hazard to workers and volunteers.

Therefore, this Statement focuses on temporary and improvised RP of workers and volunteers providing public health services to potentially contaminated people away from the affected area, and not on exposures to the passing plume or external radiation from fallout in the affected area. This Statement does *not* apply to RP within the Hot Zone or Dangerous Radiation Zone.

The availability of personal protective equipment (PPE) and authoritative guidance for first responders and first receivers is extensive (OSHA 2005, 2009, 2011; DRG 2016). However, for the large network of other responders, public health workers and volunteers who would be assisting the displaced population outside the hot zone, there is far less applicable literature on PPE and RP. Most of these responders and volunteers are not occupationally exposed to radiation as part of their regular duties, and they are not part of a RP program or an occupational bioassay monitoring program.

RP standards and guidelines that are suitable for occupational exposure scenarios will be difficult to implement for all workers who will be interacting with and providing services to potentially contaminated people. Unlike the medical response to mass casualties or crises, there is currently no equivalent provision for "crisis standards of care" when it comes to addressing the health and safety needs of this group of emergency workers.[1] Lack of guidance and potential confusion about acceptable approaches to protect their health and safety can impede emergency response operations. Lack or delay in provision of public health services (at public shelters, CRCs, etc.) may significantly increase morbidity and mortality in the affected population.

National Council on Radiation Protection and Measurements (NCRP) Report No. 179 (NCRP 2017) and its companion Commentary No. 28 (NCRP 2019) addressed the radiation dosimetry needs of all emergency workers for a range of radiation incidents. The recommendations in this Statement are applicable only to a subgroup of emergency workers which include public health and mass care workers and volunteers.

Scope

This Statement provides RP guidance related to workers and volunteers responding to a nuclear detonation incident outside the affected area. The recommendations do *not* apply to workers operating in contaminated areas. First responders (*e.g.*, firefighters, law enforcement, emergency medical services) and first receivers (clinical staff at hospitals and other medical facilities) are outside the scope of this Statement because extensive authoritative guidance already exists for them (OSHA 2005, 2009, 2011; DRG 2016). Furthermore, this Statement addresses situations where there is concern for worker safety due to the presence, or suspected presence, of airborne radioactivity. If there are known chemical, biological, or other hazards, they too should be considered.

To the extent possible, guidance from Occupational Safety and Health Administration (OSHA) Best Practices Guidance (OSHA 2005),[2] U.S. Environmental Protection Agency (EPA) Protective Action Guides and Planning Guidance for Radiological Incidents (EPA 2017), and the Health and Safety Planning Guide for Protecting Responders Following a Nuclear Detonation (DRG 2016) were used in developing this Statement.

Factors Influencing Inhalation Hazards

Many factors influence the potential health risks from exposure to airborne radioactive materials. These factors include the type of contamination (type of radionuclide, physical and chemical characteristics), environmental conditions, time after detonation, distance from ground zero, and variables influencing resuspension from contaminated surfaces. Other factors include arrival rate of the evacuees and the extent of their contamination. The most reliable method to ascertain the presence of an inhalation hazard is by direct measurements of the airborne radioactivity concentration.

[1]NCRP Report No. 179 (NCRP 2017) defined emergency workers as: "those workers who would be called to assist with the response to a radiological or nuclear incident, acknowledging that most emergency workers have jobs that do not routinely expose them to radiation significantly greater than background levels."

[2]See also OSHA (2022).

While it will be difficult to collect all necessary input parameters in the early phase of the response, a hazard assessment will take these factors and uncertainties into consideration to either eliminate the need or require RP. The use of RP should be considered the last option, according to the concept of hierarchy of controls by the National Institute for Occupational Safety and Health (NIOSH) (NIOSH 2015) which is foundational to occupational health and safety. Some examples of such controls are:

- establishing and operating a contamination screening area prior to entry to the facility;
- providing a change of clothing and footwear to arrivals;
- limiting staff time in contamination screening areas;
- utilizing electronic dosimeters and area air monitoring devices to alert workers if there should be a sudden increase in airborne radioactivity levels;
- applying effective strategies to locate ingress/egress points to minimize potential routes of radioactive contamination transport into the facility;
- applying effective strategies for use of heating, ventilation, and air conditioning equipment (*e.g.*, positioning of ventilation inlets and outlets, air velocities, and ventilation system air changes per unit time) to isolate people from airborne radioactive contamination and thereby reduce radiation exposure; and
- establishing and following procedures for proper disposal/storage of radioactively contaminated waste.

