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SUBJECT: Forwards responses to Open Items 44-48 from Containment Sys Branch 810914-17 meeting.Encl includes info re safety/relief valve & LOCA submerged structure drag loads.

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Docket No. 50-397

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

Subject: NUCLEAR PROJECT NO. 2
RESPONSES TO CSB OPEN ITEMS 44-48

Enclosed are sixty (60) copies of the responses to open items 44 - 48 from the Containment Systems Branch meeting held September 14-17, 1981. These items should be closed by receipt of this submittal.

Very truly yours,

G D Bouchey

G. D. Bouchey
Deputy Director, Safety and Security

CDT/jca
Enclosures

cc: R Auluck - NRC
WS Chin - BPA
R Feil - NRC Site

B001
S1/60

THE ATTACHED INFORMATION ON SRV AND LOCA SUBMERGED STRUCTURE DRAG LOADS WAS PRESENTED AT THE SEPTEMBER 14-18, 1981 MEETING BETWEEN THE CONTAINMENT SYSTEMS BRANCH AND WASHINGTON PUBLIC POWER SUPPLY SYSTEM.

LOCA/SRV LOADS ON SUBMERGED STRUCTURES

THE LOCA/SRV DISCHARGE DEVICES AND OTHER SUBMERGED STRUCTURES ARE IDENTIFIED IN TABLE 1 ON PAGE 2 AND SHOWN IN FIGURES ON PAGES 3, 4.

THE MOST SIGNIFICANT HYDRODYNAMIC LOAD(S) FOR EACH STRUCTURE IS IDENTIFIED IN TABLE 1.

THE LOCA WATER CLEARING (JET), AIR CHARGING, POOL SWELL, FALLBACK LOADS COMPLY WITH ACCEPTANCE CRITERIA IN NUREG-808 WITH THE FOLLOWING CLARIFICATION AGREED UPON WITH NRC DURING THE MEETING OF SEPTEMBER 16, 1981. BOTH THE RING VORTEX MODEL AND THE LOCA BUBBLE CHARGING MODEL WILL BE USED AND THE LARGEST (MAXIMUM) INDUCED FLOW FIELDS (VELOCITY AND ACCELERATION) ANYWHERE IN THE POOL WILL BE USED TO DEFINE LOCA JET/BUBBLE LOADS.

THE METHODOLOGY USED FOR DEFINING LOCA STEAM CONDENSATION LOADS IS SUMMARIZED ON PAGE 5.

THE METHODOLOGY USED FOR DEFINING SRV LOADS IS SUMMARIZED ON PAGES 6, 7, 8.

