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August 10, 1982

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Byron Station Units 1 and 2
Braidwood Station Units 1 and 2
High and Moderate Energy Pipe
Break Analyses
NRC Docket Nos. 50-454, 50-455,
50-456, and 50-457

References (a): June 28, 1982, letter from
T. R. Tramm to H. R. Denton.

(b): January 19, 1982, letter from
T. R. Tramm to H. R. Denton.

(c): January 9, 1982, letter from
T. R. Tramm to H. R. Denton.

Dear Mr. Denton:

This is to provide advance copies of information to be included in the Byron/Braidwood FSAR regarding the analyses of high and moderate energy pipe breaks. NRC review of this information should close Outstanding Item 3 of the Byron SER.

Enclosed with this letter is a revised response to question 010.40. This response contains additional information requested by the NRC during the review of previous versions transmitted in references (a), (b) and (c). This version will be incorporated into the FSAR in the next amendment.

Please address further questions regarding this matter to this office.

One signed original and fifteen copies of this letter and the enclosure are provided for your use.

Very truly yours,

T. R. Tramm

T. R. Tramm
Nuclear Licensing Administrator

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QUESTION 010.40

"Provide a response to Question 010.17 and include the following in your response. Provide the results of analyses of the effects on safety-related systems of failures in any high or moderate energy piping system in accordance with the J. F. O'Leary letter of July 12, 1973, as defined in Branch Technical Position ASB 3-1, Appendix C. Provide a table which identifies the method of protection provided all safety-related systems listed in FSAR Table 3.6-1 from failures of any high or moderate energy systems listed in FSAR Table 3.6-2. Include figures depicting the locations of failures relative to the systems of FSAR Table 3.6-1 giving dimensions, locations and protective method for each postulated break or crack in a high or moderate energy system. Include the assumptions used in your analysis such as flowrates through postulated cracks, pump room areas, sump capacities, and floor drainage system capacities."

RESPONSE

I. INTRODUCTION

To ensure safe and reliable operation of the Byron and Braidwood Nuclear Power Stations, the possibility of high or moderate energy line breaks have been considered in the design. This response documents a confirmatory study of the potential high and moderate energy line breaks which demonstrates that all design features necessary to mitigate the results of line breaks have been incorporated.

Standard Review Plans (SRP) 3.6.1 and 3.6.2 were used as the basis for this study. SRP 3.6.1 includes Branch Technical Position (BTP) APCSB 3-1. Appendix B of the BTP, the attachment to letters sent to applicants and licensees by A. Giambusso in December 1972, and Appendix C to the BTP, the July 12, 1973 letter to applicants, reactor vendors and architect-engineers from J. F. O'Leary, provide the basis for identification of high energy line breaks and evaluation of their consequences.

Piping drawings which identify the high energy lines are included in the FSAR (Figures 3.6-1 through 3.6-12). Breaks have been postulated at the locations required by Branch Technical Position APCSB 3-1 for the purpose of assessing pipe whip and jet impingement effects. Pressure and temperatures in areas were calculated assuming the break occurs in the limiting location in the area. Locations of mitigating features such as pipe restraints and impingement shields are shown in Section 3.6 of the FSAR. Drawings showing the location of high energy lines have been provided to the NRC ASB reviewer. These drawings also indicate location of subcompartment walls and pipe tunnels.

II. SCOPE

The effects of high and moderate energy line breaks inside containment have been assessed as described in FSAR Sections 3.6 and 6.2. Additionally, an investigation into the effects of high and moderate energy line breaks outside containment has been made and is described in this response. Non-safety related areas, such as the turbine building, were not investigated because damage to or failure of equipment in these areas will not affect plant safety.

The possible effects considered are structural loads due to pressurization, increases in pressure and temperature which could affect environmental qualification of equipment, and damage due to pipe whip and jet impingement. Flooding is a potential effect but is not addressed in this response. The response to Question 010.47 demonstrates that high and moderate energy line breaks will not cause flooding which would adversely affect the plant safety.

Because of variations in requirements, techniques, and failure effects, high and moderate energy lines are addressed separately. Similarly, the pipe whip, subcompartment pressurization, and environmental analysis all have somewhat different approaches. The following sections are divided to reflect these distinctions.

III. HIGH ENERGY LINE ANALYSIS

Standard Review Plans 3.6.1 and 3.6.2 were followed in defining and identifying high energy lines. High energy lines are those larger than 1 inch diameter for which either:

a. The service temperature is greater than 200° F; or

b. The design pressure is greater than 275 psig.

