Background Regarding the Need to Have a Replacement Safety System Unavailability Performance Indicator

There are several significant issues associated with the current safety system unavailability (SSU) performance indicator (PI). Principal among these issues are the concerns that the SSU PI is neither plant-specific nor sufficiently risk-informed, and therefore it may not accurately indicate the risk significance of system performance calculated from the reported data. To resolve these and other concerns, a NRC/Industry Working Group has developed a replacement indicator for the SSU PI that is intended to more accurately reflect risk-significant performance of the monitored systems. This new PI will be called, "The Pilot Mitigating Systems PI (MSPI)." The MSPI will involve calculating unavailability and unreliability by train separately, using the raw data reported as unavailable hours for planned and corrective maintenance; and valid demands and failures of the monitored active components for unreliability. Each of the two parameters will have an algorithm that will calculate a total delta core damage frequency (Δcdf) index for unavailability (all trains) and for unreliability (all trains). The two indexes will be subsequently summed together to indicate a single overall system performance index. Although the index is not a true indicator of core damage frequency, it does give relative changes in plant risk due to changes in the performance health of the monitored system.

Algorithm for Combining UA and UR for a Two-Train System:

$$\mathbf{Total\Delta CDF_{MSPI} = Total\Delta CDF_{Unreliability} + Total\Delta CDF_{Unavailability}}$$

$$\mathbf{Total\Delta CDF_{MNPI} = (\Delta CDF_{UnRel\text{-}train\ A} + \Delta CDF_{UnRel\text{-}train\ B}) + (\Delta CDF_{UnAvail\text{-}train\ A} + \Delta CDF_{UnAvai\text{-}trainB})}$$

Unreliability Equation:

$$Total\Delta CDF_{UR} = \Delta CDF_{UR\text{-}train\ A} + \Delta CDF_{UR\text{-}train\ B}$$
$$\Delta CDF_{UR\text{-}Train\ A} = [Q_P (FV_{UR\text{-}Train\ A})/UR_{PRA\text{-}Train}](UR_{Bayesian\ Update\text{-}Train} - UR_{Baseline\text{-}Train})$$
$$\Delta CDF_{UR\text{-}Train\ B} = [Q_P (FV_{UR\text{-}Train\ B})/UR_{PRA\text{-}Train}](UR_{Bayesian\ Update\text{-}Train} - UR_{Baseline\text{-}Train})$$
$$UR_{Bayesian\ Update\text{-}Train} = \sum UR_{Bayesian\ Update\text{-}Component}$$
$$UR_{Baseline\text{-}Train} = \sum UR_{Baseline\text{-}Component}$$

Unavailability Equation:

$$Total\Delta CDF_{UA} = \Delta CDF_{UA\text{-}train\ A} + \Delta CDF_{UA\text{-}train\ B}$$
$$\Delta CDF_{UA\text{-}train\ A} = [Q_P (FV_{UA\text{-}Train\ A})/UA_{PRA\text{-}Train}](UA_{Train} - UA_{Baseline\text{-}Train})$$
$$\Delta CDF_{UA\text{-}train\ B} = [Q_P (FV_{UA\text{-}Train\ B})/UA_{PRA\text{-}Train}](UA_{Train} - UA_{Baseline\text{-}Train})$$

Definitions:

$FV_{UR\text{-}Train\ A}$	Fussel-Vessely value from PRA model for train A, unreliability only
$FV_{UR\text{-}Train\ B}$	Fussel-Vessely value from PRA model for train B, unreliability only
$UR_{Baseline\text{-}Train}$	The historical train unreliability value based on 1995-1997 industry data
$UR_{Baseline\text{-}Component}$	The historical unreliability value o a component in a monitored train, based on 1995-1997 industry data
$UR_{Bayesian\ Update\text{-}Component}$	The Bayesian updated value of actual 12 quarter unreliability (sum of Bayesian updates by component to derive train value)
$UR_{Bayesian\ Update\text{-}Train}$	The Bayesian updated value of actual 12 quarter unreliability (sum of Bayesian updates by component to derive the train value)
$UR_{PRA\text{-}Train}$	The unreliability of the monitored train as assumed in the PRA model
Q_P	Baseline CDF value from the PRA, assuming normal maintenance

