NRC Form 366 (9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/85

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Palisades Plant	0 5 0 0 0 2 5 5	1 OF 0 5

TITLE (4) DEGRADATION OF BORAFLEX NEUTRON ABSORBER IN SURVEILLANCE COUPONS - SUPPLEMENTAL REPORT

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
0 8	1 7	9 3	9 3	- 0 0 7 -	0 1	1 1	0 8	9 3	N/A	0 5 0 0 0
									N/A	0 5 0 0 0

OPERATING MODE (9): N

POWER LEVEL (10):

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check one or more of the following)* (11)

20.402(b)	20.405(c)	50.73(a)(2)(iv)	73.71(b)
20.405(a)(1)(i)	50.36(c)(1)	50.73(a)(2)(v)	73.71(c)
20.405(a)(1)(ii)	50.36(c)(2)	50.73(a)(2)(vii)	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
20.405(a)(1)(iii)	50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	
20.405(a)(1)(iv)	X 50.73(a)(2)(ii)	50.73(a)(2)(viii)(B)	
20.405(a)(1)(v)	50.73(a)(2)(iii)	50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER	
	AREA CODE	
Cris T. Hillman	6 1 6	7 6 4 - 8 9 1 3

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)

		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES *(If yes, complete EXPECTED SUBMISSION DATE)*	X NO				

ABSTRACT *(Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines)* (16)

On August 17, 1993 the plant was in cold shutdown for refueling. A Boraflex surveillance coupon was removed from the spent fuel pool in order to conduct a visual inspection, neutron attenuation test and a hardness test. While removing the coupon from the spent fuel pool, a dark debris cloud was observed in the spent fuel pool around the edges of the coupon. Upon removal of the sheet metal coupon cover, the Boraflex material was found to be approximately 90 percent disintegrated or missing. Additional coupons were removed from the spent fuel pool and examined; varying amounts of Boraflex material were found missing.

The cause of this event is unknown.

Corrective action will include performing blackness testing on the spent fuel pool racks.

EVENT DESCRIPTION

On August 17, 1993 the plant was in cold shutdown for refueling. A Boraflex surveillance coupon was removed from the spent fuel pool [DB] in order to conduct a visual inspection, neutron attenuation test and a hardness test. Boraflex is the trade name of a boron impregnated, polymer-based sheet material that is utilized as a neutron absorber in the construction of spent fuel pool (SFP) storage racks [DB;RK]. The material was manufactured by Brand Industrial Services, Inc. The use of the Boraflex allows minimal center to center cell spacing in the SFP storage racks. The Boraflex is sandwiched between two strips of stainless steel sheet metal (refer to Figure 1 in Attachment 1).

While removing the coupon from the spent fuel pool, a dark debris cloud was observed in the spent fuel pool around the edges of the coupon. Upon removal of the sheet metal coupon cover, the Boraflex material was found to be approximately 90 percent disintegrated or missing. Five additional coupons were removed from the spent fuel pool and examined; varying amounts of Boraflex material was found missing.

Boraflex surveillance coupons are not part of the SFP storage racks, but rather are placed in the SFP to be examined and tested periodically to judge the condition of the Boraflex in the SFP storage racks. The first coupon removed on August 17 was being tested to fulfill a five year surveillance interval commitment made to the NRC. In a similar manner to that in the surveillance coupons, the Boraflex in the spent fuel pool storage racks is contained in a stainless steel wrapper. The wrapper assembly is then attached to the walls of the storage cells of the storage racks.

There are two types of coupons at Palisades (refer to Figure 1): Full length coupons and short set coupons. Some full length coupons have the Boraflex bonded to one side of their sheet metal wrapper; in others, the Boraflex is not bonded. Four of the five coupons removed for testing were full length coupons and the other was a short set coupon. Three of the full length coupons had Boraflex bonded to the sheet metal. Material lost from the full length coupons varied from 38 percent to an estimated 90 percent. All of the Boraflex material in the short set coupon was retained. The Boraflex material in the full set coupons was from a different batch of material than that used in the short set coupons.

Neutron attenuation testing performed on the Boraflex material remaining in the surveillance coupons showed no loss of boron areal density, within measurement tolerances, from the original condition. There was no thinning of the remaining material.

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CAUSE OF THE EVENT

The cause of the event is unknown at this time. Known contributors to the degradation of Boraflex are:

1. Neutron flux which leads to depletion of impregnated boron.
2. Gamma flux which causes changes in the material characteristics of the base polymer resulting in hardening and embrittlement.
3. Chemical exposure of the boric acid environment in the SFP may lead to deterioration or erosion.

ANALYSIS OF THE EVENT

An analysis of the present spent fuel pool storage configuration was completed to ensure there was no possibility of a criticality occurring in the spent fuel pool under worst case conditions. The analysis conservatively assumed there was no Boraflex present in the storage racks and no boron in the spent fuel pool water.

Further analysis by the manufacturer of the spent fuel pool storage racks, Westinghouse, has been completed. The Westinghouse results, and the results of in-house analyses are provided in Attachment 1, the interim results of the Palisades Boraflex Program.

Westinghouse was contracted to determine whether the licensing design basis requirement of a 5 percent shutdown margin was being met, assuming no Boraflex remained in the storage racks and no boron existed in the spent fuel pool water. A burnup versus enrichment curve provided in the analysis reported that the fresh fuel enrichment equivalency requirement for spent fuel stored in the SFP racks containing Boraflex had dropped from the technical specification value of 1.5 to 1.0 weight percent. Some assemblies that were in Region II racks did not meet this lower enrichment equivalency.

Using the results of the Westinghouse analysis, a CASMO-3 based analysis was completed to identify the highest reactivity assemblies in Region II. As a result, the 23 most reactive assemblies were moved from the Region II racks and replaced with assemblies which met the new burnup versus enrichment curve. Westinghouse then completed a KENO-Va based calculation considering the most reactive assembly after the 23 spent fuel assemblies had been removed. The calculation showed K_{eff} to be below 0.95 (0.947 including uncertainties) with no credit taken for Boraflex or soluble boron.

