NEAR-TERM DECAY HEAT AND AGE OF SPENT FUEL IN COMMERCIAL POWER REACTOR INVENTORIES

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ABSTRACT

Projections based upon utility supplied data indicate that several commercial nuclear power reactors will require additional spent fuel storage capacity. These storage needs are beyond those which currently exist in the reactor spent fuel storage pools. A key parameter needed to design out-of-pool or consolidated storage capacity to handle these needs is the decay heat of the spent fuel to be stored. Calculations of the heat of the additional spent fuel requiring storage have been made. These calculations indicate small differences in the decay heat of the selected fuel assemblies depending upon whether the oldest or the coldest fuel in the existing inventory is selected first for out-of-pool or consolidated storage.

INTRODUCTION

A number of commercial nuclear power plants in the United States are projected to require additional spent fuel storage capacity, beyond that which they can provide in existing at-reactor storage basins, within the next several years. In spent fuel storage facility design, the radioactive decay heat released from the spent fuel is an important design parameter. Thus, knowledge of the decay heat that would be associated with the spent fuel assemblies which require additional storage capacity is important in planning, optimizing and implementing new storage concepts.

This paper presents calculated estimates of the radioactive decay heat for the total projected commercial power reactor inventory in 1986 and 1990. In addition, the decay heat is shown for that increment of spent fuel which exceeds the projected available storage capacity in each year through 1990 and, therefore, requires additional storage.

SELECTION CRITERIA

The spent fuel assemblies requiring additional storage were selected based upon two scenarios for withdrawal of fuel from a reactor's storage basin. The first method moves the oldest fuel (i.e. that with the longest post-irradiation time in the reactor basin) to additional storage. The second method selects the coldest fuel (i.e. that fuel with the lowest decay heat) first. In general, the oldest fuel in storage in reactor pools will be the coldest fuel. In some situations, however, this may not be the case: an assembly may be removed from the reactor core early for some reason, resulting in a lower exposure and a lower heat output; or a *particular* assembly may have had lower exposures due to its placement in the reactor core.

Projections of spent fuel storage requirements used in this study are based on information in the DOE Spent Fuel Data Base. This information is obtained directly from each nuclear utility as part of DOE's Commercial Spent Fuel Management Program, and is used in preparing the annually updated Spent Fuel Storage Requirements[1] report. The most recent report is based on data through September 30, 1982. The data base was subsequently updated to December 31, 1982, and this updated data was used in this study. The requirements for additional storage used in the study were those for the "maximum at-reactor capacity" case, which assumes that all reactor storage basins are increased to their maximum spent fuel storage capacities, as estimated by the operating utilities, using current NRC-licensed technology (i.e. reracking). Capacity enhancement using rod consolidation or dry storage technologies was not considered because these technologies are not currently licensed; however, such technologies may eventually be licensable and used to provide the additional storage capacity that is projected to be required. The reference case assumes no transshipments between pools except as currently licensed by the Nuclear Regulatory Commission (NRC). A full core discharge capability (full core reserve or FCR) is assumed to be maintained for each reactor, except that only one FCR is maintained when two reactors share a common pool or when two reactors at a site have connected individual pools.

DECAY HEAT CALCULATIONS

The decay heat of the spent fuel was interpolated from a table of values calculated using the ORIGEN-2[2] computer code. This table yields the heat output of spent fuel in watts per metric ton as a function of two variables: discharge burnup and time since discharge. PWR and BWR ORIGEN-2 calculations were made for a series of discharge burnups bracketing the existing inventory of spent fuel. These results were plotted as a function of age, and intermediate values were interpolated and used to form the tabular data in the spent fuel heat function. These curves are shown in Fig. 1 and Fig. 2.

Some of the projected exposure data required for this analysis were not supplied by the utilities. Maximum exposures of 26,300 MWD/MTU for BWR reactors and 36,000 MWD/MTU for PWR reactors were used when utility data were unavailable. These exposures are the assumed equilibrium values for generic reactors shown in the DISFUL[3] output. Only 2% of the fuel discharged through 1990 is affected by this assumption.

Figures 3 and 4 show the decay heat of spent fuel transferred each year based on the oldest fuel being selected first (Fig. 3) or the coldest fuel being

(a) Operated by Battelle Memorial Institute for the U.S. Department of Energy.

