POLICY ISSUE

(NEGATIVE CONSENT)

August 30, 1990

SECY-90-307

For: The Commissioners

From: James M. Taylor
Executive Director for Operations

Subject: IMPACTS OF SOURCE TERM TIMING ON NRC REGULATORY POSITIONS

Purpose: To respond to the Commission's request (as stated in Staff Requirements Memorandum M900109, dated February 13, 1990) to propose changes to regulatory positions as soon as possible for both current and advanced reactor designs in those areas where the NRC has a sufficient technical basis from available research results (e.g., fission product timing).

Summary: The staff will recommend, via a forthcoming commission paper titled "Staff Study on Source Term Update and Decoupling Siting From Design," a phased approach to develop regulatory positions reflecting insights achieved through updated source term research. As part of this effort, an evaluation was performed to determine whether more realistic treatment of source term timing would result in less demanding requirements. A number of items were evaluated and it appears feasible, based on source term timing considerations, to relax the closure time for containment purge/vent

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isolation valves and BWR main steam isolation valves. Although not related to source term timing, it also appears feasible to relax the closure time for PWR main steam isolation valves and the starting time for emergency diesel generators. Plant-specific safety analyses that also address non-radiological considerations would be needed to demonstrate that these relaxations will not result in unacceptable consequences.

Discussion: The NRC has been undertaking research to develop an updated source term methodology for assessing the consequences of postulated severe accident events for light-water reactors. Current licensing practice assumes an instantaneous fission product release from the core into the containment. This is recognized as being a very unrealistic method of assessing the consequences of postulated severe accidents.

This paper addresses some of the potential impact of more realistic estimates of source term timing on regulatory requirements. The work presented here is part of a larger effort under way to assess the regulatory positions regarding updated source term, as described in the aforementioned forthcoming commission paper.

There are numerous surveillance tests required in each plant's technical specifications to demonstrate that systems, subsystems, and components perform their functions within specified time limits. Actually, only a few of these time constraints have bases that are directly related to source term timing. The staff identified the following systems, subsystems, and components as candidates for study since their functional time constraints appeared to be directly related to the source term timing: (1) the containment isolation system in general, with emphasis on main steam isolation valves (MSIV) and containment purge/vent isolation valves, (2) control room emergency ventilation, (3) standby gas treatment system for BWRs, (4) main steam isolation valve leakage control system for BWRs, and (5) exhaust air filtration and cleanup systems for PWRs. Although emergency diesel generator (EDG) start time is not directly related to source term timing, it was investigated because related questions were raised by the Commission.

A detailed description of the findings for all candidate items is provided in the enclosed paper titled "Possible Changes in Regulatory Positions Because of Updated Source Term Timing for Current and Advanced Reactor Designs."

Of the items evaluated, from a regulatory viewpoint it appears feasible and may be beneficial on a plant-specific basis to relax (1) the containment purge/vent isolation valve closure time, (2) the MSIV closure time, and (3) the EDG start time. Changes in regulatory guidance documents (regulatory guides and standard review plan sections) would be needed for the purge/vent isolation valve closure time. The standard technical specifications for the BWR MSIV closure time would have to be changed. No changes in existing regulatory documents are needed to permit a slower PWR MSIV closure time or EDG start time. In each of these cases, however, plant-specific analyses by the licensee would be needed to assure that a relaxation would be consistent with the plant safety analysis and the existing design. Technical specification revisions, if requested, could then be favorably considered. Requesting relaxed technical specifications, preparing the plant-specific analyses, and use of any revised regulatory documents would be entirely voluntary on the part of the licensee.

Current staff guidance in Standard Review Plan requires that purge/vent isolation valve closure times should not exceed 5 seconds to facilitate compliance with 10 CFR Part 100 regarding offsite radiological consequences. Even though on a case-by-case basis the staff has in the past accepted closure times as long as 15 seconds, the staff's position has always been that purge/vent isolation valves should be closed as fast as practical.

A limited radiological evaluation was performed by the staff to assess the impact of PWR purge/vent isolation valve and BWR MSIV closure times from 5 to 30 seconds. Past experiences of the staff indicate that radioactive iodine is the controlling source term in the reactor coolant during this time period, therefore the source term was assumed to be only the radioactive iodine contained in the reactor coolant. Based on staff best estimates and past FSAR calculations, it was estimated that for a typical LWR, beyond about 30 seconds after a postulated design basis accident (DBA) large-break loss-of-coolant accident (LOCA), gap activity is predicted to be transported to the reactor coolant, and the accumulated offsite doses increase rapidly. This time estimate is preliminary and will be confirmed by additional calculations under way as described in the afore-mentioned forthcoming commission paper. The radiological evaluation included (1) licensing-type calculations to assure that the dose limitations of 10 CFR Part 100 would not be exceeded and (2) realistic-type calculations to confirm that slower purge/vent isolation valve or BWR MSIV closure times would not result in a substantial decrease in overall protection to the public health and safety. The radiological evaluation showed that closure times of up to 30 seconds should be feasible for the purge/vent isolation valves and the BWR MSIVs.

The current 10-second fast-start requirement for EDGs and more importantly the rapid loading requirements are a result of the Emergency Core Cooling Systems (ECCS) rule contained in 10 CFR 50.46 and Appendix K, but was <u>not</u> a result of the assumed radiological consequences from a large-break LOCA. Conservative models and codes used in the past for licensing calculations indicated that fast-start and rapid loading were needed for EDGs to keep the peak cladding temperature of fuel elements below 2200°F after a large-break LOCA, as required by 10 CFR 50.46. Subsequent extensive research performed by the industry and by the NRC resulted in the revision of the ECCS rule in

1988 to permit more realistic analyses of ECCS performance. It appears that relaxation of the EDG fast-start time is feasible and can be approximately 30 seconds for both PWRs and BWRs.