WORKSHOP ESSENTIALS
(Items to be Brought to Workshop)

1) Come with site specific FAQs (participants)

2) System Risk significant functions and its success criteria (participants)

3) Schematics with demarcation of boundary including check valves (participants)

4) Identify Active Components (participants)

5) Support System Cooling: How components cooled? (participants)

6) Developed Data Reporting Spreadsheet (NEI)

Timeline:

Due week before April 13 -- Draft of guidelines incorporating changes

Due May 3 -- Final draft of guidelines

Due May 22 -- Format for Workshop

May 23 -- ROP Public Meeting

May 30 -- ACRS Subcommittee Meeting

June 5 -- Full ACRS Meeting

June 12-14 -- SSU PI Workshop

June 26-27 -- .ROP Public Meeting

4/4 Afternoon Session **NRC AND NEI:**

Agree On

1) Equations
   component level

2) NRC perform parallel Analysis during pilot

3) PI Index Approach

4) How to Treat Identical Train W/Diff. Risk Values

5) Swing Trains Modeled and Included in PRA

6) Count Demands the Same as EPIX

7) How to Determine Baseline Value for UA

8) Treatment of Old FAQs for UA Relative to New UA/UR PI

Disagree on/ or need to Resolve (R)

1) Single Indicator (R)
   How To Accomplish (i.e., or gate, change in threshold, etc.) Don't need to resolve until July, Aug (#2,5 of handout issues rolled-in/resolved by this resolution - methodology

2) Significance of outcome of performance issue tied to PI. No SDP on Demand Failure * (R)

3) Determine criteria when indicator is invalid (grey) (#5 of handout issues rolled-in/resolved by this resolution) JT's #2 Open Issue

4) Model Normally Running System (FV Key)** (R)

5) Verify Appropriateness of Values Used In Data Tables* (R)

6) Relationship Btn G/W Threshold and MR Criteria (R)

7) Isolation Condensers Included/ Replacement?

* Resolve Prior to Workshop
** Resolve During Pilot

LIST OF PLANTS PARTICIPATING IN THE ROP SYSTEM UNAVAILABILITY PERFORMANCE INDICATOR PILOT PROGRAM CURRENT AS OF 4/19/2002

Plant Name	Status of Revision 3 SPAR Model	Tentative Dates for Onsite QA Review
Millstone 2	Plant's PRA model changed significantly since SPAR model reviewed 3 yrs. ago	6/3-7
Millstone 3	SPAR model to be completed in 2 weeks	6/3-7
Hope Creek	SPAR model completed; needs onsite review	5/13-17
Salem 1 & 2	Plant's PRA model was undergoing major revision 2 yrs ago when onsite review conducted	5/13-17
Limerick 1 & 2	SPAR model completed; onsite review conducted	N. A.
Surry 1 & 2	SPAR model completed; needs onsite review	6/24-28
Braidwood 1 & 2	SPAR model completed; onsite review conducted	N. A.
Prairie Island 1 & 2	SPAR model completed; needs onsite review	5/28-31
Cooper	SPAR model completed; onsite review conducted	N. A.
Palo Verde 1, 2, & 3	SPAR model to be completed in 2 weeks; needs onsite review	6/17-21
South Texas 1 & 2	SPAR model to be completed in 4 weeks; needs onsite review	7/8-12
San Onofre 2 & 3	SPAR model completed; onsite review conducted	N. A.