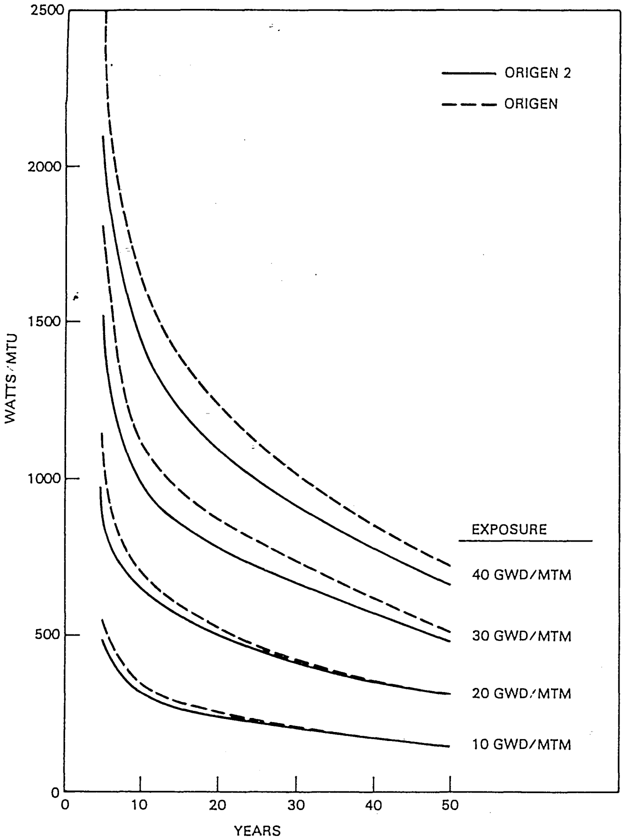

Fig. 1. Decay heat versus exposure and time since discharge for PWR fuel.

selected first (Fig. 4). The oldest decay heat values are as much as 10% higher than the coldest values when averaged over all reactors in a given year. Individual reactors show larger differences, so selection of coldest assemblies rather than oldest assemblies may be significant for specific sites.

Figures 5 through 8 show the heat and number of assemblies discharged from all U.S. reactors operating or projected to operate through the year specified. The number of spent fuel assemblies with decay heat rates less than 1 kw/assembly are shown versus the decay heat per assembly (in kilowatts) in Fig. 5 for 1986 and Fig. 7 for 1990. (Note: the scale is expanded for heat less than 0.1 kw). The number of assemblies at least five years old versus the age of each assembly (in years) are shown in Fig. 6 for 1986 and Fig. 8 for 1990. The average heat for the BWR assemblies is near 0.25 kw/assembly, while the average for the PWR assemblies is near 0.6 kw/assembly.

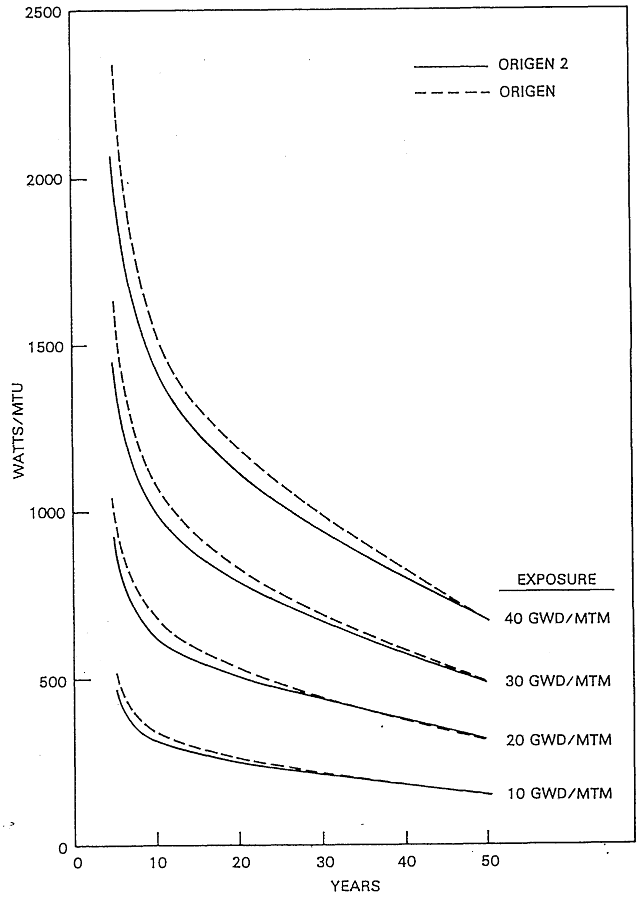

Fig. 2. Decay heat versus exposure and time since discharge for BWR fuel.

