Table G-1. Analytical Results Used in Calculations

Stream: Sulfur by-product (24)

Analyte	Method	Units	Test Period		Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)										
Manganese	SW6010	ug/g	3	<	2					
Mercury	DGA/CVAA	ug/g	3		0.11					
Mercury	DGA/CVAA	ug/g	3		0.08					
Molybdenum	SW6010	ug/g	3	<	20					
Molybdenum	SW6010	ug/g	3	<	20					
Nickel	SW6010	ug/g	3	<	4					
Nickel	SW6010	ug/g	3	<	4					
Potassium	SW6010	ug/g	3	<	20					
Potassium	SW6010	ug/g	3	<	20					
Selenium	SW7740	ug/g	3		38					
Selenium	SW7740	ug/g	3		10					
Silicon	SW6010	ug/g	3	<	20					
Silicon	SW6010	ug/g	3	<	20					
Sodium	SW6010	ug/g	3	<	20					
Sodium	SW6010	ug/g	3	<	20					
Titanium	SW6010	ug/g	3		3					
Titanium	SW6010	ug/g	3	<	2					
Vanadium	SW6010	ug/g	3	<	2					
Vanadium	SW6010	ug/g	3	<	2					
Zinc	SW6010	ug/g	3		28					
Zinc	SW6010	ug/g	3	<	2					

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Water Quality Parameters									
Chemical Oxygen Demand	EPA 410.1	mg/L	2	47.4	41.2	28.4	35.4	39	24
Specific conductance	EPA 120.1	umhos	2	19,100	18,600	18,400	19,000	18,700	900
TSS	EPA 160.2	mg/L	2	3.04	18.6	< 1	< 1	7.38	24
Total phenolics	EPA 420.2	mg/L	2	0.738	0.895	0.95	0.916	0.861	0.27
pH	EPA150.1		2	8.25	7.9	8.03	8.18	8.06	0.44
Ionic Species									
Ammonia as N	EPA 350.1	mg/L	2	2,450	2,340	2,540	2,660	2,440	250
Chloride	EPA 300.0	mg/L	2	0.715	0.217	0.359	0.179	0.43	0.64
Cyanide, amenable	SW9012	mg/L	2	11.6	7.54	12	9.92	10.4	6.1
Cyanide, total	SW9012	mg/L	2	14.8	10.6	14.8	12.8	13.4	6
Fluoride	EPA 340.2	mg/L	2	2.56	2.1	2.63	2.61	2.43	0.72
Formate	IC	mg/L	2	3.49	3.2	3	3	3.23	0.61
Phosphate, total (as P)	EPA 365.1	mg/L	2	0.76	0.635	0.699	0.697	0.698	0.16
Sulfate	EPA 300.0	mg/L	2	8.8	6.68	3.98	7.48	6.49	6
Thiocyanate	SM412K	mg/L	2	8.75	14.9	8.75	10.3	10.8	8.8
Metals, total									
Aluminum	SW6010	mg/L	2	0.782	1.26	0.941	1.06	0.994	0.6
Antimony	SW6010	mg/L	2	< 0.076	< 0.076	< 0.076	< 0.076	< 0.076	---
Arsenic	SW7060	mg/L	2	< 0.00065	0.0217	< 0.00065	< 0.00065	0.00745	0.031
Barium	SW6010	mg/L	2	0.749	0.831	0.912	0.926	0.831	0.2
Beryllium	SW6010	mg/L	2	< 0.00051	< 0.00051	< 0.00051	< 0.00051	< 0.00051	---
Boron	SW6010	mg/L	2	0.0449	0.0273	0.0363	0.0271	0.0362	0.022
Cadmium	SW7131	mg/L	2	0.00172	0.0188	0.00205	0.0018	0.00752	0.024
Calcium	SW6010	mg/L	2	5.83	6.52	6.9	7.02	6.42	1.3
Chromium	SW6010	mg/L	2	< 0.0052	< 0.0052	< 0.0052	< 0.0052	< 0.0052	---
Cobalt	SW6010	mg/L	2	< 0.0041	< 0.0041	< 0.0041	< 0.0041	< 0.0041	---
Copper	SW6010	mg/L	2	0.0109	0.0458	< 0.0092	< 0.0092	0.0204	0.055
Iron	SW6010	mg/L	2	1.21	2.01	2.4	1.55	1.87	1.5
Lead	SW7421	mg/L	2	0.0474	1.14	0.0441	0.0632	0.411	1.6
Magnesium	SW6010	mg/L	2	2.08	2.2	2.33	2.37	2.2	0.31
Manganese	SW6010	mg/L	2	0.00186	0.00483	0.00376	0.00459	0.00348	0.0037
Mercury	SW7470	mg/L	2	< 0.000033	0.00231	0.000060	0.000050	0.000796	0.0033

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Metals (continued)														
Molybdenum	SW6010	mg/L	2	<	0.0074	<	0.0074	<	0.0074		0.00783	<	0.0074	---
Nickel	SW6010	mg/L	2	<	0.014	<	0.014	<	0.014	<	0.014	<	0.014	---
Phosphorus	SW6010	mg/L	2		0.666		0.732		0.709		0.734		0.702	0.083
Potassium	SW6010	mg/L	2		0.918	<	0.82	<	0.82		0.956	<	0.82	---
Selenium	SW7740	mg/L	2	<	0.0006		0.159		0.0007		0.00434		0.0533	0.23
Silicon	SW6010	mg/L	2		8.82		9.41		8.8		8.97		9.01	0.86
Sodium	SW6010	mg/L	2		2.89		3.03		2.98		3.02		2.97	0.18
Titanium	SW6010	mg/L	2		0.0199		0.0751		0.031		0.042		0.042	0.073
Vanadium	SW6010	mg/L	2	<	0.0045	<	0.0045	<	0.0045	<	0.0045	<	0.0045	---
Zinc	SW6010	mg/L	2		0.0938		0.828		0.164		0.0939		0.362	1
Aldehydes														
Acetaldehyde	SW8315	ug/mL	2	<	0.01	<	0.01		0.023	<	0.01		0.011	0.026
Acrolein	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	---
Benzaldehyde	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	---
Formaldehyde	SW8315	ug/mL	2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	---
Volatile Organic Compounds														
1,1,1-Trichloroethane	SW8240	ug/L	2	<	11	<	11	<	22	<	22	<	22	---
1,1,2,2-Tetrachloroethane	SW8240	ug/L	2	<	8	<	8	<	16	<	16	<	16	---
1,1,2-Trichloroethane	SW8240	ug/L	2	<	3.5	<	3.5	<	6.7	<	6.7	<	6.7	---
1,1-Dichloroethane	SW8240	ug/L	2	<	8	<	8	<	15	<	15	<	15	---
1,1-Dichloroethene	SW8240	ug/L	2	<	4.5	<	4.5	<	8.6	<	8.6	<	8.6	---
1,2-Dichloroethane	SW8240	ug/L	2	<	11	<	11	<	21	<	21	<	21	---
1,2-Dichloropropane	SW8240	ug/L	2	<	2.1	<	2.1	<	4	<	4	<	4	---
1,4-Bromofluorobenzene	SW8240	ug/L	2		614		599		1,140		1,140		784	770
1,4-Dichlorobenzene	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
2-Hexanone	SW8240	ug/L	2	<	9	<	9	<	18	<	18	<	18	---
4-Methyl-2-pentanone(MIBK)	SW8240	ug/L	2	<	6.4	<	6.4	<	12.3	<	12.3	<	12.3	---
Acetone	SW8240	ug/L	2		87.7		96.3		134		145		106	61
Benzene	SW8240	ug/L	2		2,300		2,670		2,250		2,970		2,410	570
Bromodichloromethane	SW8240	ug/L	2	<	4.8	<	4.8	<	9.3	<	9.3	<	9.3	---
Bromomethane	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
Carbon disulfide	SW8240	ug/L	2	<	6.4	<	6.4	<	12.3	<	12.3	<	12.3	---

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Volatile Organic Compounds (continued)														
Carbon tetrachloride	SW8240	ug/L	2	<	10	<	10	<	20	<	20	<	20	---
Chlorobenzene	SW8240	ug/L	2	<	4.1	<	4.1	<	8	<	8	<	8	---
Chloroethane	SW8240	ug/L	2	<	10	<	10	<	19	<	19	<	19	---
Chloroform	SW8240	ug/L	2	<	7	<	7	<	13	<	13	<	13	---
Chloromethane	SW8240	ug/L	2	<	6.8	<	6.8	<	13	<	13	<	13	---
Dibromochloromethane	SW8240	ug/L	2	<	3.2	<	3.2	<	6.2	<	6.2	<	6.2	---
Ethyl benzene	SW8240	ug/L	2	<	8	<	8	<	15	<	15	<	15	---
Methyl ethyl ketone	SW8240	ug/L	2	<	21	<	21	<	40	<	40	<	40	---
Methylene chloride	SW8240	ug/L	2		103		89.2		120		128		104	38
Styrene	SW8240	ug/L	2	<	5.6	<	5.6	<	10.8	<	10.8	<	10.8	---
Tetrachloroethene	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
Toluene	SW8240	ug/L	2	<	5.3	<	5.3	<	10.2	<	10.2	<	10.2	---
Tribromomethane(Bromoform)	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
Trichloroethene	SW8240	ug/L	2	<	5.9	<	5.9	<	11.4	<	11.4	<	11.4	---
Vinyl acetate	SW8240	ug/L	2	<	8	<	8	<	16	<	16	<	16	---
Vinyl chloride	SW8240	ug/L	2	<	9	<	9	<	17	<	17	<	17	---
cis-1,3-Dichloropropene	SW8240	ug/L	2	<	5.4	<	5.4	<	10.4	<	10.4	<	10.4	---
m&p-Xylene	SW8240	ug/L	2	<	6.6	<	6.6	<	12.7	<	12.7	<	12.7	---
o-Xylene	SW8240	ug/L	2	<	5.2	<	5.2	<	10	<	10	<	10	---
trans-1,2-Dichloroethene	SW8240	ug/L	2	<	7	<	7	<	14	<	14	<	14	---
trans-1,3-Dichloropropene	SW8240	ug/L	2	<	5.4	<	5.4	<	10.4	<	10.4	<	10.4	---
Semivolatile Organic Compounds														
1,2,4-Trichlorobenzene	SW8270	ug/L	2	<	0.54	<	0.55	<	0.55	<	0.54	<	0.55	---
1,2-Dichlorobenzene	SW8270	ug/L	2	<	0.66	<	0.66	<	0.66	<	0.66	<	0.66	---
1,3-Dichlorobenzene	SW8270	ug/L	2	<	0.44	<	0.45	<	0.45	<	0.44	<	0.45	---
1,4-Dichlorobenzene	SW8270	ug/L	2	<	1.7	<	1.8	<	1.8	<	1.7	<	1.8	---
2,4,5-Trichlorophenol	SW8270	ug/L	2	<	0.35	<	0.36	<	0.36	<	0.35	<	0.36	---
2,4,6-Tribromophenol	SW8270	ug/L	2		139		127		158		145		141	39
2,4,6-Trichlorophenol	SW8270	ug/L	2	<	0.42	<	0.42	<	0.42	<	0.42	<	0.42	---
2,4-Dichlorophenol	SW8270	ug/L	2	<	0.44	<	0.44	<	0.44	<	0.44	<	0.44	---
2,4-Dimethylphenol	SW8270	ug/L	2	<	0.72	<	0.72	<	0.72	<	0.72	<	0.72	---
2,4-Dinitrophenol	SW8270	ug/L	2	<	1.3	<	1.3	<	1.3	<	1.3	<	1.3	---

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period		Result 1			Result 2			Result 3			Result 3D		Average	95% CI
Semivolatile Organic Compounds (continued)																	
2,4-Dinitrotoluene	SW8270	ug/L	2	<	0.35		<	0.35		<	0.35		<	0.35	<	0.35	---
2,6-Dinitrotoluene	SW8270	ug/L	2	<	0.67		<	0.68		<	0.68		<	0.67	<	0.68	---
2-Chloronaphthalene	SW8270	ug/L	2	<	0.87		<	0.88		<	0.88		<	0.87	<	0.88	---
2-Chlorophenol	SW8270	ug/L	2	<	0.58		<	0.59		<	0.59		<	0.58	<	0.59	---
2-Fluorobiphenyl	SW8270	ug/L	2		71.3			62.2			76.8			60.9		70.1	18
2-Fluorophenol	SW8270	ug/L	2		155			138			183			158		159	56
2-Methylnaphthalene	SW8270	ug/L	2	<	0.88		<	0.89		<	0.89		<	0.88	<	0.89	---
2-Methylphenol	SW8270	ug/L	2	<	0.52		<	0.52		<	0.52		<	0.52	<	0.52	---
2-Nitroaniline	SW8270	ug/L	2	<	0.56		<	0.57		<	0.57		<	0.56	<	0.57	---
2-Nitrophenol	SW8270	ug/L	2	<	0.84		<	0.85		<	0.85		<	0.84	<	0.85	---
3,3'-Dichlorobenzidine	SW8270	ug/L	2	<	4		<	4.1		<	4.1		<	4	<	4.1	---
3-Nitroaniline	SW8270	ug/L	2	<	0.56		<	0.56		<	0.56		<	0.56	<	0.56	---
4,6-Dinitro-2-methylphenol	SW8270	ug/L	2	<	3.1		<	3.2		<	3.2		<	3.1	<	3.2	---
4-Aminobiphenyl	SW8270	ug/L	2	<	4.5		<	4.5		<	4.5		<	4.5	<	4.5	---
4-Bromophenylphenyl ether	SW8270	ug/L	2	<	0.31		<	0.32		<	0.32		<	0.31	<	0.32	---
4-Chloro-3-methylphenol	SW8270	ug/L	2	<	0.41		<	0.42		<	0.42		<	0.41	<	0.42	---
4-Chlorophenylphenyl ether	SW8270	ug/L	2	<	0.49		<	0.5		<	0.5		<	0.49	<	0.5	---
4-Methylphenol/3-Methylphenol	SW8270	ug/L	2		1.47	F		0.97	F		1.43	F	<	0.48		1.29	0.69
4-Nitroaniline	SW8270	ug/L	2	<	0.68		<	0.68		<	0.68		<	0.68	<	0.68	---
4-Nitrophenol	SW8270	ug/L	2	<	0.83		<	0.84		<	0.84		<	0.83	<	0.84	---
Acenaphthene	SW8270	ug/L	2	<	0.66		<	0.66		<	0.66		<	0.66	<	0.66	---
Acenaphthylene	SW8270	ug/L	2	<	0.67		<	0.68		<	0.68		<	0.67	<	0.68	---
Acetophenone	SW8270	ug/L	2	<	0.59		<	0.59		<	0.59		<	0.59	<	0.59	---
Aniline	SW8270	ug/L	2	<	1.1		<	1.1		<	1.1		<	1.1	<	1.1	---
Anthracene	SW8270	ug/L	2		0.782		<	0.73			1.02			0.735	<	0.73	---
Benz(a)anthracene	SW8270	ug/L	2	<	0.79		<	0.8		<	0.8		<	0.79	<	0.8	---
Benz(a)pyrene	SW8270	ug/L	2	<	0.72		<	0.73		<	0.73		<	0.72	<	0.73	---
Benzidine	SW8270	ug/L	2	<	22		<	22		<	22		<	22	<	22	---
Benzo(b)fluoranthene	SW8270	ug/L	2	<	0.71		<	0.71		<	0.71		<	0.71	<	0.71	---
Benzo(g,h,i)perylene	SW8270	ug/L	2	<	0.76		<	0.77		<	0.77		<	0.76	<	0.77	---
Benzo(k)fluoranthene	SW8270	ug/L	2	<	1		<	1		<	1		<	1	<	1	---
Benzoic acid	SW8270	ug/L	2	<	6.6		<	6.6		<	6.6		<	6.6	<	6.6	---

Table G-1. Analytical Results Used in Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Semivolatile Organic Compounds (continued)														
Benzyl alcohol	SW8270	ug/L	2	<	0.47	<	0.47	<	0.47	<	0.47	<	0.47	---
Butylbenzylphthalate	SW8270	ug/L	2	<	0.52	<	0.52	<	0.52	<	0.52	<	0.52	---
Chrysene	SW8270	ug/L	2	<	0.8	<	0.81	<	0.81	<	0.8	<	0.81	---
Di-n-butylphthalate	SW8270	ug/L	2	<	0.52	<	0.52	<	0.52	<	0.52	<	0.52	---
Di-n-octylphthalate	SW8270	ug/L	2	<	0.7	<	0.71	<	0.71	<	0.7	<	0.71	---
Dibenz(a,h)anthracene	SW8270	ug/L	2	<	0.88	<	0.89	<	0.89	<	0.88	<	0.89	---
Dibenzofuran	SW8270	ug/L	2	<	0.66	<	0.67	<	0.67	<	0.66	<	0.67	---
Diethylphthalate	SW8270	ug/L	2	<	0.71	<	0.71	<	0.71	<	0.71	<	0.71	---
Dimethylphthalate	SW8270	ug/L	2	<	0.44	<	0.45	<	0.45	<	0.44	<	0.45	---
Diphenylamine/N-NitrosoDPA	SW8270	ug/L	2	<	0.71	<	0.71	<	0.71	<	0.71	<	0.71	---
Fluoranthene	SW8270	ug/L	2		5.34		3.35		8.16		6.83		5.62	6
Fluorene	SW8270	ug/L	2	<	0.77	<	0.78	<	0.78	<	0.77	<	0.78	---
Hexachlorobenzene	SW8270	ug/L	2	<	0.58	<	0.59	<	0.59	<	0.58	<	0.59	---
Hexachlorobutadiene	SW8270	ug/L	2	<	0.78	<	0.79	<	0.79	<	0.78	<	0.79	---
Hexachlorocyclopentadiene	SW8270	ug/L	2	<	2.2	<	2.2	<	2.2	<	2.2	<	2.2	---
Hexachloroethane	SW8270	ug/L	2	<	2	<	2	<	2	<	2	<	2	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/L	2	<	0.83	<	0.84	<	0.84	<	0.83	<	0.84	---
Isophorone	SW8270	ug/L	2	<	0.37	<	0.37	<	0.37	<	0.37	<	0.37	---
N-Nitroso-di-n-propylamine	SW8270	ug/L	2	<	0.62	<	0.62	<	0.62	<	0.62	<	0.62	---
N-Nitrosodimethylamine	SW8270	ug/L	2	<	0.55	<	0.56	<	0.56	<	0.55	<	0.56	---
Naphthalene	SW8270	ug/L	2	<	0.78	<	0.79	<	0.79	<	0.78	<	0.79	---
Nitrobenzene	SW8270	ug/L	2	<	0.59	<	0.6	<	0.6	<	0.59	<	0.6	---
Pentachloronitrobenzene	SW8270	ug/L	2	<	1.9	<	2	<	2	<	1.9	<	2	---
Pentachlorophenol	SW8270	ug/L	2	<	0.53	<	0.53	<	0.53	<	0.53	<	0.53	---
Phenanthrene	SW8270	ug/L	2		2.12	<	0.7		2.79		2.32	<	2.1	---
Phenol	SW8270	ug/L	2		520		444		563		504		509	150
Pyrene	SW8270	ug/L	2		22.5		15.7		34.3		29.4		24.2	23
bis(2-Chloroethoxy)methane	SW8270	ug/L	2	<	0.59	<	0.6	<	0.6	<	0.59	<	0.6	---
bis(2-Chloroethyl)ether	SW8270	ug/L	2	<	0.65	<	0.65	<	0.65	<	0.65	<	0.65	---
bis(2-Chloroisopropyl)ether	SW8270	ug/L	2	<	0.6	<	0.61	<	0.61	<	0.6	<	0.61	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/L	2	<	1.1	<	1.1	<	1.1	<	1.1	<	1.1	---
p-Chloroaniline	SW8270	ug/L	2	<	0.98	<	0.99	<	0.99	<	0.98	<	0.99	---

Table G-1. Analytical Results Used In Calculations

Stream: Sour Condensate (7)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Semivolatile Organic Compounds (continued)									
p-Dimethylaminoazobenzene	SW8270	ug/L	2	< 0.53	< 0.53	< 0.53	< 0.53	< 0.53	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Water Quality Parameters									
Chemical Oxygen Demand	EPA 410.1	mg/L	2	54.8	52.1	52.1	50.1	53	3.9
Specific conductance	EPA 120.1	umhos	2	76	76	63.3	62.8	71.8	18
TSS	EPA 160.2	mg/L	2	1	3.47	1.18	2.22	1.88	3.4
Total phenolics	EPA 420.2	mg/L	2	0.498	0.564	0.576	0.578	0.546	0.1
pH	EPA150.1		2	8.7	8.7	8.85	8.88	8.75	0.22
Ionic Species									
Ammonia as N	EPA 350.1	mg/L	2	7.19	8.8	5.91	5.56	7.3	3.6
Chloride	EPA 300.0	mg/L	2	0.946	0.861	0.83	0.837	0.879	0.15
Cyanide, amenable	SW9012	mg/L	2	< 0.01	0.019	0.0815	0.116	0.0352	0.1
Cyanide, total	SW9012	mg/L	2	1.99	1.25	1.13	1.16	1.46	1.2
Fluoride	EPA 340.2	mg/L	2	2.01	1.51	1.99	1.94	1.84	0.7
Formate	IC	mg/L	2	3.32	3.14	2.99	2.97	3.15	0.41
Phosphate, total (as P)	EPA 365.1	mg/L	2	0.301	0.25	0.22	0.245	0.257	0.1
Sulfate	EPA 300.0	mg/L	2	< 0.047	< 0.047	< 0.047	< 0.047	< 0.047	---
Thiocyanate	SM412K	mg/L	2	1.15	0.608	0.707	0.904	0.822	0.72
Metals, total									
Aluminum	SW6010	mg/L	2	0.432	0.518	0.535	0.591	0.495	0.14
Antimony	SW6010	mg/L	2	< 0.076	< 0.076	< 0.076	< 0.076	< 0.076	---
Arsenic	SW7060	mg/L	2	0.00268	0.00426	0.00446	0.0047	0.0038	0.0024
Barium	SW6010	mg/L	2	0.507	0.516	0.56	0.567	0.528	0.07
Beryllium	SW6010	mg/L	2	0.00115	< 0.00051	< 0.00051	< 0.00051	0.000553	0.0013
Boron	SW6010	mg/L	2	0.027	0.0626	0.0269	0.0359	0.0388	0.051
Cadmium	SW7131	mg/L	2	0.00392	0.00528	0.00578	0.00546	0.00499	0.0024
Calcium	SW6010	mg/L	2	2.64	2.57	2.65	2.87	2.62	0.11
Chromium	SW6010	mg/L	2	0.00766	0.01	0.00845	0.0106	0.0087	0.003
Cobalt	SW6010	mg/L	2	< 0.0041	< 0.0041	< 0.0041	< 0.0041	< 0.0041	---
Copper	SW6010	mg/L	2	0.0124	0.0155	0.0155	0.017	0.0145	0.0044
Iron	SW6010	mg/L	2	1.22	1.12	1.22	1.29	1.19	0.14
Lead	SW7421	mg/L	2	0.213 S	0.385 S	0.388 S	0.384 S	0.329	0.25
Magnesium	SW6010	mg/L	2	1	1.03	0.984	0.996	1	0.058
Manganese	SW6010	mg/L	2	0.00317	< 0.0016	0.00317	0.00579	0.00238	0.0034
Mercury	SW7470	mg/L	2	0.000060	< 0.000033	≤ 0.000033	< 0.000033	< 0.000033	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Molybdenum	SW6010	mg/L	2	0.0128	0.0123	0.009	< 0.0074	0.0114	0.0051
Nickel	SW6010	mg/L	2	0.0404	0.0178	< 0.014	0.0366	0.0217	0.042
Phosphorus	SW6010	mg/L	2	0.26	0.26	0.211	0.163	0.244	0.07
Potassium	SW6010	mg/L	2	1.16	< 0.82	1.14	< 0.82	0.903	1.1
Selenium	SW7740	mg/L	2	0.0226	0.0361	0.0364	0.0353	0.0317	0.02
Silicon	SW6010	mg/L	2	7.14	7.39	7.15	7.21	7.23	0.35
Sodium	SW6010	mg/L	2	3.79	3.8	3.77	3.99	3.79	0.038
Titanium	SW6010	mg/L	2	0.015	0.0214	0.0232	0.0232	0.0199	0.011
Vanadium	SW6010	mg/L	2	< 0.0045	< 0.0045	< 0.0045	< 0.0045	< 0.0045	---
Zinc	SW6010	mg/L	2	0.188	0.27	0.28	0.272	0.246	0.13
Aldehydes									
Acetaldehyde	SW8315	ug/mL	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	---
Acrolein	SW8315	ug/mL	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	---
Benzaldehyde	SW8315	ug/mL	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	---
Formaldehyde	SW8315	ug/mL	2	< 0.01	< 0.01	< 0.01	0.01	< 0.01	---
Volatile Organic Compounds									
1,1,1-Trichloroethane	SW8240	ug/L	2	< 0.87	< 0.87	< 0.87	< 0.87	< 0.87	---
1,1,2,2-Tetrachloroethane	SW8240	ug/L	2	< 0.63	< 0.63	< 0.63	< 0.63	< 0.63	---
1,1,2-Trichloroethane	SW8240	ug/L	2	< 0.27	< 0.27	< 0.27	< 0.27	< 0.27	---
1,1-Dichloroethane	SW8240	ug/L	2	< 0.59	< 0.59	< 0.59	< 0.59	< 0.59	---
1,1-Dichloroethene	SW8240	ug/L	2	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34	---
1,2-Dichloroethane	SW8240	ug/L	2	< 0.82	< 0.82	< 0.82	< 0.82	< 0.82	---
1,2-Dichloropropane	SW8240	ug/L	2	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	---
1,4-Bromofluorobenzene	SW8240	ug/L	2	46.1	45.2	45.4	46.7	45.6	1.2
1,4-Dichlorobenzene	SW8240	ug/L	2	< 0.56	< 0.56	< 0.56	< 0.56	< 0.56	---
2-Hexanone	SW8240	ug/L	2	< 0.71	< 0.71	< 0.71	< 0.71	< 0.71	---
4-Methyl-2-pentanone(MIBK)	SW8240	ug/L	2	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49	---
Acetone	SW8240	ug/L	2	4.75	4.19	6.63	5.1	5.19	3.2
Benzene	SW8240	ug/L	2	< 0.46	< 0.46	< 0.46	< 0.46	< 0.46	---
Bromodichloromethane	SW8240	ug/L	2	< 0.37	< 0.37	< 0.37	< 0.37	< 0.37	---
Bromomethane	SW8240	ug/L	2	< 0.54	< 0.54	< 0.54	< 0.54	< 0.54	---
Carbon disulfide	SW8240	ug/L	2	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Volatile Organic Compounds (continued)														
Carbon tetrachloride	SW8240	ug/L	2	<	0.8	<	0.8	<	0.8	<	0.8	<	0.8	---
Chlorobenzene	SW8240	ug/L	2	<	0.32	<	0.32	<	0.32	<	0.32	<	0.32	---
Chloroethane	SW8240	ug/L	2	<	0.77	<	0.77	<	0.77	<	0.77	<	0.77	---
Chloroform	SW8240	ug/L	2	<	0.53	<	0.53	<	0.53	<	0.53	<	0.53	---
Chloromethane	SW8240	ug/L	2	<	0.52	<	0.52	<	0.52	<	0.52	<	0.52	---
Dibromochloromethane	SW8240	ug/L	2	<	0.25	<	0.25	<	0.25	<	0.25	<	0.25	---
Ethyl benzene	SW8240	ug/L	2	<	0.59	<	0.59	<	0.59	<	0.59	<	0.59	---
Methyl ethyl ketone	SW8240	ug/L	2	<	1.6	<	1.6	<	1.6	<	1.6	<	1.6	---
Methylene chloride	SW8240	ug/L	2	<	3		3.63		3.66		3.5	<	3	---
Styrene	SW8240	ug/L	2	<	0.43	<	0.43	<	0.43	<	0.43	<	0.43	---
Tetrachloroethene	SW8240	ug/L	2	<	0.54	<	0.54	<	0.54	<	0.54	<	0.54	---
Toluene	SW8240	ug/L	2	<	0.41	<	0.41	<	0.41	<	0.41	<	0.41	---
Tribromomethane(Bromoform)	SW8240	ug/L	2	<	0.56	<	0.56	<	0.56	<	0.56	<	0.56	---
Trichloroethene	SW8240	ug/L	2	<	0.46	<	0.46	<	0.46	<	0.46	<	0.46	---
Vinyl acetate	SW8240	ug/L	2	<	0.64	<	0.64	<	0.64	<	0.64	<	0.64	---
Vinyl chloride	SW8240	ug/L	2	<	0.69	<	0.69	<	0.69	<	0.69	<	0.69	---
cis-1,3-Dichloropropene	SW8240	ug/L	2	<	0.41	<	0.41	<	0.41	<	0.41	<	0.41	---
m&p-Xylene	SW8240	ug/L	2	<	0.51	<	0.51	<	0.51	<	0.51	<	0.51	---
o-Xylene	SW8240	ug/L	2	<	0.4	<	0.4	<	0.4	<	0.4	<	0.4	---
trans-1,2-Dichloroethene	SW8240	ug/L	2	<	0.54	<	0.54	<	0.54	<	0.54	<	0.54	---
trans-1,3-Dichloropropene	SW8240	ug/L	2	<	0.42	<	0.42	<	0.42	<	0.42	<	0.42	---
Semivolatile Organic Compounds														
1,2,4-Trichlorobenzene	SW8270	ug/L	2	<	0.54	<	0.5	<	0.53	<	0.49	<	0.53	---
1,2-Dichlorobenzene	SW8270	ug/L	2	<	0.66	<	0.6	<	0.64	<	0.6	<	0.64	---
1,3-Dichlorobenzene	SW8270	ug/L	2	<	0.44	<	0.41	<	0.43	<	0.4	<	0.43	---
1,4-Dichlorobenzene	SW8270	ug/L	2	<	1.7	<	1.6	<	1.7	<	1.6	<	1.7	---
2,4,5-Trichlorophenol	SW8270	ug/L	2	<	0.35	<	0.32	<	0.34	<	0.32	<	0.34	---
2,4,6-Tribromophenol	SW8270	ug/L	2		177		157		153		152		162	32
2,4,6-Trichlorophenol	SW8270	ug/L	2	<	0.42	<	0.39	<	0.41	<	0.38	<	0.41	---
2,4-Dichlorophenol	SW8270	ug/L	2	<	0.44	<	0.4	<	0.43	<	0.4	<	0.43	---
2,4-Dimethylphenol	SW8270	ug/L	2	<	0.72	<	0.66	<	0.7	<	0.65	<	0.7	---
2,4-Dinitrophenol	SW8270	ug/L	2	<	1.3	<	1.2	<	1.3	<	1.2	<	1.3	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Semivolatile Organic Compounds (continued)									
2,4-Dinitrotoluene	SW8270	ug/L	2	< 0.35	< 0.32	< 0.34	< 0.31	< 0.34	---
2,6-Dinitrotoluene	SW8270	ug/L	2	< 0.67	< 0.62	< 0.65	< 0.61	< 0.65	---
2-Chloronaphthalene	SW8270	ug/L	2	< 0.87	< 0.8	< 0.84	< 0.79	< 0.84	---
2-Chlorophenol	SW8270	ug/L	2	< 0.58	< 0.54	< 0.57	< 0.53	< 0.57	---
2-Fluorobiphenyl	SW8270	ug/L	2	58.8	56.5	68.2	61.9	61.2	15
2-Fluorophenol	SW8270	ug/L	2	175	154	150	143	160	33
2-Methylnaphthalene	SW8270	ug/L	2	< 0.88	< 0.81	< 0.86	< 0.8	< 0.86	---
2-Methylphenol	SW8270	ug/L	2	< 0.52	< 0.48	< 0.51	< 0.47	< 0.51	---
2-Nitroaniline	SW8270	ug/L	2	< 0.56	< 0.52	< 0.55	< 0.51	< 0.55	---
2-Nitrophenol	SW8270	ug/L	2	< 0.84	< 0.77	< 0.82	< 0.77	< 0.82	---
3,3'-Dichlorobenzidine	SW8270	ug/L	2	< 4	< 3.7	< 3.9	< 3.7	< 3.9	---
3-Nitroaniline	SW8270	ug/L	2	< 0.56	< 0.51	< 0.54	< 0.51	< 0.54	---
4,6-Dinitro-2-methylphenol	SW8270	ug/L	2	< 3.1	< 2.9	< 3.1	< 2.9	< 3.1	---
4-Aminobiphenyl	SW8270	ug/L	2	< 4.5	< 4.1	< 4.3	< 4.1	< 4.3	---
4-Bromophenylphenyl ether	SW8270	ug/L	2	< 0.31	< 0.29	< 0.31	< 0.29	< 0.31	---
4-Chloro-3-methylphenol	SW8270	ug/L	2	< 0.41	< 0.38	< 0.4	< 0.38	< 0.4	---
4-Chlorophenylphenyl ether	SW8270	ug/L	2	< 0.49	< 0.45	< 0.48	< 0.45	< 0.48	---
4-Methylphenol/3-Methylphenol	SW8270	ug/L	2	< 0.48	0.994 F	< 0.47	< 0.44	0.49	1.1
4-Nitroaniline	SW8270	ug/L	2	< 0.68	< 0.62	< 0.66	< 0.62	< 0.66	---
4-Nitrophenol	SW8270	ug/L	2	< 0.83	< 0.76	< 0.81	< 0.75	< 0.81	---
Acenaphthene	SW8270	ug/L	2	< 0.66	< 0.6	< 0.64	< 0.6	< 0.64	---
Acenaphthylene	SW8270	ug/L	2	< 0.67	< 0.62	< 0.65	< 0.61	< 0.65	---
Acetophenone	SW8270	ug/L	2	< 0.59	< 0.54	< 0.57	< 0.53	< 0.57	---
Aniline	SW8270	ug/L	2	< 1.1	< 1	< 1.1	< 1	< 1.1	---
Anthracene	SW8270	ug/L	2	< 0.72	< 0.66	< 0.7	< 0.66	< 0.7	---
Benz(a)anthracene	SW8270	ug/L	2	< 0.79	< 0.73	< 0.77	< 0.72	< 0.77	---
Benz(a)pyrene	SW8270	ug/L	2	< 0.72	< 0.66	< 0.7	< 0.65	< 0.7	---
Benzidine	SW8270	ug/L	2	< 22	< 20	< 21	< 20	< 21	---
Benzo(b)fluoranthene	SW8270	ug/L	2	< 0.71	< 0.65	< 0.69	< 0.64	< 0.69	---
Benzo(g,h,i)perylene	SW8270	ug/L	2	< 0.76	< 0.7	< 0.74	< 0.7	< 0.74	---
Benzo(k)fluoranthene	SW8270	ug/L	2	< 1.03	< 0.95	< 1	< 0.94	< 1	---
Benzoic acid	SW8270	ug/L	2	21.5	< 6	< 6.4	< 6	9.23	26

