

MODELING AND ANALYSES OF POSTULATED U<sub>F</sub> RELEASE  
ACCIDENTS IN GASEOUS DIFFUSION PLANT

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# MODELING AND ANALYSES OF POSTULATED UF<sub>6</sub> RELEASE ACCIDENTS IN GASEOUS DIFFUSION PLANT

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## ABSTRACT

Computer models have been developed to simulate the transient behavior of aerosols and vapors as a result of a postulated accident involving the release of uranium hexafluoride (UF<sub>6</sub>) into the process building of a gaseous diffusion plant. UF<sub>6</sub> undergoes an exothermic chemical reaction with moisture (H<sub>2</sub>O) in the air to form hydrogen fluoride (HF) and radioactive uranyl fluoride (UO<sub>2</sub>F<sub>2</sub>). As part of a facility-wide safety evaluation, this study evaluated source terms consisting of UO<sub>2</sub>F<sub>2</sub> as well as HF during a postulated UF<sub>6</sub> release accident in a process building. In the postulated accident scenario, ~7,900 kg (17,500 lb) of hot UF<sub>6</sub> vapor is released over a 5 min period from the process piping into the atmosphere of a large process building. UO<sub>2</sub>F<sub>2</sub> mainly remains as airborne-solid particles (aerosols), and HF is in a vapor form. Some UO<sub>2</sub>F<sub>2</sub> aerosols are removed from the air flow due to gravitational settling. The HF and the remaining UO<sub>2</sub>F<sub>2</sub> are mixed with air and exhausted through the building ventilation system. The MELCOR computer code was selected for simulating aerosols and vapor transport in the process building. MELCOR model was first used to develop a single volume representation of a process building and its results were compared with those from past lumped parameter models specifically developed for studying UF<sub>6</sub> release accidents. Preliminary results indicate that MELCOR predicted results (using a lumped formulation) are comparable with those from previously developed models. This was followed by a multi-volume representation of the process building to evaluate spatial effects in conjunction with plant-specific nuances related to ventilation flow distribution effects. We found that a more detailed representation of the process building can significantly reduce the source term magnitude, whereas spatial effects of aerosol transport are of secondary

importance. Specifically, we found that much less source term was predicted if we include a separate ventilation pathway in the cell housing (where the pipe break occurs).

## INTRODUCTION

The gaseous diffusion process is currently employed at two plants in the United States: the Paducah Gaseous Diffusion Plant and the Portsmouth Gaseous Diffusion Plant.

A lumped parameter model was developed in the past to evaluate the transient behavior occurring as a result of the postulated accidental release of uranium hexafluoride (UF<sub>6</sub>) in various process buildings of the gaseous diffusion plant (GDP) complex [Williams, 1986]. The model included treatment of UF<sub>6</sub> in solid, liquid, and vapor phases, whereas both HF and H<sub>2</sub>O could exist in liquid and vapor phases. Self-association (polymerization) of HF also was included. The model solves mass and energy balance equations for a compartment with a single volume representation, assuming that all the atmospheric materials are uniformly mixed in the volume. For aerosol transport, it specifies gravitational settling at a constant deposition velocity of 1cm/s. This model only considers aerosol deposition by gravitational settling, and neglects other mechanisms. Also by assuming a simple geometry for the entire process building, spatial effects of aerosol distribution and potential additional equipment and piping surfaces for aerosol deposition are also neglected. Motivation for the present study was to verify degree of conservatism in previous evaluations using a more systematic and mechanistic approach.

The ventilation system used in the GDP process building produces significantly different airflow patterns under summer and winter conditions. For conservatism, only the summer ventilation pattern is considered in the current

study, and is shown in Figure 1. Furthermore, because of voluminous size of the building ( $\sim 0.5 \times 10^6 \text{ m}^3$ ), only a portion of the building is assumed to be involved in a release and transport of aerosol/vapor materials. During summer, the ventilation system works as an once-through system in which air is drawn into the operating floor by pressure difference, forced to the cell floor by large blowers. About 66% of air is exhausted through motor exhaust, and the remainder exhausted through the roof vents and wall louvers. The volume of the cell floor affected by the release is assumed to be a portion of the total volume (e.g., only one of six or eight units in the process building). The cell floor space is divided into two volumes: one for the cell housing volume and the other for the remainder.

New computer models have been developed to simulate the transient behavior of aerosols and vapor as a result of a postulated accident involving the release of  $\text{UF}_6$  in process building at GDP. When  $\text{UF}_6$  is released into atmosphere, it will undergo an exothermic chemical reaction with  $\text{H}_2\text{O}$  vapor in the air to form uranyl fluoride ( $\text{UO}_2\text{F}_2$ ) and hydrogen fluoride (HF). Selected for the current study is the case with a break of a depleted  $\text{UF}_6$  piping located inside the cell housing (B-line), at high (operating) power in the process building. In this scenario,  $\text{UF}_6$  vapor is assumed to be released through a small break in the so-called B-line at a constant rate of 26.458 kg/s (58.33 lb/s) over 5 minutes<sup>1</sup>. Total amount of the released  $\text{UF}_6$  is 7,937 kg (17,500 lb). Since  $\text{UF}_6$  is released under relatively hot conditions (e.g., 417 K & 1.4 atm), it is in a vapor state.

The MELCOR computer code was selected for simulating aerosols and vapor transport in process building [Summers, 1991]. This code has been developed by the US Nuclear Regulatory Commission (NRC), and widely used for simulating postulated severe accidents in nuclear facilities. This code is written in a highly modularized fashion, and each module is designed to allow the user to change selected important parameters for maximizing capability for sensitivity studies.

MELCOR model was first used to develop for a single volume representation of the process building and its results were compared with those from the previous model developed by Williams; hereafter referred to the cascade-summer (CSCDSM) model for convenience. Thereafter, a study was extended to examine the effect of finer nodalization by specifying the cell housing as a separate volume to observe spatial effects from multi-volume calculations on aerosol/vapor transport.

### ASSESSMENT OF AEROSOL DEPOSITION MODELS OF CSCDSM AND MELCOR

This section describes aerosol deposition models in CSCDSM and MELCOR, along with comparisons of

<sup>1</sup> For a break of 10 inch opening,  $\text{UF}_6$  vapor is released at  $\sim 33 \text{ m/s}$  which is much below the critical flow.

MELCOR results against CSCDSM predictions for a set of simplified conditions.