Only a limited number of systems in the auxiliary building meet either of these criteria. The following systems have been identified as containing high energy lines in the auxiliary building:

Chemical and Volume Control	(CV)
Auxiliary Steam	(AS)
Steam Generator Blowdown	(SD)
Radioactive Waste Processing	(WX)
Boric Acid	(AB)
Main Steam	(MS)
Feedwater	(FW)
Auxiliary Feedwater	(AF)
Residual Heat Removal	(RH)
Safety Injection	(SI)

Systems which are normally not used or at reduced temperature and pressure are not necessarily required to be considered as high energy lines. A guideline has been established (Branch Technical Position MEB 3-1) that if the system is at high energy conditions less then 2% of the time, it may be considered a moderate energy line and its normal conditions applied to the line break analysis. On this basis, the last three systems (AF, RH, SI) are not considered as high energy systems. The Byron/Braidwood AF system is not used for normal startup as at some other plants. The only high energy line in the boric acid system is a steam supply line to the boric acid batching tank. This line is essentially a part of the auxiliary steam system and, as a result, was not identified in FSAR Table 3.6-2.

Subcompartment pressurization is investigated for all lines with temperatures above 200° F. Lower temperature lines do not have the potential for flashing to steam and thus will not increase the pressure of a subcompartment in the event of a break. Pressurization is of concern only in small subcompartments with relatively large high energy lines or subcompartments with limited pressure relief venting.

High energy lines below 200° F have only minor effects on the environmental conditions. The absence of steam and the ability to drain warm liquid from the break area limits the temperature rise from these breaks. The auxiliary building HVAC has sufficient capacity to accommodate these lower temperature breaks. Breaks of other high energy lines may influence the expected maximum temperature in some areas of the auxiliary building even if high pressures do not result. The auxiliary building contains several large areas with high energy lines that are not subject to pressurization but are investigated for environmental effects.

Certain postulated break locations in high energy piping systems are used to investigate the potential for damage due to pipe whip and jet impingement. The guidelines in Standard Review Plan 3.6.2 are used to determine the number and locations of the pipe breaks. Pipe restraints are added as required to prevent damage to structures and safety-related equipment.

IV. MODERATE ENERGY LINE BREAKS

Moderate energy lines are lines which operate at temperatures below 200° F and pressures below 275 psig. A break in a moderate energy line will not result in flashing of the liquid to steam and, as a result, has no potential for pressurization of areas. The relatively low temperature and reduced heat transfer effects of the liquid blowdown precludes significant temperature increases in the area of the break. The reduced break area applicable to these breaks and the absence of steam allows the auxiliary building HVAC to maintain temperatures within those specified in the environmental qualification program. The results of moderate energy line breaks are, therefore, confined to the physical effects of liquid discharge into the plant. Plant safety is affected only if equipment required to mitigate the break or to safely shut down the plant can be damaged by resultant flooding or water spray. Flooding is discussed in the response to Question 010.47. Water spray was not found to affect plant safety because of the separation of redundant safe shutdown systems and components. Moderate energy line breaks do not result in pipe whip.

As an example, the auxiliary building basement at elevation 330 feet is subject to severe flooding following a moderate energy line failure in the essential service water system. The limiting failure in this area is a crack in a 36-inch essential service water line. The predicted leak rate is 2.8 ft^3/sec. The basement is divided into two completely independent sections. These sections are separated by a wall which has been designed to withstand the flooding. Each section contains redundant essential service water pumps which can supply both units. Therefore, flooding or spray from a break cannot affect the equipment in the other section of the basement and essential service water will be supplied to both units.

This separation is well documented in the Fire Protection Report. This report lists and locates equipment required for safe shutdown. When redundant safe shutdown systems are separated by fire walls or by more than 20 feet, spray from a crack in a moderate energy line would not impair the safe shutdown capability of the plant.

A moderate energy line break in the component cooling system was given special consideration because the component cooling system is not supplied with a Category I source of makeup water. A leak in this system could theoretically drain the surge tanks and result in damage to the component cooling pumps.

A significant leakage in the component cooling system is not expected. The system is a moderate energy, low pressure system and is not subject to severe loading. In the event the system is inoperable, the plant may be safely maintained in a hot shutdown condition until the component cooling system is restored.

If a crack is postulated in one of the large lines in the system, the level in the surge tank of the affected unit will drop. When the level reaches the low setpoint level, alarms will sound and the affected units component cooling pumps will be automatically tripped to prevent damage to the pumps.

If reactor water or demineralized water makeup is available, the component cooling pumps may be restarted and the unit operated normally while the leak is located and isolated. Otherwise, the reactor will be tripped because of the interruption of component cooling to the reactor coolant pumps and the unit will be placed in a hot shutdown condition. Component cooling is not required to safely maintain the unit in hot shutdown mode. The component cooling system can be operated after a failure of the piping by closing the appropriate system valves to isolate the break location and maintain component cooling flow.

