LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
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Technical Note **LIGO-E950083-B – E** 07/09/96

Science Requirements for the LIGO Beam Tube Baffles

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A	Sys. Eng.	N/A	Initial release	Initial release
B	Sys. Eng.	E960106	pp. 6 - 8; pp 12 & ff	Resolved TBD baffle locations.

1 SCOPE

1.1. Identification

This Beam Tube Baffle Science Requirements Document defines those requirements for the beam tube baffles which follow from LIGO science requirements and other specifications.

This document provides certain specifications representing a particular design where experimentation and analysis has identified an acceptable implementation for the baffle concept: these include serration details; positioning details; baffle types.

Optical and vacuum properties are requirements, derived from experimentation with different baffling material candidates. In this area, it is likely that the specifications will involve definition of process, rather than achievement of performance. Confidence that required performance can be met when specified processes are followed has been established through a series of experiments which assessed optical and vacuum properties of baffle coatings and substrates.

1.2. Purpose

The Beam Tube Baffles are needed to reduce the amount of phase-modulated scattered light reaching the photodetectors in the length sensing subsystems of the interferometers. They prevent the guided reflection of light from one end of the beam tube to the other, and they mask the beam tube walls from direct viewing by the LIGO suspended test mass mirrors. The baffles must have two key properties:

- they must have acceptably low backscatter;
- they must minimize the amount of forward diffraction which can reach the far test mass mirror.

The baffle properties specified in this document are derived from a goal to keep the noise due to scattered light at a level at or below 0.1 the (amplitude) Standard Quantum Limit for a 1000 kg test mass. This goal is discussed in greater detail in LIGO-T950102-00-E.

2 APPLICABLE DOCUMENTS

Information and requirements appearing in this document are derived from previously released LIGO technical and scientific documents. The relevant documents are listed in Table 2-1. The requirements represented here form the basis of various other LIGO documents

Table 2-1:Documents relevant to LIGO Beam Tube Requirements

DOCUMENT TITLE	ID NUMBER
LIGO Science Requirements Document	LIGO-E950018-00-E
Scattered Light Noise for LIGO	LIGO-T950102-00-E
Specifications for the Baffle Serrations in the LIGO Beam Tubes	LIGO-T960012-00-R

3 REQUIREMENTS

3.1. Mechanical

The baffles shall consist of nominally 0.036”(1 mm) thick 304L SS sheet metal conformed to a truncated conical surface. The larger base of this cone is welded to a cylindrical band of similar material which will have the same diameter as the beam tube internal diameter; the smaller base of the cone shall protrude into the beam tube and define the clear aperture. This smaller base shall be serrated along the circumference. The serrations are designed to minimize diffraction. The serrations are characterized by an average periodicity and average peak-to-valley height and a pseudorandom fluctuation about these average values. The LA site will use a single type of baffle; the WA site will require two baffle types because of the presence of 2 km and 4 km interferometers within the same vacuum envelope. If a 2km scale interferometer were to be installed at LA at some later date, the same two baffle design approach would have to be retrofitted in the LA beam tubes as is described for the WA site.

3.1.1. Full Serration Baffles

Full serration baffle (FS) types are required in LA and throughout most of the WA Beam Tube subsystem.

3.1.1.1 Height and Inclination

The FS baffles shall be inclined to the beam tube wall at an angle of $35° \pm 3°$ and are *directed away from the nearest reflecting face of a mirror.* As shown schematically in Fig. 3-1, the baffles shall have serrations along the edge projecting into the beam tube. The projection of a baffle at the highest point of the serrations, in the radial plane perpendicular to the axis of the beam tube, shall be nominally 9 ± 0.5 cm.

3.1.1.2 Serrations

The serrations along the edge of the baffle which projects into the radial plane perpendicular to the beam tube axis shall have a sawtooth form with the following characteristics:

a individual teeth shall have fixed base angles of $\theta_B = 70^\circ$ +/- 3°;

b the sides of the teeth shall be straight to +/- 2°;

c the peaks and valleys shall have radii of curvature no greater than 0.4 mm [1/64”];

d the average peak-to-valley (P-V) shall be 8 mm +/- 0.5 mm;

e the heights of the peaks and the depths of the valleys shall be characterized by variations that are uncorrelated and are each normally distributed about their means with standard deviations $\sigma_{P \text{ or } V}$ = 1.0 mm +/- 0.1 mm. The pseudorandom realization of this pattern shall not have excursions exceeding 2.8σ, and the pattern shall not repeat on a scale < 50cm;

f the coherence length of the pseudorandom pattern within one cycle shall be < 2 cm;

g the pitch of the teeth is variable and is determined by constraints introduced in items a., b., and c. above. The typical pitch is 6 mm;