Plants use the values of valve closure times and EDG start times for a variety of safety analyses. Therefore, relaxing the timing requirements for these items will impact more than radiological consequences. A variety of transient and accident analyses, environmental qualification of equipment, and starting times of other engineered safety features could be affected. Plant-specific safety analyses would be needed to demonstrate that these relaxations will not result in unacceptable consequences, and to support any requested changes to the plant technical specifications.

Conclusions: It appears feasible and beneficial to relax (1) the containment purge/vent isolation valve closure time, (2) the MSIV closure time, and (3) the EDG start and loading requirements. Changes in regulatory guidance documents (regulatory guides and standard review plan sections) would be needed to relax the purge/vent isolation valve closure time. This will be accomplished as part of the effort described in the aforementioned forthcoming commission paper.

Relaxing the timing requirements for the above items would impact more than radiological consequences. Plant-specific safety analyses would be needed to demonstrate that these relaxations will not result in unacceptable consequences, and to support changes to the plant technical specifications. In addition, greater potential benefits would result from these relaxations for future plants than for current plants, since future plants could optimize their design and analyses to maximize the benefits from relaxed timing requirements and take full benefit in specifying equipment. Benefits for current plants, however, would be limited to having somewhat less demanding technical specifications.

Recommendations: That the Commission note:

1. That unless otherwise instructed, the staff intends to prepare a generic letter for current and future plants in the first half of calendar year 1991, which will:

   (a) Provide results of the source term timing study (probably as a NUREG/CR report). These results are expected to confirm the minimum 30-second time to fuel failure after a postulated DBA large-break LOCA.

   (b) Transmit the conclusions contained in enclosure to this commission paper.

   (c) Provide guidance on plant-specific analyses needed to request timing relaxation.

2. The scope of this paper is aimed primarily at current plants, therefore the conclusions and the possible relaxation of some regulatory positions are applicable to those plants. As a minimum, these potential benefits would also apply to future plants. Additional regulatory position changes are likely for future plants, and will be discussed in the aforementioned forthcoming commission paper.

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Enclosure:

Possible Changes in Regulatory Positions
Because of Updated Source Term Timing
for Current and Advanced Reactor Designs

SECY NOTE: In the absence of instructions to the contrary, SECY will notify the staff on Friday, September 14, 1990, that the Commission, by negative consent, assents to the action proposed in this paper.

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Enclosure

POSSIBLE CHANGES IN REGULATORY POSITIONS BECAUSE OF UPDATED SOURCE TERM TIMING FOR CURRENT AND ADVANCED REACTOR DESIGNS

OFFICE OF NUCLEAR REGULATORY RESEARCH
U.S. NUCLEAR REGULATORY COMMISSION

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1. INTRODUCTION

A major NRC research effort has been under way since the early 1980s to develop an updated source term (fission product releases) methodology for light-water reactors for assessing the consequences of postulated severe accident events. Potential regulatory applications of the updated source term methodology are also being evaluated.

The Commission was briefed by the staff on the status of this research on January 9, 1990. In a Staff Requirements Memorandum dated February 13, 1990, the Commission endorsed the staff's recommendations to study options of decoupling reactor siting requirements from plant designs for future reactors. The rulemaking effort and findings on updated source term and decoupling of reactor siting from design will be discussed in a forthcoming commission paper titled "Staff Study on Source Term Update and Decoupling Siting from Design."

The Commission also directed the staff to propose changes to regulatory positions for both current and advanced reactor designs in areas that the NRC has a sufficient technical basis from available research results (e.g., fission product timing). The possible relaxations of some regulatory positions that may result from more realistic treatment of source term timing, as addressed in this technical paper, are mostly applicable to current plants. As a minimum, these potential benefits would also apply to future plants. Additional regulatory position changes are likely for these future plants and will be discussed in the aforementioned forthcoming commission paper.

2. AREAS INVESTIGATED

Many surveillance tests included in each plant's technical specifications require demonstration that components, subsystems, and systems perform their functions within specified time limits. Many of these time constraints have a basis that is not directly related to source term timing. Some examples are:

° Protection system instrumentation response time testing to ensure that various safety functions are initiated in a time period consistent with the plant's safety analysis. One example is that a reactor trip occurs in a timely manner so that core thermal-hydraulic parameters remain within analyzed bounds. Another example is that a safety system is actuated within the time period assumed by the safety analysis.

° Individual valve stroke timing tests as a partial demonstration that the valves have not significantly degraded.

- Emergency diesel generator start times and sequencing of electrical loads.

The staff evaluated a number of technical specification surveillance items to determine which could be affected by source term timing. Identified items listed below are discussed in the following sections.

- Containment isolation system (in general) with particular emphasis on the main steam isolation valves and containment purge/vent isolation valves

- Control room emergency ventilation

- Standby gas treatment system (BWR)

- Main steam isolation valve leakage control system (BWR)

- Exhaust air filtration and cleanup systems (PWR)

- Although not directly related to source term timing, emergency diesel generator start time was investigated

- Radiological consequence calculation on applicable items with a more realistic treatment of the source term timing

2.1 Containment Isolation System

The function of the containment isolation system is to permit the normal and emergency passage of fluids through penetrations in the containment boundary while preserving the ability of the boundary to prevent or limit the escape of fission products that may result from postulated accidents. The containment isolation system includes portions of all fluid systems penetrating the containment that performs the isolation function.

