



Radiation

Aim

To provide learners with an awareness to radioactive materials, transportation of radioactive materials and the arrangements in place for dealing with radiation incidents

Objectives

- Describe national arrangements for dealing with radiation incidents
- Identify radioactive materials through labelling and placarding
- Describe the principles of radiation protection
 - Irradiation vs Contamination.
- Outline decontamination practices

How safe can it be?

Ionising Radiation
Regulations 2017

Radiation (Emergency
Preparedness and Public
Information) 2019

Radioactive Substances
act 1993

High Activity Sealed
Radioactive Sources and
Orphan Sources
Regulations 2015

Ionising Radiations
(Medical Exposure)
Regulations 2018

Justification of Practices
Involving Radiation
Regulations 2004

Mutual Aid Schemes

- Health Security Agency – Centre for radiation, chemical and environmental hazards (CRCE)
- N.A.I.R (01235 834 590): aim is to assist the police and other emergency responders to protect the public from hazards of radioactive substances where no formal contingency arrangements exist.
 - Police must be involved
- RADSAFE (0800 834 153): assistance to transportation incidents
 - Must be a member => must display appropriate RADSAFE placard



Radsafe Incident Notification Service

- Radsafe will divert their 24/7 Emergency Number to NCEC on a dedicated line on 1st April 2017.
- NCEC's role is:
 - To take details of the incident
 - To send standard response documentation to the caller
 - To notify the closest Radsafe member who will dispatch a responder to the scene
 - To update the caller on the ETA of the Radsafe Responder
 - To notify the EA or SEPA
 - To send an email with details of the incident

RADSAFE Advice Document



Generic Advice

Do

Send casualties to hospital without delay if there are life threatening injuries

Keep appliances upwind

Set cordon area at 45m

Wear BA or CPS if on rescue or fire fighting duty

Use dosimeters and survey meters

Extinguish fires

Seek advice on decontamination (In general, shower and contain "run off")

Bag up clothing and equipment

Spray cool nuclear fuel flask for at least 30min if flask involved in a fire using ground monitors if possible

