CHAPTER 11

WASTE MANAGEMENT

INTRODUCTION

A fair amount of radioactive material is produced as an unwanted by-product of nuclear generation. This radioactive waste, or *radwaste* for short, must be managed wisely so that radiation exposure to station staff and the general public is minimised.

The Waste Management System includes all facilities and procedures for dealing with radwaste in solid, liquid and gaseous forms. Although most of you will not become all that involved with radwaste management (other than as producers of waste!), it is worth learning something about it. The nuclear power industry is certainly showing the way for other industries to follow. Once you appreciate how we deal with radwaste, you will be in a better position to counter some of the arguments put forth by the anti-nuclear people.

SOLID WASTE

There are two quite distinct types of solid waste. One is spent fuel and the other is all the rest of the stored waste, including the trash and garbage (generally not radioactive) that accumulates as a result of plant operation and maintenance.

Spent Fuel

The spent fuel bundles removed from the reactor contain the fission products produced during reactor operation. This spent fuel is therefore extremely radioactive (see page 59 if you need convincing). Because of its high activity, spent fuel creates lots of heat for several years after being taken from the reactor and it needs to be cooled to stop it melting. Present plans are that spent fuel will be stored in the station's Spent Fuel Storage Bay for about seven years before it is transferred to a *Dry Fuel Storage Site* next to the SRWMF (see later).

The Government has spent zillions of dollars on radwaste research with the result that underground vaults were selected as the best option for long-term storage of spent fuel. The plan was to load the spent fuel into specially designed vaults about 1 km deep in rock that hasn't budged for millions of years, and then to just leave it there to decay to harmless levels. Good in theory.

In practice, it has been difficult to find a site that the local citizens would accept. You must have heard of the *NIMBY* reaction ("not in my backyard") that greets most major developments. Furthermore, public consultation has shown that most people would prefer the stuff to be stored

above ground where we can keep an eye on it. So that's what we're doing for the next few decades in the Dry Fuel Storage Site. If and when the Government makes a decision to establish a Canadian repository for spent fuel, our grandchildren will be happy to ship the stuff to them. But don't hold your breath.

Stored Wastes

All solid radioactive wastes generated at Point Lepreau G.S. are stored in an on-site **Solid Radioactive Waste Management Facility (SRWMF,** pronounced *Smurf*). The types of waste that have to be stored are:

a) general wastes such as paper, rags, laboratory glassware, wood, plastics, fabrics, rubber, etc.,
b) contaminated tools, piping, assorted pieces of plumbing,
c) filters,
d) activated reactor components,
e) ion exchange resins from the purification of radioactive process systems (heat transport, moderator, fuelling machine and spent fuel bays).

We categorise solid radwastes as shown in the Table. Why? Because we've always done it this way. Type I wastes are made up of items listed in a) and b) above, and Type II and III wastes are usually found among c), d) and e). The main difference in how we deal with the three types is that the procedural controls are much tighter for types II and III wastes.

TABLE 11.1 SOLID RADWASTE TYPES

Type I	< 2 mSv/h gamma at contact
Type II	2 – 125 mSv/h gamma at contact
Type III	> 125 mSv/h gamma at contact

The SRWMF

The SRWMF has the following functions:

a) store the waste in a retrievable fashion for ultimate disposal;
b) isolate stored radwaste from the environment;
c) minimise radiation exposure to station staff and the general public.

The location of the SRWMF is shown here. There are good reasons for having it on site. Some of the ones I can think of are:

a) minimal transportation and access problems,
b) the SRWMF can be managed easily from the station,
c) common security for both station and SRWMF,
d) remote from population centres and sources of water used by the public,
e) easily expanded to meet future needs.

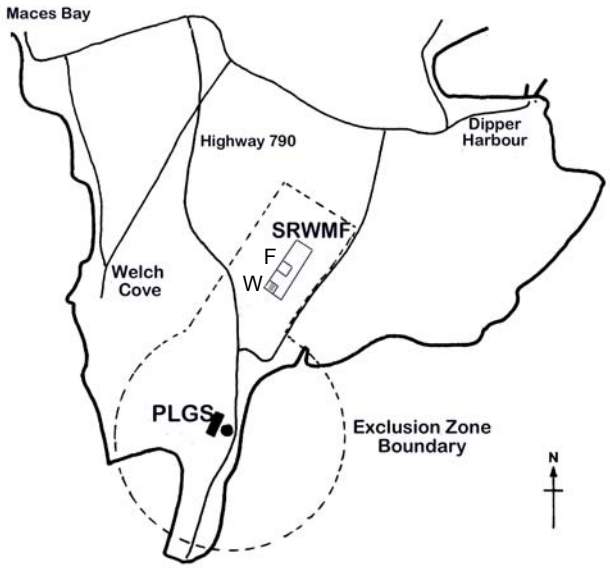


Fig. 11.1 Location of the SRWMF

The rectangular shape in Fig. 11.1 marked SRWMF shows the area reserved for present and future facilities. So far we've needed only one SRWMF, indicated with "W". The Dry Fuel Storage Site is at "F". Fig. 11.2 shows you an aerial view of both facilities.

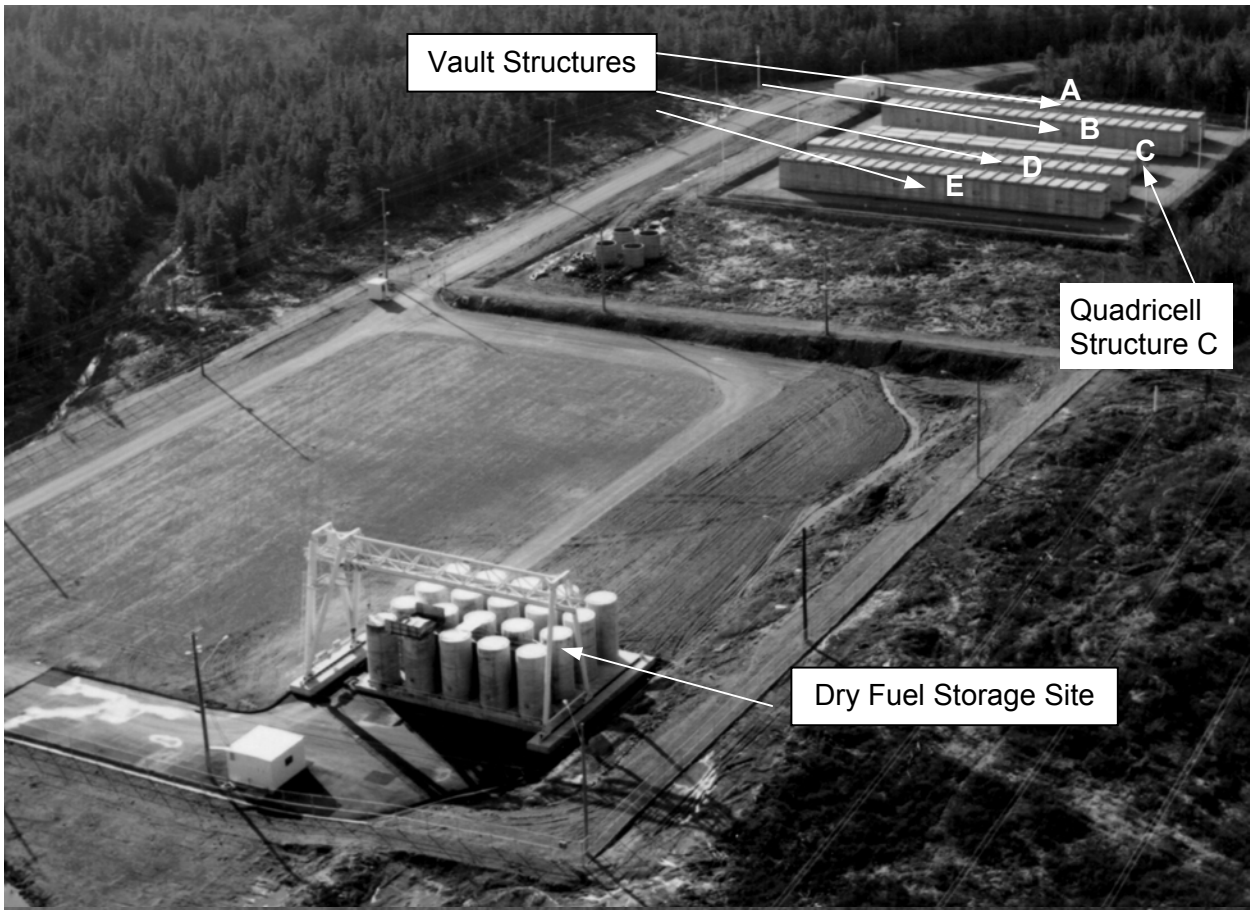


Fig. 11.2. Aerial View of the Dry Fuel Storage Site and the SRWMF

The initial development (W in Fig. 11.1) covers an area of about 80 m x 80 m with four vault structures and one quadricell structure.

Vault Structures

These are four rectangular above-ground concrete vaults. A, B, and D have four equal compartments, each of which is able to take about 140 m^3 of waste. (E has only about 2½ compartments available for low-level waste.) The covers and walls of the vaults can reduce a dose rate of 125 mSv/h inside the vault to less than 25 μSv/h outside it.

The vaults are used to store Type I and Type II waste. They can also accept Type III waste, if it is shielded first. (We did this with some flux detector sections.) Almost all of the waste stored in the vaults is expected to decay to "inactive levels" by the end of the 50-year design life of the structures.

In order to save space, any compactible waste is reduced to 20% of its original volume at the station. The compacted waste is stored in the vault in plastic-lined cardboard containers sealed in plastic bags.

Fig. 11.3. Vault Structure

Even so, out of the 14½ compartments available, we only had about 1½ left by the summer of 2000. So what to do? We could build more structures, but they are very expensive. It costs us about **$3000/m^3** to store waste there.

A better option is to:
1. retrieve most of the really low-level waste,
2. sort it into inactive and active waste,
3. send the inactive waste to a landfill dump, and
4. return the active waste to the vault structures.

This is what we plan to do and it should free up about half of the vault space, because there is a lot of waste in there now that isn't active at all. For example, less than half of 1% of all the waste in the vaults had contact fields of over 2 mGy/h when it was put there.