Current licensing guidance is detailed in Standard Review Plan (SRP) Section 6.2.4, "Containment Isolation System" (Ref. 1). This guidance was developed primarily from General Design Criteria (GDC) 54, 55, 56, and 57 of Appendix A of 10 CFR Part 50. These GDCs establish explicit requirements for isolation valves in lines penetrating the containment. Specifically, they address the number and location of isolation valves, valve actuation provisions, valve position, and valve type. Other guidance documents include Regulatory Guide 1.141, "Containment Isolation Provisions for Fluid Systems" (Ref. 2), which references ANSI N271-1976 (Ref. 3).

The timing of valve actuation is also discussed in SRP 6.2.4, which states that in meeting the requirements of GDC 54 the performance capability of the isolation function should reflect the importance to safety of isolating system lines. Consequently, containment isolation valve closure times should be selected to ensure rapid isolation of the containment following postulated accidents. The SRP states that valve closure times should be less than one minute, regardless of valve size. Valves in lines that provide a direct path from the reactor to the environment may have to close much quicker than in one minute.

There are typically two major pipe lines that penetrate the reactor vessel or containment and can provide a direct path from the reactor to the environment. These pathways are the containment purge/vent systems and the main steam lines in BWRs.

2.1.1 Containment Purge/Vent Isolation V

Containment purge/vent systems are used in a v ety of ways, such as controlling containment pressure and reducing the airborne activity within the containment to facilitate personnel access during reactor power operation.

Containment purge/vent isolation valves vary in size from approximately 3 inches to 42 inches in diameter. The smaller diameter valves are frequently standard-type gate valves, whereas the large diameter valves are typically of the butterfly type. Isolation valves greater than 3 inches that are used for containment purge and venting during power operation (modes 1, 2, 3, or 4) are required to be operable under the most severe DBA flow-loading conditions and close within the time limit specified in the technical specification (5 seconds). Containment purge/vent isolation valves are leak-rate tested in accordance with 10 CFR Part 50, Appendix J, and are also within the scope of Section XI of the ASME Boiler and Pressure Vessel Code.

Branch Technical Position (BTP) CSB 6-4, "Containment Purging During Normal Plant Operations," (part of SRP 6.2.4), states that purge system isolation valve closure times, including instrumentation delays, should not exceed 5 seconds to facilitate compliance with 10 CFR Part 100 regarding offsite radiological consequences. Even though on a case-by-case basis, the staff has in the past accepted closure times as long as 15 seconds, the staff's position has always been that purge/vent isolation valves should be closed as fast as practical. The BTP also states that since a passive, sealed containment system is inherently more reliable than an open containment with an active isolation system, purging/venting during reactor operation should be minimized or possibly eliminated, which has been the NRC's longstanding position.

Containment isolation valve closure times are typically presented in plant technical specifications. Based on large-break LOCA radiological considerations alone from a limited scope evaluation as discussed in the following paragraphs, it may be possible to increase the 5-second purge/vent isolation valve closure time up to 30 seconds. A relaxation of the closure time for containment purge/vent isolation valves from that in the current technical specifications may be beneficial for the larger diameter butterfly valves, since relaxation would permit a reduced disc velocity and less severe loads on the valve seat.

For a large-break LOCA, several plant-specific safety analyses would be required to evaluate the acceptability of a longer closure time for the purge/vent isolation valves, and the results of these analyses are likely to be more limiting than the radiological consequences. Example are:

1. Valve operability characteristics would have to be reviewed. The review would have to ensure that delaying the valve closure time would not subject the valves to a higher differential pressure that was beyond the design capability of the valves.

2. A large-break LOCA might create debris, particularly insulation and the hardware used to attach the insulation to the reactor coolant system piping. A plant-specific assessment of a longer closure time would have to include a reevaluation of B.1.g of BTP CSB-6-4 which states, "Provisions should be made to ensure that isolation valves closure will not be prevented by debris which could potentially become entrained in the escaping air and steam." As the valve closure time exceeds 15 seconds, there is a greater concern that debris might prevent complete valve closure, or result in excessive valve leakage. The staff plans to study this further and perhaps revise the SRP in conjunction with the longer-term efforts as will be described in the aforementioned forthcoming commission paper.

3. A longer purge/vent isolation valve closure time will allow more air to be exhausted from the containment and reduce containment pressure. This has two potential adverse effects which must be considered on plant-specific basis. First, the lower containment pressure can adversely affect ECCS effectiveness, particularly in regard to core reflood rate. Second, there is a potential for a vacuum to be created within the

containment as containment sprays condense steam.

4. The impact of slower purge/vent isolation valve closure on the structural integrity of downstream safety-related ventilation systems, including dynamic effects, would have to be considered.

Plant-specific radiological analyses would also be required to justify a less stringent purge/vent isolation valve closure time. The analysis would have to consider the predicted earliest time of fuel cladding failure for a large-break LOCA. In addition, a reevaluation of the fuel handling accident analysis would be required. Mitigation of such an accident, if it occurs inside of containment, relies on timely isolation of the containment purge system. The purge/vent valve isolation signal for this accident is initiated by a high radiation level. Depending on the physical location of the radiation monitors and the air transport time from the monitors to the valve inlet (during containment purge system operation), too slow a valve closure time might result in a significant release from the containment prior to complete valve closure in the event of a refueling accident.

Focusing on the radiological consequences of the design basis large-break loss-of-coolant accident (LOCA) analysis, a limited scope evaluation was performed. The approach was to evaluate closure of the purge/vent isolation valves at various time intervals, thereby determining the impact of increasing fission product releases to the environment. The source term was assumed to be only the radioactive iodine contained in the reactor coolant. (See Section 2.7 for a more detailed description of the radiological consequence analyses.)

This evaluation was limited to the initial 30 seconds of the postulated accident, and the results for a PWR plant are presented in Table 1 of Section 2.7. Based on the results of this limited evaluation, there is the potential to increase purge/vent isolation valve closure times up to 30 seconds. During this time period, the source term is dominated by reactor coolant activity. Once the fuel gap activity is predicted to be transported to the reactor coolant, the accumulated off-site doses increase rapidly.

