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Radiation Protection Equipment for Nuclear Emergency

Presentation by Fahmi Alfa Muslimu

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Overview of Radiation Protection

Basics of Radiation

Radiation is energy that comes from **a source** and travels through space and may be able to **penetrate** various materials. It can be in the form of particles or electromagnetic waves.

Risks

Exposure to high levels of radiation can cause serious health effects, including **radiation sickness, burns**, and **increased risk** of cancer. It is crucial to **limit exposure to radiation** to protect human health.

Protection Measures

Various protection measures such as shielding, time, and distance are essential to reduce the exposure to radiation. **Proper equipment** and **protocols** are necessary to ensure safety during nuclear emergencies.

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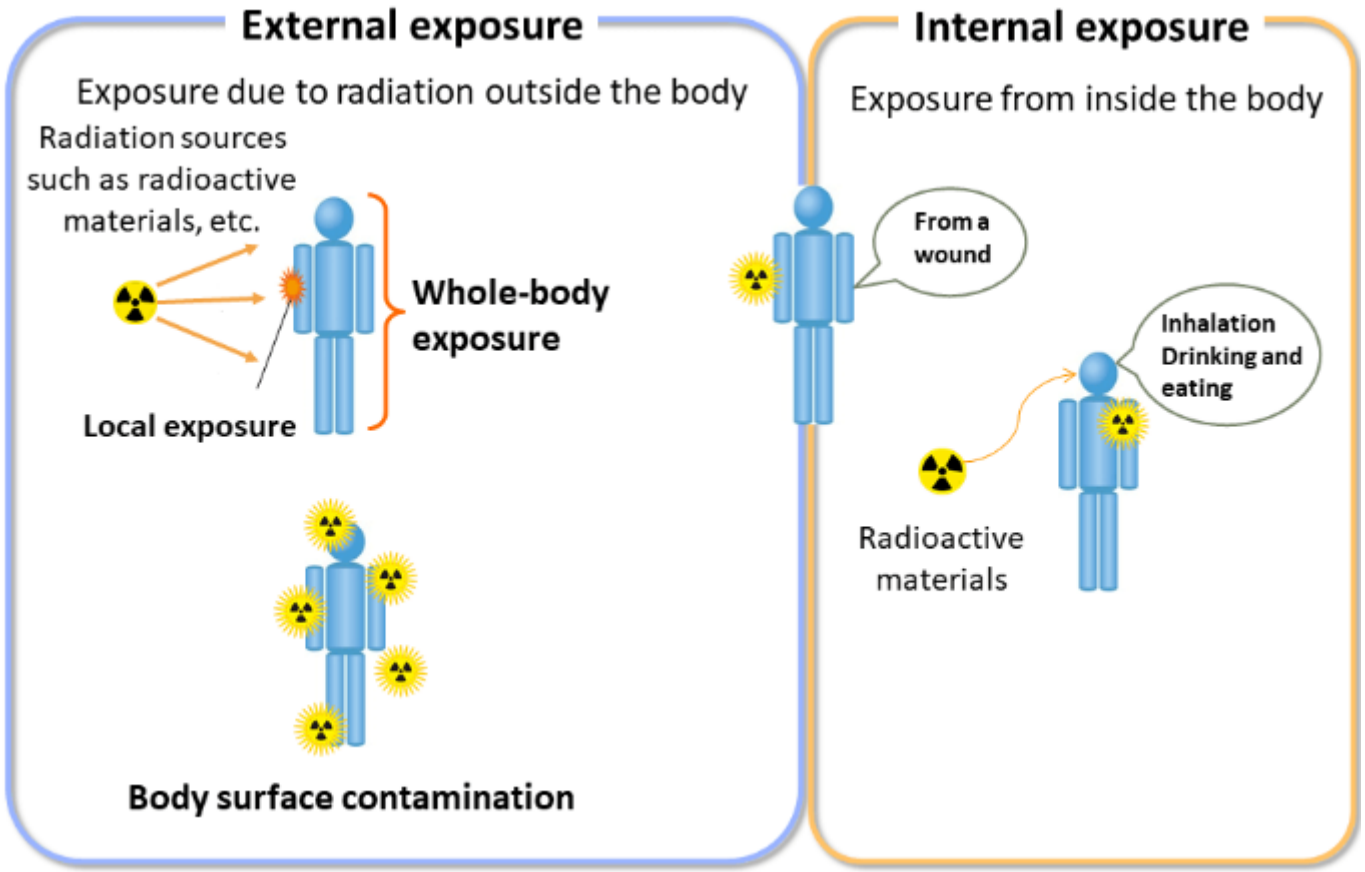
Radiation Exposure