Following the relocation of the 23 most reactive fuel assemblies and the completion of the KENO-Va analysis, an additional CASMO-3 based analysis was performed. Reactivity equivalencing using CASMO-3 shows that all fuel assemblies currently located in the Region II racks have a reactivity less than or equal to the assembly considered in the KENO-Va analysis.

Until the results of blackness testing on the SFP racks are known, no fuel assemblies will be moved into the Region II racks unless they either meet the new burnup versus enrichment curve with no Boraflex or are shown by reactivity equivalencing to be less reactive than the most reactive assembly considered by in the KENO-Va calculation.

Based on the results of these analyses, the temporary requirement for daily sampling and analysis of SFP Boron has been discontinued. Prior to discontinuing the daily sampling and analysis, the action was discussed with the Palisades NRC Senior Resident Inspector.

Safety Significance

Subcriticality in the spent fuel pool, at greater than 5 percent, is assured by the presence of over 1720 ppm of boron in the water. The licensing design basis assumes a 5 percent subcriticality margin with no boron in the pool water and a minimum storage rack spacing. Based on the results of these analyses, assuming no Boraflex remained in the storage racks and no boron existed in the spent fuel pool water and the present configuration of spent fuel in the Region II storage racks, the greater than 5 percent subcriticality margin licensing design basis is being met.

CORRECTIVE ACTION

Corrective action for this event includes:

1. Notifying the operating staff of the possible deteriorated condition of the Boraflex and making them aware not to dilute the spent fuel pool boron concentration below the plant administrative limit of 1800 ppm.

2. Corrective action to perform daily sampling and analysis of the spent fuel pool boron concentration was performed until the analyses described in Attachment 1 were completed.

3. Analyses to determine subcriticality in the spent fuel pool have been completed and are described in Attachment 1.

4. Determining the condition of the Boraflex neutron absorber material in the spent fuel pool storage racks. This activity is expected to occur following the loading of additional spent fuel storage casks in 1994.

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(9-83)

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LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

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ADDITIONAL INFORMATION

Refer to NRC Information Notice 93-70: "Degradation of Boraflex Neutron Absorber Coupons."

A detailed description of our analyses and results are provided in Attachment 1 to this LER.

Palisades Boraflex™ Program

Background

Boraflex™ is a boron impregnated, polymer-based sheet material. This material was utilized as a neutron absorber in the construction of the Palisades Region II SFP racks to allow for smaller center-to-center cell spacing. Industry experience and testing has raised long-term concerns with the durability of Boraflex™ when utilized for this particular application. To quantify and evaluate any degradation, an action item, AIR A-NL 92-225, was initiated to track actions associated with our NRC commitment PW081688A.This commitment required placement of Boraflex™ surveillance coupons (see figure 1) for ease of material testing. Below is an outline of the steps to be taken to address this commitment.

Current Coupon Status

A total of 12 Boraflex™ coupons were available in one of the following three locations:

1. Store room - replacement coupons of original condition.

2. SFP long term - coupons placed between SFP racks containing assemblies with > 1 year decay time prior to placement in Region II racks.

3. SFP accelerated - coupons placed between SFP racks containing assemblies which were placed in Region II (credit for burnup region) shortly after discharge from core (1 to 2 months).

Additionally, the coupons are one of the following three types:

1. Short coupon set - full-length specimen holder with a total of 24 1" x 4.5" placed in 8 rows of 3 each equally spaced along the length of the specimen holder.

2. Full length bonded - full length specimen holder with a 6" x 128" Boraflex™ sample bonded to the specimen holder in a manner consistent with that used to manufacture the Region II rack cells.

3. Full length unbonded - identical to above except that Boraflex™ sample was not bonded to specimen holder.

At least one of each type of coupon is in each of the three sample locations. A total of five coupons have been removed for testing.

Degradation Mechanisms

Three prime contributors(1) to the degradation of Boraflex™ are:

1. Neutron flux - leads to depletion of impregnated boron.

2. Gamma flux - leads to changes in the material characteristics of the base polymer. Primary concern is hardening/embrittlement.

3. Chemical exposure - boric acid environment of SFP may lead to Boraflex™ edge deterioration/erosion.

Scope of Testing

In order to adequately evaluate the Boraflex™ coupons for known modes of degradation, the following testing program was implemented:

1. Visual inspection upon removal with emphasis on the following:

   - Length, width and thickness measurements
   - Discoloration
   - Cracking
   - Flexibility
   - Edge deterioration
   - Erosion

2. Neutron attenuation

   - Determination of actual B^{10} concentration per square cm.

3. Material hardness

   - Informational testing.

Evaluation Method

To adequately assess the performance of Boraflex, relative to assumptions made in the Region II SFP rack criticality analysis, two parameters are of key interest:

1. Boron areal density
2. Physical size and condition

(1)An Assessment of Boraflex Performance in Spent Nuclear Fuel Storage Racks
EPRI NP-6159
December 1988

In order to gain representative samples, covering a range of gamma exposures, a total of five Surveillance coupons were removed. These represent different bonding techniques as well. Specific type and placement information is shown in Figure 2.

Method of Testing

Boraflex™ surveillance coupons were removed from the SFP on 8-17-93 and 8-19-93. Figure 2 maps the particular coupons removed. During coupon removal, a dark, cloudy material was seen spilling from the sides and bottom of the full length coupons. The severity of this cloudiness appears to be directly proportional to the amount of Boraflex™ material missing from the individual coupons.

Initial visual inspections were conducted for the full length coupons. These inspections were performed following coupon removal and prior to coupon shipment. Anomalies are noted in Table 1, Visual Results column.

