May 5, 2003

Mr. Robert H. Bryan, Chairman
Westinghouse Owners Group
Tennessee Valley Authority
Mail Code LP4J-C
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

SUBJECT: SAFETY EVALUATION OF TOPICAL REPORT WCAP-15666, "EXTENSION OF REACTOR COOLANT PUMP MOTOR FLYWHEEL EXAMINATION" (TAC NO. MB2819)

Dear Mr. Bryan:

On August 24, 2001, the Westinghouse Owners Group (WOG) submitted WCAP-15666, "Extension of Reactor Coolant Pump Motor Flywheel Examination," dated July 2001, for NRC staff review. The August 24, 2001, submittal was supplemented by letters dated April 23 and November 15, 2002.

The staff has found that the subject topical report is acceptable for referencing in licensing applications to the extent specified and under the limitations delineated in the report and in the associated NRC safety evaluation (SE). The SE defines the basis for acceptance of the report.

Our acceptance applies only to matters approved in the subject report. We do not intend to repeat our review of the acceptable matters described in the report. When the report appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this topical report will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that the WOG publish an accepted version of this topical report within three months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed safety evaluation between the title page and the abstract. It must be well indexed such that information is readily located. Also, it must contain in appendices historical review information, such as questions and accepted responses, and original report pages that were replaced. The accepted version shall include a "-A" (designated accepted) following the report identification symbol.

If the NRC's criteria or regulations change so that its conclusion in this letter, that the topical report is acceptable, is invalidated, the WOG and/or the applicant referencing the topical report will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the topical report without revision of the respective documentation.

Sincerely,

/RA/

Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 694

Enclosure: Safety Evaluation

cc w/encl:
Mr. Gordon Bischoff, Project Manager
Westinghouse Owners Group
Westinghouse Electric Company
Mail Stop ECE 5-16
P.O. Box 355
Pittsburgh, PA 15230-0355

Mr. Hank A. Sepp, Jr.
Manager, Regulatory & Licensing
Westinghouse Electric Company
Nuclear Services
Post Office Box 355
Pittsburgh, PA 15230-0355

If the NRC's criteria or regulations change so that its conclusion in this letter, that the topical report is acceptable, is invalidated, the WOG and/or the applicant referencing the topical report will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the topical report without revision of the respective documentation.

Sincerely,

/RA/

Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 694

Enclosure: Safety Evaluation

cc w/encl:
Mr. Gordon Bischoff, Project Manager
Westinghouse Owners Group
Westinghouse Electric Company
Mail Stop ECE 5-16
P.O. Box 355
Pittsburgh, PA 15230-0355

Mr. Hank A. Sepp, Jr.
Manager, Regulatory & Licensing
Westinghouse Electric Company
Nuclear Services
P.O. Box 355
Pittsburgh, PA 15230-0355

DISTRIBUTION:
PUBLIC **(No DPC Folder for 10 working days)**
PDIV-2 Reading
RidsNrrDlpmLpdiv (HBerkow)
RidsNrrPMGShukla
RidsOgcRp
RidsAcrsAcnwMailCenter
WBateman (NRR/DE/EMCB)
PPatnaik (NRR/DE/EMCB)
MTschiltz (NRR/DSSA/SPSB)
SDinsmore (NRR/DSSA/SPSB)
RidsNrrLAEPeyton

ADAMS ACCESSION NO.: ML031250595 NRR-043

OFFICE	PDIV-2/PM	PDIV-2/PM	PDIV-2/LA	PDIV-2/SC	PDIV/D
NAME	BBenney	BPham	EPeyton	SDembek	HBerkow
DATE	4/25/03	4/28/03	4/25/03	5/2/03	5/5/03

DOCUMENT NAME: G:\PDIv-2\Wog\WCAP-15666.wpd
OFFICIAL RECORD COPY

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-15666,

"EXTENSION OF REACTOR COOLANT PUMP MOTOR FLYWHEEL EXAMINATION"

