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QUARTERLY TECHNICAL PROGRESS REPORT
LMFBR SAFETY PROGRAMS
JULY-SEPTEMBER 1971

AEC Research and Development Report

Atomics International
North American Rockwell

P.O. Box 309
Canoga Park, California 91304

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JULY-SEPTEMBER 1971

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Program: Reactor Development

AEC Task: 6-D, -E, and -F - Nuclear Safety, Gaseous Effluents, Sodium Fires

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I. PROJECT OBJECTIVES

The general objective of this project is to develop experimentally verified analytical models for postulated LMFBR accidents involving release and transport of energy and aerosols (sodium, PuO_2 , and fission products) in support of: (1) FFTF safety development needs, and (2) LMFBR Demonstration Plant Safety analysis, engineered safeguards design, and siting. Postulated LMFBR accidents under consideration by this project include sodium pool and spray fires, core disassembly accidents, and fuel accidents. Information derived from this project is essential to the realistic assessment of FFTF-LMFBR accident consequences, required for placing meaningful limits upon the design pressure and leak rates of containment barrier, as well as the site boundary. The objectives of this project correspond to those of Tasks 10-2.6 and 2.7 of the "LMFBR Program Plan, Section 10, Safety" (WASH-1110).

II. PROGRESS DURING REPORT PERIOD

A. SIMULATIONS OF SODIUM JET DISCHARGE

1. Water Jet Impingement Tests

A test program is being conducted to characterize the behavior of a sodium jet which discharges into an inerted (oxygen content up to ~ 2 vol%) LMFBR primary heat transfer system cell following a hypothetical pipe-rupture accident. This information will be used, in conjunction with appropriate analytical modeling, for realistic engineering analyses of pipe-rupture accident consequences for LMFBR primary cell design pressure criteria. The test program is designed to study jet breakup and droplet formation, as well as the heat transfer

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Figure 1. Water Jet for Impingement Tests

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characteristics of the resulting breakup phase, for various rupture and jet impingement configurations. The initial phase of this program is being performed with water. Water jets discharging from 1-, 2-, and 4-in. diameter pipes are allowed to strike a horizontal plate (9 ft diameter) placed at various heights above the exit from the pipes. The exit velocity at the mouth of the pipe is also varied. The radial rainout distribution and the droplet size distribution are obtained by collecting the rainout, both in empty containers and in dewar flasks filled with liquid nitrogen. Photographs of the droplet spread are also obtained. (See Figures 1 and 2.)

Figure 1 shows that the water jet has not broken up in its travel (upward) length of 2 ft. The exit velocity was 17 fps, and the pipe diameter is 1 in. ($H/D = 24$). Table 1 shows additional configuration data for the 1- and 4-in. diameter pipes. Figures 2a and 2b show typical rainout patterns of the breakup of the jet released from a 4-in. diameter pipe. The base of the parabola or bell was located 10 ft below the impinged plate. In Figure 2a, the plate was located 18 in. above the pipe exit ($H/D = 4.5$). The exit velocity was between 12 and 15 fps. Figure 2b shows the rainout pattern when the exit velocity was 36 fps, and the plate was 38 in. above the pipe exit. Table 1 shows some of the pertinent rainout characteristics of the 1- and 4-in. diameter jets as a function of velocity. In general, as the velocity increases, the diameter of the rainout increases.

The rainout configuration, from impingement on a horizontal plate, has two characteristic shapes. For low velocities, a bell or cylinder of droplets falls at the edge of a circular sheet formed on the plate (velocities of 15 to 17 fps). For higher velocities, a parabolic configuration of droplets occurs, and the diameter of the parabolic base increases with velocity. Both bell and parabolic rainout configurations occur in a velocity range between 12 and 25 fps. Figure 3 shows a profile of the rainout, as mass percentage observed at radial distances within the formation and as a function of nozzle velocity. The figures show the approximate fractions of the rainout configuration which are in the two regions previously discussed. The data are typical for both 1- and 4-in. diameter jets at $H/D = 4.5$. When $H/D = 10$, the instability factor of the jet becomes controlling, and only the parabolic pattern is formed.

