5.1 Transition Probability Matrices

The optimal policy is very sensitive to the choice of covariate bands and it is thus very important to choose these bands with great care. As explained in Chapter 3 is it generally recommended to select the lower bands shorter than the upper bands especially for vibration covariates, because vibration covariate values tend to be closely grouped under normal wear-out of a component and outlier values only occur sporadically. The data used for this research also shows this behavior. See the PDF's of the two covariates below, represented by continuous Weibull distributions:

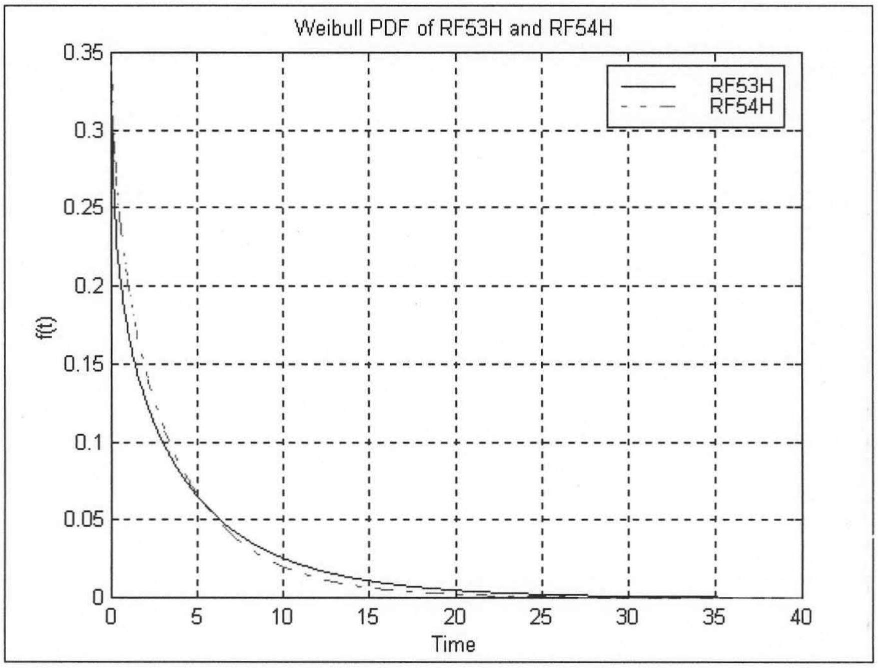

Figure 5.1.: *PDF of observed RF53H values*

After evaluation of Figure 5.1., the following bands were selected that resulted in realistic cost models (explained later):

RF53H		RF54H	
Band	**Frequency**	**Band**	**Frequency**
[0-5]	67	[0-3]	54
(5-10]	15	(3-7]	28
(10-15]	11	(7-11]	11
(15-26.84]	4	(11-15]	4
(26.84-∞)	1	(15-∞)	1

Table 5.1.: *Selected bands and observed frequencies*

With the above covariate bands the transition rates were determined and transition matrices were calculated. For example, the transition probabilities for covariate RF53H for an observation interval of 50 days are given in Table 5.2.

BANDS	[0-5]	(5-10]	(10-15]	(15-26.84]	(26.84-∞)
[0-5]	0.913	0.068	0.014	0.004	0.001
(5-10]	0.208	0.481	0.173	0.088	0.050
(10-15]	0.063	0.260	0.228	0.216	0.233
(15-26.84]	0.010	0.064	0.104	0.234	0.588
(26.84-∞)	0	0	0	0	1

Table 5.2.: *TPM for RF53H (for observation interval of 50 days)*

From the table it can be seen that if RF53H is currently between 0 and 5, then after 50 days it will be still within the same limits, with a probability of 91.3%. If it is currently between 5 and 10, it will stay there with a probability 48.1%, but it can also decrease, with the probability 20.8%, i.e. it can improve. This is very realistic in practice since vibration levels most often increase with the deterioration process but it can sometimes decrease because of specific wear mechanisms present in the component as was observed in the data. Similarly was the TPM for RF54H determined. See Table 5.3.

