Radioactive Material Production,
Transportation, Use, and Possible Misuse

First Responder RDD/IND Protocols
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Emphasize that:

1) High activity sources are difficult to obtain
2) Once obtained, measures are taken to ensure the safety and security of the source.
3) The Regulatory agencies continually check up on the users to make sure they follow the requirements.

4) Pictured above is the Cherenkov radiation produced at University of Missouri-Rolla campus, the UMR Nuclear Reactor (UMRR)

5) Also picture is The Fast Flux Test Facility (FFTF) is a 400-megawatt (thermal) liquid-metal (sodium) cooled fast neutron flux nuclear test reactor owned by the U.S. Department of Energy (DOE). The facility is located in the 400 Area of DOE's Hanford Site in southeastern Washington State. Currently, the FFTF is being deactivated. This reactor produces many unique isotopes.
Radioisotope Thermoelectric Generators (RTG)

The picture shown is of some Sr-90 RTGs up in Alaska, these range from 2 – 5 feet in height. RTGs use the heat generated by the decaying radioactive material to generate electricity. They make about 500 watts (enough to light 5 100 watt light bulbs) but are extremely reliable and maintenance free for decades of operation in remote areas (like space or deep ocean). These generally have very radioactive sources of (4 to 500 kCi) in order to make the heat. The source resides at the center of the generator as is about the size of a large soup can. Typically the radioactive material itself is in a chemically inert form (i.e. ceramic) and then placed in a double walled steel capsule. These sources undergo extensive testing (i.e. vibration, crushing, fire, cold, etc.) to ensure the don’t break open in an accident.

These sources are very robust and the RTG is designed to meet Type-B shipping container requirements, including surface dose rates below 200 mrem/hr on contact.

1 year after being removed, spent fuel activity is ~ 1Tbq/kg [27 ci/kg] (source Finland radiation and nuc authority)

Nuclear fuels and Spent nuclear fuels. Emphasize that unused nuclear reactor fuel is not highly radioactive. After use however, the fission products build up and make the waste very radioactive. They are an external hazard and can not be handled directly. If dispersed they will be and internal and external hazard.

Pressed into ceramic pellets and clad in special metals capable of withstanding the harsh conditions inside a reactor core. When spent fuel is transported, it is placed into shipping container that are able to withstand the most heinous accident conditions. If appropriate, show the shipping cask trials (locomotive hitting cask) video.
Narrative

Here are some examples of radioactive isotopes commonly used in industry.

{Read slide if time permits}

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note: this slide can be removed for an overview
For over thirty years, spent fuel shipments have traversed our nation's highways and, over that time, over five thousand highly-radioactive fuel assemblies have been transported. Even with all of this experience and history, there has not been one single radiation release of any kind despite a few serious traffic accidents. This excellent safety record is due to the design, engineering, planning, and regulation related to the dry casks used for the transportation of spent fuel.

A variety of casks have been designed and tested and are being used. Lighter casks, from 25 to 40 tons are designed to hold up to 7 fuel assemblies. Heavier casks, up to 120 tons, are designed to carry up to 36 assemblies. These heavier casks may be transported by rail. In general, the casks are cylindrical with multiple walls and shields that give the casks their extreme strength and radiation shielding characteristics. In one such design, shown below, the spent fuel is sealed in a water-filled stainless steel cylinder with walls 1/2 inch thick and clad with 4 inches of a heavy metal (usually lead) for radiation shielding. This container is surrounded by 5 inches of water and encased in a corrugated stainless steel outer package. Another cask, designed by the Babcox & Wilcox Company and designation "BR-100" is also shown.

Source: NUCLEAR TECHNOLOGY & INFORMATION ON REACTOR SAFETY
http://www.geocities.com/ntirs/index.html

Safety in the shipment of nuclear material is achieved by a combination of factors, including the physical properties of the nuclear material itself, the ruggedness of the container, and the operating procedures applicable to both the transportation package and the vehicle transporting the package.

Materials Shipping Requirements
NRC performs inspections to determine whether transportation package users have taken the appropriate package measurements to ensure radiation levels are not exceeded. NRC inspections also focus on whether casks have been properly inspected for certain specific criteria, such as leak-tightness, that bolts and other equipment are intact, and that the packages are safe for transport.

Safeguards (Security) Requirements
For transportation of spent fuel, NRC performs inspections to determine that the spent fuel is physically protected against radiological sabotage.
Plutonium 238

Plutonium 238 is a non-fissile, alpha emitting isotope with a half life of 87 years. A sample of pure material would produce approximately 0.54 kilowatts/kilogram of thermal power. In some configurations, the surface temperature of a Pu-238 fuel element can reach 1050 degrees C. These characteristics make Pu-238 the most capable heat generating isotope. It will outlast most customers; even after 20 years a Pu-238 based power source will produce 85% of its initial power output. It has a high energy density, allowing power system mass and volume to be minimized. It is also easy to shield and its emissions will not interfere with sensitive instrumentation.

Unfortunately, Pu-238 is difficult to manufacture, making it extremely expensive. An accurate price is difficult to determine because of the lack of an open market, but the recent estimates by experts in the field indicate that the material costs several thousand dollars per gram in kilogram sized lots if it is available at all. Since RTG conversion efficiency is on the order of six to eight percent, this puts the price of a 50 W power supply at close to a million dollars.

There is also the public relations problem associated with the word plutonium. Frequent readers of Atomic Energy Insights might understand that plutonium is not as dangerous as Ralph Nader says it is, but that realization has not yet permeated the general public's consciousness. Most political decision makers are also not knowledgeable enough about nuclear physics to understand that Pu-238 cannot be used to produce a nuclear weapon; it has the wrong number of nucleons to be a fissile isotope.

Strontium 90

Sr-90 is a beta emitter with a 28.1 year half life. A pure sample will supply 0.46 kilowatts/kilogram of thermal power when new, or about 15 percent less than a similar mass of Pu-238. Additionally, an Sr-90 based RTG will deteriorate about three times as fast as one based on Pu-238; a 20 year old power supply will produce only 61 percent of the initial power output.

Because of the lower energy density, a Sr-90 fuel rod will not get as hot as a Pu-238 rod. A new rod, depending on configuration, might be able to achieve a surface temperature of only 700 to 800 degrees C. This is important because a lower temperature available to the hot junction of a thermocouple will reduce the thermoelectric conversion efficiency of the RTG. Because of these characteristics, a Sr-90 RTG will be about 50 to 100 percent heavier than a Pu-238 RTG of the same power output. For space based applications, where every payload gram is carefully controlled, this mass difference makes it uneconomical to consider Sr-90.

