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MAY 29 1985

MEMORANDUM FOR: D. F. Ross, Deputy Director
Office of Nuclear Regulatory Research

THRU: M. Silberberg, Assistant Director
Accident Source Term Program Office, RES

FROM: R. O. Meyer
Accident Source Term Program Office, RES

SUBJECT: SOURCE TERM CODE PACKAGE

At your SARP review group meeting of May 22, it became evident that information about the Source Term Code Package had not been distributed widely enough. I hope to remedy that situation with this memo and its enclosures.

Two things ought to be emphasized. (1) The Source Term Code Package remains basically the reviewed BMI-2104 suite of codes. The changes that are now being made involve developments that were made (and discussed) during the course of the review. (2) The quality assurance work at BNL addresses the code package itself and was not intended to cover QA for a new round of calculations at BCL.

The enclosures describe the Source Term Code Package now being assembled at BCL and the related quality assurance at BNL.

Original Signed by

R. Meyer
Accident Source Term Program Office
Office of Nuclear Regulatory Research

Enclosures:
1. A new section (Sect. 3.5.3) in NUREG-0956.
2. 4/16/85 memo describing the code package.
3. Part of the BNL 189 on A-3284 (FY 85).

RES:ASTPO Meyer:md 5/28/85

RES:ASTPO Silberberg 5/29/85

C/6

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as large as iodine within the fuel pellets. The cesium not reacted with iodine is believed to react with steam to form cesium hydroxide. However, the presence of some elemental iodine is possible for certain sequences. Elemental iodine has been observed experimentally, as a consequence of hydrogen combustion in the presence of aerosols containing CsI (Ref. 3.22). Elemental iodine and hydrogen iodide are also believed to be formed in-vessel in BWR reactors because of reactions with B_4C control materials (Ref. 3.23). Further, in early separate effects measurements at Oak Ridge National Laboratory, a very small amount of elemental iodine was observed during experiments on releases from fuel in steam (Ref. 3.24). Therefore, the effect of some elemental iodine in the containment atmosphere is being investigated parametrically with the iodine model in use in the Federal Republic of Germany (Ref. 3.25).

A further consideration about the chemistry of iodine is its tendency to react with organic materials to form volatile organic iodine compounds. Organic compounds from many sources are available in the containment atmosphere to form these reaction products. Since removal processes that would lower airborne concentrations of cesium iodide and other aerosols are not effective for organic forms of iodine, the process of formation of organic iodine will likely form a limit for iodine release following containment failure below which removal processes are not likely. The range of this release is uncertain, but is likely to be on the order of one percent of the core inventory.

Tellurium (Te) is an extremely reactive metal, forming compounds with unoxidized Zircaloy and remaining with the core material as long as most of the cladding remains unoxidized. This process is modeled in CORSOR, where the release of Te is dependent on the portion of Zircoloy remaining unoxidized. Following cladding oxidization, the release rate of Te is increased sharply. This modeling of the retention of Te with the fuel until ex-vessel oxidization of the cladding for certain sequences accounts for a calculated Te leakage release fraction larger than cesium and iodine leakage release fractions.

3.5.3 Source Term Code Package

In the previous sections, remedies have already been described for some of the problems affecting the BMI-2104 calculations. For example, an improved model

for the core-concrete interaction, CORCON Mod 2, became available shortly after publication of BMI-2104. This newer version does not suffer from the viscosity-related problems of CORCON Mod 1 (see Section 3.1.3). In addition, certain inconsistencies, like the use of INTER instead of CORCON within the MARCH code (see Section 3.1.1), could be rectified with some reprogramming. Furthermore, most of the data handling problems (see introductory paragraphs in Chapter 3) could be alleviated with automated coupling of the codes.

Work was thus begun in August 1984 to produce an improved version of the BMI-2104 suite of codes that is now referred to as the Source Term Code Package. Major features of this code package are described in Table 3.5. The Source Term Code Package is seen to retain all of the basic features of the BMI-2104 analytical procedure, which was extensively reviewed, and the modifications that have been made resulted largely from the peer review process. The code package should be operational in June 1985, and code release and documentation are scheduled for September 1985.

3.5.4 Summary

In summary, the BMI-2104 suite of codes reflects the state of the art as it existed in the 1983-84 time period and represents a major advancement in the source term analytical procedure since WASH-1400. While the NRC recognizes the desirability of further review and documentation, it can be noted that the codes are fully operational, that an extensive peer review has been conducted, and that a large amount of documentation has already been published on the codes. A slightly improved version of the codes, referred to as the Source Term Code Package, will be available soon to facilitate the analysis of additional accident sequences.

