ATTACHMENT A

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket No. 50-352
PHILADELPHIA ELECTRIC COMPANY	)	(TS Iodine)
	)	
(Limerick Generating Station, Unit 1)	)	(ASLBP No. 87-550-03-LA)

AFFIDAVIT OF RICHARD J. CLARK, JR.,
IN RESPONSE TO THE LICENSING BOARD'S
QUESTIONS OF MARCH 17, 1988

I, Richard J. Clark, Jr., being duly sworn according to law, state as follows:

1. I am employed in the Office of Nuclear Reactor Regulation (NRR) of the Nuclear Regulatory Commission. I am presently the Licensing Project Manager for Philadelphia Electric Company's Limerick Generating Station Units 1 & 2. My professional qualifications and responsibilities were provided to the Licensing Board on February 18, 1988, in my affidavit that was attached to the NRC staff's "Response of NRC Staff in Support of Licensee's Motion for Summary Disposition" also dated February 18, 1988.

2. The purpose of this affidavit is to provide the information requested in the Licensing Board's Order of March 17, 1988. I have set forth below the Staff's response to questions 1 through 5. Because question 6 relates to facts set forth in the Licensee's affidavit, dated November 20, 1987, it is more appropriate that the Licensee respond to this question.

Question 1

Please define "iodine spike" as used in the proposed amendment.

Response

As I stated in item 12 of my affidavit of February 18, 1988, the NRC has been closely monitoring the performance of nuclear fuel. The information on all aspects of fuel performance, including iodine spiking, is summarized in a publicly available annual report (NUREG/CR-3950 series). The definition of iodine spiking, which is included at the beginning of this section each year, is stated below:

> Iodine spiking (i.e., a temporary increase in coolant iodine concentration) is frequently observed at reactors where leaking fuel rods are present. These temporary increases in iodine concentrations have been observed to occur following shutdowns, start-ups, rapid power changes, and coolant depressurizations. An iodine spike is characterized by a rapid increase in the iodine concentration in the coolant by as much as three orders of magnitude, followed by a return to prespike concentration. The latter characteristic distinguishes the spiking phenomenon from a step-wise permanent (i.e., until the failed fuel is removed from the core) increase in coolant activity level caused by the sudden failure of one or more fuel rods. (NUREG/CR-3602, Section 4.2.3. (1986)).

Note that the iodine spikes are temporary increases in coolant iodine concentration. The proposed amendment concerns reporting requirements on iodine spikes which exceed the Technical Specification limits.

Question 2

Based on the definition used in Question 1, how is the presence or absence of iodine spikes determined?

Response

As stated in item 14 of the Licensee's affidavit of November 23, 1987, the iodine concentration in the primary coolant is determined on a daily basis. These spikes have been observed only following a significant rapid change in reactor power levels-particularly sudden decreases in reactor power. Section 3/4.4.5 of the Limerick Technical Specifications, appended hereto as Attachment B, specifies the primary coolant specific activity sample and analysis program. This Technical Specification requires that if thermal power is changed by more than 15% of rated thermal power in 1 hour, then an isotopic analysis for iodine must be performed between 2 and 6 hours following the change in thermal power. This analysis would detect any iodine spike, if a spike were to occur. Also, if there were a significant iodine spike in the coolant, and carryover of iodine in the steam, the iodine would be detected by the main steam line radiation monitors.

Question-3

Are iodine spikes required to be reported to NRC? If so, describe the specific reporting requirements.