Strontium, however, has some advantages over plutonium. It is a fissile product with a high yield; about five percent of all fission reactions produce Sr-90. Since Sr-90 has a long half life compared to the time that reactor fuel spends in a core, it is quite feasible to mine Sr-90 from spent nuclear fuel. Sr-90 is considered by most of its current owners to be an expensive waste problem; perhaps some of them would pay to get rid of it.

Strontium is not associated with nuclear weapons and has never been called the most deadly element known to man. There is a precedence in the United States for widely licensing small quantities of sealed Sr-90; it is used in some aircraft ice detection systems.

There is also a precedent for its use in earth based RTGs; most of the Soviet ocean bottom and Arctic devices used SR-90 heat sources. (Chmielewski)
Masses are difficult to disperse

“Top strength” industrial radiography sources can be ~100 Curies and produce ~ 2 R/min @ 1m

Strong Radiography Sources
~2 R/min @ 1 meter

Facility Sources:
Stronger sources exist in facility based system Produce 200 R/min at 1m
Co-60 Sources: 1.32 R/hr @ 1m per 1 Ci
Therefore: 13,200 R/hr (200 R/min) @ 1m per 10,000 Ci
or 150,000 R/hr (2,000 R/min) @ 1 ft per 10,000 Ci
or 20 R/hr @ 25 meter per 10,000 Ci
Irradiating blood is recognized as the most effective way of reducing the risk of Graft-Versus-Host Disease (GVHD). This disease most commonly occurs in patients with severely weakened immune systems, and is recognized as a risk associated with blood transfusions. Transfusion-Associated GVHD (TA-GVHD) has become a major concern in current transfusion practices for immunodeficient and immunosuppressed patients because of the associated high mortality rate. Immunosuppressive therapies have not proven effective for TA-GVHD.

The unit pictured above Weighs 1150 kg (2,535 lb.) or 1479 kg (3,260 lb.) And uses a 650, 1450 or 2900 Ci Cs-137 Source.
If time permits, the TEPP movie on source testing can be very valuable.
Conclusion:
Radioactive Material Production, Transportation, and Use

- High Activity Radioactive Material is highly regulated.
- Industrial Sources are very robust and made not to leak.
- When dangerous quantities are shipped, the material is in a container capable of withstanding harsh accident conditions.
- Very high activity industrial/medical sources are facility based and difficult to remove.
External Exposures

- Focused radiation or localized contamination can result in radiation effect to specific areas on the body.
- Whole body exposure can result from:
  - A passing radioactive cloud or smoke
  - A large, distant point source
  - Exposure from contamination deposited on the ground
Internal Exposures

- Once radioactive material is deposited in the body, it can expose the person from within.
- The magnitude of the dose will depend on many factors:
  - How much material was deposited,
  - How it got into the body (ingestion, inhalation, absorption, or injection)
  - Chemical form of the radioactive material,
  - the radiation it produces,
  - How quickly it decays, and
  - How quickly the body eliminates the material
Not all exploded sources will disintegrate. Responders should be careful to check that the intended RDD didn’t simply bury a hot source in the ground or pavement. These sources can actually be more dangerous as their external dose rates could overexposure responders that stay in the area.
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**Internal Exposures**

- Dose from internal depositions are usually expressed by summing dose that will be received over the next 50 years from a one time internal deposition.
  - Referred to as Committed Effective Dose Equivalent (CEDE).
  - This dose calculation/estimate takes into account factors on the previous slide.
  - Even with a large CEDE, there may or may not be acute effects from the exposure.

*Do not use internal doses to predict acute exposure effects like nausea and vomiting.*
Early: Nausea & vomiting => Usually happens within a few hours of large (> 100 rad) exposures. The higher the dose, the sooner and more severe the symptom.  
Burns and wounds heal slowly => For localized exposures, burns and tissue necrosis.  
Hair loss, Fatigue, & medical complications =>

<table>
<thead>
<tr>
<th>Dose (rads)</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-50</td>
<td>First sign of physical effects (drop in white blood cell count)</td>
</tr>
<tr>
<td>100</td>
<td>Threshold for vomiting (within a few hours of exposure)</td>
</tr>
<tr>
<td>320 - 360</td>
<td>~ 50% die within 60 days (with minimal supportive care)</td>
</tr>
<tr>
<td>480 - 540</td>
<td>~50% die within 60 days (with supportive medical care)</td>
</tr>
<tr>
<td>1,000</td>
<td>~ 100% die within 30 days</td>
</tr>
</tbody>
</table>

A good example of this is the use of a large (> 1 Ci) Cs-137 or similar amounts of spent fuel.  
**Radiological injury or death is more likely to occur from an intact source as it irradiates nearby people.**  
Once dispersed, the acute external radiation becomes less of a hazard and reducing the chronic exposure from internal deposition becomes the primary health concern. Of course the financial/civil burden of denial of facility/area use is also a significant factor.

Internal dose is measured as CEDE = Committed Effective Dose Equivalent. This is equal to the total dose received by an individual over the next 50 years from an internal deposition. In addition to radiological decay, all radioactive material has a "biological half life" which describes how our bodies eliminate the radioactive material.
Expose people to an external source of radiation. Sources could be placed in areas of high population (subways, stadiums, etc..) and expose passersby.
* Only a few individuals might be injured before the threat is discovered
* medically detectable effects from available sources not likely (Time, Distance, Shielding)
* Source easily found once threat is known

Disperse radioactive material using conventional means.
• Requires putting the radioactive material in a dispersible form (i.e. fine powder or liquid)
• If there is enough activity to be a threat once dispersed, then performing the prerequisite chemistry can be lethal to the chemist.
* Even without a lot of radioactivity, public hysteria to being “sprayed” can be a major issue. Remember the “med fly” spraying, (for those of us in California).

Detonate a radioactive dispersal device (a ‘dirty bomb’)
Combining Radioactive sources with explosives
• Satisfying “bang” to announce event
• Radiation Exposure unlikely to produce health effects, but..
• Contamination will greatly complicate emergency response effort.
* Like above, commercial high activity sources may not easily be distributed, even with an explosion.
* Source easily found once threat is known

Detonate an improvised nuclear device
very hard to do...
If it comes up, the older (cold war) definition of a ‘Dirty Bomb’ was used for nuclear weapons that created an excessive amount of fallout. However, the term currently used in the news media is the slang term defined above.

But this is NOT the current definition.
A Case Study: Goiania, Brazil 1987

- The 1.4 kiloCi (4,400 Ci) Cs-137 medical teletherapy source was breached by scrap metal recyclers.
- Everyone was impressed by “the glowing blue stones.” Children & adults played with them.
- Serious radiological accident recognized 10 days later when Acute Radiation Syndrome symptoms were recognized by hospital staff.
- 112,000 people (10% of Goiania’s population) were surveyed at an Olympic Stadium. Significant psycho-social impacts.
- 4 deaths, 28 skin injuries, 50 internal depositions, significant contamination: 85 residences (41 demo-ed)

Narrative:

In 1985, the Goiania Institute of Radiotherapy moved to a new location taking a Cobalt-60 teletherapy and discharging an obsolete Cesium-137 teletherapy unit in a partially demolished session of the old building in downtown Goiania.