Source : https://www.env.go.jp/en/chemi/rhm/basic-info/2018/01-01-04.html

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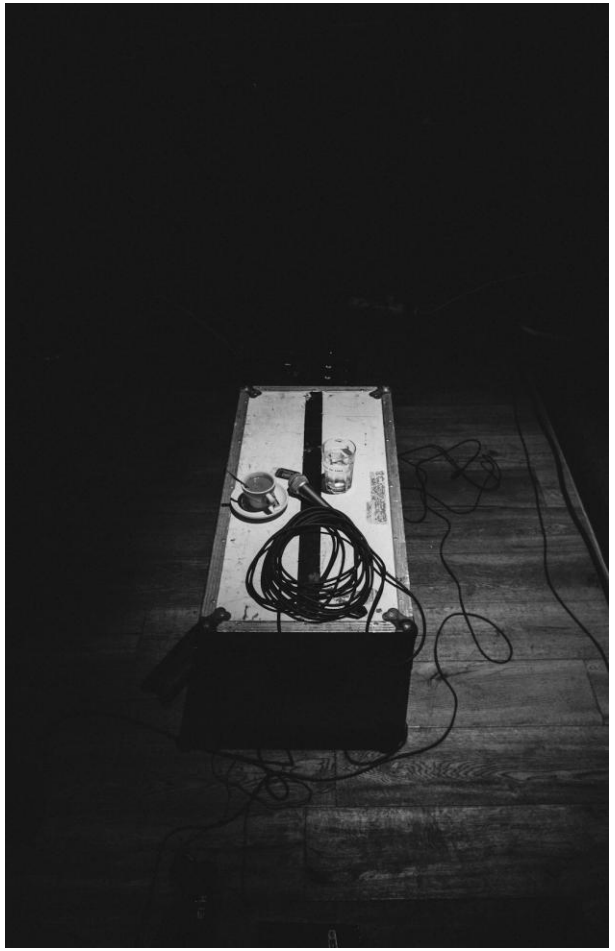
Types of Radiation Protection Equipment

Primary Equipment

Includes **radiation detectors**, **dosimeters**, and **personal protective gear** essential for monitoring and safeguarding individuals in nuclear emergency situations.

Decontamination Gear

Equipment like **contamination suits, shower systems**, and **scrubbing tools** used to remove radioactive particles from people and equipment after exposure.



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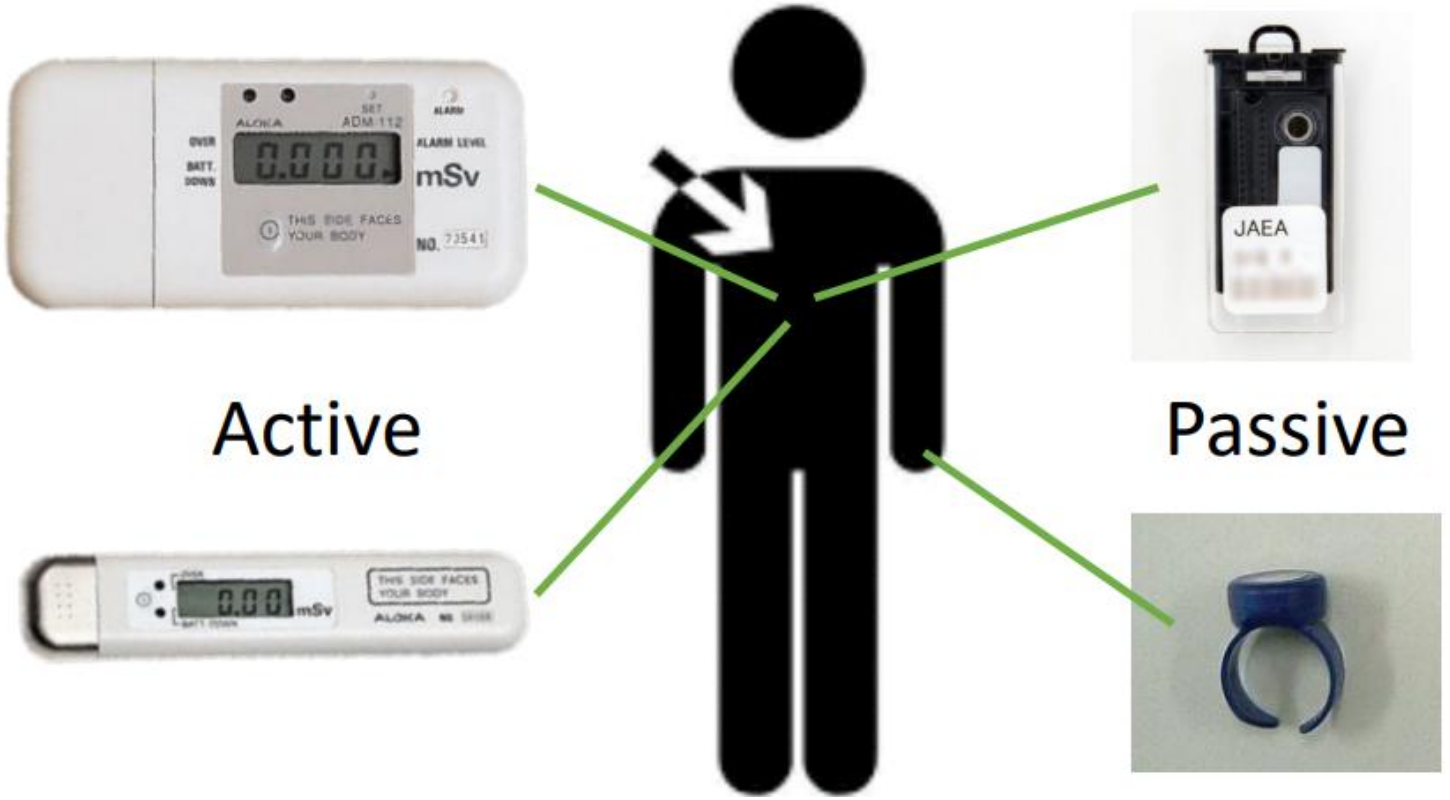
External monitoring