While many factors influence the potential health risks from exposure to airborne radioactive materials, any actions to **reduce the airborne radioactivity concentration** could have a significant impact on the actual respiratory risk posed, and the potential need for RP.

In the early phases of a response to a public health emergency, sufficient resources may not be available when requested to manage the radiological contaminants either prior to entry or within the facility itself. As a result, during such time there may be potential for levels of radioactive contamination within the facility that necessitate RP.

If there is potential for inhalation exposure, it is prudent to apply some type of strategically placed environmental surveillance and monitoring of the facility to assess and record the levels of airborne and surface contamination. Determination of airborne contamination levels will allow definitive decisions to be made regarding the use of any type of RP. If resources for monitoring airborne contamination are not immediately available, it can be estimated by directly measuring deposited radioactive materials on surfaces or assessing removable contamination (wipe samples). Decisions regarding the need and the methods for active surveillance of air contamination levels at the facility will be made by the appropriate health and safety authority.[3] When measurements are made it is important to document the measurement results, and when measurements are not made it is important to document the reasons why such environmental surveillance at the facility is not warranted.

[3]The term "appropriate health and safety authority" in this statement is used to denote a person assigned duties as a science officer, safety officer within incident command structure, or other qualified individual responsible for performing hazard assessment to evaluate the need for use of RP within the scope of this statement. The term does not refer to a governmental body or agency.

Types of Respiratory Protection

NIOSH and OSHA provide a wealth of information about different types of respirators and their properties, including assigned protection factors, as well as the requirements for using them. Examples of RP include filtering facepiece respirators (N95 or KN95 mask), elastomeric respirators with various types of filter cartridges, and powered air purifying respirators (NIOSH 2018a). Elastomeric respirators have the advantage of reusability as long as proper cleaning/decontamination procedures are followed. If the supply of disposable respirators is limited or is in question, use of elastomeric respirators may provide an effective alternative.

If RP is required for some response workers, the safety officer or the appropriate health and safety authority decides which type of RP is most appropriate. Required RP program elements found in 29 CFR 1910.134[4] (OSHA 2011; NIOSH 2018b) include: procedures for selecting respirators; medical evaluations; fit testing; procedures for proper use of respirators; procedures for cleaning, storage, and maintenance; procedures to ensure adequate air quality, quantity and flow rate; training of response workers; and regular evaluation of the program.

In contrast to filtering facepiece respirators and other types of respirators designed to protect the wearer, face coverings such as surgical masks and cloth masks are intended to function as source control devices. In healthcare settings, for example, surgical masks are intended primarily to protect the patient from respiratory secretions of the healthcare worker while they also protect the clinician from large droplet splashes and sprays of bodily fluids from patients (NIOSH 2016). Face coverings such as surgical masks and cloth masks are typically loose fitting and they do not provide the same level of protection for the wearer as respirators. ASTM International has issued standard specifications for barrier face coverings (ASTM 2021). NIOSH has issued interim guidance on masks and face coverings that incorporate the ASTM F3502-21 standard (NIOSH 2021a, 2021b).

Face coverings are not respirators and should not be used in situations where RP is needed and available.

Investigations of filtration efficiencies for various types of face coverings (*e.g.*, surgical masks, cloth masks, double masking) have demonstrated that face coverings may offer some protection to the wearer from particulates through filtration, including filtration of fine droplets and particles less than 10 μm (Dato et al. 2006; van der Sande 2008; Shakya et al. 2017; Clase et al. 2020; Long et al. 2020; Ueki et al. 2020; Whiley et al. 2020; CDC 2021). Published information about degrees of protection offered by face coverings vary and are not directly comparable or easily quantifiable. The differences among the reported results stem in large part from varying details of experimental design, including differences in air flow rates, use of human subjects versus mannequins, use of actual masks versus pieces of cloth, and differences in the types of fabric used, among other factors. The evidence does suggest, however, that how well a face covering fits the face of the individual is as important, if not more important, than the particular material or fabric used (Hill et al. 2020; Brooks et al. 2021).

