EDO Principal Correspondence Control

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FINAL REPLY:

Lawrence S. Criscione
Springfield, Illinois

TO:

Borchardt, EDO

FOR SIGNATURE OF : ** GRN ** CRC NO:

Leeds, NRR

DESC: ROUTING:

2.206 - MODE 2 Descending (EDATS: OEDO-2010-0333)

Borchardt
Virgilio
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DATE: 04/30/10

ASSIGNED TO: CONTACT:

NRR Leeds

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Incoming Task Received: 2.206

April 30, 2010

1412 Dial Court
Springfield, IL 62704

Mr. William Borchardt
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subj: 10CFR2.206 Request Concerning MODE 2 Descending

Dear Mr. Borchardt:

I am submitting the information contained below to you as a 10CFR2.206 request. The address above is my home address; however, I work in the Washington, DC area and make it home to Illinois infrequently. Please send all correspondence to me electronically at either my personal email account (LSCriscione@hotmail.com) or my work email. If you must send me a hard copy, please send it to me at Mail Stop CSB/C2 A7.

Please note that, in the basis for my petition, I reference an event documented in SER 253 which is a proprietary document owned by the Institute of Nuclear Power Operations. I am aware of the event described in SER 253 because of my work experience in the nuclear industry (in 2005 I was working at a utility which was an INPO member). I believe that the 2005 event which occurred at Surry is important to the basis for my request; however, because Surry voluntarily reported the event to INPO I can appreciate the need to protect the utility's confidentiality. Please ensure that any public distribution of this request protects INPO's and Dominion's proprietary information.

Another basis for my petition is an event that occurred at Callaway Plant in 2003. I know of this event through my own first hand investigation of it and not through any proprietary information. To my knowledge Ameren Corporation never officially shared this information with INPO or any other industry group which compiles Operating Experience. In fact, when I left Ameren in November 2007 there were very few licensed operators at Callaway Plant who were aware of this event. I believe that Ameren has been attempting to cover up the October 21, 2003 Incident since the day it occurred and for that reason I believe any redaction of this information from my request basis would only serve to assist Ameren in preventing the nuclear industry (and their own operators) from learning from this incident.

Please be assured there are no new allegations present in this request. Although I might not agree with the final resolutions, all allegations have been documented by Region IV as either RIV-2007-A-0028, RIV-2007-A-0096 or RIV-2009-A-0036. This request is an attempt to ensure a lesson learned from the October 21, 2003 Incident is addressed in the industry.

Very respectfully,

Lawrence S. Criscione

Lawrence S. Criscione, PE
(573) 230-3959

EDO --G20100264

§1. Actions Requested

§1.1 Modify Technical Specifications of all Westinghouse Pressurized Water Reactors

Add a requirement to the "Reactivity" section of Westinghouse Improved Technical Specifications (ITS) requiring the following:

1. MODE 2 Descending is defined as entry into MODE 2 from MODE 1.
2. The reactor be in MODE 3 within 30 minutes of reaching MODE 2, Descending.
3. The reactor is not normally operated in MODE 2 after a down power from 100% power. That is, reactor power is not intentionally maintained in MODE 2 during a down power, but instead MODE 2 Descending is merely a transitional stage to get to MODE 3. If reactor power cannot be sustained above 5% power, then the reactor should be shut down. (Holding power low in MODE 1, such as while equipment repairs are being effected, is acceptable).
4. The control banks should be fully inserted within 15 minutes of reaching MODE 3.
5. Exceptions to any of the above items are allowed only for pre-planned tests and surveillances.

The above five items are not intended to be verbatim representations of what should be added to the Technical Specifications. The above items are concepts of what needs to be incorporated into the Technical Specifications; the exact way to word the requested changes to the Technical Specifications is being left to the US NRC to determine. This 10CFR2.206 request is a request to somehow incorporate the five items above into the Improved Technical Specifications for Westinghouse PWRs.

§1.2 Consider Modifying Technical Specifications of other reactor designs

If appropriate, consider revising the Technical Specifications of plants which were designed by other vendors (e.g. General Electric BWRs, Babcock & Wilcox PWRs, Combustion Engineering PWRs). My concern is with item §1.1. This concern is only being included for completeness. Regardless of whether item §1.1 is accepted or rejected, I need not receive feedback on this item; any feedback I receive regarding item §1.1 will be sufficient for explanation of this item.

