LOS ALAMOS SCIENTIFIC LABORATORY
UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO 87544

OFFICE MEMORANDUM

TO : Dean D. Meyer, Group Leader, H-1 DATE: Jan. 22, 1970

FROM : Roland A. Jalbert, H-1

SUBJECT: PLUTONIUM HAZARD EVALUATION FOR GMX-11 CONFINEMENT EXPERIMENTS

SYMBOL : H-1

The proposed continuation of the GMX-11 confinement experiments involving explosively driven plutonium-239 has been reevaluated in the light of recent experimental work and hazard analyses and the largeramounts of plutonium and high explosive that are anticipated compared to those that were originally planned.

A serious release of plutonium would take place in the wake of a major failure of the confinement vessel which would not be contained by the safety vessel. Most of the plutonium, it is believed,would be deposited in chunks and smaller particles within a radius of a few hundred meters. However, a substantial fraction of the total amount would be of respirable size (10 microns or less) or somewhat larger and be carried downwind to be deposited as fallout or to expose those in the path of the cloud. The purpose of this memorandum is to assess these two hazards.

INHALATION

In order to calculate the possible lung burdens, certain premises have been established.

1. The release is entirely at ground level and is treated as a point release. (COMMENT: This is unrealistic and any deviation from this will tend to make the potential lung burdens downwind smaller. Since no data, appropriate for our conditions, are available, this "worse-case" situation is used. In the treatment of fallout, however, a release at ground level could not be employed and a line source with a cloud height of 200 meters is used. Thus, the two sets of results are not compatible.)

2. The cloud of respirable particles behaves as a gas whose concentration is not altered by filtration, fallout, turbulent mixing, etc., and which obeys the standard diffusion equations.

3. A wind speed of 2 m/sec (4.3 mph) is used. At any distance the maximum cloud concentration and integrated lung exposure vary inversely as the speed. Thus, a lower speed would tend to increase the exposures proportionately. (COMMENT: This would tend to be offset by diminished concentration due to increased fallout and filtration of the larger particles and a tendency for the cloud of smaller particles to rise as it progressed due to midday ground heating.) A wind speed of 2 m/sec or greater occurs about 75% of the time in the Los Alamos area.

4. The experiments take place near midday or early afternoon, when weather conditions are most favorable.

5. The fraction of the total plutonium that would be airborne as respirable particles is taken as 20%. This is based on experimental work done on 1-point detonation of weapons systems. (COMMENT: For many configurations used or proposed at GMX-11, the number may be high by a factor of 4 or more. In any case, the factor of 20% seems to be conservative in the light of the way confinement vessels are likely to fail.)

6. The 1965 ICRP Task Group lung model is used, in which 12% of the respirable plutonium inhaled is retained in the lung with a 500-day biological half life.

7. A breathing rate of 10^3 m^3/8 hours or 3.5×10^{-4} m^3/sec is used.

The obvious question that comes up in an analysis of such a potential accidental release is how much material can (a few) members of the public be "safely" exposed to.

For purposes of establishing a basis for evaluating the results, the "acceptable lung burden" that is adopted here for members of the public or radiation workers is 16 nCi of plutonium-239. If one adopts the lung model suggested by the 1965 ICRP Task Group on Lung Dynamics, the integrated dose or burden can then be calculated for the organs of interest.

The 16 nCi, eliminated from the lung with a half life of 500 days, result in a lifetime lung dose equivalent of approximately 30 rems. This can be compared to the maximum permissible radiation exposure for the lungs of radiation workers of 15 rems/yr recommended by the NCRP. A recent study of the biological effects of plutonium-239 indicates a very low probability of any noticeable effect due to 3 rads absorbed by the lung from plutonium-239 alpha radiation (the 3 rads and 30 rems are equivalent in this case).

of the 16 nCi, 1.3 nCi end up permanently in the bone and liver and 1.3 nCi end up permanently in the lymph nodes. The NCRP also recommends the maximum permissible body burden of 40 nCi of plutonium-239 with bone as the critical organ.

Another basis for the 16 nCi (which result in a lifetime lung dose equivalent of 30 rems) is 10CFR100, which allows the siting of a light water reactor such that in the event of an accident [of low probability] persons in the "low population zone" might be exposed to up to 25 rems whole-body radiation. The Los Alamos townsite is assumed to qualify as a low population zone. Furthermore, one could very well argue that a 30-rem lifetime dose equivalent to the lung is not as serious as 25 rems given to the whole body at one time.

