New Folder Name Coupon System Calculations

LIGO-T930004-00-B

* * * FACSIMILE MESSAGE * * *

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FAX NUMBER IS: 815 439 6010
VERIFY NUMBER IS: 815 439 6000

PAGE: 1 **OF:** 11

DATE: December 7, 1993

TO: Larry Jones
Caltech
Pasadena, CA

FAX NO.: 818/304-9834

FROM: Warren A. Carpenter
Process Design Department
CBI Technical Services Co.

RE: Coupon System Calculations
LIGO QUALIFICATION TEST FACILITY
930212 File #2.2.2

Attached are the calculations for the coupon outgassing system. I have put part of the calculations on a spreadsheet so I have shown the equations on an expanded version of the spreadsheet. The major discrepancy between your work and ours seems to be the accumulation pressure. You said that after 24 hours, the hydrogen partial pressure reaches the -8 torr range. We calculate that the partial pressure will be in the -6 torr range after 10 hours. Please review. If you have a chance, we would like to discuss when you are here tomorrow.

Regards,

Warren A. Carpenter
Senior Engineer

COUPON TEST SYSTEM VOLUME

CHAMBER VOLUME

$$\pi R^2 L = \pi (2)^2 (24) = 301.6 \text{ in}^3 \checkmark$$

COUPON VOLUME

$$n(L)(w)(t) = 50(18)(1)(.125) = 112.5 \text{ in}^3 \checkmark$$

UNUSED CHAMBER VOL

$$= \text{CHAM VOL} - \text{COUPON VOL} = 301.6 - 112.5 \text{ in}^3$$

$$= 189.1 \text{ in}^3 \checkmark$$

VOL SYSTEM (FOR OUTGASSING TEST)

PIPING (2 1/2") W/FITTINGS ~ 80" LONG

$$\text{VOL} = \frac{\pi (2.5)^2}{4} (80) = 392.7 \text{ in}^3 \checkmark$$

TOTAL VOLUME $= 189.1 + 392.7 \text{ in}^2 = 581.8 \text{ in}^3 \checkmark$

$$= 581.8 \text{ in}^3 (.0164 \text{ L/in}^3) = 9.54 \text{ L} \checkmark$$

SUBJECT	OFFICE	REVISION	REFERENCE NO.
L160	CBI	1	930212

MADE BY	CHKD BY	MADE BY	CHKD BY	SHT 1 OF 1
WAC	RWW	WAC	RWW	
DATE 11/30/93	DATE 12/6/93	DATE 12/6/93	DATE 12/6/93	

SURFACE AREAS - COUPON TEST SYSTEM

SHELL 4" ϕ x 24" = $\pi(4)(24) = 302 \text{ in}^2 = 1946 \text{ cm}^2$ ✓

ENDS $(2)\pi(2)^2 = 25.1 \text{ in}^2$ ✓ $= 162 \text{ cm}^2$ ✓

PIPING ~ 80 in of 2.5" ϕ TUBING

$A = \pi D L = \pi(2.5)(80) = 628$ ✓ $= 4054 \text{ cm}^2$ ✓

SUBJECT	OFFICE		REVISION		REFERENCE NO.
	MADE BY	CHKD BY	MADE BY	CHKD BY	SHT ___ OF ___
	DATE 12/6/93	DATE 12/6/93	DATE	DATE	

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COUPON TEST SYSTEM PUMPING SPEED

TUBING LENGTH

NOZZLE NECK 4"
1ST CROSS 3.38" TO ℄ CROSS
F.F. TO TMP 44"

$L/D = \frac{51.9"}{2.5} = 20.6$ ✓

$a' = .06$ —

$C_{PIPE} = 11.6\, a' A = 11.6(.06)\frac{\pi(2.5)^2}{4}(2.54)^2 = 22.0$ L/S AIR

$C_{PIPE\ H_2} = 22. \sqrt{\frac{29}{2}} = 83.9$ L/S H_2 ✓

$S_p = 43$ L/S H_2

$S_n = \frac{1}{\frac{1}{C_{PIPE}} + \frac{1}{S_p}} = 28.4$ L/S ✓

SUBJECT	OFFICE	REVISION		REFERENCE NO.
L160	CBI			930212
MADE BY / CHKD BY	MADE BY	CHKD BY		SHT ___ OF ___
WAC / JZW				
DATE 11/22/93 / DATE 12/7/93	DATE	DATE		

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$\frac{2.5"}{} \times \frac{2.54\,cm}{in} \times \frac{m}{100\,cm}$

