New Folder Name Vacuum Equipment

L. Jones
Dec. 1, 1992

VACUUM EQUIPMENT: CONFIGURATION PRINCIPLES

A. Chamber specifics:

1. Air Lock Chamber (ALC)[1], LIGO Dwg. 1101013:

   a. general size:

   - horizontal axis main body, 72" ID[2], length TBD by contractor[3]; axis 43" above local floor
   - vertical axis dome, 104" ID[4], tall enough to allow lifting of 50 cm (20") dia. test mass from 37 cm (14.5") below beam tube axis to clear air lock gate (57" minimum lift); height also determined by stack height (69" above top of support beams) and lift drive specific requirements; dome support surface is 94" above local floor
   - left and right hand versions to be made, for symmetry about arm angle bisector (affects 48" ID tube and 8" OD tube port details)

   b. features:

   - 60" dia. clearance airlock between main body and dome; axis coincident with dome axis; bottom of airlock 24" above main body horizontal axis
   - support beam frame (see LIGO Dwg. 1101018) of 6" x 12" solid stainless steel beams, 60" x 60" minimum through clearance centered on dome axis, above airlock and below dome:
     - penetrates vacuum wall with bellows seals (see LIGO Dwg. 1101011): bellows maximum spring rates 250 lb/in axial and 1700 lb/in lateral, each of 4 penetrations; bellows mounted with ConFlat-type seals
     - convenient, external adjustments for frame position: linear: axial, +/- xx"; lateral, +/- yy"; vertical, +/-zz"; rotational: roll, +/- LL°, pitch, +/- MM°, yaw, +/- NN°
     - resonant frequency range, 45 – 23 Hz with total stack and optics mass ranging from 6,000 to 24,000 lb
     - externally mounted on solid supports duplicating mounting dimensions of Newport heavy duty isolators #XHB-20, for future ease of isolator installation (supports mounted on removable pedestals, by separate contract)
     - internal elements drilled and tapped in a utility pattern to provide flexibility for future mounting of stack and lift support frame
     - isolation stack and lift system are by separate contract

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1 formerly called Test Mass Chamber, Type 1, or TMC-1

2 to provide maximum flexibility for positioning test masses and local steering beams

3 minimize to facilitate shipping and handling

4 to provide sufficient annular space around the 60" dia. internal clearance hole for isolation stack elements and lift provisions

- two 48" ID ports, coaxial, with axis horizontal and perpendicular (in plan view) to 72" dia. axis:
  - axis is 12" closer to vertex[5] than vertical axis of dome, and 7" below 72" dia. axis[6]
  - outboard port is for emergency access, with minimum length neck for best access; inboard port is for laser throughput
- utility ports located in housing between airlock and dome (for electrical feedthroughs, roughing and ion pump connections, back-to-air purge, etc.):
  - (6) 14" OD tube ports with blind flanges and ConFlat-type seals
  - (12) 10" OD tube ports with blind flanges and ConFlat-type seals
- optics ports located in main body and 48" access cover (for beam pickoffs, visual inspection, steering beams, etc.)[7] in accordance with instructions from D. Shoemaker and M. Zucker:
  - (12) 8" OD tube ports with blind flanges and ConFlat-type seals
- seals on large ports are as follows:
  - 104" ID dome flange and 48" ID port flanges: dual o-ring, with capability of replacing inboard o-ring with metal seal (plan is to use o-rings for frequent openings, metal seal and o-ring for long term closures); includes annular channel between o-rings, manifolded to a single 1 1/2" OD tube pumpout port with ConFlat-type seal; minimum conductance between this flange and any point of the pumped annuluses is to be greater than 0.3 l/s for air, in molecular flow[8]
  - 72" ID main body flanges: metal seals
- miscellaneous:
  - marking requirements: each chamber separable part (except fasteners and seals) shall be marked to designate original build assembly and to aid traceability from performance history logs
  - centering pins and lifting lugs shall be included on dome and access cover to aid mating of flanges
  - dome design shall provide for guides to limit off-axis movement while raising or lowering

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[5] this offset affects the centering of lifted components within the 60" dia. air lock; see reflected beam layout for an example

[6] this offset affects the width of tube plane available as the beam is positioned vertically for various test mass positions: assuming that the range of test mass positions will vary from 0" to 14.5" below beam tube axis, the 7" low offset nearly balances this range to maximize available width inside the 48" ID tube for reflected beam spread

[7] note: windows for all chambers are purchased later, under separate contract

[8] this permits adequate pumping of o-ring permeation gases

2. Vertical Axis Chamber (VAC)[9], LIGO Dwg. 1101009:

   a. general size:

      - vertical axis main body, 104" ID, with bottom skirt for floor mounting and a separation flange 100" above local floor for top access
      - two sets of 60" ID ports on horizontal, orthogonal axes, with intersection offset 7.5" from main body vertical axis in both x and y directions[10]; neck length is minimized to maximize access
      - current plan **is to use one chamber design**, with no changes, for all positions of beamsplitter systems and test mass (type 2) systems; this means that:
         - the 60" crossed ports are offset in the plan view for all purposes, whether applicable of not, and that test mass chamber placement in the floor plan cannot be symmetrical
         - height of chamber mounting surface to 60" ID port centerline is 14" lower than prior TMC-2 chamber; this height difference must be made up with a rigid riser stand
         - optics port placement must cover all needs; some will be beyond stated needs for each function

   b. features:

      - support beam frame identical to that on the ALC above; height of support is selected to be identical with ALC, from a common reference[11]
         - isolation stack is by separate contract
      - utility ports located near support beam frame plane (for electrical feedthroughs, roughing and ion pump connections, back-to-air purge, etc.):

        CF. ALC

        • 6 (8) 14" OD tube ports with blind flanges and ConFlat-type seals
        • 12 (6) 10" OD tube ports with blind flanges and ConFlat-type seals
      - optics ports located between 60" ID ports in plan view: on, above, and below the plane of their axes[12] (for beam pickoffs, visual inspection, steering beams, etc.) in general accordance[13] with instructions from D. Shoemaker and M. Zucker:
         - (9) 8" OD tube ports with blind flanges and ConFlat-type seals

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9 replaces former diagonal chamber and former TMC-2

10 this was felt to better balance the positioning load for the beamsplitter function without penalizing the test mass function

11 local floors are offset 18"

12 this assumes that the main laser beam in VAC (beamsplitter function) will always be at the same height as the 60" ID port center lines

13 exception: ports are not planned in the quadrant where the 60" necks intersect each other rather than the chamber shell; if desired, ports could be placed in each quadrant, and at 45°, with the penalty of ~6" greater neck length at 3 of the 4 positions

- seals on large ports are as follows:
  - 104" ID dome (separation) flange and 60" ID flanges: dual o-ring, with capability of replacing inboard o-ring with metal seal (specifics same as for ALC)
- miscellaneous:
  - marking requirements: specifics same as for ALC
  - centering pins and lifting lugs shall be included on dome and 60" ID port covers to aid mating of flanges; 60" ID throughput flanges shall include centering pins

3. Horizontal Access Module (HAM), LIGO Dwg. 1101010:
   a. general size:
      - horizontal axis body, 84" ID, length 72" between dished covers; axis 47" above local floor
      - two 60" ID ports on horizontal axis, intersecting and perpendicular to main body axis
   b. features:
      - support beam frame (see LIGO Dwg. 1101041) of 5" OD x 0.5" wall stainless steel tubing: cf ALC
        - penetrates vacuum wall with bellows seals (see LIGO Dwg. 1101012): bellows maximum spring rates 120 lb/in axial and 800 lb/in lateral, each of 4 penetrations; bellows mounted with ConFlat-type seals
        - frame position adjusted externally: linear: axial, +/- x"; lateral, +/- y"; vertical, +/-z"; rotational: roll, +/- L°, pitch, +/- M°, yaw, +/- N°
        - resonant frequency (vertical plane) 53 – 27 Hz with total stack and optics mass ranging from 1500 to 6000 lb
        - externally mounted on solid supports duplicating mounting dimensions of Newport isolators #XLB-10, for future ease of isolator installation (supports mounted on removable pedestals, by separate contract)
        - isolation stack is by separate contract
      - utility ports located near support beam frame plane (for electrical feedthroughs, ion pump connection, back-to-air purge, etc.):
        - (8) 10" OD tube ports with blind flanges and ConFlat-type seals
        - (1) 14" OD tube port with blind flange and ConFlat-type seal

        cf. ALC
      - optics ports located in dished 84" ID covers (for beam pickoffs, visual inspection, steering beams, etc.) in accordance with instructions from D. Shoemaker and M. Zucker:
        - (10) 8" OD tube ports with blind flanges and ConFlat-type seals

- seals on large ports are as follows:
  - 84" ID and 60" ID flanges: dual o-ring, with capability of replacing inboard o-ring with metal seal (specifics same as for ALC)
- miscellaneous:
  - marking requirements: specifics same as for ALC
  - centering pins and lifting lugs shall be included on dished 84" ID covers to aid mating of flanges; 60" ID throughput flanges shall include centering pins
  - lifting lugs included on main body

B. Station specifics:

1. Corner station, Site 1, LIGO Dwg. xxxxxxx:

   a. general layout[14]:

   - VAC (beamsplitter function) installed with vertical axis at (–7.5", –7.5", z), with intersection of 60" port axes at (0, 0, –4")[15]; securely mounted on a rigid[16] pedestal which is anchored to the floor; each of the four 60" ports is connected to a 60" ID x 24" long access connector (compressible spool piece)[17] and a 60" ID x 12" long spool piece[18] for connection to:
     - VAC (test mass function, right arm) installed with vertical axis at (172.5", –7.5", z), with intersection of 60" port axes at (180", 0", 0")[19]; securely mounted on a rigid pedestal which is anchored to the floor; the inline 60" port connects "down arm,"[20] in series, with a 48" gate valve and a 72" to 48" adapter with optics ports TBD, mounted on the right arm ALC mentioned below
     - VAC (test mass function, left arm) installed with vertical axis at (–7.5", 172.5", z), with intersection of 60" port axes at (0", 165", 0"); securely mounted on a rigid pedestal which is anchored to the floor; the inline 60" port connects "down arm," in series, with a 48" gate valve and a 72" to 48" adapter with optics ports TBD, mounted on the left arm ALC mentioned below

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[14] note: orthogonal coordinate system is based on (0, 0, 0) representing the vertex of the axes of the beam tubes for the two arms, and (r, l, z) represents the respective distances along the right arm, along the left arm, and above that vertex

[15] initial interferometers are planned to be 4" (10 cm) below beam tube axis; proposed policy is to position the VAC (beamsplitter) and related HAMs such that the height of their 60" port axes is at the same elevation as the test mass; this height will be adjusted if the test mass is shifted vertically

[16] dynamic requirements TBD

[17] designed for convenient removal to provide access to chamber internals

[18] this extra piece is necessary for adequate access room around pedestals and spool removal around external support beams

[19] chamber is rotated such that the support beam frame is parallel to that of the adjoining ALC unit, with 60" ID port axes offset aligned with that of the VAC (beamsplitter function)

