CONSUMERS POWER CO. 50-255 Palisades

Addl info re; A Steam Generator Eddy Current Testing.....dtd Dec 1974

Rec'd w/ltr 1-31-75.....#1315

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NOTICE

DEADLINE RETURN DATE _____

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NOTICE

MARY JINKS, CHIEF
CENTRAL RECORDS STATION

1. Provide the summer 1974 and December 1974 raw ECT data for the tubes inspected during December 1974.

Answer

Enclosed is the raw data taken in December 1974 coupled with the data taken in the summer of 1974. It should be noted that where duplicate data existed for the summer 1974, these results are averaged. Readings of less than 20% are denoted by the number 19.

Although the data indicates that the June 1974 reading for tube Line 47, Row 46 in Quadrant III was zero, a rereading of the eddy current tape revealed a defect of 50-60% which had been missed. Also, the June 1974 values for tubes Line 39, Row 50, Quadrant III and Line 7, Row 102, Quadrant II were found to be <20% rather than zero by similar rereading of the tapes.

The computer printout does not include the data indicated to be between supports and one tube with a defect of 52% at #10 support plate. The data between support plates is presented below.

Line	Row	
Quadrant II		
25	86	<20% Between #3 and #5 Support
24	85	<20% Between Egg Crates
4	85	30% Between Egg Crates
11	100	40% Above #10
58	49	52% Between #2 Egg Crate and Top Support
Quadrant III		
3	96	34% Above #6
11	96	46% Between Egg Crates
14	93	46% Above #10
38	85	45% Below #10 - Multiple 24% Above #10
42	85	45% Multiple Above #10
48	91	52% Above #10
46	89	32% Above #10
34	45	Multiple 49% From #6 to Egg Crate 2
33	44	45% Between #4 and #6
32	45	35% Multiple Above #6

12-74

PALISADES "A" STM GEN
EDDY CURRENT TESTS
(ALL DEFECTS SHOWN

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
1	[redacted]1923	2	1	88	19	3			
					55	4			1
3	10901926	2	1	90	19	6			
					35	4			
					40	5		1	
6	11002224	2	1	100	22	4			
					33	6	1		
8	20893626	2	2	89	36	6			
					50	3			2
10	20911926	2	2	91	19	6			
					46	3		2	
12	20931923	2	2	93	19	3			
					25	5			
					35	6			
					48	4		3	
16	30861923	2	3	86	19	3			
					42	6		4	
18	40853223	2	4	85	32	3			
					44	EC1		5	
20	40891927	2	4	89	19	7			
					35	EC1			
					46	3		6	
23	40952423	2	4	95	24	3			
					48	7		7	
25	41032524	2	4	103	35	4			
					45	EC1		8	
27	51004028	2	5	100	40	EC1		9	
28	61032532	2	6	104	25	10			
					41	EC2		10	
30	70864823	2	7	86	48	3		11	
31	70921927	2	7	92	19	7			
					25	EC1			
					42	3		12	
34	70941937	2	7	94	19	EC2			
					30	3			
					36	7			
					36	EC1	2		
38	70963628	2	7	96	36	EC1			
					40	3			
					40	7		13	
41	71021923	2	7	102	19	3			
					45	EC2			
					69	10			3
44	71042932	2	7	104	29	10			
					34	3			
					48	EC2		14	
47	81052532	2	8	105	25	10			
					25	3	3		
49	90861930	2	9	86	19	EC2			
					30	3	4		
51	90884323	2	9	88	43	3		15	
52	90923126	2	9	92	31	EC1			
					45	3			
					52	7			4

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
55	[illegible]2723	2	9	106	27	3			
56	100873523	2	10	87	35	3	5		
57	100913323	2	10	91	33	3	6		
58	101051922	2	10	105	19	10			
					19	HLB			
					29	3			
61	110902828	2	11	90	28	EC1			
					33	3			
					36	7	7		
64	111003830	2	11	100	38	EC2			
					46	3		16	
66	111063037	2	11	106	30	HLB			
					35	3	8		
68	120873523	2	12	87	35	3			
					35	EC1			
					46	7		17	
71	120892223	2	12	89	22	2			
					40	7			
					46	EC1		18	
74	120951923	2	12	95	19	3			
					46	EC1		19	
76	121051937	2	12	105	19	HLB			
					35	3	9		
78	130583424	2	13	58	34	4	10		
79	130603724	2	13	60	37	4	11		
80	130881932	2	13	88	19	10			
					34	3			
					37	EC1	12		
83	130923123	2	13	92	31	3			
					38	HLB			
					45	EC1		20	
86	140593224	2	14	59	32	4	13		
87	140852232	2	14	85	22	10			
					38	3			
					46	EC1		21	
90	140871932	2	14	87	19	10			
					19	12			
					41	3			
					46	EC2		22	
94	140951923	2	14	95	19	3			
					19	10			
					19	12			
					49	EC2		23	
98	141053423	2	14	105	34	3	14		
99	151043923	2	15	104	39	3	15		
100	160514524	2	16	51	45	4		24	
101	160533924	2	16	53	39	4	16		
102	160613024	2	16	61	30	4	17		
103	160913230	2	16	91	32	EC2			
					34	3	18		
105	161031937	2	16	103	19	HLB			
					36	3	19		
107	170903623	2	17	90	36	3			
					43	EC2		25	

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
109	[redacted]1934	2	17	100	19	12			
					29	3			
111	171044923	2	17	104	49	3		26	
112	180534224	2	18	53	42	4		27	
113	180593024	2	18	59	30	4	20		
114	180633624	2	18	63	36	4	21		
115	180654023	2	18	65	40	3			
					45	EC2		28	
117	180673930	2	18	67	39	EC2			
					45	3		29	
119	180892623	2	18	89	26	3			
					38	EC2	22		
121	180932432	2	18	93	24	10			
					40	EC2			
					47	3		30	
124	180951932	2	18	95	19	10			
					21	12			
					45	3		31	
127	181034623	2	18	103	46	3		32	
128	190543624	2	19	54	38	4	23		
129	190643224	2	19	64	32	4	24		
130	190903730	2	19	90	37	EC2			
					41	3		33	
132	200513024	2	20	51	30	4	25		
133	200552924	2	20	55	29	4			
134	200633324	2	20	63	33	4	26		
135	200871928	2	20	87	19	EC1			
					44	3		34	
137	200891923	2	20	89	19	3			
					42	EC2		35	
139	200933823	2	20	93	36	3	27		
140	200954223	2	20	99	42	3		36	
141	210443624	2	21	44	36	4	28		
142	210623024	2	21	62	30	4	29		
143	210881930	2	21	88	19	EC2			
					19	10			
					37	3	30		
146	210924223	2	21	92	42	3			
					44	EC2		37	
148	211004023	2	21	100	40	3		38	
149	211044423	2	21	104	44	3		39	
150	211063823	2	21	106	36	3	31		
151	220454224	2	22	45	42	4		40	
152	220573824	2	22	57	38	4	32		
153	220593824	2	22	59	38	4	33		
154	220871930	2	22	87	19	EC2			
					20	3			
					20	10	34		
157	220912532	2	22	91	25	10			
					42	3			
					42	EC2		41	
160	220994523	2	22	99	45	3		42	
161	221053723	2	22	105	37	3	35		
162	2305844424	2	23	58	44	4		43	

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
163	[redacted]62023	2	23	86	20	3			
164	230903032	2	23	90	30	10			
					38	3			
					44	EC2		44	
167	231044023	2	23	104	40	3		45	
168	240493324	2	24	49	33	4	36		
169	240613424	2	24	61	34	4	37		
170	240853623	2	24	85	36	3	38		
171	240954723	2	24	95	47	3		46	
172	240974923	2	24	97	49	3		47	
173	241054223	2	24	105	42	3		48	
174	250403024	2	25	40	30	4			
					30	EC1	39		
176	250604524	2	25	60	45	4		49	
177	250804123	2	25	86	41	3			
					40	EC2		50	
179	251043923	2	25	104	39	3	40		
180	251064323	2	25	106	43	3		51	
181	260472424	2	26	47	24	4			
					46	EC1		52	
183	260493928	2	26	49	39	EC1	41		
184	260859923	2	26	89	39	3	42		
185	260954923	2	26	95	49	3		53	
186	260974023	2	26	97	40	3		54	
187	270564724	2	27	56	27	4			
188	270583224	2	27	58	32	4	43		
189	270862037	2	27	86	20	HLB			
					47	3		55	
191	270883134	2	27	88	31	12			
					38	3	44		
193	270902037	2	27	90	20	HLB			
					44	3		56	
195	270922334	2	27	92	23	12			
					45	3		57	
197	271043823	2	27	104	38	3	45		
198	280494030	2	28	49	40	EC2		58	
199	280853023	2	28	85	36	3	46		
200	280892032	2	28	89	20	10			
					43	3		59	
202	280953623	2	28	95	38	3	47		
203	280974823	2	28	97	48	3		60	
204	280994423	2	28	99	44	3		61	
205	281054023	2	28	105	48	3		62	
206	290504030	2	29	50	40	EC2		63	
207	290604324	2	29	60	43	4		64	
208	290863823	2	29	86	38	3	48		
209	291044623	2	29	104	46	3		65	
210	291064123	2	29	106	41	3		66	
211	300514230	2	30	51	42	EC2		67	
212	300593924	2	30	59	39	4	49		
213	300874423	2	30	87	44	3		68	
214	300894023	2	30	89	40	3		69	
215	300954823	2	30	95	48	3		70	
216	300974023	2	30	97	40	3		71	