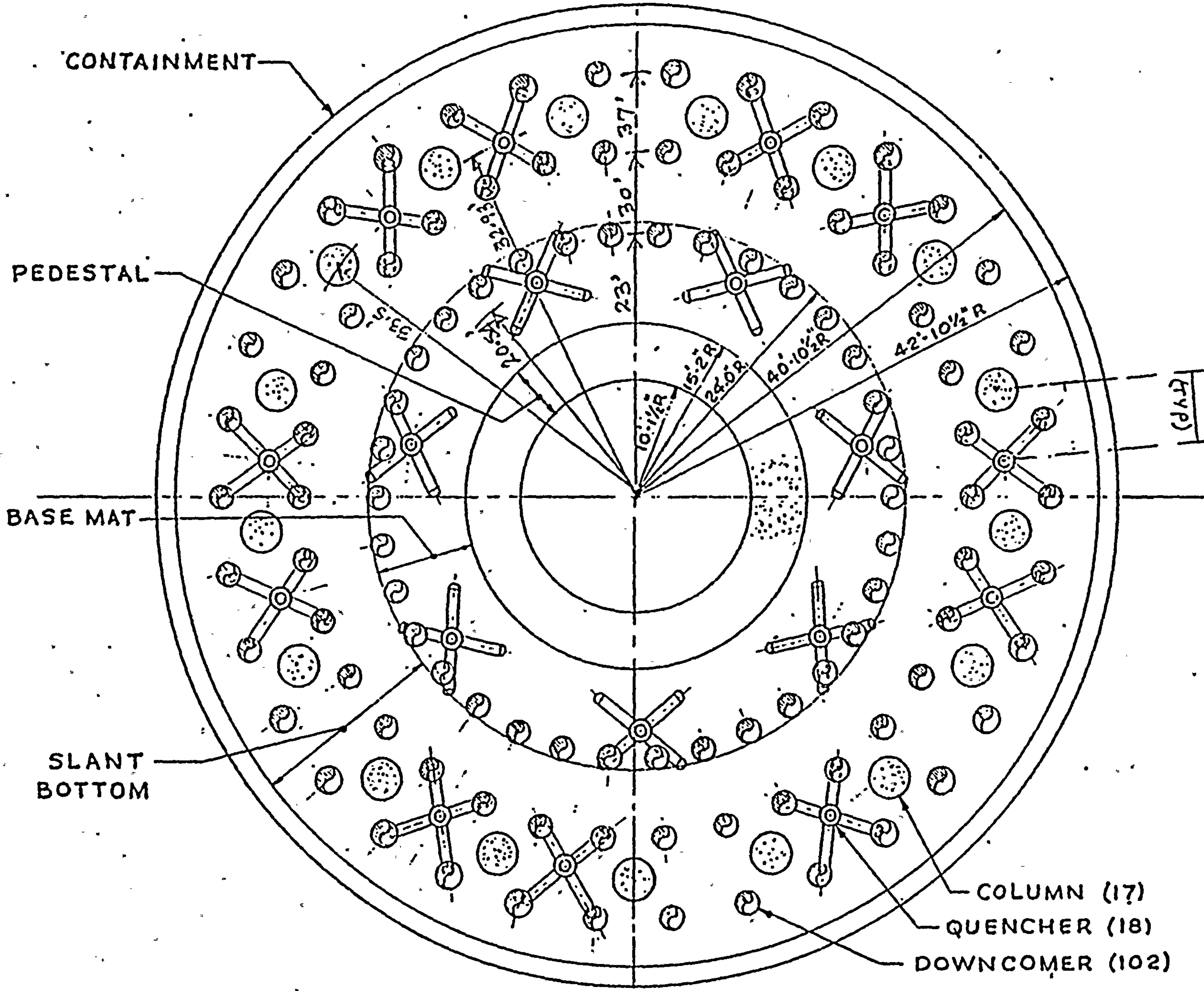
TABLE 1

LOCA/SRV Loads on Submerged Structures

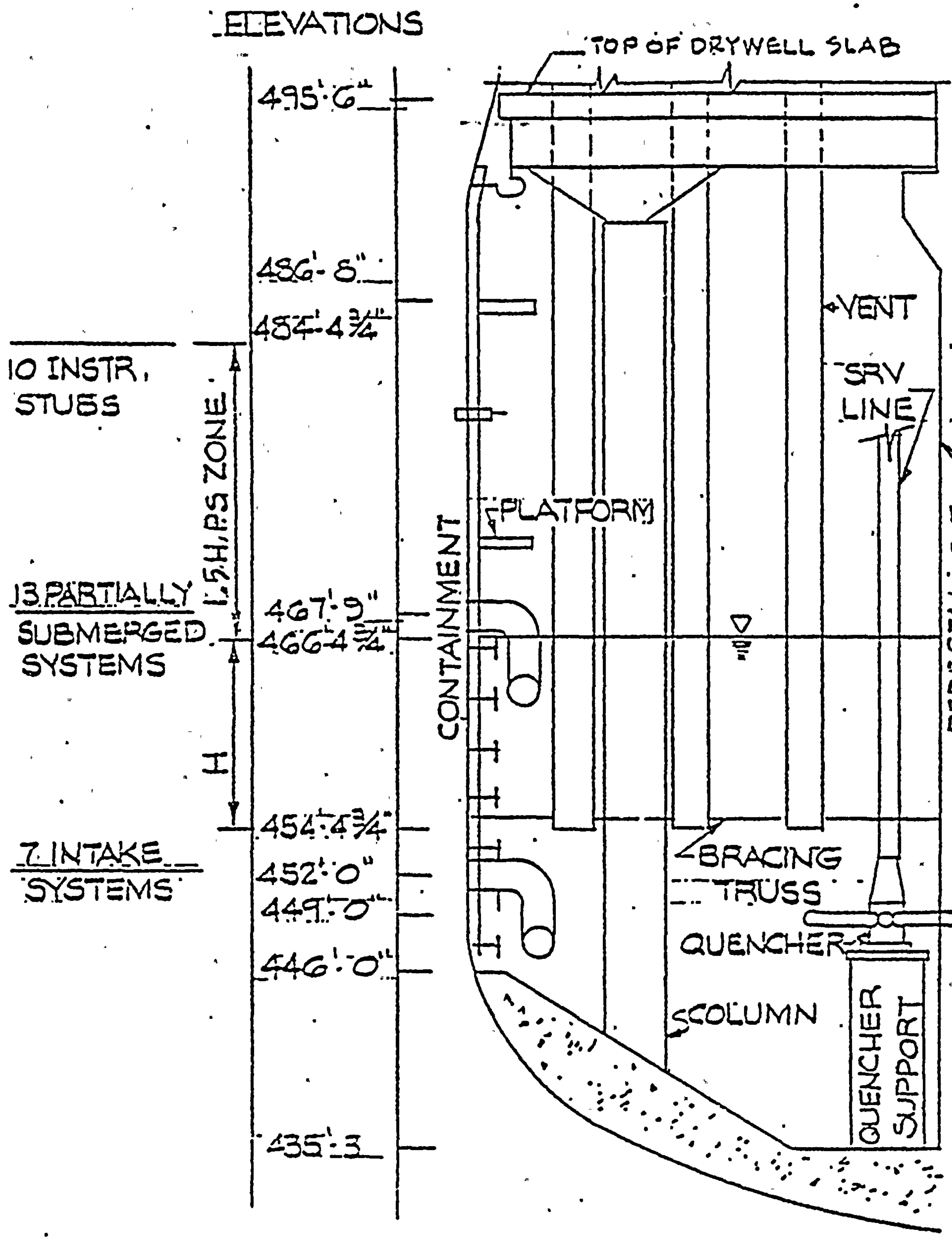
Identification of Structures	Identification of Most Significant Hydrodynamic Load
1. (a) SRV Line	SRV (Due to actuation of adjacent SRV)
(b) Quencher*	LOCA jet on arms
(c) Quencher Support*	None significant
2. Downcomer Vents*	SRV
3. Concrete Columns	SRV
4. Bracing Truss* @ Vent Exit	Pool Swell Drag
5. Platform with Grating (@ Elev. 472'-4", 78% open area)	Pool Swell Drag
6. Miscellaneous Piping, penetrations and supports along containment boundary	
(a) Below vent exit (Elev. 454'-4 3/4")	LOCA jet and SRV
(b) Above vent exit, below initial pool surface (Elev. 466'-4 3/4")	Pool Swell Drag
(c) Above initial pool surface, below maximum pool swell elevation (484'-4 3/4")	Pool Swell Impact

* Loads on discharge devices and their supports during discharge through the devices are addressed elsewhere.

PLAN OF WNP-2 WETWELL SHOWING LOCATION OF DISCHARGE DEVICES



WNP-2 SUPPRESSION POOL GEOMETRY & KEY ELEVATIONS



LOCA STEAM CONDENSATION LOADS ON SUBMERGED STRUCTURES

GENERIC "DRAG LOAD" METHODOLOGY AND PLANT UNIQUE FLOW FIELDS ARE BEING USED FOR LOCA CHUGGING AND C.O. LOADS ON SUBMERGED STRUCTURES IN COMPLIANCE WITH ACCEPTANCE CRITERIA.

GENERIC METHODOLOGY IDENTIFIES THREE COMPONENTS OF FLOW INDUCED LOADS ON SUBMERGED STRUCTURES: ACCELERATION DEPENDENT AND VELOCITY SQUARE DEPENDENT IN-LINE LOADS, VELOCITY SQUARE DEPENDENT LIFT LOAD (NORMAL TO THE DIRECTION OF FLOW).