BANDS	[0-3]	(3-7]	(7-11]	(11-15]	(15-∞)
[0-3]	0.893	0.090	0.014	0.0009	0.0004
(3-7]	0.239	0.547	0.184	0.017	0.011
(7-11]	0.108	0.078	0.609	0.96	0.105
(11-15]	0	0	0	0.212	0.787
(15-∞)	0	0	0	0	1

Table 5.3.: *TPM for RF54H (for observation interval of 50 days)*

5.2 Cost Function and Optimal Replacement Policy

As mentioned earlier, were the costs provided by the Twistdraai plant, $C_f = R\,162\,200$ and $C_p = R\,25\,000$ based on averages over the two year data horizon. Further details about the cost estimation are not available.

No fixed inspection frequency was used at the plant which made calculations somewhat more difficult. The transition probability matrices were estimated based on transition rates (as described in Chapter 3, section 6.2.2.) and a future inspection interval of 50 days was used for the cost model. With all preliminary calculations completed, the cost function (equation (6.17.) of Chapter 3) was hence calculated using the backward recursive procedure. The result is shown graphically in Figure 5.2. in terms of the threshold risk level, d (or $h(t,\overline{z(t)})\cdot K$) for convenience.

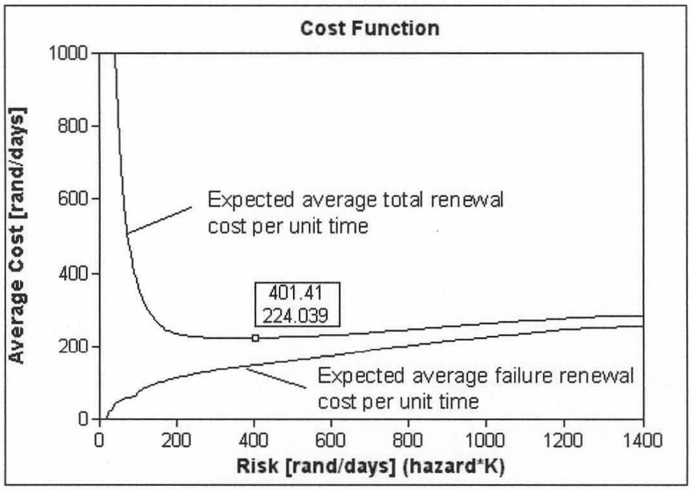

Figure 5.2.: *Estimated cost function in terms of risk*

A distinct optimum exist at a risk of R 401.41 / day or a hazard rate of $h = 0.0029$. This optimum is not very sensitive to slight deviations from the decision rule. With the optimal risk known it is also possible to represent the replacement rule and warning level function graphically (equations (6.24.) and (6.26.) of Chapter 3):

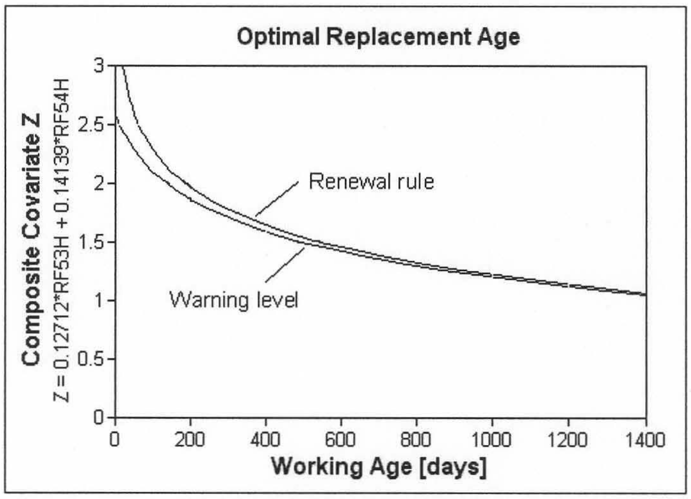

Figure 5.3.: *Decision policy*

5.3 Evaluation of Optimal Renewal Policy

First a summary of the performance of the optimal renewal policy is presented in Table 5.4. below, whereafter detailed comments follow.

