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PROCESS WASTE ASSESSMENT FOR THE RADIOGRAPHY LABORATORY

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ABSTRACT

This Process Waste Assessment was conducted to evaluate the Radiography Laboratory, located in Building 923. It documents the processes, identifies the hazardous chemical waste streams generated by these processes, recommends possible ways to minimize waste, and serves as a reference for future assessments of this facility.

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Introduction

The Department of Energy (DOE) Orders 5400.1 and 5400.3 mandate the development of a waste minimization program.[1,2] The program's goals are to:

1. reduce volumes of hazardous wastes and toxicity,
2. implement a system of tracking and reporting improvements, and
3. devise a method for performing assessment and minimization tasks.

To satisfy the requirements of this program, Sandia conducts process waste assessments (PWAs) to identify waste generating processes. The information collected from a PWA is then used to identify waste minimization opportunities.

This PWA was conducted on the Radiography Laboratory, according to Sandia's revised *Process Waste Assessment Plan*.[3] This PWA documents the processes, identifies the waste streams and waste minimization opportunities, and serves as a reference for future assessments of this facility. It will be reevaluated in 18 to 24 months, after the lab personnel have had enough time to implement the recommendations and the results are compared with the baseline established in this assessment.

Summary

The Radiography Laboratory provides film radiography or radioscopy (electronic imaging) of weapon and nonweapon components.[4] It is now in Building 923, but will be relocated in June 1994 to Building 941, Rooms 115–120. The Building 923 layout includes four radiography cells. These cells are shielded with thick cement or lead walls and ceilings to permit the safe operation of radiation devices. Two darkrooms are used for film and print developing. One darkroom contains a DuPont NDT 100 automatic film processor. The other darkroom contains an Agfa-Gevaert semiautomatic print processor and a contact printer.[5] The facility also has a control room, a viewing area, a utility and wash room, and a large hallway, which acts as a staging area for the cells.

The Radiography Laboratory has six x-ray machines and one gamma ray source. It also has several other sealed beta- and gamma-ray isotope sources of low microcurie (μCi) activity.[4]

The photochemical processes generate most of the Radiography Laboratory's routinely generated hazardous waste, and most of that is generated by the DuPont film processor. Because the DuPont film processor generates the most photochemical waste, it was selected for an estimated material balance.

The Radiography Laboratory generated a significant amount of nonroutine hazardous waste during a housecleaning of obsolete materials from inventory once in 1993 and once

in 1994. It also generated a small amount of low-level radioactive waste in 1994. This waste was from obsolete radioactive sources, which had been in the lab's inventory for a number of years.

The Radiography Laboratory generates a relatively low volume of hazardous waste annually, but the lab personnel are very aware of the need to minimize the generation of hazardous waste and to cut costs. They have already taken steps to do so. For example, they have minimized the volume of prepared and stored photochemicals by about 50% because they now purchase the chemicals in 14-gallon kits, instead of in 30-gallon kits. Recommendations for future waste minimization activities are:

- Evaluate the possibility of minimizing the volume of waste photochemicals by extending the time between bath replacement. Feasibility of this option would depend on whether film quality would be affected and on how much money could be saved.
- Implement real-time radioscopy, which would cut down on film and chemical usage.[5]
- Evaluate the efficiency and/or effectiveness of using the Building 913 Photography Laboratory for film processing rather than using the Radiography Laboratory's own processing equipment.

Process Waste Assessment

Facility

Radiography Laboratory, Building 923.

Products

Film radiography and electronic imaging analysis.

