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by

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DISCLAIMER

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SUMMARY

Hazards assessments and accompanying accident and human health and risk calculations are routinely done to establish Emergency Planning Zone (EPZ) boundaries for facilities managing hazardous and/or radioactive materials. This paper reviews the underlying U.S. Department of Energy (DOE) guidance, assesses the degree of conformance to the guidance in recent hazards assessments performed to support selection of EPZ boundaries, and compares the consistency of the accident analysis approaches and underlying key assumptions. Recommendations are made on the basis of these reviews, as well as from knowledge of the approaches used in safety assessments performed in support of safety analysis reports (SARs) and environmental impact statements (EISs).

I. INTRODUCTION AND OVERVIEW

The purpose of this study was to determine a measure of the conformance with existing DOE guidance[1-3] and the consistency among hazards assessments performed to support selection of EPZ boundaries for various DOE facilities. A somewhat analogous comparison of safety assessments performed in support of recent EIS documentation[4] showed a wide variation in assumptions used in determining the potential health effects and risks. This inconsistency made a comparison of the risks of similar actions evaluated in different EISs next to impossible without a careful review of the supporting analyses.

To evaluate the conformance and consistency issues for accident analyses supporting emergency planning, a sampling of recent assessments[5-9] was selected to ensure coverage of a variety of different facilities, sites, and various radiological and chemical hazards. The remainder of this paper will briefly summarize the relevant DOE guidance, synopsize the facilities and hazards in the documents reviewed, make the salient accident analysis comparisons, draw conclusions, and make recommendations.

II. DOE GUIDANCE AND CRITERIA

DOE guidance for defining EPZs is found in the *Emergency Management Guide — Hazards Assessment.*[1] This guidance was developed to assist DOE field elements and operating contractors in complying with DOE 5500.3A, *Planning and Preparedness for Operational Emergencies.*[2] DOE 5500.3A was subsequently superseded by DOE O 151.1, *Comprehensive Emergency Management System,*[3] and it is expected that DOE guidance for hazards assessments will be modified accordingly and likely be made less prescriptive regarding determination of the EPZ.

Under DOE guidance, the minimum size (radius) of the EPZ depends on the highest emergency classification (General Emergency or Site Area Emergency) that the facility might generate, the distance of the facility from the site boundary, the maximum distance at which a threshold for early severe health effect (ESHE) would be expected for the most severe event analyzed (distance to ESHE), and criteria to ensure that the EPZ is reasonable. For radiological doses, the ESHE is 100 rem from external penetrating radiation or uniformly distributed internal emitters; or organ doses from the U.S. Environmental Protection Agency *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, Appendix B.*[10] For nonradiological releases, the ESHE for a given hazardous material is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed up to one hour without experiencing or developing life-threatening health effects (i.e., Emergency Response Planning Guide 3 [ERPG-3] or equivalent).[1]

For assessments in which the highest emergency classification is General Emergency, DOE guidance recommends that the minimum EPZ radius be the greater of the distance to ESHE or 5 km. For assessments in which the highest emergency classification is Site Area Emergency, DOE guidance recommends that the minimum EPZ radius be the greater of the distance to ESHE or 2 km, or the distance from the facility to the site boundary if less than 2 km. The DOE guidance also provides an EPZ determination logic diagram and "tests of reasonableness" that are designed toward increasing the size of the EPZ if reasonable.

III. SELECTED COMPARISONS

A. Documents Selected for Comparison

Hazards assessments for facilities at any single site and performed in a similar time frame tend to have the same characteristics and in fact are often done by the same technical teams. Further, hazards assessments done for radiological hazards are often done by teams with somewhat different backgrounds than those performed by teams for chemical hazards. As a result, the documents reviewed[5-9] were chosen to cover a variety of different sites and various radiological and chemical hazards to provide as much diversity as possible among the studies considered. Table 1 summarizes the facility and concomitant radiological and chemical hazards characteristics of the documents analyzed.

B. Elements Compared

Distances for EPZ boundaries were chosen by employing various radioactive or chemical source term development models and using the resultant source terms to drive atmospheric transport and dose conversion or health effects models. These models depend on a variety of key assumptions, starting of course with the selection of hazardous materials of concern and the accident sequences to be analyzed. The following discussion summarizes the comparisons of the major accident analysis elements.

1. Hazards considered. Both chemical and radiological hazards were considered among the various studies reviewed. Threshold quantities were screened and documented using 10 *Code of Federal Regulations* [CFR] 30.72 for radiological

TABLE 1 Facilities and Chemical and Radiological Hazards Assessed in the Documents Selected for Comparison

DOE Site[a]	Facilities Considered	Chemical Hazards Considered	Radiological Hazards Considered	Materials Exceeding Threshold Quantity	Reference
INEL	Hazardous Waste Storage Facility	Lead, mercury	None	Lead, mercury	5
INEL	Waste Experimental Reduction Facility	All chemicals in inventory	None; inventory much lower than threshold quantity	None	6
SNL/NM	Simulation Technology Laboratory, Bldg. 970	Fluorine gas mixture (5% fluorine and 95% helium)	None; inventory much lower than threshold quantity	Fluorine gas mixture (5% fluorine and 95% helium)	7
Pantex Plant	All on-site facilities	None	Plutonium, tritium, cobalt-60	Plutonium, tritium, cobalt-60	8
Kansas City Plant	All on-site facilities	All chemicals in inventory	None	Hydrochloric acid, ammonia, sulfur dioxide, methylene chloride, cyclohexylamine, toluene diisocyanate	9

[a] INEL = Idaho National Engineering Laboratory; SNL/NM = Sandia National Laboratory at New Mexico.

hazards and 40 CFR Parts 302 and 355 for chemical hazards. In some studies, these threshold quantities were used to limit the number of chemicals considered for airborne releases; in other studies, the entire inventory of chemicals was assumed to be accidentally released.