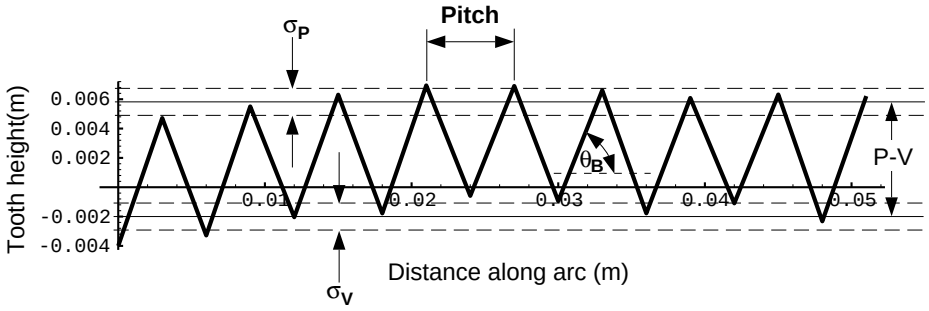
h the overlap region of the baffle where they are joined together shall be designed so that only one of the two baffle surfaces has serrations projecting into the aperture: an overlap of < 5 teeth is allowable.

i if the baffle is fabricated from segments which are joined, the random pattern of serrations at the joint must match up so that no discontinuous steps (< 0.010” or 0.25 mm) are present in the serration pattern.

j successive baffles placed into the beam tube should be arranged so that the serration patterns from baffle-to-baffle are staggered randomly with at least a 5° scatter (this corresponds to rotational variations of 2” or 5cm at the tube wall).

The above descriptions are referred to the projection of the baffle when it is viewed in the plane normal to the beam tube longitudinal axis. Figure 3-1 shows a schematic of the serrations projected onto this plane.

Figure 3-1: A representative section of serrated baffle. View is a projection of an installed baffle in the plane normal to the beam tube axis.



The baffle is expected to be constructed of sheet metal stock. The baffle configuration in the plane of the baffle material (when the conical surface is flattened) is shown in Appendix A, Figure A-1.

3.1.2. Smooth Baffles

Smooth baffle types have no serrations (NS) and are required in the WA Beam Tube subsystem near the midstations in the modules connecting midstations to the corner station. They are interspersed with the FS type baffles in this region.

Type NS baffles have a lower profile and [i] serve to shield the beam tube wall from direct viewing by the mid-station testmass while [ii] are too low to be directly viewed by testmasses at the vertex and end stations. Referring to Figure A-1, the outer radius of type NS baffles is identical to type FS; the inner radius shall be R_{mb}= 38.457” [976.81 mm]

3.1.2.1 Height and Inclination

The NS baffles are inclined to the beam tube wall at an angle of $35^\circ \pm 3^\circ$ and are *directed away from the nearest mirror.* The projection of a baffle, in the radial plane perpendicular to the axis of the beam tube, shall be 5.9 ±0.3 cm.

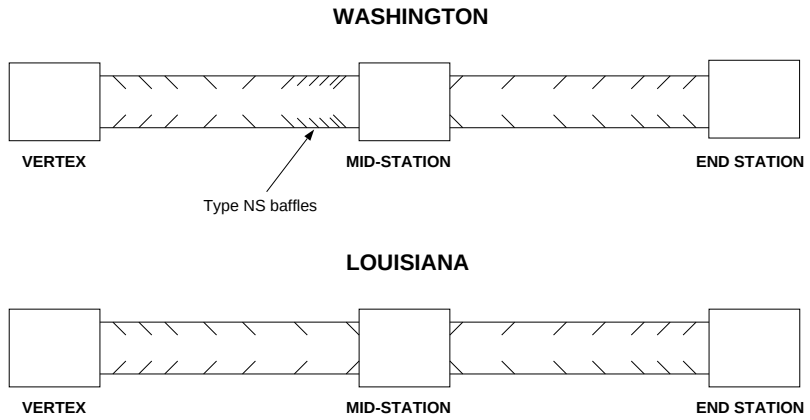
3.1.2.2 Edges

The edge of the NS baffle which projects into the beam tube shall be finished to prevent the build-up of material when the baffles are coated for optical performance. This is to minimize the possibility of glints from the smooth edge. If the baffle is fabricated from segments which are joined, the joint must match up so that no discontinuous steps (<0.010” or 0.25 mm) are present at the small diameter of the cone.

3.1.3. Arrangement within Beam Tubes

Figure 3-2 depicts the general arrangement of baffles along the arms of the interferometer. The arrangement in Louisiana shall be symmetric about the mid-station. Along each 2km module, before and after the mid-station, the baffles shall be arranged with the conical apex pointing *away* from the reflecting face of the nearest test mass mirror. In Washington, the presence of a test mass at the mid-station dictates an asymmetric arrangement: in the module between the corner station and the mid-station, the baffle inclinations, but not the spacings, shall be arranged symmetrically about the midpoint of the 2 km module; between the mid-station and the end station, the arrangement is identical to that for the corresponding module in Louisiana.

Figure 3-2: Arrangement of baffles along the beam tubes (all are FS-type baffles except where noted)



3.1.3.1 Hanford, WA

Baffle spacings are selected so that in the plane of the face of a suspended test mass, it shall not be possible to view the beam tube wall directly from anywhere within a circle, centered on the beam tube axis, of diameter 0.94 m. This requirement can be met by using 458 type FS baffles and 134 type NS baffles.

Baffle placements for Hanford are listed in Appendix B, Table B-1

3.1.3.2 Livingston, LA

Baffle spacings are selected so that in the plane of the face of a suspended test mass, it shall not be possible to view the beam tube wall directly from anywhere within a circle, centered on the beam tube axis, of diameter 0.94 m. This requirement can be met by using 426 type FS baffles and 0 type NS baffles.