[20] along the arm, away from the vertex

- HAM units connected to the VAC (beamsplitter function) as follows: along the –r axis: in series, three HAMs, a 30" ID mode cleaner tube (47'–4"between HAM centers), and two HAMs; along the –l axis: in series, two HAMs, a 30" ID mode cleaner tube, and two HAMs; end HAM in each string has 60" ID port capped with blind flange with three optics ports, located in accordance with instructions from D. Shoemaker and M. Zucker[21]; each HAM securely mounted on a rigid pedestal which is anchored to the floor

- second VAC (beamsplitter function) installed with vertical axis at (363", 363", z), with intersection of 60" port axes at (355.5", 355.5", –4"); securely mounted on a rigid pedestal which is anchored to the floor; each of the four 60" ports is connected to a 60" ID x 24" long access connector and a 60" ID x 12" long spool piece for connection to:
  - 48" ID tube, connected to 48" gate valve, connected to 48" ID tube, connected to 48"side port on ALC (test mass function, right arm) installed with intersection of vertical axis and 72" ID body axis at (367.5", 0", 0"), anchored to the floor; the inline 72" ID port connects "down arm" with a 72" ID beam tube manifold, mentioned below
  - 48" ID tube, connected to 48" gate valve, connected to 48" ID tube, connected to 48"side port on ALC (test mass function, left arm) installed with intersection of vertical axis and 72" ID body axis at (0", 367.5", 0"), anchored to the floor; the inline 72" ID port connects "down arm" with a 72" ID beam tube manifold, mentioned below
  - HAM units connected to the VAC (beamsplitter function) as follows: in the +r direction, in series, three HAMs, a 30" ID mode cleaner tube and two HAMs; in the +l direction, in series, two HAMs, a 30" ID mode cleaner tube and two HAMs; end HAM in each string has 60" ID port capped with blind flange with three optics ports, located in accordance with instructions from D. Shoemaker and M. Zucker; each HAM securely mounted on a rigid pedestal which is anchored to the floor

- 72" ID beam tube manifolds, one for each arm, axes coincident with beam tubes, each with provisions for adding up to four more ALC units[22], connected "down arm," in series, to:
  - 72" to 48" adapter, with optics ports TBD
  - 48" gate valve
  - long LN_2 pump
  - ports for future pumping provisions
  - 48" gate valve
  - tee to roughing pump system

[21] center port (laser beam line) is offset 7.5" from 60" ID port axis to provide extra room on one side of HAMs for longer component strings

[22] by means of flanged (metal seals), removable spool pieces

- tube termination interface: locations, ref.: (1836", 0", 0"), (0", 1836", 0")

- pumping system:
  - roughing pump set, one near each of two tube termination interfaces
  - rough pumping manifold, running along each beam tube manifold and connected at the ends to the roughing pump sets; connected via gate valve to each ALC and VAC (test mass function) via 10" gate valves; connected to each 48" tube leading to VAC (beamsplitter function) on the diagonal bisecting the angle between the arms via 10" gate valves; connections provided for future ALCs and 48" tubes; size dictated by performance requirement on pumpdown times
  - ion pumps, diode type: 3000 l/s capacity on each ALC (mounted above the air lock) and VAC (test mass function); 6000 l/s capacity on each VAC (beamsplitter function)—HAM array
  - annulus pumping systems, for each chamber: connections with valves for rough pumping and venting, ion pumps to maintain 10^{-5} torr

- back to air purge systems:
  - Class 100 HEPA filtered air supply, with appropriately cleaned ducting and valves leading to each isolatable volume[23]

- provisions for air showers: (on hold for now)

2. Corner station, Site 2 (LIGO Dwg. zzzzzzzz):

   a. general layout:

   - VAC (beamsplitter function) installed with vertical axis at (–7.5", –7.5", z), with intersection of 60" port axes at (0, 0, –4"); securely mounted on a rigid pedestal which is anchored to the floor; each of the four 60" ports is connected to a 60" ID x 24" long access connector (compressible spool piece) and a 60" ID x 12" long spool piece for connection to:
     - VAC (test mass function, right arm) installed with vertical axis at (172.5", –7.5", z), with intersection of 60" port axes at (180", 0", 0"); securely mounted on a rigid pedestal which is anchored to the floor; the inline 60" port connects "down arm[24]" with a 48" gate valve, which connects with a 72" to 48" adapter with optics ports TBD, mounted on the right arm beam tube manifold mentioned below

[23] specification could call for a "smart" system, with variable throttling to maintain maximum flow short of condensation from expansion cooling

[24] along the arm, away from the vertex

- VAC (test mass function, left arm) installed with vertical axis at (–7.5", 172.5", z), with intersection of 60" port axes at (0", 165", 0"); securely mounted on a rigid pedestal which is anchored to the floor; the inline 60" port connects "down arm" with a 48" gate valve, which connects with a 72" to 48" adapter with optics ports TBD, mounted on the left arm beam tube manifold mentioned below
- HAM units connected to the VAC (beamsplitter function) as follows: along the –r axis: three HAMs, a 30" ID mode cleaner tube (47'–4"between HAM centers), and two HAMs; along the –l axis: two HAMs, a 30" ID mode cleaner tube, and two HAMs; end HAM in each string has 60" ID port capped with blind flange with three ports; each HAM securely mounted on a rigid pedestal which is anchored to the floor

- 72" ID beam tube manifolds, one for each arm, axes coincident with beam tubes, each with provisions for adding up to two more ALC units[25], connected "down arm" to:
  - 72" to 48" adapter, with optics ports TBD
  - 48" gate valve
  - long LN_2 pump
  - ports for future pumping provisions
  - 48" gate valve
  - tee to roughing pump system
  - tube termination interface
- pumping system:
  - roughing pump set, one near each of two tube termination interfaces, per Figure nnnn
  - rough pumping manifold, running along each beam tube manifold and connected at the ends to the roughing pump sets; connected via gate valve to each VAC (test mass function) via 10" gate valves; connections provided for future ALCs and 48" tubes; connections to "down arm" ends of manifolds and to long LN_2 pumps via 10" gate valves; manifold size dictated by performance requirement on pumpdown times
  - ion pumps, diode type: 3000 l/s capacity on each VAC (test mass function); 6000 l/s capacity on VAC (beamsplitter function)—HAM array
  - annulus pumping systems, for each chamber: connections with valves for rough pumping and venting, ion pumps to maintain 10^{-5} torr
- back to air purge systems:
  - Class 100 HEPA filtered air supply, with appropriately cleaned ducting and valves leading to each isolatable volume

[25] by means of flanged (metal seals), removable spool pieces

- provisions for air showers: (on hold for now)

3. End station, Sites 1 and 2 (LIGO Dwg. yyyyyyyy):

   a. general layout:

      - series connection of the following, in sequence, for each of four end stations:
        - tube termination interface
        - tee to roughing pump system
        - 48" gate valve
        - ports for future pumping provisions
        - short LN2 pump
        - provisions for future 48" gate valve
        - 72" to 48" adapter, with optics ports TBD
        - 72" ID beam tube manifold, with provisions for adding up to two ALC units[26] at a later date
        - 72" to 48" adapter, with optics ports TBD
        - 48" gate valve
        - VAC (test mass function) installed with vertical axis at (), with intersection of 60" port axes at (); securely mounted on a rigid pedestal which is anchored to the floor
      - pumping system:
        - roughing pump set, near tube termination interface
        - rough pumping manifold, running along beam tube manifold and connected at one end to the roughing pump set; connected via 10" gate valve to VAC (test mass function); connections provided for future ALCs; connection to beam tube manifold and to short LN_2 pump via 10" gate valves; manifold size dictated by performance requirement on pumpdown times
        - ion pumps, diode type: 3000 l/s capacity on VAC (test mass function)
        - annulus pumping systems, for VAC (test mass chamber): connections with valves for rough pumping and venting, ion pumps to maintain 10^{-5} torr
      - back to air purge systems:
        - Class 100 HEPA filtered air supply, with appropriately cleaned ducting and valves leading to each isolatable volume
      - provisions for air showers: (on hold for now)

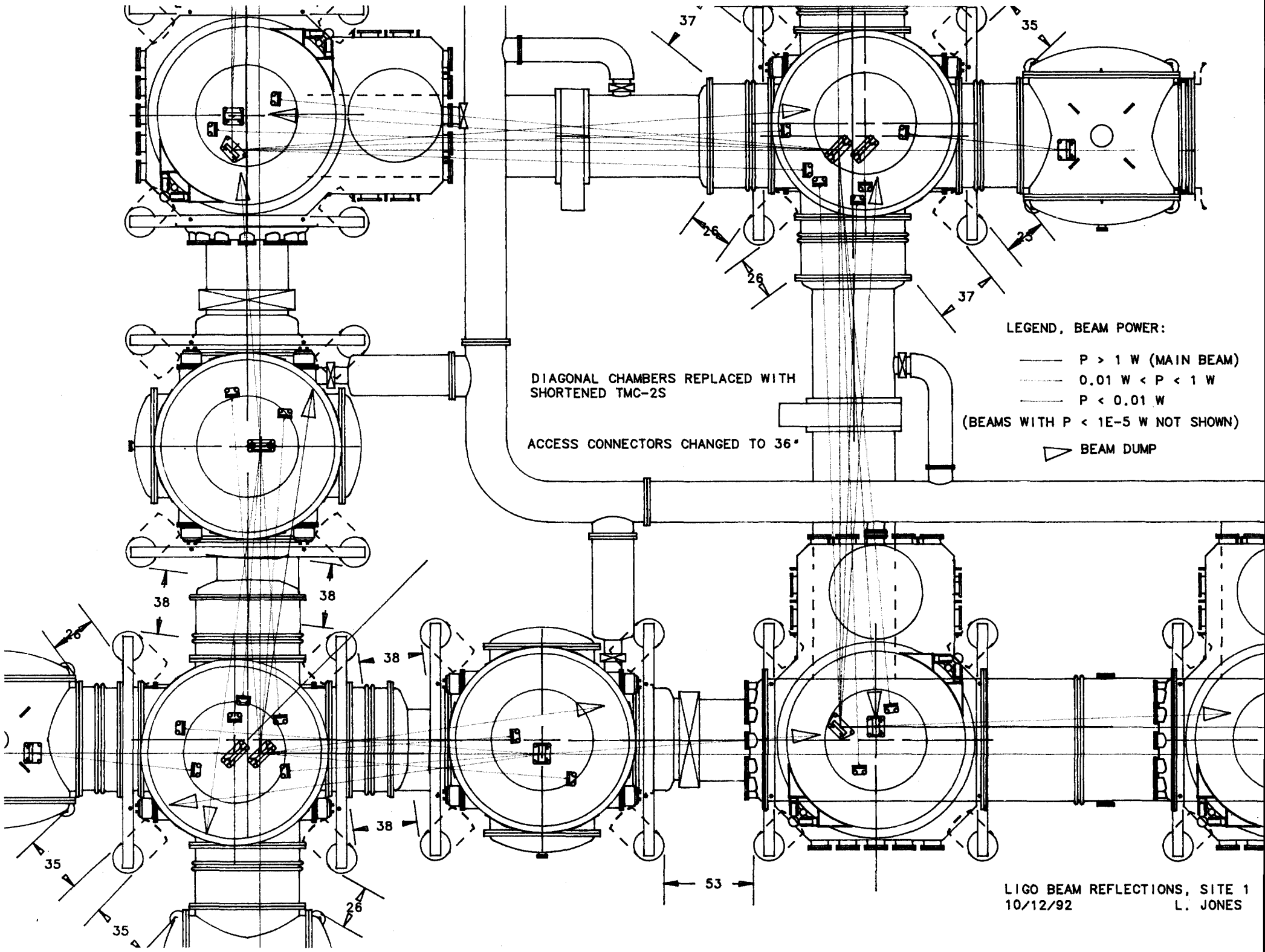
[26] by means of flanged (metal seals), removable spool pieces

