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Beaver Valley Power Station
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June 14, 1991

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Subject: Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
Main Feedwater Piping Elbow Cracking
and Misalignment (TAC 79769)

Ref: Letter from A.W. DeAgazio (Nuclear Regulatory Commission) to J.D. Sieber (Duquesne Light Company), Subject: Main Feedwater Piping Elbow Cracking and Misalignment (TAC 79769), April 17, 1991.

This letter provides a response to the main feedwater system piping verification requested in the referenced letter. Each requested verification is presented followed by the actions taken to determine acceptability.

REQUESTED VERIFICATION

Verification that the affected feedwater piping satisfies the licensing basis for plant piping.

ACTIONS

A. Design change 1684 replaced monoballs on the A and C main feedwater lines with passive (rigid box) supports during the eighth refueling outage.

B. The operating manual procedures have been revised so that the main feedwater bypass regulating valves are normally closed above 30 percent power.

C. With the above changes in design and operation, applicable pipe rupture criteria in Regulatory Guide 1.46 can be satisfied at all power levels. Applicable pipe rupture criteria will be incorporated into the UFSAR as shown in the Attachment.

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REQUESTED VERIFICATION

Verification that the feedwater lines are free of binding or interference with pipe-rupture restraints under all thermal conditions.

ACTIONS

A. Main feedwater piping was walked down at the completion of design change 1684 and replacement of an elbow on the "C" loop. It has been verified that the lines are free of binding or interference with the pipe rupture restraints.

B. Analytical evaluations of main feedwater pipe movement were reviewed to verify that spacing at pipe supports and rupture restraints are adequate under all thermal conditions. This review entailed a comparison of existing gaps at restraints versus calculated displacements under all thermal conditions. Under stratified conditions, the piping will close gaps at specific restraints. This was incorporated in the analyses and it has been determined that piping will remain within the design basis stress criteria under all thermal conditions.

C. Temperature and displacement instrumentation has been installed at certain locations on main feedwater piping loops A and C to gather more information and further define Global Thermal Stratification effects. Each temperature monitoring location has a minimum of three (3) thermocouples located at the top, bottom and on the side of the pipe. Each displacement location has three (3) lanyards to measure the veritcal, lateral and axial deflections of the pipe.

Based upon the actions summarized above, we have concluded that the main feedwater piping has been restored to a satisfactory configuration for plant operation. Should you have any questions regarding this response, please contact Mr. Ken McMullen at (412) 393-5214.

Sincerely,

J. D. Sieber

J. D. Sieber
Vice President
Nuclear Group

Attachment

cc: Mr. J. Beall, Sr. Resident Inspector
Mr. T. T. Martin, NRC Region I Administrator
Mr. A. W. DeAgazio, Project Manager
Mr. R. Saunders (VEPCO)

ATTACHMENT

Beaver Valley Power Station, Unit No. 1
Main Feedwater Piping Elbow
Cracking and Misalignment (TAC 79769)

Updated Final Safety Analysis Report
Changes to Incorporate Regulatory Guide 1.46
Pipe Rupture Criteria

The missile with the highest kinetic energy-to-impact area ratio (KE/A), which is considered the most destructive missile, is a propane bottle relief device (Type 3) with KE/A of 7656 ft-lb per square inch. The KE/A of 9195 ft-lb per square inch for the design basis missile compared to the maximum KE/A from Table 5.2-15 justifies the "exclusion from further analysis" approach of the safety related equipment isolated by missile proof walls.

5.2.6.2 Exterior Missiles

The containment has not been analyzed for exterior missiles generated by hypothetical aircraft accidents, due to the site being located more than 5 miles from any airport (Table 2.1-7).

Tornado generated missiles discussed in Section 2.7 include one potential missile equivalent to a 35-ft long wooden utility pole impacting at a velocity of 150 mph.