WESTINGHOUSE OWNERS GROUP

PROJECT NO. 694

1.0 INTRODUCTION

On August 24, 2001, the Westinghouse Owners Group (WOG) submitted Topical Report (TR) WCAP-15666, "Extension of Reactor Coolant Pump Motor Flywheel Examination" (Reference 1), dated July 2001 for NRC staff review. Further clarifying information was submitted on April 23, 2002 (Reference 2), and November 15, 2002 (Reference 3). The TR states that the currently approved 10-year inspection interval for flywheels does not coincide with the reactor coolant pump (RCP) refurbishment schedules which typically occur at 10 to 15-year intervals at all domestic Westinghouse plants, but could extend to a maximum of 20 years. The TR provides the technical justification to extend the RCP motor flywheel examination frequency for all domestic Westinghouse plants from the currently approved 10-year inspection interval, to an interval not to exceed 20 years to enable domestic Westinghouse plants to conduct their flywheel examination during a planned RCP refurbishment. The technical justification in the TR assumes a leak-before-break (LBB) in the reactor coolant system piping to limit RCP overspeed to 1500 revolutions per minute (rpm) in the deterministic evaluation, and a risk assessment that includes all credible flywheel speeds.

Reference 3 included revised pages of WCAP-15666, Revision 0 that the WOG will incorporate into the approved version of the TR in accordance with guidance provided on the NRC website.

2.0 REGULATORY EVALUATION AND BACKGROUND

The function of the RCP in the reactor coolant system (RCS) of a pressurized water reactor plant is to maintain an adequate cooling flow rate by circulating a large volume of primary coolant water at high temperature and pressure through the RCS. Following an assumed loss of power to the RCP motor, the flywheel, in conjunction with the impeller and motor assembly, provides sufficient rotational inertia to assure adequate primary coolant flow during RCP coastdown, thus resulting in adequate core cooling. A concern regarding the overspeed of the RCP and its potential for failure led to the issuance of Regulatory Guide (RG) 1.14, "Reactor Coolant Pump Flywheel Integrity," Revision 1, August 1975 (Reference 4). Reference 4 describes a method acceptable to the NRC staff of implementing the requirements of General Design Criterion 4, "Environmental and Missile Design Basis," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities."

Operating plants have inspected their flywheels for more than 20 years and there have been no service-induced flaws identified which would have affected flywheel integrity. On the basis of this inspection record and the contributing factors of savings in inspection cost and personnel radiation exposure, the WOG submitted TR WCAP-14535, "Topical Report on Reactor Coolant Pump Flywheel Inspection Elimination," to the NRC in January 1996, following the WOG program MUHP-5042 for elimination of the RCP flywheel inspection. The NRC staff evaluated the deterministic methodology of WCAP-14535 and concluded that even for flywheels meeting the design criteria of RG 1.14, as modified in the safety evaluation report (SER) dated September 12, 1996, inspections should not be completely eliminated (Reference 5).

The SER granted relief from the frequency of conducting the flywheel examination recommended by RG 1.14, by allowing extension of the examination frequency from 40 months to 10 years for flywheels having designated material strength and fracture toughness. It further relaxed the examination guidance by recommending an in-place ultrasonic examination over the volume from the inner bore of the flywheel to the circle of one-half the outer radius or an alternative surface examination (magnetic particle testing [MT] and/or liquid penetrant testing [PT]) of exposed surfaces defined by the volume of the disassembled flywheel. Nevertheless, the currently approved 10-year inspection interval for flywheels does not coincide with RCP refurbishment schedules which typically occur at 10 to 15-year intervals at all domestic Westinghouse plants, but could extend to a maximum of 20 years. Therefore, it is desirable to extend the examination frequency to a 20-year interval so that the flywheel examination may be conducted during a planned RCP refurbishment.