Process Description

The Radiography Laboratory provides film radiography or radioscopy (electronic imaging) of weapon and nonweapon components.[4] It is currently located in Building 923, but will be relocated in June 1994 to Building 941, Rooms 115–120. Figure 1 shows the facility layout. Rooms 101, 103, 105, and 108 are radiography cells, which are shielded with thick cement or lead walls and ceilings to permit the safe operation of a wide variety of radiation devices. Rooms 106 and 109 are used as darkrooms and contain film and print processors. Room 109 is also used as a lab. Room 102 is a control room, and Room 104 is a film reading room. The facility also has a large hallway, which acts as a staging area for the cells, a utility room, and a wash room.[4]

The Radiography Laboratory has six x-ray machines and one sealed gamma-ray source, which cover the energy spectrum 5–420 kV. Five of the machines are installed in cabinets or cells and are used in the lab only. One of the x-ray machines and the Ir-192 radiographic source are portable and can be used for field operations. The Ir-192 isotope is a maximum 100-Curie source and is contained in a shielded shipping/handling container.[4]

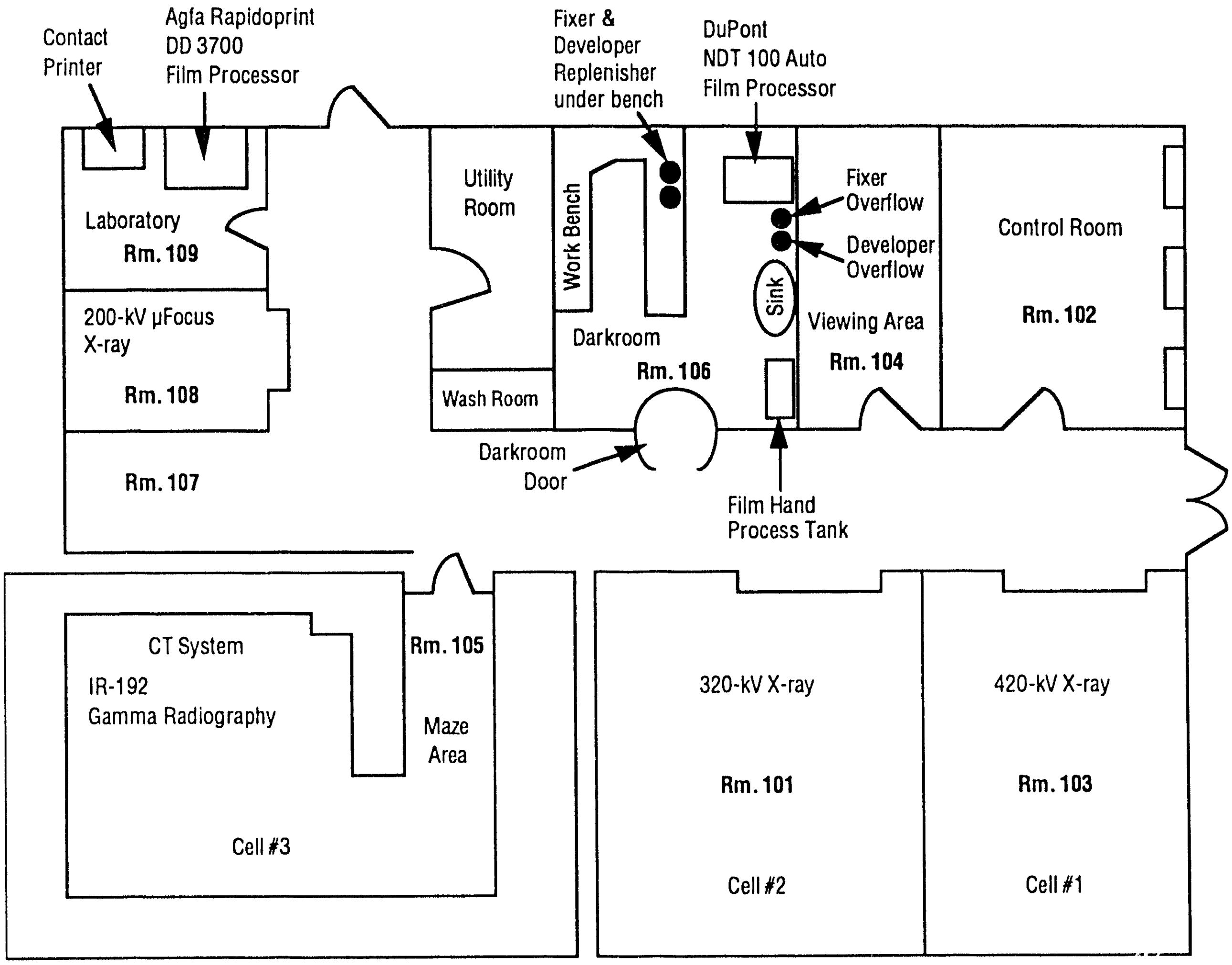

Figure 1. Layout of the Radiography Laboratory—Building 923.[6]

The Radiography Laboratory also has sealed beta- and gamma-ray isotope sources of low μCi activity, which are stored safely in Room 105. These isotope radiation sources are used infrequently for material characterization studies involving techniques such as radiation transmission gaging, back scatter measurements, and x-ray fluorescence studies.[4]