Response

The present Technical Specifications - which would not be changed by the proposed amendment - require the plant to shutdown if the primary coolant iodine activity exceeds 4 microcuries per gram or if the iodine activity exceeds 0.2 microcuries per gram for 48 hours. If an iodine spike would cause either of these limits to be exceeded, Commission regulations require notification of NRC within one hour [10 C.F.R. 50.72(b)(1)] and submission of a Licensing Event Report [10 C.F.R. 50.73(a)(2)]. As stated in item 18 of the Licensee's affidavit of November 23, 1987, the Licensee reports iodine spikes in excess of 0.2 microcurie per gram to state and local officials and to the NRC pursuant to the Station Emergency Plan. The present Technical Specifications also require 30 day and 92 day reports if the iodine activity exceeds 0.2 microcurie per gram for 48 hours or if this limit is exceeded for 500 hours in any consecutive 6 month period. These latter reporting requirements would be eliminated by the proposed amendment because they are duplicative of the recently revised regulations in 50.72 and 50.73 noted above.

Question 4

Volumes 1, 2 and 3 of NUREG/CR-3950 summarize fuel performance for the years 1983, 1984 and 1985. The fuel performance data for 1986 and later is not yet published. Assuming the data is available, have there been any incidents of iodine spiking (as defined in response to Question 1) at any BWR's in the United States since 1985? If so, identify the iodine spike as to Plant name and time of event.

Response

There have been no reportable incidents of iodine spiking in any BWR in 1986 or 1987. NUREG/CR-3950 Volume 4 covering fuel performance data for 1986 has been published; a copy of Section 4.2.3 on iodine spiking is enclosed as Attachment C. Note that the section leads off with the definition of iodine spiking provided in response to Question 1. The report on 1987 fuel performance is in preparation but the draft report will not be available before the end of 1988.

Question 5

Have there been any iodine spiking events at the Limerick Plant?

Response

There have been no reportable events of iodine spiking at Limerick.

Question 6

The Licensee's affidavit provides some information on iodine concentrations in the reactor coolant. There is some question as to the peak iodine concentration, subsequent to the first fuel cycle of operation. Please state the highest iodine concentration measured in the reactor coolant in any fuel cycle up to and including the current date (end of February 1988 would suffice). If the highest reading was in the first cycle, state the highest iodine concentration found in reactor coolant in any later cycles.

Response

The Licensee will respond to this question.

I hereby certify that the answers are true and correct to the best of my knowledge.

Richard J. Clark

Richard J. Clark, Jr.

Subscribed and sworn to before me
this 4th day of April, 1988

Malinda L. McDonald
Notary Public

My commission expires: 7/1/90

ATTACHMENT B.

3/4.4.5 SPECIFIC ACTIVITY

LIMITING CONDITION FOR OPERATION

3.4.5 The specific activity of the primary coolant shall be limited to:

a. Less than or equal to 0.2 microcurie per gram DOSE EQUIVALENT I-131, and

b. Less than or equal to $100/\bar{E}$ microcuries per gram.

APPLICABILITY: OPERATIONAL CONDITIONS 1, 2, 3, and 4.

ACTION:

a. In OPERATIONAL CONDITION 1, 2, or 3 with the specific activity of the primary coolant;

1. Greater than 0.2 microcurie per gram DOSE EQUIVALENT I-131 but less than or equal to 4 microcuries per gram, operation may continue for up to 48 hours provided that the cumulative operating time under these circumstances does not exceed 800 hours in any consecutive 12-month period. With the total cumulative operating time at a primary coolant specific activity greater than 0.2 microcurie per gram DOSE EQUIVALENT I-131 exceeding 500 hours in any consecutive 6-month period, prepare and submit a Special Report to the Commission pursuant to Specification 6.9.2 within 30 days indicating the number of hours of operation above this limit. The provisions of Specification 3.0.4 are not applicable.

2. Greater than 0.2 microcurie per gram DOSE EQUIVALENT I-131 for more than 48 hours during one continuous time interval or for more than 800 hours cumulative operating time in a consecutive 12-month period, or greater than 4 microcuries per gram, be in at least HOT SHUTDOWN with the main steam line isolation valves closed within 12 hours.

