



LIGO Laboratory / LIGO Scientific Collaboration

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LIGO

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Bill Of Materials for the production of the HAM optical
bench Seismic Attenuation System prototype

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1 List of drawings for HAM-OPTICAL BENCH LIGO-D050100-00-D to D050165

Seismic attenuator

Draw.	Type	Title	Name details and drawings (xxx)
H-OPT.100	Assembly	Section D-D	1-1.1(114)-2(127)-3-3.1(117)-64-64.1-64.2-75(113)-gr.1-gr.2-gr.3-gr.4-gr.5
H-OPT.101	Assembly	Section A-A	
H-OPT.102	Assembly	Section C-C	4(128)-gr.1-gr.2-gr.3-gr.4-gr.6
H-OPT.103	Assembly	Section E-E	7-8-8.1-8.2-73-74(142)-gr.1-gr.2-gr.3-gr.4-gr.5-gr.6
H-OPT.104	Assembly	Section B-B	gr.2-gr.3-gr.5
H-OPT.105	Assembly	LVDT-actuator	5-5.1-6(130)-65-68(129)-72(123)-gr.3.1-gr.3.2
H-OPT.106	Assembly	Filter	9-77(121)-10-11-12-19-20(124)-13-22-23-23.1-23.2(122)-14-15-18(125)-16-17(126)-21-24-26-27-28-72(123)-25(120)
H-OPT.107	Assembly	Inverted pendulum	29-30-66-67(135)-31-35-62-63(136)-32-33-71(138)-34-36-37-38-39-40-41(137)-94-95(154)
H-OPT.108	Assembly	Slide	42-43-45-46-47-50-51(143)-44-48-49-52-76(139)
H-OPT.109	Assembly	Motorized vertical spring	53-54-55-56-60-61(140)57-58-59-69-70(141)-76(139)
H-OPT.113	Details	Tube suspension	64-64.1-64.2-75(100)
H-OPT.114	Details	Base	1-1.1(100)
H-OPT.115	Details	Base	1.2-1.3(100)
H-OPT.116	Details	Base	1.4-1.5-1.6(100)
H-OPT.117	Details	Table	3-3.1(100)
H-OPT.118	Details	Table	3.2-3.5(100)
H-OPT.119	Details	Table	3.3-3.4(100)
H-OPT.120	Details	Blade	25(106)
H-OPT.121	Details	Platform	9-77(106)
H-OPT.122	Details	Filter	13-22-23-23.1-23.2(106)
H-OPT.123	Details	Filter	21-24-26-27-28-72(106)
H-OPT.124	Details	Filter	10-11-12-19-20(106)
H-OPT.125	Details	Filter	14-15-18(106)
H-OPT.126	Details	Filter	16-17(106)
H-OPT.127	Details	Suspension filter	2(100)
H-OPT.128	Details	Filter's plate	4(102)
H-OPT.129	Details	LVDT actuator	65-68(105)
H-OPT.130	Details	LVDT actuator	5-5.1-6(105)

Draw.	Type	Title	Name details and drawings (xxx)
H-OPT.135	Details	Inverted pendulum	29-30-66-67(107)
H-OPT.136	Details	Inverted pendulum	31-35-62-63(107)
H-OPT.137	Details	Inverted pendulum	34-36-37-38-39-40-41(107)
H-OPT.138	Details	Inverted pendulum	32-33-71(107)
H-OPT.139	Details	Slide	44-48-49-52-76(108)
H-OPT.140	Details	Motorized vertical spring	53-54-55-56-60-61(109)
H-OPT.141	Details	Motorized vertical spring	57-58-59-69-70(109)
H-OPT.142	Details	Mounting tools	7-8-8.1-8.2-73-74(103)
H-OPT.143	Details	Slide	42-43-45-46-47-50-51(108)
H-OPT.144	Assembly	Mounting blade tool	78-80-81(145)-79-82-83-84-85-86(146)-87-88-89-90-91-92(147)
H-OPT.145	Details	Mounting blade tool	78-80-81(144)
H-OPT.146	Details	Mounting blade tool	79-82-83-84-85-86(144)
H-OPT.147	Details	Mounting blade tool	87-88-89-90-91-92(144)
H-OPT.148	Details	Mounting top plate tool	93
H-OPT.149	Assembly	Horizontal calibrator	96-96.1-97-98-99(152)-100-101-102(153)
H-OPT.150	Assembly	Horizontal calibrator	
H-OPT.151	Assembly	Horizontal calibrator	
H-OPT.152	Details	Horizontal calibrator	96-96.1-97-99(149)
H-OPT.153	Details	Assembly	100-101-102(149)
H-OPT.154	Details	Inverted pendulum	94-95(107)
H-OPT.155	Details	Horizontal calibrator	98(149)
H-OPT.156	Assembly	Vertical calibrator	Gr.7 (157)
H-OPT.157	Assembly	Large filter	102(153)-103(158)-104-109-111-112-114-117-120(160)-105-110-113-116(161)-106-107-115(163)-108-118(162)-119(159)
H-OPT.158	Details	Large filter	103(157)
H-OPT.159	Details	Large filter	119(157)
H-OPT.160	Details	Large filter	104-109-111-112-114-117-120(157)
H-OPT.161	Details	Large filter	105-110-113-116(157)
H-OPT.162	Details	Large filter	108-118(157)
H-OPT.163	Details	Large filter	119(157)
H-OPT.164	Assembly	Filter's test	121-122-123(165)
H-OPT.165	Details	Filter's test	121-122-123(164)

