UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

July 5, 1996

NRC INFORMATION NOTICE 96-39: ESTIMATES OF DECAY HEAT USING ANS 5.1 DECAY HEAT STANDARD MAY VARY SIGNIFICANTLY

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to the sensitivity of analytical results to input parameters used with American Nuclear Society standard 5.1 on decay heat (Reference). It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Background

American Nuclear Society standard 5.1 (ANS 5.1 standard) for decay heat generation in nuclear power plants provides a simplified means of estimating nuclear fuel cooling requirements that can be readily programmed into computer codes used to predict plant performance. The ANS 5.1 standard models the energy release from the fission products of U-235, U-238, and Pu-239 using a summation of exponential terms with empirical constants. Corrections are provided to account for energy release from the decay of U-239 and Np-239, and for the neutron activation of stable fission products. Although the empirical constants are built into the standard, certain data inputs are left to the discretion of the user. These options permit accounting for differences in power history, initial fuel enrichment, and neutron flux level.

Description of Circumstances

During a review of decay heat estimates calculated using various codes for the same plant, the staff found that the predicted decay heat varied considerably. This was unexpected because the analyses were made using the 1979 ANS 5.1 standard and were to be used in "best-estimate" thermal-hydraulic analyses.

The staff compared calculations of decay heat using MELCOR, TRAC, RELAP, and a vendor code for a pressurized water reactor operating at 1933 megawatts thermal (MWT). The staff made 3 calculations using RELAP but varied certain inputs. These calculations appear as $RELAP_1$, $RELAP_2$, and $RELAP_3$ in the following tables. The decay heat estimates in MWT calculated for 2 hours after shutdown of the reactor using the various codes and allowable inputs were as follows:

MELCOR -	20.70 MWT
Vendor code -	22.15 MWT
$RELAP_1$ -	22.02 MWT
$RELAP_2$ -	26.13 MWT
$RELAP_3$ -	20.82 MWT
TRAC -	22.02 MWT
ORIGEN -	20.90 MWT

It should be noted that the differences in predicted decay heat resulted from the parameters selected for input and not from the codes themselves.

The last entry in the table was not calculated by the ANS 5.1 standard but was calculated by the ORIGEN computer code. ORIGEN does not use empirical methods to calculate decay heat but tracks the buildup and decay of the individual fission products within the reactor core during operation and shutdown. ORIGEN also includes the effect of element transmutation from neutron capture, both in fissile isotopes and fission products. Because ORIGEN is a rigorous calculation of all decay heat inputs, it was used in the calculations for decay heat in attached Figure 1 and is contrasted with attached Figure 2 using decay heat internally calculated by RELAP to the ANS 5.1 standard.

<u>Discussion</u>

The staff found that the different decay heat estimates occurred because the ANS 5.1 standard was not fully utilized in the selection of inputs. Attached Table 1 shows the various inputs to the codes to estimate decay heat. Attached Table 2 shows the effect of different assumptions on best estimate calculations of decay heat 2 hours after shutdown of the reactor.

The variation in peak cladding temperatures with various predictions of decay heat may be seen by comparing the attached Figures 1 and 2. These figures are plots of the peak cladding temperatures for a hypothetical beyond-design-basis loss-of-feedwater event. For Figure 1, values of decay heat predicted by the ORIGEN code were input directly into RELAP. Figure 2 is the same event with the decay heat internally calculated by RELAP using the ANS 5.1 standard. Input assumptions to the standard were those that produced the highest values of decay heat denoted in Table 1 as $RELAP_2$. The difference in predicted peak core cladding temperatures (approximately 250° K [630° F]) demonstrates the importance of carefully selecting required input parameters when using ANS 5.1 because analytical results may be significantly affected. Depending on the input parameters selected the results may be conservative or nonconservative.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Brian Grimes

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Attachments:
1. Table 1, "Decay Heat Options Using ANS 5.1, 1979"
2. Table 2, "Relative Importance of Options 7200 Seconds (2 hours) After Reactor Shutdown"
3. Figure 1, "Peak Core Cladding Temperature Calculated by ORIGEN" and Figure 2, "Peak Core Cladding Temperature Calculated by ANS 5.1"
4. List of Recently Issued NRC Information Notices

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Attachments Filed in Jocket.