Filter Storage Structure

About 1½ compartments of vault structure A have been specifically modified to accept the storage of spent filter elements. The filters are transferred from the station in a shielded flask, and are then lowered into a vertical metal pipe/concrete matrix. Low activity filters that don't require the shielded flask are stored in the vault structures.

Quadricell Structures

There is one row of nine quadricells indicated by "C" in Fig. 11.2. Each quadricell has four identical square compartments with 0.7 m thick walls. Inside each compartment is a concrete cylinder with 0.25 m thick walls. The cylinders have concrete lids, and each cell has another lid (0.3 m thick) that covers the cylinder lid. It's a pretty rugged structure as shown on the right.

Fig. 11.4. Quadricell Structure

The wall thickness and lids will reduce gamma dose rates from 12 Sv/h inside the cylinder to below 25 μSv/h outside the quadricell structure.

The quadricells are intended to store high-level wastes such as PHT resins, moderator resins and highly activated reactor components. At present (spring 2001), they are still empty.

If and when we do store resins in there, we'll do this with shielded flasks. I don't intend to go into this here, especially since we haven't even done it yet, but Fig. 11.5 will give you some general clues as to how we might go about it. It also shows you the internal structure of the quadricells.

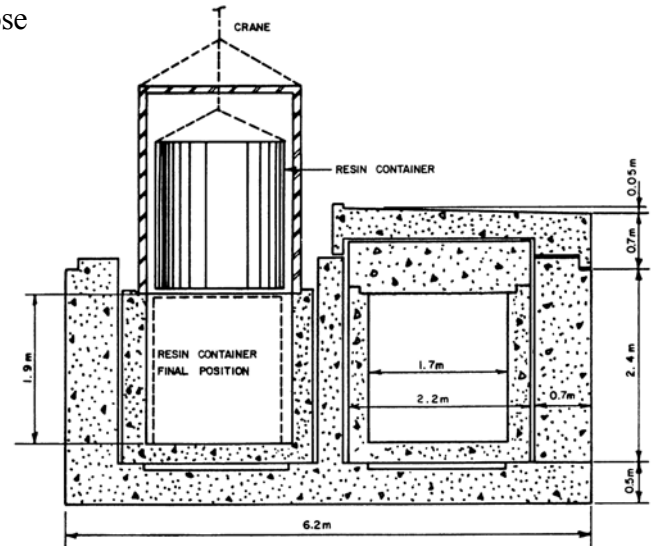


Fig. 11.5. Spent Resin Handling

Dry Fuel Storage Site

This is called by various names. Its official name is SRWMF Phase II, but most people just call it the Canister Site. The canisters are made of concrete and we build them on site. The picture below is a more recent view than Fig. 11.2. We fill up about ten canisters a year. The first ten were installed in 1991. Fig. 11.7 gives you some details of the canister construction.

Fig. 11.6. Canister Site

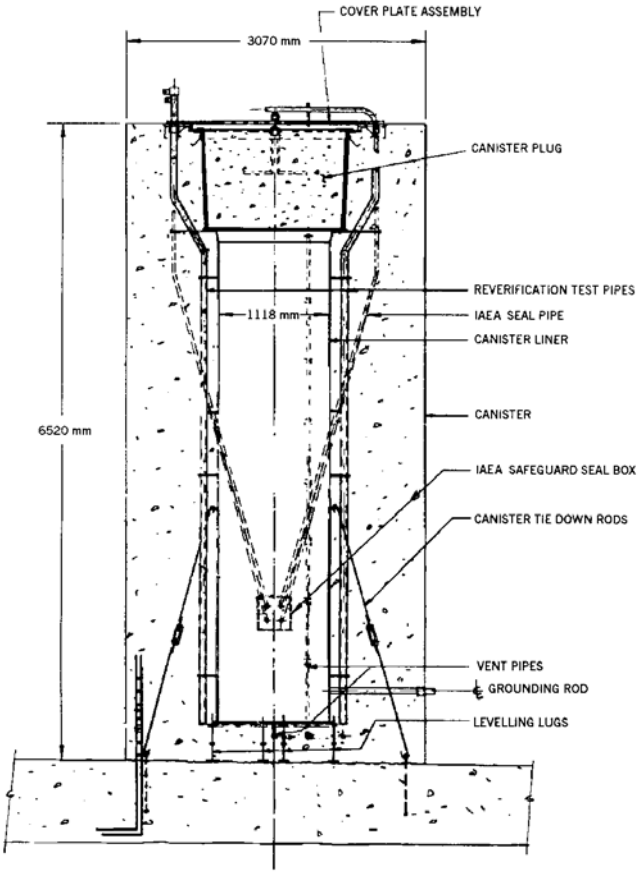


Fig. 11.7. Dry Storage Canister.

Licensing Issues

The SRWMF sites have their own licence distinct from the Operating Licence for the station. They also have their own OP&P (*Operating Policies & Principles*). A licence violation at the SRWMF counts as a black mark against our operations in the same way as a license violation in the station does.

Waste Handling in the Station

At present (i.e., summer of 2001), all waste from Zone 3 is considered as active waste, even if it isn't. The advantage of doing this is that we will never risk sending even slightly active waste to a landfill site. The disadvantage is that it is very expensive at \$3000/m^3. As the vaults fill up, the disadvantage is becoming dominant. We plan to segregate Zone 3 waste into active and inactive wastes by providing "Active" and "Clean" waste bins to feed a two-stage monitoring process:

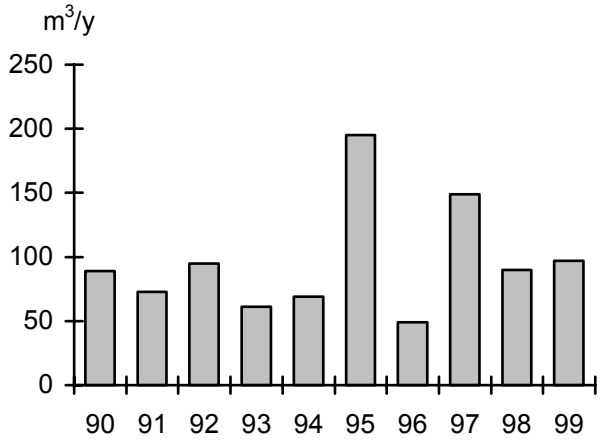


Fig. 11.8. Waste Volumes sent to the SRWMF

1. First monitor the waste in the Waste Bag Monitor in the Crane Hall. If it is cleared as clean, send it to the Waste Handling Building.
2. Monitor the waste again with a newer, more sensitive Waste Bag Monitor, and check for tritium contamination. If it passes as clean, it is put in a Dumpster to be picked up by a contractor who dumps it in a local landfill site. If it is active, it goes to the SRWMF.

We expect that 60% or more of the Zone 3 waste will turn out to be inactive.

Fig. 11.9 shows the Bag Monitor in the Crane Hall being modelled by Quinton Saunders. The waste bag is put in the shielded cavity on the left, and then the shielding door is closed and the count begins.

Fig. 11.9. Bag Monitor

Zone 2 waste goes through exactly the same process as is planned for Zone 3 waste. Zone 1 waste goes into the dumpster directly without any monitoring. Now you'll

appreciate how important it is that you monitor carefully any items you are taking into Zone 1, and that you follow the rules on Release Permits described in Chapter 9.

All radwaste is sent to the Waste Handling Room S-129 (shown in Fig. 9.34 on page 322.) This applies to both wet waste and dry waste. We have two compactors there for reducing the volumes of compactible dry wastes. In general, we can reduce their volumes by about 80%. The waste is compacted into cardboard boxes, which are then sealed in plastic wrapping. The boxes are stored in the Waste Storage Room S-141 on the opposite side of the Crane Hall until they are shipped to the vaults in the SRWMF. We also have a shredder to reduce the volumes of light metals, wood, and plastics.

When you bring radwaste to the Waste Handling Room — properly contained in the right plastic bags — make sure that you fill out the Radwaste Log kept there so that Tony Harris (or whoever is the Waste King then) knows what he's getting into. This is important.

Fig. 11.10. Waste Compactors

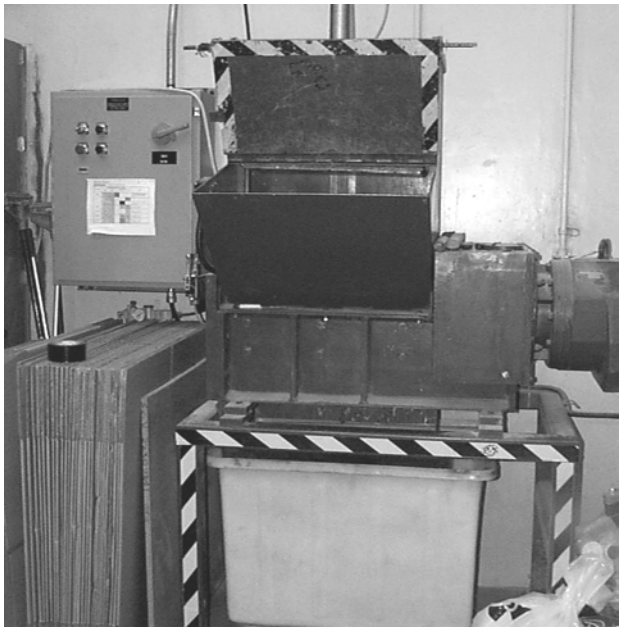


Fig. 11.11. Waste Shredder

What can you do to help in Waste Management?

We've already mentioned that it cost \$3000/m^3 to dispose of radwaste in the SRWMF vaults. You can help to hold down these costs by following some basic principles.

Don't Create Unnecessary Radwaste

In work planning, look for ways to avoid creating radwaste. For example, remove the packaging of replacement components before you bring them into the field, so that this clean waste doesn't end up as active waste. Cotton gloves are washed and reused, rubber gloves are not. Browns are reused, Dispos are not.

Separate Inactive Waste from Active Waste

We want to keep inactive waste away from active waste. Here are some ways of doing this:

- Remove the contaminated part of an item (e.g., a contaminated chair seat) so that the rest can be sent to inactive waste.
- Label tritiated waste and keep it away from inactive waste.
- Keep inactive oil and solvents separate from contaminated, because the inactive stuff can be burned or recycled at much less cost.
- If equipment, piping, walls are to be removed, make sure that the material is monitored and segregated as active versus inactive.
- Before starting any new project that may create a lot of waste, call the lads in the Waste Management group so that some smart thinking can go into waste reduction (no, I'm not implying that you aren't smart.)