4. Mid station, Site 1 (LIGO Dwg. yyyyyyyyy):

   a. general layout:

      - series connection of the following, in sequence, for each of two mid stations:
        - tube termination interface
        - tee to roughing pump system
        - 48" gate valve
        - ports for future pumping provisions
        - short LN2 pump
        - provisions for future 48" gate valve
        - 72" to 48" adapter, with optics ports TBD
        - 72" ID beam tube manifold, with ALC unit installed on its "down arm" end with intersection of vertical axis and 72" ID body axis at (), anchored to the floor; provisions for adding up to two more ALC units[27]
        - 72" to 48" adapter, with optics ports TBD
        - 48" gate valve
        - long LN_2 pump
        - ports for future pumping provisions
        - 48" gate valve
        - tee to roughing pump system
        - tube termination interface; distance from tube termination interface at other side of midstation is 98"-5"
      - pumping system:
        - roughing pump set, one near each of two tube termination interfaces
        - rough pumping manifold, running along beam tube manifold and connected at the ends to the roughing pump sets; connected via 10" gate valve to ALC; connections provided for future ALCs; connections to beam tube manifold and to short LN_2 pumps via 10" gate valves; manifold size dictated by performance requirement on pumpdown times
        - ion pumps, diode type: 3000 l/s capacity on ALC
        - annulus pumping systems, for ALC: connection with valves for rough pumping and venting, ion pumps to maintain 10^{-5} torr
      - back to air purge systems:
        - Class 100 HEPA filtered air supply, with appropriately cleaned ducting and valves leading to each isolatable volume
      - provisions for air showers: (on hold for now)

[27] by means of flanged (metal seals), removable spool pieces


37
35
26
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LEGEND, BEAM POWER:
P > 1 W (MAIN BEAM)
0.01 W < P < 1 W
P < 0.01 W
(BEAMS WITH P < 1E-5 W NOT SHOWN)
BEAM DUMP
DIAGONAL CHAMBERS REPLACED WITH SHORTENED TMC-2S
ACCESS CONNECTORS CHANGED TO 36"
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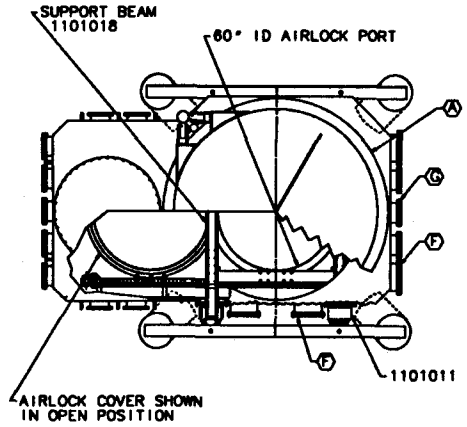
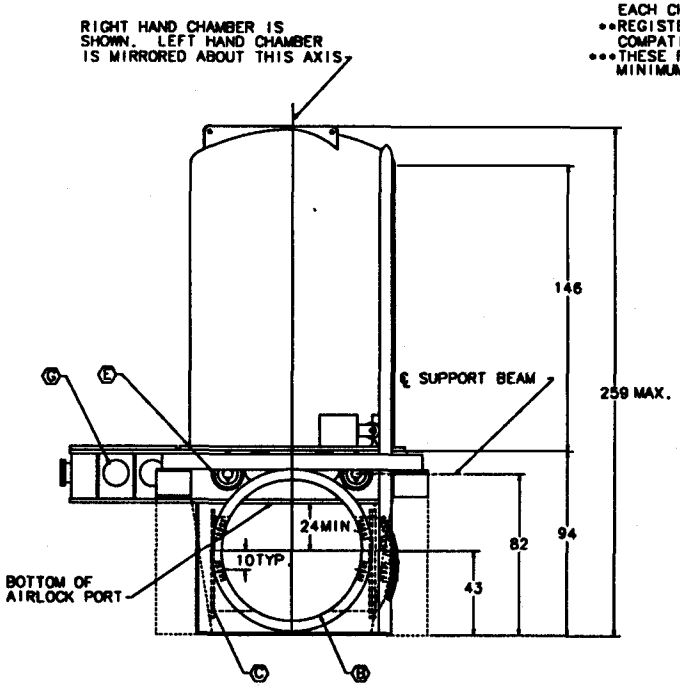
53
LIGO BEAM REFLECTIONS, SITE 1
10/12/92
L. JONES

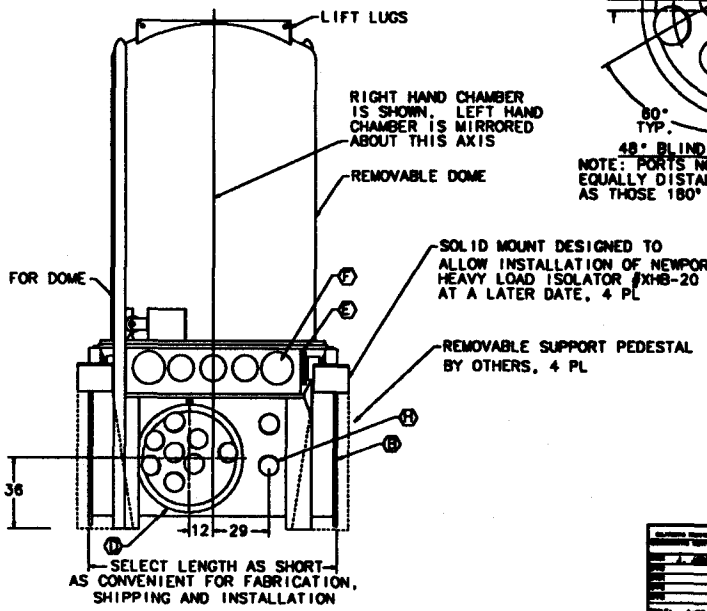


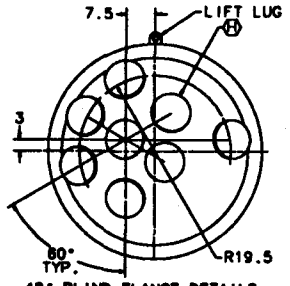
NOTES:
1. HEADS ARE ASME F&D.
2. PROVIDE EXTERNAL ACCESS TO ALL VACUUM SEALS FOR LEAK CHECKING.
3. INCLUDE CENTERING PINS ON NOZZLE FLANGES WHERE APPROPRIATE.
4. ALL LINEAR DIMENSIONS ARE IN INCHES.
5. TOLERANCES, UNLESS OTHERWISE SPECIFIED: LINEAR, ±0.1 INCHES
   ANGULAR, ± 1 DEGREE
6. MARK PARTS PER SPECIFICATION: CHAMBER ID. IS 1TXX,
   WHERE XX REPRESENTS A SERIALIZED CHAMBER NO.: 1, 2, 3,..ETC.
7. NOZZLE SCHEDULE PER TABLE BELOW:

ITEM	SIZE	QUANTITY	FLANGE TYPE	PURPOSE
(A)	104° ID TUBE	1	O/O-O/METAL•	MAJOR ACCESS
(B)	72° ID TUBE	2	METAL SEAL	LASER BEAM
(C)	48° ID TUBE	1	O/O-O/METAL•	LASER BEAM
(D)	48° ID TUBE	1	O/O-O/METAL•,WITH BLIND FLANGE	EMERGENCY ACCESS (MINIMIZE NECK LENGTH)
(E)	14° OD TUBE	4	CONFLAT••	SUPPORT BEAMS
(F)	14° OD TUBE	6	CONFLAT••, WITH BLIND FLANGE	ELECTRICAL FEEDTHROUGHS ROUGHING & ION PUMPS, UTILITY
(G)	10° OD TUBE	12	CONFLAT••, WITH BLIND FLANGE	ELECTRICAL FEEDTHROUGHS, BACK-TO-AIR PURGE
(H)	8° OD TUBE•••	12	CONFLAT••, WITH BLIND FLANGE	OBSERVATION, BEAM PICKOFFS
(I)	1 1/2° OD TUBE	1	CONFLAT••, WITH BLIND FLANGE	ANNULUS PUMPOUT

•DUAL O-RING DESIGN, WITH CAPABILITY OF REPLACING INBOARD O-RING WITH METAL SEAL. THESE FLANGES EACH INCLUDE AN ANNULAR CHANNEL BETWEEN O-RINGS, MANIFOLDED TO A SINGLE PUMPOUT PORT ON EACH CHAMBER, WITH CONFLAT•• SEAL.
••REGISTERED TRADEMARK, VARIAN VACUUM PRODUCTS COMPATIBLE ALTERNATIVES ARE ACCEPTABLE
•••THESE FLANGES ARE TANGENT TO LOCAL VACUUM WALL, WITH MINIMUM NECK LENGTH



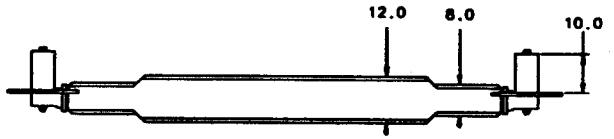


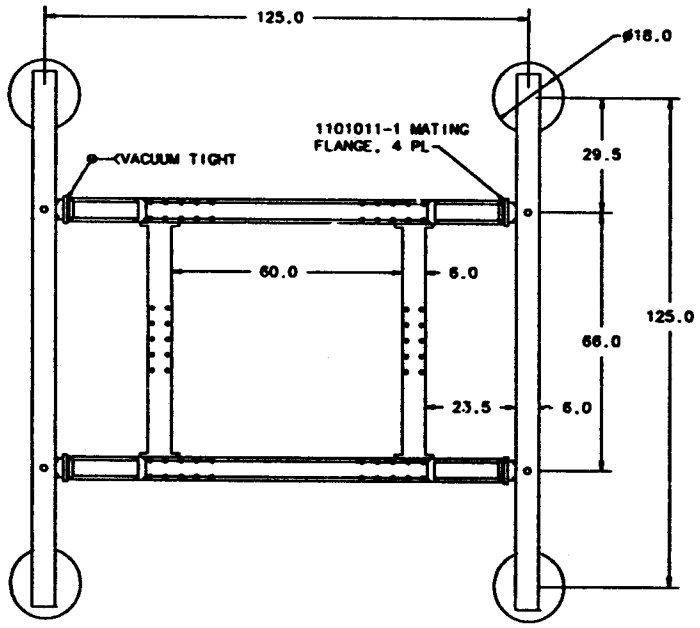


48° BLIND FLANGE DETAILS
NOTE: PORTS NOT DIMENSIONED ARE EQUALLY DISTANT FROM 7.5,3 PORT AS THOSE 180° AWAY.

