RADIOACTIVE WASTE DISPOSAL IN A PRIVATE URBAN ACADEMIC MEDICAL CENTER

J. Ovadia and K.J. Francis
Michael Reese Hospital & Medical Center
Department of Medical Physics
Chicago, Illinois 60616

ABSTRACT

Prior to 1979 all of Michael Reese Hospital's low level radioactive waste (LLW) was shipped to Sheffield, Illinois (approximately 100 miles) for burial. This method was an economical, convenient and expedient means of LLW disposal. Since 1979 all generators of LLW have been confronted with escalating costs, erratic service, and cumbersome regulations for shipping and burying wastes. Additional disposal procedures, i.e. use of sanitary sewer, storage-for-decay, incineration and volume reduction before shipment, became relevant and were assessed. The implementation of these alternative methods and our experiences at Michael Reese Hospital will be discussed.

BACKGROUND INFORMATION

Michael Reese Hospital and Medical Center is a 900 bed teaching hospital with a large biomedical research program. Radioactive materials have both clinical and research applications. As a generator of low level radioactive wastes the program falls into the classification of a large institution (as discussed in the introduction to the session). The utilization of radioactive materials in most medical centers is well characterized with respect to the isotopes and activities used at each specific location, e.g. nuclear medicine, radioimmunoassay laboratories, or research laboratories.

Figure 1 represents 1979 data of clinical isotope use by the nuclear medicine division for imaging, and is typical of large institutions. Note that the predominant isotope is Tc-99m; all isotopes used are short-lived (hours/days), and the yearly activities (except for Tc-99m and Xe-133) are quite small. Most of the activity is either lost to decay or injected into patients for diagnostic imaging. The material ultimately left for disposal can easily be held for decay (generally ten half-lives) and properly disposed of as normal (non-radioactive) trash.

ISOTOPE	HALF-LIFE	STUDIES/YEAR	ACTIVITY/YEAR
Technetium 99m (Molybdenum 99)	6 hr (2.8 d)	6,000	150 Ci (30 Ci)
Gallium 67	3.3 d	800	8 Ci
Xenon 133	5.3 d	600	50 Ci
Thallium 201	3 d	300	0.3 Ci
Iodine 123	13 hr	200	0.1 Ci
Iodine 131	8 d	50	0.5 Ci
Ytterbium 169	32 d	10	0.01 Ci

Fig. 1. Clinical Use of Isotopes for Imaging at Michael Reese Hospital

Figure 2 represents corresponding data for clinical radioimmunoassay (RIA) tests. Note that the primary isotopes used are H-3, Co-57 and I-125 in millicurie quantities per year. The bulk of material for disposal is aqueous liquid (wash) and assay test tubes.

STUDIES	# OF TESTS PER MONTHS	TOTAL ACTIVITY PER YEAR
Iodine 125 (60 day half-life)		
Thyroid fcn,Cardiac fcn, Cancer Antigen	1,500	2mCi
Steroid Hormones	500	20 mCi
Hepatitis A & B Antigen	200	2 mCi
Renin, Angiotestin	100	0.5 mCi
Pituitary, Pancreas Hormones	1,000	100 mCi
Ferritin, Folate, I.G.E.	250	0.7 mCi
Tritium: (12.3 years half-life)		
Steroid Hormones	1,000	0.4 mCi
Aldosterone	40	0.1 mCi
Cobalt 57: (270 days half-life)		
B-12	50	0.2 mCi

Fig. 2. Clinical Use of Isotopes for Radioimmunoassay at Michael Reese Hospital.

It is difficult to define precisely the use of isotopes for research, in the manner done for clinical procedures. The number of isotopes, and their activities and half-lifes, vary greatly according to the research protocol. Control is maintained via a radiation safety office, established to implement NRC and State of Illinois regulations. All applications for isotope use are reviewed by a Research Radioisotope Committee. The radiation safety office orders and distributes all radioactive materials to the various approved laboratories. Wastes are generated (under an approved protocol) in specific locations with known isotopes and activities. Personnel of the radiation safety office collect all wastes from the laboratories and supervise all the waste disposal procedures.

HISTORICAL OVERVIEW

Prior to 1979 all waste generated (except for diagnostic imaging wastes) at our institution was shipped for commercial burial to Sheffield, Illinois, a distance of approximately 100 miles. The Sheffield site closed March of 1979. Subsequent to this event wastes were shipped to Richland, Washington, a distance in excess of 1500 miles. Along with increased transportation distance came additional regulations from the State of Washington and the Department of Transportation which resulted in dramatic price increases. Since 1979 commercial burial costs have more than quadrupled. Although increasing costs motivated a reassessment of disposal methods, many other problems surfaced.