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Internal monitoring

Direct method :

- Whole body counting
- Lung counting
- Thyroid Counting

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Internal monitoring

Indirect method :

- Bioassays, measuring the amount of radioactive material contained in the urine or feces

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Personal Protective Gear

Gear	Function	Specifications
Radiation Suit	Protection against direct radiation exposure	Lead-lined with full-body coverage
Dosimeter	Measure radiation exposure level	Digital display with real-time monitoring
Respirator	Filters out radioactive particles	High-efficiency particulate air (HEPA) filter
Gloves and Boots	Protection for extremities	Lead-lined and puncture-resistant

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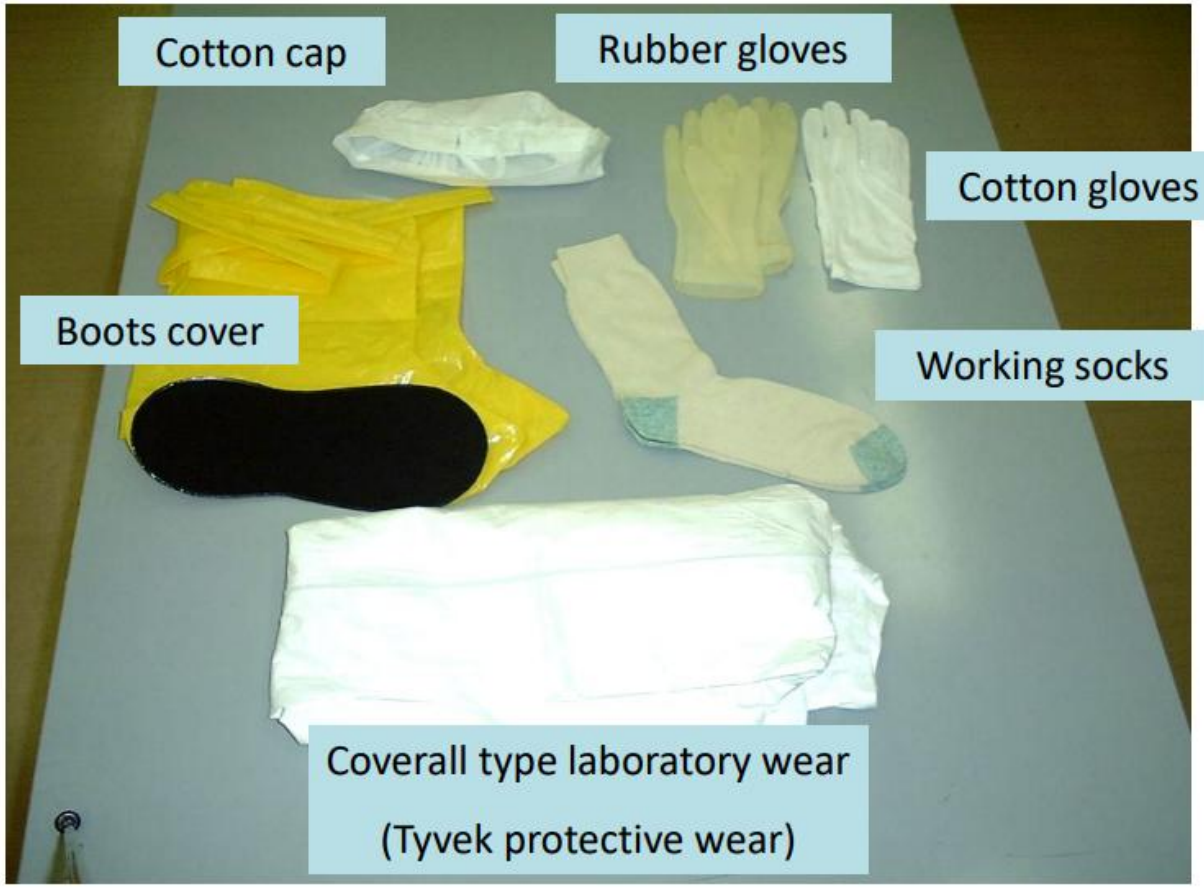
Protective gear for body contamination



