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TO: Mr Parr	ORIG none signed	CC	OTHER	SENT NRC PDR XX; SENT LOCAL PDR XX		
CLASS	UNCLASS XXXXX	PROP INFO	INPUT	NO CYS REC'D 1	DOCKET NO: 50-275/323	

DESCRIPTION:

Ltr re our 6-13-75....trans the following:

DIST PER LA WILSON

ENCLOSURES:

Info concerning secondary system fluid flow instability in the Diablo Canyon design....

(15 cys encl rec'd)

PLANT NAME: Diablo Canyon 1 & 2

FOR ACTION/INFORMATION 8-8-75 ehf

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77 BEALE STREET • SAN FRANCISCO, CALIFORNIA 94106 • (415) 781-4211

JOHN C. MORRISSEY
VICE PRESIDENT AND GENERAL COUNSEL
MALCOLM H. FURBUSH
ASSOCIATE GENERAL COUNSEL
WILLIAM B. KUDER
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ATTORNEYS

August 5, 1975

Mr. Olan D. Parr, Chief
Light Water Reactors
Project Branch 1-3
Division of Reactor Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Re: Dockets 50-275-OL
50-323-OL

Dear Mr. Parr:

Your letter dated June 13, 1975 requested information concerning the consideration of secondary system fluid flow instability in the Diablo Canyon design. As stated in our letter of June 30, 1975, we have considered such instability and have modified steam generator feedwater piping to preclude damage from this source. Fifteen copies of information on each of the six specific areas listed in the enclosure to your letter are attached.

Kindly acknowledge receipt of the above material on the enclosed copy of this letter and return it to me in the enclosed addressed envelope.

Very truly yours,

Philip A. Crane, Jr.

8395

Attachments
CC w/attachment: ASLB Members
All Parties

July 31, 1975

Diablo Canyon Units 1 and 2

Secondary System Fluid Flow Instability

Information Requested By NRC Letter Dated June 13, 1975

Question 1. Describe all potential operating occurrences that could cause the level of the water/steam interface in the steam generator to drop below and uncover the feedwater sparger (or inlet nozzles), and allow steam to enter the sparger and the feedwater piping. Such uncoverings could lead to "water hammer" that could result in deleterious consequences for the system piping (e.g., Indian Point 2 feedwater line failure, November 13, 1973).

Response: Operating instructions constrain the operator to maintain steam generator water level above the feedwater distribution ring at all times. It is unlikely, but possible, that the ring nevertheless may become uncovered during the normal start up process. Since the steam generator water level could shrink to below the ring following a reactor trip, any event resulting in a reactor trip could uncover the ring. Additionally, the ring could be uncovered in a faulted steam generator in the event of a zero power steam line or feed line break, which is expected not to occur.

In addition to the dropping of the water level below the feedwater distribution ring, allowing the ring and a part of the feedwater line to drain, the water hammer phenomenon requires that the water level be rising to above the ring with a feedwater flow above a threshold value. Therefore, the dropping of the water level below the ring is not sufficient in itself for water hammer to occur. The modifications made at our plant described under Question 5 should preclude the occurrence of "water hammer" and if it should occur, will reduce the intensity so as to preclude deleterious consequences for the system piping.

Question 2. Describe and show by isometric diagrams, the routing of the main and auxiliary feedwater piping from the steam generators outwards through containment up to the outer isolation valve and restraint. When describing the piping run, note all valves and reference continually, the elevation of the inlet nozzles and/or sparger with respect to the piping run elevation.

Response: Isometric diagrams of the routing of the main and auxiliary feedwater piping from the steam generators outwards through containment up to the outer isolation valve and restraint are attached. A schematic drawing indicating the supports and restraints for a typical feedwater line is attached also. The feedwater piping leaves all steam generators at a nominal elevation of 154'-4 1/16". One foot horizontally from the steam generator feedwater nozzle, the lines turn downward with 45° elbows. After passing downward at a 45° angle for approximately 5½ inches of pipe, the lines return to the horizontal thru a second 45° elbow. The lines are now at elevation 152'-10½", approximately 18 inches below the inlet nozzles. This portion of the lines pass thru the crane wall. The lines continue horizontally until they turn downward at 90° elbows. The vertical run of pipe is 8 feet 8 inches from the steam generator shell for steam generators 1 and 4 and 10 feet 9 inches from the steam generator shell for steam generators 2 and 3.

(All the feedwater piping described to this point is illustrated in Figures 10.4-4 A and B of the FSAR which are attached). All feedwater lines continue vertically downward until they reach a nominal elevation of 129'-0", which is 25 feet 4 inches below the steam generator nozzles. At this elevation, they turn horizontally and run 21 feet 7 inches at which point they attach to the flued heads of the containment penetrations and are anchored. They continue, passing thru the containment. The horizontal runs at this elevation vary from approximately 34 to 37 feet long. These horizontal runs are 18°-28' or 21°-05' out of the vertical planes of the horizontal runs previously described (see isometric drawings for exact dimensions). In these horizontal runs, outside the containment, the lines to steam generators 1 and 2 have auxiliary feedwater nozzles and then motor operated isolation gate valves. These are the outer isolation valves for these two lines. All lines turn downward and run from approximately 9 to 17 feet vertically (see isometric drawings for exact dimensions). In these vertical runs, the lines to steam generators 3 and 4 have auxiliary feedwater nozzles. All lines turn horizontally, at elevations varying from 119'-5" to 112'-6", that is, from 35 to 42 feet below the steam generator nozzles. The lines to steam generators 3 and 4 have motor operated isolation gate valves immediately after they make this horizontal turn. These are the outer isolation valves for these two lines. All four feedwater lines (for each unit) eventually join together and run thru the number 1 feedwater heaters to the feedwater pumps.

All auxiliary feedwater lines join the respective main feedwater lines outside the containment penetrations, which are anchor points for the steam generator feedwater lines. The Unit 1 steam generator 1-1 auxiliary feedwater line has a 4 foot 3 inch run horizontally from the nozzle on the feedwater line at elevation 129'-0", 25 feet 4 inches below the steam generator feedwater nozzle. It turns 90° in the horizontal plane and runs a further 3 feet 3 inches. This run includes a check valve. The line turns and runs vertically downward to elevation 117'-11", 36 feet 5 inches below the steam generator feedwater nozzle. The line turns from the vertical and runs horizontally 15 feet 5 inches. In this run, there is a manual gate valve which is the isolation valve for this line. Each of the four auxiliary feedwater lines continues, dividing and eventually arriving at a motor driven auxiliary feedwater pump and at the turbine driven auxiliary feedwater pump.

The Unit 1 steam generator 1-2 auxiliary feedwater line has a three foot horizontal run at elevation 129'-0", 25 feet 4 inches below the steam generator nozzles. This run contains a check valve. The line turns 78°-19' in the horizontal plane and runs for an additional 3 feet 6 inches and contains a manual gate valve which is the isolation valve for this line.

The Unit 1 steam generator 1-3 auxiliary feedwater line has a 5 foot 0 inch horizontal run, which contains a check valve, at elevation 125'-0", 29 feet 4 inches below the steam generator feedwater nozzle, where it leaves the feedwater line. It turns vertically downward and passes thru a manual gate valve which is the isolation valve.

The Unit 1 steam generator 1-4 auxiliary feedwater line runs 3 feet 3 inches horizontally after leaving the feedwater line at elevation 125'-0", 29 feet 4 inches below the steam generator feedwater nozzle. This run contains a check valve. The line turns vertically downward and encounters a manual gate valve which is the isolation valve.