5.2.6.3 Criteria for Protection Against Dynamic Effects Associated with a Major Pipe Rupture

The containment vessel and all essential equipment within the containment are adequately protected against the effects of blowdown jet forces and pipe whip resulting from a postulated pipe rupture of reactor coolant (Class 1), main steam, and feedwater (Class 2) lines. The criteria for adequate protection permits limited damage when analysis or experiment demonstrates that:

1. Leakage through the containment will not cause offsite dose consequences in excess of 10CFR part 100 guidelines.

2. The minimum performance capabilities of the engineered safety systems are not reduced below that required to protect against the postulated break.

3. A pipe break which is not a loss of reactor coolant will not cause a loss of reactor coolant or steam or feedwater line break. Also, a reactor coolant system pipe break will not cause a steam-feedwater system pipe break and vice versa.

This level of protection is assured by adherence to the following design criteria.

Placement of Piping and Components

The routing of pipe and the placement of components minimize the possibility of damage.

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The polar crane wall serves as a barrier between the reactor coolant loops and the containment liner. In addition, the refueling cavity walls, various structural beams, the operating floor, and the crane wall, enclose each reactor coolant loop into a separate compartment, thereby preventing an accident, which may occur in any loop, from affecting another loop or the containment liner. The portion of the steam and feedwater lines within the containment have been routed behind barriers which separate these lines from all reactor coolant piping. The barriers described above will withstand loadings caused by jet forces and pipe whip impact forces.

Other than for the Emergency Core Cooling System lines, which must circulate cooling water to the vessel, the engineered safety features are located outside of the crane wall. The Emergency Core Cooling System lines are routed outside of the crane wall so that the penetrations are in the vicinity of the loop to which they are attached.

Supplemental Protection

In those regions where the careful layout of piping and components cannot offer adequate protection against the dynamic effects associated with a postulated pipe rupture, restraints to prevent excessive pipe movement or special shielding is provided.

The careful layout of piping and components offers adequate protection against the dynamic effects associated with a postulated pipe rupture except in the case of the main steam and feedwater lines outside the crane wall and the pressurizer surge line.

In the case of the pressurizer surge line, a sufficient number of restraints are provided such that, following a single break, the unrestrained pipe movement of either end of the ruptured pipe about a plastic hinge formed at the nearest pipe whip restraint cannot impact any structure, system or component important to safety.

The basis for selecting break locations in the main steam and feedwater systems, whose piping is similar to ASME Boiler and Pressure Vessel Code, Section III, Class 2 piping, is discussed below, and is consistent with Regulatory Guide 1.46 "Protection Against Pipe Whip Inside Containment." Since the probability of rupture is strongly related to stress, only a limited number of break locations are postulated. Supplemental protection is provided on the main steam and feedwater lines for breaks at ~~all~~ locations ~~where the stress exceeds 80 percent of the allowable stress. A minimum of three break locations were postulated by the following criteria:~~ described below:

1. At the two terminal points

2. At the point of maximum primary plus secondary stress

3. At any other point where the primary plus secondary stress exceeds 80 percent of its allowable; i.e., $0.8\ (S_A + S_{\cancel{m}\,h})$, ~~or the secondary stress exceeds 80 percent of its allowable; i.e., 0.8 S_A, or the primary stress exceeds 80 percent of its allowable; i.e., 0.8 (1.2 S_m)~~.

The main steam and feedwater piping (similar to ASME Boiler and Pressure Vessel Code III, Class 2 piping) requires pipe break restraints in order to protect the integrity of the containment lines. ~~Of the~~ There are six piping runs. ~~five~~ Each run~~s each~~ contains a total of ~~four~~ three or more postulated break points. ~~The break locations are picked where there is a sharp change in stress level along the length of pipe. There seems to be no reasonable method to pick one point versus another when the stress level does not vary appreciably along the pipe run~~.

Table 5.2-16 gives the pipe break locations postulated for the three main steam and three main feedwater pipe runs inside the containment building. The loop A main steam line contains three break points and/or areas. Figures 5.2-33 through 5.2-38 coordinate the point numbers, given in Table 5.2-16 to a location along the pipe run. The restraint locations for main steam lines and for main feedwater lines are provided in Figures 5.2-39 and 5.2-40 respectively. Restraint locations are based upon what were, at the time of design fixing, the prevailing criteria for number and type of break.