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
217	992037	2	30	99	20	HLB			
					42	3		72	
219	301054823	2	30	105	48	3		73	
220	310604424	2	31	60	44	4		74	
221	310864123	2	31	86	41	3		75	
222	310983823	2	31	98	38	3	50		
223	311044523	2	31	104	45	3		76	
224	320513528	2	32	51	35	EC1	51		
225	320531924	2	32	53	19	4			
					52	EC2			5
227	320594024	2	32	59	40	4		77	
228	320614324	2	32	61	43	4		78	
229	320873023	2	32	87	30	3	52		
230	320893923	2	32	89	39	3	53		
231	320953923	2	32	95	39	3	54		
232	320993223	2	32	99	32	3	55		
233	321013123	2	32	101	31	3	56		
234	321074423	2	32	107	44	3		79	
235	330521923	2	33	52	19	3			
					35	EC1			
					56	EC2			6
238	330584224	2	33	58	42	4		80	
239	330604224	2	33	60	42	4		81	
240	330884923	2	33	88	49	3		82	
241	330963823	2	33	96	38	3	57		
242	341003323	2	34	100	33	3	58		
243	340573524	2	34	57	35	4	59		
244	340833523	2	34	85	35	3	60		
245	340873023	2	34	87	30	3	61		
246	340893523	2	34	89	35	3	62		
247	340973923	2	34	97	39	3	63		
248	341034223	2	34	103	42	3		83	
249	341073023	2	34	107	30	3	64		
250	350963223	2	35	96	32	3	65		
251	350983523	2	35	98	35	3	66		
252	351003623	2	35	100	36	3	67		
253	351044323	2	35	104	43	3		84	
254	360592824	2	36	59	28	4			
					42	11		85	
256	360954423	2	36	95	44	3		86	
257	370443626	2	37	44	36	EC1			
					42	6		87	
259	370461926	2	37	46	19	6			
					46	EC1		88	
261	370483428	2	37	48	34	EC1	68		
262	370943623	2	37	94	36	3	69		
263	380452528	2	38	45	25	EC1			
					40	6		89	
265	380855223	2	38	85	52	3			7
266	380893932	2	38	89	39	10			
					42	3		90	
268	380954323	2	38	95	43	3		91	
269	381013923	2	38	101	39	3	70		
270	390461928	2	39	46	19	EC1			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
					38	6			
272	390541924	2	39	54	19	4			
					19	11			
					30	EC2	72		
275	390603024	2	39	60	20	4			
					48	11		92	
277	390623033	2	39	62	30	11	73		
278	390863823	2	39	86	38	3	74		
279	390943923	2	39	94	39	3	75		
280	400454626	2	40	45	46	6		93	
281	400591924	2	40	59	19	4			
					19	11			
					19	HLB			
284	400611924	2	40	61	19	4			
					35	11	76		
286	400853223	2	40	85	32	3	77		
287	400874023	2	40	87	40	3		94	
288	401054323	2	40	105	43	3		95	
289	401073023	2	40	107	30	3	78		
290	410504828	2	41	50	48	EC1		96	
291	410601933	2	41	60	19	11			
					19	HLB			
					30	4	79		
294	410943123	2	41	94	31	3	80		
295	410963723	2	41	96	37	3	81		
296	411043723	2	41	104	37	3	82		
297	420513333	2	42	51	33	11			
					42	EC2		97	
299	420571924	2	42	57	19	4			
					34	11	83		
301	420611937	2	42	61	19	HLB			
					35	4			
					40	11		98	
304	421014023	2	42	101	40	3		99	
305	421073023	2	42	107	30	3	84		
306	430501933	2	43	50	19	11			
					19	HLB			
					36	EC2	85		
309	430561924	2	43	56	19	4			
310	430601937	2	43	60	19	HLB			
					20	11			
					42	4		100	
313	430642233	2	43	64	22	11			
314	440571924	2	44	57	19	4			
					32	11	86		
316	440611924	2	44	61	19	4			
					32	11			
					40	HLB		101	
319	450583224	2	45	58	32	4			
					46	11		102	
321	450603033	2	45	60	30	11			
					30	HLB			
					35	4	87		
324	450641933	2	45	64	19	11			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
325	460024023	2	45	102	40	3		103	
326	460453624	2	46	45	36	4			
					40	6		104	
328	460571924	2	46	57	19	4			
					34	HLB	88		
330	460611937	2	46	61	19	HLB			
					29	4			
					35	11	89		
333	460914523	2	46	91	45	3		105	
334	460954423	2	46	95	44	3		106	
335	470481933	2	47	46	19	11			
					25	4			
					44	EC2		107	
338	471062523	2	47	106	35	3	90		
339	480591924	2	48	59	19	4			
					47	11		108	
341	480615133	2	48	61	51	11			8
342	480853923	2	48	85	39	3	91		
343	480953223	2	48	95	32	3			
					35	HLB	92		
345	490482224	2	49	48	22	4			
					36	EC2	93		
347	490502524	2	49	50	25	4			
348	490602933	2	49	60	29	11			
349	490924423	2	49	92	44	3		109	
350	500874023	2	50	87	40	3		110	
351	500922437	2	50	93	24	HLB			
					50	3			9
353	510864823	2	51	86	48	3		111	
354	510921937	2	51	92	19	HLB			
					46	3		112	
356	510944037	2	51	94	40	HLB		113	
357	510962937	2	51	96	29	HLB			
					41	3		114	
359	510984723	2	51	98	47	3		115	
360	511022823	2	51	102	28	3			
361	520571924	2	52	57	19	4			
					42	HLB		116	
363	520874623	2	52	87	46	3		117	
364	520894423	2	52	89	44	3		118	
365	520913237	2	52	91	32	HLB			
					46	3		119	
367	520973927	2	52	97	39	HLB			
					46	3		120	
369	530561924	2	53	56	19	4			
370	530923823	2	53	92	38	3	94		
371	540571924	2	54	57	19	4			
					29	HLB			
373	540874423	2	54	87	44	3		121	
374	540894523	2	54	89	45	3		122	
375	540923737	2	54	95	37	HLB	95		
376	540971923	2	54	97	19	3			
					36	HLB	96		
378	541031923	2	54	103	19	3			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
					38	HLB	97		
380	550462528	2	55	46	25	EC1			
					30	10			
					36	4			
					40	EC2		123	
384	550903924	2	55	90	39	3	98		
385	560534024	2	56	53	40	4		124	
386	560554324	2	56	55	43	4		125	
387	560596524	2	56	59	25	4			
388	570623224	2	57	62	32	4	99		
389	580443224	2	58	49	32	4	100		
390	580613024	2	58	61	30	4	101		
391	600614824	2	60	51	46	4		126	
392	600614024	2	60	61	40	4		127	
393	20851943	3	2	85	19	3			
					19	TS			
					35	7	102		
396	20951944	3	2	95	19	4			
					19	6			
					43	5		128	
399	20971944	3	2	97	19	4			
					19	6			
					43	5		129	
402	30443344	3	3	44	33	4	103		
403	30861947	3	3	86	19	7			
					35	3	104		
405	30881943	3	3	88	19	3			
					19	6			
					19	10			
408	30901946	3	3	90	19	6			
					19	TS			
					43	3		130	
411	30941943	3	3	94	19	3			
					19	TS			
					36	6	105		
414	30961943	3	3	96	19	3			
					19	4			
416	40473757	3	4	47	37	HLB	106		
417	40851958	3	4	85	19	TS			
					25	EC1			
					30	3	107		
420	40871956	3	4	87	19	TS			
					36	EC1			
					48	3		131	
423	40951943	3	4	95	19	3			
					19	6			
					19	7			
					19	TS			
427	40971943	3	4	97	19	3			
					19	6			
					19	7			
430	50861956	3	5	86	19	TS			
					40	3		132	
432	50881958	3	5	88	19	TS			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
					35	3			
					36	EC1	108		
435	50501943	3	5	90	19	3			
					19	TS			
					40	EC1		133	
438	50921958	3	5	92	19	TS			
					30	3			
					35	EC1	109		
441	60993448	3	6	99	34	EC1	110		
442	61003650	3	6	103	36	EC2	111		
443	70801950	3	7	66	19	EC2			
					39	TS			
					40	3		134	
446	80851958	3	8	85	19	TS			
					30	3			
					39	EC2	112		
449	80871958	3	8	87	19	TS			
					39	3	113		
451	80931943	3	8	93	19	3			
					19	TS			
					42	EC1			
					46	7		135	
455	80971943	3	8	97	19	3			
					19	TS			
					30	6			
					42	EC1		136	
459	80993548	3	8	99	35	EC1	114		
460	81031954	3	8	104	19	12			
					25	10			
					40	EC2		137	
463	90881958	3	9	88	19	TS			
					48	3		138	
465	90921943	3	9	92	19	3			
					19	TS			
					46	7		139	
468	90941943	3	9	94	19	3			
					19	TS			
					48	EC1		140	
471	100851958	3	10	85	19	TS			
					30	EC2			
					45	3		141	
474	100921943	3	10	95	19	3			
					19	TS			
					46	EC1		142	
477	110941943	3	11	94	19	3			
					19	TS			
					40	EC1		143	
480	110961943	3	11	96	19	3			
					19	TS			
482	120591944	3	12	59	19	4			
483	120851948	3	12	85	19	EC1			
					34	EC2			
					44	3		144	
486	120871958	3	12	87	19	TS			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
					40	3			
					42	EC2		145	
489	120971943	3	12	97	19	3			
					25	EC2			
491	120991943	3	12	99	19	3			
					19	10			
					30	EC2	115		
494	130581944	3	13	56	19	4			
495	130604144	3	13	60	41	4		146	
496	130863050	3	13	86	30	EC2			
					43	3		147	
498	140592844	3	14	59	28	4			
499	140613158	3	14	61	31	TS			
					40	4		148	
501	140871958	3	14	87	19	TS			
					24	EC2			
					30	3	116		
504	140931543	3	14	93	19	3			
					30	EC2	117		
506	140951943	3	14	95	19	3			
					19	TS			
					32	EC2	118		
509	140971953	3	14	97	19	11			
					19	TS			
					32	3	119		
512	150441944	3	15	44	19	4			
513	150463944	3	15	46	39	4	120		
514	150602444	3	15	60	24	4			
515	150622544	3	15	62	25	4			
516	150861956	3	15	86	19	TS			
					30	EC2			
					40	3		149	
519	150881943	3	15	88	19	3			
					19	TS			
					40	EC2		150	
522	150901958	3	15	90	19	TS			
					24	3			
					40	EC2		151	
525	150921943	3	15	92	19	3			
					19	TS			
					40	EC2		152	
528	170443544	3	17	44	32	4	121		
529	170464044	3	17	46	40	4		153	
530	170543044	3	17	54	30	4	122		
531	170563644	3	17	56	36	4	123		
532	170644144	3	17	64	41	4		154	
533	170683043	3	17	68	30	3			
					40	10			
					46	EC2		155	
536	170902552	3	17	90	25	10			
					35	TS			
					46	EC2		156	
539	170921943	3	17	92	19	3			
					19	11			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
					19	TS			
					30	10			
					42	EC2		157	
544	170961943	3	17	96	19	3			
					19	10			
					19	TS			
					25	12			
548	170982054	3	17	98	20	12			
					25	3			
550	171001954	3	17	100	19	12			
					31	3	124		
552	171064743	3	17	106	47	3		158	
553	180514344	3	18	51	43	4		159	
554	180871952	3	18	87	19	10			
					19	TS			
					30	3			
					45	EC2		160	
558	180891943	3	18	89	19	3			
					19	10			
					19	TS			
					46	EC2		161	
562	180911943	3	18	91	19	3			
					19	EC2			
					31	10	125		
565	180951952	3	18	95	19	10			
					19	12			
					19	TS			
					31	3	126		
569	180973643	3	18	97	36	3	127		
570	190564044	3	19	56	40	4		162	
571	190643744	3	19	64	27	4	128		
572	190901943	3	19	90	19	3			
					19	TS			
					22	10			
					42	EC2		163	
576	190964743	3	19	96	47	3		164	
577	190983043	3	19	98	30	3	129		
578	191064443	3	19	106	44	3		165	
579	200473044	3	20	47	30	4	130		
580	200493544	3	20	49	35	4	131		
581	200553044	3	20	55	30	4	132		
582	201034643	3	20	103	46	3		166	
583	201053443	3	20	105	34	3	133		
584	210444044	3	21	44	40	4		167	
585	210561944	3	21	58	19	4			
					40	TS		168	
587	210881943	3	21	88	19	3			
					19	TS			
					30	EC2	134		
590	211002543	3	21	100	25	3			
591	220553044	3	22	55	30	4	135		
592	220591958	3	22	59	19	TS			
					25	"			
594	220611958	3	22	61	19	TS			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
					30	4	136		
596	220871952	3	22	87	19	10			
					19	TS			
					25	EC2			
599	220954843	3	22	95	48	3		169	
600	221034243	3	22	103	42	3		170	
601	230443044	3	23	44	30	4	137		
602	230561958	3	23	56	19	TS			
					38	4	138		
604	230581958	3	23	58	19	TS			
					30	4	139		
606	230601958	3	23	60	19	TS			
					24	4			
608	230623044	3	23	62	30	4	140		
609	230881943	3	23	88	19	3			
					19	TS			
					24	10			
					38	EC2	141		
613	230922543	3	23	92	25	3			
614	230962943	3	23	96	29	3			
615	231045743	3	23	104	57	3			10
616	240451944	3	24	45	19	4			
					42	EC1		171	
618	240551958	3	24	55	19	TS			
					37	4	142		
620	240571958	3	24	57	19	TS			
					31	4	143		
622	240851943	3	24	85	19	3			
					19	TS			
					20	EC2			
					45	EC1		172	
626	240871958	3	24	87	19	TS			
					34	2			
					40	EC2		173	
629	240973843	3	24	97	38	3	144		
630	241014543	3	24	101	45	3		174	
631	250441944	3	25	44	19	4			
					34	6			
					48	EC1		175	
634	250463144	3	25	46	31	4			
					55	EC1			11
636	250582658	3	25	58	26	TS			
					32	4	145		
638	250602658	3	25	60	26	TS			
					31	4	146		
640	250861943	3	25	88	19	3			
					19	TS			
					22	10			
643	250943943	3	25	94	39	3	147		
644	250964843	3	25	96	48	3		176	
645	260571958	3	26	57	19	TS			
					26	4			
647	260591958	3	26	59	19	TS			
					28	4			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
649	60613158	3	26	61	31	TS			
					36	4	148		
651	260891954	3	26	89	19	12			
					19	TS			
					22	3			
654	260911943	3	26	91	19	5			
					19	12			
656	260932243	3	26	93	22	3			
657	270461944	3	27	46	19	4			
					31	EC1			
					35	6	149		
660	270561958	3	27	56	19	TS			
					26	4			
662	270581958	3	27	58	19	TS			
					28	4			
664	270881958	3	27	86	19	TS			
					20	3			
666	270943443	3	27	94	34	3	150		
667	280571956	3	28	57	19	TS			
					31	4	151		
669	280591958	3	28	59	19	TS			
					36	4	152		
671	280611958	3	28	61	19	TS			
					20	4			
					36	5	153		
674	280893543	3	28	89	25	3	154		
675	280931943	3	28	93	19	3			
676	281034043	3	28	103	40	3		177	
677	290501948	3	29	50	19	EC1			
678	290602358	3	29	60	23	TS			
					36	4	155		
680	290901943	3	29	90	19	3			
681	290922743	3	29	92	27	3			
682	290943143	3	29	94	31	3	156		
683	300494150	3	30	49	41	EC2			
					45	2		178	
685	300551958	3	30	55	19	TS			
					20	4			
687	300913943	3	30	91	39	3	157		
688	300972043	3	30	97	20	3			
689	301053443	3	30	105	34	3	158		
690	310581958	3	31	58	19	TS			
					36	4	159		
692	310943043	3	31	94	36	3	160		
693	310962043	3	31	96	20	3			
694	311063843	3	31	106	38	2	161		
695	320454946	3	32	45	49	6		179	
696	320513548	3	32	51	35	EC1			
					39	EC2	162		
698	320532044	3	32	53	20	4			
					34	EC2	163		
700	320592544	3	32	59	25	4			
701	320914043	3	32	91	40	3		180	
702	321034943	3	32	103	49	3		181	