2.2 MITIGATING SYSTEMS CORNERSTONE

The objective of this cornerstone is to monitor the availability, reliability, and capability of systems that mitigate the effects of initiating events to prevent core damage. Licensees reduce the likelihood of reactor accidents by maintaining the availability and reliability of mitigating systems. Mitigating systems include those systems associated with safety injection, decay heat removal, and their support systems, such as emergency ac power. This cornerstone includes mitigating systems that respond to both operating and shutdown events.

(Not all aspects of licensee performance can be monitored by performance indicators and risk-informed baseline inspections are used to supplement these indicators.)

There are two sets of indicators in this cornerstone:

- Mitigating System Performance Index
- Safety System Functional Failures

Mitigating system performance Index

Purpose

The purpose of the mitigating system performance index is to monitor the risk impact of changes in performance of selected systems. It is comprised of two elements - system unavailability and system unreliability.

Indicator Definition

Mitigating system performance index (MSPI) is the sum of changes in a simplified core damage frequency evaluation resulting from changes in train unavailability and train unreliability relative to baseline values.

Train unavailability is the ratio of the hours the train was unavailable to perform its risk-significant functions during the previous 12 quarters while critical to the number of critical hours during the previous 12 quarters. (Fault exposure hours are not included; unavailable hours are counted only for the time required to recover the train's risk-significant functions.)

Train unreliability is the probability that the trainwould not perform its risk-significant at power functions when called upon during the previous 12 quarters.

Baseline values are the values for unavailability and unreliability against which current changes in unavailability and unreliability are measured. See Appendix F for further details.

The MSPI is calculated separately for each of the following five systems for each reactor type.

BWRs

- emergency AC power system
- high pressure injection systems (high pressure coolant injection, high pressure core spray, or feedwater coolant injection)
- heat removal systems (reactor core isolation cooling)
- residual heat removal system
- support cooling system (includes risk significant direct cooling functions provided by service water and component cooling water or their cooling water equivalents for the above four monitored systems)

PWRs

- emergency AC power system
- high pressure safety injection system
- auxiliary feedwater system
- residual heat removal system
- support cooling system (includes risk significant direct cooling functions provided by service water and component cooling water or their cooling water equivalents for the above four monitored systems)

Data Reporting Elements

The following data elements are reported for each system

- ΔCDF due to unavailability for each monitored system
- ΔCDF due to unreliability for each monitored system

During the pilot, the following additional data elements are reported monthly for each system

- critical hours
- unavailable hours by train
- the following unreliability data elements defined in Appendix F

  - n_d = total number of failures on demand during the previous 12 quarters
  - d = total number of demands during the previous 12 quarters
  - n_r = total number of failures to run during the previous 12 quarters
  - t = total number of run hours during the previous 12 quarters
  - T = mission time based on plant-risk model assumptions

Calculation

The MSPI for each system is the sum of the ΔCDF for unavailability for the system plus and ΔCDF for unreliability for the system during the previous twelve quarters.

MSPI = ΔCDF system unavailability + ΔCDF system unreliability.

See Appendix F for the calculational methodology for ΔCDF system unavailability and ΔCDF system unreliability.

Definition of Terms

A train consists of a group of components that together provide the risk significant at power functions of the system as explained in the additional guidance for specific mitigating systems. Fulfilling the risk significant at power function of the system may require one or more trains of a system to operate simultaneously. The number of trains in a system is determined as follows:

- for systems that primarily pump fluids, the number of trains is equal to the number of parallel pumps necessary to satisfy the risk-significant functions or the number of flow paths in the flow system (e.g., number of auxiliary feedwater pumps). For a system that contains an installed spare pump, the number of trains would equal the number of flow paths in the system.

- for systems that provide cooling of fluids, the number of trains is determined by the number of parallel heat exchangers, or the number of parallel pumps, whichever is fewer.

- for emergency AC power systems the number of trains is the number of class 1E emergency (diesel, gas turbine, or hydroelectric) generators at the station that are installed to power shutdown loads in the event of a loss of off-site power (This does not include the diesel generator dedicated to the BWR HPCS system, which is included in the scope of the HPCS system).