The two darkrooms (Rooms 106 and 109) are used to support the radiographic operations. A DuPont NDT 100 automatic film processor and an x-ray film hand processing tank are located in Room 106. The hand processing tank is used rarely and as a backup only. Room 109 contains an Agfa-Gevaert semiautomatic print processor, which is used for developing radiographic prints, and a contact printer.[5]

The DuPont NDT 100 automatic film processor is a self-contained unit fitted with tanks, automatic chemical replacement, and a rinse-water unit. The rinse-water flows freely through the processor to the sewer. The volume of effluent discharged to the sewer is about 2.5 gallons per minute when the unit is running. The unit automatically shuts off when film is not being processed. The unit is not run on a continuous schedule, so the volume of waste can fluctuate considerably from month to month. Therefore, determining a total annual rinse-water effluent volume is not possible. The lab personnel evaluated a recirculation/filtration system for this unit to reduce the volume of water used and therefore, effluent sent to the sewer. However, the system took up too much darkroom space and the amount of water saved would not be significant enough to install the system.[5]

The Agfa-Gevaert print processor is a small, semiautomatic unit. It uses one quart of activator and one quart of fixer for each processing cycle. The chemicals are added to the unit at the beginning of each new process operation, and at the end of the operation, they are bottled and saved for future use.[5]

Figure 2 shows the a general process flow for the facility.

Waste Stream Profiles

The DuPont NDT 100 and the Agfa-Gevaert processors generate most of the Radiography Laboratory's routinely generated hazardous waste. Figures 3 and 4 show the process flow, and Tables 1 and 2 show the working bath chemistry for each of these units.