PLANT UNIQUE FLOW FIELDS ARE BEING DEFINED CONSISTENTLY WITH CHUGGING AND C.O. BOUNDARY LOADS.

REPRESENTATIVE PLANT UNIQUE CHUGGING FLOW FIELDS SHOW THAT THE CHUGGING LOADS ON SUBMERGED STRUCTURES ARE DUE TO ACCELERATION OR PRESSURE GRADIENTS ESTABLISHED IN THE POOL DURING THE IMPULSIVE CHUGGING PHENOMENON, I.E., VELOCITY DEPENDENT LOADS ARE SMALL.

SRV LOADS ON SUBMERGED STRUCTURES

- CAORSO SRV TEST DATA ON SUBMERGED STRUCTURES ARE EXAMINED TO SUPPLEMENT THEORETICAL APPROACHES OF ACCEPTANCE CRITERIA.

- THE DATA AND THEIR CORRELATION WITH THEORETICAL APPROACHES OF THE ACCEPTANCE CRITERIA CONFIRM THAT SRV LOADS ARE PRIMARILY DUE TO PRESSURE GRADIENTS ESTABLISHED IN THE POOL DURING THE SRV DISCHARGE, I.E., VELOCITY DEPENDENT LOADS ARE SMALL.

- THE DYNAMIC PRESSURE GRADIENTS MEASURED ACROSS CAORSO COLUMN, VENT AND SRV LINE ARE USED TO DEFINE THE PEAK LOAD VALUES AT QUENCHER ELEVATION, TO DEFINE THE SPATIAL DISTRIBUTIONS AND TO DEFINE TIME HISTORY.

- THE PRESSURE TIME HISTORIES RECORDED ON SUBMERGED STRUCTURES SHOW WAVEFORM CHARACTERISTICS SIMILAR TO THOSE RECORDED AT POOL BOUNDARY. THE SRV LOADS ON SUBMERGED STRUCTURES ARE DEFINED CONSISTENTLY WITH THE PLANT UNIQUE BOUNDARY LOADS. (SEE PAGE 7.)

SRV LOAD ON WNP-2 STRUCTURES

$$P_{\substack{\text{WNP-2}\\\text{Structure}}} \left(\frac{\text{Force}}{\text{Unit Length}}\right) = \left(\frac{\pi}{4} D^2\right) \times \left(\frac{d_{\text{Caorso}}}{d_{\text{WNP-2}}}\right)^2 \times \alpha P_b \times \text{Load Margin}$$

where D = diameter of the structure

α = a load gradient factor established using Caorso SRV test data on submerged structures (see Page 8)

d_{Caorso} = horizontal distance of the structure from the nearest actuating quencher in Caorso plant (see Page 8)

$d_{\text{WNP-2}}$ = horizontal distance of the WNP-2 structure from the nearest actuating quencher (see Page 3)

