POLICY ISSUE
(Notation Vote)

March 31, 2009 SECY-09-0051

FOR: The Commissioners

FROM: R. W. Borchardt
Executive Director for Operations

SUBJECT: EVALUATION OF RADIOLOGICAL CONSEQUENCE MODELS AND CODES

PURPOSE:

The purpose of this paper is to request Commission approval of the staff's recommendation on how guidance from the U.S. Environmental Protection Agency (EPA) Manual of Protective Action Guides (PAG Manual) and Protective Actions for Nuclear Incidents could be incorporated into an improved economic consequence model. This paper also provides the staff's determination of the best computer code to assess the radiological consequences of a radiological dispersal device (RDD).

SUMMARY:

In the Staff Requirements Memorandum (SRM) COMPBL-08-0002/COMGBJ-08-0003, dated September 10, 2008, "Economic Consequence Model," the Commission directed the staff to consider how guidance from the Department of Homeland Security (DHS)/Environmental Protection Agency (EPA) PAG Manual could be incorporated into an improved economic consequence model and to consider if the Explosive Release Atmospheric Dispersion (ERAD) model or another computer code is preferable to the MELCOR Accident Consequence Code System, Version 2.4 (MACCS2) for estimating radiological consequences of RDDs. The Nuclear Regulatory Commission (NRC) staff evaluated the work efforts of Federal inter-agency task groups to determine what models and computer codes have been developed for the assessment of the radiological consequences of an RDD; and if these models and computer codes would be better tools for the assessment of the radiological consequences of RDD events rather than an upgrade to the MACCS2 code to add RDD events to its primary function of assessing consequences from reactor accidents.

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In the course of the review of the economic models and computer codes used to assess consequences from an RDD, the staff concluded that while the planned upgrade of the economic model in MACCS2 would benefit from insights from the ongoing interagency work, the MACCS2 code itself was inadequate for RDD consequence assessment. Therefore, upgrades to the MACCS2 code for RDD assessment is not considered as a viable option and the staff recommends that the Commission approve Option 1 to use the radiological and economic consequence assessment model already developed and supported by the Federal family for RDD consequence modeling. Under this option, the staff would also use the insights from the Department of Energy (DOE)/National Nuclear Security Administration (NNSA) economic consequence model in the planned upgrades to MACCS2 to better support the intended uses of the MACCS2 code.

BACKGROUND:

Traditionally, the NRC radiological consequence analyses have been conducted to evaluate potential effects of severe nuclear power plant accidents. The MACCS2 was developed to support offsite consequence estimates for Level 3 probabilistic risk assessments of severe accidents at light water reactors. Such assessments have long served as the foundation for NRC regulatory decisions. In fact, some of the agency's earliest regulatory decisions on physical protection were based on these assessments, which included analyses of health and safety, land contamination, and economic consequences. However, the terrorist attacks of September 11, 2001, have raised awareness of the potential for other types of radiological events and consequences such as RDDs.

The staff's objective is to be prepared to realistically assess and support an integrated Federal response to the consequences of radiological events such as RDDs. In SRM COMPBL-08-0002/COMGBJ-08-0003, the Commission directed the staff to consider how guidance from the PAG Manual could be incorporated into an improved economic consequence model and to consider if the ERAD model or another computer code is preferable to MACCS2 for estimating the radiological consequences of RDDs.

The staff has worked closely with its Federal partners in the development of the DHS document, "Planning Guidance for Protection and Recovery following the RDD and Improvised Nuclear Device Incidents"; the revision to the EPA PAG Manual, which fully incorporates the DHS guidance; and the 2009 White House Office of Science and Technology Policy document, "Planning Guidance for Response to a Nuclear Detonation." Furthermore, the NRC continues to serve as Chair of the Radiation Source Security and Protection Task Force. To respond to an additional DHS request for further analysis of RDD consequences, the Task Force formed the multiagency Radiation Sources Subgroup to evaluate, among other things, consequences other than the deterministic health effects that form the basis of the established International Atomic Energy Agency categorization (e.g., economic, physical, psychological, and social disruption consequences).