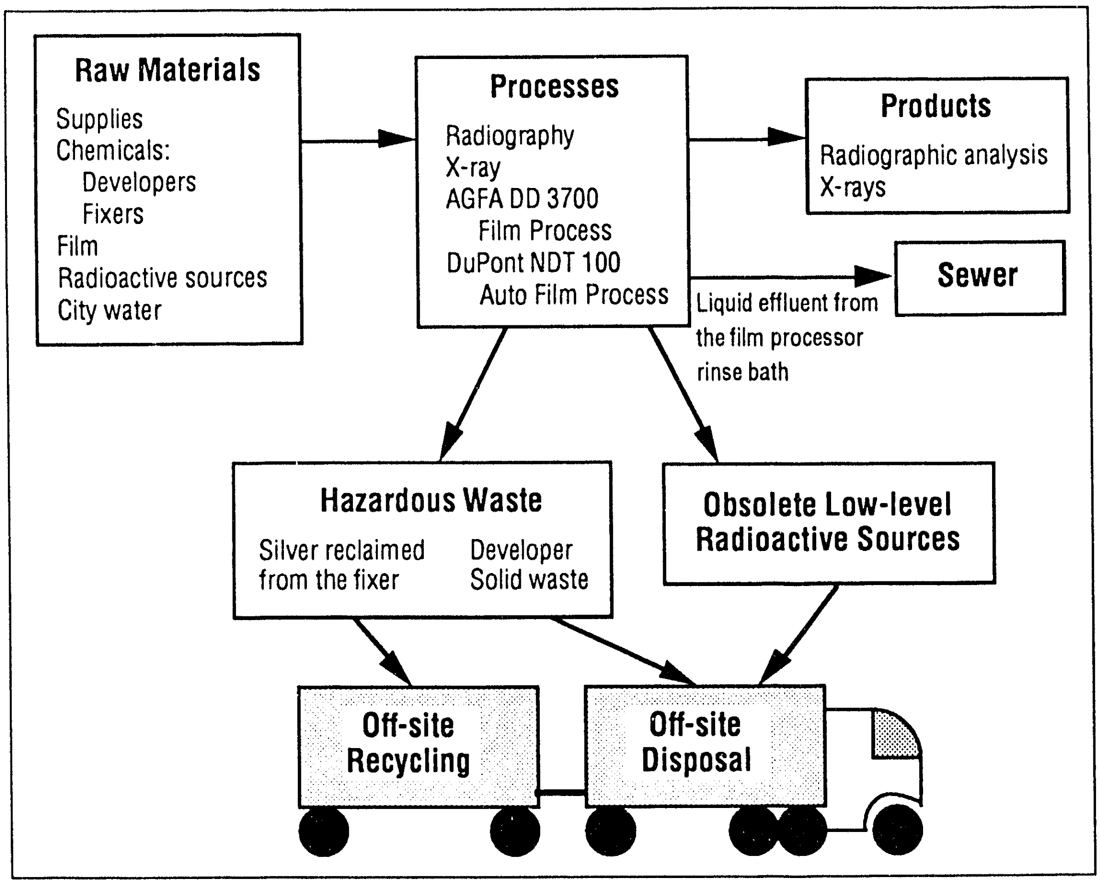

Figure 2. Laboratory Area General Process Flow Diagram.

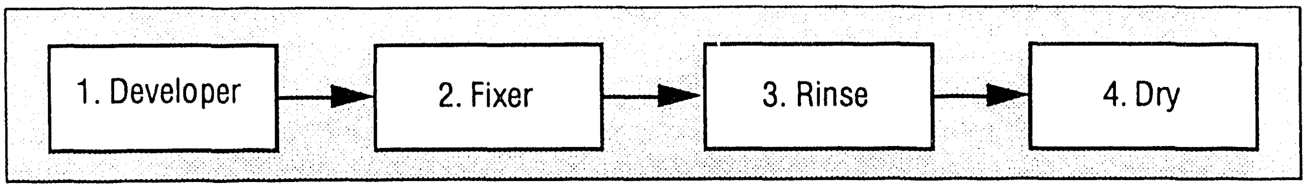

Figure 3. DuPont NDT 100 Automatic X-ray Film Processor Process Flow.

Table 1. DuPont NDT 100 Automatic X-ray Film Processor Working Bath Chemistry.

Type of Bath and I.D.	Chemical Composition of Working Bath[7,8]	Weight %	Volume of Bath (L)	pH
1. Kodak Industrex Developer Parts A, B, & C	Water	85–90	19	10.4
	Potassium sulfite	5–10		
	Hydroquinone	1–5		
	Potassium acetate	1–5		
	Glutaraldehyde	1–5		
2. Kodak Industrex Fixer and Replenisher Parts A & B	Water	80–85	19	4.0
	Ammonium thiosulfate	10–15		
	Sodium sulfate	1–5		
3. Rinse	City water	100	19	—

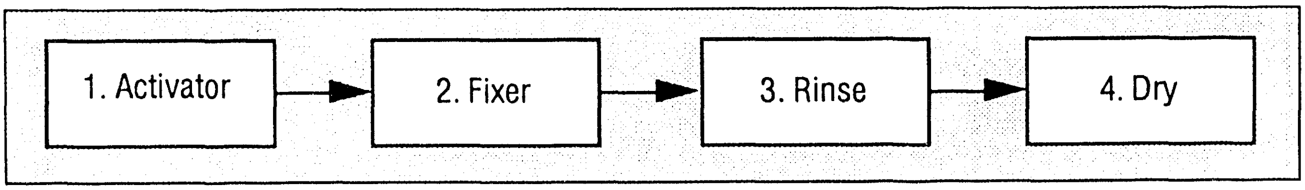

Figure 4. Agfa-Gevaert DD 3700 Print Processor Process Flow.