Baffle placements for Hanford are listed in Appendix B, Table B-2

3.2. Optical Properties

The baffles shall have the optical properties listed in Table 3-2.

Table 2-2: Optical properties of the Beam Tube Baffles

Wavelength band (μm)	Specular reflectance	Diffuse Backscatter Probability	Glints Backscatter Probability
	All quantities referred to 55° angle of incidence		
$0.5 < \lambda < 1.1$	R < 0.10 Averaged. over S & P polarizations	P[Backscatter] < 2×10^{-3} sr^{-1}	P[Backscatter] < 1×10^{-3} sr^{-1}

The above optical properties shall apply to 100% of the baffle side facing the nearest mirror (i.e., the surface inclined away from the nearest mirror) and must apply to at least that portion of the baffle surface extending from the inner radius to at least 75% of the way toward the outer radius on the side facing the distant mirror (i.e., inclined towards the farther mirror).

3.3. Vacuum Properties

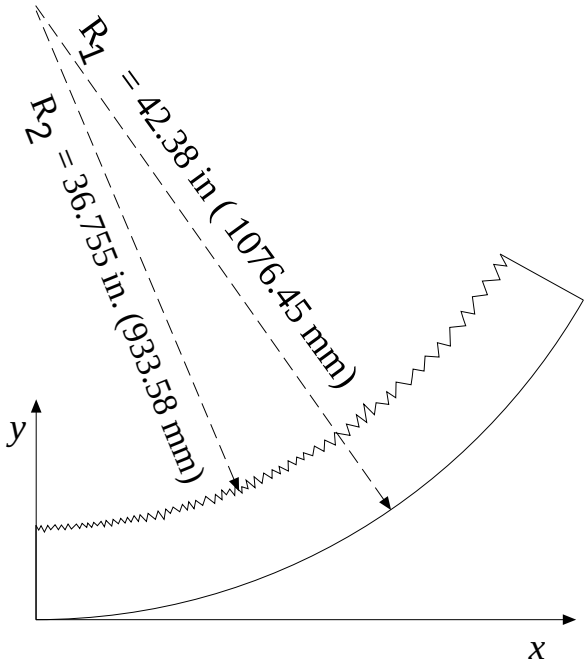
The completed baffle assemblies shall not produce appreciable gas load within the LIGO Beam Tube vacuum envelope. Table 3-3 presents these requirements..

Table 2-3: Vacuum properties of the Beam Tube Baffles

Species	Requirement
H_2	J < 2×10^{-12} torr-liter/cm^2/s
Hydrocarbons $[H_{2n}C_n]$	< 0.1 monolayer on surface of baffle (via XPS assay) J < 2×10^{-16} torr-liter/cm^2/s

APPENDIX A

Figure A-1: Schematic of a baffle section shown in the plane of the baffle material (note that the serrations are not to scale)



The radius dimensions indicated in the figure correspond to R_1: the radius of the back of the baffle, which is welded a the cylindrical band 0.040" thick (refer to Figure 2, LIGO-T960012-00-R), and R_2: the average radius of the serration pattern, respectively. These values assume the baffle material to be sheet stock of 0.040" (approximate) thickness. Table A-1 lists the [x,y] coordinates of the peaks and valleys of a pseudorandom pattern having the properties described earlier. These coordinates are referred to the coordinate system shown in the figure above.

Table A-1: [x,y] coordinates (in inches, to.001" precision) of the serrated edge in the plane of the baffle (when the conical surface is flattened) are given for a single quadrant.

X	Y	X	Y	X	Y	X	Y
0.000	5.947	9.184	7.165	17.854	10.500	25.443	16.000
0.135	5.323	9.532	6.478	18.218	10.080	25.741	15.800
0.267	5.952	9.500	7.121	17.996	10.790	25.418	16.320
0.382	5.437	9.686	6.761	18.444	10.290	25.898	16.000
0.477	5.907	9.669	7.069	18.293	10.760	25.639	16.410
0.592	5.409	9.920	6.588	18.632	10.390	26.081	16.120
0.675	5.832	9.878	7.277	18.472	10.870	25.721	16.680
0.777	5.399	10.110	6.840	18.743	10.580	26.237	16.340
0.870	5.885	10.074	7.372	18.600	11.010	26.008	16.700
0.988	5.397	10.313	6.927	18.966	10.610	26.381	16.460
1.075	5.861	10.277	7.420	18.770	11.190	26.137	16.830

