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THE EVALUATION OF RADIOACTIVE RELEASES FROM CHEMICAL PLANTS*

By

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ABSTRACT

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Recent accidental releases of radioactive material at ORNL have resulted in the establishment of building and ventilation design criteria and the requirement for a hazards evaluation for those facilities which contain radioactive material of physiological hazard greater than that equivalent to one gram of Pu²³⁹.

A quantitative method for estimating the hazards associated with the maximum credible accident in a radiochemical facility has been developed. The maximum credible accidents in such facilities are chemical or nuclear explosions which disperse radioactive aerosol and gases into ventilation streams which exhaust to the atmosphere. Approximate physical properties of these aerosols and gases have been combined with the efficiency of ventilation cleanup devices and meteorological correlations to evaluate the hazard to the environment.

The method of evaluation has been applied to ORNL radiochemical facilities, which have been modified to meet the new containment criteria, to demonstrate the acceptably low personnel exposure and ground contamination that would result from the maximum credible accident in each facility.

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** Speaker.

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1.0 INTRODUCTION

The Bldg. 3019 evaporator explosion and other accidental releases of activity in the fall of 1959 precipitated a review of ORNL radiochemical facilities, the aim of which was to outline building changes that were required to confine the effects of the maximum credible accident to the involved facility. Such building changes were considered advisable to prevent jeopardizing laboratory personnel and other laboratory facilities in the event of such an accident. This review led to the establishment of building and ventilation design criteria, one requirement of which was that secondary building containment would be placed around all process cells which could otherwise leak significant activity directly to the environment in the event of an accident. It was specified that these criteria, along with the necessity of a reactor-type hazards evaluation, would apply to those facilities which contain radioactive material of physiological hazard greater than that equivalent to 1 g of Pu²³⁹.

Maximum credible accidents in such radiochemical facilities are chemical or nuclear explosions which disperse radioactive aerosols or gases into ventilation streams which exhaust to the atmosphere. A realistic hazard evaluation must take into consideration the physical properties of the radioactive gas or aerosol that is formed and the efficiency of air cleanup devices for removal of these radioactive materials prior to discharge to the atmosphere.

We have attempted to make such an evaluation of ORNL radiochemical facilities using properties of aerosols and gases that are found in the literature. The studies, in general, have demonstrated the adequacy of secondary containment and present air cleanup devices but have pointed up the necessity for reliability of these devices, particularly filters, and have indicated areas in which further experimental work is required.



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2.0 THE BUILDING 3019 EVAPORATOR EXPLOSION

The need for adequate primary and secondary containment was acutely demonstrated in the Bldg. 3019 evaporator explosion. A chemical explosion occurred in an evaporator complex that contained approximately 1500 g of Pu as solution, precipitate, and scale and scattered 600 mg of the Pu through a cell door, blown open by the explosion, directly to the environment. Although no personnel were injured or received an intolerable radiation dose during the accident, a portion of ORNL was significantly contaminated. In addition, the operating area of the facility was contaminated by air flow through open pipe chases and other penetrations which communicated through the cell wall.

A post-explosion examination of the facility revealed that the loss of plutonium to the environment would have been maintained within acceptable limits if (1) the door had not been blown open, (2) the penetrations through the cell wall had been minimized, and (3) the entire cell bank had been contained within a building. The release of plutonium through the existing cell and vessel ventilation filters was determined to be negligible.

The cell ventilation cleanup system, consisting of pocket-type roughing filters backed up by absolute filters, collected approximately 1.5 g of Pu and there was no measurable contamination on the exhaust side of the absolute filters. Examination of the roughing and absolute filters indicated that the roughing filters contained 98.8% of the plutonium and that the particles collected by the filters had a mass mean particle size of 0.67μ with a standard deviation of 2.3.

3.0 CONTAINMENT CRITERIA FOR A PROJECTED RADIOCHEMICAL FACILITY

A schematic diagram of a radiochemical facility which meets the minimum recommended design criteria is shown in Fig. 1. The diagram depicts a typical vessel in a process cell which is completely surrounded by a building. The cell, which constitutes primary containment, is capable of withstanding the blast effects of the maximum credible explosion without rupture and permits only a minimum leakage of radioactive material to the secondary containment shell, the building structure. Other criteria for the process vessels, cells, and buildings are as follows:

Filters are to be located such that they will be protected from the maximum credible explosion.

Process vessels are maintained at a vacuum of at least 2 in. w.g. during normal operation by a VOG system which passes through a local scrubber and filter system as well as plant treatment system before being exhausted at a stack.

A cell is maintained at a vacuum of at least 1 in. w.g. during normal operation.

