AUG 29 1985

Distribution:
Subj
Circ
Chron
Branch r/f
JMitchell
JMitchell r/f
RMeyer
MSilberberg
OEBassett
WMorrison
RMinogue
D?oss
TMargulies, RES
HRichings, NRR
MErnst

17

Dr. Richard Denning
Battelle Columbus Laboratory
505 King Avenue
Columbus, OH 43201

Dear Dr. Denning:

After many discussions, the following describes our understanding of the decay heat situation in the MARCH-3 code (MARCH2-CORCON) and our request for a modification to alter the decay heat calculation.

The decay heat calculations in MARCH2 and in the stand-alone version of CORCON are based on different types of calculational models. MARCH2 uses the simplified formula of the 1979 ANS 5.1 decay heat standard, which assumes only U-235 fission at a constant power level (except for a constant multiplicative factor of 1.02 to account for U-238 decay heat at extremely short times after shutdown). CORCON uses the decay heats of inventories of individual radionuclides based on an ORIGIN calculation for a PWR or a BWR plant. These different models result in about a 20% difference in decay heat at the times of interest for core concrete interactions. Therefore, in the Source Term Code Package, when control is switched from the MARCH2 model to the CORCON model, there would be a drop in the decay heat were no action taken to resolve the difference. Following investigation of the sources of the difference, it was concluded that for reasons outlined below the MARCH2 model should be adjusted downward by about 8% and the CORCON model normalized to agree with the MARCH2 model, producing roughly a 12% upward adjustment. An input quantity, Q MeV/fission, is available for producing about the right adjustment in MARCH, but for the long term, the model in MARCH should be changed to accommodate fissions in Pu-239 and U-238 as well as in U-235.

The default value in MARCH2 for Q, the total recoverable energy associated with one fission, is 200 MeV/fission. This value has been used in all the calculations to date. The value of Q to use as input to the standard for any given fissioning species is, actually, dependent on several parameters including the neutron flux spectrum and the time in the cycle. Therefore, it is necessary to provide a value that is appropriate for the particular problem. At the end of an equilibrium cycle in an LWR, about equal numbers of fissions are taking place in U-235 and in Pu-239 (about 40% in each) with about equal numbers of fissions also taking place in U-238 and in Pu-241 (about 10% in each). Based on evaluations by R. Sher,* values of Q for each of the fissioning species have been determined by H. Richings of the Core Performance Branch in NRR. His values are: 202 MeV/fission for U-235, 211 MeV/fission for Pu-239, 206 MeV/fission for U-238 and 213 MeV/fission for Pu-241. Since the decay heat for core melt accident

* R. Sher, "Fission Energy Release for Sixteen Fissioning Nuclides," EPRI report NP-1771 prepared by Stanford Univ., March 1981.

RPMIS

C/11

considerations is dependent mainly on the operating history in the few days just before the accident, to provide an average Q value consistent with an inventory at the end of a cycle, a value of 207 MeV/fission should be used.

Further, in the ANS standard the constant multiplicative factor of 1.02, which provides a bounding decay heat in the first 10 seconds following shutdown, is not appropriate for the long times from shutdown of core melt accidents. Since the factor appears in the numerator of the decay heat equation and the Q factor appears in the denominator, raising the Q value by 1.02 will effectively eliminate this factor.

In addition, the nuclides born of Pu-239 fission exhibit less decay heat than those born of U-235 fission independent of the effects of differences in Q. In the time period between 10,000 and 100,000 seconds, the differences between the decay heats is changing from about 10% to about 3% with Pu-239 fissions producing lower decay heat. An overall 4% reduction would account for the equal fission fractions and be closer to the value at 10,000 seconds, where the decay heat is a larger fraction of the total available heat. This correction can also be made by adjustment of the value of Q input.

To accommodate all the above effects, a final effective value of Q to input is then:

$$207 \times 1.02 \times 1.04 = 220 \text{ MeV/fission.}$$

The decay heat equation in MARCH2 (i.e., in the simplified version of the standard) also includes the heat produced by the decay of U-239 and subsequently by Np-239. There is a normalizing factor R in the equation to give the number of atoms of U-239 produced by one fission in U-235, which is also dependent on reactor parameters. The default value of 0.8 has been used and continues to be appropriate for reactor conditions at the end of an equilibrium cycle. Both T. England (LASL) and H. Richings agree that the magnitude of this contribution to the toal heat is less than 20%. Since this second term in the ANS standard is not affected by the Q value, the total correction to MARCH2 due to a 10% increase in Q value would be a net reduction in decay heat of approximately 8%.

