My name is Bill Heasom, and I am a licensed professional engineer in the state of Pennsylvania. I live a little over a mile from the CFC facility, so I have become greatly interested in the irradiator installation since I learned about it a few weeks ago.

Although I am not familiar with NRC codes in particular, I am familiar with engineering codes governing the design, construction, and inspection of concrete and steel structures, and the engineering issues that arise when such structures are placed in the earth.

A recent project that I completed is a manure storage facility, is a concrete tank 70 feet in diameter set 14 feet deep in the earth. It is designed to store the manure generated by a Mennonite farmer's 65 head dairy herd. It is designed to protect surface and underground water from contamination. That structure was built in conformance with local, state, and Federal (Natural Resources Conservation Service). The walls are 10" thick reinforced concrete and the outside of the tank has a groundwater interception system and a monitoring well so that the leak-proof integrity of the tank may be monitored over time. The construction sequence included inspection steps at key junctures. The design and construction of the project was informed by similar structures that have been built throughout Pennsylvania, ones which have proved to give satisfactory service over time (Hard copy of drawing attached).

From what I can glean from my preliminary research, the Genesis irradiator for which a permit is being sought by CFC Logistics for their facility near my home meets a lower standard of care than the manure pit. I understand from reading the permit application on the NRC web site (and also from viewing a photograph of the Genesis irradiator on the CFC website) that the device is assembled from a stainless steel plate, a steel plate, an unspecified number of "I-beams", with a concrete filler. The 20 foot deep assembly was leak tested last July at the GrayStar factory and was dropped onto a poured slab at the bottom of pit excavated at the CFC warehouse in February of this year. Apparently the 6" walls of the device were also filled with concrete on-site and after leak testing. Such deep and narrow concrete walls prove difficult to construct properly when the walls are formed conventionally. Often, there are voids left in the wall, especially near the bottom, that must be repaired after the formwork is removed. How has the NRC established that the walls contain no voids and that the assembled device, in place, is as leak-proof as it was when the factory leak-test was performed? Who inspected and documented the placing of the irradiator, the pouring of the concrete, the backfill around the irradiator, and the finish welding and slab placement steps? Were test cylinders taken for the wall concrete? Has the NRC seen and evaluated structural calculations proving the strength of the assembly to resist the earth pressure with a sufficient factor of safety to survive a shock load from an earthquake, extreme weather event, or accident at the factory? If such an event causes the walls to deform, will the tank remain water tight and will the plenum at the bottom still be completely accessible? What provision has been made to monitor the earth around the box to ensure that the irradiator does not ever leak into the groundwater? There is a geologists' report evaluating the allowable foundation bearing capacity at the bottom of the pit and noting the presence of groundwater and the nature of the shaly soil layers above the bedrock. Has the NRC obtained or sought a geologist's and a geotechnical engineer's opinion regarding the interaction of the side walls of the irradiator with the soil placed around it? Does the NRC have information giving the range of groundwater conditions (including events of 100 year frequency) at the site?

Since the Milford site is proposed as the first installation of this device and there is no experience with these devices in the field to give us confidence of its ongoing structural integrity given the vicissitudes of use and time, we must ask that extraordinary efforts be taken pre-permit to conservatively evaluate a wide range of possible failure modes. And, we must admit that prototypes are almost always accompanied by unexpected and unforeseen problems. We neighbors must ask you to consider the wisdom of placing such an unproven device into a meat packing warehouse in the center of residential development. It would at seem that at least requiring the device to be located in a surrounding concrete vault in the ground, rather than directly into the ground would be a reasonable and prudent requirement. The extra layer would allow that any leaking water might be intercepted and tested. It would also provide extra structural protection for the irradiator and provide a structural redundancy for the 6 inch walls of the irradiator.

There is another set of concerns regarding the plenum at the bottom of the pool. I understand that additional shock or "drop" testing is to be done in order to prove the ability of the plenum to survive an accident. I also understand that the testing is to be real (rather than simulated) and is to be conducted by a third party (rather than the manufacturer or owner of the device). I have another concern regarding the plenum assembly. NRC permit application filings describe the plenum as filled with air, with the cobalt-60 pencils being air cooled. Within those documents, it is also stated that the plenum assembly should survive a brief period of power outage because the uncooled cobalt pencils should only reach a temperature of several hundred degrees Fahrenheit, a temperature they may also reach while confined inside their storage casks (according to the document). Has the NRC investigated the scenario of the irradiator running at its full licensed capacity of cobalt and surviving an extend power blackout? And, given the high surface temperature of the pencils during such a period, has the NRC investigated what may happen if even a small amount of water makes its way into the plenum? From the description of the plenum, it appears that the positive pressure of the air supply may be necessary to ensure that no water makes its way inside—after all, the plenum begins with water inside and it is the air pumped to it that originally expels the water. My concern is that water may contact the pencils while they are at a high temperature and cause a shock failure of their stainless steel jackets that will result in a leakage of radioactive material into the irradiator pool. Or, a sudden pressure increase inside the plenum caused by intruding water quickly vaporizing after contacting the high temperature surfaces of the cobalt pencils may rupture the plenum structure or seals. Again, the fact that this unit is a prototype calls for a more rigorous and thorough investigation of all possible failure modes before placing it into service.

The general safety issue with this plant is the increased possibility for terrorism, either here or elsewhere using pencils that are stored or shipped here. Attached is a hard copy of testimony by Dr. Kelly, the President of the Federation of American Scientists and a letter from Rep. Meserve to the NRC dated June 11, 2002 that references the Kelly testimony. What is the possibility of the radioactive contents of a cobalt-60 pencil being dispersed as a result of explosion? Although Dr. Kelly, doesn't mention the specific size of pencil studied in the hypothetical incident, it seems to similar to those planned for the CFC facility.

The scenario of havoc that can be wreaked using one cobalt-60 pencil in conjunction with a conventional explosive begs a very good and thorough answer to the question: "What is the long-term, fail-safe plan for security at this irradiator facility? And, how will we be able to know that the security plan is continuously and meticulously implemented through the years?

For my own investigation, I have looked at sketches of pencils from two vendors: Nordion and Institute of Isotopes (attached). Both use a double jacket of welded stainless steel around the cobalt material and both appear to be of similar dimensions. The Institute of Isotopes sketch shows a diameter of 1.1 cm for all sizes. The length for the 3510 Curie pencil is 45.1 cm. The thickness of both jackets together is 2 mm with the cobalt-60 loosely assembled inside as disks. Such an assembly can be made reliably water and air tight, but will not have much structural strength. On the CFC permit application to the NRC, the point is made that the pencils will never bear a load other than their own weight. So, it seems plausible that a conventional explosive could be effective in exposing and dispersing the cobalt material inside. Or, persons unconcerned with their own safety could get at the cobalt material with a hack saw.

The operating status quo for this facility is to have the cobalt-60 pencils to be located either in casks or underwater. But, there will be significant periods of the operation that will not be typical:

- The irradiator is a prototype and is scheduled to commence operations with a smaller amount of material in the plenum (17,000 Ci, I believe). The license they are seeking is for 1,000,000 Ci. So, there will be one or many events where the additional pencils must be imported and transferred from casks to the plenum. There will be delivery events. And, there may be periods of time when the pencils are stored in casks, not underwater. Even if the pencils were completely safe underwater, there will be many times when many pencils are *not* submerged.
- Cobalt-60 has a half life of 5 years. How does the operation deal with the declining potency of the sources? If they were to ramp up to the full 1,000,000 Ci licensed capacity (which seems a reasonable number, given what I have seen as operating capacities for other commercial irradiators) then how do they deal with the diminution of radiation over time? Are they willing to allow more time for treatment (twice as long after 5 years)? Or, will they rotate fresh pencils into the plenum in order to maintain a high radiation potential? The second option seems the most likely from an economic standpoint. In any case, the pencils will have to be changed from time to time and this procedure will involve delivery, transfer, and transshipment of pencils—all steps which occur out of the protective water.
- I have learned that optimal irradiation doses for different materials and different effects vary. They may span several orders of magnitude (50 Gray to 100 kGray or 2000x). CFC has declared that they will be using the irradiator to treat a

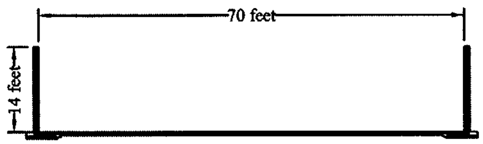
variety of products—from meat to pharmaceuticals. They can achieve a partial range of dosages by varying the time of exposure, but to cover a large range of dosages in an operationally practical way they will also need to change the number of pencils in the plenum. If that is part of their operating plan, it will involve the transfer and storage out of the water of some of the pencils.

- Over years of operation, there will likely be maintenance procedures or unexpected events that will require that the pool be drained or the plenum serviced. These operations will involve the temporary relocation of the cobalt pencils.