$= .063\ m$

$57.4" = 1.31\ m$

$T = 20 + 273 = 293$

$M = 2$

$$V = 38.1 \left(\frac{T}{M}\right)^{\frac{1}{2}} \frac{D^3}{L}$$

$$= 38.1 \sqrt{\left(\frac{293}{2}\right)} \frac{(.063)^3}{1.31}$$

$$= .088\ m^3/s \times 100 = 88\ L/s$$

$S_p = 43\ L/s\ H_2$

$$S_s = \frac{1}{\frac{1}{43} + \frac{1}{88}}$$

$S = 29\ L/s\ H_2$

S

SUBJECT	OFFICE		REVISION		REFERENCE NO.
LIGO	CBI				93020
	MADE BY: Raul	CHKD BY:	MADE BY:	CHKD BY:	SHT ___ OF ___
	DATE: 1/7/93	DATE:	DATE:	DATE:	

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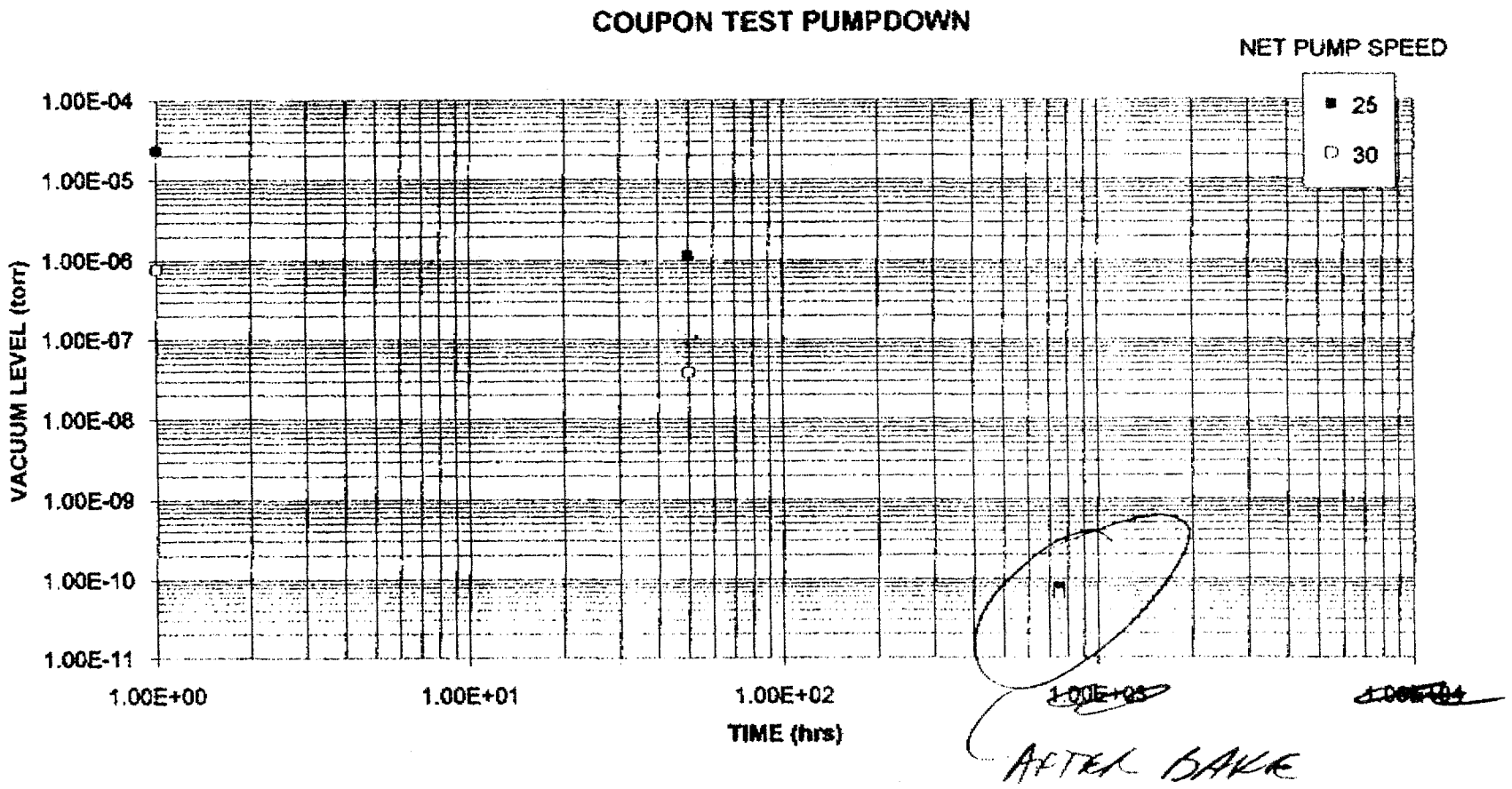
LIGO COUPON TEST OUTGASSING CALCULATION