The Unit 2 steam generator 2-1 auxiliary feedwater line has a 1 foot 4 inch run horizontally from the nozzle on the feedwater line at elevation 129'-0", 25 feet 4 inches below the steam generator feedwater nozzle. It turns and runs vertically downward thru a check valve to elevation 110'-1", 44 feet 3 inches below the nozzle. It turns and runs horizontally 4 feet 1 inch and turns 90° in the horizontal plane. After this turn, it contains the manual isolation gate valve for the line.

The Unit 2 steam generator 2-2 auxiliary feedwater line has a 1 foot 4 inch run horizontally from the nozzle on the feedwater line at elevation 129'-0", 25 feet 4 inches below the steam generator feedwater nozzle. It turns and runs vertically downward thru a check valve to elevation 112'-1", 42 feet 3 inches below the nozzle. It turns and runs horizontally. After this turn, it contains the manual isolation gate valve for the line.

The Unit 2 steam generator 2-3 auxiliary feedwater line has a 5 foot 1 inch run which contains a check valve horizontally from the nozzle on the feedwater line at elevation 125'-0", 29 feet 4 inches below the steam generator feedwater nozzle. It turns and runs vertically downward thru the manual isolation gate valve for the line.

The Unit 2 steam generator 2-4 auxiliary feedwater line has a 3 foot 5/8 inch run which contains a check valve horizontally from the nozzle on the feedwater line at elevation 125'-0", 29 feet 4 inches below the steam generator feedwater nozzle. It turns and runs vertically downward thru the manual isolation gate valve.

Question 3. Describe all analyses of the piping system in which dynamic forcing functions were assumed. Also, provide the results of any test programs that were carried out to verify that either uncovering of the feedwater lines could not occur at your facility, or if it did occur, the water hammer effect did not result.

Response: Analyses of the piping system in which dynamic forcing functions were assumed have not been carried out for our facility. The modifications made, described under Question 5, were based partially on a calculational model resulting from an analytical investigation by the nuclear steam supply system manufacturer. These analyses were general in nature and based on small scale, low pressure experimental results. This calculational model indicated a dependence of water hammer intensity on the length of horizontal run of the feedwater pipe run adjacent to the steam generator. Experience at other plants appears to confirm the dependence indicated by the model.

A test program that tracked and predicted a flow instability event has not been carried out for our facility because the facility has not reached that state of completion, among other reasons. Such a test program is not anticipated because we believe that the modifications which have been made will preclude such an event from occurring. We do plan to perform a demonstration that such an event does not occur. This demonstration, as presently conceived, will be performed during hot functional testing and over the range of feedwater flow available from the motor driven auxiliary feedwater pumps.

Question 4. In order to bound the consequences of this event, discuss the possibility of a sparger or nozzle uncovering, and the consequent pressure wave effects that would occur in the piping following a design basis accident with concurrent turbine trip and loss of off-site power.

Response: Following a large loss of coolant accident, assuming a consequent reactor trip, the uncovering by the water of the steam generator feedwater distribution ring is likely to occur. For consequent water hammer pressure wave effects to occur, the feedwater flow rate would have to exceed the water hammer threshold flow rate during the time the ring is being recovered with water. It is believed that with the modifications described under Question 5 made to the steam generators, there is no threshold flow rate or that it has been raised substantially. It is expected that this will be verified by the demonstration discussed under Question 3. However, should pressure wave effects occur, no pipe damage would be expected because the modifications made to reduce the length of the feedwater piping horizontal runs adjacent to the steam generators are believed to have reduced the possible water hammer intensity to below damaging levels, as indicated by the experience at other plants and by the calculational model discussed under Question 3.

Question 5. If plant system design changes are to be made to preclude the occurrence of flow instabilities, describe these changes or modifications, and discuss the reasons that made this alternative

superior to other alternatives that might have been applied. Discuss the quality assurance program that will be followed to assure that the planned system modifications will have been correctly accomplished at the facility.

Response: One change has been made to plant system design to preclude the occurrence of flow instabilities, and one change has been made to preclude damage from flow instabilities, should they occur. A vent consisting of an inverted U-bend has been added to each steam generator feedwater distribution ring and to each nozzle-ring tee. These vents communicate with the steam generator steam space. This modification was made for the reason that it is the only change known at this writing which is believed to have been demonstrated to prevent the occurrence of flow instabilities in steam generators of the type installed at our plant. Based on a test conducted at the Doel plant in Belgium, these vents appear to avoid the conditions which could propel a water slug and result in water hammer.

The steam generator feedwater piping has been modified to minimize the length of horizontal piping which could be drained when the steam generator water level is below the feedwater distribution ring. This modification consisted of installing two 45° elbows in such a manner as to create a water trap and is illustrated in FSAR Figures 10.4-4A and 4B, copies of which are attached. Experience with steam generator feedwater line water hammer at other plants and the calculational model discussed under Question 3 have indicated that a short length of piping adjacent to the steam generator has the effect of reducing the intensity of the possible water hammer. This alternative for shortening the line is superior to other alternatives that might have been applied because it used material available without a delay and because it obtained the desired result with the minimum installation cost and with the lowest possible added permanent pressure loss in the feedwater lines. This alternative also required the minimum revision of concrete in the crane walls, which had been erected before the need for a design modification had become apparent.

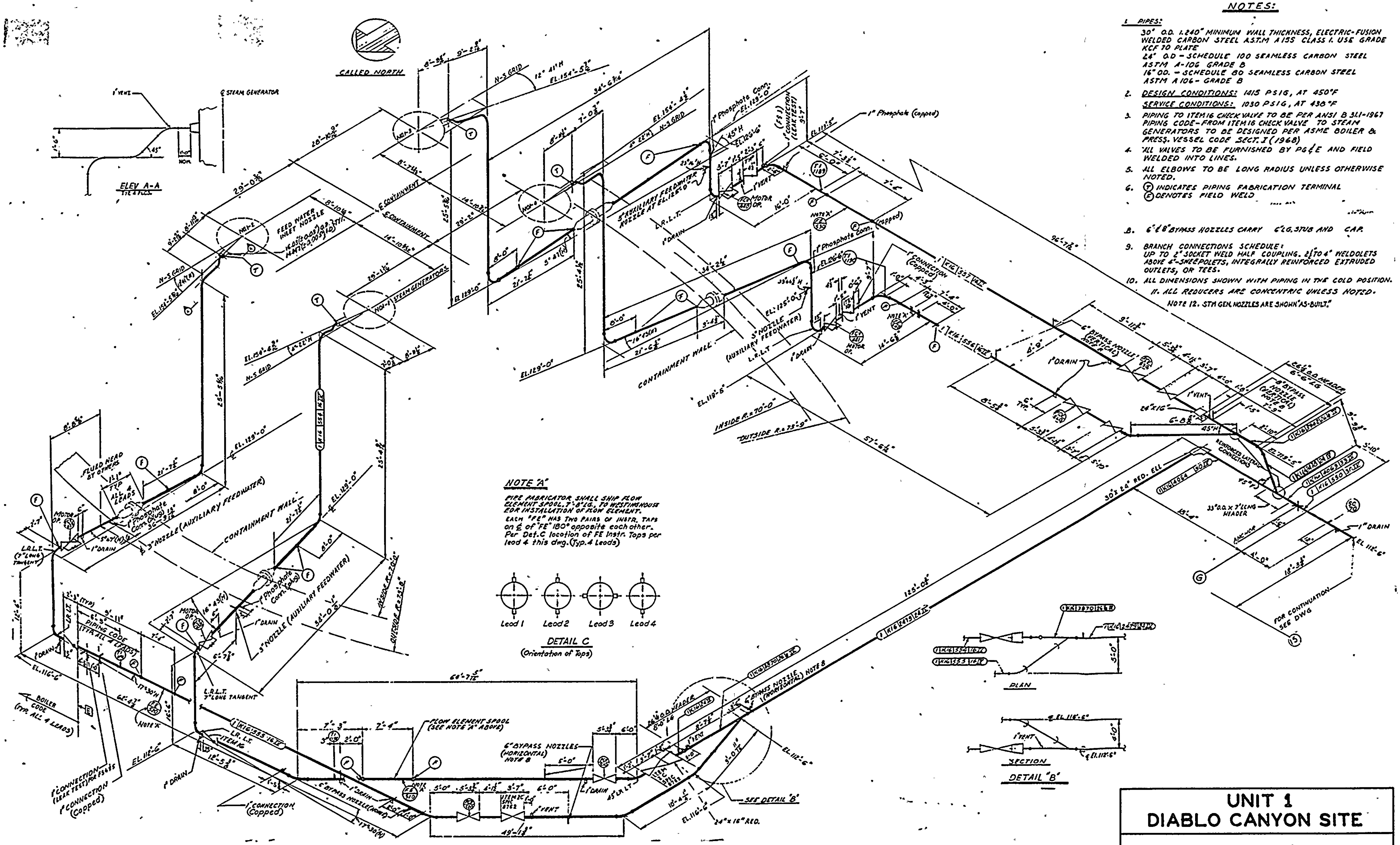
The modifications described above were carried out in conformance with the quality assurance program described in Section 17.1 of the Diablo Canyon Final Safety Analysis Report.