	Theoretical Optimal Policy	Renew Only at Failure Strategy	Theoretical Policy Applied	Real Policy
Cost	224.04	401.41	214.03	345.16
Preventive Renewal Cost	75.31 (33.6%)	0 (0%)	100.56 (47.0%)	63.21 (18.3%)
Failure Renewal Cost	148.73 (66.4%)	401.41 (100%)	113.47 (53.0%)	281.95 (81.7%)
Preventive Renewals	76.7%	0%	80.0%	42.1%
Failure Renewals	23.3%	100%	20.0%	57.9%
MTTR	254.49 days	404.08 days	263.6 days	214.6 days

Table 5.4.: *Summary of renewal policy performance (All costs are in R/day)*

The table shows that the theoretical model predicts an average cost of R 224.4 / day when using the calculated optimal renewal policy, with 66.4% of the cost due to failures, although failures only occur 23.3% of the time. This is due to a relatively high renewal cost ratio of R 162 200 / R 25000 = 6.5. The average time between renewals is calculated to be 254.5 days. If no renewal policy is used, except at failures, it would result in a mean time between failures of 404.1 days, close to an estimate of 415.5 days obtained from the simple Weibull model (see section 4.1.), but with an average cost of renewal of R 401.4 / day. This would be 44.2% more expensive than using the optimal policy.

To evaluate the above mentioned theoretical costs, it should be compared with: (a) the real replacement costs realized for the analyzed histories, (b) the cost that would be obtained if the theoretical optimal policy was used for the analyzed histories

(a) It is very important to realize that there are two options when using real histories for the cost calculation. Every failure or suspension (preventive renewal) has a clearly defined cost, either C_f or C_p, but this is not the case for temporary suspensions or calendar suspensions. A conservative approach is to exclude all temporary suspensions from the calculation (TSE method) or a less conservative method is to include them all in the calculation as true suspensions (TSI method). The TSI method could be justified by counting the replacement cost at the beginning of the history as an installation cost, so that the calculated average replacement cost would be a "current" average cost. With a large number of histories, and not many temporary suspensions, both methods will give similar results. With a small number of histories and many temporary suspensions, the TSE method usually gives an overestimation of the real average cost value. Using both methods, the real average replacement cost for the pumps over the analysis horizon was R 345.16 / day (using the TSI method, counting 11 failures and 16 suspensions), or R 385.58 / day (using the TSE method, counting 11 failures and 8 suspensions). So, if the TSI method cost is compared to the theoretical optimal cost, the saving would be (345-224)/345 = 35%. The real policy is slightly better than the policy to replace only at failure, with a saving of (401-345)/401 = 14%. The real average time to renewal is 214.6 days, calculating only completed histories (failures and true suspensions). The theoretical mean time to renewal is 254.5 days which can also be considered as an advantage of the theoretical optimal policy.

(b) The optimal theoretical decision policy is applied on all 27 histories. Three situations are considered: (i) immediate renewal based on the most recent inspection record; (ii) renewal based on an earlier inspection record (with that renewal time counted); and (iii) no renewal based on all inspection records. After appying the theoretical policy, the number of failures was reduced from 11 to 4, which is then 4/19 = 21% of all renewals (temporary suspensions excluded), close to the theoretical value of 23%. Renewal times were not significantly reduced, which resulted in a significant reduction of the average cost. Using the TSI method, the average renewal cost is R 214 / day, close to the theoretical cost of R 224 / day, so the real saving would be (345-214)/345 = 38%. Using the TSE method, the average cost is R 215 / day (one real temporary suspension is included in the calculation as a definite suspension, due to (ii)), surprisingly close to the previous value. The average renewal time is 263.6 days (7 undecided temporary suspensions excluded), close to the theoretical value of 254.5 days.