V. SUBCOMPARTMENT PRESSURIZATION

For the purpose of protecting subcompartments from overpressurization, the CV, AS, SD, WX, MS, and FW systems were traced through the auxiliary building and all subcompartments containing high energy lines were identified. The most severe break in the subcompartment was analyzed.

The main steam (MS) and feedwater (FW) systems are routed entirely in an enclosed tunnel in the auxiliary building. The limiting break in this tunnel is a main steam line rupture. Section C3.6 fully describes an analysis of a break in this tunnel.

The remainder of the auxiliary building was surveyed level by level to identify all subcompartments which could be pressurized by high energy line breaks. Figures Q10.40-1 through Q10.40-5 identify all areas containing high energy lines. The identification of the limiting line in each zone is also included. The zone numbers do not correspond to environmental qualification zones (Section 3.11).

Figure Q10.40-1 represents elevation 346 feet 0 inch. Zone 1, the recycle waste evaporator room, has been analyzed and the results are reported in Section A3.6 of the FSAR. Zones 2 and 3, letdown reheat heat exchanger rooms and valve areas, have been analyzed and the results are reported in Section A3.6. The assessment in A3.6 addressed Zone 3, the more limiting zone.

Figure Q10.40-2 represents elevation 364 feet 0 inch. Assessment of Zones 5A and 5B, the positive displacement charging pump areas, predict a peak pressure of 2.42 psid and a peak temperature of 190° F. These results are being added to Section A3.6 of the FSAR. Zones 6A, 6B, 7A, and 7B, the centrifugal charging pump rooms, contain high pressure, low temperature lines. Failure of these lines (normal temperature of 115° F) will not cause pressurization or increase temperatures. Pipe whip and impingement are considered. Zones 9A and 9B contain portions of the steam generator blowdown system. Control valves upstream of these lines limit the blowdown flow and prevent the postulated breaks from impacting plant design. Zones 8A and 8B, blowdown condenser rooms, have been analyzed and the results are included in FSAR Section A3.6. Zones 11 and 12, blowdown condenser rooms, have been analyzed and the results are reported in Section A3.6.

Figure Q10.40-3 represents elevation 383 feet 0 inch. Zones 11A, 11B, 11C, and 11D, letdown heat exchanger rooms, have been analyzed and the results are reported in Section A3.6. Zone 13, the auxiliary steamline piping tunnel, has been analyzed and the results are reported in Section A3.6. Zones 12A and 12B are very similar to Zones 11A through 11D in break size and subcompartment size and, therefore, the existing results are adequate. Zones 10A and 10B are large areas with only small high energy lines. The impact of a break in these areas is discussed in Section VI.

Figure A10.40-4 represents elevation 401 feet 0 inch. Zones 16A, 16B, and 16C, the surface condenser rooms, have been analyzed and the results have been reported in Section A3.6. Zone 15, boric acid tank room, has been analyzed and the results have been reported in Section A3.6. Zone 14 is a large open area. The limiting high energy line break is a 2-inch auxiliary steam line. This event is discussed in Section VI.

Figure Q10.40-5 represents elevation 426 feet 0 inch. Zones 18A, 18B, and 18C, radwaste evaporator rooms, have been analyzed and the results are reported in Section A3.6.

VI. ENVIRONMENTAL QUALIFICATION

A program to document the environmental qualification of electrical equipment is underway for Byron/Braidwood. The scheduled completion date for this program is June 1982. This program will establish that the equipment required to safely shut down the plant will be operable under potentially adverse environmental conditions.

One of the potential causes of severe environmental conditions is a break or crack in a high or moderate energy line. This could cause an increase in pressure, temperature, or humidity or a flooding condition in the area of the break. Flooding is addressed in the response to Question 10.47 and will not be discussed here.

The basic design of the Byron/Braidwood stations includes features to mitigate the impact of line breaks on the ability to safely shut the plant down. Some of the features are:

a. Essential safety systems are redundant or backed up by other safety systems;

b. The effectiveness of the redundancy is protected by separation of redundant systems to the greatest extent possible;

c. Walls and compartments have been included to both protect equipment and to isolate breaks;

d. Large high energy lines such as main steam, feedwater, and auxiliary steam are partially or completely enclosed in protective tunnels in the auxiliary building;

e. Efforts have been made to minimize the number of high energy lines in areas containing safety related equipment and to minimize the size and length of high energy lines. For example, Byron/Braidwood uses motor and diesel driven auxiliary feedwater pumps rather than turbine driven pumps, thereby eliminating the associated high energy steamlines.

The zones identified in Section V for high energy line breaks analysis are included in the environmental zones. Table 3.11-2 and Figure 3.11-1 have been updated to include these environmental conditions. The subcompartment transient conditions calculated in the pressurization analysis are used for qualification of equipment in the subcompartment required to safely shut down the plant following the postulated break.