$V = 12 \text{ to } 15 \text{ fps exit, } H = 18 \text{ in. ,}$
 $D = 4 \text{ in. , } V' = 9 \text{ to } 13 \text{ fps}$
 at impact

b. $V = 38 \text{ fps exit, } H = 38 \text{ in. ,}$
 $D = 4 \text{ in. , } V' = 31 \text{ fps}$
 at impact

Figure 2. Rainout Patterns of Breakup of Water Jet

TABLE 1
WATER JET TESTS (SODIUM SIMULATION)

Nozzle Diameter (in.)	Height/Diameter Ratio (H/D)	Nozzle Velocity (fps)	Mass at Mean Radius (%)		Mean Radius (ft)		50% Droplet Size (in.)		Maximum Spray Radius* (ft)
			Bell	Parabolic	Bell	Parabolic	Bell	Parabolic	
1	4.5 ↓	4.8	37		1.5		0.185		2
1		12.0	26		2.5		0.22		3
1		19.0	8	13	3.5	9	0.21		14
1		23.0	8.5	17	4.0	12	0.28		16
1		32	8.5	15	4.0	14	0.24	0.13	10
4		12.5		66		6	0.26		16
4		21		25		14	0.26		22
4		38		46		20	0.25		22

*Distance from the plate to the ground is 10 ft.

a. 1-in. Diameter Nozzle, $H/D = 4.5$

b. 4-in. Diameter Nozzle, $H/D = 4.5$

Figure 3. Radial Formation of Rainout for Various Jet Nozzle Velocities

Figure 4 shows how the vertical height of a jet varies with pipe size and exit velocity. It is obvious that the water jets from smaller pipes break up into drops with sufficient drag to reduce their travel distance.

Droplet size distribution shows little variation with radial distance, jet velocity, or pipe size. At low jet impact velocities, where the water column just reaches the plate, a waterfall formation occurs, and large sheets are observed when the water column falls upon itself. The median droplet size (mass averaged over impact velocities of 4 to 36 fps) over the whole fallout area for either formation is shown in Figure 5. High impact velocities (approaching 36 ft/sec) produce fine droplets at the outer edge of the formation; however, the mass percent is <5% of the total.

From these preliminary water jet experiments, it appears that droplet size may not change dramatically with pipe size and jet velocity. Thus, the sodium jet tests may be planned, based on these few water studies and the hydrodynamic model discussed later.

2. Sodium Jet Discharge Calibration Tests

A series of tests were conducted to calibrate the electromagnetic (EM) flowmeter system previously used in the sodium jet discharge into an air environment. The test equipment and setup are shown in Figure 6. The same setup will also be used in future tests. Known quantities of sodium were charged into the system through the receiver reservoir at ambient pressures, then transferred to the large sodium storage tank at high velocities, using nitrogen gas as the drive medium. All test data and pretest conditions (i. e., sodium temperature, drive pressure, timing event markers, etc) were recorded on magnetic tape. Test signals from two electromagnetic flowmeters, and the pressure of the nitrogen drive gas reservoir, were also recorded during each test. A 14-l gas reservoir was placed in line with the flowing nitrogen, in order to reduce the pressure loss as the gas expanded into the charge line and reservoir volume. During each test, the drive pressure was maintained for a sufficient length of time to expel all of the sodium from the system. Nearly constant velocities were obtained during this period.

