Assessment of Risk Due to Vehicle Accident for the Plutonium Solution Transfer from H-Area to F-Area (U)

by

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Revision 1
SAFETY ENGINEERING DEPARTMENT

ASSESSMENT OF RISK DUE TO VEHICLE ACCIDENT
FOR THE PLUTONIUM SOLUTION TRANSFER
FROM H-AREA TO F-AREA (U)

AG Sarrack

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SAVANNAH RIVER SITE

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**ASSESSMENT OF RISK DUE TO VEHICLE ACCIDENT
FOR THE PLUTONIUM SOLUTION TRANSFER
FROM H-AREA TO F-AREA (U)**

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ABSTRACT

Transporting radioactive material onsite (intrasite transfers) via truck or train must be performed in a safe manner. Adequate safety is assured for each transfer, as documented in the corresponding Onsite Safety Assessment (OSA). One aspect of the OSA is to show that the package to be used for the transfer meets onsite acceptance criteria. The activity being analyzed in this report is the movement of plutonium solution from H-area to F-area. Because there is no certifiably acceptable method of transferring plutonium solutions with greater than 20 curies, all reasonable mitigative controls will be implemented to minimize the likelihood of an accidental release, and a probabilistic analysis will be used to evaluate the risk associated with the move.

The purpose of this report is to document the evaluation of risk due to vehicle accident associated with transporting plutonium solution from H-area to F-area. Included in the report is a list of the required mitigative controls which reduce the predicted accident and release frequencies to those reported in the summary.

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1.0 INTRODUCTION

The objective of this report is to document an evaluation of risk due to a vehicle accident associated with the transfer of a plutonium solution from H-area to F-area, and to identify mitigative controls required to achieve the level of safety reported. Revision 1 of this document revised the title to reflect that this risk analysis is limited to the risk due to vehicle accidents, and the references have also been revised for completeness.

2.0 METHOD

2.1 Assumptions and Definitions

1. The distance to be traveled from H-area to F-area for this task is less than 4 miles. This is based on an odometer check while driving the planned route. (The actual odometer reading was 3.8 miles.)
2. The total number of trips from H-area to F-area with plutonium solution will be less than 10. This is based on a cask capacity of 930 gallons, of which 830 gallons will be plutonium solution, and 100 gallons will be nitric acid flush solution.
3. The task of transporting the plutonium solution from H-area to F-area is completed within 1 year, and the cask is evaluated for risk for this task only. As a result, the probability of an accident during this task is equal to the frequency of the accident (per year).
4. By blocking the road to all traffic (other than the escort vehicles and the tractor trailer) and limiting speed to 25 mph, multi-vehicle accident rates are reduced by a factor of 1,000, based on engineering judgment.
5. Roads will be blocked to all other traffic during the transfer, site security will provide escorts ahead and behind the trailer, speeds will be limited to 25 mph, and trains will not be allowed to travel on the track crossing Road 4 during the transfer. In addition, travel will be limited to daylight hours, and will not be allowed during rain, snow, or severe wind conditions.

2.2 Input Data

1. The designers of the cask used for this transfer claim that it is built to meet Type B requirements (Reference 4). Review of cask integrity documentation is insufficient to support this claim. The package is, however, a robust design that would withstand all foreseeable accidents on a vehicle traveling at a maximum of 25 mph.
2. The accident rate (prior to implementing mitigative controls) for this transfer is 2.2×10^{-6} accidents per mile (Reference 3).

2.3 Analytical Methods and Computations

Accident Frequency

The total "at risk" mileage to be traveled for this transfer, D_r , is the product of the number of trips (10) and the length of each trip (4 miles), for a total of 40 miles. The generic rate of tractor trailer accidents, R_g , is approximately 2.2×10^{-6} per mile (Reference 3). This generic rate is conservative because primary contributors to accident frequency such as fatigue, alcohol, and excess speed are negligible contributors for onsite travel.

The frequency of an accident involving the plutonium cask during transfer, F_g , is equal to the product of the accident rate, R_g , and the distance of at risk travel, D_r . Without any controls reducing the accident rate, the frequency would be calculated by the following equation:

$$\begin{aligned} F_g &= R_g D_r \\ &= (2.2 \times 10^{-6} \text{ accidents per mile}) \times (40 \text{ miles per year}) \\ &= 8.8 \times 10^{-5} \text{ accidents per year} \end{aligned}$$

Mitigative Controls

Accidents may involve running off the road, collision with other vehicles or with other objects, or fire. The fractional distribution of each type of accident (Reference 3) is summarized in the first two columns of Table 1. In order to reduce the probability of an accident that could cause a radioactive release, the following mitigative controls will be implemented:

- Transfers will be limited to daylight, fair weather travel.
- Roads will be closed to all other traffic.
- Escort vehicles will lead and follow the transport vehicle.
- Trains will not be run on track crossing Road 4 during transfer.
- Travel speed will be limited to 25 mph.

Release Frequency Calculation

The amount of credit given for each of these controls depends on the accident type, as summarized in Table 1. Column 3 shows the reduction factors taken for closing the road to other traffic, providing an escort, and stopping trains. Column 4 shows the reductions for limiting travel speed to 25 mph. Column 5 summarizes conditional probabilities that a release occurs, given the accident type, assuming a travel speed of 25 mph. Details on each of these reduction factors are provided in the following paragraphs.

Transfers will be limited to daylight, fair weather travel

During adverse weather conditions, accident rates increase dramatically. Generic accident data include accidents during these higher risk travel conditions. By limiting transfers to fair weather conditions, the overall accident rate is decreased. Implementing this control is a good practice for transportation of high level radioactive material; however, this reduction is not credited in this calculation.