LIGO PROJECT
AIR LOCK CHAMBER ASSEMBLY (ALC)
1101013
EDITION: 11-24-92

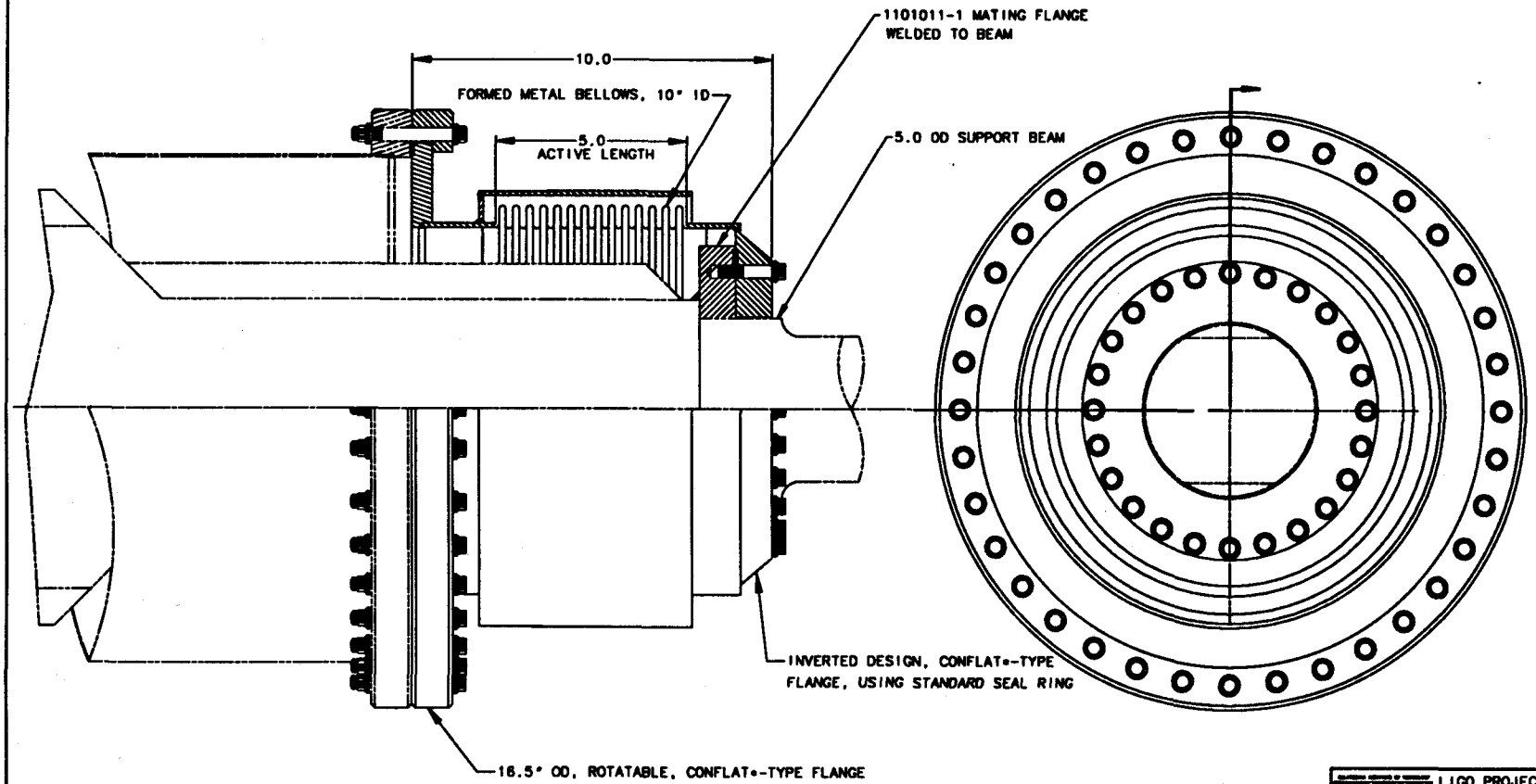
NOTES:
1. ALL LINEAR DIMENSIONS ARE IN INCHES
2. TOLERANCES, UNLESS OTHERWISE SPECIFIED: LINEAR, +/- 0.1 INCH
   ANGULAR, +/- 1 DEGREE





LIGO PROJECT
SUPPORT BEAM ASSEMBLY, LARGE CHAMBERS
T1010181
EDITION: 08-25-92

NOTES:
1. BELLOWS SPRING RATES: AXIAL <250 LB/IN, LATERAL <1700 LB/IN.
2. RATED PRESSURE DIFFERENTIAL (EXTERNAL) ≥ 40 PSI AT 300 DEGREES F
3. DESIGN LIFE OF BELLOWS, AT +/- 20 MINUTES ROTATIONAL STROKE: 1000 CYCLES
4. ALL LINEAR DIMENSIONS ARE IN INCHES
5. TOLERANCES,UNLESS OTHERWISE SPECIFIED:LINEAR, +/- 0.1 INCH
ANGULAR, +/- 1 DEGREE



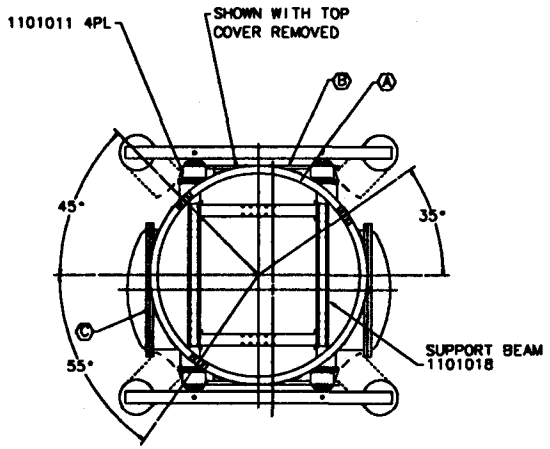
®REGISTERED TRADEMARK, VARIAN ASSOCIATES, INC.

LIGO PROJECT

10" ISOLATION BELLOWS
(CONFIGURATION)

1101011

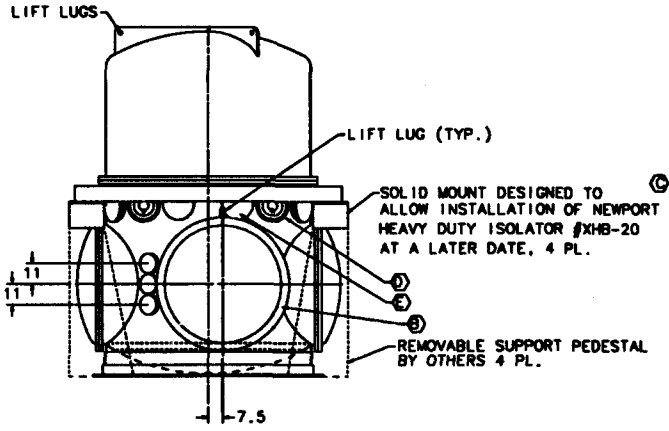
EDITION:12-1-92

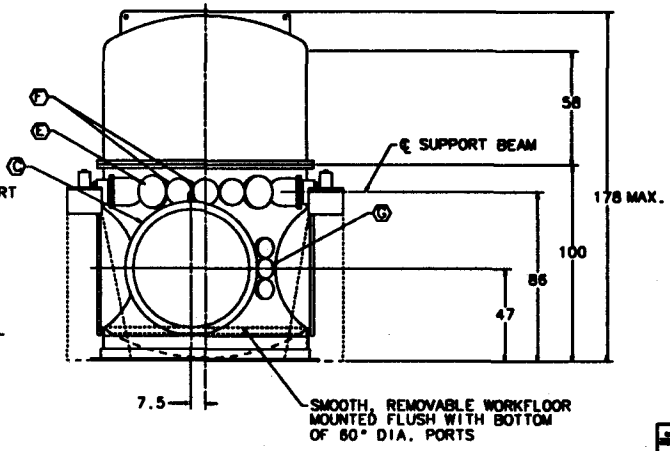


NOTES:
1. HEADS ARE ASME F&D.
2. PROVIDE EXTERNAL ACCESS TO ALL VACUUM SEALS FOR LEAK CHECKING.
3. INCLUDE CENTERING PINS ON NOZZLE FLANGES WHERE APPROPRIATE.
4. ALL LINEAR DIMENSIONS ARE IN INCHES.
5. TOLERANCES, UNLESS OTHERWISE SPECIFIED: LINEAR, ±0.1 INCHES
   ANGULAR, ± 1 DEGREE
6. MARK PARTS PER SPECIFICATION: CHAMBER ID. IS 2TXX,
   WHERE XX REPRESENTS A SERIALIZED CHAMBER NO.: 1, 2, 3,..ETC.
7. NOZZLE SCHEDULE PER TABLE BELOW:

ITEM	SIZE	QUANTITY	FLANGE TYPE	PURPOSE
Ⓐ	104° ID TUBE	1	O/O-O/METAL•	MAJOR ACCESS
Ⓑ	60° ID TUBE	2	O/O-O/METAL•	LASER BEAM, ACCESS (MINIMIZE NECK LENGTH)
Ⓒ	60° ID TUBE	2	O/O-O/METAL•, WITH BLIND FLANGE	ACCESS (MINIMIZE NECK LENGTH)
Ⓓ	14° OD TUBE	4	CONFLAT••	SUPPORT BEAMS
Ⓔ	14° OD TUBE•••	8	CONFLAT••, WITH BLIND FLANGE	AIR SHWR, BACK-TO-AIR PURGE ROUGHING & ION PUMPS, UTILITY
Ⓕ	10° OD TUBE•••	6	CONFLAT••, WITH BLIND FLANGE	ELECTRICAL FEEDTHROUGHS
Ⓖ	8° OD TUBE•••	9	CONFLAT••, WITH BLIND FLANGE	OBSERVATION, BEAM PICK-OFFS
Ⓗ	1 1/2° OD TUBE	1	CONFLAT••, WITH BLIND FLANGE	ANNULUS PUMPOUT

•DUAL O-RING DESIGN, WITH CAPABILITY OF REPLACING INBOARD O-RING WITH METAL SEAL. THESE FLANGES EACH INCLUDE AN ANNULAR CHANNEL BETWEEN O-RINGS, MANIFOLDED TO A SINGLE PUMPOUT PORT ON EACH CHAMBER, WITH CONFLAT•• SEAL.
••REGISTERED TRADEMARK, VARIAN VACUUM PRODUCTS; COMPATIBLE ALTERNATES ARE ACCEPTABLE.
•••THESE FLANGES ARE TANGENT TO LOCAL VACUUM WALL, WITH MINIMUM NECK LENGTH.