Question 6. Discuss the effects of reduced auxiliary feedwater flow as a possible means of reducing the magnitude of induced pressure waves including positive means (e.g., interlocks) to assure sufficient low flow rates and still meet the minimum requirements for the system safety function.

Response: It is not known that reduced auxiliary feedwater flow has any effect as a possible means of reducing the magnitude of induced pressure waves. Tests at other plants and water hammer incidents

at other plants establish that water hammer can be precluded by limiting the rate of cold feedwater flow to a value below a water hammer threshold number. It is believed that with the design modifications made at our plant described under Question 5, there is no threshold flow rate or that it has been raised substantially. The demonstration described under Question 3 is expected to show that water hammer will not occur over the range of feedwater flows available from the motor driven auxiliary feedwater pumps. As a conservative measure, feedwater flow will be limited administratively to the value for which it has been demonstrated that water hammer will not occur whenever there is the possibility that steam generator water level has reached a level at which the possibility exists that the feedwater distribution header may be uncovered or drained.

Experience at other plants, which do not have the vent modification described under Question 5 which appears to avoid the conditions which could result in water hammer, has lead the nuclear steam system supplier to recommend for such plants a limit of 150 gpm feedwater flow per steam generator when water levels exist which could allow a water hammer to occur. This is considered to be the worst case in this regard which could pertain to our plant, that is, that the vent modifications would not have any beneficial effect. Even in this limiting case, the minimum requirements for the safety system function would not be compromised, since 350 gpm is the minimum feed water flow required and can be delivered to three steam generators without exceeding 150 gpm to each.



NOTES:

1. PIPES:
   30" O.D. 1.240" MINIMUM WALL THICKNESS, ELECTRIC-FUSION WELDED CARBON STEEL A.S.T.M A 155 CLASS I. USE GRADE KCF 70 PLATE
   24" O.D - SCHEDULE 100 SEAMLESS CARBON STEEL ASTM A-106 GRADE B
   16" OD. - SCHEDULE 80 SEAMLESS CARBON STEEL ASTM A 106 - GRADE B
2. DESIGN CONDITIONS: 1415 PSIG, AT 450°F
   SERVICE CONDITIONS: 1030 PSIG, AT 436°F
3. PIPING TO ITEM 16 CHECK VALVE TO BE PER ANSI B 31.1-1967 PIPING CODE - FROM ITEM 16 CHECK VALVE TO STEAM GENERATORS TO BE DESIGNED PER ASME BOILER & PRESS. VESSEL CODE SECT. I (1968)
4. ALL VALVES TO BE FURNISHED BY PG&E AND FIELD WELDED INTO LINES.
5. ALL ELBOWS TO BE LONG RADIUS UNLESS OTHERWISE NOTED.
6. (T) INDICATES PIPING FABRICATION TERMINAL
   (F) DENOTES FIELD WELD
8. 6" & 8" BYPASS NOZZLES CARRY 6" LG. STUB AND CAP.
9. BRANCH CONNECTIONS SCHEDULE:
   UP TO 2" SOCKET WELD HALF COUPLING. 2½ TO 4" WELDOLETS ABOVE 4"-SWEEPOLETS, INTEGRALLY REINFORCED EXTRUDED OUTLETS, OR TEES.
10. ALL DIMENSIONS SHOWN WITH PIPING IN THE COLD POSITION.
11. ALL REDUCERS ARE CONCENTRIC UNLESS NOTED.

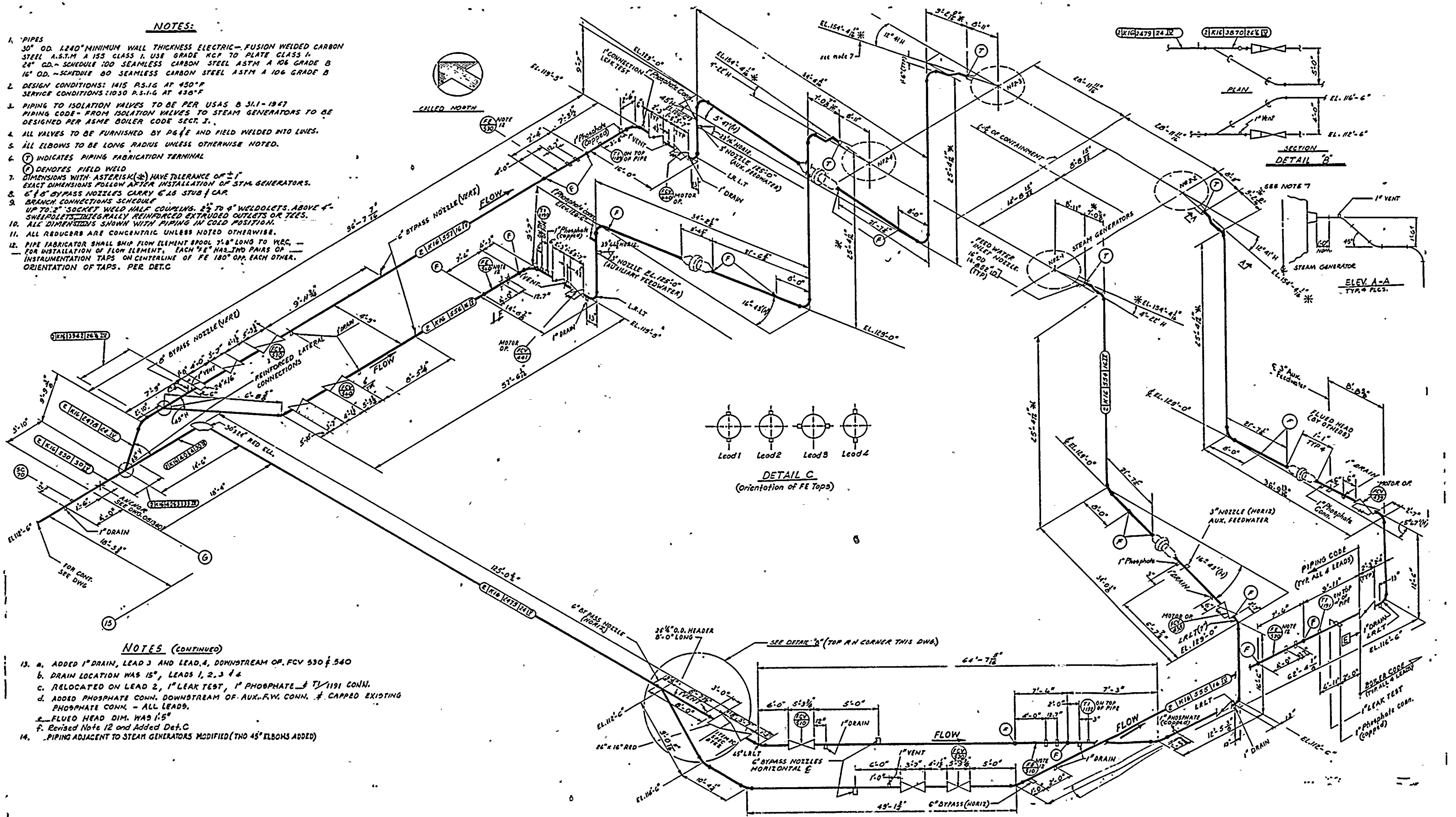
NOTE 12. STM GEN. NOZZLES ARE SHOWN "AS-BUILT."