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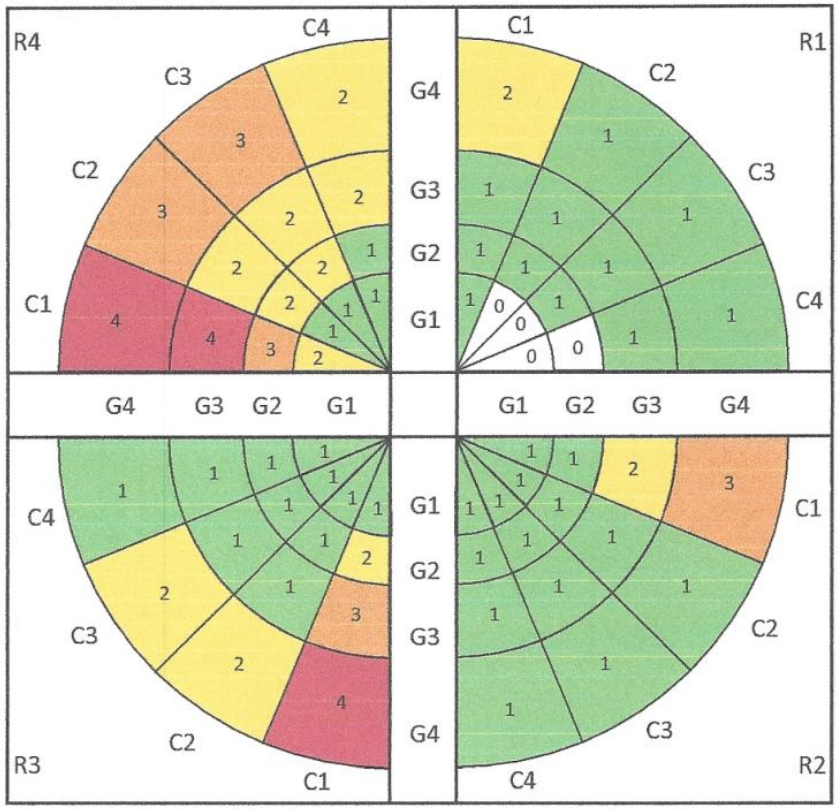
Respiratory selection

Figure 3

Control banding approach for bioaerosols in general workplace environments

(See Clauses 7.3.4.2 and 7.3.4.3.4 to 7.3.4.3.8, Figure 1, and Annex K.)

General workplace environments	
Risk group	
Agents not associated with disease or serious adverse health effects in healthy adult humans	R1
Agents associated with human disease or adverse health effects that are rarely serious and for which preventive or therapeutic interventions are usually available	R2
Agents associated with serious or lethal human disease or adverse health effects for which preventive or therapeutic interventions might be available (high individual risk but low community risk)	R3
Agents likely to cause serious or lethal human disease or adverse health effects for which preventive or therapeutic interventions are not usually available (high individual risk and high community risk)	R4
Generation rate	
Low release of bioaerosol / pathogen — vacuuming with a HEPA filter	G1
Medium release of bioaerosol / pathogen — soaking then shovelling	G2
High release of bioaerosol / pathogen — misting then shovelling	G3
Very high release of bioaerosol / pathogen — dry sweeping	G4
Control level	
Indoor — poorly ventilated ACH ≤ 1	C1
Indoor — ventilation 1 < ACH ≤ 4 Outdoor — no wind	C2
Indoor — ventilation 4 < ACH ≤ 6 Outdoor — low wind	C3
Indoor — ventilation > 6 Outdoor — moderate wind	C4