X	Y	X	Y	X	Y	X	Y
1.211	5.312	10.576	6.873	19.327	10.600	26.579	16.550
1.312	5.873	10.523	7.533	19.087	11.280	26.271	17.010
1.423	5.436	10.869	6.910	19.526	10.830	26.648	16.780
1.509	5.930	10.829	7.376	19.319	11.410	26.403	17.140
1.644	5.412	10.990	7.090	19.687	11.030	26.856	16.860
1.741	5.994	10.938	7.650	19.519	11.490	26.593	17.250
1.928	5.297	11.252	7.100	19.874	11.130	26.869	17.080
2.025	5.907	11.197	7.661	19.666	11.680	26.701	17.320
2.156	5.433	11.482	7.169	20.107	11.240	27.007	17.140
2.231	5.922	11.419	7.768	19.855	11.900	26.664	17.630
2.368	5.436	11.721	7.255	20.369	11.400	27.224	17.300
2.454	6.021	11.660	7.794	20.169	11.910	26.905	17.750
2.613	5.470	11.966	7.282	20.471	11.620	27.430	17.440
2.687	5.999	11.887	7.948	20.275	12.110	27.020	18.020
2.862	5.407	12.211	7.414	20.855	11.550	27.511	17.730
2.958	6.128	12.152	7.890	20.592	12.210	27.219	18.130
3.139	5.534	12.422	7.451	20.994	11.820	27.739	17.840
3.220	6.184	12.336	8.100	20.760	12.390	27.399	18.300
3.434	5.498	12.669	7.568	21.179	12.000	27.923	18.010
3.508	6.128	12.588	8.144	20.913	12.630	27.543	18.520
3.735	5.421	12.901	7.651	21.439	12.150	28.048	18.240
3.811	6.121	12.794	8.378	21.144	12.830	27.736	18.650
3.979	5.611	13.186	7.772	21.628	12.390	28.200	18.400
4.034	6.139	13.090	8.390	21.463	12.770	27.859	18.840
4.195	5.660	13.530	7.721	21.838	12.430	28.394	18.560
4.240	6.128	13.425	8.370	21.592	12.980	28.086	18.960
4.379	5.722	13.709	7.945	21.994	12.630	28.466	18.760
4.411	6.078	13.599	8.588	21.756	13.150	28.164	19.140
4.585	5.579	13.984	8.022	22.175	12.780	28.549	18.940
4.640	6.216	13.881	8.599	21.972	13.220	28.336	19.210
4.807	5.746	14.139	8.225	22.419	12.840	28.683	19.030
4.851	6.298	14.056	8.675	22.195	13.320	28.384	19.400
5.061	5.715	14.333	8.277	22.558	13.010	28.937	19.120
5.100	6.233	14.232	8.808	22.321	13.500	28.576	19.570
5.296	5.701	14.584	8.309	22.627	13.250	29.063	19.330
5.331	6.218	14.452	8.978	22.405	13.710	28.630	19.850
5.464	5.864	14.832	8.448	22.894	13.300	29.124	19.610
5.497	6.392	14.707	9.060	22.644	13.810	28.843	19.940
5.755	5.717	15.027	8.619	22.989	13.530	29.335	19.710
5.787	6.304	14.914	9.150	22.786	13.930	29.001	20.100
5.994	5.774	15.315	8.607	23.270	13.540	29.452	19.890
6.028	6.483	15.209	9.094	23.043	13.990	29.048	20.360
6.254	5.917	15.478	8.733	23.410	13.690	29.486	20.160
6.275	6.426	15.363	9.248	23.136	14.230	29.202	20.490
6.510	5.850	15.637	8.885	23.711	13.770	29.658	20.280

X	Y	X	Y	X	Y	X	Y
6.530	6.444	15.550	9.263	23.429	14.310	29.340	20.640
6.686	6.068	15.715	9.046	23.774	14.040	29.839	20.410
6.700	6.582	15.629	9.414	23.519	14.520	29.404	20.900
6.958	5.971	15.930	9.022	23.948	14.190	29.996	20.640
6.972	6.651	15.787	9.618	23.694	14.670	29.647	21.030
7.156	6.222	16.182	9.111	24.240	14.250	30.083	20.840
7.162	6.650	16.047	9.657	23.875	14.920	29.720	21.240
7.443	6.009	16.400	9.211	24.284	14.610	30.242	21.010
7.448	6.623	16.261	9.760	24.102	14.940	29.906	21.380
7.693	6.073	16.584	9.357	24.458	14.670	30.270	21.220
7.694	6.796	16.466	9.809	24.189	15.150	29.988	21.530
7.958	6.214	16.737	9.474	24.689	14.790	30.476	21.320
7.953	6.866	16.646	9.815	24.373	15.340	30.153	21.670
8.203	6.326	16.937	9.460	24.825	15.010	30.530	21.510
8.196	6.872	16.791	9.997	24.538	15.510	30.178	21.880
8.448	6.336	17.155	9.558	24.990	15.180	30.679	21.680
8.440	6.763	17.014	10.070	24.781	15.540	30.269	22.100
8.615	6.398	17.328	9.692	25.124	15.300		
8.601	6.930	17.172	10.240	24.910	15.660		
8.857	6.403	17.593	9.744	25.316	15.380		
8.841	6.916	17.436	10.280	25.075	15.780		
8.991	6.612	17.805	9.853	25.488	15.490		
8.980	6.934	17.632	10.430	25.185	15.990		
9.213	6.466	18.003	10.010	25.643	15.680		

APPENDIX B

Table B-1: Baffle installation details, Hanford, WA.