3. Greater than $100/\bar{E}$ microcuries per gram, be in at least HOT SHUTDOWN with the main steamline isolation valves closed within 12 hours.

b. In OPERATIONAL CONDITION 1, 2, 3, or 4, with the specific activity of the primary coolant greater than 0.2 microcurie per gram DOSE EQUIVALENT I-131 or greater than $100/\bar{E}$ microcuries per gram, perform the sampling and analysis requirements of Item 4.a) of Table 4.4.5-1 until the specific activity of the primary coolant is restored to within its limit. A Special Report shall be prepared and submitted to the Commission pursuant to Specification 6.9.2 within 30 days. This report shall contain the results of the specific activity analyses and the time duration when the specific activity of the coolant exceeded 0.2 microcurie per gram DOSE EQUIVALENT I-131 together with the following additional information.

LIMITING CONDITION FOR OPERATION (Continued)

ACTION: (Continued)

c. In OPERATIONAL CONDITION 1 or 2, with:

1. THERMAL POWER changed by more than 15% of RATED THERMAL POWER in 1 hour*, or
2. The off-gas level, at the SJAE, increased by more than 10,000 microcuries per second in 1 hour during steady-state operation at release rates less than 75,000 microcuries per second, or
3. The off-gas level, at the SJAE, increased by more than 15% in 1 hour during steady-state operation at release rates greater than 75,000 microcuries per second,

perform the sampling and analysis requirements of Item 4.b) of Table 4.4.5-1 until the specific activity of the primary coolant is restored to within its limit. Prepare and submit to the Commission a Special Report pursuant to Specification 6.9.2 at least once per 92 days containing the results of the specific activity analysis together with the below additional information for each occurrence.

Additional Information

1. Reactor power history starting 48 hours prior to:
   a) The first sample in which the limit was exceeded, and/or
   b) The THERMAL POWER or off-gas level change.
2. Fuel burnup by core region.
3. Clean-up flow history starting 48 hours prior to:
   a) The first sample in which the limit was exceeded, and/or
   b) The THERMAL POWER or off-gas level change.
4. Off-gas level starting 48 hours prior to:
   a) The first sample in which the limit was exceeded, and/or
   b) The THERMAL POWER or off-gas level change.

SURVEILLANCE REQUIREMENTS

4.4.5 The specific activity of the reactor coolant shall be demonstrated to be within the limits by performance of the sampling and analysis program of Table 4.4.5-1.

*Not applicable during the startup test program.

TABLE 4.4.5-1

PRIMARY COOLANT SPECIFIC ACTIVITY SAMPLE AND ANALYSIS PROGRAM

TYPE OF MEASUREMENT AND ANALYSIS	SAMPLE AND ANALYSIS FREQUENCY	OPERATIONAL CONDITIONS IN WHICH SAMPLE AND ANALYSIS IS REQUIRED
1. Gross Beta and Gamma Activity Determination	At least once per 72 hours	1, 2, 3
2. Isotopic Analysis for DOSE EQUIVALENT I-1 131 Concentration	At least once per 31 days	1
3. Radiochemical for $\bar{E}$ Determination	At least once per 6 months*	1
4. Isotopic Analysis for Iodine	a) At least once per 4 hours, whenever the specific activity exceeds a limit, as required by ACTION b.	1**, 2**, 3**, 4**
	b) At least one sample, between 2 and 6 hours following the change in THERMAL POWER or off-gas level, as required by ACTION c.	1, 2
5. Isotopic Analysis of an Off-gas Sample Including Quantitative Measurements for at least Xe-133, Xe-135, and Kr-88	At least once per 31 days	1

*Sample to be taken after a minimum of 2 EFPD and 20 days of POWER OPERATION have elapsed since reactor was last subcritical for 48 hours or longer.