Acceptable level						Air-purifying options	APF	Atmosphere-supplying options
0	1	2	3	4	5			
					5	No air-purifying option available	10000	SCBA (pressure-demand) full-facepiece SCBA (pressure-demand) tight-fitting hood Multi-functional SCBA/airline
				4 to 5		Powered air-purifying full-facepiece Powered air-purifying helmet/hood with SWPF study	1000	Airline (continuous-flow) full-facepiece Airline (pressure-demand) full-facepiece Airline (continuous-flow) helmet/hood with SWPF study
			3 to 5			Powered air-purifying half-facepiece Air-purifying (negative-pressure) full-facepiece	50	Airline (pressure-demand) half-facepiece Airline (continuous-flow) half-facepiece
		2 to 5				Powered air-purifying loose-fitting facepiece/visor Powered air-purifying helmet/hood without SWPF study	25	Airline (continuous-flow) loose-fitting facepiece/visor Airline (continuous-flow) helmet/hood without SWPF study
	1 to 5					Air-purifying (negative-pressure) half-facepiece (including filtering facepieces)	10	No atmosphere-supplying option available
						No respiratory protection required	<1	No respiratory protection required

CSA-Z94.4-18 : Selection, use and care of respirators

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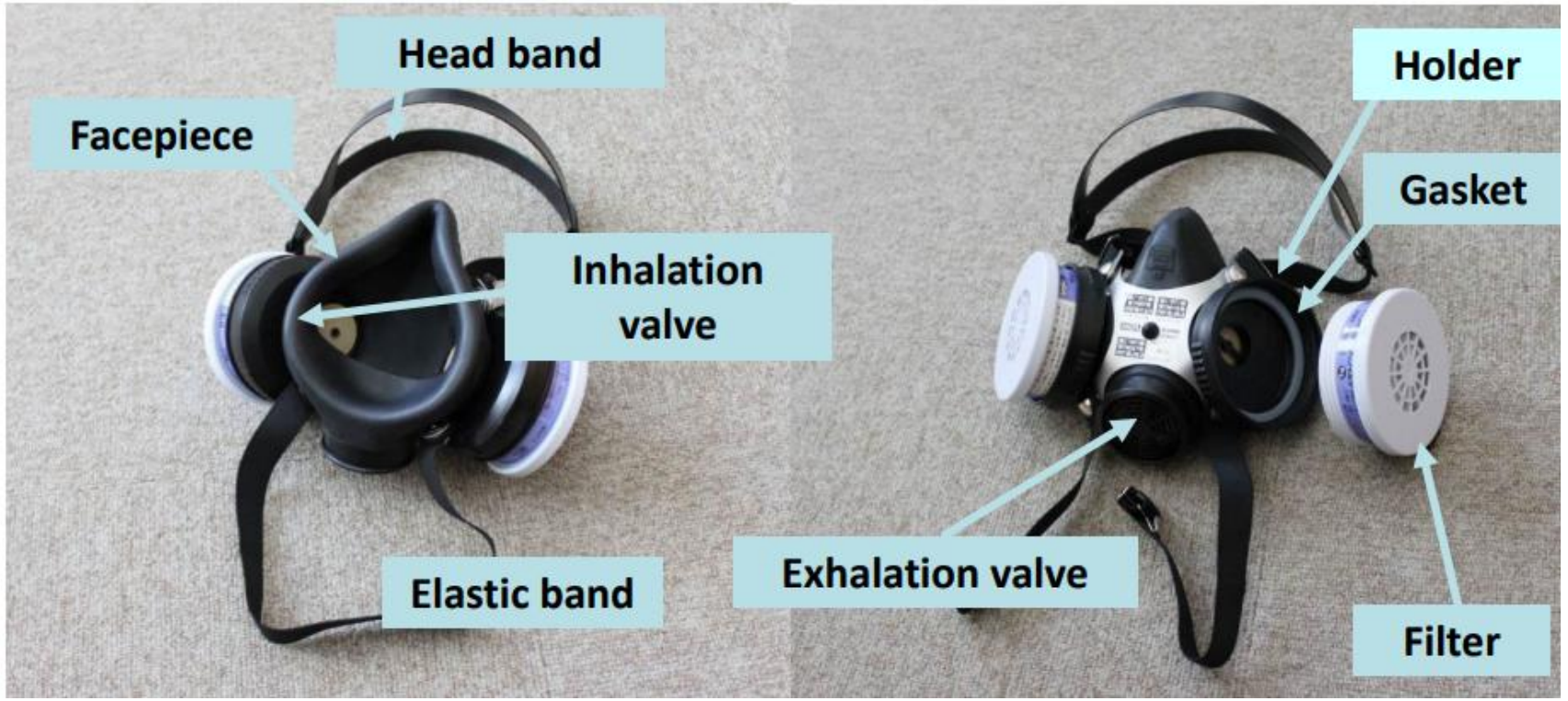
Respiratory Protection Equipment (Half-face Mask)