Restraints offer good supplemental protection since pipe displacements are minimized and large kinetic energies are prevented.

The placement of the restraints will prevent excessive pipe displacements in the event of either a longitudinal split or circumferential break, or both, depending on the state of stress in the line.

In the area where the feedwater and the main steam piping penetrate the containment shell, the liner is also protected by an overlay of 1 1/2 inch thick quenched and tempered steel plate.

<u>Methods of Analysis</u>

Analyses are performed for pipe impact and jet impingement. In addition, major equipment supports are analyzed to ensure adequacy under postulated pipe rupture loads transmitted by attached piping.

For the purposes of design, unless otherwise stated, the pipe break event is considered a faulted condition, and the pipe, its restraint or barrier, and the structure to which it is attached are designed accordingly.

Restraints which require plastic deformation are based on 50 percent of ultimate strain.

The forces associated with both longitudinal and circumferential ruptures are considered in the design of supports and restraints in order to ensure continued integrity of vital components and engineered safety features.

The break area for both postulated break types is the cross-sectional area of the pipe. The break length for the postulated longitudinal breaks is assumed to be equal to twice the pipe diameter.

The analysis takes advantage of limiting factors on the blowdown thrust force, such as line friction, flow restrictors, pipe configuration, etc. A rise time is applied to the thrust force to simulate the crack opening time. A one millisecond rise time is assumed for circumferential breaks. For longitudinal splits, a rise time is computed based on the growth of a crack from a critical length to a length of two pipe diameters at a propagation rate of 500 ft/second.

Pipe Restraints

The restraints are designed with a gap sufficient to prevent interference with the normal thermal dynamic motion of the lines. This permits the pipe to acquire kinetic energy which must be dissipated upon impact into the restraint. This energy was conservatively set equal to the product of peak thrust times displacement. No energy dissipation mechanisms operating prior to impact, such as plastic deformation in the pipe, were considered. Static analyses of the deformation of the restraints and bolts provided the force displacements characteristics of the restraints. The area (energy) under this force-displacement curve was matched to the kinetic energy of the impacting pipe to determine the deformation and load. Based on recent, more detailed analyses, the conservatism of this design approach has been proven.

Figures 5.2-39 and 5.2-40 show the configurations of typical piping restraints and locations of such restraints for the main steam system and feedwater system, respectively. Figures 5.2-41 and 5.2-42 show the similar information for the pressurizer surge line.

The restraints consist of a circular arch (or yoke) and a welded base support structure that is bolted to a supporting wall. These restraints are designed so that, by the use of self-adjusting shims, the gap between the pipe and the inner surface of the restraint is kept as small as practicable while still allowing free thermal expansion of the pipe during plant operation.

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The barrier provided near the containment penetration is attached to the pipe penetration sleeve.

Equipment Supports

The internal structural system of the containment is designed to mitigate loading due to rupture in the main reactor coolant lines and the main steam and feedwater lines. Incident rupture is considered in only one line at a time. The support system is designed to preclude damage to or rupture of any of the other lines as a result of the incident. The snubber and key systems are designed to deliver rupture thrusts on the steam generator into the internal structural system. In determining the steam generator support reactions, the system is reduced to a dynamic model consisting of a suitable number of masses and resistance elements. The dynamic problem is solved by numerical methods, using a thrust time history as loading. Resistance, dynamic amplification of the thrust, and rebound forces are calculated as a function of time. The reactor vessel and support system is similarly treated.

5.2.6.4 Pipe Whip Analysis

The analysis of the restrained piping within the containment was completed and the fabrication of restraints begun before any officially acceptable criteria for analysis was published. Subsequent to the completion of the analysis, analytical methods and criteria to be used in determining pipe whip analysis was transmitted to DLC from the AEC. The analytical methods and criteria are provided in Attachment A to Section 5.2, "Pipe Whip Analysis Guidelines". The analytical methods and criteria used were similar to, but not identical with, those outlined in Attachment A. To facilitate a comparison, the original criteria is provided in Attachment B using the format of Attachment A and a point-by-point comparison is presented. Emphasis is placed on those criteria which differ.