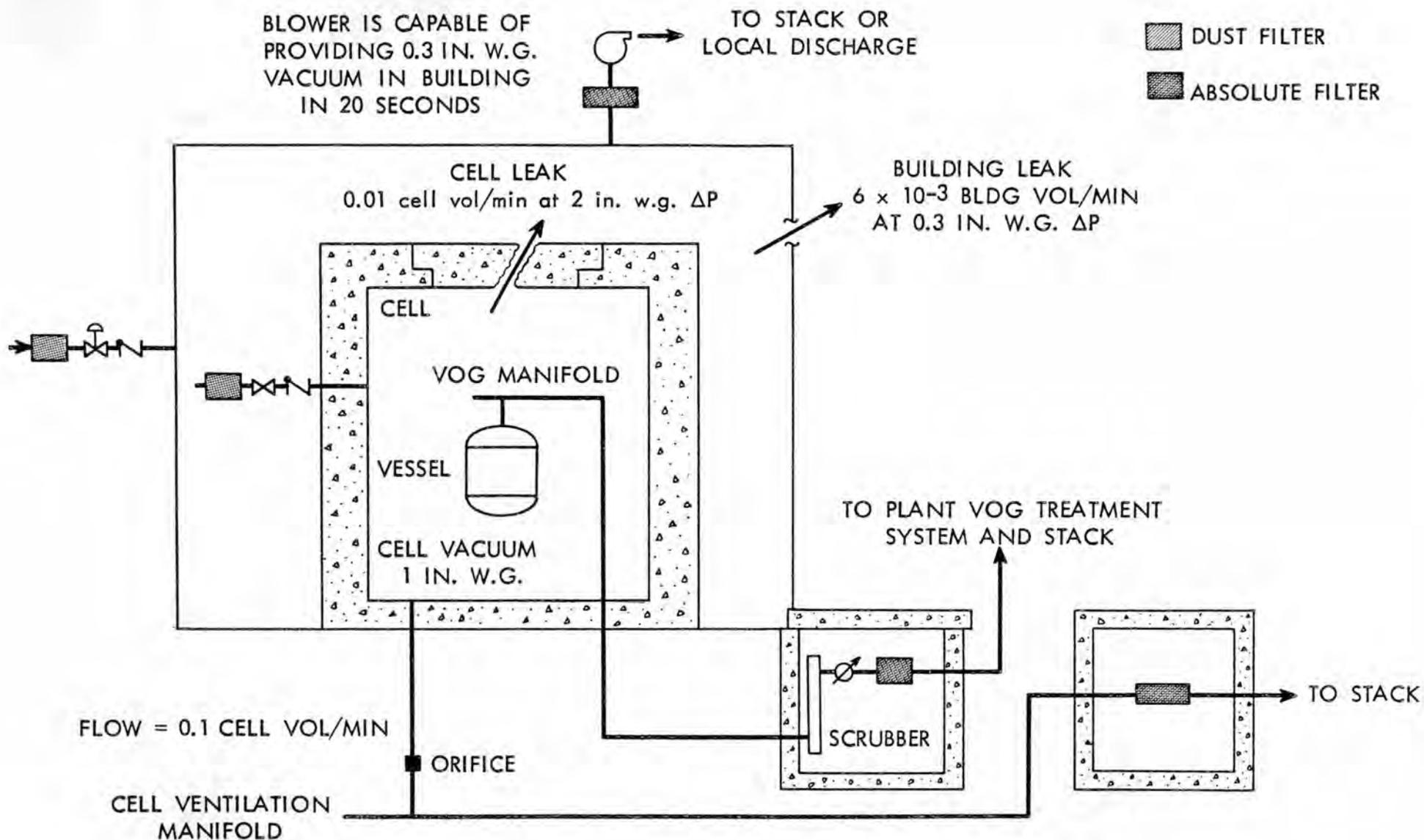


Fig. 1. Schematic diagram of minimum containment provisions for radiochemical facilities.

The cell ventilation exhaust capacity is at least equivalent to 1/10 of a cell volume per minute. The air intake to the cell is through a roughing filter and check valve. The cell exhaust passes to a cell ventilation manifold, roughing and absolute filters, and from thence to the stack. The cell is sealed such that the leak rate is less than or equal to 1/100 of a cell volume per minute at 2 in. w.g. differential pressure.

The building is maintained at a few hundredths of an inch w.g. vacuum during normal operation. The intake is through duct filters and check valves. The exhaust is through roughing and absolute filters located at the roof of the building or at the stack. The cell ventilation blower must have sufficient capacity to evacuate the building to 0.3 in. w.g. vacuum in 20 seconds by closing the intake. The building is sealed such that a leak rate of no more than 6×10^{-3} building volumes per minute will occur at a differential pressure of 0.3 in. w.g. This criterion is included to ensure that the building vacuum will be capable of balancing a vacuum of 0.3 in. w.g. that could be created on the lee side of a building by a 30-mile-per-hour wind. At ORNL it is pertinent to assume that winds of speed greater than 30 miles per hour are sufficiently rare as to be incredible.