Baffle number[a]	Location[b]	Type[c]	Orientation[d]	Nearby Avoidance Zone[e]
1	45.746	FS	A	V-GV
2	46.335	FS	A	
3	46.976	FS	A	
4	47.654	FS	A	
5	48.369	FS	A	
6	49.124	FS	A	
7	49.921	FS	A	
8	50.762	FS	A	
9	51.651	FS	A	
10	52.589	FS	A	
11	53.579	FS	A	
12	54.625	FS	A	
13	55.73	FS	A	
14	56.896	FS	A	
15	58.127	FS	A	
16	59.426	FS	A	
17	60.799	FS	A	E-AZ
18	62.318	FS	A	
19	63.927	FS	A	
20	65.63	FS	A	
21	67.432	FS	A	
22	69.34	FS	A	
23	71.36	FS	A	
24	73.498	FS	A	
25	75.762	FS	A	E-AZ
26	78.22	FS	A	
27	80.826	FS	A	
28	83.589	FS	A	
29	86.518	FS	A	
30	89.623	FS	A	
31	92.915	FS	A	
32	96.404	FS	A	
33	100.103	FS	A	
34	104.024	FS	A	
35	108.181	FS	A	
36	112.588	FS	A	
37	117.259	FS	A	
38	122.211	FS	A	

Table B-1: Baffle installation details, Hanford, WA.

Baffle number[a]	Location[b]	Type[c]	Orientation[d]	Nearby Avoidance Zone[e]
39	127.461	FS	A	
40	133.026	FS	A	
41	138.926	FS	A	
42	145.18	FS	A	
43	151.81	FS	A	
44	158.838	FS	A	
45	166.289	FS	A	
46	174.187	FS	A	E-AZ
47	182.656	FS	A	
48	191.639	FS	A	
49	201.168	FS	A	
50	211.277	FS	A	
51	222	FS	A	
52	233.374	FS	A	
53	245.44	FS	A	
54	258.239	FS	A	
55	271.817	FS	A	
56	286.219	FS	A	
57	301.496	FS	A	
58	317.703	FS	A	
59	334.894	FS	A	
60	353.13	FS	A	E-AZ
61	372.307	FS	A	E-AZ
62	392.754	FS	A	E-AZ
63	413.968	FS	A	
64	436.439	FS	A	
65	460.243	FS	A	
66	485.457	FS	A	
67	512.166	FS	A	
68	540.458	FS	A	
69	570.427	FS	A	E-AZ
70	602.297	FS	A	
71	636.064	FS	A	
72	671.84	FS	A	
73	709.746	FS	A	E-AZ
74	749.37	FS	A	E-AZ
75	788.994	FS	A	E-AZ
76	828.618	FS	A	E-AZ
77	868.242	FS	A	E-AZ
78	907.866	FS	A	E-AZ
79	947.489	FS	A	E-AZ
80	987.113	FS	A	E-AZ

Table B-1: Baffle installation details, Hanford, WA.

Baffle number[a]	Location[b]	Type[c]	Orientation[d]	Nearby Avoidance Zone[e]
81	1026.737	FS	A	E-AZ
82	1066.514	FS	T	V-AZ
83	1106.138	FS	T	V-AZ
84	1145.762	FS	T	V-AZ
85	1185.386	FS	T	V-AZ
86	1225.01	FS	T	V-AZ
87	1264.634	FS	T	V-AZ
88	1304.258	FS	T	V-AZ
89	1343.882	FS	T	V-AZ
90	1364.201	FS	T	E-AZ
91	1383.506	FS	T	V-AZ
92	1403.825	FS	T	E-AZ
93	1423.13	FS	T	V-AZ
94	1443.449	FS	T	E-AZ
95	1462.754	FS	T	V-AZ
96	1483.073	FS	T	E-AZ
97	1502.378	FS	T	V-AZ
98	1522.697	FS	T	E-AZ
99	1542.002	FS	T	V-AZ
100	1562.321	FS	T	E-AZ
101	1581.626	FS	T	V-AZ
102	1601.945	FS	T	E-AZ
103	1621.25	FS	T	V-AZ
104	1641.569	FS	T	E-AZ
105	1660.874	FS	T	V-AZ
106	1681.193	FS	T	E-AZ
107	1700.498	FS	T	V-AZ
108	1708.299	NS	T	
109	1720.817	FS	T	E-AZ
110	1728.268	NS	T	
111	1740.122	FS	T	V-AZ
112	1748.274	NS	T	
113	1760.441	FS	T	E-AZ
114	1768.244	NS	T	
115	1779.746	FS	T	V-AZ
116	1788.258	NS	T	
117	1800.065	FS	T	E-AZ
118	1808.23	NS	T	
119	1819.37	FS	T	V-AZ
120	1825.339	NS	T	
121	1831.129	NS	T	
122	1839.689	FS	T	E-AZ

Table B-1: Baffle installation details, Hanford, WA.

Baffle number[a]	Location[b]	Type[c]	Orientation[d]	Nearby Avoidance Zone[e]
123	1845.432	NS	T	
124	1850.989	NS	T	
125	1858.994	FS	T	V-AZ
126	1865.246	NS	T	
127	1871.253	NS	T	
128	1879.313	FS	T	E-AZ
129	1883.866	NS	T	
130	1888.269	NS	T	
131	1892.528	NS	T	
132	1898.618	FS	T	V-AZ
133	1903.591	NS	T	
134	1908.357	NS	T	
135	1912.924	NS	T	
136	1918.937	FS	T	E-AZ
137	1922.829	NS	T	
138	1926.567	NS	T	
139	1930.159	NS	T	
140	1933.61	NS	T	
141	1938.242	FS	T	V-AZ
142	1941.344	NS	T	
143	1944.325	NS	T	
144	1947.191	NS	T	
145	1949.944	NS	T	
146	1952.591	NS	T	
147	1955.135	NS	T	
148	1958.561	FS	T	E-AZ
149	1960.995	NS	T	
150	1963.33	NS	T	
151	1965.569	NS	T	
152	1967.717	NS	T	
153	1969.776	NS	T	
154	1971.751	NS	T	
155	1973.645	NS	T	
156	1975.461	NS	T	
157	1977.866	FS	T	V-AZ
158	1979.458	NS	T	
159	1980.986	NS	T	
160	1982.454	NS	T	
161	1983.864	NS	T	
162	1985.218	NS	T	
163	1986.518	NS	T	
164	1987.766	NS	T	