Physical size of the Boraflex coupons was determined by measuring the remaining portion of the Boraflex material and comparing to the original dimensions for a percentage of material lost. This was performed at University of Michigans' Ford Reactor facility by CPCo personnel. Results are presented in Table 1.

Shore A hardness testing was performed on coupon 7705G. A variety of locations were tested again by CPCo personnel. Results are presented in Table 1.

Boron areal density was calculated from neutron attenuation data obtained by University of Michigan personnel. U of M procedure NRC-007 Revision 3 was utilized. For the full length coupons, a total of seven neutron attenuation measurements were taken for each coupon. These were performed at approximately 16" intervals along the length of each coupon. For the short set, a total of 16 measurements were taken, two at each of the eight sample locations. Average B^{10} density, of remaining material, is presented in Table 1. Actual attenuation and corresponding B^{10} density is presented in Table 2, along with the corresponding material thickness, as this information was utilized in the boron areal density calculation.

Lastly, to quantify the cumulative gamma dose received by each coupon, a Northeast Technology Corporation, Lotus 1-2-3 template was utilized. Specifics of input data are detailed in engineering analysis **EA-BWB-93-01**. Resulting gamma exposures are also presented in Table 1.

Potential Implications

Based on the significant degradation of the surveillance coupons, the integrity of the actual rack Boraflex™ should be considered as suspect until such time as rack blackness testing can be performed. This inference is contradictory to industry experience related to Boraflex™ degradation but represents a conservative approach. Also in favor of normal rack Boraflex™ degradation, is the SFP silica level. Although a spike was noted earlier in the year, most likely due to recycled boric acid additions to support MSB (Multi-Assembly Storage Basket) loading, silica levels are in the range of 1 to 4 ppm (Refer to SFP Boron/Silica graph). This is somewhat elevated but within the range of other plants also utilizing Boraflex™ type racks (Refer to Table 4). Additionally, the short set coupons showed almost no degradation whatsoever, beyond the anticipated embrittlement. Of the Boraflex™ which remained in the full length coupons, no thinning or loss of boron areal density was noted. These factors tend to suggest that it is likely that the rack Boraflex™ is still reasonably intact.

Potential Contributing Factors

Several factors which could contribute to the accelerated degradation of Boraflex™ have been considered. Chemical reaction of the SFP water with the Boraflex™ was explored from the following perspectives:

1. pH of the SFP water
2. Relatively high SFP boron concentration
3. A past, inadvertent hydrazine addition to the SFP

These factors were discussed with Boraflex™ experts within the industry. The SFP pH typically ranges from approximately 4.8 to 5.2. Occasional spikes to near 7.0 have occurred. Due to MSB loading activities, SFP boron levels have been relatively high, in the range of 2900 ppm, at times. Lastly, one inadvertent hydrazine addition to the SFP did occur, albeit some time ago. None of these factors were considered to have a significant, adverse impact on the condition of Boraflex™.

Another factor, which relates to our inability to correlate coupon data to rack performance as well, is the varying heat code and base material lot numbers associated with the actual manufacture of the Boraflex™ sheet material. As shown in Table 3, three different heat codes were utilized in the manufacture of the rack and short coupon set Boraflex™, while only one heat code, but two different lots of base material, were used in the manufacture of Boraflex™ for the full length coupons. While this could be construed as significant, it is also necessary to consider that these lots were all manufactured in accordance with a certified QA program. As well, the composition and production of Boraflex™ is relatively simple and well within the realm of modern manufacturing techniques. Relative consistency among varying batches can reasonably be relied upon. This leads to concluding that a manufacturing defect causing the gross degradation appears unlikely.

Mechanical construction differences do exist between the SFP racks and the surveillance coupons. The racks were constructed by folding a 75 mil thick, 36" wide and approximately 146" long sheet of stainless steel into a 9" square box. The resulting seam was then welded. To each side of this box, a sheet of Boraflex™ was laid. Over this sheet, a 20 mil thick, 8" wide and approximately 146" long sheet of stainless steel, stamped to form a 42 mil recess approximately the width and length of the Boraflex™ sheet, was laid and then tack welded in place along the sides. Spots of RTV were used to hold the Boraflex™ in place during this process. This was repeated for each of the four sides of the box. Series of these boxes were then arranged in a checkerboard fashion and welded again at the corners to form a rack. Open cells at the periphery were closed by a single sheet of 75 mil stainless steel with a Boraflex™ sheet enclosed in a similar manner(Refer to Figure 3).

Full length coupon construction is similar, however, two sheets of 20 mil stainless steel were utilized for closure. As well, the seams were closed via bolting. At the time of coupon construction, it was believed that this would approximate the rack conditions while allowing for inspection of the Boraflex™ without the use of destructive opening methods. The short sets were likewise fabricated except that only one full length sheet of stainless steel was utilized. The groupings of three coupon strips were enclosed by a second 20 mil thick stainless steel sheet approximately 8" square. Each of these squares was bolted down using 8 fasteners. This is significant in that it appears, from visual inspections, as though a water-tight seal was formed around the short set coupon.

During removal of the full length coupons, a cloudy material was seen flowing from the sides and bottom of the coupon. This suggests that water was able to pass through the seams of the coupons. The composition of irradiated Boraflex™ does reduce to mainly silica and boron carbide with time, silica being the primary binding agent as most of the polymer deteriorates. This water exchange through the coupon interior could easily carry away varying amounts of silica, depending on the rate of water exchange. Once the binding agents have been reduced, rapid degradation of the structure of the Boraflex™ logically follows. This is a possibility agreed upon by experts in the industry.

Due to the construction differences, the full length coupons are far more flimsy than the SFP racks. A rigid base is simply not afforded. This likely resulted in more "open" seams on the full length coupons, allowing for a higher than normal water exchange rate. This cannot be conclusively shown, however, until a determination of the actual rack Boraflex™ condition is made. For this, blackness testing is required.