Two young men without permanent jobs looking for a way to make some money learned that there was a heavy equipment at an abandoned and partially demolished hospital building in downtown Goiania.

Possibly on September 13, they forced the entrance of the building and decided to remove the shielding head of the teletherapy unit and sell it to a junk yard.

The two men, the owner of the junk yard and his two employees initiated attempts to dismantle the equipment.

The rotating assembly and a capsule containing about 1400 Curies of Cesium-137 were dismantled presumably on September 18.

The capsule was ruptured and the cesium released.

Pieces of the source were distributed among the junk yard owner’s relatives, neighbors and most close friends.

Everyone was impressed with the “power of the stone” as it glowed blue in the dark.

Some of them scrubbed the material on the skin in order to appreciate its brightness.

Residences about 100 miles from Goiania were found with cesium contamination.

The owner’s wife observed the occurrence of the first symptoms of acute radiation syndrome among her relatives and decided to look for medical assistance at the Hospital for Tropical Diseases.

Pieces of the source were put in a bag that she took along with her by bus to the hospital.

The Brazilian Nuclear Energy Commission was notified by a goianian physicist about the occurrence of a serious radiological accident.

UCRL-PRES-149903; This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.
Example: Brazil’s 1.37 kCi (1,370 Ci) Cs-137 Source Made Into a “Dirty Bomb”

- Using Fictional “North Pointe” Example
- This model assumes “worse case” in that:
  - The source was 100% aerosolized (unrealistic)
  - Small explosive (~1 stick of dynamite)

Very unrealistic scenario…. But it’s just to provide you with a frame of reference.
Trouble In North Pointe...

Explosion at Freeway

Explosion and Fire at Hospital

School Bus Crash
Long Range Effects

- Explosion at Freeway
- Explosion and Fire at Hospital
- School Bus Crash
Detectable Ground Contamination Can Be Found Miles Downwind

Twice Background Detected
(~ 90 cpm) 0.001 mrem/hr

Light Wind

Explosion and Fire

10 miles

83 cpm
School Bus 100 mrem/hr

Bridge:
0.11 mR/hr

Hospital:
2.09 mR/hr
**Useful Points of Reference**

- **1 rem in 4 days:** Shelter is above 10mR/hr line.
- **School Bus:** 2 hours of victim stabilization & rescue near scene.
  - 200 mrem total dose
- **Hospital:** 10 hours of firefighting and rescue.
  - 40 mrem total dose
Putting It in Perspective

- Although easily measured for miles,
- Shelter area may only be a few blocks, and
- Responders unlikely to get high exposures
I have been reviewing extensive materials on this subject and performing my own analysis. The general consensus about RDDs can be summed up by the following points.

1) The primary *radiological health* concern from an RDD is from dispersal and internal uptake of radioactive material. If there was enough to be of an external exposure concern for folks out of the "blast zone", then it would have been a very lethal point source to begin with and would have been difficult for the terrorist to set up & transport without keeling over before setting it off. However, it should be noted that a real exposure concern may be from source fragments at the scene.

2) Internal Exposures cause chronic long term doses that *generally* do not produce acute effects, even if they exceed dose levels that would have caused death or injury for an acute exposure. The primary concern for the internally exposed population is the long term increased risk of cancer. [The exception to this would inhaling enough material to "burn" the inside of your lungs resulting in pulmonary edema, though this would require extended breathing of the "smoke"]

3) Increased risk of cancer is not an "injury." The definition of Injury should be limited to Acute Radiation Syndrome (ACS) and Acute Cutaneous Syndrome (ACS) (burns caused by high levels of skin contamination with high energy beta emitters).

4) The *primary* issues surrounding the radiological aspect of an RDD are not additional deaths or injuries, but:
   a) Physically injured personnel receive a delay in treatment due to fear of contamination.
Some Federal Guidelines Do Exist...

But what does it mean to these guys?

<table>
<thead>
<tr>
<th>Activity being performed</th>
<th>Limitations or conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay Times?</td>
<td>None</td>
</tr>
<tr>
<td>Turn Back Dose?</td>
<td>None</td>
</tr>
<tr>
<td>Decontaminate!</td>
<td>Person fully aware of the role involved use this limit only on a voluntary basis.</td>
</tr>
<tr>
<td>Fight Fires...</td>
<td>None</td>
</tr>
<tr>
<td>Rescue Victims...</td>
<td>None</td>
</tr>
<tr>
<td>...or wait for the Experts?</td>
<td>Person fully aware of the role involved use this limit only on a voluntary basis.</td>
</tr>
</tbody>
</table>

*Taken from Table 2-2 of EPA 400-R-89-001 Manual of Protective Action Guides and Protective Actions for Nuclear Incidents.*
This guidance was put together from various sources.

Notice the Turn-back dose is different than the life saving dose.

Notice that the decon guidance uses relative terms, but doesn’t tell you what instrument to use. Many instruments can even detect alphas!

Equipment decon equipment is > 10 times background… try to do your 2x background survey with that!

[click]

Here is a typical Staytime table used in a Response Organization’s Protocol. To use this you have to:

1) Know what dose is appropriate for you ant your situation

2) Know what the dose rate is in the area of concern

   • This would mean that (1) someone has to go in and take a measurement and (2) the dose rate is fairly constant
   • Radiation fields are rarely consistent and in some cases decay will effect this significantly.
“Results can then be visualized in 2 or 3 dimensions quite readily. Wind patterns, as well as plume transport and dispersion can be readily visualized, as in these examples”
To be fair these photos were taken at different phases of the incident. (the guy in the blue helmet is a controller)

The Police officer on the left is one of the 1st on the scene and is wearing his uniform and a full face respirator. He is searching for, and helping evacuate, victims.

The EPA team on the right is wearing level A, they are doing surveys later in the day… though I understand that not all of the victims had been evacuated when they started.
What is the Appropriate DECON?