5	VACUUM VESSEL SHELL							
6	AREA =	1.95E+03	sq cm					
7	K-1 =	3.00E-08	T L/sq cm - s		Q-1 =	5.84E-05	T L/S	
8	K-50 =	1.50E-09	T L/sq cm - s		Q-50 =	2.92E-06	T L/S	
9	K-AB=	1.00E-13	T L/sq cm - s		Q-AB=	1.95E-10	TL/S	
10	VESSEL HEADS							
11	AREA =	1.62E+02	sq cm					
12	K-1 =	3.00E-08	T L/sq cm - s		Q-1 =	4.86E-06	T L/S	
13	K-50 =	1.50E-09	T L/sq cm - s		Q-50 =	2.43E-07	T L/S	
14	K-AB=	1.00E-13	T L/sq cm - s		Q-AB=	1.62E-11	TL/S	
15	STAINLESS STEEL VALVES, FITTINGS AND PIPE							
16	AREA =	4.05E+03	sq cm					
17	K-1 =	3.00E-08	T L/sq cm - s		Q-1 =	1.22E-04	T L/S	
18	K-50 =	1.50E-09	T L/sq cm - s		Q-50 =	6.08E-06	T L/S	
19	K-AB=	1.00E-13	T L/sq cm - s		Q-AB=	4.05E-10	TL/S	
20	ALUMINUM							
21	AREA =	0.00E+00	sq cm					
22	K-1 =	0.00E+00	T L/sq cm - s		Q-1 =	0.00E+00	T L/S	
23	K-50 =	0.00E+00	T L/sq cm - s		Q-50 =	0.00E+00	T L/S	
24	K-AB=	0.00E+00	T L/sq cm - s		Q-AB=	0.00E+00	TL/S	
26	COUPONS							
27	AREA OF EA. COUP. =	2.63E+02	sq cm	(including 2 sides and 6 edges)				
28	NO OF COUP.=	50			TOTAL AREA =	13150	sq cm	
29	K-1 =	3.00E-08	T L/sq cm - s		Q-1 =	3.95E-04	T L/S	
30	K-50 =	1.50E-09	T L/sq cm - s		Q-50 =	1.97E-05	T L/S	
31	K-AB=	1.00E-13	T L/sq cm - s		Q-AB=	1.32E-09	TL/S	
36	TOTAL OUTGASSING FLOW							
37	Q-1 =	5.79E-04	T L/S					
38	Q-50 =	2.90E-05	T L/S					
39	Q-AB =	1.93E-09	T L/S					
42	PUMPING SYSTEM EVALUATION							
44	PUMPING SPEED (PER PUMP) =		2.50E+01	L/sec				
45	CALCULATED PARTIAL PRESSURE		P-1 =	2.32E-05	TORR			
46			P-50 =	1.16E-06	TORR			
47			P-AB =	7.72E-11	TORR			
48	PUMPING SPEED (PER PUMP) =		3.00E+01	L/sec				
49	CALCULATED PARTIAL PRESSURE		P-1 =	1.93E-05	TORR			
50			P-50 =	9.66E-07	TORR			

Notes:
AB subscript denotes "after bake" and is for hydrogen only
outgassing rates for 1 and 50 hours represent total pressure rates
shading denotes input data required

12/7/93

	A	B	C	D	E	F	G	H	I
51				P-AB =	6.44E-11	TORR			
52									
53			SYSTEM VOLUME =		9.54E+00	LITERS			
54		COUPON OUTASSING RATE (TOTAL) =			1.32E-09	TL/S			
55		SYSTEM OUTGASSING RATE (TOTAL) =			4.01E-10	TL/S	(vessel and piping to 1st valve only)		
56		TOTAL SYSTEM OUTGASSING RATE =			1.72E-09	TL/S			
57		ACCUMULATION TIME =			36000	SEC	10.00	HOURS	
58		GAS GENERATION =			6.18E-05	TORR LITERS			
59		END PRESSURE =			6.47E-06	TORR			
60									
61									
62		THE OUTGASSING RATES WERE CALCULATED USING AFTER BAKE DATA							
63									
64									
65									
66									
67									
68									


COUPON TEST PUMPDOWN
NET PUMP SPEED
25
30
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
VACUUM LEVEL (torr)
1.00E+00
1.00E+01
1.00E+02
TIME (hrs)
AFTER BAKE