Compensatory Actions

A conservative interpretation to the surveillance coupon data disallows Palisades to take credit for the Boraflex poison in SFP Region II. A CASMO-3 based analysis was completed determining the k_∞ of the Region II racks when considered completely filled with the most reactive fuel in the racks at that time. The results are provided in engineering analysis **EA-RDR-93-06** and show a $k_\infty \leq 0.9855$ with no Boraflex and 0.0 ppm Boron in the pool water. Since CASMO-3 has not been accepted as a criticality code and the result did not show compliance to design basis commitment of $k_{eff} \leq 0.95$ Westinghouse, the rack manufacturer, was contracted to do a separate analysis. Daily SFP Boron sampling was begun to give sufficient notice of any dilution trends assuring a safe configuration under all credible situations. Westinghouse delivered a conservative Burnup vs. Enrichment curve to ensure a k_{eff} below ANSI Standard 0.95. The reported fresh fuel enrichment equivalency dropped from the Tech. Spec. value of 1.5 to 1.0 w/o. Many assemblies presently in Region II racks did not meet this lower enrichment equivalency.

At this point another CASMO-3 based analysis was completed showing the highest reactivity assemblies in Region II. An ordered ranking of these assemblies is reported in engineering analysis **EA-RDR-93-07**. The 23 most reactive assemblies were moved from the Region II racks and replaced with assemblies which meet the Burnup vs. Enrichment curve provided by Westinghouse. Westinghouse then completed a KENO_Va based calculation considering the most reactive assembly after the 23 had been removed. K_{eff} was shown to be below 0.95 (0.947 including uncertainties) with no credit for Boraflex™ or soluble boron taken. A description of the calculation is found in Westinghouse's Region II criticality report titled **"Criticality Analysis To Support Current Fuel Storage in the Palisades Region 2 Spent Fuel Racks with no Boraflex Panels"**. Reactivity equivalencing using CASMO-3 as reported in engineering analysis **EA-RDR-93-07** shows that all fuel assemblies currently residing in the Region II racks are of reactivity less than or equal to the assembly considered in the Westinghouse analysis. Until the results of Blackness testing are known, no fuel assemblies will be moved into the Region II racks unless they either meet the Burnup vs. Enrichment curve with no Boraflex™ or are shown by reactivity equivalencing to be less reactive than the most reactive assembly considered by Westinghouse in their KENO Va calculation. At this time, daily SFP Boron samples are no longer necessary.

A Safety Review was completed and attached to **EA-RDR-93-07**. The Analysis shows that remaining in a condition where no credit is taken for Boraflex™ panels in the Region II racks does not increase the probability or consequences of either accidents or malfunctions of safety related equipment. No previously unanalyzed accidents or malfunctions are introduced and the margin of safety is not reduced.

Long-term Action

In order to determine the actual condition of the SFP rack Boraflex™, blackness testing of the racks is required. This involves placing a neutron source and four neutron detectors into individual fuel cells to map the presence/absence of neutron absorbing material. For this testing to be effective, the blackness testing service provider recommends that background gamma radiation levels be below 20R/hr. Higher radiation levels lead to detector saturation which precludes neutron count rate monitoring.

SFP rack background gamma radiation levels were measured utilizing an underwater dose rate meter. Results are shown in Figure 2. These show that to reduce background radiation levels below 20R/hr, fuel assemblies can be no closer than 3 to 4 cells away, in all directions. As a minimum, an approximately 7x7 area would need to be cleared of fuel assemblies to allow for testing the center cell. Given only 13 non-occupied fuel locations, this is simply not possible at this time.

To compensate for the delay in blackness testing, the fuel assemblies in the SFP were re-arranged to remove the most reactive assemblies from Region II racks and replace them with lower reactivity assemblies. The resultant k_{eff} is ≤ 0.95 as outlined previously. This assures a safe configuration during all credible scenarios, including dilution to zero ppm boron concentration, without relying on credit for Boraflex™. Silica levels continue to remain well within the range of other facilities utilizing Boraflex™ racks. As silica level is an indicator of Boraflex™ degradation, this is the best indicator that our rack Boraflex™ degradation is likely consistent with that experienced by others. Given the current safe configuration, low SFP silica levels, mechanical design differences between coupons and racks, it appears reasonable to align rack blackness testing such that it coincides with the dry fuel storage loading effort, scheduled to commence spring of 1994. This will open additional fuel locations in the SFP to allow for blackness testing of a representative number of fuel locations without requiring excessive fuel movement to reduce background radiation levels. Any further actions with respect to this issue, will be based on the actual condition of the rack Boraflex™.

For additional information regarding Boraflex™, contact:

Paul J. Kluskowski
Plant Reactor Engineer

For additional information regarding criticality analyses, contact:

Guy C. Packard
Physics Design Supervisor

Table 1 Interim Results

Coupon #	Coupon Type	Visual Results	% of Material Lost	Boron-10 Areal Density (gm/cm2)	Shore A Hardness	γ Exposure
7709G	Accelerated, Full length, Bonded	Most of boraflex material was gone. Some sludge-like material in bottom area.	Loss is estimated at 90%. No further eval.	Insufficient material present.	Insufficient material present.	1.40 E 10 Rads
7705G	Long term, Full length, Bonded	Approx. half of boraflex was gone. Numerous cracks noted. Small amounts of sludge.	Loss was measured at 50%.	Average density was .00941	92 to 99 was the range at the top and middle. Near the bottom the range was 76 to 85.	5.92 E 9 Rads
7706G	Long term, Full length, Bonded	Approx. half of boraflex was gone. Numerous cracks noted. Small amounts of sludge.	Loss was measured at 50%.	Average density was .00912	NA	5.95 E 9 Rads
7712G	Long term ,Full length, Unbonded	Approx. one third of boraflex was gone. Numerous cracks noted. Small amounts of sludge.	Loss was measured at 38%.	Average density was .01000	NA	6.26 E 9 Rads
Short set 1	Accelerated, Short length, Unbonded	Embrittlement was noted. No loss or cracking.	Loss was measured at 0%.	Average density was .00934	NA	1.47 E 10 Rads