LIGO PROJECT
VERTICAL AXIS CHAMBER ASSEMBLY (VAC)
1101006
EDITION: 11-20-92

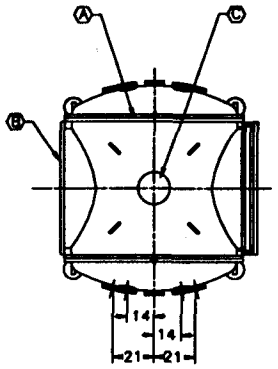
NOTES:
1. HEADS ARE ASME F&D.
2. PROVIDE EXTERNAL ACCESS TO ALL VACUUM SEALS FOR LEAK CHECKING.
3. INCLUDE CENTERING PINS ON NOZZLE FLANGES WHERE APPROPRIATE.
4. ALL LINEAR DIMENSIONS ARE IN INCHES.
5. TOLERANCES, UNLESS OTHERWISE SPECIFIED: LINEAR, ±0.1 INCHES
   ANGULAR, ± 1 DEGREE
6. MARK PARTS PER SPECIFICATION: CHAMBER ID IS HMXX,
   WHERE XX REPRESENTS A SERIALIZED CHAMBER NO.: 1,2,3,.. ETC.
7. NOZZLE SCHEDULE PER TABLE BELOW:

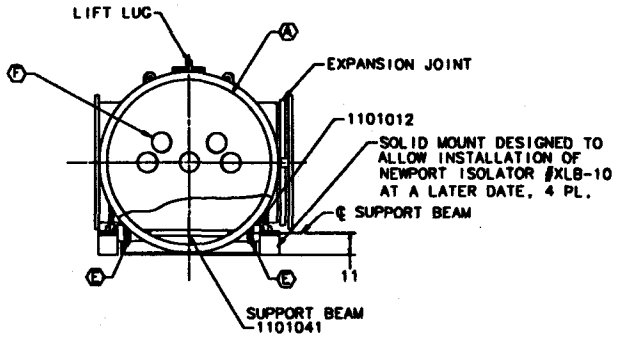
ITEM	SIZE	QUANTITY	FLANGE TYPE	PURPOSE
(A)	84° ID TUBE	2	O/O-O/METAL•	MAJOR ACCESS
(B)	60° ID TUBE	2	O/O-O/METAL•	LASER BEAM
(C)	14° TUBE FEEDTHROUGH	1	CONFLAT••, WITH BLIND FLANGE	ION PUMP/AIR SHOWERS, BACK-TO-AIR PURGE
(D)	10° OD TUBE	8	CONFLAT••, WITH BLIND FLANGE	ELECTRICAL FEEDTHROUGHS, UTILITY
(E)	8° OD TUBE	4	CONFLAT••	SUPPORT BEAMS
(F)	8° OD TUBE•••	10	CONFLAT••, WITH BLIND FLANGE	OBSERVATION, PICKOFFS
(G)	1 1/2° TUBE	1	CONFLAT••, WITH BLIND FLANGE	ANNULUS PUMPOUT

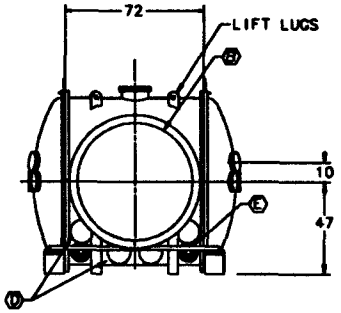
• DUAL O-RING DESIGN, WITH CAPABILITY OF REPLACING INBOARD O-RING WITH METAL SEAL. THESE FLANGES EACH INCLUDE AN ANNULAR CHANNEL BETWEEN O-RINGS, MANIFOLDED TO A SINGLE PUMPOUT PORT ON EACH CHAMBER, WITH CONFLAT•• SEAL.

•• REGISTERED TRADEMARK, VARIAN VACUUM PRODUCTS; COMPATIBLE ALTERNATIVES ARE ACCEPTIBLE

••• THESE FLANGES ARE TANGENT TO LOCAL VACUUM WALL, WITH MINIMUM NECK LENGTH







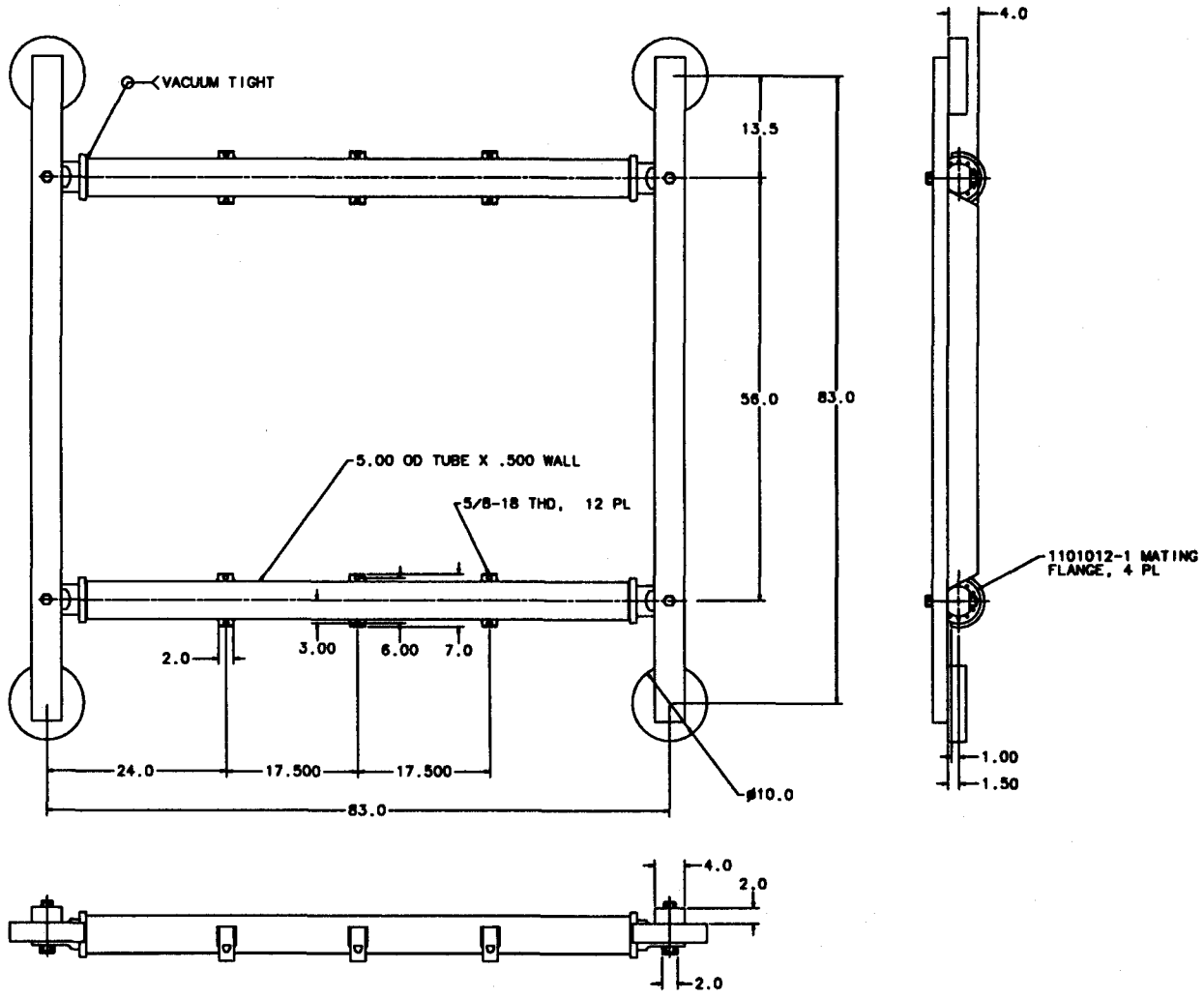
LIGO PROJECT

HORIZONTAL AXIS MODULE (HAM)

1101010

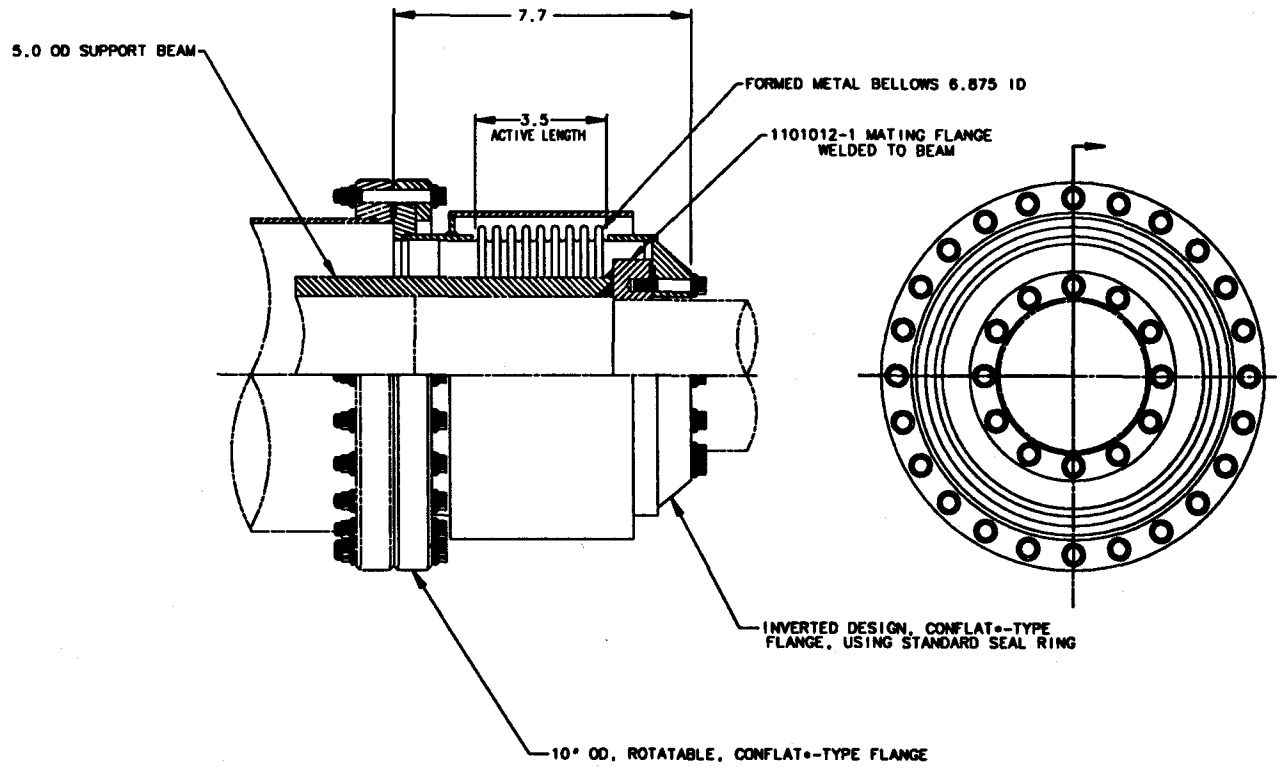
EDITION: 11-20-92

NOTES:
1. ALL LINEAR DIMENSIONS ARE IN INCHES
2. TOLERANCES, UNLESS OTHERWISE SPECIFIED: LINEAR, +/- 0.1 INCHES
ANGULAR, +/- 1 DEGREE