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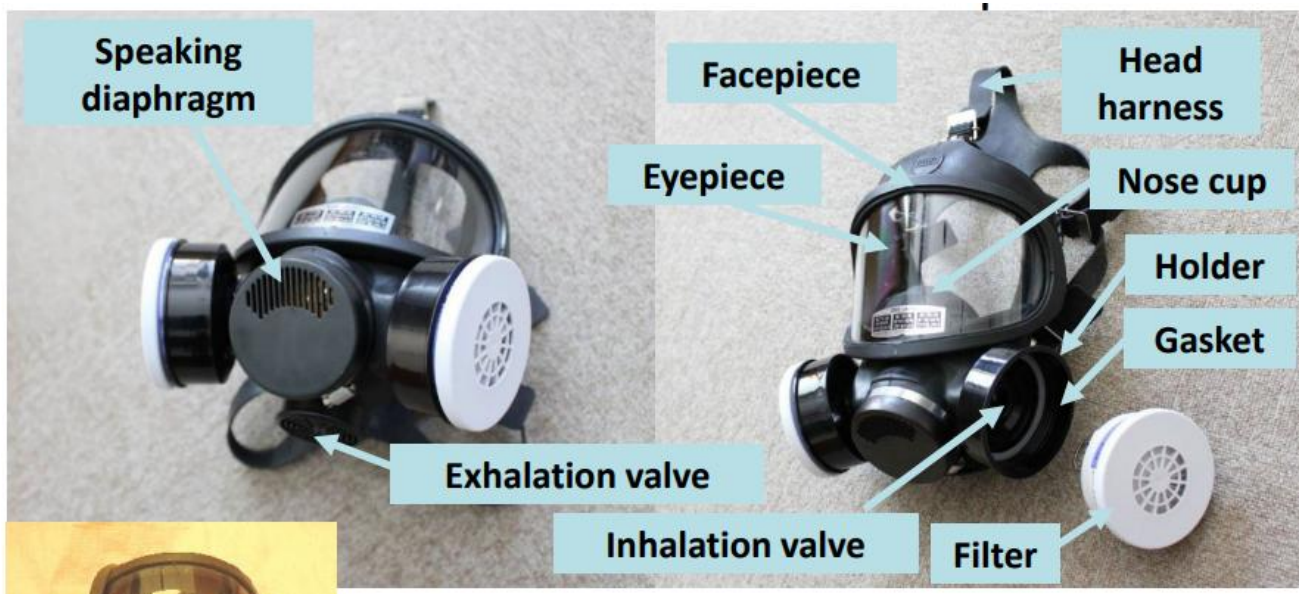
Respiratory Protection Equipment (Full-face Mask)



Charcoal filter

(For radioactive iodine collection)

Photos by TEPCO
https://www.meti.go.jp/earthquake/nuclear/pdf/120227_03v.pdf

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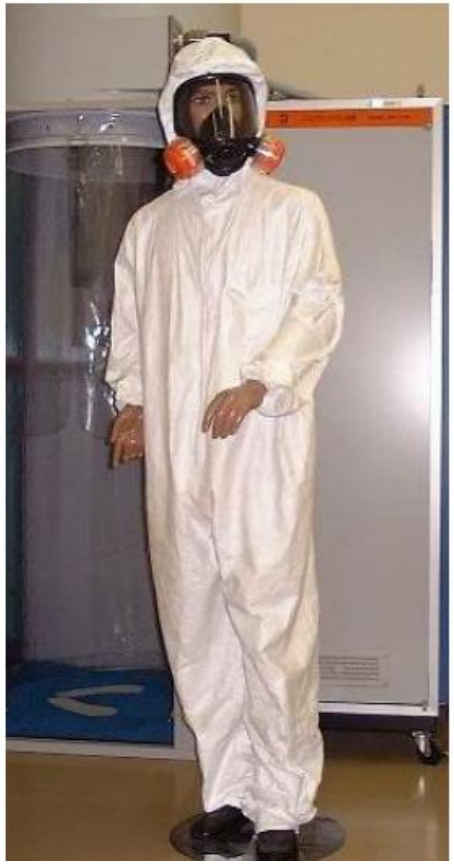
Respirator and Coverall Type Laboratory Wear

Half-face Mask

Full-face Mask



Vinyl Protective Clothes

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Various kind of respirators

Major Types of Respirators

Air-purifying respirators, which remove contaminants from the air.

