PCRV TENDON
INTERIM SURVEILLANCE
REPORT

AUGUST 1988

Fort St. Vrain Nuclear Generating Station
Public Service Company of Colorado

ABSTRACT

This report is the sixth consecutive semiannual report to be submitted under the current requirements of the interim surveillance program established to monitor corrosion in the Prestressed Concrete Reactor Vessel (PCRV) prestressing tendons.

Surveillance findings are reported for the following interim surveillance program groups of tendons: (1) control tendons for visual inspection and liftoff testing, and (2) "new" tendons for visual inspection.

Also, the findings of the fourth semiannual visual surveillances on the worst-case tendon group, including Tendon CM 4.6, are reported.

The major findings, facts and conclusions reported herein are summarized below:

- No new noneffective wires have been observed in any of the control tendons since the start of the interim surveillance program in June 1985.
- Based on the control tendon surveillance results to date, the rate of corrosion in the tendon system continues to be extremely low or nonexistent and of no immediate concern.
- The tendon liftoff loads measured to date for the control tendons, in all cases, continue to be well above the minimum design loads for each tendon type; moreover, the measured liftoff loads do not exhibit any trend towards significant load relaxation or load loss.
- Based upon the lack of any increase in the number of noneffective wires, there is no indication that corrosion is continuing in any of the 33 previously-surveilled "new" tendons.
- Based upon a lack of increase in noneffective wires in the worst-case tendons, it is evident that the corrosion rate remains at a very low level in these tendons.
- No increase in noneffective wires was observed in Tendon CM 4.6. Approximately one-third quart of water was drained from Tendon CM 4.6, which is the same as the previous six-month amount.
- To date, 370 of the total 448 PCRV tendons, or 82.6 percent, have had a visual inspection on at least one end at least one time since March 1, 1984.

- Of the 370 tendons surveilled since March 1, 1984, a total of 63, or 17.0 percent, have been observed with noneffective wires. These 63 tendons include 58 tendons with only 7 or fewer noneffective wires each and only 5 tendons with 16 or more noneffective wires each.

- Tendon surveillance results continue to demonstrate that, left in their present condition, every PCRV tendon will likely sustain load above the minimum required load for many years to come.

CONTENTS

1.0 INTRODUCTION

This report is being submitted to comply with the requirements of the interim surveillance program which has been set up to monitor corrosion in the Prestressed Concrete Reactor Vessel (PCRV) prestressing tendons (Reference: P-85071, dated March 5, 1985). This is the sixth consecutive semiannual report to be submitted under this program; the first through fifth reports were submitted under Letters P-86042 (January 22, 1986), P-86463 (July 18, 1986), P-87021 (January 19, 1987), P-87234 (July 20, 1987) and P-88002 (January 8, 1988), respectively. As explained in the January 1986 report, the effective start date for the interim surveillance program was established as July 21, 1985, with the findings of the tendon surveillances performed during each six-month interval to be reported at the end of each period.

Based upon continuing favorable surveillance results showing virtually no progression of corrosion, Public Service Company of Colorado (PSC) believes it very appropriate to convert to an annual surveillance and reporting schedule as proposed and justified in Letter P-87234, dated July 20, 1987 (for ease of reference, included as Attachment 1 to the Cover Letter P-88300 for this report).

The present submittal reports the findings of tendon surveillances performed since the January 1988 report; more specifically,, the actual tendon surveillances included in this report were performed between March 1 and July 23, 1988.

In addition to the control and new tendon groups as part of the interim surveillance program, this report also covers the findings of the fourth semiannual visual surveillances performed on the five(5) worst-case tendons as established in the Attachment (pp. 10 and 11) to Letter P-86491, dated July 29, 1986.

2.0 PCRV TENDON SURVEILLANCE INFORMATION

2.1 FINDINGS OF THE SIXTH SIX-MONTH INTERIM SURVEILLANCE PROGRAM PERIOD

The PCRV tendon interim surveillance program scope and requirements were discussed in detail in Section 2.1 of the January 1986 report (P-86042). The findings of the surveillances performed during the sixth six-month interim surveillance period are reported here. For ease of comparison and cohesiveness from report to report, the tabular, graphical, text and organizational format of findings continue to appear in the same manner in this report as in the earlier reports.

2.1.1 Visual Inspection

2.1.1.1 Control Tendons

The control tendon group for visual inspection is that group of tendons which, once selected, remains the same for each semiannual visual inspection period. The tendons chosen as control tendons for visual inspection, selected during the first six-month interim surveillance period and initially presented in the January 1986 report, are as follows:

Circumferential	Top Crosshead	Bottom Crosshead	Longitudinal	
CM 1.1	TIRM2	BIRM4	VM-10	VM-37
CO 14.4		BILM3	VI-20	VI-40
CM 16.3			VM-20	VM-40

A historical surveillance information summary for each end of each control tendon, including the findings during this latest six-month surveillance period, is presented in Table 2.1-1.

The general observation and discussion of findings relative to the control tendons provided in Section 2.2.1.1 of the January 1986 report (P-86042) remains applicable here. Based on the line of reasoning from this discussion and referring to the findings reported in Table 2.1-1, it should be noted that no new noneffective wires have been observed in any of the control tendons during this latest (sixth) semiannual surveillance period as compared with previous surveillances. In fact, no new noneffective wires have been observed in any of the twelve(12) control tendons for the three-year period since the start of the interim surveillance program in June 1985.