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Semivolatile Organic Compounds (continued)														
Benzyl alcohol	SW8270	ug/L	2	<	0.47	<	0.43	<	0.45	<	0.42	<	0.45	---
Butylbenzylphthalate	SW8270	ug/L	2	<	0.52	<	0.47	<	0.5	<	0.47	<	0.5	---
Chrysene	SW8270	ug/L	2	<	0.8	<	0.74	<	0.78	<	0.73	<	0.78	---
Di-n-butylphthalate	SW8270	ug/L	2	<	0.52	<	0.48	<	0.5	<	0.47	<	0.5	---
Di-n-octylphthalate	SW8270	ug/L	2	<	0.7	<	0.65	<	0.68	<	0.64	<	0.68	---
Dibenz(a,h)anthracene	SW8270	ug/L	2	<	0.88	<	0.81	<	0.86	<	0.8	<	0.86	---
Dibenzofuran	SW8270	ug/L	2	<	0.66	<	0.61	<	0.64	<	0.6	<	0.64	---
Diethylphthalate	SW8270	ug/L	2	<	0.71	<	0.65	<	0.69	<	0.64	<	0.69	---
Dimethylphthalate	SW8270	ug/L	2	<	0.44	<	0.41	<	0.43	<	0.4	<	0.43	---
Diphenylamine/N-NitrosoDPA	SW8270	ug/L	2	<	0.71	<	0.65	<	0.69	<	0.64	<	0.69	---
Fluoranthene	SW8270	ug/L	2		2.23		3.07		2.54		3.29		2.61	1.1
Fluorene	SW8270	ug/L	2	<	0.77	<	0.71	<	0.75	<	0.7	<	0.75	---
Hexachlorobenzene	SW8270	ug/L	2	<	0.58	<	0.54	<	0.57	<	0.53	<	0.57	---
Hexachlorobutadiene	SW8270	ug/L	2	<	0.78	<	0.71	<	0.76	<	0.71	<	0.76	---
Hexachlorocyclopentadiene	SW8270	ug/L	2	<	2.2	<	2	<	2.1	<	2	<	2.1	---
Hexachloroethane	SW8270	ug/L	2	<	2	<	1.8	<	1.9	<	1.8	<	1.9	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/L	2	<	0.83	<	0.76	<	0.81	<	0.76	<	0.81	---
Isophorone	SW8270	ug/L	2	<	0.37	<	0.34	<	0.36	<	0.34	<	0.36	---
N-Nitroso-di-n-propylamine	SW8270	ug/L	2	<	0.62	<	0.57	<	0.6	<	0.56	<	0.6	---
N-Nitrosodimethylamine	SW8270	ug/L	2	<	0.55	<	0.51	<	0.54	<	0.5	<	0.54	---
Naphthalene	SW8270	ug/L	2	<	0.78	<	0.72	<	0.76	<	0.71	<	0.76	---
Nitrobenzene	SW8270	ug/L	2	<	0.59	<	0.54	<	0.58	<	0.54	<	0.58	---
Pentachloronitrobenzene	SW8270	ug/L	2	<	1.9	<	1.8	<	1.9	<	1.8	<	1.9	---
Pentachlorophenol	SW8270	ug/L	2	<	0.53	<	0.49	<	0.51	<	0.48	<	0.51	---
Phenanthrene	SW8270	ug/L	2	<	0.67	<	1.89		0.861	<	0.61	<	1.89	---
Phenol	SW8270	ug/L	2		380		434		372		392		395	84
Pyrene	SW8270	ug/L	2		9.1		13.6		11		14.4		11.2	5.6
bis(2-Chloroethoxy)methane	SW8270	ug/L	2	<	0.59	<	0.55	<	0.58	<	0.54	<	0.58	---
bis(2-Chloroethyl)ether	SW8270	ug/L	2	<	0.65	<	0.6	<	0.63	<	0.59	<	0.63	---
bis(2-Chloroisopropyl)ether	SW8270	ug/L	2	<	0.6	<	0.56	<	0.59	<	0.55	<	0.59	---
bis(2-Ethylhexyl)phthalate	SW8270	ug/L	2	<	1.05	<	0.96	<	1.02	<	0.95	<	1.02	---
p-Chloroaniline	SW8270	ug/L	2	<	0.98	<	0.9	<	0.95	<	0.89	<	0.95	---

Table G-1. Analytical Results Used in Calculations

Stream: Sweet Water (8)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Semivolatile Organic Compounds (continued)														
p-Dimethylaminoazobenzene	SW8270	ug/L	2	<	0.53	<	0.49	<	0.51	<	0.48	<	0.51	---

Table G-1. Analytical Results Used in Calculations

Stream: Scrubber Water

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Water Quality Parameters									
TSS	EPA 160.2	Wt. %	3						
Ionic Species									
Ammonia as N	EPA 350.1	mg/L	3						
Chloride	EPA 300.0	mg/L	3						
Cyanide, amenabl	SW9012	mg/L	3						
Cyanide, total	SW9012	mg/L	3						
Fluoride	EPA 340.2	mg/L	3						
Thiocyanate	SM412K	mg/L	3						
Metals, total									
Aluminum	SW6010	mg/L	3						
Antimony	SW6010	mg/L	3						
Arsenic	SW7060	mg/L	3						
Barium	SW6010	mg/L	3						
Beryllium	SW6010	mg/L	3						
Boron	SW6010	mg/L	3						
Cadmium	SW7131	mg/L	3						
Calcium	SW6010	mg/L	3						
Chromium	SW6010	mg/L	3						
Cobalt	SW6010	mg/L	3						
Copper	SW6010	mg/L	3						
Iron	SW6010	mg/L	3						
Lead	SW7421	mg/L	3						
Magnesium	SW6010	mg/L	3						
Manganese	SW6010	mg/L	3						
Mercury	SW7470	mg/L	3						
Molybdenum	SW6010	mg/L	3						
Nickel	SW6010	mg/L	3						
Phosphorus	SW6010	mg/L	3						
Potassium	SW6010	mg/L	3						
Selenium	SW7740	mg/L	3						
Silicon	SW6010	mg/L	3						
Sodium	SW6010	mg/L	3						

Table G-1. Analytical Results Used in Calculations

Stream: Scrubber Water

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Titanium	SW6010	mg/L	3						
Vanadium	SW6010	mg/L	3						
Zinc	SW6010	mg/L	3						

Table G-1. Analytical Results Used in Calculations

Stream: Recycled Char Filtrate

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Water Quality Parameters									
TSS	EPA 160.2	Wt. %	3						
Ionic Species									
Ammonia as N	EPA 350.1	mg/L	3						
Chloride	EPA 300.0	mg/L	3						
Cyanide, amenabl	SW9012	mg/L	3						
Cyanide, total	SW9012	mg/L	3						
Fluoride	EPA 340.2	mg/L	3						
Thiocyanate	SM412K	mg/L	3						
Metals, soluble									
Aluminum	SW6010	mg/L	3						
Antimony	SW6010	mg/L	3						
Arsenic	SW7060	mg/L	3						
Barium	SW6010	mg/L	3						
Beryllium	SW6010	mg/L	3						
Boron	SW6010	mg/L	3						
Cadmium	SW7131	mg/L	3						
Calcium	SW6010	mg/L	3						
Chromium	SW6010	mg/L	3						
Cobalt	SW6010	mg/L	3						
Copper	SW6010	mg/L	3						
Iron	SW6010	mg/L	3						
Lead	SW7421	mg/L	3						
Magnesium	SW6010	mg/L	3						
Manganese	SW6010	mg/L	3						
Mercury	SW7470	mg/L	3						
Molybdenum	SW6010	mg/L	3						
Nickel	SW6010	mg/L	3						
Phosphorus	SW6010	mg/L	3						
Potassium	SW6010	mg/L	3						
Selenium	SW7740	mg/L	3						
Silicon	SW6010	mg/L	3						
Sodium	SW6010	mg/L	3						

Table G-1. Analytical Results Used in Calculations

Stream: Recycled Char Filtrate

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Titanium	SW6010	mg/L	3						
Vanadium	SW6010	mg/L	3						
Zinc	SW6010	mg/L	3						

Table G-1. Analytical Results Used in Calculations

Stream: Selectamine Solvent

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ash	D3174	Wt. %	1						
Ash	D3174	Wt. %	3						
Density	Density	g/mL	1						
Density	Density	g/mL	3						
HSS	titration	Wt. %	1						
HSS	titration	Wt. %	3						
TSS	EPA 160.2	mg/L	1						
TSS	EPA 160.2	mg/L	3						

Table G-2. Analytical Results Not Used in Calculations

Stream: Raw Syngas (5a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29)								
Antimony	SW6010	ug/Nm3	3					
Arsenic	SW7060	ug/Nm3	3					
Barium	SW6010	ug/Nm3	3					
Beryllium	SW6010	ug/Nm3	3					
Cadmium	SW7131	ug/Nm3	3					
Chromium	SW6010	ug/Nm3	3					
Cobalt	SW6010	ug/Nm3	3					
Copper	SW6010	ug/Nm3	3					
Lead	SW7421	ug/Nm3	3					
Manganese	SW6010	ug/Nm3	3					
Mercury	ICP/MS	ug/Nm3	3					
Molybdenum	SW6010	ug/Nm3	3					
Nickel	SW6010	ug/Nm3	3					
Selenium	SW7740	ug/Nm3	3					
Vanadium	SW6010	ug/Nm3	3					

Table G-2. Analytical Results Not Used in Calculations

Stream: Scrubbed Raw Syngas (5b)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29)								
Antimony	SW6010	ug/Nm3	3					
Arsenic	SW7060	ug/Nm3	3					
Barium	SW6010	ug/Nm3	3					
Beryllium	SW6010	ug/Nm3	3					
Cadmium	SW7131	ug/Nm3	3					
Chromium	SW6010	ug/Nm3	3					
Cobalt	SW6010	ug/Nm3	3					
Copper	SW6010	ug/Nm3	3					
Lead	SW7421	ug/Nm3	3					
Manganese	SW6010	ug/Nm3	3					
Mercury	ICP/MS	ug/Nm3	3					
Molybdenum	SW6010	ug/Nm3	3					
Nickel	SW6010	ug/Nm3	3					
Selenium	SW7740	ug/Nm3	3					
Vanadium	SW6010	ug/Nm3	3					

Table G-2. Analytical Results Not Used in Calculations

Stream: Sour Syngas (11)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Antimony	SW6010	ug/Nm3	1	<	16.6	<	17.5	<	17.2	<	17	---
Arsenic	SW7060	ug/Nm3	1		0.337		0.18		0.274		0.264	0.66
Barium	SW6010	ug/Nm3	1	<	0.188		0.228		0.224	<	0.19	---
Beryllium	SW6010	ug/Nm3	1	<	0.112	<	0.117	<	0.116	<	0.12	---
Cadmium	SW7131	ug/Nm3	1		0.28		0.371		0.328		0.326	0.81
Chromium	SW6010	ug/Nm3	1		2.78		2.46		2.18		2.47	6.1
Cobalt	SW6010	ug/Nm3	1	<	0.89	<	0.937	<	0.922	<	0.94	---
Copper	SW6010	ug/Nm3	1	<	2	<	2.11	<	2.07	<	2.1	---
Lead	SW7421	ug/Nm3	1	<	0.218		1.53	<	0.226		0.584	1.5
Manganese	SW6010	ug/Nm3	1	<	0.339	<	0.357	<	0.351	<	0.36	---
Mercury	ICP/MS	ug/Nm3	1		0.754		1.34		0.51		0.868	2.2
Molybdenum	SW6010	ug/Nm3	1	<	1.62	<	1.7	<	1.67	<	1.7	---
Nickel	SW6010	ug/Nm3	1	<	3.08		6.06	<	3.19	<	3.2	---
Selenium	SW7740	ug/Nm3	1	<	0.129	<	0.136	<	0.134	<	0.14	---
Vanadium	SW6010	ug/Nm3	1	<	0.993	<	1.05	<	1.03	<	1	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Sweet Syngas (12)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Antimony	SW6010	ug/Nm3	1	<	16.7	<	16	<	14.9	<	17	---
Arsenic	SW7060	ug/Nm3	1	<	0.142		0.162		0.274		0.169	0.42
Barium	SW6010	ug/Nm3	1		0.328		0.208		0.292		0.276	0.69
Beryllium	SW6010	ug/Nm3	1	<	0.112	<	0.107	<	0.1	<	0.11	---
Cadmium	SW7131	ug/Nm3	1		0.532		0.49		0.425		0.482	1.2
Chromium	SW6010	ug/Nm3	1		2.57		2.23		2.12		2.31	5.7
Cobalt	SW6010	ug/Nm3	1	<	0.895	<	0.856	<	0.798	<	0.9	---
Copper	SW6010	ug/Nm3	1	<	2.01		11.8	<	1.8		4.57	11
Lead	SW7421	ug/Nm3	1	<	0.219	<	0.21	<	0.195	<	0.22	---
Manganese	SW6010	ug/Nm3	1	<	0.341	<	0.326	<	0.304	<	0.34	---
Mercury	ICP/MS	ug/Nm3	1	<	0.0664	<	0.0635	<	0.0592	<	0.066	---
Molybdenum	SW6010	ug/Nm3	1	<	1.63		1.77	<	1.45	<	1.6	---
Nickel	SW6010	ug/Nm3	1	<	3.1	<	2.97	<	2.76	<	3.1	---
Selenium	SW7740	ug/Nm3	1	<	0.13	<	0.125	<	0.116	<	0.13	---
Vanadium	SW6010	ug/Nm3	1	<	0.998	<	0.955	<	0.89	<	1	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Acid Gas (14)

Analyte	Method	Units	Test Period		Result 1			Result 2			Result 3			Average	95% CI
Metals-Vapor Phase (M-29)															
Antimony	SW6010	ug/Nm3	1	<	19.3		<	18		<	16.4		<	19	---
Arsenic	SW7060	ug/Nm3	1		1.44			0.636			0.354			0.81	2
Barium	SW6010	ug/Nm3	1		2.9			0.589			0.321			1.27	3.2
Beryllium	SW6010	ug/Nm3	1	<	0.13		<	0.121		<	0.11		<	0.13	---
Cadmium	SW7131	ug/Nm3	1		0.628			0.43			0.358			0.472	1.2
Chromium	SW6010	ug/Nm3	1		105			28.5			14.9			49.5	120
Cobalt	SW6010	ug/Nm3	1		2.09		<	0.966		<	0.878			1	2.5
Copper	SW6010	ug/Nm3	1		6.66			6.22			7.49			6.79	17
Lead	SW7421	ug/Nm3	1		0.869		<	0.487			0.733			0.615	1.5
Manganese	SW6010	ug/Nm3	1		42.7			13.4			4.19			20.1	50
Mercury	ICP/MS	ug/Nm3	1		0.541			0.708			1.68			0.976	2.4
Molybdenum	SW6010	ug/Nm3	1		9.56			3.44			3.65			5.55	14
Nickel	SW6010	ug/Nm3	1		633			275			137			348	870
Selenium	SW7740	ug/Nm3	1		0.577	S		0.473	S	<	0.382	S		0.414	1
Vanadium	SW6010	ug/Nm3	1		1.62		<	1.08		<	0.979		<	1.1	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Tall Gas (15)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Antimony	SW6010	ug/Nm3	1	<	20.5	<	172	<	20.6	<	170	---
Arsenic	SW7060	ug/Nm3	1	<	0.175	<	1.47	<	0.176	<	1.5	---
Barium	SW6010	ug/Nm3	1		0.403	<	1.95	<	0.234	<	1.9	---
Beryllium	SW6010	ug/Nm3	1	<	0.138	<	1.16	<	0.138	<	1.2	---
Cadmium	SW7131	ug/Nm3	1		0.349		5.12		0.885		2.12	5.3
Chromium	SW6010	ug/Nm3	1		3.08		25.8		2.72		10.5	26
Cobalt	SW6010	ug/Nm3	1	<	1.1		18.8	<	1.11		6.63	16
Copper	SW6010	ug/Nm3	1		2.95		45.3		9.61		19.3	48
Lead	SW7421	ug/Nm3	1	<	0.269		8.79		3.86		4.26	11
Manganese	SW6010	ug/Nm3	1	<	0.419	<	3.51	<	0.421	<	3.5	---
Mercury	ICP/MS	ug/Nm3	1		3.4		27.8		5.43		12.2	30
Molybdenum	SW6010	ug/Nm3	1	<	2	<	16.7	<	2.01	<	17	---
Nickel	SW6010	ug/Nm3	1		22.6	<	31.9		14.2	<	32	---
Selenium	SW7740	ug/Nm3	1	<	0.16	<	40.1	<	4.81	<	40	---
Vanadium	SW6010	ug/Nm3	1		1.67	<	10.3	<	1.23	<	10	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Natural Gas (99)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Antimony	SW6010	ug/Nm3	2	<	15.5	<	17.9	<	15.7	<	18	---
Arsenic	SW7060	ug/Nm3	2	<	0.132	<	0.152	<	0.133	<	0.15	---
Barium	SW6010	ug/Nm3	2		0.202	<	0.202		0.204	<	0.2	---
Beryllium	SW6010	ug/Nm3	2	<	0.104	<	0.12	<	0.105	<	0.12	---
Cadmium	SW7131	ug/Nm3	2		0.368		0.543		0.393		0.435	1.1
Chromium	SW6010	ug/Nm3	2		1.89		1.43		2.86		2.06	5.1
Cobalt	SW6010	ug/Nm3	2	<	0.832	<	0.956	<	0.838	<	0.96	---
Copper	SW6010	ug/Nm3	2	<	1.87	<	2.15	<	1.89	<	2.2	---
Lead	SW7421	ug/Nm3	2	<	0.419		10.1		1.89		4.07	10
Manganese	SW6010	ug/Nm3	2	<	0.317	<	0.364	<	0.319	<	0.36	---
Mercury	ICP/MS	ug/Nm3	2	<	0.0617	<	0.0709	<	0.0622	<	0.071	---
Molybdenum	SW6010	ug/Nm3	2	<	1.51	<	1.74	<	1.52	<	1.7	---
Nickel	SW6010	ug/Nm3	2	<	2.88	<	3.31	<	2.9	<	3.3	---
Selenium	SW7740	ug/Nm3	2	<	0.362 S		0.479 S		0.55 S		0.403	1
Vanadium	SW6010	ug/Nm3	2	<	0.929	<	1.07	<	0.935	<	1.1	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Average	95% CI
Metals-Vapor Phase (M-29)								
Antimony	SW6010	ug/Nm3	2	< 27.2	< 26.4	< 24.9	< 27	---
Arsenic	SW7060	ug/Nm3	2	< 0.232	< 0.225	< 0.212	< 0.23	---
Barium	SW6010	ug/Nm3	2	0.534	< 0.299	< 0.282	< 0.3	---
Beryllium	SW6010	ug/Nm3	2	< 0.183	< 0.177	< 0.167	< 0.18	---
Cadmium	SW7131	ug/Nm3	2	4.52	0.957	0.468	1.98	4.9
Chromium	SW6010	ug/Nm3	2	2.01	< 1.82	< 1.72	< 1.8	---
Cobalt	SW6010	ug/Nm3	2	< 1.46	< 1.42	< 1.33	< 1.5	---
Copper	SW6010	ug/Nm3	2	7.81	< 3.19	3.8	4.4	11
Lead	SW7421	ug/Nm3	2	< 0.357	0.873	< 0.326	0.405	1
Manganese	SW6010	ug/Nm3	2	25.2	< 0.539	2.1	9.19	23
Mercury	ICP/MS	ug/Nm3	2	4.35	6.29	7.72	6.12	15
Molybdenum	SW6010	ug/Nm3	2	4.09	< 2.57	3.73	3.04	7.5
Nickel	SW6010	ug/Nm3	2	< 5.05	< 4.91	< 4.62	< 5.1	---
Selenium	SW7740	ug/Nm3	2	< 0.212	< 0.206	< 0.194	< 0.21	---
Vanadium	SW6010	ug/Nm3	2	< 1.63	< 1.58	< 1.49	< 1.6	---
PAHs/SVOCs-Particulate Phase								
2-Chloronaphthalene	SW8270	ug/Nm3	2	< 0.374	< 0.403	< 0.392	< 0.4	---
2-Methylnaphthalene	SW8270	ug/Nm3	2	< 0.447	< 0.493	< 0.479	< 0.49	---
Acenaphthene	SW8270	ug/Nm3	2	< 0.454	< 0.49	< 0.479	< 0.49	---
Acenaphthylene	SW8270	ug/Nm3	2	< 0.252	< 0.273	< 0.265	< 0.27	---
Anthracene	SW8270	ug/Nm3	2	< 0.275	< 0.276	< 0.293	< 0.29	---
Benzo(a)anthracene	SW8270	ug/Nm3	2	< 0.331	< 0.34	< 0.361	< 0.36	---
Benzo(a)pyrene	SW8270	ug/Nm3	2	< 0.51	< 0.546	< 0.537	< 0.55	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	2	< 0.414	< 0.443	< 0.437	< 0.44	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	2	< 0.623	< 0.666	< 0.658	< 0.67	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	2	< 0.507	< 0.539	< 0.534	< 0.54	---
Chrysene	SW8270	ug/Nm3	2	< 0.387	< 0.393	< 0.42	< 0.42	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	2	< 0.672	< 0.716	< 0.709	< 0.72	---
Fluoranthene	SW8270	ug/Nm3	2	< 0.262	< 0.26	< 0.279	< 0.28	---
Fluorene	SW8270	ug/Nm3	2	< 0.354	< 0.38	< 0.372	< 0.38	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	2	< 0.513	< 0.549	< 0.541	< 0.55	---
Naphthalene	SW8270	ug/Nm3	2	< 0.301	< 0.333	< 0.324	< 0.33	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Incinerator (16)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)												
Phenanthrene	SW8270	ug/Nm3	2	<	0.265	<	0.266	<	0.282	<	0.28	---
Pyrene	SW8270	ug/Nm3	2	<	0.225	<	0.23	<	0.248	<	0.25	---
PAHs/SVOCs-Vapor Phase												
2-Chloronaphthalene	SW8270	ug/Nm3	2	<	0.464	<	0.46	<	0.475	<	0.48	---
2-Methylnaphthalene	SW8270	ug/Nm3	2	<	0.53	<	0.563	<	0.572	<	0.57	---
Acenaphthene	SW8270	ug/Nm3	2	<	0.563	<	0.556	<	0.575	<	0.57	---
Acenaphthylene	SW8270	ug/Nm3	2	<	0.311	<	0.31	<	0.32	<	0.32	---
Anthracene	SW8270	ug/Nm3	2	<	0.331	<	0.33	<	0.337	<	0.34	---
Benzo(a)anthracene	SW8270	ug/Nm3	2	<	0.477	<	0.426	<	0.441	<	0.48	---
Benzo(a)pyrene	SW8270	ug/Nm3	2	<	0.662	<	0.623	<	0.637	<	0.66	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	2	<	0.54	<	0.51	<	0.52	<	0.54	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	2	<	0.811	<	0.763	<	0.778	<	0.81	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	2	<	0.656	<	0.619	<	0.63	<	0.66	---
Chrysene	SW8270	ug/Nm3	2	<	0.553	<	0.496	<	0.513	<	0.55	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	2	<	0.871	<	0.823	<	0.837	<	0.87	---
Fluoranthene	SW8270	ug/Nm3	2	<	0.315	<	0.313	<	0.32	<	0.32	---
Fluorene	SW8270	ug/Nm3	2	<	0.437	<	0.433	<	0.448	<	0.45	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	2	<	0.666	<	0.626	<	0.64	<	0.67	---
Naphthalene	SW8270	ug/Nm3	2		ND		ND		ND		ND	---
Phenanthrene	SW8270	ug/Nm3	2	<	0.318	<	0.32	<	0.327	<	0.33	---
Pyrene	SW8270	ug/Nm3	2	<	0.325	<	0.29	<	0.3	<	0.32	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
Metals-Vapor Phase (M-29)												
Antimony	SW6010	ug/Nm3	1	<	19.5	<	17.6	<	21.3	<	21	---
Arsenic	SW7060	ug/Nm3	1	<	0.166	<	0.15	<	0.182	<	0.18	---
Barium	SW6010	ug/Nm3	1		0.894		0.23		0.558		0.561	1.4
Beryllium	SW6010	ug/Nm3	1	<	0.131	<	0.118	<	0.143	<	0.14	---
Cadmium	SW7131	ug/Nm3	1		0.38		0.216		2.73		1.11	2.8
Chromium	SW6010	ug/Nm3	1		2.17	<	1.22	<	1.47	<	1.5	---
Cobalt	SW6010	ug/Nm3	1	<	1.05	<	0.945	<	1.14	<	1.1	---
Copper	SW6010	ug/Nm3	1	<	2.35	<	2.13		3.06	<	2.4	---
Lead	SW7421	ug/Nm3	1	<	0.256	<	0.231	<	0.279	<	0.28	---
Manganese	SW6010	ug/Nm3	1	<	0.398	<	0.36		4.32		1.57	3.9
Mercury	ICP/MS	ug/Nm3	1		0.108	<	0.0701	<	0.0847	<	0.085	---
Molybdenum	SW6010	ug/Nm3	1	<	1.9	<	1.72	<	2.07	<	2.1	---
Nickel	SW6010	ug/Nm3	1		5.55	<	3.27	<	3.96	<	4	---
Selenium	SW7740	ug/Nm3	1		0.953		0.671		0.533		0.719	1.8
Vanadium	SW6010	ug/Nm3	1	<	1.17	<	1.05	<	1.27	<	1.3	---
PAHs/SVOCs-Particulate Phase												
2-Chloronaphthalene	SW8270	ug/Nm3	1	<	0.458	<	0.125	<	0.287	<	0.46	---
2-Methylnaphthalene	SW8270	ug/Nm3	1	<	ERR	<	0.118	<	0.341	<	0.34	---
Acenaphthene	SW8270	ug/Nm3	1	<	0.554	<	0.132	<	0.339	<	0.55	---
Acenaphthylene	SW8270	ug/Nm3	1	<	0.306	<	0.0786	<	0.19	<	0.31	---
Anthracene	SW8270	ug/Nm3	1	<	0.341	<	0.1	<	0.206	<	0.34	---
Benzo(a)anthracene	SW8270	ug/Nm3	1	<	0.41	<	0.157	<	0.284	<	0.41	---
Benzo(a)pyrene	SW8270	ug/Nm3	1	<	0.613	<	0.168	<	0.411	<	0.61	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	1	<	0.499	<	0.154	<	0.345	<	0.5	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	1	<	0.747	<	0.182	<	0.488	<	0.75	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	1	<	0.606	<	0.161	<	0.404	<	0.61	---
Chrysene	SW8270	ug/Nm3	1	<	0.475	<	0.172	<	0.325	<	0.48	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	1	<	0.805	<	0.207	<	0.531	<	0.81	---
Fluoranthene	SW8270	ug/Nm3	1	<	0.324	<	0.104	<	0.201	<	0.32	---
Fluorene	SW8270	ug/Nm3	1	<	0.43	<	0.125	<	0.275	<	0.43	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	1	<	0.616	<	0.164	<	0.411	<	0.62	---
Naphthalene	SW8270	ug/Nm3	1	<	0.386	<	ERR	<	0.228	<	0.39	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Turbine Exhaust Gas (13)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Average	95% CI
PAHs/SVOCs-Particulate Phase (continued)												
Phenanthrene	SW8270	ug/Nm3	1	<	0.33	<	0.1	<	0.201	<	0.33	---
Pyrene	SW8270	ug/Nm3	1	<	0.279	<	0.114	<	0.197	<	0.28	---
PAHs/SVOCs-Vapor Phase												
2-Chloronaphthalene	SW8270	ug/Nm3	1	<	0.485	<	0.486	<	0.492	<	0.49	---
2-Methylnaphthalene	SW8270	ug/Nm3	1	<	0.52	<	0.568	<	0.564	<	0.57	---
Acenaphthene	SW8270	ug/Nm3	1	<	0.561	<	0.561	<	0.61	<	0.61	---
Acenaphthylene	SW8270	ug/Nm3	1	<	0.317	<	0.318	<	0.33	<	0.33	---
Anthracene	SW8270	ug/Nm3	1	<	0.293	<	0.297	<	0.345	<	0.34	---
Benzo(a)anthracene	SW8270	ug/Nm3	1	<	0.268	<	0.247	<	0.51	<	0.51	---
Benzo(a)pyrene	SW8270	ug/Nm3	1	<	0.348	<	0.297	<	0.66	<	0.66	---
Benzo(b)fluoranthene	SW8270	ug/Nm3	1	<	0.324	<	0.275	<	0.581	<	0.58	---
Benzo(g,h,i)perylene	SW8270	ug/Nm3	1	<	0.355	<	0.3	<	0.768	<	0.77	---
Benzo(k)fluoranthene	SW8270	ug/Nm3	1	<	0.324	<	0.275	<	0.628	<	0.63	---
Chrysene	SW8270	ug/Nm3	1	<	0.303	<	0.275	<	0.578	<	0.58	---
Dibenz(a,h)anthracene	SW8270	ug/Nm3	1	<	0.423	<	0.357	<	0.887	<	0.89	---
Fluoranthene	SW8270	ug/Nm3	1	<	0.203	<	0.207	<	0.337	<	0.34	---
Fluorene	SW8270	ug/Nm3	1	<	0.427	<	0.425	<	0.474	<	0.47	---
Indeno(1,2,3-cd)pyrene	SW8270	ug/Nm3	1	<	0.31	<	0.264	<	0.664	<	0.66	---
Naphthalene	SW8270	ug/Nm3	1	<	ERR	<	0.39	<	0.388	<	0.39	---
Phenanthrene	SW8270	ug/Nm3	1	<	0.279	<	0.286	<	0.334	<	0.33	---
Pyrene	SW8270	ug/Nm3	1	<	0.196	<	0.179	<	0.337	<	0.34	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Raw Coal (1a)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3	Result 3D		Average	95% CI
Ionic Species													
Chloride	D4208	ug/g	1	<	100	<	100	<	100		<	100	---
Chloride	D4208	ug/g	2	<	100	<	100	<	100		<	100	---
Chloride	D4208	ug/g	3	<	100	<	100	<	100		<	100	---
Fluoride	D3751/SIE	ug/g	1		90		80		90			86.7	220
Fluoride	D3751/SIE	ug/g	2		100		80		100			93.3	230
Fluoride	D3751/SIE	ug/g	3		90		80		100			90	220
Metals													
Antimony	SW7041	ug/g	1	<	1	<	1	<	1		<	1	---
Antimony	SW7041	ug/g	2	<	1	<	1	<	1		<	1	---
Antimony	SW7041	ug/g	3	<	1	<	1	<	1		<	1	---
Arsenic	SW7060	ug/g	1	<	1	<	1		1		<	1	---
Arsenic	SW7060	ug/g	2		6	<	1		1			2.5	6.2
Arsenic	SW7060	ug/g	3	<	1	<	1		3			1.33	3.3
Beryllium	SW6010	ug/g	1	<	0.2	<	0.2	<	0.2		<	0.2	---
Beryllium	SW6010	ug/g	2	<	0.2	<	0.2	<	0.2		<	0.2	---
Beryllium	SW6010	ug/g	3	<	0.2		0.2	<	0.2		<	0.2	---
Cadmium	SW7131	ug/g	1	<	0.2	<	0.2	<	0.2		<	0.2	---
Cadmium	SW7131	ug/g	2		0.8	<	0.2	<	0.2			0.333	0.83
Cadmium	SW7131	ug/g	3	<	0.2	<	0.2	<	0.2		<	0.2	---
Chromium	SW6010	ug/g	1		5		4		4			4.33	11
Chromium	SW6010	ug/g	2		4		4		6			4.67	12
Chromium	SW6010	ug/g	3		4		4		5			4.33	11
Cobalt	SW6010	ug/g	1		2		2		3			2.33	5.8
Cobalt	SW6010	ug/g	2		1		3		2			2	5
Cobalt	SW6010	ug/g	3		2		3		3			2.67	6.6
Copper	SW6010	ug/g	1		11		11		11			11	27
Copper	SW6010	ug/g	2		11		11		14			12	30
Copper	SW6010	ug/g	3		2		12		12			8.67	22
Lead	SW7421	ug/g	1		3		2		2			2.33	5.8
Lead	SW7421	ug/g	2		2		2		3			2.33	5.8
Lead	SW7421	ug/g	3		3		1		3			2.33	5.8
Manganese	D4326	Wt. %	1	<	0.01	<	0.01		0.01		<	0.01	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Raw Coal (1a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Manganese	D4326	Wt. %	2	< 0.01	< 0.01	0.01		< 0.01	---
Manganese	D4326	Wt. %	3	< 0.01	< 0.01	< 0.01		< 0.01	---
Manganese	SW6010	ug/g	1	8	8	8		8	20
Manganese	SW6010	ug/g	2	8	8	10		8.67	22
Manganese	SW6010	ug/g	3	9	10	10		9.67	24
Molybdenum	SW6010	ug/g	1	< 2	< 2	< 2		< 2	---
Molybdenum	SW6010	ug/g	2	< 2	< 2	< 2		< 2	---
Molybdenum	SW6010	ug/g	3	< 2	< 2	< 2		< 2	---
Nickel	ICP/MS	ug/g	1	21.3	18.9	19.6	11.4	19.9	50
Nickel	ICP/MS	ug/g	2	18.6	18.3	21.1		19.3	48
Nickel	ICP/MS	ug/g	3	19.3	18.9	18.9		19	47
Selenium	SW7740	ug/g	1	2	< 1	1		1.17	2.9
Selenium	SW7740	ug/g	2	3	8	< 1		3.83	9.5
Selenium	SW7740	ug/g	3	2	3	< 1		1.83	4.6
Vanadium	SW6010	ug/g	1	13	13	14		13.3	33
Vanadium	SW6010	ug/g	2	13	12	16		13.7	34
Vanadium	SW6010	ug/g	3	14	13	14		13.7	34

Table G-2. Analytical Results Not Used in Calculations

Stream: Coal Slurry (32)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Ionic Species														
Chloride	D4208	ug/g	1	<	100	<	100	<	100			<	100	---
Chloride	D4208	ug/g	2	<	100	<	100	<	100			<	100	---
Chloride	D4208	ug/g	3	<	100	<	100	<	100	<	100	<	100	---
Fluoride	D3751/SIE	ug/g	1		80		80		90				83.3	210
Fluoride	D3751/SIE	ug/g	2		80		80		60				73.3	180
Fluoride	D3751/SIE	ug/g	3		70		80		80		80		76.7	190
Metals														
Antimony	SW7041	ug/g	1	<	1	<	1	<	1			<	1	---
Antimony	SW7041	ug/g	2	<	1	<	1	<	1			<	1	---
Antimony	SW7041	ug/g	3	<	1	<	1	<	1	<	1	<	1	---
Arsenic	SW7060	ug/g	1	<	1		1	<	1			<	1	---
Arsenic	SW7060	ug/g	2		2		2		1				1.67	4.1
Arsenic	SW7060	ug/g	3	<	1	<	1		1		1	<	1	---
Beryllium	SW6010	ug/g	1	<	0.2	<	0.2	<	0.2			<	0.2	---
Beryllium	SW6010	ug/g	2	<	0.2	<	0.2	<	0.2			<	0.2	---
Beryllium	SW6010	ug/g	3	<	0.2	<	0.2	<	0.2	<	0.2	<	0.2	---
Cadmium	SW7131	ug/g	1	<	0.2	<	0.2	<	0.2			<	0.2	---
Cadmium	SW7131	ug/g	2	<	0.2	<	0.2	<	0.2			<	0.2	---
Cadmium	SW7131	ug/g	3	<	0.2	<	0.2	<	0.2	<	0.2	<	0.2	---
Chromium	SW6010	ug/g	1		4		4		4				4	9.9
Chromium	SW6010	ug/g	2		4		4		4				4	9.9
Chromium	SW6010	ug/g	3		4		3		4		4		3.67	9.1
Cobalt	SW6010	ug/g	1		3		2		2				2.33	5.8
Cobalt	SW6010	ug/g	2		2		2		2				2	5
Cobalt	SW6010	ug/g	3		3		2		3		2		2.67	6.6
Copper	SW6010	ug/g	1		11		11		11				11	27
Copper	SW6010	ug/g	2		11		11		11				11	27
Copper	SW6010	ug/g	3		11		11		11		10		11	27
Lead	SW7421	ug/g	1		2		2		2				2	5
Lead	SW7421	ug/g	2		2		2		1				1.67	4.1
Lead	SW7421	ug/g	3		2		2		2		1		2	5
Manganese	D4326	Wt. %	1	<	0.01		0.01	<	0.01			<	0.01	---