3.0 TECHNICAL EVALUATION AND VERIFICATION

The primary regulatory position of RG 1.14 regarding flywheel design concerns three critical speeds: (a) the critical speed for ductile failure, (b) the critical speed for non-ductile failure, and (c) the critical speed for excessive deformation of the flywheel. This regulatory position specifies, as a design criterion, that the normal speed of the flywheel should be less than one-half of the lowest of the critical speeds, and the loss-of-coolant accident (LOCA) overspeed should be less than the lowest of these three critical speeds.

3.1 Material Information

All of the RCP motor flywheels for domestic Westinghouse plants are made of SA533 Grade B, Class 1 steel. The ordering specifications for the Westinghouse flywheel materials in December 1969 required that the reference nil-ductility transition temperature (RT_{NDT}) from both longitudinal and transverse Charpy specimens be less than 10°F. The Westinghouse equipment specification was changed in January 1973 to require both Charpy and drop-weight tests to ensure that RT_{NDT} is no greater than 10°F. Even though it is likely that most, if not all, of the flywheels in operation have an RT_{NDT} of 10°F or less, a range of RT_{NDT} values from 10°F to 60°F were assumed in the integrity evaluation.

3.2 Analysis for Critical Speed Based on Ductile Fracture

RG 1.14 permits the use of elastic stress analysis methods and the acceptance criteria of ASME Code, Section III to predict the critical speed based on ductile fracture of the flywheel. The ASME Code requires that the stress limits for the general primary membrane stress intensity P_m and the primary membrane plus primary bending stress intensity P_m+P_b be $0.7S_u$

and $1.05S_u$, respectively, for the faulted loading combination, where S_u is the minimum specified ultimate tensile stress of the material. The TR used these limits and employed the minimum specified S_u value of 80 ksi for flywheel material SA-533, Grade B to arrive at the critical speeds for two flywheel groups under ductile fracture conditions shown in Table 2-6 in the TR. There are 11 groups representing all domestic Westinghouse flywheels. The TR identified two groups that bound the 11 groups and used these two groups in the evaluation. One group was selected with the maximum bore and the largest outside diameter (OD) and the other group with the minimum bore and the next largest OD. Table 2-6 in the TR indicates that the minimum calculated limiting speed assuming no cracks is 3430 rpm. In accordance with RG 1.14, the normal speed should be less than one-half of the critical speeds as calculated for ductile failure, non-ductile failure, and excessive deformation of the flywheel which in this case is 1715 rpm. Since the normal operating speed of a flywheel is 1200 rpm, the regulatory position for flywheel integrity stated in RG 1.14 is, therefore, satisfied. Even assuming a 10-inch long crack located radially from the keyway, the above criterion is satisfied since the minimum critical speed is 3012 rpm and the normal operating speed of 1200 rpm is still less than one-half of this critical speed (1506 rpm). The other criterion for flywheel integrity outlined in RG 1.14 is that the predicted LOCA overspeed should be less than the lowest of the above calculated critical speeds. Since the predicted LOCA overspeed is in all cases less than 1500 rpm assuming a LBB scenario, this criterion is also satisfied for the ductile failure limiting speeds of 3430 rpm (assuming no crack) and 3012 rpm (assuming a 10-inch long crack emanating from keyway) which are higher than the LOCA overspeed of 1500 rpm.