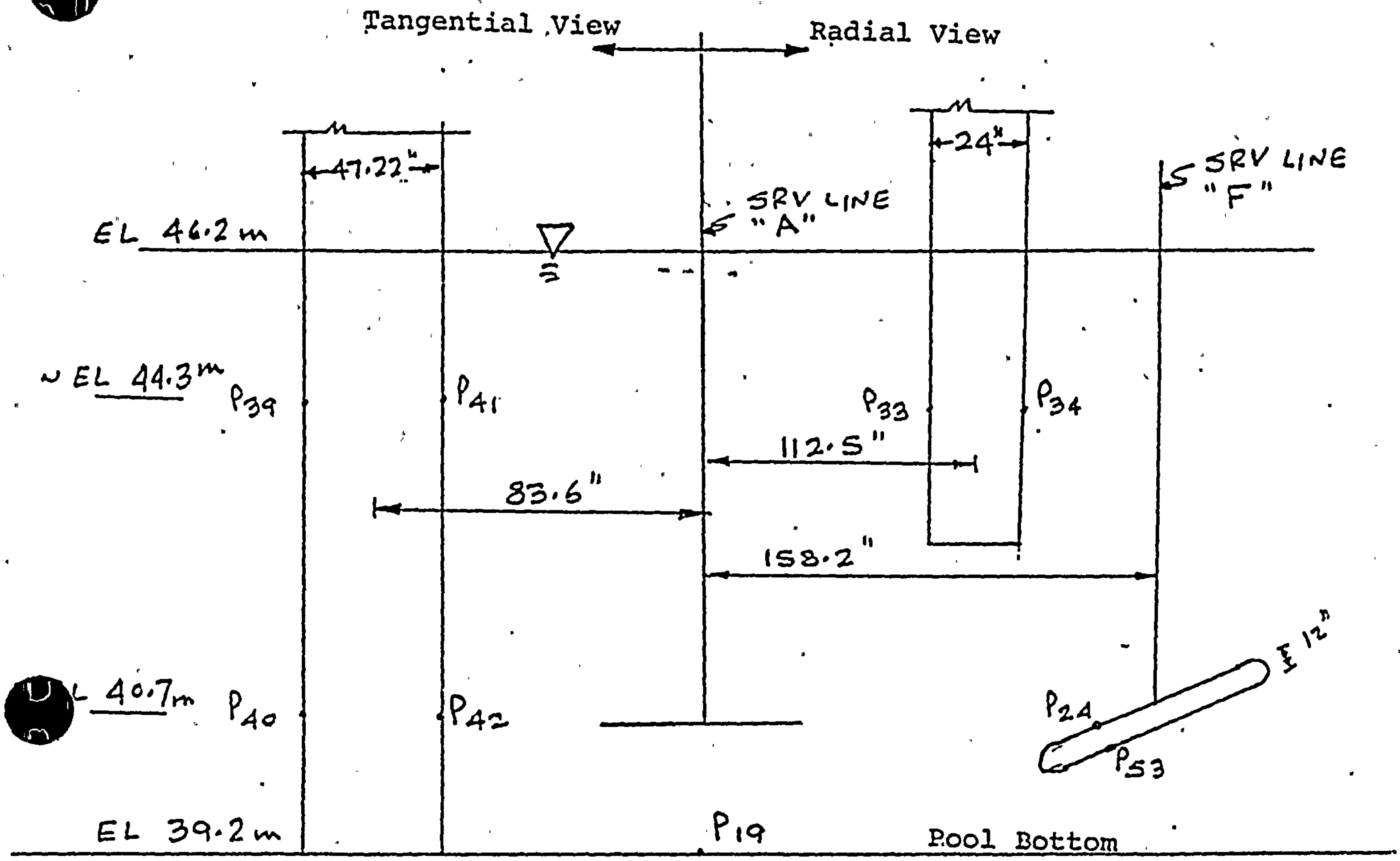
P_b = boundary pressure load definition from Reference 1 including any modifications agreed upon with NRC

Load Margin = a minimum value of 1.4 is used for all piping which are adequately braced and a value of 2.0 is used for the column which is the only unbraced structure and is closest in distance from the nearest quencher

NOTE: For miscellaneous piping which run along the suppression pool boundary, the load gradient factor α equal to that for the column is specified.

Reference 1: "SRV Loads - Improved Definition and Application Methodology for Mark II Containments," Technical Report (Proprietary), prepared by Burns and Roe, Inc. for application to Washington Public Power Supply System Nuclear Project No. 2, submitted to the Nuclear Regulatory Commission on 7/29/80.