Based on the control tendon surveillance results to date, the rate of corrosion in the tendon system continues to be extremely low or nonexistent and of no immediate concern.

TABLE 2.1-1

CONTROL TENDONS
HISTORICAL SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires(3)	Liftoff Load (kips)(4)
CM 1.1	I	07/22/88	L	0	1336
(169)	I	11/03/87	L	0	1325
	I	05/22/87	L	0	1347
	I	11/04/86	L	0	1350
	I	06/12/86	L	0	1371
	I	10/15/85	L	0	1392
	I	10/02/84	L	0	1315
	III	06/21/88	L	0	1314
	III	10/27/87	L	0	1318
	III	05/26/87	L	0	1318
	III	10/29/86	L	0	1318
	III	06/11/86	L	0	1314
	III	10/17/85	L	0	1327
	III	10/02/84	L	0	1275
CO 14.4	II	05/18/88	L	0	1220
(152)	II	09/17/87	L	0	1246
	II	04/01/87	L	0	1224
	II	10/29/86	L	0	1218
	II	06/07/86	L	0	1275
	II	12/20/85	L	0	1237
	II	10/17/84	L	0	1180
	VI	06/14/88	L	0	1182
	VI	09/19/87	L	0	1160
	VI	04/10/87	L	0	1175
	VI	10/24/86	L	0	1167
	VI	06/09/86	L	0	1208
	VI	12/19/85	L	0	1196
	VI	10/17/84	L	0	1150
CM 16.3	III	05/31/88	L	0	1402
(169)	III	09/15/87	L	0	1374
	III	05/01/87	L	0	1379
	III	09/29/86	L	0	1310
	III	06/07/86	L	0	1387
	III	12/13/85	L	0	1380
	III	03/25/85	L	0	1352

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TABLE 2.1-1 (cont.)

CONTROL TENDONS
HISTORICAL SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires(3)	Liftoff Load (kips)(4)
CM 16.3 (cont.) (169)	V	06/10/88	L	0	1370
	V	09/15/87	L	0	1349
	V	04/29/87	L	0	1360
	V	10/16/86	L	0	1299
	V	06/11/86	L	0	1372
	V	12/16/85	L	0	1373
	V	03/26/85	L	0	1368
TIRM2 (169)	III-IV	06/01/88	L	0	1358
	III-IV	11/06/87	L	0	1325
	III-IV	05/13/87	L	0	1376
	III-IV	10/24/86	L	0	1359
	III-IV	05/21/86	L	0	1392
	III-IV	12/18/85	L	0	1377
	III-IV	02/05/85	L	0	1364
	VI-I	06/16/88	L	0	1370
	VI-I	11/05/87	L	0	1353
	VI-I	05/19/87	L	0	1368
	VI-I	10/21/86	L	0	1281
	VI-I	05/20/86	L	0	1391
	VI-I	12/17/85	L	0	1380
	VI-I	02/13/85	L	0	1370
BIRM4 (169)	III-IV	06/23/88	V	0	N/A
	III-IV	11/02/87	L	0	1357
	III-IV	03/09/87	L	0	1338
	III-IV	10/31/86	L	0	1363
	III-IV	04/18/86	L	0	1395
	III-IV	12/30/85	L	0	1372
	III-IV	03/85	V	0	N/A
	III-IV	09/11/84	L	N/R	1291
	III-IV	04/01/84	V	N/R	N/A

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TABLE 2.1-1 (cont.)

CONTROL TENDONS
HISTORICAL SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires(3)	Liftoff Load (kips)(4)
BIRM4 (cont.)	VI-I	06/30/88	L	0	1299
(Load Cell)	VI-I	11/02/87	L	0	1333
	VI-I	03/16/87	L	0	1289
	VI-I	11/05/86	L	0	1306
	VI-I	04/29/86	L	0	1364
	VI-I	11/27/85	L	0	1344
	VI-I	03/85	V	0	N/A
	VI-I	09/11/84	L	N/R	1307
	VI-I	04/01/84	V	N/R	N/A
	VI-I	12/71	V	N/R	N/A
BILM3	III-IV	03/15/88	V	0	N/A
(169)	III-IV	11/03/87	V	0	N/A
	III-IV	03/09/87	V	0	N/A
	III-IV	10/31/86	V	0	N/A
	III-IV	04/18/86	L	0	1398
	III-IV	01/03/86	L	0	1352
	III-IV	03/85	V	0	N/A
	III-IV	09/12/84	L	0	1287
	III-IV	04/01/84	V	N/R	N/A
	VI-I	03/13/88	V	1	N/A
	VI-I	11/04/87	V	1	N/A
	VI-I	03/16/87	V	1	N/A
	VI-I	11/07/86	V	1	N/A
	VI-I	04/30/86	L	1	1319
	VI-I	12/03/85	L	1	1298
	VI-I	03/85	V	1	N/A
	VI-I	09/12/84	L	1	1279
	VI-I	04/01/84	V	N/R	N/A
VM-10	Top	03/28/88	L	7	1366
(169)	Top	07/16/87	L	7	1370
	Top	02/05/87	L	7	1375
	Top	09/25/86	L	7	1305
	Top	05/24/86	L	7	1413
	Top	06/20/85	L	7	1388
	Top	01/17/85	V	7	N/A
	Top	04/09/84	L	3	1344
	Top	03/28/84	V	3	N/A

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TABLE 2.1-1 (cont.)