5.2.7 Corrosion Protection and Coatings

5.2.7.1 Steel Liner

The exterior of the steel liner is not coated because it is in intimate contact with the concrete and has adequate protection from corrosion. The interior of the steel liner has an inorganic zinc coating with a white epoxy topcoating which provides protection for both normal operating and accident conditions.

5.2.7.2 Concrete and Structural Steel

All interior concrete and structural steel surfaces in the containment structure were given a coating suitable for service under DBA conditions. The steel floor grating is galvanized.

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TABLE 5.2-16

PIPE BREAK LOCATIONS~~(1)~~

Location	Main Steam Lines 32-SHP-56	32-SHP-57	32-SHP-58	Feedwater Lines 16-WFPD-22	16-WFPD-23	16-WFPD-24
Terminal Points	3 200	3 300	3 400	199 244(1)	98 128(1)	140 188
Point of Maximum Primary + Secondary Stress	84	204	204	~~307~~ 203	~~102~~ 110	~~144~~ 184
Point Where $P + S > .8 (S_a + S_h)$	None	None	None	245(1) ~~None~~ 203 307	~~None~~ 127(1) 110	~~None~~ 188
~~Point Where $P > .8$ Allowable = $.8(1.2) S_a$~~	~~None~~	~~15~~	~~203(2) 204(2)~~	~~203(2) 202(2) 307~~	~~102(2) 101(2) 110~~	~~144(2) 143(2)~~
~~Point Where $S > .8 S_a$~~	~~None~~	~~None~~	~~None~~	~~None~~	~~None~~	~~None~~
Total Points	3	~~4~~ 3	~~4~~ 3	5	~~5~~ 4	~~4~~ 3
Total Areas	3	~~4~~ 3	~~3(2)~~ 3(1)	~~4(2)~~ 4(1)	~~4(2)~~ 3(1)	~~3(2)~~ 3(1)

Where: P = Primary Stress
S = Secondary Stress

S_h, S_a are defined in ASME III NC3611

Note: ~~(1) With the exception of Pt 180 on 16-WFPD-24 all points listed above are at elbows.~~

(1) ~~(2)~~ Because of the proximity of two points, the area between the two points is considered one break area.

not preclude the system's ability to perform its function. The positions of these valves are indicated in the control room. The instrumentation, control and electrical equipment of this system conforms to the requirements of Institute for Electrical and Electronic Engineers (IEEE) 279-1971 Criteria for Protection Systems for Nuclear Power Generating Stations and IEEE 308-1971 Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

10.3.5.2 Description

10.3.5.2.1 Condensate and Feedwater Systems

Condensate is withdrawn from the condenser hotwells by two half-size capacity motor-driven condensate pumps. The pumps discharge into a common header which carries the condensate through two steam jet air ejector condensers arranged in parallel and through one gland steam condenser. A flow control valve and a bypass around the gland steam condenser ensure that no more than maximum design flow passes through the gland steam condenser. Downstream of the gland steam condenser, the common header divides into two lines which carry the condensate through the tube side of two trains of heat exchangers arranged in parallel, each consisting of one heater drain cooler and five low pressure feedwater headers (No. 2 through 6), each half-capacity. The effluent from each train combines into a common suction header for the two half-size design capacity steam generator feedpumps. Manual valves permit isolation of one train of heaters for maintenance without a station shutdown.

The condenser hotwell is designed to operate at normal level such that 4 minutes of condensate flow (71,000 gal) is available to supply the condensate pumps. A 200,000 gal turbine plant demineralized water storage tank floats on the system. Each of the two vertical barrel-type condensate pumps is rated at 9,700 gpm at 1,078 ft TDH. Minimum flow of approximately 3,000 gpm total for each of the two condensate pumps is maintained by an orifice measuring device downstream of the gland steam condenser. The orifice measuring device operates the recirculation valve as shown in Figure 10.3-4.