A summary of the mass of sodium and the steady-state velocity involved in each test is presented in Table 2. Figure 7 shows typical EM flowmeter data

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Figure 4. Height of Water Column (Above nozzle) vs Exit Velocity

Figure 5. 50% Droplet Size Resulting From 1- and 4-in. Diameter Nozzles at Various Velocities ($V' = 4$ to 36 fps)

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Figure 6. Sodium Jet Discharge Calibration Apparatus

a. Test 9B - 65 psig Drive Pressure

b. Test 5 - 325 psig Drive Pressure

Figure 7. Sodium Discharge Tests

TABLE 2
SODIUM JET DISCHARGE CALIBRATION TEST SUMMARY

Test No.	Quantity of Sodium (lb)	Drive Pressure (psig)	Constant Average Velocity (fps)
4	7.4	275	84 ± 1
5	7.6	325	96 ± 4
9B	9.3	65	34 ± 2

during the calibration runs. A single test (Test No. 4) was conducted, using 275 psig drive pressure which was sustained for 9.1 sec, to simulate the discharge velocity obtained during the first sodium jet test in air.⁽¹⁾ The results from this test show that the peak velocity in the first sodium jet test in air was 50 fps.

B. MODELS OF JET IMPINGEMENT BEHAVIOR

1. Scaling of Experiments with Impinging Jets

It previously has been proposed that a sodium or water jet impinging on a wall or ceiling would spread out over the surface in a sheet, with little or no splashing into droplets. Experiments with water jets now show that the expected range of velocities extends to velocities so high that no sheet is formed, all the liquid recoiling from the plate as droplets. At low velocities, the sheet is formed, however; and, at intermediate velocities, there is a transition, with the sheet diminishing and the droplets increasing as the velocity increases. Thus, it has become necessary to consider how to predict, from experiments on jets with diameters from 1 to 4 in., the nature of this transition in a jet which, in the pipe-rupture accident, is 16 in. in diameter.

The significant parameters defining the conditions of the experiment are:

D = diameter of nozzle = initial diameter of jet

D' = diameter of jet at impact

H = distance from nozzle to ceiling (assumed to be vertical)

V = velocity of jet at nozzle

V' = velocity of jet at impact

ρ = density of liquid

η = viscosity of liquid

σ = surface tension of liquid

The list of initial conditions is redundant to some extent, as the initial conditions are related by the conservation law for the liquid,

$$D^2 V^2 = D'^2 V'^2, \quad \dots (1)$$

and by that for its energy,

$$V^2 = V'^2 + 2gH, \quad \dots (2)$$

where g is the acceleration of gravity.

From the three independent initial values and the three material properties, three dimensionless combinations can be constructed that determine the course of events. These are the Reynolds number,

$$Re = \rho V' D' / \eta, \quad \dots (3)$$

the Weber number,

$$We = V'^2 D' / 2\sigma, \quad \dots (4)$$

and the geometrical ratio, D'/H .

Since the diameter D' is necessarily smaller in the experiments than in the intended applications to accidents, while the material properties, ρ , η , and σ , are hard to vary in a compensating manner, the two parameters, H and V , are the only ones subject to convenient control. Thus, only two of the three dimensionless parameters can be chosen independently, and a fully satisfactory scaling scheme is not possible. However, many partial scaling schemes are possible, in each of which two functions of the three dimensionless numbers are held constant. The three most obvious ones are as follows:

Non-Geometrical: "Physical Scaling" — The values of Re and We are correct, while the geometrical ratio, D'/H , is left uncontrolled.

Non-Weber: "Reynolds Scaling" — Re and D'/H are correct, while the Weber number, We , is left uncontrolled.

Non-Reynolds: "Weber Scaling" — We and D'/H are correct, and Re is uncontrolled.

The success of such schemes depends on the insensitivity of the system's behavior to the variable left uncontrolled.

If the attempt is made to find an alternative to the preceding general and formal discussion, by considering the details of the processes that occur in the system, serious difficulties are encountered in the actual impact of the jet. On the other hand, some progress is possible, as regards the behavior of the jet during its flight from the nozzle to the plate. It appears, both in our experiments and from the literature,* that the integrity of the jet's surface is rapidly destroyed by entrainment of air, if the jet velocity is sufficiently high. A "mixing zone," containing both air and liquid, is formed between an inner core of pure liquid and the surrounding pure air. The thickness of this zone is said* to increase linearly with distance from the nozzle, so that the inner core has the form of a cone with the nozzle as its base and its vertex downstream from the nozzle, while the outer surface of the mixing zone is a truncated cone, expanding downstream from the nozzle.