UNIT 1
DIABLO CANYON SITE

PIPING ISOMETRIC DIAGRAM
FEEDWATER PIPING TO STEAM GENERATORS

NOTES:

1. PIPES
   30" OD. 1.240" MINIMUM WALL THICKNESS ELECTRIC-FUSION WELDED CARBON STEEL A.S.T.M A 155 CLASS 1. USE GRADE KCF 70 PLATE CLASS 1.
   24" OD.~SCHEDULE 100 SEAMLESS CARBON STEEL ASTM A 106 GRADE B
   16" OD.~SCHEDULE 80 SEAMLESS CARBON STEEL ASTM A 106 GRADE B
2. DESIGN CONDITIONS: 1415 P.S.I.G AT 450°F
   SERVICE CONDITIONS: 1030 P.S.I.G AT 436°F
3. PIPING TO ISOLATION VALVES TO BE PER USAS B 31.1-1967
   PIPING CODE- FROM ISOLATION VALVES TO STEAM GENERATORS TO BE DESIGNED PER ASME BOILER CODE SECT. I.
4. ALL VALVES TO BE FURNISHED BY PG&E AND FIELD WELDED INTO LINES.
5. ALL ELBOWS TO BE LONG RADIUS UNLESS OTHERWISE NOTED.
6. (T) INDICATES PIPING FABRICATION TERMINAL
   (F) DENOTES FIELD WELD
7. DIMENSIONS WITH ASTERISK(*) HAVE TOLERANCE OF ±1"
   EXACT DIMENSIONS FOLLOW AFTER INSTALLATION OF STM. GENERATORS.
8. 6" & 8" BYPASS NOZZLES CARRY 6" L6 STUB & CAP.
9. BRANCH CONNECTIONS SCHEDULE
   UP TO 2" SOCKET WELD HALF COUPLING. 2½" TO 4" WELDOLETS. ABOVE 4"- SWEEPOLETS, INTEGRALLY REINFORCED EXTRUDED OUTLETS OR TEES.
10. ALL DIMENSIONS SHOWN WITH PIPING IN COLD POSITION.
11. ALL REDUCERS ARE CONCENTRIC UNLESS NOTED OTHERWISE.
12. PIPE FABRICATOR SHALL SHIP FLOW ELEMENT SPOOL 7'-8" LONG TO W.E.C. — FOR INSTALLATION OF FLOW ELEMENT. EACH "FE" HAS TWO PAIRS OF INSTRUMENTATION TAPS ON CENTERLINE OF FE 180° OPP. EACH OTHER. ORIENTATION OF TAPS. PER DET.C

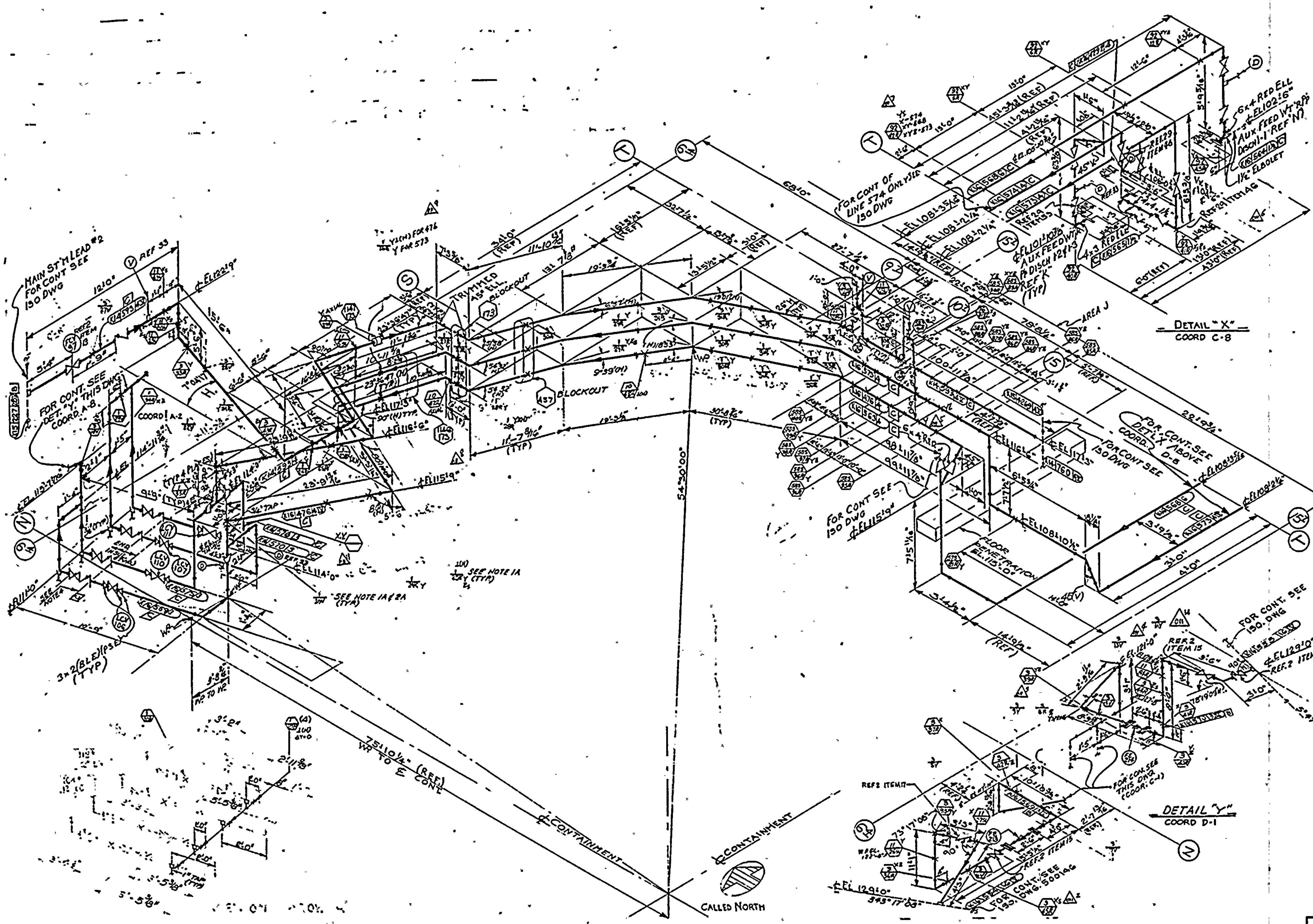


NOTES (CONTINUED)