The large general areas containing high energy lines are not subject to pressurization but the temperature in the area may be affected. The general areas were examined to locate limiting high energy lines and a conservative affected area was defined. Large areas separated from breaks by doorways or other restrictive passages were not evaluated because of the restricted flow and the relatively large areas which dilute the break flow. Only two areas were identified which contain high energy lines.

The areas identified as 4A, 4B, 10A, and 10B are actually interconnected. All are affected by breaks at various locations in a three inch letdown line in the chemical and volume control system. Orifices in the system limit the flow to a maximum of 120 gpm. The portion of the break which flashes to steam will rise to the upper portions of Zone 4A/4B and flow out through openings into the upper levels of the auxiliary building. The break flow duration will be limited because two main control board alarms (high flow and high letdown heat exchanger outlet temperature) will immediately sound. The break will be isolable with containment isolation valves. As a result of the limitied flow from this break and the dilution area which is extremely large, the temperature of the air in these zones will not exceed the maximum temperatures predicted during operating transients and an additional accident environment is not necessary. If the break is in the upper portion of Zone 10A/10B, the potential exists for heating a restricted area with no natural ventilation. None of the equipment in this area is required for safe shutdown following a letdown line failure. This scenario is discussed further in the Byron/Braidwood equipment qualification report.

The other area investigated was Zone 15 at elevation 401 feet. This open area contains a two inch auxiliary steam line. Failure of this line would release steam into the general area. The only equipment required for plant shutdown which could be affected are the boric acid transfer pump motors. The pumps are not required to bring the plant to a hot standby condition. Cold shutdown can be achieved by using water from the refueling water storage tank to increase the reactor coolant boron concentration, eliminating the need for the boric acid transfer pumps. Under certain conditions, required boration may be achieved using only the charging system. Under other conditions, reactor coolant letdown may also be required. Since a total loss of capability to charge or let down the reactor coolant system would not result from an auxiliary steamline break, cold shutdown capability will not be lost. Flow into adjacent areas would eventually occur but the dilution would be so great that the temperature of the adjacent areas would remain effectively unchanged.

Table 3.11-2 and Figure 3.11-1 have been updated to include the environmental conditions discussed here.

Moderate energy line breaks do not impact the equipment qualification parameters. For lines with operating temperatures significantly above the normal area temperature, the crack flow rate and potential for heat transfer has been checked to ensure that sufficient HVAC capacity exists to prevent failure of required safety related equipment.

VII. PIPE WHIP

The methodology employed in the analysis of pipe whip is explained in detail in Subsection 3.6.2. Standard Review Plan 3.6.2 is followed. As discussed in the previous section, plant design features eliminate most pipe whip concerns.

Break locations have been defined for all high energy lines following the procedures in Standard Review Plan Section 3.6.2. Structural, piping, and equipment targets have been located in the vicinity of the breaks and the potential for damage assessed. Restraints have been added where required to protect the plant structure or systems.

Of the systems listed in Section III, the main steam and feedwater are of most concern due to the large size and high pressure. The postulated break locations and the resulting restraint locations for the main steam and feedwater lines in the auxiliary building (main steam tunnel) are shown in Figures 3.6-43 and 3.6-44.

In the remaining systems for which high energy line breaks must be postulated (CV, AS, SD, WX, AB systems), the lines in many cases are not highly stressed or do not have the potential of impacting safety systems. The CV system, which contains high pressure lines, has been investigated and nine pipe restraints have been added.

VIII. JET IMPINGEMENT

The approach to jet impingement is described in FSAR Subsection 3.6.2. The break locations defined for the pipe whip investigation were also examined for jet impingement effects. The majority of locations had no effect on equipment required for safe shutdown. This was a result of the criteria used in design to maintain separation of redundant systems and the use of compartments to isolate high energy line break effects. Equipment which could be affected by jet impingement was analyzed and moved or protected if protection was required.

IX. CONCLUSION

High and moderate energy line breaks have been addressed following the guidelines of Standard Review Plan Sections 3.6.1 and 3.6.2. As a result of the plant design and the plant safety systems, failure of high or moderate energy lines will not prevent safe shutdown of the plant.