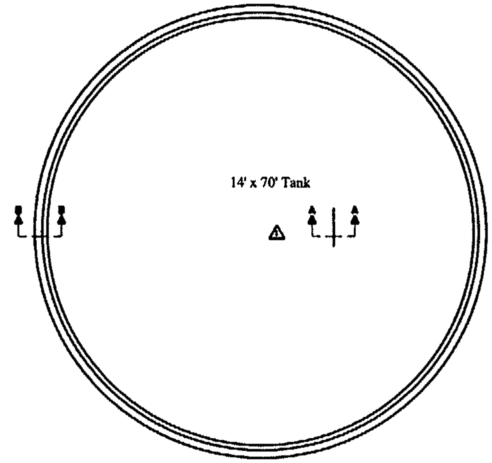
I believe that considering the possibility of a mishap or attack occurring only while the pencils are submerged is to ignore an important part of how the plant will have to operate in reality. And, I believe that the number of pencils involved combined with the necessity of moving them into and out of the facility and to relocate them from cask storage at the facility creates many opportunities to lose track of one of them. Can the NRC guarantee that every single pencil delivered to, shipped from, and stored at the Milford site will be accounted for at every single moment of time? This standard of care is the one which must be applied given the tremendous danger of having even one, out of the many hundreds of pencils that will pass through the Milford site, fall into the wrong hands.

As to the effect of an explosion on the pencils in their submerged state, I believe that scenario merits further study. One result of a bungled attack (such as concealing an insufficiently potent explosive with a timer in one of the pallets to be irradiated) might be an underwater explosion that ruptures some of the pencils as well as the walls of the irradiator, possibly resulting in a leak of contaminated water into the groundwater.

Quite a mop-up job for the night shift! Quite a juicy story for the Washington Post!!



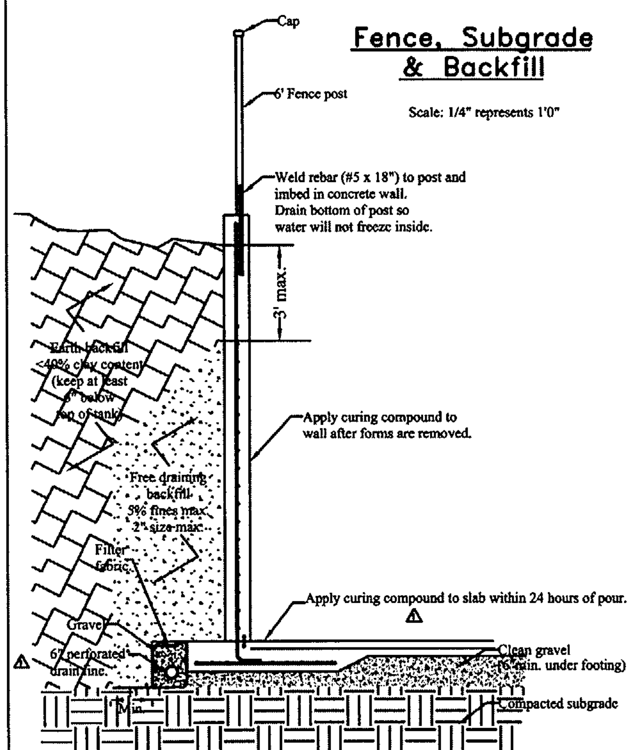
Tank Section



Tank Plan View

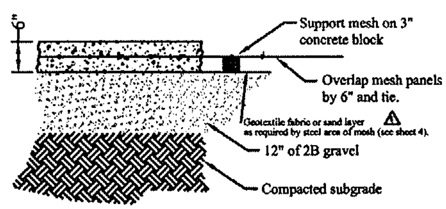
Fence, Subgrade & Backfill

Scale: 1/4" represents 1'0"



Section B-B

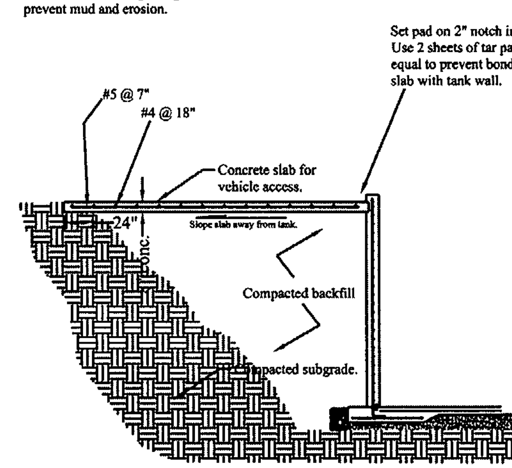
Slab Details

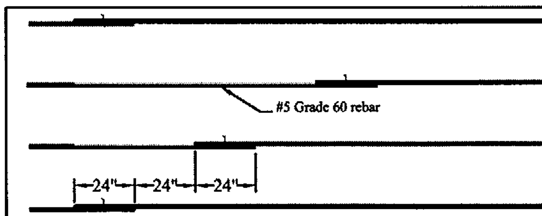


Section A-A

Vehicle Access Slab Section

If heavy tank wagons or trucks will be driven within a distance of 14' from the edge of the tank, cast a 8" thick concrete slab along the traffic route by the tank. The concrete slab should be large enough to eliminate any wheel loads directly on the natural ground or backfill by the tank. The purpose of the slab is to distribute the loading along the tank wall and prevent mud and erosion.





Splice Overlap and Stagger For Wall and Footing Ring Steel

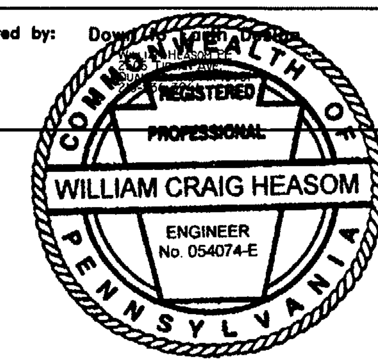
Prepared for: JOHN BRUBAKER
SIEGFRIEDALE ROAD
KUTZTOWN, PA 19530
610-683-6098

REVISIONS:	
△	08/07/02

Manure Storage Facility
DETAIL SHEET 1

Dwg: details1 | Date: 03/25/2002 | Sheet: 5 of 14

Prepared by:



EDWARD J. MARKEY
7TH DISTRICT, MASSACHUSETTS
www.house.gov/markey

ENERGY AND COMMERCE COMMITTEE
RANKING MEMBER
SUBCOMMITTEE ON
TELECOMMUNICATIONS AND
THE INTERNET
RESOURCES COMMITTEE

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June 11, 2002

The Honorable Richard A. Meserve
Chairman
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Chairman:

I am writing to request information related to the security of radioactive irradiators used in the U.S. I believe that in light of yesterday's arrest of a suspected Al Qaeda terrorist who allegedly planned to detonate a radioactive dirty bomb, there are some important public policy questions that Congress and the Commission need to consider about these irradiation facilities.

At my direction, earlier this year my staff requested information from the NRC staff regarding the number, size, and location of irradiators in the U.S. I received the NRC's response to this inquiry on May 2, 2002, which provided the requested information, but asked that this unclassified information not be released publicly at this time due to security concerns. While the type of information requested appears to be available from a wide variety of public sources, including the NRC's web site, I will, of course, honor the NRC's request for confidential treatment. After receiving the NRC response, I directed my staff to undertake an analysis of the data that summarized how many of these facilities are located around the country and classifying them by size, not disclosing any specific information regarding their identities and locations. A copy of this document was subsequently provided by my staff to the NRC staff, who concurred that this information did not raise the same security concerns and that it was acceptable for public release and discussion.

Irradiators are radioactive materials used for the purposes of irradiating objects or materials[1]. According to the materials you provided to me, there are hundreds of these facilities located in 48 States. Table 1 provides a list of the number (and radioactive activity) of irradiators in each State, which are generally located in industrial facilities, hospitals, and research institutions. I am concerned that radioactive materials at these facilities, which can range from activities of fractions of a Curie to several

[1] According to the NRC, an irradiator is a facility that uses radioactive sealed sources for the irradiation of objects or materials, and in which radiation dose rates exceeding 5 grays (500 rads) per hour exist at 1 meter from the sealed radioactive sources in air or water, as applicable for the irradiator type, but does not include irradiators in which both the sealed source and the area subject to irradiation are contained within a device and are not accessible to personnel. See http://www.nrc.gov/reading-rm/doc-collections/cfr/part036/part036-0002.html

millions of Curies and are used for everything from research to the irradiation/sterilization of food and medical equipment, could also be acquired and assembled into dirty bombs. I want to know what measures are being undertaken to prevent this from happening.