§2. Facts that Constitute the Basis for the Request

§2.1 NRC Information Notice 97-62

On February 21, 1997 at a Westinghouse PWR north of Chicago, control room operators were attempting to maintain the reactor critical near the Point of Adding Heat when they failed to recognize that the nuclear fission reaction had shut down. While attempting to raise reactor power, IN 97-62 notes that the following occurred:

> *With the Unit 1 reactor substantially subcritical, a licensed reactor operator withdrew control rods continuously in an attempt to take the reactor to the critical stage, disregarding established procedural controls for conducting a safe reactor startup.*

The details of the incident are available at:

> *http://www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/1997/in97062.html*

Although there were many human performance issues which led to this event, the event would never had occurred if the plant's Technical Specifications required that MODE 2 Descending be treated as a transitional period. The plant's procedure for tripping the turbine required that reactor power be lowered to below the Point of Adding Heat (POAH). As discussed below in item §2.4, at such a low power the natural feedback between temperature and core reactivity is either no longer existent or substantially degraded.

§2.2 INPO SER 253

On February 4, 2005 at a Westinghouse PWR in Virginia, control room operators were attempting to maintain the reactor critical near the Point of Adding Heat when they failed to recognize that the nuclear fission reaction had shut down and reactor power had decayed into the source range. Reactor power remained in the source range for approximately two hours, during which time the control room operators failed to recognize that reactor power was below the Point of Adding Heat. Once the operators recognized that power was below the POAH, they diluted boron from the reactor coolant and withdrew control rods in an attempt to raise reactor power. Although their actions succeeded in restoring reactor power, their actions essentially amounted to (in the words of IN 97-62) "disregarding established procedural controls for conducting a safe reactor startup".

INPO SER 253, "Unplanned Reactor Operations Below the Point of Adding Heat" is proprietary information which is not available to the public. The lack of a US NRC written Information Notice on the February 4, 2005 incident restricts public knowledge of this significant incident.

Although there were many human performance issues which led to this event, the event would never had occurred if the plant's Technical Specifications required that MODE 2 Descending be treated as a transitional period. The control room operators had been instructed to maintain MODE 2 while repairs were being made to steam plant equipment. As discussed below in item §2.4, throughout MODE 2 the natural feedback between temperature and core reactivity is substantially degraded and, below the POAH, is no longer existent.

§2.3 October 21, 2003 Incident at Callaway Plant

§2.3.1 The Objective Data

On October 21, 2003 Callaway Plant was shutting down to MODE 3 to comply with T/S 3.8.7 (concerning loss of a safety related inverter). At approximately 9:38 am, with the plant in MODE 1, 8% power, a temperature transient occurred which resulted in average coolant temperature (T_{avg}) lowering 9°F over a 25 minute period. This drop in average coolant temperature resulted in the reactor being operated below the Minimum Temperature for Critical Operation (551°F) for approximately 10 minutes (between 10:00 am and 10:13 am) and also resulted in the letdown system isolating on low pressurizer level at 10:00 am.

At 10:13 am, the operators tripped the main turbine in order to allow recovery of average coolant temperature to above the Minimum Temperature for Critical Operation. When the turbine was tripped, the reactor was in MODE 2 at 4.9% reactor power.

Between 10:13 am and 10:14 am, average coolant temperature rose from 552°F to 555°F while "start up rate" went from -0.01 decades per minute (dpm) to -0.16 dpm. The 3°F temperature rise resulted in a negative reactivity insertion which caused the nuclear fission reaction to shut down. This passive shut down of the nuclear fission reaction was occurring while the operators were restoring the letdown system to service.

By 10:18 am, the same time the operators completed restoration of 75 gpm letdown and exited the off-normal procedure for "Loss of Letdown", the nuclear fission rate was 20% of what it had been five minutes earlier (the Intermediate Range Nuclear Instrument reading had gone from 1.4E-5 ion chamber amps to 2.4E-6 ica). The reactor had shut down to the point where it would have been unwise to attempt to recover criticality without using the Reactor Startup procedure. By 10:25 am reactor power was below the POAH and start up rate was the nominal "-1/3 dpm" rate expected during a reactor shutdown.