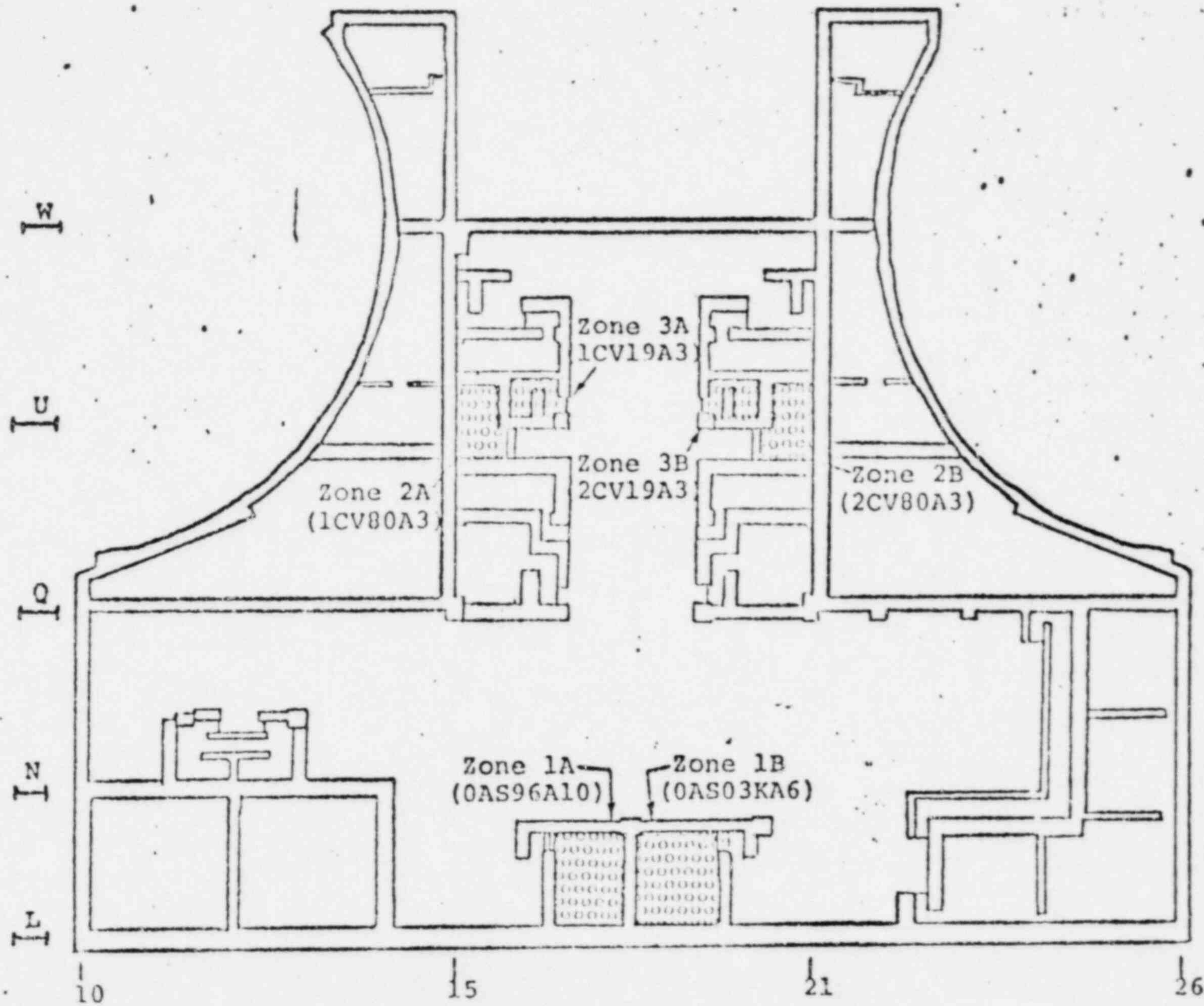

FIGURE Q010.40-1: HELB Zones of Influence - El. 346'0"

