ENCLOSURE

SAFETY EVALUATION REPORT
BWROG LICENSING TOPICAL REPORT NEDO-31558,
POSITION ON REGULATORY GUIDE 1.97,
REQUIREMENTS FOR POST-ACCIDENT NEUTRON FLUX MONITORING SYSTEM

1.0 INTRODUCTION

By letter dated June 13, 1988, the Boiling Water Reactor Owners' Group (BWROG) requested that the staff expedite its review of BWROG Licensing Topical Report (LTR) NEDO-31558 "Position on NRC Regulatory Guide (R.G.) 1.97, Revision 3, Requirements for Post-Accident Neutron Monitoring System", submitted by letter dated April 1, 1988. The LTR provides an event analysis of selected postulated events where post-accident neutron flux monitoring instrumentation might be required, the effect of neutron flux monitoring instrumentation failure, and proposed functional criteria based on the event analysis.

2.0 BACKGROUND

The following is a chronology of events for neutron flux monitoring as related to R.G. 1.97:

In December 1980, R.G. 1.97, Revision 2, was issued recommending that Category 1 neutron flux monitoring instrumentation be used to monitor reactivity control in boiling water reactors (BWRs).

In March 1983, based on a number of surveys within the nuclear power industry it was concluded, by the staff, that existing neutron flux monitoring instrumentation that was available to the industry did not conform to the criteria of R.G. 1.97. However, the staff was informed that instrumentation to conform to the criteria of R.G. 1.97 was under development.

Beginning February 1985, with the issuance of the first R.G. 1.97 Safety Evaluation Reports (SERs), the staff acknowledged that fully qualified neutron flux monitoring systems were not available and instructed applicants and licensees to follow industry development and install qualified neutron flux monitoring systems when they became available. The SERs also included acceptance of existing neutron monitoring systems for interim use until fully qualified neutron flux monitoring systems became available.

Early in 1987, the staff was informed that fully qualified neutron flux monitoring systems were now available to the nuclear power industry.

Beginning in December 1987, R.G. 1.97 SERs acknowledged that industry had developed neutron flux monitoring systems that meet the R.G. 1.97 criteria and instructed applicants and licensees to evaluate these newly developed systems and install neutron flux monitoring instrumentation which complies with the Category 1 criteria of R.G. 1.97. The SERs also included acceptance of existing neutron flux monitoring systems for interim use until fully qualified neutron flux monitoring systems were installed.

R.G. 1.97 recommends Category 1 neutron flux monitoring instrumentation to monitor reactivity control during post-accident situations. R.G. 1.97 specifies neutron flux as a key variable for determining the accomplishment of reactivity control because it is a direct measurement and not an indirect lagging indication. The regulatory guide specifies that Category 1 systems should be environmentally qualified. 10 CFR 50.49 explicitly references this regulatory guide and therefore requires that all Category 1 equipment shall be environmentally qualified. Existing installed neutron flux monitoring instrumentation typically do not meet these environmental qualification requirements for detectors, cables, and detector drive mechanisms. Some existing systems are not powered by Class 1E power supplies.

R.G. 1.97 recommends that the neutron flux monitoring instrumentation be capable of monitoring a range of 10^{-6}% to 100% full power. Initiating and post reactor shutdown events could involve environmental conditions more extreme than the conditions the typical existing neutron flux monitoring instrumentation was designed to operate in. Neutron flux monitoring instrumentation capable of monitoring readings down to the 10^{-6}% power level must be able to operate satisfactorily in these extreme environmental conditions. The instrumentation must be reliably in place immediately after initial shutdown, and be fully operable for an extended period of time, i.e., in the order of six hours.

3.0 EVALUATION

The LTR provides a discussion of BWR safety analyses relevant to post-accident neutron flux monitoring instrumentation requirements and uses the results of the analyses to establish functional design criteria. These criteria include several deviations from the recommendations of R.G. 1.97. Among these deviations is a proposed "alternate" requirement for the range recommendation of the neutron flux monitoring system (LTR Section 5.2.1), reducing the R.G. 1.97 recommendations of 10^{-6}% to 100% power to an "alternate" of 1% to 100% power. This in effect would eliminate any requirement (for this purpose) for the source range monitor (SRM) and intermediate range monitor (IRM) instruments.