Table 2. Agfa-Gevaert DD 3700 Print Processor Working Bath Chemistry.

Type of Bath and I.D.	Chemical Composition of Working Bath[9,10]	Weight %	Volume of Bath (L)	pH
1. Agfa G-182B Rapidoprint Activator	Sodium hydroxide	1–5	1	13.5
	Sodium sulfite	1–5		
	Water	90–98		
2. Agfa QS04 Fixer	Ammonium thiosulfate	10–15	1	5.0
	Sodium sulfite	1–5		
	Acetic acid	1–5		
	Water	75–88		
3. Rinse	City water	100	1	—

Waste Generation

Based on data from 1992 to May 1994, the major portion of the hazardous waste generated by the Radiography Laboratory is photochemicals (see Table 3), which come from the two darkrooms that support the film radiographic process. The DuPont NDT 100 generates the largest volume of routine hazardous waste—an average of 22 kg (about 5 gallons) of developer per month and a similar amount of fixer. (This amount is based on an annual total volume of approximately 260 L each.) The processor is not run on a continuous schedule, so the volume of waste can fluctuate considerably from month to month. Similarly, the volume of rinse water used by the unit is difficult to quantify because of the infrequency of operation. The Agfa-Gevaert processor contributes a small amount to the total photographic waste.

Table 4 lists nonroutine hazardous wastes generated by the Radiography Laboratory during housecleaning once in 1993 and once in 1994.[5]

A small amount of radioactive waste is generated nonroutinely, when radioactive sources become obsolete and are sent out as low-level radioactive hazardous waste.[5] Table 5 identifies the low-level radioactive wastes generated by the Radiography Laboratory during a cleanup in April 1993.

Table 3. Routinely Generated Hazardous Wastes.[11]

Waste Stream ID	Volume generated (1992)	Volume generated (1993)	Volume generated (1994—to 5/94)	Cost of Disposal*
Fixer	355.8 L	267.4 L	150.0 L	$200/55-gal. drum (208 L)
Developer	261.2 L	255.8 L	146.0 L	$200/55-gal. drum
Stop Bath	7.6 L	17.0 L	0	$200/55-gal. drum
Activator	0	8.0 L	0	$200/55-gal. drum
Stabilizer	18.9 L	0	0	$200/55-gal. drum
Film/Paper	15.0 kg	273.0 kg**	37 kg	$6.25/kg
Filters	0.9 kg	0.7 kg	0.28 kg	$950/55-gal. drum + $85/drum transport
Empty Containers	0.9 kg	10.5 kg	6.35 kg	$950/55-gal. drum + $85/drum transport
Wipes/Rags	5.5 kg	3.8 kg	1.25 kg	$950/55-gal. drum + $85/drum transport
Batteries	16 ea.	48 ea.	1.16 kg	$0.88/kg + $17.86/kg transport
Aerosol	4 ea.	56 ea.	0	$600/55-gal.drum

*Includes only disposal and transportation costs. Does not include administrative charges.