If it is established that significant fission product releases are delayed, regulatory documents that relate the assumptions or descriptions used for determining containment isolation timeliness would be revised as part of the effort to be discussed in the aforementioned forthcoming commission paper. These documents include Regulatory Guides 1.3 and 1.4, SRP 15.6.5, and SRP 6.2.4 and its accompanying branch technical position (Refs. 4-6, 1).

2.1.2 Main Steam Isolation Valves

Another significant path to the environment is the main steam lines that penetrate containment. To limit the release of coolant inventory and radioactivity from various postulated events, isolation of steam lines in LWRs is also rapid, i.e., the main steam isolation valves (MSIVs) close in about 5 seconds. Five-second closure time is typically used to facilitate various design basis analyses and is often included in plant technical specifications.

In order to evaluate the impact of increasing the MSIV closure time, the bases and assumptions used in various safety analyses must be investigated. The following licensing items for PWRs and BWRs could be affected by MSIV closure delays:

- LOCA analysis
- Containment response analyses
- Equipment qualification
- Abnormal transients
- Radiological consequence analysis

For PWRs, the MSIVs are part of the secondary system, therefore any delay in the closure of the MSIVs is not dictated by radiological factors. The impact would be related to the increased thermal-hydraulic challenges inside the containment and reactor vessel. For example, during a main steam line break (MSLB) inside containment, longer MSIV closure time increases containment pressure due to increased back flow from the intact steam generators. This could incur reductions in existing safety margins; therefore, plant-specific reanalyses would be required to determine the feasibility of increasing the MSIV closure time.

For BWRs, the main steam lines provide a direct path from the reactor to the environment. It is anticipated that the limiting design basis event would be a postulated MSLB outside containment. Radiological consequences and core uncovery would be the two major factors that may limit the MSIV closure time. (A description of the BWR MSIVs is provided below in this section.) In addition, before isolation of the main steam line following the MSLB outside containment, large amounts of coolant inventory would be released into the auxiliary building. Typically, the auxiliary building forms part of the secondary containment boundary. This event would provide a challenge to the auxiliary building subcompartment structure, and thereby may potentially jeopardize the secondary containment boundary and safety-related equipment inside.

The overall design capabilities of the auxiliary building and the equipment within are usually not up to the same standards as the containment and its comparable equipment. Therefore, in addition to radiological consequences, the principal factors that will dictate the required closure time of the MSIVs for BWRs are related to equipment qualification and structural design characteristics of the auxiliary building, which would have to be evaluated on a plant-specific basis.

Also, MSIV closure time of 5 seconds is assumed for many of the BWR accident and transient analyses. All of these analyses would have to be evaluated on a plant-specific basis to justify a longer MSIV closure time. The LOCA and MSLB analyses would consider the predicted earliest time of fuel cladding failure rather than the current assumption of an instantaneous release of fission products from the core to the containment. The impact of a longer MSIV closure time on the consequences of severe reactivity events (e.g. control rod drop accident) would also have to be analyzed using current assumptions. It is expected that a reanalysis of the various safety analyses would demonstrate that, with some reduction in the existing safety margins, a MSIV closure time of up to 30 seconds could be allowed.

A limited scoping evaluation was performed on a BWR focusing on the radiological consequences of a postulated MSLB outside containment. The source terms were derived in a manner similar to that described in the purge/vent case discussed above (see Section 2.7 for a more detailed description of the radiological consequence analyses).

SRP Section 15.6.4 (Ref. 7) provides two acceptance criteria for a BWR MSLB outside containment: (1) the dose should not exceed the guideline values of 10 CFR Part 100 if the assumed iodine spike corresponds to the value used in the standard technical specifications (STS) and (2) The dose should not exceed 10 percent of these values if the maximum equilibrium iodine concentration allowed in the STS is assumed. The results, shown in Table 2 of Section 2.7, show that these criteria are satisfied.

Based on these results from the standpoint of radiological consequences, the MSIV closure time could be increased to about 30 seconds for BWRs. Up to 30 seconds, reactor coolant activity dominates, then gap activity quickly dominates the source term and accumulated off-site doses increase rapidly.

In general, the MSIVs used in BWR plants are typically Y-pattern globe valves that are mounted in a horizontal position in each main steam line with one valve located inside the drywell (inboard MSIV) and a second valve outside the primary containment (outboard MSIV). Normal steam flow tends to close the valves, and higher inlet pressure tends to hold the valves closed. During approximately the first 75 percent of closing, the valves have little effect on flow reduction, because the flow is choked by a venturi restrictor located between the reactor pressure vessel and the inboard MSIV. After the valves are approximately 75 percent closed, flow is reduced as a function of the valve area versus travel characteristic.

Current plant technical specifications for BWR MSIVs typically require closure within 3 to 5 seconds. The MSIV fast (automatic) closure time is adjustable to between 3 and 10 seconds. This design aspect may be the controlling factor which limits potential relaxations in existing BWR plants unless the valves are modified. A relaxation of the closure time for MSIVs from that in the current technical specifications may permit a reduced disc velocity and less severe loads on the valve seat. This relaxed closure time must be (1) within the time established by the design basis accident analysis to limit the release of reactor coolant, (2) within the time established by revised radiological dose calculations, and (3) within the design limitations of the MSIVs. It should be noted that while intuitively a relaxation of MSIV closure time may appear desirable, a review of 220 LERs ranging from 1980 to 1990 did not identify fast closure as a major cause of valve degradation and failure. This is probably due to the fact that fast valve closure may result in an increase in maintenance and does not directly result in valve failure that would be identified in LERs.