That does not look like warm water and I doubt that is a soft bristle brush.
What is the Right Equipment?
Solutions are Community Specific

- Every community balances the “risk / benefit” equation differently and has different needs.
- Most important to have a scaleable approach.
- Planning is often more important than the plan itself.
- A sound scientific basis is important
"Results can then be visualized in 2 or 3 dimensions quite readily. Wind patterns, as well as plume transport and dispersion can be readily visualized, as in these examples"

(this is an animated slide)
“Results can then be visualized in 2 or 3 dimensions quite readily. Wind patterns, as well as plume transport and dispersion can be readily visualized, as in these examples”
"Results can then be visualized in 2 or 3 dimensions quite readily. Wind patterns, as well as plume transport and dispersion can be readily visualized, as in these examples"
Radiological Emergency Response
Assistance and Resources

Inhalation issues are only during the “plume passage.” although there will be some concern with resuspension of material (either by wind, equipment movement, or fires) this dose is small compared to the potential

- **Primary concern** is external exposure from the material deposited on the ground (a.k.a. groundshine)

- **Inhalation dose is a very minor concern** except to those outdoors and near the explosion. Responders will usually arrive after most the radiotoxic smoke has dissipated
ERG Equivalent for RDD

- Area of highest concern limited to 500 m (worse case)
- Within 500m, Primary inhalation hazard is gone within 10 minutes (prior to arrival of most responders)
- For likely scenarios, primary concerns of the early first responder are:
  - Protection from groundshine,
  - Provide guidance on how to handle contamination, &
  - Assess inhalation concern
- Although inhalation exposure not the primary focus, respiratory protection still advised
As Measurements are Made...

- **Hazard Detection, Identification, & Control**
  Establish control zones consistent with NCRP and CRCPD

<table>
<thead>
<tr>
<th>Radiation Level</th>
<th>Zone Description</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 mrem/hour</td>
<td>Outer Exclusion Zone</td>
<td>Outer boundary for small incidents. No legal restrictions outside this area.</td>
</tr>
<tr>
<td>10 mrem/hour or Contamination above 1,000 R/μm² or 100 Bq/cm²</td>
<td>Hot Zone</td>
<td>Proceed for Emergency Operations (life saving, fire fighting, etc.). Shelter/vacate public, isolate area, and minimize responder time spent in this area.</td>
</tr>
<tr>
<td>10,000 mrem/hour (10 R/h)</td>
<td>High Radiation Hazard Zone</td>
<td>Proceed for time sensitive, mission critical emergency operations such as life saving.</td>
</tr>
<tr>
<td>200,000 mrem/hour (200 R/h)</td>
<td>“Turn Back” Level</td>
<td>At this dose rate, the likelihood of successful rescue of victims is potentially outweighed by dose effects to the responders.</td>
</tr>
</tbody>
</table>
Defining Outer Boundary & Exits/Triage/Monitoring Points

As additional resources arrive,* establish Hot Zone boundary and triage evacuees:

a) Boundaries should be established based on urban landscape features (e.g., streets, parks, etc.). In the urban environment, turbulent wind conditions will make warm zone boundaries very irregular.

b) Establish exit points, monitor to ensure < 10 mR/h

c) If possible monitor at the exits to identify (triage) highly contaminated individuals

d) If mass self-evacuation
   • Do not detain people in the contaminated area
   • Establish evacuation routes to channel self-evacuees away from Hot Zone

*The time sensitive, critical response operations (e.g., life saving, fire fighting) in the Hot Zone take precedent over warm zone activities.
After 30 minutes, the inhalation hazard is greatly reduced as the particles settle out of the air.

One out of the smoke/dust area, Stop using ad-hoc protection.
After 30 minutes, the inhalation hazard is greatly reduced as the particles settle out of the air.

One out of the smoke/dust area, Stop using ad-hoc protection.
Use Natural boundaries for Warm Zone, Exits, and Monitoring sites

- Dangerous Radiation Zone (~10R/h)
- Hot Zone Boundary based on natural breaks & <10mR/h
- Evacuees directed to triage & monitoring sites
- Triage & Monitoring sites: identify & manage highly contaminated

Graphic courtesy of LANL, a DOE program; contact information for more information.
**Medical Triage**

a)  *Medical emergencies (life threatening injury) take precedent over radiological monitoring or decontamination*

b)  Some may need medical assessment because of their exposure or radioactive material inhalation. A priority for decontamination and medical follow up are:
- People with high levels of contamination on their clothes
- People with wounds exhibiting high levels of radiation
- People with upper body contamination (this is an indicator they were outside and close to the explosion)

c)  If the source is not $^{137}$Cs, $^{60}$Co, or $^{90}$Sr, high doses and acute radiation effects are not possible with explosive RDD

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Life threatening injuries take precedent over radiological monitoring or decontamination. Contamination is not an immediate danger to the life of the victim or the responder.

There is the possibility of source fragments inside a wound, treatment (and source removal) of these victims should not be delayed.

You cannot get a significant lung dose (radioactive material uptake) without getting significant external contamination on the upper body.
First Responder PPE
a) Uniform
b) Goggles
c) Half-face APR
d) Gloves

Level A and B protection are ineffective against a primary dose concern; groundshine radiation. Using level A or B may actually increase a responders dose as it limits functionality and communication which will increases their working time in the radiation field.
Public Decontamination Considerations

- **Contaminated Public, 2 Possibilities:**
  - A few individuals close (within few hundred meters) to the release may require prompt decontamination for their safety and safety of others. These highly contaminated individuals also warrant medical follow-up.
  - Majority of those contaminated do not need decontamination on an urgent basis and are **not** a danger to themselves or others.

- **Radiological Decontamination requirements far less difficult than chemical or biological decontamination:**
  - Removal of outer layer of clothing
  - Gentle washing with soap & warm water on exposed skin & hair
  - Decon staff needs only minor respiratory protection
Decontamination strategies must consider:

Self decontamination strategies, and
Decontamination of special needs population

Pre-established reception centers throughout a community with supplies rapid set-up can facilitate decontamination of population.
Acute Exudative Radiodermatitis is characterized by inflamed skin with redness, pain, and oozing body fluids. Medical care may be needed. This is the deterministic health effect of greatest concern because it occurs at the lowest level of concentrated surface contamination.

Based on information in Appendix B of Reference 2, the threshold dose to the skin for acute exudative radiodermatitis is in the range of 1,200 to 2,000 rad (as used here, 1 rad = 1 rem). The lower end of the range (1,200 rem) is conservatively assumed.