Two half-size steam generator feedpumps, each rated at 15,200 gpm and 1,700 ft TDH, are furnished to supply feedwater to the three steam generators. Each feedpump is equipped with two 4,000 hp electric motor drivers in tandem. Minimum flow for each pump is maintained by administrative control and an automatic recirculation control and alarm system, consisting of: flow measuring nozzles, flow totalizer, controller, and recirculation valves. The recirculation valves normally maintain a minimum flow of 8,000 gpm per pump. Feedwater leaves the first-point heaters at 440°F.

The steam generator feedpumps discharge through two half-size design capacity high pressure feedwater heaters (No. 1), arranged in parallel, to a common discharge header for distribution to the steam generators through individual feedwater flow control valves,

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positioned by the three-element feedwater control system for each steam generator. A manual bypass around each first-point heater allows isolation of these heaters for maintenance without a station shutdown. During low power operation or hot shutdown, when feedwater flow is below 20 percent of design flow, a bypass valve around each feedwater control valve provides steam generator level and feedwater flow control. The automatic control of the steam generator water level at low power using the feedwater bypass valve is also discussed in Section 7.7.1.7.

INSERT ----->

An automatic bypass is used to bypass all the low pressure heaters between the condensate pump discharge and the steam generator feedpump suction in the event of a sudden load reduction. This enables the condensate pumps to supply adequate suction to the steam generator feedpumps.

Drains from the moisture separator reheater units and the No. 1 and No. 2 feedwater heaters are collected in the heater drain tank and pumped into the suction of the steam generator feedpumps by one of the two full-capacity heater drain pumps. Drains from heater No. 3 cascade to heater No. 4 and from heater No. 4 to heater No. 5 and from heater No. 5 through the drain cooler to the condenser. Drains from heater No. 6 flow directly to the condenser. An alternate drain line is provided directly to the condenser from the heater drain tank and feedwater heaters Nos. 1, 3, 4, 5 and 6.

Condensate from the condenser hotwell may be discharged under administrative control through either a double valved connection line to the circulating water line, if activity levels permit, or through a normally closed connection to the liquid waste disposal system (Section 11.2.4). The condensers may also be emptied by pumping, with the condensate pumps, into the turbine plant demineralized water storage tank. This tank also supplies makeup to the condenser hotwells. During normal operation, discharge of condensate to the tank and makeup from the tank are automatically controlled by the hotwell level.

Chemical feed equipment is used to add chemical solutions to the discharge of the condensate pumps in the condensate and feedwater systems. The chemicals control residual oxygen content, maintain pH at levels specified in the BVPS-1 Chemistry Manual and inhibit corrosion so as to reduce pickup of metal by the feedwater.

Solutions are mixed and stored in covered feedtanks. The solutions are pumped into the main condensate system by motor-driven positive displacement pumps with manually adjustable stroke.

10.3.5.2.2 Auxiliary Feedwater System

The steam generator auxiliary feedpumps are used as an emergency source of feedwater supply to the steam generators. They are required to ensure safe shutdown in the event of a main turbine

THERMAL STRATIFICATION IN THE MAIN FEEDWATER PIPING

Insert the following paragraph where indicated in Section 10.3.5.2.1 "Condensate and feedwater Systems," Page 10.3-15.

When a reactor trip occurs feedwater control valves are closed and auxiliary feedwater flow is initiated. Flow continues into the main feedwater piping downstream through the bypass valve. Continued flow through the bypass valve combines with cold auxiliary feedwater flow to cause thermal stratification in the downstream main feedwater lines. This stratification in the main feedwater lines can cause increased stress levels in the main feedwater piping and supports. Therefore, the bypass valve around each main feedwater control valve must be isolated above 30 percent power to prevent the possibility of increased stress levels resulting from thermal stratification.[2]

Add the following reference to the list of Section 10.3 references on Page 10.3-27:

2. Letter from J.D. Sieber (Duquesne Light Company) to A.W. De Agazio (Nuclear Regulatory Commission), Subject: Main Feedwater Piping Elbow Cracking and Misalignment - TAC 79769 (June 1991).