3.3 Analysis for Critical Speed Based on Non-ductile Failure

The TR provides a linear elastic fracture mechanics analysis to predict critical speed for non-ductile fracture of the flywheel specified in Item 2.d of RG 1.14. The analysis uses the closed-form solution for a radial full-depth crack emanating from the bore of a rotating disk to calculate the applied stress intensity factor (applied K). The fracture toughness of the SA-533 B plate was obtained from the lower bound K_{IC} curve of the ASME Code, Section XI. Use of K_{IC} has been suggested in RG 1.14. The load used in calculating the applied K is based on the LOCA overspeed of 1500 rpm. Further, three values of RT_{NDT} , 0°F, 30°F, and 60°F were used in estimating the K_{IC} at an ambient temperature of 70°F. The resulting critical crack lengths for both groups of flywheels are summarized in Table 2-7 of the TR. It is shown that the critical crack lengths are 3.1 inches and 3.6 inches for Group 1 and Group 2 flywheels, respectively, having an assumed RT_{NDT} value of 60°F. Evidently, these critical crack sizes are quite large, even when considering higher values of RT_{NDT} and a lower than expected operating temperature of 70°F. In response to the staff's RAI on WCAP-14535, "Topical Report on Reactor Coolant Pump Flywheel Inspection Elimination," Westinghouse provided an allowable crack length of 0.4 inches for Group 1 and Group 2 flywheels considering the effect of shrink fit and using Section XI criteria with an assumed RT_{NDT} value of 60°F. The staff agrees that there is significant conservatism in the estimate of allowable crack length. It also stated that the ultrasonic technique used for flywheel examination confirmed detection of a reflective surface having a length of 0.33 inches. Therefore, the staff considers that it is unlikely that any defect that could challenge flywheel integrity would be missed during the examination.

Fatigue crack growth was determined from the rate formula in Appendix A of the ASME Code, Section XI. For the flywheel in each group, an initial crack length of 10 percent of the distance from the keyway to the flywheel outer radius was assumed. As to the loading, 6000 cycles of RCP starts and stops were assumed for a 60-year plant life. A crack growth of 0.08 inches after 6000 cycles is reported in Table 2-8 of the TR for the two groups of flywheels. The staff concludes that after 20 years, the maximum fatigue crack growth would be expected to be about 0.027 inches. If it is assumed that a crack of 0.33 inches was missed and the maximum expected fatigue crack growth was applied, the end-of-cycle crack size would be 0.357 inches. Therefore, the ASME Code, Section XI margin of a 0.4 inch crack length would still be maintained during the service period and a 20-year inspection period appears to be reasonable.

3.4 Compliance with the Excessive Deformation Failure Criterion

The analysis in the report uses standard closed-form formulae for rotating disks to calculate the change of flywheel inner and outer radii at the flywheel overspeed condition of 1500 rpm. The results are tabulated in Table 2-9 of the TR for Group 1 and Group 2 flywheels. The largest value is 0.006 inches for the change in the outer radius. Since deformation is proportional to the square of the angular speed, this represents an increase of 56 percent over the normal operating deformation. This increase would not result in any adverse conditions, such as excessive vibrational stresses leading to crack propagation, since the flywheel assemblies are typically shrunk-fit to the shaft and the deformations are negligible. The loss of shrink-fit due to overspeed condition for the two groups of flywheels under evaluation is estimated to be approximately 60 percent and will not cause separation of the flywheel from its shaft.

3.5 Compliance with LOCA Overspeed Criterion

RG 1.14 requires that the LOCA overspeed should be less than the lowest of the critical speeds calculated for ductile failure, non-ductile failure, and excessive flywheel deformation. The minimum calculated limiting speeds for ductile failure – assuming no cracks and a 10-inch crack – are 3430 rpm and 3012 rpm, respectively. The predicted LOCA overspeed in all cases is less than 1500 rpm. Therefore, the regulatory position in regard to compliance with LOCA overspeed criterion stated under item 2g of RG 1.14 is also satisfied.

3.6 Risk Assessment

The TR supplements the deterministic evaluation indicating that a 20-year inspection interval is too short for a crack less than 0.33 inches to grow to the ASME limiting (at 1500 rpm) crack of 0.4 inches with a risk evaluation. The risk assessment uses a methodology consistent with RG 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Current Licensing Basis" (Reference 6). The risk evaluation includes the likelihood that a crack will grow large enough to cause failure at: (1) normal operating speeds, (2) after various transient upset conditions, and (3) after the double-ended guillotine break (DEGB) LOCA with and without the simultaneous loss of power to the RCP motor.

The risk assessment requires an estimate of the conditional probability of failure of the flywheel at a given speed (i.e., rpm), an estimate of the frequency that the flywheel might attain the failure speed, and the conditional probability of core damage and large early release given a flywheel failure.