CONTROL TENDONS
HISTORICAL SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires(3)	Liftoff Load (kips)(4)
VI-20	Top	03/29/88	L	0	1442
(169)	Top	07/17/87	L	0	1396
	Top	02/03/87	L	0	1432
	Top	09/25/86	L	0	1391
	Top	05/24/86	L	0	1459
	Top	06/21/85	L	0	1437
	Top	01/30/85	V	0	N/A
	Top	04/17/84	L	0	1443
	Top	03/27/84	V	N/R	N/A
VM-20	Top	03/29/88	V	0	N/A
(169)	Top	07/17/87	V	0	N/A
	Top	02/03/87	V	0	N/A
	Top	09/24/86	V	0	N/A
	Top	05/24/86	V	0	N/A
	Top	06/21/85	V	0	N/A
	Top	01/30/85	V	0	N/A
	Top	04/17/84	L	0	1449
	Top	03/27/84	V	N/R	N/A
VM-37	Top	03/30/88	V	1	N/A
(169)	Top	07/23/87	V	1	N/A
	Top	02/09/87	V	1	N/A
	Top	09/24/86	V	1	N/A
	Top	06/16/86	V	1	N/A
	Top	06/19/85	V	1	N/A
	Top	01/19/85	V	1	N/A
	Top	04/09/84	L	1	1444
	Top	03/28/84	V	1	N/A
VI-40	Top	03/31/88	V	0	N/A
(169)	Top	07/24/87	V	0	N/A
	Top	02/09/87	V	0	N/A
	Top	09/24/86	V	0	N/A
	Top	06/04/86	V	0	N/A
	Top	06/18/85	V	0	N/A
	Top	01/30/85	V	0	N/A
	Top	04/19/84	L	0	1438
	Top	03/28/84	V	N/R	N/A

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TABLE 2.1-1 (cont.)

CONTROL TENDONS
HISTORICAL SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires(3)	Liftoff Load (kips)(4)
VM-40	Top	03/31/88	L	0	1439
(169)	Top	07/24/87	L	0	1416
	Top	02/09/87	L	0	1416
	Top	09/25/86	L	0	1355
	Top	06/04/86	L	0	1454
	Top	06/18/85	L	0	1437
	Top	01/30/85	V	0	N/A
	Top	04/19/84	L	0	1433
	Top	03/28/84	V	N/R	N/A

NOTES (by reference number):

1) Indicated by PCRV buttress number. If between two buttresses, indicated by both nearest buttress numbers. Longitudinal tendons indicated by "Top" or "Bottom".

2) L: Liftoff and visual inspection of anchor assembly and wire bundle.

   V: Visual inspection of anchor assembly only.

3) N/R: Not reported

4) N/A: Not applicable for a visual-only surveillance; i.e., no liftoff test performed.

2.1.1.2 New Tendons

The new tendons selected for visual inspection for this sixth six-month interim surveillance period are as follows:

Circumferential	Top Crosshead	Bottom Crosshead	Longitudinal	
CI 14.1	TORM1	BOLM3	VI-4	VI-18
CM 14.1		BIRM3	VM-5	VI-19
CO 14.1		BORM4	VI-9	VM-19
CI 16.1		BOLL4	VI-10	VI-23
CM 16.1		BILL4	VI-12	VM-24
CO 16.1		BIRL4	VM-12	VI-25
CM 6.2			VI-13	VM-25
CI 7.2			VI-14	VI-30
CM 7.2			VM-14	VM-31
CO 7.2			VO-14	VI-35
CI 8.2			VI-15	VI-42
CM 8.2			VI-16	VM-42
CO 8.2				

A summary of the latest surveillance information gathered during this sixth six-month interim visual-surveillance period for each end of each new tendon is presented in Table 2.1-2. Those tendon ends surveilled for the first time since original installation in the year 1970 are noted in the table.

The number of new tendons for visual inspection of each tendon type observed with noneffective wires are as follows: two(2) out of thirteen(13) new circumferential, zero(0) out of one(1) new top crosshead, two(2) out of six(6) new bottom crosshead and four(4) out of twenty-four(24) new longitudinal. The actual number of noneffective wires observed in each of these tendons is given in Table 2.1-2.

Out of the total of forty-four(44) new tendons for visual inspection, thirty-three(33) have had at least one previous surveillance on at least one end since March 1984 (the date of discovery of the tendon corrosion problems). Out of these 33 previously-surveilled new tendons, none have shown any increase in the number of noneffective wires. Based upon this lack of increase in the number of noneffective wires, there is no indication that corrosion is continuing in any of these tendons.