### Aerosol Deposition Model in CSCDSM

Two ways of aerosol deposition (settling) are assumed in CSCDSM. One mode is totally arbitrary, and the other is physical. An arbitrary mode of aerosol settling is applied only for  $\text{UF}_6$  aerosols. When a user assumes the isentropic flashing model for condensation /vaporization of  $\text{UF}_6$ <sup>2</sup>, any  $\text{UF}_6$  aerosol particles are assumed to be deposited onto the floor instantaneously upon formation. For gravitational settling, a constant particle velocity of 1 cm/s for settling is hardwired in the CSCDSM code. The amount of settled aerosols during  $\Delta t$  is calculated as

$$\Delta m_d = \frac{m_c}{V} v A \Delta t \tag{1}$$

where  $m_c$  is aerosol mass at time,  $t$ , and this value keeps changing every time step since aerosols are assumed to be uniformly mixed in the atmosphere of entire control volume at every time step. Additionally,  $V$  is the total volume,  $v$  is the aerosol settling velocity (1 cm/s), and  $A$  is the floor area. Equation (1) can be rewritten in a differential form as

$$\frac{dm_d}{dt} = \frac{m_c(t)}{V} v A \tag{2}$$

where  $m_c/V$  is the aerosol concentration. The aerosol mass at time,  $t$ , can be expressed in terms of initial mass at time zero,  $m_o$ , and settled mass,  $m_d$ , as

$$m_c(t) = m_o - m_d(t) \tag{3}$$

Equation (2) can be integrated to provide an analytical expression for aerosol mass deposited as a function of time as

$$m_d(t) = m_o \left( 1 - e^{-\frac{vA}{V}t} \right) \tag{4}$$

The aerosol magnitude deposited as a function of time using Eq. (4) is shown in Figure 2. With  $v = 1 \text{ cm/s}$ ,  $V = 2.68837 \times 10^5 \text{ m}^3$  ( $9.493875 \times 10^6 \text{ ft}^3$ ) and  $A = 2.32 \times 10^4 \text{ m}^2$  ( $2.5 \times 10^5 \text{ ft}^2$ ), Eq. (4) gives 7,996 s for 99.9 % deposition, and 5,331 s for 99 % deposition of aerosol mass.

### Aerosol Deposition Model in MELCOR

Aerosol agglomeration and deposition processes are modeled in the radionuclide (RN) package of the MELCOR code. The code allows specification of aerosol size distribution and a particular type of aerosol material. This multisectional, multicomponent aerosol dynamics model evaluates the size distribution of each type of aerosol mass,

<sup>2</sup> CSCDSM assumes two flashing models. With isentropic flashing, any  $\text{UF}_6$  aerosols are assumed to fall onto floor instantaneously upon formation. With isenthalpic flashing mode,  $\text{UF}_6$  aerosols are assumed to be dispersed uniformly throughout the process building, and subjected to gravitational settling. Therefore, the latter case is expected to yield more source term magnitude.

TABLE 1 SOURCE TERM PREDICTION BY CSCDSM.

Time (s)	CSCDSM Results		
	UF <sub>6</sub> (kg)	HF (kg)	UO <sub>2</sub> F <sub>6</sub> (kg)
300	0	501	1,787
902	0	1,461	4,498
4,062	0	1,792	4,982

or component, as a function of time. This size distribution is described by the mass in each size bin, or section. Each section may have a different chemical composition as described by the masses of various components of that section. Aerosols can directly be deposited onto the heat structure and water pool surfaces through a number of processes, including gravitational settling, diffusion to surfaces, thermophoresis (a Brownian process causing migration of particles toward lower temperature), and diffusio-phoresis (deposition induced by condensation of water vapor onto structural surfaces). Aerosols can also settle from one control volume to another through "flowthrough" areas (i.e., gravitational settling and Brownian diffusion kernels are applied to "flowthrough" areas along with heat structure and pool surfaces). Such areas will ordinarily correspond to open flow paths between the control volumes, through which aerosols and radionuclide vapors are also advected.

The MELCOR calculation of changes in aerosol distribution and location considers the following general processes:

1. aerosol phenomenological sources from other packages, such as release from fuel rods or during core-concrete interactions, and/or arbitrary user-specified sources;
2. condensation and evaporation of water and fission products to and from aerosol particles;
3. particle agglomeration (or coagulation), whereby two particles collide and form one larger particle;
4. particle deposition onto surfaces or settling through flow paths into lower control volumes;
5. advection of aerosols between control volumes by bulk fluid flows; and
6. removal of aerosol particles by engineering safety features (ESFs), such as filter trapping, pool scrubbing, and spray washout.

For our case of UF<sub>6</sub> release accident calculations, the effect of gravitational settling dominates deposition magnitude over other deposition processes (1 or 2 orders of magnitude large).

#### Comparison Between MELCOR and CSCDSM Aerosol Deposition Models

Two different aerosol deposition models of MELCOR and CSCDSM were compared. For this comparison, 6,946 kg of UO<sub>2</sub>F<sub>6</sub> aerosols were assumed to exist in a control volume as

TABLE 2 BUILDING DATA UTILIZED IN MODELING UF<sub>6</sub> RELEASES IN PROCESS BUILDING.

Ambient temperature	299.7 K
Ambient pressure	101,325.4 Pa
Cell floor volume	268,836.6 m <sup>3</sup>
Cell floor - floor area	23,225.8 m <sup>2</sup>
Cell floor temperature	305.2 K
Cell floor pressure	102,042.4 Pa
Air supply blower capacity	609.6334 m <sup>3</sup> /s
Motor exhaust blower capacity	359.085 m <sup>3</sup> /s
Exhaust rate through roof vents	104.1258 m <sup>3</sup> /s
Exhaust rate through wall louvers	146.4226 m <sup>3</sup> /s
Roof vent height	25 m
Roof vent aggregate effective radius	3.075 m
Wall louver height	19 m
Wall louver aggregate effective radius	3.26 m
Motor exhaust (stack) height	25 m
Motor exhaust aggregate effective radius	5.27 m

an initial condition for the CSCDSM calculation, whereas in MELCOR, the aerosols were assumed to be released at a constant rate of 694.6 kg/s for the period of 10 s. One control volume was assumed and no ventilation paths were considered. Thus any aerosols in the control volume settled down due to gravity. Figure 3 shows deposited aerosol mass as a function of time, calculated by CSCDSM and MELCOR with various aerosol parameters. For MELCOR calculations, two aerosol parameters were varied to observe their effects on aerosol settling. One was the slip coefficient that measures the slip between aerosol particles and bulk fluid medium. This coefficient is used for the evaluation of particle mobility, and a reasonable value used as default is to be 1.257. Another parameter was the dynamic shape factor that determines the effect of aerosol geometrical shape. For a perfect sphere, this factor becomes 1. As seen in the figure, the CSCDSM results (assuming 1 cm/s of a constant aerosol settling velocity) agree very well with the MELCOR results. The MELCOR results are also shown to slightly vary with variations of some of aerosol parameters used for the calculations. However, such variation is not significant.