The LTR justifies this alternate requirement by examining representative extreme events selected from the range of FSAR and ATWS events. The analyses and related considerations such as the availability of alternate monitoring equipment (e.g., control rod position indication or boron concentration measurements) are based on anticipated conditions resulting from standard event analyses. These might normally be considered as reasonably comprehensive for, e.g., FSAR design bases analyses. However, at least some of the instrumentation recommendations of R.G. 1.97 were intended to cover a wider range of possibilities, including conditions not necessarily to be anticipated by following the usually clearly defined paths of standard event

analyses. In particular, the proposed elimination of the 10^{-6}% to 1% power portion of the range would delete a primary purpose of the post-accident neutron flux monitoring instrumentation. This purpose was intended to provide, with maximum forewarning time, operator information (via indications of deviations from normal post shutdown flux levels) warning of possible post event approaches or return to a critical state. This might be under circumstances which would involve reactor states and evolving events and conditions not anticipated from analyses following normally considered event scenarios. It would thus be virtually impossible to either predict or demonstrate the implausibility of such event paths and resulting conditions with assurance.

Therefore, while not disputing the analyses or results presented in the LTR, it must be concluded that they do not address the above conceptual basis that set the low power range recommendations of R.G. 1.97. The required power level is set by expected flux levels existing for some extended period of time (in the order of several hours) after shutdown and for reactivity status and neutron (installed and operational) source levels resulting from normal rapid shutdown from power operation. The normal flux levels serve as a base for observable deviations of anomalous reactivity states in the (unknown) anomalous events indicated above.

10CFR50.49 requires that certain post-accident monitoring equipment (Category 1 and 2) be environmentally qualified. Therefore, based on the above evaluation, the staff continues to conclude that the Category 1 designation is appropriate and neutron flux monitoring equipment must be environmentally qualified to comply with 10CFR50.49.

To provide suitable interpretation, neutron flux monitoring detectors internal to the pressure vessel (e.g., in standard SRM locations) appear to be preferable, but neutron flux monitoring detectors external to the pressure vessel (e.g., in the drywell) could be considered. The chosen neutron flux monitoring system, should be operational during degraded core cooling conditions leading to some fuel clad failure, but not significant clad or fuel melting. Environmental conditions external to the pressure vessel to be

considered should include high temperature, high humidity, radiation, and possible flooding, associated with external LOCA conditions. Fire conditions which might affect control rod actuation and/or position readout and thus require the use of the low range neutron flux monitoring instrumentation should also be considered.

Because the functional criteria proposed in the LTR does not meet the requirements of 10 CFR 50.49, the LTR functional criteria is unacceptable.

The staff has been informed that industry has developed and made available, to the nuclear power industry, at least two different wide range neutron flux monitoring systems that satisfy all the Category 1 criteria of R.G. 1.97. Therefore, it is the staff's position that BWR licensees should evaluate these newly developed systems and install neutron flux monitoring instrumentation which fully complies with the Category 1 criteria of R.G. 1.97.

4.0 CONCLUSION

Based on our review, the staff concludes that, as an alternative to the Category 1 criteria of R.G. 1.97, the proposed LTR NEDO-31558 functional criteria for post-accident neutron flux monitoring instrumentation is unacceptable.

It is also concluded that the proposed alternate range requirement of LTR Section 5.2.1, 1% to 100% power does not meet the intent of R.G. 1.97, and is therefore unacceptable. The range of neutron flux monitoring instrumentation should remain 10^{-6}% to 100% power.

It is the staff's position that BWR licensees should install neutron flux monitoring instrumentation that fully complies with the Category 1 criteria of R.G. 1.97 and 10 CFR 50.49.