The ANS 5.1 decay heat standard also includes a time dependent factor, GMAX (t), which accounts for the decay produced by neutron absorption in fission products. The value in the standard is conservative, but based on conversations with T. England it is appropriate to use this factor in the time period of interest, 10,000 to 100,000 seconds. It is his opinion that neither ORIGIN nor CINDER would correctly account for this process, given the libraries available through the ENDF system. Since in the time period of interest GMAX is about 1.1, this effect accounts for the underprediction of the decay heat by CORCON, which is based on ORIGIN results.

In summary, the difference between the decay heat calculations of MARCH and CORCON has been resolved. The present MARCH model is too high because it does not account for fissions in Pu-239 and it includes a factor to bound the

decay heat in the time period between shutdown and 10 seconds. On the other hand, CORCON is too low because it fails to account correctly for the heat produced from neutron absorption in fission products. The adjustment to the Q value described above has been discussed with Howard Richings (NRR), Tal England (LASL), and David Bennet (SNL). All agree that this is the appropriate adjustment to make at this time.

Sincerely,

Original Signed By

M. Silberberg, Branch Chief
Fuel Systems Research Branch
Division of Accident Evaluation
Office of Nuclear Regulatory Research

cc: T. England, LANL
D. Bennet, SNL
D. Powers, SNL
K. Perkins, BNL
T. Pratt, BNL
J. Gieseke, BCL
T. Kress, ORNL