**Obsolete files were cleaned out in 1993, resulting in the greater volume of film and paper waste than in 1992.[5]

Table 4. Nonroutine Hazardous Wastes Generated in 1993/94.[11]

Miscellaneous Chemicals	Volume generated (1993)*	Volume generated (1994)*	Cost of Disposal**
Lead	37.5 kg	—	$0.88/kg + $17.86/kg transport
Iron oxide	6.0 kg	—	$950/55-gal. drum + $85/drum transport
Copper shot	50.0 kg	—	$950/55-gal. drum + $85/drum transport
Bismuth metal	55.0 kg	—	$950/55-gal. drum + $85/drum transport
Film coater/jelly	16.5 kg	—	$950/55-gal. drum + $85/drum transport
Other	7.0 kg	—	$950/55-gal. drum + $85/drum transport
Mineral oil	58.0 L	—	$120/55-gal. drum
Isopropyl alcohol	2.2 L	—	$120/55-gal. drum
Hydroquinone/ acetic acid	20.0 L	—	$150/55-gal. drum
Petroleum distillates	41.0 L	—	$120/55-gal. drum
Chlorinated alkanes	19.0 L	—	$125/55-gal. drum
Ethylene glycol	3.7 L	—	$0.49/L
Dysprosium oxide Dysprosium chloride	— —	3 kg 3 kg	$80/30-gal. drum + $20 transport
Gadolinium chloride Gadolinium acetate Gadolinium oxide Gadolinium nitrate	—	6 kg 3 kg 6 kg 4 kg	$80/30-gal. drum + $20 transport
Samarium chloride	—	2 kg	$80/30-gal. drum + $20 transport
Lead acetate	—	2 kg	$80/30-gal. drum + $20 transport
Toner/iron oxide	—	2 kg	$80/30-gal. drum + $20 transport

*Obsolete chemicals account for the major portion of the disposed chemicals.[5]
**Includes only disposal and transportation costs. Does not include administrative charges.

Table 5. Nonroutine Low-level Radioactive Waste Generated Jan.–April 1994.[12]

Isotope ID	No. of items	Total Activity (mCi)	Activity Range (mCi)	Total Weight (kg)	Waste Description
Container #559	51	83.2675	0.000002–40.0000	3.816	
Fe-55	4	4.1590	0.0090–2.700	0.077	point/pin sources, disc/capsule
Pm-147	6	2.9840	0.0020–2.500	0.308	point/pin sources, foil/Pm-147
Ni-63	2	40.0300	0.0300–40.0000	0.091	foil/beta, disc/capsule
Co-57	4	0.2430	0.0010–0.2300	0.055	point/bead, disc/capsule, point/pin sources
Ba-133	2	0.0034	0.0004–0.0030	0.043	disc/dot sources
Cd-109	4	1.0710	0.0010–0.0500	0.533	disc/capsule, point/pin source
Kr-85	3	9.2100	0.0100–8.7000	0.078	disc/capsule, steel capsule, vial
Sm-143	1	0.0001	N/A	0.044	ring source
Na-22	1	0.000002	N/A	0.003	disc
Ra-226	1	0.0100	N/A	0.015	point source
Tc-99	1	0.0001	N/A	0.016	disc
Ru-106	1	0.00008	N/A	0.061	point/pin source
Sr-90	3	0.4120	0.0020–0.4000	2.223	check, area, and point sources
Tl-204	6	18.0636	0.00008–0.0600	0.475	point/needle, point source
Th-232	1	0.0100	N/A	0.016	foils
Bi-207	1	0.0400	N/A	0.010	disc source
Mn-54	1	0.00001	N/A	0.003	disc
Co-60	2	0.60008	0.00008–0.6000	0.138	disc, calibration check
Cs-137	2	0.0091	0.0011–0.00080	0.013	disc
C-14	2	6.4100	0.0100–6.4000	0.033	point/needle, beta source
Ra-D	2	0.0020	0.0010–0.0010	0.025	point source
U-238	1	0.0100	N/A	0.036	disc, sheet sources
Container #585	2	375.0000	60.0000–315.0000	0.350	
Kr-85	1	315.0000	N/A	0.022	disc/capsule
Sr-90	1	60.0000	N/A	0.013	disc/capsule

N/A = Not applicable

Material Balance

A material balance (Fig. 5) was conducted on the DuPont NDT 100 film processor because it generates most of the Radiography Laboratory's hazardous waste. The approximations used for this material balance are based on averages from waste generation data and the process operator's knowledge.

