IMPLEMENTATION OF A NON-CONTAMINATED WASTE SEGREGATION AND ENVIRONMENTAL CONTROL PROGRAM AT A LARGE CANADIAN UTILITY

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ABSTRACT

A study of the monitoring of non-radioactive solid waste in bags recommended changes in monitoring methods and practices. A program has been carried out over an 8-month period using a large volume gamma monitor. The monitoring was carried out in a central area which also considered the requirements for handling and shipping of the active and inactive wastes. The results indicate that residual quantities of radioactivity in the inactive waste bags, were not detectable with conventional portable monitoring instruments, that the average specific radioactivity of the inactive waste stream was reduced, and that 40% of the nominally active waste could be classified as inactive. Use of the monitor is considered to improve environmental control for non-radioactive solid wastes and provide economic benefits.

BACKGROUND

Ontario Hydro owns and operates multi-unit nuclear generating stations. These are Pickering Nuclear Generating Station (NGS), 8 units, approximately 4 320 MWe gross; Bruce NGS-A, 4 units, 3 280 MWe gross. A third station Bruce NGS-B has two 885 MWe gross units operating and two 885 MWe units in various stages of construction or commissioning. A fourth station Darlington NGS is under construction. For radiation control purposes each station is divided into 3 zones. Wastes arising in the station have historically been classified as radioactive or non-radioactive according to the zone in which they arise. Non-radioactive wastes originate mainly from Zone 1 (which is an area which consists of administration offices and the cafeteria and which has a very low probability of cross contamination from adjacent areas) and Zone 2 (which is an area that is normally free from radioactive contamination but is subject to infrequent cross contamination). Zone 2 waste consists of control room wastes, janitorial wastes (except floor sweepings) and maintenance wastes (insulation, paint cans). Non-radioactive wastes are collected in large, 0.1 m^3, green garbage bags. Radioactive wastes arise in Zone 3, an area which contains active systems and in which contamination can potentially arise. The radioactive waste is in the form of used protective equipment, cleaning and maintenance materials, discarded tools and components and water system purification materials.

It is Ontario Hydro's policy that all wastes should be managed to ensure that workers and members of the public are protected from radioactive hazards but in a manner which is also economically sound practice. This study looks at the management of these wastes at the stations but at Bruce NGS-A in particular where changes have been implemented to improve environmental protection and reduce costs.

NON-RADIOACTIVE WASTE PRACTICES

To ensure efficient collection of wastes all non-radioactive waste containers are painted blue and lined with green garbage bags. These containers which are allocated singly or three on a mobile cart are placed at locations where waste commonly arises or at a current work place. When filled, a bag is sealed and taken to a collection point for transfer to a waste handling area, or sealed and taken directly to a waste handling area. At this waste handling area, which is in a low background radiation area, the waste is monitored using a hand-held contamination meter. Any bags containing detectable radioactivity are treated as radioactive waste. (Zone 2 floor sweepings which from experience are contaminated are automatically treated as radioactive waste.) At Bruce NGS-A after the green bags are monitored they are placed in a collection area for transfer by truck to a non-radioactive incinerator. This incinerator burns non-radioactive wastes from other locations at the Bruce site including a heavy water plant, Bruce NGS-B, Douglas Point NGS, and other site service facilities. All non-active nuclear station wastes are monitored for a second time using a hand-held contamination meter prior to incineration. Any waste with detectable radioactivity is treated as radioactive waste and the incident recorded. Ash from the incinerator is removed weekly, sampled, and transferred to an on-site non-active landfill site. The ash samples are analyzed by gamma spectroscopy. The distribution of radionuclides in the inactive incinerator ash is shown in Table I.

The landfill site also receives wastes from on-site construction and non-active non-incinerable wastes from plant operations. A record is maintained of the quantities of waste transferred to the landfill site. Typical quantities are shown in Table II.

The charge to Producers at the Bruce site for transporting, incinerating and disposal of ash or non-incinerable waste is \$100/m^3 of waste.

At Pickering NGS the non-radioactive waste is managed differently than waste at Bruce NGS-A. At Pickering, the contents of a bag are visually inspected and the bag is monitored before closure. Experience has shown that waste which might be contaminated can be distinguished visually. Contaminated waste is typically, protective clothing, wipers, mops, floor coverings and sweepings. Monitored waste is disposed of by a contractor to a municipal landfill. The cost for non-radioactive waste disposal at Pickering NGS is between $7/m^3 and $10/m^3.