4.0 TYPES OF DISPERSIVE ACCIDENTS

The most serious accidents that may credibly occur in large radiochemical facilities are chemical and nuclear explosions which rupture vessels that are filled with radioactive process solutions or solids. It is our current belief that a radiochemical facility can be designed in such a manner that the maximum credible explosion will correspond in gas production and blast effects to that of 3 lbs of TNT. Three pounds of TNT liberates approximately 5700 Btu of energy, generates approximately 100 cu ft of hot gases, and creates a shock wave which has a pressure of approximately 800 lbs per sq ft and an energy of approximately 230 ft-lbs per sq ft at a distance of 15 ft. Thick concrete cells of the type used in ORNL radiochemical facilities can withstand such explosive effects without rupture.

Examples of the types of explosions that may credibly occur in a radiochemical facility of special design and simulate the gas production and/or the blast effects of the reference TNT detonation are the detonation of 10 cu ft of a H₂-air mixture, the explosion of several pounds of a nitrated organic material, and a single nuclear burst of the order of 10^{18} fissions. Our studies indicate that the initial and maximum nuclear burst in vessels of the size used at ORNL will be of the order of 10^{18} fissions. A maximum credible accident will occur if the vessel is ruptured during this maximum burst, thus terminating the reaction; the accident would have less serious consequences if the vessel contains the excursion and the reaction recurs with 10^{19} to 10^{20} or more fissions until it is shut down by other means.

5.0 EFFECTS OF DISPERSIVE ACCIDENTS

The effects of the maximum chemical explosion are that an aerosol of the radioactive material would be formed in the cell air and a small fraction would reach the environment through the vessel off-gas system, cell ventilation system, and through successive leaks from the cell and from the building. The maximum nuclear burst would disperse new gaseous fission products and an aerosol composed of new nonvolatile fission products and the original radioactive material. Another effect of the maximum nuclear burst is that operating personnel would receive prompt neutron and gamma radiation through the shield. The maximum integrated dose through a 5-ft-thick concrete wall before personnel evacuate the facility would be less than 1 rem, however.

5.1 Gaseous Fission Products

The gaseous fission products which could be released in a nuclear excursion are the isotopes of xenon, krypton, bromine, and iodine. It is usually appropriate to assume that 99% of the bromine and iodine are removed in a vessel off-gas system consisting of scrubbers and absolute filters. It has been found that the isotopes with half-lives of the order of 1-10 minutes are controlling in downwind dose calculations. The maximum permissible concentrations of these isotopes are rather large, since they constitute only external radiation hazards; they make up for the higher permissible concentrations, however, because of their greater activity.

5.2 Radioactive Aerosols

The aerosol that would be dispersed in cell air by the maximum credible accident would consist of a dispersion of a radioactive solution, solid particles, or smoke. The solution-type aerosol will be emphasized, since more information is available on this type of aerosol and since most of the ORNL facilities are of the wet chemical type. Smokes and dusts may be evaluated using an analogous procedure, provided their properties are known or are assumed.

The physical properties of aerosols are such as to restrict very effectively the escape of radioactive particles to the environment. This is seen commonly in practice, since through the use of appropriate de-entrainment mechanisms the condensate from the evaporation of a radioactive solution may be made to contain only 10^{-4} to 10^{-6} of the activity of the solution. Gravitational settling is often sufficient to restrict an aerosol concentration; we have been able to show this through an approximate correlation of the solution concentration in air or vapor arising from cooling towers, evaporators, and air-sparged vessels. This correlation is shown in Fig. 2.

In order to evaluate the release of aerosols from a cell, we must be able to ascribe removal efficiencies to filters and to cracks in cell walls. For superficial