Risk Significant Functions: those at power functions of risk-significant SSCs as defined in NUMARC 93-01 (revision 3), Section 9.3, as endorsed by the NRC in Regulatory Guide 1.160 for meeting the requirements of the maintenance rule.

Success criteria are the plant specific values of parameters that identify the capability of the train/system that is required to meet the risk-significant function. Default values of parameters are the plant's design bases values unless other values are modeled in the PRA.

Clarifying Notes

Documentation

It is expected that each licensee will have identified the system boundaries, active components, risk significant functions and success criteria necessary to report this performance indicator. This information shall be readily available for NRC inspection on site. Additionally, plant-specific information used in Appendix F should also be readily available for inspection.

Success Criteria
Typical plant specific parameters that identify the capability of the train to meet the risk-significant functions include, but are not limited to:

- pressure
- temperature
- flow rate
- and ?

Monitored Systems
Systems have been generically selected for this indicator based on their importance in preventing reactor core damage. The systems include the principal systems needed for maintaining reactor coolant inventory following a loss of coolant accident, for decay heat removal following a reactor trip or loss of main feedwater, and for providing emergency AC power following a loss of plant off-site power. One risk-significant support function (support cooling system) is also monitored. The support cooling system monitors the risk significant cooling functions provided by service water and component cooling water, or their direct cooling water equivalents, for the four front-line monitored systems. No support systems are to be cascaded onto the monitored systems, e.g., HVAC room coolers, DC power, instrument air, etc.

Diverse Systems
Except as specifically stated in the indicator definition and reporting guidance, no attempt is made to monitor or give credit in the indicator results for the presence of other systems at a given plant that add diversity to the mitigation or prevention of accidents. For example, no credit is given for additional power sources that add to the reliability of the electrical grid supplying a plant because the purpose of the indicator is to monitor the effectiveness of the plant's response once the grid is lost. Another example: no credit is given in the high pressure injection system PI for additional means of providing makeup flow to the vessel, such as the use of the Automatic Depressurization System and the Core Spray system in a BWR.

Common Components
Some components in a system may be common to more than one train, in which case the effect of the performance (unavailable hours) of a common component is included in all affected trains.

System or equipment realignments and activities
Trains are generally considered to be available during periodic system or equipment realignments to swap components or flow paths as part of normal operations. Evolutions or surveillance tests that result in less than 15 minutes of unavailable hours per train at a time should not be counted as unavailable hours. The intent is to minimize unnecessary burden of data collection, documentation, and verification. Licensees should compile a list of surveillances/evolutions that meet this criterion and

have it available for inspector review.

If a licensee is required to take a component out of service for evaluation and corrective actions (for example, related to a Part 21 Notification), the unavailable hours must be included.

Treatment of Degraded Conditions

If a degraded condition results in the failure to meet an established success criterion, unavailable hours must be included for the time required to recover the train's risk-significant function(s). This condition also is counted as a demand and a demand failure. If subsequent analysis identifies additional margin for the success criterion, future unavailable hours for degraded conditions may be determined based on the new criterion. However, unavailability must be based on the criterion of record at the time the degraded condition is discovered. If the degraded condition is not addressed by any of the pre-defined success criteria, an engineering evaluation to determine the impact of the degraded condition on the risk-significant function(s) should be completed and documented. The use of component failure analysis, circuit analysis, or event investigations is acceptable. Engineering judgment may be used in conjunction with analytical techniques to determine the impact of the degraded condition on the risk-significant function. The engineering evaluation should be completed as soon as practicable. If it cannot be completed in time to support submission of the PI report for the current quarter, the comment field shall note that an evaluation is pending. The evaluation must be completed in time to accurately account for unavailability/unreliability in the next quarterly report. Exceptions to this guidance are expected to be rare and will be treated on a case-by-case basis. Licensees should identify these situations to the resident inspector.