Despite the fact that the nuclear fission reaction had shut down, the operators did not make any efforts until 12:04 pm to actively insert negative reactivity. After restoring 75 gpm letdown at 10:18 am and exiting the off-normal procedure, the operators entered the normal operating procedure for raising letdown flow from 75 gpm to 120 gpm, which they completed at 10:48 am. At 10:34 am, an Intake pump was secured and Cooling Tower Blowdown was placed in service. At 10:38 am the Control Room Supervisor authorized technicians from the Instrumentation & Controls (I&C) group to perform a normal calibration on the channel 2 Power Range Nuclear Instrument (PRNI). All of these non-emergent activities were occurring as reactor power decayed the four decades from the POAH to the source range.

By 10:39 am, reactor power was in the source range. Because the control rods were still at their last Critical Rod Heights (CRH), neutron Subcritical Multiplication prevented the Source Range Nuclear Instruments (SRNIs) from energizing for another 45 minutes. During this time, the operators secured a condensate pump at 11:01 am and the Control Room Supervisor authorized I&C techs to perform a normal calibration on the channel 3 PRNI at 11:14 am. These non-emergent activities were occurring with reactor power in the source range while the control rods were still at their Critical Rod Heights.

At 11:25 am, the channel 2 SRNI energized causing an alarm to annunciate on the reactor's Main Control Board. If they had not already recognized it, by 11:25 am the operators were certainly aware that reactor power was in the source range. From 11:25 am until 12:04 am, the operators retained the control rods at their Critical Rod Heights while they continued to perform non-emergent activities. At 11:40 the operators placed the Start-up feed pump in service. At 11:42 am the operators placed containment mini-purge in service. At 11:45, the Control Room Supervisor authorized I&C techs to perform a normal calibration on the channel 4 PRNI. At 11:51 am the operators secured the 'B' Main Feed Pump. These non-emergent activities were occurring with reactor power in the source range while the control rods were still at their Critical Rod Heights.

§2.3.2 Analysis of the Objective Data

It is my opinion that the operators did not intend for the nuclear fission reaction to shut down when they tripped the main turbine at 10:13 am. It is also my opinion that from 10:18 am through 11:25 am the control room operators did not recognize that the reactor had shut down and that reactor power had transited into the source range. I base this on the following:

- Actively controlling the fission reaction in the reactor core is a fundamental tenet of nuclear power. The Shift Manager had been a reactor operator upon a naval ship and a reactor operator instructor at a naval prototype training command (a competitive position to get). He had been a Senior Reactor Operator and Shift Technical Advisor at Callaway

Plant for several years and was of such noted ability that, for a few years, he was assigned as an instructor to train the future Senior Reactor Operators in Initial License Training. Although this background might not have prevented him from committing the very human error of failing to recognize a reactor shutdown, it certainly instilled in him the importance of actively and conservatively controlling core reactivity. I find it hard to believe that had the Shift Manager (or any of the other US NRC licensed operators in the control room) recognized the reactor had shut down, he would not have immediately recognized the importance of promptly inserting the control banks.

- From 10:19 am through 12:03 pm there are nine log entries in the Shift Manager log and eight log entries in the Reactor Operator log. None of these log entries take precedence over actively controlling core reactivity by inserting the control banks. I find it hard to believe that, had the reactor operators recognized the reactor had shut down, they would have placed such relatively unimportant tasks (e.g. raising letdown flow from 75 to 120 gpm, restoring Cooling Tower Blowdown, non-emergency manipulation of pumps at the intake and in the steam plant, starting containment mini-purge, performing normal PRNI calibration checks) above actively controlling core reactivity by inserting the control banks.

The Shift Manager on duty in the control room at Callaway Plant for the October 21, 2003 shutdown has stated (both in Quality Assurance records and in sworn testimony to the US NRC) that the shutdown of the reactor at 10:13 am was not "inadvertent". He has stated that prior to giving the order to trip the main turbine, he was aware that the reactor would go subcritical due to lack of steam demand and that it would remain subcritical due to the buildup of Xenon-135.