Such coincidence of the theoretical and actual results in some of the above cases should not be expected in general, particularly for a small sample size, but it shows that the selected statistical and decision models are reasonable. The method of comparison could be argued because the same data is used to build the model and to test it. The method can be justified however by noticing that the data is first used to build the statistical model and then to calculate the optimal decision policy, without refering to the actual renewal policy. Theoretically, the same statistical model would be obtained (within the range of a statistical error), even if the actual policy was to renew only at failure. With a larger data set (more histories) other methods can be used, such as to use a random sample of histories to build the model, and then the rest as a control group to test the model.

As a final test of the renewal decision policy's performance, more data was collected from the plant from November 1st, 1998 to February 28th, 1999. During this period only one of the pumps considered as calendar suspensions in the first data set, failed and was renewed. The decision policy's performance for this pump's history is described here, although the data from the other pumps was tested as well.

Pump PC1232 was treated as a calendar suspension after 192 days of working life in the first data set. This was on November 1st, 1998. The pump eventually failed unexpectedly 67 days later on January 6th, 1999 at an age of 259 days. A total of five inspections were done during this time. The latest inspection data is plotted on Figure 5.4. below, together with the 4 inspections from the first data set.

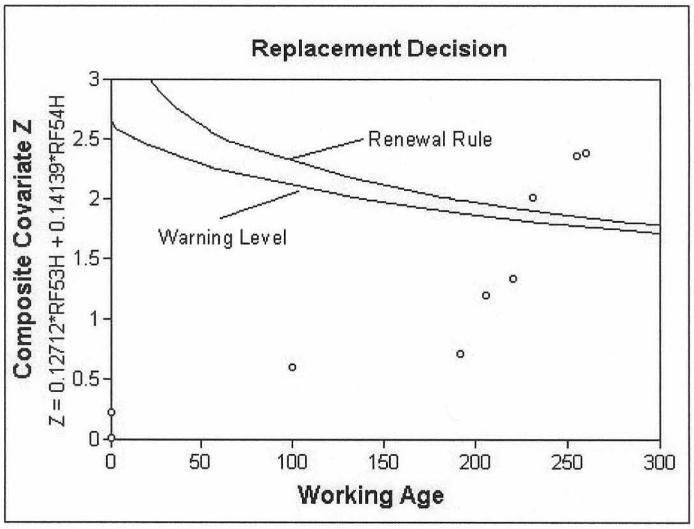

Figure 5.4.: *Example policy on PC1232*

Figure 5.4. shows clearly that the expensive unexpected failure could have been prevented if the calculated decision policy was followed. In terms of cost, the unexpected failure cost meant R 162 200 / 265 days = R 612.07 / day. If the PHM renewal policy was available and there was acted upon, R 25 000 / 235 days = R106.38 / day, would have been the result. This is another confirmation that the model is relevant and practical.

6 Conclusion

Although the final PHM was not statistically speaking a very accurate model, it proved to be of high practical value. The two covariates used in the model, RF53H and RF54H, were correctly identified as good predictors of events, somewhat contrary to statistical recommendations. This shows that a PHM analysis can never be done away from practice otherwise costly misinterpretations may be the result. The calculated optimal policy also withstood thorough evaluation and clearly showed its enormous benefits even with conservative assumptions.