Based on dose conversion factors in Appendix B of EPA 520/1-89-016 Evaluation of Skin and Ingestion Exposure Pathways (Reference 4) for the mix of radionuclides assumed to be associated with a major reactor accident, the factor to convert skin contamination to skin dose at a skin depth of 7 mg/cm², is about 7 rem/h per μCi/cm² (may also be expressed as 7 rem per μCi h/cm²). Therefore, if the activity is concentrated in a 0.2 cm² area, then the threshold MDL of activity on the spot to avoid acute exudative radiodermatitis is \(34 \text{ μCi h}\) (i.e., 1,200 rem/7 rem per μCi h/cm² x 0.2 cm²). Dividing 34 μCi h by 36 h and 336 h of exposure yields 0.95 μCi and 0.10 μCi for loose and fixed contamination respectively.
### Twice Background Not Realistic... and Impossible to Measure

<table>
<thead>
<tr>
<th>Instrument/Detector Combination</th>
<th>Fixed Contamination (0.1 mCi Threshold)</th>
<th>Loose-Plus-Fixed Contamination (1.0 mCi Threshold)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.2 x 10^1 dpm (3,700 Bq)</td>
<td>2.2 x 10^6 dpm (37,000 Bq)</td>
</tr>
<tr>
<td></td>
<td>Probe Speed (inches/s)</td>
<td>Time Needed to Monitor an Adult (minutes)</td>
</tr>
<tr>
<td></td>
<td>Height of Probe (inches)</td>
<td>Path Width (inches)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD V-700 with side window detector</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>0.25 to 0.5</td>
<td>1 to 2</td>
</tr>
<tr>
<td></td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>CD V-718 with end window detector</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>0.5 to 1</td>
<td>1 to 4</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>All tested instruments with pancake detector except the Victoreen 190</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>1 to 3</td>
<td>2 to 6</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Victoreen 190 with pancake detector</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>1 to 4</td>
<td>2 to 6</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.24</td>
</tr>
</tbody>
</table>

---

a. The values shown were derived with the detector protected by two layers of plastic vegetable wrap and in the presence of 0.1 mR/h gamma radiation background, except as noted.

b. These are calculated values assuming a skin area of 18,000 cm2 = 2790 in2.

c. Audible detection was not possible in the presence of 0.1 mR/h background. This value was derived in the presence of 0.02 mR/h background.
Note: 1 The American National Standards Institute is developing performance criteria for Personal Emergency Radiation Detectors (PERDs). There are two standards, ANSI N42.49A and ANSI N42.49B, which will be published by the Fall of 2010; ANSI N42.33 and ANSI N293 describe performance criteria for instruments used for detection and measurement of photon emitting radioactive substances for the purposes of detection and interdiction and hazard assessment. Survey Meters are generally considered an ANSI N42.33 Type I instrument, the figure below provides information on the applicable exposure rate ranges for these instruments.

Radiation detection systems deployed in support of prevention radiological nucleare detection (PPND) missions are generally too sensitive to be used within the DFZ or Hot Zone. However, they can be of great use outside the Hot Zone for the activities noted above. This includes instruments such as the Personal Radiation Detectors (defined by ANSI N42.33), survey equipment (defined by ANSI N42.33 Type I instruments noted above), Radiotrace Identification Devices (defined by ANSI N42.34), Backpack, and Mobile systems.

Definitions of the Legend categories:

Useful - This is a device that can effectively perform the designated mission or task without modification of the device or its normal mode of employment. In a sense, the device was designed or intended for that mission or task.

Marginal - The device can provide useful and relevant data in support of the designated mission or task, but with modification of the normal mode of employment. In addition, its use may create a potentially unsafe condition to the user of the device. This implies a need for care in the interpretation of the data produced by such a device under the circumstances.

Not Useful - While the device is capable of detecting nuclear radiation, its technical performance characteristics or conditions of use are such that it is unlikely to be able to provide useful information in support of the designated mission or task. In addition, its use may create a grossly unsafe condition to the user of the device.

References of Interest for Equipment selection

ANSI N42.17A (1986), "Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Extreme Environmental Conditions"
ANSI N42.17C (1989), "Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Extreme Environmental Conditions"
ANSI N42.20 (2003), "Radiation Protection Instrumentation: Performance Criteria for Active Personnel Radiation Monitors"
DHS PHEGAT (2006), "Preparedness Directors, Protection Action Guides for Radiological Dispersion Device (RDD) and Improved Nuclear Device (IND) Incidents, Notice TFR 14191
IAEA-TECDOC-1142 (2008), "Development of an Extended Framework for Emergency Response Criteria"
ICRP Publication 86 (2005), "Protecting People Against Radiation Exposure in the Event of a Radiological Attack"
NSCIP-Commandery No. 10 (2006), "Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism"
NGSP Report No. 128 (2017), "Management of Terrorist Events Involving Radiological Materials"
NPFMA 4212 (2006), Standard for Compliance of Responders to Hazardous Materials/Warfare of Mass Destruction Incidents
Equipment Characteristics

There are three primary characteristics to consider when selecting Instruments

**Sensitivity.**
- Sensitive detectors can measure very low levels of radiation.

**Selectivity.**
- There are different types of Radiation, the type of radiation and it’s energy “signature” can help distinguish common natural, medical, or commercial sources from potential threats.

**Portability.**
- Portability can be a critical element depending on how the detection system is being used.
- As a general rule, equipment sensitivity is proportional to size: larger detectors are more sensitive.
- Highly sensitive instruments may be helpful for detecting low levels of radiation, but can also be easily "overwhelmed" by levels that could easily be encountered in an emergency response.
- Alpha and Beta radiation require thin window detectors.
- Gamma spectroscopy systems (RIIDs) use the energy "signature" to identify the radionuclide, however most hand-held RIIDs have poor resolution and can incorrectly identify complex signatures.
Detection Equipment Portability

- **Human-portable** – equipment that is small enough to be carried easily by a single person either as a handheld device or in a backpack.

- **Mobile** – vehicle mounted detection systems. These systems contain the largest detectors of all five types, and are therefore the most sensitive.

- **Aerial** – detection equipment is carried by a helicopter. It is used for operations in large areas that are not easily covered with other mobile systems.

- **Re-locatable** – detection equipment that can be moved from place to place. It differs from mobile types in the sense that it can be temporarily fixed to a certain area, but has the ability to be moved if needed.

- **Fixed** – these are (typically) portal radiation monitors. This type of equipment is usually applied to choke points used by pedestrian, vehicle, and commercial traffic.
Although the perfect tool does not currently exist, there are a few different types of instruments that have some of the right properties. One example would be the one of the numerous electronic dosimeters that are currently on the market.

The Pros
These devices are becoming more common in the industry today. In addition to their small size & ruggedness, they track the exposure received by the wearer and can even alert them to hazardous situations by an audible alarm. The user simply needs to turn the unit on and wear it. Many units have low power consumption and the batteries can last for months while on.

[Click to Display Cons]

•The Cons
Although some of these devices have beta radiation detectors, when used passively, these devices won’t alert the user to alpha and beta radiation from contamination unless there was an accompanying deep dose field. Many of the units are not sensitive enough to detect low levels of radiation that may be associated with contraband concerns (microSv or fractions of a mrem)

[Click]
In summary, the issues associated with electronic Dosimeters are:

- Well suited for emergency responders who may need to quickly enter a scene, these devices can help ensure responder safety by alerting them when radiation is present, but they may not be sensitive enough to identify the radiological nature of events involving small quantities or alpha emitting isotopes.

- Units with more than 1 alarm levels preferred, one alarm used for radiation proximity “alert” (1 µSv/hr) and one used to indicate hazardous “turn back” levels (0.1 Sv/hr or 0.1 Sv).