LOCATION OF PRESSURE TRANDUCERS
ON CAORSO SUBMERGED STRUCTURES



SRV LOAD GRADIENT FROM CAORSO DATA

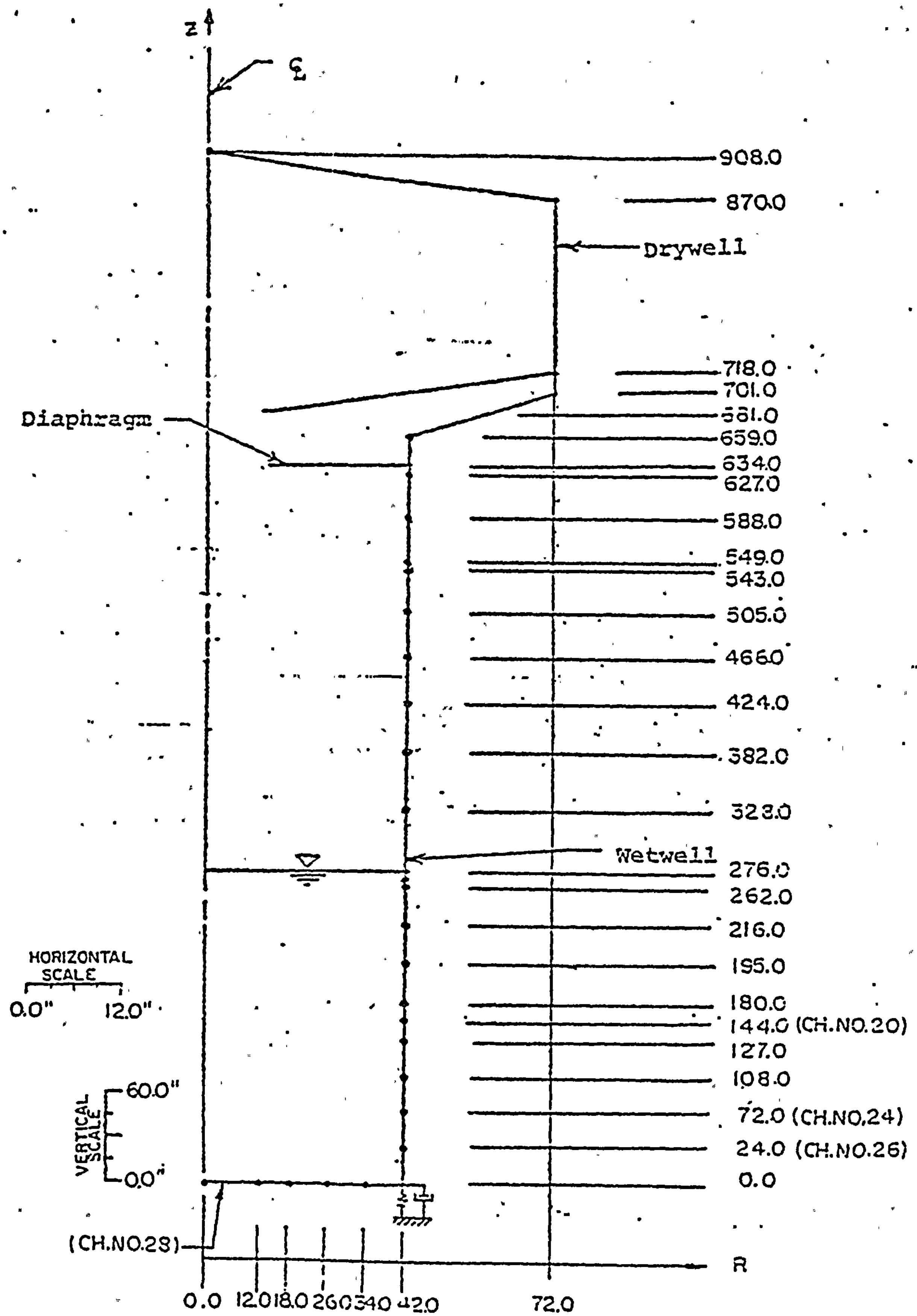
$$\text{Measured gradient across the cylindrical structure} = \frac{P_{front} - P_{back}}{\text{Diameter}} = \alpha P_{19}$$

1. P_{19}, P_f, P_b waveform characteristics are similar.
2. The value of α for each set of P_f (P_{42}, P_{41}, P_{33}, P_{24}) and P_b (P_{40}, P_{39}, P_{34}, P_{53}) is obtained from Caorso SRV test data (single and multiple valve actuations).