Table 1
Distribution of Truck Accident Types

Accident Type	Fractional Distribution	Reduction Factors			Percent of Total
		Road Closed	25 mph	Release	
Non-collision					
Jack-knife	0.077	1	0	-	0
Overturn	0.072	1	0	-	0
Run off road	0.062	1	0.01	0.05	2
Fire	0.006	1	1	0.002	1
Separation of units	0.004	1	1	0.05	14
Other	0.009	1	1	0.05	0
Collision					
Fixed object	0.114	1	0.1	0.05	39
Parked vehicle	0.093	1	0.1	0.05	32
Animal or person	0.015	1	0.1	0	0
Train	0.005	0	-	-	0
Other	0.034	1	0.1	0.05	12
Multi-vehicle accident					
Sideswipe	0.185	0.001	0.1	0.05	0
Rear-end collision	0.133	0.001	0.1	0.05	0
Angle	0.103	0.001	0.1	0.05	0
Head-on collision	0.015	0.001	0.1	0.05	0
Other	0.070	0.001	0.1	0.05	0
Total Rate (per mile)	2.2×10^{-6}	1.1×10^{-6}	1.0×10^{-7}	3.2×10^{-9}	100
Frequency (per year)	8.8×10^{-5}	4.3×10^{-5}	4.0×10^{-6}	1.3×10^{-7}	

Note: The information in columns 1 and 2 of this table comes from Reference 3.

Roads will be closed to all other traffic, escort provided, and trains stopped

As a precaution, roads will be blocked to all other traffic, escorts will be provided, and trains will not be allowed to cross Road 4 during the transfer. These controls will preclude an otherwise unlikely train accident, and will significantly reduce the probability of an accident with another vehicle. Reduction factors taken for this control are summarized in the third column of Table 1.

It is modeled that multi-vehicle accident rates are reduced by a factor of 1,000 by enforcing these controls. The only multi-vehicle accidents that could occur, given these controls, include vehicles violating road barricades and getting around the escort vehicle, or the escort vehicles themselves. Since the truck and escorts should travel approximately the same speed, without passing each other, there is an extremely low probability that these accidents would occur.

Single vehicle accidents would be less likely to occur if no other vehicles were around. (Many single-vehicle accidents are caused by the presence of other vehicles.) However, a conservative approach was taken, in that no credit is taken for reductions in those types of accidents due to these controls.

Speed will be limited to 25 mph

Limiting the speed of the transport vehicle to 25 mph not only reduces the probability that a given accident will occur, but also reduces the chance that the package will be breached, if an accident does occur.

Column 4 of Table 1 summarizes credit taken for the reduced likelihood of accidents, given the reduced speed. At 25 mph, it is assumed that a jack-knife or overturn can not happen. The probability of running off the road is reduced by a factor of 100, since virtually all accidents of this type are the result of traveling too fast for conditions. A factor of 10 reduction is taken for all collision accidents, because stopping distance is shortened and the time one has to react and prevent the accident is substantially increased when traveling at lower speeds.

Probability of Release

It is assumed that a radioactive release can not be caused by colliding with an animal or person, so this fraction of accidents is given a 0% probability of causing a release. Non-collision accidents classified as "other" are assumed to be innocuous and also have a 0% probability of causing a release.

The designers of the package for this transfer claim that it is designed to Type-B container requirements (withstand a 30 foot drop onto an unyielding surface and a 40 inch drop onto a 6 inch diameter steel bar without being breached). A study initiated by the US Nuclear Regulatory Commission determined there is a 99.4% chance that a container meeting these criteria would not be breached in a significant transportation accident (Reference 1). Although package documentation is insufficient to support the claim that it meets Type-B requirements, it is a robust design that should withstand most feasible accidents for a vehicle traveling at a maximum speed of 25 mph. For this reason, it is conservatively modeled that there is a 5% chance of release, given a single or multi-vehicle accident. The probability of breaching container integrity from a fire is calculated to be 0.2% (Reference 5). The conditional probability of fire, given an accident, is 0.02, and there is a 10% probability that the container will be within the fire.

Summary

As Table 1 shows in the bottom row, the predicted frequency of accidents resulting in a radioactive release decreases with each control. The initial accident frequency, calculated above (using 40 miles as a travel distance) is 8.8×10^{-5} per year. Implementing road closure reduces the accident frequency to 4.4×10^{-5} per year, and limiting the speed to 25 mph reduces it to 4.0×10^{-6} per year. The overall frequency of release (package breach), crediting all these controls, is calculated to be 1.3×10^{-7} per year. The overall frequency of release, without mitigative controls, would be approximately 1,000 times higher, or 1×10^{-4} per year.

Given that the mitigative actions described in this report are taken for this transportation activity, the release frequency, 1.3×10^{-7} per year, is made up primarily of accidents that involve a collision with a fixed object, parked car, or other (83%), or a non-collision event, such as a fire, separation of units, or running off the road (17%).

2.4 Results and Conclusion

With the current mitigative controls to reduce accident probability, as described above, the predicted frequency of an accident that causes a radioactive release is 1.3×10^{-7} per year. This is based on 40 miles of travel per year. If the total travel distance (carrying plutonium solution) will be more than 40 miles, the risk increases proportionally. Consequences of an accidental release of plutonium solution during transfer from H-area to F-area were not calculated because the estimated frequency of the event is well below the level usually analyzed. Events with less than 1×10^{-6} per year frequency are considered "incredible" and are not analyzed for consequences.

3.0 REFERENCES

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WESTINGHOUSE SAVANNAH RIVER COMPANY
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July 16, 1996

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