The BMI-2104 codes provide best-estimate analyses. They address natural phenomena that were either omitted or treated simplistically in previous analyses, such as WASH-1400, in a manner that produced large source terms. Large uncertainties exist in many of these codes and numerous areas have been identified for improvement, but no egregious errors have been uncovered in the analytical procedure. Research programs that will lead to code improvement and reduced uncertainties are discussed in Chapter 8.

Table 3.5 Major features of the new Source Term Code Package

CODE	IMPROVEMENT
MARCH	CORSOR and CORCON have replaced FPLOSS and INTER within the MARCH code, thus eliminating related inconsistencies.
MERGE and TRAP-MELT	These codes have been combined into a single code to treat fission product reheating.
CORSOR	An Arrhenius equiation has been used along with vaporization properties, when appropriate.
CORCON	Mod 2 has been used with its imporved treatment of viscosity.
NAUA and MARCH	A more realistic treatment of water droplets has been used at the interface between codes.
All Codes	Code interfaces have been changed to utilize tape-read output and input.

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

APR 16 1985

MEMORANDUM FOR: M. Silberberg, Assistant Director
Accident Source Term Program Office
Office of Nuclear Regulatory Research

FROM: Ralph O. Meyer
Accident Source Term Program Office
Office of Nuclear Regulatory Research

SUBJECT: NRC SOURCE TERM CODE PACKAGE

On April 10, 1985, Hans Ludewig (BNL) and I met with J. Gieseke, P. Cybulskis, H. Jordan, and K. Lee at BCL to discuss final plans for packaging the BMI-2104 Battelle suite of codes. This packaging will be done in several steps as follows.

In the next one to two months (i.e., by June 15, 1985), additions (as opposed to subtractions to be mentioned below) will be made to produce a good working code package. The constituents of this package will also be discussed below. This work will proceed with a high priority, and the BCL staff believes that this is the quickest route to new sequence calculations -- quicker than starting immediately with the uncoupled codes. BNL will assist BCL in this early phase, particularly in the area of core-concrete interactions.

In the following four to six months, subtractions from the code will be made. That is, unused options (like 4 unused in-vessel fission product release options, 2 unused meltdown models, etc.) will be removed from the package to make it more efficient and less user-dependent. A code manual will also be prepared during this time. Since we will still be utilizing the basic codes, reviewed in the BMI-2104 study, the manual for the code package will rely on existing manuals for the individual codes. The new manual will merely discuss any code changes that have been made and describe how to use the package. During this time, BNL will be actively engaged in quality assurance verification, including some detailed comparisons with BMI-2104 cases.

Following verification and documentation of this NRC Source Term Code Package, work will continue at BCL and BNL to provide additional validation (or benchmarking) with new data and mechanistic codes leading to improved versions of the code package (e.g., Mod 1).

package dupa.

The code package will consist of the following:

MARCH-3

MARCH-3 will be MARCH-2 with CORSOR-M, CORCON2 and probably VANESA (a recent version) built right into MARCH. CORSOR has already been put into MARCH at BCL. CORCON has been put into MARCH at SNL. And CORCON has been coupled directly with VANESA at BNL. Therefore, no development work should be required to assemble MARCH-3.

TRAP-MELT-3

TRAP-MELT-3 is a combination of TRAP-MELT-2 and MERGE. This work has been completed at BCL, and a draft report describing some of the revaporization calculations with this code has been completed.

NAUA/SPARC/ICEDF

Near-term changes will concentrate on better interfaces with MARCH and TRAP-MELT. An improvement is being made in the treatment of water droplets in the MARCH/NAUA interface. A small program has also been written to un-bin the VANESA output so that NAUA will get individual species. A few other modest changes are also planned.

In summary, the code package as it will exist this summer will not require any new developmental work. It will consist of the basic BMI-2104 methodology, which was reviewed, along with some improvements that were made during the course of that review (e.g., CORCON 2).

Procedurally, BCL was to give us a letter report proposing the specifications for the code package, and they did that on November 9, 1984. We were then to reply to BCL with further instructions to proceed. Our meeting of April 10, 1985 and this memorandum are intended to provide that feedback.

Ralph O. Meyer
Accident Source Term Program Office
Office of Nuclear Regulatory Research

cc: D. Ross, RES
O. Bassett, RES
J. Gieseke, BCL
P. Cybulskis, BCL
H. Jordan, BCL
K. Lee, BCL
H. Ludewig, BNL
FSRB
ASTPO

PROJECT DESCRIPTION

1. OBJECTIVE OF PROPOSED WORK

a. Background

During accidents in Light Water Reactors (LWRs) the reactor core could be damaged and fission products may be released to the primary system. If the primary system is breached fission products could in turn be released to the containment building. In containment there are a number of systems available to help prevent the fission products from being released to the environment. If these systems fail or are compromised, a fraction of the radionuclides may be released to the atmosphere with corresponding adverse effects on the surrounding environment. There are potentially a large number of different accident sequences that could lead to core damage and ultimately to core meltdown. Each individual accident sequence could result in several possible paths for fission products to reach the environment. Each path will have a unique fission product release characteristic or "source term."