- Training must be provided to ensure that the user continues to perform rescue and first aid efforts even with “alert” alarms. Additional victim casualties could result from ill trained responders who leave the scene at alert levels.

- Typical costs are several hundred dollars per unit, but models that detect beta or neutron radiation, or those with external probes can be more expensive.

[click]

I’ve summarized the description and some EXAMPLE units on this slide. Don’t try to read this eye-chart, it is there to complete your hand out. This does not represent an endorsement!
Although it looks similar to an electronic dosimeter, there is a very different kind of detector out there which I call “Personnel Radiation Proximity Alert Systems.”

The Pros
• Very sensitive. Alerts the user of any statistically significant changes to the natural background radiation levels.
• Useful for finding contraband radioactive material.
• Good battery life (often weeks of continuous operation)
• Small Size (pager or notebook sized)
• Simple operation (requires no user action, simply wear the unit)

Cons
• Will alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation.
• Does not accurately measure (or work in) high dose rates which would be of concern to emergency responders performing rescue operations.
• Won’t detect alpha or low energy beta contamination (other than by associated dose fields)
• Expensive ($800 – $2,000)
In summary
Well suited for law enforcement or inspectors, these devices can alert the wearer to any unusual radiation in their proximity. These devices are best used when there is an opportunity for a measured response, Training must be provided to ensure that the user realizes that the alarms do not necessarily indicate a hazardous situation. As in all of these cases, additional victim casualties could result from ill trained responders who leave the scene because of the proximity alarms. Training must also be provided on how to resolve the many alarms that will occur from legitimate radioactive material uses.

click
I’ve summarized the description and some EXAMPLE units on this slide. Don’t try to read this eye-chart, it is there to to complete your hand out.
Industry Standard Radiation / Contamination Survey instruments are those commonly used by health physicists and radiation control technicians at nuclear power plants, hospitals, and research laboratories. These instruments use a variety of detector technology (GM, Ion chamber, scintillator, proportional counter, etc..) to measure dose rates and contamination. Although well suited for the experienced user, they may not be appropriate for the occasional user like an emergency responder. In order to meet the needs of the occasional, novice user, manufacturers have tried to create sub-genre of instruments that are smaller and easier to use. I have labeled this category *Simplified Contamination Survey Instruments*

**Pros**
- Most have Good Sensitivity.
- Digital models can have set alarm levels
- “Open window” GM for alpha and beta contamination.
- Small Size (cell phone or notebook sized)
- Simple operation (user action required, but usually only one or two switches)
- Rugged, simple technology.

**Cons**
- Sensitive enough alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation.
- Many models can not be used in high dose rates which would be of concern to emergency responders performing rescue operations (>0.1 Sv/hr | >10R/hr).
- Low accuracy (i.e., uses pancake GM for dose measurement)
In Summary
Smaller, simpler, and often cheaper than commercial equipment, these devices are well suited for the emergency responders. There is a large variety of capabilities in this class of instrument to the appropriate features must be considered for the task and the user. Training must be provided to ensure that the user understands how to interpret readings. Using the instrument to detect contamination will require also require special training.

Typical costs are $300 - $600 dollars per unit. For the occasional user, choose the more expensive digital models as they will have alarms and are easier to operate.

[click]
I've summarized the description and some EXAMPLE units on this slide. Don't try to read this eye-chart, it is there to to complete your hand out.
Commercially available handheld NaI gamma spectroscopy has seen great improvements in the last 5 years. Mostly in the form of better analysis algorithms and easier interfaces.

Pros
- Very sensitive. Alerts the user of any statistically significant changes to the natural background radiation levels.
- Useful for finding contraband radioactive material.
- Often tracks dose rates and total dose of user while on.
- Can identify many common isotopes

Cons
- Although fairly good at identifying common isotopes with simple spectra, these units can not identify all possible isotopes of concern and can mis-identify isotopes.
- Will alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation (though the analysis capability can often help resolve this).
- Expensive ($8,000 - $12,000)
- Won’t detect alpha or low energy beta contamination.
- Requires extensive training or support to use properly
In Summary,
Their expensive prohibits them from being in every first responder’s back pocket, but they can be a valuable tool in the hands of a well trained regional responder. Although most units have been ruggedized, the technology is inherently shock sensitive and the automated analysis is not 100% effective. Accurate assessment often requires an experienced spectroscopist to assess data. Fortunately, many of the units have the ability to download the spectrum for remote analysis by an expert. However, even with an expert the limited resolution or efficiency of room temperature spectroscopy systems may be insufficient to accurately identify an isotope and higher resolution, liquid nitrogen cooled detectors would need to be used ($30,000+)

[click]
I’ve summarized the description and some EXAMPLE units on this slide. Don’t try to read this eye-chart, it is there to to complete your hand out.
Narrative:

When training first responders in radiological safety, it’s important to clearly understand your objectives.

Let’s face it, most first responders will never have to use the information you are providing them… and they know it. You can’t expect them to retain the details of radiation science, but you can let them walk away with several impressions that will serve them well if they ever do have to respond to a radiological emergency.

Unfortunately most untrained responders see the radiation symbol and stop dead in their tracks or tend to over-respond.

Often what is needed at the awareness level is to improve their understanding about radiation and their instrumentation. Through this understanding will come the confidence to effectively respond to a radiological emergency. The responder should walk away with:

- Medical emergencies take precedence over radiological monitoring,
- Used correctly, your instruments and protocols ensure responder safety, and
- They should understand the difference between contamination and radiation.

First Responder Training Objectives

- Keep the messages simple! Focus on what you want them to remember a year later.
- At the awareness level this should be;
  - Medical emergencies take precedence over radiological monitoring,
  - Used correctly, their instruments and protocols ensure their safety, and
  - The difference between contamination and radiation.

The overall objective when training first responders is to increase their confidence and lower their anxiety about effective radiological emergency response.
Questions
Exposure & Contamination

Penetrating Radiation Exposure
*PPE does not protect against this*

Internal Contamination
*PPE protects against this*

External Contamination
*PPE facilitates decontamination*

Contamination causes "groundshine"
References

- National and International regulations, recommendations, and guides evaluated:
  - OSHA Regulations
  - Other professional society and research recommendations.
References

The devices pictured and web pages referenced in this presentation were chosen as examples and in no way represent an endorsement of any manufacturer or product.


