



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JAN 10 1984

MEMORANDUM FOR: John G. Davis, Director
Office of Nuclear Materials Safety and Safeguards

FROM: Robert B. Minogue, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER NO. 137 SABOTAGE
SOURCE TERM PROGRAM - RESULTS AND PEER REVIEW

- References:
1. NUREG/CR-2472, Final Report on Shipping Cask Sabotage Source Term Investigation, dated October, 1982.
 2. SAND 82-2365, An Assessment of Spent Fuel Transportation in Urban Environs, dated June 1983.
 3. NUREG/CR-0743, Transportation of Radioactive Material in Urban Environs-Draft Environmental Assessment, dated July 1980.

Introduction

The purpose of this memorandum is to formally transmit the documented results of the Sabotage Source Term Research Program. The memorandum also encloses and discusses the conclusions of the peer review which addressed both the selection of sabotage scenario parameters and the experimental and modeling techniques pertaining to interactions between the explosive and cask/fuel materials. The program results are documented in references 1 and 2, which have been previously transmitted to your staff. The peer review letter report is attached as enclosure 1.

The subject program was directed at establishing the magnitude and characteristics of the radiological source term which could result if specified explosive devices were used to violate the containment integrity of a spent fuel shipping cask. Mutually supporting, but independent research was undertaken by both NRC and DOE. The NRC program, conducted at Battelle Columbus Laboratories (BCL), consisted of tests using less than full scale explosive devices (shaped charges) against simulated casks containing both unirradiated and irradiated fuel rods. Experimental results were used to develop an empirical model to estimate radiological releases for full scale events. A companion DOE program, conducted at Sandia National Laboratories (SNL), consisted of less than full scale and full scale tests. The full scale test involved use of a large shaped charge to attack an obsolete but structurally typical shipping cask containing an unirradiated fuel assembly. The DOE researchers used their experimental results, and an empirical model to account for differences between

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irradiated and unirradiated fuel, to estimate radiological releases for a full scale event. Both programs, therefore, were directed at the same objective, with the numerical results being obtained through different and independent analytical and experimental approaches. The estimates of the radiological source term resulting from each program were very similar in magnitude.

To attain further confidence in the validity of the approaches used to estimate the source term of interest, NRC initiated a peer review which was to focus on the technical areas normally outside the expertise of the NRC staff; namely, (1) the appropriateness of the explosive threat device evaluated in the NRC and DOE programs and (2) the reasonableness of the experimental and analytical techniques used to derive the material release estimates. The peer review was conducted by explosive effects experts at the U.S. Army Ballistic Research Laboratory.

Results

The radiological source term of major interest involved the amount of material which could be released from a spent fuel cask as respirable-sized particles. Respirable material has been the major contributor to the public health effects and economic impacts calculated in previous evaluations (reference 3). Table 1 presents the release estimates documented in references 1 and 2.

Table 1

ESTIMATES OF RESPIRABLE MATERIAL RELEASE

	<u>CASK CONTAINING</u> <u>SINGLE PWR ELEMENT</u>	<u>CASK CONTAINING</u> <u>THREE PWR ELEMENTS</u>
BCL (p 73)	8.97 grams*	(17.9 grams)*
SNL (p 91)	(17 grams)+	34 grams+

() Derived from reported values by considering relative cask-fuel geometries,

* "best estimate" values, and

+ conservative estimate

Table 2, a summary of Table II in the peer review report, presents an assessment of the ranges of release estimates derived from both BCL's and SNL's data.

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Table 2

RESPIRABLE MATERIAL RELEASE ESTIMATES
FROM A CASK CONTAINING 3 PWR ELEMENTS

	<u>LOW</u>	<u>AVERAGE</u>	<u>HIGH</u>
BCL	1.8 grams	7.2 grams	63 grams
SNL	3.12 grams	5.88 grams	32.9 grams

The 34 gram release shown for SNL in Table 1 is a rounded value calculation comparable to the 32.9 gram value in Table 2. It should be noted that these values were based on several conservative assumptions and, therefore, are considered a conservative estimate by SNL, BRL and the NRC staff. The 17.9 gram BCL best estimate in Table 1 can be compared to the Table 2 value of 7.2 grams - the difference being that the BCL value used the largest of several measured concentration values while the Table 2 value assumed an average concentration value which was smaller by a factor of 0.4.