Table B-1: Baffle installation details, Hanford, WA.

Baffle number[a]	Location[b]	Type[c]	Orientation[d]	Nearby Avoidance Zone[e]
165	1988.965	NS	T	
166	1990.117	NS	T	
167	1991.222	NS	T	
168	1992.701	FS	T	E-AZ
169	1993.702	NS	T	
170	1994.663	NS	T	
171	1995.586	NS	T	
172	1996.473	NS	T	
173	1997.324	NS	T	
174	1998.142	NS	T	
175	1998.928	NS	T	
176	1999.682	NS	T	
177	2000.406	NS	T	
178	2001.102	NS	T	
179	2001.77	NS	T	
180	2002.412	NS	T	
181	2003.028	NS	T	
182	2003.62	NS	T	
183	2004.189	NS	T	
184	2004.734	NS	T	
185	2005.259	NS	T	
186	2005.762	NS	T	
187	2006.246	NS	T	
188	2006.638	NS	T	V-PP
189	2007.131	NS	T	
190	2007.754	FS	T	V-GV
191	2028.131	FS	T	
192	2056.787	FS	T	E-AZ
193	2096.411	FS	T	E-AZ
194	2136.035	FS	T	E-AZ
195	2175.659	FS	T	E-AZ
196	2215.282	FS	T	E-AZ
197	2254.907	FS	T	E-AZ
198	2294.53	FS	T	E-AZ
199	2334.154	FS	T	E-AZ
200	2373.778	FS	T	E-AZ
201	2413.403	FS	T	E-AZ
202	2453.027	FS	T	E-AZ
203	2492.65	FS	T	E-AZ
204	2532.275	FS	T	E-AZ
205	2571.899	FS	T	E-AZ
206	2611.523	FS	T	E-AZ

Table B-1: Baffle installation details, Hanford, WA.

Baffle number[a]	Location[b]	Type[c]	Orientation[d]	Nearby Avoidance Zone[e]
207	2651.146	FS	T	E-AZ
208	2690.771	FS	T	E-AZ
209	2730.395	FS	T	E-AZ
210	2770.019	FS	T	E-AZ
211	2809.642	FS	T	E-AZ
212	2849.266	FS	T	E-AZ
213	2888.891	FS	T	E-AZ
214	2928.514	FS	T	E-AZ
215	2968.138	FS	T	E-AZ
216	3007.763	FS	T	E-AZ
217	3047.387	FS	T	E-AZ
218	3087.011	FS	T	E-AZ
219	3126.635	FS	T	E-AZ
220	3166.259	FS	T	E-AZ
221	3205.883	FS	T	E-AZ
222	3245.507	FS	T	E-AZ
223	3285.13	FS	T	E-AZ
224	3324.755	FS	T	E-AZ
225	3363.184	FS	T	
226	3399.424	FS	T	
227	3433.598	FS	T	
228	3465.825	FS	T	
229	3496.215	FS	T	
230	3524.873	FS	T	
231	3551.897	FS	T	
232	3577.382	FS	T	
233	3601.414	FS	T	
234	3624.077	FS	T	
235	3645.448	FS	T	
236	3665.601	FS	T	
237	3684.606	FS	T	
238	3702.527	FS	T	
239	3719.427	FS	T	
240	3735.364	FS	T	
241	3750.393	FS	T	
242	3764.565	FS	T	
243	3777.93	FS	T	
244	3790.533	FS	T	
245	3802.417	FS	T	
246	3813.625	FS	T	
247	3824.193	FS	T	
248	3834.159	FS	T	

Table B-1: Baffle installation details, Hanford, WA.

Baffle number[a]	Location[b]	Type[c]	Orientation[d]	Nearby Avoidance Zone[e]
249	3843.558	FS	T	
250	3852.42	FS	T	
251	3860.778	FS	T	
252	3868.659	FS	T	
253	3876.091	FS	T	
254	3883.1	FS	T	
255	3889.709	FS	T	
256	3895.941	FS	T	
257	3901.819	FS	T	
258	3907.361	FS	T	
259	3912.588	FS	T	
260	3917.516	FS	T	
261	3922.164	FS	T	
262	3926.547	FS	T	
263	3930.68	FS	T	
264	3934.577	FS	T	
265	3938.253	FS	T	
266	3941.719	FS	T	
267	3944.987	FS	T	
268	3948.069	FS	T	
269	3950.976	FS	T	
270	3953.716	FS	T	
271	3956.301	FS	T	
272	3958.738	FS	T	E-AZ
273	3961.009	FS	T	
274	3963.152	FS	T	
275	3965.175	FS	T	
276	3967.083	FS	T	
277	3968.884	FS	T	
278	3970.584	FS	T	
279	3972.188	FS	T	
280	3973.701	FS	T	E-AZ
281	3975.095	FS	T	
282	3976.411	FS	T	
283	3977.656	FS	T	
284	3978.832	FS	T	
285	3979.943	FS	T	
286	3980.994	FS	T	
287	3981.987	FS	T	
288	3982.925	FS	T	
289	3983.812	FS	T	
290	3984.65	FS	T	

Table B-1: Baffle installation details, Hanford, WA.