A Practical Guide To Incident Response, ARSCF 2007; WPM A 1, James G. Ramos, CHP Rocketdyne/Boeing


The Department of Energy, Emergency Operations Training Academy (EOTA), Computer Based Training (CBT) for the response to Weapons of Mass Destruction CDs can be copied and have been distributed to each state’s FEMA representative who can be found at http://www.fema.gov or by contacting DOE’s Emergency Operation Training Academy at 845-5170 ext.172
Need to Add some window dressing, pics of instrumentation and operators…
Detecting Weak Sources of Radiation

Time, Distance, and Shielding also apply to the probability of detection, though the principal is reversed

- **Maximize the time** the detection equipment is close to the source to increase the probability of detection.
- **Minimize the distance** between the detector and a suspected source of radiation to increase the probability of detection.
- **Reduce shielding** between the detector and the source. Remember, shielded materials are harder to detect.

**Effect of Detector Distance from Source:** 
Specified as a 1/2 drop.
Human Portable Detection Equipment

Human-portable equipment is carried easily by a single person. This category include:

- **Personal Radiation Detectors (PRD)**
- **Backpack detectors**
- **Radioisotope Identification Devices (RIID)**
- **Advanced Radioisotope Identification Devices (ARIID)**
When selecting equipment one should consider the following issues

Targeted material – improvised nuclear device, radiological dispersal device, radiation exposure device

Static operation example – screening of commercial vehicles at a highway weigh station

Constant operation example – screening cargo crossing a border into the United States

Intermittent operation example – screening commercial vehicles on given days, but not on a constant basis

Event specific operation example – at political party conventions, Super Bowl
TYPES OF PRND EQUIPMENT

(USE OF PRODUCT IMAGES DOES NOT INDICATE AN ENDORSEMENT)
In summary
Well suited for law enforcement or inspectors, these devices can alert the wearer to any unusual radiation in their proximity. These devices are best used when there is an opportunity for a measured response, as most alerts will occur from legitimate commercial, medical, or natural radioactive material. Training and protocols need to be provided to properly resolve any alarms.
Although it looks similar to an electronic dosimeter, there is a very different kind of detector out there which I call “Personnel Radiation Proximity Alert Systems.”

The Pros
- Very sensitive. Alerts the user of any statistically significant changes to the natural background radiation levels.
- Useful for finding contraband radioactive material.
- Good battery life (often weeks of continuous operation)
- Small Size
- Simple operation (requires no user action, simply wear the unit)

[Click Display Cons]

Cons
- Will alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation
- Does not accurately measure (or work in) high dose rates, due to signal overload, which would be of concern to emergency responders performing rescue operations.
- Won’t detect alpha or low energy beta contamination (other than by any associated exposue fields)
- Relatively Expensive ($800 – $2,000)
Personal Radiation Detectors (PRD)

- examples

DNC nukeAlert 551

Thermo Scientific RadEye

BNC 1703MB/GBB

STE Handheld

Lauros Mini rad-D

Global Security Antiquities • Conservation • Defense
Personal Radiation Detectors - examples (cont’d)

UltraRadiac MRAD-TRN, Ludium PRM

Polimaster 1401 GNA/GNB

This does not represent an endorsement

Polimaster 2703 GN/GNA/GNB

RNC 1703 MO-1

Polimaster 1401 MA
1704 is spectroscopic PRD like Thermo Scientific Interceptor above.

Flir bought ICx, the manufacturer of IndetiFinder and other detection instruments. ICx products had several sellers in US like Laurus (100% women owned company), Thermo Scientific.

What are the limitations of the spectroscopic PRD’s versus hand-held RRID? – In general PRDs are smaller in size, so smaller detectors, less sensitive than hand-holds. PRDs screens usually are smaller, so details in the graphical spectrum are less clear.
PRDs are advertised as being 5000 to 100000 more sensitive than electronic dosimeters.

While dosimeters’ range 1 million times higher than most PRDs’
PagerS up to ~12 mR/hr
Quick detector resolution comparison

Gamma-Ray Spectra of Natural Background

- Plastic Scintillator (no resolution)
- High Purity Germanium (excellent efficiency and resolution)
- Sodium Iodide (poor resolution)
- Cadmium Zinc Telluride (very poor resolution)
Quick detector resolution comparison

Figure 1. Comparison for LaBr₃(Ce), NaI(Tl), and HPGe spectra.
Quick detector resolution comparison

While all 3 detectors (NaI, HPGE, CZT) "see" the Iodine, only HPGE "sees" the Plutonium.

Figure 2. HPCs in comparison to NaI and CZT detectors.
Detectors can be NaI, CsI or LaBr or other exotic scintillators.
Backpacks, Pros & Cons

Pros
- Can incorporate larger and multiple detectors. Various sizes, sensors and configurations can be accommodated.
- Very sensitive. Alerts the user of any significant changes to the natural background radiation levels.
- Useful for clandestine monitoring of radiation levels.

Cons
- Requires one person to carry only one unit.
- Suitable mostly for outdoor applications; indoors use is suspicious.
- More sensitive units are bulkier and heavier.
- Expensive ($10,000 - $20,000).
- Won't detect alpha or low energy beta.
Backpacks - examples

Thermo Scientific Packeye Backpack

BNC RD-100

Nicsafe backpack

Nicsafe backpack/vest

Global Security
Anticipate • Innovate • Deliver
In Summary,
Their cost prohibits them from being in every first responder’s back pocket, but they can be a valuable tool in the hands of a well trained regional responder. Although most units have been ruggedized, the technology is inherently shock sensitive and the automated analysis is not 100% effective. Accurate assessment often requires an experienced spectroscopist to assess data. Fortunately, many of the units have the ability to download the spectrum for remote analysis by an expert. However, even with an expert the limited resolution or efficiency of room temperature spectroscopy systems may be insufficient to accurately identify an isotope and higher resolution, mechanically cooled detectors would need to be used ($80,000+).

[click]
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- Useful for finding contraband radioactive material.
- Often tracks dose rates and total dose of user while on.
- Can identify many common isotopes