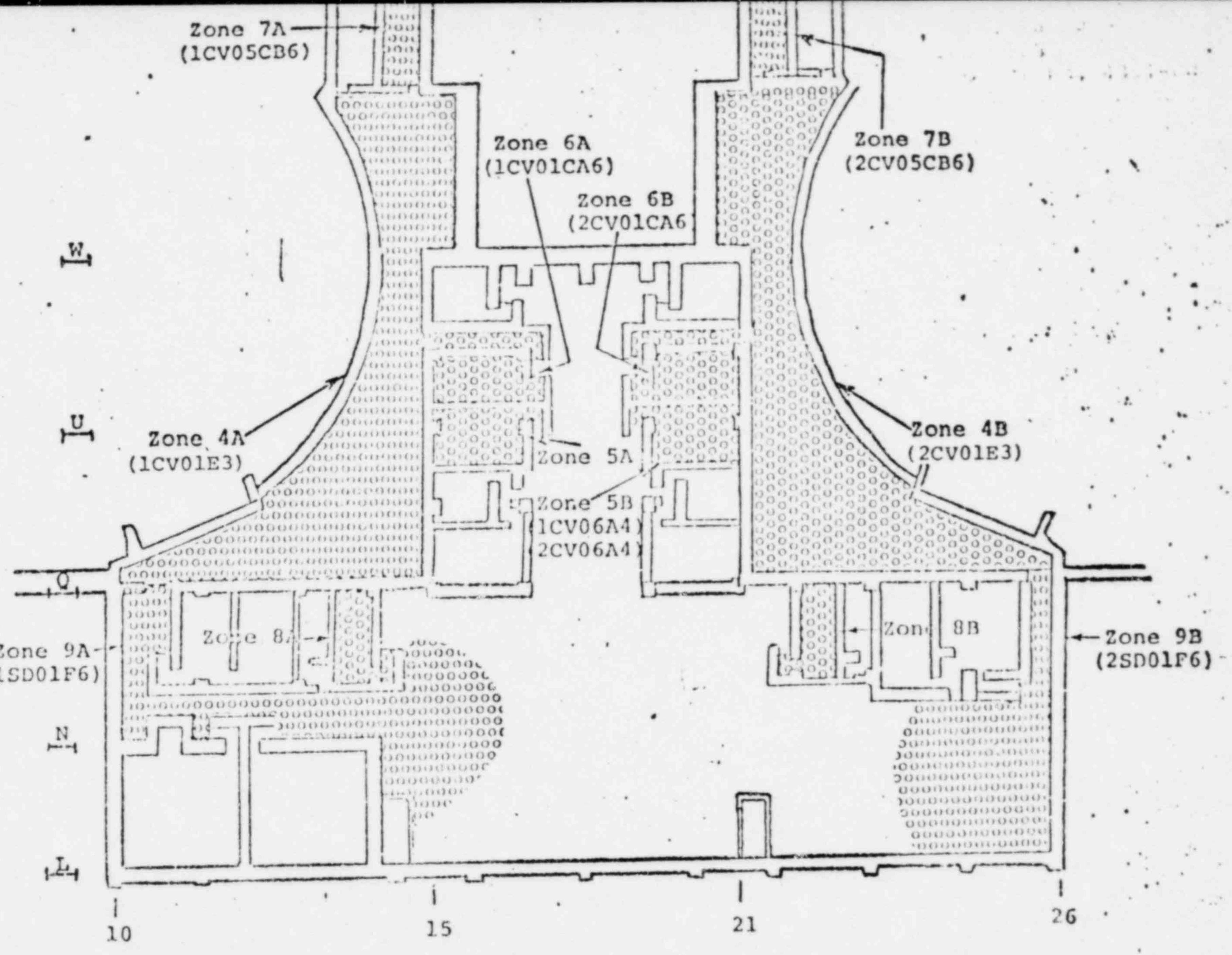

FIGURE Q010.40-2: HELB Zones of Influence - El. 364'0"