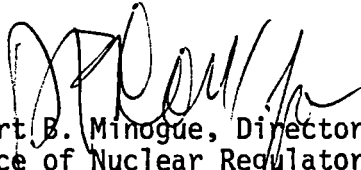
The NRC-RES staff also has reviewed the peer review report and is in agreement with all seven conclusions listed on page 9. (Information pertinent to other peer review comments is included in footnotes 1-3 in the appendix to this memorandum.) The RES staff believes these conclusions are supportive of the performance standard approach which the NMSS staff has proposed as a basis for making regulatory judgements affecting features of the interim safeguards rule. Specifically, the first two conclusions support the selection of the reference basis explosive threat. Conclusions 3 and 4 support the conservatism involved in the selection of the "softest" cask design. Such a selection maximizes the explosive interaction effects on contained spent fuel (refer to footnote 4). Conclusion 5 indicates that the geometric assumptions associated with the consequence estimates should produce upper bound values (refer to footnote 5). Conclusion 6 indicates that the SNL experiments, in which only one wall of the experimental cask was penetrated, would result, nonetheless, in a radioactive material release reasonably representative of events in which two sided cask penetration (perforation) occurred. This conclusion is not directly applicable to the BCL work since their efforts involved scaling of two-sided cask penetration events. Conclusion 7 makes the point that for both BCL and SNL efforts, reasonable engineering hypotheses have been made, but points out that a degree of uncertainty can still exist even when two independent empirical approaches produce similar results.

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Recommendation

The above results, documented in the referenced and enclosed reports, are offered for your use in supporting NRC efforts to modify the interim safe-guards rule. RES believes that these results are significant and appropriate to this regulatory decision process for the following reasons:

- (1) the magnitudes of the independently derived respirable source terms, as shown in Table 2, are all over two orders of magnitude less than the 14000 gram value available when the interim rule was initially formulated.
- (2) appropriate confidence can be had in the validity of the new results in that results are derived from full scale tests using unirradiated fuel and a proof-tested theoretical/empirical approach based on scaled tests using irradiated fuel.
- (3) appropriate conservatisms are included in the experimental and analytical assessments.


Robert B. Minogue, Director
Office of Nuclear Regulatory Research

Enclosures: As stated

APPENDIX

1. The detailed penetration/damage data referred to on page 2 of the peer review is directed at establishing the statistical basis regarding whether the reference basis shaped charge device will fully penetrate both walls of the "softest" shipping cask. The minor impact of this information on the SNL results is discussed on page 5. Since the BCL work assumed full two-wall penetration, the unavailability of the appendix material has no significant impact on their evaluation.
2. Discussion with the peer reviewers indicated that the M180 device mentioned on page 3 of the peer review report, is not now, nor can it be projected in the foreseeable future to be a replacement for the M3A1 device assumed in the BCL and SNL programs.
3. The comments on page 6 by the peer reviewers regarding the subscale, non-linear scaled experiments are made with the knowledge of the costs and scaling uncertainties associated with linear scaling. In any event, neither the BCL or SNL experimental approaches were intended to scale-up a linear subscale event but rather to gain information to develop an empirically derived model to estimate respirable material release.
4. The selected lead shielded truck cask could be used for the shipment of 1 PWR or 2 BWR assemblies, whereas the consequence analysis assumed a cask containing 3 PWR assemblies.
5. Higher burnups are associated with fuel disrupted at approximately the middle of an irradiated fuel assembly for the assumed diametral cask penetration, whereas the end-on attack would be disrupting the lower burnup regions of a fuel assembly(ies).

RES Files

Subject File No. R-2913.01

Task No.

Research Request No. ~~FIN B6012~~

FIN No. FIN A 1077

NUREG No. NUREG/CR-2472

Docket No. NUREG/CR-0742

Rulemaking No.

Other

NRC PDR

Return NRC-310

Yes

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Original Signed by

Denwood F. Ross, Jr.

for
Robert B. Minogue, Director
Office of Nuclear Regulatory Research

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