TABLE 2.1-2

NEW TENDONS
LATEST SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires	Liftoff Load (kips)(3)
CI 14.1	I	05/11/88(4)	L	1	1226
(152)	III	05/23/88(4)	L	0	1205
CM 14.1	I	05/10/88(4)	L	0	1225
(152)	III	05/23/88(4)	L	0	1196
CO 14.1	I	05/11/88(4)	L	1	1176
(152)	III	05/23/88(4)	L	0	1200
CI 16.1	I	05/13/88(4)	L	0	1378
(169)	III	05/25/88(4)	L	0	1370
CM 16.1	I	05/13/88(4)	L	0	1378
(169)	III	05/25/88(4)	L	0	1362
CO 16.1	I	05/13/88(4)	L	0	1374
(169)	III	05/25/88(4)	V	0	N/A
CM 6.2	IV	05/05/88(4)	L	0	1151
(152)	VI	04/07/88(4)	L	0	1174
CI 7.2	IV	05/04/88	L	0	1206
(152)	VI	04/07/88(4)	L	0	1213
CM 7.2	IV	05/04/88	L	0	1192
(152)	VI	04/07/88(4)	L	0	1170
CO 7.2	IV	04/28/88(4)	L	0	1135
(152)	VI	04/07/88(4)	L	0	1188
CI 8.2	IV	04/27/88(4)	L	0	1240
(152)	VI	04/06/88(4)	L	0	1234
CM 8.2	IV	04/27/88(4)	L	0	1170
(152)	VI	04/06/88(4)	L	0	1222
CO 8.2	IV	04/27/88(4)	L	0	1169
(152)	VI	04/06/88(4)	L	0	1186
TORM1	III-IV	06/02/88	V	0	N/A
(169)	VI-I	06/15/88	V	0	N/A

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TABLE 2.1-2 (cont.)

NEW TENDONS
LATEST SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires	Liftoff Load (kips)(3)
BOLM3	III-IV	03/15/88	V	1*	N/A
(169)	VI-I	03/13/88	V	0	N/A
BIRM3	III-IV	03/15/88	V	0	N/A
(169)	VI-I	03/13/88	V	0	N/A
BORM4	III-IV	03/14/88	V	3*	N/A
(169)	VI-I	03/13/88	V	0	N/A
BOLL4	II-III	03/12/88	V	0	N/A
(169)	V-VI	03/13/88	V	0	N/A
BILL4	II-III	03/12/88	V	0	N/A
(169)	V-VI	03/12/88	V	0	N/A
BIRL4	II-III	03/13/88	V	0	N/A
(169)	V-VI	03/13/88	V	0	N/A
VI-4(169)	Top	03/27/88	V	0	N/A
VM-5(169)	Top	03/27/88	V	0	N/A
VI-9(169)	Top	03/30/88	V	0	N/A
VI-10(169)	Top	03/28/88	V	5*	N/A
VI-12(169)	Top	03/28/88	L	0	1402
VM-12(169)	Top	03/28/88	V	0	N/A
VI-13(169)	Top	03/28/88	L	0	1431
VI-14(169)	Top	03/28/88	V	0	N/A
VM-14(169)	Top	03/28/88	V	0	N/A
VO-14(169)	Top	03/28/88	V	4*	N/A
VI-15(169)	Top	03/29/88	V	0	N/A
VI-16(169)	Top	03/29/88	V	0	N/A

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TABLE 2.1-2 (cont.)

NEW TENDONS
LATEST SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires	Liftoff Load (kips)(3)
VI-18(169)	Top	03/29/88	V	0	N/A
VI-19(169)	Top	03/29/88	V	0	N/A
VM-19(169)	Top	03/29/88	V	0	N/A
VI-23(169)	Top	03/29/88	V	0	N/A
VM-24(169)	Top	03/29/88	V	0	N/A
VI-25(169)	Top	03/30/88	V	0	N/A
VM-25(169)	Top	03/30/88	V	0	N/A
VI-30(169)	Top	03/30/88	V	0	N/A
VM-31(169)	Top	03/30/88	V	0	N/A
VI-35(169)	Top	03/30/88	V	1*	N/A
VI-42(169)	Top	03/31/88	V	0	N/A
VM-42(169)	Top	03/31/88	V	2*	N/A

NOTES (by reference number):

1) Indicated by PCRV buttress number. If between two buttresses, indicated by both nearest buttress numbers. Longitudinal tendons indicated by "Top" or "Bottom".

2) L: Liftoff and visual inspection of anchor assembly and wire bundle.

   V: Visual inspection of anchor assembly only.

3) N/A: Not applicable for a visual-only surveillance; i.e., no liftoff test performed.

4) First surveillance since original installation in 1970.

* These numbers of noneffective wires were identified in previous surveillance reports and have not changed.

Of the eleven(11) remaining new tendons for visual inspection with no previous surveillance record on either end, all of which are circumferential tendons, two(2) were observed with noneffective wire(s): Tendons CI 14.1 and CO 14.1, each with one(1) noneffective wire on one end only. These noneffective wire numbers are well within the surveillance results of noneffective wires found previously in other circumferential tendons.

The new-tendon observations during the sixth six-month interim surveillance program period continue to demonstrate that PCRV tendon corrosion is random in nature among the tendons of each tendon type. The observations of the latest new-tendon group also continue to show that the circumferential tendons have been subjected to some corrosion, but not to the general extent or degree of severity observed previously for the bottom crosshead and longitudinal tendons.

2.1.2 Liftoff Testing

2.1.2.1 Control Tendons

The control tendon group for liftoff testing is that group of tendons which, once selected, remains constant in identity and quantity during each six-month period of the interim surveillance program. The tendons chosen as control tendons for liftoff testing, included in the control group for visual inspection, were selected during the first six-month interim surveillance period and initially presented in the January 1986 report. These liftoff control tendons are as follows:

Circumferential	Top Crosshead	Bottom Crosshead	Longitudinal
CM 1.1	TIRM2	BIRM4	VM-10
CO 14.4		(load cell)	VI-20
CM 16.3			VM-40

The most recent and historical measured liftoff loads for each of these liftoff control tendons is presented in Table 2.1-1. The load cell reading during the most recent liftoff on Tendon BIRM4 was 1266 kips, which compares favorably with five previous readings of 1291, 1250, 1253, 1264 and 1257 kips.