New Boraflex Shore A Hardness ranges from 80 to 88
Original criticality analysis assumed B^{10} areal density $\geq$ 0.006 gms/cm^2

Table 2 Attenuation Date

Coupon ID	Original Thickness (In)	Current (1) Thickness (In)	Original Neutron Attenuation	Current (2) Neutron Attenuation
7705G - 1	0.032	0.0315	.7193	.7316
- 2	0.031	0.0306	.7115	.7299
- 3	0.031	0.0310	.7153	.7328
- 4	0.032	0.000	.7117	.2153
- 5	0.031	0.000	.7134	.0955
- 6	0.032	0.000	.7205	.1000
- 7	0.031	0.000	.7157	.0993
7706G - 1	0.029	0.0295	.7112	.7177
- 2	0.030	0.0295	.7106	.7143
- 3	0.030	0.0293	.7117	.7180
- 4	0.030	0.0305	.7073	.7223
- 5	0.029	0.0310	.7044	.7274
- 6	0.030	0.000	.7081	.0967
- 7	0.030	0.000	.7101	.1188
7712G - 1A	0.032	0.0316	.7372	.7445
- 2A	0.032	0.0319	.7318	.7544
- 3A	0.032	0.0336	.7326	.7541
- 4A	0.031	0.0323	.7340	.7491
- 5A	0.032	0.0323	.7318	.7491
- 6A	0.032	0.0320	.7352	.7659
- 7A	0.031	0.0320	.7283	.7469
GU70 -1 -1	0.025	0.0265	.7659	.7349
-2	0.025	0.0263	.7451	.7349
GU69 -2 -1	0.024	0.0250	.7225	.7171
-2	0.024	0.0252	.7310	.7128
GU70 -3 -1	0.024	0.0258	.7256	.7209
-2	0.024	0.0259	.7231	.7209
GU71 -4 -1	0.026	0.0259	.7373	.7330
-2	0.026	0.0266	.7350	.7408
GU70 -5 -1	0.023	0.0261	.7272	.7246
-2	0.024	0.0250	.7283	.7191

Coupon ID	Original Thickness (In)	Current (1) Thickness (In)	Original Neutron Attenuation	Current (2) Neutron Attenuation
GU69 -6 -1	0.025	0.0260	.7358	.7281
-2	0.025	0.0257	.7365	.7299
GU70 -7 -1	0.024	0.0251	.7320	.7158
-2	0.024	0.0251	.7293	.7190
GU71 -8 -1	0.026	0.0270	.7399	.7412
-2	0.026	0.0254	.7442	.7341

(1) Thicknesses for 7705G, 7706G, & 7712G were not taken in the same locations as originals but were measured in the closest possible locations.

(2) Neutron attenuations for coupon 7712G were measured in locations where Boraflex was known to be present.

Table 3

BORAFLEX LOT DATA

Large Coupon ID	Boron Carbide Lot No.	Sylgard 170 Elastomer Part A	Sylgard 170 Elastomer Part B
7705 G	022688-1	ET028828	ET018832
7706 G	022688-1	ET028828	ET018832
7707 G	022688-1	ET028828	ET018832
7708 G	(1) 042585-1	ET028825	ET018834
7709 G	042585-1	ET028825	ET018834
7710 G	042585-1	ET028825	ET018834
7711 G	042585-1	ET028825	ET018834
7712 G	042585-1	ET028825	ET018834
7713 G	042585-1	ET028825	ET018834
7714 G	042585-1	ET028825	ET018834
Large Coupon Material Heat Code: MA04			

Spent Fuel Pool Rack Boraflex and Small Coupon Batch Number	Boron Carbide Lot No.	Sylgard 170 Elastomer Part A	Sylgard 170 Elastomer Part B
GU69	(2) 012986-1	EU095176	ET085250
GU70	012986-1	EU095176	ET085250
GU71	012986-1	EU095176	ET085250

Repair Material	Boron Carbide Lot. No.	Sylgard 170 Elastomer Part A	Sylgard 170 Elastomer Part B
	(2) 102185-1	ET085123	EP045964

(1) These coupons were repaired with Lot No. 042585-1, but it is not clear at this time if they were replaced or the original Lot No. 022688-1 coupons were repaired.

(2) Some Spent Fuel Pool Rack Boraflex Sheets were repaired with Lot No. 102185-1, but it is not clear at this time if the original sheets were repaired or replaced.

TABLE 4
Typical Silica Levels

Facility	% Cracking/Shrinkage	SFP Silica Level
1	Unknown	.87 to 1.25 ppm
2	Unknown	3.7 to 4.0 ppm
3	Unknown	4.4 to 6.0 ppm
4	Ave 1.0% gaps	0.5 to 0.9 ppm
5	1.0 to 1.3% gaps	14 ppm
6	Unknown	7 ppm (1991)
7	2.8% shrinkage	1.0 ppm
8	Unknown	75 ppm
9	Unknown	0.6 to 1.4 ppm
10	< .34%	3.5 ppm
11	Unknown	Unknown
12	No Indications	7.2 ppm
13	0.7 to 2.8%	2.2 ppm
14	Unknown	7.8 ppm
15	< 4.0%	2.8 ppm

Facility names were withheld.