Don't Mix Wastes

If you mix waste, all of it has the worst properties of each type. For example, if you mix tritiated waste with inactive waste, *all* of it has to be handled as tritiated waste. The same principle applies when PCB-contaminated oils are mixed with clean oil. Containers must be clean too. Clean resin put into contaminated drums must be handled as radioactive. Don't put inactive waste into plastic bags marked "Radioactive Waste" because you've run out of "clean" bags.

Radiation Monitoring

Once we've got the radwaste in the SRWMF, we want to be sure that it stays there. So radiation monitoring is done to check:

a) the structures (to check if water has entered — it isn't supposed to),
b) surface run-off (rain or snow that finds its way to a drainage trench surrounding the SRWMF),
c) ground water (there are sampling holes to check activity in ground water),
d) the atmosphere (continuous air samples for tritium, particulates and radioiodines),
e) the boundary (TLDs will measure quarterly gamma radiation doses at the fence).

DERIVED EMISSION LIMITS

All solid radwastes are stored on site in the SRWMF. It is impractical to store liquid and gaseous wastes, so we release them to the environment. As you can imagine, this can't be done in any way that suits us at the time —
— our releases of radioactive liquids and gases have to be carefully monitored and controlled. We want to be sure that no member of the general public reaches the annual dose limit (or even gets close).

The dose limit for the general public is 1 mSv/y to the whole body (see page 117). The limit applies to the **Critical Group.** This is that group of people whose age, habits, and diet cause them to be more exposed than the rest of the population. You'll see a couple of examples later on.
Why not just measure the radiation in the environment (air, water, food, etc.) and calculate what dose the Critical Group will receive in a year? There are two problems with this:

First, by the time radiation emissions from the station have reached the environment, it's too late to control them. Second, the environmental levels are so low during normal plant operations that we usually can't detect them. It makes much more sense to measure emissions at the source where they'll be more concentrated and where we can detect them.

When we measure emissions at the source (the stack and the liquid waste tanks), we need to know what's OK and what isn't. The limits are known as **Derived Emission Limits (DELs).**

The DELs are derived by considering the pathways by which emissions of radioactive liquids and gases reach man, and then calculating emission limits that would correspond to the dose limits for the Critical Groups. The DELs are calculated by Health Physics following guidelines set by the Canadian Standards Association, and then reviewed and approved by the CNSC.

DELs for Airborne Emissions

Radiation releases to the atmosphere will expose the public via three major routes:

1. External radiation exposure from the plume and from fall-out.
2. Internal exposure through inhalation (and in the case of tritiated water vapour, by absorption through the skin as well).
3. Exposure through the food chain.

These exposure pathways are shown at right. There are others (two obvious ones are shown by the dotted arrows), but for Point Lepreau their contributions are minor when compared with the three indicated by the solid arrows. We calculated the DELs that would cause the annual dose limits to be reached by the Critical Group. The DELs were calculated for noble gases, tritium, iodine-131 and various particulates.

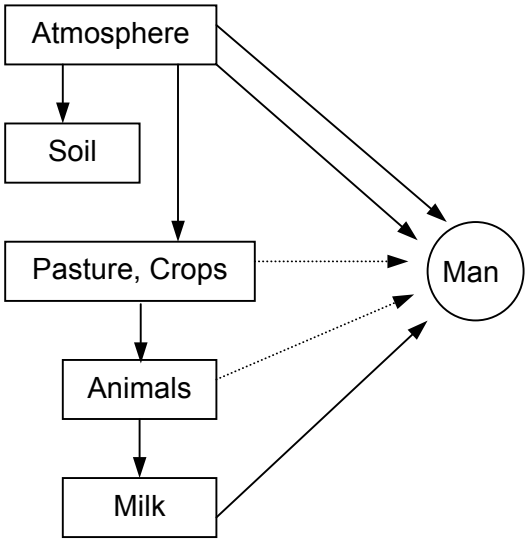


Fig. 11.12. Airborne Exposure Pathways for Man

People living at the boundary of the **Exclusion Zone** are the Critical Group for the external and inhalation pathways. The exclusion zone boundary is at least 1 km from the station and defines an area in which no one is allowed to establish permanent residence. The zone boundary is shown in Fig. 11.1.

For some radioisotopes, the pasture-cow-milk-infant pathway is the most important (infants drink the most milk and have the smallest thyroids). The cow is assumed to graze on the closest conceivable pasture-land ½ km outside the exclusion zone boundary. As I'm writing this, there are no cows there; but if any ever show up we're covered. More details on DELs are given in the Techie box.

The DELs are derived by calculating the continuous emission rate from the stack (in Bq/week) that will cause the Critical Group to be exposed at the annual limit. This is done for all the radioisotopes considered. Table 11.2 gives the results of these calculations for PLGS.

TABLE 11.2. ATMOSPHERIC DELs FOR PLGS

Radionuclide	*DEL (Bq/week)*
Tritium	8.2E15
Noble Gases	1.4E15
I-131	4.3E11
Unidentified Particulates	1.0E11

In theory, emissions of any radioisotope at the rate of its DEL (e.g., 8.2E15 Bq of tritium every week) would expose the Critical Group at their annual limit. In fact, this is unlikely to be so, because when we weren't sure of the data and had to make assumptions, we were careful to be cautious so that the DELs would be on the low side rather than the other way round.

For multiple emissions, the fractional DELs are added and if they don't exceed 1, we are sure that we haven't exceeded any public limits. For example, if we release 8.2E14Bq of tritium and 2.8E14 Bq-MeV of noble gases this week, it represents 10% of the tritium DEL and 20% of the noble gas DEL to give a total release of 30% DEL. Some comments:

Tritium:

The direct pathway (inhalation and absorption through skin) is the most important.

Noble Gases:

Direct exposure from the plume overhead is the only pathway that applies. The units are Bq-MeV/week and not Bq/week, because for this pathway the product of the activity in the plume and the gamma photon energy is the important quantity. The software used by the noble gas spectrometer in the gaseous effluent monitor does this for us automatically.

Iodine-131 and Unidentified Particulates:

The DELs for these are a lot smaller. This is because iodine attaches itself to particulates, which tend to settle out on the ground and therefore are around for a long time compared to tritium and noble gases, which are carried away by the wind. The pasture-cow-milk-infant pathway then becomes the most restrictive one for iodine-131. The most restrictive particulate is Cs-137, and its value is given in Table 11.2 for the unidentified particulates.

The DEL is a **legal** requirement that we must meet. In practice, routine emissions are much smaller than this. Emissions at the DEL level would mean that we have a very serious problem with one or more of the station systems. For each of the liquid and gaseous effluent pathways, **we have a target of no more than 5% of the legal limits**, and we have no problems in meeting this target. For example, tritium emissions at the level of 5% DEL would imply that members of the Critical Group

would get a tritium dose of 5% x 1 mSv/y = 50 μSv/y if all the assumptions that went into the calculations are correct.

DELs for Liquid Emissions

The principles are the same as for gaseous emissions, but the Critical Groups and the pathways are quite different.

At Point Lepreau we have only two important pathways:

a) internal exposure resulting from eating contaminated seafood,

b) external exposure from gamma radiation emitted by contaminated shoreline sediments and seaweeds.

All other Canadian reactors are fresh water cooled and therefore have a third pathway, namely releases to drinking water. For them, this is by far the most important —
— we've chosen to ignore it at Point Lepreau, because we don't know of anyone who drinks seawater.
We looked at all the important radionuclides likely to be released in liquid form to seawater, and calculated DELs for all of them.

The Critical Group are the clam diggers and dulse gatherers, who are assumed to eat their share of locally harvested seafood as well.

It turns out that marine life tends to concentrate radionuclides: this means that the activity of Cs-137 in 1 kg of fish, for example, will be higher than in 1 kg of the seawater in which the fish lives. Clams appear to be particularly retentive of all kinds of nuclides, with concentration factors of up to several thousand being common.

We estimated how much seafood each member of the Critical Group eats in a year by using survey data collected by the Emergency Measures Organisation. We came up with the average consumption given at the right. Demographic survey results were also used to determine how much time was spent digging clams and collecting dulse. Other factors that are considered include:

Fresh fish	30 kg/y
Lobsters	10 kg/y
Clams	10 kg/y
Dulse	3 kg/y

(a) CCW discharge flow (about 23 m^3/s),
(b) dilution factor caused by tidal flows (20:1),
(c) dose conversion factors (μSv of committed dose per Bq ingested),
(d) concentration of radioisotopes in sediment (external field).

All of the above data, taken from surveys, scientific studies and the CSA guidelines, were cobbled together to calculate a DEL for each radioisotope that could expose our seafood-eating clammers and dulsers.

Based on the analyses described above, Zn-65 is the most restrictive radionuclide. If you are interested, the DELs for all the radioisotopes we considered are listed in the Radiation Protection Directives.

ADDING LIQUID AND AIRBORNE EMISSIONS

You will appreciate that if we release 50% of the liquid DEL and 75% of the airborne DEL, we could well be breaking the law if all those clam digging, dulse gathering seafood eaters also spent 24 hours a day at the exclusion area boundary. You and I know they can't do that, but to save ourselves a lot of grief we can say that if the sum of the fractional liquid and airborne releases doesn't exceed 1, we certainly won't have violated any federal regulations. The target of 5% doesn't apply to the total release, but to each effluent pathway, i.e., gas and liquid emissions.

So how have we been doing?

Table 11.3 shows the total releases for both gaseous and liquid effluents from 1992 to 1999. Pretty impressive performance. You can see that we can easily meet our target of 5% DEL.

The DEL values given in the table are weekly averages for the gaseous releases and monthly averages for the liquid releases. Please note that all the DEL values listed here are based on a 1 mSv/y public dose limit, and not the 5 mSv/y limit that applied before 1996.

The corresponding annual doses that would have been received by a member of the Critical Group are also shown. Even our record high of 2.5 μSv in 1993 is not a big deal. Especially, when you recall from Fig. 3.2 on page 78 that the levels in natural background radiation from places around PLGS that are only a few km apart can differ by more than 50 times that.

You can see the results of our waste management program in Table 11.3, but we haven't yet looked at the systems for controlling, dispensing, and monitoring the emissions. We'll do that next, starting with liquid waste.