The tendon liftoff loads measured to date for the control tendons, in all cases, continue to be well above the minimum design loads for each tendon type as reported earlier in Letter P-84135, dated May 7, 1984. Moreover, the measured liftoff loads do not exhibit any trend towards significant load relaxation or load loss. The differences in measured liftoff load values noted for each control tendon from one liftoff to the next are within an acceptable and expected range of measurement system inaccuracies.

2.1.2.2 New Tendons

As part of the PCRV tendon interim surveillance program requirements, a new tendon group is to be randomly selected and liftoff tested during each eighteen(18)-month program period. The new tendons selected for liftoff testing may be included in any of the new tendon groups selected for six-month visual inspections during the 18-month period.

Liftoff surveillance findings on the new tendons selected for liftoff testing for the first 18-month period, covering July 21, 1985, to January 21, 1987, were reported ahead of the committed schedule in the tendon surveillance report submitted under Letter P-86463, dated July 18, 1986.

Liftoff surveillance findings on the new tendons selected for liftoff testing for the second 18-month period, covering January 21, 1987 to July 21, 1988, were also reported ahead of the committed schedule in the tendon surveillance report submitted under Letter P-88002, dated January 8, 1988.

Under the current program, the new tendons for liftoff testing for the third 18-month interim surveillance period, covering July 21, 1988, to January 21, 1990, will be selected at a later date, with the report of the liftoff surveillance findings due January 21, 1990.

2.2 WORST-CASE TENDON SURVEILLANCES

As indicated in Section 1.0, this report also covers the findings of the fourth semiannual visual inspections performed on the tendons from the worst-case tendon group. This group consists of the following five(5) tendons:

Worst-Case Tendons

CO 2.5
CM 4.6
BILU3
BILU4
VM-30

A historical surveillance information summary including the findings during this latest (fourth) semiannual period for each end of each worst-case tendon is presented in Table 2.2-1.

The number of noneffective wires has not increased in any of the worst-case tendons compared to the numbers reported in the previous three surveillance reports for the first, second and third semiannual worst-case tendon surveillance periods. Furthermore, there has been no increase in noneffective wires in the worst-case tendons for a period of at least three years (except for Tendon CM 4.6, first surveilled in March 1986) which continues to demonstrate that the corrosion rate is at a very low or nonexistent level in these tendons. This remains a favorable sign with respect to all other PCRV tendons which currently exist in a substantially lesser-corroded state.

2.2.1 Tendon CM 4.6

A full chronological summary of events relative to Tendon CM 4.6 was presented in the surveillance report dated July 1987 (P-87234). As indicated in that report, a fluorescent dye was investigated for its use in the System 46 PCRV liner cooling water system as a means of determining whether System 46 water is the source of water buildup in Tendon CM 4.6. As a result, a red fluorescent dye was added to the System 46 water on September 3, 1987.

A visual surveillance of Tendon CM 4.6 was performed on July 23, 1988. As shown in Table 2.2-1, no increase in noneffective wires was observed. Approximately one-third quart of water was drained from the tendon. This six-month accumulation is the same as the previous six-month accumulation as reported in the last (January 1988) surveillance report.

An analysis of the latest water sample from the tendon shows no conclusive trace of the fluorescent dye added to System 46.

The use of this particular red fluorescent dye will be discontinued because its detection separate from other color wavelengths in the tendon water sample is uncertain (due to a "masking" effect) and it takes considerable man-hours to prepare the dye for injection and requires injection approximately weekly. A search has begun for a different, hopefully more effective, tracer ingredient for addition to System 46 cooling water requiring less preparation time.

TABLE 2.2-1

WORST-CASE TENDONS
HISTORICAL SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires(3)	Liftoff Load (kips)(4)
CO 2.5	I	03/11/88	V	16	N/A
(169)	I	09/30/87	V	16	N/A
	I	05/26/87	V	16	N/A
	I	11/14/86	V	16	N/A
	I	07/22/86	V	16	N/A
	I	06/14/84	L	3	1295
	V	03/11/88	V	2	N/A
	V	09/30/87	V	2	N/A
	V	05/26/87	V	2	N/A
	V	11/14/86	V	2	N/A
	V	07/22/86	V	2	N/A
	V	06/14/84	L	0	1327
CM 4.6	II	07/23/88	V	20	N/A
(169)	II	11/24/87	V	20	N/A
	II	05/27/87	V	20	N/A
	II	11/14/86	V	20	N/A
	II	06/20/86	V	20	N/A
	II	04/08/86	L	20	1235
	IV	07/23/88	V	0	N/A
	IV	11/24/87	V	0	N/A
	IV	05/27/87	V	0	N/A
	IV	11/15/86	V	0	N/A
	IV	06/20/86	V	0	N/A
	IV	04/08/86	V	0	N/A
BILU3	I-II	03/16/88	V	18	N/A
(169)	I-II	11/06/87	V	18	N/A
	I-II	02/20/87	V	18	N/A
	I-II	11/14/86	V	18	N/A
	I-II	05/15/86	L	18	1016
	I-II	03/16/85	V	16	N/A
	I-II	08/14/84	L	15	975

(continued next page)

TABLE 2.2-1 (cont.)