Don't

Put hands to mouth

Eat, drink or smoke if radiation release has or is suspected to have occurred

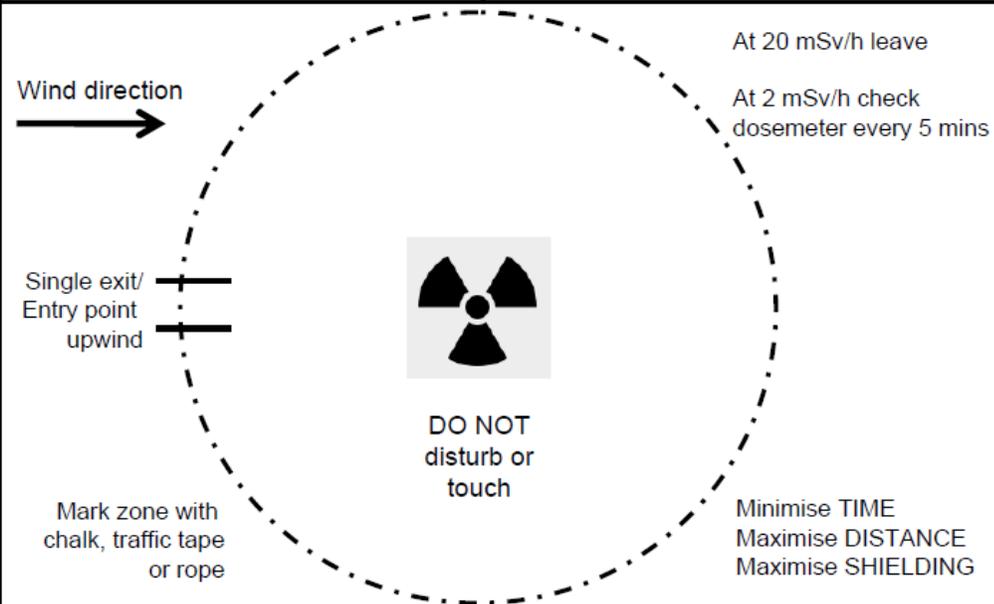
Remember

Transport is strictly controlled

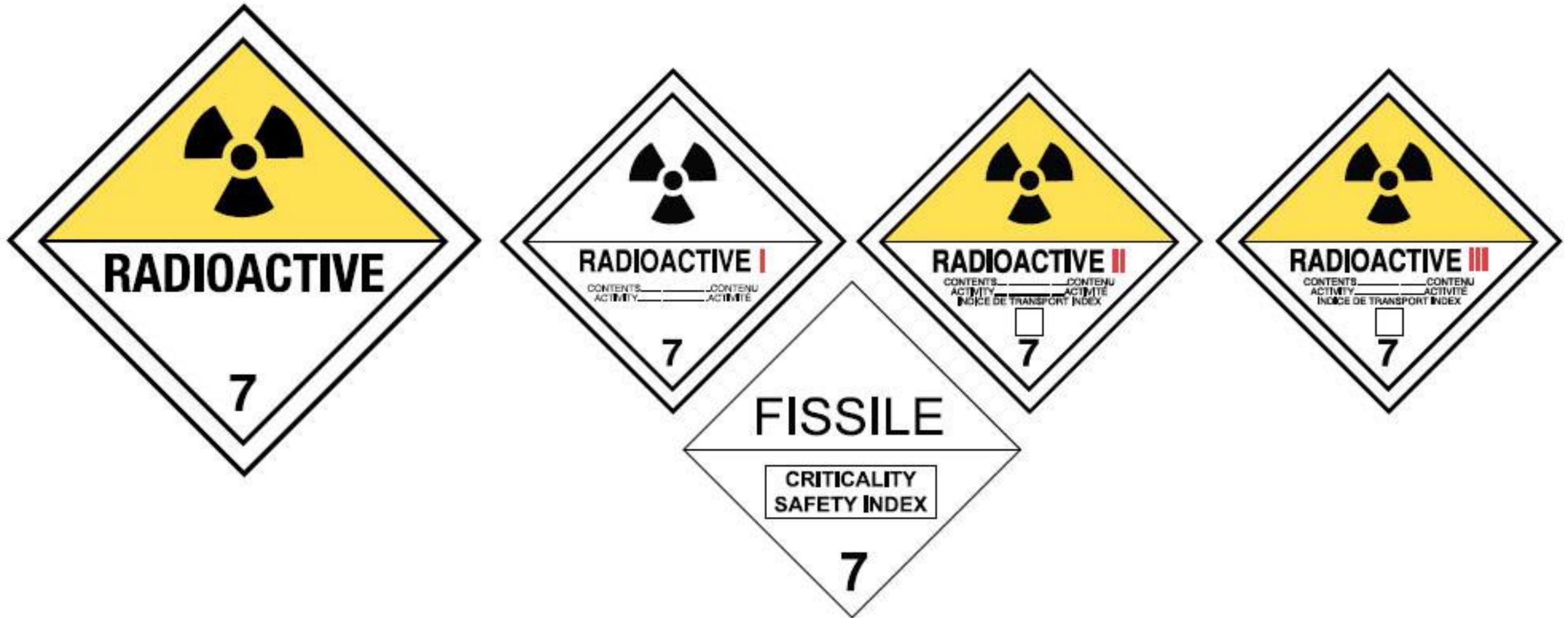
Appropriate packages are used for transport risks

Undamaged packages may have a measurable dose rate up to 2 mSv/hr (refer to documentation)

Refer to vehicle placard or documentation for advice number



Radiation Transportation & Packaging



Marking & Labelling of Packages

- Packages must also be marked on the outside in addition to the hazard warning diamond with:
 - Its permissible gross weight (if greater than 50kg)
 - Type A, Type B or Type C
 - The UN number assigned to the material it contains, preceded by the letters `UN` (other than excepted packages).

RADSAFE PLACARDING

A letter allowing to identify the Consignor (issuing site) of the load using the RADSAFE member list.