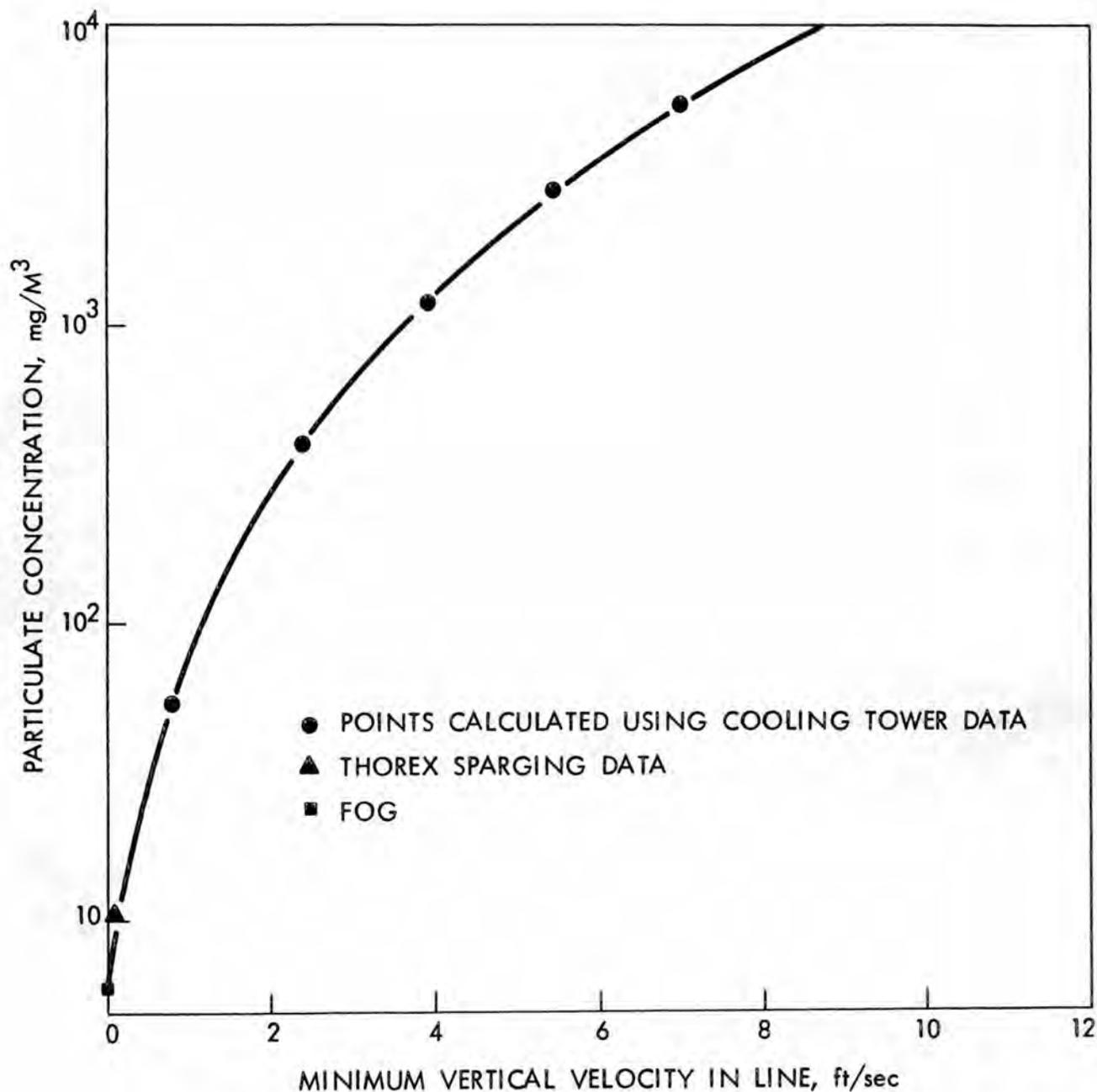


Fig. 2. The effect of minimum superficial velocity in an off-gas line on the concentration of liquid solution particles resulting from very vigorous mixing of a solution with air. (solution density = 1 g/cc)

velocities less than approximately 0.15 ft per second it has been found that an aerosol formed by vigorous mixing of a solution with air is metastable and has a concentration in the order of 10 milligrams per cubic meter. This metastable concentration is approximately equivalent to fog, which has a concentration of approximately 10 mg/M^3 and a particle size of approximately 10 microns. For orientational purposes a 1-in.-per-hr rain with mass mean particle size of 3000 microns has a concentration of 1000 mg/M^3 . At ORNL the particle size distribution of the metastable aerosol in a ventilation stream downstream from the source has consistently been found to have the particle size distribution shown in Fig. 3. Another piece of relevant information reported by Garner in Transactions of the Institution of Chemical Engineers is that the weight distribution of particles smaller than 10 to 20 microns will be fairly constant, even if there is gross entrainment of larger droplets. The knowledge that this distribution is fairly constant and constitutes approximately 10 mg/M^3 may be used to estimate the approximate concentration of particles smaller than a given size, even in an air stream which is very concentrated with liquid droplets. Practically, it is possible to assign efficiencies to an absolute filter and calculate the effluent concentration.