Table 1. Decay Heat Options Using ANS 5.1, 1979

Codes	Actinides	R-Factor	G-Factor	Si	Power History	Fissile Elements
Vendor	Yes	0.6	Not ANS	1.347	3 Yrs.	3
$RELAP_1$	No	NA	MAX	NA	Infinite	All U235
$RELAP_2$	Yes	1.0	MAX	NA	Infinite	All U235
$RELAP_3$	No	NA	No	NA	Infinite	All U235
MELCOR	Yes	0.526	Yes	0.713	1.6 Yrs.	3
TRAC	No	NA	Yes	1.0	Infinite	All U235

Notes:

Actinides: Neutron capture by U238 produces U239 which decays into Np239 which also decays, adding to the total decay heat. Not all the above code inputs included actinide decay.

R-factor: The actinide production multiplier. The standard states that the value of R shall be supplied and justified by the user.

G-factor: A decay heat multiplier to account for the effect of neutron capture in fission products. The standard provides the option of using a maximum value table for the G-factor or a best estimate equation for the first 10,000 seconds.

Si: Fissions per initial fissile atom. Si is a multiplier applied to the G-factor equation.

Power History: Length of full-power operation before shutdown.

Fissile Elements: The standard permits decay power to be fractionally attributed to the fission products of 3 fissile isotopes U235, U238, and Pu239. The vendor input attributed the fractional fission product power as 0.487 from U235, 0.069 from U238, and 0.443 from U239. The fractional fission product power input to MELCOR was 0.647 from U235, 0.0425 from U238, and 0.31 from Pu239. The other code inputs assumed all fission product power came from U235.

Table 2. Relative Importance of Options
7200 Seconds (2 hours) After Reactor Shutdown

Complete Set For:	Options as Input and Varied	Decay Heat in MWT
MELCOR	MELCOR assumptions (see Table 1)	20.70
	Increase R from .526 to .6	21.03
	Increase Si from .713 to 1.347	21.13
	Operation time from 1.6 years to 3 years	21.40
	Vendor fissile isotopes	21.12
	Vendor heavy element equation	21.86
Vendor code	Vendor G-factor equation	22.15
	ANS 5.1 G-factor and heavy element eqs.	21.12
	No actinides	18.65
	Gmax rather than equation	19.44
	Infinite operation	20.53
$RELAP_1$	All fission from U235	22.02
$RELAP_2$	Add actinides with R=1	26.13
$RELAP_3$	Remove actinides and G-factor	20.82
TRAC	Include G-factor equation with Si=1	22.02

Note: This table illustrates the relative importance of the various options contained in the 1979 ANS 5.1 standard. Starting with the decay heat rate calculated by MELCOR using the inputs listed in Table 1, the options were changed in sequence to those used in the vendor computer code. The options were then changed to those used in the $RELAP_1$ analyses, the $RELAP_2$ analyses, the $RELAP_3$ analyses, and the TRAC analyses.