RADSAFE
In An Incident Ring
0800 834153
Site Code

This placard is IN ADDITION to the transport hazard placarding



Common radiation sources/locations



Medical

X-rays – no problem once electric is isolated
Diagnostics in region of MBq
Treatment (chemo) up to 10GBq
Cobalt (60), Cesium (137) and Iodine (131)



Industry

Identify defects – Collimated arrangement
Commonly Iridium (192) activity 10 to 6000GBq



Special Nuclear Material (SNM)

Warheads, nuclear power for submarines etc.

Common radiation sources - Industry

- Level/thickness gauges
 - Encountered on production lines => 1MBq
- Moisture/Density gauges (road surfaces)
 - Combination of $^{137}\text{Caesium}$ (300MBq) and $^{241}\text{Americium}$ (1.5GBq)
- Agricultural yield gauges (crops)
 - $^{241}\text{Americium}$ (35MBq)
- Teaching and research (various sources and activity)
 - Physics department – colleges/Universities
 - Medical research Hospitals

Radiation, Radioactivity

- The term radiation is broad and may include light, radio waves, etc. In our context it describes ionising radiation.
- Radioactivity describes the property of some materials to emit ionising radiation.
- Unstable atoms change (decays) into stable forms, giving out radiation in the process:
 - Alpha particles;
 - Beta particles;
 - Gamma rays (X-rays are a subset of γ)

Activity

- A measure of radioactivity
 - Expressed in a unit called the *becquerel* (Bq)
 - *One becquerel is defined as the activity of a radioactive material in which one atom emits radiation per second.*

For example, 1 gram of Pu-239 has an activity of approximately 2,000 MBq - that means, it emits 2,000 million (2 billion), alpha particles each second!

Activity of materials



Loaf of bread

70 Bq



Coffee (1 kg)

1,000 Bq (1KBq)



An adult

4,800 Bq (4.8KBq)



Cornish granite (10 kg)

12,000 Bq (12 KBq)



1 tonne of uranium

10 billion Bq (10GBq)

Radiation Dose

- Radiation Dose provides an indication of the risk to a person from exposure to ionising radiation
- Radiation dose is provided in Sieverts (Sv) = 1KJ of energy absorbed per kilogram of body mass

Dose (Sv)

$$1 \text{ Sv} = 1,000 \text{ mSv} = 1,000,000 \text{ } \mu\text{Sv}$$

Example Doses

Chest X-ray : 20 μ Sv

Flight to New York : 42 μ Sv

UK annual average exposure : 2.7 mSv

The LD50 at 30 days after exposure is estimated to be between 3.5 to 4.5 Sv (with minimal or no treatment)