13. a. ADDED 1" DRAIN, LEAD 3 AND LEAD 4, DOWNSTREAM OF FCV 530 & 540
    b. DRAIN LOCATION WAS 15", LEADS 1, 2, 3 & 4
    c. RELOCATED ON LEAD 2, 1" LEAK TEST, 1" PHOSPHATE & TI/1191 CONN.
    d. ADDED PHOSPHATE CONN. DOWNSTREAM OF AUX. F.W. CONN. & CAPPED EXISTING PHOSPHATE CONN. - ALL LEADS.
    e. FLUED HEAD DIM. WAS 1'-5"
    f. Revised Note 12 and Added Det.C
14. PIPING ADJACENT TO STEAM GENERATORS MODIFIED (TWO 45° ELBOWS ADDED)

UNIT 2
DIABLO CANYON SITE

PIPING ISOMETRIC DIAGRAM
FEEDWATER PIPING TO STEAM GENERATORS

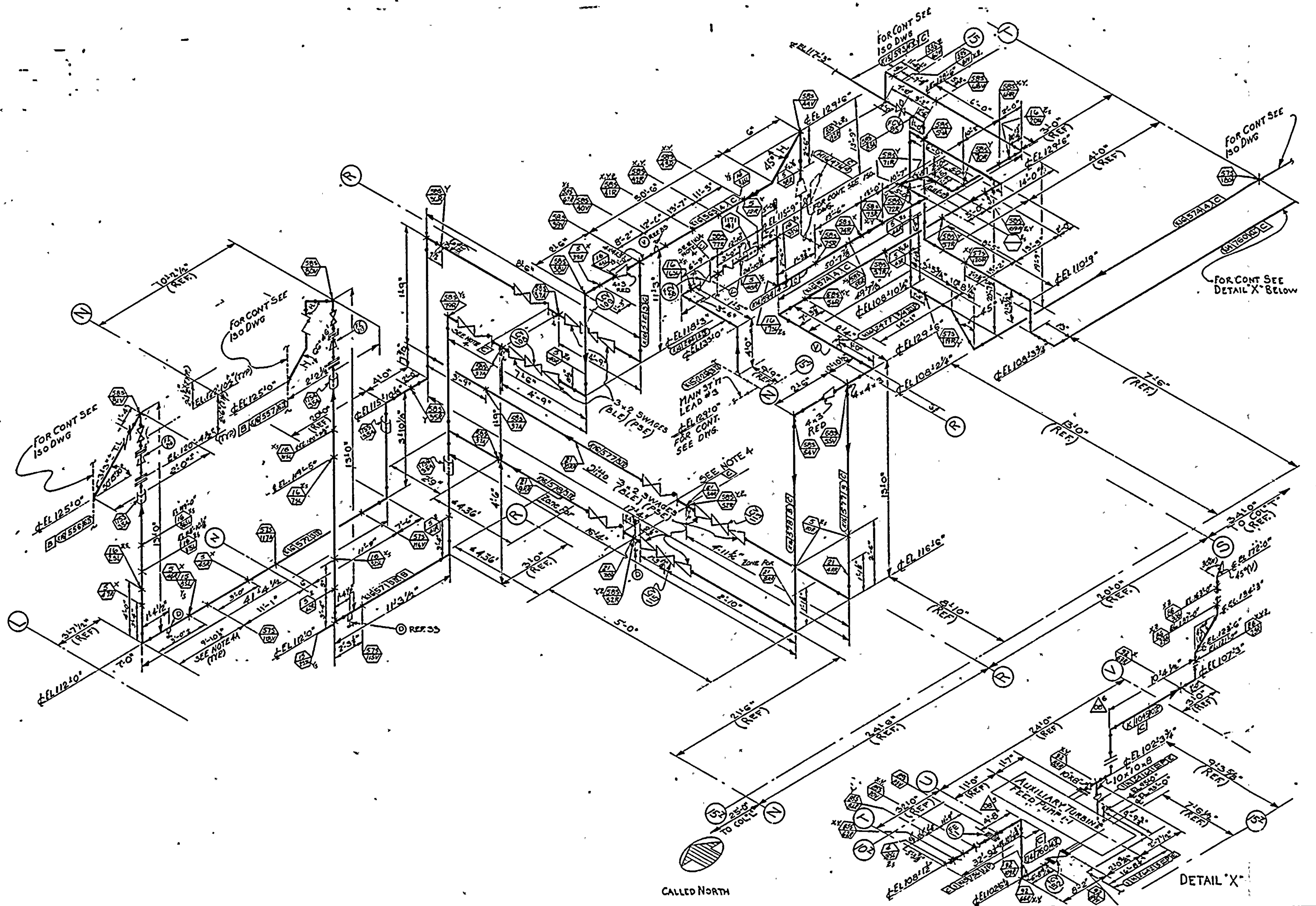


NOTES: 1_ FINAL DIMENSIONS BY FIELD MEASUREMENT
2_ (H.) = ANGLE ON HORIZONTAL PLANE
_ (V.) = ANGLE ON VERTICAL PLANE
3_ THIS DWG NOT FOR CONSTRUCTION
4- A.S.M.E. BOILER & PRESSURE VESSEL CODE PIPING; SEE NOTE #D ON GENERAL NOTES & REF'S DWG.

HANGER NOTES:
1A. UPPER CASE LETTER(S) BY HGR. SYMBOL
2A. INDICATE AXIS IN WHICH PIPE IS RESTRAINED "S" SUBSCRIPT INDICATES RESTRAINT APPEARS ON SEISMIC ANALYSIS ONLY.
3A. ALL DIMENSIONS TO THE NEAREST FOOT.