#### **BENCHMARK CALCULATIONS**

Benchmark calculations have been performed to ensure new modeling framework of source term evaluation during UF<sub>6</sub> vapor release accident in the GDP process building. The MELCOR code was used to model the framework, and its results have been compared with those obtained from the past work (e.g., CSCDSM results). The same release scenario was based as described in the previous section. Table 1 lists source term values predicted by CSCDSM.

#### MELCOR Input Description

To perform the benchmark calculations, MELCOR requires consistent input data as those used for CSCDSM

TABLE 3 ADDITIONAL DATA UTILIZED FOR MELCOR CALCULATIONS.

UF <sub>6</sub> vapor temperature at release	416.3 K
Molecular weight of UF <sub>6</sub>	352 kg/kg-mole
Relative humidity in the building	60 %
Rate of UF <sub>6</sub> release	26.458 kg/s
Period of UF <sub>6</sub> release	300 s
Total amount of UF <sub>6</sub> release	7,937 kg
Heat structure surface temperature	305.78 K
UO <sub>2</sub> F <sub>2</sub> density	6,375.3 kg/m <sup>3</sup>
Heat of reaction for UF <sub>6</sub> and H <sub>2</sub> O	318.66 kJ/kg of UF <sub>6</sub>

calculations. Table 2 lists some of data used for CSCDSM calculations [Williams, 1986]. Additional data were retrieved from the actual input deck for B-line break accident using CSCDSM, and given in Table 3.

For MELCOR calculations, UO<sub>2</sub>F<sub>2</sub> was assumed to always be solid, and HF always vapor. The UF<sub>6</sub> vapor pressure curve was developed in a form suitably utilized by MELCOR, as provided in Eq. (5) below. It was then compared with the curve obtained from the technical report by Williams [1986] as shown in Figure 4 with satisfactory agreements.

$$\log(p) = \begin{cases} -46.829 + 19.74 \log(T), & \text{for } T \in [273 \text{ K}, 337.06 \text{ K}] \\ -21.433 + 9.6925 \log(T), & \text{for } T \in [337.06 \text{ K}, 388.56 \text{ K}] \\ -16.41 + 7.7553 \log(T), & \text{for } T \in [388.56 \text{ K}, 503 \text{ K}] \end{cases} \quad (5)$$

where pressure,  $p$ , and temperature  $T$ , are in mmHg and K, respectively. The chemical reaction of UF<sub>6</sub> with moisture was assumed to be an instantaneous process, and thus the reaction rate in MELCOR was specified to be the same as the UF<sub>6</sub> release rate, 26.458 kg/s.

One-eighth section of the entire process building (one unit) was modeled as a single control volume. The MELCOR nodalization includes three control volumes, and five flow paths interconnecting these control volumes. As seen in Figure 5, a separate volume was assigned to the volume representing the motor exhaust duct. Also the environment was modeled as an arbitrarily large single control volume.

#### Description of MELCOR Results for the B-Line Break Accident

MELCOR results for the B-line break accident in the process building are illustrated in Figures 6 through 9. UO<sub>2</sub>F<sub>2</sub> and HF masses in the process building are plotted in Figure 6. During the release period of UF<sub>6</sub> (5 min), UO<sub>2</sub>F<sub>2</sub> aerosol mass is shown to increase up to about 5,000 kg at 300 s. Then it decreases due to gravitational settling and being released out of the building. In the same figure, about 100 % of HF vapor is shown to be released in about 2,000 s. CSCDSM results are compared with MELCOR predicted source term in Figure 7. Both code predictions on the HF vapor mass released into the environment are very close. For the UO<sub>2</sub>F<sub>2</sub> aerosol release, MELCOR predicted about 14%

TABLE 4 SOURCE TERM PREDICTION BY MELCOR.

Time (s)	MELCOR Results		
	UF <sub>6</sub> (kg)	HF (kg)	UO <sub>2</sub> F <sub>2</sub> (kg)
300	0	480	1,834
902	0	1,465	4,923
4,100	0	1,803	5,704

more source term than CSCDSM predictions. Figure 8 shows distribution of aerosol masses of different sizes in the process building. For this study, aerosol size was arbitrarily specified to vary between 0.4 and 1.3 micrometers. MELCOR discretized this range into five size bins. Aerosol mass in the larger size bin is shown to increase as time goes on due to agglomeration, condensation, etc. The temporal variation of mass median diameter of aerosols is shown in Figure 9. One must note that mass median diameter of aerosols does not increase beyond 1.05 micrometer. To examine the sensitivity of the user-specified aerosol size range onto aerosol growth, MELCOR calculation was repeated with 0.4 and 5 micrometer for lower and upper aerosol size limits, respectively. Its results are compared with the previous case (the size range of 0.4 and 1.3 micrometers), and shown in Figure 10. Even though the upper size limit of aerosol growth was increased to 5 micrometer from 1.3 micrometer, the mass median diameter increases only up to 1.28 micrometer. Table 4 summarizes MELCOR source term predictions for the cases with allowing aerosol deposition.

#### AEROSOL TRANSPORT WITH MULTIVOLUME BUILDING REPRESENTATION

The X-333 process building of the Portsmouth GDP that contains 640 stages (80 cells, 8 units), is 443.8 m (1,456 ft) long, 295.7 m (970 ft) wide, and 25 m (82 ft) high [Portsmouth GDP FSAR, 1985]. From symmetry considerations, only the single unit (1/8th building) of the cell floor area was modeled. For this task, the cell floor area was divided into three control volume as

CV-101 for the cell housing,

CV-102 for remaining lower volume of the building, and

CV-103 for balance of the building (upper section).

As seen in Figure 11, the cell housing was separated to take credit for the cell housing wall in retaining aerosols within the cell housing. The cell housing geometry was modeled as 4.57 m (15 feet) height with the same volume as CV-102. In other words, the lower section of the building (4.57 m) was equally divided into two volumes, CV-101 and CV-102. Between CV-101 and CV-102, three flow paths were provided in parallel at different elevations. Each flow path was estimated to have 10 m<sup>2</sup> of opening area, representing leakage through the wall between two control volumes. Also FL-104, leakage path between CV-101 and CV-104, was approximately estimated to be 100 m<sup>2</sup> opening. This size is about 1% of the total surface area of

the wall. The arrow of flow paths in Figure 11 indicates a positive direction of flow. UF<sub>6</sub> vapor was assumed to be released uniformly into CV-101, the cell housing.