While no definitive statement can be made for any specific type of face covering, it can be said that a properly fitting face covering (*i.e.*, a face covering that leaves no noticeable gap) may offer some degree of protection against liquid aerosols or dry particulates. However, if face coverings are used during a nuclear emergency, when respirators are not available, the response organization should always assume that these coverings offer minimal protection from the respiratory hazard.

[4]OSHA (2019).

A Tiered Approach to Respiratory Protection

As illustrated below, the safety authority may determine the need for RP when the inhalation hazard is known and well characterized or when an inhalation hazard is suspected. After a nuclear detonation, environmental conditions, potential hazards, availability of resources (radiation detection instruments, PPE, staffing, etc.), and degree of preparedness will vary from location to location. Thus, one specific set of recommendations for RP will not be suitable or applicable to every location at any given time. In this Statement, a tiered approach is recommended that is practical to implement and considers this variability.

This tiered approach is similar in concept to the Crisis Standards of Care (IOM 2009, 2010, 2012, 2013) for provision of medical care in response to catastrophic disasters such as that caused by natural disasters (*e.g.*, Hurricane Katrina), terrorist incidents, or pandemics (*e.g.*, COVID-19). The three general tiers used to describe surge capacity in the healthcare setting (Hick et al. 2009, 2020; CDC 2020) may be adapted and applied as a tiered approach to meeting the potentially wide range of surge-capacity needs for RP of workers and volunteers in a large-scale radiation incident:

- Conventional RP capacity measures: operational conditions (spaces, staffing, equipment, procedures) are consistent with daily practices within the organization. A major disaster triggers the activation of the organization's emergency response plan consisting of the implementation of engineering, administrative, and PPE controls that should already be part of their training and experience practices.
- Contingency RP capacity measures: operational conditions are not consistent with daily practices or recommended conventional RP approaches, but they are functionally similar. Contingency RP capacity measures need to be implemented if some workers are not part of an existing RP program early in the response.
- Crisis RP capacity measures: operational conditions are not consistent with usual standards of worker safety and health protection, but it is necessary to provide the best possible worker safety and health protection given disaster circumstances and resources available. Under crisis capacity, respirator supply is limited or unavailable. In addition, some workers are not part of an existing RP program early in the response. Crisis RP capacity measures (1) should only be implemented if cessation of emergency response services is likely to impart greater harm to the public, and (2) should only be used for a short term. Efforts should be made to implement conventional or contingent RP capacity as soon as possible.

While it is reasonable to assume that conventional RP capacity strategies could be applied for first responders/receivers, such strategies may be more difficult to implement for the increased number and type of workers considered in this Statement. This will be due to lack of resources and lack of inclusion of these workers in established RP programs. This tiered approach could be implemented in the early phases of the response to address these issues as described below and summarized in Table 1.

Implementation of the Three Tiers of Respiratory Protection Capacity

Implementation of Conventional Respiratory Protection Capacity Measures

The value of preparedness for any type of public health emergency cannot be overstated. If a response organization determines in advance of an incident that RP may be needed during an emergency, then the response organization is required to develop and implement a written RP program and designate a qualified and appropriately trained or experienced program administrator to oversee the RP program per 29 CFR 1910.134 (OSHA 2011).

Implementation of Contingency Respiratory Protection Capacity Measures

It is recognized that some workers and volunteers who may be called upon to assist with the response will not be part of an occupational RP program. Consequently, implementation of the conventional approach to RP, as specified by regulatory requirements for occupational exposures, may not be possible in the initial phases of the response to the emergency. Under these conditions, workers in need of RP should wear these respirators even if they have not been previously fit tested. If the workers exhibit any sign of breathing difficulty, they should stop wearing those respirators and be assigned to other duties that do not require RP. The safety authority should provide just-in-time training for proper wear and use of respirators and proper cleaning or disposal of them after use.