Baffle number[a]	Location[b]	Type[c]	Orientation[d]	Nearby Avoidance Zone[e]
291	3985.442	FS	T	
292	3986.19	FS	T	
293	3986.897	FS	T	
294	3987.566	FS	T	
295	3988.198	FS	T	
296	3988.754	FS	T	V-GV

a. Identifies baffle cardinal number along an arm.
b. Distance of baffle vertex from the beam tube axes vertex, in meters. Axial positioning tolerance is +/- 0.005 m.
c. FS = Full serration type; NS= no serration type.
d. Orientation: The direction the baffle face leans:
"T" -- toward the beam tube axes vertex
"A" -- away from the beam tube axes vertex
e. Identifies baffles that butt up against an avoidance zone:
"V-GV": -- vertex of baffle butts up against a gate valve
"V-AZ": -- vertex of baffle butts up against the edge of a girth-seam avoidance zone
"E-AZ": -- end of baffle's base butts up against edge of a girth-seam avoidance zone
"V-PP": -- vertex of baffle butts up against edge of a port-pump avoidance zone

Table B-2: Baffle installation details, Livingston, LA.

(See footnotes in Table B-1 for column heading definitions)

Baffle number	Location	Type	Orientation	Nearby Avoidance Zone
1	45.746	FS	A	V-GV
2	46.335	FS	A	
3	46.998	FS	A	
4	47.699	FS	A	
5	48.44	FS	A	
6	49.225	FS	A	
7	50.054	FS	A	
8	50.932	FS	A	
9	51.86	FS	A	
10	52.841	FS	A	
11	53.88	FS	A	
12	54.978	FS	A	
13	56.139	FS	A	
14	57.368	FS	A	
15	58.667	FS	A	
16	60.041	FS	A	
17	61.495	FS	A	
18	63.033	FS	A	E-AZ
19	64.712	FS	A	
20	66.49	FS	A	

Table B-2: Baffle installation details, Livingston, LA.

(See footnotes in Table B-1 for column heading definitions)

Baffle number	Location	Type	Orientation	Nearby Avoidance Zone
21	68.375	FS	A	
22	70.372	FS	A	
23	72.489	FS	A	
24	74.731	FS	A	
25	77.107	FS	A	
26	79.624	FS	A	
27	82.291	FS	A	
28	85.117	FS	A	
29	88.112	FS	A	
30	91.284	FS	A	
31	94.646	FS	A	
32	98.208	FS	A	
33	101.983	FS	A	
34	105.982	FS	A	
35	110.219	FS	A	
36	114.709	FS	A	
37	119.466	FS	A	
38	124.506	FS	A	
39	129.847	FS	A	
40	135.506	FS	A	
41	141.502	FS	A	
42	147.855	FS	A	
43	154.587	FS	A	
44	161.72	FS	A	
45	169.277	FS	A	
46	177.285	FS	A	
47	185.77	FS	A	
48	194.76	FS	A	
49	204.285	FS	A	
50	214.378	FS	A	
51	225.073	FS	A	
52	236.404	FS	A	
53	248.41	FS	A	
54	261.132	FS	A	
55	274.611	FS	A	
56	288.894	FS	A	
57	304.027	FS	A	
58	320.061	FS	A	
59	337.051	FS	A	
60	355.052	FS	A	
61	374.126	FS	A	

Table B-2: Baffle installation details, Livingston, LA.

(See footnotes in Table B-1 for column heading definitions)

Baffle number	Location	Type	Orientation	Nearby Avoidance Zone
62	394.336	FS	A	
63	415.751	FS	A	
64	438.44	FS	A	
65	462.481	FS	A	
66	487.955	FS	A	
67	515.119	FS	A	V-PP
68	543.544	FS	A	
69	573.846	FS	A	
70	605.953	FS	A	
71	639.973	FS	A	
72	676.019	FS	A	
73	714.213	FS	A	E-AZ
74	753.837	FS	A	E-AZ
75	793.461	FS	A	E-AZ
76	833.085	FS	A	E-AZ
77	872.708	FS	A	E-AZ
78	912.332	FS	A	E-AZ
79	951.956	FS	A	E-AZ
80	991.581	FS	A	E-AZ
81	1031.205	FS	A	E-AZ
82	1070.829	FS	A	E-AZ
83	1110.453	FS	A	E-AZ
84	1150.077	FS	A	E-AZ
85	1189.701	FS	A	E-AZ
86	1229.325	FS	A	E-AZ
87	1268.949	FS	A	E-AZ
88	1308.572	FS	A	E-AZ
89	1348.196	FS	A	E-AZ
90	1387.82	FS	A	E-AZ
91	1427.445	FS	A	E-AZ
92	1467.069	FS	A	E-AZ
93	1506.693	FS	A	E-AZ
94	1546.317	FS	A	E-AZ
95	1585.941	FS	A	E-AZ
96	1625.565	FS	A	E-AZ
97	1665.188	FS	A	E-AZ
98	1704.812	FS	A	E-AZ
99	1744.436	FS	A	E-AZ
100	1784.061	FS	A	E-AZ
101	1823.685	FS	A	E-AZ
102	1863.309	FS	A	E-AZ

Table B-2: Baffle installation details, Livingston, LA.