Conditional Probability of the Failure of the Flywheel

The failure of the flywheel, by analysis, is determined by the presence of a crack large enough that, if subjected to the stresses caused by a given speed, will cause the flywheel to fail. The length of a flaw that will cause failure is defined as the critical flaw size for the specified speed. The assumption is made that if a crack grows to a critical size and the flywheel attains the speed that defines that critical crack size, the flywheel will fail. Therefore, the conditional failure probability of the flywheel for any given speed is equal to the probability that a crack in the flywheel has grown to the critical crack size for that speed.

For a given set of material parameters (i.e., initial radial flaw length, reference nil ductility temperature, crack initiation toughness, etc.) the growth of a crack subject to cyclic stresses can be estimated by the methodology discussed in Section 3.3 of this safety evaluation. There are uncertainties in the precise values of these initial material parameters due to lack of knowledge, random variations in material properties, and random variations in the manufacturing processes. The uncertainties in the material parameters can be used to estimate the likelihood of cracks of various sizes developing during the operating life of a flywheel. The TR methodology simulates the growth of a crack by selecting a set of material parameters and calculating the increases in size by fatigue crack growth due to RCP startup and shutdown. After each simulated year (determined by the number of cycles per year), crack growth is calculated due to fatigue. The crack growth simulation is repeated until (1) the crack reaches the critical crack size for a given speed, (2) the end of the inspection interval is reached and the crack has grown large enough to detect, or (3) the end of operating life is reached (60 years). If the end of the inspection interval is reached and the crack has grown large enough to detect but not to the critical size, the crack is assumed detected with a given probability and repaired. After each simulated lifetime, another set of material parameters is randomly selected from the input distributions and the process is repeated.

The simulation yields a set of times required for the crack to grow to a critical crack size, or a 60-year life if a critical crack size is never attained. These times can be organized into a distribution of time to the development of any critical flaw size and, consequently, flywheel failure given the occurrence of the associated speed. The results reported in the TR indicate that the rate that a critical crack develops is well approximated as a linear function of time. The linearity of the function with time implies that the probability that a critical crack develops during any given year is a constant that can be estimated by dividing the probability that a critical crack exists at the end-of-life by the number of years in the operating life. The basic methodology of collecting flaw growth lifetimes that yield an essentially linear growth rate over 60 years was earlier reviewed and approved by the staff for developing risk-informed inservice inspection programs (Reference 7).

The TR states that the normal operating speed of the flywheel is 1189 rpm with a synchronous speed of 1200 rpm. If there is a pipe rupture in the RCP's outlet piping, the high reactor coolant pressure will force reactor coolant out through the RCP into the low pressure containment structure and hydraulic torque would be applied to the shaft in the direction of increasing shaft speed. If electrical power is maintained to the RCP motor, the motor will function as a dynamic break and limit the increase in speed of the shaft to less than 1500 rpm. If, however, electric power is lost to the RCP, the flywheel will accelerate. The maximum estimated flywheel speed is 3321 rpm for a DEGB, the largest possible break in the RCP outlet piping with simultaneous loss of electric power to the RCP motor. This is the speed that would require the smallest crack to fail – the speed used to determine the minimum critical crack size that could lead to flywheel failure. The flywheel will only fail with a crack of this size following a DEGB with simultaneous loss of electric power to the RCP motor.

The TR evaluated the likelihood of a flywheel developing a critical crack for the overspeed of 3321 rpm and the overspeed of 1500 rpm. The critical crack size for 3321 rpm is used for the DEGB with loss of electric power to the RCP motor. The 1500 rpm critical crack size is conservatively used for all other scenarios. The probability of cracks reaching these two critical sizes given different inservice inspection programs was estimated using the crack growth simulation methodology discussed above. In order to develop estimates applicable to the current fleet of reactors, the TR conservatively estimated the impact of the requested increase in the inspection interval from 10 to 20 years by assuming that, aside from the initial inspections during the first 10 years of plant life, there will be no more inspections over the operating life of the units. This is a conservative evaluation and is acceptable. The results are provided in the following table.