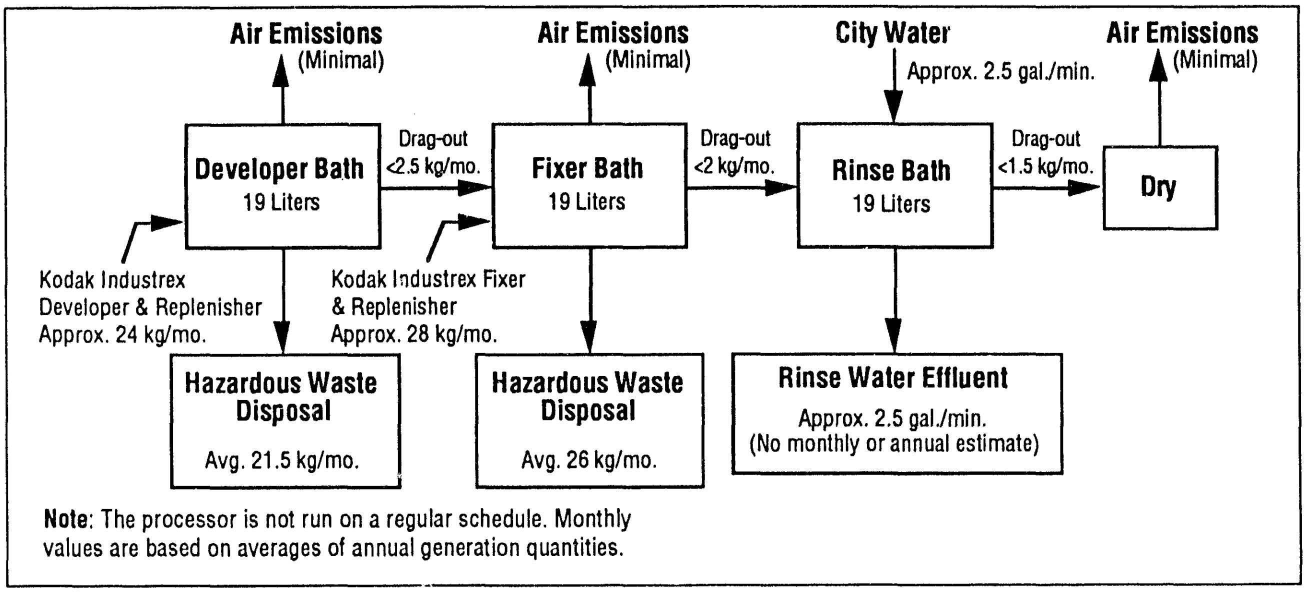

Figure 5. DuPont NDT 100 Film Processor Material Balance.

Recommendations

The Radiography Laboratory generates a low volume of photochemical waste annually, yet the lab personnel are aware of the need to minimize waste and cut costs. For instance, they evaluated a water recycling unit for the DuPont 100 film processor, but the unit was too large to use in the darkroom and the amount of water saved would not be significant. The water flow through the film processor is only 2.5 gal./min. during processing and automatically shuts off when film is not being processed. Also, lab personnel have minimized the volume of prepared and stored photochemicals by approximately 50%. They now purchase the concentrate in kits to prepare 14 gallons at a time, instead of 30 gallons.[5] This procedure reduces the inventory and the chance of storing chemicals past their shelf life.

Some other waste minimization opportunities may merit additional evaluation:

- Determining the possibility of minimizing the volume of waste photochemicals by extending the time between bath replacement. Feasibility of this option would depend on whether film quality would be affected and on how much money could be saved.
- Implementing real-time radioscopy, thereby reducing film and chemical usage.[5] The implementation cost would be low because the equipment is already available; however, this option depends on whether radioscopy is an acceptable alternative to film radiography.
- Evaluating the efficiency and/or effectiveness of using the Building 913 Photography Laboratory for film processing rather than using the Radiography Laboratory's own processing equipment, thereby eliminating the need for running and maintaining an additional process.

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