When this configuration impinges on the ceiling, the liquid in the mixing zone will probably recoil as droplets. The acceleration attending the impact will tend to separate the air and liquid, but this process is unlikely to go very far in the limited time of the impact, and, in any case, can never be complete, since its late stages must involve thin films of air or liquid (between liquid drops or air bubbles, respectively) whose further diminution is opposed by rapidly increasing viscous forces. The low cohesion and high compressibility of the "mixing zone," due to the entrained air, will tend to favor splashing or recoiling over formation of a sheet flowing on the ceiling; while the fragmented structure of this zone will

*G. Birkhoff and E. Zarantonello, Jets, Wakes, and Cavities (Academic Press, New York, 1957)

tend to result in a rainout of small drops, rather than some more coherent configuration. Thus, the mixing zone may be conceived as "preformed droplets," which have only to bounce off the ceiling to become an actual rainout.

The inner core of unmixed liquid presumably still tends to form a sheet, flowing on the ceiling. However, the quiet development of this sheet is disturbed by the impact on it of the mixing zone. The final behavior of the system then depends on the extent to which either the sheet entrains and incorporates the mixing zone, or the impact of the mixing zone makes splashes that transfer liquid from the sheet to droplets. Of course, if the distance, H , of the nozzle from the ceiling exceeds the distance from the nozzle to the vertex of the conical surface of the inner core, the inner core does not reach the ceiling, and only the mixing zone is involved in the impact. In that case, presumably, no sheet is formed, and all the liquid splashes back as droplets.

When the scaling problem is reviewed in the light of these physical considerations, it is apparent that the partition of liquid between the inner core and the mixing zone is a function of the geometrical ratio, D'/H , and the influence of that partition on the ultimate partition between sheet and droplets makes it impossible to ignore D'/H in the scaling. Also, the structure of the mixing zone [represented, for example, by the extent of air-liquid interface per unit volume in the zone, which, with the composition (represented by the air-liquid volume ratio), determines the mean hydraulic radii of the air and liquid regions] is sensitive to the surface tension of the liquid and to the turbulence of the flow, and thus to the Weber and Reynolds numbers. Consequently, none of the three simple scaling schemes previously noted seems likely to succeed.

It remains possible, however, that a single combination of the Weber and Reynolds numbers dominates the process. If this combination is velocity dependent, it can be controlled through the velocity, and satisfactory scaling becomes possible. But, if this combination is the velocity-independent ratio,

$$Re^2/We = 2\sigma\rho D'/\eta^2, \quad \dots (5)$$

then successful scaling is still impossible, without controlling material properties.

Figure 8. Aerosol Concentration and Mass Settled vs Time

Another possibility is that the viscosity is not important, in itself, but only through its influence on turbulence. In that case, the turbulence in the small experimental pipes may be artificially increased to the value naturally occurring in the large pipes of the intended application. Then Weber scaling might be satisfactory. Since, moreover, the intensity of the turbulence increases somewhat slowly with increasing Reynolds number, the breakdown of Weber scaling, even without artificial control of turbulence, may not be prohibitive.

It is necessary to scale the results of the experiments, as well as their defining parameters. The results may have the form of a distribution of liquid drops as a function of their diameter (d), the distance (R) at which they leave the ceiling, and the angle (θ) between the ceiling and the initial direction of their trajectories. Since drop size is probably far more sensitive to surface tension than to viscosity, the appropriate dimensionless parameters appear to be the angle (θ), the ratio (R/D), and a new Weber number,

$$We = \rho V'^2 d / 2\sigma \quad \dots (6)$$

These three variables, with the two or three from the defining conditions, are suitable arguments for the liquid-drop distribution function.