Table G-2. Analytical Results Not Used in Calculations

Stream: Coal Slurry (32)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Metals (continued)														
Manganese	D4326	Wt. %	2	<	0.01	<	0.01		0.01			<	0.01	---
Manganese	D4326	Wt. %	3	<	0.01		0.01	<	0.01	<	0.01	<	0.01	---
Manganese	SW6010	ug/g	1		8		8		8				8	20
Manganese	SW6010	ug/g	2		8		8		9				8.33	21
Manganese	SW6010	ug/g	3		8		9		9		8		8.67	22
Molybdenum	SW6010	ug/g	1	<	2	<	2	<	2			<	2	---
Molybdenum	SW6010	ug/g	2	<	2	<	2	<	2			<	2	---
Molybdenum	SW6010	ug/g	3	<	2	<	2	<	2	<	2	<	2	---
Nickel	ICP/MS	ug/g	1		18		13.1		17.6				16.2	40
Nickel	ICP/MS	ug/g	2		11.4		17		17.8				15.4	38
Nickel	ICP/MS	ug/g	3		9.54		16.9		19.7		20.1		15.4	38
Selenium	SW7740	ug/g	1	<	1	<	1		2				1	2.5
Selenium	SW7740	ug/g	2		3		2		1				2	5
Selenium	SW7740	ug/g	3		4	<	1	<	1		1		1.67	4.1
Vanadium	SW6010	ug/g	1		13		13		13				13	32
Vanadium	SW6010	ug/g	2		13		13		13				13	32
Vanadium	SW6010	ug/g	3		13		13		13		12		13	32
Metals (Test Phase II)														
Barium	SW6010a	ug/g	4		356		357		347		368		357	13
Boron	SW6010a	ug/g	4		21.5		38.3		36.4		36.3		33.1	12
Calcium	SW6010a	ug/g	4		9,770		9,470		9,240		9,320		9,450	370
Iron	SW6010a	ug/g	4		2,000		1,940		2,450		2,010		2,100	370
Magnesium	SW6010a	ug/g	4		1,780		1,720		1,690		1,720		1,730	65
Potassium	SW6010a	ug/g	4		98.9		103		120		122		111	19
Sodium	SW6010a	ug/g	4		995		915		853		867		908	100
Titanium	SW6010a	ug/g	4		437		437		436		435		436	1.3

Table G-2. Analytical Results Not Used in Calculations

Stream: Coal Slurry (33)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ionic Species									
Chloride	D4208	ug/g	1	< 100	< 100	< 100		< 100	---
Chloride	D4208	ug/g	2	< 100	< 100	< 100		< 100	---
Chloride	D4208	ug/g	3	< 100	< 100	< 100		< 100	---
Fluoride	D3751/SIE	ug/g	1	330	330	360		340	840
Fluoride	D3751/SIE	ug/g	2	400	300	240		313	780
Fluoride	D3751/SIE	ug/g	3	360	410	460		410	1,000
Metals									
Antimony	SW7041	ug/g	1	< 1	< 1	< 1		< 1	---
Antimony	SW7041	ug/g	2	< 1	< 1	< 1		< 1	---
Antimony	SW7041	ug/g	3	< 1	< 1	< 1		< 1	---
Arsenic	SW7060	ug/g	1	2	1	3		2	5
Arsenic	SW7060	ug/g	2	1	2	1		1.33	3.3
Arsenic	SW7060	ug/g	3	2	< 1	< 1		1	2.5
Beryllium	SW6010	ug/g	1	< 0.2	< 0.2	< 0.2		< 0.2	---
Beryllium	SW6010	ug/g	2	< 0.2	0.2	0.2		< 0.2	---
Beryllium	SW6010	ug/g	3	0.2	0.2	0.2		0.2	0.5
Cadmium	SW7131	ug/g	1	< 0.2	< 0.2	1.7		0.633	1.6
Cadmium	SW7131	ug/g	2	< 0.2	1.4	< 0.2		0.533	1.3
Cadmium	SW7131	ug/g	3	2.9	2.9	< 0.2		1.97	4.9
Chromium	SW6010	ug/g	1	5	6	6		5.67	14
Chromium	SW6010	ug/g	2	5	5	4		4.67	12
Chromium	SW6010	ug/g	3	5	5	4		4.67	12
Cobalt	SW6010	ug/g	1	2	3	2		2.33	5.8
Cobalt	SW6010	ug/g	2	2	1	1		1.33	3.3
Cobalt	SW6010	ug/g	3	2	2	2		2	5
Copper	SW6010	ug/g	1	14	15	14		14.3	36
Copper	SW6010	ug/g	2	15	14	14		14.3	36
Copper	SW6010	ug/g	3	15	14	14		14.3	36
Lead	SW7421	ug/g	1	5	6	11		7.33	18
Lead	SW7421	ug/g	2	7	5	6		6	15
Lead	SW7421	ug/g	3	8	24	23		18.3	46
Manganese	D4326	Wt. %	1	0.01	0.01	0.01		0.01	0.025

Table G-2. Analytical Results Not Used in Calculations

Stream: Coal Slurry (33)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3	Result 3D		Average	95% CI
Metals (continued)													
Manganese	D4326	Wt. %	2		0.01	<	0.01	<	0.01		<	0.01	---
Manganese	D4326	Wt. %	3		0.01		0.01		0.01			0.01	0.025
Manganese	SW6010	ug/g	1		10		10		10			10	25
Manganese	SW6010	ug/g	2		9		9		10			9.33	23
Manganese	SW6010	ug/g	3		10		10		9			9.67	24
Molybdenum	SW6010	ug/g	1	<	2	<	2	<	2		<	2	---
Molybdenum	SW6010	ug/g	2	<	2	<	2	<	2		<	2	---
Molybdenum	SW6010	ug/g	3	<	2	<	2	<	2		<	2	---
Nickel	ICP/MS	ug/g	1		16.9		21.8		22.9			20.5	51
Nickel	ICP/MS	ug/g	2		23.2		21.2		22.7			22.4	56
Nickel	ICP/MS	ug/g	3		157		205		155			172	430
Selenium	SW7740	ug/g	1		2	<	1		4			2.17	5.4
Selenium	SW7740	ug/g	2	<	1		2	<	1			1	2.5
Selenium	SW7740	ug/g	3		2		3		1			2	5
Vanadium	SW6010	ug/g	1		15		16		17			16	40
Vanadium	SW6010	ug/g	2		15		14		14			14.3	36
Vanadium	SW6010	ug/g	3		14		14		13			13.7	34
Metals (Test Phase II)													
Barium	SW6010a	ug/g	4		465		432		447	457		450	22
Boron	SW6010a	ug/g	4		33.1		39.1		35.6	40.2		37	5.2
Calcium	SW6010a	ug/g	4		11,600		10,800		11,400	11,400		11,300	560
Iron	SW6010a	ug/g	4		2,430		2,220		2,360	2,420		2,360	150
Magnesium	SW6010a	ug/g	4		2,090		1,950		2,060	2,100		2,050	110
Potassium	SW6010a	ug/g	4		130		116		133	152		133	24
Sodium	SW6010a	ug/g	4		1,120		1,030		1,080	1,620		1,210	440
Titanium	SW6010a	ug/g	4		535		535		503	504		519	29

Table G-2. Analytical Results Not Used in Calculations

Stream: Raw Gas Char-Filtered @1000 deg F (5)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (Test Phase II)									
Barium	SW6010a	ug/g	4						
Boron	SW6010a	ug/g	4						
Calcium	SW6010a	ug/g	4						
Iron	SW6010a	ug/g	4						
Magnesium	SW6010a	ug/g	4						
Potassium	SW6010a	ug/g	4						
Sodium	SW6010a	ug/g	4						
Titanium	SW6010a	ug/g	4						

Table G-2. Analytical Results Not Used in Calculations

Stream: Raw Gas Char-Filtered @500 deg F (5a)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (Test Phase II)									
Barium	SW6010a	ug/g	4						
Boron	SW6010a	ug/g	4						
Calcium	SW6010a	ug/g	4						
Iron	SW6010a	ug/g	4						
Magnesium	SW6010a	ug/g	4						
Potassium	SW6010a	ug/g	4						
Sodium	SW6010a	ug/g	4						
Titanium	SW6010a	ug/g	4						

Table G-2. Analytical Results Not Used in Calculations

Stream: Recycled Char Solids (5c)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Ionic Species									
Chloride	D4208	ug/g	3						
Fluoride	D3751/SIE	ug/g	3						
Metals									
Antimony	SW7041	ug/g	3						
Arsenic	SW7060	ug/g	3						
Beryllium	SW6010	ug/g	3						
Cadmium	SW7131	ug/g	3						
Chromium	SW6010	ug/g	3						
Cobalt	SW6010	ug/g	3						
Copper	SW6010	ug/g	3						
Lead	SW7421	ug/g	3						
Manganese	D4326	Wt. %	3						
Manganese	SW6010	ug/g	3						
Molybdenum	SW6010	ug/g	3						
Nickel	ICP/MS	ug/g	3						
Selenium	SW7740	ug/g	3						
Vanadium	SW6010	ug/g	3						

Table G-2. Analytical Results Not Used in Calculations

Stream: Slag (4)

Analyte	Method	Units	Test Period		Result 1		Result 2		Result 3		Result 3D		Average	95% CI
Ionic Species														
Chloride	D4208/IC	ug/g	1		53.8		NA		NA				53.8	---
Chloride	D4208/IC	ug/g	2		NA		NA		51.8				51.8	---
Chloride	D4208/IC	ug/g	3		NA		46.6		NA				46.6	---
Fluoride	D4208/IC	ug/g	1		21.8		NA		NA				21.8	---
Fluoride	D4208/IC	ug/g	2		NA		NA		47.5				47.5	---
Fluoride	D4208/IC	ug/g	3		NA		97.5		NA				97.5	---
Metals														
Antimony	SW7041	ug/g	1		3	<	2	<	2			<	2	---
Antimony	SW7041	ug/g	2	<	2	<	2	<	2	<	2	<	2	---
Antimony	SW7041	ug/g	3	<	2	<	2	<	2			<	2	---
Arsenic	SW7060	ug/g	1		4		5		5				4.67	12
Arsenic	SW7060	ug/g	2	<	2		4		6		6		3.67	9.1
Arsenic	SW7060	ug/g	3		5		4		7				5.33	13
Beryllium	SW6010	ug/g	1		2.2		1.9		2.6				2.23	5.5
Beryllium	SW6010	ug/g	2		2.1		2.1		2.5		2.2		2.23	5.5
Beryllium	SW6010	ug/g	3		2.2		1.9		1.7				1.93	4.8
Cadmium	SW7131	ug/g	1	<	1	<	1	<	1			<	1	---
Cadmium	SW7131	ug/g	2	<	1	<	1	<	1	<	1	<	1	---
Cadmium	SW7131	ug/g	3	<	1	<	1	<	1			<	1	---
Chromium	SW6010	ug/g	1		78		72		84				78	190
Chromium	SW6010	ug/g	2		72		93		81		73		82	200
Chromium	SW6010	ug/g	3		68		65		57				63.3	160
Cobalt	SW6010	ug/g	1		35		29		32				32	79
Cobalt	SW6010	ug/g	2		29		29		33		27		30.3	75
Cobalt	SW6010	ug/g	3		32		30		24				28.7	71
Copper	SW6010	ug/g	1		160		150		170				160	400
Copper	SW6010	ug/g	2		150		150		170		160		157	390
Copper	SW6010	ug/g	3		160		140		130				143	360
Lead	SW7421	ug/g	1	<	2		3		2				2	5
Lead	SW7421	ug/g	2		2	<	2	<	2	<	2	<	2	---
Lead	SW7421	ug/g	3		2		3		5				3.33	8.3
Manganese	D4326	Wt. %	1		0.05		0.04		0.05				0.0467	0.12

Table G-2. Analytical Results Not Used in Calculations

Stream: Slag (4)

Analyte	Method	Units	Test Period	Result 1	Result 2	Result 3	Result 3D	Average	95% CI
Metals (continued)									
Manganese	D4326	Wt. %	2	0.04	0.06	0.05	0.05	0.05	0.12
Manganese	D4326	Wt. %	3	0.05	0.05	0.04		0.0467	0.12
Manganese	SW6010	ug/g	1	130	110	120		120	300
Manganese	SW6010	ug/g	2	110	110	130	120	117	290
Manganese	SW6010	ug/g	3	120	110	98		109	270
Molybdenum	SW6010	ug/g	1	< 10	< 10	< 10		< 10	---
Molybdenum	SW6010	ug/g	2	< 10	< 10	< 10	< 10	< 10	---
Molybdenum	SW6010	ug/g	3	< 10	< 10	< 10		< 10	---
Nickel	ICP/MS	ug/g	1	295	247	270		271	670
Nickel	ICP/MS	ug/g	2	263	280	320	309	288	710
Nickel	ICP/MS	ug/g	3	323	279	229		277	690
Selenium	SW7740	ug/g	1	< 2	10	3		4.67	12
Selenium	SW7740	ug/g	2	17	13	6	< 2	12	30
Selenium	SW7740	ug/g	3	6	8	29		14.3	36
Vanadium	SW6010	ug/g	1	200	170	210		193	480
Vanadium	SW6010	ug/g	2	180	180	200	190	187	460
Vanadium	SW6010	ug/g	3	190	170	150		170	420
Metals (Test Phase II)									
Barium	SW6010a	ug/g	4	6890	6870	6970	6750	6870	140
Boron	SW6010a	ug/g	4	492	432	351	458	433	96
Calcium	SW6010a	ug/g	4	172,000	169,000	169,000	164,000	168,000	5,200
Iron	SW6010a	ug/g	4	36,000	35,500	35,700	35,300	35,600	450
Magnesium	SW6010a	ug/g	4	30,100	29,600	29,600	29,100	29,600	640
Potassium	SW6010a	ug/g	4	1,510	1,450	1,630	1,790	1,590	240
Sodium	SW6010a	ug/g	4	16,900	14,500	14,900	17,000	15,800	2,100
Titanium	SW6010a	ug/g	4	8,400	8,060	8,190	7,920	8,140	320

APPENDIX H: DESIGN DETAIL, HOT GAS PROBE

Preamble

The requirements, design and operation of the source sampling equipment for acquiring valid samples of hot syngas are addressed in this Design Description. Only those activities related to collecting samples of hot syngas are included. The sampling strategy, test methods, QA/QC procedures, analytical methods, and data analysis procedures are discussed in the document entitled "Hazardous Air Pollutant Testing at the LGTI Gasification Plant: Draft Test Plan."

Section 2 of this Design Description includes a summary of the design requirements for the hot syngas sampling device. The design philosophy, approach, and description are included in Section 3. The operation of the sampling system is described in Section 4. The detailed isolation valve information is included in Attachment A, while example heat transfer, stress, and other design calculations are given in Attachments B through G. The operational check list is provided in Attachment H.

Design Requirements

The purpose of the equipment described in this document is to obtain samples for subsequent analysis of hot raw synthesis gas and particulate matter produced by the Louisiana Gas Technology, Inc. (LGTI) gasifier. The gas and particulate matter samples were collected at a location immediately downstream of the heat recovery boiler. This location was sampled as part of a comprehensive emissions measurement program to characterize and quantify hazardous air pollutant (HAP) emissions from the LGTI facility, to define the HAP levels in selected internal process streams, and to determine the fate of HAPs in the gasification system.

Facility Description

The LGTI facility produces medium Btu synthetic gas (syngas) which is used by the existing gas turbine power generation units at Dow Chemical Company, Louisiana Division, chemical complex near Plaquemine, Louisiana. At capacity, the facility produces 30,000 MM Btu of syngas per day from approximately 2,200 tons per day of western subbituminous coal. The LGTI facility consists of a high-temperature, entrained-flow, slagging gasifier with auxiliary systems including coal slurry preparation, particulate recycle, heat recovery, Selectamine® acid gas removal, Selectox® sulfur recovery, tail gas incineration, and wastewater treatment. Oxygen for the gasifier is supplied from an over-the-fence air separation unit.

The raw, particulate-laden syngas from the gasifier is partially cooled in a heat recovery train, in which steam is generated. The particulate is then removed in a wet scrubbing system. The particulate (char) removed from the syngas is recycled to the gasifier. The syngas is further cooled through a series of heat exchangers before entering the H_2S removal process.

Advanced gasification concepts include high-temperature processes for removing particulate and reduced sulfur species. These processes would operate at temperatures as high as 1200°F to improve the thermal efficiency of the gasification/power generation system. Sampling the hot raw syngas at LGTI will help provide data that can be used in the design and operation of such high-temperature gas cleanup processes.

Sampling Methods

Representative samples of the hot raw synthesis gas were collected using reference methods, modifications of standard test methods, and methods developed by Radian for sampling synthesis gas streams. Methods that were used during the hot gas testing at LGTI include the following:

- Multi Metals (EPA Standard Method 29[1]);
- Ammonia, chloride, fluoride; Impinger collection (EPA Method 26 - modified);
- Multi Metals: Charcoal adsorption (Radian development);
- Cyanide: Impinger collection (Texas Air Control Board Method); and
- Particulate Matter: Grab sample collected in an in-stack thimble (modification of EPA Standard Method 17[2]).

Environment

The location, availability, process conditions, sampling requirements, and nitrogen needs associated with the hot gas sampling program are described in this section of the report.

The sampling port was installed through an existing 20-inch manway. The manway centerline is horizontal and is located approximately 25½ inches above the metal grating floor, which is raised above the floor of level 8. The mating portion of the manway flange which is welded to the vessel is not a standard ANSI B16.5 nozzle. This flange is made from a pierced right circular cylindrical piece of metal. The OD is approximately 30½ inches and the ID is nearly 23¼ inches. The bolt circle has been drilled and tapped, and studs have been inserted. There are no nuts on the process vessel side of the flange bolts nor has the backside of the nozzle been relieved for use of nuts. The distance between the face of the manway flange and the outside of the vessel is approximately 5½ inches.

The insulating plug which normally fills the manway during plant operation is 14 inches deep. The first 7 inches is comprised of refractory, which is backed with 7 inches of Kaowool®. There is a ring pull in the center of the plug which is used for removing the plug for vessel entry and/or inspection. There is a 1-inch high metallic retaining ring around the ID surface of the manway to position the plug and prevent it from falling into the vessel. This ring is essentially an extension of the metallic liner which protects the refractory lining on the inside of the pipe.

The area directly above the manway and the probe position is crisscrossed with structural steel and floor grating that can be used to support the isolation valves and probe assembly. A grated access platform, parallel to the centerline of the manway, is approximately 6 feet by 8 feet and is located immediately adjacent to and centered on the centerline of the manway. The platform has a standard handrail, midspan rail and kick board on all open sides. This platform is approximately 3 feet above level 8 of the facility.

Process Conditions. The approximate conditions of the process gas at the sampling location are:

- Temperature: 850-1200°F [450-650°C];
- Pressure: 350-450 psig;

- Gas flow rate: approximately 120,000 dscfm;

- Approximate composition, volume percent:

H_2O	30
H_2	28
CO	23
CO_2	16
CH_4	1.3
N_2	1.7

Lower concentrations of H_2S, COS, and NH_3 are also present in the process gas. The particulate loading in the syngas is relatively high at this point in the process..

There is considerable open (unoccupied) area immediately adjacent to the access platform on Level 8. This area is open on the sides to weather, although the manway itself is, in general, protected from direct rain and sunlight.

Sampling System Requirements. The existing manway cover and insulation plug were bored through to provide access for the sampling probe, and the manway cover were modified to accept the two, three-inch isolation valves and probe assembly. Modifications to the manway cover and insulation plug will be provided be LGTI.

The general requirements for the hot gas sampling location were:

- Port access must be secured when not being used for sampling purposes.

- Port must pass a right circular cylinder 3 inches in diameter.

- A clear space coincident to the center line of the access port must be provided equal to a rectangle approximately 48 inches square by approximately 12 feet long.

The sample stream or gas sample was drawn at flow rates of 1 to 4 scfm through the sampling probe. The temperature of the sampled gas in the probe was to be maintained above 400°F to avoid condensation and was not to exceed the maximum design temperature of the process.

Nitrogen. Up to 200 lb/hr of gaseous nitrogen at 500 psig and ambient temperature is needed at this sampling location. Taps were provided so that nitrogen that had been used in the adjacent idle dry filter portion of the process and was made available for use by the sampling crew.

Mechanical Class

All of the sampling equipment is temporary and not intended for installation beyond what is required to acquire the samples. As such, the equipment was ruggedly constructed and met nominal commercial construction requirements. Stress, earthquake, and thermal analysis formal reports were not required.

Electrical Class

All of the sampling equipment is temporary and not intended for installation beyond what is required to acquire the samples. As such, the equipment was of rugged construction and met nominal construction requirements for wet and combustible atmospheres. Good grounding practice were used throughout.

At least four 115 V outlets were located on the exterior handrails at points which could be used if needed. The plugs for these outlets are Crouse Hinds Hazardous environment connectors.

Design Description

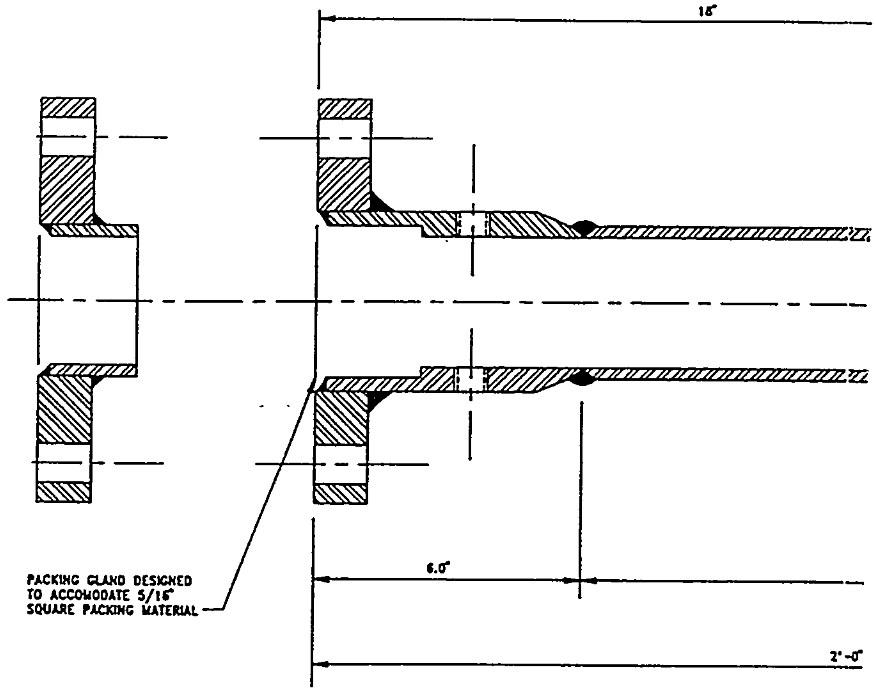
The hot gas probe design philosophy, approach, and description of the equipment to meet the design requirements are described in this section. The design is further detailed in drawings as set forth in Table 1. These drawings are included in this section. Analytical computations and detailed engineering analysis have been performed, and the calculational procedures are provided in Appendices A through G of this document.

Table 1
Drawing Hierarchy for Hot Gas Probe

Drawing Number	Title or Contents
643-004-30-02, sheet A	Sampling Gland
643-004-30-02, sheet B	Sampling Probe
643-004-30-02, sheet C	Probe Trolley
643-004-30-02, sheet D	Probe Unit: Trolley Assembly and Stiffleg
643-004-30-02, sheet E	Probe Unit: Trolley Assembly (winches on opposite end of the assembly)

Interface

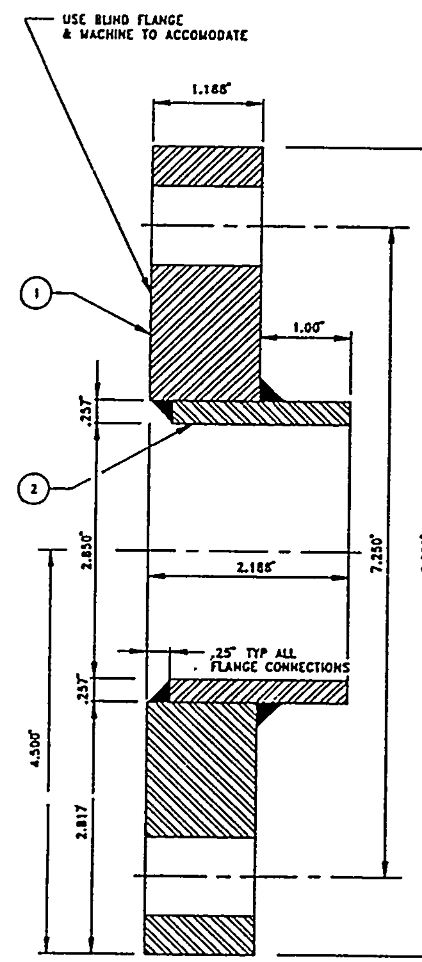
The interface between the LGTI process and Radian's sampling equipment is the inboard flange on the first (inboard) isolation valve provided by Radian, as indicated in Radian Drawing No.

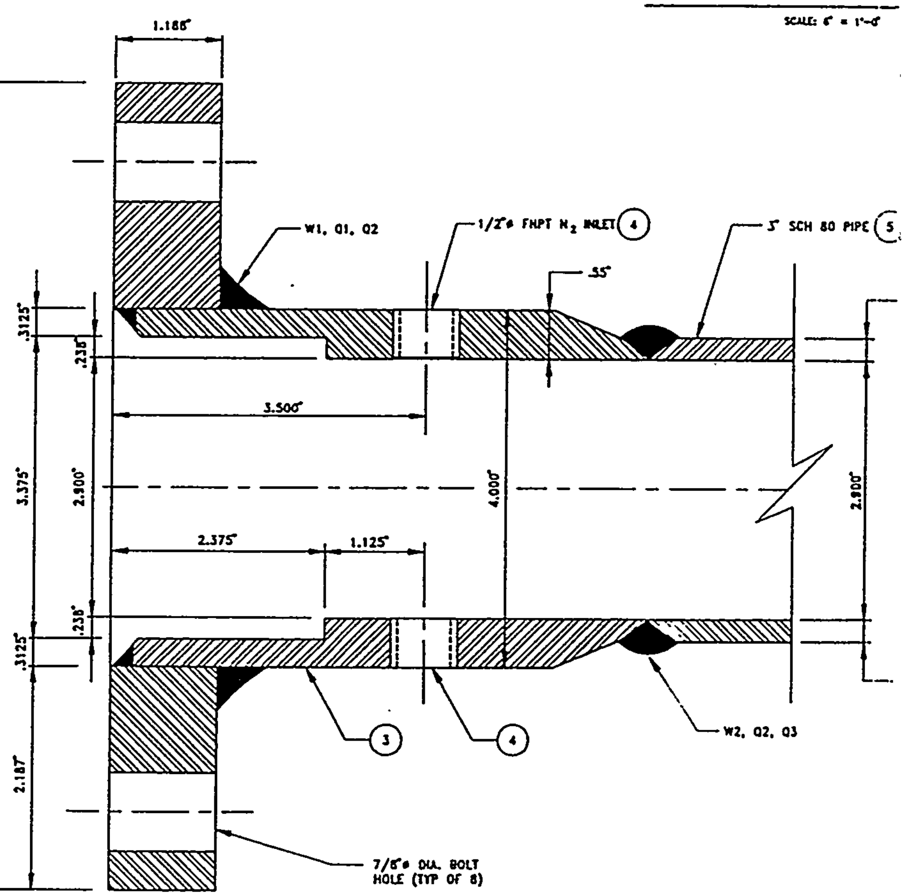


TOP VIE

GLAND ASS

SCALE: 6" = 1'-0"



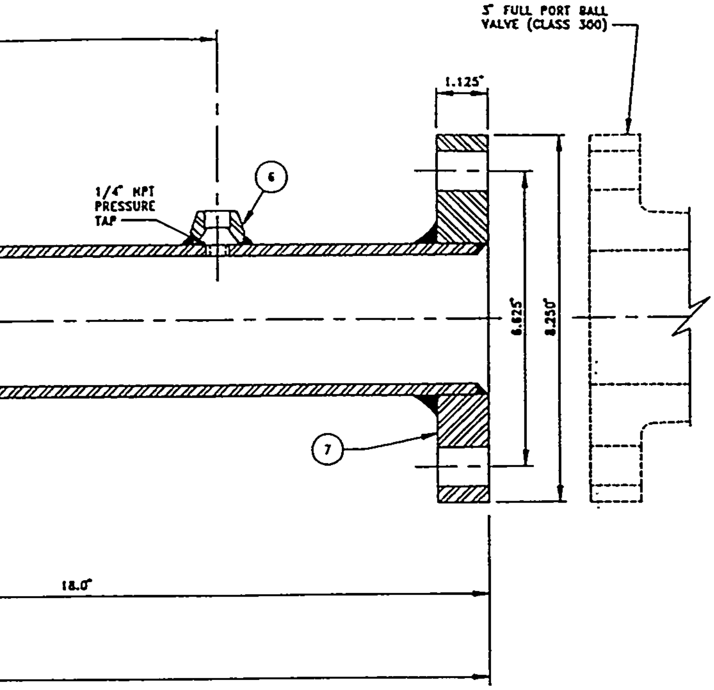


PACKING RETAINER

SCALE: 1:1

GLAND

SCALE: 1:1



MBLY

Parts List		
Item No.	Description	Quantity
1	Retainer Flange, 3.5" Blind Flange, 300#, Machined as Shown. ASTM A182, Grade F316	1
2	Retainer Tube, 3" Schedule 160 Pipe, Machined as Shown. ASTM A312, Grade TP316	1
3	Packing Gland, 3.5" XXS Pipe, Machined as Shown. ASTM A312, Grade TP316	1
4	Nitrogen Inlet Taps	2
5	Gland, 3" Schedule 80 Pipe ASTM A312, Grade TP316	1.5ft.
6	Bonney Forge 1/4" FNPT, 3000# Threadolet	1
7	3" Flange, 300# ASTM A182, Grade F316	1

Weld Specifications:

W1 = Fillet Welding Procedures

W2 = Butt Welding Procedures

Inspection Procedures:

Q1 = Dye Penetrant

Q2 = Leak Test

Q3 = Pressure Test (Hydrostatic)

Notes:

All metal components in contact with flow stream are Type 316 stainless.
All other metal components carbon steel unless noted.
All bolts will be grade B7.

NOTES:

1. ITEM 3 & 5 TO BE CONCENTRIC WITHIN 0.010" TIR AFTER WELDING.
2. BORE I.D. 2" BEYOND CIRCUMFERENTIAL WELD TO CLEANUP I.D. SURFACE AFTER WELDING.

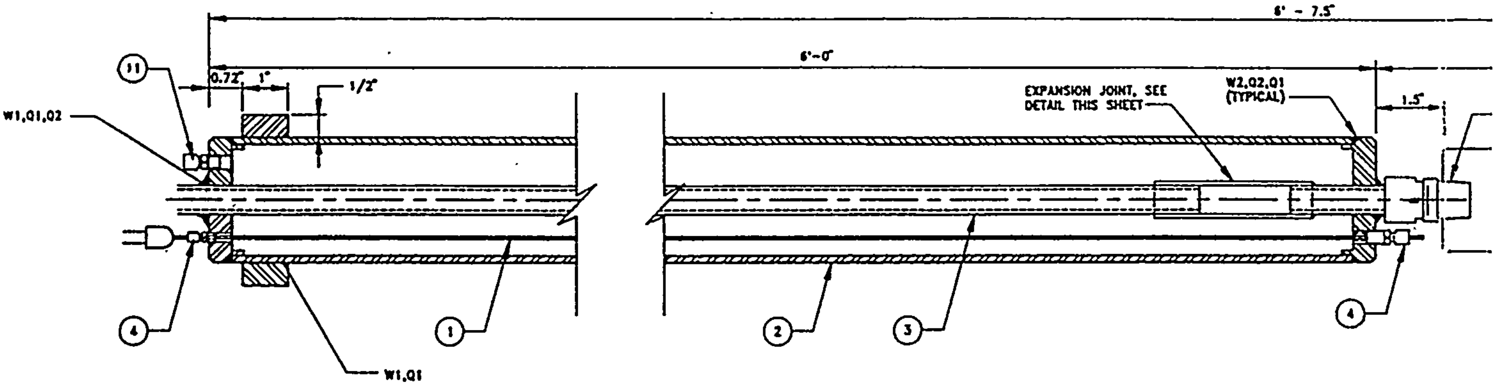
Revisions			
Number	Descriptions	Date	Approved

RADIAN CORPORATION

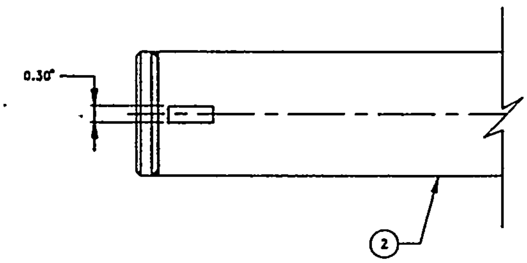
Austin, Texas 78720-1088

Scale: AS SHOWN		**DOW HOT GAS SAMPLING GLAND**		
Designed by: J.J.Z.	Date:			
Drawn by: R.D.F.	Date: 6-01-94			
Checked by:	Date: 6-01-94			
Approved By:	Date:	Contract No.:	Drawing No.:	Rev:
Tolerance (unless otherwise stated) x.xxx 0.005 x.x 0.01 x.xx 0.01		643-004-30-02	A	A

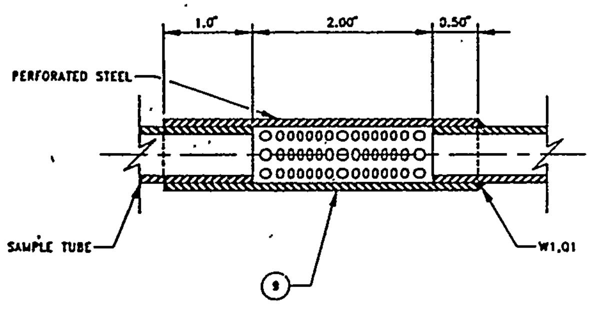
B1082A 09.22.94



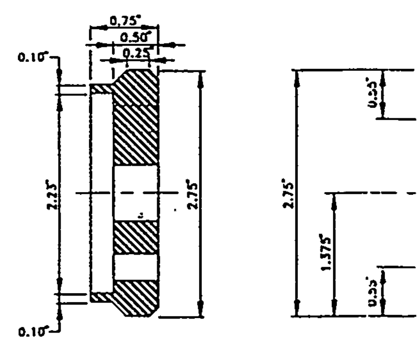
PROBE ASSEMBLY



PROBE ASSEMBLY TOP VIEW

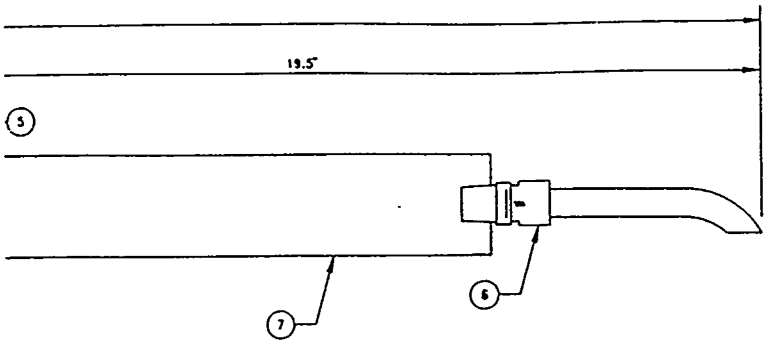


EXPANSION JOINT DETAIL



SAMPLE END AND A

BULKHEAD D



Parts List		
Item No.	Description	Quantity
1	Thermocouple, Omega CASS-18G-60	1
2	Sample Sheath, 2 3/4" Stainless steel tubing, 0.188" wall thickness ASTM A213, type 316, Seamless, H or C Finish	6ft.
3	Sample tube, 5/8" Stainless steel tubing, 0.085" wall thickness ASTM A213, type 316, Seamless, H or C Finish	6ft.
4	Thermocouple fitting, Swagelock SS-200-1-2-BT	2
5	Sample tube fitting, Swagelock SS-1010-1-8	1
6	Nozzle fitting, Swagelock SS-1010-1-8	1
7	Filter assembly, 130 mm filter	1
8	Nozzle, 5/8" Stainless steel tubing, 0.085" wall thickness, formed as shown ASTM A213, type 316, Seamless, H or C Finish	1ft.
9	Expansion joint/N_2 inlet, 16ga. perforated stainless steel sheet, 1/8" holes, 40% open	$1ft^2$
10	Sample sheath bulkheads, stainless steel stock, machined as shown ASTM A240, type 316	
11	N_2 Inlet, Swagelock SS-600-1-4	1

Weld Specifications:

W1= Filter Welding Procedure

W2= Butt Welding Procedure

Inspection Procedure:

Q1= Dye Penetrant

Q2= Leak test

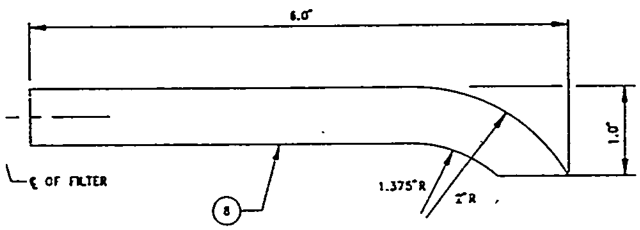
Q3= Pressure test (Hydrostatic)

Notes:

All metal components in contact with flow stream are Type 316 stainless.