Failures on Demand

Failures of active components on demand, either actual or test, while critical, are included in unreliability. Failures on demand while non-critical must be evaluated to determine whether the failure would have resulted in the train not being able to perform its risk-significant at power functions, and hence be included in unreliability. Unavailable hours are included only for the time required to recover the train's risk-significant functions and only when the reactor is critical.

Discovered Conditions

Discovered conditions that render a train incapable of performing its risk-significant functions are included in unreliability as a demand and a failure. Unavailable hours are counted only for the time required to recover the train's risk-significant functions and only when the reactor is critical.

Demand failures or discovered conditions that are not capable of being discovered during normal surveillance tests

These failures or conditions are usually of longer exposure time. Since they have not been tested on a regular basis, it is inappropriate to include them in the performance index statistics. These failures or conditions are more amenable to evaluation through the inspection process. Examples of this type are failures due to pressure locking/thermal binding of isolation valves, blockages in lines not regularly tested, or inadequate component sizing/settings under accident conditions (not under normal test conditions). While not included in the calculation of the index, they should be reported in the comment field of the PI data submittal.

Credit for Operator Recovery Actions

1. *During testing or operational alignment*:
   Unavailability of a risk-significant function during testing or operational alignment need not be included if the test configuration is automatically overridden by a valid starting signal, or the function can be promptly restored either by an operator in the control room or by a dedicated operator[1] stationed locally for that purpose. Restoration actions must be contained in a written procedure[2], must be uncomplicated (*a single action or a few simple actions*), and must not require diagnosis or repair. Credit for a dedicated local operator can be taken only if (s)he is positioned at the proper location throughout the duration of the test for the purpose of restoration of the train should a valid demand occur. The intent of this paragraph is to allow licensees to take credit for restoration actions that are virtually certain to be successful (i.e., probability nearly equal to 1) during accident conditions.

   The individual performing the restoration function can be the person conducting the test and must be in communication with the control room. Credit can also be taken for an operator in the main control room provided (s)he is in close proximity to restore the equipment when needed. Normal staffing for the test may satisfy the requirement for a dedicated operator, depending on work assignments. In all cases, the staffing must be considered in advance and an operator identified to perform the restoration actions independent of other control room actions that may be required.

   Under stressful, chaotic conditions, otherwise simple multiple actions may not be accomplished with the virtual certainty called for by the guidance (e.g., lifting test leads and landing wires; or clearing tags). In addition, some manual operations of systems designed to operate automatically, such as manually controlling HPCI turbine to establish and control injection flow, are not virtually certain to be successful. These situations should be resolved on a case-by-case basis through the FAQ process.

2. *In Response to Equipment failures*

[1] Operator in this circumstance refers to any plant personnel qualified and designated to perform the restoration function.

[2] Including restoration steps in an approved test procedure.

Operator actions to recover from an equipment malfunction or an operating error can be credited if the function can be promptly restored from the control room by a qualified operator taking an uncomplicated action (a single action or a few simple actions) without diagnosis or repair (i.e., the restoration actions are virtually certain to be successful during accident conditions). Note that under stressful, chaotic conditions, otherwise simple multiple actions may not be accomplished with the virtual certainty called for by the guidance (e.g., lifting test leads and landing wires). In addition, some manual operations of risk-significant functions designed to operate automatically, such as manually controlling HPCI turbine to establish and control injection flow, are not virtually certain to be successful. These situations should be resolved on a case-by-case basis through the FAQ process. Unavailable hours are counted for the period of time the train is taken out of service for repair. A demand failure may or may not have occurred depending on whether the prompt actions satisfy the success criteria.