TABLE 11.3. 1992 – 1999 EMISSION DATA

Year	*Gaseous Emissions*		*Liquid Emissions*		*Total*
	% DEL	μSv/y	% DEL	μSv/y	μSv/y
92	0.18	1.8	0.008	0.08	1.9
93	0.23	2.3	0.017	0.17	2.5
94	0.19	1.9	0.032	0.32	2.2
95	0.13	1.3	0.014	0.14	1.4
96	0.07	0.7	0.018	0.18	0.9
97	0.01	0.6	0.010	0.10	0.7
98	0.05	0.5	0.006	0.06	0.6
99	0.04	0.4	0.008	0.08	0.5

THE LIQUID WASTE MANAGEMENT SYSTEM

Its purpose is to collect, store, sample, and disperse any liquid radwaste produced in the station, while remaining within the target of 5% DEL.

Sources

Liquid radwastes are classified as either **Low Activity Wastes** or **Normal Activity Wastes**, depending on their origin in the station.

Low activity wastes originate mainly from showers, washroom sinks and Zone 2 floor drains. Normal activity wastes come from Reactor Building floor drains, D_2O area drains, the Upgrader, the laundries, the Spent Fuel Bays, the Decontamination Centre and the Spent Resin Handling System. They also include some of the lab wastes and some of the Zone 3 Service Building floor drains.

Storage

There are five storage tanks each of about 50 m^3 capacity; two are for normal activity waste and three are for low activity waste. These tanks are constructed of 0.3 m-thick reinforced concrete with an inner epoxy liner. The low activity wastes are automatically routed to whichever of the three low activity tanks is in service. Similarly, the normal activity wastes are collected in one of the two normal activity waste tanks. Typically, we collect about one or two tanks of liquid waste per day. A tank is taken out of service when it is about 70% full, and another tank is valved in.

Sampling

Facilities are provided in the system for recirculating the contents of any tank. This is done to achieve good mixing, so that a sample drawn off after about an hour or so will be fairly representative of what is in the tank. This grab sample is analysed for gamma and tritium activity by our friends in the Chemistry Lab.

Dispersal

The results of the grab sample will tell the Shift Supervisor (who has to authorise all liquid radwaste discharges) if it is permissible to pump the contents of the tank to the condenser cooling water duct. From there it goes to the sea.

If the sample of the tank contents has indicated an activity higher than allowable, we can treat the contents by using the filters and ion exchangers of the Spent Fuel Bay Purification System. In this procedure, the Spent Fuel Bay circuit must be valved out and the purification system is valved in to the liquid radwaste system. The tank contents are then filtered and sent to another empty tank. We expect this to be a very rare event. In fact, we've never done it yet.

Liquid Effluent Monitoring

The monitoring program has two objectives:

1. **Control —**
   — we want to prevent an unexpected release of large amounts of activity as a result of procedural or process failures. The control objective is met by analysing grab samples prior to discharge of the waste. An on-line Liquid Effluent Monitor (LEM) serves as a back-up in the event of a procedural or process failure. It also satisfies the compliance objective as described below.

2. **Compliance —**
   — we want to know exactly what was discharged from the station to demonstrate that we are complying with the DELs.

The LEM

The LEM is used both for control and compliance. Fig. 11.13 shows the LEM in the Service Building Basement. Fig. 11.14 is a schematic diagram that helps you understand how it works. The LEM samples the liquid radwaste as it is being discharged by pumping it into a disposable plastic 4 L beaker. The sample flow is constant and set at such a rate that the pump-out of one full tank (50 m^3) will deliver a total sample of about 3 L. A sodium iodide (NaI) scintillation counter views the contents of the beaker and feeds a ratemeter that has an adjustable alarm set-point.

If the alarm set-point is not reached, the sample pump stops automatically when the tank pump-out is completed. The beaker is then removed, labelled and taken to the Health Physics Lab for detailed analysis by Ge(Li) spectrometry. This gives us the information on all of the gamma-emitting nuclides. We only need to do a tritium analysis to have a complete record of what was released.

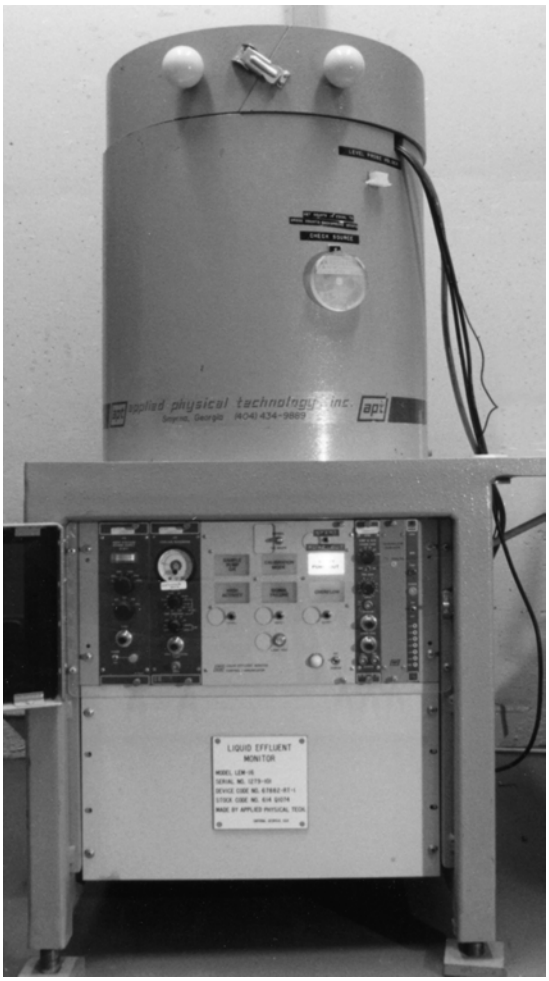


Fig. 11.13. LEM in Room S-106

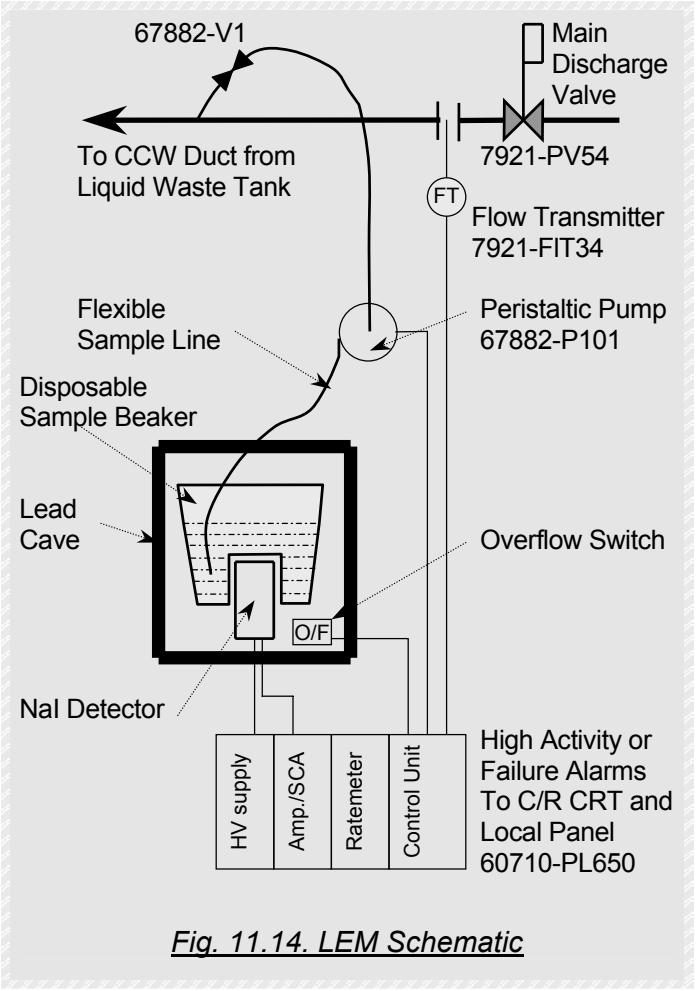


Fig. 11.14. LEM Schematic

This certainly meets the compliance objective. What about the control objective? For example, it is possible that the grab sample results on which the Shift Supervisor bases his decision to pump out a tank are wrong. Or the wrong tank may be pumped out by mistake (surely not!).
The purpose of the NaI detector in the LEM is to catch this. The alarm point is set on the assumption that every gamma photon registered by the NaI detector was emitted by our most restrictive radionuclide. There is enough sensitivity to bring in the alarm and automatically stop the pump-out. When you bear in mind that the LEM thinks everything it sees is the most restrictive radionuclide (Zn-65) and not the much less restrictive typical mixture of lots of different radionuclides, you will appreciate that we should have very good control of liquid discharges.

Of course, the LEM cannot detect tritium, because tritium doesn't emit any gamma photons. No provisions are made for tritium control, rather than compliance, because the DEL for tritium is so large (1.3E18 Bq/month), that we could dump the entire moderator water to the ocean and still not exceed the monthly limit. No kidding. This rather astonishing conclusion is due to the fact that no one drinks seawater, and that tritium does not concentrate in any marine life to a level beyond that present in the seawater.

The advantage that the LEM has over the grab sample is that if the contents of the tank are not well mixed before the pump-out, the LEM will still collect a representative sample. Also, if the wrong tank is pumped out by mistake, the LEM will still save us. It is for these reasons that the LEM sample (analysed by Health Physics) is used for compliance data, and not the grab sample (analysed by Chemistry). The Operations group is responsible for operating the liquid radwaste system.

The design of our LEM is quite different from that of liquid effluent monitors at other stations. Most of them are plagued by contamination build-up leading to lower and lower sensitivity, until everything has to be dismantled and decontaminated. We don't have this problem, because a new beaker is used for each pump out.

Still, one problem we do have is that if the LEM is unavailable, we need permission from the CNSC to pump out a waste tank. We don't have the capacity to store large volumes of water while we wait for permission to pump out. So Gerry Black and Miro Lieskovski (the Blank Cheque) are now (summer 2001) installing a redundant monitor on the discharge pipe. It has a NaI detector that looks at gamma activity flowing in the discharge pipe. The alarm logic of this monitor (called the Liquid Effluent Pipe Monitor, or LEPM) is hooked into the alarm logic of the LEM. Doing this saves us some money.

A high activity alarm or equipment failure alarm from either the LEM or the LEPM will abort the pump-out by closing the discharge valve 7921-PV54 shown in Fig. 11.14.