The following efficiencies were conservatively assigned to an absolute filter: 100% for particles greater than 5 microns, 99.95% for particles between 5 and 0.3 microns, 95% for particles between 0.3 and 0.1 microns, and 87% for particles less than 0.1 micron. The filter efficiency for particles smaller than 0.1 micron is based on data obtained at Harvard. Applying these efficiencies to the particle size distribution in Fig. 3, the effluent concentration of liquid aerosol from absolute filters is calculated to be 0.14 mg/M^3 . Calculations indicate that it is appropriate to assume that the liquid particles in the aerosol have essentially the original solution composition. In many instances it is also appropriate to assume 0.14 mg/M^3 as the filter effluent concentration of heavy element dust. This would indicate a conservatively high penetration of dust even if a large fraction is smaller than 0.1 micron, since it has been observed that heavy element dust exists in relatively stable air at concentrations only in the order of 0.1 to 1 milligram per cubic meter. It must be assumed that filters are only 87% efficient in removing smoke, since smoke particles are predominantly in the range 0.05-0.1 micron.

In evaluating the concentration of aerosols in air which leaks from a cell, it is considered that the design leak rate of a typical cell is equivalent to a flow of 100 cfm through a 5-in. orifice. Cell cracks will not simulate a single orifice but will consist of many small tortuous paths through 5 ft of concrete. The evaporator de-entrainment studies by Walsh and Schlea at SRP indicate that a single right angle impingement of characteristics that we think are indicative of cell cracks will conservatively reduce any liquid aerosol concentration to 10 mg/M^3 . Fine heavy element dust would be reduced to the order of 1 milligram per cubic meter and the concentration of smoke in leaked air would probably be no more than approximately 100 milligrams per cubic meter.

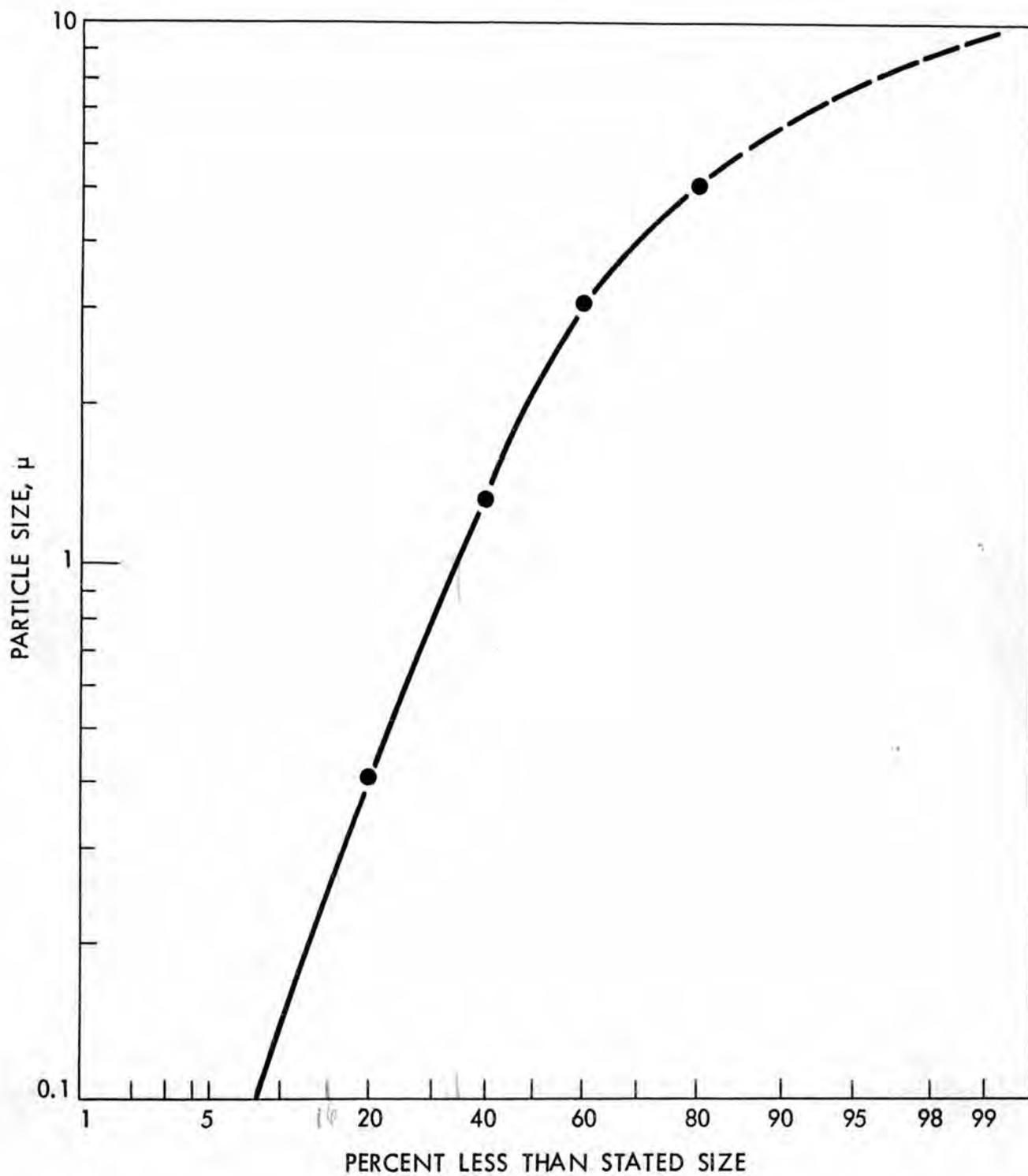


Fig. 3. The particle size distribution of a stable aerosol which has encountered several changes of direction in a pipeline.