C. LABORATORY TEST CHAMBER (LTC) AEROSOL STUDIES

1. UO₂ Vaporization Generator Tests

Analysis of the UO₂ arc vaporization experiment (Experiment 71-7) indicated a peak aerosol concentration of 15.5 $\mu\text{g}/\text{cm}^3$. The aerosol was produced in the 40 ft³, 6-ft high LTC. The suspended concentration and mass settled vs time are shown in Figure 8. The aerosol samples were collected on membrane filters, and were analyzed for mass by weighing. Samples were taken at one location in the vessel, and thus may not represent the true average during the early period of the experiment.

During the experiment, aerosol fallout samples were collected on microscopic slides. The collection period was ~ 15 sec, at intervals shown in Figure 9. Thus, the settling rate and aerosol particulate parameters, such as diameter, density, and shape, could be obtained. Photographs of a representative portion of the samples taken at various intervals during the experiment are shown

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Figure 9. Aerosol Settling Rate

in Figure 10. The photographs were taken by using a microscope and direct lighting, 30° from the horizontal. The magnification of the particles shown in the pictures is 20 μ /in. The mass of fallout in each photograph was calculated by weighing the fallout on the slide, and using the surface ratio of the slide and that portion of the slide represented by the photograph. The mass of material on each photograph, and the sample time, are shown in Table 3. The volume of the mass on each sample was determined by estimating the diameters and thicknesses of the particles. (This, combined with the weight measurement, allowed the calculation of the density of the agglomerated particulates. These values are shown in Table 3.) Further comparison of the particulate diameter-density history is illustrated in Figure 11 for the initial 20 min of UO₂ Experiment 71-7. The density of the particles is initially high, reaches a minimum, and increases during the period when the effective diameter is decreasing. Both of these phenomena are related to the concentration of the suspended material.

Table 3 also shows how Stokes diameter, computed from the mass deposition rate divided by the instantaneous concentration, compares to the optical diameter. The large difference in these two sizes may account for the collision diameter needed in the gravitational agglomeration model.

D. AEROSOL MODEL DEVELOPMENT

1. HAA-3 Model Development

As in other computer models which simulate the behavior of aerosols in closed systems, the HAA-3 model treats the agglomerated particle as an ideal sphere for the calculations of gravitational collision cross sections and Stokes settling velocities. Comparisons of model calculations and experimental data from high-initial-concentration sodium oxide and uranium oxide aerosols do not agree, if the ideal settling velocity is used. The agglomerated particles in these experiments were not spherical, and their behavior was not expected to be ideal. It is well known that nonspherical particles would settle with terminal velocities less than that which would be computed with Stokes Law for ideal particles. Agreement between model calculations and experimental data is obtained, if the calculated Stokes velocity for an ideal sphere is reduced by a correction factor as low as 0.25, to compensate for the presence of nonspherical particles.

a. Sample No. 1

b. Sample No. 2

c. Sample No. 3

Figure 10. Aerosol Fallout Samples
(Sheet 1 of 2)

d. Sample No. 4

e. Sample No. 5

f. Sample No. 6

Figure 10. Aerosol Fallout Samples
(Sheet 2 of 2)

TABLE 3
AEROSOL FALLOUT SUMMARY
(Experiment 71-7)

Sample No.	Sample Time	Mass of Sample* in Photograph (gm) ($\times 10^{-9}$)	Particle Density† (gm/cm ³)	Effective Optical Diameter (μ)	Stokes Diameter (μ)
1	3 min to 3 min 15 sec	-	-		1.07
2	5 min to 5 min 15 sec	0.61	0.92	3.8	2.92
3	7 min to 7 min 15 sec	2.3	0.53	9.1	4.4
4	9 min to 9 min 15 sec	2.8	0.63	9.1	5.2
5	11 min to 11 min 15 sec	2.7	0.62	9.2	4.75
6	20 min to 21 min	1.6	1.15	6.1	3.0

*The mass of the material in the photograph is obtained by multiplying the ratio of the surface areas of the photograph and collected sample to the mass of the collected sample.

†The photograph is typical of the many fields available. The diameter and mass measurements, as given, are only an approximation. (1 in. of the photograph is equivalent to 20 μ .)