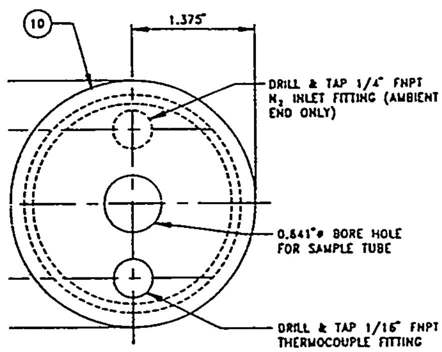
All other metal components carbon steel unless noted.

All bolts will be grade B7.



NOZZLE DETAIL

SCALE: 1:1



BIENT END

ETAILS

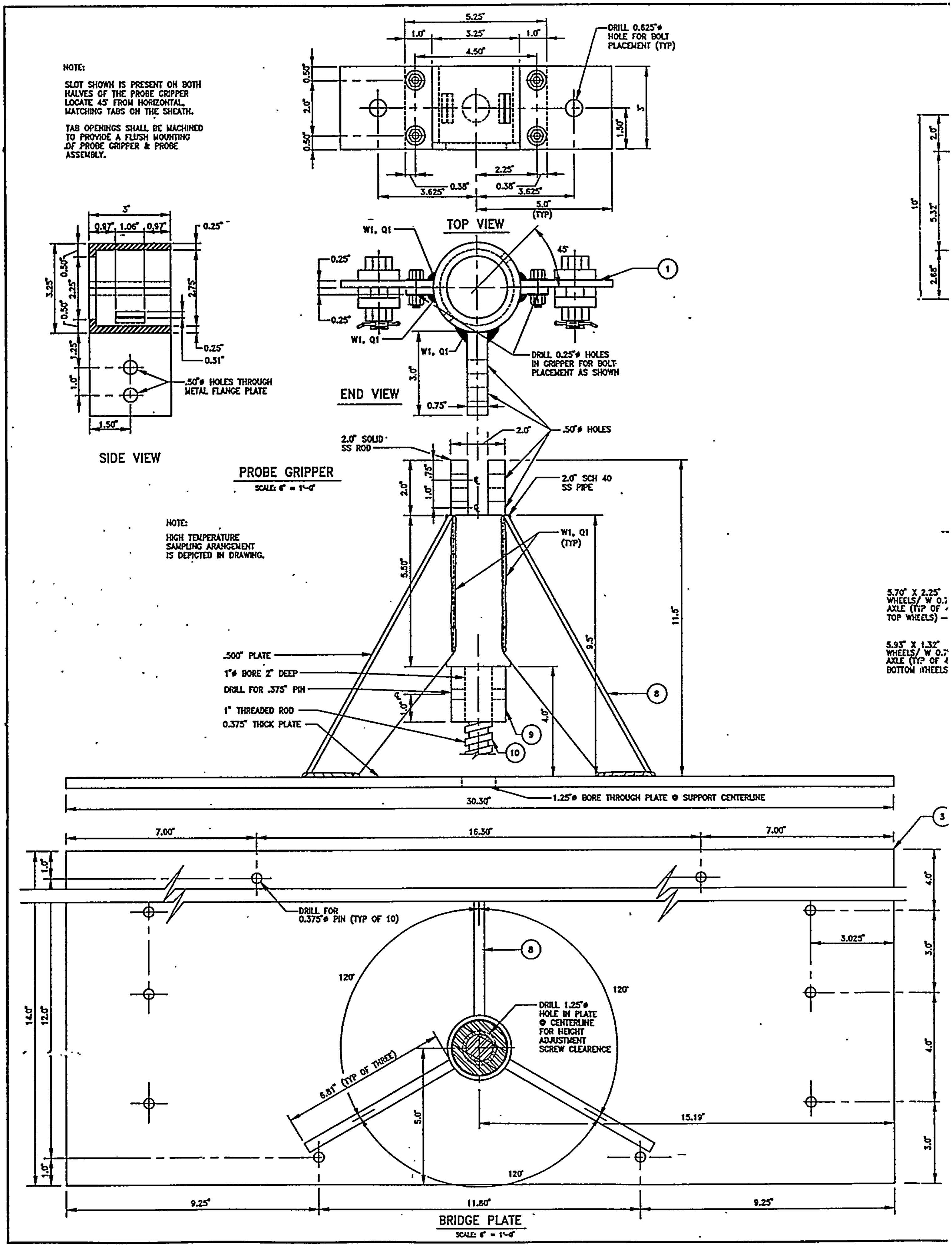
Revisions			
Number	Descriptions	Date	Approved

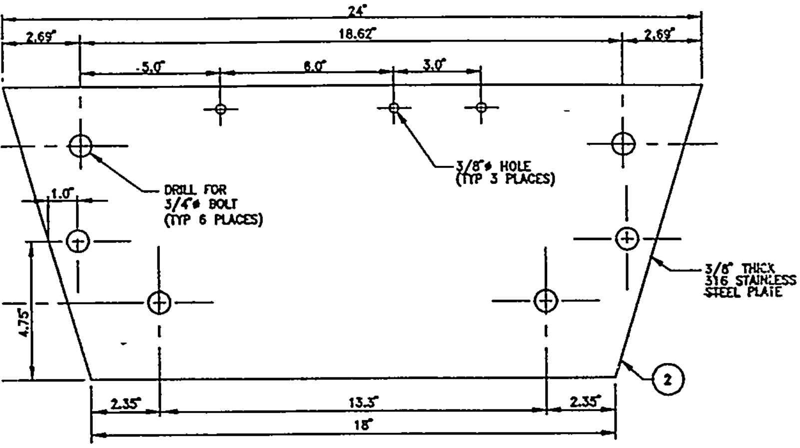
RADIAN CORPORATION

Austin, Texas 78720-1088

Scale: AS SHOWN		DOW HOT GAS SAMPLING PROBE
Designed by: J.J.Z.	Date:	
Drawn by: R.O.F.	Date: 6-01-94	
Checked by:	Date: 6-01-94	
Approved By:	Date:	Contract No.: 643-004-30-02 / Drawing No.: B / Rev: A
Tolerance (unless otherwise stated) x.xxx 0.005 x.xx 0.01		

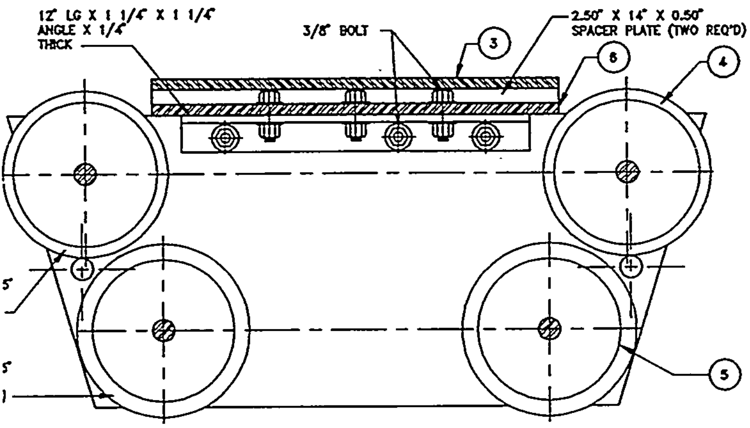
8108288 09.22.94


NOTE:
SLOT SHOWN IS PRESENT ON BOTH HALVES OF THE PROBE GRIPPER LOCATE 45° FROM HORIZONTAL, MATCHING TABS ON THE SHEATH.
TAB OPENINGS SHALL BE MACHINED TO PROVIDE A FLUSH MOUNTING OF PROBE GRIPPER & PROBE ASSEMBLY.
DRILL 0.625"⌀ HOLE FOR BOLT PLACEMENT (TYP)
TOP VIEW
W1, Q1
DRILL 0.25"⌀ HOLES IN GRIPPER FOR BOLT PLACEMENT AS SHOWN
END VIEW
.50"⌀ HOLES THROUGH METAL FLANGE PLATE
SIDE VIEW
PROBE GRIPPER
SCALE: 6" = 1'-0"
.50"⌀ HOLES
2.0" SOLID SS ROD
2.0" SCH 40 SS PIPE
NOTE:
HIGH TEMPERATURE SAMPLING ARANGEMENT IS DEPICTED IN DRAWING.
W1, Q1 (TYP)
.500" PLATE
1"⌀ BORE 2" DEEP
DRILL FOR .375" PIN
1" THREADED ROD
0.375" THICK PLATE
1.25"⌀ BORE THROUGH PLATE @ SUPPORT CENTERLINE
5.70" X 2.25" WHEELS/ W 0.7 AXLE (TYP OF 4 TOP WHEELS)
5.93" X 1.32" WHEELS/ W 0.7 AXLE (TYP OF 4 BOTTOM WHEELS
DRILL FOR 0.375"⌀ PIN (TYP OF 10)
DRILL 1.25"⌀ HOLE IN PLATE @ CENTERLINE FOR HEIGHT ADJUSTMENT SCREW CLEARENCE
6.81" (TYP OF THREE)
BRIDGE PLATE
SCALE: 6" = 1'-0"



SIDE PLATE

SCALE: 4" = 1'-0"



TROLLEY LONGITUDINAL SECTION

SCALE: 4" = 1'-0"

DOW Probe Parts List		
Item No.	Description	Quantity
1	Probe Grip, Fabricated from 3.5" XXS, 3/8" steel side tabs, and 3/4" plate for tounge	1
2	Trolley side plate, 3/8" A-666 type 316 HRAP	4
3	Probe bridge, 3/4" A-666 type 316 HRAP	1
4	Upper trolley wheels	8
5	Lower trolley wheels	8
6	Trolley bridge, 3/8" A-666 type 316 HRAP	2
7	6" I-Beam, standard weight, A-36	2012"
8	Gusset, 1/2" steel, A-666 type 316 HRAP	3
9	Grip adjuster, 2" steel stock	1
10	1" Threaded rod, 5 ACME threads/inch	1

Weld Specifications:

W1 = Fillet Welding Procedures

W2 = Butt Welding Procedures

Inspection Procedures:

Q1 = Dye Penetrant

Q2 = Leak Test

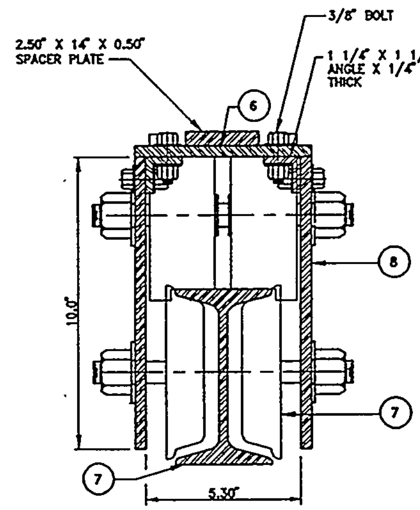
Q3 = Pressure Test (Hydrostatic)

Notes:

All metal components in contact with flow stream are Type 316 stainless.

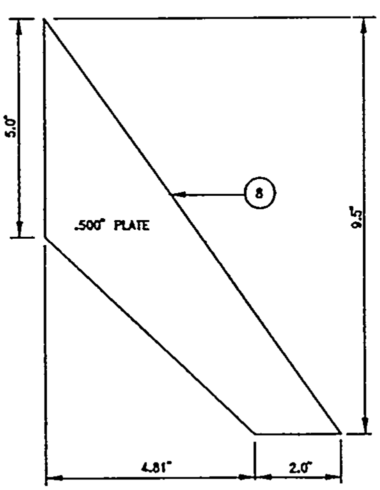
All other metal components carbon steel unless noted.

All bolts will be grade B7



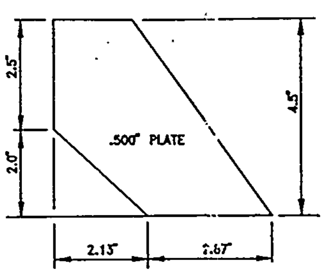
TROLLEY CROSS SECTION

SCALE: 4" = 1'-0"



HIGH TEMPERATURE GUSSET DETAIL

SCALE: 6" = 1'-0"



LOW TEMPERATURE GUSSET DETAIL

SCALE: 6" = 1'-0"

PROBE TROLLEY DETAILS

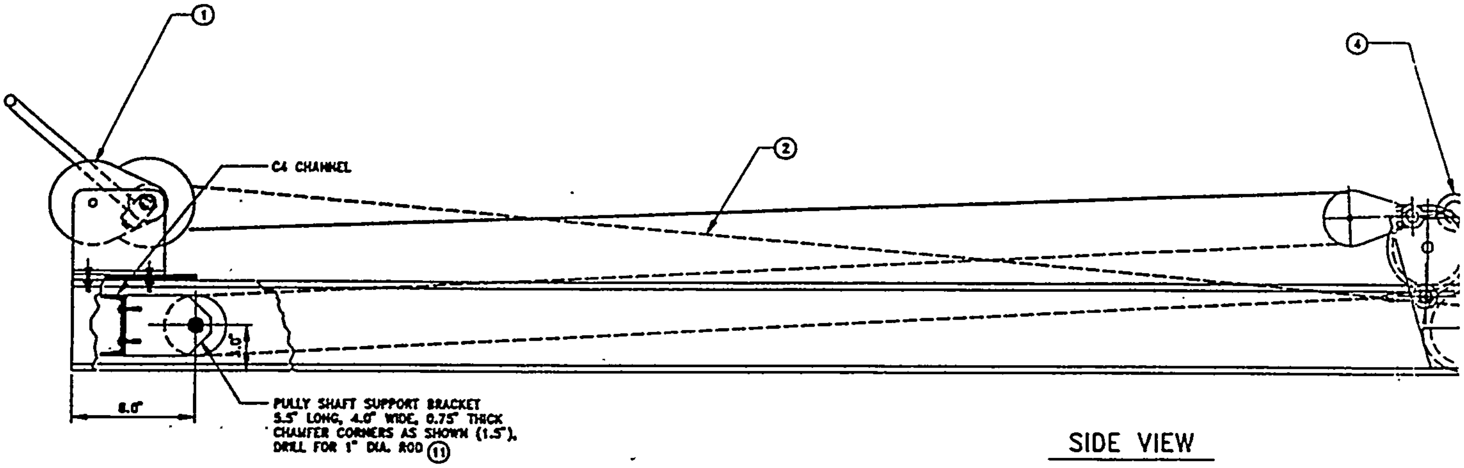
Revisions			
Number	Descriptions	Date	Approved
1	Item 3 changed from 3/8" to 3/4"	6/10/95	JJZ
2	Item 8 changed from 3/8" to 1/2"	6/10/95	JJZ

RADIAN CORPORATION

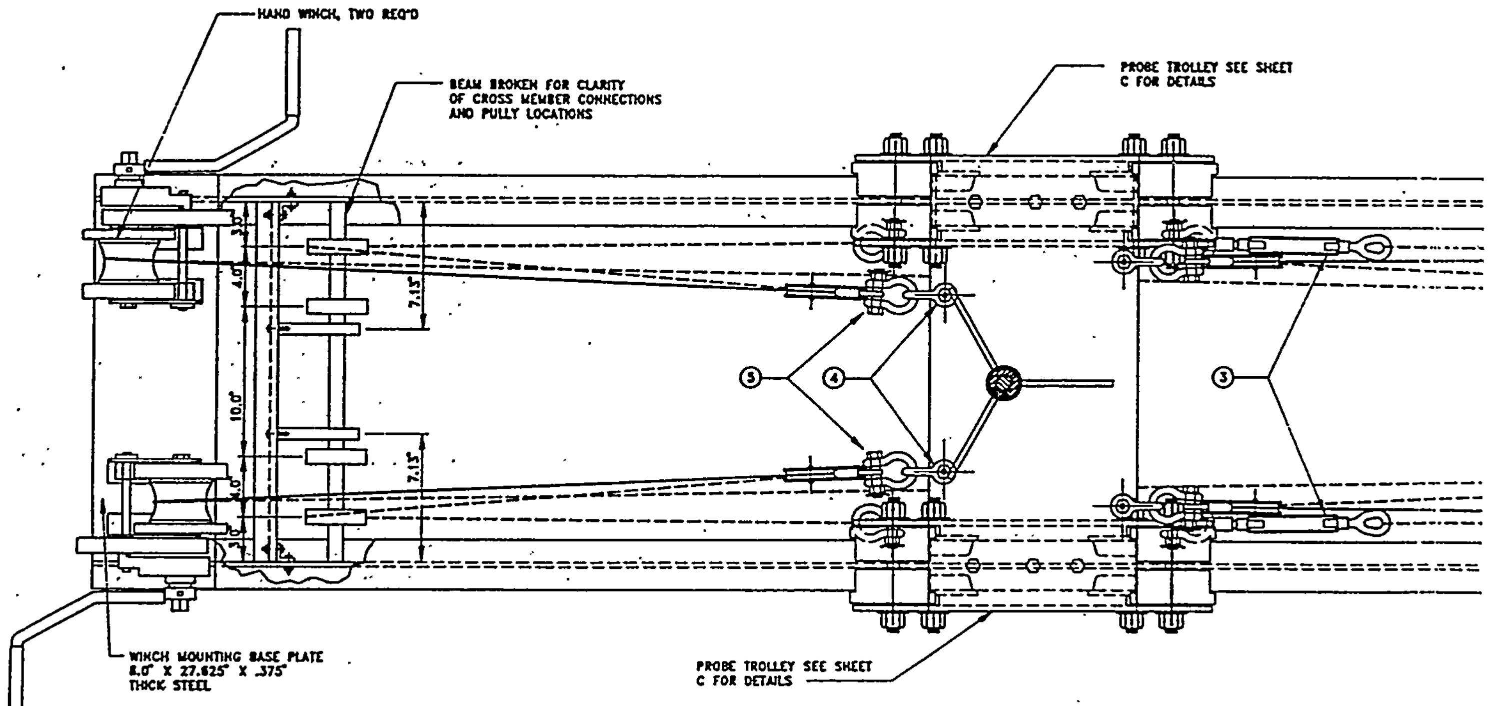
Austin, Texas 78720-1088

Scale: AS SHOWN		DOW HOT GAS PROBE TROLLEY
Designed by: J.J.Z.	Date: 8-29-94	
Drawn by: R.D.F.	Date: 8-29-94	
Checked by:	Date: 8-29-94	
Approved By:	Date:	
Tolerance: (unless otherwise stated) x.xxx 0.005 x.xx 0.01	Contract No.: 643-004-30-02	Drawing No.: C — Rev: A

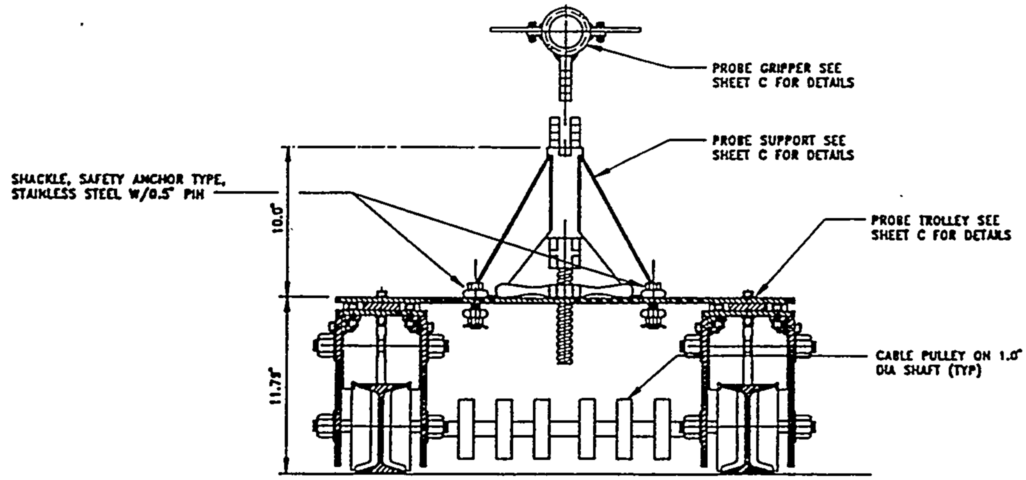
810901 09.19.95



SIDE VIEW

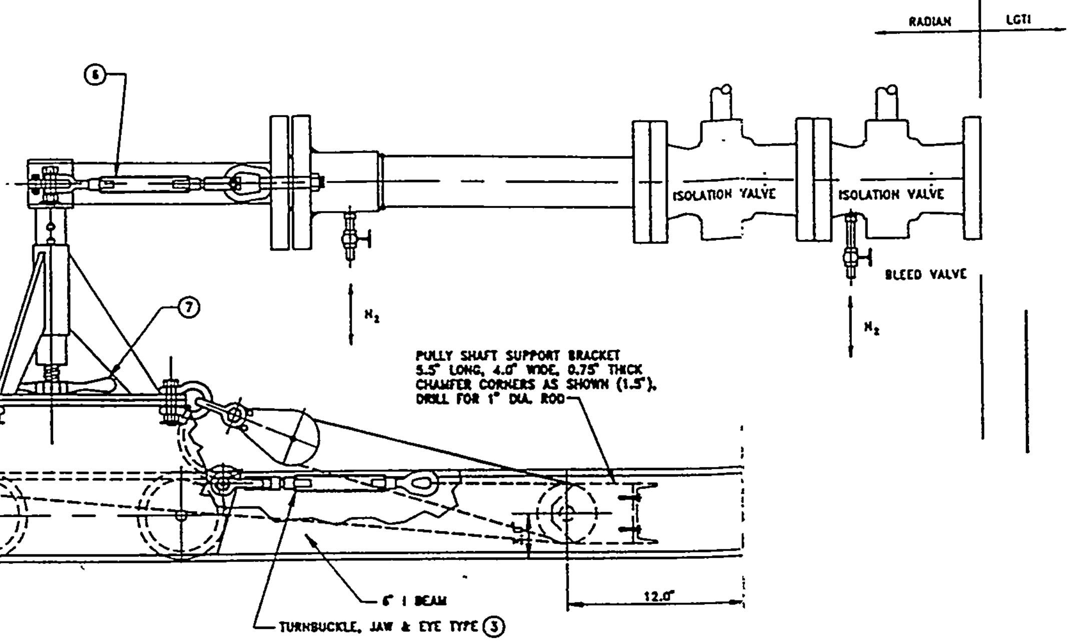


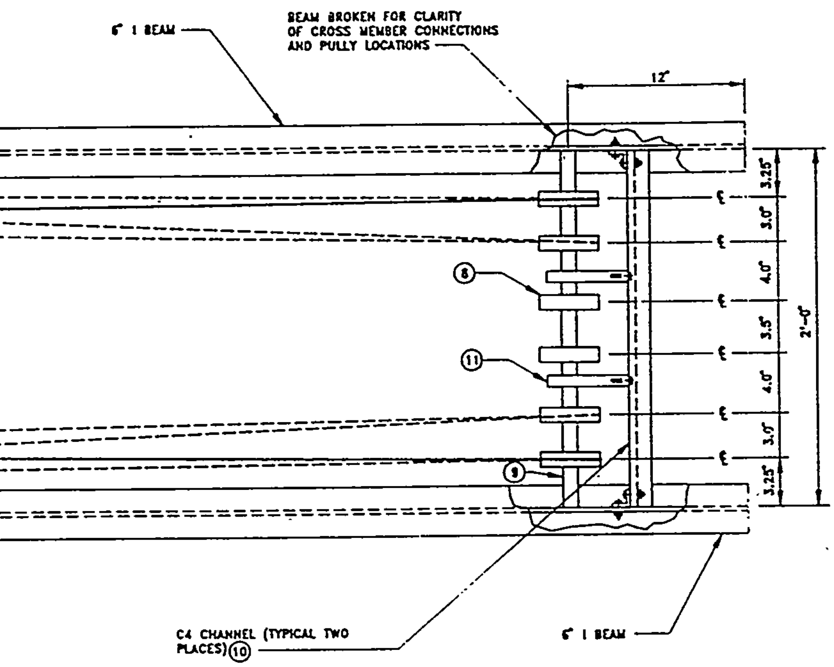
TOP VIEW



TROLLEY END VIEW

PROBE T





NOTE:

SLEEVES ON THE 1" SHAFT, BETWEEN PULLEYS ARE USED TO POSITION AND SUPPORT SHEAVES ALONG AXIS. NOT SHOWN

DOW Probe Parts List

Item No.	Description	Quantity
1	Two speed winch, with brake, 2000 lb. rating	2
2	1/4" Wire rope, 7 x 19 strand core	200'
3	3/8" Trunbuckle, Jaw and Eye type, 1160 lb rating McMaster Carr 3022T43	2
4	1/2" Shackle, 1890 lb rating, McMaster Carr 3860T55	4
5	3/8" Schackle, 1000 lb rating, McMaster Carr 3860153	2
6	Turnbuckle, Jaw and Jaw type, 1/2" bolt diameter	4'
7	Wing Nut for 1" hub, Crosby 460307	1
8	4" sheave for 1/4" cable, 1" hub, Crosby 460307	10
9	Sheave axle, 1" solid, 24" long	.2
10	Axle Strong back, C4 channel	2
11	Axle Support, Aluminum	

Weld Specifications:

W1 = Fillet Welding Process
W2 = Butt Welding Procedures

Inspection Procedures

Q1 = Dye Penetrant
Q2 = Leak Test
Pressure Test (Hydrostatic)

NOTES:

All metal components in contact with flow stream are Type 316 stainless.
All other metal components carbon steel unless noted.

All bolts will be grade 97

ROLLEY ASSEMBLY

SCALE: 1" = 6"

Revisions			
Number	Descriptions	Date	Approved

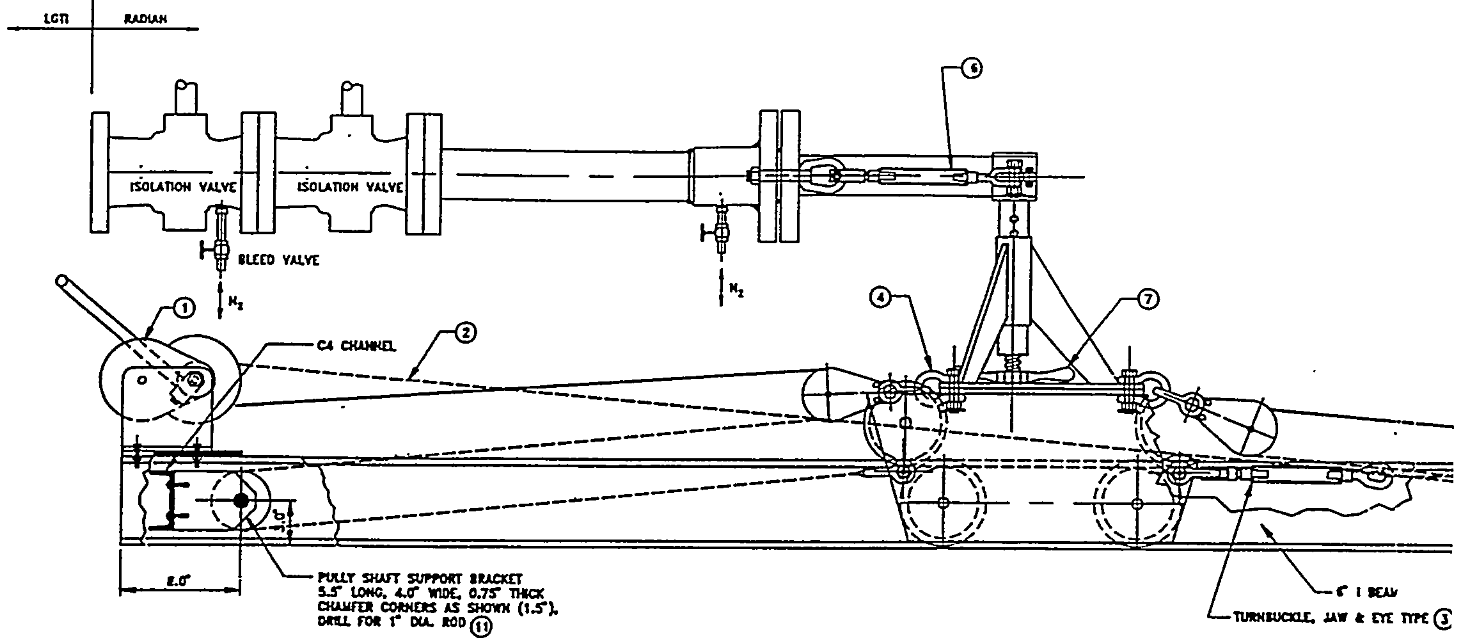
RADIAN CORPORATION
Austin, Texas 78720-1088

Scale: AS SHOWN	
Designed by: J.J.Z.	Date: 9-13-94
Drawn by: R.O.F.	Date: 9-13-94
Checked by:	Date: 9-13-94
Approved By:	Date:
Tolerance: (unless otherwise stated) x.xxx 0.005 x.xx 0.01	

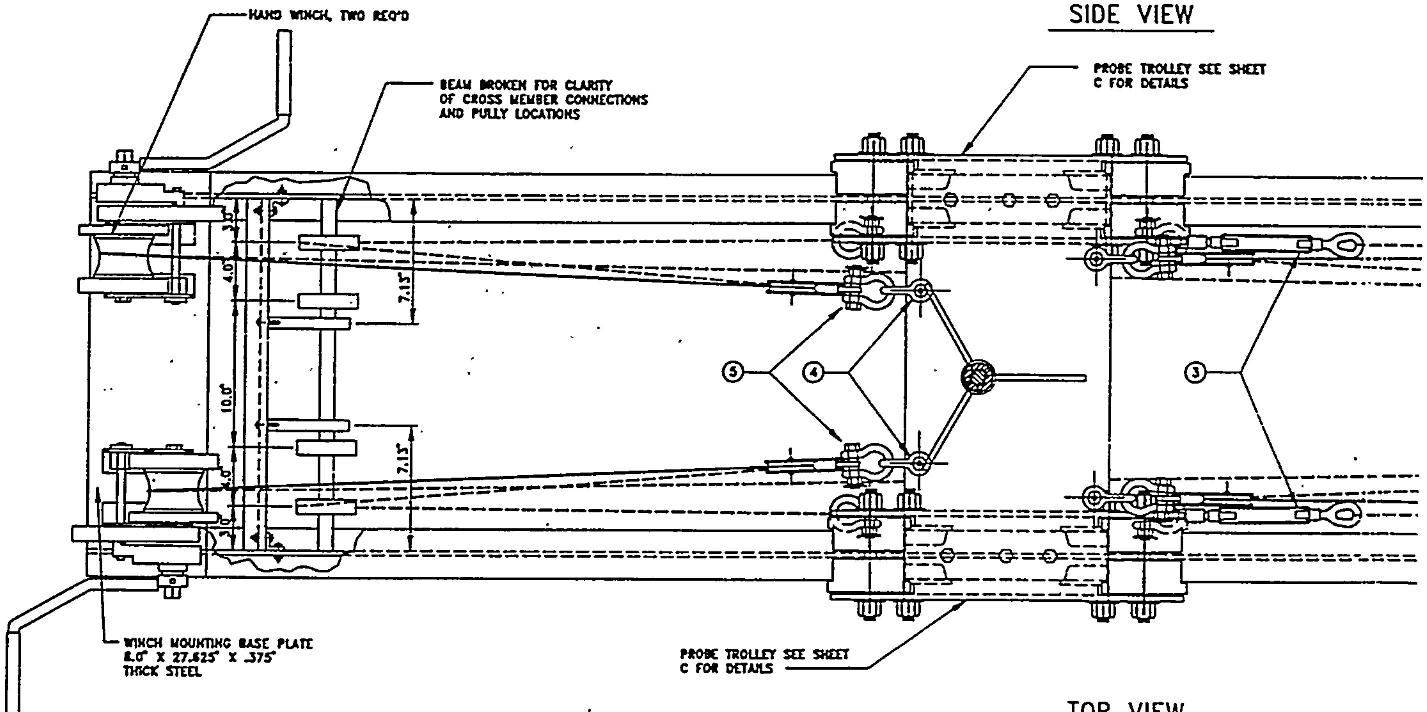
H-13

Contract No:	Drawing No:	Rev
643-004-30-02	D	A

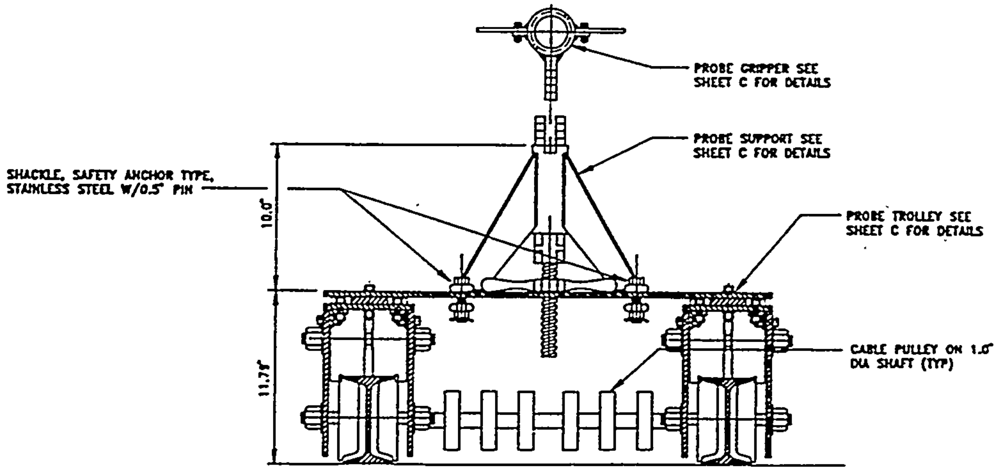
B10901A 01.13.95



SIDE VIEW

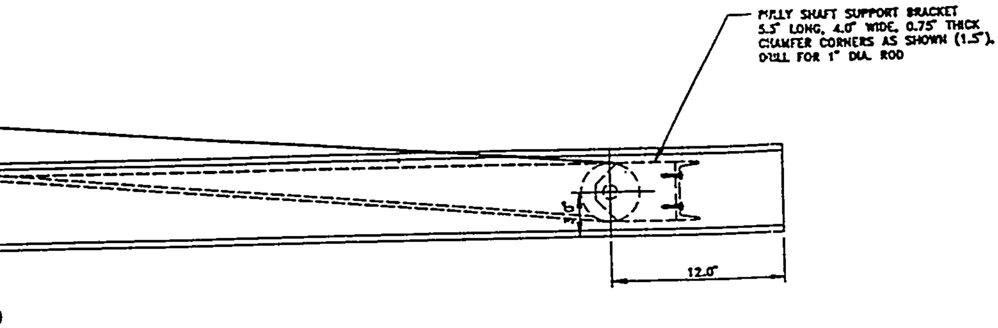


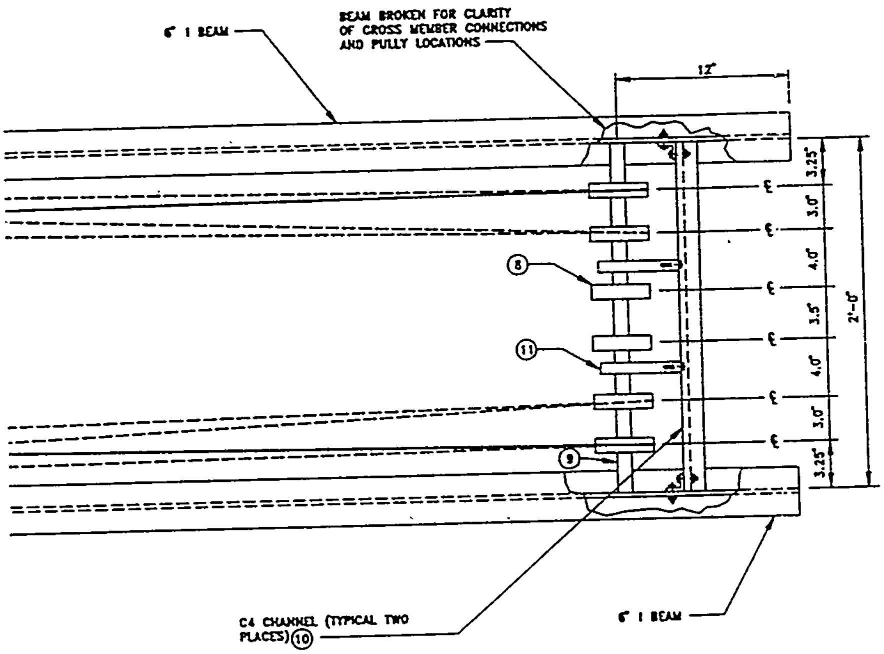
TOP VIEW



TROLLEY END VIEW

PROBE





NOTE:

SLEEVES ON THE 1" SHAFT, BETWEEN PULLEYS ARE USED TO POSITION AND SUPPORT SHEAVES ALONG AXIS. NOT SHOWN

DOW Probe Parts List

Item No.	Description	Quantity
1	Two speed winch, with brake, 2000 lb. rating	2
2	1/4" Wire rope, 7 x 19 strand core	200'
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5	3/8". Schackle, 1000 lb rating, McMaster Carr 3860153	2
6	Turnbuckle, Jaw and Jaw type, 1/2" bolt diameter	4'
7	Wing Nut for 1" hub, Crosby 460307	1
8	4" sheave for 1/4" cable, 1" hub, Crosby 460307	10
9	Sheave axle, 1" solid, 24" long	2
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Inspection Procedures

Q1 = Dye Penetrant
Q2 = Leak Test
Pressure Test (Hydrostatic)

NOTES:

All metal components in contact with flow stream are Type 316 stainless.
All other metal components carbon steel unless noted.

