IMPROVEMENT AND VERIFICATION OF
FAST REACTOR SAFETY ANALYSIS TECHNIQUES

Progress Report

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ABSTRACT

The initial steps required in establishing a linkup between BYU and the CDC-7600 computer at Lawrence Berkeley have been taken. The linkup should be completed during the next quarter. The first phase of the VENUS-II/PAD comparison study has been accomplished via the comparison of two representative excursions in a demo-sized LMFBR. A calculation that provides the work-energy obtained from an isentropic expansion of fuel-vapor down to one atmosphere has been included in VENUS-II. A technique to provide the full P-V-work curve as a function of the degree of expansion is currently under development. Previous comparisons between disassembly codes and experiments have been reviewed and an initial model for analyzing the KIWI-TNT experiment with VENUS-II is being formulated.

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INTRODUCTION AND SCOPE

During this first period of the contract, work was initiated in four of the major task areas. The activities in each area are summarized in the succeeding sections. Since most of the work was in the form of initiating longer term projects, this initial report will emphasize description of progress more than presentation of results.

CODE ACQUISITION

The initial task in this area was to develop a remote telephone linkup with the CDC-7600 computer at Lawrence Berkeley. Initial interaction with the computer personnel at Berkeley to define hardware and administrative needs has been completed. The required approval for obtaining ERDA computing rates was arranged for.

On-campus hardware was evaluated and the required modifications and additions were defined. Alternatives for acquiring the needed additional hardware are currently being examined. It appears that initial check-out of the linkup should be ready to proceed in late August.

VENUS-II/PAD INTERCOMPARISON STUDY

The initial stage of a comparison study between the VENUS-II¹ and PAD² disassembly codes has been completed. The first cases employed as a basis for comparison were defined at a meeting held in Denver on March 13, 1975. The results of this meeting were subsequently described in a letter from T. P. McLaughlin (LASL) to T. F. Heenan (ERDA) dated March 24, 1975.

Cases "a" and "b" as defined in the reference letter have been run using a 100 \$/sec reactivity insertion. The results of the VENUS-II

calculations have been transmitted to McLaughlin. A report presenting and discussing the results of this initial comparison is being prepared.

ACCIDENT CHARACTERIZATION

Two new work-energy calculations have been implemented into VENUS-II. The first of these provides the work-energy that would be obtained from the isentropic expansion of the fuel vapor following a disassembly excursion. The model is based on the corresponding-states tables of Menzies³ and their subsequent extension by Nicholson.⁴ As a result, the expansion is consistent with the ANL equation-of-state in VENUS-II since it is also based on Menzies corresponding states calculations. The model provides the work associated with an expansion down to one atmosphere. The following cubic expression provides a reasonable fit to the data.

$$W_i = (-0.09265 - 0.1471 E_i + 0.1258 E_i^2 - 0.00523 E_i^3) M_i$$

where: W_i = work done in expanding the fuel in mesh-cell i down to one atmosphere (KJ)

E_i = internal energy of mesh cell i at the end of the neutronics excursion (KJ/gm)

M_i = fuel mass in mesh cell i (gm)

The total work-energy is then obtained by summing over all the mesh cells.

An extension of the above treatment to provide a complete P-V-work expansion as a function of the final pressure is currently being developed. This improved treatment will not only provide the expansion work potential, but also a P-V relationship that can be used as a source term for hydrodynamic damage-evaluation calculations. Techniques currently used to provide these P-V relationships are based on equations-of-state that are not consistent

with the equations-of-state being used in the disassembly calculations.

A second measure of the work-energy that has been included in VENUS-II is a calculation of the total kinetic energy of the reactor materials. Such a calculation is of limited value in VENUS-II because of the restrictions on the amount of material displacement that can be analyzed with the 2-D Lagrangian hydrodynamics being used. The calculation is useful in that it can provide a comparison with the kinetic energy as calculated with the PAD code during the early stages of core expansion.

VENUS-II EXPERIMENTAL COMPARISONS

A major effort during the past quarter has been the initiation of a comparison of the VENUS-II code with experiments. Documentation describing both the KIWI-TNT^{5,6} and SNAPTRAN^{7,8,9} experiments has been obtained and reviewed. Previous comparisons² of the PAD disassembly code with these tests have also been reviewed.

Typical results from a preliminary VENUS analysis of the KIWI-TNT experiment were obtained from Cardis Allen of the NRC. These results have been reviewed and several areas where improvements can be made have been identified. The Graphite equation-of-state used in this analysis, as well as the PAD comparison studies, is being evaluated.

A preliminary VENUS-II model for the analysis of the KIWI-TNT test has been largely completed. Initial results are expected during the next quarter.

SUMMARY AND STATUS

Three milestones were identified in the 189a for completion at the end of this quarter. The first was that a preliminary comparison of VENUS-II

and PAD should be completed. This was accomplished through the comparison of cases "a" and "b" as discussed. The second milestone relates to issuing a report describing the results of this comparison. The first draft of this report is being prepared by T. P. McLaughlin at LASL and will be reviewed and expedited as soon as it is received.

The third milestone was the completion of a review of previous comparisons of disassembly codes with available experiments. This has been met as discussed in the previous section.

REFERENCES

1. J. F. Jackson and R. B. Nicholson, "VENUS-II: An LMFBF Disassembly Program," ANL-7951 (1972).
2. W. R. Stratton, L. B. Engle, and D. M. Peterson, "Reactor Power Excursion Studies," Proc. Conf. on Engineering of Fast Reactors for Safe and Reliable Operation, 3, pp 1331, Karlsruhe, Germany, (1972).
3. D. C. Menzies, "The Equation-of-State of Uranium Dioxide at High Temperatures and Pressures," UKARA TRG Report 1119 (D) (1966).
4. R. B. Nicholson, "Design Basis Accident Studies-Final Report," The Ohio State University, C00-2286-3 (1974).
5. L.D.P. King, et al., "Description of the KIWI-TNT Excursion and Related Experiments," LA-3350-MS (1966).
6. L.D.P. King, "Safety Neutronics for Power Reactors," LA-3358-MS (1965).
7. R. P. Johnson, "SNAPTRAN 10A/2 Kinetics Testing and Destruct Reactor Experiments," NAA-SR-11906 (1966).
8. W. E. Kessler et. al., "SNAPTRAN 2/10A-3 Destructive Tests Results," IDO-17019 (1965).
9. J. F. Jackson, W. R. Rhoades and L. I. Moss, "Analysis of SNAPTRAN-1 and -2 Reactor Kinetics Experiments," NAA-SR-11850 (1967).