3. *During Maintenance*
Unavailability of a risk-significant function during maintenance need not be included if the risk-significant function can be promptly restored either by an operator in the control room or by a dedicated operator[3] stationed locally for that purpose. Restoration actions must be contained in a written procedure[4], must be uncomplicated (*a single action or a few simple actions*), and must not require diagnosis or repair. Credit for a dedicated local operator can be taken only if (s)he is positioned at a proper location throughout the duration of the maintenance activity for the purpose of restoration of the train should a valid demand occur. The intent of this paragraph is to allow licensees to take credit for restoration of risk-significant functions that are virtually certain to be successful (i.e., probability nearly equal to 1). The individual performing the restoration function can be the person performing the maintenance and must be in communication with the control room. Credit can also be taken for an operator in the main control room provided (s)he is in close proximity to restore the equipment when needed. Under stressful chaotic conditions otherwise simple multiple actions may not be accomplished with the virtual certainty called for by the guidance (e.g., lifting test leads and landing wires, or clearing tags). These situations should be resolved on a case-by-case basis through the FAQ process.

Swing trains and components shared between units
Swing trains/components are trains/components that can be aligned to any unit. To be credited as such, their swing capability should be modeled in the PRA with an appropriate Fussel-Vessely value.

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[3] Operator in this circumstance refers to any plant personnel qualified and designated to perform the restoration function.

[4] Including restoration steps in an approved test procedure.

Maintenance Trains and Installed Spares

Some power plants have systems with extra trains to allow preventive maintenance to be carried out with the unit at power without impacting the risk-significant function of the system. That is, one of the remaining trains may fail, but the system can still perform its risk significant function. To be a maintenance train, a train must not be needed to perform its risk significant function.

An "installed spare" is a component (or set of components) that is used as a replacement for other equipment to allow for the removal of equipment from service for preventive or corrective maintenance without impacting the risk-significant function of the system. To be an "installed spare," a component must not be needed for the system to perform the risk significant function.

Unavailability and unreliability are monitored for an installed spare or maintenance train if it is modeled in the plant PRA. If they are substituted for a primary train/component, the primary becomes the spare.

If a maintenance train or installed spare are not modeled in the plant PRA, unavailability and unreliability are monitored only when they are substituted for a primary train/component. Unavailability and unreliability are not monitored for a component/train when that component/train has been replaced by an installed spare or maintenance train that is not modeled in the plant PRA.

Use of Plant-Specific PRA and SPAR Models change title

The MSPI is an approximation of a plant's actual PRA and is intended as an indicator of system performance. Plant-specific PRAs and SPAR models cannot be used to question the outcome of the PIs computed in accordance with this guideline.

Maintenance Rule Performance Monitoring

It is the intent that NUMARC 93-01 be revised to require consistent unavailability and unreliability data gathering as required by this guideline.

Additional Guidance for Specific Systems

Emergency AC Power Systems

Scope

The emergency AC power system is typically comprised of two or more independent emergency generators that provide AC power to class 1E buses following a loss of off-site power. The emergency generator dedicated to providing AC power to the high pressure core spray system in BWRs is not within the scope of emergency AC power.

The electrical circuit breaker(s) that connect(s) an emergency generator to the class IE buses that are normally served by that emergency generator are considered to be part of the emergency generator train.

Emergency generators that are not safety grade, or that serve a backup role only (e.g., an alternate AC power source), are not included in the performance reporting.

Train Determination

The number of emergency AC power system trains for a unit is equal to the number of class 1E emergency generators that are available to power safe-shutdown loads in the event of a loss of off-site power for that unit. There are three typical configurations for EDGs at a multi-unit station:

1. EDGs dedicated to only one unit.
2. One or more EDGs are available to "swing" to either unit
3. All EDGs can supply all units

For configuration 1, the number of trains for a unit is equal to the number of EDGs dedicated to the unit. For configuration 2, the number of trains for a unit is equal to the number of dedicated EDGs for that unit plus the number of "swing" EDGs available to that unit (i.e., The "swing" EDGs are included in the train count for each unit). For configuration 3, the number of trains is equal to the number of EDGs.