Principles of Radiation Protection

Time

- Minimise time in hazard area

Distance

- Maximise distance to hazard area

Shielding

- Maximise objects to block the pathway of hazard

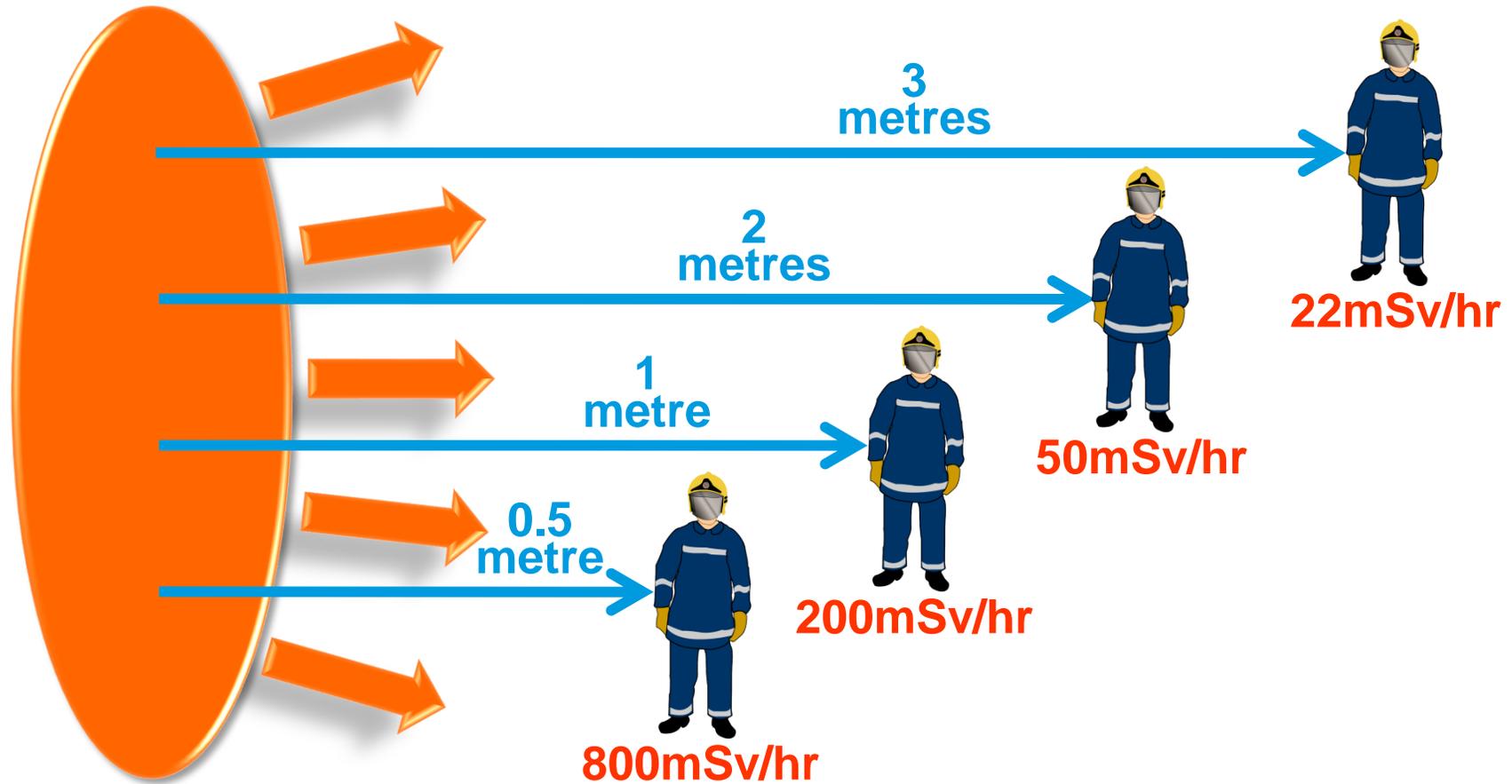
Time

- If we half the time, we half the dose rate:

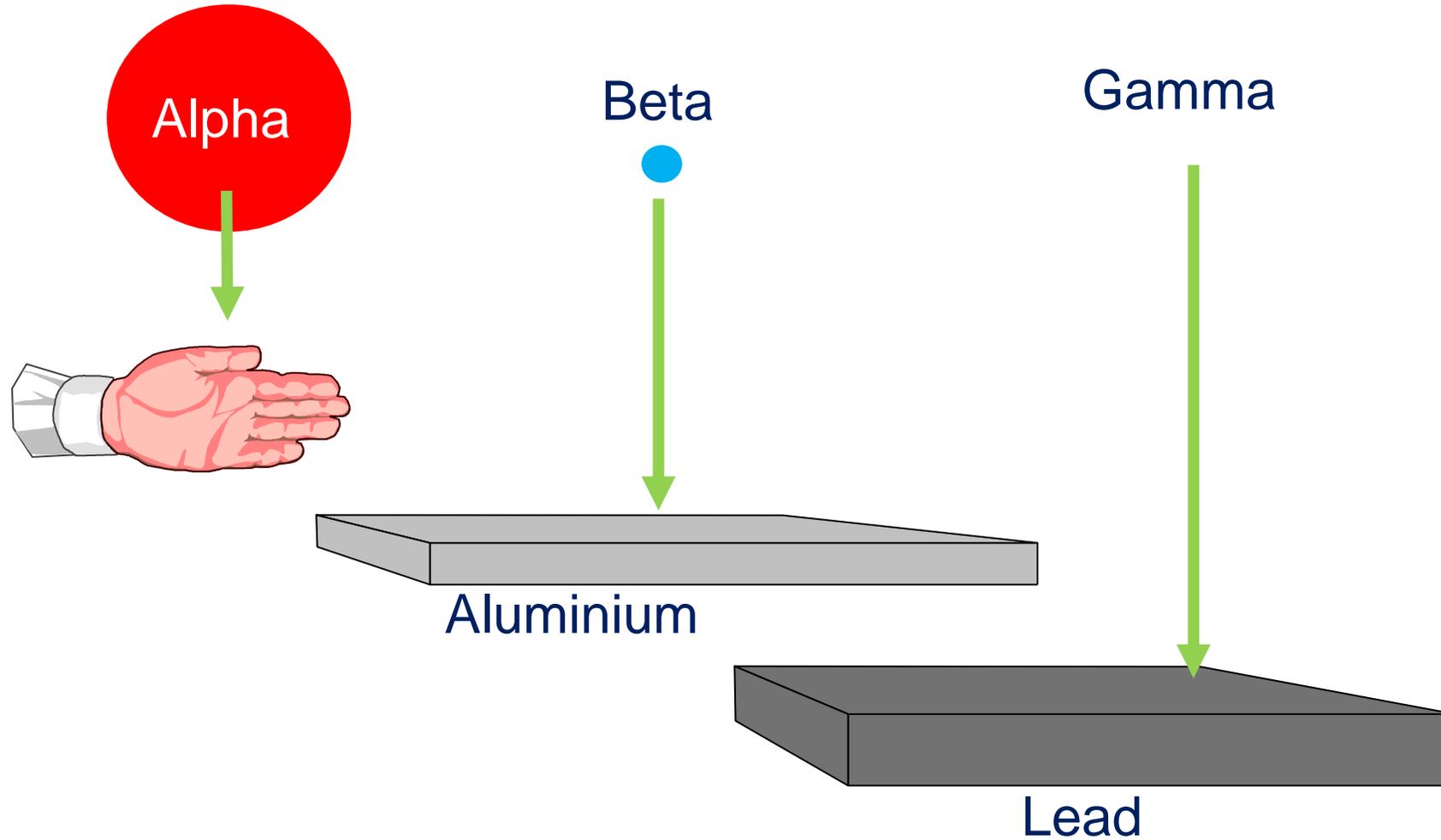
$$\text{DOSE RATE} = 160\text{mSv/hr}$$

Time exposed (min)	Absorbed dose (mSv)
60 min	160
30 min	80
15 min	40

Effect of Distance on Dose Rate



Shielding



Radiation Detection

Personal dosimeters (millisieverts = mSv)

- Measure actual dose received

Survey meters (millisieverts per hour = mSv/hr)

- Indicate dose rates at a given point

Contamination meters (counts per second = cts/s)

- Identify contamination.

Radiation Detection

Survey Meters:



Electronic Personal Dosimeters (EPD):



Alarm – Electronic Personal Dosimeter

- Pre-set to alarm at the following levels:
- During an alarm the LED will be constantly illuminated



**Dose
constraint**

	Alarm	Threshold	
	1	100 μ Sv/hr	
	2	5 mSv	
	3	100 mSv	

- EPDs are set to with a correction factor of H10 = estimated absorbed dose to a depth of 10 centimetres into flesh

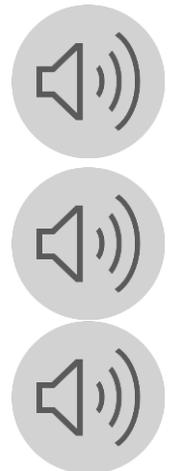
EPD TruDose™ Electronic Dosimeter



Alarm Levels

- The EPD has been pre-set to alarm at the following levels:
- During an alarm the LED will be constantly illuminated

Alarm	Threshold	Can alarm be silenced?
1. Hp10 Rate Warning	100 μ Sv/h	Y
2. Hp Dose Warning	5mSv	Y
3. Hp Dose Alarm	100mSv	N



Operation

- Survey mode (no probe attached)
 - Detects gamma (and X-ray) radiation only
 - Measures in $\mu\text{Sv/h}$ or mSv/h
 - No longer in use for HDIM
- Contamination mode (probe attached)
 - Detects alpha, beta and gamma (and X-ray) radiation*
 - Measures in counts per second (CPS)
 - Will still be used for the detection of alpha