The results of MELCOR calculations are shown in Figures 12 through 16. Figure 12 shows air mass flow rates between the cell housing volume and its surroundings. As seen in this figure, air (and aerosols and vapor) flows from CV-102 to CV-101, even during the period for UF<sub>6</sub> vapor to be released into CV-101. CV-101 cell housing volume is not pressurized much because an opening area in wall louvers is large enough for relief. The CV-102 pressure was predicted to be slightly higher than the cell housing (CV-101) pressure. A large amount of air/aerosol/vapor mixture goes into the cell housing, and escapes to the environment through wall louvers. Therefore, air flow pattern in the process building shown in Figure 13, is established. No air is seen to flow from the cell housing into other volumes within the process building.

Figure 14 shows UO<sub>2</sub>F<sub>2</sub> aerosol/deposited mass and HF vapor mass within the cell housing, CV-101. The result shows that a substantial amount of UO<sub>2</sub>F<sub>2</sub> aerosols is settled on the cell housing floor; that is ~3,100 kg versus 1,200 kg for a single node representation of the process building (Fig. 6). This is mainly due to a shorter distance for aerosols to travel to settle down (4.57 m versus 19.2 m for a single node representation), along with the fact that window louvers are the only path for aerosol release. Figure 15 shows UO<sub>2</sub>F<sub>2</sub> aerosol/deposited mass in various control volumes of the process building. As seen in the figure, no UO<sub>2</sub>F<sub>2</sub> appears in regions other than the cell housing where UF<sub>6</sub> vapor is released. This is because air flows always into the cell housing volume as described previously. Figure 16 shows source term release into the environment. Only ~3,800 kg of UO<sub>2</sub>F<sub>2</sub> aerosols are released into the environment as compared with ~5,700 kg for a single node representation (Fig. 7), thereby representing a significant decrease.

### SUMMARY AND CONCLUSION

MELCOR modeling framework was benchmarked against the CSCDSM model for a single volume representation of the process building for the B-line break accident. MELCOR predicted results comparable with those by CSCDSM. In particular, a constant velocity (1 cm/s) of aerosol deposition used in CSCDSM yields results for source term which are close to those from MELCOR single-volume model which mechanistically models aerosol physics.

For sensitivity studies of aerosol dispersion and transport in the process building, 1/8 section of the entire building was divided into several control volumes. Specifically, the process building was nodalized into three volumes to model the cell housing as a separate volume. Substantial leakage paths between the cell housing and its surrounding volumes were included. The results for this configuration show that air always flows into the cell housing because of a relatively strong air suction by wall louvers located in the cell housing. Consequently, no aerosols were predicted to leak

out of cell housing except through wall louvers. Since aerosols settle down quickly inside the cell housing (because of short settling distance), much less amount of aerosols were predicted to be released into the environment as compared to that of a single volume representation.

In summary, for the postulated accident involving the B-line break in the cell housing, the CSCDSM predictions yield very conservative results for source term magnitude, when we compare its results with MELCOR predictions with multi-volume representation of the process building.

### UNCERTAINTIES AND FUTURE WORK

There are several recognized uncertainties in the current study of source term predictions which need to be characterized. These are identified as follows:

- Structural integrity of the cell housing  
The cell housing framework is constructed of steel with 3/8-inch transite siding bolted in place [Porthmouth GDP FSAR, 1985]. The tops of the housings are 20-gauge ribbed steel removal hatches for ease of equipment removal. The bell ends of the compressors are connected to the housings with a heavy, reinforced plastic shroud bolted to the ends of the compressor with a metal ring. The cell housing is not designed to contain pressure loads from accidental release of UF<sub>6</sub> inside the housings. Structural integrity of the housings is not guaranteed when differential pressure increases above normal across the wall. If the wall falls down, aerosols and vapors can be easily entrained with air and released through motor exhausts.
- Air mixing behavior  
With a control volume modeling approach, we assumed that air, vapor and aerosols are uniformly mixed in a control volume. This may prove inadequate around motor exhaust suction that draw large quantities of air out of the building.
- UF<sub>6</sub> chemical reaction rate (non-homogeneous reaction)  
Upon being released, UF<sub>6</sub> is assumed to be mixed with air and react with moisture instantaneously. In reality, this is a rate process to take a finite time until chemical reaction between UF<sub>6</sub> and moisture completes. Un-reacted UF<sub>6</sub> will be dispersed easily, and at the same time, it can be condensed or solidified to become aerosols that are subjected to settling. Since a vapor form of UF<sub>6</sub> is expected to be more mobile than aerosols, the currently-evaluated source term magnitude may not be conservatively bounded.

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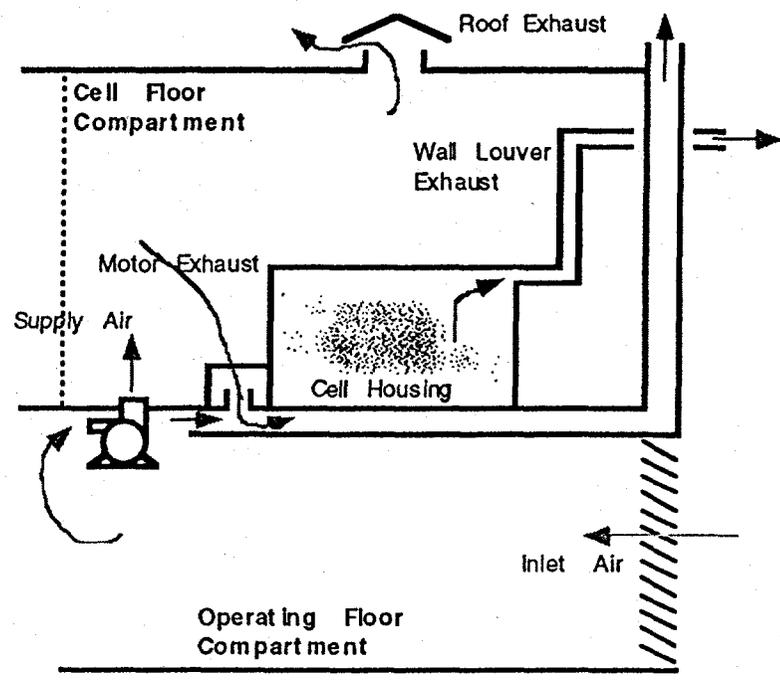


FIGURE 1 SUMMER VENTILATION PATTERN OF ONE UNIT OF THE PROCESS BUILDING.