Flywheel Group	Maximum Speed	Cumulative Probability of Critical Flaw Developing over 60 years	
		With ISI at Four Year Intervals	With ISI at Four Year Intervals Prior to 10 Years and Without ISI after 10 years
Group 1	1500 RPM	2.45E-07	2.57E-07
Group 1	3321 RPM	1.01E-02	1.02E-02
Group 2	1500 RPM	1.43E-07	1.47E-07
Group 2	3321 RPM	0.91E-02	0.91E-02

<u>Frequency of the Flywheel Attaining Failure Speeds</u>

There are three different scenarios evaluated in the risk assessment. The flaw will grow large enough to: (1) cause the flywheel to fail during normal operation, (2) cause the flywheel to fail following a transient or LOCA, (3) cause the flywheel to fail following a DEGB with simultaneous loss of electric power to the RCP motor. These three scenarios represent three different flywheel speeds but, as discussed below, the TR assigns a conservative speed to the first two scenarios that minimizes the analysis requirements and overestimates the frequency of flywheel failures.

The peak speed of the flywheel during normal operation is about 1189 rpm. The TR conservatively assumes that the 1500 rpm critical flaw size will cause the flywheel to fail during normal operation. Because the rate that critical flaws develop is well approximated as a linear function of time, the frequency with which a critical flaw will develop during any given year (and cause the flywheel to fail) can be reasonably approximated by the cumulative probability at the end of 60 divided by 60 years. Flaws large enough to cause flywheel failure at 1500 rpm will develop sooner than those that cause failure at 1189 rpm and therefore this approximation is conservative and is acceptable.

The TR states that without loss of electric power to the RCP motor, the peak speed of the flywheel following any transient (including a DEGB LOCA) is 1200 rpm. The TR conservatively assumes that the 1500 rpm critical flaw size will cause the flywheel to fail at 1200 rpm. The TR further assumes that a transient occurs every year, and that the probability that a critical flaw has developed prior to each transient is equal to the probability that a flaw develops during the 60-year operating lifetime. The failure of a flywheel is an irreversible change of state, i.e., the flywheel cannot be repaired and returned to service and there is no likelihood that more than one flywheel failure may occur during the operating lifetime. Without the possibility of multiple failures during the operating lifetime, the assumption – that the probability that a critical flaw exists prior to each transient is equal to the probability that a critical flaw will develop by the end of the 60 year operating life – is conservative and acceptable.

Given a simultaneous loss of electric power to the RCP motor and a LOCA, different break sizes would cause a range of overspeed conditions for the RCP flywheel. The TR considered a case with a primary coolant pipe size of approximately 23 inches inside diameter with an equivalent break opening of about three square feet. The TR concluded that the RCP flywheel speed following a break of three square feet during a LOCA with simultaneous loss of power to the RCP motor would never exceed 1200 rpm. Consequently, only ruptures of the main coolant piping loops contribute to overspeed events in excess of 1200 rpm.

Rather than attempt to develop a full spectrum of break sizes, overspeeds, and associated critical sizes, the TR estimated the frequency of LOCAs that result in a minimum blowdown rate of 5000 gpm, significantly less than 60 percent of the full flow from a DEGB LOCA. This LOCA frequency is conservatively used as the frequency of less frequent DEGB LOCAs. The LOCA frequency was estimated using the methods approved by the staff to estimate the pipe failure frequencies in support of risk-informed inservice inspection relief requests based on the Westinghouse methodology (Reference 7). The TR estimated a maximum LOCA frequency for LOCAs with greater than 5000 gpm blowdown to be a maximum (for the different plant types) of about 2E-6/year. This estimate is conservative based on comparison with the LOCA frequencies of 5E-6/year for LOCAs in pressurized water reactors with a radius of 6 inches (equivalent area about 0.8 feet) or greater (Reference 8). The estimate is conservative because there is substantially more piping greater than six inches in diameter that contributes to the potential for a greater than six inch break than there is piping that is greater than 23 inches in diameter that contributes to the largest DEGB breaks included in this evaluation. The staff finds that this method of estimating the LOCA frequency is appropriate for use in support of this submittal because the methodology used to develop the estimate is consistent with the methods used to estimate flaw growth in the flywheel and because the estimate is conservative compared to current best estimate LOCA frequencies.