Dose Limits

- 6mSv requires a formal investigation by the employer. There is a dose constraint of 5mSv at operational incidents, setting the dose constraint at 5mSv avoids the requirement for a formal investigation
- 20mSv requires an investigation forwarded to the HSE
- Dose Limits/Threshold values:
 - Occupational limit of 20mSv per year – males and females together
 - 100mSv exposure during one event / incident = requires informed volunteer

Radiation Health effects

Various health effects including short and long term effects are produced to radiation exposure:

- Reduced fertility
- Nausea
- Sickness
- Hair loss
- Skin reddening
- Cancers

These affects mainly become apparent above 100mSv

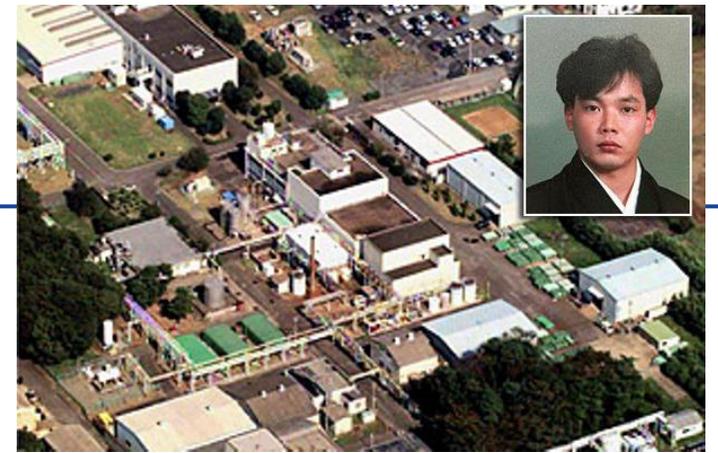
Radiation Exposure





edn

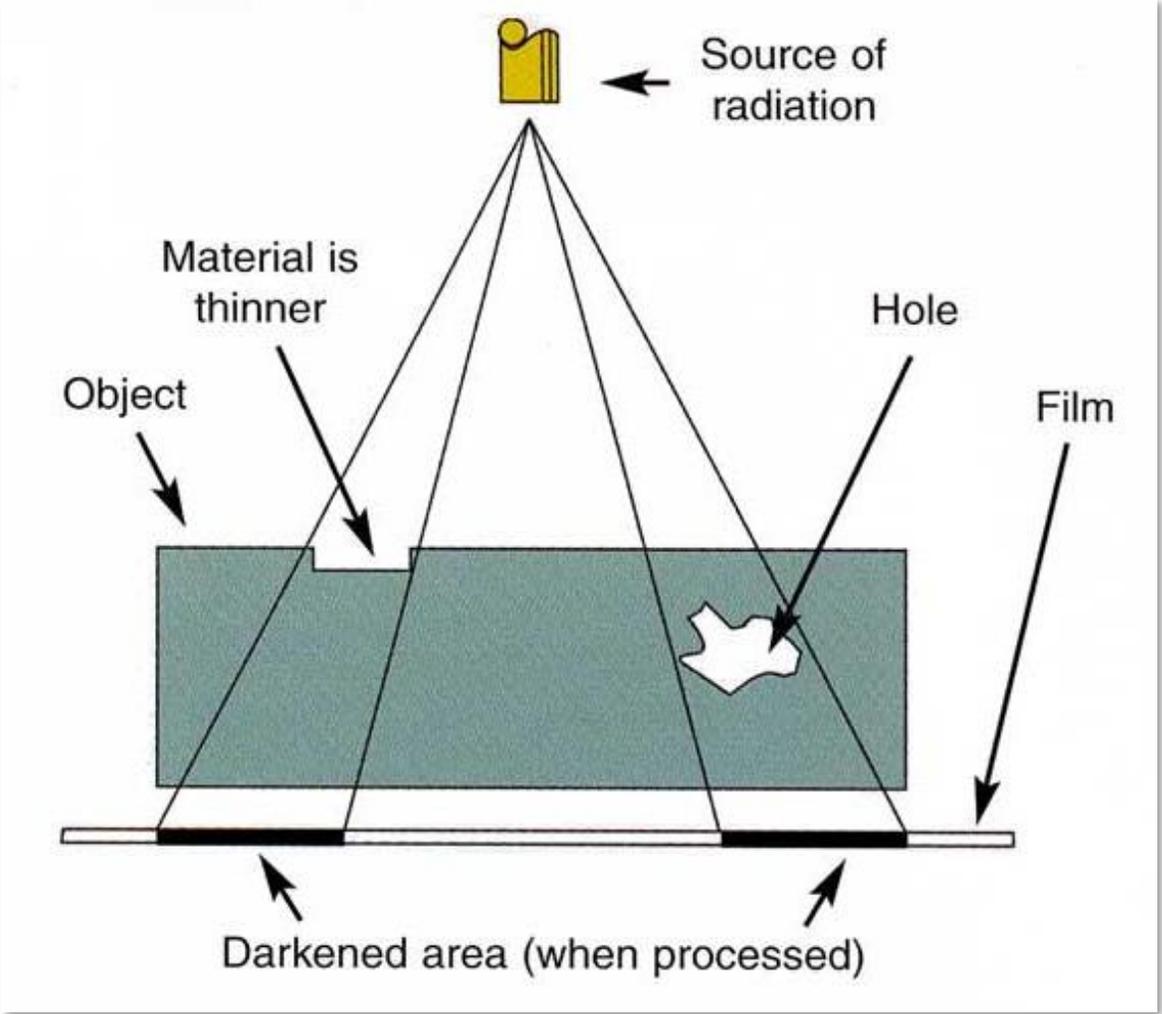
Worst Case Scenario



- Mr Ouchi
- 50mSv annual for Japanese radiation workers
- Mr Ouchi received 17Sv of radiation
- Kept alive for 83 days
- “Ouchi’s exposure to the radiation was so severe that his chromosomes were destroyed and his white blood cell count plummeted to near-zero. Most of his body had severe burns and his internal organs received severe damage”