Figure 1 Peak Core Cladding Temperature

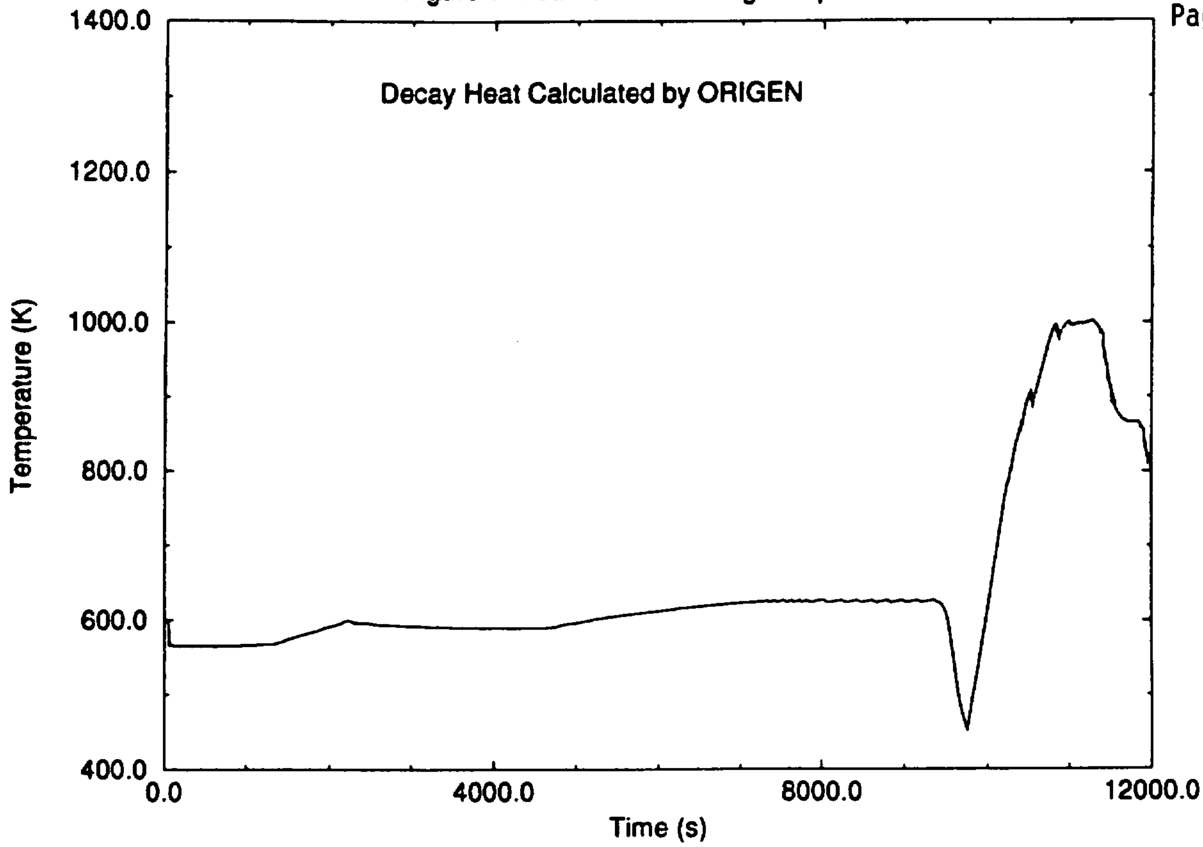
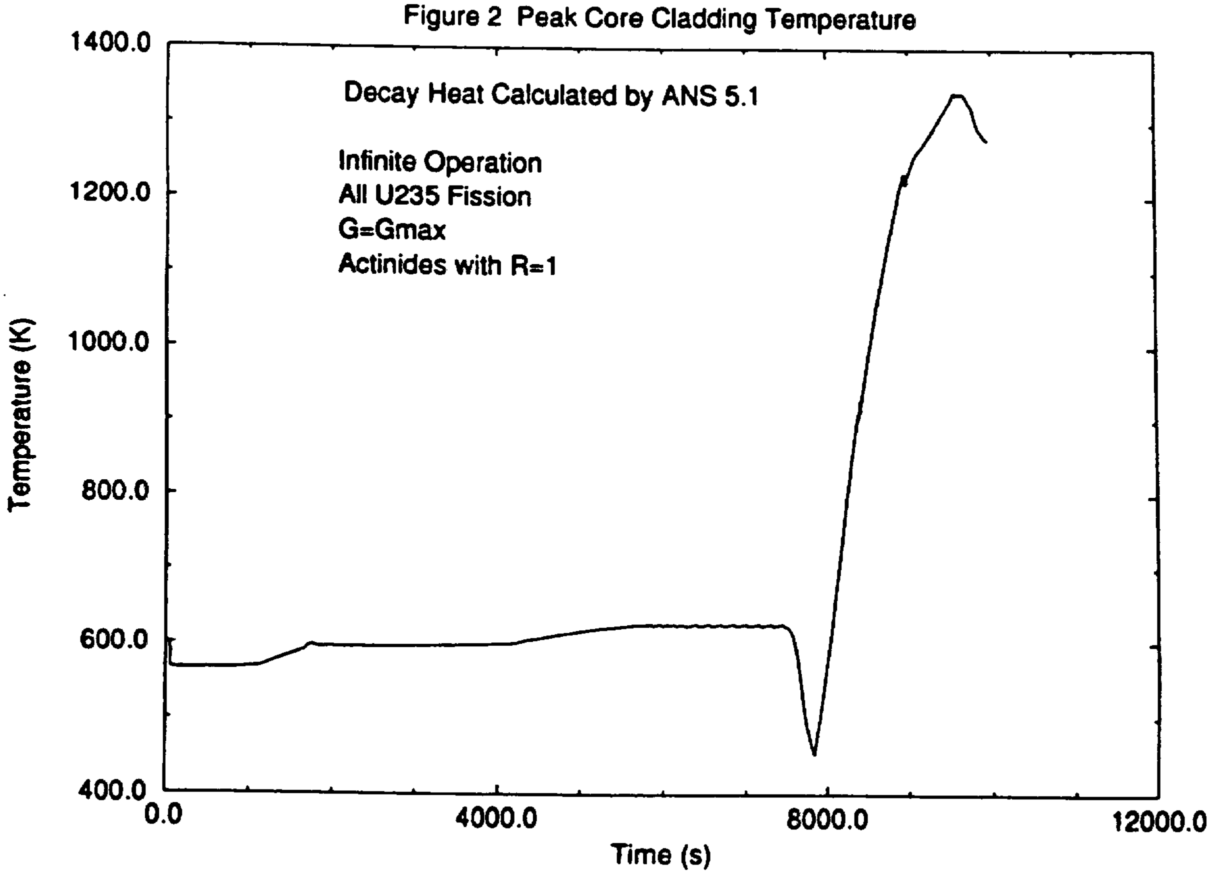


