CONF-881011--2

THE LEPRICON CODE SYSTEM: CONSOLIDATION OF TRANSPORT ANALYTICAL AND UNFOLDING PROCEDURES IN LWR PRESSURE VESSEL DOSIMETRY *

R. E. Maerker

Engineering Physics and Mathematics Division
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6364

CONF-881011--2

DE88 011403

Invited Presentation: Winter Meeting, American Nuclear Society, Washington, D.C., October 30-November 3, 1988

* Work performed for the U.S. Nuclear Regulatory Commission Office of Nuclear Regulatory Research under Interagency Agreement 0551-0551-A1 with Oak Ridge National Laboratory operated by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under contract No. DE-AC05-84OR21400.

THE LEPRICON CODE SYSTEM: CONSOLIDATION OF TRANSPORT ANALYTICAL AND UNFOLDING PROCEDURES IN LWR PRESSURE VESSEL DOSIMETRY

R. E. Maerker
Oak Ridge National Laboratory

The LEPRICON (for Least-Squares Electric Power Research Institute Consolidation program) code system has been developed over the past ten years to provide a complete analysis of Light Water Reactor (LWR) pressure vessel dosimetry. The system incorporates nine modules, as shown in Fig. 1. All but one of the modules treat various aspects of neutron transport from the core through the reactor internals to dosimetry locations in the downcomer and/or reactor cavity regions and to critical fluence locations in the pressure vessel. The LEPRICON adjustment module, on the other hand, performs a state-of-the-art least-squares analysis of the results from the transport modules, a procedure often referred to as spectral unfolding or the combining of integral and differential data.[1] In terms of development, the adjustment module alone required about 70 percent of the total effort, for reasons that soon will become apparent. The results from the LEPRICON system thus represent prior and adjusted fluences in each of 38 groups from 0.1 to 20 MeV, along with their corresponding standard deviations, at critical locations in the pressure vessel.

Sources must be obtained for each of three discrete ordinates transport calculations-Rθ, RZ, and R- and the methodology relies on the availability of PDQ7 results for relative pinwise fission distributions in the peripheral core assemblies together with in-core measurements which provide assembly-averaged axial distributions.[2] These 3-D distributions are generated by DOTSOR in the cylindrical geometry appropriate to each of the DOT4.3 and ANISN geometries for several times during dosimetry

exposure. The transport calculations use the ELXSIR library, which is somewhat finer but otherwise compatible with the SAILOR library. The 2-D and 1-D fluxes are combined using a simple synthesis procedure in DOTSYN to produce reference 3-D fluxes arising from one of the DOTSOR sources near midcycle. The remaining sources may be folded with the results of one adjoint DOT4.3 RΘ calculation in the TIMEPATCH module and a scaling technique applied to the reference fluxes to obtain composite group fluences and resulting dosimeter activities at the end of irradiation, for all the dosimeters, with the time dependence due to fuel burnup as well as the usual power variations now explicitly taken into account.[2]

The calculated activities are compared with the measurements in the LEPRICON adjustment module. Uncertainties in the calculated values arise mainly from uncertainties in the nuclear data and the as-built dimensions assumed in the transport geometry and in the methods approximations used by the DOT, DOTSOR, DOTSYN, and TIMEPATCH modules. These covariances have been the subject of considerable research and are built into the code, although most can be overridden if desired. The composite standard deviations of these calculated activities are significantly larger than those of the measurements, and hence the adjustments tend to weight the measurements more strongly. Sensitivities of the calculated quantities to all the adjustable parameters are also part of the built-in data base. Adjustments and reduced uncertainties in the calculated reactor fluxes are obtained simultaneously with those in a number of dosimetry benchmark experiments, for which sensitivities, covariances, measured activities and activities calculated using ELXSIR and the same LEPRICON methodology also form part of the built-in data base. Data for 37 benchmarks are included which required

several years of effort in analyzing measurements in ^{252}Cf fields, the ISNF at NBS, and the PCA and PSF mockup experiments at ORNL.[1]

Results of applying the LEPRICON system to two different power reactors have appeared in the literature, and the conclusion was reached in both cases that the accumulated pressure vessel fluences could be determined to within about ten percent.[3,4] One of the major discoveries was a consistent adjustment of ~8 percent downward in the iron inelastic cross section in the region 3-8 MeV. An update to the Mod-3 evaluation of ENDF/B-V natural iron, spurred by these LEPRICON findings as well as from other sources, has recently been performed,[5] and the resulting improvements in the agreement between calculations and measurements for all 37 benchmarks involving iron penetration [6] as well as in the above reactor analyses provide strong evidence for the superiority of this new evaluation and the consistency of the LEPRICON adjustment procedure. As a consequence, this set has been added to the ELXSIR library for future calculations.