Figure 1
Palisades Boraflex
Coupon Types

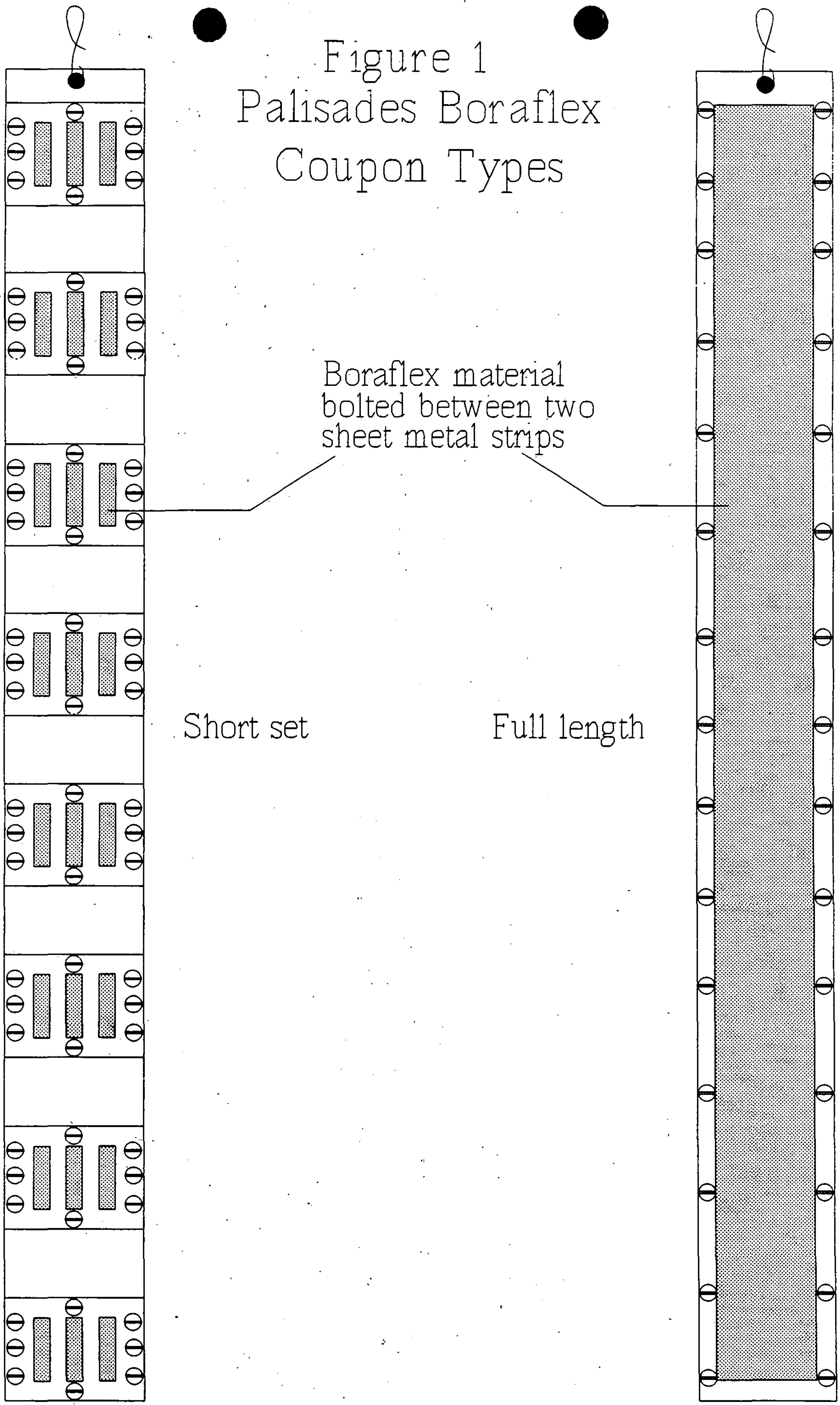
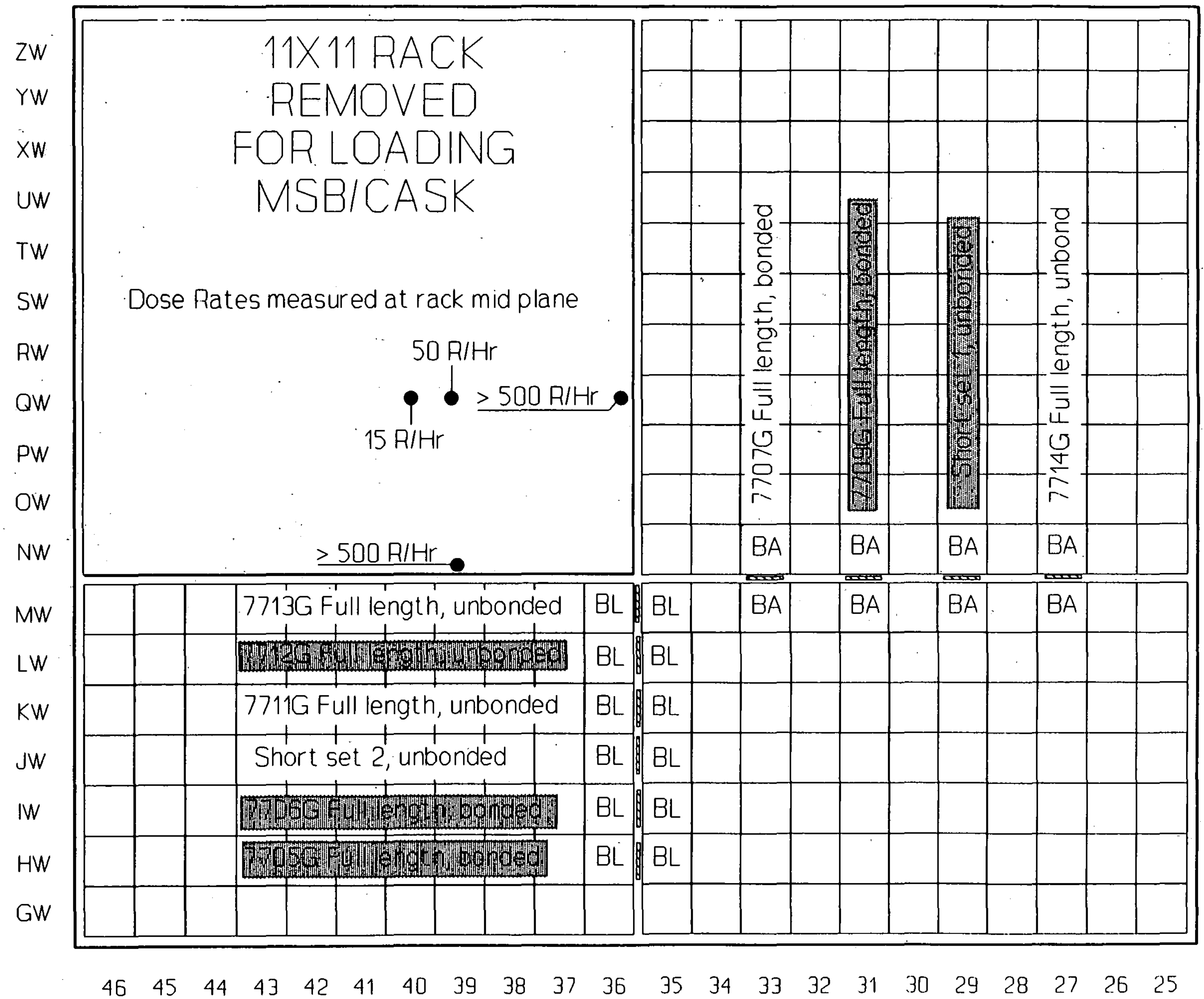