HAM-Hor_accelerometer (reference only)

Draw.	1.1 Type	1.2 Title	1.3 Name details
H-OPT.110	Assembly	Hor. Accelerometer	1-2-9-10-11-12-13-14-15-16-- 17-18-21-22-23-25-28-29-30- 31

HAM-Actuator

Draw	Type	Title	Name details
H-OPT.111	Assembly	Actuator	1-6(134)-2-3-4-5(133)
H-OPT.133	Details	Actuator	2-3-4-5(111)
H-OPT.134	Details	Actuator	1-6(111)

HAM-LVDT

Draw.	1.4 Type	1.5 Title	1.6 Name details
H-OPT.112	Assembly	LVDT	3-4-6-8(131)-1-2-5-7-7.1-9- 10(132)
H-OPT.131	Details	LVDT	3-4-6-8(112)
H-OPT.132	Details	LVDT	1-2-5-7-7.1-9-10(112)

2 List of Production parts

HAM-OPTICAL BENCH

Part number	Detailed drawing	Description	Shown assembly number	Production pieces
1	HAM.114	Base structure ass'y	HAM.100	1
1.1	HAM.114	Base structure bottom plate	HAM.114	1
1.2	HAM.115	Base structure side	HAM.114	2
1.3	HAM.115	Base structure side	HAM.114	2

1.4	HAM.116	Base structure rib	HAM.114	2		
1.5	HAM.116	Base structure rib	HAM.114	4		
1.6	HAM.116	Base structure rib	HAM.114	4		
2	HAM.127	Filter's top plate	HAM.100	1		
3	HAM.117	Optical table ass'y	HAM.100	1		
3.1	HAM.117	Optical table bottom plate	HAM.100	1		
3.2	HAM.118	Optical table side	HAM.117	2		
3.3	HAM.119	Optical table rib	HAM.117	6		
3.4	HAM.119	Optical table rib	HAM.117	6		
3.5	HAM.118	Optical table side	HAM.117	2		
4	HAM.128	Filter's bottom plate	HAM.102	1		
5	HAM.130	Sensor/actuator plate	HAM.105	4		
5.1	HAM.130	Sensor/actuator bar	HAM.105	8		
6	HAM.130	Sensor/actuator base	HAM.105	4		
7	HAM.142	Wedge	HAM.103	8		
8	HAM.142	Stiffener fastening	HAM:003	8		
8.1	HAM.142	Fastening	HAM.103	8		
8.2	HAM.142	Fastening	HAM.103	8		
9	HAM.121	Filter main platform	HAM.106	4		
10	HAM.124	Blade central support	HAM.106	4		
11	HAM.124	Central screw	HAM.106	4		
12	HAM.124	End-stop blade	HAM.106	4		
13	HAM.122	End-stop column	HAM.106	16		
Part number	Detailed drawing	in	Description	Shown assembly number	in	Production pieces
14	HAM.125		LVDT coil	HAM.106		4
15	HAM.125		Magnet yoke front	HAM.106		4
16	HAM.126		Magnet yoke back	HAM.106		4
17	HAM.126		LVDT/actuator coils	HAM.106		4
18	HAM.125		Coil adjustment plate	HAM.106		4
19	HAM.124		Washer	HAM.106		4