SPREADSHEET EXPANDED TO SHOW EQUATIONS

	A	B	C	D
1	LIGO CO			
2				
3				
4				
5	VACUUM VE			
6		AREA =	1946	sq cm
7		K-1 =	0.00000003	T L/sq cm - s
8		K-50 =	0.0000000015	T L/sq cm - s
9		K-AB=	0.0000000000001	T L/sq cm - s
10	VESSEL HEA			
11		AREA =	162	sq cm
12		K-1 =	0.00000003	T L/sq cm - s
13		K-50 =	0.0000000015	T L/sq cm - s
14		K-AB=	0.0000000000001	T L/sq cm - s
15	STAINLESS			
16		AREA =	4054	sq cm
17		K-1 =	0.00000003	T L/sq cm - s
18		K-50 =	0.0000000015	T L/sq cm - s
19		K-AB=	0.0000000000001	T L/sq cm - s
20	ALUMINUM			
21		AREA =	0	sq cm
22		K-1 =	0	T L/sq cm - s
23		K-50 =	0	T L/sq cm - s
24		K-AB=	0	T L/sq cm - s
25				
26	COUPONS			
27		AREA OF EA. COUP. =	263	sq cm
28		NO OF COUP.=	50	
29		K-1 =	0.00000003	T L/sq cm - s
30		K-50 =	0.0000000015	T L/sq cm - s
31		K-AB=	0.0000000000001	T L/sq cm - s
32				
33				
34				
35				
36	TOTAL OU			
37		Q-1 =	=$G7+$G17+$G22+$G29+$G12	T L/S
38		Q-50 =	=G8+G18+G23+G30+G13	T L/S
39		Q-AB =	=G9+G19+G24+G31+G14	T L/S
40				
41				
42	PUMPING SY			
43				
44			PUMPING SPEED (PER PUMP) =	25
45	CALCULATE			P-1 =
46				P-50 =
47				P-AB =
48			PUMPING SPEED (PER PUMP) =	30
49	CALCULATE			P-1 =
50				P-50 =

12/7/93

	A	B	C	D
51				P-AB =
52				
53				SYSTEM VOLUME =
54				COUPON OUTASSING RA
55				SYSTEM OUTGASSING RA
56				TOTAL SYSTEM OUTGAS
57				ACCUMULATION TIME =
58				GAS GENERATION =
59				END PRESSURE =
60				
61				
62		THE OUTGASSING RAT		
63				
64				
65				
66				
67				
68				

	E	F	G	H
1				
2				
3				
4				
5				
6				
7		Q-1 =	=C6*C7	T L/S
8		Q-50 =	=C6*C8	T L/S
9		Q-AB=	=C6*C9	TL/S
10				
11				
12		Q-1 =	=C11*C12	T L/S
13		Q-50 =	=C11*C13	T L/S
14		Q-AB=	=C11*C14	TL/S
15				
16				
17		Q-1 =	=C16*C17	T L/S
18		Q-50 =	=C16*C18	T L/S
19		Q-AB=	=C16*C19	TL/S
20				
21				
22		Q-1 =	=C21*C22	T L/S
23		Q-50 =	=C21*C23	T L/S
24		Q-AB=	=C21*C24	TL/S
25				
26				
27	(including 2 sides and 6 edges)			
28		TOTAL AREA =	=C27*C28	sq cm
29		Q-1 =	=C27*C29*C28	T L/S
30		Q-50 =	=C27*C30*C28	T L/S
31		Q-AB=	=C27*C31*C28	TL/S
32				
33				
34				
35				
36		Notes:		
37		AB subscript denotes "after		
38		and is for hydrogen only		
39		outgassing rates for 1 and 5(		
40		represent total pressure re		
41				
42				
43				
44	L/sec			
45	=$C$37/$D$44	TORR		
46	=$C$38/$D$44	TORR		
47	=$C$39/$D$44	TORR		
48	L/sec			
49	=$C$37/D48	TORR		
50	=$C$38/D48	TORR		

	E	F	G	H
51	=$C$39/D48	TORR		
52				
53	9.54	LITERS		
54	=G28*C31	TL/S		
55	=(C6*C9)+(C11*C14)+(C19*1900)	TL/S	(vessel and piping to 1st valv	
56	=SUM(E54:E55)	TL/S		
57	36000	SEC =	=E57/3600	HOURS
58	=E57*E56	TORR LITERS		
59	=E58/E53	TORR		
60				
61				
62				
63				
64				
65				
66				
67				
68				

SURFACE AREA OF PIPING + FITTINGS TO 1ST VALVE