Numerous reports, including yesterday's arrest of an Al Qaeda operative alleged to be involved in a plot to detonate a dirty bomb in the U.S., have confirmed terrorists' desires to use radioactive materials as weapons. As you know, the amount of damage such a device could do depends on the amount of conventional explosives used to detonate and disperse the device as well as on the amount of radioactive material used. In your April 15, 2002 letter to me[2] you stated that a dirty bomb containing a mere 1 Curie of radioactive materials could "spread low-level contamination over an area of several city blocks, possibly resulting in restriction of the area until the area was surveyed and decontaminated." An analysis recently performed by the Federation of American Scientists[3] (FAS) modeled three different dirty bomb case studies. One scenario, which involved the detonation of a single rod of cobalt (these rods are typically 1 inch in diameter and a foot long) obtained from a large food irradiation plant, was found to result in the contamination of 1000 square kilometers, with a 10% risk of death from cancer for residents living inside a 300 city block area for 40 years following the detonation.

In addition to the possibility that a terrorist could steal radioactive materials and then construct and detonate a dirty bomb, I am also concerned that a terrorist could attack a facility in which irradiators are stored/used, and detonate a bomb inside the facility itself. This could also lead to the spread of dangerous radioactive materials. Some large (millions of Curies) irradiators are used to sterilize food or medical equipment. A diagram of such a large facility, which appears on the NRC web site, is provided in Figure 1.

Under normal conditions, a shipment of goods requiring sterilization would be delivered into the facility. The cobalt rods would be lifted out of the cooling pool, the shipment would be irradiated, the rods would be replaced into the cooling pool, and the shipment removed. I am concerned that terrorists could plant a conventional bomb inside the shipment intended to be sterilized and then detonate the conventional bomb once the cobalt rods are lifted out of the cooling pools. This could blow a hole in the roof of the facility and result in the dispersal of radioactive cobalt into the surrounding community.

In light of the devastating consequences of such an event, and the clear indications that there has been a credible threat that terrorists are seeking to use radiological dirty bombs to attack America, I ask for your prompt response to the following questions:

1) Are individuals who have access to these materials required to undergo criminal and security background checks to ensure that they do not pose a security risk? If not,

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[2] See Page 41 of http://www.house.gov/markey/iss_terrorism_ltr020502.pdf
[3] See http://www.fas.org/faspir/2002/v55n2/dirtybomb.htm

why not? If there are different regulations for different amounts of radioactivity, please describe the regulations for each category of material.

2) Please describe the physical security measures (locks, guards, etc.) used to safeguard these materials. If there are different regulations for different amounts of radioactivity, please describe the regulations for each category of material.

3) Are individuals who are making deliveries (or transporting the shipments that are being irradiated) to large irradiation/sterilization facilities required to undergo criminal and security background checks to ensure that they do not pose a security risk? If not, how can you be certain that a truck driver charged with delivering a shipment of food or medical equipment for sterilization does not pose a risk of planting a conventional bomb in the shipment to be delivered into the facility?

4) Are all shipments that are being delivered to irradiation/sterilization facilities searched to ensure they do not contain explosives? If not, how can you be certain that a shipment does not contain a conventional explosive in the shipment that will then be detonated upon entry to the facility?

5) Please describe the manner in which the NRC and/or Agreement States ensure that licensees of these materials keep them secure. Are audits performed to ensure that all the materials can be accounted for? If so, how often? If not, then how do you know that all the materials are where they should be? Are these sources identified with serial numbers or some other means of identifying them if they are lost? If not, why not, and do you intend to implement such a system in the future?

6) Has the NRC conducted or funded any studies or analyses of the public health, safety and environmental risks of a terrorist attack on an irradiation/sterilization facility? If not, why not? If so, what are the worst-case risks of such an attack? Please provide copies of all studies or analyses prepared by or for the NRC on this subject.

7) Does the NRC believe the dirty bomb scenarios described in the FAS study to be credible, and the posited health, safety, and environmental consequences to be accurate? If so, what action is the NRC taking to address these possible attack scenarios? If not, please indicate the basis for any disagreement.

Thank you for your prompt attention to this important matter. Please provide your response by Friday June 28, 2002. If you have any questions or concerns, please have your staff contact Dr. Michal Freedhoff or Mr. Jeffrey S. Duncan of my staff at 202-225-2836.

Sincerely,

Edward J. Markey

Edward J. Markey

Figure 34. **Commercial Gamma Irradiator**

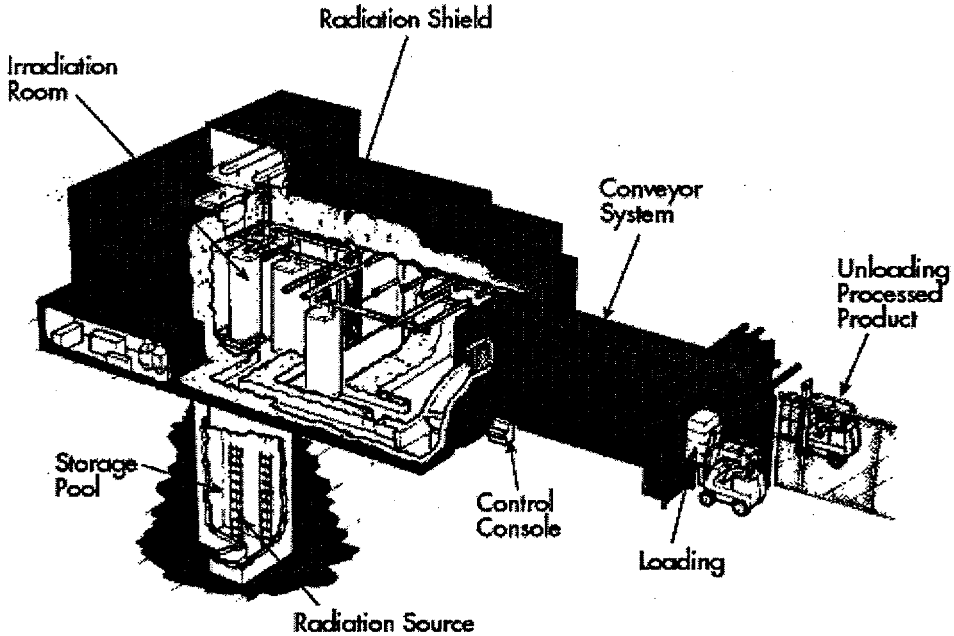


Figure 1: From http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/v13/fig034.html

Table 1: State by State List of Irradiator Sources as compiled from information provided by the NRC

State	# with less than 9.999 Curies	# with 10,000 – 49,999 Curies	# with 50,000 – 99,999 Curies	# with 100,000 – 499,999 Curies	# with 500,000 – 999,999 Curies	# with 1-5 million Curies	# with more than 5 million Curies
Alabama	2	1	0	0	0	0	0
Alaska	1	0	0	0	0	0	0
Arizona	9	1	0	0	0	0	0
Arkansas	4	0	0	0	0	1	0
California	96	14	4	1	1	2	3
Colorado	19	0	0	0	0	0	0
Connecticut	5	1	0	0	0	0	0
Delaware	2	0	0	0	0	0	0
DC	5	1	1	0	0	0	0
Florida	30	6	0	0	0	2	0
Georgia	14	1	0	1	0	0	0
Hawaii	1	0	0	0	0	0	0
Iowa	6	0	0	0	0	0	0
Illinois	74	3	1	0	1	3	2
Indiana	2	0	0	0	0	0	0
Kansas	10	3	0	0	0	0	0
Kentucky	11	0	0	0	0	0	0
Louisiana	16	2	0	0	0	0	0
Maine	2	1	0	0	0	0	0
Maryland	42	6	1	3	1	2	0
Massachusetts	63	5	0	0	0	1	0
Michigan	9	0	1	0	0	0	0
Minnesota	6	1	0	0	0	1	0
Mississippi	5	1	0	0	1	0	0
Missouri	3	0	0	0	0	0	0
Montana	2	0	0	0	0	0	0
Nebraska	7	1	0	0	0	3	0
Nevada	4	0	0	0	0	0	0
New Hampshire	2	1	0	0	0	0	0
New Jersey	31	3	1	1	0	3	0
New Mexico	6	1	0	1	0	0	1
New York	59	3	0	1	0	1	0
North Carolina	27	7	0	0	0	2	1
North Dakota	6	0	0	0	0	0	0
Ohio	22	1	0	0	0	2	0
Oklahoma	13	0	0	0	0	0	0
Oregon	11	0	0	0	0	0	0
Pennsylvania	53	8	0	0	0	1	0
Puerto Rico	5	0	0	0	0	2	0
Rhode Island	2	1	0	0	0	0	0
South Carolina	4	0	0	0	0	3	0
Tennessee	23	8	0	0	0	0	0
Texas	62	5	0	1	0	4	3
Utah	7	0	0	0	0	1	0
Vermont	2	0	0	0	0	0	0
Virginia	16	1	0	1	0	0	0
Washington	40	5	0	0	0	0	0
Wisconsin	15	2	0	0	0	0	0

25 States have 10 or more irradiator sources.
13 States have 25 or more irradiator sources.
7 States have more than 50 irradiator sources.
17 States have at least one source that is greater than 1 million Curies.