**Until the specific activity of the primary coolant system is restored to within its limits.

Attachment C

NUREG/CR-3950
PNL-5210
Vol. 4

Fuel Performance Annual Report for 1986

Prepared by W. J. Bailey/PNL
S. Wu/NRC

Pacific Northwest Laboratory
Operated by
Battelle Memorial Institute

Prepared for
U.S. Nuclear Regulatory
Commission

1.0 INTRODUCTION

Monitoring the in-reactor performance of nuclear fuel in commercial light-water power reactors yields important feedback for safety considerations and licensing procedures. Information on fuel performance through 1974 was provided in two reports (Refs. 1 and 2). Subsequently, members of the public, governing and advisory bodies, and the U.S. Nuclear Regulatory Commission (NRC) staff expressed interest in a publicly available summary of in-reactor fuel performance. As a result, a series of annual reports, of which this is the ninth, was implemented to provide such a summary. The preceding annual reports are listed below:

Report Number	Reference Number	Year Reported On
NUREG-0633	3	1978
NUREG/CR-1818 (PNL-3583)	4	1979
NUREG/CR-2410 (PNL-3953)	5	1980
NUREG/CR-3001 (PNL-4342)	6	1981
NUREG/CR-3602 (PNL-4817)	7	1982
NUREG/CR-3950 (PNL-5210) Vol. 1	8	1983
NUREG/CR-3950 (PNL-5210) Vol. 2	9	1984
NUREG/CR-3950 (PNL-5210) Vol. 3	10	1985

As noted in the first report (Ref. 3) of this annual series, the U.S. Atomic Energy Commission (AEC) and later the NRC have requested operating nuclear reactor fuel performance details through the reporting requirements of Regulatory Guide 1.16. However, over the years the material covered in these reports has changed. The 1971 version of the guide requested that a summary of fuel performance characteristics be included in semiannual operating reports and that special topical reports be used for fuel inspection details. By 1975 however, only abnormal degradation of fuel cladding and an indication of failed fuel were reportable items.[a] Reporting requirements were further reduced in 1977: only abnormal degradation of fuel cladding was to be included and the requirement for an annual operating report was eliminated.

In May 1982, the NRC proposed amending its regulations to improve the information received in Licensee Event Reports (LERs) from nuclear power plant licensees (Refs. 13-17) The new regulation became effective on January 1, 1984, and Paragraph 50.73(a)(2)(ii) of the new LER rule requires events to be reported where the plant, including its principal safety barriers (i.e., fuel cladding, reactor coolant system boundary, or the containment), was seriously degraded or was in an unanalyzed condition. Examples of situations addressed by this paragraph are "fuel cladding failures in the reactor or the storage pool that exceed expected values, that are unique or widespread, or that resulted from unexpected factors." Normal operation surveillance results, generic problems, and design trends are not addressed in the NUREG series of reports entitled "Nuclear Power Plant Operating Experience" (Refs. 18-24). Results of plant operating experience are also screened by the Electric Power Research Institute (Refs. 25-27).

As a result, the primary intent of this report series is to summarize fuel design changes, fuel surveillance programs, fuel operating experience, fuel system problems (especially generic ones) that are of concern during the reporting period, high-burnup fuel experience, and items of general significance. The reports contain extensive reference lists so the reader can acquire a greater level of detail on the topics than is included in the annual summary.

This report, though focusing on fuel operating experience during calendar year 1986, includes some overlap with the previous year. For those problems first encountered prior to 1986, some pre-1986 information will be included for the sake of continuity. In addition, information received or action taken in early 1987 will be included if pertinent to the discussion of problem areas.

(a) A two-volume report (Ref. 11) published in 1980/1981, elaborates on the reporting of abnormal degradation and fuel failures. The threshold for what constitutes abnormal degradation is not uniform throughout the industry. Therefore, the degree of degradation reported has not been uniform. The definition of failed fuel is tied to the functional, legal, and detection requirements on the fuel. The designation of fuel as failed depends on which functional requirement is not met (safety, commercial, or design), whether or not there is a legal contingency on that requirement (technical specification, fuel warranty, or design basis), and which indicator is used (coolant or off-gas activity, sipping, strain, or deflection). Thus, the definition can vary as these considerations change. Definitions of fuel damage, failure, and coolability, as these terms are applied in the NRC's review of fuel system designs, are provided in Section 4.2, Fuel System Design, of the NRC's Standard Review Plan (Ref. 12).