Without prescriptive guidance, existing regulatory documents relating to MSIV closure time would not require changes. For current or future plants to increase the MSIV closure times, the design limitations of the MSIVs need to be evaluated, and a variety of plant-specific safety analyses, as mentioned above, would have to be performed to demonstrate safety limits are still bounding.

2.2 Control Room Emergency Ventilation

The safety function of the control room emergency ventilation (CREV) is to provide a controlled environment for control room personnel and to ensure operability of control room components during design basis accident (DBA) conditions. The CREV is safety-related and is generally a subsystem of the control room area ventilation system, portions of which may not be safety-related. Monitors are located in the system intake duct plenums that are capable of detecting radiation, smoke, and toxic gases (where applicable).

In the event of a DBA, control room occupants are protected from radiation due to inleakage of outside air by closing the normal supply and exhaust isolation valves and placing the CREV in a recirculation mode. These isolation valves are generally butterfly valves or louver-type valves. Subsequently, outside air may be admitted to the control room through the emergency filter unit. The radiation monitors in the intake plenum activate an alarm at a preset radiation level and initiate CREV operation at a somewhat higher level. Therefore, changes in source term timing would have little effect on the CREV since the setpoint for radiation monitors would be unchanged.

Generic Issues 83, "Control Room Habitability Systems" which is in the final stage of completion, is investigating potential discrepancies regarding control room habitability systems and their impact on safety. The adequacy of the CREV to perform its intended safety function is a part of the resolution of GI-83.

2.3 Standby Gas Treatment System - BWR

The standby gas treatment system (SGTS, is a ventilation control system used in BWR plants that filters contaminants leaked from the primary containment and collected in the secondary containment of the reactor building. The SGTS filters out iodine and particulates and exhausts filtered air up a stack and into the environment, reducing the potential radiological consequences of an accident. For the SGTS to be fully effective, it must draw a slight vacuum in the affected enclosure region. For a design basis LOCA this takes 2 to 3 minutes to achieve after system operation is initiated. The licensing calculations do not give credit for SGTS removal of radiactive material until this is achieved.

A more realistic assessment of the timing of radioactive releases from the core to the primary containment and from the primary to the secondary containment will somewhat reduce the calculated radiological consequences. As stated above, the SGTS is not assumed effective in the licensing calculations until a slight vacuum is created within the secondary containment. Hence, any relaxation would have to be analyzed on a plant-specific basis. For the SGTS to function properly, various isolation valves and dampers must perform as designed. Typically, ventilation systems used during normal operation are first isolated, then the SGTS isolation valves and dampers would open to achieve the desired air flow arrangement. These isolation valves and dampers (part of the secondary containment integrity) usually have a stroke time of about 5 seconds. Therefore, if valve reliability can be improved by increasing the stroke time, it may be possible to increase these closure times provided the overall function of the SGTS is not affected.

Another consideration is the electric power needed for the SGTS. The SGTS is powered from the Class 1E electrical buses, which in turn are supplied by the emergency diesel generators (EDG) in the event of a loss of offsite power (LOOP) and an accident. The SGTS is not loaded onto the 1E buses as soon as other engineered safety features, such as the ECCS. If the EDG start time is relaxed from the typical current requirement of 10 seconds (see Section F below), the impact on SGTS start time would have to be evaluated and may become limiting.

2.4 MSIV Leakage Control System - BWR

Some BWR plants employ a MSIV leakage control system to collect leakage through the MSIVs and route the leakage to the intake of the SGTS. This system is manually initiated by the operator based on various plant parameters. Since there is no automatic initiation of the system, changes associated with source term timing would not directly affect the initiation of operation of the MSIV leakage control system. However, potential changes in source term composition that may result from the research (to be discussed in the aforementioned commission paper) could affect the design of, and perhaps the need for, the MSIV leakage control system. NRR is currently reviewing a request from the BWR Owners' Group to delete the MSIV Leakage Control System.

2.5 Exhaust Air Filtration and Cleanup Systems - PWR

PWR plants employ a variety of exhaust air filtration and cleanup systems to ensure radiological materials leaking from the ECCS equipment within the auxiliary building, ECCS pump room, and pipe penetration area following a LOCA are filtered and cleaned before they are released to the environment. Like the SGTS used in BWRs, operation of the PWR systems are automatically initiated and are powered from the class 1E buses. Also, like the SGTS, these systems are not loaded onto the 1E buses as quickly as the ECCS. Therefore, as discussed in Section F below, any relaxation of EDG start time would have to consider the plant-specific impact on the start time of these filtration and cleanup systems.

2.6 Emergency Diesel Generators

2.6.1. Basis of Current Requirements

Nuclear plants must have onsite backup electric power sources to supply AC power if offsite power becomes unavailable. EDGs are typically the source of backup AC power. The onsite backup power systems have two major functions:

(1) To provide power promptly (fast start and loading) to engineered safety features (ESFs) if a LOOP and an accident such as a large-break LOCA occur during the same time period, and

(2) To provide power to equipment needed to maintain the plant in a safe condition if an extended LOOP occurs.

High reliability must be designed into the EDG units and maintained throughout their service lifetime by appropriate testing, maintenance, and operating programs. Typically, current technical specifications require that EDGs be able to start from ambient conditions and reach stable rated speed and voltage within 10 seconds to mitigate effects of a large-break LOCA coincident with LOOP. This fast-start capability to supply emergency power should be demonstrated on a periodic basis through a testing program as described in Regulatory Guide 1.108, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants" (Ref. 8). There are also requirements for pre-operational and other periodic surveillance testing of EDG to ensure inservice reliability in Regulatory Guide 1.108, but the testing frequencies are different.