UNIT 1
DIABLO CANYON SITE

PIPING ISOMETRIC DIAGRAM
AUXILIARY FEEDWATER SUPPLY
STEAM GENERATORS 1-1 & 1-2

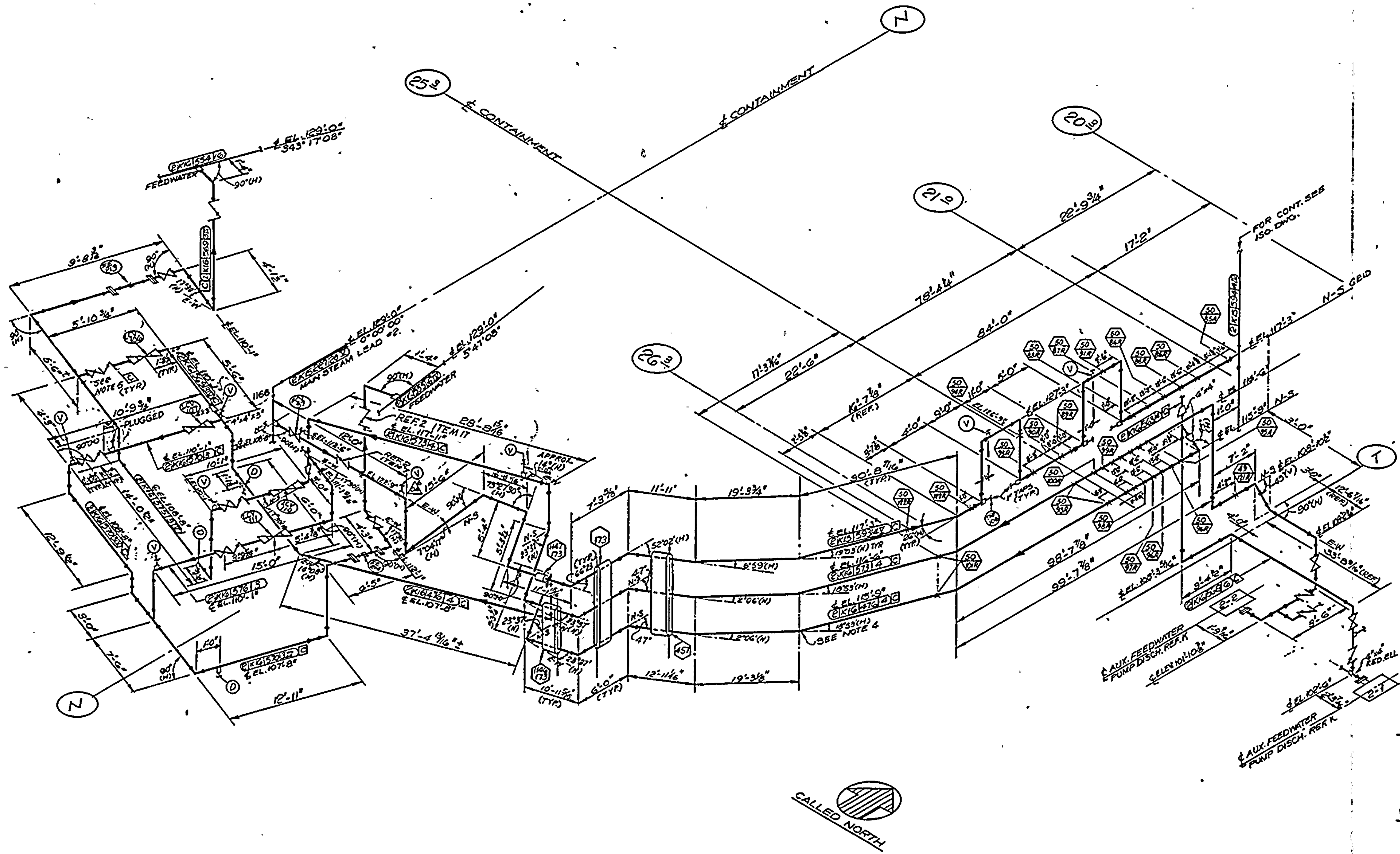


NOTES:
1. FOR FINAL DIMENSIONS SEE AREA DRAWINGS.
2. (H.) = ANGLE ON HORIZONTAL PLANE
(V.) = ANGLE ON VERTICAL PLANE
3. THIS DWG NOT FOR CONSTRUCTION
4. A.S.M.E. BOILER & PRESSURE VESSEL CODE PIPING, SEE NOTE #8 ON GENERAL NOTES & REFS DWG 049111.

HGR. NOTES:
1A. UPPER CASE LETTERS) BY HGR. SYMBOL INDICATES AXIS IN WITH PIPE IS RESTRAINED.
2A. "S" SUBSCRIPT INDICATES RESTRAINT APPEARS ON SEISMIC ANALYSIS ONLY.
3A. ALL DIMENSIONS ACCURATE TO NEAREST FOOT.

UNIT 1
DIABLO CANYON SITE

PIPING ISOMETRIC DIAGRAM
AUXILIARY FEEDWATER SUPPLY
STEAM GENERATORS 1-3 & 1-4



5. ASME BOILER & PRESSURE VESSEL CODE PIPING; SEE NOTE #8 ON GENERAL NOTES & REFERENCES DWG. 051209

4. ALL BENDS SHOWN WITHOUT WELDING SYMBOLS ARE 5D BENDS.

3. THIS DRAWING NOT FOR CONSTRUCTION

2. (V) = ANGLE ON A VERTICAL PLANE.
(H) = ANGLE ON A HORIZONTAL PLANE.

1. FINAL DIMENSION BY FIELD MEASUREMENT.

NOTES:

3A.- ALL DIMENSIONS ACCURATE TO NEAREST FT.

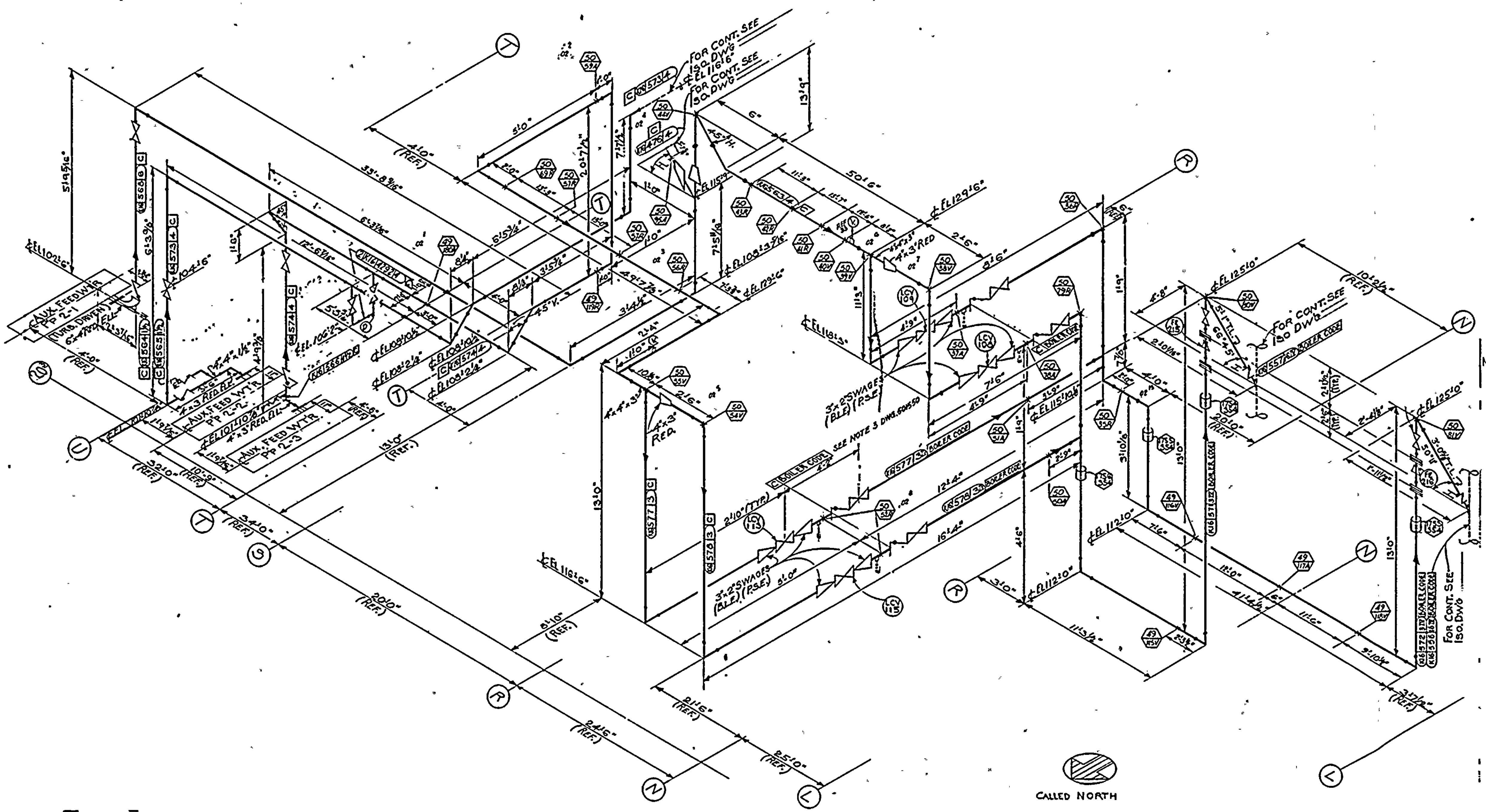
2A.- "S" SUBSCRIPT INDICATES RESTRAINT APPEARS ON SEISMIC ANALYSIS ONLY.