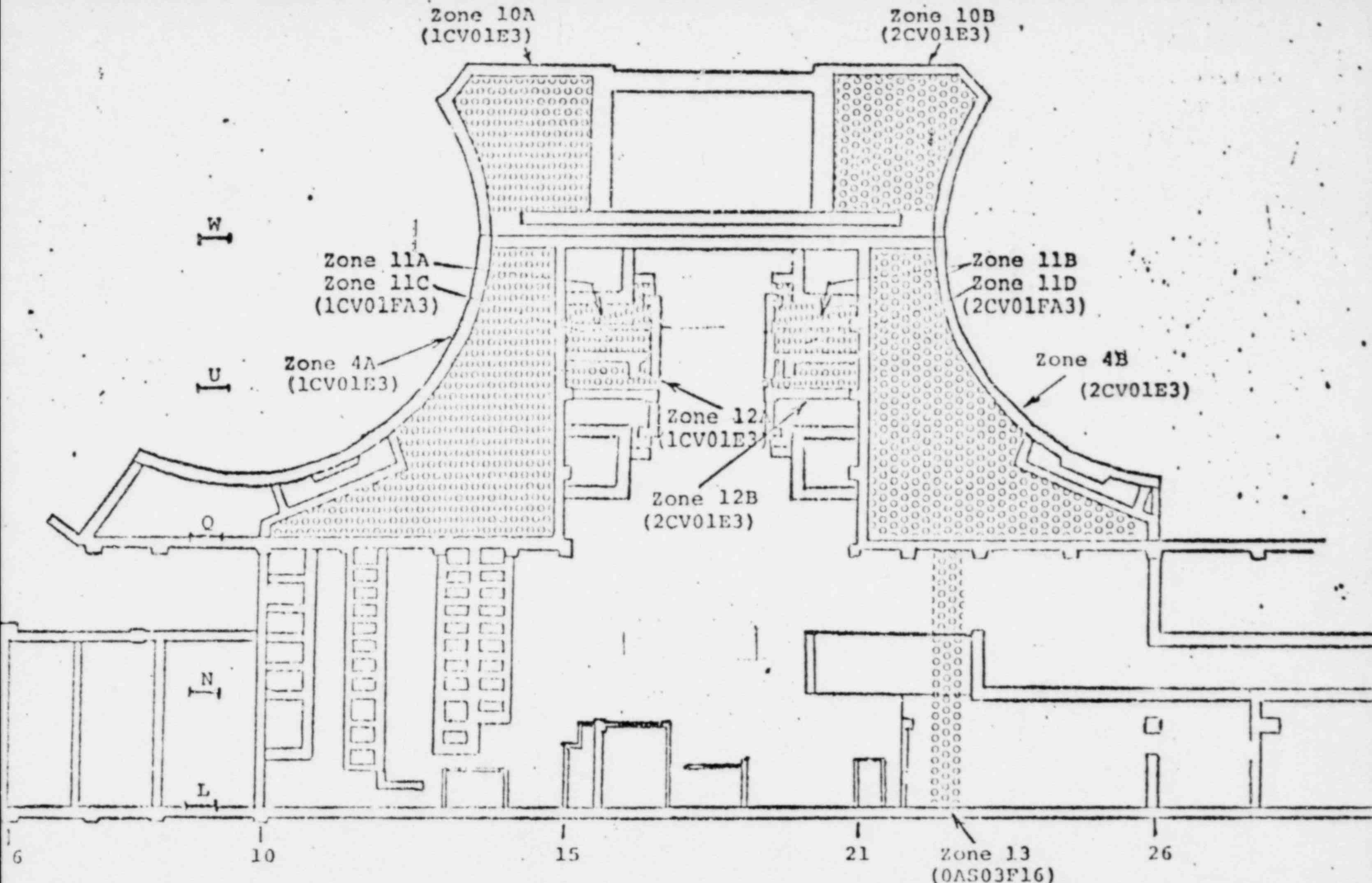

FIGURE Q010.40-3: HELB Zones of Influence - El. 383'0"