(See footnotes in Table B-1 for column heading definitions)

Baffle number	Location	Type	Orientation	Nearby Avoidance Zone
103	1902.932	FS	A	E-AZ
104	1942.556	FS	A	E-AZ
105	1982.181	FS	A	E-AZ
106	2015.303	FS	A	
107	2018.562	FS	T	
108	2052.319	FS	T	E-AZ
109	2091.944	FS	T	E-AZ
110	2131.568	FS	T	E-AZ
111	2171.192	FS	T	E-AZ
112	2210.815	FS	T	E-AZ
113	2250.439	FS	T	E-AZ
114	2290.064	FS	T	E-AZ
115	2329.687	FS	T	E-AZ
116	2369.311	FS	T	E-AZ
117	2408.935	FS	T	E-AZ
118	2448.559	FS	T	E-AZ
119	2488.184	FS	T	E-AZ
120	2527.807	FS	T	E-AZ
121	2567.431	FS	T	E-AZ
122	2607.056	FS	T	E-AZ
123	2646.68	FS	T	E-AZ
124	2686.304	FS	T	E-AZ
125	2725.927	FS	T	E-AZ
126	2765.552	FS	T	E-AZ
127	2805.175	FS	T	E-AZ
128	2844.8	FS	T	E-AZ
129	2884.423	FS	T	E-AZ
130	2924.047	FS	T	E-AZ
131	2963.671	FS	T	E-AZ
132	3003.296	FS	T	E-AZ
133	3042.92	FS	T	E-AZ
134	3082.543	FS	T	E-AZ
135	3122.167	FS	T	E-AZ
136	3161.792	FS	T	E-AZ
137	3201.416	FS	T	E-AZ
138	3241.04	FS	T	E-AZ
139	3280.663	FS	T	E-AZ
140	3320.288	FS	T	E-AZ
141	3358.172	FS	T	
142	3393.943	FS	T	
143	3427.717	FS	T	

Table B-2: Baffle installation details, Livingston, LA.

(See footnotes in Table B-1 for column heading definitions)

Baffle number	Location	Type	Orientation	Nearby Avoidance Zone
144	3459.606	FS	T	E-AZ
145	3489.533	FS	T	
146	3517.799	FS	T	
147	3544.498	FS	T	
148	3569.716	FS	T	
149	3593.534	FS	T	
150	3616.031	FS	T	
151	3637.28	FS	T	E-AZ
152	3657.726	FS	T	E-AZ
153	3676.904	FS	T	E-AZ
154	3695.212	FS	T	
155	3712.479	FS	T	
156	3728.765	FS	T	
157	3744.125	FS	T	
158	3758.613	FS	T	
159	3772.277	FS	T	
160	3785.165	FS	T	
161	3797.32	FS	T	
162	3808.785	FS	T	
163	3819.598	FS	T	
164	3829.797	FS	T	
165	3839.416	FS	T	
166	3848.488	FS	T	
167	3857.045	FS	T	
168	3865.116	FS	T	
169	3872.728	FS	T	
170	3879.908	FS	T	
171	3886.679	FS	T	
172	3893.066	FS	T	
173	3899.09	FS	T	
174	3904.771	FS	T	
175	3910.13	FS	T	
176	3915.184	FS	T	
177	3919.951	FS	T	
178	3924.447	FS	T	
179	3928.687	FS	T	
180	3932.687	FS	T	
181	3936.459	FS	T	
182	3940.017	FS	T	
183	3943.372	FS	T	
184	3946.537	FS	T	

Table B-2: Baffle installation details, Livingston, LA.

(See footnotes in Table B-1 for column heading definitions)

Baffle number	Location	Type	Orientation	Nearby Avoidance Zone
185	3949.522	FS	T	
186	3952.338	FS	T	
187	3954.994	FS	T	
188	3957.498	FS	T	
189	3959.86	FS	T	
190	3962.088	FS	T	
191	3964.19	FS	T	
192	3966.172	FS	T	
193	3968.041	FS	T	
194	3969.804	FS	T	
195	3971.467	FS	T	E-AZ
196	3972.94	FS	T	
197	3974.333	FS	T	
198	3975.652	FS	T	
199	3976.901	FS	T	
200	3978.084	FS	T	
201	3979.203	FS	T	
202	3980.262	FS	T	
203	3981.265	FS	T	
204	3982.215	FS	T	
205	3983.114	FS	T	
206	3983.965	FS	T	
207	3984.77	FS	T	
208	3985.533	FS	T	
209	3986.255	FS	T	
210	3986.938	FS	T	
211	3987.585	FS	T	
212	3988.198	FS	T	
213	3988.754	FS	T	V-GV