1A.- UPPER CASE LETTER BY HANGER SYMBOL INDICATES AXIS IN WHICH PIPE IS RESTRAINED

HANGER NOTES:

UNIT 2
DIABLO CANYON SITE

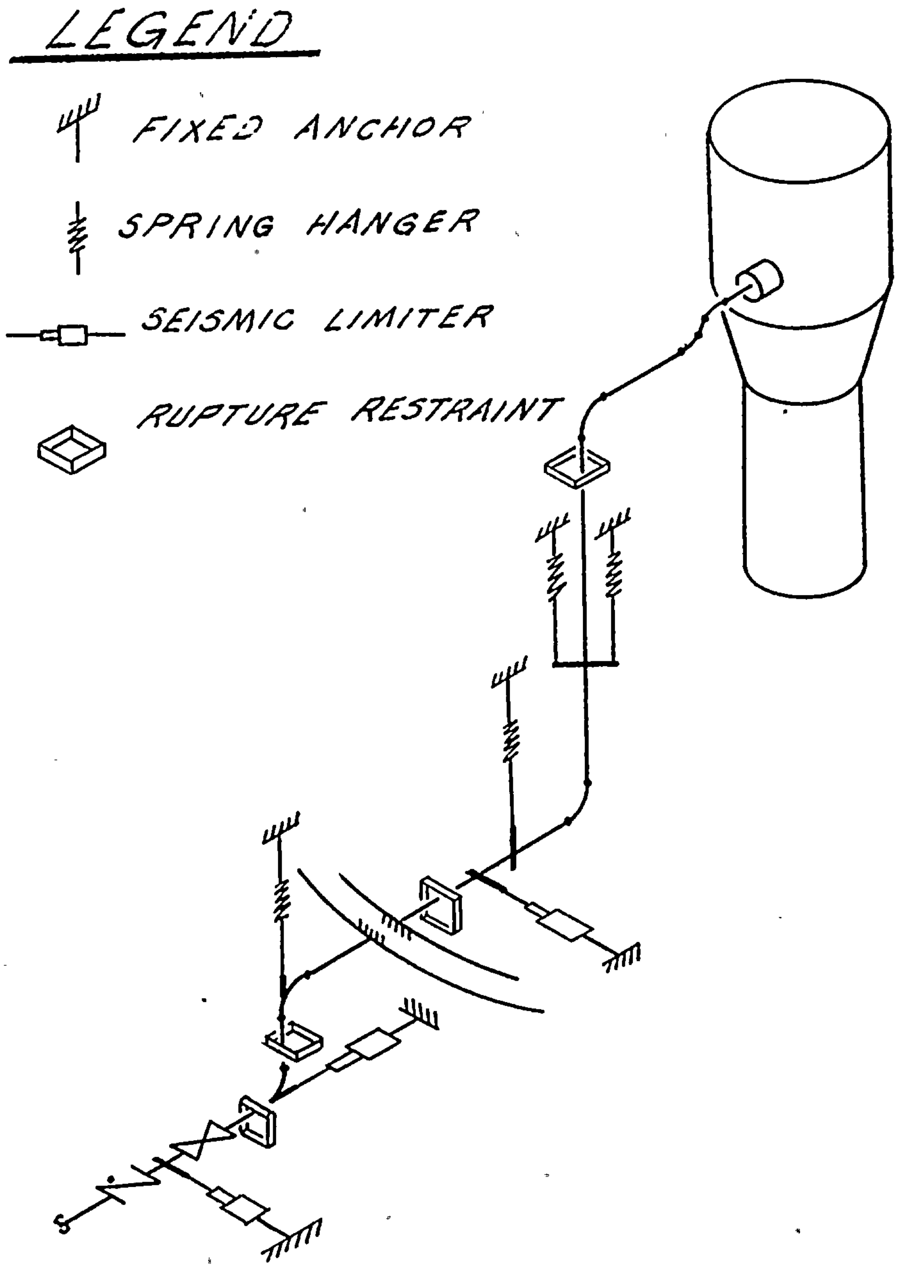
PIPING ISOMETRIC DIAGRAM
AUXILIARY FEEDWATER SUPPLY
STEAM GENERATORS 2-1 & 2-2



NOTES: 1_ FINAL DIMENSIONS BY FIELD MEASUREMET
2_ (H.) ANGLE ON HORIZONTAL PLANE
_ (V.) ANGLE ON VERTICAL PLANE
3_ THIS DWG NOT FOR CONSTRUCTION
4_ REF. /17\ COORD. 2-C THIS DWG. ADDED BYPASS 2-K16-4292-4 ON LINES 573 & 574 PER ECO M-100 & ECO M-449.