Appendix

Pump Identification	Age (days)	Date	RF043H [mm/s]	RF13H [mm/s]	RF23H [mm/s]	RF53H [mm/s]	HFD3H [mm/s]	LNF3H [mm/s]
PC1131	159	2/7/97	0.00	0.70	0.30	0.80	1	0
PC1131	295	6/23/97	0.15	0.30	0.25	0.55	0	1
PC1131	387	9/23/97	0.30	3.00	0.90	8.00	1	0
PC1131	394	9/30/97	0.80	2.40	1.00	12.30	1	0
PC1131	397	10/3/97	250.00	175.00	20.00	17.00	1	0
PC1131	530	2/13/98	0.10	11.50	3.20	11.00	0	0
PC1131	533	2/16/98	0.30	8.80	3.50	13.00	1	0
PC1131	554	3/9/98	0.50	7.00	3.80	16.00	0	0
PC1131	578	4/2/98	1.00	19.50	1.50	2.00	1	0
PC1131	597	4/21/98	0.30	27.50	1.50	1.60	1	0
PC1131	639	6/2/98	0.50	31.00	6.00	4.00	1	0
PC1131	689	7/22/98	0.00	9.00	2.00	0.80	0	0
PC1131	690	7/23/98	0.00	8.27	1.82	0.67	0	0
PC1131	703	8/5/98	0.05	1.20	0.95	0.20	1	0
PC1131	712	8/14/98	0.05	0.50	0.80	1.40	1	0
PC1131	765	10/6/98	0.05	0.40	0.70	2.70	1	0
PC1131	791	11/1/98	0.50	9.00	2.00	12.00	0	0
PC1132	239	4/28/97	0.00	0.90	0.30	1.50	0	0
PC1132	386	9/22/97	0.10	7.00	0.60	2.10	1	0
PC1132	394	9/30/97	0.20	8.00	0.50	11.00	1	0
PC1132	397	10/3/97	0.10	6.20	0.20	3.00	0	0
PC1132	491	1/5/98	0.10	5.00	0.50	1.00	0	0
PC1132	499	1/13/98	0.10	27.50	2.00	2.50	0	0
PC1132	533	2/16/98	0.10	35.00	2.50	12.00	0	0
PC1132	543	2/26/98	5.00	19.00	26.00	9.00	0	0
PC1132	544	2/27/98	5.61	16.94	28.93	8.56	0	0
PC1132	557	3/12/98	3.00	43.00	9.00	2.00	0	0
PC1132	558	3/13/98	1.00	41.00	14.00	3.00	0	0
PC1132	597	4/21/98	4.00	29.00	3.70	2.60	0	1
PC1132	689	7/22/98	0.10	5.60	1.70	0.30	0	1
PC1132	712	8/14/98	0.10	3.40	0.60	0.90	0	1
PC1132	751	9/22/98	0.99	3.01	0.30	2.99	0	1
PC1132	791	11/1/98	0.08	4.65	0.17	2.01	0	0
PC1231	239	4/28/97	0.30	5.50	1.90	1.00	0	0
PC1231	295	6/23/97	1.30	10.40	2.20	1.00	0	0
PC1231	390	9/26/97	1.00	56.00	12.00	3.00	0	0
PC1231	530	2/13/98	0.30	18.10	6.10	8.50	1	0
PC1231	563	3/18/98	0.09	12.00	1.18	10.24	1	0
PC1231	578	4/2/98	1.00	33.00	18.00	6.00	1	1
PC1231	653	6/16/98	0.22	3.57	0.98	0.57	0	0
PC1231	698	7/31/98	0.68	8.11	1.47	0.61	0	0
PC1231	791	11/1/98	0.73	38.64	7.68	1.86	0	0
PC1232	583	4/7/98	0.50	56.00	9.00	4.00	0	0
PC1232	592	4/16/98	0.40	54.00	4.00	6.50	0	0