References for Section 10.3

1. DLC NED Analysis 8700-21-5, Rev. 0. Addendum 1, dated June 1986.

INSERT ----->

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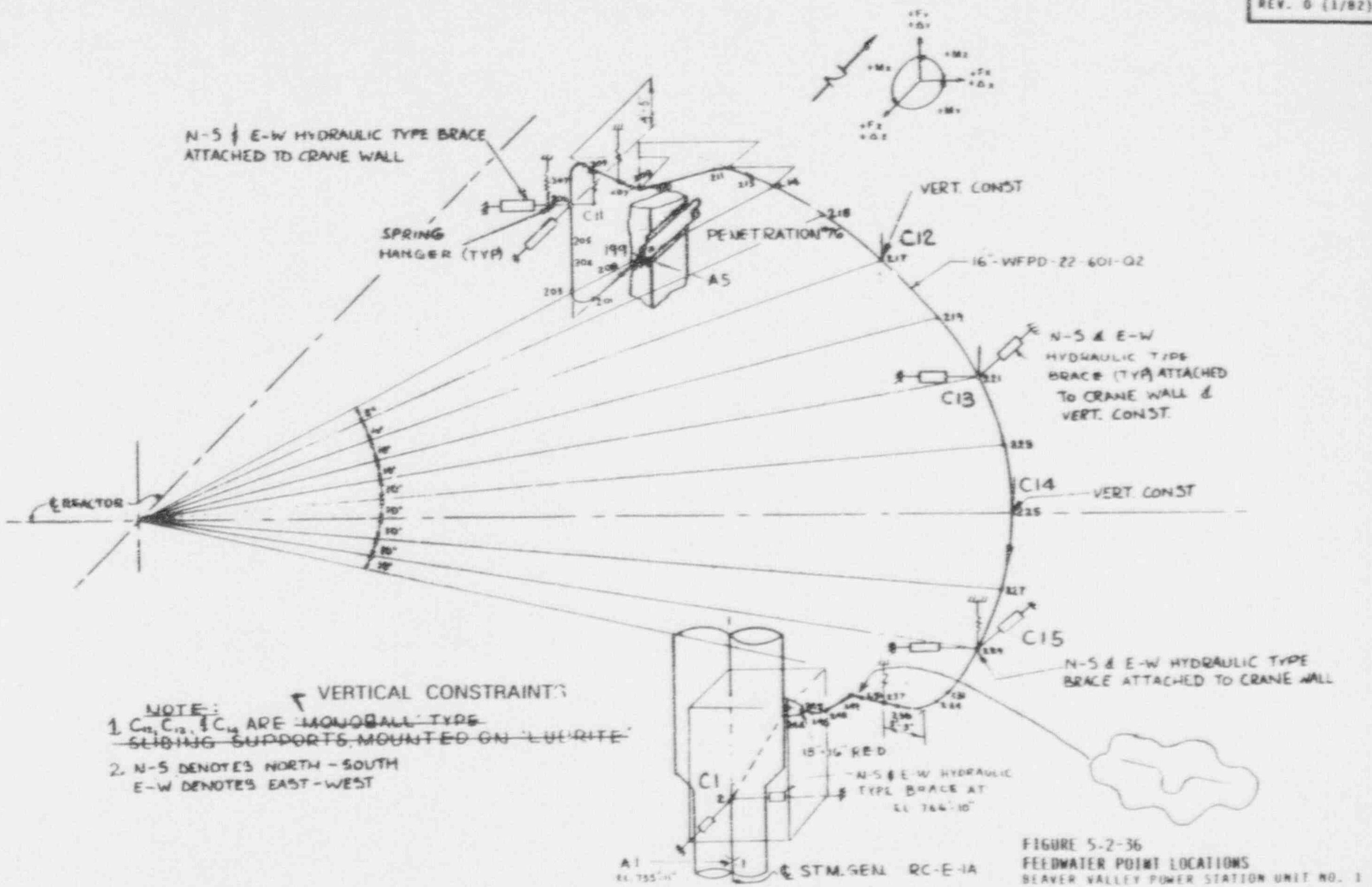

FIGURE 5.2-36
FEEDWATER POINT LOCATIONS
BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT

REV. 0 (1/82)