All bolts will be grade 87

TROLLEY ASSEMBLY

SCALE: 1" = 1"

Revisions			
Number	Descriptions	Date	Approved

RADIAN CORPORATION
Austin, Texas 78720-1088

Scale: AS SHOWN		DOW HOT GAS PROBE UNIT
Designed by: J.J.Z.	Date: 9-13-94	
Drawn by: R.D.F.	Date: 9-13-94	
Checked by:	Date: 9-13-94	
Approved By:	Date:	Contract No.: 643-004-30-02 / Drawing No.: E / Rev: A
Tolerance: (unless otherwise stated) x.xxx 0.005 x.xx 0.01		

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643-004-30-02, Sheet D. This valve mates with the cover flange of the existing 20-inch manway. The isolation valves provided by Radian are equipped with 3-inch, 300#, ANSI B 16.5, raised-face, bolted flanges. LGTI provided the gaskets and bolting necessary to mount these valves to the manway cover.

The manway cover had provisions for the flange seating surface and the mounting bolts. In addition, a 3-inch diameter hole, on center with the bore of the manway, was needed. The 3-inch diameter hole penetrated the entire length of the insulation plug which normally resides on the inside of the manway cover.

Radian required clean, pressurized nitrogen for use as a purge and syngas sample quench gas. The existing nitrogen source at 500 psig and ambient temperature with a maximum flow rate of 200 lb/hr was adequate for all of the needs of this sampling program.

No electrical power was required for the probe or the probe positioner, but electrical power was needed for the sampling/analytical equipment.

Isolation Valves

Radian supplied two 3-inch, Neles-Jamesbury 300#, AISI type 316 SS body, full port, ball valves with metallic ball seals and graphite packing stem seals for isolation of the sample port. These valves were arranged in a double block and bleed arrangement (Manufacturer's Data Sheet provided in Attachment A). The valve located closest to the process vessel is the one which sees the most severe duty. According to the manufacturers literature (provided in Attachment A), the operation of these valves at 500 psi and 450°F is within the operating envelope of the valve. Heat transfer calculations were performed by Radian assuming that the 3-inch diameter probe access hole through the insulating plug is open, and the valve is exposed to 1200°F gas in the duct. Based upon these calculations (which are provided in Attachment B), the temperature of the face of the ball in the ball valve should not exceed 450°F. When the probe is inserted and process gas is being extracted, the valve temperature should be below 450°F, as shown in the calculations presented in Attachment C. Thus, the valves will operate within their design envelope under all foreseeable operating conditions. As with most equipment, short excursions outside the operating envelope will not likely lead to catastrophic failure. The selected valves were considered safe for the intended service in this sampling program.

The outboard isolation valve was tapped (in the inboard end) with a 1/4-inch female NPT opening to provide for the injection of high pressure nitrogen (500 psi) for purging the valve and probe sheath assembly to keep them clear of particulate buildup. During insertion and withdrawal of the probe assembly, this port was used to pressure/depressure the enclosure and to purge the enclosure of air or syngas. A pressure gage was attached to the port line to monitor the pressure between the two isolation valves.

Packing Gland

The pressure seal at the outboard end of the probe sheath was provided by a packing gland. The gland spool piece consisted of a 4-inch O.D. x 2-15/16 inch i.d. AISI Type 316 SS pipe and was capable of operating at 500 psig and the full 1200°F maximum syngas stream temperature. Details of the packing gland are shown in Radian Drawing No. 643-002-30-02, Sheet A.

High-temperature Graphoil packing was used; bolts in the packing gland retainer were provided for tightening and loosening of the packing for probe insertion and withdrawal. The inboard end of the gland assembly consisted of a standard 3-inch 300# flange for mating with the outboard isolation valve. A ½-inch NPT port was machined into the gland pipe. Nitrogen was introduced through this port for purging and to raise the pressure of the gland assembly to slightly above system pressure before opening the ball valves. A pressure gage (Omega Model No. PGH-45L-600) was also installed at this location. Depressuring during extraction of the probe assembly could also be accomplished through this port. A continuous purge of nitrogen was introduced into the rear most vent connection to reduce potential penetration of particulate into the open valves and the probe hole in the refractory during testing.

All gases extracted from the process pipe during sampling, except the gas trapped between the double block valves during probe withdrawal, were routed either to a location remote from the immediate sampling area.

Sampling Probe

The sampling probe is an adaptation of probes used by Radian for similar sampling in other projects. Details of the probe are shown in Radian Drawing No. 643-004-30-02, Sheet B. The essence of the design is that sample gas was allowed to pass through the probe, while particulate material was either collected or prevented from entering the probe by use of an in-stack thimble or filter. After passing into the probe, the collected gas can be quenched with nitrogen, if needed, to a temperature less than 850°F. Nitrogen quench gas flow can be controlled such that the temperature of the sample gas does not fall below 400°F at the outlet end of the sample probe.

The components which fit on the in-stack end of the probe are commercial products. Two different tips were provided; one with a nozzle and in-stack filter housing to collect samples of particulate, and another tip which consisted of a filter only to exclude particulate when collecting gas samples.

The probe design provides for a balanced pressure. The quench nitrogen flows in the annular space between the sheath and the sample tube in a direction from the cool end of the probe toward the end inserted into the process pipe. The quench nitrogen enters the sample gas line near the front of the probe through the perforated expansion joint in the sample line tube, mix with the sample and flow in the opposite direction to the exit end of the probe. The probe thus functions as a counter current heat exchanger with very low Reynolds numbers for the gas passes. In addition, the perforated metal expansion section of the sample line provides for differential thermal expansion between the sample line and the probe sheath. The probe sheath and the sample line are designed to withstand 500 psig at 1200°F as either an internal or external pressure without failure, as shown in the analysis presented in Attachment D.

AISI type 316 stainless steel was selected for probe construction. This material performed well during sampling. There are many factors which went into this selection process but paramount was safety and performance for the intended duration of service. The life of the probe is anticipated to be several hundred hours. Probe life expectancy is governed more by handling and duration of sampling effort than on material degradation properties. On this basis, hot strength, both yield and tensile, and hot Young's Modulus are of much greater concern than creep strength and creep elongation. Additionally, AISI 316 is stable and does not suffer major degradation from the contents of the process gas stream at temperatures up to 1200°F. The material was selected for all of the reasons above, but in addition, it is readily available in many forms and shapes and is competitive in price.

The probe is separate from the positioner and can be replaced or shifted without disassembling either the gland or the positioner and supporting structure. Thus, probes can be changed with very little lost time or effort other than that associated with moving the probes and isolating them from the process pipe.

Probe Insertion Mechanism

There is approximately 3,000 lbs. of force exerted on the probe from the process stream when in the sampling configuration. The method selected to control the motion and position of the probe was a trolley that is moved by a system of wire ropes/cables and capstans. Details of the probe trolley assembly are provided in Radian Drawing 643-004-30-02. Sheet C. The arrangement of this mechanism is shown in Radian Drawing 643-004-30-02, Sheets D and E. Stress calculations for trolley components are given in Appendices E and F. Several pulleys are used to keep the load per strand at reasonable levels and to keep the wire rope from becoming too heavy and stiff. Redundant sets of pulleys and wire rope are used on each side of the trolley to reduce binding, to distribute the loads, and to provide a means of controlling the trolley position should one of the cables should break. The positioner was set up to either push or pull the probe and to maintain the probe in position. Withdrawing the probe was somewhat easier than insertion. Initially, it was thought that caking of char around the probe sheath might make probe motion difficult unless the probe could be worked back and forth, and/or a force could be exerted to withdraw the probe.. Thus, the positioner can push or pull with equal ease (char buildup proved to be no problem during the sampling). Each side of the positioner has a mechanical advantage of 3 on force applied. This reduces the cable tension to reasonable levels of 500 lbs per strand. Aircraft control cable of ¼ inch, 7x19 IWRC stainless steel was selected for the positioners.

Motion of the probe is achieved through the use of "boat" winches used as capstans. The wire is not stored on the winches but is wrapped and discharged. Thus the probe is moved by passing cable around the capstan. The capstans have two speeds, are reversing, and have mechanical brakes. This provided very good control, "feel," and accuracy, and safe positioning of the probe was possible under all test conditions. The capstans were hand cranked for extremely positive control at all times..

Mechanical Support

The cool end of the probe is restrained from motion in the vertical plane by use of stiff leg attached to the cold end of the probe and a trolley which runs on a rail mounted to the deck. This system is shown in Radian Drawing No. 643-004-30-02, Sheet C. The trolley is nothing more than a modification of a standard I-beam hoist trolley. The principal modification was the addition of rollers such that the trolley could sustain positive and negative vertical loads.

As it was heated from a cold (ambient) condition, the process vessel was expected to move several inched vertically relative to the access platform. Thus, provision were made to adjust the height of the stiff leg using a power screw. The power screw allowed for height adjustments up to ± 2 inches of travel, which was sufficient to match the vertical movement of the manway port..

Probe Operation

The probe testing and operating procedures, including safety considerations, are described in this section. Only those procedures associated with operating the probe assembly are discussed here. Other activities related to the actual gas sampling are described in the Test Plan.

Safety Considerations

A primary consideration in operating the sampling probe was safety. Every effort was made to ensure safe operation. A set of detailed and comprehensive check lists were prepared for each sampling operation (e.g., probe insertion, probe withdrawal). The appropriate check list was followed during each sampling effort. As each individual required action was performed in the sequence of activities, the task leader for the hot gas sampling effort checked off the action on the check list. An example check list is included in Attachment H.

One potential safety problem was leakage of raw syngas through the gland seal. Before inserting the probe into the syngas through the isolation valves, the probe assembly was purged with nitrogen. The assembly was then pressurized with nitrogen, and the gland seal was checked for leaks by monitoring the pressure drop in the assembly over a given period of time.

During the actual sampling, the gland seal was periodically monitored for leaks using portable CO and H_2S monitors. The annular space between the probe sheath and the probe assembly was continually purged with nitrogen, so any gas leaking through the packing gland was predominantly nitrogen. However, if significant syngas leakage was indicated, the packing gland can be tightened until the leak has been stopped. If the leak cannot be adequately controlled by this action, the sampling can be stopped and the probe withdrawn.

When withdrawing the probes, small quantities of syngas may enter the gland assembly. During depressuring of the gland assembly, the vented gas was routed to a line vented to the atmosphere at a location removed from the immediate sampling area.

Bench Testing

After the sampling system was fabricated and assembled, it was bench-tested at Radian's Austin laboratories. The assembly was completely pressure-tested (hydrostatically) to validate the integrity of the system. Then, the probe assembly was attached to a simulated 3-inch gasifier port, and a hydrostatic resistance was supplied at the sampling end of the probe to simulate the anticipated pressure of the gasifier. The probe insertion and withdrawal operations was successfully tested with this system. Minor deficiencies were identified and corrected before shakedown testing was conducted at the LGTI facility.

Initial System Shakedown

The initial system shakedown was conducted at a lower temperature location (~500°F) on the heat exchange vessel. The probe assembly was installed in this location at the LGTI facility during a scheduled shutdown. Shortly after the plant was started up, initial shakedown of the gas sampling system was conducted. All of the testing operations were performed during this test of the probe system. These operations include sampling probe insertion, gas sampling, particulate collection, and sampling probe withdrawal. Minor deficiencies in a few of these operations were identified and corrected before the sampling effort was conducted at the higher temperature location. Particulate collection times and potential blinding of the filters with particulate were evaluated during this shakedown period and found to be satisfactory.

The operation of the sampling probe system during each of the major activities is described below.

Sample Probe Insertion. Insertion of the sampling probe is described below.

Before inserting the probe, the packing gland was removed so that the sample probe could be more easily positioned in the gland assembly section. The back end of the probe was fastened to and supported on the support trolley. The packing material was inserted into the gland, the retainer/follower was then be partially tightened. The nitrogen purge through the purge valve in the gland assembly was started, and the assembly system was purged with nitrogen to remove all oxygen in the system. At the same time, the flow of dilution nitrogen was started to purge the probe. When all of the oxygen was purged from the gland assembly, the gas outlet valve between the inboard and outboard valves was closed. The probe assembly system was then pressured with nitrogen to approximately 25 psi above the gasification system pressure. When the selected pressure was achieved, the system was blocked in, and the pressure drop in the system (due to nitrogen leaking from the packing gland) was monitored If excessive nitrogen leakage (pressure decline) occurred, the packing gland nuts were tightened to reduce the leakage to an acceptable level.

After the leak rate through the packing gland had been reduced to an acceptable level, the system was once more pressured up to process pressure (with nitrogen). The isolation valves were then opened. The winches were used to move the probe through the inboard valve and into the syngas stream. The probe tip was positioned at the desired location and held in place with the winch system. Retainers were then attached to positively restrain the probe and prevent any possibility of an unplanned retraction. If necessary, the packing gland was tightened further to reduce leakage while collecting gas samples. The nitrogen purge flow through the gland assembly inlet valve was adjusted to a rate sufficient to keep the annular space between the probe sleeve and the refractory relatively free of particulate accumulations. The nitrogen quench flow was designed to maintain the temperature of the sampled gas at approximately 500°F. In actual sampling at the high temperature location, the gas temperatures were low enough that dilution/quench nitrogen was unnecessary. Gas samples were then collected. During the gas sampling, the packing gland was regularly monitored for CO and H_2S leakage. If leakage of these syngas constituents was observed (it was not observed during the testing), the packing gland could be tightened further. If the leakage could not be stopped, sampling was to be halted, and the probe withdrawn.

Sampling Probe Withdrawal. The withdrawal of the sampling probe is described below.

The sampling probe was withdrawn immediately after the planned sampling was completed. Before beginning to withdraw the probe, the packing gland can be loosened slightly, if needed. Possible leakage of syngas through the packing gland did not occur, because of the continuous nitrogen purge through the probe assembly. Nevertheless, gland leakage was monitored with portable CO and H_2S monitors while the plug probe was being withdrawn.

Using the mechanical winches, the probe was withdrawn past both isolation valves. The inboard isolation valve was then closed, and the nitrogen purge was temporarily shut off. The gland assembly section and the area between the two isolation valves was then depressured through the outlet valve located between the two isolation valves. When the system was completely depressured, the nitrogen purge was again started. The purge nitrogen entered through the valve located in the gland assembly and exited through the valve located between the two isolation valves. The exiting nitrogen was monitored for CO and H_2S. When the CO and H_2S levels in the exiting nitrogen fell to an acceptable level, the purge nitrogen floe was stopped. The outboard isolation valve was then closed The probe sheath was also purged with nitrogen. After purging was complete, the probe was completely withdrawn. This completed the sampling sequence.

References

1. 40 CFR 266, Subpart A. "Method 29: Determination of Metals Emissions in Exhaust Gases from Hazardous Waste Incineration and Similar Combustion Processes: Proposed Method."

2. 40 CFR 60, Appendix A. Test Methods. "Method 17: Determination of Particulate Emissions from Stationary Sources (In-Stack Filtration Method)."

ATTACHMENT A

MANUFACTURERS DATA SHEET

ISOLATION VALVES

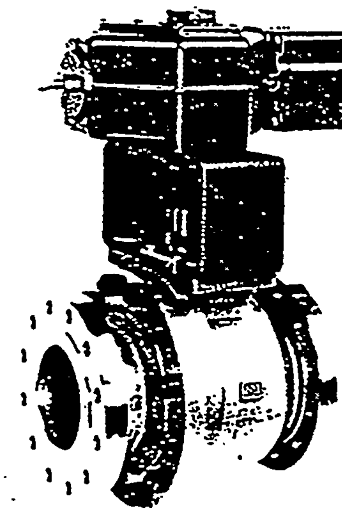
3-INCH - CLASS 300

NELES-JAMESBURY

BULLETIN B109-1

SPECIFICATIONS

2" – 12" MBV ANSI CLASS 150 AND 300 METAL-SEATED FLOATING BALL FULL PORT FLANGED BALL VALVES



Series MBV metal-seated ball valves are suitable for a wide range of applications in both on/off and control service. The valves are used in handling a variety of liquids, gases and abrasive slurries for industries ranging from chemical and petroleum to power and pulp and paper.

MBV metal-seated ball valves are particularly well suited for minimizing the erosive effects associated with high velocities and the problems related to high temperature sealing. MBV valves are rated for ANSI Class 150 - 300 and are available in sizes 2" -12". In addition, the 8" through 12" sizes are available in ANSI 300 short pattern allowing replacement of most gate valves without changing existing piping.

FEATURES:

WIDE RANGE OF METAL SEATS

- Metal seat designs are available for handling the most severe application conditions. Standard seat construction is a scraper design to eliminate build up on the sealing surfaces of the ball.

PROVEN SIDE-SPLIT BODY DESIGN

- The off-center split body is designed with a spiral wound body seal to virtually eliminate the potential for body leakage.
- Capable of withstanding high pipeline stresses without adversely affecting the body seal.

FULL BORE

- Full bore design resists plugging and bridging in slurries, pulp, polymers and solids handling applications.
- Highest C_v per valve size means the smallest possible valve can be used, resulting in easier installation and lower costs.

RELIABLE STEM SEAL

- Adjustable packing of V-Ring PTFE or die-formed graphite provides for long life.
- Optional live-loaded packing designs are also available.

SUPERIOR STEM TO BALL CONNECTION

- Splined shaft and drive plate provides superior strength required for high pressure, slurries and solids handling processes.
- Minimizes deadband and hysteresis, providing excellent control.
- Large diameter shaft provides high transfer torque capability.
- Inherent stem retention.

TIGHT SHUTOFF IN EITHER DIRECTION

- Shutoff to ANSI/FCI 70-2, Class V.
- Superior shutoff even in low pressure applications.

FIRE TESTED

- Series MBV metal-seated ball valves are fire-tested to meet API 607 and BS6755 Part 2.

SUPERIOR CONTROL CHARACTERISTICS

- Equal percentage flow characteristics and dynamic stability identical in both directions.
- Wide rangeability - 100:1 to 300:1 depending on size.

TWO-STAGE THROTTLING

- Total pressure drop generated on both sides of valve so flow velocity is lower than a single restriction valve.
- Reduced tendency for cavitation, erosion, dewatering, etc.

EASY TO AUTOMATE - SINGLE SOURCE RESPONSIBILITY

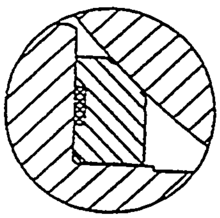
- Manual gear, pneumatic double-acting or spring-return actuators for on-off applications.
- For control applications, dedicated limit switches and pneumatic and electro-pneumatic positioners.

VALVE BODY RATINGS

These are maximum working pressure ratings of the valve body only. The differential pressure/temperature ratings, shown on the preceding page, determine the practical pressure limitations according to actual service conditions. Test pressures are for hydrostatic test with ball half open.

Temp ° F	Body Rating – psi (bar)			
	316 Stainless Steel		Carbon Steel	
	150 lb.	300 lb.	150 lb.	300 lb
-20 to 100 (-29 to 38)	275 (19)	720 (50)	285 (20)	740 (5
200 (93)	240 (17)	620 (43)	260 (18)	675 (4
400 (204)	195 (13)	515 (36)	200 (14)	635 (4
600 (316)	140 (10)	450 (31)	140 (10)	550 (3
800 (427)	80 (6)	415 (29)	80 (6)	410 (2
1000 (538)	20 (1)	365 (25)	—	—
Test Pressure	425 (29)	1100 (76)	450 (31)	1125 (7

SEAT DESIGNS



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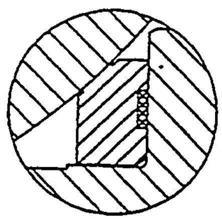

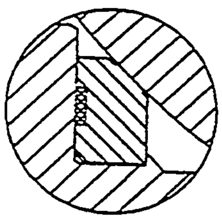

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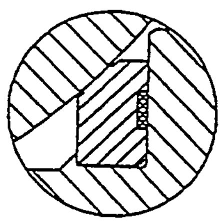

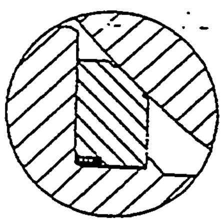

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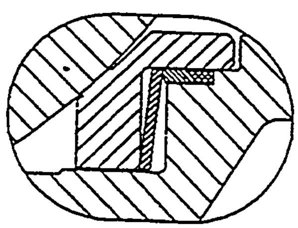


S SEAT – SCRAPING GENERAL SERVICE (BIDIRECTIONAL)

Application advantages: General services with unloc seat requirement.
Seat Material: AISI 316 + Celsit® 50 Nb
Seals: PTFE
Temp Range: -50°F to +450°F (-45°C to +232°C)

K SEAT – SCRAPING LOCKED SEAT (BIDIRECTIONAL)

Application advantages: Locked scraper seat for use sulphite service, low pH applications, pulp stock, as well hydrocarbon liquids and vapors.
Seat Material: AISI 316 + *Celsit* 50 Nb
Seals: PTFE
Temp Range: -50°F to +450°F (-45°C to +232°C)

H SEAT – HIGH TEMPERATURE LOCKED SEA (BIDIRECTIONAL)

Application advantages: Ideal for high temperatures, l pressure differentials, and abrasive solids applications inclu ing ash and coal gasification.
Seat Material: AISI 316 + *Celsit* 50 Nb
Seals: Graphite
Spring: Ni based Superalloy
Temp Range: with 316/HCR ball -320°F to +800°F (-195° to +427°C); with Nickel boron coated ball -320°F to 1000°F (-195°C to 538°C).

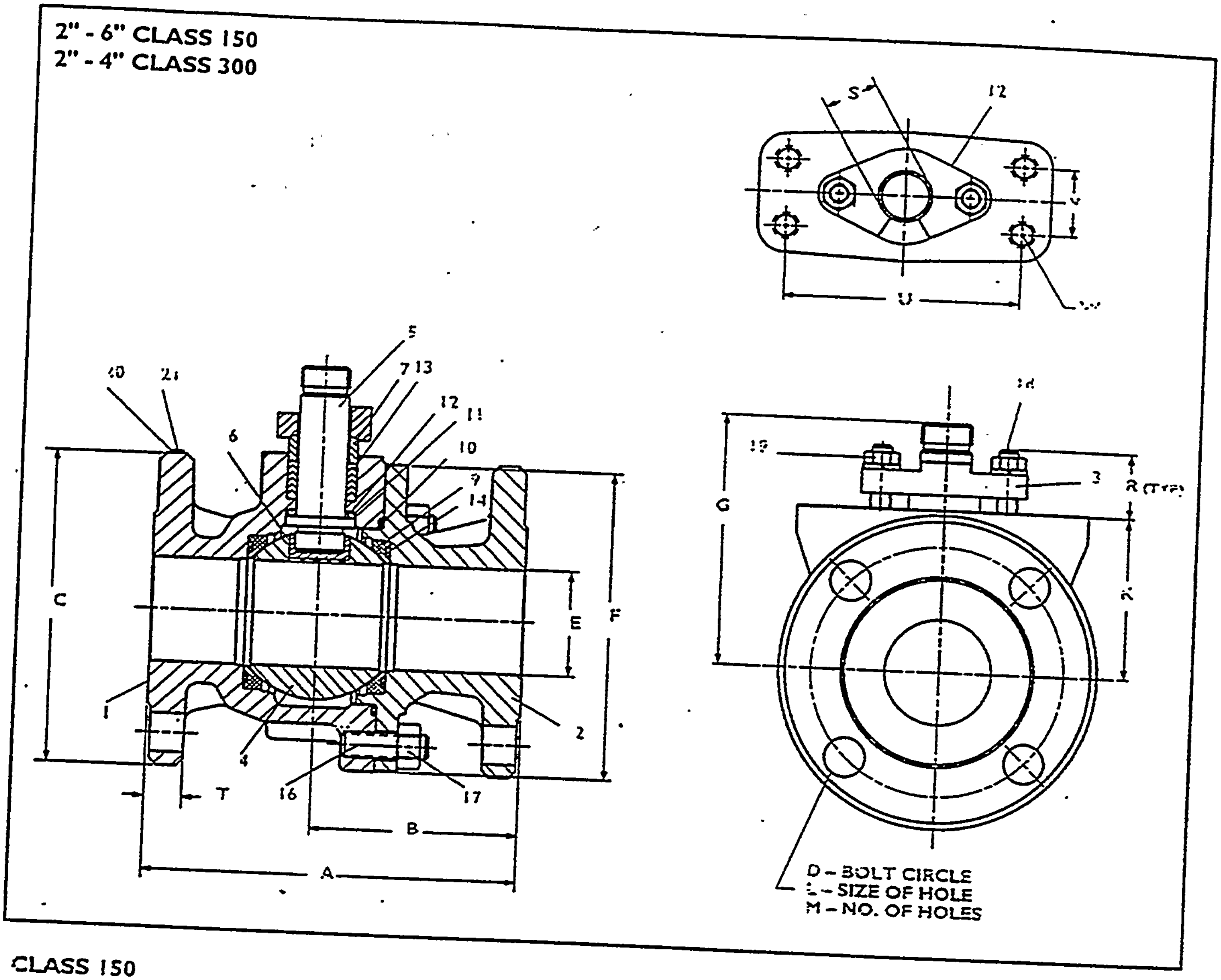
Celsit® is a registered trademark of Bohler Bros.

STANDARDS AND SPECIFICATIONS

Series MBV valves covered in this bulletin are available to conform to the following industry standards and specifications:

API 6D	American Petroleum Institute – Specifications for Pipeline Valves
API 607 rev. 3	American Petroleum Institute – Fire Test for Soft Seated Valves (Division of refining)
API 598	American Petroleum Institute – Valve inspection and testing
ANSI B16.10	American National Standard – Face-to-Face and End-to-End Dimensions of Ferrous Valves
ANSI B16.5	American National Standard – Steel Pipe Flanges and Flanged Fittings
ANSI B16.34	American National Standard – Steel Valves – Flanged and Buttwelded End
ANSI B31.1	American National Standard – Power Piping
ANSI B31.3	American National Standard – Chemical Plant and Petroleum Refinery Piping
ANSI/FCI 70-2-1976	American National Standard – For Control Valve Seat Leakage
NACE Standard MR-01-75	National Association of Corrosion Engineers – Sulfide Stress Cracking Resistant Materials for Oilfield Equipment
BS 6755, Part 2	Testing of valves – specification for fire type-testing requirements
MSS SP-25	Manufacturers Standardization Society – Standard marking System for Valves
MSS-SP-55	Manufacturers Standardization Society – Quality Standards for Steel Castings
ISO 5752:1982	International Standard for Organization Metal Valves for use in Flanged Piping Systems
BS2080:1974	British Standards Institute – Specification for face-to-face dimensions of flanged and buttweld steel valves.

DIMENSIONS



CLASS 150

Valve Size	A	B	C	D	E	F	G	K	L	M	R	S	T	U	V	W	Weight lbs. (kg)
						APPROXIMATE DIMENSIONS, inches (mm)											
2 (50)	7.00 (178)	3.95 (100)	6.00 (152)	4.75 (121)	2.00 (50)	5.90 (150)	4.95 (126)	3.09 (78)	.75 (19)	4	1.24 (31)	.98 (25)	.75 (19)	4.33 (110)	1.26 (32)	1/2-13	24 (11)
3 (80)	8.00 (203)	4.00 (102)	7.50 (191)	6.00 (152)	3.00 (80)	7.38 (187)	4.95 (126)	3.90 (99)	.75 (19)	4	1.24 (31)	.98 (25)	.94 (24)	4.33 (110)	1.26 (32)	1/2-13	50 (23)
4 (100)	9.00 (229)	4.60 (117)	9.00 (229)	7.50 (191)	4.00 (100)	9.50 (241)	7.50 (191)	5.51 (140)	.75 (19)	8	1.73 (44)	1.36 (35)	.94 (24)	5.10 (130)	1.26 (32)	1/2-13	97 (44)
6 (150)	15.50 (394)	8.25 (210)	11.00 (279)	9.50 (241)	6.00 (150)	13.50 (343)	11.96 (304)	7.25 (184)	.88 (22)	8	1.72 (44)	1.77 (44)	1.00 (25)	6.30 (160)	1.58 (40)	5/8-11	200 (90)

CLASS 300

Valve Size	A	B	C	D	E	F	G	K	L	M	R	S	T	U	V	W	Weight lbs. (kg)
						APPROXIMATE DIMENSIONS, inches (mm)											
2 (50)	8.50 (216)	3.75 (95)	6.50 (165)	5.00 (127)	2.00 (50)	5.67 (144)	4.95 (126)	3.06 (78)	.75 (19)	8	1.24 (31)	.98 (25)	.88 (22)	4.33 (110)	1.26 (32)	1/2-13	36 (16)
3 (80)	11.13 (283)	4.88 (124)	8.25 (210)	6.63 (168)	3.00 (80)	7.94 (202)	7.50 (191)	4.69 (119)	.88 (22)	8	1.73 (44)	1.36 (35)	1.13 (29)	5.10 (130)	1.26 (32)	1/2-13	75 (34)
4 (100)	12.00 (305)	6.63 (168)	10.00 (254)	7.88 (200)	4.00 (100)	9.94 (252)	8.91 (226)	5.63 (143)	.88 (22)	8	1.72 (44)	1.77 (45)	1.38 (35)	6.30 (160)	1.58 (40)	5/8-11	145 (65)

BILL OF MATERIALS

Part No.	Part Name	Material	
1	Body	Carbon Steel ASTM A216 Type WCB	316 Stainless Steel ASTM A351 Type CF8M
2	Body Cap	Carbon Steel ASTM A216 Type WCB	316 Stainless Steel ASTM A351 Type CF8M
3	Compression Plate	Carbon Steel	316 Stainless Steel
4	Ball	316 Stainless Steel	
5	Stem	316 Stainless Steel or Nitronic® 50	
6	Spline Driver	316 Stainless Steel	
7	Compression Ring	316 Stainless Steel	
9	Seat	316 Stainless Steel and *Celsit* 50 Nb	
10	Body Seal	Spiral Wound PTFE/Stainless Steel or Graphite/Stainless Steel	
11	Secondary Stem Seal	Graphite	
12	Lower Stem Seal	PTFE	
13	Upper Stem Seal	PTFE (V-type), Graphite	
14	Back Seal	PTFE	
15	Seat Spring*	Nickel based Superalloy	
16	Body Stud	ASTM A193 Gr B7 or <u>B8</u>	
17	Body Stud Nut	ASTM A194 Gr 2H or <u>8B</u>	
18	Bonnet Stud	ASTM A193 Gr B7 or <u>B8</u>	
19	Bonnet Stud Nut	ASTM A194 Gr 2H or <u>8B</u>	
20	ID Tag	Stainless Steel	
21	Rivets	Stainless Steel	

*With H seat construction only.

Inconel is a registered trademark of Inco.
Nitronic is a registerd trademark of Armco Stainless Steel Div.

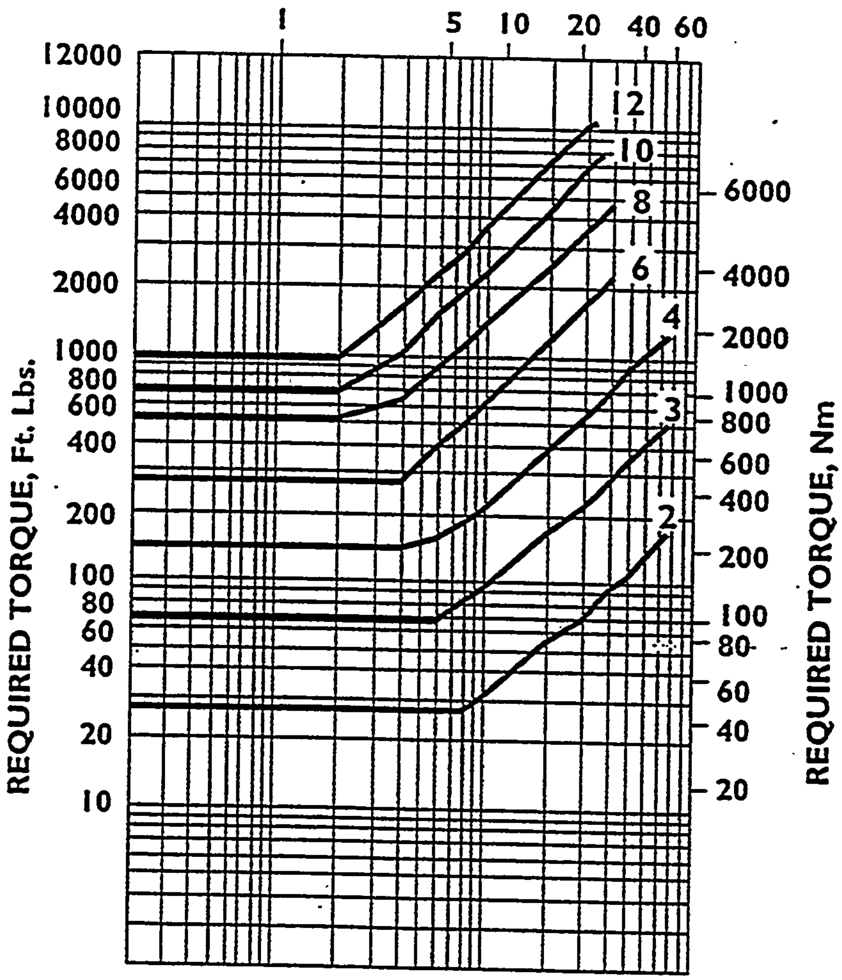
OPENING TORQUE – S, K AND H SEATS

The torque chart for MBV valves is to be used as a guide for actuator selection. Additional requirements may be imposed by media characteristics, trim and frequency of valve operation. The charts are for for S, K and H seats on clean liquids and dry gases.

For difficult services such as slurries, semi-solids and oxygen, please consult the factory. If in doubt, select the larger actuator.

Torque output values and actuator selection tables for the different types of Neles-Jamesbury actuators are contained in bulletins listed below:

Manual Gear Actuators	A100-1
Handgear Actuators	A100-2
Cylinder Actuators	A107-1
Spring-Diaphragm Actuators	A110-1
Spring-Diaphragm Actuators	A110-2
Electric Actuators	A120-2
Enhanced Electric Actuators	A121-1



S, K & H SEATS

OPERATING HANDLES

Series MBV metal seated ball valves are optionally available with manual handles in sizes 2" through 4" provided the differential pressure does not exceed the values shown in the table below.