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
703	330544443	3	32	109	43	3		182	
704	330441958	3	33	44	19	TS			
					45	5			
					45	6		183	
707	330464646	3	33	46	46	6		184	
708	330483646	3	33	48	36	6			
					46	EC1		185	
710	330521958	3	33	52	19	TS			
					47	EC2		186	
712	330541944	3	33	54	19	4			
					30	EC2	164		
714	330584144	3	33	58	41	4		187	
715	330883443	3	33	88	34	3	165		
716	340453046	3	34	45	30	6	166		
717	340513053	3	34	51	30	11			
					46	EC2			
					47	EC1		188	
720	340593144	3	34	59	31	4	167		
721	350442948	3	35	44	29	EC1			
722	350461958	3	35	46	19	TS			
					35	EC1	168		
724	350583344	3	35	58	23	4	169		
725	350602444	3	35	60	24	4			
726	350864243	3	35	86	42	3		189	
727	350884043	3	35	88	40	3		190	
728	350943843	3	35	94	38	3	170		
729	360431946	3	36	43	19	6			
					42	EC1		191	
731	360471948	3	36	47	19	EC1			
					19	TS			
733	360514848	3	36	51	48	EC1		192	
734	360551944	3	36	55	19	4			
					25	TS			
					30	EC2	171		
737	360871958	3	36	87	19	TS			
					41	3			
					42	4		193	
740	360894243	3	36	89	42	3		194	
741	370443448	3	37	44	34	EC1			
					44	6		195	
743	370461948	3	37	46	19	EC1			
744	370521953	3	37	52	19	11			
					52	EC2			12
746	370541953	3	37	54	19	11			
					30	EC2	172		
748	370603044	3	37	60	30	4			
					36	11			
					39	TS	173		
751	370944443	3	37	94	44	3		196	
752	380474448	3	38	47	44	EC1		197	
753	380511958	3	38	51	19	TS			
					46	EC1		198	
755	380851952	3	38	85	19	10			
					37	3	174		

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
757	390514743	3	38	91	47	3		199	
758	380954243	3	38	95	42	3		200	
759	381034543	3	38	103	45	3		201	
760	390441958	3	39	44	19	TS			
					36	6			
					46	EC1		202	
763	390482448	3	39	48	24	EC1			
					28	6			
765	390503457	3	39	50	34	HLB			
					53	EC1			
					66	EC2			13
768	390561944	3	39	56	19	4			
					34	HLB	175		
770	390601953	3	39	60	19	11			
					30	4	176		
772	390863743	3	39	86	37	3	177		
773	390903443	3	39	90	34	3	178		
774	400451946	3	40	45	19	6			
					50	EC1			14
776	400472548	3	40	47	25	EC1			
					30	6	179		
778	400491958	3	40	49	19	TS			
					30	EC2			
					50	EC1			15
781	400512257	3	40	51	22	HLB			
					29	EC1			
783	400613553	3	40	61	35	11			
					40	4			
					40	TS		203	
786	400854343	3	40	85	43	3		204	
787	400874643	3	40	87	46	3		205	
788	400894843	3	40	89	48	3		206	
789	400953243	3	40	95	32	3	180		
790	400992843	3	40	99	28	3			
791	410401958	3	41	40	19	TS			
					45	EC1			
					50	EC2			16
794	410501958	3	41	50	19	TS			
					41	EC1		207	
796	410522950	3	41	52	29	EC2			
					31	11	181		
798	410923543	3	41	92	35	3	182		
799	410943043	3	41	94	30	3	183		
800	410964043	3	41	96	40	3		208	
801	410983843	3	41	98	38	3	184		
802	420475248	3	42	47	52	EC1			17
803	420512550	3	42	51	25	EC2			
					31	11	185		
805	420611958	3	42	61	19	TS			
					30	4	186		
807	420854552	3	42	85	45	10			
					47	3		209	
809	420875143	3	42	87	51	3			18
810	420913843	3	42	91	38	3	187		

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
811	[illegible]53743	3	42	105	37	3			
812	430481948	3	43	48	19	EC1			
					19	TS			
814	430501958	3	43	50	19	TS			
					38	11			
					45	EC2		210	
817	430521958	3	43	52	19	TS			
					34	4	189		
819	430631952	3	43	58	19	10			
					28	HLB			
					40	3		211	
822	430904943	3	43	90	49	3		212	
823	430923543	3	43	92	35	3	190		
824	430984343	3	43	98	43	3		213	
825	431004843	3	43	100	48	3		214	
826	440451958	3	44	45	19	TS			
					26	4			
828	440611944	3	44	61	19	4			
					19	TS			
					30	11	191		
831	440853252	3	44	85	32	10			
					43	3		215	
833	440954743	3	44	95	47	3		216	
834	440993043	3	44	99	30	3	192		
835	450442946	3	45	44	25	6			
					45	4		217	
837	450461958	3	45	46	19	TS			
					20	4			
					24	HLB			
					34	EC1	193		
841	450501944	3	45	50	19	4			
					19	11			
					40	EC2			
					40	HLB		218	
845	450902557	3	45	90	25	HLB			
					28	10			
					34	EC2			
					48	3		219	
849	450921952	3	45	92	19	10			
					19	12			
					36	3			
					41	PLB		220	
853	450944943	3	45	94	49	3		221	
854	450963843	3	45	98	38	3	194		
855	451003643	3	45	100	26	3	195		
856	460471948	3	46	47	19	EC1			
					30	4	196		
858	460873357	3	46	87	33	HLB			
					37	EC2			
					43	3		222	
861	460891957	3	46	89	19	HLB			
					32	10			
					40	EC2			
					46	3		223	