RADIOACTIVE WASTE PRACTICES

This description of waste handling practices applies to those materials deposited in garbage type bags and excludes materials such as water purification filters and IX resins which are handled differently. Wastes arising in station Zone 3 areas are deposited in clear, 0.07m^3 polyethylene bags labelled with a trefoil symbol and "Radioactive Waste." These bags are placed in yellow garbage cans which are located singly, or in threes at fixed locations and current work locations. The cans are labelled "incinerable," "compactible" or "non-processible" according to the physical characteristics of the waste they are intended to receive. When the bags are full they are removed from the can, monitored using a medium range gamma meter, inspected to ensure that waste has not been placed in an inappropriate bag, and sealed using colour-coded tape to indicate incinerable, compactible or non-processible waste. A waste bag having a radiation dose-rate greater than 2.5 mrem/hr on contact has the dose rate marked on the bag tape. The bags are either taken directly to a waste handling area or taken to a pick-up location. Bags having greater than 2.5 mrem/hr dose-rate on contact are taken directly to the waste handling area. Wastes in this area are managed to reduce the dose-rate in generally accessible areas to less than 2.5 mrem/hr. In the waste handling area the bags are placed in yellow containers of 1 m^3 capacity according to their physical classification. These containers meet the CTC (or DOT) specification 7A Type A. When a container is full it is closed and the type of waste, incinerable, compactible or non-processible, and the dose-rate at 1 meter are recorded on the shipping documents. These containers are then shipped to a waste volume reduction and storage facility at the Bruce site for waste processing and storage. This facility which has an incinerator and a baler receives wastes from Pickering NGS in addition to the Bruce Stations. A schematic of the waste handling system is shown in Fig. 1.

TABLE I

The Distribution of Radionuclides in Ash From the Active and Inactive Incinerators

	Radionuclide	Active Incinerator Ash % (50 samples)	Inactive Incinerator Ash % (50 samples)
Artificial	Cs-137	11	17
	Co-60	25	9
	Zr-95	6	3
	Nb-95	11	5
	Cs-134	–	5
	Ce-144	15	4
	Ru-106	7	–
	Cr-51	6	–
	Zn-65	6	–
	Other	13	20
Natural	K-40	–	27
	Pb-212, Pb-214, Ac-228, Bi-214, Tl-208	–	10
Specific Activity		~ 100 nCi/g	~ 20 pCi/g

TABLE II

Average Annual Volumes of Bagged Radioactive and Non-Radioactive Wastes for 1982-1984 from Four Reactor-Units at Pickering NGS and Bruce NGS-A

Station	Non-Radioactive	Radioactive
Pickering NGS (m^3)	4 300	1 280
Bruce NGS-A (m^3)	2 300	2 000

The charges to a station for handling radioactive bagged wastes varies with the classification. The current charges are $860/m^3 for incinerable and compactible wastes and $1 250/m^3 for non-processible waste. The differential is used to encourage sorting at source and is not related to the

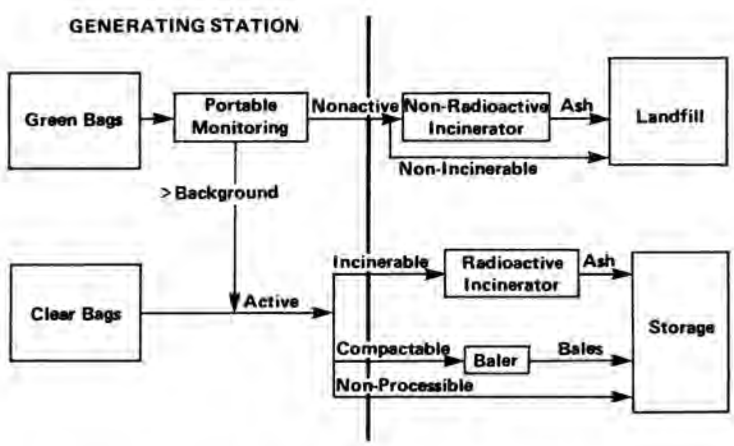

Fig. 1. The Conventional Waste Handling System

storage cost. The capital cost of storage space in an existing facility is $350/m^3$. The capital cost of storage space in a recently constructed facility is expected to be $300/m^3$.