Half mask/Dust mask
APF=10
Needs to be fit tested

Half mask (Elastomeric)
APF=10
Needs to be fit tested

Full facepiece (Elastomeric)
APF=50
Needs to be fit tested

Original Illustrations created by Attilis & Associates

Loose-Fitting Powered Air-Purifying Respirator (PAPR)
APF= 25

Hood Powered Air-Purifying Respirator (PAPR)
APF= 25

Atmosphere-supplying respirators, which provide clean air from an uncontaminated source.

Full Facepiece Supplied-Air Respirator (SAR) with an auxiliary Escape Bottle
APF=1,000
APF = 10,000 (if used in "escape" mode)
Needs to be fit tested

Full Facepiece Abrasive Blasting Continuous Flow
APF=1,000
Needs to be fit tested

Full Facepiece Self-Contained Breathing Apparatus (SCBA)
Pressure demand mode is APF=10,000
Needs to be fit tested

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Various kind of respirators

Assigned Protection Factor (APF) means the workplace level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program as specified by this section.

Fit factor means a quantitative estimate of the fit of a particular respirator to a specific individual, and typically estimates the ratio of the concentration of a substance in ambient air to its concentration inside the respirator when worn.

$$\text{Overall Fit Factor} = \frac{\text{Number of exercises}}{1/ff_1 + 1/ff_2 + 1/ff_3 + 1/ff_4 + 1/ff_5 + 1/ff_6 + 1/ff_7 + 1/ff_8}$$

Where ff_1, ff_2, ff_3, etc. are the fit factors for exercises 1, 2, 3, etc.

Exercise

*Jika kadar kontaminasi Compound X di udara adalah **60 µg/m³**, maka dengan memakai masker half-face (**APF 10**), jumlah zat yang terhirup turun menjadi sekitar **6 µg/m³**. Jika menggunakan masker full-face (**APF 50**), berapa nilai zat yang terhirup?..... (µg/m³)*

OHSA 3352-02 2009 Assigned Protection Factors for the revised respiratory protection standards.

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Various kind of respirators

Table A-1. CNP REDON Quantitative Fit Testing Protocol		
Exercises(1)	Exercise procedure	Measurement procedure
Facing Forward	Stand and breathe normally, without talking, for 30 seconds.	Face forward, while holding breath for 10 seconds.
Bending Over	Bend at the waist, as if going to touch his or her toes, for 30 seconds.	Face parallel to the floor, while holding breath for 10 seconds
Head Shaking	For about three seconds, shake head back and forth vigorously several times while shouting.	Face forward, while holding breath for 10 seconds.
REDON 1	Remove the respirator mask, loosen all facepiece straps, and then redon the respirator mask.	Face forward, while holding breath for 10 seconds.
REDON 2	Remove the respirator mask, loosen all facepiece straps, and then redon the respirator mask again.	Face forward, while holding breath for 10 seconds.

[1] Exercises are listed in the order in which they are to be administered.

OHSA 3352-02 2009 Assigned Protection Factors for the revised respiratory protection standards.

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Table 1: comparison of training frequency, assigned protection factor (APF) for full-face, cartridge change-out schedules

Standard	CSA Z94.4 -93	CSA Z94.4 -02	CSA Z94.4-11	CSA Z94.4-18	OSHA 29CFR 1910.134
User training frequency	8.1.3 Annual	8.3 At least every 2 years	No specific frequency 8.2.4 Required when a review cannot confirm that the individual remains qualified or as indicated by the program administrator	No specific frequency 8.2 Required when a review cannot confirm that the individual remains qualified or as indicated by the program administrator	Annual
APF for a full-face respirator	100	10, 100[1]	10, 50[1]	10, 50[1]	50
Cartridge change-out schedules	Not covered in the standard	**6.3.2.1.1 Required.** Established by a qualified person	**10.2.1.1 Required.** Established by a qualified person	**10.2.1.1 Required.** Established by a qualified person	**Required.** Established by a qualified person
Change-out schedule can be based on	Not covered in the standard	**6.3.2.1.1** • ESLI • Maximum use time • Good warning properties • Breathing resistance	**10.2** • ESLI • Maximum use time • Breathing resistance. Warning properties cannot be used	**10.2** • ESLI • Maximum use time • Breathing resistance Warning properties cannot be used	**ESLI** • Maximum use time • Breathing resistance • Warning properties cannot be used
Use of air purifying respirators against contaminants with poor warning properties	**6.3.2.3** Not permitted. Use a supplied air respirator.	**6.3.2.2.4** Permitted change-out schedule must be established by a qualified person or use supplied air	**10.2.1.1** Permitted Change-out schedule must be established by a qualified person or use supplied air	**10.2.1.1** Permitted Change-out schedule must be established by a qualified person or use supplied air	Permitted Change-out schedule must be established by a qualified person or use supplied air