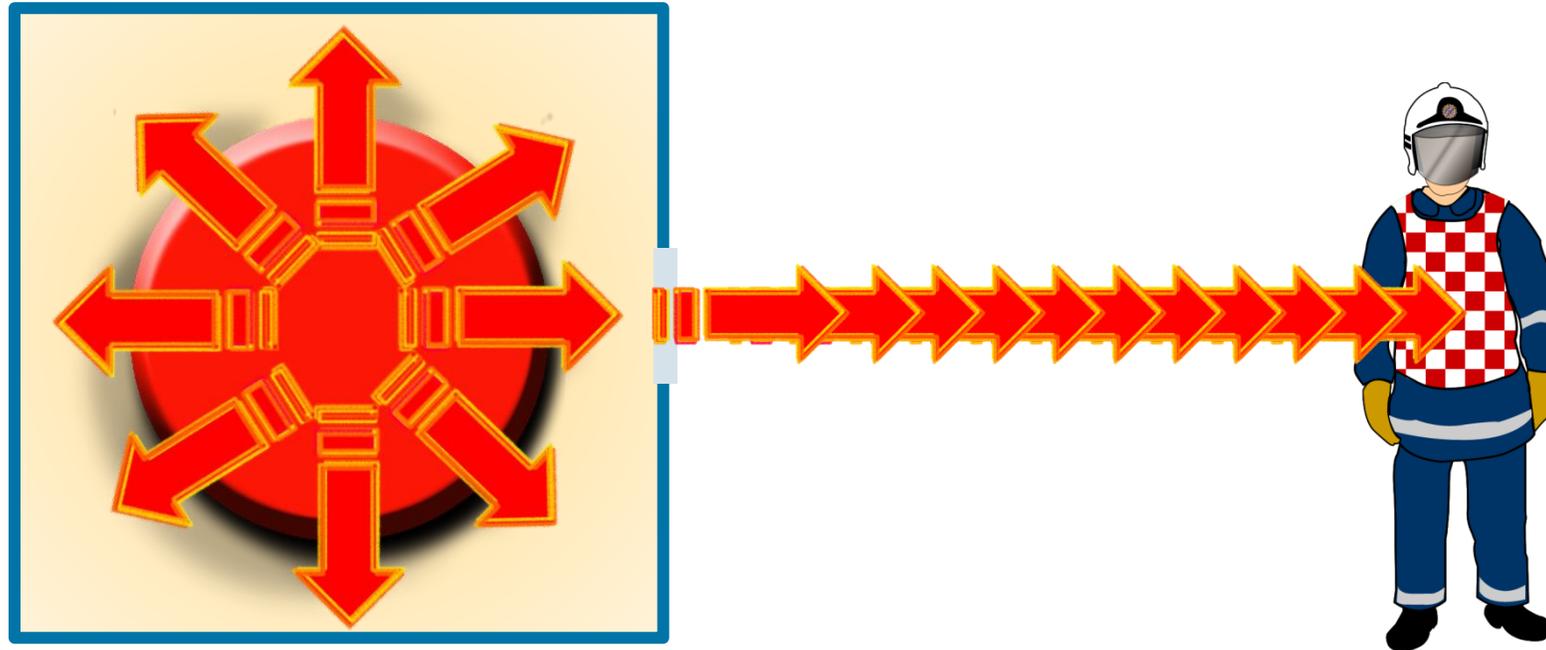


Defect detectors



Irradiation by a Collimated Source

Sealed Source

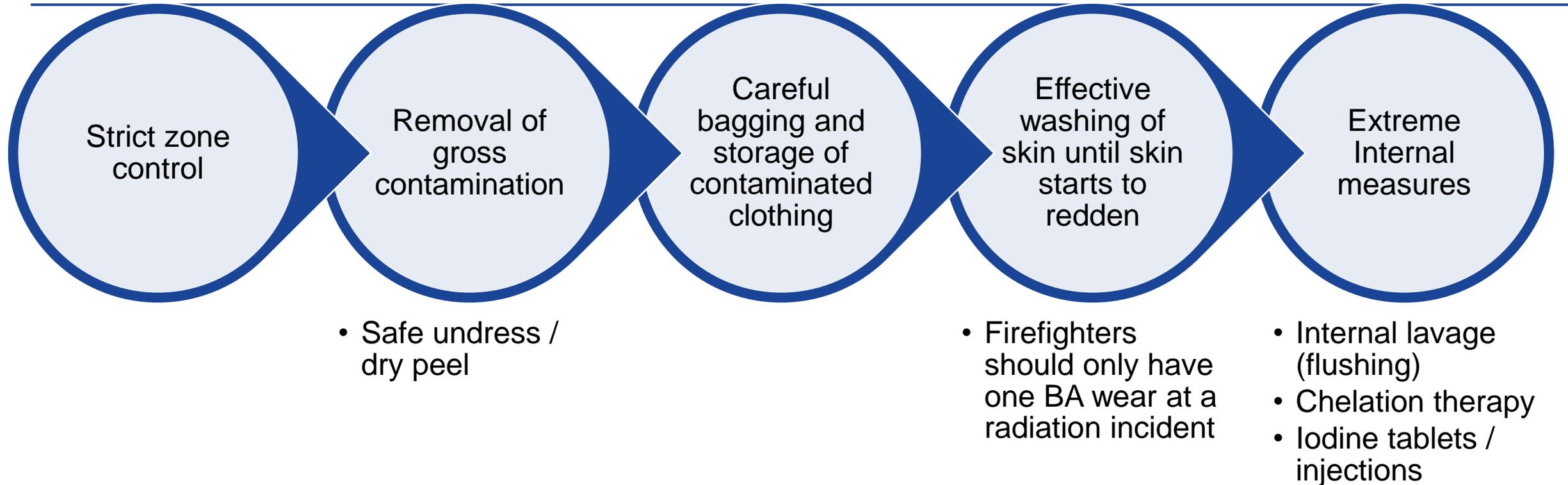


Radiation Exposure

- Truck driver
- Driving unaware that collimated source camera 'shutter' was open
 - *Source was behind the driver's seat*
- 12 minutes of exposure
- 20 Ci = 740 GBq



Radioactive Decontamination



- Waste water must be contained at all costs! – including emergency and casualty decontamination
- Firekit is sufficient protection against alpha and low energy beta radiation
- Implement time, distance, shielding into the tight brief
- Occupational records will require updating post incident.