In conclusion, the complete LEPRICON methodology provides a comprehensive and accurate analysis of LWR dosimetry, and as a result has been recommended as serving the needs of the NRC for extended pressure vessel lifetime monitoring.[7]

REFERENCES

1. R. E. Maerker, B. L. Broadhead, J. J. Wagschal, Nucl. Sci. Eng. 91, 4, 369 (1985).

2. R. E. Maerker, M. L. Williams, B. L. Broadhead, Nucl. Sci. Eng. 94, 4, 291 (1986).

3. R. E. Maerker, B. L. Broadhead, B. A. Worley, M. L. Williams, J. J. Wagschal, Nucl. Sci. Eng. 93, 2, 137 (1986).

4. R. E. Maerker, Nucl. Sci. Eng. 96, 4, 263 (1987).

5. C. Y. Fu, D. M. Hetrick, "Update of ENDF/B-V Mod-3 Iron: Neutron-Producing Reaction Cross Sections and Energy-Angle Correlations," ORNL/TM-9964, ENDF-341, Oak Ridge National Laboratory (1986).

6. See also R. E. Maerker, Trans. Am. Nucl. Soc. 55, 551 (1987).

7. F. B. K. Kam, R. E. Maerker, M. L. Williams, F. W. Stallmann, "Pressure Vessel Fluence Analysis and Neutron Dosimetry," NUREG/CR-5049, ORNL/TM-10651, Oak Ridge National Laboratory (1987).

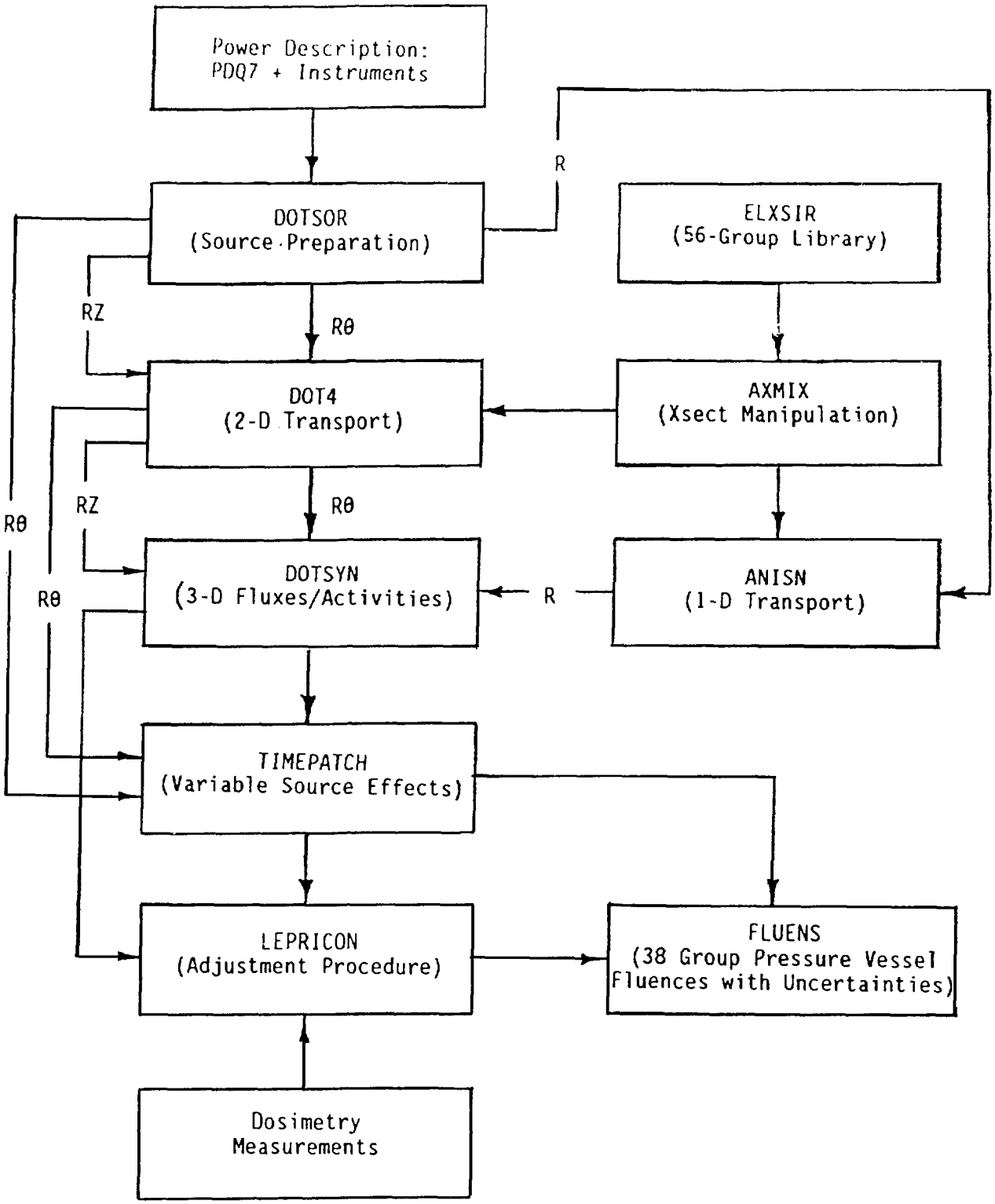

Fig. 1. LEPRICON System Flow Chart