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
865	470973543	3	46	97	35	3			
866	470465148	3	47	46	51	EC1			
					56	4			
					74	EC2			19
869	470481948	3	47	48	19	EC1			
					30	4			
					53	EC2			20
872	470501944	3	47	50	19	4			
					30	HLB			
					40	EC2		224	
875	470904057	3	47	90	40	HLB			
					44	EC2			
					46	3		225	
878	470921952	3	47	92	19	10			
					19	HLB			
					44	3		226	
881	470941954	3	47	94	19	12			
					42	3		227	
883	470962057	3	47	96	20	HLB			
					42	3		228	
885	480871952	3	48	87	19	10			
					19	HLB			
					45	3		229	
888	480891952	3	48	89	19	10			
					33	HLB			
					38	3	196		
891	480912252	3	48	91	22	10			
					46	3		230	
893	480951954	3	48	95	19	12			
					25	HLB			
					38	3	199		
896	490481948	3	49	48	19	EC1			
					34	4			
					50	EC2			21
899	490941954	3	49	94	19	12			
					19	HLB			
					40	3		231	
902	490961957	3	49	96	19	HLB			
					40	3		232	
904	500494644	3	50	49	46	4			
					49	EC2		233	
906	500532544	3	50	53	25	4			
907	500671557	3	50	87	19	HLB			
					46	3		234	
909	500893357	3	50	89	33	HLB			
					43	3		235	
911	500994543	3	50	99	45	3		236	
912	510484450	3	51	48	44	EC2			
					46	4		237	
914	510522244	3	51	52	22	4			
915	520491952	3	52	49	19	10			
					42	4			
					45	EC2		238	
918	520532944	3	52	53	29	4			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
					30	HLB	00		
920	520571944	3	52	57	19	4			
921	520593257	3	52	59	32	HLB			
					38	4	201		
923	520613044	3	52	61	30	4	202		
924	520634144	3	52	63	41	4		239	
925	520914443	3	52	91	44	3		240	
926	520954343	3	52	95	43	3			
					44	HLB		241	
928	530542457	3	53	54	24	HLB			
					37	4	203		
930	530542944	3	53	04	29	2			
931	530904143	3	53	90	41	3		242	
932	540491952	3	54	49	19	10			
					25	4			
					40	EC2		243	
935	540573044	3	54	57	30	4	204		
936	550483550	3	55	48	35	EC2			
					45	4			
					47	EC1			
					56	10			22
940	550501950	3	55	50	19	EC2			
					25	10			
					42	4		244	
943	550524044	3	55	52	40	4		245	
944	550543244	3	55	54	32	4	205		
945	550584344	3	55	58	43	4		246	
946	550603544	3	55	60	35	4	206		
947	550664243	3	55	66	42	3		247	
948	550924843	3	55	92	48	3		248	
949	560451944	3	56	45	19	4			
					19	EC2			
					19	10			
					46	EC1		249	
953	560514244	3	56	51	42	4		250	
954	560894643	3	56	89	46	3		251	
922	570461952	3	57	46	19	10			
					45	EC2			
					51	4			
					51	EC1			23
959	570642544	3	57	64	25	4			
960	580451944	3	58	45	19	4			
					19	10			
					44	EC1		252	
963	580473144	3	58	47	31	4			
					34	EC2	207		
965	580513144	3	58	51	31	4	208		
966	580554544	3	58	55	45	4		253	
967	580613444	3	58	61	34	4	209		
968	580633744	3	58	63	37	4	210		
969	580653343	3	58	65	38	3	211		
970	590441944	3	59	44	19	4			
					19	EC2			
					19	10			

	TUBE	QUAD	LINE	ROW	DEFECT	LOCATION	N30	N40	N50
					38	EC1	212		
974	590463544	3	59	46	35	4			
					37	EC2	213		
976	590522044	3	59	52	28	4			
977	590603444	3	59	60	34	4	214		
978	600494544	3	60	49	45	4		254	
979	600513944	3	60	51	39	4	215		
980	600534244	3	60	53	42	4		255	
981	600575244	3	60	57	52	4			24

2. Provide a summary of the December 1974 ECT results by defect size for the following ranges of defect sizes: 30-39%, 40-49%, etc.

Answer

Attached, in addition to the summary, is a listing of data taken in December 1974, broken down into segments between 30% and 80%. In listing these data, an effort was made to list a tube only once. Each tube is listed in the appropriate interval corresponding to the maximum defect existing on the tube.

Also attached is a listing of tubes whose eddy current indications decreased by 5% or more.

SUMMARY OF DECEMBER 1974
Eddy Current Testing Results

Eddy Current Testing Indication of Defect Size	Number of Tubes
30 - 39	215
40 - 49	255
50 - 59	23
60 - 69	3
70 - 79	1

INCREMENTAL LISTING OF TUBES

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥70%				
Quadrant III	47	46	74	50-60
Eddy Current Readings ≥60 <70				
Quadrant II	7	102	69	<20
Ditto	48	61	61	30
Quadrant III	39	50	66	<20
Eddy Current Readings ≥50 <60				
Quadrant II	1	88	55	34
Ditto	2	89	50	29
"	9	92	52	37
"	32	53	52	45
"	33	52	56	<20
"	38	85	52	48
"	50	93	50	45
"	11	100	52	<20
"	58	49	52	<20 (Between EC2 & Top Supp)
Quadrant III	23	104	57	40
Ditto	25	46	55	42
"	37	52	52	44
"	40	45	50	46
"	40	49	50	30
"	41	46	50	<20
"	42	47	52	45
"	42	87	51	40
"	47	48	53	<20
"	49	48	50	34
"	55	48	56	<20
"	57	46	51	<20 <4 (34 EC-1)
"	60	57	52	40
"	48	91	52	<20 (Above #10)
Eddy Current Readings ≥40 <50				
Quadrant II	1	90	40	
Ditto	2	91	46	
"	2	93	48	
"	3	86	42	
"	4	85	44	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥40 <50 (Contd)				
Quadrant II	4	89	46	
Ditto	4	95	48	
"	4	103	45	
"	5	100	40	
"	6	103	41	
"	7	86	48	
"	7	92	42	
"	7	96	13	
"	7	104	48	
"	9	88	43	
"	11	100	48	
"	12	87	48	
"	12	89	46	
"	12	95	46	
"	13	92	45	
"	14	85	46	
"	14	87	46	
"	14	95	49	
"	16	51	45	
"	17	90	43	
"	17	104	49	
"	18	53	42	
"	18	85	45	
"	18	87	45	
"	18	93	47	
"	18	95	45	
"	18	103	46	
"	19	90	41	
"	20	87	44	
"	20	89	42	
"	20	99	42	
"	21	92	44	
"	21	100	40	
"	21	104	44	
"	22	45	42	
"	22	91	42	
"	22	99	45	
"	23	58	44	
"	23	90	44	
"	23	104	40	
"	24	95	47	
"	24	97	49	
"	24	105	42	
"	25	60	45	
"	25	86	46	
"	25	106	43	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥40 <50 (Contd)				
Quadrant II	26	47	46	
Ditto	26	95	49	
"	26	97	40	
"	27	86	47	
"	27	90	44	
"	27	92	45	
"	28	49	40	
"	28	89	43	
"	28	97	48	
"	28	99	44	
"	28	105	48	
"	29	50	40	
"	29	60	43	
"	29	104	46	
"	29	106	41	
"	30	51	42	
"	30	87	44	
"	30	89	40	
"	30	95	48	
"	30	97	40	
"	30	99	42	
"	30	105	48	
"	31	60	44	
"	31	86	41	
"	31	104	45	
"	32	59	40	
"	32	61	43	
"	32	107	44	
"	33	58	42	
"	33	60	42	
"	33	88	49	
"	34	103	42	
"	35	104	43	
"	36	59	42	
"	36	95	44	
"	37	44	42	
"	37	46	46	
"	38	45	40	
"	38	89	42	
"	38	95	43	
"	39	60	48	
"	40	45	46	
"	40	87	40	
"	40	105	43	
"	41	50	48	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥40 <50 (Contd)				
Quadrant II	42	51	42	
Ditto	42	61	40	
"	42	101	40	
"	43	60	42	
"	44	61	40	
"	45	58	46	
"	45	102	40	
"	46	45	40	
"	46	91	45	
"	46	95	44	
"	47	48	44	
"	48	59	47	
"	49	92	44	
"	50	87	44	
"	51	86	48	
"	51	92	46	
"	51	94	40	
"	51	96	41	
"	51	98	47	
"	52	57	42	
"	52	87	46	
"	52	89	44	
"	52	91	48	
"	52	97	46	
"	54	87	44	
"	54	89	45	
"	55	46	40	
"	56	53	40	
"	56	55	43	
"	60	51	48	
"	60	61	40	
Quadrant III	2	95	43	
Ditto	2	97	43	
"	3	90	43	
"	4	87	48	
"	5	86	40	
"	5	90	40	
"	7	86	40	
"	8	93	46	
"	8	97	42	
"	8	103	40	
"	9	88	48	
"	9	92	48	
"	9	94	48	
"	10	85	45	
"	10	95	46	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥40 <50 (Contd)				
Quadrant III	11	94	40	
Ditto	12	85	44	
"	12	87	42	
"	13	60	41	
"	13	86	43	
"	14	61	40	
"	15	86	40	
"	15	88	40	
"	15	90	40	
"	15	92	40	
"	17	46	40	
"	17	64	41	
"	17	88	48	
"	17	90	48	
"	17	92	42	
"	17	106	47	
"	18	51	43	
"	18	87	45	
"	18	89	46	
"	19	56	40	
"	19	90	42	
"	19	96	47	
"	19	106	44	
"	20	103	46	
"	21	44	40	
"	21	58	40	
"	22	95	48	
"	22	103	42	
"	24	45	42	
"	24	85	45	
"	24	87	40	
"	24	101	45	
"	25	44	48	
"	25	98	48	
"	28	103	40	
"	30	49	45	
"	32	45	49	
"	32	91	40	
"	32	103	49	
"	32	105	43	
"	33	44	45	
"	33	46	46	
"	33	48	48	
"	33	52	47	
"	33	58	41	
"	34	51	47	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥40 <50 (Contd)				
Quadrant III	35	86	42	
Ditto	35	88	40	
"	36	43	42	
"	36	51	48	
"	36	87	42	
"	36	89	42	
"	37	44	44	
"	37	94	44	
"	38	47	44	
"	38	51	46	
"	38	91	47	
"	38	95	42	
"	38	103	45	
"	39	44	46	
"	40	61	40	
"	40	85	43	
"	40	87	46	
"	40	89	48	
"	41	50	41	
"	41	96	40	
"	42	85	47	
"	43	50	45	
"	43	88	40	
"	43	90	49	
"	43	98	43	
"	43	100	48	
"	44	85	43	
"	44	95	47	
"	45	44	45	
"	45	50	40	
"	45	90	48	
"	45	92	41	
"	45	94	49	
"	46	87	43	
"	46	89	46	
"	47	50	40	
"	47	90	48	
"	47	92	44	
"	47	94	42	
"	47	96	42	
"	48	87	45	
"	48	91	46	
"	49	94	40	
"	49	96	40	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥40 <50 (Contd)				
Quadrant III	50	49	49	
Ditto	50	87	46	
"	50	89	43	
"	50	99	45	
"	51	48	46	
"	52	49	45	
"	52	63	41	
"	52	91	44	
"	52	95	44	
"	53	90	41	
"	54	49	40	
"	55	50	42	
"	55	52	40	
"	55	58	43	
"	55	88	42	
"	55	92	48	
"	56	45	46	
"	56	51	42	
"	56	89	46	
"	58	45	44	
"	58	55	45	
"	60	49	45	
"	60	53	42	
Total			255	
Eddy Current Readings ≥30 <40				
Quadrant II	1	100	33	
Ditto	7	94	36	
"	8	105	35	
"	9	86	30	
"	10	87	35	
"	10	91	33	
"	11	90	36	
"	11	106	35	
"	12	105	35	
"	13	58	34	
"	13	60	37	
"	13	88	37	
"	14	59	32	
"	14	105	34	
"	15	104	39	
"	16	53	39	
"	16	61	30	
"	16	91	34	
"	16	103	38	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥30 <40 (Contd)				
Quadrant II	18	59	30	
Ditto	18	63	36	
"	18	89	38	
"	19	54	38	
"	19	64	32	
"	20	51	30	
"	20	63	33	
"	20	93	38	
"	21	44	38	
"	21	62	30	
"	21	88	37	
"	21	106	38	
"	22	57	38	
"	22	59	38	
"	22	87	30	
"	22	105	35	
"	24	49	33	
"	24	61	34	
"	24	85	36	
"	25	46	30	
"	25	104	39	
"	26	49	39	
"	26	89	39	
"	27	58	32	
"	27	88	38	
"	27	104	38	
"	28	85	36	
"	28	95	38	
"	29	86	38	
"	30	59	39	
"	31	98	38	
"	32	51	35	
"	32	87	30	
"	32	89	39	
"	32	95	39	
"	32	99	37	
"	32	101	31	
"	33	96	38	
"	33	100	33	
"	34	57	35	
"	34	85	35	
"	34	87	30	
"	34	89	39	
"	34	97	39	
"	34	107	30	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥30 <40 (Contd)				
Quadrant II	35	96	32	
Ditto	35	98	35	
"	35	100	36	
"	37	48	34	
"	37	94	36	
"	38	101	39	
"	39	46	38	
"	39	54	30	
"	39	62	30	
"	39	86	38	
"	39	94	34	
"	40	61	35	
"	40	85	32	
"	40	107	30	
"	41	60	30	
"	41	94	31	
"	41	96	37	
"	41	104	37	
"	42	57	34	
"	42	107	30	
"	43	50	36	
"	44	57	32	
"	45	60	35	
"	46	57	34	
"	46	61	35	
"	47	106	35	
"	48	65	39	
"	48	95	35	
"	49	48	36	
"	53	92	38	
"	54	95	37	
"	54	97	36	
"	54	103	38	
"	55	90	39	
"	57	62	32	
"	58	49	32	
"	58	61	30	
Quadrant III	2	85	35	
Ditto	3	44	33	
"	3	86	35	
"	3	94	36	
"	4	47	37	
"	4	85	30	
"	5	88	38	
"	5	92	35	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥30 <40 (Contd)				
Quadrant III	6	99	34	
Ditto	6	103	36	
"	8	85	39	
"	8	87	39	
"	8	99	35	
"	12	99	30	
"	14	87	30	
"	14	93	30	
"	14	95	32	
"	14	97	32	
"	15	46	39	
"	17	44	35	
"	17	54	30	
"	17	56	36	
"	17	100	31	
"	18	91	31	
"	18	95	31	
"	18	97	36	
"	19	64	37	
"	19	98	30	
"	20	47	30	
"	20	49	35	
"	20	55	30	
"	20	105	34	
"	21	88	30	
"	22	55	30	
"	22	61	30	
"	23	44	30	
"	23	56	38	
"	23	58	30	
"	23	68	30	
"	23	88	38	
"	24	55	37	
"	24	57	31	
"	24	97	38	
"	25	58	32	
"	25	60	31	
"	25	94	39	
"	26	61	36	
"	27	46	35	
"	27	94	34	
"	28	57	31	
"	28	59	36	
"	28	61	36	
"	28	89	35	
"	29	90	36	
"	29	94	31	