20	HAM.124	Filter's structural column	HAM.106	32		
21	HAM.123	Blade clamp plate	HAM.106	32		
22	HAM.122	Connection table	HAM.106	4		
23	HAM.122	Connection, nose (point)	HAM.106	1		
23.1	HAM.122	Connection nose (flat)	HAM.106	2		
23.2	HAM.122	Connection nose (line)	HAM.106	1		
24	HAM.123	Tuning pusher	HAM.106	32		
25	HAM.120	GAS blade	HAM.106	32		
25.1	HAM.120	GAS blade $\frac{3}{4}$ width	HAM.106	8		
25.2	HAM.120	GAS blade $\frac{1}{2}$ width	HAM.106	8		
25.3	HAM.120	GAS blade $\frac{1}{4}$ width	HAM.106	8		
26	HAM.123	Blade clamp	HAM.106	32		
27	HAM.123	Guide left	HAM.106	32		
28	HAM.123	Guide right	HAM.106	32		
29	HAM.135	LIGO-I flex joint base	HAM.107	2		
30	HAM.135	Main flex joint	HAM.107	4		
31	HAM.136	LIGO-I safety tube extension	HAM.107	4		
32	HAM.138	Safety tube	HAM.107	4		
33	HAM.138	Maintenance locking screw	HAM.107	4		
34	HAM.137	Flex joint connector	HAM.107	4		
35	HAM.136	IP leg	HAM.107	4		
36	HAM.137	Small flex joint	HAM.107	4		
37	HAM.137	Top leg disk	HAM.107	4		
Part number	Detailed drawing	in	Description	Shown assembly number	in	Production pieces
38	HAM.137		1/2 cup retainer	HAM.107		4
39	HAM.137		Small flex joint base plate	HAM.107		4
40	HAM.137		1/2 cups	HAM.107		8
41	HAM.137		Disk	HAM.107		4
42	HAM.143		Support	HAM.108		4
43	HAM.143		Hor. movement screw	HAM.108		4

44	HAM.139	Sled	HAM.108	4		
45	HAM.143	Rod	HAM.108	4		
46	HAM.143	Motor flange	HAM.108	4		
47	HAM.143	Hor. movement nut	HAM.108	4		
48	HAM.139	Spring clamp	HAM.108	8		
49	HAM.139	Spring support	HAM.108	8		
50	HAM.143	Central spring clamp	HAM.108	4		
51	HAM.143	Central spring support	HAM.108	4		
52	HAM.139	Bushing	HAM.108	8		
53	HAM.140	Vert. movement screw	HAM.109	4		
54	HAM.140	Vert. movement nut	HAM.109	4		
55	HAM.140	Rod	HAM.109	4		
56	HAM.140	Counter rotation	HAM.109	4		
57	HAM.141	Spring clamp support	HAM.109	4		
58	HAM.141	Spring clamp	HAM.109	4		
59	HAM.141	Spring clamp	HAM.109	4		
60	HAM.140	Joint	HAM.109	4		
61	HAM.140	Support plate	HAM.109	4		
62	HAM.136	C. weight bell	HAM.107	2		
63	HAM.136	C. weight	HAM.107	8		
64	HAM.113	Support tube ass'y	HAM.100	2		
64.1	HAM.113	Support tube endcap	HAM.100	4		
64.2	HAM.113	Supportbushingt tube spools	HAM.100	22		
Part number	Detailed drawing	in	Description	Shown assembly number	in	Production pieces
65	HAM.129		LVDT/actuator LIGO-I spacer	HAM.105		4
66	HAM.135		Ddv-LIGO extension spool	HAM.107		2
67	HAM.135		Flex joint base	HAM.107		2
68	HAM.129		LVDT/act. transport plate	HAM.105		8
69	HAM.141		Vert. spring clamp support	HAM.109		4
70	HAM.141		Spacer	HAM.109		8

71	HAM.138	Adv-LIGO flex joint base	HAM.107	2		
72	HAM.123	Electrical connection bar	HAM.105	8		
73	HAM.142	LIGO_I transport column	HAM.103	4		
73.1	HAM.142	Adv. LIGO transport column	HAM.103	4		
74	HAM.142	Transport braket	HAM.103	4		
75	HAM.113	Support tube	HAM.100	4		
76	HAM.139	Hor.-vert. spring	HAM.108/9	12		
77	HAM.121	Mounting tool	HAM.106	4		
78	HAM.145	Support base	HAM.144	2		
79	HAM.146	Tie rod	HAM.144	8		
80	HAM.145	Curve-gauge	HAM.144	4		
81	HAM.145	Curve-gauge	HAM.144	2		
82	HAM.146	Spacer	HAM.144	8		
83	HAM.146	Clamp spacer	HAM.144	2		
84	HAM.146	Fork stop block	HAM.144	2		
85	HAM.146	Clamp blade	HAM.144	2		
86	HAM.146	Clamp blade	HAM.144	2		
87	HAM.147	Clamp blade tip	HAM.144	1		
88	HAM.147	Axis of rotation	HAM.144	2		
89	HAM.147	Rotary jar	HAM.144	1		
90	HAM.147	Rotary jar	HAM.144	1		
91	HAM.147	Tie rod	HAM.144	1		
92	HAM.147	Handle	HAM.144	1		
Part number	Detailed drawing	in	Description	Shown assembly number	in	Production pieces
93	HAM.148		Alignment part 2 and 4	HAM.148		4
93.1	HAM.148		Alignment part 2 and 4	HAM.148		4
94	HAM.154		Magnets separator 35.5	HAM.107		16
94	HAM.154		Magnets separator 51	HAM.107		32
95	HAM.154		Magnets support	HAM.107		8
96	HAM.152		Clamping cups	HAM.149		4