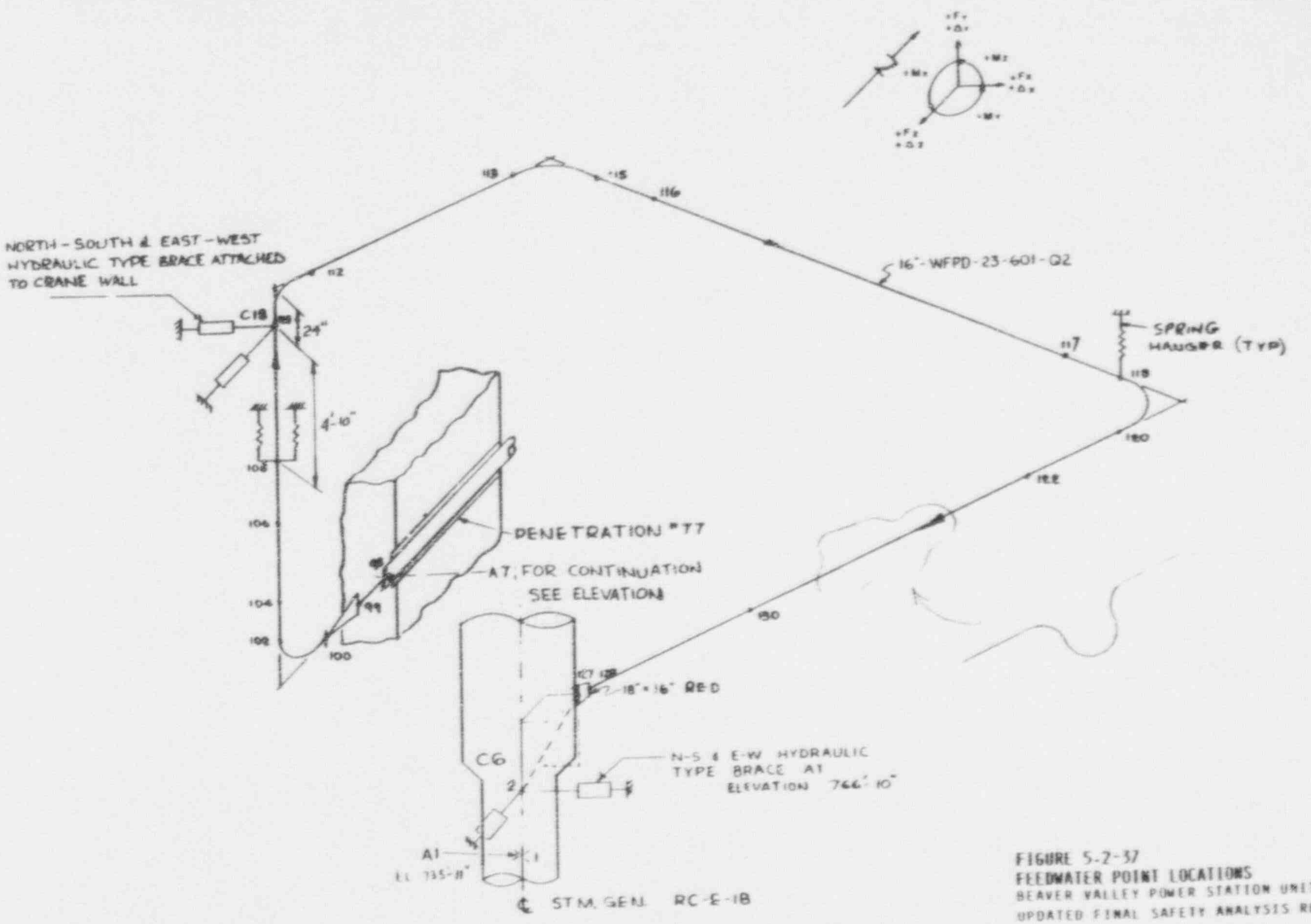

FIGURE 5.2-37
FEEDWATER POINT LOCATIONS
BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT

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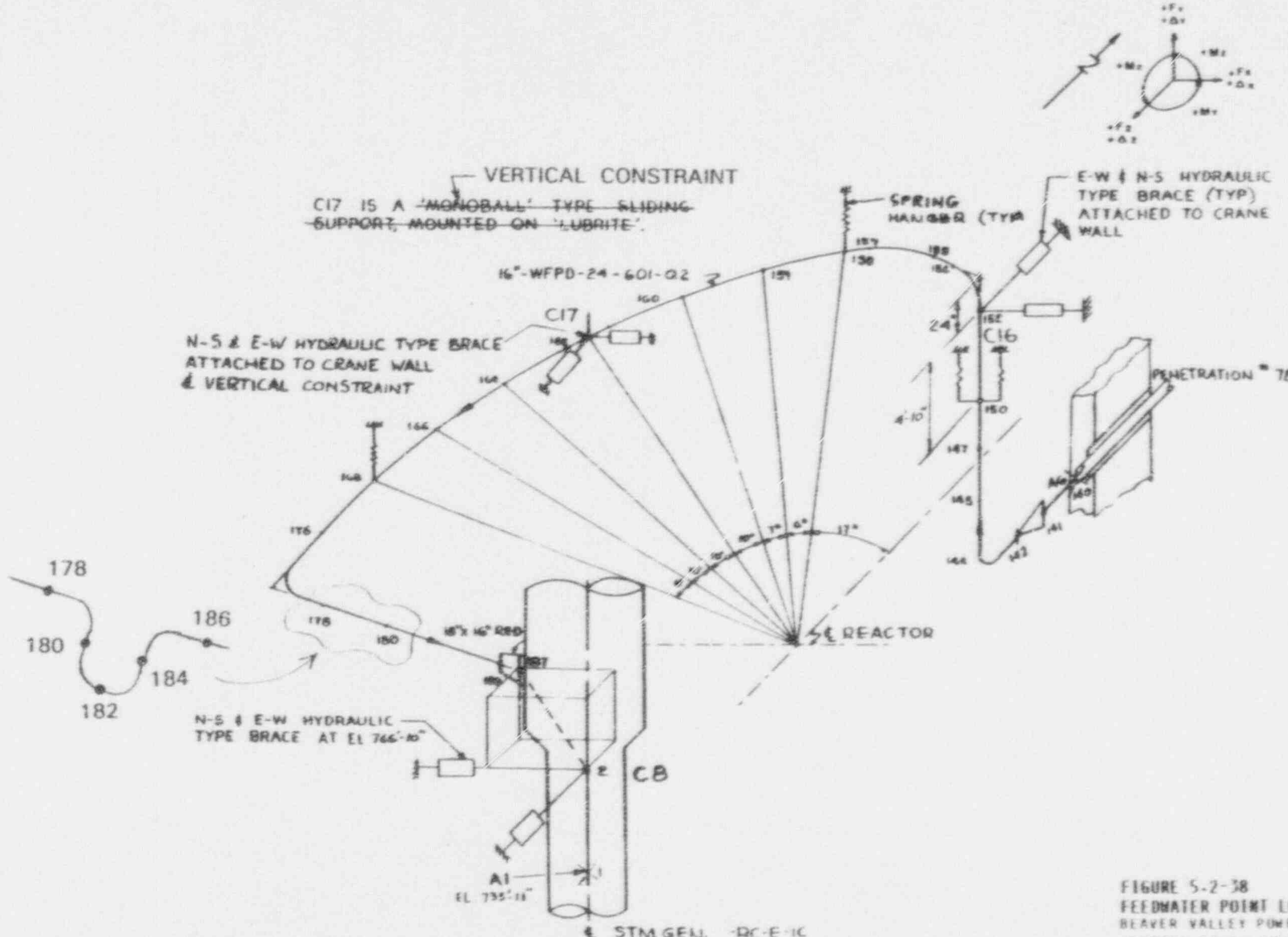

FIGURE 5.2-38
FEEDWATER POINT LOCATIONS
BEAVER VALLEY POWER STATION UNIT NO. 1
UPDATED FINAL SAFETY ANALYSIS REPORT