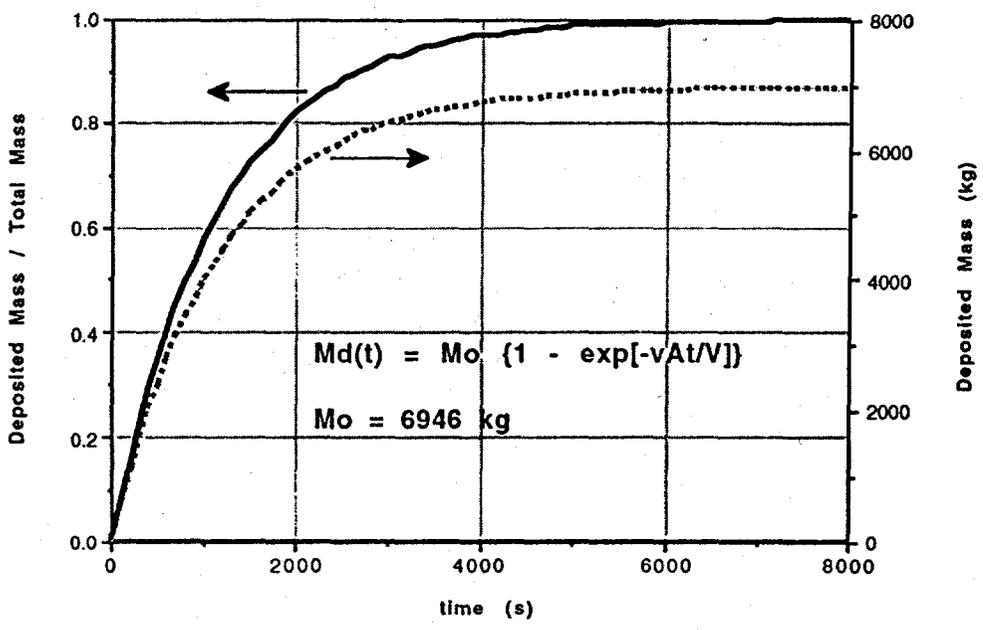


FIGURE 2 AEROSOL MASS DEPOSITED ON FLOOR PREDICTED BY CSCDSM MODEL.

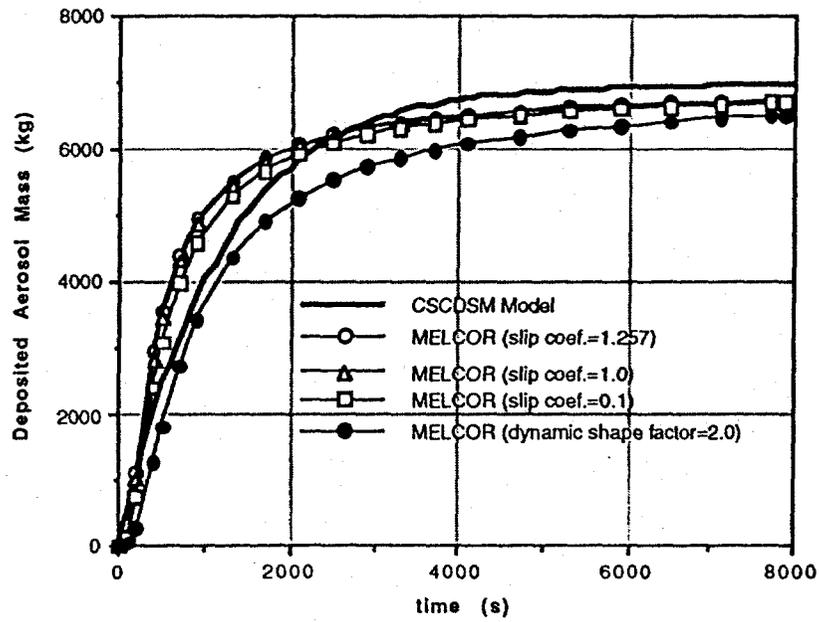


FIGURE 3 DEPOSITED AEROSOL MASS CALCULATED BY CSCDSM AND MELCOR.

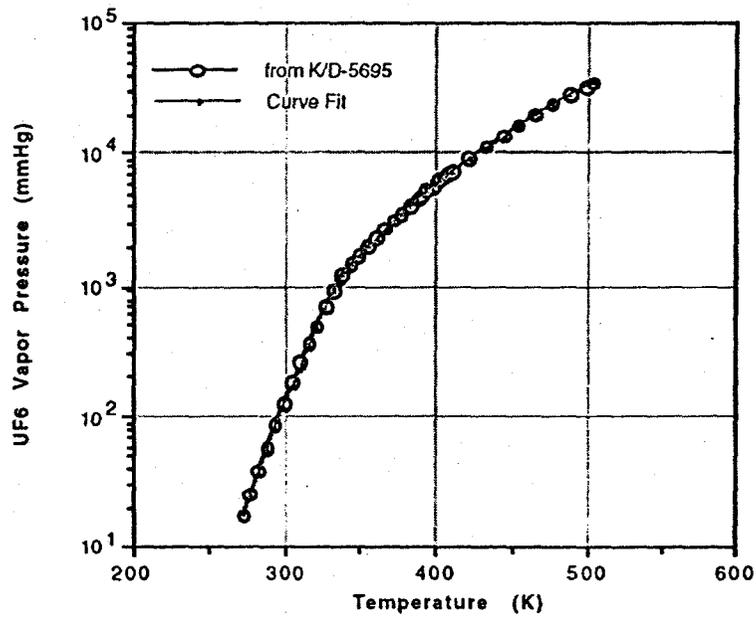


FIGURE 4 UF<sub>6</sub> VAPOR PRESSURE CURVE.

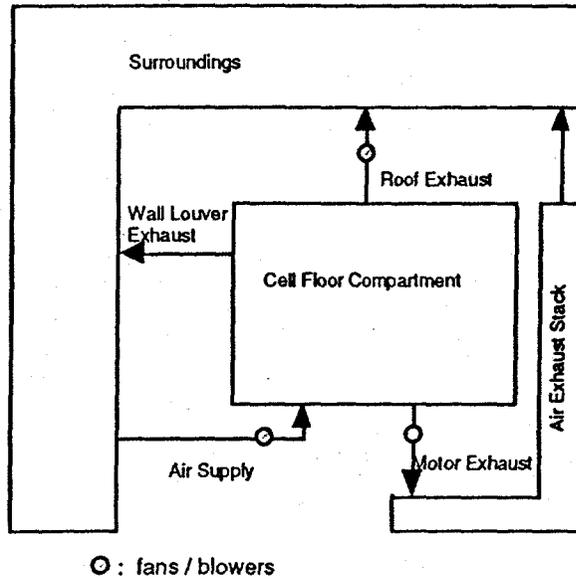


FIGURE 5 MELCOR NODALIZATION FOR BENCHMARK CALCULATIONS.