This 1986 annual report contains the following information: fuel surveillance requirements (Section 2.0), fuel design changes and summary of fuel surveillance programs (Section 3.0), fuel operating experience (Section 4.0), problem areas observed during 1986 (Section 5.0, which is in Appendix B because of the amount of detailed information included), summary of high-burnup fuel experience (Section 6.0), items of general significance (Section 7.0), references (Section 8.0), historical background on fuel reliability (Appendix A), and defective fuel currently in storage (Appendix C).

detected in 1983. At least 31 of the >134 fuel assemblies were found in 1984. Fuel rod failures due to debris-induced fretting were noted at three domestic plants in 1986. Metallic debris has also infrequently caused rod cluster control assembly malfunctions and charging pump seizures.

Three foreign plants have also had fuel rod failures caused by this mechanism. Those plants are Almaraz-1 and Korea Nuclear-1 and -5 (Ko-Ri). In 1984, Korea Nuclear-1 had rod failures in one assembly. Almaraz-1 had two failed assemblies in 1985 (Refs. 138 and 167). Korea Nuclear-5 (Ko-Ri) had six failed assemblies in 1986 (Ref. 126).

Information received or published by the NRC in 1986 on fuel rod failures due to debris in primary coolant systems is provided in Section 5.1.1 (see Appendix B).

4.2.3 Iodine Spiking

Iodine spiking (i.e., a temporary increase in coolant iodine concentration) is frequently observed at reactors where leaking fuel rods are present. These temporary increases in iodine concentrations have been observed to occur following shutdowns, start-ups, rapid power changes, and coolant depressurizations. An iodine spike is characterized by a rapid increase in the iodine concentration in the coolant by as much as three orders of magnitude (Ref. 176), followed by a return to prespike concentration. The latter characteristic distinguishes the spiking phenomenon from a step-wise permanent (i.e., until the failed fuel is removed from the core) increase in coolant activity level caused by the sudden failure of one or more fuel rods (Ref. 176). Iodine spiking is discussed in two EPRI reports (Refs. 177 and 178) that were published in 1986. In the latter report, it is stated that a preliminary analysis of coolant and off-gas activity data indicates that the normalized iodine-131 levels generally ranged from 5×10^{-4} to 2×10^{-3} μCi/ml per failed rod.

The NRC has developed Standard Technical Specifications (Table 18) for primary coolant iodine concentrations that make allowance for iodine spikes by permitting temporary excursions (not to exceed 48 hours) above the "equilibrium" concentration limit. For each excursion above the equilibrium limit, a Licensee Event Report is required. Some BWRs (e.g. Brunswick-1 and -2, Hatch-2, La Crosse) and approximately one-half of the operating PWRs have this type of technical specification. It is important to note in Table 18 that there are differences in reporting requirements: some BWRs have allowable limits on coolant activity that are substantially higher than those for many of the PWRs.

Since 1982-1983, the number of iodine spiking or radioactive gas release events has decreased each year and fewer plants are involved, as shown in Table 19. Information on the four plants that reported iodine spiking in 1986 is shown in Table 20. All plants that reported iodine spiking or radioactive gas release events during the period 1980-1986 are listed in Table 21. Details for the 1986 events at those plants are provided in Section 5.1.2 (see Appendix B).

4.2.4 PWR Fuel Assemblies Damaged by Baffle Jetting

Fuel rod damage or failure due to baffle jetting was first noted in 1973 in domestic PWRs and in 1971 at a foreign PWR. As shown in Table 22, degradation of fuel assemblies by this mechanism has occurred in 9 of the past 13 years at domestic plants (a total of 8 domestic plants have been involved).