Industrial sources

Cobalt-60 (Half life: 5.27 years)

Cobalt metal double encapsulated in stainless steel (KO-33 or KO-36) and sealed by argon ar welding.

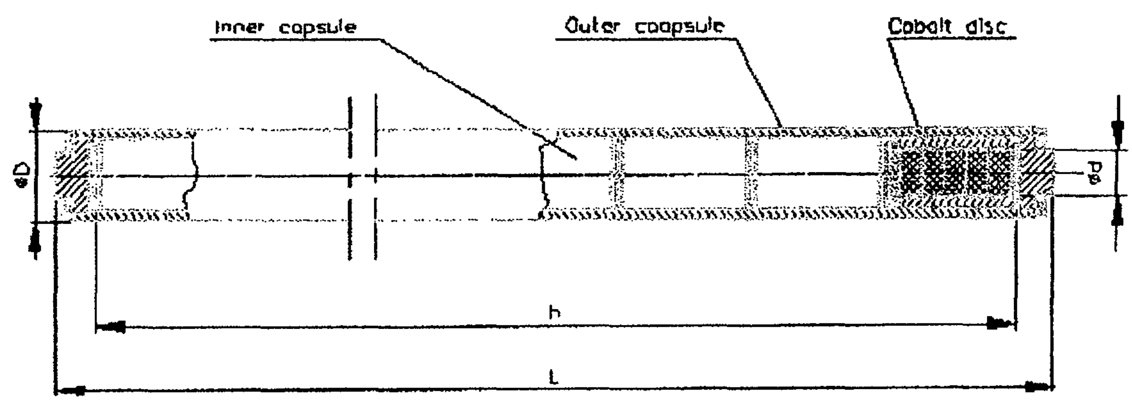
Recommended working life: 20 years

Quality control:

Ultrasonic test "A"
Vacuum bubble test

Type code	Overall dimensions		Active dimensions		Maximum equivalent activity		MSZ classification
	D [mm]	L [mm]	d [mm]	h [mm]	TBq	Ci	
CoS-43 HH	11	451	7	437	130	3510	E 64434
CoS-44 HH	11	220	7	207	60	1622	E 64434
CoS-45 HH	11	81.5	7	69	17	459	E 64545

CoS-43 HH CoS-44 HH CoS-45 HH

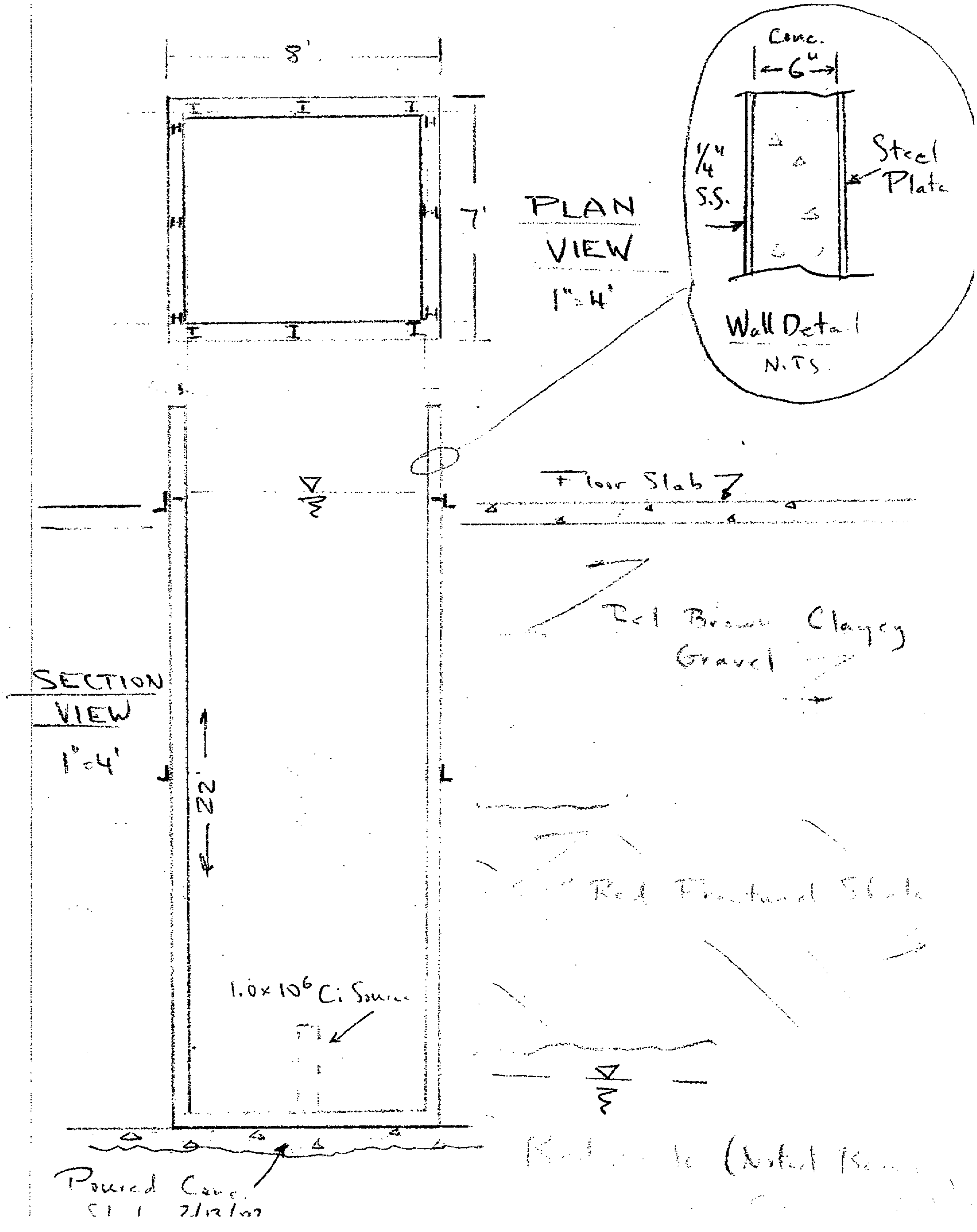


Other radiation sources

Sources for gauges (Cobalt-60)
Gamma radiography sources (Iridium-192)
Medical sources (Cobalt-60)

Technical information

Genesis Irradiator (Compiled From Text Notes in NRC Filing)



Testimony of
Dr. Henry Kelly, President
Federation of American Scientists
before the
Senate Committee on Foreign Relations
March 6, 2002

Introduction

Surely there is no more unsettling task than considering how to defend our nation against individuals and groups seeking to advance their aims by killing and injuring innocent people. But recent events make it necessary to take almost inconceivably evil acts seriously. We are all grateful for the Committee's uncompromising review of these threats and its search for responses needed to protect our nation. Thank you for the opportunity to support these efforts.

My remarks today will review the dangers presented by radiological attacks, situations where nuclear materials that could be released, without using a nuclear explosive device, for the malicious purpose of killing or injuring American citizens and destroying property. Our analysis of this threat has reached three principle conclusions:

1. Radiological attacks constitute a credible threat. Radioactive materials that could be used for such attacks are stored in thousands of facilities around the US, many of which may not be adequately protected against theft by determined terrorists. Some of this material could be easily dispersed in urban areas by using conventional explosives or by other methods.

2. While radiological attacks would result in some deaths, they would not result in the hundreds of thousands of fatalities that could be caused by a crude nuclear weapon. Attacks could contaminate large urban areas with radiation levels that exceed EPA health and toxic material guidelines.

3. Materials that could easily be lost or stolen from US research institutions and commercial sites could contaminate tens of city blocks at a level that would require prompt evacuation and create terror in large communities even if radiation casualties were low. Areas as large as tens of square miles could be contaminated at levels that exceed recommended civilian exposure limits. Since there are often no effective ways to decontaminate buildings that have been exposed at these levels, demolition may be the only practical solution. If such an event were to take place in a city like New York, it would result in losses of potentially trillions of dollars.

The analysis I will summarize here was conducted by Michael Levi, Director of the Strategic Security Program at the Federation of American Scientists (FAS), and by Dr. Robert Nelson of Princeton University and FAS.