96.1	HAM.152	Clamping cups	HAM.149	4		
96.1	HAM.152	Clamping cups	HAM.149	4		
97	HAM.152	Support ring ass'y	HAM.149	4		
98	HAM.155	Main support tube	HAM.149	4		
99	HAM.152	Top plate	HAM.149	4		
100	HAM.153	wire	HAM.149	4		
101	HAM.153	Adjustment screw	HAM.149	4		
102	HAM.153	½ cups	HAM.149-157	16		
103	HAM.158	Filter main platform	HAM.157	4		
104	HAM.160	Tuning pusher	HAM.157	32		
105	HAM.161	Magnet yoke back	HAM.157	4		
106	HAM.163	Coil adjust. plate	HAM.157	4		
107	HAM.163	LVDT coil	HAM.157	4		
108	HAM.162	Blade central support	HAM.157	4		
109	HAM.160	End-stop plate	HAM.157	4		
110	HAM.161	Electrical conn. bar	HAM.157	4		
111	HAM.160	End-stop column	HAM.157	16		
112	HAM.160	End-stop column	HAM.157	16		
113	HAM.161	Blade clamp plate	HAM.157	4		
114	HAM.160	Blade clamp	HAM.157	32		
115	HAM.163	LVDT/act.coils	HAM.157	4		
116	HAM.161	Magnet yoke front	HAM.157	4		
117	HAM.160	Guide right	HAM.157	32		
Part number	Detailed drawing	in	Description	Shown assembly number	in	Production pieces
118	HAM.162		End-stop plate	HAM.157		4
119	HAM.159		GAS blade	HAM.157		32
120	HAM.160		Guide left	HAM.157		32
121	HAM.165		½ cup	HAM.164		8
122	HAM.165		Nut	HAM.164		8
123	HAM.165		wire	HAM.164		4

		Actuator		
1	HAM.134	Coil spool base	HAM.111	4
2	HAM.133	Coil tray	HAM.111	8
3	HAM.133	Flux guides	HAM.111	8
4	HAM.133	Central flux guide	HAM.111	4
5	HAM.133	Coil1/2 spools	HAM.111	8
6	HAM.134	Magnet base	HAM.111	4
		LVDT		
1	HAM.132	Insulator washer	HAM.112	32
2	HAM.132	Insulator bushing	HAM.112	32
3	HAM.131	Lateral plate	HAM.112	16
4	HAM.131	Lateral plate	HAM.112	8
5	HAM.132	Top plate	HAM.112	8
6	HAM.131	Bottom support	HAM.112	4
7	HAM.132	Small coil support	HAM.112	4
7.1	HAM.132	Small coil cabling connectror	HAM.112	4
8	HAM.131	Large coil	HAM.112	8
9	HAM.132	Small coil	HAM.112	4
10	HAM.132	Holder small coil	HAM.112	8

Commercial supplies

-Ring seeger J 19x1 V	HAM.108	N°16
-Oriental motor flexible coupling MC120505	HAM.108	N°4
-Stepping motor AML B17.2-R	HAM.108	N°4
-Stepping motor AML B17.2-R	HAM.109	N°4
-Bunting Magnets NEB3590	HAM.106	N°32
-Bunting Magnets NEP3054NP/N35P500500	HAM.107	N°128
-Bunting Magnets NEB3586NP/N35P500500	HAM.111	N°64
-Bunting Magnets NEB3586NP/N35P500500	HAM.157	N°64

3 Bolt and screw list

List of Stainless Steel screws and bolts needed to assemble one unit of HAM-SAS
(S) stands for silver plated for mating with Stainless Steel parts
Of each kind provide at least 10% spares (when plating, process screws in units of full boxes).

Wash, degrease and bake-out clean assembly screws according to UHV specifications.