A DEGB must be accompanied by a simultaneous loss of power to the RCP motor in order for the flywheel speed to exceed 1200 rpm. Loss of power to the RCP motor is most likely caused by a loss of station power caused by transfer from the offsite electrical grid to the onsite emergency electrical grid, and failure of the emergency grid to properly load and operate. The probability of the loss of station power is dependent on the LOCA because the changing electrical configuration and loads induced by the LOCA may cause the loss of power. Evaluation of the potential for loss of station power indicates that a reasonable estimate for the probability of loss of station power following a LOCA is about 1.2E-2 (Reference 9). The TR uses this conditional probability.

Consequence Estimate

The flywheel has the potential to catastrophically fail, resulting in flywheel fragments which are essentially high energy missiles that could impact other structures, systems, and components important to plant safety. The TR reports that the initial investigations indicate that there is not much uniformity with respect to the layout of critical targets that potential flywheel fragments could impact given its failure and, therefore, a generic damage scenario is difficult to develop. The TR assumes that a flywheel failure would lead directly to core damage and large early release. Therefore, the adequacy of a generic scenario and the quality of the probabilistic risk assessment analysis used to support the TR methodology are not issues and the consequence evaluation is acceptable.

Risk Estimates

The three scenarios that characterize the risk evaluation are: (1) failure of the flywheel during normal operation, (2) failure of the flywheel following a transient or LOCA, (3) failure of the flywheel following a DEGB with simultaneous induced loss of electric power to the RCP motor. The TR includes a fourth scenario: a transient or a LOCA with a break area less than three square feet along with simultaneous loss of power to the RCP motor. The flywheel overspeed for this event is less than the 1500 rpm assumed for a transient and the initiating event frequency is about a factor of 100 less frequent because the conditional probability of loss of station power following a LOCA is about 1E-2. Consequently, this fourth scenario is a subset of the normal transient scenario that contributes far less to the risk and is not included in the table below. The detailed results for all the scenarios for each of the two flywheel types are provided in Tables 3-12 and 3-13 of the TR and summarized below for the three primary scenarios.

As can be seen in the table, the bounding estimated increase in risk associated with increasing the flywheel inspection interval from 10 to 20 years is about 1E-8/year for the transient or LOCA scenario without loss of electric power to the RCP motor. This estimate is about a factor of ten below the very small change in large early release frequency (LERF) guideline of 1E-7/year in RG 1.174. The risk increase estimated for the other scenarios are very small and are provided to illustrate that the expected increase in risk from these scenarios is negligible compared to the dominant scenario.

Operating Condition and Scenario Characteristics	Increase in CDF and LERF Group 1	Increase in CDF and LERF Group 2
Normal Operation 1500 Maximum rpm Initiating event frequency Flywheel failure is the initiating event	2.0E-10/year	7E-11/year
Transient or LOCA 1500 Maximum rpm Initiating event frequency One per year	1.2E-8/year	4E-9/year
Large LOCA (2E-6/year) with simultaneous loss of RCP motor power (1.4E-2) 3321 Maximum rpm Initiating event frequency DEGB (2.8E-8/year)	3E-12/year*	< 1E-12/year*

*The TR rounds the probability of flaws that fail at 3321 rpm to 1E-2 at the end of 60 years for both Groups and regardless of whether the inspection interval is 10 or 20 years. The increase in risk for Group 1 is derived from Table 3-8 of the TR. The increase in risk for Group 2 is derived from the number of significant digits in the frequencies reported in Table 3-8 of the TR.