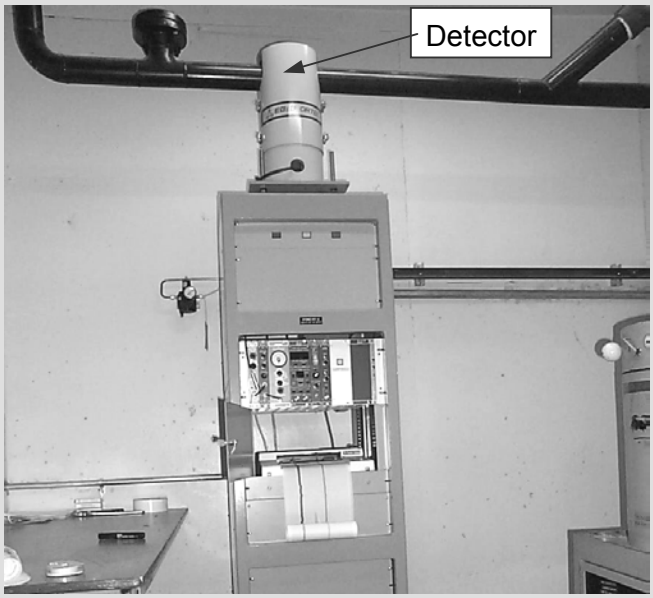


Fig. 11.15. LEPM

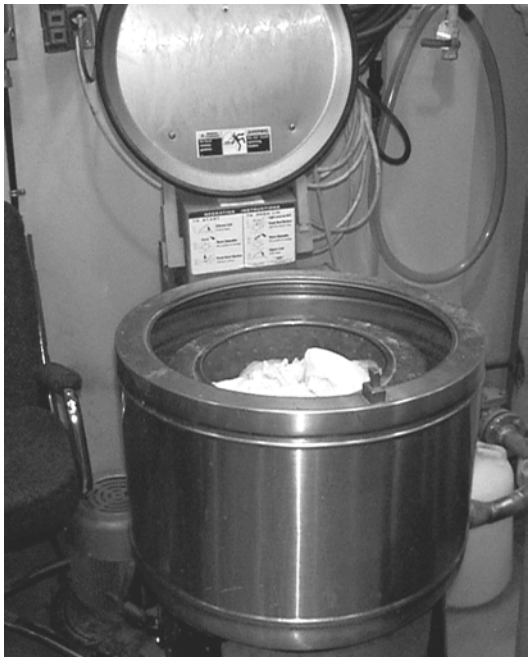
What can you do to help?

Resin Handling

Be careful in decontamination or cleanup involving active resin. Don't dispose of active resin beads down floor drains or active sinks. The activity on these beads is not diluted in the CCW duct, hence, it is a potential environmental hazard. These beads should be placed in carboys or drums and reported to the Waste Management group for ultimate disposal.

Inactive Sumps

Several sumps in the Service Building and in the Turbine Building discharge directly to the environment and are not sampled by the Liquid Effluent Monitor (e.g., Oily Sump 9 in the T/B). You mustn't dump water containing any detectable activity in such sumps, because the radioactive release would not be monitored. These sumps are identified as INACTIVE SUMPS by Lamacoid signs. Inactive sumps are pumped out to the on-site lagoons, which are sampled monthly for radioactivity.



Miscellaneous Liquid Wastes

Other liquid wastes may include such things as used oil in drums, or sump liquids that are to be removed by a commercial contractor. It is essential that these liquids be sampled and analysed for tritium and gamma radiation before release. Take all liquid wastes

in sealed buckets to the Waste Handling Room, and fill out the log kept there to tell the lads what they are dealing with.

We have a centrifuge for drying wet wastes like mops, rags, etc. First this waste is flushed with water until no residual tritium can be detected when sniffing it with a Scintrex. It is then centrifuged to spin out most of the moisture. After that it is hung in a fume hood to dry.

Fig. 11.16. Centrifuge for Drying Wastes

GASEOUS WASTE MANAGEMENT

Gaseous effluents are released to the environment via the stack. Gaseous effluents, however, are released continuously, whereas liquid effluents are released on a batch basis after the results of a grab sample indicate that it is OK to do so. We obviously can't run a proper ventilation system in this way. We'll outline below how the exhausts from the station ventilation systems are controlled and filtered, and in more detail, how the exhausts are monitored.

Station ventilation systems are normally designed (and ours is no different) so that air from all areas that could become contaminated is passed through filters and then up a stack to be dispersed in the environment. The arrangement for Point Lepreau is shown schematically in Figure 11.17. There are three main sources of potentially contaminated air:

1. the exhaust from potentially contaminated areas of the Service Building (known as the "Central Contaminated Exhaust"),
2. the exhaust from the Spent Fuel Bays,
3. and the exhaust from the Reactor Building.

Let's briefly run through them one at a time.

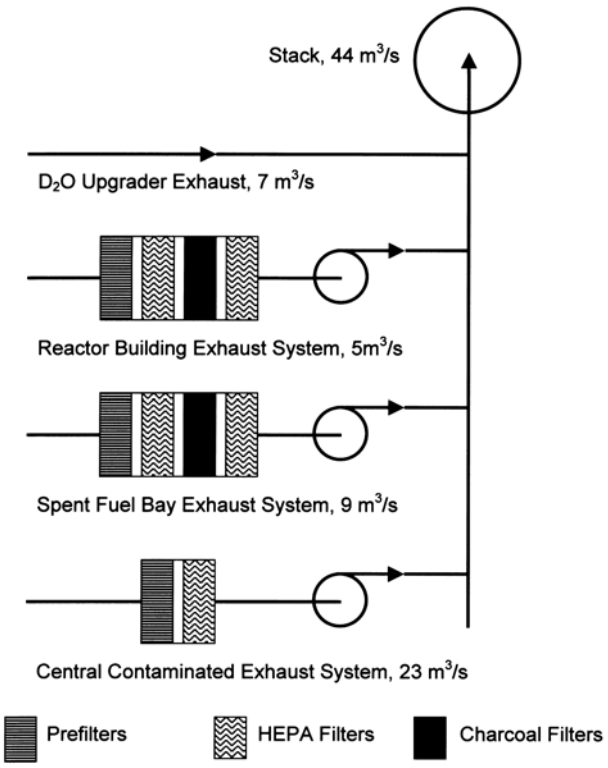


Fig. 11.17. Contaminated Exhaust Systems

Central Contaminated Exhaust

This system takes air from all Zone 3 areas of the Service Building, except for the Spent Fuel Bays. Via a common duct, the air is drawn through a filter bank consisting of a prefilter (to take out all the crap that flies around in the atmosphere, e.g., seagulls, golf balls, paper aeroplanes, etc.) and a High Efficiency Particulate Air (HEPA) filter. HEPA filters will remove 99.97% of all particles having a diameter of 0.3 microns or more. This is an impressive performance compared with your home furnace filter, which does well to trap 40% of such particles. There is no charcoal filter for removing radioiodine, because there won't be any in the rooms served by this system. An exhaust fan downstream of the filters sends the filtered air to the stack.

Spent Fuel Bay Exhaust

The ventilation exhaust from the Spent Fuel Bays also passes through its own filter bank. This consists of a prefilter, a HEPA filter, an activated charcoal filter and finally another HEPA filter. The charcoal filter should have better than 99% efficiency for all forms of radioiodine, and the purpose of the final HEPA filter is to trap any charcoal dust that might be released from the charcoal filter.

Reactor Building Exhaust

The Reactor Building exhaust runs through a third filter bank having the same components as the SFB exhaust system. In addition, the R/B exhaust is equipped with two isolating dampers in series, which will close automatically on high R/B pressure (increases of a few percent) or increased activity in the R/B exhaust duct. All the dryers serving D_2O areas in the R/B are located in the Service Building, which means that air is passed from the R/B to the S/B and back again. These ducts are automatically sealed on high R/B pressure or activity.
All three filter banks have bypass ducts, which can be put into service when maintenance on the filters is required. A fourth source of contaminated air is the exhaust from the D_2O Upgrader area. This is also fed to the stack.

Not shown in Figure 11.17 is the Non-Contaminated Exhaust System. This draws air from rooms that we expect never to become contaminated, like washrooms (we are talking about radioactive contamination here), and exhausts it to the atmosphere through fans mounted on the roof of the Service Building.

The four potentially contaminated exhausts are discharged to the atmosphere via the stack, which is 2.3 m in diameter and about 60 m high. Such a stack results in much better atmospheric dispersal than exhausting the air at roof level.

Gaseous Effluent Monitoring

We monitor the radioactivity content of the stack exhaust continuously. Our stack monitor is called the GEM (for Gaseous Effluent Monitor), although of course we are not monitoring gases only, but also vapours (radioiodine and tritium) and particulates. Stack monitoring should meet the compliance and control objectives, just as for liquid releases:

1. **Control —** We should monitor continuously the emission rate of each type of activity. There are two reasons for this: one is that changing release rates alert us to changing conditions in the station, and the other is that if the release rates become very high, we will want to take action to contain the source.

2. **Compliance —** We need a measurement of the total amount of each type of activity emitted, so that we know where we stand with respect to our weekly limits, the DELs.

Problems Encountered with Gaseous Effluent Monitoring

The gaseous emission pathway is more difficult to monitor than the liquid pathway. There are a couple of reasons for this:

1. **Volume —** a typical liquid pump-out is 30 m^3, whereas 3.8E6 m^3 of air exits the stack each day. Nuclides such as particulates and radioiodines must be concentrated on filters for counting, if we want to be able to see anything at all.

2. **Range of DELs —** in liquids, most of the DELs are within a factor of 10 or 100 from each other. (The exception is tritium, which is not controlled by the LEM.) In gaseous effluents, noble gases have an enormously high DEL, because they do not concentrate in people (nor much in ventilation filters either). A Gaseous Effluent Monitor has to distinguish a few Bq of I-131 or particulates from over thousands of Bq of noble gases, since these have similar impacts on the environment. Since this is difficult to do, these monitors end up being very complicated.

The Stack Monitoring System

There are several subsystems:

a) the Sampling System,

b) the Gaseous Effluent Monitor (GEM) consisting of:
   1) a particulate monitor,
   2) a radioiodine monitor,
   3) a low range noble gas monitor,
   4) a high range noble gas monitor,
   5) a tritium sampler,

c) the Noble Gas Spectrometer,

d) the C-14 Sampler.