2. Spectrum of accidents considered. Both internal and external events were considered in each of the various studies reviewed. The internal events considered varied by document but overall included container breaches from a variety of operational mishaps (e.g., forklift accident), benign equipment failures (e.g., container corrosion and breach), energetic equipment failures (e.g., overpressure failures), fire, and in one case, even containment breach by gunfire.

The external events also varied by document but overall included natural phenomena and severe weather conditions, unplanned man-made initiators such as aircraft crashes and natural gas explosions, and acts of sabotage and terrorism. However, characterization of the frequencies for these events was based on either engineering judgment or other studies such as SARs, or was lacking altogether. In a number of cases the various accident initiators and/or ensuing accident sequences were judgmentally grouped as leading to a common endpoint, such as release of the threshold-quantity-exceeding chemicals in a predetermined set of release categories.

3. Source term estimation. An airborne radiological or chemical source term can be treated as a product of terms according to

$$\text{Source term} = \text{MAR} \times \text{DF} \times \text{ARR} \times \text{RT}$$

where MAR is the material at risk, DF is the damage fraction or fraction of MAR exposed to accidental stresses capable of rendering the MAR airborne, ARR is the airborne release rate of the fraction of material subjected to accidental stresses and actually rendered airborne, and RT is the release time. In some cases, the latter two terms are combined to yield an instantaneous release and an airborne release fraction is determined. For particulate releases, various phenomenological considerations (e.g., settling, respirability) or containment characteristics (e.g., leakage paths, filters) are sometimes factored in to reduce the ARR.

A mix of conservative and seemingly nonconservative assumptions tended to be made in determining the source terms for the various documents. The MAR was defined through the screening process as described above. In some analyses, the entire inventory of hazardous materials was included (i.e., DF=1) in sequences where arguments could have been made to delimit the material affected by the accident (i.e., DF<1). On the other hand, severe fire sequences were sometimes restricted to relatively small fractions of the MAR, with a rationale to support a lack of propagation to the rest of the MAR not being clearly made. Engineering judgment and a variety of reference documents were cited as the basis for selecting the airborne release rates, overall release times, and/or their equivalents.

4. Atmospheric transport. Various generic or site-tailored atmospheric dispersion codes were used to estimate distances to various concentration levels of the chemical hazard of concern or the consequences of postulated accidental radioactive releases. The meteorological conditions assumed in the analyses varied: depending on the document, "typical" (undefined but assumed here to refer to 50%-probable meteorology), 95%-probable, and 99.5%-probable meteorological conditions were used. DOE guidance calls for two sets of meteorological conditions to be considered for postulated release scenarios: 95% worst-case wind speed and stability, and a "typical" set of meteorological conditions.

5. Results. In the cited studies, the predicted distances to various threshold concentrations varied widely, and the proposed EPZ values ranged from 100 m to 10 mi (16 km), depending on the facility and site analyzed, with variations as appropriate to account for the demographic situations at each facility and site. Emergency classification predictions for the various sequences ranged from alerts to general emergencies, with the majority of accidents analyzed having Site Area Emergency as the emergency classification.

IV. SUMMARY AND CONCLUSIONS

None of the five hazards assessments reviewed appeared to completely follow DOE guidance. The four hazard assessments with chemical risks have substantially smaller EPZs than recommended in the DOE guidance, whereas the one facility with radiological hazards (Pantex Plant) has a substantially larger EPZ. The "tests of reasonableness" were apparently applied in certain cases to reduce, not increase, the size of the EPZ.

Various modeling assumptions and computer codes were used in the sample of assessments discussed above. Although the difference in applications among the various documents led to the predicted distances to various threshold concentrations and the proposed minimum EPZ radii varying widely, it is clear that the differences in proposed concentrations were also a strong function of the variation in assumptions used in the accident analysis modeling. This suggests that facilities similar in terms of the hazards actually present but located in different DOE installations may have considerably different EPZ boundaries. Economic considerations — for example, the desire to reduce the EPZ boundaries to simplify emergency planning requirements — may provide a strong incentive for installations in more populated regions to reduce the level of conservatism in their supporting hazards assessments relative to the level used by more remote sites.

More detailed analysis guidance, even at the risk of being prescriptive, should be developed to improve the consistency among assessments. In particular, guidance as to what levels of frequency to consider in assessing accident sequences, as well as more guidance in determining the frequencies per se, would be useful. Release rates are a strong function of both the physical characteristics of the material at risk and the accident stresses, and the latest guidance[11] should be used. Reviews of both radiological and chemical source term development methods and codes are ongoing within DOE. Finally, the analyses performed for SARs are often used to support EPZ boundary selection. Developing guidance on to how to best use the latest standards on safety analysis for EPZ determination should be considered.

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