Background

Materials are radioactive if their atomic nuclei (or centers) spontaneously disintegrate (or decay) with high-energy fragments of this disintegration flying off into the environment. Several kinds of particles can so be emitted, and are collectively referred to as radiation. Some materials decay quickly, making them sources of intense radiation, but their rapid decay rate means that they do not stay radioactive for long periods of time. Other materials serve as a weaker source of radiation because they decay slowly. Slow rates of decay mean, however, that a source may remain dangerous for very long periods. Half of the atoms in a sample of cobalt-60 will, for example, disintegrate over a five year period, but it takes 430 years for half of the atoms in a sample of americium-241 to decay.

The radiation produced by radioactive materials provides a low-cost way to disinfect food sterilize medical equipment, treat certain kinds of cancer, find oil, build sensitive smoke detectors, and provide other critical services in our economy. Radioactive materials are also widely used in university, corporate, and government research laboratories. As a result, significant amounts of radioactive materials are stored in laboratories, food irradiation plants, oil drilling facilities, medical centers, and many other sites.

a. Commercial Uses

Radioactive sources that emit intense gamma-rays, such as cobalt-60 and cesium-137, are useful in killing bacteria and cancer cells. Gamma-rays, like X-rays, can penetrate clothing, skin, and other materials, but they are more energetic and destructive. When these rays reach targeted cells, they cause lethal chemical changes inside the cell.

Plutonium and americium also serve commercial and research purposes. When plutonium or americium decay, they throw off a very large particle called an alpha particle. Hence, they are referred to as alpha emitters. Plutonium, which is used in nuclear weapons, also has non-military functions. During the 1960s and 1970s the federal government encouraged the use of plutonium in university facilities studying nuclear engineering and nuclear physics. Americium is used in smoke detectors and in devices that find oil sources. These devices are lowered deep into oil wells and are used to detect fossil fuel deposits by measuring hydrogen content as they descend.

b. Present Security

With the exception of nuclear power reactors, commercial facilities do not have the types or volumes of materials usable for making nuclear weapons. Security concerns have focused on preventing thefts or accidents that could expose employees and the general public to harmful levels of radiation. A thief might, for example, take the material for its commercial value as a radioactive source, or it may be discarded as scrap by accident or as a result of neglect. This system works reasonably well when the owners have a vested interest in protecting commercially valuable material. However, once the materials are no longer needed and costs of appropriate disposal are high, security measures become lax, and the likelihood of abandonment or theft increases.

Concern about the intentional release of radioactive materials changes the situation in fundamental ways. We must wrestle with the possibility that sophisticated terrorist groups may be interested in obtaining the material and with the enormous danger to society that such thefts might present.

Significant quantities of radioactive material have been lost or stolen from US facilities during the past few years and thefts of foreign sources have led to fatalities. In the US, sources have been found abandoned in scrap yards, vehicles, and residential buildings. In September, 1987, scavengers broke into an abandoned cancer clinic in Goiania, Brazil and stole a medical device containing large amounts of radioactive cesium. An estimated 250 people were exposed to the source, eight developed radiation sickness, and four died.

In almost all cases, the loss of radioactive materials has resulted from an accident or from a thief interested only in economic gain. In 1995, however, Chechen rebels placed a shielded container holding the Cesium-137 core of a cancer treatment device in a Moscow park, and then tipped off Russian reporters of its location.

Enhanced security measures at commercial sites that use dangerous amounts of radioactive material are likely to increase the cost of using radioactive materials and may possibly stimulate development and use of alternative technologies for some applications.

c. Health Risks

Gamma rays pose two types of health risks. Intense sources of gamma rays can cause immediate tissue damage, and lead to acute radiation poisoning. Fatalities can result from very high doses. Long-term exposure to low levels of gamma rays can also be harmful because it can cause genetic mutations leading to cancer. Triggering cancer is largely a matter of chance: the more radiation you're exposed to, the more often the dice are rolled. The risk is never zero since we are all constantly being bombarded by large amounts of gamma radiation produced by cosmic rays, which reach us from distant stars. We are also exposed to trace amounts of radioactivity in the soil, in building materials, and other parts of our environment. Any increase in exposure increases the risk of cancer.

Alpha particles emitted by plutonium, americium and other elements also pose health risks. Although these particles cannot penetrate clothing or skin, they are harmful if emitted by inhaled materials. If plutonium is in the environment in particles small enough to be inhaled, contaminated particles can lodge in the lung for extended periods. Inside the lung, the alpha particles produced by plutonium can damage lung tissue and lead to long-term cancers.

Case Studies

We have chosen three specific cases to illustrate the range of impacts that could be created by malicious use of comparatively small radioactive sources: the amount of cesium that was discovered recently abandoned in North Carolina, the amount of cobalt commonly found in a single rod in a food irradiation facility, and the amount of americium typically found in oil well logging systems. The impact would be much greater if the radiological device in question released the enormous amounts of radioactive material found in a single nuclear reactor fuel rod, but it would be quite difficult and dangerous for anyone to attempt to obtain and ship such a rod without death or detection. The Committee will undoubtedly agree that the danger presented by modest radiological sources that are comparatively easy to obtain is significant as well.

Impact of the release of radioactive material in a populated area will vary depending on a number of factors, many of which are not predictable. Consequences depend on the amount of material released, the nature of the material, the details of the device that distributes the material, the direction and speed of the wind, other weather conditions, the size of the particles released (which affects their ability to be carried by the wind and to be inhaled), and the location and size of buildings near the release site. Uncertainties inherent in the complex models used in predicting the effects of a radiological weapon mean that it is only possible to make crude estimates of impacts; the estimated damage we show might be too high by a factor of ten, or underestimated by the same factor. The following examples are then fairly accurate illustrations, rather than precise predictions.

In all three cases we have assumed that the material is released on a calm day (wind speed of one mile per hour). We assume that the material is distributed by an explosion that causes a mist of fine particles to spread downwind in a cloud. The blast itself, of course, may result in direct injuries, but these have not been calculated. People will be exposed to radiation in several ways.

- First, they will be exposed to material in the dust inhaled during the initial passage of the radiation cloud, if they have not been able to escape the area before the dust cloud arrives. We assume that about 20% of the material is in particles small enough to be inhaled. If this material is plutonium or americium (or other alpha emitters), the material will stay in the body and lead to long term exposure.

- Second, anyone living in the affected area will be exposed to material deposited from the dust that settles from the cloud. If the material contains cesium (or other gamma emitters) they will be continuously exposed to radiation from this dust, since the gamma rays penetrate clothing and skin. If the material contains plutonium (or other alpha emitters), dust that is pulled off the ground and into the air by wind, automobile movement, or other actions will continue to be inhaled, adding to exposure.

- In a rural area, people would also be exposed to radiation from contaminated food and water sources.

The EPA has a series of recommendations for addressing radioactive contamination that would likely guide official response to a radiological attack. Immediately after the attack, authorities would evacuate people from areas contaminated to levels exceeding these guidelines. People who received more than twenty-five times the threshold dose for evacuation would have to be taken in for medical supervision.

In the long term, the cancer hazard from the remaining radioactive contamination would have to be addressed. Typically, if decontamination could not reduce the danger of cancer death to about one-in-ten-thousand, the EPA would recommend the contaminated area be eventually abandoned. Decontaminating an urban area presents a variety of challenges. Several materials that might be used in a radiological attack can chemically bind to concrete and asphalt, while other materials would become physically lodged in crevices on the surface of buildings, sidewalks and streets. Options for decontamination would range from sandblasting to demolition, with the latter likely being the only feasible option. Some radiological materials will also become firmly attached to soil in city parks, with the only disposal method being large scale removal of contaminated dirt. In short, there is a high risk that the area contaminated by a radiological attack would have to be deserted.

We now consider the specific attack scenarios. The first two provide examples of attacks using gamma emitters, while the last example uses an alpha emitter. In each case, we have calculated the expected size of the contaminated area, along with other zones of dangerously high contamination. The figures in the Appendix provide a guide to understanding the impact of the attacks.

Example 1- Cesium (Gamma Emitter) – Figure 1

Two weeks ago, a lost medical gauge containing cesium was discovered in North Carolina. Imagine that the cesium in this device was exploded in Washington, DC in a bomb using ten pounds of TNT. The initial passing of the radioactive cloud would be relatively harmless, and no one would have to evacuate immediately. But what area would be contaminated? Residents of an area of about five city blocks, if they remained, would have a one-in-a-thousand chance of getting cancer. A swath about one mile long covering an area of forty city blocks would exceed EPA contamination limits, with remaining residents having a one-in-ten thousand chance of getting cancer. If decontamination were not possible, these areas would have to be abandoned for decades. If the device was detonated at the National Gallery of Art, the contaminated area might include the Capitol, Supreme Court, and Library of Congress, as seen if figure one.