PC1232	597	4/21/98	0.60	48.00	9.00	3.50	0	0
PC1232	599	4/23/98	0.05	7.00	2.10	0.60	1	1
PC1232	699	8/1/98	0.33	34.16	5.76	2.48	0	0
PC1232	791	11/1/98	0.24	32.40	2.44	4.09	0	0
PC2131	156	2/4/97	0.00	9.00	1.20	0.40	0	0
PC2131	159	2/7/97	0.10	5.80	2.20	0.60	0	1
PC2131	178	2/26/97	0.20	4.00	3.30	1.35	0	1
PC2131	179	2/27/97	0.00	8.30	2.00	0.90	0	0
PC2131	184	3/4/97	0.00	36.39	2.00	1.00	0	1
PC2131	239	4/28/97	0.09	3.65	1.60	1.55	1	0
PC2131	241	4/30/97	0.05	3.10	0.75	1.70	1	0
PC2131	295	6/23/97	0.10	2.55	2.20	1.40	1	0
PC2131	386	9/22/97	0.40	5.60	7.50	0.70	1	0
PC2131	470	12/15/97	1200.00	120.00	30.00	10.00	0	0
PC2131	535	2/18/98	0.20	20.90	1.60	4.80	0	0
PC2131	583	4/7/98	2.00	77.00	46.00	11.00	0	0
PC2131	597	4/21/98	2.00	66.00	43.00	6.00	0	0
PC2131	604	4/28/98	1.00	74.00	37.50	5.00	1	0
PC2131	611	5/5/98	0.01	20.00	4.10	11.60	1	0
PC2131	631	5/25/98	0.10	18.00	10.00	72.33	1	0
PC2131	640	6/3/98	0.60	10.50	2.80	5.90	1	0
PC2131	689	7/22/98	0.09	1.70	0.40	0.50	1	0
PC2131	768	10/9/98	0.10	1.92	0.55	0.66	1	0
PC2131	774	10/15/98	0.14	2.66	0.76	1.12	1	0
PC2131	791	11/1/98	0.16	13.37	1.08	3.69	0	0
PC3131	241	4/30/97	0.10	6.80	3.90	1.30	1	0
PC3131	295	6/23/97	0.80	29.00	17.00	14.00	1	0
PC3131	386	9/22/97	0.50	37.00	6.50	4.00	1	0
PC3131	450	11/25/97	0.20	20.52	6.00	3.00	1	0
PC3131	550	3/5/98	0.09	7.20	3.74	1.27	1	0
PC3131	651	6/14/98	0.96	33.06	17.34	16.80	1	0
PC3131	750	9/21/98	0.59	40.33	6.43	4.16	1	0
PC3131	791	11/1/98	0.20	19.48	5.82	3.39	1	0
PC3132	239	4/28/97	0.10	2.40	0.15	0.39	1	0
PC3132	295	6/23/97	0.20	9.60	1.80	1.60	1	1
PC3132	386	9/22/97	0.20	24.00	3.00	3.50	1	1
PC3132	450	11/25/97	0.50	32.00	21.00	13.00	0	0
PC3132	506	1/20/98	0.97	37.56	48.37	26.84	0	0
PC3132	566	3/21/98	0.12	2.44	0.16	0.45	1	1
PC3132	711	8/13/98	0.19	11.04	1.92	1.82	1	1
PC3132	791	11/1/98	0.20	27.60	3.27	3.39	1	1
PC3232	239	4/28/97	0.30	11.50	3.80	0.60	1	0
PC3232	295	6/23/97	1.00	43.00	8.00	6.00	1	0
PC3232	386	9/22/97	2.00	39.00	6.00	6.00	1	0
PC3232	535	2/18/98	0.00	66.00	44.00	7.00	0	0
PC3232	563	3/18/98	0.00	75.72	56.86	7.33	1	0
PC3232	591	4/15/98	0.00	235.00	22.00	10.00	0	0
PC3232	604	4/28/98	2.00	175.00	18.00	7.00	0	0

PC3232	639	6/2/98	3.00	74.00	9.00	3.00	0	0
PC3232	722	8/24/98	0.00	20.50	14.80	1.90	1	1
PC3232	723	8/25/98	0.00	21.45	15.10	1.96	1	1
PC3232	748	9/19/98	0.18	7.59	2.96	0.39	1	0
PC3232	783	10/24/98	0.62	26.66	5.44	4.50	1	0
PC3232	791	11/1/98	1.28	28.08	3.72	4.08	1	0