REFERENCES

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2. A. G. CROFF, "A User's Manual for the ORIGEN-2 Computer Code," ORNL/TM-7175, Oak Ridge National Laboratory, (1980).

3. M. JAIN and W.A. FRANKS, "DISFUL Manual," DOE/SR/01069-1, S. M. Stoller Corporation, (1981).

ACKNOWLEDGMENT

This paper was prepared under Contract DE-AC06-76RLO-1830 for the Richland Operations Office of the U.S. Department of Energy (DOE), as part of DOE's Commercial Spent Fuel Management Program.

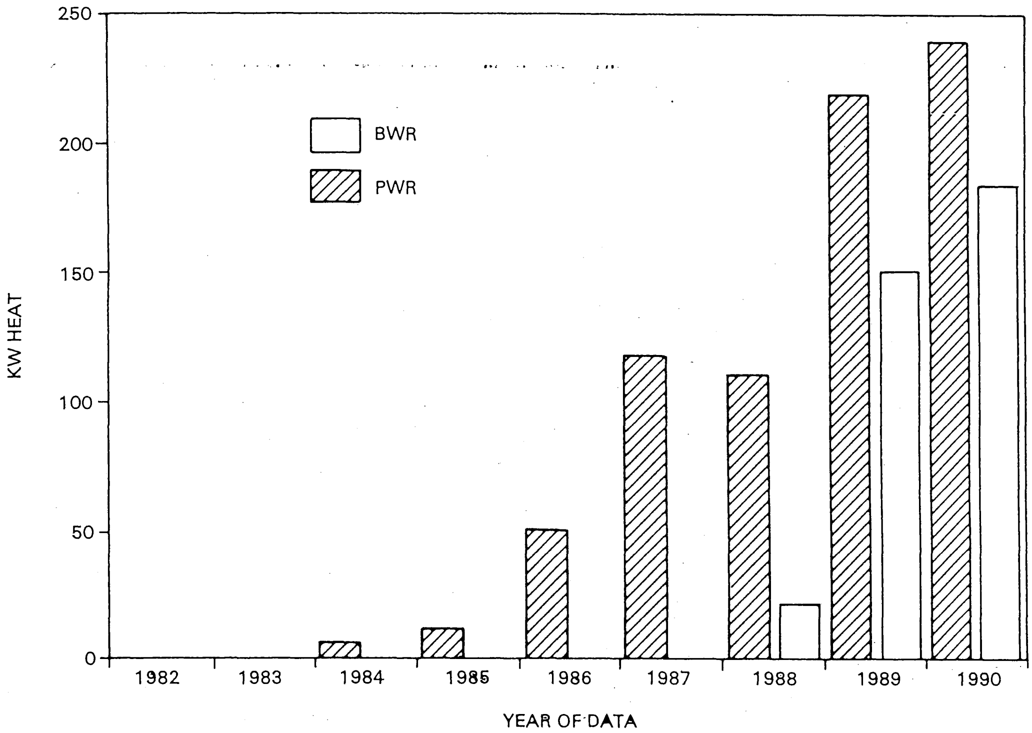

Fig. 3. Decay heat of transferred spent fuel (coldest fuel shipped first).