The NRC staff evaluated the work efforts of these and other Federal interagency task groups to determine what models and computer codes have been developed for the assessment of the radiological consequences of an RDD. The NRC staff also evaluated whether these models and computer codes would be better tools for the assessment of the radiological consequences

of RDD events rather than an upgrade to the MACCS2 code that would add RDD events to its primary function of assessing consequences from reactor accidents.

In an April 3, 2007, memorandum to the Commission, "Treatment of Land Contamination and Offsite Economic Consequences in the SOARCA [State-of-the-Art Reactor Consequence Analysis] Project," the staff informed the Commission that significant technical limitations exist to the current economic models used in MACCS2 for calculating land contamination consequences. The Commission directed that the SOARCA project not be delayed in order to include an assessment of economic consequences. The staff recently provided a Commission paper with results of the SOARCA analysis for the Peach Bottom Atomic Power Station and the Surry Power Station that does not address economic consequences. Independent of its possible use for RDD event assessment, the staff proposed the improvement of the economic model as one of the two major MACCS2 upgrades described in a memorandum to the Chairman dated August 6, 2008. The Chairman approved the staff's recommendation in a memorandum dated September 10, 2008.

DISCUSSION:

The PAG Manual includes the concept of optimization for recovery from a radiological event. "Optimization" is a flexible, multi-attribute decision making process that seeks to weigh many factors. Optimization analyses are interrelated, quantitative and qualitative assessments independently applied at each stage of decision making and applied independently for each event. Optimization includes economic (e.g., cleanup costs, waste disposal costs, economic impact on places of historical significance, economic impact on businesses, and medical costs), psychosocial, human health risk, ecological risk, and technical feasibility factors. Incorporating the relevant factors from the PAG Manual into an economic model would produce a model that is complex, and alignment with optimization principles used in the PAG Manual is extremely difficult to incorporate into a computer code as such a model must include qualitative factors such as sensitivity analyses and expert judgment from many different stakeholders.

In response to a 2007 Government Accountability Office review of the DOE/NNSA Global Threat Reduction Initiative, DOE/NNSA developed in cooperation with several Federal agencies, a classified report that examined the magnitude of the economic impact of the explosion of a significant RDD on a major urban center. DOE/NNSA compared a particular area before the detonation of an RDD to the same area after the event using a methodology designed to accurately estimate the nature and extent of the physical damages to the affected area, determine the size and geographic location of the area exposed to radioactive contamination, estimate both the cost and time needed to decontaminate the area, estimate how other critical infrastructures are affected by the blast (either through damage to the buildings or through decreased workforce participation), and estimate the health impacts of the blast and resulting contamination. Completing these tasks requires a set methodology that allows for application to many varied RDD scenarios and that allows for replication for purposes of quality assurance and accountability. This economic assessment methodology also requires clear links between assumptions made to conduct the analysis and the results of the analyses, thereby providing the means through which sensitivities between assumptions and results can be identified clearly.

The DOE/NNSA study combined the ERAD model with the Automated Consequence Report for Insidious Dispersal (ACRID) model to calculate the radiological consequences of RDDs. The ERAD model considers the momentum effects in estimating its complex source term. The ERAD model corresponds to a Level 2 probabilistic risk assessment code in that it determines the source based on RDD characteristics and scenario parameters. Importantly, it also evaluates the first few seconds of the release as the plume rises and spreads. The ACRID model has been used for RDDs in conjunction with the economic model for evaluation of the contamination area. The ACRID model takes into account RDD characteristics and scenario parameters, including location, prevailing winds, and weather conditions. It takes the deposition contours generated by the ERAD model from a Monte Carlo dispersion calculation and calculates contamination contours and doses (total effective dose equivalent) to determine the contamination area as a function of the assumed return criterion (dose limit). Importantly, the ACRID model also determines the physical damage from blast effects. The combination of the ERAD and ACRID models contains all the information and analytical models necessary to account for the differences between RDDs and reactor accidents.