6.0 METHODS OF EVALUATION

The downwind radiation dose that would be received from the release of radioactive material from a stack or elevated source during unchanging weather conditions may be expressed as the product of the curies released, atmospheric dilution factor, and appropriate conversion factors divided by the mpc_a . This relation is shown in Fig. 4. The mpc_a of a radionuclide may be considered as that concentration of the radionuclide in air which will cause 100 mr of radiation dose in 40 hr of exposure. In the case of radionuclides which are predominantly internal radiation hazards, the bulk of the dose does not occur during the exposure period but is accumulated over a lifetime, due to the presence of the radionuclide in the body. In the downwind exposure calculation we chose to use the so-called maximum average atmospheric dilution factor (Fig. 5), which is a measure of the maximum downwind ground concentration averaged over a period of the order of 1/2 hr and is an approximate measure of the maximum downwind ground concentration averaged over a several-minute period. We chose to evaluate the constant at a conservatively low wind speed of approximately 3 miles per hour, since this is the average ORNL wind speed and since it constitutes approximately the worst case. The plume rise of a stack causes the effective atmospheric dilution to be greater at significantly lower wind speeds, and of course at very high wind speeds the dilution is significantly greater because of the extreme turbulence. We applied this concept to the calculation of the downwind internal and external dose arising from the gaseous fission products and from the aerosol; it implicitly assumes that the aerosol which escapes through an absolute filter is of such a small size that it behaves as a gas and is inhaled and exhaled as a gas. We think it is a fairly good approximation, since the aerosol particles which escape through an absolute filter are generally less than 0.1 micron in size and have negligible settling velocity.

The downwind dose resulting from the release of gaseous fission products or aerosol through the vessel off-gas system is calculated using the relations given in Figs. 5 and 6. In calculating the effects of the gaseous fission products, it is assumed that a sustained or single burst of 10^{18} fissions occurs in the vessel and that the gaseous fission products continuously leave the vessel and are entrained as they are formed. For each gaseous radionuclide the maximum downwind dose is calculated taking into consideration decay of the radionuclide in transit to the ground and the decontamination factor for the radionuclide in the vessel off-gas treatment system. In general, it may be assumed that the decontamination factor for xenon and krypton gases is 1 and that the iodine and bromine isotopes are decontaminated by a factor of 10-100 in the caustic scrubber. The aerosol release is calculated assuming that aerosol is continuously generated in the vessel for a 1-hr period following the accident and is continuously entrained in the air which is normally flowing through the vessel off-gas manifold. It is assumed that the filter effluent contains a concentration of 0.14 milligrams per cubic meter of air which has the original solution composition of radioactive material.

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MAXIMUM AVERAGE GROUND DOSE RESULTING FROM
RELEASE OF RADIOACTIVE MATERIAL FROM A STACK

$$\text{DOSE, rem} = D = \frac{Qk (0.1) (1.44)}{(\text{mpc}) (1.44 \times 10^5)} = \frac{10^{-6} Qk}{(\text{mpc})}$$

Q = QUANTITY OF MATERIAL RELEASED, CURIES

(mpc) = CONCENTRATION, CURIES/M³, OF RADIONUCLIDE
IN AIR THAT CAUSES 0.1 rem OF RADIATION DOSE
FOR 40 HOURS OF EXPOSURE (SEE NBS-69)

Fig. 4

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MAXIMUM AVERAGE ATMOSPHERIC DILUTION FACTOR AND
DECAY TIME OF RADIONUCLIDES EN ROUTE TO THE GROUND

$$k = \text{MAX. AVG. DILUTION FACTOR, SEC/M}^3 = \frac{2}{\pi e u h^2}$$

u = WIND SPEED, M/SEC

h = EFFECTIVE STACK HEIGHT, M

$$t_D = \text{DECAY TIME, SEC} = t_v + \frac{1}{u} \left(\frac{h^2}{C^2} \right)^{\frac{1}{2-n}}$$

t_v = DECAY TIME EN ROUTE TO STACK

C = ATMOSPHERIC DIFFUSION CONSTANT (SEE AECU-3066)

n = ATMOSPHERIC STABILITY PARAMETER (SEE AECU-3066)