Table A.1.: *Inspection data for bearing 3*

Pump Identification	Age (days)	Date	RF044H [mm/s]	RF14H [mm/s]	RF24H [mm/s]	RF54H [mm/s]	HFD4H [mm/s]	LNF4H [mm/s]
PC1131	159	2/7/97	0.05	0.85	0.30	0.10	1	0
PC1131	295	6/23/97	0.20	0.45	0.25	0.12	0	1
PC1131	387	9/23/97	0.10	4.00	1.70	6.20	1	0
PC1131	394	9/30/97	2.30	4.00	2.10	5.00	0	0
PC1131	397	10/3/97	4.00	4.60	2.80	6.00	1	0
PC1131	530	2/13/98	0.10	13.20	3.50	5.50	0	0
PC1131	533	2/16/98	0.20	10.00	3.80	7.00	1	0
PC1131	554	3/9/98	0.30	5.00	4.20	10.00	0	0
PC1131	578	4/2/98	0.70	42.00	3.00	3.00	1	0
PC1131	597	4/21/98	0.50	52.00	2.00	5.00	1	0
PC1131	639	6/2/98	0.50	47.00	8.00	5.00	1	0
PC1131	689	7/22/98	0.00	14.00	2.00	1.20	0	0
PC1131	690	7/23/98	0.00	13.04	1.73	1.08	0	0
PC1131	703	8/5/98	0.20	2.25	0.90	0.40	1	0
PC1131	712	8/14/98	0.05	0.58	1.30	0.41	1	1
PC1131	765	10/6/98	0.05	0.40	2.10	0.60	1	1
PC1131	791	11/1/98	0.20	12.00	2.00	7.00	0	0
PC1132	239	4/28/97	0.00	1.65	0.30	0.72	0	1
PC1132	386	9/22/97	0.10	12.20	0.70	7.80	1	0
PC1132	394	9/30/97	0.10	14.00	0.90	8.20	1	0
PC1132	397	10/3/97	0.20	12.00	0.90	12.00	1	0
PC1132	491	1/5/98	1.00	10.00	0.80	30.00	1	0
PC1132	499	1/13/98	0.10	66.00	4.00	12.00	0	0
PC1132	533	2/16/98	0.00	65.00	3.00	10.00	0	0
PC1132	543	2/26/98	1.00	120.00	38.00	7.00	0	0
PC1132	544	2/27/98	1.13	126.88	42.38	6.64	0	0
PC1132	557	3/12/98	1.00	34.00	5.00	2.50	1	0
PC1132	558	3/13/98	2.00	27.50	6.50	1.00	0	0
PC1132	597	4/21/98	1.00	24.00	4.20	5.40	0	1
PC1132	689	7/22/98	0.10	4.80	0.70	0.40	0	0
PC1132	712	8/14/98	0.05	2.70	0.30	0.40	0	0
PC1132	751	9/22/98	0.13	1.61	0.06	1.54	0	1
PC1132	791	11/1/98	0.15	7.80	0.56	7.68	1	0
PC1231	239	4/28/97	0.00	9.00	0.60	0.40	0	0
PC1231	295	6/23/97	0.30	16.50	2.30	0.30	0	0
PC1231	390	9/26/97	0.00	67.00	6.00	4.00	0	0
PC1231	530	2/13/98	0.00	21.00	6.00	6.00	1	1