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Eddy Current Readings ≥30 <40 (Contd)				
Quadrant III	30	91	39	
Ditto	30	105	34	
"	31	58	36	
"	31	94	36	
"	31	106	38	
"	32	51	39	
"	32	53	34	
"	33	54	30	
"	33	88	34	
"	34	45	30	
"	34	59	31	
"	35	46	35	
"	35	58	33	
"	35	94	38	
"	36	55	30	
"	37	54	30	
"	37	60	39	
"	38	85	37	
"	39	56	34	
"	39	60	30	
"	39	86	37	
"	39	90	34	
"	40	47	30	
"	40	95	32	
"	41	52	31	
"	41	92	35	
"	41	94	30	
"	41	98	38	
"	42	51	31	
"	42	61	30	
"	42	91	38	
"	42	105	37	
"	43	52	34	
"	43	92	35	
"	44	61	30	
"	44	99	30	
"	45	48	34	
"	45	98	38	
"	45	100	36	
"	46	47	30	
"	46	97	35	
"	48	89	38	
"	48	95	38	
"	52	53	30	
"	52	59	38	
"	52	61	30	
"	53	54	37	

Eddy Current Readings ≥30 <40 (Contd)

	Line	Row	12/74 Reading (%)	6/74 Reading (%)
Quadrant III	54	57	30	
Ditto	55	54	32	
"	55	60	35	
"	58	47	34	
"	58	51	31	
"	58	61	34	
"	58	63	37	
"	58	85	38	
"	59	44	38	
"	59	48	37	
"	59	60	34	
"	60	51	39	
Total			215	

Tubes Whose Eddy Current Readings Decreased by 5% or More

	Line	Row	12/74 Reading (%)	6/74 Reading (%)	Difference
Quadrant II	7	94	36	41	-5
Ditto	11	100	38	49	-11
"	19	54	38	43	-5
"	20	51	30	40	-10
"	20	55	29	39	-10
"	21	44	38	48	-10
"	22	45	42	48	-6
"	22	59	38	44	-6
"	26	97	40	47	-7
"	27	104	38	48	-10
"	32	99	32	45	-13
"	34	57	35	42	-7
"	35	96	32	42	-10
"	36	59	42	48	-6
"	37	48	34	40	-6
"	38	89	42	48	-6
"	38	95	43	48	-5
"	39	60	30	46	-16
"	39	86	38	48	-10
"	39	94	39	45	-6
"	40	87	40	46	-6
"	40	105	43	49	-6
"	40	107	30	35	-5
"	41	46	30	35	-5
"	41	96	37	42	-5

Tubes Whose Eddy Current Readings Decreased by 5% or More (Contd)

	Line	Row	12/74 Reading (%)	6/74 Reading (%)	Difference
Quadrant II	42	61	35	47	-12
Ditto	42	107	30	42	-12
"	43	64	22	30	-8
"	44	61	32	40	-8
"	45	60	30	40	-10
"	46	57	34	49	-15
"	46	61	29	44	-15
"	47	48	44	49	-5
"	47	106	35	43	-8
"	49	50	25	48	-23
"	50	87	40	49	-9
"	51	96	29	36	-7
"	51	102	28	33	-5
"	52	57	42	48	-6
"	56	59	25	38	-13
"	57	62	32	46	-14
"	58	61	30	48	-18
"	60	61	40	46	-6
Quadrant III	5	88	35	44	-9
Ditto	15	60	24	34	-10
"	15	62	25	30	-5
"	17	44	35	40	-5
"	17	46	40	48	-8
"	17	54	30	45	-15
"	17	56	36	45	-9
"	17	96	25	40	-15
"	19	64	37	44	-7
"	20	47	30	40	-10
"	22	87	25	35	-10
"	23	56	38	48	-10
"	23	60	24	30	-6
"	23	88	24	32	-8
"	23	92	25	35	-10
"	23	96	29	34	-5
"	24	57	31	45	-14
"	24	85	20	30	-10
"	25	88	22	30	-8
"	26	57	26	44	-18
"	27	46	35	48	-13
"	28	57	31	45	-14
"	28	59	36	45	-9
"	29	92	27	34	-7
"	29	94	31	40	-9

Tubes Whose Eddy Current Readings Decreased by 5% or More (Contd)

	Line	Row	12/74 Reading (%)	6/74 Reading (%)	Difference
Quadrant III	30	55	20	30	-10
Ditto	30	97	20	30	-10
"	30	105	34	40	-6
"	31	94	36	45	-9
"	31	96	20	30	-10
"	31	106	38	45	-7
"	32	59	25	30	-5
"	34	35	30	35	-5
"	35	60	24	32	-8
"	35	86	42	48	-6
"	35	88	40	48	-8
"	36	87	42	48	-6
"	36	89	42	48	-6
"	38	95	42	47	-5
"	39	48	28	42	-14
"	39	90	34	40	-6
"	40	95	32	47	-15
"	40	99	28	35	-7
"	41	52	29	35	-6
"	41	92	35	45	-10
"	41	94	30	44	-14
"	43	92	35	40	-5
"	43	98	43	48	-5
"	44	99	30	36	-6
"	45	44	29	44	-15
"	45	48	20	25	-5
"	45	50	40	46	-6
"	46	47	30	35	-5
"	47	94	42	48	-6
"	48	91	22	35	-13
"	51	52	22	32	-10
"	52	33	29	48	-11
"	53	64	29	35	-6
"	54	57	30	35	-5
"	57	64	25	34	-9
"	58	63	37	48	-11
"	59	52	28	40	-12
"	59	60	34	42	-8
"	60	51	39	48	-9
"	60	53	42	47	-5

3. Identify which tubes were plugged in the December 1974 outage in accordance with your 50% plugging criteria.

Answer

As a result of the eddy current inspection conducted in December 1974, one tube was plugged. This tube is located in Quadrant III of the "A" steam generator at Line 47, Row 46. This tube showed an eddy current testing indication of 74% through wall penetration at the #2 egg crate.

Subsequent investigation revealed that this defect had been missed in the June 1974 eddy current inspection. A review of the tape containing the eddy current trace for this tube showed that a defect was present in June 1974, and that the defect amounted to a through-wall penetration of 50% to 60%. As this defect exceeded the plugging criterion established for the June 1974 eddy current inspection, it was plugged.

Based upon the results of a statistical analysis of the eddy current data taken in December 1974 compared to that taken in June 1974, it was concluded that little, if any, additional wastage has taken place in the time period between these two inspections. The results of this statistical analysis were reported in a January 3, 1975 submittal.