Similar fuel failures due to baffle jetting have also been observed at foreign PWRs, including Goesgen, Jose de' Cabrera, Korea Nuclear-1 (Ko-Ri),

TABLE 19. Iodine Spiking or Radioactive Gas Release Events at Domestic Plants

Year	No. of Plants	Total No. of Events
1986	4	8
1985	4	11
1984	3	16
1983	10	36
1982	12	>36
1981	12	>18
1980	5	>5

TABLE 20. Data for the Five Plants that had Iodine Spiking Events in 1986

	No. of Events						
Plants	1980	1981	1982	1983	1984	1985	1986
Crystal River-3	(a)	(a)					1
Hatch-2							(b)
San Onofre-2							1
San Onofre-3				3	10	5	1
Surry-1		7	13	3	4	3	4
Trojan		(a)					1

(a) Information being checked.
(b) Plant has been run at 85% power since January 1986 to decrease off-gas activity caused by leaking fuel (Refs. 184 and 185).

TABLE 21. Iodine Spiking or Radioactive Gas Release Events

Reactor	Reactor Type		Nuclear Steam System Supplier (NSSS)[a]					Iodine Spiking or Radioactive Gas Release (No. of Events)						
	BWR	PWR	AC	B&W	C-E	GE	W	1980	1981	1982	1983	1984	1985	1986
Arkansas-1		●		●					X					
Arkansas-2		●			●			X	X					
Big Rock Point	●					●						X[b]		
Brunswick-2	●					●		X	X	X				
Calvert Cliffs-1		●			●					X				
Calvert Cliffs-2		●			●						X(3)			
Catawba-1		●					●						X(1)	
Cook-1		●					●						X(2)	
Cook-2		●					●		X	X				
Crystal River-3		●		●				X	X					X(1)
Davis Besse-1		●		●				X	X	X	X(5)			
Farley-1		●					●			X				
Ft. Calhoun-1		●			●							X(1)		
Ginna		●					●				X(1)			
Hatch-2	●					●				X				(c)
La Crosse	●		●						X					
Millstone-2		●			●					X(3)	X(2)			
North Anna-1		●					●		X	X(4)	X(7)			
Palisades		●			●				X	X(2)	X(1)			
Prairie Island-1		●					●			X				
Prairie Island-2		●					●				X(3)			
San Onofre-2														X(1)
San Onofre-3		●			●						X(3)	X(10)	X(5)	X(1)
St. Lucie-1		●			●			X	X	X(6)	X(2)			
Surry-1		●					●		X(7)	X(13)	X(3)	X(4)	X(3)	X(4)
Surry-2		●					●			X				
Trojan		●					●		X					
Yankee Rowe		●					●		X					X(1)
			No. of Reactors:					5	12	12	10	4	4	4

(a) Allis-Chalmers (AC), Babcock & Wilcox (B&W), Combustion Engineering (C-E), General Electric (GE), and Westinghouse (W).
(b) Plant output voluntarily restricted because of high off-gas release rate (however, it is only about 5% of Technical Specification limit).
(c) Plant has been run at 85% power since January 1986 to decrease off-gas activity caused by leaking fuel (Refs. 184 and 185).

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USNRC

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

In the Matter of	)	
	)	
PHILADELPHIA ELECTRIC COMPANY	)	Docket No. 50-352-OLA
	)	(TS Iodine)
(Limerick Generating Station,	)	
Unit 1)	)	(ASLBP No. 87-550-03-LA)

CERTIFICATE OF SERVICE

I hereby certify that copies of "RESPONSE OF NRC STAFF TO BOARD ORDER DATED MARCH 17, 1988, REQUESTING CLARIFYING INFORMATION" and "AFFIDAVIT OF RICHARD J. CLARK, JR., IN RESPONSE TO THE LICENSING BOARD'S QUESTIONS OF MARCH 17, 1988" in the above-captioned proceeding have been served on the following by deposit in the United States mail, first class, or as indicated by an asterisk through deposit in the Nuclear Regulatory Commission's internal mail system, this 4th day of April, 1988:

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Administrative Judge
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555*

Dr. George A. Ferguson
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