PC1231	563	3/18/98	0.08	10.00	5.05	5.87	1	1
PC1231	578	4/2/98	2.00	51.00	16.00	9.00	1	1
PC1231	653	6/16/98	0.00	6.75	0.41	0.27	0	0
PC1231	698	7/31/98	0.22	10.72	1.35	0.15	0	0
PC1231	791	11/1/98	0.00	46.90	4.14	2.64	0	0
PC1232	583	4/7/98	0.00	71.00	8.00	3.00	0	0
PC1232	592	4/16/98	0.05	53.00	3.00	2.00	0	0
PC1232	597	4/21/98	1.00	57.00	6.00	3.00	0	0
PC1232	599	4/23/98	0.15	7.90	3.50	0.90	0	1
PC1232	699	8/1/98	0.00	49.70	5.28	1.92	0	0
PC1232	791	11/1/98	0.03	36.57	2.04	1.24	0	0
PC2131	156	2/4/97	0.00	15.50	2.10	0.50	0	1
PC2131	159	2/7/97	0.00	7.00	1.80	0.40	0	1
PC2131	178	2/26/97	0.05	6.70	2.30	0.40	0	0
PC2131	179	2/27/97	0.00	12.20	2.20	0.40	0	0
PC2131	184	3/4/97	0.00	47.97	1.51	0.40	0	1
PC2131	239	4/28/97	0.05	9.60	1.10	0.70	0	0
PC2131	241	4/30/97	0.10	8.10	1.00	0.70	1	0
PC2131	295	6/23/97	0.20	6.10	1.50	0.40	1	0
PC2131	386	9/22/97	1.70	21.00	1.40	3.70	1	0
PC2131	470	12/15/97	78.00	48.00	12.00	9.00	0	0
PC2131	535	2/18/98	0.50	27.00	7.40	7.00	0	0
PC2131	583	4/7/98	2.00	62.00	39.00	6.00	0	0
PC2131	597	4/21/98	2.00	64.00	38.00	4.00	0	0
PC2131	604	4/28/98	2.00	61.00	37.00	5.00	1	0
PC2131	611	5/5/98	0.01	24.00	6.00	1.40	1	0
PC2131	631	5/25/98	0.01	10.00	10.00	1.00	1	0
PC2131	640	6/3/98	0.20	26.00	1.00	4.00	1	0
PC2131	689	7/22/98	0.05	4.60	0.25	0.33	1	0
PC2131	768	10/9/98	0.05	4.20	0.30	0.20	1	0
PC2131	774	10/15/98	0.06	5.89	0.37	0.48	1	0
PC2131	791	11/1/98	0.34	17.55	4.66	5.60	0	0
PC3131	241	4/30/97	0.10	8.00	1.70	1.00	1	0
PC3131	295	6/23/97	0.70	35.00	10.00	7.00	1	0
PC3131	386	9/22/97	2.00	33.00	5.00	7.00	1	0
PC3131	450	11/25/97	3.13	20.00	4.00	2.00	1	0
PC3131	550	3/5/98	0.10	8.08	1.81	1.20	1	0
PC3131	651	6/14/98	0.71	39.20	9.80	7.70	1	0
PC3131	750	9/21/98	2.40	36.30	4.90	6.58	1	0
PC3131	791	11/1/98	3.47	21.40	4.08	1.80	1	0
PC3132	239	4/28/97	0.20	3.60	0.25	0.55	1	0
PC3132	295	6/23/97	0.30	12.20	0.90	2.20	1	1
PC3132	386	9/22/97	0.05	35.00	2.50	2.40	1	1
PC3132	450	11/25/97	0.00	81.00	8.00	6.50	0	0
PC3132	506	1/20/98	0.04	141.55	15.78	12.77	0	0
PC3132	566	3/21/98	0.23	4.32	0.25	0.59	1	0
PC3132	711	8/13/98	0.37	15.61	1.06	2.35	1	1
PC3132	791	11/1/98	0.06	39.90	3.25	2.61	1	1

PC3232	239	4/28/97	0.01	16.00	2.30	0.30	1	0
PC3232	295	6/23/97	1.00	48.00	9.00	4.00	1	0
PC3232	386	9/22/97	1.00	52.00	4.00	3.00	1	0
PC3232	535	2/18/98	0.00	91.00	26.00	8.00	0	0
PC3232	563	3/18/98	0.00	102.83	34.32	9.86	0	0
PC3232	591	4/15/98	0.00	280.00	10.00	15.00	0	0
PC3232	604	4/28/98	0.00	150.00	9.00	8.00	0	0
PC3232	639	6/2/98	5.00	73.00	6.00	6.00	0	0
PC3232	722	8/24/98	0.00	27.00	10.00	0.80	0	0
PC3232	723	8/25/98	0.00	27.62	10.14	0.73	0	0
PC3232	748	9/19/98	0.00	12.00	1.84	0.23	1	0
PC3232	783	10/24/98	0.73	30.72	5.85	3.20	1	0
PC3232	791	11/1/98	0.72	31.20	2.96	1.95	1	0

Table A.2.: *Inspection data for bearing 4*