1. After the closing of Sheffield, only one of the three commercial sites was available to us for burial. The sporadic closures of the Washington site since 1979 created additional problems and anxieties.
2. Multiple agencies (NRC, States, DOT, etc.) began to enforce cumbersome regulations. Just keeping current in order to comply became a challenge.
3. The State of Washington required each waste generator using its burial facilities to accept liability, in an amount not to exceed five million dollars, for any problems associated with the disposal. Each waste generator utilizing commercial burial is assuming indefinite liability.
4. As packaging requirements changed, the ratio of the volume of waste to the actual shipment volume decreased (example, animal carcasses: waste volume less than 4 cubic feet, shipped volume 7.5 cubic feet).
5. The concept of burying liquid scintillation fluids, primarily an organic solvent with trace amounts of beta emitters, is seriously flawed. It is our opinion that the solvent is the hazard and burial is an improper means of disposal.

The impact of these problems on generators of low level radioactive wastes demand the minimization of volume shipped for commercial burial and the reassessment of alternative disposal methods. The methods considered include the use of:

1. Sanitary Sewer.
2. Storage-for-Decay and disposal as non-radioactive waste.
3. Incineration.
4. Proper disposal of deregulated wastes (H-3 & C-14 in scintillation fluids or animal carcasses).
5. Compacting wastes before shipment for commercial burial.

The characteristics of the waste shipped for burial according to half-life, physical form, volume, activity and specific activity appears in Fig. 3. This data represents mostly research contributions, except for I-125. For the long half-lived isotopes of tritium and carbon-14 the volume of the solid and scintillation fluid waste streams were significant. For isotopes of moderate half-lifes, i.e. greater than 60 days but less than a year, the total waste volume was minimal. For short-lived isotopes, i.e. less than 60 days, the volume of the solid and aqueous liquid waste streams were significant. Notice that the specific activity of all the identified waste streams is minimal.

Form	Volume (Cu. Ft.)	Activity mCi	Spec. Activity mCi/Cu. Ft.
Long-Lived: C-14 (5730y) & H-3 (12,34y)			
Solid	200	12	0.06
Aqueous Liquid	24	10	0.40
Scintillation	340	14	0.04
Moderate Half-Life: Co-57 (270d), Ca-45 (165d) & S-35 (87d)			
Solid	18	0.2	0.01
Aqueous Liquid	5	3	0.6
Scintillation	27	11	0.4
Short-Lived: I-125 (60d), Cr-51 (28d), P-32 (14d), I-131 (8d)			
Solid	450	31	0.07
Aqueous Liquid	110	19	0.17
Scintillation	25	1.2	0.05

Fig. 3. Radioactive Waste Shipped by Michael Reese Hospital (1979)

SPECIFIC WASTE STREAMS SOLUTIONS AND EXPERIENCES

Disposal of Aqueous Wastes

The easiest waste stream to reduce was that of aqueous waste, via the controlled release to the sanitary sewer system (10CFR 20.303). The following procedure is implemented and has proved practical: Users collect the liquid in two gallon containers with a label indicating the isotope, activity and date entered. When filled, the users transport the container to the radiation safety office for assay, dilution and disposal. A computer program facilitates the generation of a final disposal record, which includes the following information:

1. Radioisotope(s), Date
2. Activity of each isotope for the day, month and year
3. Per cent limit of each isotope for the day, month and year
4. Total activities and per cent limits

Table I shows that upon implementation in 1982 no aqueous liquid waste was shipped for commercial burial; the total activity disposed via sanitary sewer was 41 mCi, well below the one curie per year limit.

YEAR	SHIPPED VOLUME	SHIPPING COST
1980	105 ft^3	$1060
1981	116 ft^3	$1575
1982	0	0

Table I. Disposal of Aqueous Waste

Disposal of Scintillation Vial Waste

The NRC amended its regulations March of 1981 to allow the disposal of liquid scintillation fluids containing tracer levels of tritium and carbon-14 without regard to their radioactivity, 10CFR 20.306. Since scintillation fluid is an organic solvent it can not be disposed via the sanitary sewer or as normal trash. The ideal method is incineration, or utilized as a fuel supplement, since the combustion products are water and carbon dioxide. An existing pathological incinerator was tested as a disposal alternative; and a practical protocol was developed. Glass and/or plastic vials with the fluid contents are burned. This circumvents having to separate the fluid from the vials and providing a controlled injection method. Table II demonstrates that in 1982, after complete implementation of burning H-3 & C-14 scintillation fluids, the volume shipped for commercial burial was significantly reduced. The remaining volume contained the isotopes of P-32, S-35 and Ca-45. The incineration of these isotopes must be licensed by the NRC. With the goal of maximum volume reduction, this process was investigated. Since the existing pathological incinerator is seldom used and has a relatively small stack exhaust, proper dilution of the regulated isotopes is not possible. The alternative was to adopt the method utilized by the University of Illinois, Champaign/Urbana campus. The method is incineration, as a fuel supplement, via the power plant.