Pressure Class	Valve Designation	Handle Length inches (mm)	Handle Designation	Maximum Differential psi (bar)
150	MT0200C_	12 (305)	BHK-058	285 (20)
	MT0300C_	12 (305)	BHK-058	110 (8)
	MT0400C_	18 (457)	BHK-059	50 (3.5)
300	MA0200D_	12 (305)	BHK-058	450 (31)
	MA0300D_	18 (457)	BHK-059	170 (12)
	MA0400D_	18 (457)	BHK-060	50 (3.5)

HOW TO ORDER

To specify an MBV Full port ball valve, make a selection from each of the boxes shown below.

1	2	3	4	5	6	7	8	9	10	11
MA	0600	D	A	GA	J2	SH	KTT	A	—	—

Example: This example is for a 6" ANSI Class 300 long pattern, full bore ball valve of standard construction with a carbon steel body, hard chrome plated stainless steel ball, stainless steel stem, *Celsit*-TFE style "K" seat, TFE packing, and B7 body bolting.

1	Valve Series & Style
MA	Full bore, Class 300, long pattern
MS*	Full bore, Class 300, short pattern
MT	Full bore, Class 150

*8" - 12" Class 300 valves only.

2	Size
0200	2" (50 mm)
0300	3" (80 mm)
0400	4" (100 mm)
0600	6" (150 mm)
0800	8" (200 mm)
1000	10" (250 mm)
1200	12" (300 mm)

3	Pressure Class
C	ANSI Class 150
D	ANSI Class 300

4	End Connectors
A	Raised Face (ANSI B16.5)

5	Special Construction
GA	Standard
NA	NACE

6	Body Material
J2	Carbon Steel (WCB)
S6	316 Stainless Steel (CF8M)

7	Ball & Stem Material
SH	316/HCR & 316
SL	316/Nibo & *Nitronic 50* XM-19

8	Seat & Seal Material
STT	Unlocked (S-profile)/ *Celsit*-TFE/TFE
KTT	Locked (K-profile)/ *Celsit*-TFE/TFE
HGG	Locked (H-profile)/ *Celsit* graphite/graphite

9	Body Bolting	
	Bolts	Nuts
A	Carbon Steel A193 Gr B7	Carbon Steel A194 Gr 2H
B	Stainless Steel A193 Gr B8	Stainless Steel A194 Gr 8B

10	Model Code
	Not Required for Ordering

11	Modifier Code
	Please Describe, Factory will supply code.

INTERNATIONAL MANUFACTURING and SALES LOCATIONS

UNITED STATES Glens Falls, New York; Worcester, Massachusetts
CANADA Ottawa, Ontario
MEXICO San Juan del Rio; Queretaro Mexico
BRAZIL Sao Jose dos Campos
FINLAND Helsinki
ENGLAND Basingstoke, Hampshire
FRANCE Wittenheim
PEOPLE'S REPUBLIC of CHINA Shanghai

Our products are available through Neles-Jamesbury sales offices in Australia, Austria, Belgium, Germany, Italy, Japan, The Netherlands, Norway, Portugal, Saudi Arabia, Singapore, South Korea, Spain, Sweden, Switzerland, United Arab Emerites, Venezuela as well as through a world-wide network of representatives.

NELES-JAMESBURY

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ATTACHMENT B

HEAT TRANSFER CALCULATIONS

NO PROBE IN SAMPLE CAVITY

NO PROBE - ESTIMATE OF FIRST ISOLATION VALVE TEMPERATURE

Direct Radiation

Determine the heat which could be transmitted through the hole in the refractory of the process pipe. Assume the hole is black, the receptor gray, and the gas does not interact with the radiant heat transfer. Compare this energy with the energy which could be lost through natural convection at the valve body to estimate the maximum likely temperature of the face of the ball in the first isolation valve.

Assume

$T_1 := (1200 + 460) \cdot R$

$T_{amb} := (100 + 460) \cdot R$

Disc dimensions

Ref: Rohsenow, Warren W. and James P. Hartnett, "Handbook of Heat Transfer," McGraw Hill, 1973, pg 15-44, Fig 4a, configuration 3.

$a := 1.5 \cdot in$

$b := 1.5 \cdot in$

$c := 0.25 \cdot in$ $\quad X := \frac{a}{c}$ $\quad Y := \frac{c}{b}$

$Z := 1 + (1 + X^2) \cdot Y^2$

$F_{A111} := \frac{1}{2} \cdot \left(Z - \sqrt{Z^2 - 4 \cdot X^2 \cdot Y^2}\right)$ $\quad F_{A111} = 0.847$

$A_1 := \pi \cdot a^2$ $\quad \sigma := 0.173 \cdot 10^{-8} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R^4}$

Assume

$T_{10} := (300 + 460) \cdot R$

$Q_{110} := \sigma \cdot A_1 \cdot F_{A111} \cdot \left(T_1^{\,4} - T_{10}^{\,4}\right)$

$Q_{110} = 521.959 \cdot \frac{BTU}{hr}$

This is the energy input to the valve body due to radiant heat transfer.

Next estimate the heat loss through the sides of the first isolation valve body. Assume natural convection from the sides but no energy transfer from the ends of the valve. Further, assume the valve body can be represented by a hollow right circular cylinder of diameter 6 inches by 8 inches long.

$D_o := 6 \cdot in$ $\quad L := 8 \cdot in$

$A_{10} := \pi \cdot D_o \cdot L$ $\quad A_{10} = 150.796 \cdot in^2$

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{(D_o)} \cdot \frac{ft}{R} \right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

Ref: McAdams, "Heat Transmission," McGraw Hill, 1954, pg 177, eqn (7-7a)

$$Q_{10} := A_{10} \cdot h_c \cdot (T_{10} - T_{amb})$$

$$Q_{10} = 252.893 \cdot \frac{BTU}{hr}$$

This is the energy lost through natural convection at the valve body

---

Determine the valve temperature if Q10 = Q110

$$Q_{10} := Q_{110}$$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^{\,4} - T_{10}^{\,4}\right) + T_{amb}$$

$T_{10} = 972.79 \cdot R$

$t_{10} := T_{10} - 460 \cdot R$

$t_{10} = 512.79 \cdot R$ This temperature is F

With this temperature, re-estimate the heat loss to the environment and recompute.

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{(D_o)} \cdot \frac{ft}{R} \right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

$$Q_{10} := A_{10} \cdot h_c \cdot (T_{10} - T_{amb})$$

$$Q_{10} = 625.621 \cdot \frac{BTU}{hr}$$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^4 - T_{10}^4\right) + T_{amb}$$

$T_{10} = 877.737 \cdot R$

$t_{10} := T_{10} - 460 \cdot R$

$t_{10} = 417.737 \cdot R$ This temperature is F

Another iteration

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{(D_o)} \cdot \frac{ft}{R}\right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

$$Q_{10} := A_{10} \cdot h_c \cdot (T_{10} - T_{amb})$$

$$Q_{10} = 451.06 \cdot \frac{BTU}{hr}$$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^4 - T_{10}^4\right) + T_{amb}$$ $T_{10} = 914.515 \cdot R$

$t_{10} := T_{10} - 460 \cdot R$ $t_{10} = 454.515 \cdot R$ This temperature is F

Another iteration

$$h_c := 0.27 \cdot \left[\frac{T_{10} - T_{amb}}{(D_o)} \cdot \frac{ft}{R}\right]^{0.25} \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$$

$$Q_{10} := A_{10} \cdot h_c \cdot (T_{10} - T_{amb})$$

$$Q_{10} = 517.241 \cdot \frac{BTU}{hr}$$

$$T_{10} := \frac{\sigma \cdot A_1 \cdot F_{A111}}{A_{10} \cdot h_c} \cdot \left(T_1^4 - T_{10}^4\right) + T_{amb}$$ $T_{10} = 899.72 \cdot R$

$t_{10} := T_{10} - 460 \cdot R$ $t_{10} = 439.72 \cdot R$ This temperature is F

Another iteration

$$h_c := 0.27\cdot\left[\frac{T_{10} - T_{amb}}{(D_o)}\cdot\frac{ft}{R}\right]^{0.25}\cdot\frac{BTU}{hr\cdot ft^2\cdot R}$$

$$Q_{10} := A_{10}\cdot h_c\cdot(T_{10} - T_{amb})$$

$$Q_{10} = 490.402\cdot\frac{BTU}{hr}$$

$$T_{10} := \frac{\sigma\cdot A_1\cdot F_{A111}}{A_{10}\cdot h_c}\cdot\left(T_1^{\,4} - T_{10}^{\,4}\right) + T_{amb}$$

$T_{10} = 905.56\cdot R$

$$t_{10} := T_{10} - 460\cdot R$$

$t_{10} = 445.56\cdot R$ This temperature is F

Another iteration

$$h_c := 0.27\cdot\left[\frac{T_{10} - T_{amb}}{(D_o)}\cdot\frac{ft}{R}\right]^{0.25}\cdot\frac{BTU}{hr\cdot ft^2\cdot R}$$

$$Q_{10} := A_{10}\cdot h_c\cdot(T_{10} - T_{amb})$$

$$Q_{10} = 500.962\cdot\frac{BTU}{hr}$$

$$T_{10} := \frac{\sigma\cdot A_1\cdot F_{A111}}{A_{10}\cdot h_c}\cdot\left(T_1^{\,4} - T_{10}^{\,4}\right) + T_{amb}$$

$T_{10} = 903.239\cdot R$

$$t_{10} := T_{10} - 460\cdot R$$

$t_{10} = 443.239\cdot R$ This temperature is F

The ball valve may achieve a temperature near 450 F if no plug is present to block radiation and all of the other assumptions are valid. This represents an upper bound estimate of the temperature since the radiant energy will interact with the gas, the re-radiation from the walls of the hole in the insulation will not act as a black surface, and there will be heat loss at locations other than the valve body.

ATTACHMENT C

ESTIMATING THE TEMPERATURE OF THE ISOLATION VALVES DURING SYNGAS SAMPLING (PROBE INSERTED)

Summary

The temperature of the inboard isolation valve must remain below 450°F at all times. The probe assembly system with the sampling probe in position during the gas sampling period was simulated. The calculations showed that the temperature of the probe sheath at the inboard isolation valve should be less than 118°F. Therefore, we have concluded that the temperature of the inboard isolation valve should be well below the maximum operating temperature of approximately 450°F during the gas sampling periods. However, we feel that it would be prudent to monitor the temperature of the valve at all times.

Approach

To simulate the system with the gas sampling probe in place, we chose a countercurrent heat exchanger model, assuming no heat loss to the surroundings (Figure 1). This model provides a conservative estimate of the gas temperature profile in the shell side. Since the shell wall temperature cannot be greater that the shell gas temperature, the isolation valve temperature should not be greater than the shell gas temperature. Therefore, the objective of this analysis is to find the temperature profile of the shell gas and to use the profile to obtain the maximum temperature of the isolation valves.

To meet this objective, an analytical solution for convective heat transfer to the shell gas was derived, assuming that the heat transfer coefficients and gas properties could be expressed by their values at the appropriate average gas temperatures. The radiation heat transfer was also computed, but it was found to be negligibly small compared to the convective heat transfer. Therefore, the solution presented here only considers convective heat transfer.

The analytical solution is expressed as follows:

$$T_{shell,gas} = \frac{\left(\alpha - \phi_{1a}\ e^{-\beta a}\right)}{\beta}$$

where

$$\alpha = U_o * \left(\frac{T_{2a}}{W_1 * C_1} - \frac{T_{1a}}{W_2 * C_2}\right)$$

$$\beta = U_o * \left(\frac{1}{W_1 * C_1} - \frac{1}{W_2 * C_2}\right)$$

$$\phi_{1a} = \alpha - \beta T_{1a}$$

and

U_o = Overall outside heat transfer coefficient at average temperature;

W_1 = Mass flow rate of nitrogen through the shell side;

W_2 = Mass flow rate of mixed gas through the tube side;

C_1 = Heat capacity of nitrogen at average shell gas temperature;

C_2 = Heat capacity of mixed gas at average tube gas temperature;

T_{1a} = Nitrogen temperature at entrance of shell (70°F);

T_{2a} = Mixed gas temperature at outlet of tube (500°F); and

A = Outside heat transfer surface area, ft^2.

We assumed that the quench nitrogen flowed through the shell side of the probe sheath and mixed with the syngas in the probe The mixed gas flows through the probe (tube side of the heat exchanger model). A process simulation program (MAX by Aspen Technologies) was used to calculate flow rates and properties of the various gas streams (i.e., shell side inlet and outlet, mixed gas inlet and outlet, and syngas). The specifications for the simulator program (Table 1) were the shell nitrogen inlet temperature (70°F), the process gas composition, the syngas temperature (1,200°F), and the temperature of the mixed gas at the outlet of the sampling probe (500°F). The simulator calculated the required flow rates.

An iterative procedure was used to obtain average transport properties that were used in the heat transfer calculations. For the first iteration, the shell gas outlet temperature was assumed. The simulator program results were entered into a spreadsheet containing the analytical solution. The spreadsheet calculated a shell gas outlet temperature, which was then entered into the simulator program to recalculate the gas properties. This iteration on the shell gas outlet temperature was continued until the simulator value converged to the analytical value.

Results

Table 2 and Figure 2 present the results for the calculated temperature profile. The results show that the maximum temperature of the shell gas is 118°F near the location of the inboard isolation valve. From this result, we have concluded that, with the sampling probe in place, the temperature of the isolation valves will be well below the maximum temperature rating of 450°F at 500 psig.

Table 1. Required Data

Probe Geometry

Tube O.D.	0.625	inch
Tube wall	0.083	inch
Tube ID	0.459	inch
External Area	0.164	ft2/ft length
Internal Area	0.0011	ft2
Shell ID	2.454	inch
Shell wall	0.148	inch
Internal Area	0.647	ft2/ft length
Annulus X-Section	0.0307	ft2
Length	5.00	ft
Annulus D	0.1524	ft
4*x-Area/Wet Perim	0.1524	ft

Transport Properties

H.T. Coef. tube gas to tube:	21.803	Btu/(hr-ft2-F)
H.T. Coef. tube to shell gas:	0.583	Btu/(hr-ft2-F)
Overall H.T. coeff. (outside area)	0.556	Btu/(hr-ft2-F)
Nitrogen heat capacity (105 F)	7.284	Btu/(lbmol-R)
Mixed Gas heat capacity (522 F)	7.599	Btu/(lbmol-R)
Nitrogen Viscosity (105 F)	0.045	lb mass/ft-hr
Mixed Gas Viscosity (522 F)	0.066	lb mass/ft-hr
Nitrogen Density (105 F)	1.976	lb/ft3
Mixed Gas Density (522 F)	0.958	lb/ft3
Tube Side Reynolds # (522 F)	8101	
Shell Side Reynolds # (105 F)	1309	
Tube Side Prandtl # (522 F)	0.623	
Shell Side Prandtl # (105 F)	0.754	
Tube Side Thermal Cond. (522 F)	0.032	BTU-ft/(hr-ft2-F)
Shell Side Thermal Cond. (105 F)	0.015	BTU-ft/(hr-ft2-F)

Shell Gas

Inlet Temp	70	F
Inlet Pressure	425	psia
Mass flow	0.003	lb/sec
Mass flow	11.75	lb/hr
Mol. Wt	28.01	
Calculated Shell flow	2.65	scfm

Tube Gas

Inlet Temp	1200	F
Outlet Temp	500	F
Inlet Pressure	400	psia
Mass flow	0.004	lb/sec
Mass flow	16.04	lb/hr
Mol. Wt	25.36	
Calculated mixed gas flow	4.00	scfm

Table 2. Estimated Shell and Tube Temperatures as a Function of Axial Position

Distance Along H.E. (inches)	Total Area as f(distance) (ft^2)	Calculated Nitrogen Temperature (F)	Calculated Mixed Gas Temperature (F)
0.00	0.0000	70	500.0
6.00	0.0818	76	504.1
12.00	0.1636	83	508.1
18.00	0.2454	89	512.1
24.00	0.3272	95	516.1
30.00	0.4091	102	520.1
36.00	0.4909	108	524.0
42.00	0.5727	114	527.9
48.00	0.6545	120	531.8
54.00	0.7363	126	535.7
60.00	0.8181	132	539.6

Aspen Sensitivity Study Results

N2 Block Outlet Temperature (F)	Mixed Gas Temp (F)	Average Shell Gas Temp (F)	Average Tube Gas Temp (F)
80.00	506.00	75	503
90.00	513.00	80	507
100.00	519.00	85	510
110.00	525.00	90	513
120.00	532.00	95	516
130.00	538.00	100	519
140.00	544.00	105	522
150.00	551.00	110	526
160.00	557.00	115	529

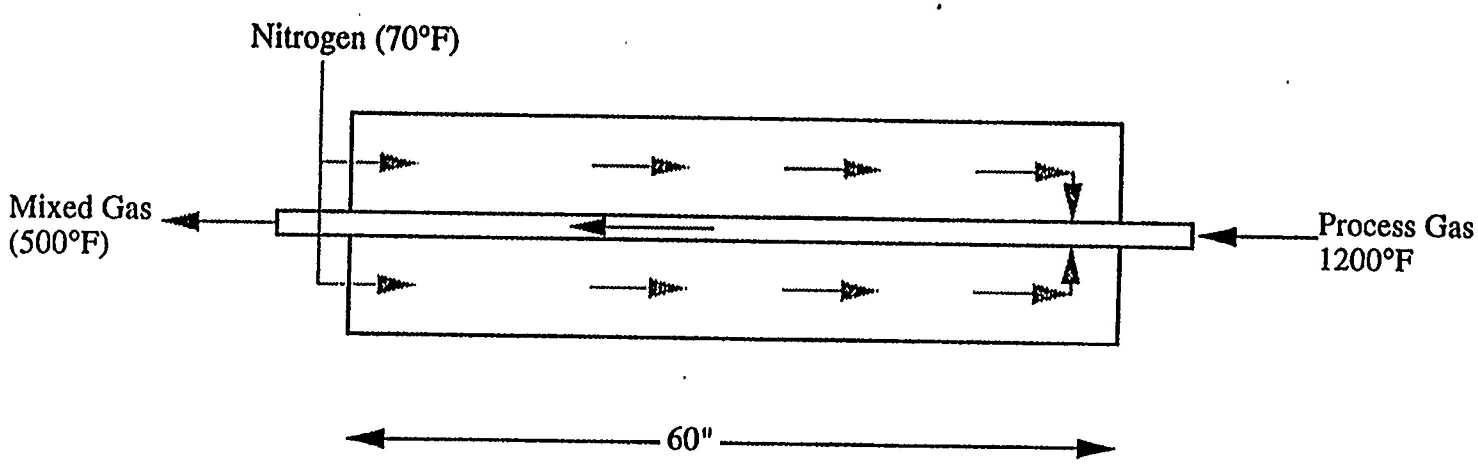

Figure 1. Simplified diagram for heat-exchange portion of sampling probe.

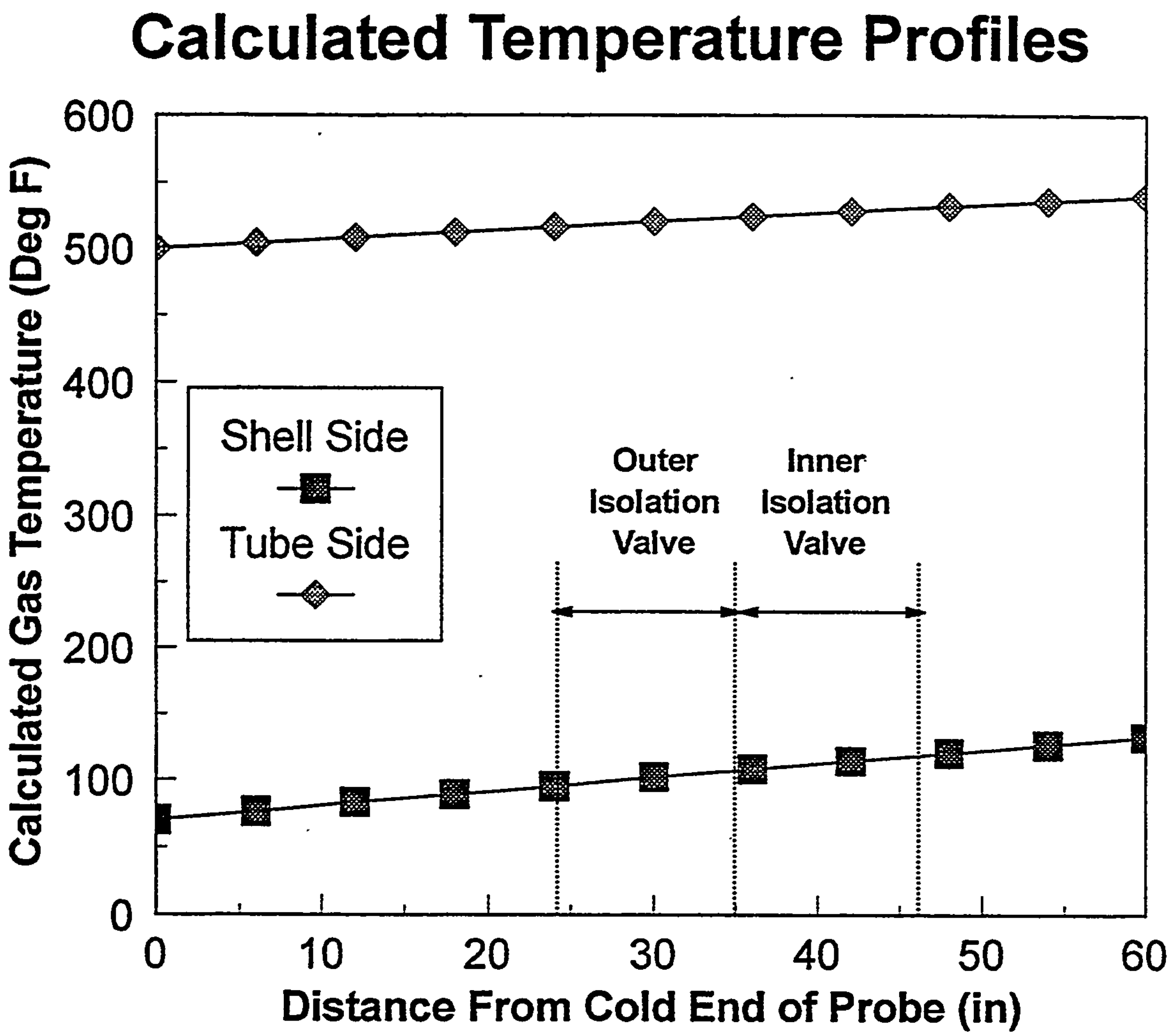

Figure 2. Calculated Temperature Profiles for Shell- and Tube-gases.

ATTACHMENT D

COLLAPSE PRESSURE OF PROBE SHEATH AND SAMPLE TUBE

Pressure Calculations for Probe

Compute minimum wall thickness for probe sheath and for sample line. Use methods and data from ANSI B31.3, "Chemical Plant and Petroleum Refining Piping."

Assume a 500 psig differential can exist across either one in either an internal or external pressure situation.

Sample Line

$D_c := \frac{5}{8} \cdot in$ $t_c := 0.083 \cdot in$

$z_c := \frac{D_c}{6}$ $z_c = 0.104 \cdot in$

Allowable stress per B31.3, tbl A-1, pg 174-175

Joint Efficiency, Quality Factor, B31-3 tbl A-1A

Therefore t < Dc/6 and equation 3b of B31.3, para 304.1.2, 1993 applies for internal pressure

$w_c := \frac{D_c}{t_c}$ $w_c = 8$

$S := 7400$ psi @ 1200 F

$E := 1$

For Internal Pressure

$$P_{c1} := \frac{2 \cdot S \cdot E \cdot t_c}{D_c}$$ Para 304.1.2, eqn 3b, pg 20

$P_{c1} = 1965$

For External Pressure

From BPVC, Sec VIII, Div 1, para UG-28 for external pressure

$A_c := \frac{1.1}{w_c}$ $A_c = 0.146$

$S_1 := 1.5 \cdot S$ $S_1 = 11100$

$S_2 := 0.9 \cdot 30000$ $S_2 = 27000$

Above allowable stresses per UG-28

$A_c := 0.10$ Per code

$B_c := 10000$ Per Fig 5, UHA 28.2

$$p_{a1} := \left[\frac{2.167}{\left(\frac{D_c}{t_c}\right)} - 0.0833 \right] \cdot B_c$$

$p_{a1} = 2045$ This is in psi

$$p_{a2} := \frac{2 \cdot S_1}{\left(\frac{D_c}{t_c}\right)} \cdot \left[1 - \frac{1}{\left(\frac{D_c}{t_c}\right)} \right]$$

$p_{a2} = 2557$ This is in psi

The lower of these pressures, 2045 psi, defines the maximum allowable external pressure in accordance with B31.3
The maximum allowable internal pressure is 1965

==

Sheath

$D_s := 2.75\cdot in$ $t_s := 0.148\cdot in$ $z_s := \frac{D_s}{6}$ $z_s = 0.458\cdot in$

For Internal Pressure

Therefore t < Dc/6 and equation 3b of B31.3, para 304.1.2, 1993 applies for internal pressure

$S := 7400$

$E := 1$

$$P_{s1} := \frac{2\cdot S\cdot E\cdot t_s}{D_s}$$

$P_{s1} = 797$ This is the maximum allowable internal pressure for the sheath

---

For External Pressure

$L_s := 72\cdot in$ Same references and procedures as above.

$v_s := \frac{L_s}{D_s}$ $v_s = 26$ $w_s := \frac{D_s}{t_s}$ $w_s = 19$

$A_s := 0.003$ per Fig 5, UGO 28.0

$B_s := 7800$ Per Fig 5, UHA 28.2

$S_1 := 1.5\cdot S$ $S_1 = 11100$

$S_2 := 0.9\cdot 30000$ $S_2 = 27000$

$$P_{b1} := \frac{4\cdot B_s}{3\cdot\left(\frac{D_s}{t_s}\right)}$$

$P_{b1} = 560$ This is in psi

The maximum allowable internal pressure is 790 psi, and the maximum allowable external pressure is 560 psi.

Both of the tubes can withstand a maximum pressure differential of 560 psi from either side, i.e. external pressure or internal pressure.

ATTACHMENT E

STRESS CALCULATIONS FOR TROLLEY COMPONENTS

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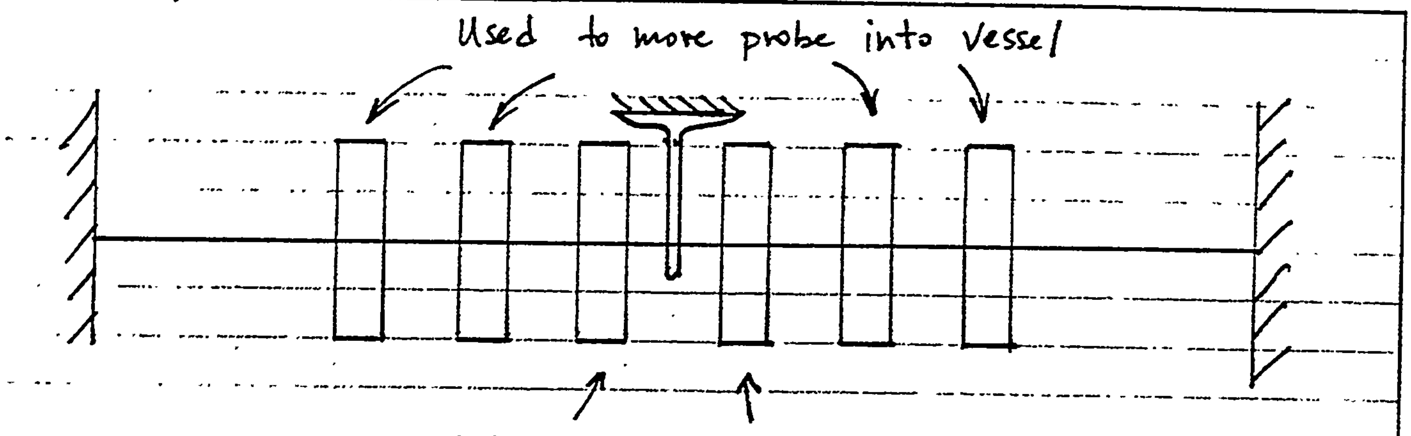
CALCULATION SHEET

CALC. NO.

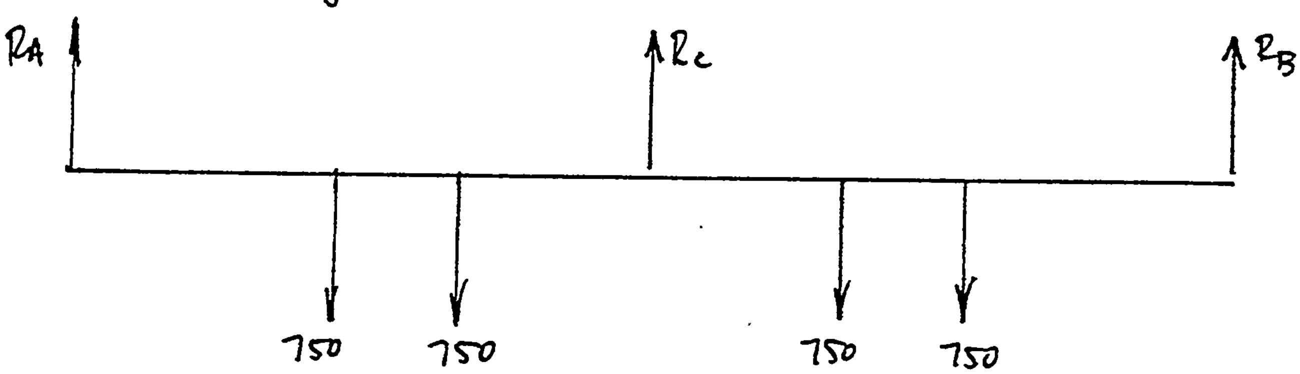
SIGNATURE ______ DATE ______ CHECKED ______ DATE ______

PROJECT Dow Hot Gas — JOB NO. ______

SUBJECT Pulley Axle - Stress Calcs — SHEET 1 OF 7 SHEETS

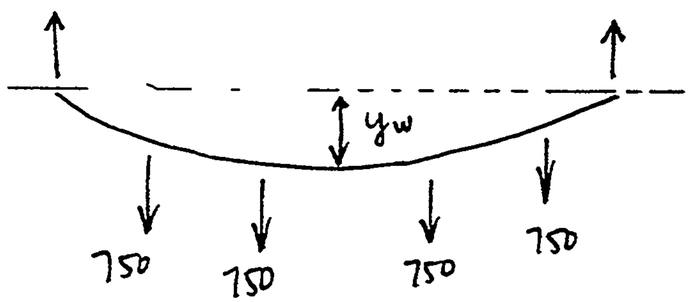


Assume that none of the cables have broken
Probe is going in.



With the addition of the center bearing support, R_c, this becomes a statically indeterminate structure. Although there are several methods which will solve this, I'll use the method of superposition, adding the deflection of each force linearly.

Reference: Mechanics of Materials, A. Higdon, E.H. Ohlsen, et. al. p. 429, Appendix D.



Now, examine the deflection of each force independantly & add together the resulting deflections of all forces

$$y_{center} = -\frac{Pb\,(3L^2 - 4b^2)}{48EI}$$

b = dist from simply supported end

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CALCULATION SHEET

CALC. NO.

SIGNATURE ____ DATE ____ CHECKED ____ DATE ____

PROJECT Dow Hot Gas JOB NO. ____

SUBJECT Pulley Axle - Stress Calcs SHEET 3 OF 7 SHEETS

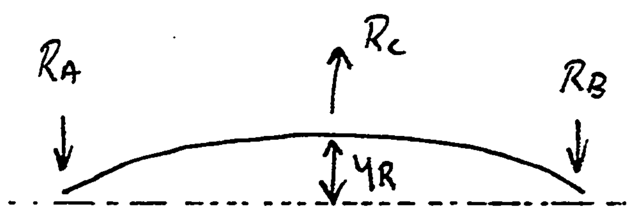
Looking at the forces on the left side.

$$\frac{1}{2} y_w = -\frac{750 \cdot 5.5\,(3 \cdot 24^2 - 4 \cdot 5.5^2)}{48 \cdot 30\times10^6 \cdot \frac{\pi}{64} 1^4}$$

$$- \frac{750 \cdot 8\,(3 \cdot 24^2 - 4 \cdot 8^2)}{48 \cdot 30\times10^6 \cdot \frac{\pi}{64} 1^4}$$

$$\frac{1}{2} y_w = -0.094 - 0.125$$

$y_w = 0.44''$ down } due to the load of ~~foo~~ four 750# forces



$$y_R = \frac{R_c L^3}{48EI}$$

$y_w + y_R = 0$ due to the presence of the bearing @ R_c

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CALCULATION SHEET

CALC. NO.

SIGNATURE ______ DATE ______ CHECKED ______ DATE ______

PROJECT: DOW Hot Gas JOB NO. ______

SUBJECT: Pulley Axle - Stress Calcs SHEET 4 OF 7 SHEETS

$$-0.44 + \frac{R_c L^3}{48EI} = 0$$

$$R_c = \frac{0.44 \cdot 48EI}{L^3} = \frac{0.44 \cdot 48 \cdot 30 \times 10^6 \cdot \frac{\pi}{64}}{24^3}$$

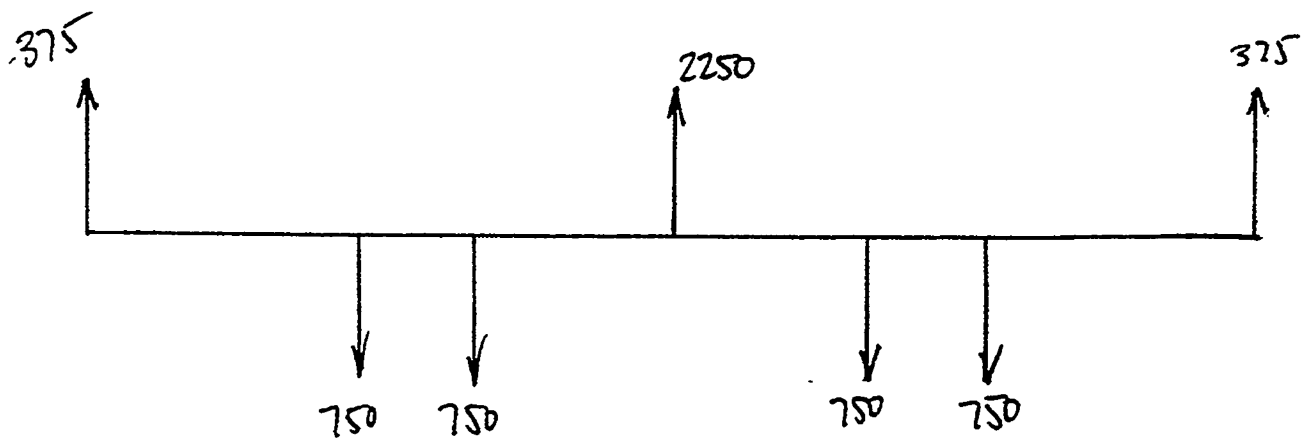
$$R_c = 2250 \text{ lb.}$$

$$+\uparrow \Sigma F_y = 0$$

$$R_A + R_B + R_C = 3000$$

$R_A = R_B$ so, $2R_A = 3000 - 2250$

$$R_A = R_B = 375 \text{ lb.}$$



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CALCULATION SHEET

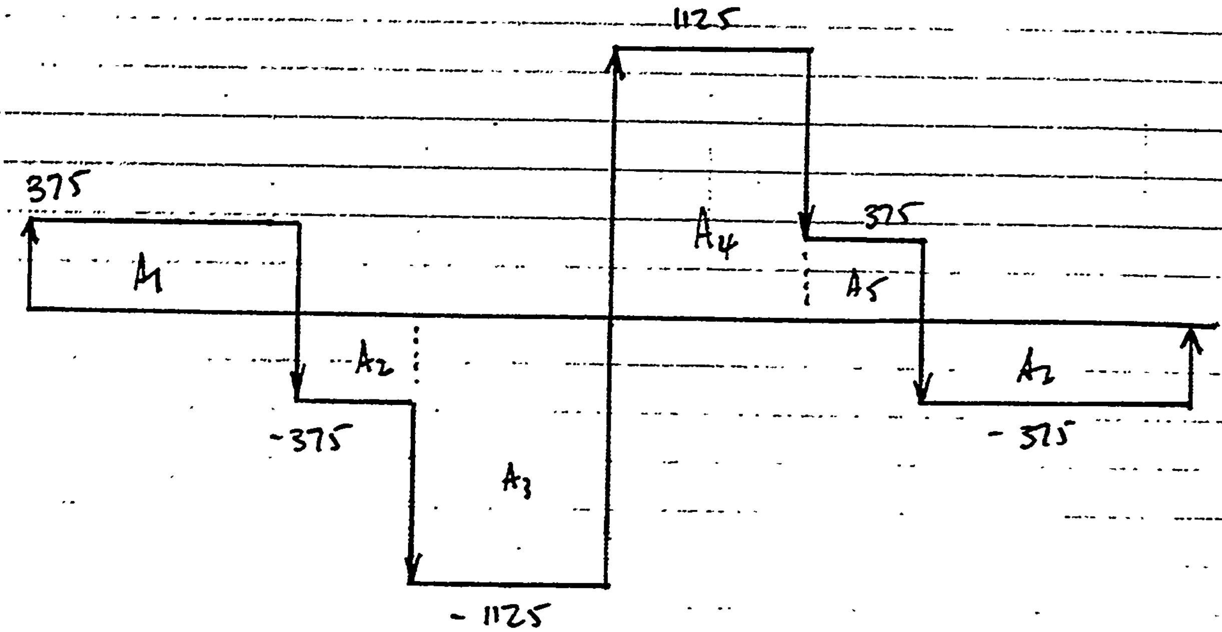
CALC. NO. ____

SIGNATURE ____ DATE ____ CHECKED ____ DATE ____

PROJECT Dow Hot Gas   JOB NO. ____

SUBJECT Pulley Axle – Stress Calcs   SHEET 5 OF 7 SHEETS

Shear Diagram (lb)   1 square = 200#

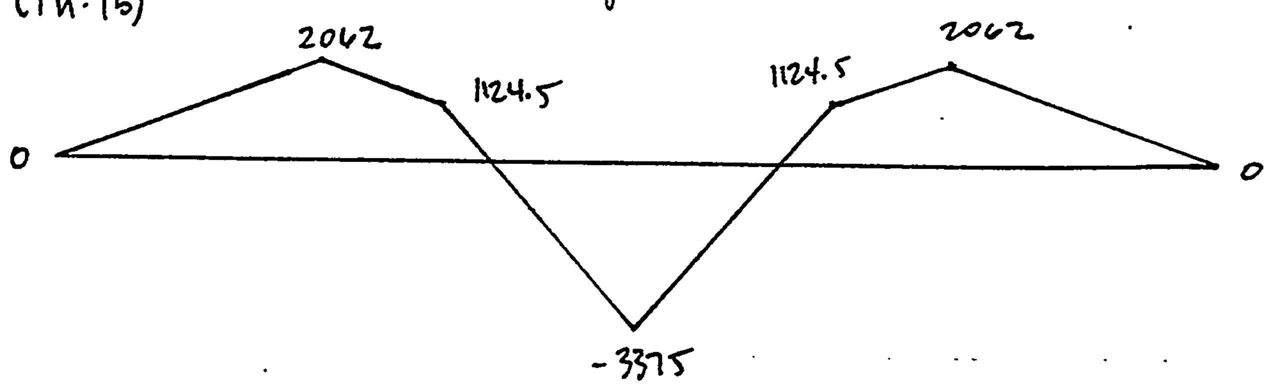


$A_1 = A_6 = 5.5 \cdot 375 = 2062$

$A_2 = A_5 = 2.5 \cdot 375 = 937.5$

$A_3 = A_4 = 4 \cdot 1125 = 4500$

Moment Diagram (in·lb)   1 square = 1000 in·lb



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CALCULATION SHEET

CALC. NO.