[1] APF of 10 if qualitative fit testing (QLFT), if quantitative fit testing (QNFT) APF per table above

Table 2: Comparison of fit testing protocols

Standard	CSA Z94.4 Selection, Use and Care of Respirators				OSHA 29CFR 1910.134	ANSI Z88.2-1992 RP with ANSI Z88.10-2001 Fit Test Methods	ISO 16975-3:2017 RPD – Selection, Use & Maintenance, Part 3	HSE 282/28 Fit Testing of RPE (Asbestos)
	1993	2002	2011	2018				
Fit testing frequency	Required initially and following any change (respirator used or personal)				Required initially and following any change (respirator used or personal)			
	7.1.3 Recommended annually	7.1.3 Required at least every 2 year;. Recommended annually	9.1.6 Required at least every 2 years.	9.1.6 Required at least every 2 years.	Required at least annually	Required annually	Recommend annually	Required annually
No. exercises for QLFT	6	6	7 (added bending over where space allows)	7 (added bending over where space allows)	7 exercises	List of 14 possible exercises: 6 required, 1 optional	7 exercises	7 exercises
Duration of exercise	At least 60 sec	At least 30 sec	At least 30 sec	At least 30 sec	At least 60 sec	At least 30 sec	At least 60 sec	At least 60 sec

Fit testing is not required for loose-fitting respirators, Facial hair must not interfere with the respirator sealing surface. Individuals must be clean shaven (12-24 hours) for fit testing and respirator use (CSA Z94.4-18, sec. 9.2.2).

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Decontamination Equipment

Decontamination Showers

Critical for removing radioactive contaminants from individuals quickly to minimize the spread of radiation and prevent further exposure.

Scrubbing Tools

Tools such as brushes, sponges, and decontamination solutions used to clean equipment and surfaces to reduce contamination levels.

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Workplace monitoring

Provide information :

- Evaluation of radiation conditions
- Assessment of potential exposures
- On-going review of classification of workplace
- Dose rate of standby areas
- Air concentration of standby areas

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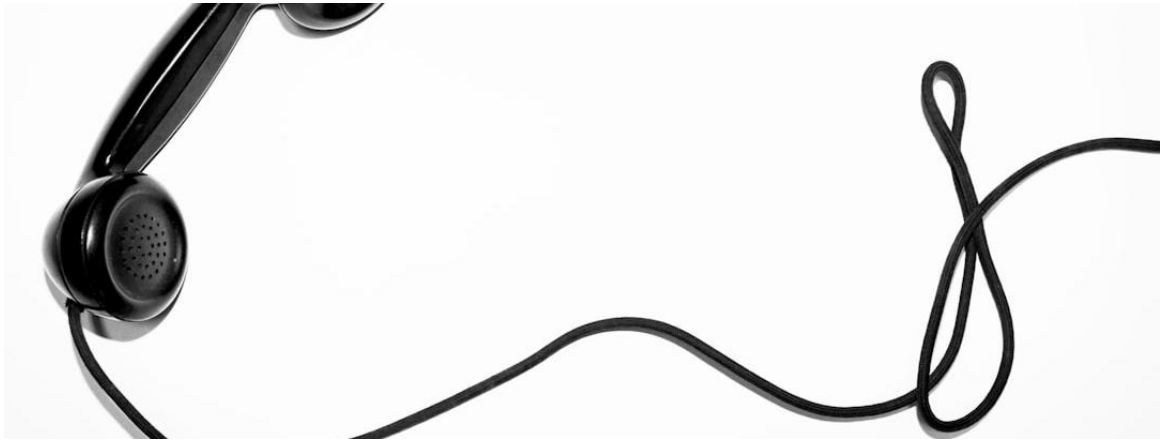
Emergency Communication Devices



Radios and Handheld Devices

Crucial for maintaining communication among response team members, coordinating rescue efforts, and receiving important updates and instructions.

Satellite Phones

Ensure communication reliability in areas with disrupted or limited cellular network coverage, allowing for constant contact during emergencies.

Question?

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