RADIATION EMERGENCY ASSISTANCE CENTER/TRAINING SITE

The REAC/TS Radiation Accident Registry: An Overview

Introduction. Over the past four years, REAC/TS has presented a number of case reports from its Radiation Accident Registry. Victims of radiological or nuclear incidents must meet certain dose criteria for an incident to be categorized as an "accident" and be included in the registry. Although the greatest numbers of "accidents" in the United States that have been entered into the registry involve radiation devices, the greater percentage of serious accidents have involved sealed sources of one kind or another. But if one looks at the kinds of accident scenarios that have resulted in extreme consequence, i.e., death, the greater share of deaths has occurred in medical settings.

Serious Radiation Accidents. Although criticalities required for nuclear power production and nuclear weapons detonations have occurred in the United States, a nuclear *detonation* has not caused a human death since those that ended World War II. On the other hand, a report from the Los Alamos National Laboratory (McClaughlin et al. A Review of Criticality Accidents 2000 Revision. LA-13638), using data from the United States and former Soviet Union, describes 60 *criticality* incidents in the history of the atomic age. But only 20 *criticality* incidents have resulted in serious consequences worldwide (see Table 1) and only a few of those have actually caused fatalities.

Table 1. Types of Devices Involved in Serious Radiation Accidents Worldwide (1944–1 July 2012)

Radiation Devices			**326**
	Sealed Sources	214	
	X-Ray Devices	86	
	Accelerators	25	
	Radar Generators	1	
Radioisotopes			**108**
	Diagnosis and Therapy	50	
	Transuranics	28	
	Fission Products	11	
	Tritium	2	
	Radium Spills	1	
	Other	16	
Criticalities			**20**
	Critical Assemblies	8	
	Reactors	6	
	Chemical Operations	6	
		Total	**454**

The greatest numbers of serious radiation accidents have occurred with sealed sources, which include brachytherapy sources used in radiation oncology for cancer therapy and industrial radiography devices used to identify defects in metallic structures, among others (n=214 of 454). Radioisotopes used in medical diagnosis and therapy have caused over 10 percent of serious radiation accidents (n=50 of 454). The radioisotopes most commonly entered into the registry include uranium most frequently involved (150 cases), followed distant second through fourth plutonium (47 cases), americium (42 cases), and thorium (32 cases).

Note that the first incident, in Idaho, with three deaths, is a "nonradiation-related" incident. The deaths in the Idaho SL-1 experimental reactor accident were not the direct result of exposure to ionizing radiation. Although a reactor criticality was the proximate cause of the deaths, the direct cause of the deaths of three U.S. servicemen was physical trauma as they were traumatized by a cooling jacket steam explosion when the reactor went critical. The New Mexico and Rhode Island incidents were associated with nuclear criticalities in industrial environments and the direct and proximate causes of the deaths were radiation-related. The Oklahoma case was probably a suicide using an industrial radiography device and certainly should not be categorized as an "accident." Of all of the cases, the majority were during the conduct of medical diagnosis or therapy (n=21 of 30).

Table 2. U.S. Deaths from Radiological or Nuclear Incidents (1944–1 July 2012)

State	Number of Deaths	Circumstances
Idaho	3	Reactor criticality—deaths as a result of physical trauma from steam explosion, not ionizing radiation (nonradiation death)
Washington	1	Radiation therapy (nonradiation death)
New Mexico	3	2–Research with critical assemblies 1–Chemical operations/criticality
Rhode Island	1	Chemical operations/criticality
Oklahoma	1	Probably self-inflicted injury (radiography source)
Ohio	10	Radiation therapy
Pennsylvania	1	Radiation therapy (brachytherapy source)
Texas	7	Nuclear medicine therapy
	2	Radiation therapy/computer programming
Wisconsin	1	Nuclear medicine therapy
Total U.S. Deaths	**30**	

The Medical Consequences of U.S. Accidents Resulting in Fatalities. As seen in Table 2, four deaths in the United States have been the result of radiological or nuclear accidents for which exposure to ionizing radiation was not the *direct* cause of death. The Idaho SL-1 experimental reactor criticality caused overheating of the reactor cooling vessel and an explosion from super-heated steam impaled one serviceman with a control rod. Two other servicemen died from explosive blunt-force trauma. The Washington State fatality was also a nonradiation death when a victim died from tumor pathology before succumbing to radiation-therapy injuries.

The remaining accidents in Table 2 were all radiation-related. The deaths in New Mexico were as a result of radiation exposure following criticalities and involved significant acute radiation syndrome (ARS) and soft-tissue injuries. The Rhode Island criticality was caused by mishandling of a liquid assembly in a fuels recovery plant. That accident also resulted in severe ARS and soft-tissue injuries. Death occurred in advance of full maturation of the soft-tissue injuries.

The Oklahoma case was probably a suicide, as an industrial radiographer exposed his torso to a misappropriated radiography source for a period of time certain to cause death by ARS. The 10 deaths in Ohio occurred because of a medical physics miscalculation of exposure to a ^{60}Co teletherapy source. Inaccurate calculations involving an underestimate of source strength using the wrong graph paper resulted in an increased time of exposure and serious ARS and local radiation injuries.

The Pennsylvania radiation-related fatality was caused by a retained 155.4 GBq (4.2 Ci) brachytherapy source being used to treat a squamous carcinoma of the anus. The octogenarian female died with severe ARS and local injuries. Doses to her rectum and bladder were estimated to be 7,770 Gy and 2,080 Gy respectively. The nine Texas cases were from two scenarios: (1) two deaths from teletherapy malfunction because of a software error resulting in serious soft-tissue injuries and (2) seven deaths from the loss of ^{90}Y from therapeutic microspheres used as the transport mechanism (see the REAC/TS article in the October *Health Physics News*, page 34 that resulted in serious ARS). And finally, a death in Wisconsin occurred from the use of ^{198}Au for liver/spleen scanning during which a dose miscalculation resulted in doses to the liver and spleen of 60 Gy and 80 Gy, respectively, and severe ARS.

Conclusion. Although radiation-related incidents are exceedingly rare, the consequences of exposure or significant internal contamination can be fatal. As a final note, all of the incidents described herein were preventable, that is, appropriate human conduct would have prevented them. The root cause of each was human error and they were not, in fact, "accidents."

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