Fig. 5

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GROUND DOSE FROM VESSEL OFF-GAS SYSTEM RELEASE

A. GASEOUS FISSION PRODUCTS (FROM 10^{18} FISSIONS)

$$D_{AV} = \sum_i \left[\frac{Q_i^0 e^{-\lambda_i t D}}{X_i} \right] \frac{10^{-6} k}{(\text{mpc})_i}$$

X_i = DECONTAMINATION FACTOR FOR i

λ_i = DECAY CONSTANT FOR i , SEC^{-1}

Q_i^0 = CURIES OF i FORMED IN 10^{18} FISSIONS

$$= \frac{(10^{18} \lambda_i) (\text{FISSION YIELD})}{3.7 \times 10^{10}}$$

B. AEROSOL OF LONG-LIVED RADIOACTIVE SOLUTION

$$D_{BV} = \left[(A_V)(m)(0.14 \text{ mg}/\text{M}^3)(4.77 \times 10^{-4})(3.6 \times 10^3) \right] \frac{10^{-6} k}{(\text{mpc})}$$

A_V = VOG FLOW RATE, cfm

m = CONC. OF ACTIVITY IN SOLUTION, CURIES/mg

Fig. 6

The equations for evaluation of the cell ventilation system release are given in Fig. 7. It is assumed that a burst of 10^{18} fissions occurs which ruptures the process vessel and scatters its contents throughout the cell, terminating the reaction. It also assumes that the gaseous fission products are evenly distributed in the cell and remain mixed. The downwind dose from individual gaseous fission products is calculated taking into consideration decay in the cell and in transit to the ground and decontamination of individual gaseous radionuclides in the treatment system. The downwind aerosol dose is calculated assuming that aerosol is entrained in a volume of air equivalent to one cell volume which passes through the exhaust at the bottom of the cell to the cell ventilation manifold. If one wished to take into account additional generation of aerosol which might occur in the cell ventilation manifold, one would multiply the aerosol downwind dose by the ratio of the air flow rate at the filter to the cell purge rate.

The effect of a release to the secondary containment shell may be calculated using the equations in Figs. 8 and 9. The volume of cell air which leaks to the secondary containment cell is calculated knowing the cell leak rate at 2 in. of water differential pressure and assuming turbulent flow during the period in which the cell is pressurized. A pseudo dose to personnel in the secondary containment shell may be calculated by assuming that the leaked cell air is uniformly distributed in the volume of the secondary cell and personnel are exposed to this air for 2 minutes before evacuation. The concentration of aerosol in the leaked air is calculated considering impingement which occurs in the tortuous path through the cell wall and the gaseous fission product concentration is that concentration obtained by dispersing all of the gaseous fission products in the volume of the cell.

The release of activity from the secondary containment shell is by two mechanisms: the normal ventilation flow through the absolute filter and the building leakage which occurs if there is a significant wind to create a lee vacuum on the building. The downwind ground concentration for individual gaseous fission products and the aerosol is calculated using the equations in Fig. 10. The downwind dose is the sum of the dose which occurs from the leak from the building during the 20-second period which is required to evacuate the building to 0.3 in. w.g. vacuum and the release through the building ventilation system. For the gaseous fission products, appropriate corrections are made for decay inside the building and in transit through the building ventilation system.

In addition to the dose calculations, we calculated the downwind ground contamination that will occur from fallout of the radioactive particulate matter using equations given in AECU-3066 and the nomograms in ORO-176. The particle size of solution particles released from the secondary containment shell leak was assumed to be approximately 10 microns and the particle size released through the filter ventilation system was assumed commensurate with the filter efficiencies. The results were expressed as the distance downwind from the source to which the ground is contaminated

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GROUND DOSE FROM CELL VENTILATION RELEASE

A. GASEOUS FISSION PRODUCTS

$$D_{AC} = \sum_i \left[\frac{RQ_i^0 e^{-\lambda_i t D}}{(R + \lambda_i) X_i} \right] \frac{10^{-6} k}{(\text{mpc})_i}$$

R = CELL AIR REMOVAL RATE CONSTANT= CELL VOLUMES/SEC

B. AEROSOL OF LONG-LIVED RADIOACTIVE SOLUTION

$$D_{BC} = \left[\frac{V_C (0.14) m}{35.3} \right] \frac{10^{-6} k}{(\text{mpc})}$$

V_C = CELL VOLUME, cu ft

Fig. 7

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VOLUME OF RADIOACTIVE AIR RELEASED TO BUILDING
(SECONDARY CONTAINMENT SHELL)

$$V_L = \text{LEAKAGE VOLUME, cu ft} = \frac{1}{W_L} \int_0^t p^{1/2} dt$$

t = ELAPSED TIME WHILE CELL IS ABOVE ATMOSPHERIC PRESSURE

P = PRESSURE RELATIVE TO ATMOSPHERIC, in. H₂O

W_L = RESISTANCE, (in. H₂O)^{1/2} / (cu ft/SEC)