LIGO PROJECT
SUPPORT BEAM ASSEMBLY, HAM CHAMBER
1101041
EDITION: 05-28-92

NOTES:
1. BELLOWS SPRING RATES: AXIAL <120LB/IN, LATERAL <800 LB/IN.
2. RATED PRESSURE DIFFERENTIAL (EXTERNAL) ≥ 40 PSI AT 300 DEGREES F
3. DESIGN LIFE OF BELLOWS, AT +/- 20 MINUTES ROTATIONAL STROKE: 1000 CYCLES
4. ALL LINEAR DIMENSIONS ARE IN INCHES
5. TOLERANCES,UNLESS OTHERWISE SPECIFIED: LINEAR, +/- 0.1 INCHES
   ANGULAR, +/- 1 DEGREE



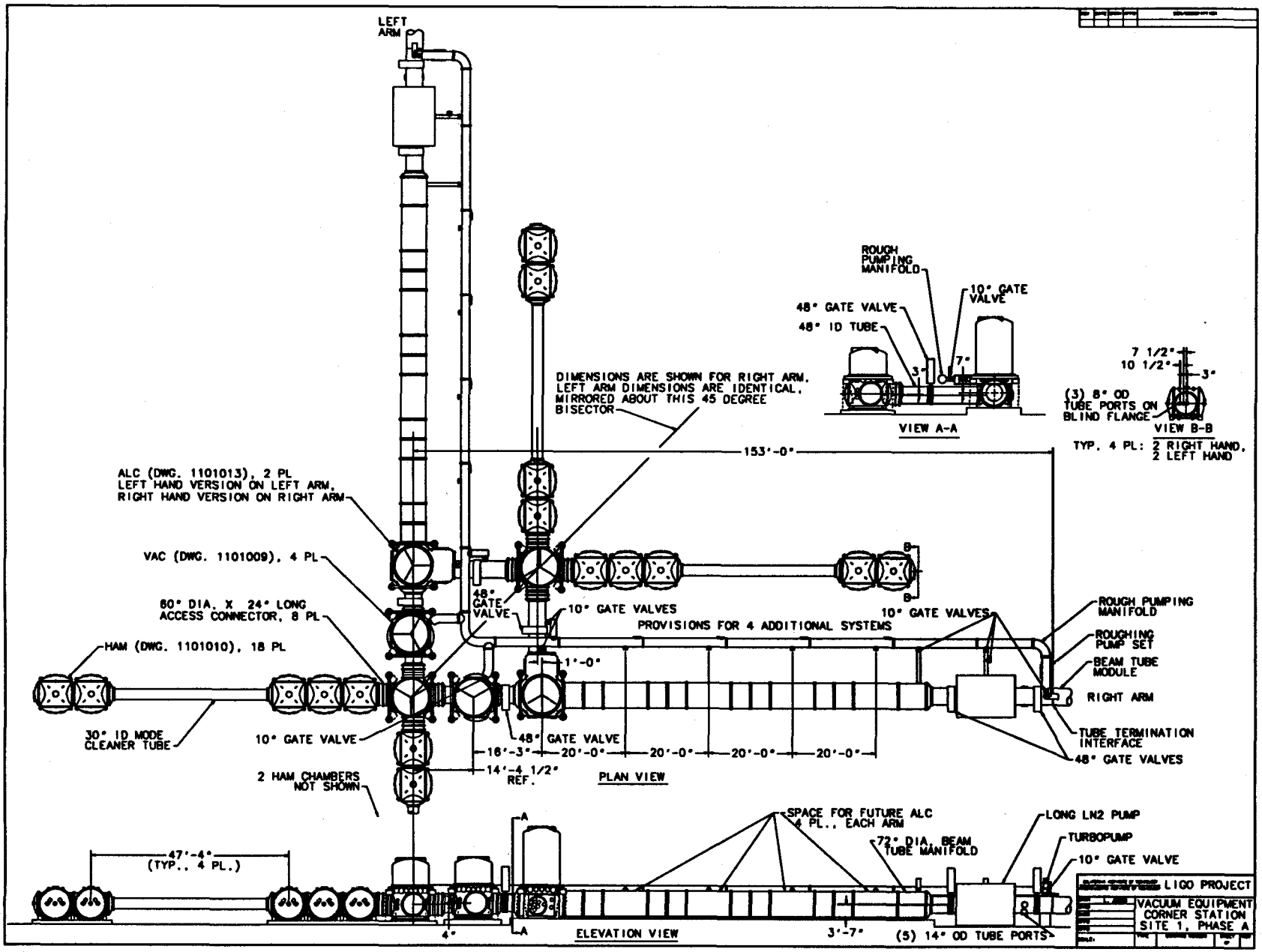
•REGISTERED TRADEMARK, VARIAN ASSOCIATES, INC.

LIGO PROJECT

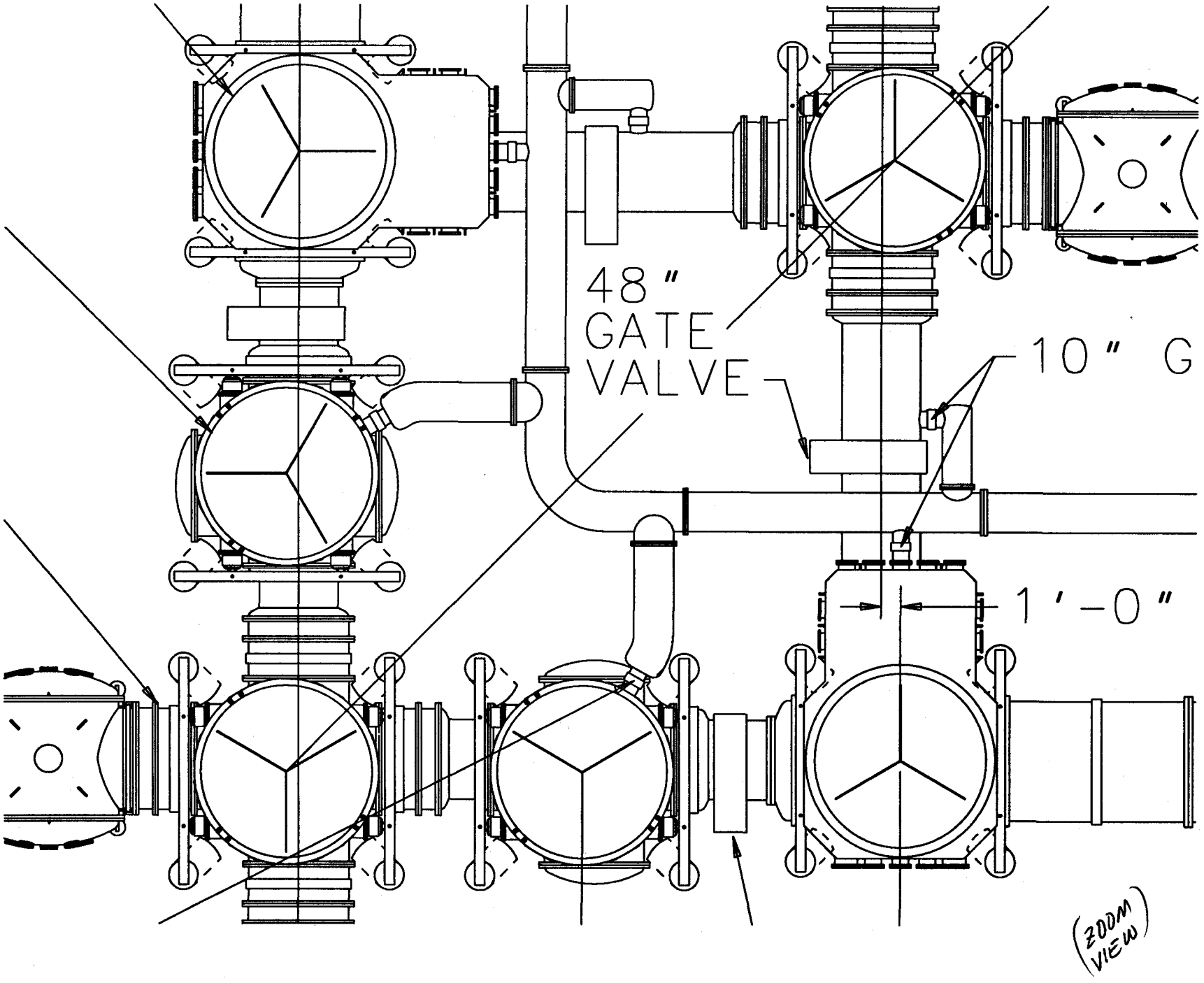
7" ISOLATION BELLOWS (CONFIGURATION)