Example 2 – Cobalt (Gamma Emitter) – Figures 2 and 3

Now imagine if a single piece of radioactive cobalt from a food irradiation plant was dispersed by an explosion at the lower tip of Manhattan. Typically, each of these cobalt "pencils" is about one inch in diameter and one foot long, with hundreds of such pieces often being found in the same facility. Admittedly, acquisition of such material is less likely than in the previous scenario, but we still consider the results, depicted in figure two. Again, no immediate evacuation would be necessary, but in this case, an area of approximately one-thousand square kilometers, extending over three states, would be contaminated. Over an area of about three hundred typical city blocks, there would be a one-in-ten risk of death from cancer for residents living in the contaminated area for forty years. The entire borough of Manhattan would be so contaminated that anyone living there would have a one-in-a-hundred chance of dying from cancer caused by the residual radiation. It would be decades before the city was inhabitable again, and demolition might be necessary.

For comparison, consider the 1986 Chernobyl disaster, in which a Soviet nuclear power plant went through a meltdown. Radiation was spread over a vast area, and the region surrounding the plant was permanently closed. In our current example, the area contaminated to the same level of radiation as that region would cover much of Manhattan, as shown in figure three. Furthermore, near Chernobyl, a larger area has been subject to periodic controls on human use such as restrictions on food, clothing, and time spent outdoors. In the current example, the equivalent area extends fifteen miles.

To summarize the first two examples, materials like cesium, cobalt, iridium, and strontium (gamma emitters) would all produce similar results. No immediate evacuation or medical attention would be necessary, but long-term contamination would be render large urban areas useless, resulting in severe economic and personal hardship.

Example 3 – Americium (Alpha Emitter) – Figures 4 and 5

A device that spread materials like americium and plutonium would create present an entirely a different set of risks. Consider a typical americium source used in oil well surveying. If this were blown up with one pound of TNT, people in a region roughly ten times the area of the initial bomb blast would require medical supervision and monitoring, as depicted in figure four. An area 30 times the size of the first area (a swath one kilometer long and covering twenty city blocks) would have to be evacuated within half an hour. After the initial passage of the cloud, most of the radioactive materials would settle to the ground. Of these materials, some would be forced back up into the air and inhaled, thus posing a long-term health hazard, as illustrated by figure five. A ten-block area contaminated in this way would have a cancer death probability of one-in-a-thousand. A region two kilometers long and covering sixty city blocks would be contaminated in excess of EPA safety guidelines. If the buildings in this area had to be demolished and rebuilt, the cost would exceed fifty billion dollars.

Recommendations

A number of practical steps can be taken that would greatly reduce the risks presented by radiological weapons. Our recommendations fall into three categories: (1) Reduce opportunities for terrorists to obtain dangerous radioactive materials, (2) Install early warning systems to detect illicit movement of radioactive materials, and (3) Minimize casualties and panic from any attack that does occur. Since the US is not alone in its concern about radiological attack, and since we clearly benefit by limiting access to dangerous materials anywhere in the world, many of the measures recommended should be undertaken as international collaborations.

1)_Reduce access to radioactive materials

Radioactive materials facilitate valuable economic, research and health care technologies. Measures needed to improve the security of facilities holding dangerous amounts of these materials will increase costs. In some cases, it may be worthwhile to pay a higher price for increased security. In other instances, however, the development of alternative technologies may be the more economically viable option. Specific security steps include the following:

- Fully fund material recovery and storage programs. Hundreds of plutonium, americium, and other radioactive sources are stored in dangerously large quantities in university laboratories and other facilities. When these materials are actively used and considered a valuable economic asset, they are likely to be well protected. But in all too many cases they are not used frequently, resulting in the risk that attention to their security will diminish over time. At the same time, it is difficult for the custodians of these materials to dispose of them since in many cases only the DOE is authorized to recover and transport them to permanent disposal sites. The DOE Off-Site Source Recovery Project (OSRP), which is responsible for undertaking this task, has successfully secured over three-thousand sources and has moved them to a safe location. Unfortunately, the inadequate funding of this program serves as a serious impediment to further source recovery efforts. Funding for OSRP has been repeatedly cut in the FY2001 and 2002 budgets and the presidential FY2003 budget proposal, significantly delaying the recovery process. In the cases of FY01 and FY02, the 25% and 35% cuts were justified as money being transferred to higher priorities; the FY03 would cut funding by an additional 26%. This program should be given the needed attention and firm goals should be set for identifying, transporting, and safeguarding all unneeded radioactive materials.

- Review licensing and security requirements and inspection procedures for all dangerous amounts of radioactive material. HHS, DOE, NRC and other affected agencies should be provided with sufficient funding to ensure that physical protection measures are adequate and that inspections are conducted on a regular basis. A thorough reevaluation of security regulations should be conducted to ensure that protective measures apply to amounts of radioactive material that pose a homeland security threat, not just those that present a threat of accidental exposure.

- Fund research aimed at finding alternatives to radioactive materials. While radioactive sources provide an inexpensive way to serve functions such as food sterilization, smoke detection, and oil well logging, there are sometimes other, though possibly more expensive, ways to perform the same functions. A research program aimed at developing inexpensive substitutes for radioactive materials in these applications should be created and provided with adequate funding.

2) Early Detection

- Expanded use of radiation detection systems. Systems capable of detecting dangerous amounts of radiation are comparatively inexpensive and unobtrusive. Many have already been installed in critical locations around Washington, DC, at border points and throughout the US. The Office of Homeland Security should act promptly to identify all areas where such sensors should be installed, ensure that information from these sensors is continuously assessed, and ensure adequate maintenance and testing. High priority should be given to key points in the transportation system, such as airports, harbors, rail stations, tunnels, highways. Routine checks of scrap metal yards and land fill sites would also protect against illegal or accidental disposal of dangerous materials.

- Fund research to improve detectors. Low-cost networking and low-cost sensors should be able to provide wide coverage of critical urban areas at a comparatively modest cost. A program should be put in place to find ways of improving upon existing detection technologies as well as improving plans for deployment of these systems and for responding to alarms.

3) Effective Disaster response

An effective response to a radiological attack requires a system capable of quickly gauging the extent of the damage, identifying appropriate responders, developing a coherent response plan, and getting the necessary personnel and equipment to the site rapidly. The immediate goal must be to identify the victims that require prompt medical attention (likely to be a small number) and to ensure that all other unauthorized personnel leave the affected area quickly, without panic, and without spreading the radioactive material. All of this requires extensive training.

- Training for hospital personnel and first responders. First responders and hospital personnel need to understand how to protect themselves and affected citizens in the event of a radiological attack and be able to rapidly determine if individuals have been exposed to radiation.

  There is great danger that panic in the event of a radiological attack on a large city could lead to significant casualties and severely stress the medical system. Panic can also cause confusion for medical personnel. The experience of a radiological accident in Brazil suggests that a large number of people will present themselves to medical personnel with real symptoms of radiation sickness – including nausea and dizziness – even if only a small fraction of these people have actually been exposed to radiation. Medical personnel need careful training to distinguish those needing help from those with psychosomatic symptoms. While generous funding has been made available for training first responders and medical personnel, the program appears in need of a clear management strategy. Dozens of federal and state organizations are involved, and it is not clear how materials will be certified or accredited. Internet-based tools for delivering the training will almost certainly be necessary to ensure that large numbers of people throughout the US get involved. In the US, there are over 2.7 million nurses and over a million police and firefighters who will require training, not to mention the medics in the US armed services. However, there appears to be no coherent program for developing or using new tools to deliver needed services, and to ensure that training and resource materials are continuously upgraded and delivered securely.