FOR A FACILITY IN WHICH ORNL CONTAINMENT CRITERIA ARE MET:

$$V_L \leq (0.1 V_C) \left[\frac{V_{EX}}{V_C} - \frac{1}{407} \right] \left[\frac{407 V_{EX}}{4 V_C} - \frac{1}{4} \right]^{1/2}$$

V_C = CELL VOLUME, cu ft

V_{EX} = EXPLOSION VOLUME, cu ft

Fig. 8

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PSEUDO TWO-MINUTE DOSE TO PERSONNEL BEFORE
EVACUATION OF THE SECONDARY CONTAINMENT SHELL

A. GASEOUS FISSION PRODUCTS

$$D_{AP} = \sum_i Q_i \frac{V_L}{V_C} \left(\frac{1 - e^{-120\lambda_i}}{\lambda_i} \right) \frac{(35.3) (10^{-6})}{V_B (mpc)_i}$$

V_B = SECONDARY CONTAINMENT SHELL VOLUME, cu ft

B. AEROSOL OF LONG-LIVED RADIOACTIVE SOLUTION

$$D_{BP} = \left[(10 \text{ mg/M}^3) (m) (V_L) \right] \frac{(120) (10^{-6})}{V_B (mpc)}$$

Fig. 9

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GROUND DOSE FROM SECONDARY CONTAINMENT SHELL RELEASE

A. GASEOUS FISSION PRODUCTS

$$D_{AS} = \sum_i Q_i^o \frac{V_L (10^{-6})}{V_C(\text{mpc})_i} \left[\frac{R_L k_L (1 - e^{-(R_L + \lambda_i)20})}{R_L + \lambda_i} + \frac{R_B k_B e^{-\lambda_i t_D}}{(R_B + \lambda_i)} \right]$$

$$R_L = \text{LEAK RATE CONSTANT, SEC. CONT. VOLS./SEC} = \frac{6 \times 10^{-3}}{60}$$

$$R_B = \text{VENTILATION RATE CONSTANT, SEC. CONT. VOLS./SEC} \approx \frac{0.1}{60}$$

$$k_L = \text{ATMOSPHERIC DILUTION FACTOR FOR LEAK, SEC/M}^3 \text{ (} u = 30 \text{ mph)}$$

$$k_B = \text{ATMOSPHERIC DILUTION FACTOR FOR BUILDING VENTILATION, SEC/M}^3$$

B. AEROSOL OF LONG-LIVED RADIOACTIVE SOLUTION

$$D_{BS} = \frac{(10) (m) (V_L) (10^{-6})}{(35.3) (\text{mpc})} \left[k_L R_L (20) + k_B \left(\frac{0.14}{10} \right) \right]$$

Fig. 10

to the hazard and required decontamination level. The hazardous level for beta-gamma contamination was considered to be that concentration in curies per square meter which would give a reading of 2-1/2 mr per hr above ground as determined by a GM survey meter with an open window. For alpha materials the hazardous ground concentration in curies per square meter was considered to be the arithmetic product of 250,000 times the mpc air for 40 hr of exposure.

7.0 RESULTS AND CONCLUSIONS

Using the methods that have been described, we were able to show to our satisfaction that the effects of what we considered to be the maximum credible accident in ORNL radiochemical facilities, which have been revised to meet the containment criteria, result in acceptable personnel exposure and downwind ground contamination. In our large wet-chemical facilities, such as Bldg. 3019, it was calculated that operating personnel or Laboratory personnel downwind from the facility could receive no more than a few multiples of the weekly permissible dose and that the ground downwind from the facilities would not be contaminated beyond 10% of the maximum permissible ground level.

One significant conclusion has been that, even if the filter effluent concentration which we have assumed is conservative by a factor of 100, the controlling dose downwind from a facility is that due to the release through the filtered vessel and cell ventilation systems rather than from the release through leaks in the cell and building. This suggests that the use of a filter with better particulate removal efficiencies than those which we assumed could conceivably justify the location of a secondarily contained radiochemical facility in an uncontrolled, populated area.

It is our hope that these containment criteria and methods of evaluation will stimulate investigation, particularly into the properties of aerosols and efficiency of air cleanup devices. The availability of better hazards evaluation data and cleanup devices will permit more public assurance and more realistic containment and siting criteria for radiochemical plants. It will possibly also permit a more realistic assessment of the safety of industrial plants in which nonradioactive but physiologically hazardous chemicals are handled.

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