DAE:FSRB	DAE:FSRB	DAE:FSRB
Mitchell:md	Meyer	Silberberg
8/14/85	8/ /85	8/25/85

15

USNRC SOURCE TERM CODE PACKAGE AND ITS APPLICATION

R. O. MEYER

USNRC

5TH ANNUAL INFORMATION EXCHANGE MEETING

ON CORE MELTDOWN RESEARCH

Shelter Island, NY

October 17, 1985

C/18

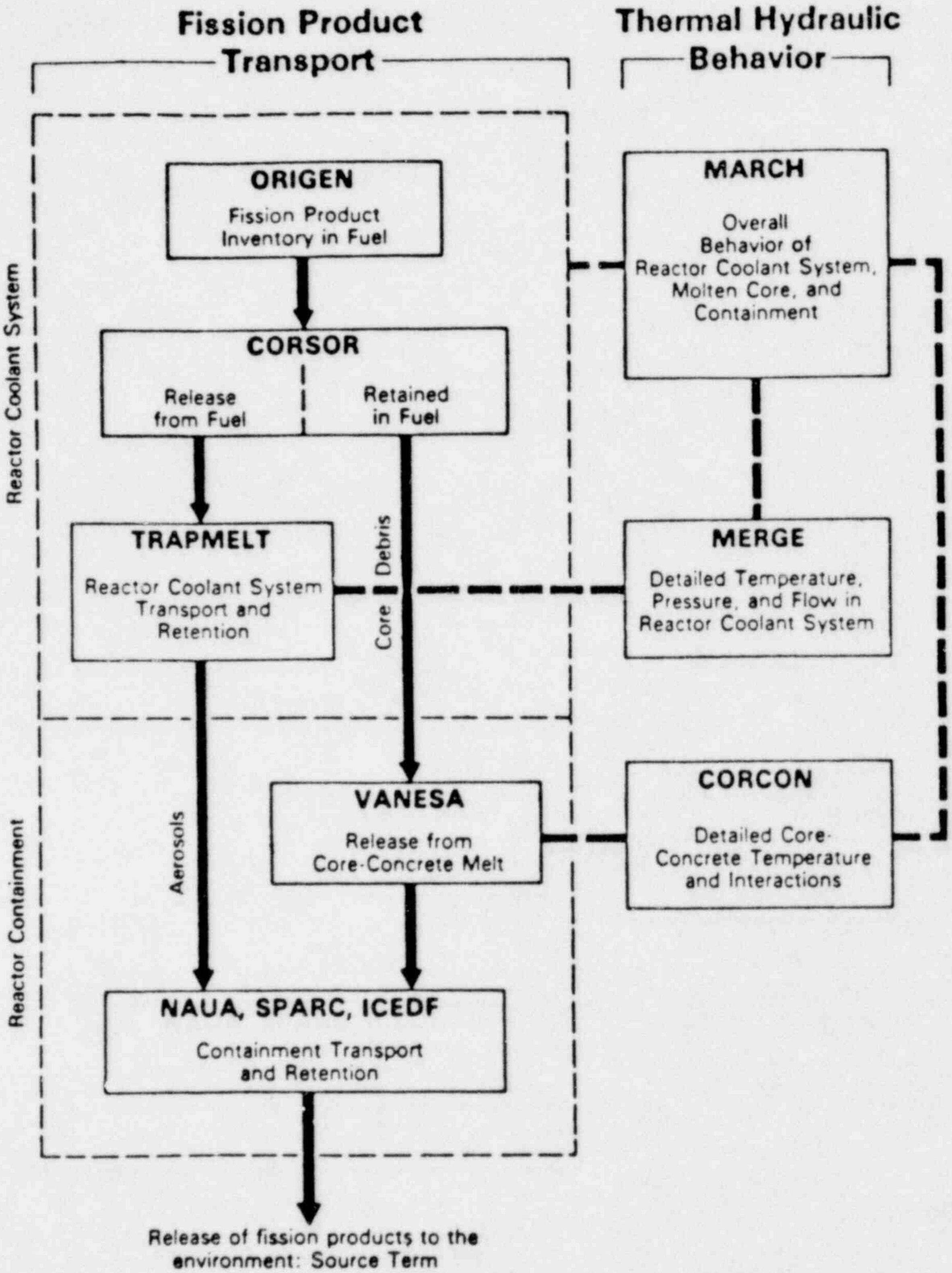

Figure ES.1 BMI-2104 suite of codes as used in the source term reassessment.

Table 3.6 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 equation has been used along with vaporization properties.
CORCON	Mod 2 has been used with its improved 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 use tape-read output and input.