You won't normally be involved with stack monitoring, but for the sake of completeness, I've included some of the details in the technical section that follows.

The Sampling System

Being reasonable people, we decided that it was easier to bring a sample of the stack flow to the monitor rather than to mount the monitor inside the stack.

It is important that the portion diverted is a representative sample. The air flow in the stack does not become uniform until it has travelled roughly ten stack diameters from the last bend or obstruction. Anywhere beyond that point we can get

a representative sample using a multi-nozzle probe.

Using a representative sample and remote monitors has several advantages. For example, since the sample is going to another location, we can choose the location. At Point Lepreau, we chose Room D1-334, the D_2O Upgrader Monitoring Room right outside the Control Equipment Room. Room D1-334 is air-conditioned and this should help to increase the reliability of the equipment. Also, since the monitors don't have to be supported inside the stack, we can easily add as much lead shielding as needed to lower background radiation to an acceptable level.

Fig. 11.18 shows a photograph of the GEM, and Fig. 11.19 shows you the stack-monitoring layout.

Fig. 11.18. The GEM

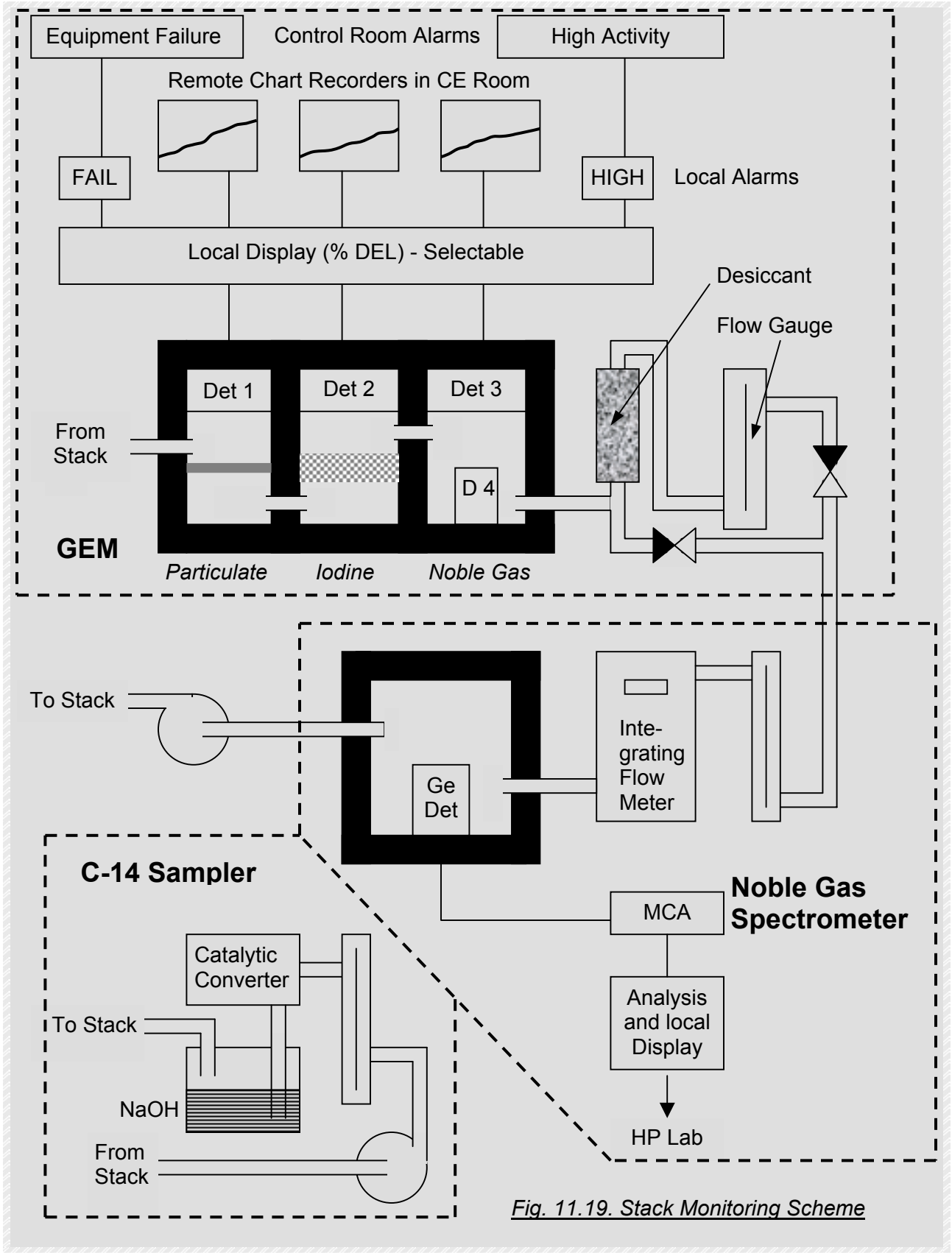


Fig. 11.19. Stack Monitoring Scheme

With the help of Fig. 11.19, we will look at the four GEM components, i.e. the particulate monitor, the iodine monitor, and the low and high range noble gas monitors.

The Particulate Monitor

The air first passes through a particulate filter where a beta scintillation detector (Det 1) measures the beta activity in the collected dust. The count rate of this instrument is directly proportional to the total activity that has passed up the stack. A local digital display indicates the activity collected on the filter paper, and a remote recorder in the Control Equipment Room traces out how the filter paper's activity changes with time.

This monitor can record release rates from less than 1 % DEL to several hundred % DEL based on the cautious assumption that all of the particulate activity is due to the most restrictive isotope. The filter is changed daily and sent to the Health Physics Lab for detailed analysis of the particulate activity that was actually released.

The Radioiodine Monitor

After the particulates have been removed, the sample stream is passed through an activated charcoal cartridge where the radioiodines are collected. A gamma scintillation detector (Det 2) detects and counts the 0.364 MeV gamma photons emitted by I-131. These are registered in one channel of a pulse height analyser. A second channel is used to accumulate the background count, and the instrument digitally displays the difference count, which is a measure of the accumulated I-131 activity.

Again, there is remote recording in the Control Equipment Room. The charcoal cartridge is also changed daily, and analysed in the Health Physics Lab.

The Noble Gas Monitor

The magnitude of a noble gas release (Bq-MeV) depends on the activity released (Bq) and the isotopic mixture (MeV). There are two ways of measuring this:

(a) Use a spectrometer to find out how much of each nuclide there is and calculate the answer, or

(b) Use a detector whose count rate is proportional to both activity and energy (that is, the efficiency increases linearly with gamma energy).

Of these, (a) is more sensitive and accurate while (b) is simpler and cheaper. The **low-range monitor** (Det 3 in Fig. 11.19) is a single NaI detector feeding a pulse height analyser. It tries to operate on principle (a), but doesn't work well for the following reasons:

- It uses a cheap, low-resolution detector and then tries to do fancy maths with the output.
- It is not sensitive enough to the nuclides that are really of interest such as Kr-88 and Ar-41.
- It can't look at enough nuclides.

In short, it is not sensitive enough, inaccurate, complex and expensive, i.e., neither (a) or (b). And those are its good points. We use it only for the alarm function.

The **high-range noble gas monitor** consists of a small Geiger tube (D4) that is designed to operate on principle (b). It can measure over 2000 times the daily limit, and will be needed only under severe accident conditions.

Unlike the particulate and the radioiodine monitors, the low and high range monitors both measure the *rate of release***,** rather than total release which is what we want. Therefore, the rate information is sent to a microprocessor in the GEM (Fig. 11.18), which converts it to integrated release and feeds it to a digital display indicating the total percentage of the limit that has been released. The scaler is reset to zero daily, when the particulate and charcoal filters are changed.

Alarms and Displays

The GEM contains a microprocessor to store and retrieve all the information generated by the detectors. However, regardless of what I said above, there is only *one* digital display. You have to rotate a thumb-wheel switch to ask the computer to display particulate, radioiodine or noble gas information.

Alarm set-points are set locally. If any alarm is exceeded, it will bring in a "High Stack Activity" alarm in the Control Room, as well as a local alarm indication on the GEM. In addition, the GEM is equipped with "Equipment Failure" alarms, which come in on loss of sample flow or detector failure.

The Tritium Sampler

A fraction of the stack sample flow is diverted through a desiccant that traps tritiated water vapour. This desiccant is changed daily, and analysed to determine the amount of tritium emitted. There are virtually no limits to its lower or upper limits of detection.

Noble Gas Spectrometer

Because the low-range noble gas detector in the GEM gives such poor information, we have developed a **Noble Gas Spectrometer**. (This was Jim O'Donnell's final masterpiece before he left us for Operations.) As the sample exits from the GEM it enters another shielded chamber to count low levels of noble gases. A germanium detector (similar to the Ge(Li) detectors mentioned on page 158) continuously counts the gas in this chamber over a 24 hour period to get a picture of the average activity in the chamber. The spectrum is then sent to the HP Lab to be analysed; there the lads determine the activity of each noble gas radionuclide. A dedicated computer controls the spectrometer and provides an on-line analysis.

The Noble Gas Spectrometer is used to measure noble gas releases during normal operation. It is not reliable (dead time losses) for high releases; for these, the high range Geiger tube (D4) of the GEM would be better. It displays the total release and the release rate for 3 groups of noble gases:

1. Ar-41; since this is an activation product, its production depends on a different set of factors than the other noble gases, which are fission products. Also, Ar-41 is the most important chronic noble gas release.
2. Kr-88, Xe-138; these are of interest because they produce radioactive particulate daughters (as discussed on page 252). High concentrations of these two nuclides indicate a potential for contamination in the Reactor Building.

3. Others; the spectrometer also looks at several other fission product noble gases such as Xe-133, Xe-135, Kr-87, etc. Since all this detail is of no interest to most sane people, these nuclides are added together for the display.

The three groups above are totalled for comparison with the 5% weekly operating target.

C-14 Sampler

C-14 is a pure beta emitter whose production from nitrogen in air was discussed on page 255. Its chemical form is usually as one of the gases $C^{14}O_2$ or $C^{14}H_4$. Since it is a gas, it will not be collected in the particulate filter of the GEM; and since it emits no gamma, the other detectors will not see it.