In order to define a "source term", information is needed on the amount and chemical form of the fission product species released and also on the characteristics of the release. The release characteristics are the timing of release, release duration, release height and release energy. In the Reactor Safety Study (RSS) models of the physical processes associated with particular accident sequences were developed to assess the magnitudes and timings associated with the release, transport, and deposition of the radioactive materials from the core through the primary system and containment and into the environment. However, it has been suggested that the methodology used to generate source terms in the RSS may contain simplifications, which would tend to overpredict the release of fission products and hence result in overly conservative estimates of off-site consequences.

Significant research activity in this area has been undertaken following the publication of the RSS in 1975. An updated basis for estimating fission product behavior was published in NUREG-0772 by RES/NRC. In addition, updated fission product source term methods were developed under the direction of the Accident Source Term Program Office (ASTPO) and published in BMI-2104. Several computer codes (refer to BMI-2104) were developed to calculate source terms. Consequently, calculating individual source terms is now a highly complex processes involving significant data transfer between all of the ASTPO codes. In addition, as these codes are not coupled, a number of coupled phenomena cannot be readily addressed, e.g., local heating effects due to primary system retention of fission products. It was therefore decided by the NRC staff to fund Battelle Columbus Laboratories (BCL) to integrate these codes into one self-consistent code package. This package would eliminate the need for assuring correct data transfer and compatibility between codes and also allow the user to assess the influence of the coupled phenomena.

b. Objective

The objective of the activities described in this project is to provide quality assurance of the BCL code package described above in Section 1a. BNL staff will obtain the code package from BCL and install it on the BNL computing system. The code package will be reviewed specifically to ensure that models and options have

(See Continuation Sheet)

1. OBJECTIVE OF PROPOSED WORK (Cont.)

been correctly implemented. In addition, the coupling of the various codes in the package will be carefully checked. Finally, the portability of the code package and its ease of use will be assessed.

2. SUMMARY OF PRIOR EFFORTS

Not Applicable.

3. WORK TO BE PERFORMED AND EXPECTED RESULTS

a. Work Requirements

As directed by the NRC Project Manager, R. O. Meyer, BNL staff will perform the following tasks:

Task 1

BNL staff will obtain the Source Term Code Package from BCL and install it on the BNL computer.

Task 2

The code package will be reviewed at BNL for (a) correct implementation of BMI-2104 models and options, (b) adequacy of code couplings, and (c) portability and ease of use.

Task 3

The code package will be exercised for selected plants and accident sequences. The specific plants and accident sequences to be analyzed will be selected by the NRC Project Manager in consultation with BNL staff.

Task 4

It will be necessary for BNL staff to iterate with BCL staff to obtain corrections for any problems discovered during the review.

Task 5

A report will be provided to the NRC Project Manager briefly summarizing the BNL effort and describing the state of readiness of the Source Term Code Package.

b. Meetings and Travel

The BNL staff will participate in meetings at the NRC Headquarters in Silver Springs, Maryland. In addition, BNL staff may visit other laboratories or institutions and participate at professional meetings.

(See Continuation Sheet)

MONTHLY HIGHLIGHTS FOR MAY 1985

"Source Term Code Package Verification"

(FIN A-3284)

BNL Principal Investigator: W. T. Pratt (FTS 666-2630)

NRC Project Manager: R. O. Meyer (FTS 427-4461), ASTPO

1. Scope/Purpose:

Updated fission product source term methods were developed under the direction of the Accident Source Term Program Office (ASTPO) and published in BMI-2104. The several computer codes developed as part of this effort are being integrated at BCL into one self-consistent code package. The objective of this BNL project is to provide quality assurance of the BCL code package. BNL will obtain the code package from BCL and install it on the BNL computing system. The code package will be reviewed to ensure correct implementation of the models and options. In addition, the coupling of the various codes in the package will be carefully checked.

2. Work Performed During Period:

Work on this project was initiated and discussions were held with the NRC Project Manager related to the scope of work. A meeting was held at BCL to discuss final plans for packaging the suite of BCL codes.

3. Problems/Delays:

The level of effort on this project will be increased after the working code package is received at BNL.

4. Summary of Progress to Date/Milestones:

See Item 2.

5. Next Reporting Period:

A working version of the code package is expected by June 15, 1985.

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