Clarifying Notes

The emergency diesel generators are not considered to be available during the following portions of periodic surveillance tests unless recovery from the test configuration during accident conditions is virtually certain, as described in "Credit for operator recovery actions during testing," can be satisfied; or the duration of the condition is less than fifteen minutes per train at one time:

- Load-run testing
- Barring

An EDG is not considered to have failed due to any of the following events:

- spurious operation of a trip that would be bypassed in a loss of offsite power event
- malfunction of equipment that is not required to operate during a loss of offsite power event (e.g., circuitry used to synchronize the EDG with off-site power sources)
- failure to start because a redundant portion of the starting system was intentionally disabled for test purposes, if followed by a successful start with the starting system in its normal alignment

BWR High Pressure Injection Systems

(High Pressure Coolant Injection, High Pressure Core Spray, and Feedwater Coolant Injection)

Scope

Plants should monitor either the high-pressure coolant injection (HPCI), the high-pressure core spray (HPCS), or the feedwater coolant injection (FWCI) system, whichever is installed. The turbine and governor (or motor-driven FWCI pumps), and associated piping and valves for turbine steam supply and exhaust are within the scope of these systems. Valves in the feedwater line are not considered within the scope of the these systems. The emergency generator dedicated to providing AC power to the high-pressure core spray system is included in the scope of the HPCS. The HPCS system typically includes a "water leg" pump to prevent water hammer in the HPCS piping to the reactor vessel. The "water leg" pump and valves in the "water leg" pump flow path are ancillary components and are not included in the scope of the HPCS system.

Train Determination

The HPCI and HPCS systems are considered single-train systems. The booster pump and other small pumps are ancillary components not used in determining the number of trains. The effect of these pumps on system performance is included in the system indicator to the extent their failure detracts from the ability of the system to perform its risk-significant function. For the FWCI system, the number of trains is determined by the number of feedwater pumps. The number of condensate and feedwater booster pumps are not used to determine the number of trains.

BWR Heat Removal Systems
(Reactor Core Isolation Cooling or check:Isolation Condenser)

Scope

The Reactor Core Isolation Cooling (RCIC) system turbine, governor, and associated piping and valves for steam supply and exhaust are within the scope of the RCIC system. Valves in the feedwater line are not considered within the scope of the RCIC system. The Isolation Condenser and inlet valves are within the scope of Isolation Condenser system.

Train Determination

The RCIC system is considered a single-train system. The condensate and vacuum pumps are ancillary components not used in determining the number of trains. The effect of these pumps on RCIC performance is included in the system indicator to the extent that a component failure results in an inability of the system to perform its risk significant function

BWR Residual Heat Removal Systems

Scope

The functions monitored for the BWR residual heat removal (RHR) system are the risk-significant functions. The pumps, heat exchangers, and associated piping and valves for those functions are included in the scope of the RHR system.

Train Determination

The number of trains in the RHR system is determined by the number of parallel RHR heat exchangers.

PWR High Pressure Safety Injection Systems

Scope

The scope includes the pumps and associated piping and valves from both the refueling water storage tank and from the containment sump to the pumps, and from the pumps into the reactor coolant system piping. For plants where the high-pressure injection pump takes suction from the residual heat removal pumps, the residual heat removal pump discharge header isolation valve to the HPSI pump suction is included in the scope of HPSI system. Some components may be included in the scope of more than one train. For example, cold-leg injection lines may be fed from a common header that is supplied by both HPSI trains. In these cases, the effects of testing or component failures in an injection line should be reported in both trains.

Train Determination

In general, the number of HPSI system trains is defined by the number of high head injection paths that provide cold-leg and/or hot-leg injection capability, as applicable.

For Babcock and Wilcox (B&W) reactors, the design features centrifugal pumps used for high pressure injection (about 2,500 psig) and no hot-leg injection path. Recirculation from the containment sump requires operation of pumps in the residual heat removal system. They are typically a two-train system, with an installed spare pump (depending on plant-specific design) that can be aligned to either train.