If you accept my opinion (i.e. that the reactor shutdown at 10:13 am on October 21, 2003 was "inadvertent" and that the control room operators were unaware the reactor had shut down until the Channel 2 SRNI energized at 11:25 am) then the October 21, 2003 shutdown is another example (similar to the 1997 Zion event and the 2005 Surry event) of control room operators, who were tasked with maintaining a Westinghouse PWR critical in MODE 2 Descending, failing to recognize the reactor had gone subcritical. Although accepting my opinion (that the reactor shutdown was "inadvertent" and unnoticed) supports the basis for the five items requested in section §1.1, accepting Ameren's and Region IV's version of the October 21, 2003 shutdown provides an even stronger support for the basis.

Region IV has accepted the Shift Manager's assertion that, prior to giving the order to trip the turbine, he was aware that the reactor would shut down due to lack of steam demand. Region IV has investigated the October 21, 2003 shutdown and found that "*...the operator responses were not inconsistent with the procedures, the plant configuration, or their training.*" This equates to accepting the following (which are alluded to in the sworn testimonies of the US NRC licensed operators):

- The Shift Manager (along with the three other US NRC licensed reactor operators) allowed a 3565 MWth commercial reactor to passively shut down due to a combination of Xenon-135 buildup and lack of steam demand and took no action to actively drive the shutdown. Since the US NRC licensed reactor operators recognized that Xenon-135 was building up, they did not bother to actively insert negative reactivity for 110 minutes because they were busy doing other tasks, such as the 17 items logged in the two control room logs.
- Once 75 gpm letdown flow was restored at 10:18 am and the off-normal procedure for "Loss of Letdown" exited, the Reactor Operator (who holds a RO license issued by the US NRC) believed it was more important that he perform the normal operating

procedure to raise letdown flow to 120 gpm instead of actively controlling core reactivity by inserting the control banks.

- The Balance of Plant operator (who holds a RO license from the US NRC) believed he was too busy to insert the control banks because he had to secure an Intake pump and place Cooling Tower Blow Down in service.
- The Control Room Supervisor (who holds a SRO license from the US NRC) believed he was too busy to direct insertion of the control banks because he was still awaiting confirmation that a valve line up of some Auxiliary Feedwater valves, which was required for exiting the off-normal procedure for "Loss of Safety Related Instrument Power", was complete. (The "Loss of Safety Related Instrument Power had been entered at 8:21 am and all actions had been completed by 8:33 am with the exception of the valve line up which was being performed outside the control room by a non-licensed equipment operator).
- When the Source Range Nuclear Instruments energized at 11:25 and 11:38 am (more than an hour after the reactor had shut down) the US NRC licensed reactor operators still did not recognize that it was not prudent to continue to maintain the control rods at their critical rod heights.
- Following the exiting of the off-normal procedure for the "Loss of Safety Related Instrument Power", with reactor power in the source range and the control rods at their last critical rod heights, for ten to twelve minutes the Shift Manager and the crew discussed their response to the two off-normal procedures ("Loss of Letdown" and "Loss of Safety Related Instrument Power") and then briefed the remaining steps necessary to complete the reactor shutdown (even though they all knew the reactor had actually shut down over 90 minutes earlier and that all they were doing was inserting the control banks).

The "basis for the request" in item §1 is that the USNRC must make the actions which occurred in the control room at Callaway Plant "*inconsistent with the procedures*". That is, by changing the Tech Specs as requested in item §1, the USNRC will essentially prevent Westinghouse PWRs from having procedures which allow the operators to attempt to maintain MODE 2 Descending. The changes requested in section §1 will also place a time limit (15 minutes) on how long the reactor can be in MODE 3 without its control banks fully inserted.

Normally, the reactor is actively shut down by inserting the control banks. However, in the event the reactor passively shuts down, if the level of activity in the control room is so urgent that the operators believe they cannot insert the control banks within 15 minutes, then the reactor should be tripped.