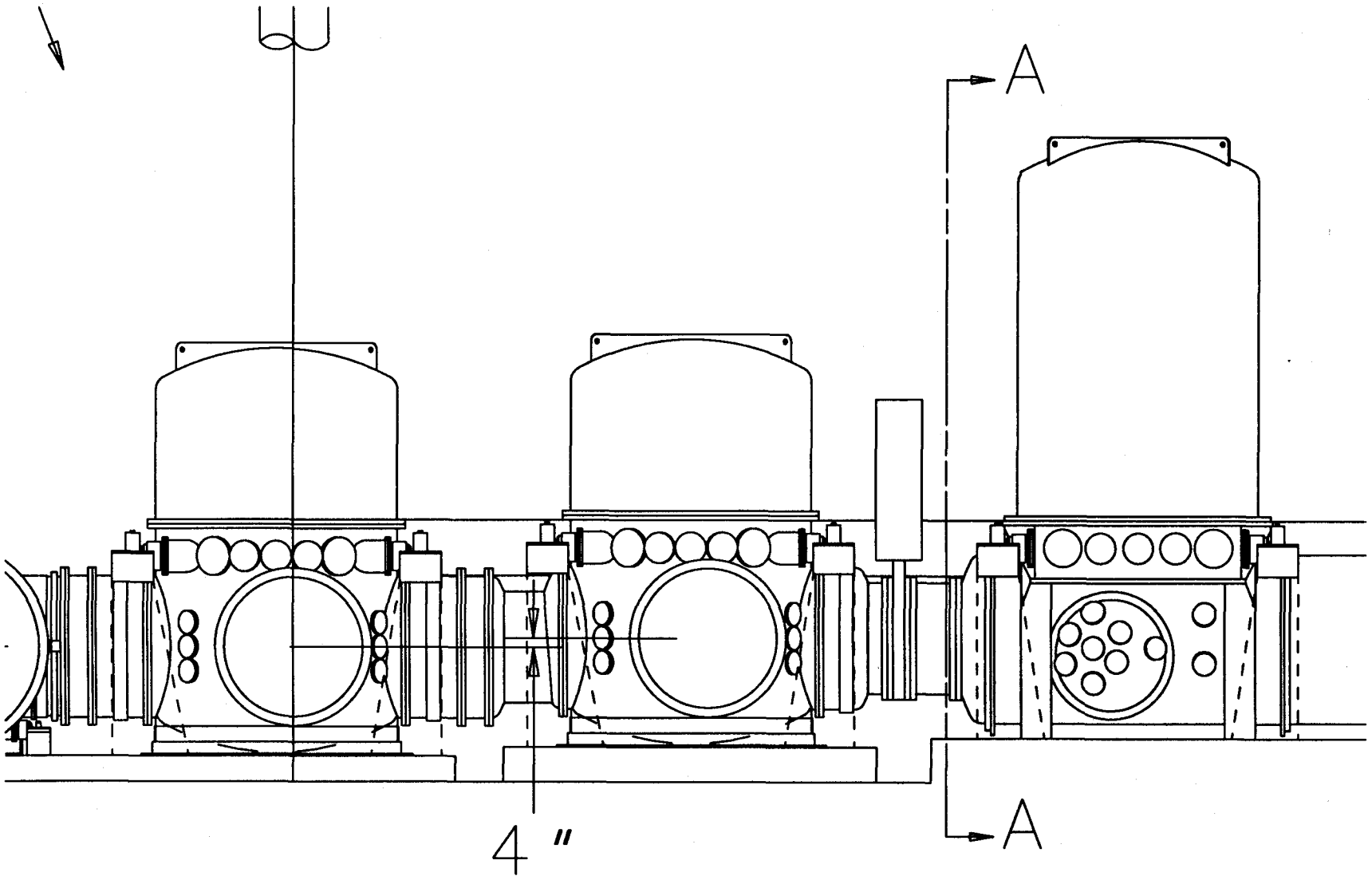
1101012 -1

EDITION: 12-1-92

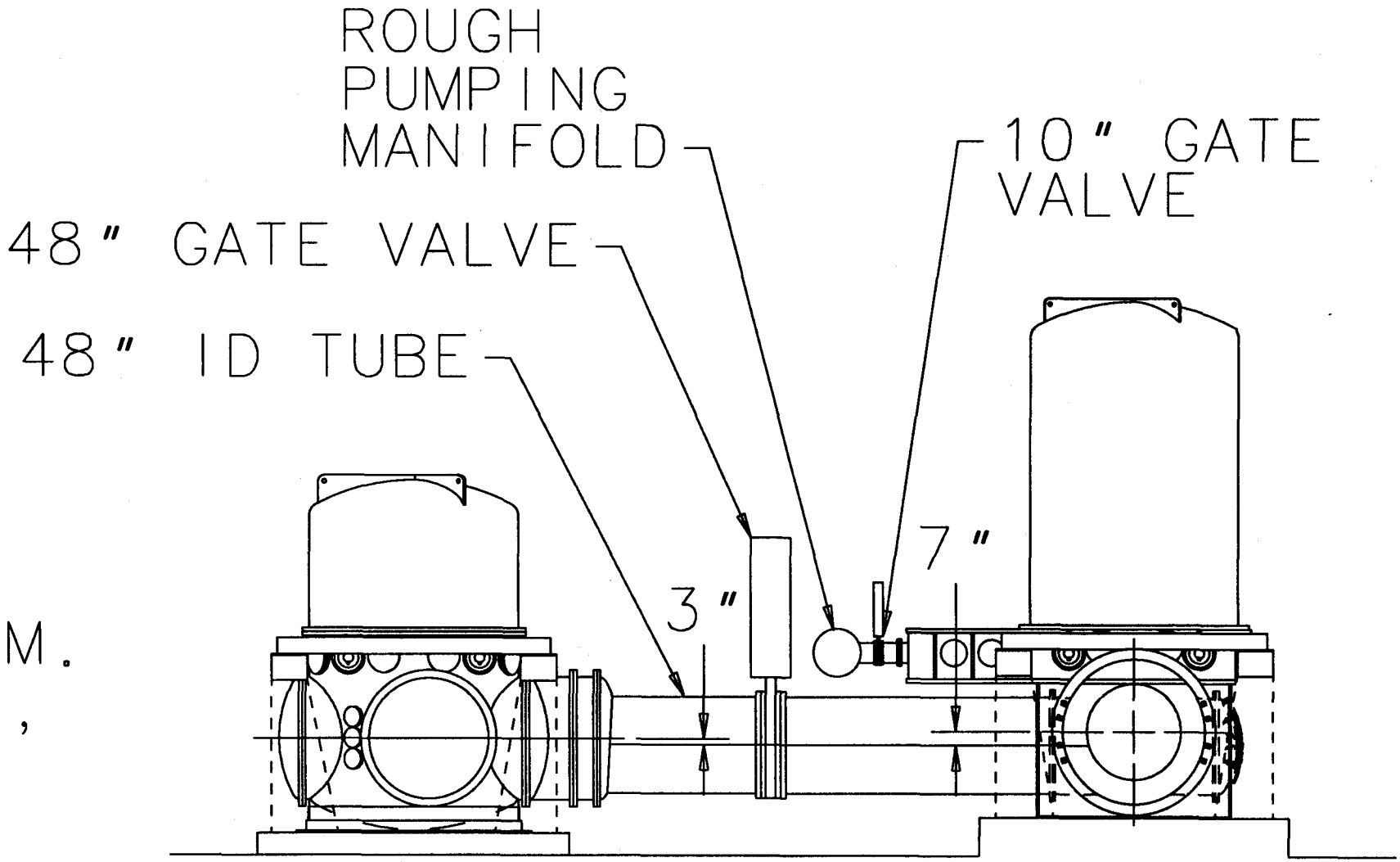


EDITION: 11-25-92


48"
GATE
VALVE
10" G
1'-0"
(ZOOM VIEW)



(ZOOM VIEW)



M.

,

VIEW A-A

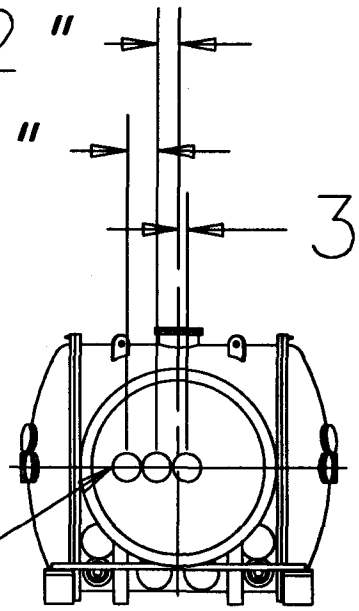
(ZOOM VIEW)

7 1/2"

10 1/2"

3"

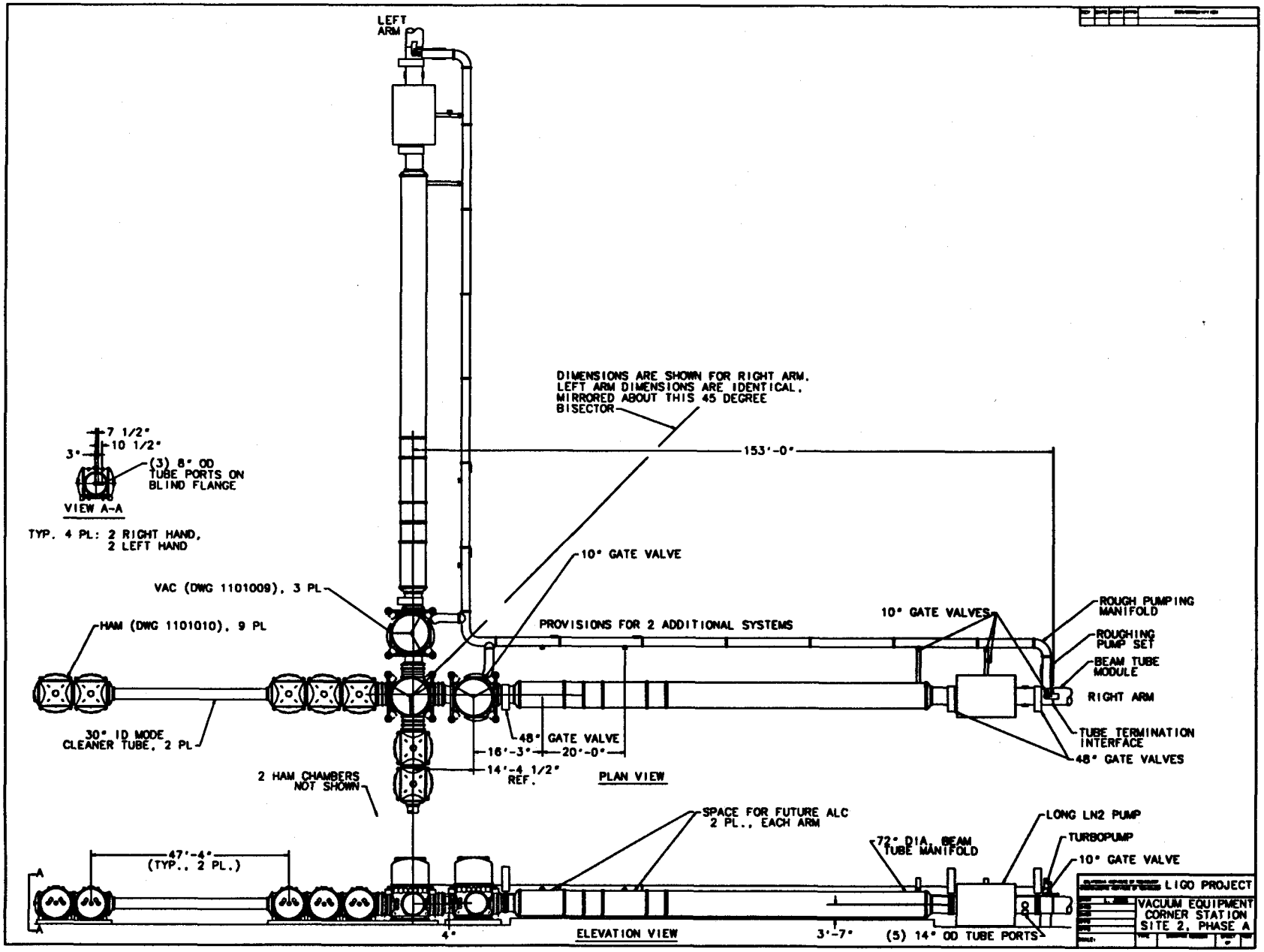
(3) 8" OD TUBE PORTS ON BLIND FLANGE



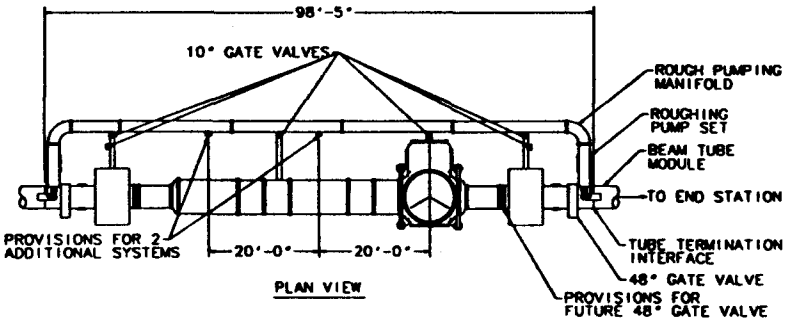
VIEW B-B

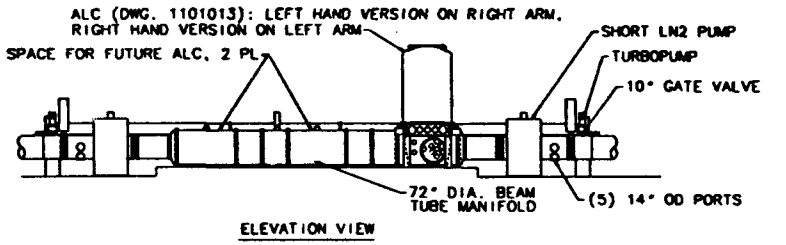
TYP. 4 PL: 2 RIGHT HAND, 2 LEFT HAND

(ZOOM VIEW)