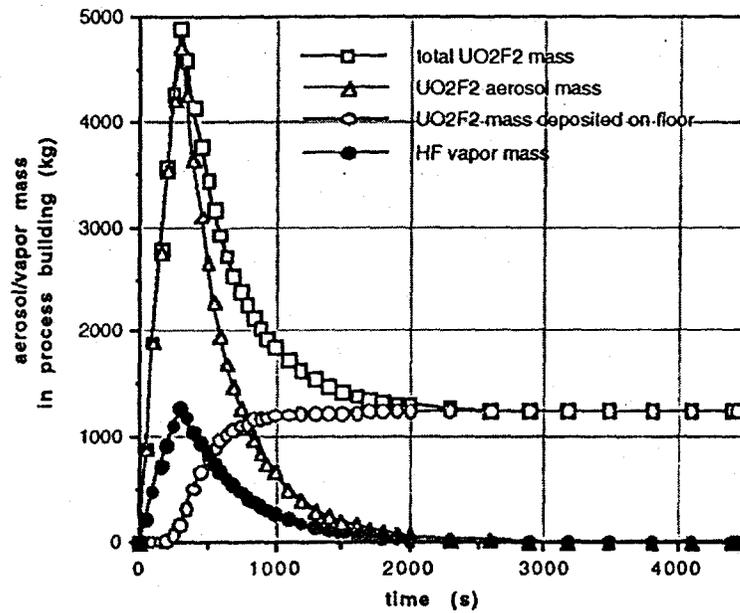


FIGURE 6 AEROSOL AND VAPOR MASS DISTRIBUTION IN THE PROCESS BUILDING PREDICTED BY MELCOR FOR THE B-LINE BREAK ACCIDENT.

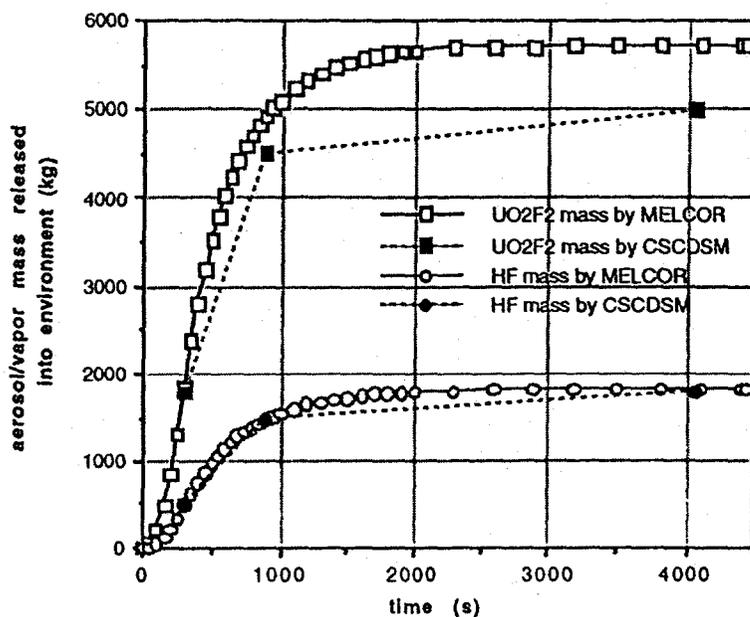


FIGURE 7 COMPARISON IN PREDICTED AEROSOL AND VAPOR MASS RELEASED INTO THE ENVIRONMENT BY MELCOR AND CSCDSM FOR THE B-LINE BREAK ACCIDENT.

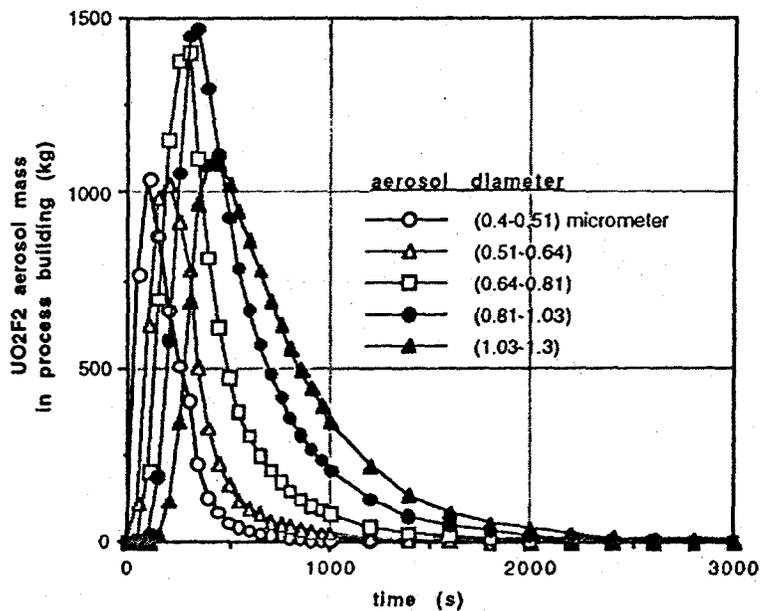


FIGURE 8 AEROSOL AND VAPOR MASS OF DIFFERENT SIZE BINS IN THE PROCESS BUILDING PREDICTED BY MELCOR FOR THE B-LINE BREAK ACCIDENT.

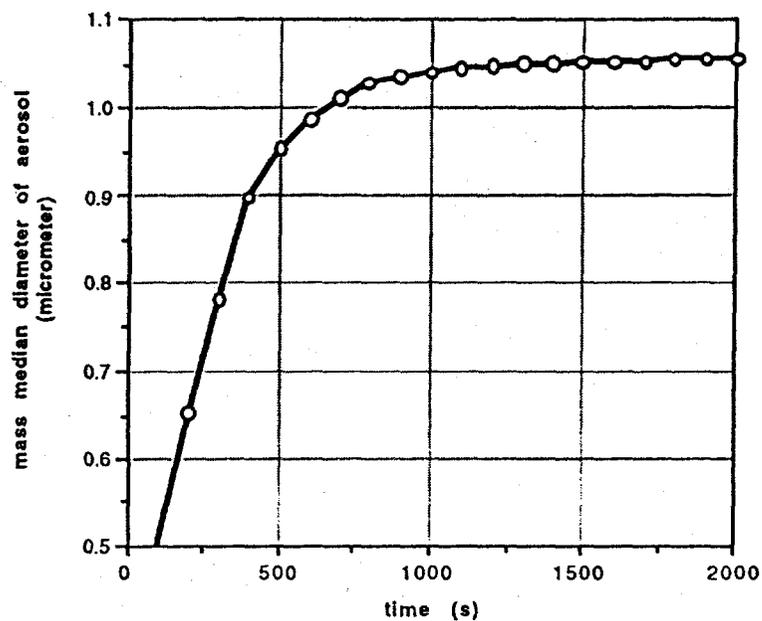


FIGURE 9 MASS MEDIAN DIAMETER OF AEROSOLS IN THE PROCESS BUILDING PREDICTED BY MELCOR FOR THE B-LINE BREAK ACCIDENT.