Figure 11. Aerosol Particle Diameter and Density vs Time

A review and interpretation of the literature was made, to evaluate the effects of agglomerate density and shape on the settling velocity of nonspherical particles.

Data from Kay and Johnstone⁽¹⁾ and Lane and Stone⁽²⁾ have been re-examined, to evaluate the changes in Stokes settling velocity due to changes in the particle density or shape resulting from agglomeration. The data which were analyzed were the measured Stokes velocity and the particle mass. The measurements were made, using a Millikan cell, for a variety of aerosol materials.

The Stokes settling velocity for ideal spheres (V_I) is proportional to $CD^2\rho$:

$$V_I = \frac{gD^2\rho_I}{18\eta} , \quad \dots (7)$$

where:

g = acceleration due to gravity

η = viscosity of gas

D = diameter of sphere

ρ_I = ideal density of sphere

C = Cunningham's correction factor

The effective size (D_w) of the particle agglomerate is computed from the measured mass and measured Stokes velocity (V_{Si}):

$$D_w = 2 R_w = \frac{2 Mg}{6\pi\eta V_{Si}} . \quad \dots (8)$$

The effective density (ρ_w) is then computed by:

$$\rho_w = \frac{3M}{4\pi(R_w)^3} , \quad \dots (9)$$

where:

M = mass of particle

R_w = the Whytlaw-Gray radius

ρ_w = the effective density, based on the R_w

Figure 12 compares the experimental ratios of V_{Si}/V_I and ρ_w/ρ_I , where:

$$\rho_w/\rho_I = (V_{Si}/V_I)^3 \quad \dots (10)$$

All of the data fit Equation 10.

Figure 13 shows that the computed effective density decreases more for loosely packed than for tightly packed aggregates. Figure 13 also shows how R_w varies with mass for different degrees of packing.

2. Shape Factor Effects

Experiments have shown that the resistance (F_M) offered by a fluid is given by Stoke's law, even for particles of nonspherical shape, if the numerical coefficient (μ) is adjusted according to the shape of the particle:

$$F_M = 6\pi\eta V_s r\mu \quad \dots (11)$$

where:

μ = dynamic shape factor

V_s = settling velocity

r = particle radius

The ratio (μ) of the resistance of a given particle to that of a spherical particle having the same volume is called the dynamic shape factor of the particle. According to Stober,⁽³⁾ the dynamic shape factor can be defined as: (1) the ratio of the Stokes settling velocity of an ideal sphere (V_I) to the settling velocity of a nonspherical particle (V_{Si}), (2) the ratio of the square of the radius of the ideal sphere (R_I) to the square of the Stokes radius of the nonspherical particle (R_s), (3) the ratio of the resistive force for a nonspherical particle to the resistive force of a sphere with the same volume:

Figure 12. Comparison of Velocity and Density Ratios

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Figure 13. Comparison of Effective Particle Density and Particle Radius for Several Types of Agglomerated Ammonium Chloride

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Figure 14. Effect of Number of Particles in an Aerosol Agglomerate on the Dynamic Shape Factor

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$$\mu = \frac{V_I}{V_{Si}} = \frac{R_I^2}{R_s^2} = \frac{V_{Si} R_w 6 \pi \eta}{V_I R_s 6 \pi \eta} \quad \dots (12)$$

Experiments on the effect of shape factor on settling velocity have been performed by others, using ellipsoids of revolution, circular cylinders, and other solid bodies of known geometrical shapes. The data from these studies demonstrate that the values of μ for elongated bodies of different shapes, but with the same axial ratio, are very close to one another. Rod-like particles have similar shape factors to prolate ellipsoids, and disc-shaped particles may be treated as oblate ellipsoids. The resulting error is less than a few percent. Stober⁽³⁾ has evaluated the dynamic shape factor for prolate and oblate ellipsoids, and compared them to values for cluster and elongated aerosol particles. It was found that round cluster agglomerates of uniform spherical particles have dynamic shape factors which are influenced by the packing density of the cluster, but not by the size of the cluster. Elongated agglomerates have shape factors which are proportional to the cube root of the number of particles in the linear agglomerate. Figure 14 shows the theoretical curve from Fuchs⁽⁴⁾ and from Stober⁽³⁾ for prolate ellipsoids, clusters, and chain agglomerates. The experimental data shown in Figure 14 are derived from Kay and Johnstone and Lane and Stone. It can be seen that the Stober relationships approximate the data very well, for both cluster and chain agglomerates. Stober states that the maximum value of μ for clusters is 1.25 (Figure 14, Curve No. 1), and the relationship for chains (Figure 14, Curve No. 3) is