**Cons**
- Although fairly good at identifying common isotopes with simple spectra, these units can not identify all possible isotopes of concern and can also mis-identify isotopes.
- Will alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation (though the analysis can often resolve this)
- Expensive ($10,000 - $20,000)
- Won’t detect alpha or low energy beta contamination.
- Requires extensive training or support to use properly
Some models like Canberra InSpector, IdentiFinder, BNC SAM 935, BNC 940 have options with different detectors: NaI, CsI, LaBr, and other exotic crystals, He-3 tubes for neutrons.
## RIIIDs Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>IdentifiFinder-U</th>
<th>BNC SAM 940</th>
<th>Polimaster PM240K</th>
<th>Thermo Sci, FH 40 NBR</th>
<th>Ludium Model 703</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma Det’n</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Neutron Det’n (optional)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Weight (oz)</td>
<td>2.95</td>
<td>4.5</td>
<td>3.5</td>
<td>2.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Length (in)</td>
<td>9 x 2.75 x 3.5</td>
<td>12 x 5 x 4</td>
<td>9.5 x 2.2 x 2.2</td>
<td>8 x 1.4 x 2</td>
<td>12 x 5 x 4</td>
</tr>
<tr>
<td>Detector</td>
<td>1.4 x 2 Nal</td>
<td>2 x 2 Nal (1.5 x 1.5 LAB)</td>
<td>CsI(Tl)</td>
<td>Nal + Org. Scint</td>
<td>2 x 2 Nal (3 x 3)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>1000cpm per uR/hr</td>
<td>2 cpm per uR/hr</td>
<td>38 cpm per uR/hr</td>
<td>15 cpm per uR/hr (30)</td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td>≤0.1%</td>
<td>7% (±0.3%)</td>
<td></td>
<td></td>
<td>7%</td>
</tr>
<tr>
<td>Temp. (deg. F)</td>
<td>4 to 131</td>
<td>4 to 131</td>
<td>-32 to 131</td>
<td>4 to 131</td>
<td>4 to 131</td>
</tr>
<tr>
<td>Battery Type</td>
<td>AA</td>
<td>AA</td>
<td>AA</td>
<td>AA</td>
<td>NiMH AA</td>
</tr>
</tbody>
</table>
In Summary,

Their cost/price prohibits them from being in every first responder’s back pocket, but they can be a valuable tool in the hands of a well trained regional responder. Although most units have been ruggedized, the technology is inherently shock sensitive and the automated analysis is not 100% effective. Accurate assessment often requires an experienced spectroscopist to assess data. Fortunately, many of the units have the ability to download the spectrum for remote analysis by an expert. However, even with an expert the limited resolution or efficiency of room temperature spectroscopy systems may be insufficient to accurately identify an isotope and higher resolution, mechanically cooled detectors would need to be used ($80,000+).
Advanced Radio-Isotope Identification Devices (ARIIDs) - examples

ORTEC Detective

ORTEC Micro-Detector-HX

CANBERRA Falcon 5000

ORTEC Micro-Detector
## ARIID Specifications

<table>
<thead>
<tr>
<th></th>
<th>ORTEC Detective</th>
<th>ORTEC micro-Detective</th>
<th>CANBERRA Falcon 5000</th>
<th>ORTEC micro-Detective-FIX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Detectors</strong></td>
<td>HPGe(γ), GM, optional He-3 (n)</td>
<td>HPGe(γ), GM, optional He-3 (n)</td>
<td>HPGe(γ), GM, optional He-3 (n)</td>
<td>HPGe(γ), GM, optional He-3 (n)</td>
</tr>
<tr>
<td><strong>Weight (oz)</strong></td>
<td>26.3</td>
<td>15.2</td>
<td>34.1 (with housings)</td>
<td>15.2</td>
</tr>
<tr>
<td><strong>Length (in)</strong></td>
<td>15.5 x 7 x 14</td>
<td>14.7 x 6 x 11</td>
<td>17 x 7 x 17</td>
<td>14.7 x 5.8 x 11</td>
</tr>
<tr>
<td><strong>Temp. (°F)</strong></td>
<td>32 - 104</td>
<td>14 - 104</td>
<td>(-4) - 122</td>
<td>14 - 104</td>
</tr>
<tr>
<td><strong>Time to cool</strong></td>
<td>&lt; 10 hours</td>
<td>&lt; 10 hours</td>
<td>3-4 hours</td>
<td>&lt; 10 hours</td>
</tr>
<tr>
<td><strong>Battery life</strong></td>
<td>&gt;3 hours</td>
<td>3 hours</td>
<td>8 hours</td>
<td>3 hours</td>
</tr>
</tbody>
</table>
These are usually built to meet the requirements of the customer and can have various configurations. They can have large and multiple detectors with high overall sensitivity, gamma and neutron detectors, often radioisotope identification capabilities, GPS positioning and data transmission capabilities. All kinds of detectors are possible – NaI, LaBr, HPGe, He-3, plastic scintillators, gas filled detectors (GM), etc.
Mobile devices

Pros
- Very sensitive; can incorporate large and multiple detectors
- Useful for covering large areas.
- Can be tailored towards specific requirements.
- Often have additional capabilities – radioisotope identification, GPS, data transmission, computer analysis, take images
- Can be used for clandestine monitoring of radiation levels.

Cons
- Can be very expensive ($15,000 -50,000 or more)
- Won't detect alpha or beta contamination (sources)
- Requires training.
Mobile devices - examples

Thermo Scientific Mobile ARIS

TSA MDS134A

Mirion SPIR-ident-mobile

BNC Textron IST RadTruck

SAIC Exploranium GR-460
There is a wide variety of portal monitors: pedestrian, vehicle, rail, cargo containers; large and small, one sided, two sided or multiple sides (left, right, above and even below), simple alarm producing or spectroscopic with radioisotope identification and data transmission capabilities. The more sophisticated the portal monitor is the more experienced personnel is required and more maintenance is generally needed.
Portal monitors

Pros

- Can incorporate large and multiple detectors both for gamma and neutron emitting sources.
- Very sensitive.
- Most are maintenance free and do not require frequent calibration.
- Can be set up for unattended and/or covert operation.
- More sophisticated systems have radioisotope identification capabilities.
- Optional vehicle speed alarm, video monitor, license plate image.

Cons

- Simpler, non-spectroscopic systems produce false alarms due to legitimate radioactive material traffic (industrial and medical sources, natural radioactive materials).
- More sophisticated spectroscopic systems are expensive and require experienced or trained personnel.
- Could be very expensive ($50,000 - $500,000).
Portal monitors - examples

WF Portal monitor RCVL

Detectors inside a panel

Polimaster 5000A

SAIC/Exploranium AT 98a

Polimaster 5000A

Canberra GPS Portal 55
Talk through how this maps to ConOps, mention CTOS for equipment training, DNDO for mission planning, etc. (more to follow from Sean on this topic)
More likely to come into play during secondary screening activities or response to actual release/exposure incident.
Electronic dosimeters are not designed for search, location or identification of radioactive material, although in some cases they can be used for limited search. Some models allow dose (rate) information to be downloaded. Other models have different levels for several alarms (alarm 1, alarm2, for gamma, for neutron, for dose, for dose rate).
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- Low accuracy (i.e., uses pancake GM for dose measurement)
In Summary
Smaller, simpler, and often cheaper than commercial equipment, these devices are well suited for the emergency responders. There is a large variety of capabilities in this class of instrument to the appropriate features must be considered for the task and the user. Training must be provided to ensure that the user understands how to interpret readings. Using the instrument to detect contamination will require also require special training.

Typical costs are $300 - $600 dollars per unit. For the occasional user, choose the more expensive digital models as they will have alarms and are easier to operate.

[click]
I’ve summarized the description and some EXAMPLE units on this slide. Don’t try to read this eye-chart, it is there to to complete your hand out.