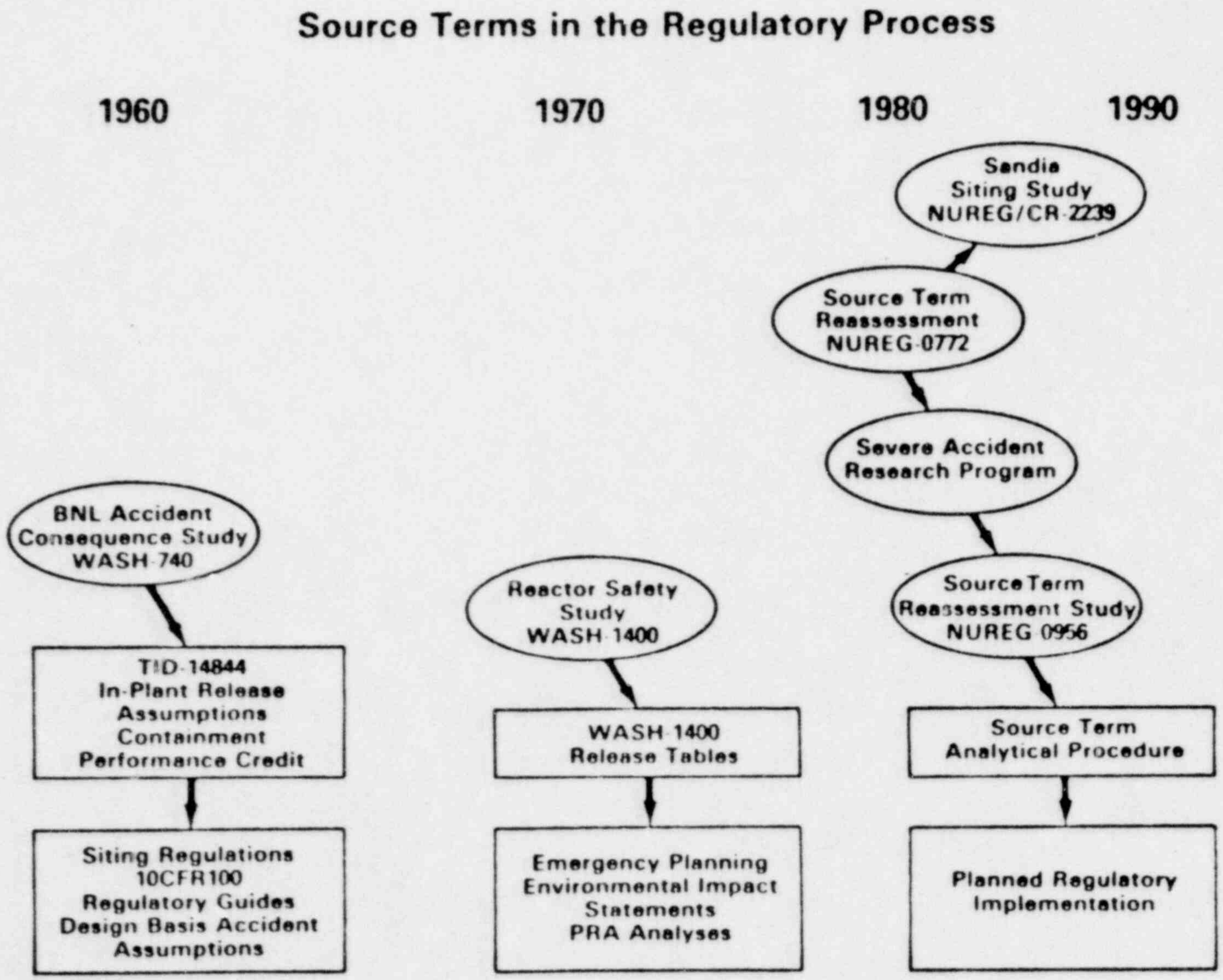

Figure 2.1 History of source term assessment and relationship to regulatory process.

Regulatory Areas Targeted for Source Term Related Changes

1. Resolution of Safety Issues Related to Severe Accidents - Prevention and Mitigation of Severe Accidents, Maintaining Containment Integrity in Case of Severe Accidents

2. Containment Performance Requirements - Leak Rate Test, Undetected Breach of Containment Integrity

3. Environmental Qualification of Equipment Important to Safety - Qualification Requirements for Design Base Accidents

4. Emergency Planning - Onsite Planning, Offsite Emergency Planning Zones, Graded Response

5. Accident Consequences and Indemnification - Definition of an Extraordinary Nuclear Occurrence, Extension of the Price-Anderson Act

6. Air Filtration and Other Fission Product Attenuation Systems - Containment Spray Systems, Recirculating Air Filters, Control Room Air Filters and Filtered Building Exhausts were designed for Elemental Iodine and for Instantaneous Release - Automatic Actuation of PWR Spray Systems

7. Accident Monitoring and Management, Onsite and Offsite Instrumentation - Diagnostic Capability of Offsite Monitors

8. Offsite Contamination, and Recovery - Present Basis is WASH-1400, Predistribution of Potassium Iodide

9. Safety Issue Evaluation - Prioritization of Generic Issues is presently based on WASH-1400.

10. Siting - Explicit Consideration of Severe Accidents in Siting, Use of Source Term in Siting

6

October 23, 1985

Status of the Source Term Code Package (STCP) at BNL

Code	Status	Comments
MARCH3 (MARCH2/CORSOR/CORCON)	Operational	• Sample Problem runs to completion • Several inconsistencies have been uncovered, which are being investigated and resolved.
TRAP-MERGE (TRAP-MELT/MERGE)	Operational	• Sample Problem runs to completion • Use of 1971 Standards instead of 1979 Standard Decay Heat in MARCH • Many errors have been found and corrected at both BNL and BCL • BCL asserts that the impact of these errors on Peach Bottom calculations are not significant. This must be verified through calculations.
VANESA	Loaded	• Sample Problem is being exercised
SPARC	Loaded	• Sample Problem is being exercised
NAUA	Loaded	• Sample Problem is being exercised

C/19