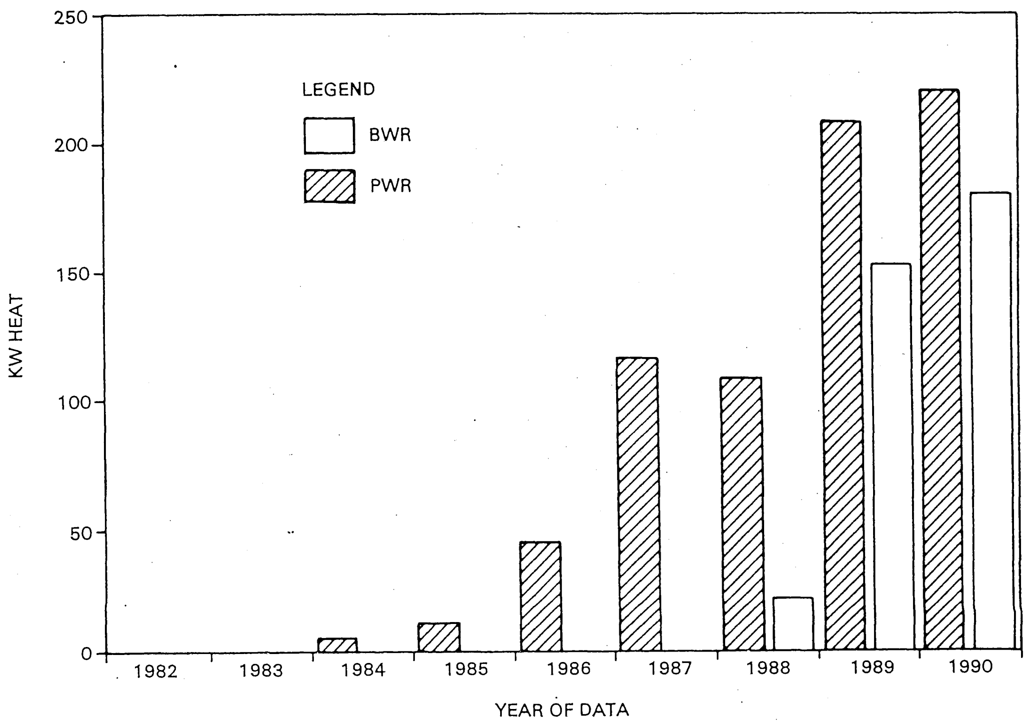

Fig. 4. Decay heat of transferred spent fuel (coldest fuel shipped first).

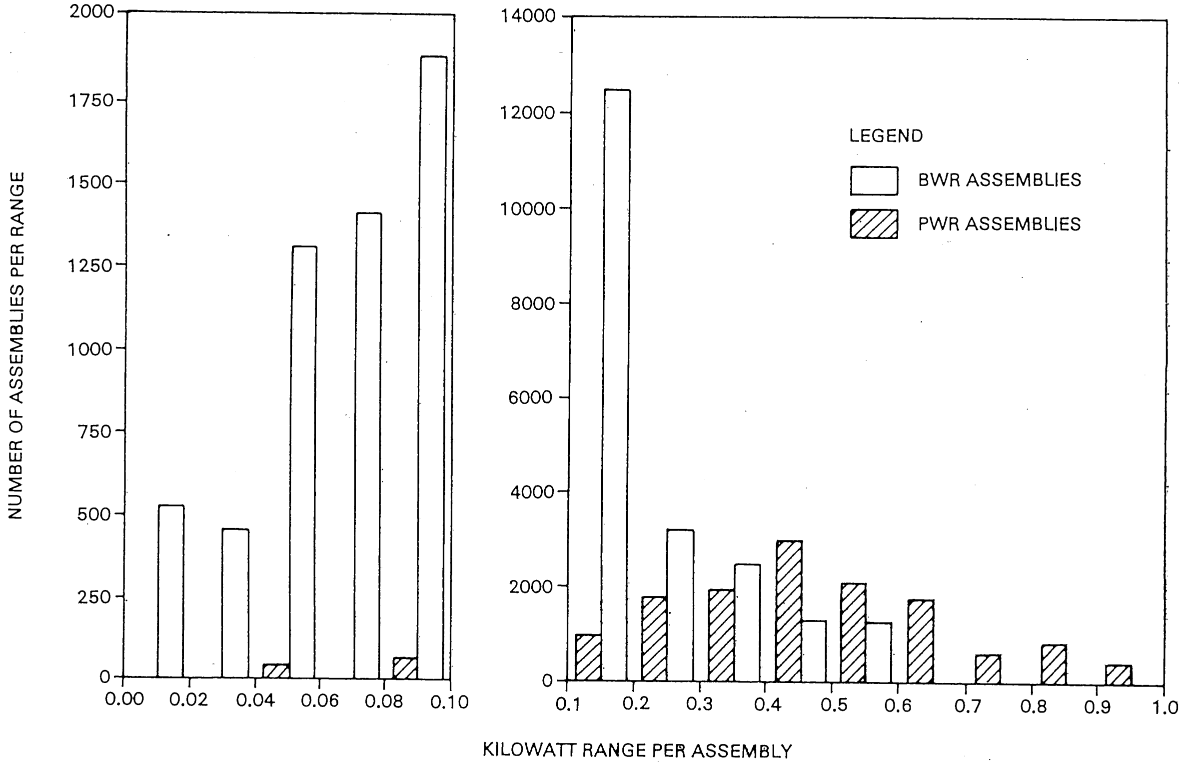

Fig. 5. Heat and number of spent fuel assemblies at least 5 years old in 1986.