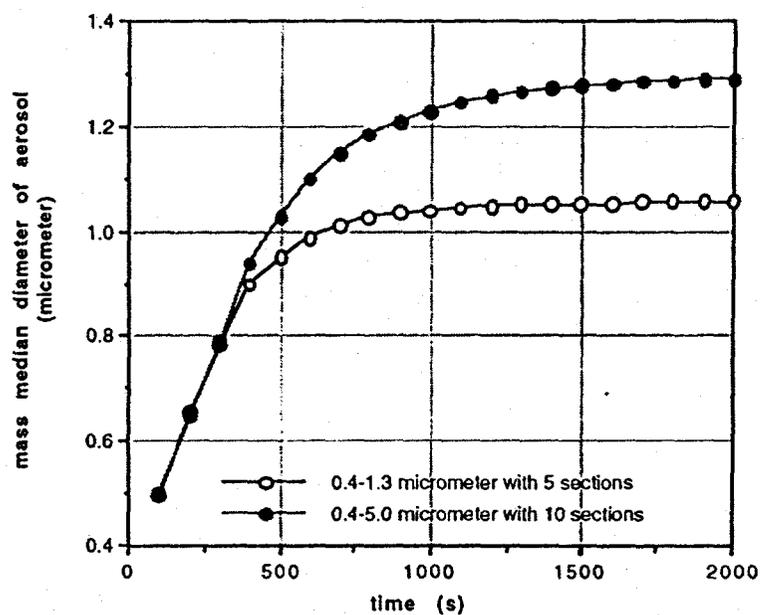


FIGURE 10 MASS MEDIAN DIAMETER OF AEROSOLS WITH TWO DIFFERENT UPPER SIZE LIMITS PREDICTED BY MELCOR.

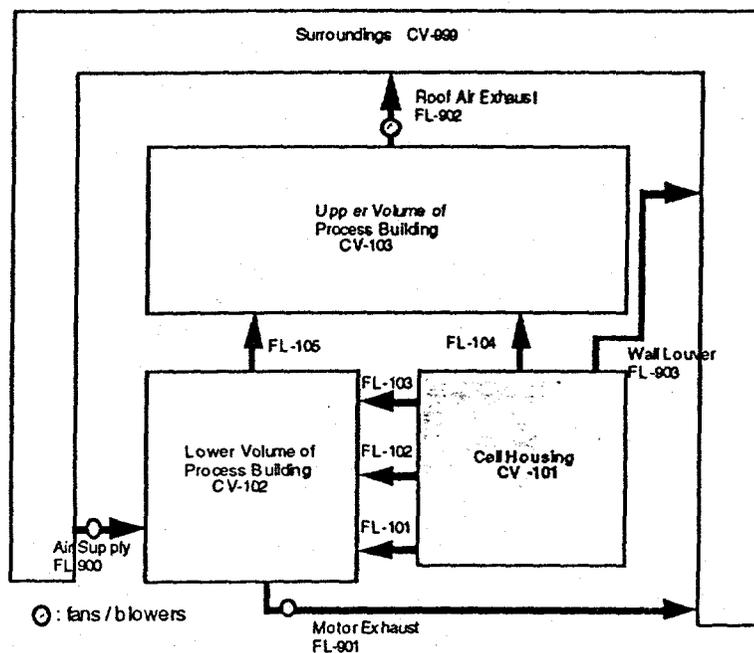


FIGURE 11 MELCOR NODALIZATION FOR THREE VOLUME PROCESS BUILDING.

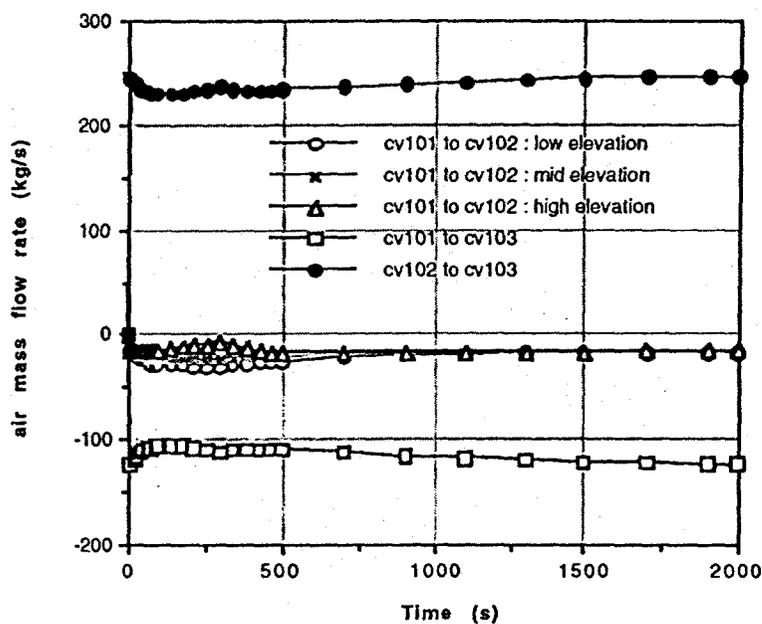


FIGURE 12 AIR MASS FLOW RATES FOR THREE VOLUME PROCESS BUILDING.