In their investigation of the October 21, 2003 Incident at Callaway Plant, the US NRC noted the following:

1. *The NRC found that the crew's actions were not consistent with the conservative operating practices expected of control room operators.*
2. *The NRC identified no activities that were ongoing that prevented the operators from inserting the control rods...*
3. *...appropriate attention to reactivity management would have the operators insert the control rods well before the time they were actually inserted.*
4. *The inspectors found that not inserting the control rods soon after the reactor went sub-critical was not consistent with effective command and control and good plant operational awareness.*

5. *The NRC did not find that the implementation of either off-normal procedure prevented the control room operators from inserting the control rods at any time during the shutdown.*
6. *A review of the low power and shutdown procedures, the sequencing of activities, and the pre-evolution practice training did not provide the operators with the expected focus on reactivity management, including the impact of the plant configuration on transient initiators.*
7. *In summary, the NRC determined that operator actions on October 21, 2003, were not consistent with effective command and control and reactivity management practices encouraged by the NRC and the nuclear industry.*

In spite of the items noted above, the inspectors from Region IV had to concede that, allowing a 3565 MWth commercial reactor to passively shut down and then delaying 106 minutes before taking any action to actively ensure this large reactor remains shutdown, did not violate any of the plant's operating procedures or the plant's Final Safety Analysis Report (FSAR). The following were noted by the inspectors:

- *The inspectors verified that no procedural guidance existed with respect to timeliness as to how fast the control rods needed to be inserted.*
- *The inspectors determined that the operating crew's actions were consistent with the off normal, low power, and shutdown procedures.*
- *...the operator responses were not inconsistent with the procedures, the plant configuration or their training.*
- *...nor was there any inspection or investigatory evidence to imply that the operators acted outside their training and procedures to keep the control rods out after the plant was shutdown.*

When the incident occurred in October 2003, it went undocumented in the plant's Corrective Action program. When the significance of the incident was accidently uncovered (during an analysis of past reactor shutdowns to support a revision to the shutdown procedure) in February 2007, the Operations Department refused to have it investigated. Ameren, the utility which owns Callaway Plant, has yet to share the incident with the Institute of Nuclear Power Operations so that other nuclear plants might benefit from the "lessons learned". The October 21, 2003 shutdown at Callaway Plant demonstrates that nuclear utilities cannot be relied upon to always make conservative decisions with regard to reactor safety. In order to ensure utilities properly control core reactivity, the US NRC must provide, in their Technical Specifications, specific requirements for conservatively operating in MODE 2 Descending.

§2.4 MODE 2 Descending

§2.4.1 MODE 2 Ascending

The three examples above (Zion 1997, Callaway 2003, Surry 2005) all occurred during MODE 2 Descending which, as explained in the items below, is a very difficult environment to operate in. However, MODE 2 Ascending is quite different. Reactor plants successfully operate in MODE 2 Ascending all the time, particularly during the "start of cycle" control rod testing. During MODE 2 Ascending, transient Xenon-135 is typically non-existent. Decay heat is relatively steady and quite low and therefore does not challenge temperature-reactivity feedback. Evolutions at MODE 2 Ascending are usually planned well in advance allowing for adequate Pre-Evolution Practice (PrEP) and the development of accurate reactivity management plans.

Nothing in the requests made in section §1 should be construed as applying to MODE 2 Ascending. The requests in section §1 deal entirely with MODE 2 Descending. MODE 2 Ascending is a completely different affair than MODE 2 Descending and should not have the same restrictions placed upon it.

§2.4.2 The Point of Adding Heat (POAH) and Non-Fission Heat Rate (NFHR)

The Point of Adding Heat is typically taken to be the point at which the energy produced from nuclear fission starts to have a noticeable impact on the heat being generated by the primary plant.

The Non-Fission Heat Rate (NFHR) of a commercial PWR is the rate of heat production from sources other than nuclear fission. During the initial reactor startup following a refueling outage, the NFHR is dominated by the friction heat generated by the reactor coolant pumps (RCPs). RCP heat rate is typically around 1% rated reactor power for a 4 loop Westinghouse plant.

During MODE 2 Descending, the NFHR is dominated by decay heat. Decay heat varies with multiple factors which are defined as the "reactor power-history". The reactor power history is constantly changing with time. At a 4 loop Westinghouse plant, the NFHR during MODE 2 Descending is typically between 2% and 1% rated reactor power.

The POAH is intimately tied to the NFHR. Below the POAH, the thermal power output of the plant is the NFHR. So, as fission power lowers below the POAH, thermal power output of the reactor plant stays constant.