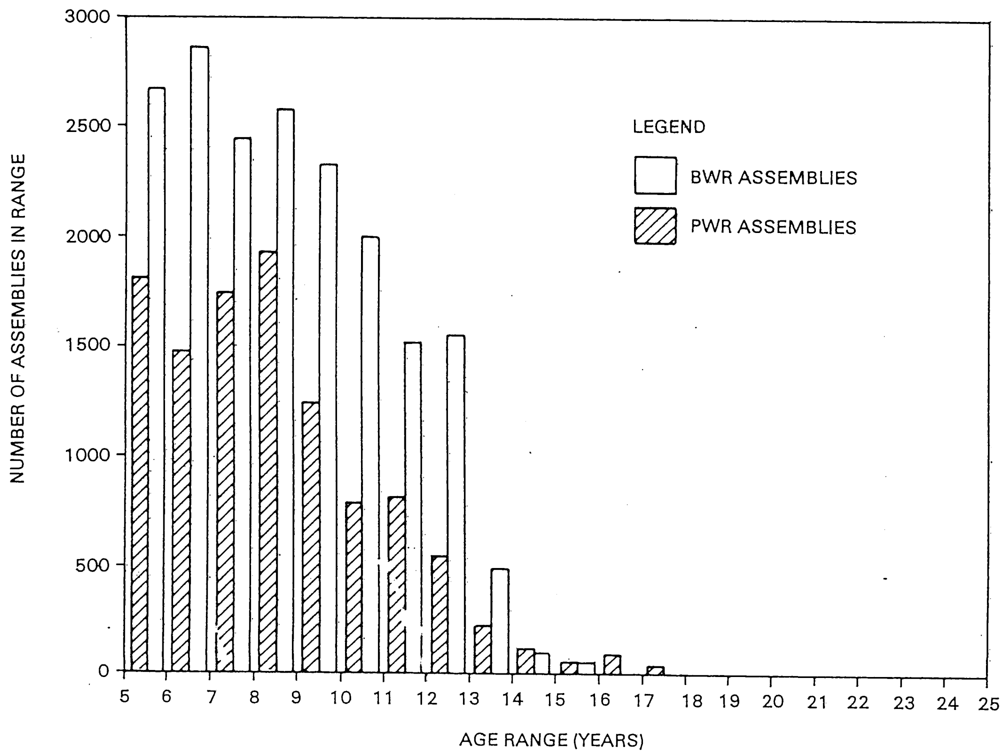

Fig. 6. Age and number of spent fuel assemblies with decay heat less than 1 kW in 1986.