The quantities of radioactive waste arising are shown in Table II.

NON-ACTIVE WASTE MONITORING USING PORTABLE INSTRUMENTS

Three types of monitoring instrument are in use for monitoring for activity in non-active waste bags. At Pickering NGS the Victoreen Thyac III with a 489-4 probe (and recently the Eberline E-140N with a HP-260 pancake probe) are used. At Bruce NGS-A a Victoreen Model 496 with a 489-110 pancake probe is used. At the incinerator facility an Eberline E-140N with a HP-260 pancake probe is used.

These instruments have different responses to radiation. The Geiger-Muller pancake probes of the type used at the incinerator facility have a large window area and a higher sensitivity than the thin walled detector probes used at Pickering NGS. These instruments detect both beta and gamma radiation but are approximately 30 times more sensitive to beta radiation than gamma depending upon the radionuclide. See Fig. 2 [1].

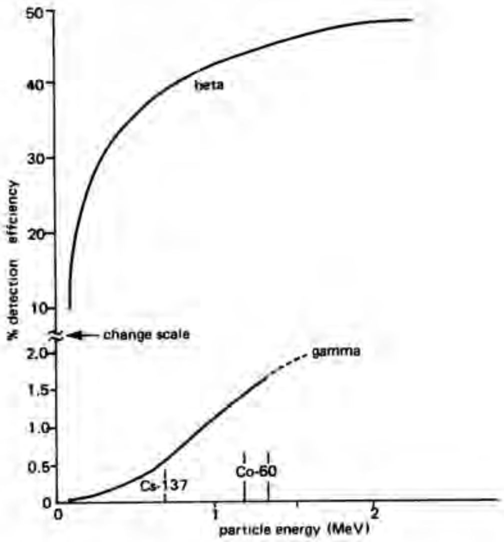

Fig. 2. The Response of a HP260 Pancake Probe to Beta and Gamma Radiation

Instrument response time is one of the important factors when waste bag monitoring because the probe is held in place for only a short period of time (0.5-1.5 seconds). Instrument response is also affected by radionuclide mix and distance from the source. For the latter the detected radiation changes from predominantly beta to predominantly gamma as distance increases.

The procedure for determining whether a bag contains radioactivity using a pancake probe is to:

- check that the monitoring instrument is working correctly
- check that the background radiation of the monitoring location is less than 500 CPM
- pass the probe slowly over the surface of the bag while observing the meter scale and note any deflection above background
- declare any bag "radioactive" which causes the monitor to read above background.

Using this procedure field tests showed that portable instruments could detect a 1 µCi source of Cs-137 in the center of a waste bag. These tests were conducted with a radiation background of 250 CPM and the minimum detectable reading was taken to be twice background.

Problems Associated with the use of Portable Instruments

The correct use of portable instruments can yield satisfactory results for contamination monitoring. However, the reliability of portable monitoring has been found to be inconsistent.

The qualitative nature of the instrument, the monitoring technique employed and operator error can lead to small quantities of radionuclides escaping undetected with the non-radioactive wastes. Attempts have been made to quantify the magnitude of this release using information from Bruce NGS-A and Douglas Point NGS at the Bruce site. Waste bags are routinely monitored at the Station and at the incinerator facility prior to incineration. Any bags containing detectable radioactivity are reclassified as active waste. Analysis of the results of monitoring conducted in 1980, looked at the frequency with which activity was detected in non-radioactive waste at the station and at the incinerator facility. For the first half of the year, when monitoring was carried out at the Station in background radiation fields which varied from 500 to 2 000 CPM and floor sweepings from Zone 2 were regarded as non-active, between 1-2% of waste was found to contain radioactivity at the incinerator facility. In the second half of the year when the background was consistently below 500 CPM and floor sweepings (which accounted for almost one half of the bags found to contain radioactivity) were excluded the number of bags detected containing radioactivity was reduced. Of a total of 1 400 bags per month from Bruce NGS-A activity was detected in between 0.2% to 0.6% of the bags received at the incinerator facility.