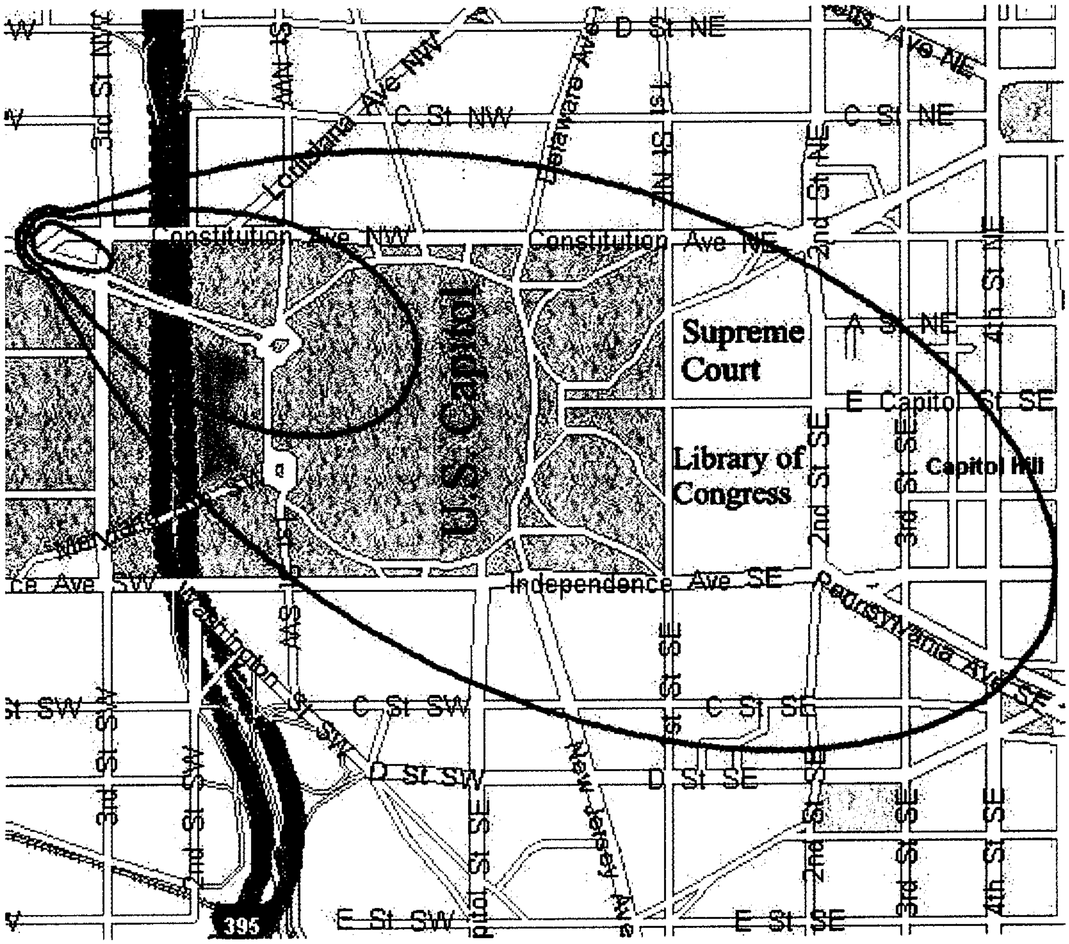
- Decontamination Technology. Significant research into cleanup of radiologically contaminated cities has been conducted in the past, primarily in addressing the possibility of nuclear war. Such programs should be revisited with an eye to the specific requirements of cleaning up after a radiological attack. As demonstrated above, the ability to decontaminate large urban areas might mean the difference from being able to continue inhabiting a city and having to abandon it.

Conclusion

The events of September 11 have created a need to very carefully assess our defense needs and ensure that the resources we spend for security are aligned with the most pressing security threats. The analysis summarized here shows that the threat of malicious radiological attack in the US is quite real, quite serious, and deserves a vigorous response. Fortunately, there are a number of comparatively inexpensive measures that can and should be taken because they can greatly reduce the likelihood of such an attack. The US has indicated its willingness to spend hundreds of billions of dollars to combat threats that are, in our view, far less likely to occur. This includes funding defensive measures that are far less likely to succeed than the measures that we propose in this testimony. The comparatively modest investments to reduce the danger of radiological attack surely deserve priority support.

In the end, however, we must face the brutal reality that no technological remedies can provide complete confidence that we are safe from radiological attack. Determined, malicious groups might still find a way to use radiological weapons or other means when their only goal is killing innocent people, and if they have no regard for their own lives. In the long run our greatest hope must lie in building a prosperous, free world where the conditions that breed such monsters have vanished from the earth.