Many USNRC licensed operators do not understand the concept of the POAH. Statements in IN 97-62 imply that at Zion, the POAH was taken to be "0.025-percent" reactor power without recognition that this value could vary significantly based on power history. During the investigation of the October 21, 2003 Incident at Callaway Plant I encountered a Shift Manager (who is now the Operations Manager) who informed me the POAH was 1% power at Callaway Plant (which, although this is an excellent thumb rule for the NFHR during the startup of a fresh reactor core, was stated without any qualifier that it is only good for post-refueling start-ups). I encountered another Shift Manager who stated the POAH is 10^{-8} ion chamber amps (10^{-8} ica is actually used as the hold point for taking reactor physics data because it is below the POAH).

The figure at the end of this submittal (entitled "Departure of IRNI and ΔT upon approach to the POAH") displays the Intermediate Range Nuclear Instrument (IRNI) data and the primary calorimetric data (ΔT) from the October 21, 2003 inadvertent reactor shutdown at Callaway Plant. The core ΔT meter is a primary calorimetric which outputs in percent rated reactor power (the ΔT instruments measure the temperature rise across the core and multiply it by a scaling factor to produce a measure of the percent of rated reactor power which the reactor plant is producing). The IRNI measures the neutrons produced by nuclear fission. Thus the ΔT instruments provide a measure of total heat rate whereas the IRNIs provide a measure of fission heat rate.

Note in the figure that at about 10:23 am, the ΔT reading has asymptotically approached a steady level of 1.75% (corresponding to ~62 MWth). After 10:23 am, as the nuclear fission rate (i.e. IRNI ion chamber amps) lowers, the ΔT remains constant. This indicates the POAH was reached at about 10:23 am. At 10:23 am, the average IRNI reading was 2.1E-7 ica (corresponding to approximately 2.4 MWth). Thus, the POAH for this shutdown was 2.4 MWth and the NFHR was 62 MWth.

§2.4.3 Temperature-Reactivity Feedback

Westinghouse PWRs typically, but not always, have a negative Moderator Temperature Coefficient (MTC). For this section, it will be assumed the MTC is negative, as was the case during the Zion, Surry and Callaway incidents.

When a Westinghouse PWR has a negative MTC, its power level is inherently stable. When positive reactivity is added to the core (such as during a control rod withdrawal), the fission rate rises. The increased fission rate, in turn, causes the temperature to rise (assuming the fission rate is above the POAH). This temperature rise causes the reactor cooling water to become less dense and thereby allow more neutrons to "leak" from the active portion of the core. The increased neutron leakage results in a lowering of reactor power back to its steady state level.

Likewise, when negative reactivity is added to the core (such as during the build-up of Xenon-135), the fission rate lowers. Assuming the fission rate is above the POAH, the lower fission rate results in the reactor coolant temperature lowering. This temperature drop causes the reactor cooling water to become denser and thereby enabling it to moderate more neutrons. As more neutrons are moderated, neutron leakage is decreased and so more neutrons are available to cause fissions. This causes the fission rate to rise, returning the reactor to a steady state power.

Below the POAH, this natural Temperature-Reactivity feedback is non-existent. This is because below the POAH the heat rate from nuclear fission is negligible and, since there is no inherent feedback between Non-Fission Heat Rate and temperature, as reactor power lowers the total heat rate remains relatively unchanged. Since total heat rate remains constant, temperature does not "follow" (i.e. lower with) reactor power and there is thus no increase in the moderator density to "turn" reactor power. Therefore it is substantially more difficult for the reactor operators to maintain the reactor critical below the Point of Adding Heat.

The phenomenon in the above paragraph is well recognized and appreciated in the commercial nuclear industry. However, what is not always appreciated (and was not appreciated at Zion, Surry and Callaway) is that Temperature-Reactivity feedback is substantially degraded throughout MODE 2 Descending and not just at the POAH. Although 5% reactor power is well above the Point of Adding Heat, it is not "well" above the Non-Fission Heat Rate. For an aggressive shutdown rate (e.g. 10%/hour or greater) from 100% power, the NFHR when the plant is at 5% rated reactor power is typically more than 25% of the total power being produced (that is, for a 3565 MWth rated plant entering MODE 2 Descending, around 130 MWth is being generated from fission and 50 MWth is being generated from decay heat and pump heat). With such a relatively large fraction of total power independent of core reactivity (in particular, reactivity due to temperature effects) the inherent Temperature-Reactivity feedback is degraded. The problem gets substantially worse as total power is lowered closer to the NFHR.