SIGNATURE DATE CHECKED DATE

PROJECT: Dow Hot Gas JOB NO.

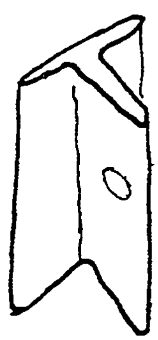
SUBJECT: Pulley Axle - Stress Calcs SHEET 6 OF 7 SHEETS

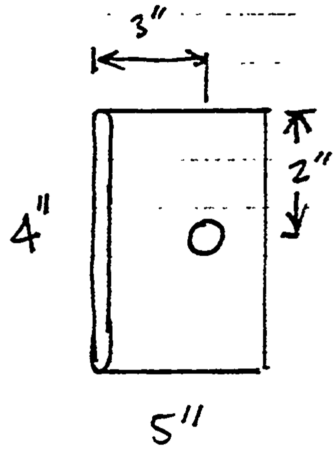
$$\sigma = \frac{Mc}{I}$$

The largest moment acting on the shaft is at the center bearing.

$$\sigma = \frac{(3375 \text{ in-lb})(0.5 \text{ in})}{\frac{\pi}{64}(1 \text{ in})^4} = 34.4 \text{ ksi}$$

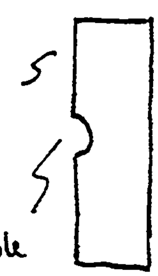
Now check the stress at the bearing.





web thickness = 0.230"

A.



$A = 3 \text{ in} \cdot 0.230 \text{ in} = 0.69 \text{ in}^2$

$P = 2250$ lb. (from shear diagram)

$\sigma = \frac{P}{A} \cdot K_T$ Due to the presence of the hole, $K_T = 2$.

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CALCULATION SHEET

CALC. NO. ____

SIGNATURE ____ DATE ____ CHECKED ____ DATE ____

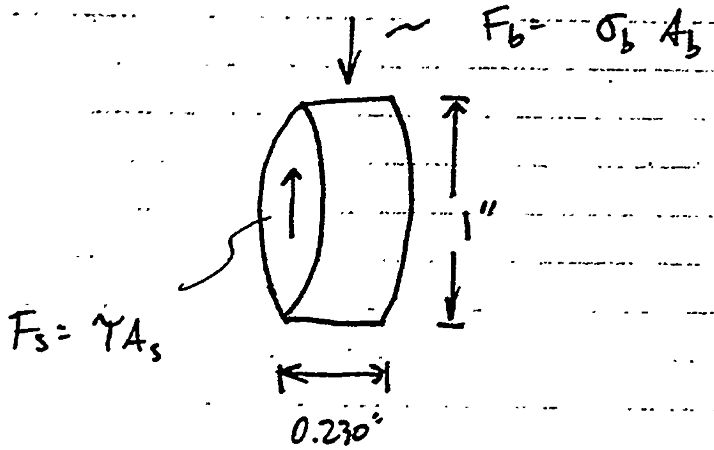
PROJECT Dow hot Gas JOB NO. ____

SUBJECT Pulley Axle - Stress Calcs SHEET 7 OF 7 SHEETS

$$\sigma = \frac{2250 \text{ lb}}{0.69 \text{ in}^2} \cdot 2 = 6523 \text{ psi}$$

6.5 Ksi is acceptable for structural steel

Look at the bearing stresses, & shear stresses



$$F_b = 2250 \text{ lb} = \sigma_b \cdot (1 \text{in})(.230 \text{ in})$$

$$\sigma_b = 9.8 \text{ ksi}$$

$$F_s = 2250 \text{ lb} = \tau \cdot \frac{\pi}{4} (1 \text{in}^2)$$

$$\tau = 2.9 \text{ ksi}$$

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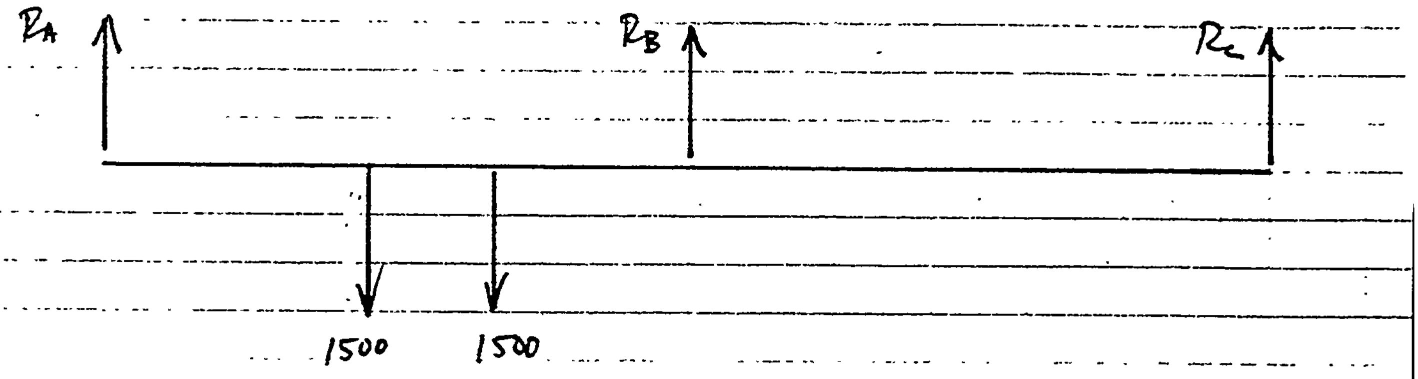
CALCULATION SHEET

CALC. NO.

SIGNATURE ______ DATE ______ CHECKED ______ DATE ______

PROJECT Dow Hot Gas JOB NO. ______

SUBJECT Pulley Axle - Stress Calcs SHEET 1 OF 4 SHEETS



This is the type of loadings if one of the cables breaks.

Use the superposition method.

Due to the 1500# force on the left:

$$y_w = - \frac{-Pb\,(3L^2 - 4b^2)}{48EI}$$

$$y_w = - \frac{1500 \cdot 5.5\,(3 \cdot 24^2 - 4 \cdot 5.5^2)}{48 \cdot 30\times10^6 \cdot \frac{\pi}{64}} - \frac{1500 \cdot 8\,(3 \cdot 24^2 - 4 \cdot 8^2)}{48 \cdot 30\times10^6 \cdot \frac{\pi}{64}}$$

$$y_w = -\ 0.1876 - 0.25 = -.44$$

$$y_r = \frac{R_b L^3}{48EI}$$

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CALCULATION SHEET

CALC. NO.

SIGNATURE ______ DATE ______ CHECKED ______ DATE ______

PROJECT Dow Hot Gas JOB NO. ______

SUBJECT Stress Calcs - Pulley Axle SHEET 2 OF 4 SHEETS

$y_w + y_R = 0$

$$\frac{R_b L^3}{48EI} = 0.44$$

$$R_b = \frac{0.44 \cdot 48EI}{L^3} = \frac{0.44 \cdot 48 \cdot 30 \cdot 10^6 \frac{\pi}{64}}{24^3}$$

$R_b = 2250$ lb.

$\Sigma M_A = 0$

$-1500 \cdot 5.5 - 1500 \cdot 8 + R_b \cdot 12 + R_c \cdot 24 = 0.$

$-8250 - 12000 + 2250 \cdot 12 + R_c \cdot 24 = 0$

$R_c = -281$ lb.

$\Sigma F_y = 0$

$R_A + R_B + R_C = 3000$

$R_A = 3000 - R_B - R_C = 3000 - 2250 + 281$

$R_A = 1031$ lb.

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CALCULATION SHEET

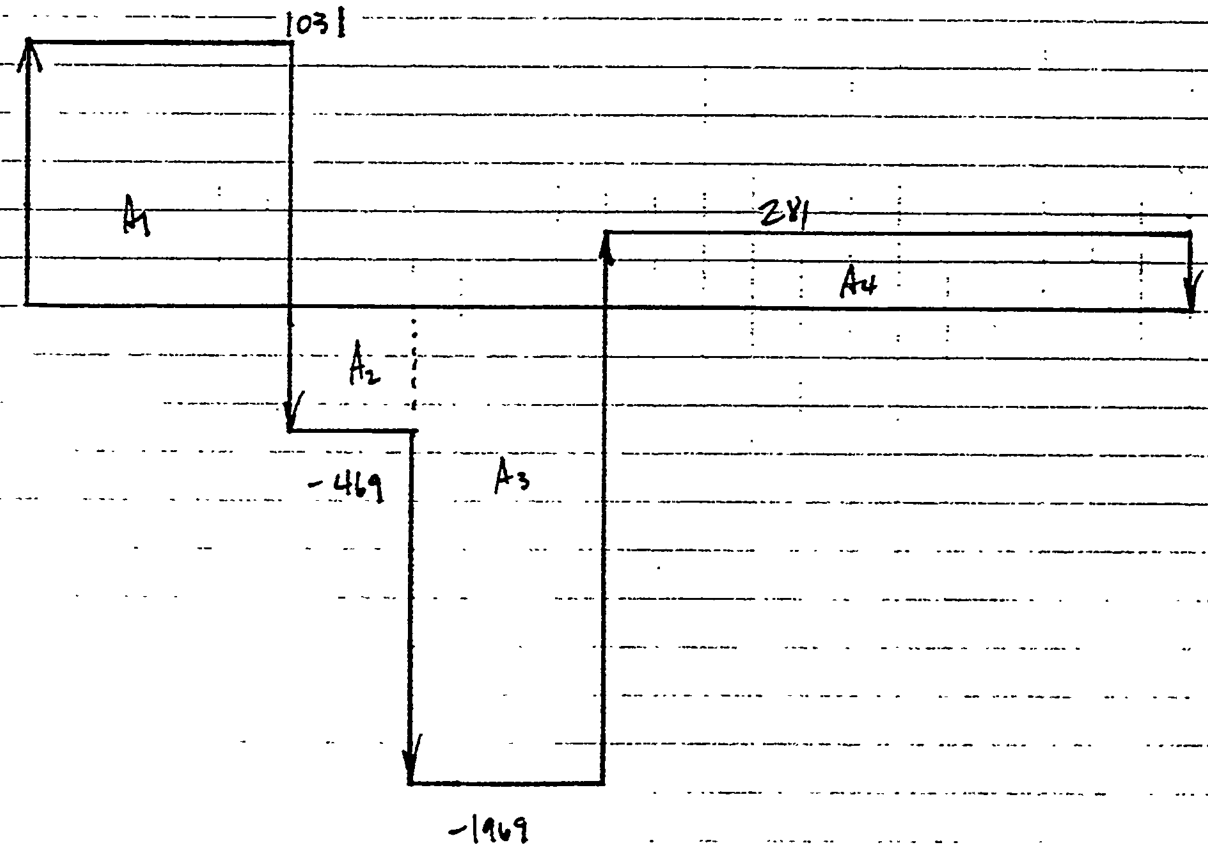
CALC. NO.

SIGNATURE DATE CHECKED DATE

PROJECT Dow Hot Gas JOB NO.

SUBJECT Pulley Axle - Stress Calcs. SHEET 3 OF 4 SHEETS

Shear Diagram



$A_1 = 5.5 \cdot 1031 = 5670$

$A_2 = 2.5 \cdot -469 = 1172.5$

$A_3 = 4 \cdot -1969 = 7876.$

$A_4 = 12 \cdot 281 = 3375$

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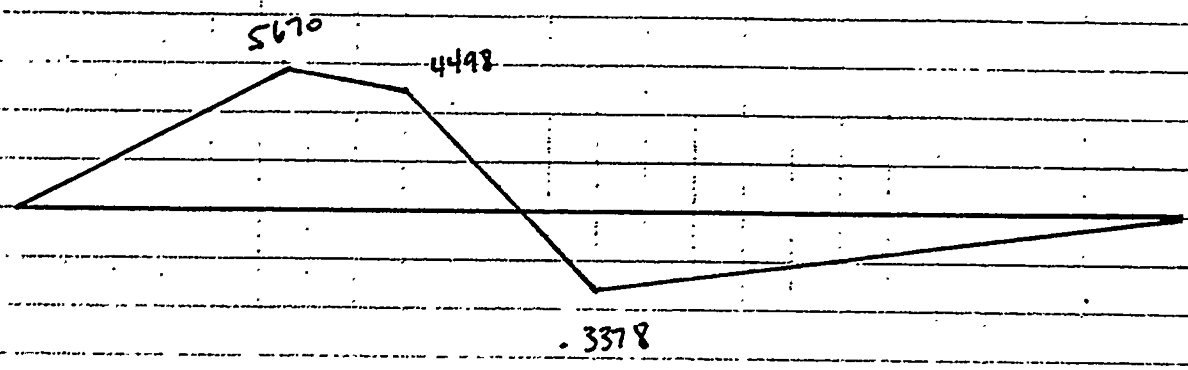
SIGNATURE ______ DATE ______ CHECKED ______ DATE ______

PROJECT Dow Hot Gas JOB NO. ______

SUBJECT Pulley Axle - Stress Calcs SHEET 4 OF 4 SHEETS

1 square = 2000 in·lb



$$\sigma_{max} = \frac{M_{max}\, c}{I}$$

$$\sigma_{max} = \frac{(5670 \text{ in·lb})(0.5 \text{ in})}{\frac{\pi}{64}(1 \text{ in})^4} = 57.7 \text{ ksi}$$

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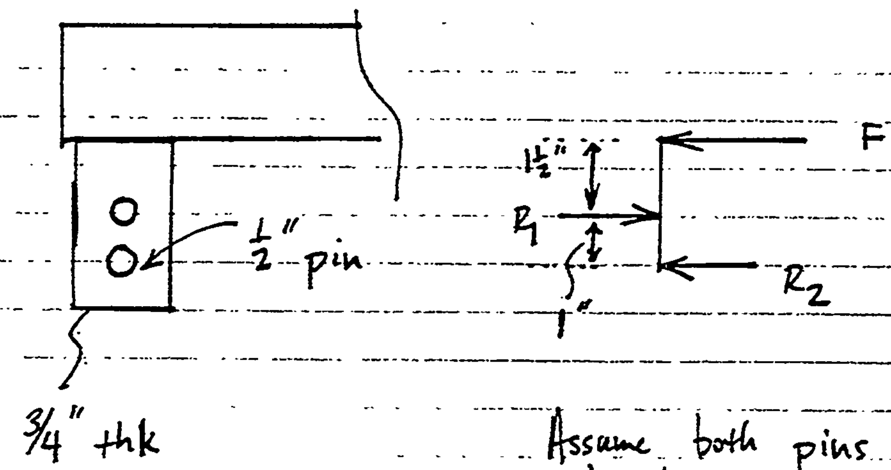
CALCULATION SHEET

CALC. NO. ____

SIGNATURE ____ DATE ____ CHECKED ____ DATE ____

PROJECT Dow Hot Gas JOB NO. ____

SUBJECT Probe Gripper Stresses SHEET 1 OF 2 SHEETS



Assume both pins are in tact.

F_0 = Force of the probe = 3000 lbs.

R_1 = Reaction force of top pin

R_2 = Reaction force of bottom pin

$\circlearrowleft + \quad \Sigma M_{R_2} = 0$

$$F \cdot 2.5 - R_1 \cdot 1 = 0$$

$$R_1 = 2.5 \cdot F = 2.5 \cdot 3000$$

$$R_1 = 7500 \text{ lbs.}$$

$\overset{+}{\rightarrow} \quad \Sigma F_x = 0$

$$-F + R_1 - R_2 = 0$$

$$R_2 = 7500 - 3000 = 4500. \text{ lbs.}$$

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CALCULATION SHEET

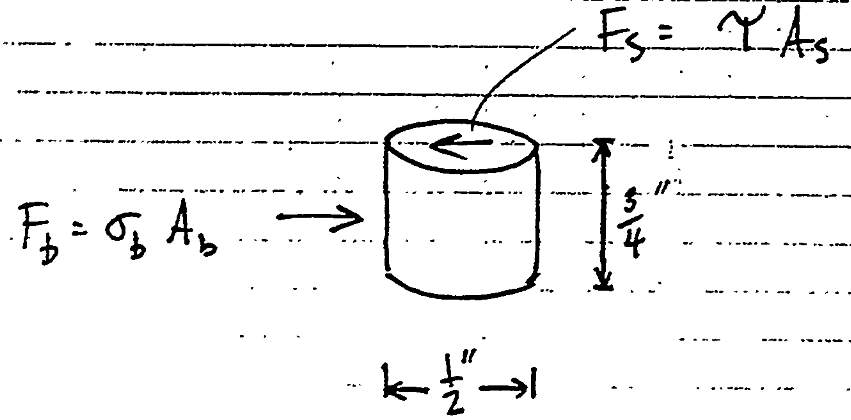
CALC. NO.

SIGNATURE DATE CHECKED DATE

PROJECT Dow Hot Gas JOB NO.

SUBJECT Probe Gripper Stresses SHEET 2 OF 2 SHEETS

Pin Cross-section



Shear Stress on the top pin

$$7500 = \tau \frac{\pi}{4} (0.5)^2$$

shear stress = τ = 38.2 ksi

shear stress per side = 38.2 ksi/2 = 19.1 ksi.

Bearing Stress on the top pin

$$7500 = \sigma_b \left(\tfrac{1}{2}''\right)\left(\tfrac{3}{4}''\right)$$

$$\sigma_b = 20 \text{ ksi}$$

* Shear & Bearing stresses will be less on bottom pin.

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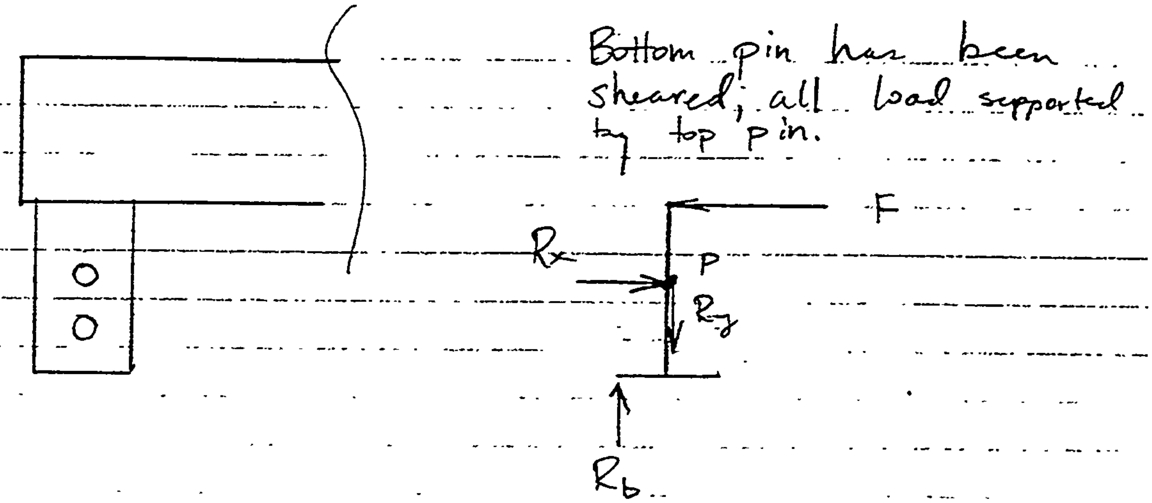
CALCULATION SHEET

CALC. NO.

SIGNATURE ______ DATE ______ CHECKED ______ DATE ______

PROJECT Dow Hot Gas JOB NO. ______

SUBJECT Probe Gripper Stresses SHEET 1 OF 4 SHEETS



F = Force of the probe = 3000 lbs.

R_x = Reaction force in the x-direction

R_y = Reaction force in the y-direction

R_b = Reaction force at the bottom of the tounge; results from the shearing of one pin

$\circlearrowleft + \; \Sigma M_P = 0$

$F \cdot 1.5 - R_b \cdot 1 = 0$

$R_b = 1.5 \cdot F = 4500 \text{ lb}$

$+\uparrow \; \Sigma F_y = 0$

$R_b - R_y = 0$

$R_y = R_b = 4500$

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CALCULATION SHEET

CALC. NO.

SIGNATURE ______ DATE ______ CHECKED ______ DATE ______

PROJECT Dow Hot Gas ______ JOB NO. ______

SUBJECT Probe Gripper Stresses ______ SHEET 2 OF 4 SHEETS

$\xrightarrow{+} \Sigma F_x = 0$

$R_x - F = 0$

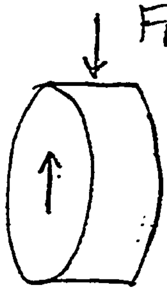
$R_x = F = 3000 \text{ lb.}$

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{3000^2 + 4500^2}$

$R = 5408 \text{ lb.}$

$F_b = \sigma A_b$

$F_s = \tau A_s$



$F_s = 5408 \text{ lb} = \tau \left(\frac{\pi}{4}\right)(0.5 \text{ in})^2$

$\tau = 27.5 \text{ ksi}$

$F_b = 5408 \text{ lb} = \sigma (0.5 \text{ in})(0.75 \text{ in})$

$\sigma = 14.4 \text{ ksi}$

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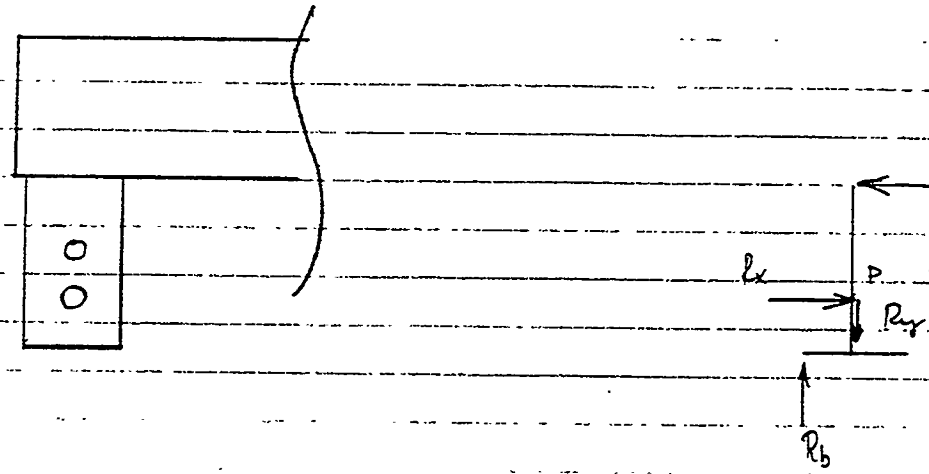
CALCULATION SHEET

CALC. NO.

SIGNATURE DATE CHECKED DATE

PROJECT *Dow Hot Gas* JOB NO.

SUBJECT *Probe Gripper - Stresses* SHEET *3* OF *4* SHEETS



Top pin has been sheared; all load supported by bottom pin.

F = Force of the probe = 3000 lbs

Rx = Reaction force in the x-direction

Ry = Reaction force in the y-direction

Rb = Reaction force at the bottom of the tounge; results from shearing one pin

$\circlearrowleft + \quad \Sigma M_P = 0$

$F \cdot 2.5 - R_b \cdot 1 = 0$

$R_b = 2.5 \cdot F = 7500$

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CALCULATION SHEET

CALC. NO.

SIGNATURE DATE CHECKED DATE

PROJECT Dow Hot Gas JOB NO.

SUBJECT Probe Gripper - Stresses SHEET 4 OF 4 SHEETS

$+\uparrow \quad \Sigma F_y = 0$

$R_b - R_y = 0$

$R_b = R_y = 7500$

$\xrightarrow{+} \quad \Sigma F_x = 0$

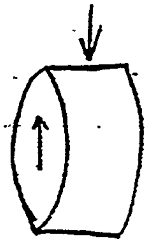
$R_x - F = 0$

$R_x = F = 3000$

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{3000^2 + 7500^2}$

$R = 8078$ lb

$F_b = \sigma A_b$



$F_s = \tau A_s$

$F_s = \tau \cdot A_s$

$8078 = \tau \frac{\pi}{4} (0.5)^2$

$\tau = 41.1$ Ksi

$F_b = \sigma A_b$

$8078 = \sigma \, (0.5 \text{ in}) \, (0.75 \text{ in})$

$\sigma = 21.5$ Ksi

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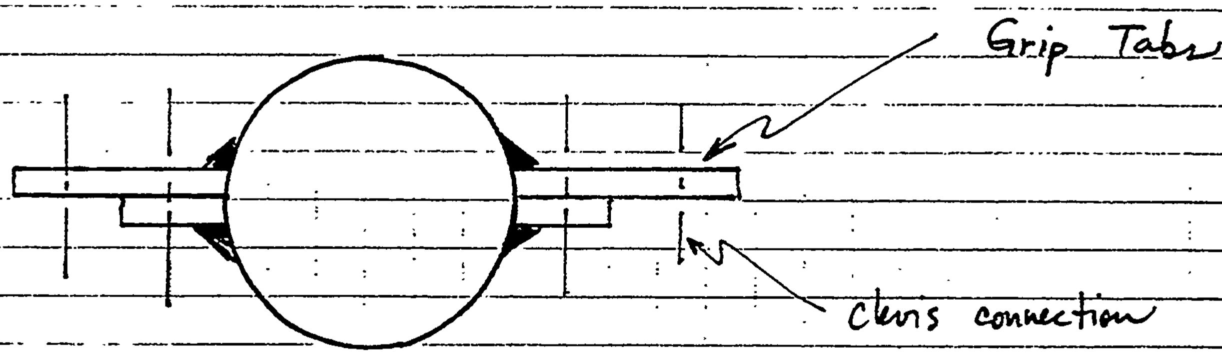
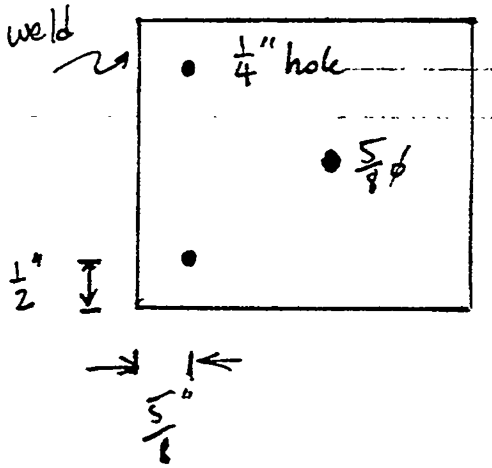
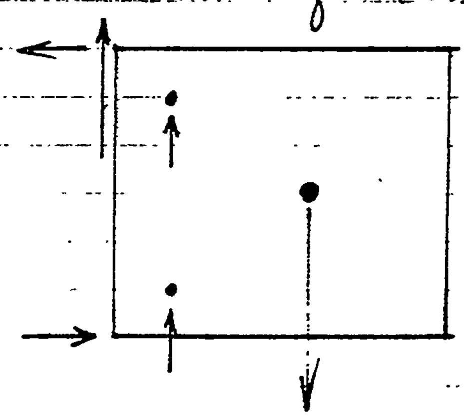


The grip tabs will be connected to clevis pins & hold the probe in position during the sampling process.

Top View of Tab.



FBD of Tab.



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CALCULATION SHEET

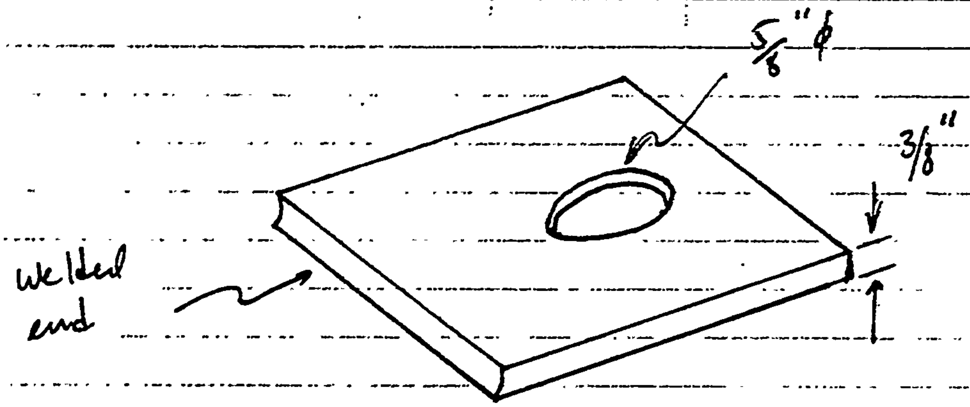
CALC. NO. ____

SIGNATURE ____ DATE ____ CHECKED ____ DATE ____

PROJECT Dow Hot Gas JOB NO. ____

SUBJECT Probe Grip Tabs SHEET 2 OF 2 SHEETS

The point of the highest load concentration will be at the clevis connection (i.e. the 5/8" hole).



Bearing Stress

$F_b = \sigma A_b = 1500$

$1500 = \sigma \cdot \left(\frac{5}{8} \cdot \frac{3}{8}\right)$

$\sigma = 6400$ psi

Shear Stress

$F_s = \tau A$

$1500 = \tau \cdot \frac{\pi}{4} \left(\frac{5}{8}\right)^2$

$\tau = 4890$ psi

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CALCULATION SHEET

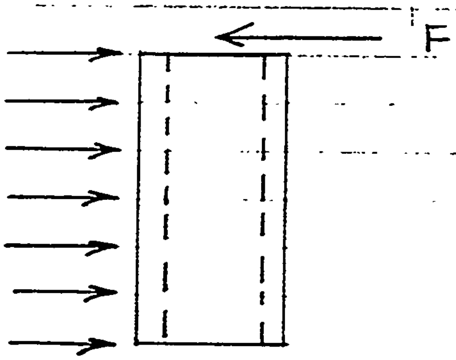
CALC. NO. ______

SIGNATURE ______ DATE ______ CHECKED ______ DATE ______

PROJECT ______ JOB NO. ______

SUBJECT Vertical Support Stresses SHEET 1 OF 3 SHEETS

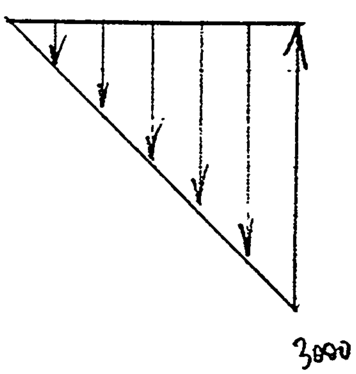
Assume the Force, F = 3000 lbs, is distributed equally over the length of the 2" pipe.



F = 3000 lb.

Load/length = 500 lb/in

Shear Diagram



Moment Diagram

$$\text{Area} = \tfrac{1}{2}\, b \cdot h$$

$$= \tfrac{1}{2}\, 6 \cdot 3000 = 9000 \text{ in/lb}$$

$$M_{max} = 9000 \text{ in-lb}$$

$$\sigma_{max} = \frac{M_{max}\, c}{I}$$

$$\sigma_{max} = \frac{(9000 \text{ in-lb})(1 \text{ in})}{\frac{\pi}{64}(2.375^4 - 2.067^4)}$$

$$\sigma_{max} = 13{,}518 \text{ psi}$$

RADIAN CORPORATION

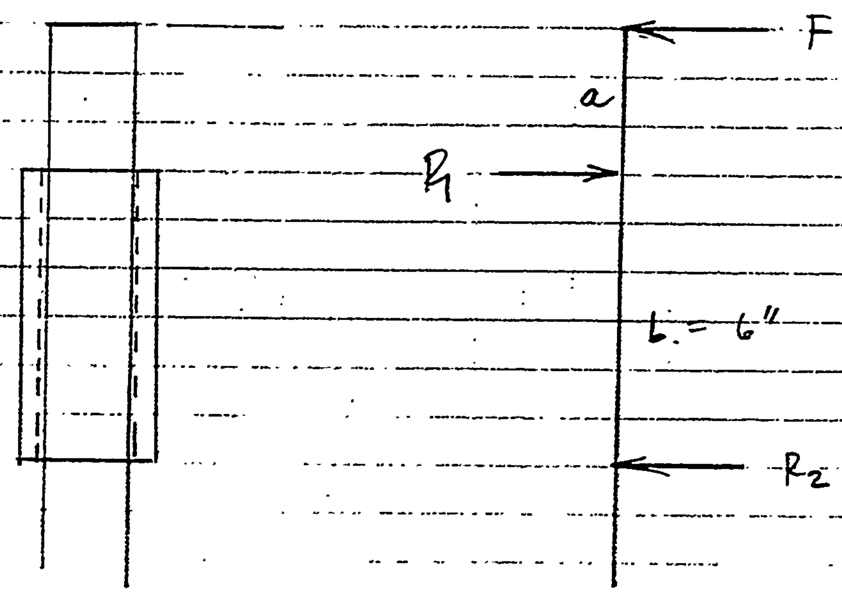
CALCULATION SHEET

CALC. NO.