YEAR	SHIPPED VOLUME	SHIPPING COST
1980	463 ft^3	$6520
1981	461 ft^3	$7790
1982	69 ft^3	$1650

Table II. Disposal of Scintillation Vial Waste

Representatives of our institution visited U of I March of 1980. By November of 1980 a technical proposal was approved by the engineering department, at Michael Reese. A license application was submitted to the NRC February of 1981. The NRC responded March of 1982 with a contingent approval: "Must submit evidence that all State and local jurisdictions have been notified of your plans to incinerate radioactive waste and that all pertinent State and local regulations have been met". That same month the Illinois Department of Nuclear Safety was informed and they approved our plans. The Illinois Environmental Protection Agency was contacted and responded in June of 1982 with the statement: "After the USNRC approves your plan the Agency will be in a position to review your request". Catch-22! The City of Chicago Environmental Protection Agency was contacted next and responded in September of 1982 with: "Incineration is not allowed in boilers: restate as an addition to fuel" then "must complete the new boiler installation permit forms and an application for storage tank". It is our understanding that no action could be expected until after the mayoral election in April 1983.

The various dates of the steps undertaken have been given to emphasize the cumbersomeness of any procedure requiring a license to incinerate. A deregulation by the NRC of all trace isotopes used in scintillation fluids would be a welcome advance.

Disposal of Solid (Dry) Waste

As seen in Fig. 3, the greatest portion of the solid waste is short-lived, specifically less than 60 days. This makes a storage-for-decay program particularly attractive for a large medical center. Since the principal isotope of this category is I-125, a storage period of ten half-lifes, or two years, should be implemented. A request for 1500 square feet of storage space was submitted to the Hospital's administration, in 1981, but was effectively tabled, due to lack of perceived urgency and the difficulty in allocation of any space. A storage area of 1100 square feet was finally acquired one year later (December 1982). A NRC license application was submitted February 1983. A volume reduction of 50 per cent or approximately 290 cubic feet is anticipated.

Table III illustrates the effect of manual compaction of waste before shipment for burial. A compactor, consisting of a hand crank, geared drive and a ram, was built by the Department's machine shop, after the hospital rejected a purchase requistion for a commercial compactor costing approximately $15,000.

YEAR	SHIPPED VOLUME	SHIPPING COST
1980	707 ft^3	$8110
1981	752 ft^3	$10780
1982	578 ft^3	$12300

Table III. Disposal of Solid (Dry) Waste

Disposal of Animal Carcasses

The inception of 10CFR 20.306 in March of 1981 allowing for the disposal of animal carcasses containing tracer amounts of H-3 & C-14 has had a minimum effect to date. The only practicable alternative method of disposing animal carcasses is cremation, i.e. incineration. Since this operation would require a large capital investment and the waste volume shipped for burial was generally small, 240 cubic feet during 1981, this plan was abandoned. As shown in Table IV the volume tripled and the cost quadrupled in 1982. The dramatic increase is due to a new research project which involves the use of microspheres in goats. At this rate a capital investment for an incinerator could be amortized over a few years. However, due to the unpredictability of waste volumes generated by changing research projects and limited funds, acquisition of such an incinerator is not being considered.

YEAR	SHIPPED VOLUME	SHIPPING COST
1980	293 ft^3	$3590
1981	240 ft^3	$3720
1982	802 ft^3	$17900

Table IV. Disposal of Animal Carcasses

PROGRAM SUMMARY

The annual cost of shipping for commercial burial for the solid, scintillation fluid, aqueous liquid and animal carcass waste streams is shown in Table V. Significant reductions can be seen for vial (scintillation fluids) and aqueous liquids. Cost of solid waste disposal is expected to be reduced by a factor of two when the storage-for-decay program is initiated. The sudden volume increase of animal carcasses during 1982 defeated the cost reduction efforts.

YEAR	SOLID COST	VIAL COST	LIQUID COST	ANIMAL COST	SUPPLIES COST	TOTAL COST
1980	$8110	$6520	$1060	$3590	$10 K	$29 K
1981	$10780	$7790	$1575	$3720	$10 K	$34 K
1982	$12300	$1650	0	$17900	$10 K	$42 K

Table V. Cost for Transportation and Disposal of Low Level Radioactive Waste

CONCLUSION

The ultimate goal of low level radioactive waste generators is to reduce the volume shipped for commercial burial. The reassessment and utilization of alternative disposal methods is essential and practical.

The development of regional compacts for low level waste management should reduce the costs. The incorporation of an incineration facility at the regional disposal site would solve the main problem large medical installations still have. This is not too different from the approach described by the French participants in this symposium.