There are paper work requirements which must be met in order to transition from MODE 2 back into MODE 1. For this reason, a reactor operator tasked with maintaining the reactor critical in MODE 2 Descending is not going to operate near 5% reactor power. Reactor operators tasked with maintaining the reactor critical in MODE 2 Descending will likely set themselves a band of 2% to 4% rated reactor power as read on the ΔT meters.

Consider a Westinghouse PWR operating in MODE 2 Descending at around 3% power with a NFHR of 1.5% rated reactor power and a fission heat rate of 1.5% rated reactor power. It is possible for a negative reactivity insertion to occur which lowers reactor power below the POAH before the degraded Temperature-Reactivity feedback has an opportunity to recover reactor power. When this occurs (and it occurred at Callaway Plant in 2003 and Surry in 2005) it is up to the operator to quickly recognize the lowering reactor power and to respond to the reactivity transient by either withdrawing control rods or diluting the boron concentration. This is not an activity that operators at commercial power plants are familiar with. Reactor operators at Westinghouse PWRs typically withdraw control rods and dilute boron in response to slow "temperature transients" and not in response to the significantly quicker "reactivity transient".

During MODE 2 Descending, reactor plant control rooms are busy places. During both the Surry and the Callaway incidents the reactor operators were distracted with an unexpected isolation of the letdown system. The on-shift supervisors for the Zion and Callaway incidents were distracted by the status of the work being performed on the out of service equipment which was requiring the plant shutdown. It is not unexpected that, with the level of distraction typically present in the control room of a reactor plant which is conducting abnormal maintenance and is operating at an unfamiliar power level, a reactor operator would occasionally not respond in time to a reactivity transient to avoid an inadvertent reactor shutdown. When this occurs, there is no safety significance provided the reactor operator recognizes the shutdown has occurred. However, as explained in item §2.4.4, it is possible to miss the inadvertent shutdown and assume the plant is still critical; this is what happened in 2005 at Surry.

§2.4.4 Masking of Fission Power Indications

Commercial nuclear plants typically operate at 100% power and spend only a slight fraction of their operating cycle in MODE 2. At 100% reactor power, the best indications of the core fission rate are the ΔT instruments and the Secondary Calorimetric computer point. There are also four channels of Power Range Nuclear Instruments (PRNIs). The reactor operators do not typically reference the INRIs in MODE 1 and MODE 2 Descending because they are scaled in ion chamber amps whereas the power limits (100% for MODE 1 and 5% for MODE 2) are given in percent of rated reactor power. However, when reactor power is near the Non-Fission Heat Rate, the IRNIs are the only accurate indication of the fission rate.

When operating near the NFHR, the ΔT instruments do not accurately indicate fission rate; the ΔT instruments indicate the total heat rate across the reactor core and therefore are biased at low power towards the NFHR. At Callaway Plant on October 21, 2003, when the actual fission power output of the reactor was 2.4 MWth (0.07% of rated reactor power), the ΔT instruments were indicating 1.75% power.

The Secondary Calorimetric computer point is designed to indicate the total thermal megawatts being produced by the reactor core. Since, in MODE 2 Descending, decay heat rate is a large part of the power output of the reactor core, the Secondary Calorimetric computer point is biased at low power towards the NFHR.

The PRNIs measure the radiation, both neutron and gamma, being emitted from the reactor core. They are scaled to translate this radiation measure into a reading of percent of rated reactor power. In MODE 2 Descending, a disproportionate amount of the radiation being emitted from the reactor core is coming from the gamma decay of fission product daughters (e.g. from the decay of the "nuclear waste" in the fuel). Since the "decay gammas" are indiscriminately detected along with the neutrons and "fission gammas", the PRNIs are biased at low power towards the NFHR.

As an analogy, imagine you are at a rest stop sitting in an idling car. Although the engine's RPM meter provides indication that the car is idling, it is not your primary indication. Your primary indication is that, as you read your map, you can feel the slight vibration of the engine and you can hear the engine noise. Now suppose a large diesel powered truck pulls up next to you and the vibration and noise caused by the truck's diesel is significantly greater than the vibration and noise of your own engine. Unless you are watching your RPM meter, if your engine stalls you might not notice it until you finish looking at your map and place your car in drive.