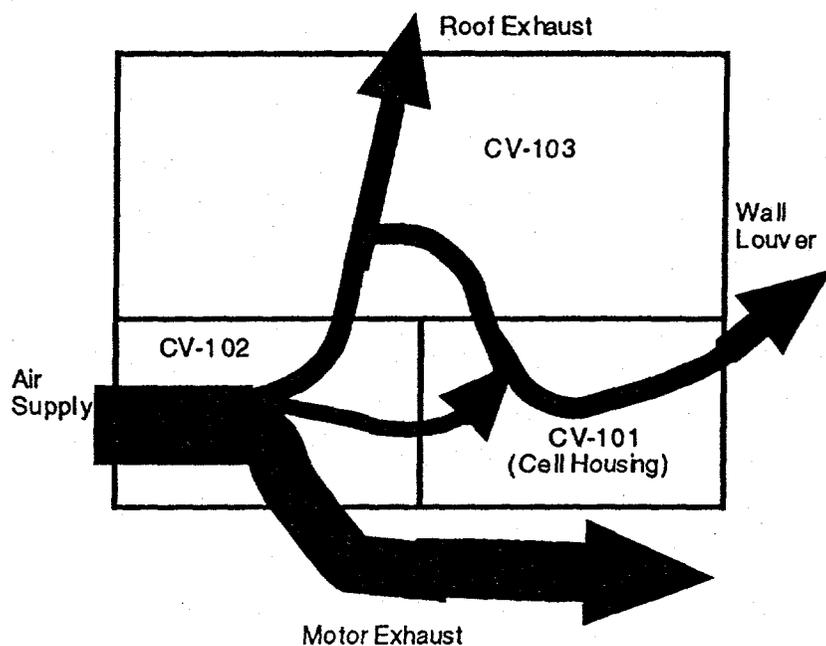


FIGURE 13 MELCOR PREDICTED AIR FLOW PATTERN WITHIN THE PROCESS BUILDING FOR THREE VOLUME PROCESS BUILDING.

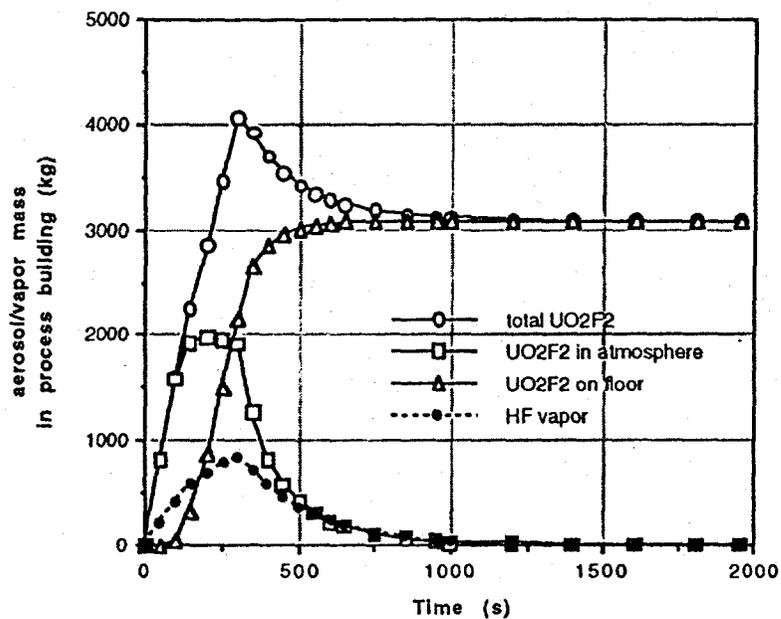


FIGURE 14 AEROSOL/VAPOR MASS IN THE CELL HOUSING FOR THREE VOLUME PROCESS BUILDING.

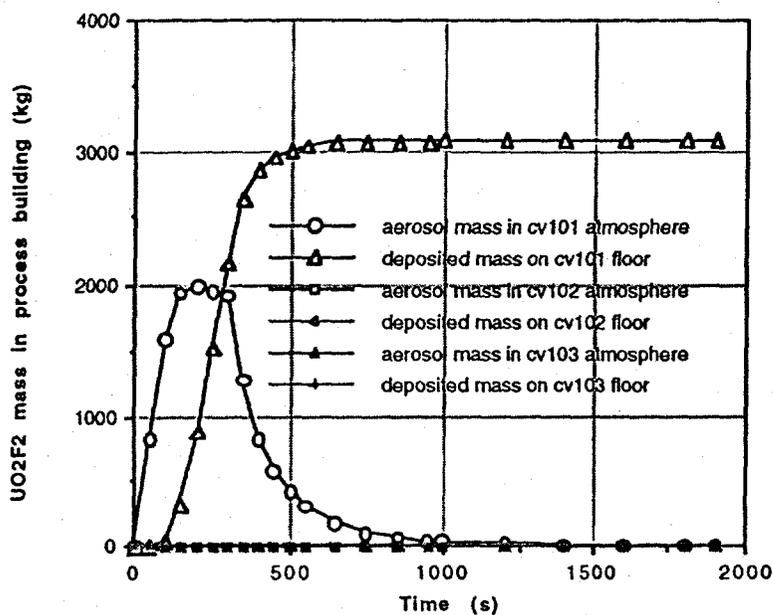


FIGURE 15 AEROSOL/DEPOSITED MASS OF  $UO_2F_2$  IN VARIOUS REGIONS FOR THREE VOLUME PROCESS BUILDING.

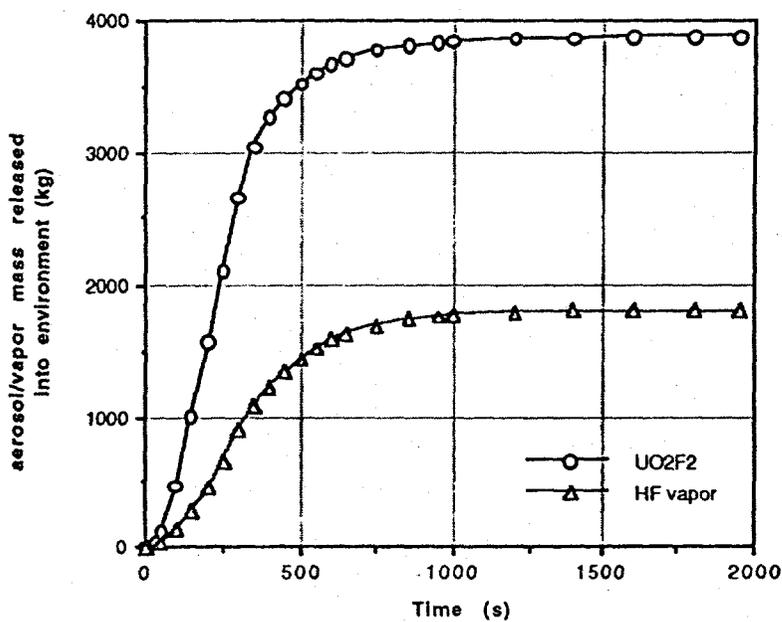


FIGURE 16  $UO_2F_2$  AND HF MASS RELEASED INTO THE ENVIRONMENT FOR THREE VOLUME PROCESS BUILDING.