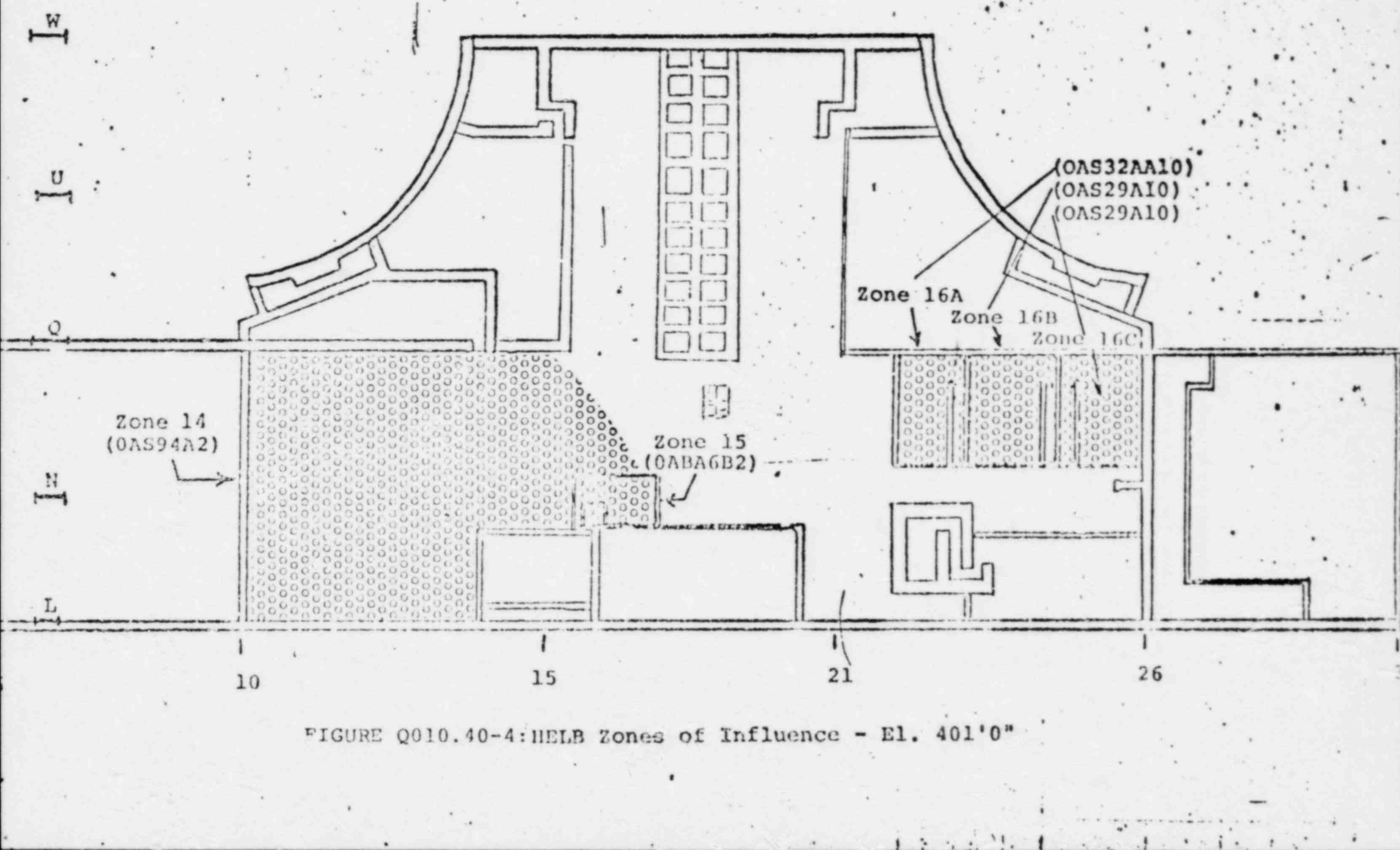

FIGURE Q010.40-4: HELB Zones of Influence - El. 401'0"

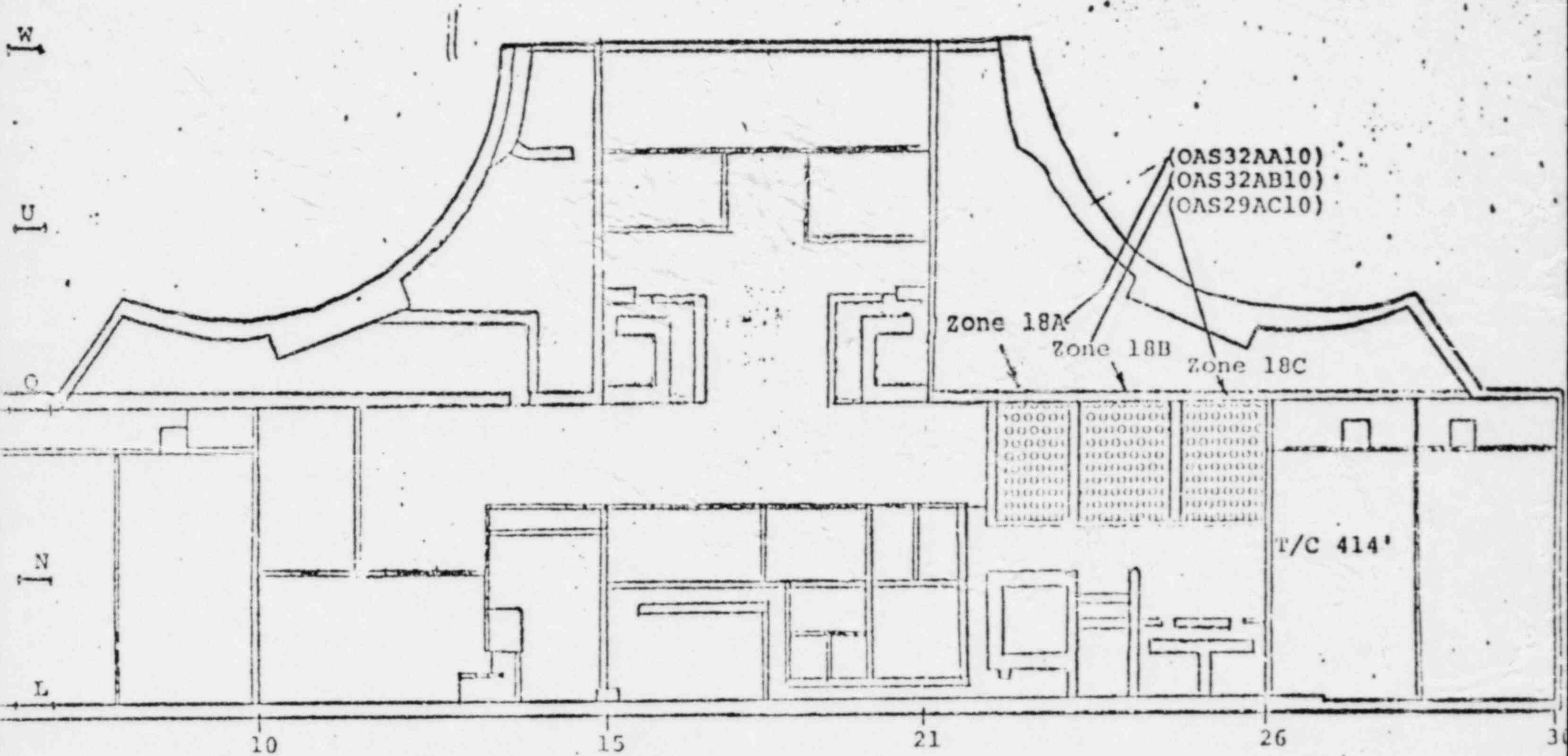

FIGURE Q010.40-5: HELB Zones of Influence - El. 426'0"