

## Productivity Techniques and Quality Aspects in the Criticality Safety Evaluation of Y-12 Type-B Fissile Material Packages

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### INTRODUCTION

The inventory of certified Type-B fissile material packages consists of ten performance-based packages for offsite transportation purposes, serving transportation programs at the Y-12 National Security Complex. The containment vessels range from 5 to 19 in. in diameter and from 17 to 58 in. in height. The drum assembly external to the containment vessel ranges from 18 to 34 in. in diameter and from 26 to 71 in. in height. The weight of the packaging (drum assembly and containment vessel) ranges from 239 to 1550 lb.

The older DT-*mn* series of Cellotex-based packages are being phased-out and replaced by a new generation of Kaolite-based (“Y-12 patented insulation”) packages capable of withstanding the dynamic crush test 10 CFR 71.73(c)(2). Three replacement packages are in various stages of development; two are in use. The U.S. Department of Transportation (DOT) 6M specification package, which does not conform to the U.S. Nuclear Regulatory Commission requirements for Type-B packages, is no longer authorized for service on public roads. The ES-3100 shipping package is an example of a Kaolite-based Type-B fissile material package developed as a replacement package for the DOT 6M. With expanded utility, the ES-3100 is designed and licensed for transporting highly enriched uranium and plutonium materials on public roads. The ES-3100 provides added capability for air transport of up to 7-kg quantities of uranium material.

This paper presents the productivity techniques and quality aspects in the criticality safety evaluation of Y-12 packages using the ES-3100 as an example.

### BACKGROUND

The ES-3100 package is a containment/outer drum system. The outer drum system is a recessed,

double-compartment body with a removable top for insertion and removal of the containment vessel. The body weldment liner outer cavity and the top plug weldment contain a cast refractory insulation (Kaolite) that protects the containment vessel from heat absorption, shock, and impact. The body weldment liner inner cavity contains 277-4 special dry mix, which serves as a strong neutron absorber. The inside diameter of the drum is 18.25 in. with an overall height of 43.5 in. including the cover and lid. The containment assembly is a high-integrity, leaktight, post-load leak-testable system consisting of a stainless-steel vessel body and lid, an outer and an inner O-ring installed in two concentric grooves on the lower flange, and an evacuation port located between the O-rings in the containment vessel flange. These features facilitate a pressure rise or drop leakage test following assembly or 10 CFR 71 compliance testing.

The safety analysis for a Type-B package is complicated. Due to the general-purpose nature of the ES-3100, the criticality evaluation requires a large number of parametric cases for establishing the envelope of nuclear safety. Techniques have been adopted for streamlining the development and generation of quality models. A stacked-unit geometry is used as the framework for a package model. Details of the model components are described by parameter variables rather than fixed numbers, which allows continuity and consistency in changes made to geometry and material compositions. Automated calculation of model parameters is employed which makes parametric evaluations using these complex models feasible. Comments are embedded in the model descriptions for documenting sources of information and features of the model. The quality and productivity techniques employed are summarized using the ES-3100 as an example.

### TECHNIQUE

A detailed ES-3100 geometry model is

accurately constructed using many simple geometric shapes. The selection of these components is governed by two of KENO V.a's geometry constraints: geometry regions must be composed of uniform and homogeneous materials, and exterior regions must completely enclose interior regions. It is apparent from a cross-section view of the package that these constraints could not be simultaneously applied to the entire ES-3100 packaging. However, these constraints could be applied to vertical segments of the package. Segments (i.e., simple components) are defined by starting at the bottom of the package and defining geometry regions radially outward until the drum surface is reached. A vertical segment is extended upward to the point where the KENO V.a constraints are violated. This vertical position is the termination point of a segment (i.e., the interface with the adjacent segment above it). The vertical segments are constructed accordingly, ignoring the minor variations in the ES-3100 geometry (i.e., radii of curvature, beveled edges, nuts and bolts). The KENO V.a geometry model for the ES-3100 is then assembled from the vertical segments. The resulting calculation model geometry includes the package content, the containment vessel, the stainless-steel liner, the inner-liner weldment cavity filled with 277-4, the outer-liner cavity filled with Kaolite, the top plug (Kaolite and steel shell), the silicone rubber pads, and the stainless-steel drum.

A PERL script called Write-Once-Read-Many (WORM) is used to create a series of KENO V.a input files. The input to WORM is a template of the KENO V.a input to be generated. Rather than manually calculate each value that appears in the KENO V.a input files, the analyst incorporates arithmetic statements into the template file. These statements define surfaces and establish relationships between the surfaces in the geometry portion of the calculation model, and they maintain or adjust material balances within the associated regions of the model. Through careful programming of the WORM input file, the analyst is able to adjust features of the calculation model whereby changes are correctly permeated

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throughout the input specifications for series of cases.

Comments statements may be embedded in the WORM input for describing various aspects of the template file. A single-quote character at the beginning of each line signifies that the comment line will be printed in the series of KENO V.a input files generated, while a pound sign hides the comment line from the input files.

#### QUALITY ASSURANCE BENEFITS

The association of model input with the parameters and features illustrated on design drawings can be documented in the KENO V.a input files via the WORM template file. Calculated values for inspection points can be embedded in comment fields of the KENO V.a input along with the design reference values. Calculated model characteristics and parametric values can be embedded into the KENO V.a input file for later extraction into reports and records. Systematic formatting of input files allows for a quick and easy determination of file differences. Intelligent checking of the input can be accomplished where the focus is on the WORM template file and template file differences rather than on each KENO V.a input file in its entirety. Well documented models reduce the learning curve and increase the confidence level for subsequent analysts and reviewers who assume responsibility for the work.

#### REFERENCES

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