SIGNATURE _____ DATE _____ CHECKED _____ DATE _____

PROJECT _____ JOB NO. _____

SUBJECT Vertical Support - Stresses SHEET 2 OF 3 SHEETS



Looking at the forces on the 2" rod which moves up & down

$\circlearrowleft + \Sigma M_1 = 0$

$F \cdot a = R_2 \cdot 6$

$R_2 = \dfrac{F \cdot a}{6}$ In a worst case scenario, $a = 6"$.

$R_2 = F = 3000$ lb

$\xrightarrow{+} \Sigma F_x = 0$

$R_1 - F - R_2 = 0$ $R_1 = 6000$ lbs

H-73

RADIAN CORPORATION

CALCULATION SHEET

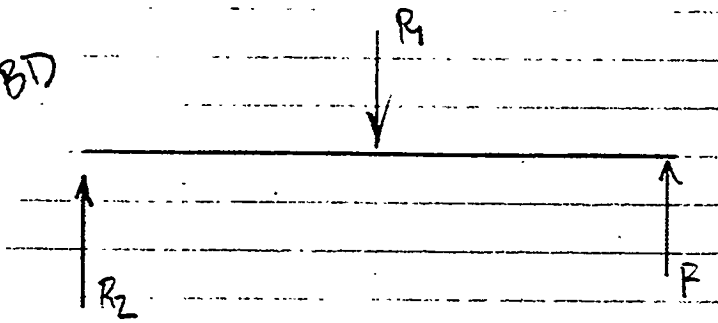
CALC. NO.

SIGNATURE DATE CHECKED DATE

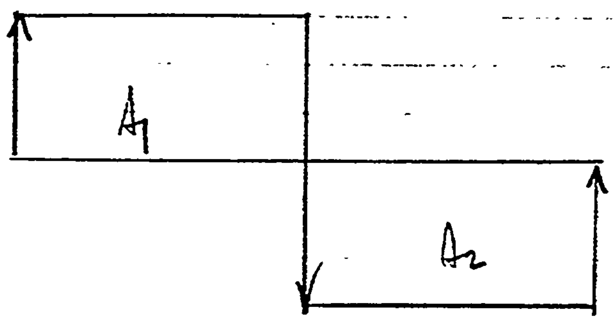
PROJECT JOB NO.

SUBJECT Vertical Support – Stresses SHEET 3 OF 3 SHEETS

FBD

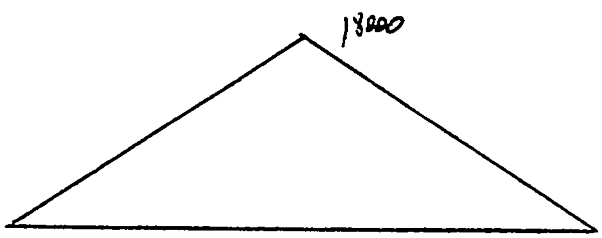


V



$A_1 = A_2 = 3000 \cdot 6 = 18000.$

M



$M_{max} = 18{,}000$ in·lb

$$\sigma_{max} = \frac{M_{max}\, c}{I}$$

$$\sigma_{max} = \frac{18000 \text{ in}\cdot\text{lb} \cdot 1 \text{ in}}{\frac{\pi}{64} \cdot (2 \text{ in})^4}$$

$\sigma_{max} = 22{,}918$ psi

10.88 30702

RADIAN CORPORATION

CALCULATION SHEET

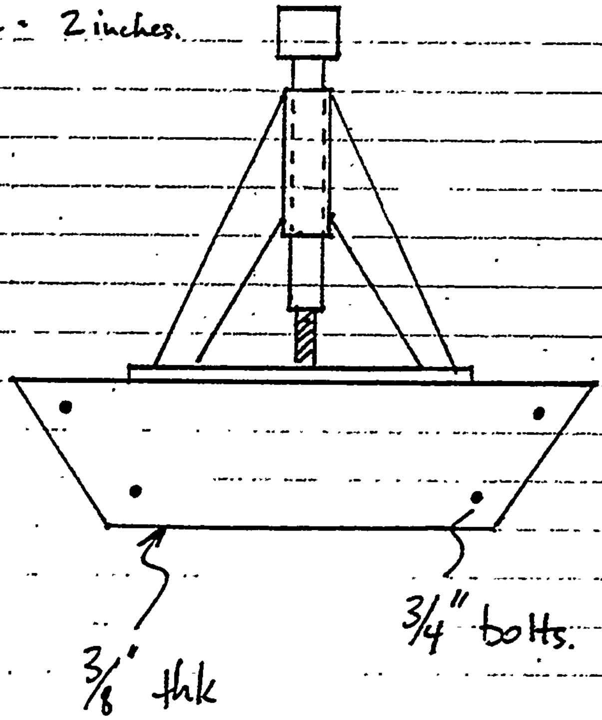
CALC. NO. ______

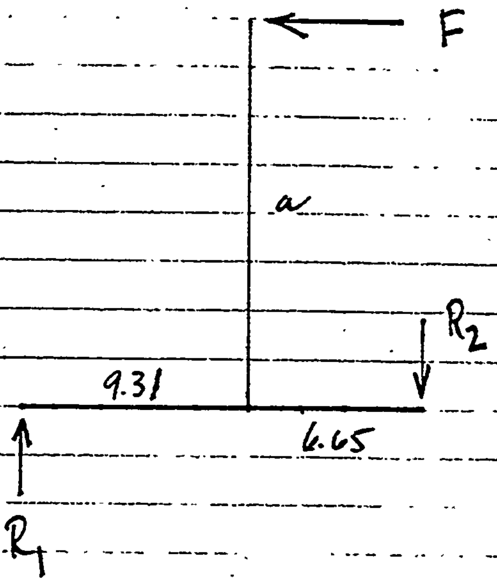
SIGNATURE ______ DATE ______ CHECKED ______ DATE ______

PROJECT: DOW Hot Gas   JOB NO. ______

SUBJECT: Trolley Wheel Stresses   SHEET 1 OF 2 SHEETS

1 square = 2 inches.





* Please note – this analysis is for a single car. In our design we will have two cars supporting the vert. supports

$$\circlearrowleft + \quad \Sigma M_{R_1} = 0$$

$$F \cdot a - R_2 \cdot (9.31 + 6.65) = 0$$

$$R_2 = \frac{F \cdot a}{15.96}$$

$$+\uparrow \quad \Sigma F_y = 0$$

$$R_1 = R_2 = \frac{F \cdot a}{15.96}$$

The load on each wheel is $\frac{1}{2}$ the reaction force shown (i.e. load $= \frac{1}{2} R_1 = \frac{1}{2} R_2$).

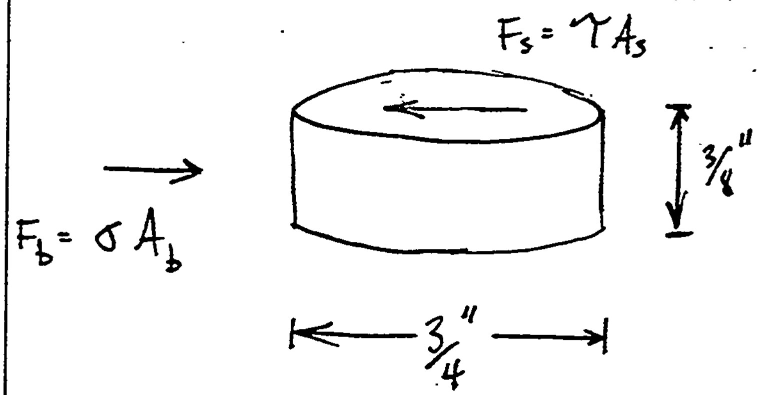
10-88-30702

Assume $F = 3000$ lbs. $a = 15''$

$$R_1 = R_2 = \frac{3000 \cdot 15}{15.96} = 2819 \text{ lbs.}$$

load per wheel = 1410 lbs

Check the shear force / stresses on the axle



This represents a hole in the trolley side plate which the bolt (axle) passes through

Shear Force = $F_s = \tau A_s$

$$1410 \text{ lbs} = \tau \left(\frac{\pi}{4}\right)(0.75 \text{ in})^2$$

shear stress = $\tau = 3192$ psi

Bearing Force = $F_b = \sigma_b A_b$

$$1410 \text{ lbs} = \sigma_b \left(\frac{3}{8} \text{ in}\right)\left(\frac{3}{4} \text{ in}\right)$$

bearing stress = $\sigma_b = 5013$ psi

ATTACHMENT F

CALCULATIONS FOR VALVE SUPPORT

RADIAN CORPORATION

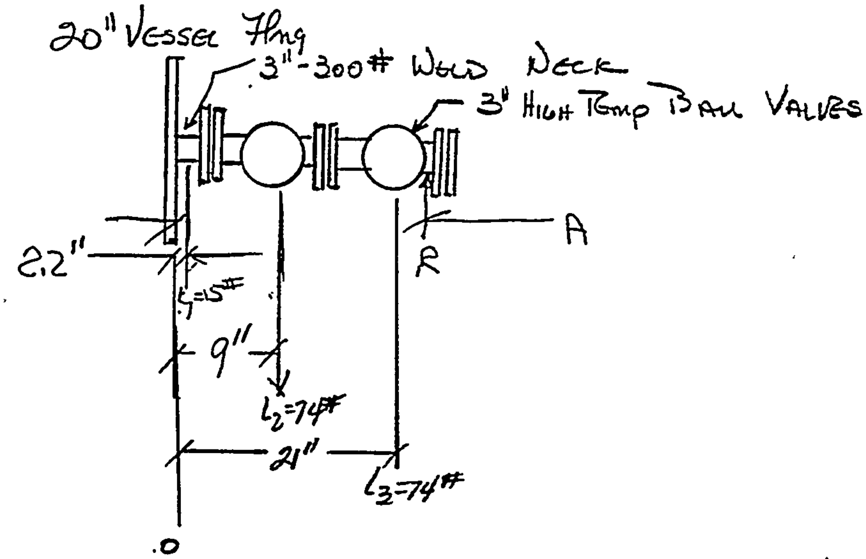
CALCULATION SHEET

CALC. NO.

SIGNATURE C Thomas DATE 10/11/94 CHECKED DATE

PROJECT LGTI JOB NO.

SUBJECT Valve Support W/o GLAND SHEET 1 OF 1 SHEETS



INSTALL VALVES WITH BALL LOCATED TOWARD OUTBOARD END OF TRAIN

NEEDED - WEIGHT R TO REDUCE BENDING & SHEAR LOAD AT OUTSIDE OF 20" FLANGE TO MINIMUM. THIS IS A TEMPORARY WEIGHT UNTIL GLAND & PROBE ARE INSTALLED

ASSUME DIMENSION A = 26"

MOMENTS ABOUT EDGE OF OUTSIDE SURFACE OF 20" FLANGE

$$\Sigma M_o = -(L_1 * 2.2) - (L_2 * 9") - (L_3 * 21) + R * 26$$

$$= -(15)(2.2) - (74)(9) - 74(21) + (R)26$$

$$R = \frac{2253}{26} \text{ lb}$$

$$= 87 \text{ lb}$$

If double strand supported as shown in final $R_2 = 44$ lb

Stress at Weld Neck Flange to Vessel Flange Joint

Given

Load diagram on the following page.

Compute the center of gravity and weight of the probe.

2 3/4 Dia x 0.148 wall $w_o := 4.113 \cdot \frac{lb}{ft}$ $L_p := 7 \cdot ft + \left(7 + \frac{1}{2}\right) \cdot in$

5/8 Dia x .083 wall $w_i := 0.4805 \cdot \frac{lb}{ft}$ $L_p = 7.625 \cdot ft$

End Cap $w_e := 1.683 \cdot \frac{lb}{in}$ $w_p := (w_o + w_i) \cdot L_p + 2 \cdot w_e \cdot \frac{1}{2} \cdot in$

$w_p = 36.708 \cdot lb$

Center of Gravity $L_{pcg} := \frac{L_p}{2}$ $L_{pcg} = 3.813 \cdot ft$

Measured from nose of probe.

Taking Moments around outside edge of vessel flange

Loads

$L_1 := 15 \cdot lb$ $L_4 := 97 \cdot lb$ $i := 1 .. 14$

$L_2 := 74 \cdot lb$

$L_3 := L_2$ $L_5 := w_p$ $A_i := 28 + i \cdot 2$

Probe Withdrawn

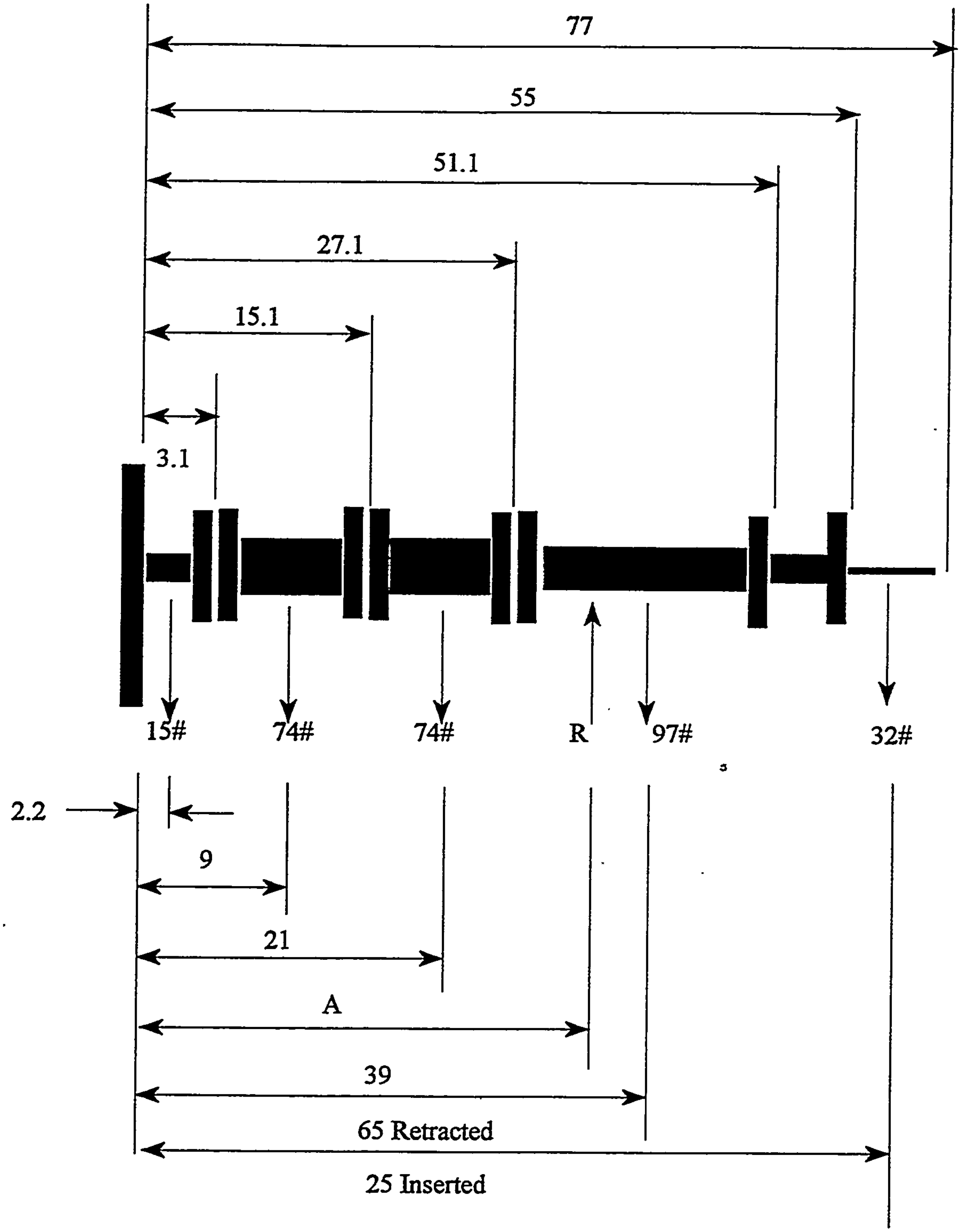
$$R_i := \frac{L_1 \cdot 2.2 + L_2 \cdot 9 + L_3 \cdot 21 + L_4 \cdot 39 + L_5 \cdot 65}{A_i}$$

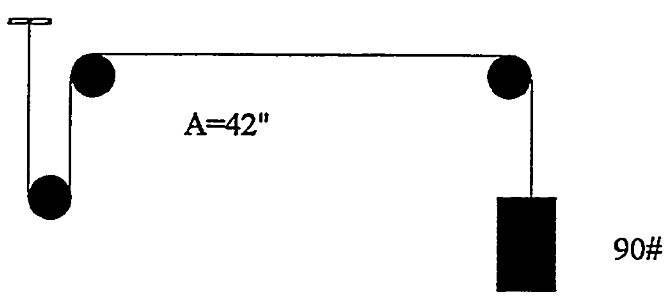
A =

	0
0	0
1	30
2	32
3	34
4	36
5	38
6	40
7	42
8	44
9	46
10	48
11	50
12	52
13	54
14	56

R = (·lb)

	0
0	0
1	280.735
2	263.189
3	247.707
4	233.946
5	221.633
6	210.551
7	200.525
8	191.41
9	183.088
10	175.459
11	168.441
12	161.962
13	155.964
14	150.394


77
55
51.1
27.1
15.1
3.1
15#
74#
74#
R
97#
32#
2.2
9
21
A
39
65 Retracted
25 Inserted


A=42"
90#

Select Then

$A := 42 \cdot in$ $R := 180 \cdot lb$

Sum of Forces in Vertical Direction

$$V := L_1 + L_2 + L_3 - R + L_4 + L_5$$

$$V = 116.708 \cdot lb$$

Moment at the weld neck-vessel flange joint.

Probe Withdrawn

$$M_w := (L_1 \cdot 2.2 + L_2 \cdot 9 + L_3 \cdot 21 + L_4 \cdot 39 + L_5 \cdot 65) \cdot in - R \cdot A$$

$$M_w = 71.837 \cdot ft \cdot lb$$

Probe Inserted

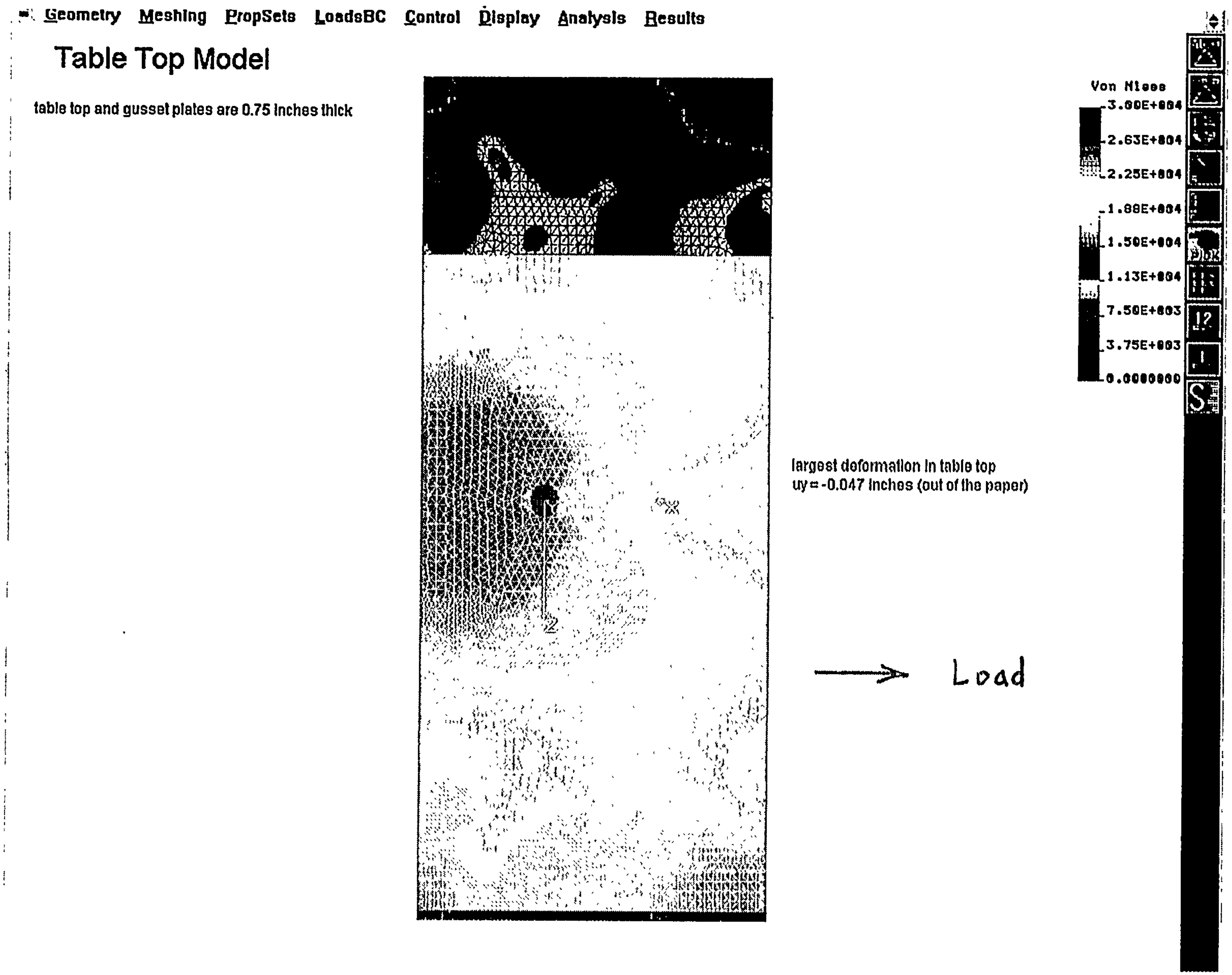
$$M_i := (L_1 \cdot 2.2 + L_2 \cdot 9 + L_3 \cdot 21 + L_4 \cdot 39 + L_5 \cdot 25) \cdot in - R \cdot A$$

$$M_i = -50.524 \cdot ft \cdot lb$$

These are the loads which are imposed on the weld neck-vessel flange joint by the sampling port.

ATTACHMENT G

STRESS CALCULATIONS FOR TROLLEY PLATE



2-D View of 3/4" Table Top (Top View)

ATTACHMENT H

EXAMPLE CHECKLIST FOR PROBE OPERATION

Hot Gas Sampling Probe Operation: Check List

Run ID___________ **Start Time** _________ **Probe Tip**_______________
Date _____________ **Stop Time** _________

Operation	Activity	Done
Configure Probe Tip	Attach thimble/thimble holder (particulate samples) or sintered metal filter (gas samples) to probe tip	
	Tighten connection to probe tip (nozzle orientation (_______)	
Configure Valves for Initial Insertion	Both isolation (3-inch ball valves) are in the closed position	
	Sheath inlet/outlet valve (9) is closed	
	Probe outlet valve (10) is closed	
	Nitrogen purge valve (3) on gland is closed	
	Gland outboard vent valve (4) is closed	
	Gland inboard vent valve (2) is open	
	Isolation valve vent valve (12) is open - valves (11) & (1) closed	
	Probe dilution nitrogen manifold valve (7) is disconnected from probe sheath inlet (@ quiick-connect)	
	Probe outlet manifold [valves (6) & (8) are connected and valve (CV-3)] is disconnected from probe outlet	
	Packing gland nuts are loosened	
	Nitrogen regulators (R-1) and (R-2) are adjusted to an outlet pressure of 400 psig	
Insert Probe into Gland	Align probe with packing gland inlet	
	Adjust vertical position of probe as necessary for proper alignment	
	Using winches, insert probe into gland to a depth of about 22 inches (as marked on probe sheath and/or on trolley rails)	
	Fasten retaining clamps on rail behind trolley wheels	
	Partially tighten (snug) packing gland nuts	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ____________

Operation	Activity	Done
Purge Air from Gland	Gland inboard vent valve **(2)** is open	
	Open nitrogen purge valve **(3)**	
	Set nitrogen purge rate to gland at 1 scfm using control valve **CV-1**	
	Purge gland for 3 minutes with nitrogen at 1 scfm	
Purge Air from Probe	Open probe outlet valve **(10)** to atmosphere	
	Close gland inboard vent valve **(2)**	
	Continue nitrogen purge rate to gland at 1 scfm through control valve **CV-1**	
	Purge probe for 3 minutes with nitrogen at 1 scfm	
Purge Air from Probe Sheath	Open sheath inlet/outlet valve **(9)** and valve **(5)** to atmosphere	
	Close probe outlet valve **(10)**	
	Continue nitrogen purge rate to gland at 1 scfm through control valve **CV-1**	
	Purge probe sheath for 3 minutes with nitrogen at 1 scfm	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ______________

Operation	Activity	Done
Adjust Nitrogen Leak Rate through Packing Gland	Close sheath inlet/outlet valve **(9)** and valve **(5)**	
	Continue nitrogen purge rate at 1 scfm through nitrogen purge valve **(3)** until pressure in probe assembly is 400 psig **(PI-3** and **PI-2)**	
	Monitor pressure between the isolation valves **(PI-1)**. Pressure _________ psig	
	Close nitrogen purge valve **(3)** to seal probe assembly	
	Measure pressure loss in probe assembly for 10 minutes. Pressure loss _________ psi /10 minutes	
	If pressure loss in gland assembly is greater than 25 psi in 10 minutes, tighten packing gland nuts	
	Open nitrogen purge valve **(3)** and repressure gland assembly to 400 psig	
	Monitor pressure loss again in the gland assembly	
	Continue adjusting packing gland nuts and monitoring pressure until pressure loss is less than 25 psi/10 minutes	
	Final pressure loss is __________psi in 10 minutes	
Prepare for Full Probe Insertion	Probe outlet valve **(10)** is closed	
	Sheath inlet/outlet valve **(9)** is closed	
	Gland inboard vent valve **(2)** is closed	
	Gland outboard vent valve **(4)** is closed	
	Isolation valve vent system [valves **(1)** and **(11)**] are closed	
	Nitrogen purge valve **(3)** is closed	
	Pressure in gland assembly **(PI-2** and **PI-3)** is 350 (___) psig	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ______________

Operation	Activity	Done
Purge Air/Syngas from Void Space Between the Isolation Valves	Record pressure in void space between the isolation valves (PI-1). Pressure is ___________	
	Open Isolation valve vent valve **(1)** to depressure void space to atmosphere	
	After depressuring, close vent valve **(1)**	
	Leave vent valve **(12)** open	
	Open valve **(11)** to direct nitrogen to void space between the isolation valves	
	Adjust nitrogen flow rate to about 1 scfm, using valve **CV-1** to control flow	
	Continue nitrogen flow until pressure between the isolation valves reaches 400 psig (PI-1)	
	Close nitrogen valve **(11)** in preparation for depressuring	
	Open vent valve **(1)** to depressure the void space to atmosphere	
	Close vent valve **(1)**	
	Open nitrogen valve **(11)** to repressure void space between the isolation valves	
	Repressure void space to 400 psig	
	Close nitrogen valve **(11)** in preparation for depressuring	
	Open vent valve **(1)** to depressure the void space a second time	
	Close vent valve **(1)**	
	Open nitrogen valve **(11)** to repressure the void space for the last time	
	Repressure the void space to 400 psig	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ______________

Operation	Activity	Done
Adjust Pressure in Probe to 450 psig	Adjust pressure in gland and probe system to approximately 400 psig	
	Open valve **(3)**. **PI-1 = PI-2 =** ______ psig	
	Open outboard isolation valve **(LGTI PERSONNEL MUST OPEN/CLOSE THE ISOLATION VALVES)**	
	Open nitrogen purge valve **(3)**	
	Adjust nitrogen flow, using **CV-1**, to gland and probe to about 0.5 scfm	
	Increase the pressure in the probe system up to 450 psig **(PI-2)**, or to 50 psig above process pressure	
	Close nitrogen valve **(11)**	
Insert Probe Fully into Vessel	Be sure that valve **(9)** is closed	
	Be sure that valve **(10)** is closed	
	With probe system at 450 psig (or 15 psig above process pressure), open inboard isolation valve **(LGTI PERSONNEL MUST OPEN/CLOSE THE ISOLATION VALVES)**	
	Be sure that nitrogen purge valve **(3)** is open	
	Adjust nitrogen purge rate to 1 scfm using **(CV-1)**	
	Using the winch system, insert the probe into the vessel to the predetermined position	
	With probe inserted, secure the positioner with turnbuckles	
	Secure the rail clamps at the rear wheels of the trolley	
	Monitor CO/H_2S levels at the packing gland to detect leaks	
	If CO or H_2S levels are above 100 or 25 ppmv, respectively, at the gland, tighten the packing gland nuts	
	Continue tightening gland nuts and monitoring until CO and H_2S levels are below 100 and 25 ppmv, respectively	
	With retainers (turnbuckles) in place, disconnect, if practical, (but leave in position) the probe gripper from the probe itself	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ______________

Operation	Activity	Done
Prepare for Sampling	Maintain nitrogen purge rate through nitrogen control valve **(CV-1)** and nitrogen purge valve **(3)** - N_2 rate ______ scfm	
	Connect dilution nitrogen manifold valves **(5)** and **(7)** to probe	
	Connect probe outlet manifold [valve **(6)**, valve **(8)**, filter, and probe outlet control valve **(CV-3)**] to probe outlet	
	Close valves **(5)**, **(7)**, **(6)**, and **(8)**	
	Connect sampling manifold to probe outlet manifold **(CV-3)**	
	Connect outlet of sampling manifold to syngas vent line	
	Connect and check operation of all thermocouples	
Particulate Collection	Open valve **(10)**	
	Open valve **(8)**. Record start time for particulate collection. Time __________	
	Using control valve **(CV-3)**, set syngas rate at the target flow rate (1-4 scfm) through the probe and sampling manifold.	
	Open valve **(7)**	
	Open valve **(9)**	
	Monitor temperature at orifice and ΔP across orifice	
	If needed for temperature control, usi control valve **(CV-2)**, to adjust dilution nitrogen flow to the probe sheath at the target flow rate (0-2 scfm)	
	Maintain flows at the target rates for an elapsed time of ______ minutes or until the pressure drop across the thimble and filter has reached 25 psi (pressure at **PI-3** is _______psi)	
	After the target elapsed time or pressure drop has been reached, close valve **(9)** to stop flow of dilution nitrogen	
	Close valve **(10)** to stop syngas flow. Record stop time for particulate collection. Time ___________	
	Close valve **(7)**	
	Close valve **(8)**	
	Prepare for probe withdrawal (see withdrawal procedures)	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ___________

Operation	Activity	Done
Syngas Sample Collection	Open valve **(10)**	
	Open valve **(8)**	
	Using control valve **(CV-3)**, set syngas rate at the target flow rate (1-4 scfm) through the probe and sampling manifold.	
	Open valve **(7)**	
	Open valve **(9)**	
	Using control valve **(CV-2)**, adjust dilution nitrogen flow to the probe sheath at the target flow rate (0-2 scfm)	
	Connect gas sampling trains to sampling manifold, and proceed with gas sampling	
	Begin collecting integrated gas sample (for verifying nitrogen flow rate). Start time __________	
	Maintain flows at the target rates until all scheduled gas sampling has been completed or until the pressure drop across the thimble and filter has reached _25_ psi (pressure at PI-3 is ______psi)	
	After syngas sampling has been completed or maximum allowable pressure drop has been reached, close valve **(9)** to stop flow of dilution nitrogen	
	Discontinue collecting the integrated gas sample. Stop time __________	
	Close valve **(10)** to stop syngas flow	
	Close valve **(7)**	
	Close valve **(8)**	
	Prepare for probe withdrawal (see withdrawal procedures)	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID ___________

Operation	Activity	Done
Prepare for Probe Withdrawal	Nitrogen purge valve **(3)** open , with purge nitrogen flow at 1 scfm	
	Isolation vent valves **(1)** and **(11)** closed	
	Gland vent valves **(2)** and **(4)** closed	
	Sheath inlet/outlet valve **(9)** closed	
	Dilution nitrogen valve **(7)** closed	
	Probe outlet valve **(10)** closed	
	System is at process pressure of approximately _____psig	
	Restraints (turnbuckles) attached	
	Packing gland nuts are tight	
	Connect probe to probe gripper	
Withdraw Probe into Gland	Detach dilution nitrogen manifold [valves **(5)** and **(7)**] from probe assembly (quick- disconnect)	
	Maintain purge nitrogen flow at 1 scfm through nitrogen purge valve **(3)**	
	Secure and disconnect sample manifold from probe system	
	Disconnect probe outlet manifold [valves **(6)**, **(8)** and **CV-3**] from probe outlet valve **(10)**	
	Disconnect turnbuckles (restraints) from probe	
	Remove (or move back) rail clamps from rail behind trolley	
	Withdraw the probe, using the winch mechanism, just clear of the outboard isolation valve (clear of both isolation valves)	
	Probe sheath will be hot - Use caution in handling!	
	If resistance to withdrawal is high, loosen packing gland nuts slightly (no more than 1/4 turn)	
	After loosening packing gland nuts, check for excessive leakage (using CO/H_2S monitor) around packing gland	
	After the probe clears both isolation valves, close inboard isolation valve. **(LGTI personnel must open/close the isolation valves)**	

Hot Gas Sampling Probe Operation: Check List (contd.)

Run ID__________

Operation	Activity	Done
Depressure Probe and Probe System	Close the nitrogen purge valve **(3)** to stop the flow of purge nitrogen	
	Open the probe outlet valve **(10)** slightly to slowly depressure the probe system to the syngas vent line	
Purge Probe and Probe Gland with Nitrogen	After system has been completely depressured, open valves **(11)** and **(12)** to direct nitrogen purge to the probe	
	Adjust nitrogen purge rate to1 (____) scfm, using valve **(CV-1)** to control the nitrogen flow rate	
	Purge system for 5 minutes, venting the purge nitrogen through the probe outlet valve **(10)** and syngas vent line	
Purge Probe Sheath with Nitrogen	Continue nitrogen purge at 1 (_____) scfm through valve **(12)**	
	Open sheath inlet/outlet valve **(9)** and valve **(5)** to atmosphere	
	Close probe outlet valve **(10)**	
	Allow nitrogen purge to flow out to atmosphere through valves **(9)** and **(5)**	
	Monitor purge nitrogen stream at the outlet of the sheath inlet/outlet valve **(9)** and valve **(5)**	
	When CO and H_2S levels in the nitrogen purge are below 25 ppm and 5 ppm, respectively, purge may be stopped	
	Close valves **(11)** and **(9)** to stop nitrogen purge	
	Close the outboard isolation valve. **(LGTI personnel must close this valve)**	

Hot Gas Sampling Probe Operation: Check List (contd.)		
Operation	**Activity**	**Done**
Withdraw Probe from Gland	Unfasten restraints from trolley rails	
	Disconnect valves **(10)**, **(8)**, and **(6)** assembly	
	Withdraw probe completely clear of gland **USE CAUTION - PROBE MAY BE VERY HOT!**	
	Support the free end of the probe on the probe support until probe is cool enough to handle	

APPENDIX I: GLOSSARY

AAS	Atomic absorption spectrophotometry
Btu	British Thermal Unit
CI	Confidence interval
CVAAS	Cold vapor atomic absorption spectrophotometry
CVAFS	Cold vapor atomic fluorescence spectrophotometry
DL	Detection limit
dscfm	Dry standard cubic feet per minute (1 atm., 60°F)
ESP	Electrostatic precipitator
FCEM	Field Chemical Emissions Monitoring
GC/MS	Gas chromatography/mass spectroscopy
GFAAS	Graphite furnace atomic absorption spectrophotometry
HGAAS	Hydride generation atomic absorption spectrophotometry
HHV	Higher heating value
IC	Ion chromatography
ICP-AES	Inductively coupled plasma argon emissions spectrometry
IS	Invalid sample
MS/MSD	Matrix spike/matrix spike duplicate
NA	Not analyzed
NC	Not calculated
ND	Not detected
NIST	National Institute of Standards and Technology (formerly NBS)
Nm^3	Normal cubic meter (1 atm, 0°C)
NO_x	Nitrogen oxides
NS	Not able to obtain a sample
PAH	Polynuclear aromatic hydrocarbons
POM	Polycyclic organic matter
QA/QC	Quality assurance/quality control
RPD	Relative percent difference
VOC	Volatile organic compound
VOST	Volatile organic sampling train
XAD	Trade name for a resin used in gaseous sample collection