Figure 1: Long-term Contamination Due to Cesium Bomb in Washington, DC

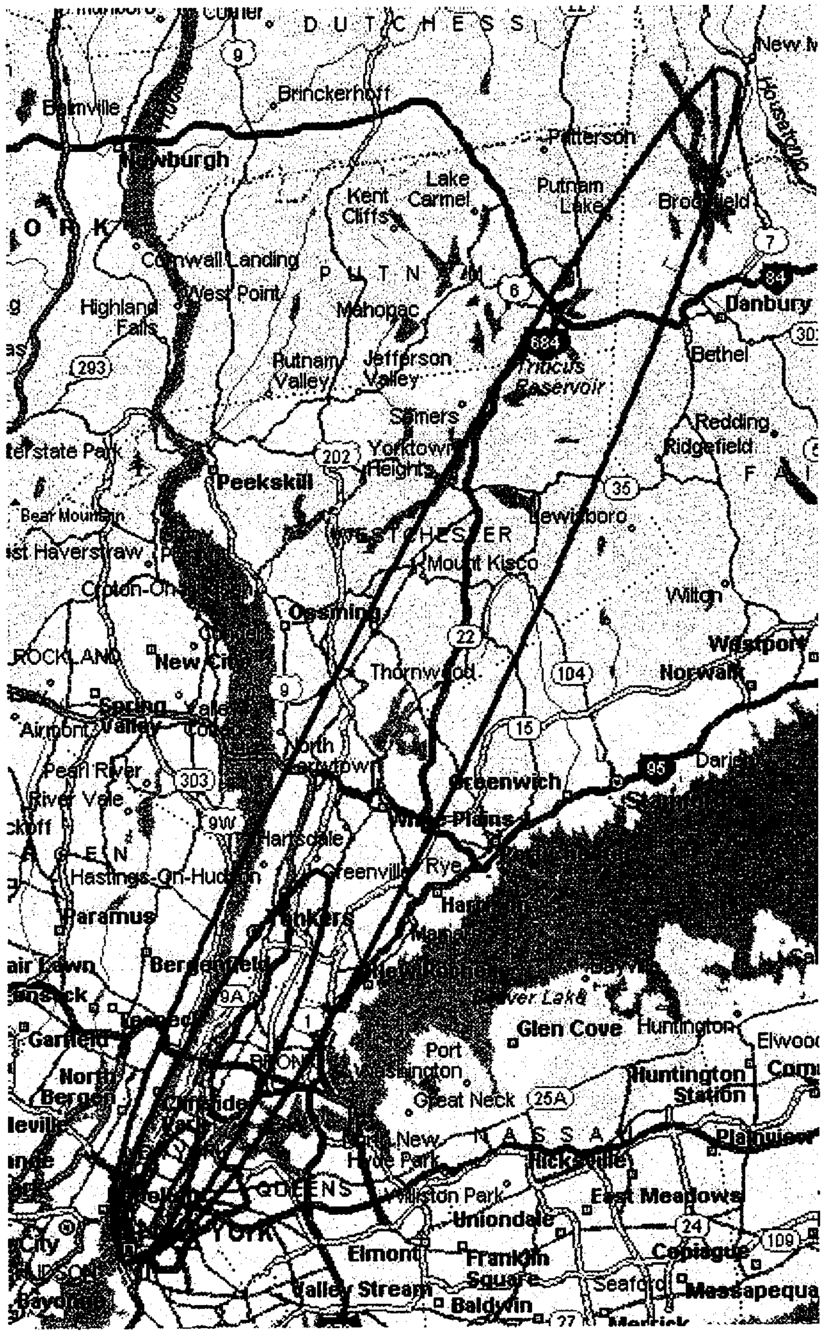


Inner Ring: One cancer death per 100 people due to remaining radiation

Middle Ring: One cancer death per 1,000 people due to remaining radiation

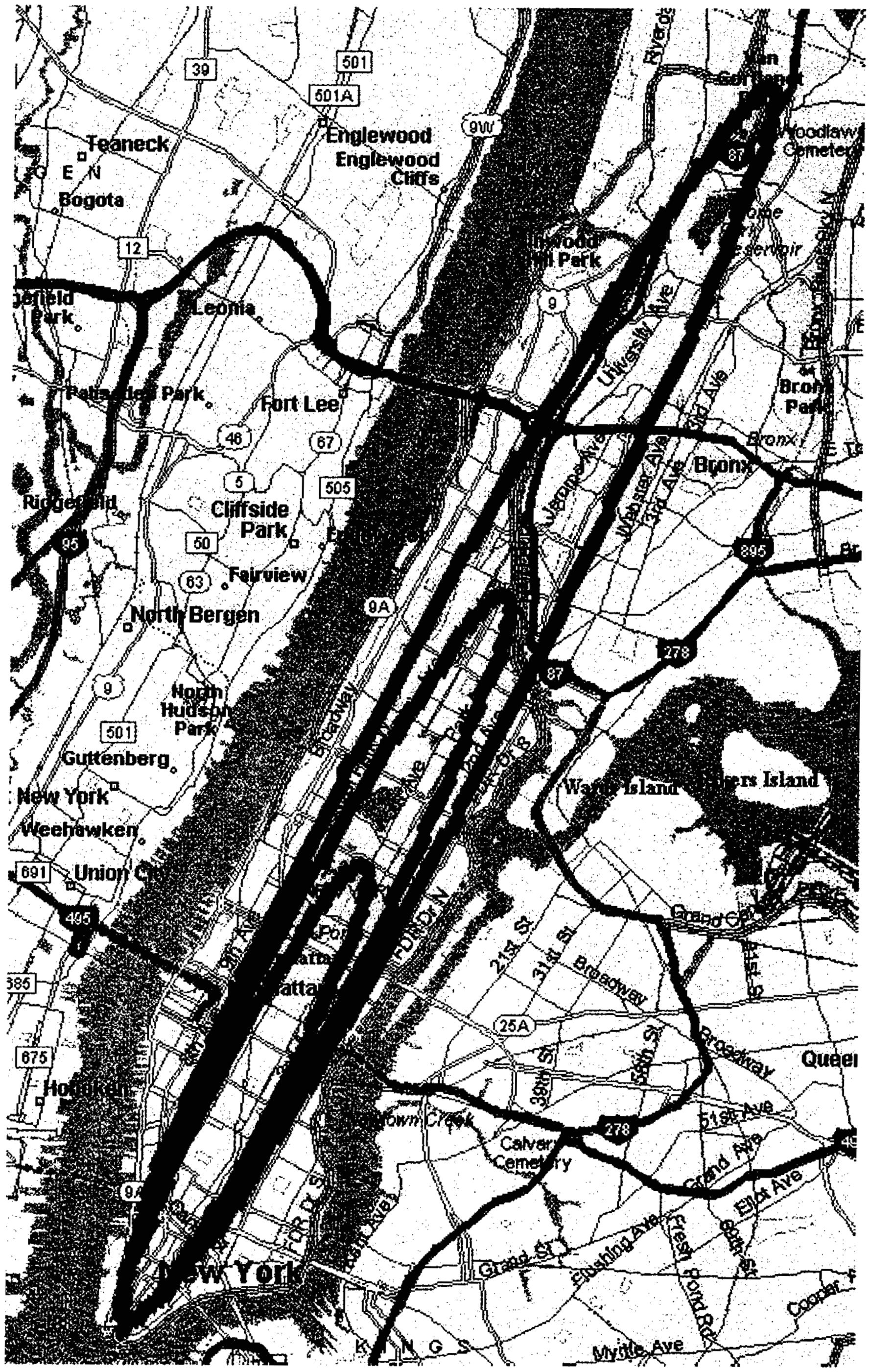
Outer Ring: One cancer death per 10,000 people due to remaining radiation
EPA recommends decontamination or destruction

Figure 2: Long-term Contamination Due to Cobalt Bomb in NYC – EPA Standards



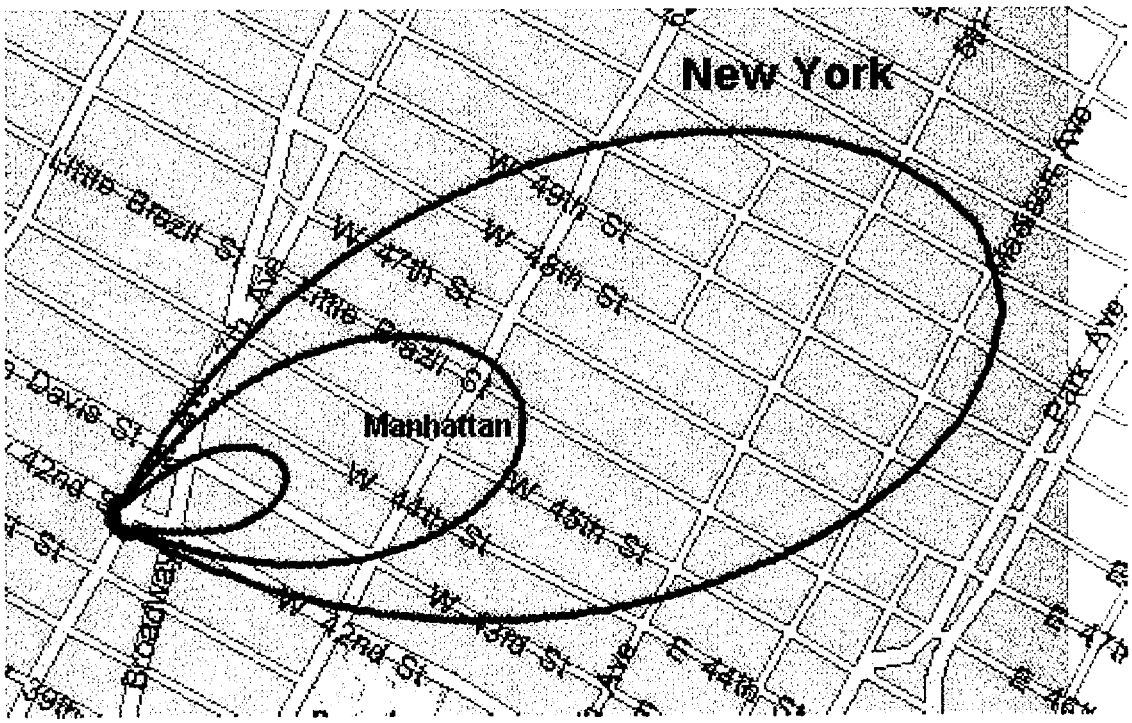
Inner Ring: One cancer death per 100 people due to remaining radiation
Middle Ring: One cancer death per 1,000 people due to remaining radiation
Outer Ring: One cancer death per 10,000 people due to remaining radiation
EPA recommends decontamination or destruction

Figure 3: Contamination Due to Cobalt Bomb in NYC – Chernobyl Comparison



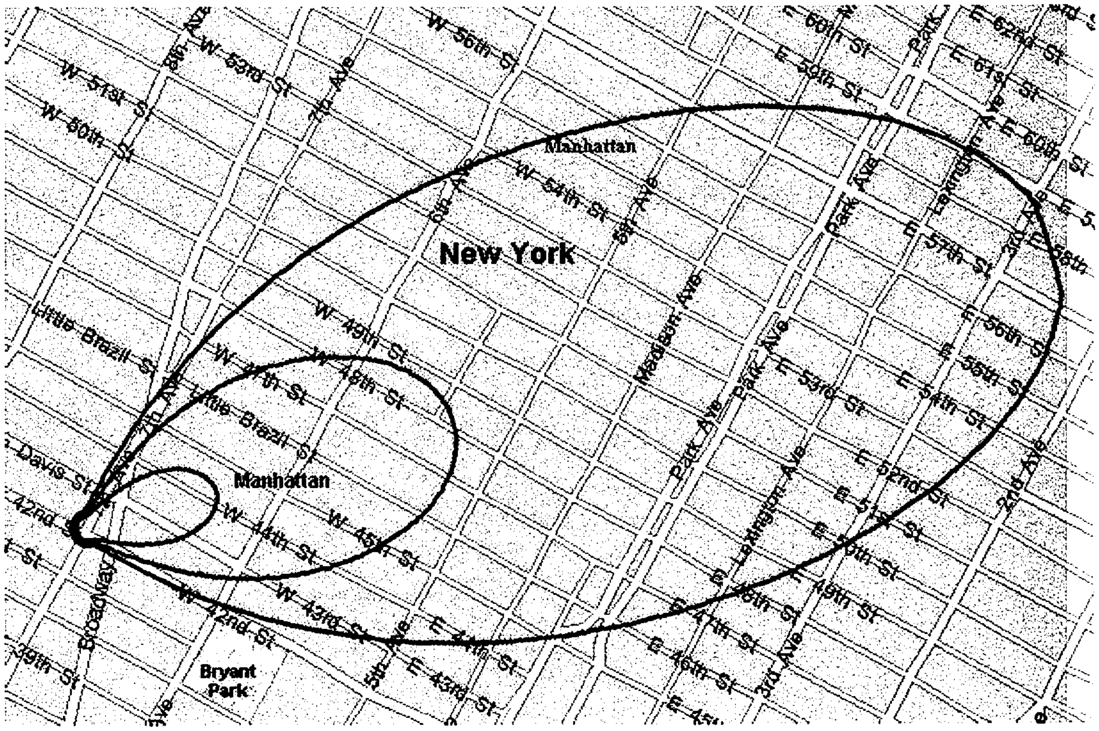
Inner Ring:	Same radiation level as *permanently closed* zone around Chernobyl
Middle Ring:	Same radiation level as *permanently controlled* zone around Chernobyl
Outer Ring:	Same radiation level as *periodically controlled* zone around Chernobyl

Figure 4: Immediate Effects Due to Americium Bomb in New York City



Inner Ring:	All people must receive medical supervision
Middle Ring:	Maximum annual dose for radiation workers exceeded
Outer Ring:	Area should be evacuated before radiation cloud passes

Figure 5: Contamination Due to Americium Bomb in New York City



Inner Ring:	One cancer death per 100 people due to remaining radiation
Middle Ring:	One cancer death per 1,000 people due to remaining radiation
Outer Ring:	One cancer death per 10,000 people due to remaining radiation EPA recommends decontamination or destruction