It should be noted that the 10-second fast-start and rapid loading requirement for EDGs were a result of the ECCS rule contained in 10 CFR 50.46 and Appendix K and was not a result of the assumed radiological consequences of a large-break LOCA. Old conservative models and codes used for licensing calculations indicated that a 10-second start time and rapid loading for EDGs was needed to keep the peak cladding temperature (PCT) of fuel elements below 2200°F after a large-break LOCA, as required by 10 CFR 50.46.

Subsequent extensive research performed by the industry and the NRC, which included experiments, computer code development, and code assessment, allowed more accurate calculation of ECCS performance along with reasonable estimate of uncertainty. This research resulted in the revision of the ECCS rule in 1988 (53 FR 35996, 9/16/88) to permit more realistic analyses of ECCS performance. In addition to the revised rule, Regulatory Guide 1.157, "Best-

Estimate Calculations of Emergency Core Cooling System Performance" (Ref. 9) was published in 1989.

2.6.2 Potential for Less Stringent EDG Starting and Loading Times

2.6.2.1. Range of EDG Start Time that Appears Feasible

The industry has performed some general studies regarding the effect of the new ECCS rule on the potential relaxation of EDG fast-start time (Refs. 10, 11). Based on these studies, relaxation of EDG fast-start time may be feasible. It appears that the fast-start and loading sequence can be relaxed by 20 to 40 seconds for both PWRs and BWRs. (For more details, see 2.6.3.3 below.)

Generic Safety Issue B-56, "Diesel Reliability" was established by the NRC to address the EDG reliability issue raised by Unresolved Safety issue A-44, "Station Blackout." Field experience seems to indicate that un-lubricated fast-starts, rapid loading, and a large number of tests all incrementally increase EDG stress and wear, and may result in less EDG reliability. Relaxation in EDG start testing with regard to the frequency of starting, pre-lubrication and slow loading has been available since 1984 (i.e., Generic Letter 84-15, Ref. 12). Potential relaxation of EDG fast-start time was included in the GSI B-56 study. (This and other benefits for relaxation of EDG fast-start time are discussed in 2.6.2.2 below.) A draft (Revision 3) of Regulatory Guide 1.9, "Selection, Design, Qualification, Testing, and Reliability of Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants," is being prepared, has received review by NRR and OGC, and has been forwarded to the ACRS and CRGR for review. Coordination with the Nuclear Management and Resources Council (NUMARC) on this draft regulatory guide and their NUMARC 8700, Appendix D, "EDG Reliability Programs," has been maintained during the course of the GSI B-56 study. Regulatory Guide 1.108 will be superseded by Regulatory Guide 1.9, Rev. 3, once it is approved and issued. In Draft Regulatory Guide 1.9, the fast-start time for the 6-month (or 184 days) testing to simulate a large-break LOCA coincident with LOOP refers to the time specified in plant technical specifications.

2.6.2.2 Benefits

As mentioned above, fast starts, rapid loading, and a large number of tests may contribute to increased EDG stress and wear. Relaxation, particularly of the rapid loading requirements, would result in reduced thermal stresses.

2.6.3 Constraints

2.6.3.1 Changes Needed to Regulatory Documents

It is clear that provisions are already in place in the revised ECCS rule for licensees to seek relaxation of the EDG fast-start and loading testing time. However, each licensee will have to request a technical specification amendment on this issue, informing the staff of the proposed EDG test time together with new safety analyses results for pecific plant. All safety analyses that used the fast-start times in the licensing process would need to be re-evaluated to justify a less stringent EDG start time.

2.6.3.2 Future Plants

Section 3.4.5, Chapter 5, "Equipment Safety Systems," of the EPRI draft "Advanced Light Water Reactor Requirements Document," (Ref. 13) states that the ALWR engineered safety systems must be designed so that the onsite power source start time need not be shorter than 20 seconds and the combined start time and load sequencing time need not be shorter than approximately 40 seconds. In addition to reasons already mentioned above, the ALWR Steering Committee stated (See draft SER on Chapter 5 of ALWR Requirements Document, Ref. 14) that this relaxed 20-second EDG start time will allow the use of a ramp generator to control the acceleration of the EDG to full speed. The EDG can accelerate freely up to approximately 50 percent speed, at which point the governor controls the acceleration to full speed following a predetermined ramp, thereby eliminating any overshoot. With the ramp generator, the engine will safely get to full speed in 13 to 14 seconds. A 6- to 7-second margin is then provided before load sequencing to allow lube oil pressure to build up and stabilize, thereby, reducing the likelihood of a failure to start from low lube oil pressure and minimizing engine wear from improper engine lubrication before any large load is applied.

The staff draft SER on Chapter 5 of the ALWR Requirements Document (Ref. 14), states:

> "The staff finds that the longer starting period allowed for the diesel generator will likely improve the reliability for those conditions at which it is directed. This is based on the assumption that the sequencing on the engineered safety system loads can be delayed with no adverse effects on the functional capability of the respective systems. Also, the amount of unreliability added by the ramp generator circuitry in the diesel generator must be considered.

The use of increased starting and loading intervals is acceptable, providing the increased intervals are properly incorporated into plant-specific accident analyses and shown by such analyses to result in acceptable consequences. The staff will require the ALWR designer/applicant to demonstrate the acceptability of such an analysis."

2.6.3.3 EDG Start and Load Sensivity Studies for Current Plants

(1) PWRs

An industry study (Ref. 11) on PWRs used the more realistic WCOBRA/TRAC code on a typical Westinghouse four-loop PWR. The sensitivity studies showed that the EDG fast-start time can be increased from 10 seconds to 33 seconds with an increase in peak cladding temperature (PCT) from 1706°F to 1795°F. Moreover, even if the EDG fast-start time were increased to 53 seconds, the Appendix K PCT limit of 2200°F would not be exceeded.