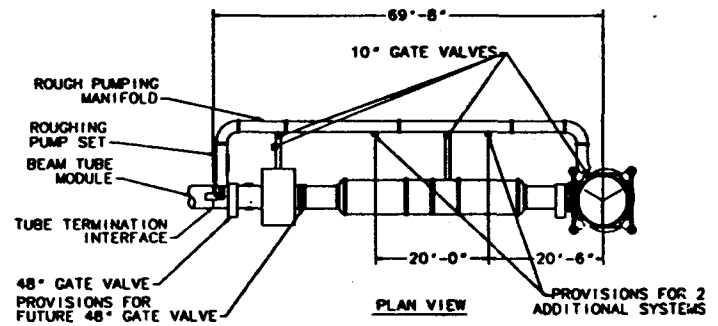
EDITION: 11-25-92

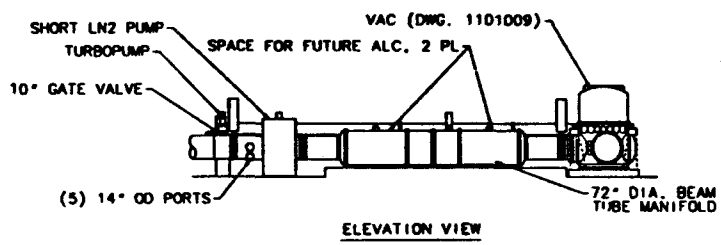




MID STATION: SITE 1

(RIGHT ARM SHOWN)





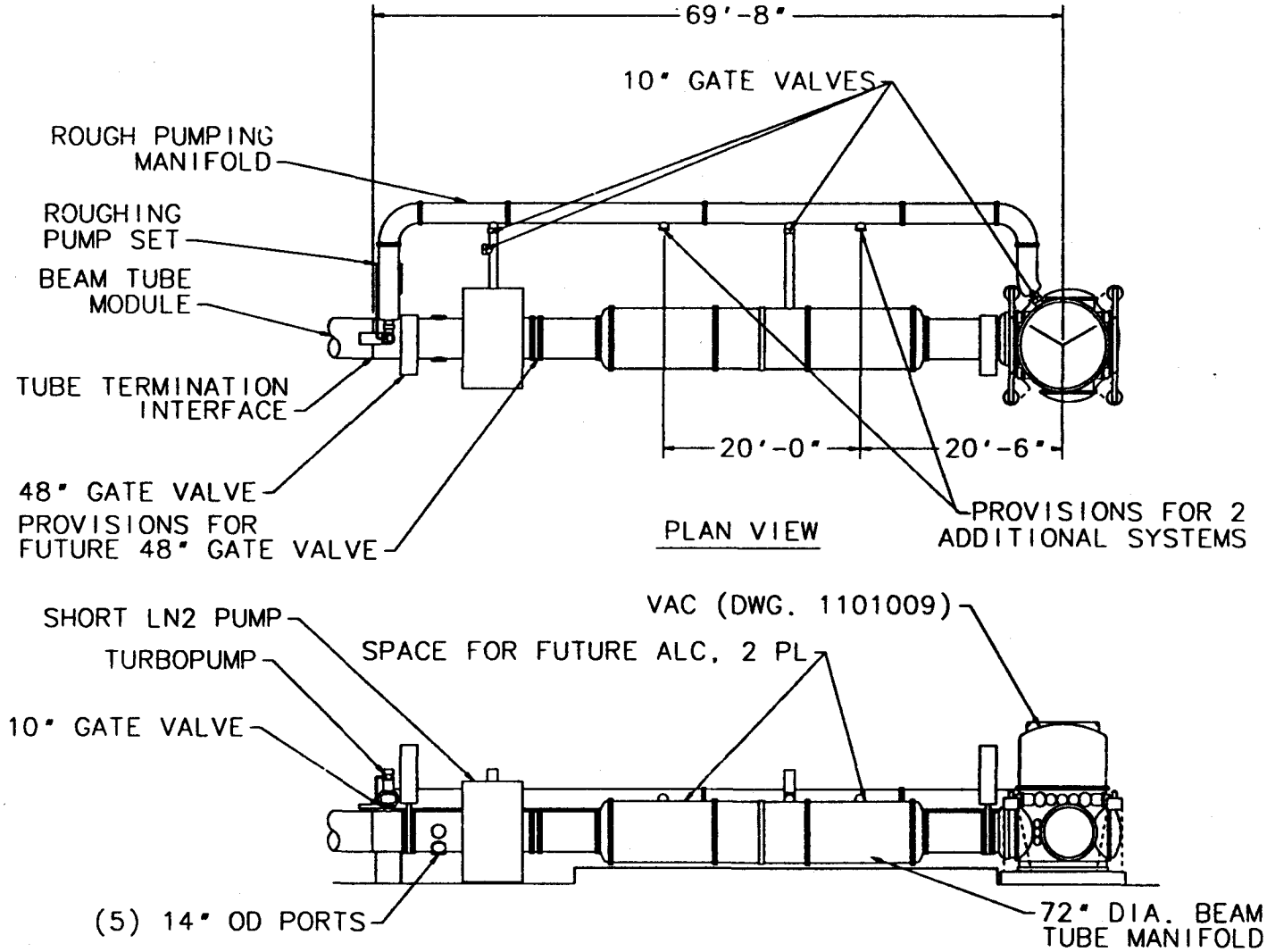
END STATION: SITES 1 & 2

(RIGHT ARM SHOWN)

LIGO PROJECT

VACUUM EQUIPMENT MID & END STATIONS PHASE A

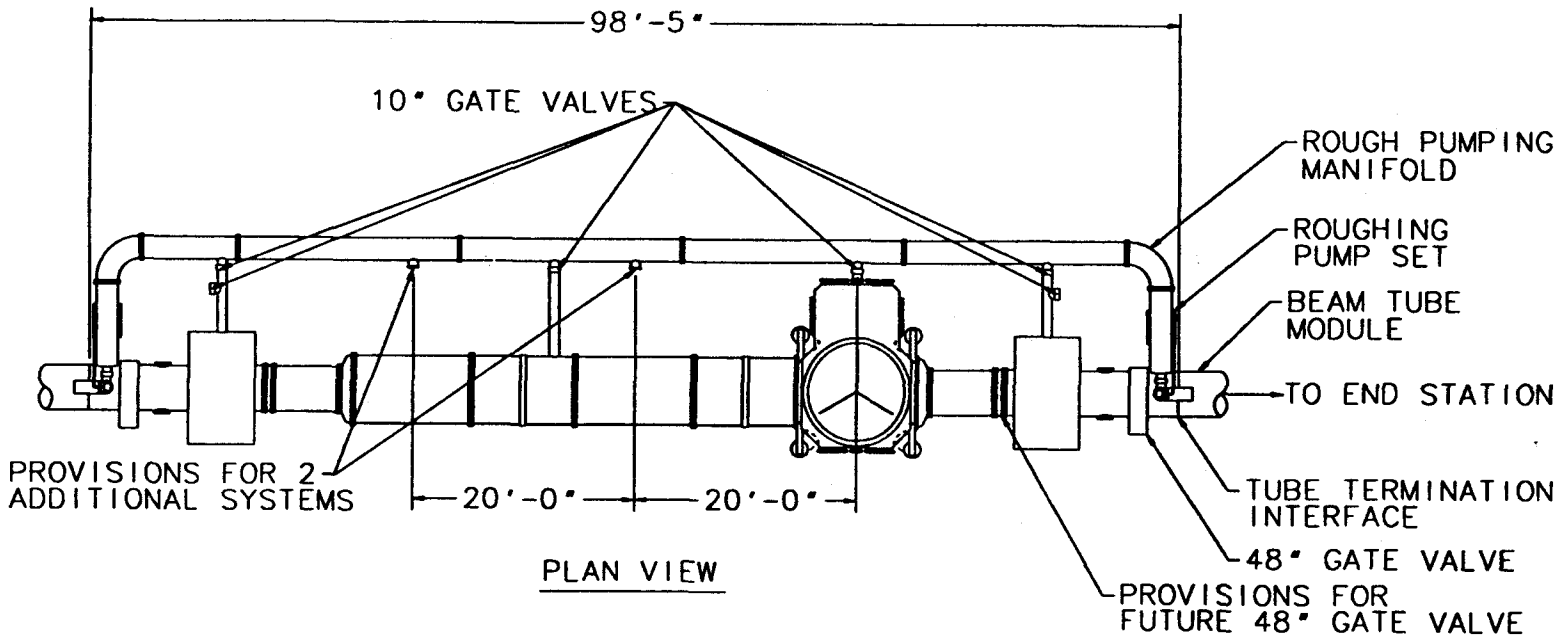
EDITION: 11-30-92



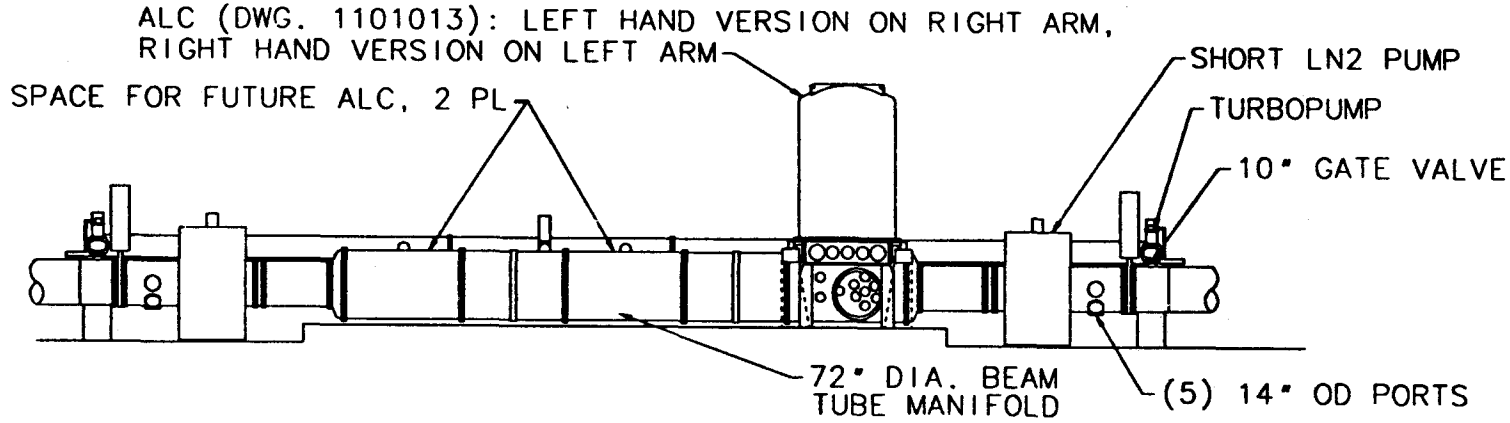
END STATION: SITES 1 & 2

(RIGHT ARM SHOWN)

(ZOOM VIEW)



PLAN VIEW



ELEVATION VIEW

MID STATION: SITE 1

(RIGHT ARM SHOWN)

(ZOOM VIEW)