Steps were taken to improve radiation control at Bruce NGS-A including revised work practices and physical changes within the Station. A quantitative measure of the effectiveness of these changes in terms of the residual radioactivity in non-radioactive waste could not be obtained using portable contamination meters. Studies concluded that further improvements could be facilitated by the use of semi-automatic monitors, centralized monitoring facilities, clearly defined responsibilities and standardized monitoring practices. It was decided not to try to implement these changes at all stations until some experience had been obtained. It was agreed that initial changes would be justified for Bruce NGS-A. If these changes provided the improvements expected then justification for adoption in other stations would be made.

Specifications were required for a central waste handling and monitoring facility and for a semi-automatic gamma monitor. In the design of the station specific provision for centralized monitoring of non-radioactive waste was not made. Station personnel had designated one area for active waste handling and monitoring and another for inactive waste. It was decided to keep these areas and plan new requirements when more was known about the type of semi-automatic monitor that would be obtained.

SPECIFICATION FOR A SEMI-AUTOMATIC MONITOR

Prior to purchasing a monitor a specification was prepared to identify the performance characteristics required. This specification included the nature of the working environment, the size of the bag to be handled, the energy response characteristics of the monitor, bag weighing capability, alarms and data management requirements. In specifying the energy response characteristics of the monitor, data from the gamma spectrometric analysis of incinerator ash was used to identify the energy range of radionuclides to be monitored. In preparing this specification consideration was given to the significance of beta emitters present in the waste and in particular the contribution to total radioactivity of pure beta emitters. Studies concluded that the principal pure beta emitters in waste would be: tritium ~ 0.4 mCi/m^3; C-14 ~ 0.2 nCi/m^3; Sr-90 ~ 10% of Cs-137 and Fe-55 ~ 1%. Consideration of the magnitude and potential environmental impact of pure beta emitting radionuclides was important and studies have indicated that these pure beta emitters do not compromise the integrity of the monitoring process for the inactive waste stream at our nuclear stations. However, the main beta emitters in incinerable wastes would be Ce-144 and Ru-106 which are also gamma emitters and therefore measurable on a gamma sensitive instrument.

Data handling was given special consideration because of, the quantity of data, the intention to analyse data at a location remote from the station, and the possibility that data would be received for analysis from more than one monitoring location. In order to analyse the data efficiently it was decided to incorporate a microcomputer and floppy disc arrangement for data collection. This seemed a convenient way of allowing for the transfer of data to another location. The system was also suitable for handling larger quantities of data that could arise if a monitor was provided at other stations.

Performance of the Monitor

The monitor purchased for Bruce NGS-A is a WCM-11 which is a modified National Nuclear Corporation WCM-10. The WCM-10 monitor had previously been evaluated for segregating inactive waste from the active waste stream at the Tennessee Valley Authority Sequoyah Nuclear Plant [2]. The WCM-10 used at Sequoyah was a large volume cavity type monitor with a counting volume measuring 24" x27" x 29". It had six plastic scintillator detectors which were heavily shielded. Waste was placed inside the cavity via a heavy shielded door. Radioactivity detected in the waste appeared on a digital readout which was calibrated in nanocuries. The monitor also contained a scale for weighing each bag. The modified monitor in use at Bruce NGS-A has only four scintillator detectors and although it is also heavily shielded it does not have a door. The door was removed to allow the convenient and safe addition to and removal of waste bags from the monitor's cavity. In addition a microcomputer has been added to collect data on a floppy disc for analysis. This allows the bag monitoring results for each day to be sequentially numbered to discriminate each data set. The information normally recorded includes, Station name, bag number, radioactivity, bag weight, high activity indication, and specific activity. The size of the monitor cavity is 30" wide by 35" high x 35" deep. Over a test period starting in April 1985 data has been analysed to examine the performance of the monitor, the radioactivity in active and inactive waste and the potential for reducing waste volumes.

The monitor performed very reliably. Calibration is carried out weekly using standard liquid sources of different radionuclides. Occasional adjustment has been necessary to correct for photomultiplier drift. Personnel using the monitor find it more convenient than hand monitoring although the monitoring time is about the same. When operating the monitor with a 10 second bag count it was found that the average daily waste load of 150 bags would take approximately 2.5 hours. These 150 bags are typically made up of 95, 0.1 m^3, green, inactive bags and 55, 0.07 m^3, clear, active bags.

