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A COMMON SENSE APPROACH TO CONSEQUENCE ANALYSIS AT A LARGE DOE SITE (U)

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The primary objective of the Probabilistic Safety Assessment (PSA) at the U. S. Department of Energy (DOE) Savannah River Site (SRS) is to quantify health and economic risks posed by K Reactor operation to the nearby offsite and onsite areas from highly unlikely severe accidents. The overall risk analyses have also been instrumental as defensible bases for analyzing existing safety margins of the restart configuration; determining component, human action, and engineering system vulnerabilities; comparing measures of risk to DOE and commercial guidelines; and prioritizing risk-significant improvements. The key final phase of these probabilistic risk calculations, a third level of analysis or Level 3 PSA, requires the determination of the conditional consequences to onsite workers and the DOE reservation facilities, given low-probability, postulated fuel-melting accidents with accompanying atmospheric releases have occurred. A modified version of the commercial reactor-based MACCS 1.5 code, MACCS/ON, is used in the context of the SRS PSA to perform the consequence determinations. The updated code is applicable to other large DOE sites for risk analyses of facility operations, and is compatible with proposed modifications planned by code developers, Sandia National Laboratories.

MACCS origins and development to date have been consistent with the needs of NUREG-1150 and similar commercial reactor risk studies. The new consequence evaluation methodology contained in MACCS/ON yields more realistic risk estimates posed to a large, co-located workforce typical of DOE sites. The code accounts for dose and health effects incurred during the initial exposure to radioactivity in the airborne plume. In addition to risk-dominant fission products, tritium in the source term is modeled for uptake through inhalation and skin absorption. A second major change, a limited evacuation model, allows sensitivity studies to be performed modeling preferred exit directions and evacuation timing. Thirdly, meteorological data input to the code for Latin Hypercube Sampling is now consistent with the SRS five-year, quality-assured database used in design basis event analysis. The consequence analyst also may vary evacuation speed based on time-of-day and precipitation conditions at the start of the release, and may model day- and night-shift worker distributions. Finally, MACCS/ON accepts site-specific input for Gaussian plume model parameters, and allows processing G stability category meteorology. The latter modification improves the scrutability of MACCS through validation efforts, since MACCS dose estimates compare well with 99.5% meteorology, worst-sector

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codes typically applied to support safety analysis report analysis.

MACCS/ON is a risk applications code, best applied in a PSA context. Hypothetical source terms are drawn from the K Reactor PSA, Level 1 (identification of initiating events and respective frequency of occurrence, plus binning into similar states of reactor core damage) and Level 2 (prediction of plant response to these damage states and development of groups of similar radiological releases to the environment) analyses for operation at 2500 MW_{th}. The base model for this study allows preferred-direction evacuation (PDE), and is different from the radial evacuation model currently in MACCS 1.5. The simple PDE approach models exit roadways from the facility area in which non-essential workers are evacuating. The roadways are assumed to bear traffic loads preferentially, based on the initial wind direction during plume release, timing of the airborne release, and traffic controls instituted by DOE site security. MACCS/ON is exercised to provide an illustration of the capabilities of the revised code in the following sensitivity studies:

Evacuation Timing and Recommended Direction. In the base case, non-essential workers begin evacuation at 0.5 h from shutdown for internal initiators, and 1.0 h for external (seismic) events. The first sensitivity study consists of doubling, then quadrupling the base case timings. Sensitivity assessments of the parameters used in the base model indicate that evacuation timing, relative to reactor shutdown, have mean risk impacts of 24%, 62%, and 26% for total effective dose equivalent, individual acute fatality risk, and individual latent fatality risk for the onsite workers, respectively. The second sensitivity was performed on exit roadway loading. The study indicates uncoordinated evacuation, in the initial period after reactor scram, will lead to individual risk levels approaching and potentially exceeding DOE Safety Guideline values as the evacuation becomes less directed.

Five-Year Meteorological Data. Latin Hypercube Sampling of the SRS five-year meteorological file relative to the one-year basis file does not change the probabilistic risk results significantly. The results are elevated in the five-year assessment, but only acute fatality risk is increased appreciably (factor of ~3).

Time-Of-Day And Incidence of Precipitation. Mean indices of risk applying the five-year meteorological data set are increased if the MACCS/ON input evacuation speeds are reduced to account for night time travel and the incidence of rainfall. However, only close-in early fatalities are affected markedly (48% increase). Other measures are insensitive to the speed reduction within the context of the risk study.

Thus, MACCS/ON is a flexible Level 3 PSA tool for determination of best-estimate worker risk as part of a full-scope PSA for DOE facilities. It also can elicit sensitivities associated with the selected parameters. It is a useful interim methodology for PSA studies for both reactor and processing facilities until the expanded radionuclide data and a network evacuation model are made available. Other codes should be applied in some instances. For example, alternatives are better suited for DOE emergency response planning requiring refined network evacuation models. In addition, many DOE facilities are located on terrain with variable spatial detail. It would be prudent in these cases to utilize models with dispersion and wind field characteristics providing more detail than available with a Gaussian model and a flat-earth basis code.

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