Figure 2 Peak Core Cladding Temperature



LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
96-38	Results of Steam Generator Tube Examinations	06/21/96	All holders of OLs or CPs for pressurized water reactors
96-37	Inaccurate Reactor Water Level Indication and Inadvertent Draindown During Shutdown	06/18/96	All pressurized water reactor facilities holding an operating license or a construction permit
96-36	Degradation of Cooling Water Systems Due to Icing	06/12/96	All holders of OLs or CPs for nuclear power reactors
96-35	Failure of Safety Systems on Self-Shielded Irradiators Because of Inadequate Maintenance and Training	06/11/96	All U.S. Nuclear Regulatory Commission irradiator licensees and vendors
96-34	Hydrogen Gas Ignition during Closure Welding of a VSC-24 Multi-Assembly Sealed Basket	05/31/96	All holders of OLs or CPs for nuclear power reactors
96-33	Erroneous Data From Defective Thermocouple Results in a Fire	05/24/96	All material and fuel cycle licensees that monitor temperature with thermocouples
96-32	Implementation of 10 CFR 50.55a(g)(6)(ii)(A), "Augmented Examination of Reactor Vessel"	06/05/96	All holders of OLs or CPs for nuclear power reactors
96-31	Cross-Tied Safety Injection Accumulators	05/22/96	All holders of OLs or CPs for pressurized water reactors
96-30	Inaccuracy of Diagnostic Equipment for Motor-Operated Butterfly Valves	05/21/96	All holders of OLs or CPs for nuclear power reactors
96-29	Requirements in 10 CFR Part 21 for Reporting and Evaluating Software Errors	05/20/96	All holders of OLs or CPs for nuclear power reactors

OL = Operating License
CP = Construction Permit

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Original signed by Brian K. Grimes

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*See previous concurrence

Tech Editor reviewed and concurred on 03/19/96

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DATE	04/02/96 03/19/96	05/16/96	07/ 1 /96		

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