WORST-CASE TENDONS
HISTORICAL SURVEILLANCE INFORMATION SUMMARY

Tendon No. (Number of Orig. Wires)	Tendon End(1)	Surveillance Date	Surv. Type(2)	Number of Noneffective Wires(3)	Liftoff Load (kips)(4)
BILU3 (cont.)	IV-V	03/15/88	V	20	N/A
(169)	IV-V	11/06/87	V	20	N/A
	IV-V	03/02/87	V	20	N/A
	IV-V	11/14/86	V	20	N/A
	IV-V	05/16/86	L	20	1249
	IV-V	03/16/85	V	20	N/A
	IV-V	08/14/84	L	12	1223
	IV-V	04/13/84	L	8	1228
BILU4	I-II	03/16/88	V	28	N/A
(169)	I-II	11/06/87	V	28	N/A
	I-II	02/20/87	V	28	N/A
	I-II	08/11/86	L	28	1056
	I-II	07/22/86	V	28	N/A
	I-II	03/15/85	V	28	N/A
	I-II	05/15/84	L	17	1150
	I-II	04/01/84	V	17	N/A
	IV-V	03/15/88	V	3	N/A
	IV-V	11/06/87	V	3	N/A
	IV-V	03/02/87	V	3	N/A
	IV-V	07/22/86	V	3	N/A
	IV-V	03/15/85	V	3	N/A
	IV-V	05/15/84	L	N/R	1140
	IV-V	04/01/84	V	N/R	N/A
VM-30	Top	03/30/88	V	22	N/A
(169)	Top	07/22/87	V	22	N/A
	Top	02/11/87	V	22	N/A
	Top	09/25/86	V	22	N/A
	Top	06/16/86	L	22	1312
	Top	01/17/85	V	22	N/A
	Top	04/09/84	L	21	1296
	Top	03/29/84	V	21	N/A

(continued next page)

TABLE 2.2-1 (cont.)

WORST-CASE TENDONS
HISTORICAL SURVEILLANCE INFORMATION SUMMARY

NOTES:

1) Indicated by PCRV buttress number. If between two buttresses, indicated by both nearest buttress numbers. Longitudinal tendons indicated by "Top" or "Bottom".

2) L: Liftoff and visual inspection of anchor assembly and wire bundle.

   V: Visual inspection of anchor assembly only.

3) N/R: Not reported

4) N/A: Not applicable for a visual-only surveillance; i.e., no liftoff test performed.

It therefore cannot be concluded at this time whether or not System 46 is the source of the water drained from the tendon tube. It is still believed, as reported earlier, highly unlikely that System 46 is the source and that, more likely, the source is evaporation and recondensation of water from low spots within the horizontal tendon tube itself.

As evidenced by a liftoff test in April 1986, Tendon CM 4.6 is carrying effective PCRV prestress load and remains an effective member of the tendon system.

2.3 SUPPLEMENTAL TENDON SURVEILLANCES

One(1) additional tendon over and above the control, new and worst-case tendon groups was surveilled during the past six-month period. This tendon, BORL4 (bottom crosshead), was subjected to a visual surveillance on both ends. No increase in noneffective wires was observed over previous surveillances. (Note: Previous surveillance indicated one(1) noneffective wire in one end only.)

2.4 COLLECTIVE TENDON SURVEILLANCE INFORMATION SUMMARIES

2.4.1 Tendons with Noneffective Wires

Table 2.4-1 provides a complete summary of all tendon ends surveilled through July 23, 1988 (the effective surveillance cutoff date for this report), which have been observed with noneffective wires, and the number of noneffective wires in each. Table 2.4-1 in this report is an update of Table 2.4-1 from the January 1988 report (P-88002).

Since the January 1988 report, two(2) additional tendons have been observed with noneffective wire(s): Tendons CI 14.1 and CO 14.1, each with one(1) noneffective wire on one end. Neither of these two tendons had a documented surveillance prior to the January 1988 report since original installation in 1970.

Sixteen(16) tendons previously surveilled with noneffective wires prior to the January 1988 report were resurveilled within the past six months; of these sixteen tendons, none were observed with an increase in the number of noneffective wires.