$$\mu = 0.862 (N)^{1/3} \quad \dots (13)$$

where:

N = number of particles

A settling velocity correction term which agrees with the existing studies on the effect of the shape factor on settling velocity is suggested for HAA-3. If the code could compute the number of unitary particles in each agglomerate, the shape factor could be computed from Equation 13. In the gravitational agglomeration kernel, the corrected settling velocities can still be used, but the particle sizes should be corrected to simulate the larger effective size of a loose agglomerate.

The relationship between the effective size and the ideal size computed in HAA-3 is the particle shape factor,

$$\frac{R_w}{R_I} = \mu = \frac{V_I}{V_{Si}} \quad \dots (14)$$

The increase in cross-sectional area ($R_w^2 > R_I^2$) would then imply a decrease in the gravitational collision efficiency factor (α) which is presently used to fit experimental data.

This would make the theoretical and fitted efficiencies agree more closely. However, R_w might still be less than the true collision radius.

III. EVALUATION OF EFFORT TO DATE

The simulation tests of sodium jet impingement on a horizontal surface with water have generated significant initial data for the realistic evaluation of primary system vault pressurization following a pipe-rupture accident. The results which have been obtained thus far indicate that simple liquid sheet flow following jet impingement, with droplet formation at the edge of the sheet, indeed occurs at low jet velocities (e. g., <10 fps). However, at the higher velocities, similar to the maximum estimated for FFTF primary pipe-rupture flow (~38 fps), a parabolic droplet rainout configuration is formed. Although the effective volume swept by the rainout is greater than that for the simple sheet case, the mean droplet size is almost a factor of 10 larger than was estimated for droplets formed in the sheet flow case. This information is now being applied to the re-evaluation of FFTF HTS cell pressure rise following a pipe-rupture accident. Additional information required for confident prediction of cell pressure rise includes: (1) testing of sodium jet impingement behavior for comparison with water jet data, in conjunction with hydrodynamic modeling for scaling of experimental results, and (2) testing of other pipe-rupture configurations, to compare consequence potential with the configuration currently being studied.

Information now being obtained concerning the true characteristics of non-spherical aerosol particles should allow substantial improvement in the description of the gravitational agglomeration process for agglomerate shapes occurring under postulated accident conditions. Modifications to the numerical treatment of gravitational agglomeration, resulting from appropriate use of nonspherical aerosol density and shape, will permit a reduction in the uncertainties in the value of gravitational collision efficiency, leading to a more meaningful evaluation of experimentally observed values and those derived from theoretical treatments in the literature.

IV. NEXT REPORT PERIOD ACTIVITIES

The test program on simulation of sodium jet discharge and impingement will continue, with initial sodium jet tests in inert atmosphere in LTV; and additional water jet tests, for a different pipe-rupture configuration, will be initiated.

Hydrodynamic modeling of jet impingement will continue, in conjunction with scaling of experimental results and application to primary system cell pressure analysis for hypothetical pipe-rupture accidents.

An improved assessment will be prepared of FFTF HTS cell pressure rise following a guillotine pipe-rupture accident.

Testing of modified techniques for arc vaporization of UO_2 aerosols will continue, in preparation for LTV tests with aerosol concentrations $\gtrsim 10 \mu\text{g}/\text{cm}^3$.

Test procedures and preparations will be developed for initiating two cell sodium pool tests.

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