MACCS2 was developed to support offsite consequence estimates for Level 3 probabilistic risk assessments and cost-benefit analyses and for planning purposes for nuclear power plants. MACCS2 accepts source term, weather, and other inputs and estimates doses to populations; early health effects; latent health effects; and economic consequences, including the pathways of cloud shine, ground shine, inhalation, skin deposition, and the food chain. However, because nuclear plants are sited away from urban areas, and because the release mechanism does not involve an energetic dispersal of radioactive material characteristic of an RDD, MACCS2 does not effectively deal with the unique shape, size, or momentum-specific attributes of the plume that may result from an RDD, particularly in an urban setting. The shape of the source plume of radioactive material following an RDD detonation is dominated by momentum effects that are likely to carry the plume vertically beyond the mixing height that would provide an upper boundary for the buoyant releases that are considered in MACCS2. In addition, MACCS2 does not support an assessment of the physical damage from blast effects.

OPTIONS:

The staff identified the following two options related to the staff's recommendation:

(1) Use the radiological consequence assessment model already developed and supported by the Federal agencies for RDD consequence modeling.

This option offers the following advantages:

- It will ensure comprehensive and consistent Federal policy on economic consequences from RDD hazards.
- It is cost effective in that it will not repeat costly work for those RDD economic consequence analyses that are already completed.
- It promotes a common understanding among stakeholders by providing a consistent consequence analysis that can be replicated for various RDD incidents.

- Insights from this complex model can be used, as appropriate, to include upgrades to the MACCS2 model to better support its intended uses.

This option has the following disadvantage:

- The NRC would be reliant upon national laboratories and the Federal interagency working group(s) to maintain the RDD economic consequence model.

(2) Obtain funding and contractor support to develop a unique NRC model for RDD economic consequence analysis.

This option offers the following advantage:

- The NRC would have its own RDD specific economic consequence model, and as such would be able to independently maintain the model.

This option has the following disadvantages:

- The development of the NRC model appears to be cost prohibitive, considering that an RDD economic consequence model is currently available. For example, estimates from DOE/NNSA for its 2008 economic consequence study of four isotopes range from $1.5 million to $2.5 million.

- A verified and validated model already exists, which is supported by other Federal agencies for RDD economic consequence modeling. A redundant Federal model may create inefficiencies among the other trilateral agencies (i.e., DOE/NNSA and the DHS Domestic Nuclear Detection Office) and create credibility issues stemming from possible differing model conclusions.

- The NRC may face an added communication burden in describing why the NRC chose to create its own model rather than use the model already developed and supported by multiple Federal agencies.

RESOURCES:

There is no cost to NRC if the agency uses the DOE/NNSA developed methodology as recommended (Option 1). The staff estimates the Option 2 cost for analysis of a limited number of isotopes is $1.5 million to $2.5 million and is not currently funded in the Agency's fiscal year (FY) 2009 budget or the FY 2010 budget request.

RECOMMENDATION:

The staff recommends that the Commission approve Option 1 to use the radiological and economic consequence assessment model already developed and supported by other Federal agencies for RDD consequence modeling. Under this option, the staff would also use the insights as appropriate from the DOE/NNSA economic consequence model in the planned upgrades to MACCS2 to better support the intended uses of MACCS2. During the review of the economic models and computer codes used to assess consequences from an RDD, the

staff concluded that although the planned upgrade of the economic model in MACCS2 would benefit from insights gained through the ongoing interagency work, the MACCS2 code is not readily amenable to upgrading in order to perform RDD consequence assessments. Since existing codes now contain all the necessary models and have undergone extensive validation and verification, upgrades to MACCS2 for the assessment of RDD radiological assessment is not considered a desirable option. In addition, if MACCS2 were upgraded, there would be security concerns about the public availability of a code that would provide detailed information necessary for estimating the source term resulting from an RDD. The staff determined that the interagency model is preferable to MACCS2 for estimating the radiological consequences of RDDs.

COORDINATION:

The Office of the General Counsel reviewed this package and has no legal objection. The Office of the Chief Financial Officer reviewed this package and determined that it has no financial impact.

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