A separate sampling system for C-14 has been installed which collects $C^{14}O_2$ in a NaOH solution. This system includes a catalytic converter to change organic forms of C-14 to CO_2 so that it can be collected in the NaOH solution. I bet you had a spine-tingling need to know that. The NaOH solution is analysed in the HP Lab using liquid scintillation counting.

Short-Lived Daughters of Noble Gases

Kr-88 and Xe-138 produce short-lived particulate daughters. During a release, particulates and radioiodines are effectively removed from the effluent stream while noble gases continue on through. If Kr-88 and Xe-138 are present, some will decay and will be collected on the particulate filter causing the particulate monitor to alarm. It has no way of distinguishing these short-lived nuclides from the long-lived particulates for which it was calibrated. In such a case the filter can be taken to the Chemistry Lab for immediate spectrometric analysis.

ENVIRONMENTAL MONITORING

You will recall that we measure radiation emissions at the source rather than in the environment. If the emissions are small, they are normally too dispersed and diluted to be detectable in the environment. And if they are large, it is too late to control them. This is why we measure emissions at the source, and compare them with the DELs. But this is all theory. It is obviously important to find out what's actually happening out there. We have a fairly comprehensive environmental monitoring program, whose main objectives are to:

a) provide assurance to the CNSB and the public that the environmental impact of station operation is known and that it is within anticipated limits. Annual reports are sent to all interested parties,

b) provide a check, where possible, on the validity of the DEL calculations,

c) maintain a database of results to identify trends,

d) look into the fate of released radionuclides to see if any significant pathways to humans have been overlooked,

e) provide the capability for environmental monitoring in emergency conditions.

Environmental monitoring is used as a backup program to show compliance with the CNSC Regulations. Results of the program have also been invaluable at public hearings, because we were able to **prove** that the operation of the station has had a negligible effect on environmental radiation levels.

How? By starting a pre-operational environmental monitoring program as early as October 1976. We looked for all those radionuclides that could or would be released from the station once it started up. We did this on a continual basis, and the "before and after" results are indistinguishable (except for tritium).

Fig. 11.20 is an example. It shows the gross beta activity collected on environmental air sample filters at Dipper Harbour from January 1980 until December 1989. You can see that the levels before and after the station was put in service are the same. (These levels are very small: each vertical axis runs from 0 to 0.014 Bq/m^3).

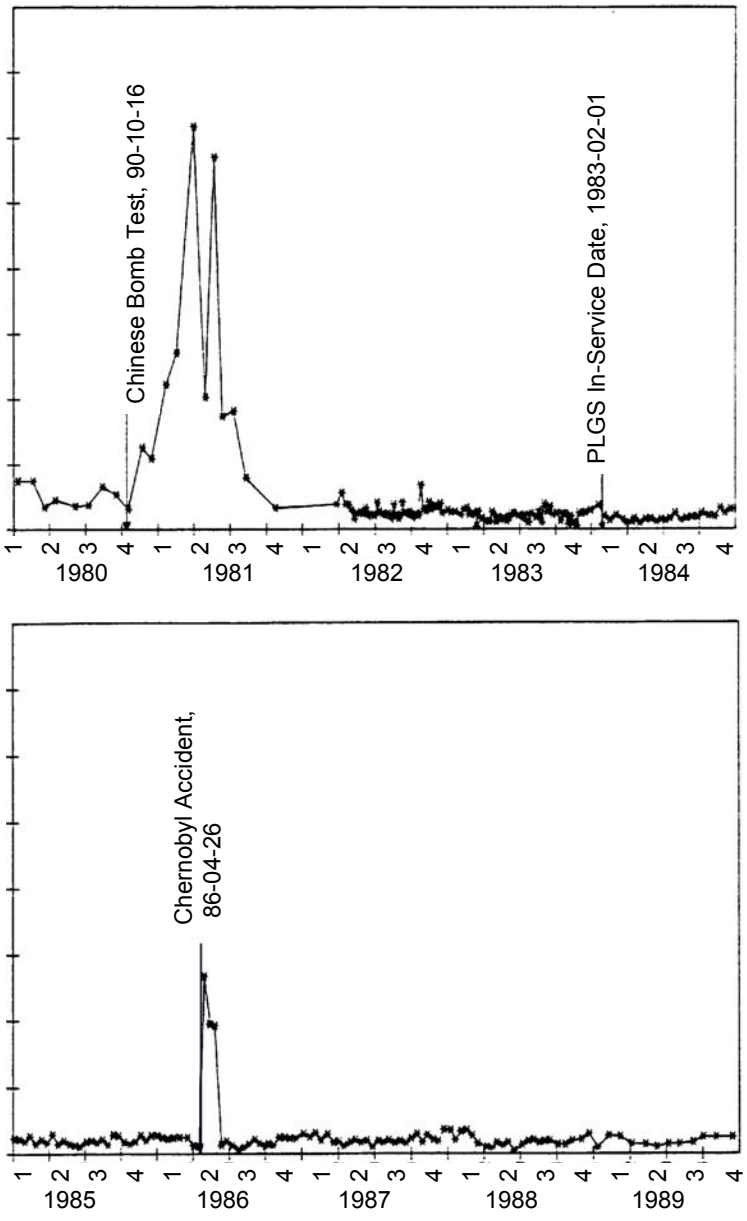


Fig. 11.20. Gross Beta Activity at Dipper Harbour

The big increase in the first half of 1981 is due to fallout of radioactive cerium, cesium, ruthenium, zirconium, and niobium from a Chinese bomb test in October 1980. You'll notice a smaller peak in 1986 as a result of the Chernobyl accident. Some Toronto citizens offered me real folding money for KI pills after Chernobyl. No such offers came my way after the Chinese bomb test, although the levels were more than twice as high, and lasted about a year instead of three months. That's the power of the Press…

The long-lived fission products in fallout and in Lepreau emissions are the same. That's why we include a Bocabec site (near St. Andrews) in our program. If environmental activity stems from fallout, we'll see it there too. If the activity originates from the station, we won't see anything at Bocabec. Frosty says that you never see anything happening at Bocabec.

The Operational Monitoring Program

By "operational", we mean the environmental program we've been running since the station became operational in 1983. It was based on the important pathways to man only, because the ICRP has said (in ICRP 26) that *if a man is adequately protected (from radiation) then other living things are also likely to be sufficiently protected*.

We mentioned the important pathways when discussing the DELs, but they are worth repeating:

1. external exposure from gaseous effluents,
2. thyroid exposure from inhalation of radioiodine vapour,
3. thyroid exposure from the consumption of milk contaminated with radioiodine,
4. internal exposure from the consumption of contaminated seafood,
5. external exposure from contaminated shoreline sediments.

Atmospheric and terrestrial radiation monitoring checks the first three pathways, and monitoring of seafood, seawater and the shoreline checks the other two.

Atmospheric Monitoring

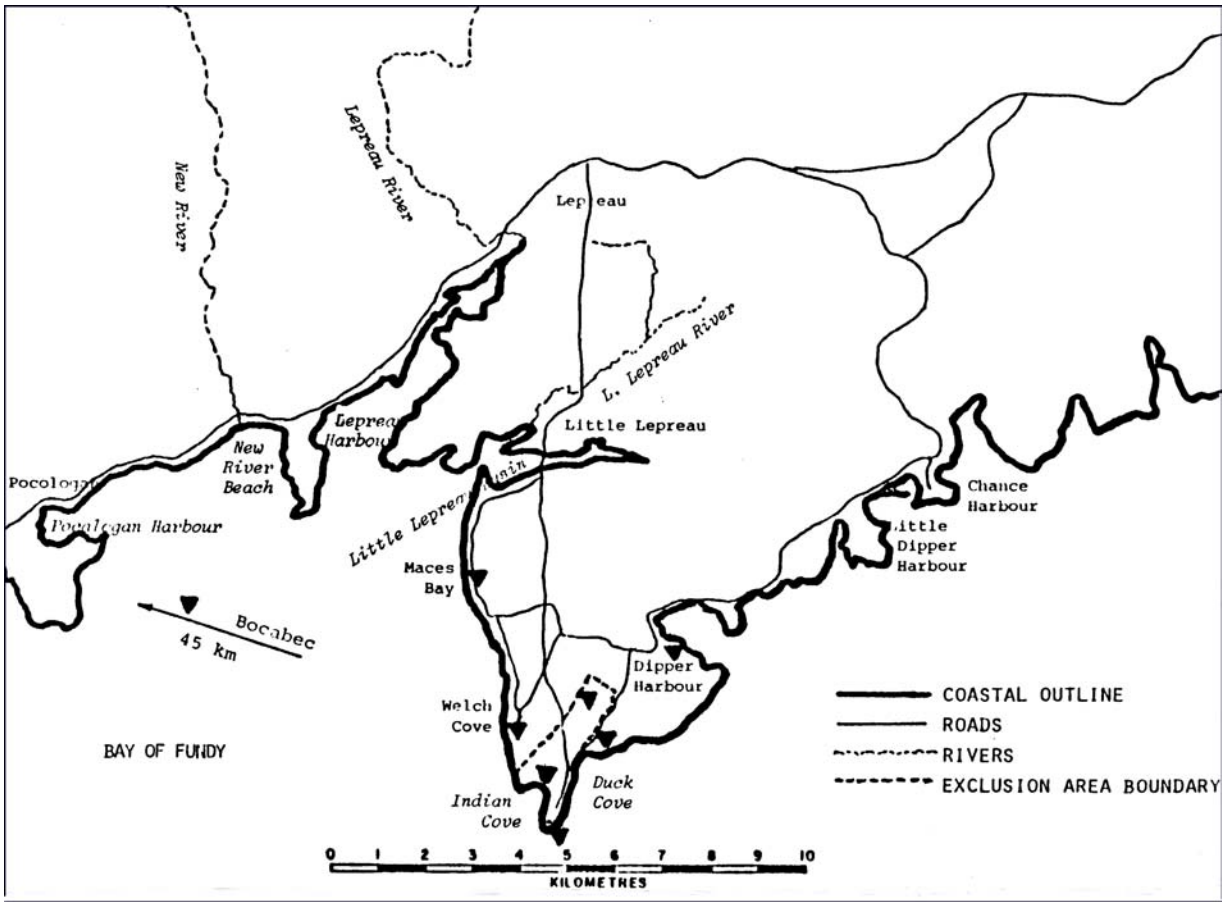


Fig. 11.21. Sites of Environmental Air Monitoring Stations

We have eight air monitoring stations (their locations are shown in Fig. 11.21), from which particulate, radioiodine and tritium samples are obtained on a continuous basis. Fig. 11.23 shows the sampling equipment. Seven of the stations are within the range of influence of Point Lepreau, and the eighth one is our reference station in Bocabec 45 km from the station. Each air monitoring station also has TLDs to measure the total gamma radiation dose at its location for each quarter year. In addition, there are almost another 80 sites for TLD measurements near the station.