A statistical investigation was launched into the eddy current testing techniques following the implementation of the 50% plugging criteria in the summer of 1974 because:

a. Wide variations both positive and negative in two sets of eddy current testing data obtained one day apart on 87 tubes in a foreign steam generator.
b. Wide variations both positive and negative in two sets of eddy current testing data obtained approximately one month apart (during plant shutdown) on approximately 110 tubes in the Palisades steam generators.
c. Wide variations both positive and negative in the data sets obtained during the full testing of the Palisades Plant steam generators.

d. The conclusion of no increased wastage from the metallographic examination of a tube extracted from Palisades steam generators that, according to the eddy current testing evaluation, had shown a large increase in wastage between fall 1973 and summer 1974. During this period the plant was shut down. The metallographic conclusion was, "There has been thought that wastage has progressed during shutdown. The observation that an indigenous oxide film persisted on wasted areas examined from tubes removed in June 1974 indicates wastage had terminated, rather than continued during the shutdown period. Moreover, for wastage to have continued, one would expect phosphate salt deposits immediately adjacent to wastage regions, which were considered to have propagated during shutdown. Such was not the case. Rather, these surfaces were effectively clean." (R. C. Youngdahl transmittal to Directorate of Licensing dated August 20, 1974, Attachment B, Page 4.)

Attachment A to the August 20, 1974 submittal summarized significant (<15%) increases in wastage that eddy current testing data indicated had occurred during the shutdown period from fall 1973 to summer 1974. Similar data for significant decreases were not included in this attachment because it was recognized that no reasonable mechanism for tube healing existed and statistical evaluation tools had not yet been developed to evaluate the significance of the data. The tubes indicating significant (>15%) increases (approximately 250) to above 50% as well as other tubes having increases to above 50% and tubes that had previously indicated above 50% through-wall degradation were plugged.

Following this plugging, the results of the statistical investigation showed that no significant wastage had occurred between fall 1973 and summer 1974. These conclusions and the techniques used to arrive at the conclusions and the evaluation of the December 1974 eddy current testing results are detailed in the attached (and previously informally submitted) August 8, August 27 and September 26, 1974 letters from J. Jaech to D. Noble and the eddy current testing

report submitted January 3, 1975. Also following the tube plugging, the results of the metallographic examination described above became available.

The attached letters also conclude that, based on both physical and eddy current measurements, there is about a 12.7% conservative bias in the eddy current measurement.

The fact that some tubes do show an indication, based upon the December 1974 inspection, of more than 50% through-wall penetration, may be attributed to several different sources. One may conclude that isolated locations exist where wastage is still taking place. Because the mean wastage was essentially zero, however, one must then also conclude that isolated locations exist where the tubes are healing themselves. This second conclusion, clearly, is not realistic. While a large number of the measurements taken in December 1974 agree very well with previous measurements, isolated occurrences of substantial deviations, both plus and minus, do exist. These substantial deviations appear as tails to the bell-shaped normal distribution curve expected from measurements of finite accuracy.

Consumers Power Company has concluded that good reasons exist for not plugging tubes that may have shown greater than 50% through-wall penetration in the December 1974 inspections.

a. In all cases, except for the tube missed in the June 1974 inspection and subsequently plugged, the indications are still less than 73% through-wall penetration required to withstand an LOCA. This level of defect is identified by Regulatory Guide 1.83 as the limit of acceptability. The water chemistry environment within the steam generators has been changed from coordinated phosphate to volatile treatment.

   Flushing reports submitted in accordance with the Technical Specifications show that the conversion to volatile treatment has been achieved and the secondary water can be maintained fully in accordance with volatile treatment specifications.

b. Industry experience, both actual operating experience and pot-boiler testing, has shown that volatile water treatment does

not attack the steam generator tubes at as rapid a rate as phosphate treatment has in various plants.

c. No known mechanism exists for causing wastage at a rate which would have to be assigned to a few of the Palisades tubes based upon the difference in observed eddy current indications and the period of operation between measurements (7.5 effective full power days).

d. These tubes may provide valuable assistance in determining the limitation of eddy current testing in steam generator tubes if they are saved for subsequent inspections. If they are plugged, their usefulness is destroyed.

e. There is no known wastage mechanism for only a few isolated tubes to undergo attack.

Therefore, no tubes other than previously described were plugged.

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August 8, 1974

Mr. Daniel M. Noble
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Dear Dan:

This summarizes my findings as a result of my visit to Jackson on August 6-7, 1974 to explore the statistical aspects of the Eddy current testing of Palisades generator tubes.

The initial problem as defined is to evaluate the measurement error associated with a reported tube "wastage" value as determined by Eddy current testing. More generally, the problem is to distinguish between actual tube wastage and reported wastage, where this latter value includes the effects of measurement errors.

Statistical Model

In many measurement situations, the problem of evaluating measurement errors is relatively simple. This is true when there exist good calibration standards and when a measured value is not too dependent on the human element. Unfortunately, with Eddy current testing neither of these conditions exist. The calibration standard is of questionable quality, and the human interpretation of the source data plays a major role in determining the reported value. Thus, reliance must be placed on making inferences about the sizes of measurement errors based on data that consist of reported wastages for individual tubes.

The largest data base consists of paired measurements. That is, measurements are made of a large number of tubes at one point in time and repeated later on the same tubes. Unfortunately, actual corrosion may take place between the two time periods which complicates the problem. However, such data can be useful if some assumptions can be made.

This situation is modeled.

Let x_i = reported wastage at time 1 for tube i (% wastage)

y_i = reported wastage at time 2 for tube i

Throughout this discussion, restrict attention to value of x_i and y_i that are above the detection limit of 20%..

Assume the following models

$$x_i = \mu_i + \varepsilon_i$$

$$y_i = \mu_i + w_i + \eta_i$$

where μ_i is the "true" wastage at time 1 for tube i, ε_i is a random error of measurement, w_i is the true incremental wastage for tube i that occurs between times 1 and 2, and η_i is also a random error of measurement. Note that at time 2, the true wastage for tube i is then $\mu_i + w_i$.

Before proceeding further, a comment on this model is in order. It is assumed that w_i, the incremental wastage, is independent of μ_i, the initial wastage. The adequacy of this assumption can be checked in a gross way now (more on this later), and when data are taken at a third time period, the assumption can be relaxed. For now, however, assume that w_i and μ_i are independent.

Assume that μ_i, ε_i, w_i, and η_i are random variables with mean values μ_o, ε_o, w_o, and η_o and with variances σ^2_μ, σ^2_ε, σ^2_w, and σ^2_η respectively. A number of statistics can be calculated from the data. These include the means of the x and y values, denoted by $\bar{x}$ and $\bar{y}$ respectively, their variances, denoted by s^2_x and s^2_y respectively, and the covariance between the x and y values, denoted by s_{xy}.

$$s_{xy} = \left\{\Sigma x_i y_i - \Sigma x_i \Sigma y_i / n\right\} / (n-1)$$

where n is the total number of paired tubes in question.

Now, it follows that

$\bar{x}$ estimates $\mu_o + \varepsilon_o$

$\bar{y}$ estimates $\mu_o + w_o + \eta_o$

s^2_x estimates $\sigma^2_\mu + \sigma^2_\varepsilon$

s^2_y estimates $\sigma^2_\mu + \sigma^2_w + \sigma^2_\eta$

s_{xy} estimates σ^2_μ

From the above, note that $(\bar{y} - \bar{x})$ estimates $w_o + (\eta_o - \varepsilon_o)$. Thus, the observed change in average wastage estimates the true average increase for the tubes in question plus the difference in measurement biases. If the measurement bias is the same at both periods of time, then this has no affect on determining w_o since $(\eta_o - \varepsilon_o)$ becomes zero.

However, in order to estimate the true average wastage (as opposed to incremental wastage) at any point in time, there must be no measurement bias, i.e., η_o and ε_o must be zero. Note also that for data of the type under discussion, it is impossible to distinguish between actual incremental wastages and measurement biases. Supplementary data must be made available (more on this later).

Turning your attention to s_x^2, s_y^2, and s_{xy}, note that there are 3 statistics and 4 unknowns. However, it is not unreasonable to assume that $\sigma_\varepsilon^2 = \sigma_\eta^2$, i.e., the measurement precision is the same for both time periods. When this assumption is made, then we obtain the following estimates of the parameters:

$$\hat{\sigma}_\mu^2 = s_{xy}$$

$$\hat{\sigma}_\varepsilon^2 = \hat{\sigma}_\eta^2 = s_x^2 - s_{xy}$$

$$\hat{\sigma}_w^2 = s_y^2 - s_x^2$$

These results are now applied to some data sets.

Japanese Data

For purposes of our discussion, the first data set is referred to as the Japanese data. For these data, the "time 2" data were taken after a period of plant operation. The data are somewhat different from those just discussed in the sense that at time 2, duplicate wastage measurements were taken. Direct use is made of these duplicate measurements momentarily, but for the present, use the method of analysis just described except that y_i is now the average of 2 measurements. This means that s_y^2 then estimates $\sigma_\mu^2 + \sigma_w^2 + \sigma_\eta^2/2$, and the estimate of σ_w^2 is changed accordingly.

For the 87 data points in question, the following results are obtained.

$$\bar{y} - \bar{x} = 12.3 \text{ (\% wastage increase)}$$

$$s_x^2 = 123.73$$

$$s_y^2 = 146.83$$

$$s_{xy} = 108.25$$

$$\hat{\sigma}_\mu^2 = 108.25 \rightarrow \hat{\sigma}_\mu = 10.40$$

$$\hat{\sigma}_\varepsilon^2 = \hat{\sigma}_\eta^2 = 15.48 \rightarrow \hat{\sigma}_\varepsilon = 3.93$$

$$\hat{\sigma}_w^2 = 146.83 - 108.25 - 7.44 = 30.84 \rightarrow \hat{\sigma}_w = 5.55$$

The key parameter is σ_ε (or σ_η), the measurement error standard deviation for a given measurement. This is about 4% wastage for these data so that roughly speaking, a true wastage is within ± 8% of the reported wastage for a given tube with about 95% confidence.

This data set also provides a direct estimate of σ_ε because of the duplicate measurements made at time 2. In general, duplicate measurements made at a given point in time will tend to depict less scatter than at different points in time because of more stable measurement conditions. This is true here also where the direct estimate of σ_ε is 2.38% (as opposed to 3.93%). I regard this lower value as a limiting value and would accept the 3.93% value as being more descriptive of actual measurement performance.

Before leaving the Japanese data, we investigate briefly the validity of the assumption that w_i is independent of μ_i, i.e., that the increase in wastage is independent of the wastage at time 1. This data set affords a good opportunity to do this because the μ_i values vary over a wide range, from 25% to 80%. The data were divided into 3 groups on the basis of the μ_i values, and values of $(\bar{y} - \bar{x})$ were computed for each group with the following results:

Group	$(\bar{y} - \bar{x})$
$x_i \leq 43\%$	12.0
$44\% \leq x_i \leq 53\%$	13.7
$x_i \geq 54\%$	8.6

Since the $(\bar{y} - \bar{x})$ values are fairly constant and independent of x_i, it follows that for these data, the assumption that μ_i and w_i are independent is reasonably valid. I hestitate to generalize on this, however, and at this point would caution that the assumption bears watching. The Palisades data to be taken within the next few months will be very useful in determining if those tubes that show the highest wastage between times 1 and 2 will continue to exhibit such accelerated wastage rates.