4.0 CONCLUSIONS

The change in risk estimate includes numerous conservative assumptions including:

- The use of the 1500 rpm critical crack size for 1189 and 1200 rpm scenarios.
- The use of the probability that a critical crack exists at the end of the 60 year life as the probability that the crack would exist during each operating year.
- The use of 100 start-ups and shutdowns per calender year when simulating the fatigue crack growth.
- Not crediting any flywheel inspections and repairs after the first 10 years of operation.
- Characterizing the DEGB flow rate as 5000 gpm or higher.
- The failure of the flywheel will cause core damage and a large early release event with a probability of 1.

The staff finds that these conservative assumptions provide a bounding estimate of the change in risk associated with the increase of the examination interval from 10 to 20 years. The bounding estimate is below the very small change in LERF guidelines in RG 1.174 and the staff finds that the increase in risk is small and is consistent with the Commission's Safety Goal Policy Statement.

The TR also addresses the other key principles of risk-informed licensing actions. No changes to the evaluation of design basis accidents and safety analysis margins are being made. Nondestructive examinations will still be conducted, but on a less frequent basis not to exceed 20 years. Therefore, the staff finds the requested change to be well-defined, consistent with defense-in-depth philosophy, contains adequate margin of safety, and incorporates a performance measurement strategy to monitor the change. The staff also finds that the risk evaluation is consistent with the risk-informed methodology and guidelines described in RG 1.174 and that the potential change in risk caused by the extension of the inspection interval from 10 to 20 years is small and acceptable.

The request is a change from the current RG 1.14 guidance. The staff finds that the regulatory positions in RG 1.14 concerning the three critical speeds are satisfied, and that the evaluation indicating that critical crack sizes are not expected to be attained during a 20-year inspection interval is reasonable and acceptable. The potential for failure of the RCP flywheel is, and will continue to be, negligible during normal and accident conditions.

5.0 REFERENCES

1. Letter from Robert H. Bryan, Westinghouse Owners Group, to Chief, Information Management Branch, USNRC, August 24, 2001, enclosing Westinghouse Electric Company Report WCAP-15666, "*Extension of Reactor Coolant Pump Motor Flywheel Examination*," Non-Proprietary Class 3, dated July 2001.

2. Letter from Robert H. Bryan, Westinghouse Owners Group, to Chief, Information Management Branch, USNRC, *Transmittal of Response to Request for Additional Information (RAI) Regarding WCAP-15666-NP, Rev. 0, "Extension of Reactor Coolant Pump Motor Flywheel Examination" (MUHP-3043)*, April 23, 2002.

3. Letter from Robert H. Bryan, Westinghouse Owners Group, Chief, Information Management Branch, USNRC, *Transmittal of Revised Pages of WCAP-15666-NP, Rev. 0, Rev. 0, "Extension of Reactor Coolant Pump Motor Flywheel Examination" and Clarification to RAI Response Number 3.a (MUHP-3043)*, November 15, 2002.

4. U.S. Nuclear Regulatory Commission, "Reactor Coolant Pump Flywheel Integrity," Regulatory Guide 1.14, Revision 1, August 1975.

5. U.S. Nuclear Regulatory Commission, Letter from Brian W. Sheron to Sushil C. Jain (Duquesne Light Company), "Acceptance for Referencing of Topical Report WCAP-14535, Topical Report on Reactor Coolant Pump Flywheel Inspection Elimination," dated September 12, 1996.

6. U.S. Nuclear Regulatory Commission, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Regulatory Guide 1.174, July 1998.

7. WCAP-14572, Revision 1-NP-A, *"Westinghouse Owners Group Application of Risk-Informed Methods to Piping Inservice Inspection Topical Report,"* February 1999.

8. *Rates of Initiating Events at U. S. Nuclear Power Plants: 1987 - 1995*, NUREG/CR-5750, February 1999.

9. *Evaluation of LOCA With Delayed Loop and Loop With Delayed LOCA Accident Scenarios*, NUREG/CR-6538, July 1997.

Principal Contributors: P. Patnaik
S. Dinsmore

Date: May 5, 2003