Figure 2



Coupon # and type. Shading indicates coupon removed

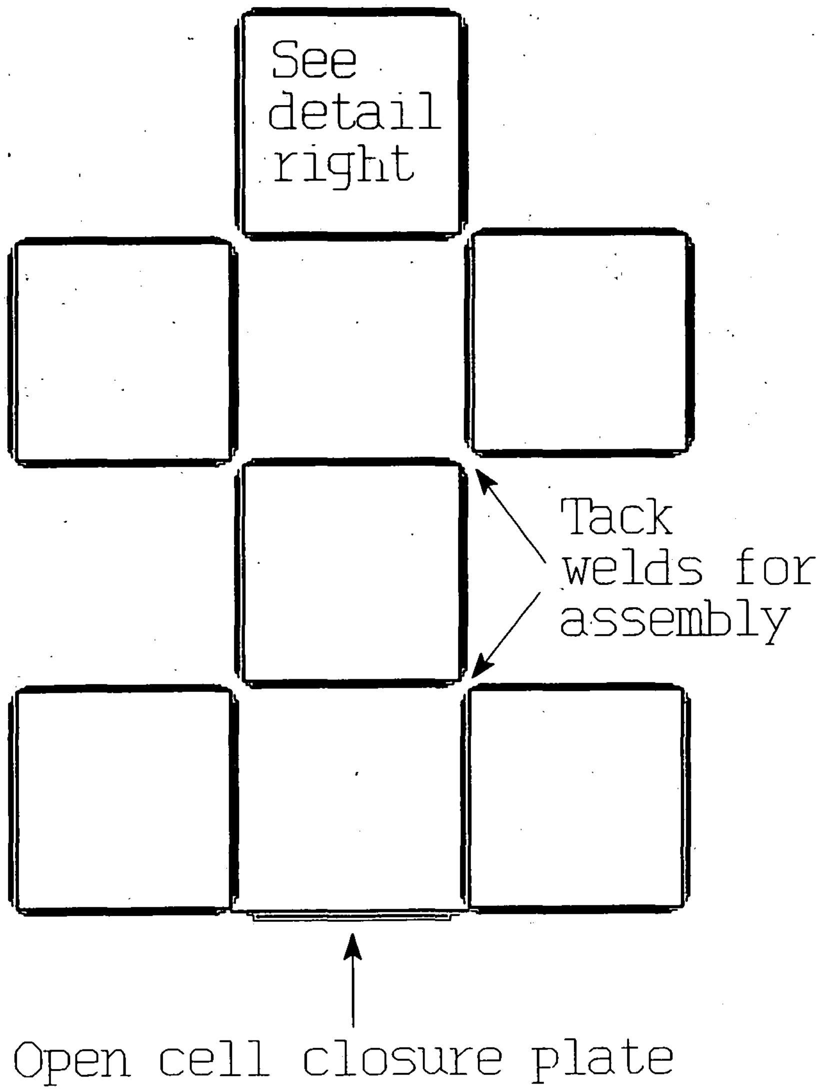
Actual coupon location

BL Long-term Boraflex Fuel location

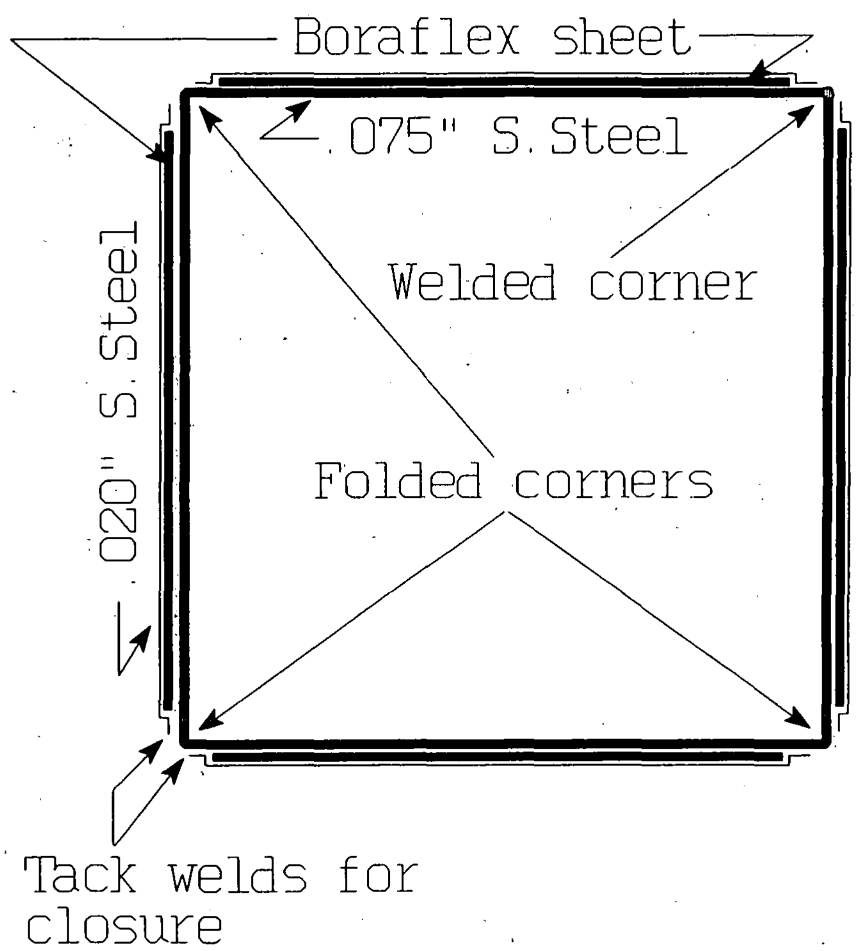
BA Accelerated Boraflex Fuel location

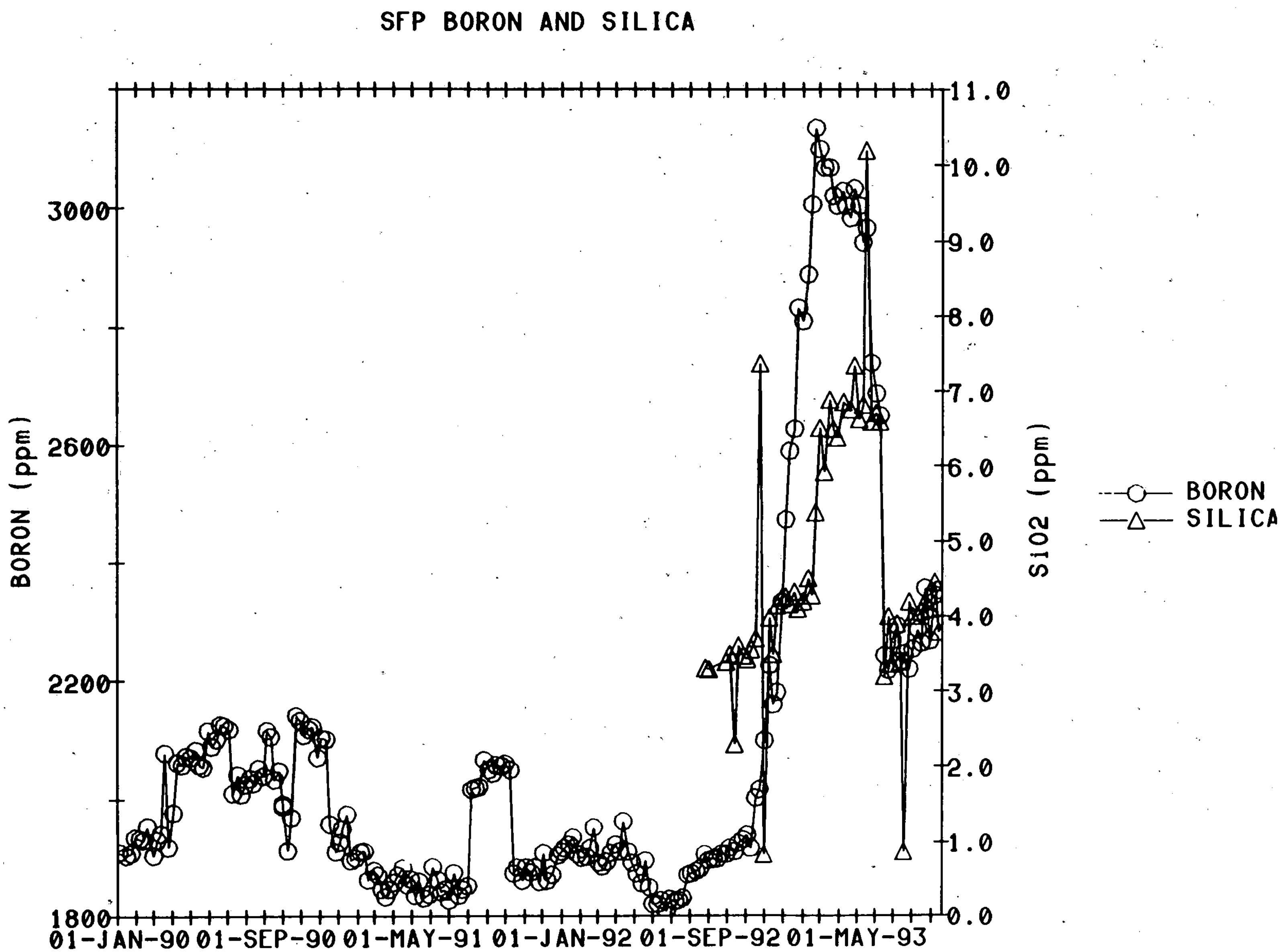
Figure 3 Rack construction

Rack assembly method



Detailed cell view




SFP BORON AND SILICA
BORON (ppm)
SiO2 (ppm)
3000
2600
2200
1800
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
01-JAN-90
01-SEP-90
01-MAY-91
01-JAN-92
01-SEP-92
01-MAY-93
BORON
SILICA