Palisades Data

The Palisades data that were analyzed consisted of wastages for a subset of tubes in the A generator measured in June of 1974 and remeasured several weeks later. During this period of time, the plant was not in operation.

The data had been written on data sheets, and as I transcribed the pertinent data for analysis, a definite lack of randomness was noted in the $(y_i - x_i)$ values. The first subset of the data consisted of values that were largely positive, while a second subset contained a large number of negative values.

In returning to the original source data, it was found that the demarcation point in the data coincided with two different sets of original data, one set with pages numbered 1-5, and corresponding to Quadrant II, and the second set with pages numbered 1-4 and corresponding to Quadrant III. It is apparent that some relative bias exists between the two data sets, and if the reason(s) for this bias can be determined, it should hopefully lead to measurements of improved quality. The relative bias in the two sets of data in question is over 7%, and hence, is not inconsequential.

For purposes of this discussion, the data were divided into the two subsets and the parameters were estimated separately. The results are as follows:

	Set 1	Set 2
n	57	48
$\bar{x}$	52.9	54.1
$\bar{y}$	57.4	51.6
$(\bar{y} - \bar{x})$	4.5	-2.5
s_x^2	7.11	10.87
s_y^2	35.17	40.25
s_{xy}	5.33	1.62
$\hat{\sigma}_\mu$	2.31	1.27
$\hat{\sigma}_w$	5.30	5.42
$\hat{\sigma}_\varepsilon$	1.33	3.04

Bias in Eddy Current Results

The best way to estimate the Eddy current measurement bias is to compare Eddy current results with those based on direct physical measurement of tubes removed from the generator. This was done for seven tubes with the results as follows.

	% Wastage	
Eddy Current	Physical	Difference
50	37	13
30	18	12
45	30	15
61	41	20
71	60	11
72	65	7
76	65	11

The average difference is 12.7%, with the Eddy current results on the high side. If the random error of measurement for the physical measurement is assumed to be small relative to that for Eddy current, then the estimate of this error standard deviation for Eddy current is 4.03%. This corresponds to σ_ε.

Summary

(1) The random measurement error standard deviation for a single measurement is about 2-4%.

(2) The Eddy current method is biased high by about 13% (absolute).

(3) There is an apparent shifting bias of some magnitude in the Eddy current method. That is, the bias depends on the set of measurement conditions that exist at the time of measurement.

As I indicated to you, I will try and contact Clyde Denton of Zetech and obtain further information on measurement precision and accuracy. I will keep you informed.

Sincerely,

John

John L. Jaech
Staff Consultant

JLJ:jak

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August 27, 1974

Mr. Daniel M. Noble
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Dear Dan:

As we had planned, I visited Zetec on August 26 for discussions with Clyde Denton on Eddy current inspection of generator tubes, especially from point of view measurement errors. Clyde was most cooperative and eager to assist in the evaluation of such errors, and in reducing their effects to the extent feasible.

With reference to my report of August 8, you will recall that we were bothered by the non-randomness in the Palisades inspection results of June-July, 1974. Clyde explained that the June data had been created by a reader who had the results of earlier inspections before him and who had been hesitant to report decreased wastages in the June data. On the other hand, Clyde himself generated the July data completely independent of prior knowledge. Thus, the June data are perturbed by biases while the July data form the more realistic set.

To correct this situation, Clyde volunteered to re-read the June tapes himself. He will then give me the corrected results and I will redo the analysis reported in the August 8 letter.

I also discussed some of the other points we had raised during my visit with you. The following are Clyde's reactions.

With respect to the advisability of routinely taking duplicate measurements, he does not feel that this is worthwhile. He feels that the trace data themselves are quite reproducible. Although this point did not occur to me at the time, it would seem that the use of two readers, operating independently, might be beneficial if the incentive is there to reduce the error.

The human element has been removed to the extent possible. The key tasks in reducing a trace to a percent wastage involves locating the two points on the pattern that define the slope. Once this is done, all else is mechanized and is independent of the operator. There seems to be no way to lessen further operator influence on a reported result.

I brought up the question of adequacy of calibration standards. Clyde does feel that he needs improved standards and intends to move in this direction. He feels that this need has become more apparent now that wastage surveillance has become so important. However, with respect to the 13% estimated bias between the Eddy current data and the physical measurements, Clyde does not feel that the bias is this large. In his opinion, physical measurements are also subject to large errors and will tend to be biased on the low side.

With respect to probe changes, the operating procedures call for probe replacement upon breakage. Apparently probes do not wear out as such but rather break first because of the tight bends they must traverse. He also feels that the trace data are not much affected by which probe is used.

Finally, I asked about the advisability of indicating on the data sheets those instances when traces are especially difficult to interpret. Clyde feels that this serves no useful purpose because of the frequency with which this occurs, and because operator judgement as to which traces fit this category becomes so important.

I will keep you informed as more information develops on this subject.

Sincerely,

John

John L. Jaech
Staff Consultant

JLJ:jak

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September 26, 1974

Mr. Daniel M. Noble
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Dear Dan:

With reference to my earlier communications on the subject of Eddy current testing of Palisades generator tubes, Clyde Denton has completed re-reading the June tapes and supplied me with a corrected set of data. Although this removed some of the apparent anomalies in the June-July, 1974 data, there is still some strong evidence of nonrandomness in the data which makes it very difficult to sort out the effects of measurement error from actual tube wastage.

The problem is portrayed in Table I which gives frequency distributions of wastage for quadrants II and III.

TABLE I

	Frequency Distributions of Percent Wastage	
Percent Wastage	Quadrant II	Quadrant III
23 to 25	|	
20 to 22	||	
17 to 19	||	
14 to 16	𝍸 ||	
11 to 13	𝍸 ||||	
8 to 10	𝍸	|
5 to 7	||	||||
2 to 4	𝍸 ||||	𝍸 ||||
-1 to 1	𝍸 𝍸 ||||	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸
-4 to -2	||||	𝍸 |
-7 to -5		||
-10 to -8		||

There are two conclusions to be drawn on the basis of the Table I data. First, it is evident that the data for quadrants II and III are different for some reason. Second, it is also quite obvious that within the quadrant II data, there is more than one population present, i.e., the distribution is bimodal.

It is the second point that is particularly bothersome, although the facts that the distributions for the two quadrants differ also poses a problem because there is no apparent reason why actual wastages should differ. Thus, the problem reduces to trying to uncover the reason(s) for the nonrandomness.

Further investigation suggests that the data of Table I might perhaps be categorized by date of measurement for the last set of measurements made around July 1, 1974. Table II presents the data in this way.

TABLE II

Wastage Data

Percent Wastage	Measurement Date ≤ 6/28	Measurement Date > 6/28
23 to 25		1
20 to 22		2
17 to 19		2
14 to 16		8
11 to 13		9
8 to 10	2	4
5 to 7	3	3
2 to 4	11	7
-1 to 1	24	20
-4 to -2	7	3
-7 to -5	2	
-10 to -8	2	

This partitioning of the data presents the same sort of problem as the partitioning by quadrant, since most of the measurements made in Quadrant II occurred on or after June 29 while most of those made in Quadrant III occurred on or before June 28.

I can offer no explanation for the nonrandomness in the data but can only observe that there must be reasons for it, and that uncovering the reasons might prove to be a very important result from point of view of making inferences about tube wastage. In the meanwhile, it is necessary

to group the data using some criterion in order to obtain valid estimates of measurement errors.

In forming the grouping, I note from Table I that all the quadrant III data and part of the quadrant II data form one group while the remaining part of the quadrant II data form the second group. There appear to be obvious time trends in the quadrant II data. Referring to the original 5 data sheets of quadrant II data, form a group consisting of the first 8 observations on page 1 (42-79 to 11-104), observations 4 through 9 on page 2 (10-97 to 19-96), and observations 7 on page 4 through 5 on page 5 (56-45 to 36-91). The distributions of the wastage data are then as follows.

TABLE III

Grouped Wastage Data

Percent Wastage	Group 1	Group 2
23 to 25	|	
20 to 22	||	
17 to 19	||	
14 to 16	𝍸 ||	|
11 to 13	𝍸 |||	|
8 to 10	|||	|||
5 to 7	|	𝍸 |
2 to 4	||	𝍸 𝍸 𝍸 |
-1 to 1		𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 ||||
-4 to -2		𝍸 𝍸
-7 to -5		||
-10 to -8		||

The nonrandomness has now been removed from the data. I repeat, however, that the real key to evaluating the wastage data consists in uncovering the reason(s) why the group 1 and group 2 distributions are different.

The methodology discussed in my August 8, 1974 letter to you is now applied to the Table III data. The results are summarized in Table IV using the same notation as in the August 8 letter.

TABLE IV

Parameter Estimates

	Group 1	Group 2
n	25	84
$\bar{x}$	51.0	51.8
$\bar{y}$	63.7	52.6
$(\bar{y} - \bar{x})$	12.7	0.8
s_x^2	28.08	26.41
s_y^2	28.23	35.88
s_{xy}	17.54	24.38
$\hat{\sigma}_u$	4.19	4.94
$\hat{\sigma}_w$	0.39	3.08
$\hat{\sigma}_\varepsilon$	3.25	1.42

First, consider the Group 1 data. It is quite evident that s_x^2 and s_y^2 are not really different and therefore, σ_w is not truly different from zero. This says that all 25 tubes involved "wasted" by the same amount between times 1 and 2; i.e., by 12.7%. Such an occurrence is difficult to accept; and it seems more reasonable to me to suspect that the 12.7% increase in wastage reflects a measurement bias rather than an actual wastage.

Consider Group 2. In this instance, the average wastage is only 0.8%, clearly not different from zero. Although the best estimate of σ_w is 3.08 for this set of data, the facts that the average wastage is essentially zero and that s_x^2 and s_y^2 are not statistically different suggests that, as with Group 1, σ_w does not differ from zero. Thus, revised estimates of the parameters are in Table V.

TABLE V

Revised Parameter Estimates

	Group 1	Group 2
$\hat{\sigma}_u$	4.19	4.94
$\hat{\sigma}_w$	0	0
$\hat{\sigma}_\varepsilon$	3.26	2.60

In summary, I suspect that there was no actual tube wastage during the one month period of non-operation, but that the average incremental wastage of 12.7% for the 25 tubes that comprise Group 1 was the result of a measurement bias. The random error of measurement is about 3% (one standard deviation).

I plan on doing nothing further with these data unless you wish my assistance in trying to uncover reasons for the nonrandomness in the data.