As discussed earlier, it is essential to monitor and document the radiological conditions at the facility and implement measures to reduce or eliminate the need for RP. Quantitative measurements should be accomplished rapidly (and possibly continuously) to establish airborne concentrations and determine the necessity of respirators. If a hazard assessment by the appropriate health and safety authority determines that inhalation hazard is not likely, RP should be suspended. If continued use of RP is needed for some workers, every effort should be made, as resources and priorities allow, to implement procedures consistent with conventional capacity (*i.e.*, implement a RP program).

Organizations should document the reasons why certain elements of a RP program cannot be immediately implemented, document the steps that have been taken to meet the requirement of the standard, and work to implement those missing elements as soon as practicable. Depending on the potential for internal contamination, implementing a worker bioassay monitoring program should be considered.

Implementation of Crisis Respiratory Protection Capacity Measures

In the early phases of a response, it is possible that supply of N95 (or KN95) filtering facepiece respirators or other respirators designed and certified to protect against particulates may be limited or not available. In addition, some workers may not be part of an occupational RP program early in the response. Under these conditions, delay in provision of critical public health and mass care services could have a detrimental effect on the safety and well-being of large populations.

Under these conditions, allocation of any available respirators should be prioritized for the staff having work duties that present a higher potential for internal exposure, such as initial interaction with people arriving at the facility or assisting them with decontamination. When respirators are not available, use of face coverings may be considered as a temporary crisis measure until proper RP, if needed, can be obtained. The use of the face coverings as a crisis capacity strategy is based on the premise that any protection, however imperfect, may help reduce exposure to the workers. Face coverings are not a substitute for RP. Workers should be informed that these devices cannot be relied upon as a form of RP. Under these conditions, it is essential to monitor and document the radiological conditions as soon as and by any means possible.

If a hazard assessment by the appropriate health and safety authority determines that an inhalation hazard is not likely, RP should be suspended. If continued use of RP is needed for some workers, every effort should be made, as resources and priorities allow, to implement procedures consistent with contingency capacity with the goal to returning to conventional

RP capacity. Depending on the potential for internal contamination, implementing a worker bioassay monitoring program should be considered.

> Crisis capacity strategies should only be implemented if conventional and contingency capacity are insufficient or unavailable to support the response, and cessation of critical public health and mass care services can impart greater harm to the public.

Ethical Considerations

The underlying ethical value that supports this three-tiered methodology is the prevention of harm expressed in the ethical principle of nonmaleficence, *i.e.*, “do no harm” (Beauchamp and Childress 2019). As a tiered method, it allows for the use of measures which may result in a difference in the degree of protection afforded the workers. Even so, both actual and potential prospects for prevention of harm exists. Also, built into the tiers is an ethical imperative to plan for and execute tasks that will eventually improve the degree of protection from harm, as needed.

Additional values, expressed in principles of autonomy and justice, support actions required by the implementation of the three-tiered approach. Respecting a worker's autonomy by providing transparency regarding potential risks and ensuring that these workers are treated equitably are actions that strengthen its ethical status. Exercise of these principles requires the virtue of prudence, requiring foresight to exercise good judgment in applying universal principles to practical matters. While all three tiers incorporate prudential judgment, contingency and crisis capacity measures reflect the need for prudence.

Communicating with Staff and Volunteers

Regardless of which capacity tier is applied for RP, it is essential to ensure that all workers (including volunteers) are briefed about potential risks they may encounter and the health and safety practices they should follow. Many workers in a disaster response situation have not had prior training in health and safety operations for such an emergency setting, and it is important to provide them with ample opportunity to ask questions from the appropriate health and safety authority and to provide them with just-in-time training as needed. Such training must include information on the inhalation hazards to which workers may be exposed, the nature of the health risks (*e.g.*, stochastic effects), and on the proper use of RP equipment, including donning and doffing, maintenance, storage, disposal, and limitations of their use.

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