The distribution of radioactivity in green and clear bags is shown in Table III. This table summarizes the results of monitoring 6 560 green bags and 3 630 clear bags.

TABLE III

The Distribution of Radioactivity in Green (Non-Active) and Clear (Active) Waste Bags

Activity Range nCi/bag	Percentage of Bags in Range: Green	Clear
0 - 100	86.2	28.6
101 - 200	5.4	7.2
201 - 300	2.2	4.3
301 - 400	1.2	3.3
401 - 500	0.64	2.2
801 - 600	0.64	1.9
601 - 700	0.30	2.0
701 - 800	0.28	2.0
801 - 900	0.35	1.5
901 - 1 000	0.26	1.5
>1 000	2.53	45.5

This table shows that the radioactivity of a large percentage of nominally radioactive waste is in the same range as nominally non-radioactive waste. It is interesting that the data for clear bags corresponds closely with that obtained for dry active waste at the Sequoyah plant using the WCM-10, (2).

When considering the operating criteria for the test period two primary requirements were established:

- The monitor should not allow any bags to pass which contain radioactivity that could be detected by a hand-held portable monitor.

- There should not be an increase in the total activity released with non-active waste.

Shown in Fig. 3 is the average specific activity which would be released in non-active green bags and in active clear and non-active green bags for various maximum activities in a monitored bag.

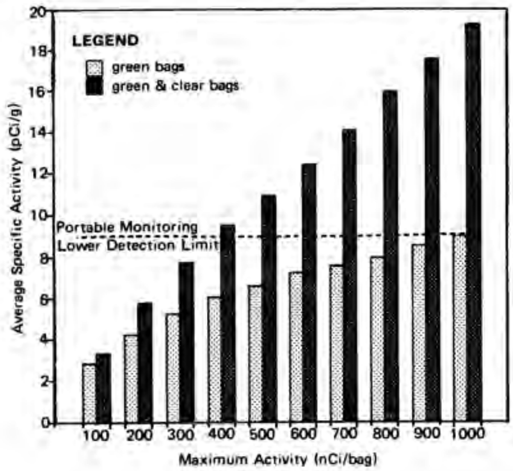

Fig. 3. The Variation of Average Specific Activity of Waste with Maximum Activity

The specific activity of the non-radioactive waste stream is ~ 9 pCi/g. In order for the operation of the WCM11 monitor to meet the two criteria the specific activity of the resulting non-active waste stream should be less than 9 pCi/g and the maximum activity per bag should be less than 1000 nCi. It is shown in Fig. 3 that at a maximum activity per bag of 300 nCi the non-active waste stream will meet the two criteria. During the test period this maximum activity of 300 nCi per bag has been used to discriminate between the active and non-active waste streams. The result has been that the average specific activity of inactive waste has been reduced to 8 pCi/g and personnel at the incinerator facility, using hand-held monitors, have not detected any activity in the inactive waste stream. Ash from the non-radioactive waste incinerator has been analysed by gamma spectroscopy since 1977 when the incinerator first operated. The radioactivity in the ash produced during the test period was typical of that found in ash prior to the test. The distribution of radionuclides commonly found in this ash is shown in Table I. It is observed that approximately 40% of these radionuclides are naturally occurring.

With the introduction of the monitor test program the process for handling wastes was changed to that shown in Fig. 4.

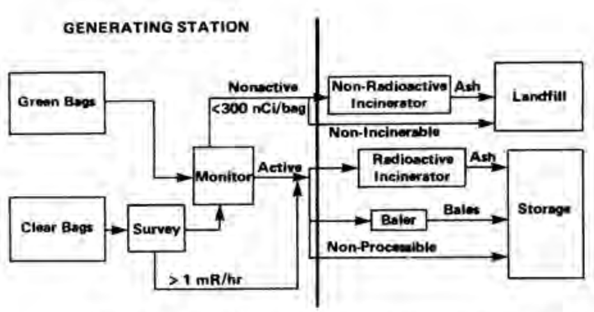

Fig. 4. Modified Waste Handling System

During the test period, a portion of the clear waste bags with a dose-rate less than 1 mrem/hr (this was 80% of the bags) was routed through the bag monitor. Approximately 40% of these bags contained less than 300 nCi and were sent to the non-radioactive waste incinerator during the test period. According to the test results this fraction of waste could be classified as inactive.