All clean assembly screws to be stored in clean plastic boxes and/or sealable bags
Black steel screws should be used in the dirty assembly instead of the silver plater stainless steel screws.

Screw type	Thread type and length (mm)	Number needed	Detailed in Drawing number
Tommy head (socket cap)	M12x35	N° 64	Draw. 100
Tommy head (socket cap)	M10x20	N° 64	Draw. 103
Tommy head (socket cap)	M10x50	N° 16	Draw. 103
Tommy head (socket cap)	M12x30	N° 16	Draw. 103
Tommy head (socket cap)	M16x35	N° 8	Draw. 103
Tommy head (socket cap)	M10x25 (S)	N° 80	Draw. 106
Tommy head (socket cap)	M10x35 (S)	N° 128	Draw. 106
Tommy head (socket cap)	M10x40 (S)	N° 96	Draw. 106
Tommy head (socket cap)	M12x40 (S)	N° 64	Draw. 106
Tommy head (socket cap)	M8x20 (S)	N° 76	Draw. 106
Tommy head (socket cap)	M5x30 (S)	N°24	Draw. 106
Tommy head (socket cap)	M4x12 (S)	N°32	Draw. 106
Tommy head (socket cap)	M4x12	N°12	Draw. 106
Flat head	M3x8 (S)	N°12	Draw. 106
Tommy head (socket cap)	M10x30	N° 32	Draw. 107
Tommy head (socket cap)	M10x25 (S)	N° 16	Draw. 107
Tommy head (socket cap)	M10x35	N° 8	Draw. 107
Tommy head (socket cap)	M4x12	N° 8	Draw. 107
Tommy head (socket cap)	M4x12 (S)	N° 8	Draw. 107

Screw type	Thread type and length (mm)	Number needed	Detailed in Drawing number
Flat head	M10x25 (S)	N° 8	Draw. 108
Tommy head (socket cap)	M6x60 (S)	N° 8	Draw. 108
Tommy head (socket cap)	M6x50 (S)	N° 8	Draw. 108
Tommy head (socket cap)	M5x16	N° 16	Draw. 108
Tommy head (socket cap)	M4x16 (S)	N° 24	Draw. 108
Nut	M3	N° 16	Draw. 108
Grub	M5x8	N° 16	Draw. 108
Tommy head (socket cap)	M10x30	N° 8	Draw. 109
Tommy head (socket cap)	M10x70	N° 8	Draw. 109
Tommy head (socket cap)	M5x12	N° 8	Draw. 109
Tommy head (socket cap)	M5x20	N° 8	Draw. 109
Tommy head (socket cap)	M3x12	N° 8	Draw. 109
Nut	M6	N° 4	Draw. 109
Nut	M3	N° 16	Draw. 109
Grub	M4x5	N° 4	Draw. 109
Tommy head (socket cap)	M5x12 (S)	N° 24	Draw. 111
Tommy head (socket cap)	M5x12	N° 24	Draw. 111
Flat head	M2.5x6 (S)	N° 48	Draw. 111
Tommy head (socket cap)	M5x12	N° 32	Draw. 112
Tommy head (socket cap)	M3x8	N° 64	Draw. 112
Flat head	M3x5	N° 4	Draw. 112
Flat head	M4x16 (S)	N° 16	Draw. 112
Flat head	M2.5x5	N° 8	Draw. 112
Tommy head (socket cap)	M10x100	N° 2	Draw. 144
Tommy head (socket cap)	M6x35	N° 2	Draw. 144
Tommy head (socket cap)	M6x20	N° 4	Draw. 144
Tommy head (socket cap)	M12x35	N° 8	Draw. 149
Hexagonal head	M12x40	N° 32	Draw. 149
Nut	M18	N° 8	Draw. 149
Grub	M10x15	N° 4	Draw. 149

Screw type	Thread type and length (mm)	Number needed	Detailed in Drawing number
Hexagonal head	M12x40	N° 32	Draw. 156
Tommy head (socket cap)	M10x25	N° 64	Draw. 157
Tommy head (socket cap)	M12x55	N° 96	Draw. 157
Tommy head (socket cap)	M12x45	N° 128	Draw. 157
Tommy head (socket cap)	M12x30	N° 16	Draw. 157
Tommy head (socket cap)	M8x25	N° 64	Draw. 157
Tommy head (socket cap)	M6x55	N° 16	Draw. 157
Tommy head (socket cap)	M5x45	N° 32	Draw. 157
Tommy head (socket cap)	M5x16	N° 32	Draw. 157
Tommy head (socket cap)	M4x12	N° 16	Draw. 157
Tommy head (socket cap)	M3x10	N° 32	Draw. 157