The containment cooling effects of relaxed EDG start times were evaluated using the COCO computer code. When the maximum delay as determined by the WCOBRA/TRAC large-break LOCA analysis was used, the peak containment pressure during the transient remained well below the containment design pressure limit. However, the equipment qualification design envelope was exceeded. Equipment qualification considerations limited the diesel start time to a maximum of 45 seconds. An evaluation of non-LOCA accident scenarios showed that EDG fast-start times greater than 30 seconds could have an impact on the analyses of feedwater piping failures and the loss of AC power transients.

It was concluded in this study that, for this typical Westinghouse four-loop PWR, an EDG fast-start time of 30 seconds was feasible with currently acceptable licensing calculations, and only a large-break LOCA calculation and a containment temperature study would be needed.

From this industry study, it is apparent that for time periods beyond about 30 seconds, factors other than ECCS performance (such as equipment qualification and other non-LOCA accident scenarios) may be the limiting factors restricting the relaxation of EDG fast-start time. Therefore, all safety analyses should be carefully re-evaluated by the licensee to assess the effect of relaxing the EDG fast-start time and to ensure there are no adverse safety consequences from this relaxation. This justification should be submitted to the staff for evaluation when the licensee is requesting a technical specification amendment.

(2) BWRs
An industry study on BWRs (Ref. 10) used the more realistic thermal-hydraulic code SAFER/GESTR to perform a sensitivity study on a typical BWR/6. The PCT for various start-up durations of the EDG and stroke times of the associated injection valves were calculated.

The study results show that for a 1600°F PCT, the EDG fast-start time can be 70 seconds (compared to the present 10 seconds). The EDG fast-start time can be increased to 118 seconds before the 2200°F PCT limit is reached.

Unlike the PWR study, no effects other than the ECCS performance were evaluated. Therefore, 70 seconds for 1600°F PCT may not be the limiting EDG fast-start time. For instance, starting the SGTS depends on EDG as the power source. Since the licensing calculations do not give credit for SGTS operation until a slight vacuum is achieved within the secondary containment, this may limit the EDG start time.

2.7. Radiological Consequence Calculation

Previous calculations of the radiological consequences from a design basis large-break LOCA events assumed that a TID-14844 (Ref. 15) source term was instantaneously released from the fuel into the containment. However, new research has suggested that a much more realistic approach would utilize a delay in the release of the source terms. This section discusses the consequences of this new research by calculating the effect of a delay on the closure time for (1) containment purge valves after a design basis large-break LOCA in a PWR and (2) MSIVs after a MSLB outside of containment in a BWR.

The first task for these calculations was to estimate the timing and radiological elements. Based on staff best estimates and past FSAR calculations, it was concluded that a release would most likely consist of the following:

1. An initial 30 seconds of coolant activity (I-131),
2. Followed by at least five to six minutes of gap activity,
3. Followed by large fission product releases comparable to those in TID-14844.

These are estimated to be a limiting case for a typical PWR. Further calculations are being performed to verify this estimate and to extend to a range of plant types. This will be discussed in the aforementioned forthcoming commission paper.

Subsequent analysis by the staff determined that if the dose consequences of Part 100 were not to be exceeded, only coolant activity could be allowed to escape the containment.

Next, conservative (licensing-basis-type) calculations were performed to determine the radiological consequences of delaying the closure of either the purge or MSIV after a LOCA. For a PWR large-break LOCA, the following conservative assumptions were used:

1. The maximum coolant activity permitted by typical plant technical specifications for above 80% power levels ($60 \mu Ci/g$) was assumed to exist.

2. Release was through the 18-inch purge/vent system at the choked flow rate (132 lb/sec at break flow).

3. X/Q due to a ground level release in 2 hours was assumed to be 2.8×10^{-4} sec/m^3 at exclusion area (site) boundary.

4. Breathing rate was 3.47×10^{-4} m^3/sec (from Regulatory Guide 1.4, Ref. 5).

5. Conversion factor of 1.485×10^6 Rem/Ci for thyroid was used (from ICRP 2, Ref. 16).

The dose in rems is then calculated from the following equation:

Dose = (Flow rate)(Time)(Concentration)(Conversion Factor) (X/Q)(Breathing Rate).

For a BWR MSLB outside of containment, the following assumptions were used.

1. The maximum coolant activity permitted by typical plant technical specifications ($4 \mu Ci/g$) was assumed to exist.

2. Release was through the steam pipe at choked flow rate for a typical BWR (6,500 lb/sec).

3. X/Q due to a ground release in 2 hours was assumed to be 2.8×10^{-4} Sec/m^3 at exclusion area (site) boundary.

The results of the conservative calculations for valve closure times of 5 to 30 seconds in 5-second increments are shown in Table 1 for the PWR large-break LOCA and Table 2 for the BWR MSLB. The maximum change in the overall dose commitment at 30 seconds would be well within 10 CFR Part 100 guidelines. The dose was more realistically calculated by assuming the following:

1. Maximum equilibrium coolant activity before shutdown permitted by typical plant technical specifications was assumed (1μCi/g for the PWR and 0.2μCi/g for the BWR).

2. X/Q was a factor of 10 lower. (Based on past FSARs)

These results are shown in Table 1 for the PWR large-break LOCA and Table 2 for the BWR MSLB.

In addition to the licensing-basis-type calculations described above, more realistic calculations were performed to determine if slower closing times for the containment purge valves and MSIVs would represent a substantial impact to the overall protection of public health and safety.

The more realistic calculations estimated the population dose from increased valve closure times. X/Q values as a function of distance were obtained from Regulatory Guides 1.3 and 1.4 (Refs. 4 and 5) for the BWRs and PWRs cases, respectively. The population dose in person-rem was then calculated by assuming a uniform population density of 340 persons/mi^2, and integrating over the population density times the dose as a function of distance. The results were then multiplied by the probability of the event (estimated by RES/ARGIB to be 10^{-3} for the BWR MSLB and 10^{-6} for a PWR large break LOCA). These results were integrated from the exclusion area boundary (1000 meters) to 50 miles to obtain the probability-weighted population dose shown in Tables 3 and 4 for the generic PWR and BWR cases, respectively.