Fig. 11.22. One of our Air Monitoring Stations

Terrestrial Monitoring

Monitoring milk produced near the station checks the pasture pathway. In 1979 we had access to a nearby cow (between Chance Harbour and Dipper Harbour), but it was eaten. So the best we can do now is to check milk from the commercial dairy herds nearest Point Lepreau. The DELs are very conservative, because they assume that cows living 1.5 km from the station produce all the milk. (*Conservative* has nothing to do with politics, it means *cautious, purposely low.*) Fresh water from the Lepreau area is also collected and analysed at regular intervals. We don't expect to see radionuclides from Point Lepreau G.S. in well water, because the only route is via atmospheric emissions settling on the ground and then reaching the underground streams.

Fig. 11.23. Air Sampling Equipment

Ocean Monitoring

Every quarter year, samples of seawater are collected and analysed. At the same time, shoreline sediments are collected from about ten locations within 30 km of Point Lepreau G.S., because significant emissions of radionuclides to seawater should be traceable by analysing these sediments. Gamma dose rate measurements with a very sensitive survey meter are also made.

Dulse, an edible seaweed (tried it?), is harvested from the Lepreau area. It is collected twice a year and compared with "reference dulse" from Grand Manan.

Commercially important seafood (lobster, clams, various types of fish, scallops, crabs, and periwinkles) are collected quarterly and analysed for radioactivity content.

SRWMF Monitoring

The SRWMF has its own environmental radiation monitoring program as mentioned on page 358. Station staff do gamma surveys, and collect water samples from the structures and their under-drainage. Such samples are sent to the Environmental Monitoring Lab in Fredericton for analysis. Other water samples are taken from bore holes (ground water), from surface rainwater run-off, and from nearby streams and puddles. TLDs hang on the SRWMF fence, and we also look at soil, berries, and vegetation.

So What Do We Find?

After almost 20 years of operation the only evidence of station emissions that we have found is tritium in air. All other samples show background levels of radioactivity. Tritium can occasionally run as high as 4 Bq/m^3 — a person living in this concentration all the time would receive about 1 μSv/y.

If you are ever required to collect environmental samples, please be sure to use a virgin container for the sample. We once saw a pinch of tritium in the run-off from the SRWMF, which was later traced to a plastic sample bottle that had been used for something else before.

If we were to find significant increases in environmental radiation levels, we would step up our sampling frequencies to get a better grip on things. Not that we don't have a grip on them now.

It's worth noting that other agencies (Health and Welfare Canada, NB Health, and the Bedford Institute of Oceanography in Dartmouth) also conduct independent monitoring programs around Point Lepreau. Their programs include plants and wild beasties in addition to the standard pathways to people that we look at. So far, all of our results have been consistent.

A final note of cheer is that when you compare the accumulation of radionuclides in the environment with other industrial pollutants (e.g., arsenic, mercury, etc.), the radionuclides will eventually disappear by decay, but stable pollutants will be around forever.

Fig. 11. 24. Health Physics Department's Environmental Monitoring Lab in Fredericton

SUMMARY

All solid radwaste (other than spent fuel) produced at Point Lepreau G. S. is stored in the Solid Radioactive Waste Management Facility (SRWMF). Type I (below 2 mSv/h gamma on contact) and Type II (below 125 mSv/h gamma on contact) is stored in the vaults. Type III waste (everything above 125 mSv/h gamma on contact) is stored in the quadricells unless it is shielded first, and filters are stored in the filter storage structure.

Airborne and liquid radwastes are not stored, but are released routinely during normal operations. Releases are monitored at the source and compared with the Derived Emission Limits (DELs). These limits are set such that no member of the general public will be exposed to more than 1 mSv/y of whole body dose from all important pathways. We have an operating target of remaining below 5% of the DELs for each pathway (gaseous and liquid).

Liquid radwastes are collected in five holding tanks, sampled, monitored, and pumped to the Bay of Fundy on a batch basis. Pump-out is authorised by the Shift Supervisor. A sample of the liquid waste is collected continuously for compliance purposes by the Liquid Effluent Monitor (LEM), which also has the function of stopping the pump-out for high activities. We also have a back-up Liquid Effluent Pipe Monitor (LEPM), which we use when the LEM is unavailable.

There are four main ventilation systems for potentially contaminated air: D_2O Upgrader, Spent Fuel Bay, Reactor Building and Central Contaminated Exhaust. These areas are exhausted continuously. The Gaseous Effluent Monitor (GEM) monitors the activity of the exhaust flows.

We also have a fairly comprehensive environmental monitoring program to provide assurance to the AECB and the public that the environmental impact of station operation is known and within anticipated limits. There has been no increase in environmental levels of radiation around Point Lepreau G.S. since the start-up in 1983, other than for small amounts of tritium in air close to the station.

Also from the Darwin site, one of the more memorable stories. Larry was not given a Darwin Award, because he survived unharmed.

California Larry Walters of Los Angeles is one of the few to contend for a Darwin Award and live to tell the tale. "I have fulfilled my twenty-year dream," said Walters, a former truck driver for a company that makes TV commercials. "I'm staying on the ground. I've proved the thing works."

Larry's boyhood dream was to fly. But fates conspired to keep him from his dream. He joined the Air Force, but his poor eyesight disqualified him from pilot status. After he was discharged from the armed services, he sat in his backyard watching jets fly overhead.

He hatched his weather-balloon scheme while sitting outdoors in his "extremely comfortable" Sears lawnchair. He purchased forty-five weather balloons from an Army-Navy surplus store, tied them to his tethered lawnchair dubbed the Inspiration I, and filled the four-foot-diameter balloons with helium. Then he strapped himself into his lawnchair with some sandwiches, Miller Lite beer, and a pellet gun.

Larry's plan was to sever the anchor and lazily float up to a height of about thirty feet above his backyard, where he would enjoy a few hours of flight before coming back down. He figured he would pop a few brews, then pop a few of the forty-two balloons when it was time to descend, and gradually lose altitude. But things didn't work out quite as Larry planned.

When his friends cut the cord anchoring the lawnchair to his Jeep, he did not float lazily up to thirty feet. Instead, he streaked into the LA sky as if shot from a cannon, pulled by a lift of forty-two helium balloons holding thirty-three cubic feet of helium each. He didn't level off at a hundred feet, nor did he level off at a thousand feet. After climbing and climbing, he levelled off at sixteen thousand feet.

*At that height he felt he couldn't risk shooting any of the balloons, lest he unbalance the load and really find himself in trouble. So he stayed there, drifting with his beer and sandwiches for several hours while he considered his options. At one point he crossed the primary approach corridor of Los Angeles' LAX airspace, and Delta and TWA pilots radioed in incredulous reports of the strange sight**).*

Eventually he gathered the nerve to shoot a few balloons, and slowly descended through the night sky. The hanging tethers tangled and caught in a power line, blacking out a Long Beach neighbourhood for twenty minutes. Larry climbed to safety, where he was arrested by waiting members of the Los Angeles Police Department. As he was led away in handcuffs, a reporter dispatched to cover the daring rescue asked him why he had done it. Larry replied nonchalantly, "A man can't just sit around."

The Federal Aviation Administration was not amused. Safety Inspector Neal Savoy said, "We know he broke some part of the Federal Aviation Act, and as soon as we decide which part it is, a charge will be filed."

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*) For example, "we just passed a guy in a lawn chair with a gun."

PROBLEMS

1. Why do we store different levels of solid radwaste differently at the SRWMF?

2. The radwaste procedures state that radwaste is not to be put into the vaults or quadricells when it is raining. Can you think why?

3. Without looking at the text, list as many advantages as you can for having the SRWMF on site.

4. You have been asked to take a 4 L sample of the ground water at the SRWMF. What kind of container should you use for this?

5. Assume that you are a NEW at Point Lepreau G.S. and live in Dipper Harbour, 5 km from the station. Would the dose limits for the general public apply to you while you were at home?

6. Why is the DEL for airborne particulates a lot smaller than the DEL for noble gases?

7. Would you expect there to be significant differences in the DELs for airborne and liquid emissions at Gentilly and Point Lepreau?

8. The third week in January 1986 was abnormal in terms of atmospheric releases. We released the following:

   9.0E12 Bq of tritium
   2.5E6 Bq of I-131
   8.6E10 Bq-MeV of noble gases.

   a) Using the DELs for Point Lepreau G.S. given on page 360, calculate the total % DEL released for that week.

   b) Compare this release with the average weekly release for 1985, which was 0.036 % DEL. Give two reasons why they might have increased. (Hint: the tritium release was about 4.5 times greater than the average weekly release for 1985, but the I-131 release was about 30 times greater.)

9. Give three reasons why the DAC values for radionuclides dispersed into the atmosphere outside the station will be different than for the same radionuclides within the station.

10. Explain why we can be reasonably confident that dangerous quantities of radioactive substances will not be released during the operation of Point Lepreau G.S., but why it is practically inevitable that traces of radioactive substances will be released.

11. Why do we monitor liquid effluents both by means of a grab sample and by using the LEM?

12. Why does the LEM not monitor the tritium discharged in liquid effluents? How do we obtain the tritium data?

13. Why do we have an activated charcoal filter in the Spent Fuel Bay Exhaust System, but not in the Central Contaminated Exhaust System?

14. Suppose that we release a large quantity of particulate activity into the Central Contaminated Exhaust System. What fraction of it goes up the stack after passing through the HEPA filter?

15. What is the reason for the change in sampling frequency in Fig. 11.20 (page 374) starting with the second quarter of 1982?

16. Four of our eight environmental air-monitoring stations are located on private property in Maces Bay, Welch Cove, Dipper Harbour and Bocabec. Can you think of advantages of this approach compared to having them on NB Power property?

17. Why do we have one station as far away as Bocabec (45 km from Point Lepreau as the seagull flies)?

18. Can you think of something you can do every day to ensure that our gaseous waste management program runs the way it is supposed to?