Reactor operators tasked with maintaining the reactor critical in MODE 2 Descending are in an unfamiliar setting. The level of distraction in the control room is typically much greater than normal. The instruments they normally monitor provide false indications of fission power. Their only accurate indication of fission power reads out in ion chamber amps on a logarithmic scale. They are using their primary tools (rods and boron) to respond to relatively quick reactivity transients instead of to slower temperature transients. The inherent stability of Temperature-Reactivity feedback is substantially degraded. And, to add to their problems, the plant is typically experiencing a Xenon-135 transient.

§2.4.5 Transient Xenon-135

Since the buildup and subsequent decay of Xenon-135 is dictated by many variables (primarily power history, but core age and axial offset can greatly complicate the response to Xenon-135) it provides a significant challenge to the operator. Plant procedures might address how to generically respond to Xenon-135, but since the specific levels of Xenon-135 which will be encountered in future shutdowns cannot be predicted when the procedure is being written, the procedure cannot provide anything better than generic guidance. Xenon-135 transients contributed to the Zion, Callaway and Surry incidents. Xenon-135 transients are usually most severe when the operator is most vulnerable – when the natural Temperature-reactivity feedback is degraded during MODE 2 Descending.

Xenon-135, by contrast, is easily handled in MODE 2 Ascending where Xenon is typically either decaying or essentially non-existent.

§2.4.6 Economic Drawback to Requested Action

It is my task in this 10CFR2.206 request to provide a basis for my request and not to argue against it. However, it should be recognized that preventing utilities from operating their reactors in MODE 2 Descending for more than 30 minutes could have potential economic drawbacks.

I believe any economic drawback from being forced to operate above 5% power during steam plant repairs is outweighed by the fact that the evolution is more likely to be successful if conducted with reactor power far enough above the Non-Fission Heat Rate that there is no degradation to the inherent reactor stability afforded by Temperature-Reactivity feedback.

§2.5 Summary

The Technical Specifications for Westinghouse PWRs should forbid entry into MODE 2 Descending for any reason other than to transition into MODE 3 within 30 minutes (with the only exception being planned special test procedures or surveillances). The bases for this request are:

1. There is no economic need for a commercial reactor plant to operate in MODE 2 Descending. MODE 2 Descending need only be normally entered to transition to MODE 3.
2. In MODE 2 Descending the inherent stability of the reactor plant is challenged due to Temperature-Reactivity feedback being degraded. This greatly challenges the reactor operators attempting to maintain the reactor critical.
3. In MODE 2 Descending the indications which the reactor operators normally monitor (ΔT channels, PRNI channels, Secondary Calorimetric computer point) do not accurately indicate the fission rate. The only indications which accurately report fission rate (the IRNI channels) are not "human factored" (they are logarithmically scaled and read out in ion chamber amps instead of "percent rated reactor power").
4. In MODE 2 Descending, significant Xenon-135 transients are typically present, which challenge the reactor operators in their attempts to maintain the reactor critical.
5. At least two significant events (Zion 1997 and Surry 2005) occurred during MODE 2 Descending characterized by reactor operators inadvertently returning a shutdown reactor core to criticality.
6. During the October 21, 2003 shutdown at Callaway Plant, the US NRC licensed reactor operators allowed the reactor to passively shut down through five decades of power without taking any action to actively drive the reactor shutdown. Then the US NRC licensed reactor operators performed non-emergent tasks for over 80 minutes with reactor power in the source range and the control rods at their last critical rod heights. Despite recognizing that "*...appropriate attention to reactivity management would have the operators insert the control rods well before the time they were actually inserted*", the Region IV inspectors had to also note that "*...the operator responses were not inconsistent with the procedures, the plant configuration, or their training.*" Taken as a whole, the US NRC's investigation of the October 21, 2003 shutdown at Callaway Plant concluded that, although it was inappropriate to take 106 minutes to insert the reactor control rods, the delay did not violate any US NRC regulations. One of my intents with this 10CFR2.206 request is to ensure that, in the future, inappropriately delaying the active control of a shutdown reactor is a violation of NRC regulations (i.e. the plant's Technical Specifications).

Departure of IRNI and ΔT upon approach to the POAH

Intermediate Range Nuclear Instrument (IRNI) and Primary Calorimetric (ΔT) Data from Callaway Plant on 10-21-2003