UNIT 2
DIABLO CANYON SITE

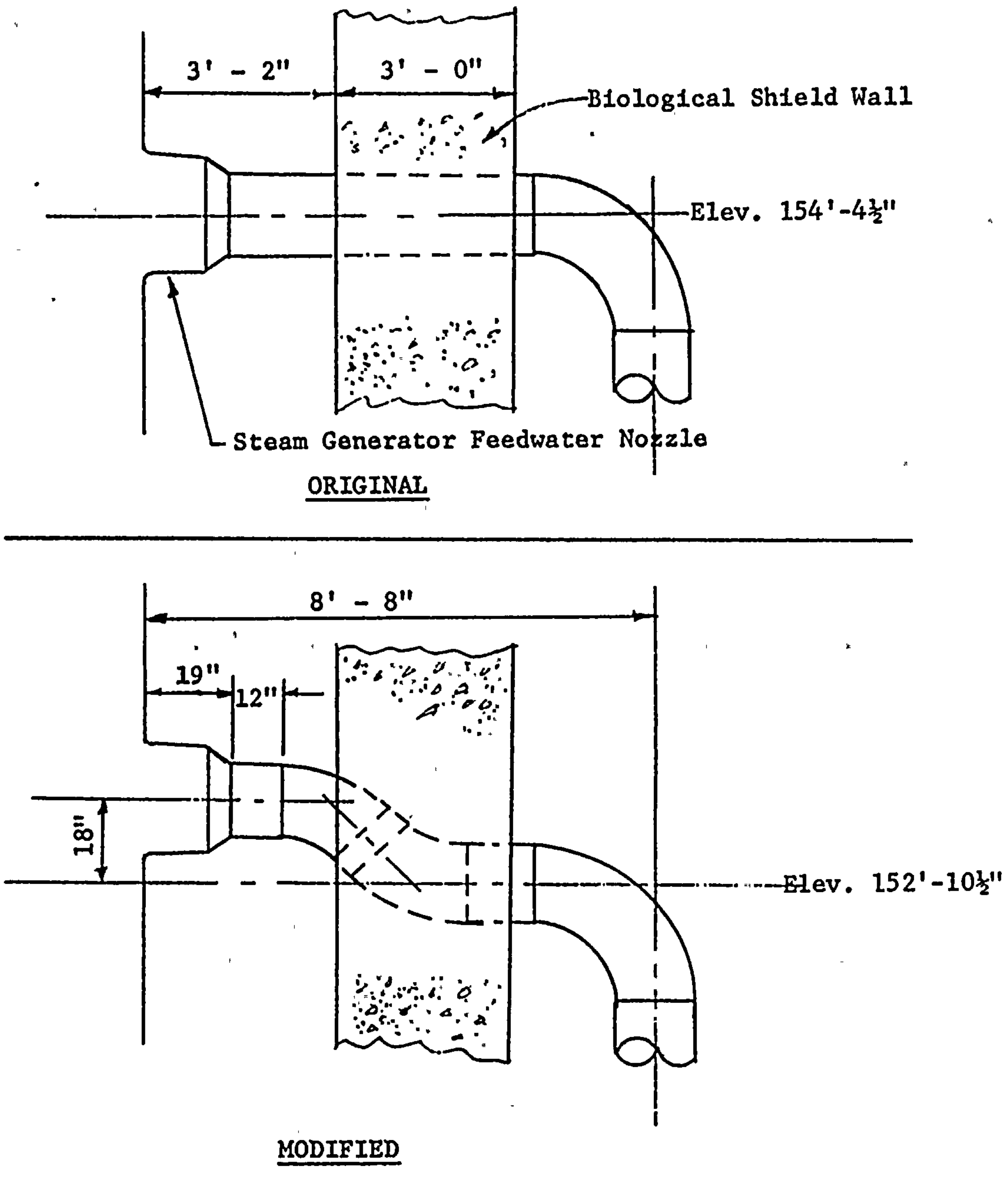
PIPING ISOMETRIC DIAGRAM
AUXILIARY FEEDWATER SUPPLY
STEAM GENERATORS 2-3 & 2-4



UNITS 1 AND 2
DIABLO CANYON SITE

FEEDWATER PIPING
TYPICAL SUPPORT ARRANGEMENT

STEAM GENERATORS 1 and 4

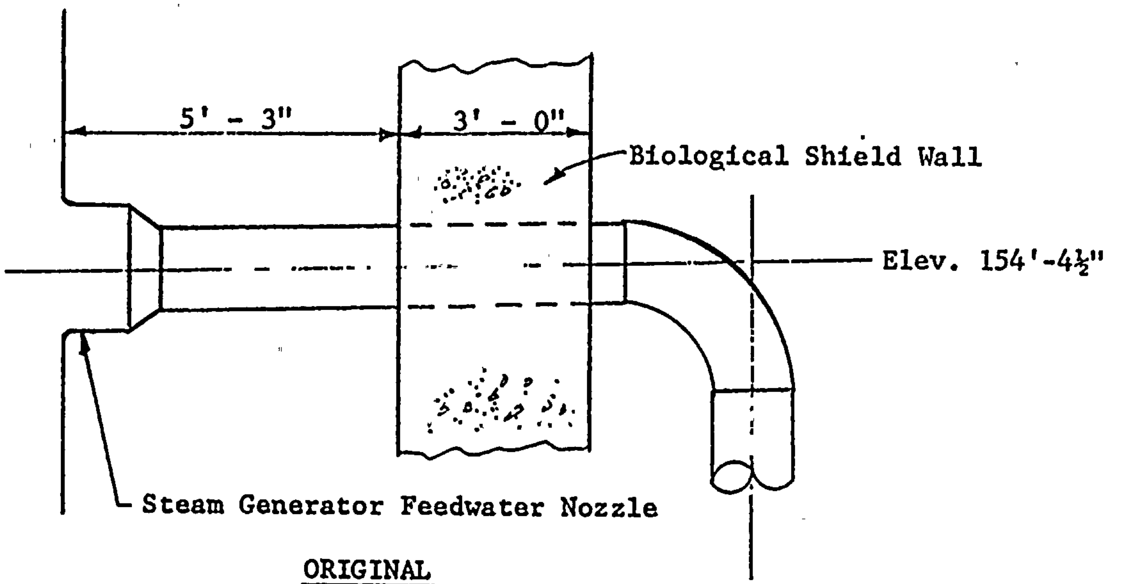


UNITS 1 AND 2
DIABLO CANYON SITE

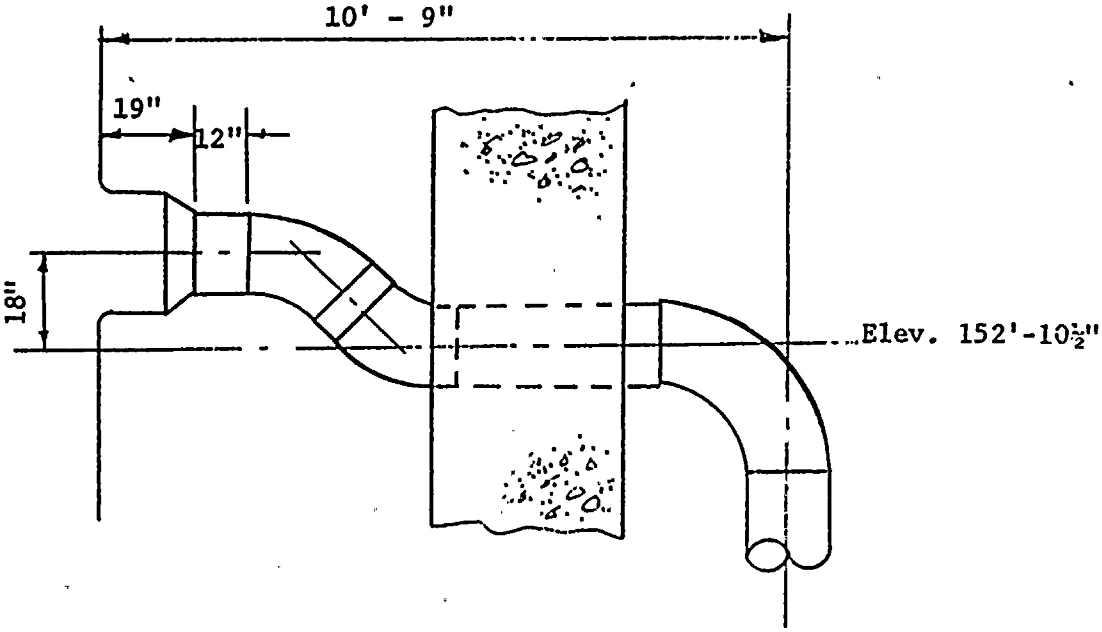
FIGURE 10.4-4A
REVISION OF STEAM GENERATOR
FEEDWATER PIPING
STEAM GENERATORS 1 AND 4

Amendment 29 June 1975

STEAM GENERATORS 2 and 3



ORIGINAL



MODIFIED

UNITS 1 AND 2
DIABLO CANYON SITE

FIGURE 10.4-4B
REVISION OF STEAM GENERATOR
FEEDWATER PIPING
STEAM GENERATORS 2 AND 3

Amendment 29 June 1975