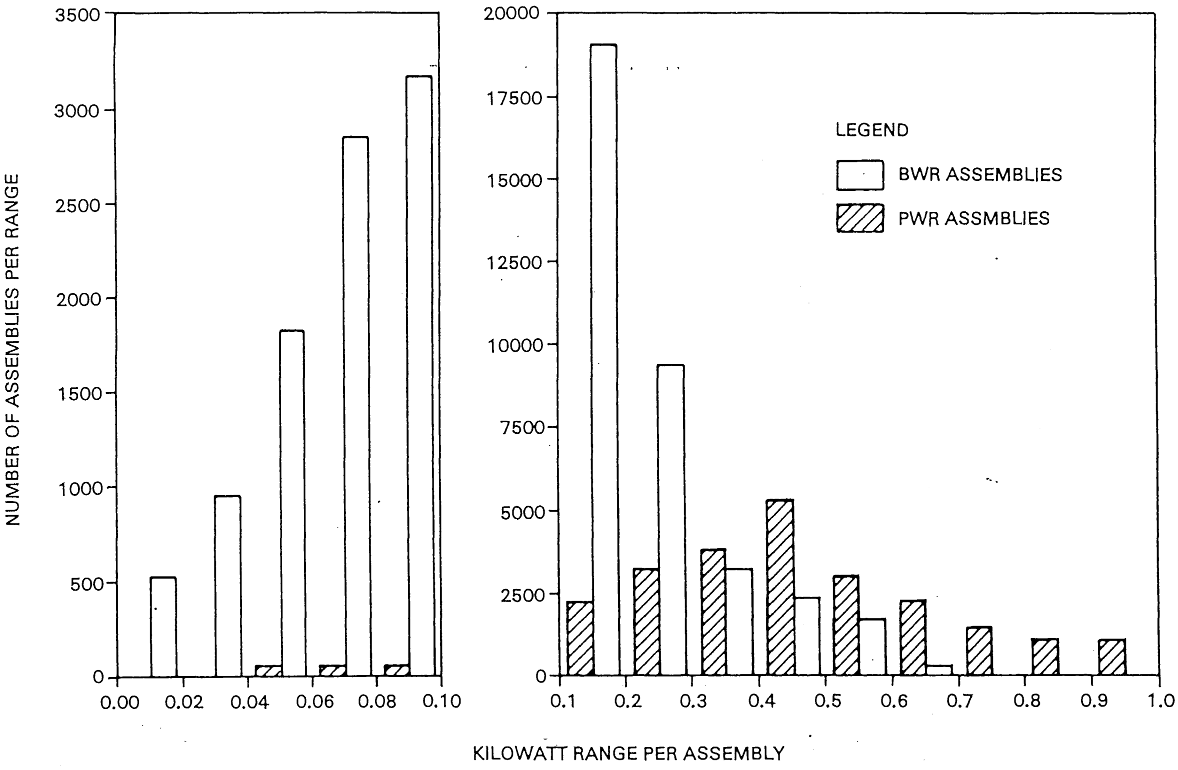

Fig. 7. Heat and number of spent fuel assemblies at least 5 years old in 1990.

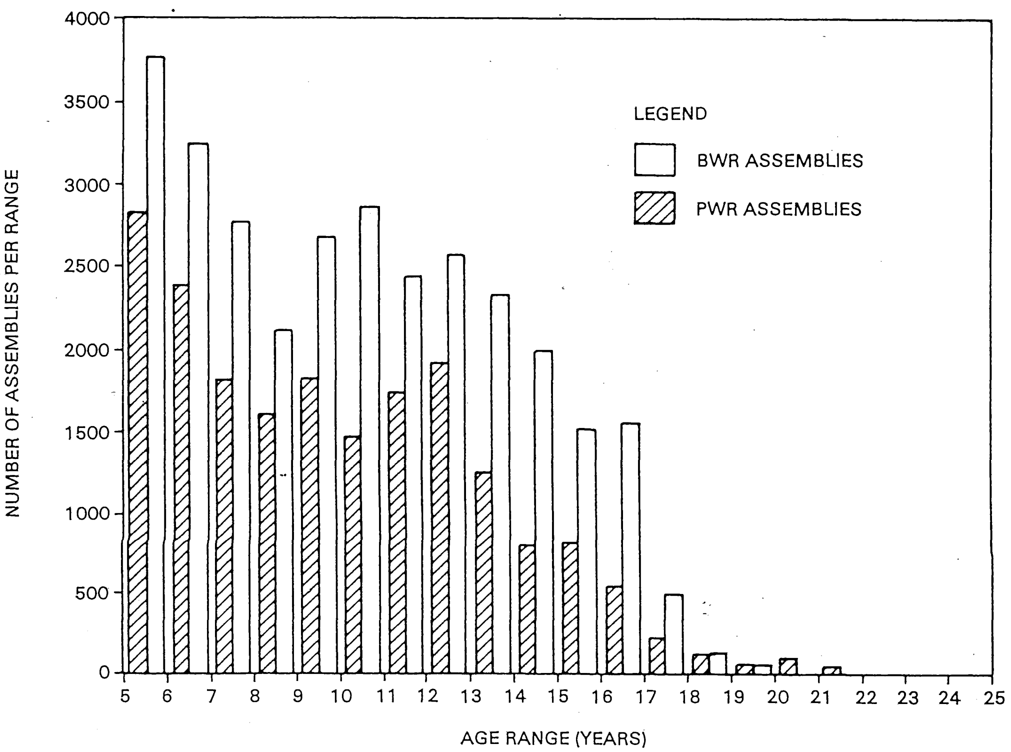

Fig. 8. Age and number of spent fuel assemblies with decay heat less than 1 kW in 1990.