Sincerely,

John

John L. Jaech
Staff Consultant

JLJ:jak

4. Provide sufficient evaluation of the wastage observed in the summer 1974 and the December 1974 inspections to verify that wastage has not progressed in the Palisades Plant steam generators.

Answer

The raw data obtained during the December 1974 ECT of the "A" steam generator shows wide variation both positive and negative in some cases from the data previously obtained during the summer 1974 inspection. These variations are similar to variations observed between data collected previously at the Palisades Plant (fall 1973 to summer 1974 data and data which compared approximately 110 tubes tested about 30 days apart during the summer 1974) as well as similar to variations observed in two sets of data obtained in a foreign steam generator. Two alternatives exist with regard to evaluation of the data. One alternative is to evaluate the data using statistical techniques to determine if a pattern exists in the data which indicates that wastage has taken place during the interval of interest. The second alternative is to accept the data as is, assuming that the significant variations in both the increased wastage and decreased wastage directions are not appreciably caused by the ECT technique.

The purpose of the statistical analysis (the first alternative) is to determine the true wastage of a given tube. The problem is complicated by the fact that the measurement error with ECT is quite large. On top of this random error of measurement, with the collecting, interpreting, and processing of such a volume of data, there is the likelihood that "mistakes" beyond the range of expected errors will be made. These can occur due to misidentification of tubes, misreading of the ECT tapes, or mistakes in recording the wastage value. This problem is common in statistical analysis with values that are unexplainable being identified as "outliers." The fact that outliers can be expected to occur with ECT is important to keep in mind, for it may not be possible to find a rational explanation for a small number of tubes that may appear to exhibit a large increase in wastage over a short period. On the other hand, the data would indicate that some tubes apparently experience appreciable "healing." These data points

can also be identified as outliers. Since outliers have been shown to occur in both directions, it seems that the rational explanation is that they are due to "mistakes" in the measurement process.

The random error of measurement can be evaluated based on data that consist of paired measurements. That is, if a tube is measured twice, then the paired data can be used to estimate the measurement error. If, in fact, actual wastage occurred, this can be taken into account. Consider the following model:

Let xi = Reported Wastage at Time 1 for Tube i

yi = Reported Wastage at Time 2 for Tube i

μ_i = True Wastage at Time 1 for Tube i

w_i = True Incremental Wastage Between Times 1 and 2 for Tube i

Thus, for example, if there were no error of measurement, then:

$$xi = \mu_i$$

$$yi = \mu_i + w_i$$

However, there is a measurement error, which we will depict by ε_i at Time 1 and by η_i at Time 2. The model becomes:

$$xi = \mu_i + \varepsilon_i$$

$$yi = \mu_i + w_i + \eta_i$$

It is assumed that ε_i and η_i both have mean values of zero, ie, <u>on the average</u>, the true value will equal the observed value. (This appears to be on the conservative side since a relative bias of about 13% has been demonstrated between ECT results and those found by metallographic examination, with ECT results on the high side.) Further, assume that both ε_i and η_i have the same variance, designated by σ^2_μ.

The problem is to estimate the parameters from the data. It is easily shown that:

$(\bar{y} - \bar{x})$ estimates w_o, the average increase in true wastage.

s^2_x estimates $\sigma^2_\mu + \sigma^2_\eta$

s^2_y estimates $\sigma^2_\mu + \sigma^2_w + \sigma^2_\eta$

s_{xy} estimates σ^2_μ

where s_x^2 is the sample variance among the xy values, s_y^2 is the sample variance among the y_i values, and s_{xy} is the sample covariance between the x_i and y_i values.

This model is applied to the inspection data of June 1974 (Time 1) and December 1974 (Time 2). The results are as follows:

$$(\bar{y} - \bar{x}) = 0.62\% \text{ (Estimated Increase in Wastage)}$$

$$s_x^2 = 47.81$$

$$s_y^2 = 55.95$$

$$s_{xy}^2 = 28.67$$

Therefore, the following estimates are found for the standard deviations:

$$\hat{\sigma}_\mu = 5.35$$

$$\hat{\sigma}_w = 2.85$$

$$\hat{\sigma}_\eta = 4.37$$

The best estimate of the average increase in wastage is 0.62%. The best estimate of the standard deviation of how much individual tubes might have differed from this average of 0.62% is 2.85%. The best estimate of the random error standard deviation is 4.37%. The estimate of actual wastage increase is very small and is of questionable statistical significance. In fact, s_x^2 and s_y^2 will both estimate the same quantity if σ_μ^2 is deemed to be zero. In this case, the random error standard deviation is 4.82%.

Some additional data confirm the above results. In June 1974, there was a number of tubes that were measured in duplicate. Based on 80 such pairs, the estimated $\hat{\sigma}_\eta = 4.78\%$, in excellent agreement with the June 1974 - December 1974 data. The conclusion is that the agreement between the June and December data was the same as the agreement between the two sets of June data, confirming the conclusion that no wastage occurred between June and December.

A similar conclusion follows if the September 1973 data are compared with the June 1974 data. For the 80 sets of duplicates just mentioned, the June readings were also available. The differences, June 1974 minus September 1973, are given in the frequency distribution table.

6/74 - 9/73 Wastage (%)	Number of Tubes
11 - 13	2
8 - 10	3
5 - 7	7
2 - 4	12
-1 - 1	31
-4 - -2	13
-7 - -5	10
-10 - -8	1
-13 - -11	1

The average is 0.0, implying no actual wastage. The estimate of σ_η is $\hat{\sigma}_\eta = 3.66$, in qualitative agreement with the previous results.

It is concluded that very little, if any, wastage has occurred between September 1973 and December 1974. The few tubes that seem to have wasted can be explained as being due to "mistakes" in the measurement process.

If the tubes measured in December 1974 are regarded as a sample of the tubes in the generator, then on the basis of the December measurements, the best estimate of the distribution of actual wastages is that the mean is 37.81 and the variance is (28.67 + 8.14) = 36.81, or the standard deviation is 6.07. Thus, the estimate of the percentage of actual wastages that exceed 50% is found from a table of the normal distribution (t value is (50-37.81)/6.07 = 2.01) to be 2.2%. The estimated percentages that exceed other true wastage values are as follows:

True Wastage	"t"	Percentages That Exceed This
50%	2.01	2.22%
55%	2.83	0.23%
60%	3.65	<0.1%
65%	4.48	
70%	5.30	
73%	6.12	

This applies to the population from which the tubes were sampled, ie, those considered to be the most prone to wastage.

Assuming the observed variations in data were not appreciably affected by the ECT technique (the second alternative), one must explain the increases and decreases in the tube wastage indications. The decreased wastage indications show that some tubes are healing

themselves. No known mechanism exists for this phenomenon and it is difficult to postulate a mechanism. It is easier to postulate a mechanism that would cause wastage increases to occur in the interval between tests although it is not possible to postulate it occurring on only a few tubes. Postulated mechanisms are a shutdown wastage mechanism, the previously observed wastage mechanism during power operation and possibly fretting due to flow induced vibration. Evaluation of these postulated mechanisms shows that none were likely to have occurred. A summary of these evaluations follows:

a. Shutdown Mechanism - The plant was in a shutdown the majority of the time during the interval between eddy current tests. Because of large increases in wastage indications (based on ECT results) during a previous inspection interval, detailed investigations have already been performed to determine a shutdown wastage mechanism. These investigations failed to identify a shutdown wastage mechanism for Inconel tubing. These results were also confirmed by metallographic examination. The conclusion of the metallographic examination was, "There has been thought that wastage has progressed during shutdown. The observation that an indigenous oxide film persisted on wasted areas examined from tubes removed in June 1974 indicates wastage had terminated, rather than continued during the shutdown period. Moreover, for wastage to have continued, one would expect phosphate salt deposits immediately adjacent to wastage regions which were considered to have propogated during shutdown. Such was not the case. Rather, these surfaces were effectively clean." (R. C. Youngdahl transmitted to the Directorate of Licensing dated August 20, 1974, Attachment B, Page 4.)

   Wherever and whenever possible the generators have been operated so as to minimize the effect of a shutdown mechanism if one is occurring. This has been done by keeping the generators hot (300°) and under continuous or periodic blowdown.

   Therefore, we have concluded there is no shutdown wastage mechanism.

b. Wastage During Operation - Wastage during power operation has been shown to occur only in the presence of very high phosphate ion concentrations during power operation and to be stifled by all volatile water treatment. The "Steam Generators - Secondary Water Chemical Flushing Report" submitted to the Directorate of Licensing, November 6, 1974 shows that the steam generators were converted to operation within the specifications for all volatile chemistry control shortly after resuming power operation following the summer 1974 eddy current testing. The report shows that power operation with secondary water phosphate ion concentrations of greater than 1 ppm was limited to approximately one day and operation with concentrations of greater than 5 ppm was limited to about two hours.

The results of pot-boiler tests performed by Nuclear Steam System Suppliers and industry experience in the conversion from phosphate to volatile secondary water chemistry treatments shows that wastage is stopped once all volatile secondary water specifications are achieved. Assuming the indications of increased wastage are not a product of the ECT techniques and are, in fact, actual wastage, a wastage rate can be calculated. If the time period for the rate is assumed to be that which corresponds to power operations with phosphates greater than 1 ppm, the wastage rate calculated is more than 100 times greater than that previously observed through industry experience or induced in pot-boiler testing. If the total time of power operation (including the period within volatile specifications) is used to determine the wastage rate, the rate calculated is still in excess of 10 times greater than any rate previously observed.

Further, the tubes tested in December 1974 were selected because they had previously experienced wastage. No mechanism is known by which only a few of these tubes could selectively experience active wastage during this time interval of power operation.

As there is no known mechanism for experiencing wastage at the rates described above and selectively as described above, we have

concluded that significant wastage is not likely to have occurred during the power operation in October 1974 and that the observed increases in the ECT data will have to be explained by some other phenomenon which involves the eddy current method.

c. Fretting Due to Vibration - The possibility of fretting due to vibration has been considered. It was concluded that this was not the cause because of the short interval of operation between the test intervals. It is not conceivable that, during power operation in excess of 10,000 hours, fretting would produce less than a 20% through-wall penetration and yet in the next 600-700 hours, 40% additional through-wall penetration. Further, there is no geometrical pattern consistency as would be expected from fretting. Also, numerous tube samples have been previously removed from the generators and examined with no observation of fretting damage.

In addition, the possibility of intergranular (IG) attack has been considered. The tubes showing large increases in ECT indication were not previously affected by IG attack. The ECT patterns were typical of wastage and not IG-type defects. Further, as concluded in the January 3, 1975 ECT report, the previously experienced IG attack has been shown to have been stifled.

Based on investigation conducted and considerations summarized above, we have concluded that reasonable assurance exists that wastage observed in the Palisades Plant steam generators has not progressed since summer 1974 and, in addition, since the fall of 1973.