For two-loop Westinghouse plants, the pumps operate at a lower pressure (about 1600 psig) and there may be a hot-leg injection path in addition to a cold-leg injection path (both are included as a part of the train).

For Combustion Engineering (CE) plants, the design features three centrifugal pumps that operate at intermediate pressure (about 1300 psig) and provide flow to two cold-leg injection paths or two hot-leg injection paths. In most designs, the HPSI pumps take suction directly from the containment sump for recirculation. In these cases, the sump suction valves are included within the scope of the HPSI system. This is a two-train system (two trains of combined cold-leg and hot-leg injection capability). One of the three pumps is typically an installed spare that can be aligned to either train or only to one of the trains (depending on plant-specific design).

For Westinghouse three-loop plants, the design features three centrifugal pumps that operate at high pressure (about 2500 psig), a cold-leg injection path through the BIT (with two trains of redundant valves), an alternate cold-leg injection path, and two hot-leg injection paths. One of the pumps is considered an installed spare. Recirculation is provided by taking suction from the RHR pump discharges. A train consists of a pump, the pump suction valves and boron injection tank (BIT) injection line valves electrically associated with the pump, and the associated hot-leg injection path. The alternate cold-leg injection path is required for recirculation, and should be included in the train with which its isolation valve is electrically associated. This represents a two-train HPSI system.

For Four-loop Westinghouse plants, the design features two centrifugal pumps that operate at high pressure (about 2500 psig), two centrifugal pumps that operate at an intermediate pressure (about 1600 psig), a BIT injection path (with two trains of injection valves), a cold-leg safety injection path, and two hot-leg injection paths. Recirculation is provided by taking suction from the RHR pump discharges. Each of two high pressure trains is comprised of a high pressure centrifugal pump, the pump suction valves and BIT valves that are electrically associated with the pump. Each of two intermediate pressure trains is comprised of the safety injection pump, the suction valves and the hot-leg injection valves electrically associated with the pump. The cold-leg safety injection path can be fed with either safety injection pump, thus it should be associated with both intermediate pressure trains. This HPSI system is considered a four-train system for monitoring purposes.

PWR Auxiliary Feedwater Systems

Scope

The scope of the auxiliary feedwater (AFW) or emergency feedwater (EFW) systems includes the pumps and the components in the flow paths from both the condensate storage tank and the alternative water source (e.g., the service water system). Startup feedwater pumps are not included in the scope of this indicator.

Train Determination

The number of trains is determined primarily by the number of parallel pumps. For example, a system with three pumps is defined as a three-train system, whether it feeds two, three, or four injection lines, and regardless of the flow capacity of the pumps. Some components may be included in the scope of more than one train. For example, one set of flow regulating valves and isolation valves in a three-pump, two-steam generator system are included in the motor-driven pump train with which they are electrically associated, but they are also included (along with the redundant set of valves) in the turbine-driven pump train. In these instances, the effects of testing or failure of the valves should be reported in both affected trains. Similarly, when two trains provide flow to a common header, the effect of isolation or flow regulating valve failures in paths connected to the header should be considered in both trains.

PWR Residual Heat Removal System

Scope

The functions monitored for the PWR residual heat removal (RHR) system are those that are required to be available when the reactor is critical. These typically include low-pressure injection and the post-accident recirculation mode used to cool and recirculate water from the containment sump following depletion of RWST inventory. The pumps, heat exchangers, and associated piping and valves for those functions are included in the scope of the RHR system.

Train Determination

The number of trains in the RHR system is determined by the number of parallel RHR heat exchangers. Some components are used to provide more than one function of RHR. If a component cannot perform as designed, rendering its associated train incapable of meeting one of the risk-significant functions, then the train is considered to be failed. Unavailable hours would be reported as a result of the component failure.