TABLE 2.4-1
SUMMARY OF TENDONS OBSERVED WITH NONEFFECTIVE WIRES

Tendon Number	Tendon End[1]	Number of Original Wires	First Surveillance Date[2]	Total Number of "As-found" Noneffective Wires Observed First Surveillance	Latest Surveillance Date [3]	Total Number of Noneffective Wires Observed Latest Surveillance Date [3]	Total Number of New or Additional Noneffective Wires Observed Between First and Latest Surveillance Dates [3]
VM-1	Bottom	169	05/21/85	1	N/S	N/S	N/S
VI-2	Top	169	03/28/84	5	07/16/87	5	0
VM-8	Top	169	03/28/84	3	01/28/87	4	1
VI-10	Top	169	03/28/84	5	03/28/88	5	0
VM-10	Top	169	03/28/84	3	03/28/88	7	4
VM-11	Top	169	03/28/84	1	07/16/87	1	0
VO-14	Top	169	03/28/84	4	03/28/88	4	0
VM-17	Top	169	03/23/84	4	07/17/87	6	2
VM-17	Bottom	169	04/05/84	3	05/21/85	3	0
VM-29	Top	169	03/27/84	1	07/21/87	1	0
VM-30	Top	169	03/29/84	21	03/30/88	22	1
VM-31	Bottom	169	05/23/85	1	N/S	N/S	N/S
VI-35	Top	169	04/19/84	0	03/30/88	1	1
VM-37	Top	169	03/28/84	1	03/30/88	1	0
VM-42	Top	169	03/28/84	1	03/31/88	2	1
BI103	I-II	169	08/14/84	15	03/16/88	18	3
BI103	IV-V	169	04/13/84	8	03/15/88	20	12
BIRU3	I-II	169	03/15/85	1	11/06/87	1	0
BI104	I-II	169	04/01/84	17	03/16/88	28	11
BI104	IV-V	169	04/01/84	1	03/15/88	3	2
BORU4	IV-V	169	04/01/84	3	07/01/86	3	0
BILI3	II-III	169	03/18/85	1	03/19/87	1	0
BOLI4	V-VI	169	04/01/84	1	03/13/88	0	0
BORI4	V-VI	169	03/18/85	1	03/13/88	1	0
BOIM3	III-IV	169	04/01/84	1	03/15/88	1	0
BIIM3	VI-I	169	09/12/84	1	03/13/88	1	0
BOIM4	III-IV	169	04/01/84	2	11/03/87	3	1
BORM4	III-IV	169	04/01/84	1	03/14/88	3	2
TIRI2	IV-V	169	02/22/85	1	05/15/87	1	0
TORI2	I-II	169	06/25/84	0	06/26/86	1	1
TORI2	IV-V	169	06/29/84	0	06/26/86	1	1
TOIM1	III-IV	169	02/01/85	1	N/S	N/S	N/S
CO 1.1	N/R	169	04/04/84	2	10/85	0(Both Ends)	0
CM 2.1	I	169	10/21/85	2	N/S	N/S	N/S
CI 5.1	III	152	08/15/86	1	N/S	N/S	N/S
CM 6.1	III	152	08/15/86	1	N/S	N/S	N/S
CI 14.1	I	152	05/11/88	1	N/S	N/S	N/S
CO 14.1	I	152	05/11/88	1	N/S	N/S	N/S
CI 15.1	I	152	12/03/84	1	N/S	N/S	N/S
CI 15.1	III	152	12/03/84	1	N/S	N/S	N/S
CO 1.2	IV	169	09/20/86	5	N/S	N/S	N/S
CO 1.2	VI	169	09/10/86	1	N/S	N/S	N/S
CO 4.2	VI	152	08/20/86	1	N/S	N/S	N/S

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TABLE 2.4-1 (Continued)
SUMMARY OF TENDONS OBSERVED WITH NONEFFECTIVE WIRES

Tendon Number	Tendon End[1]	Number of Original Wires	First Surveillance Date[2]	Total Number of "As-found" Noneffective Wires Observed First Surveillance	Latest Surveillance Date [3]	Total Number of Noneffective Wires Observed Latest Surveillance Date [3]	Total Number of New or Additional Noneffective Wires Observed Between First and Latest Surveillance Dates [3]
CO 12.2	IV	152	05/17/85	1	N/S	N/S	N/S
CO 12.2	VI	152	05/06/85	1	N/S	N/S	N/S
CO 16.2	IV	169	06/13/85	1	N/S	N/S	N/S
CM 1.3	V	169	09/21/84	1	N/S	N/S	N/S
CO 5.3	III	152	09/06/85	1	N/S	N/S	N/S
CO 8.3	III	152	09/19/85	3	N/S	N/S	N/S
CI 10.3	III	152	10/02/85	1	N/S	N/S	N/S
CM 11.3	V	152	04/23/87	1	N/S	N/S	N/S
CO 16.3	III	169	03/22/85	1	N/S	N/S	N/S
CO 16.3	V	169	03/22/85	1	N/S	N/S	N/S
CI 5.4	VI	152	08/16/85	2	N/S	N/S	N/S
CM 6.4	II	152	08/07/85	1	N/S	N/S	N/S
CM 7.4	II	152	08/06/85	1	N/S	N/S	N/S
CO 9.4	VI	152	07/25/85	1	N/S	N/S	N/S
CO 15.4	II	152	04/12/87	1	N/S	N/S	N/S
CO 15.4	VI	152	04/14/87	1	N/S	N/S	N/S
CM 16.4	II	169	04/09/87	1	N/S	N/S	N/S
CO 2.5	I	169	06/14/84	3	03/11/88	16	13
CO 2.5	V	169	06/14/84	0	03/11/88	2	2
CM 7.5	V	152	01/24/86	1	N/S	N/S	N/S
CM 9.5	I	152	02/05/86	1	N/S	N/S	N/S
CI 14.5	I	152	07/01/87	1	N/S	N/S	N/S
CM 15.5	I	152	11/01/84	1	N/S	N/S	N/S
CM 15.5	V	152	11/01/84	1	N/S	N/S	N/S
CM 17.5	I	169	10/06/87	1[4]	N/S	N/S	N/S
CM 4.6	II	169	04/08/86	20	07/23/88	20	0
CI 12.5	II	152	12/04/84	1	N/S	N/S	N/S
CI 12.6	IV	152	12/04/84	1	N/S	N/S	N/S
CM 13.6	II	152	09/11/87	1	N/S	N/S	N/S
CI 14.6	II	152	01/11/85	2	N/S	N/S	N/S
CM 14.6	IV	152	01/01/85	1	N/S	N/S	N/S
CO 17.6	N/R	169	01/75	1	N/S	N/S	N/S

NOTES (by reference number):

1) Indicated by PCRV buttress number. If between two buttresses, indicated by both nearest buttress numbers. Longitudinal tendons indicated by "Top" or "Bottom". "N/R" means end surveilled not reported.