WASTE HANDLING AREA

In establishing an area for handling, monitoring and shipping waste off-site, consideration was given to the requirements for moving waste containers, for shipping waste and for minimizing the contribution to background radiation of waste in the monitoring area. Within Bruce NGSA this has been done by adapting the area shown in Fig. 5.

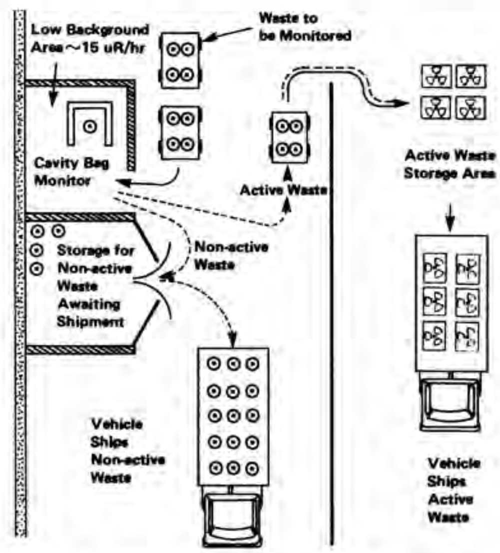

Fig. 5. Waste Handling Area at Bruce NGSA

The waste monitor is located in a shielded area where the background radiation is low. This area is adjacent to a wide corridor which has convenient vehicle access. Waste bags having less than 1 mrem/hr contact dose rate are placed in a mobile cart in this corridor. Non-active monitored waste is placed in an area adjacent to the monitor to await shipment. Active waste and waste with greater than 1 mrem/hr contact dose rate is taken to an active waste area where it is containerized prior to shipment. It is planned to improve non-radioactive waste handling by using a large roll-off container to collect the waste after monitoring. Further changes may be made in the future to accommodate a waste sorting activity. An area which includes facilities for waste sorting has been proposed for Bruce NGS-B and is shown in Fig. 6.

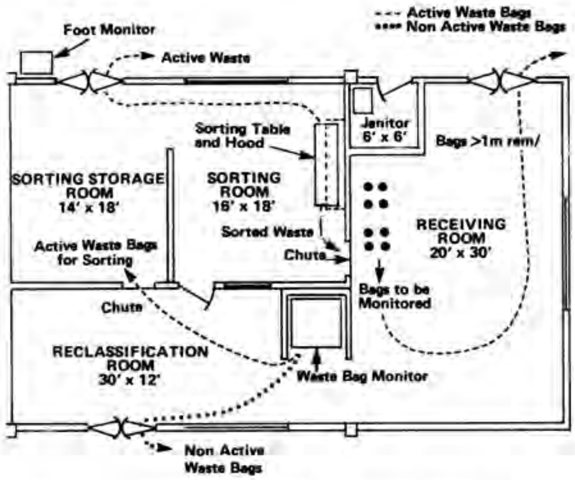

Fig. 6. Proposed Waste Handling Area for Bruce NGS-B

CONCLUSIONS AND FUTURE WORK

The semi-automatic monitor has demonstrated that it can eliminate the releases of small quantities radioactivity in the non-radioactive bagged waste stream which are experienced with hand-held monitors. The monitor can also segregate bags of waste containing insignificant quantities of radioactivity from a nominally active waste stream. At Bruce NGSA this represents approximately 40% of the monitored bags. During the period that the monitor has been in use there has been a small reduction in the average specific activity of the non-active waste stream. Environmental protection has been improved by use of the monitor.

Segregation of the inactive component from nominally active waste has reduced incinerable waste by 30%. Implementation of a permanent segregation program at Bruce NGSA and other stations could, therefore, provide a significant reduction in the overall radioactive waste handling, processing, and storage costs.

Current plans are to justify installation of semi-automatic monitoring in Bruce NGS-B, Pickering NGS and Darlington NGS.

Based on current experience, we plan to conduct a trial solid waste sorting program at Bruce NGS-B when the waste handling and monitoring area have been installed.

The results of the test program have also indicated that the improved understanding of the radiological nature of the waste, provided by computerized data analysis, also promised potential economic benefits. This potential will be further investigated.

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