Additional calculations of population dose were calculated by INEL using the MACCS code (Ref. 17). Two PWR plants, Surry and Zion, were used. These results are included in Table 3, where all radiological pathways were taken into account and the integration was over a 1000-mile radius from each plant. In addition, the actual population density and meteorological data for each plant were used, making for a more realistic calculation than the generic calculations.

The calculations for the generic PWR in Table 3 show that the increased probability-weighted population dose from delaying the closure of the purge valve would be negligible. This conclusion is supported by the Zion and Surry results, which are up to 100 times smaller in value than the generic PWR calculations. One reason for the higher numbers from the calculations for the generic PWR is the conservative population density used; another reason is that the population density around a plant is not uniform, and higher populations some distance from the plant have a relatively small effect on the total population dose.

The BWR MSLB results in Table 4, however, are not negligible, but they are small enough (less than 10 person-rem) that the closure of MSIVs under 30 seconds would not represent a substantial impact to the overall protection of public health and safety. On the other hand, results from MACCS (Ref. 17) indicate that more realistic calculations would yield even smaller probability-weighted population doses. If a BWR were assumed at the Surry site, the thyroid population dose for a 30-second valve closure time would have been 0.1 person-rem rather than 9 person-rem. At the Zion site, the thyroid population dose for a 30-second valve closure time would have been 0.3 person-rem.

Table 1. Dose Commitment for Individual at Site Boundary from PWR Design Basis LOCA*

Time (sec) of purge valve closure	Thyroid Dose (Rems) licensing basis	More realistic
5	2.59	0.0043
10	5.19	0.0087
15	7.77	0.013
20	10.36	0.017
25	12.95	0.022
30	15.54	0.026

* Assumptions: RCS water activity - 60 (technical specifications limit for power level above 80%) and 1 (more realistic) μCi/g - Iodine 131 equivalent.
Release through 18" purge/vent system at choked flow rate.
Purge Valve closure time includes setpoint and instrumentation delays and valve stroke time.

Table 2. Dose commitment for Individual at Site Boundary from BWR MSLB Outside of Containment*

Time (sec) of MSIV closure	Thyroid Dose (Rems) licensing basis: Iodine spike	Maximum equil.	More realistic
5	8.5	0.43	0.043
10	17.0	0.85	0.085
15	24.5	1.2	0.12
20	34.0	1.7	0.17
25	42.5	2.1	0.21
30	51.0	2.6	0.26

* Assumptions: RCS water activity - 4 (technical specifications limit) and 0.2 (maximum equilibrium and more realistic) μCi/g.
Release through MSIV at choked flow rate.
MSIV closure time includes setpoint and instrumentation delays and valve stroke time.

Table 3. Probability-Weighted Population Dose from PWR Design Basis LOCA*

Time (sec) of purge valve closure	Thyroid Population Dose (Person-rem) Generic	Surry	Zion
5	1.5E-4	1.8E-6	5.0E-6
10	3.0E-4	3.8E-6	9.8E-6
15	4.6E-4	5.7E-6	1.5E-5
20	6.1E-4	7.5E-6	2.0E-5
25	7.6E-4	9.5E-6	2.5E-5
30	9.1E-4	1.1E-5	3.0E-5

* Assumptions: RCS water activity - 1 μCi/g.
Release through 18" purge/vent system at choked flow rate.
Purge Valve closure time includes setpoint and instrumentation delays and valve stroke time.

Table 4. Probability-Weighted Population Dose for BWR MSLB Outside of Containment*

Time (sec) of MSIV closure	Thyroid Population Dose (Person-rem) Generic
5	1.5
10	3.0
15	4.5
20	6.0
25	7.5
30	9.0

* Assumptions: RCS water activity - 0.2 μCi/g.
Release through MSIV at choked flow rate.
MSIV closure time includes setpoint and instrumentation delays and valve stroke time.

3. CONCLUSIONS

Relaxation of requirements appears feasible and beneficial for the containment purge/vent isolation valve closure time, the MSIV closure time, and the EDG start time. Only the first item and the MSIV closure time for BWRs are directly related to source term timing. Changes in regulatory requirement documents would be needed only for the purge/vent valve closure time.

Relaxing the timing requirements of each of these items affects more than radiological consequences, therefore plant-specific safety analyses would be needed. A few examples of the plant-specific considerations are:

(1) Relaxing of the purge/vent isolation valve closure time may subject these valves to differential pressures beyond their design capacity.

(2) Slower BWR MSIV closure time would increase the amount of high-temperature fluid discharged to the auxiliary building and therefore may jeopardize the integrity of the secondary containment boundary or exceed the environmental qualification of equipment in the auxiliary building.

(3) EDG start times are currently based on ECCS considerations. If the start times are relaxed, safety analyses would have to be reviewed and possibly revised to reflect the later start time of ECCS and other ESFs.

From the examples cited above, it is apparent that there is a greater potential benefit from less stringent timing requirements for future plants than for current plants. Future plants could optimize their design and analyses to maximize the benefits from relaxed timing requirements and take full benefit in specifying equipment. Current plants would be largely limited to having somewhat less demanding technical specifications.

The scope of this paper is aimed primarily at current plants, therefore the conclusions and the possible relaxation of some regulatory positions are applicable to those plants. As a minimum, these potential benefits would also apply to future plants. Additional regulatory position changes are likely for future plants, and will be discussed in the aforementioned forthcoming commission paper.

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