2) March, 1984, or after, except tendon CO 17.6 (no surveillance after January, 1975). (March, 1984, is the month and year of discovery of the tendon corrosion problems.)

3) "N/S" means that this tendon end has not been surveilled since first surveillance date.

4) Two(2) additional wires failed during liftoff for a total of three(3) "as-left" noneffective wires.

To date, 370 of the total 448 PCRV tendons have been surveilled on at least one end since March 1, 1984. Of these 370 tendons surveilled, a total of sixty-three(63) tendons, or 17.0 percent, have been observed with one or more noneffective wires each. These 63 tendons include fifty-eight(58) tendons with seven(7) or fewer noneffective wires each and only five(5) tendons with sixteen(16) or more noneffective wires each (these are the five worst-case tendons of Section 2.2 of this report).

2.4.2 Tendon Surveillance Historical Information

The PCRV Tendon Surveillance Plan Drawings, showing graphical end views, with specific historical surveillance information, of all PCRV tendon ends, have been updated to include all tendon surveillances through July 23, 1988. These updated drawings, Numbers 1A through 1D, are included in Appendix A of this report. Reference the key on the drawings for an explanation of the information provided for each tendon end.

2.4.3 Number and Percentage of Tendons Surveilled To Date

Table 2.4-2 provides a complete summary of the number and percentage of tendons of each type which have had a given combination of liftoff and/or visual surveillances performed on them at least one time between March 1, 1984 (the approximate start date of increased tendon surveillances), and July 23, 1988 (the effective surveillance cutoff date for this report). Table 2.4-2 is a revised update of Table 2.4-2 of the January 1988 tendon surveillance report (P-88002).

For the table count, no tendon has been counted more than once. All possible end combinations of surveillance types, including no surveillance, for any tendon are categorically tabularized. Therefore, the total sum of surveillances (and no surveillances) shown for each tendon type (each column) equals the total number of tendons of that type in the PCRV.

As observed in Table 2.4-2, 370 of the total 448 PCRV tendons, or 82.6 percent, have had at least a visual inspection on at least one end at least one time since March 1, 1984. This is an increase of 3.1 percent in total tendons surveilled since the last (January 1988) tendon surveillance report.

TABLE 2.4-2

SUMMARY OF TENDONS[1] LIFTOFF[2] AND/OR VISUAL-ONLY[3]
INSPECTED AT LEAST ONE TIME BETWEEN MARCH 1, 1984, AND JULY 31, 1988

			TENDON TYPE[4]						
			LONGITUDINAL [5]	BOTTOM CROSSHEAD	TOP CROSSHEAD	CIRCUMFERENTIAL HEAD	CIRCUMFERENTIAL BARREL	TOTALS	
	Total Number Of Tendons This Type[6]		90	24	24	100	210	448	
SURVEILLANCE	Liftoff, both ends	Number	N/A	19	13	41	132	205	370
		% of Total	N/A	79.2	54.2	41.0	62.9	57.3[7]	82.6%
	Liftoff, one end Visual only, other end	Number	8	1	9	14	21	53	
		% of Total	8.9	4.2	37.5	14.0	10.0	11.8	
	Liftoff, one end No visual or liftoff, other end	Number	74	0	2	11	0	87	
		% of Total	82.2	0	8.3	11.0	0	19.4	
	Visual only, both ends	Number	2	4	0	4	3	13	
		% of Total	2.2	16.7	0	4.0	1.4	2.9	
	Visual only, one end No visual or liftoff, other end	Number	N/A	0	0	2	5	7	
		% of Total	N/A	0	0	2.0	2.4	2.0[7]	
	Visual only, top end No visual, bottom end	Number	5	N/A	N/A	N/A	N/A	5	
		% of Total	5.6	N/A	N/A	N/A	N/A	5.6[8]	
	No liftoff or visual, either end	Number	1	0	0	28	49	78	
		% of Total	1.1	0	0	28.0	23.3	17.4	

NOTES (by reference number):

1) No tendon is counted more than once in the tabulation.

2) A liftoff includes visual inspection of anchorage assembly and wire bundle; therefore, a liftoff takes precedence over a "visual - only" inspection in the tabulation.

3) "Visual - only" means visual inspection of anchorage assembly only; i.e., no liftoff performed to inspect wire bundle.

4) "N/A" means not applicable for this tendon type.

5) Longitudinal tendons can only be lifted off on top end.

6) Most, but not all, PCRV tendons are accessible for liftoff and/or visual inspection.

7) Longitudinal tendons excluded from total number of tendons for this total percentage.

8) This total percentage is based on the total number of longitudinal tendons.

The remaining accessible tendons not surveilled to date, all of which are circumferential tendons, will be included in the groups of new tendons for subsequent surveillance periods until all accessible PCRV tendons have been surveilled. The proposed revised surveillance schedule, as outlined in Letter P-87234, would accelerate completion of surveillance of all remaining accessible tendons without a surveillance to date.

APPENDIX A

PCRV TENDON SURVEILLANCE PLAN DRAWINGS

Drawing Number	Tendon Type
1A	Longitudinal
1B	Circumferential Layers 2, 5 and 4
1C	Circumferential Layers 1, 6 and 3
1D	Top Crosshead Bottom Crosshead

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