Calculated Maximum Integrated Lung Burdens
(As a function of Distance Downwind and Assumptions 1-7 Above)
Per kg Release

Distance (m)	Weather Conditions		
	Unstable (nCi)	Neutral (nCi)	Stable (nCi)
100	610	6000	94,000
1000	14	150	3,000
1350 (K-Site Road)	8.1	85	1,800
1400 (Kappa Site)	8.1	85	1,800
1600 (GMX-4, GMX-11)	6.4	70	1,500
1900 (State Highway 4)	4.7	51	1,100
2440 (Pajarito Road)	3.2	34	780
2700 (Pajarito Site)	2.6	29	660
4230 (S Site)	1.3	14	340
4600 (Trailer Court, LAMPF, TA-3)	1.1	12	310
5150 (Trinity Drive)	0.95	10	250
8100 (End of town, Barranca Mesa)	0.44	4.8	130

Calculated Maximum Integrated Lung Burdens
(As a Function of Distance Downwind and Assumptions 1-7 Above)
Per 3.5 kg Release

Distance (m)	Warning Time (min)	Weather Conditions		
		Unstable (nCi)	Neutral (nCi)	Stable (nCi)
100		2100	21,000	3.3×10^5
1000		48	510	1.1×10^4
1350 (K Site Road)	11	28	300	6,200
1400 (Kappa Site)	11	28	300	6,200
1600 (GMX-4, GMX-11)	13	22	250	5,200
1900 (State Highway 4)	16	16	180	3,900
2440 (Pajarito Road)	20	11	120	2,700
2700 (Pajarito Site)	22	9.2	100	2,300
4230 (S Site)	35	4.4	49	1,200
4600 (Trailer Court, LAMPF, TA-3)	38	4.0	43	1,100
5150 (Trinity Drive)	43	3.3	36	880
8100 (End of town, Barranca Mesa)	67	1.5	17	460

Acceptable risk value: 16 nCi

FULL WIDTH OF CLOUD AT 0.1 MAXIMUM CONCENTRATION

Distance (m)	Weather Conditions		
	Unstable (m)	Neutral (m)	Stable (m)
5000 (Beginning of town)	1600	620	180
8100 (End of town, Barranca Mesa)	2400	1070	280

These distances and cloud widths apply approximately for the White Rock/Pajarito Acres residential area also.

The weather conditions that exist in the Los Alamos area during the daytime generally tend to approach the unstable condition above. It is the informed opinion of our meteorologists that by midday, unstable conditions or unstable/neutral conditions exist about 95% of the time. Five percent of the time would see neutral conditions with stable conditions occurring rarely. In marginal situations, it is impossible to predict or even to assess accurately (with our available means) the weather

conditions that would be a factor in predicting the hazard of potential release. (COMMENT: An educated guess by a meteorologist, perhaps with help from a smoke pot, might be of some value in some suspiciously ominous weather situations.)

Perhaps of greater importance is wind velocity. Wind speed has already been mentioned but wind direction is also of interest. About 33% of the time, the wind is from the south with the Los Alamos townsite in direct line with the firing point. Roughly 50% of the time at least part of the townsite could be affected. Wind prediction, however, is difficult more than a few hours in advance, particularly if the wind is light, when it would be of greatest concern.

Therefore, any attempt to set weather limits as a condition for firing would, in my estimation, be difficult and probably not practicable.

FALLOUT

Calculations of the possible contamination levels are difficult due to lack of data concerning the cloud height resulting from a rupture of a confinement vessel. It has been estimated that an unconfined detonation using the maximum amount of high explosive (22 lb) proposed for the six-foot vessel would result in a maximum cloud height of approximately 200 ft. Confinement should decrease this height significantly. However, for lack of any data, this number was used to estimate the maximum levels that would be expected downwind.

The amount of plutonium that would be carried downwind to contribute to the fallout problem apart from the expected heavy local contamination is assumed to be 40% of the total, or about 1.5 kg if the maximum of 3.5 kg is used. An average wind speed of 1.5 m/sec was used with a wind shear of 0° over the full height. At distances over 5000 meters, the maximum contamination levels and areas contaminated to a given level are fairly independent of wind speed (from 1.5 to 14 m/sec) and wind shear (0 to 40°).

To obtain the results below, a slightly stable meteorological condition was assumed. This worse possible situation is encountered rarely in Los Alamos as has been mentioned earlier. It is used here because the calculations were based on experimental work done under such adverse conditions.

Contamination Level ($\mu g/m^2$)	Maximum Distance (m)	Area Contaminated to Given Level (km^2)
1000	1,600	0.18
100	5,000 (Edge of town)	1.1
30	8,000 (End of town)	2.7
10	13,000	6.4
1	29,000	37

As mentioned earlier, the prevailing midday weather conditions at Los Alamos are generally unstable to neutral/unstable (95%) or neutral(5%). Such conditions would tend to decrease the maximum contamination levels at any distance by at least one to two orders of magnitude.

For purposes of comparison in this assessment, the maximum acceptable contamination levels in residential areas is conservatively taken to be 10 $\mu g/m^2$. Thus, in the above worse case situation, decontamination of a part of the townsite would probably be required. Areas of higher contamination would mostly be government land which are presently controlled or could be, if necessary, if decontamination proved ineffectual.

The contamination levels that could result should not pose an immediate health hazard to employees or the public compared to that resulting from inhalation during cloud passage. However, they will cause concern and conceivably result in considerable effort and expenditure to decontaminate large areas to the lowest practicable levels.

The results contain herein are in fair agreement with those of Don McKown (12 May 1967) if one allows for differences in assumed weather conditions and quantities of material involved.