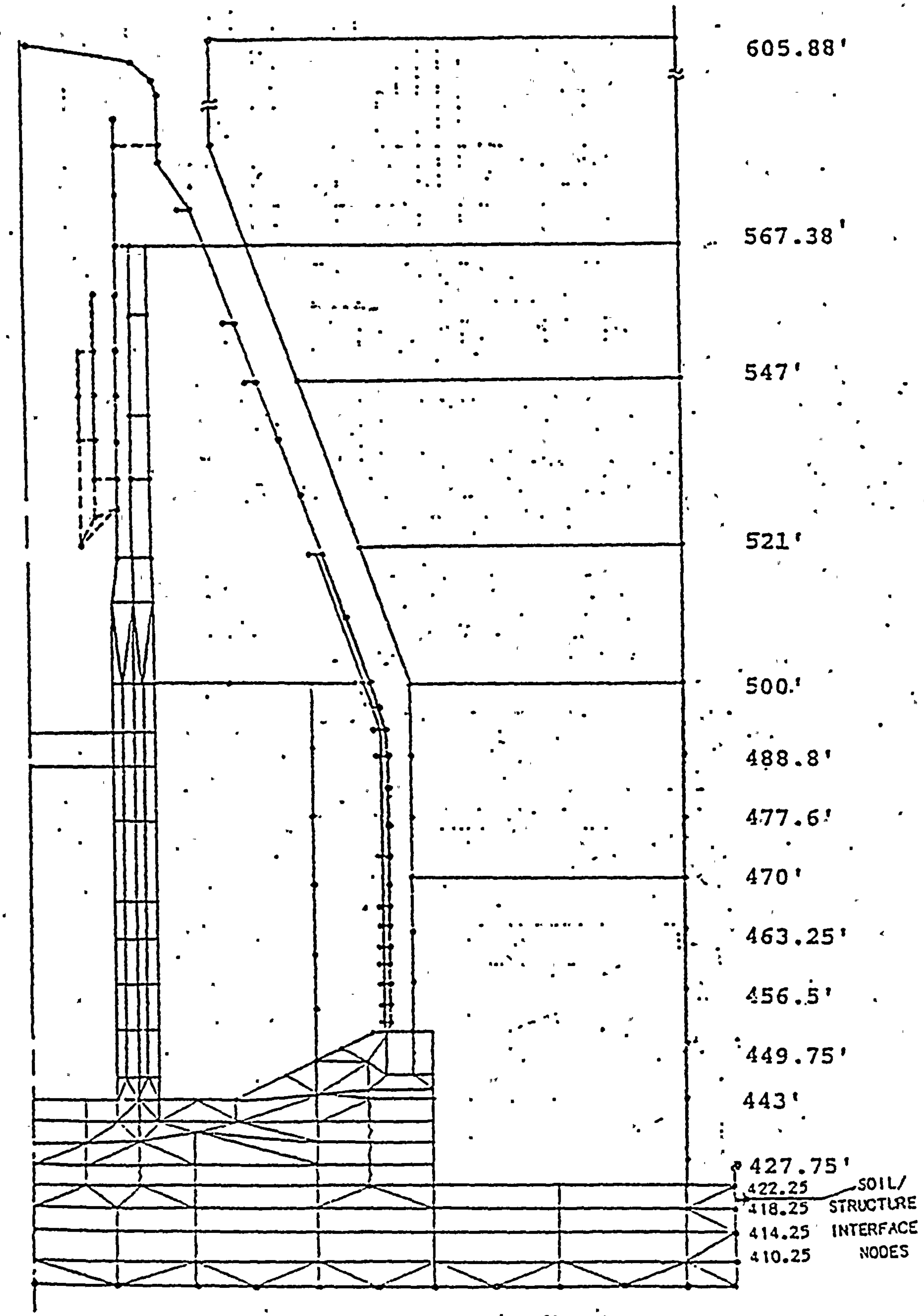
Questions on the WPPSS Revised Chugging Load Definition and Application Methodology

1. The finite element model of the WNP-2 reactor building used to obtain responses to the chugging loads is of the 'refined' type stated to give more realistic results. For the same input source the refined model shows a smaller response, in general, than a conventional model. However, when the sources are inferred from the 4TCO response, a conventional structural model is apparently used for the 4T tank. The conventional model would infer a smaller source from a particular response than the refined model. Comment on this apparent discrepancy of using a conventional model for inferring the source but a refined model for applying it.

THE FINITE ELEMENT MODELS OF THE 4T SYSTEM, FIG. 3-17, AND THE WNP-2 BUILDING, FIG. 5-5, ARE BOTH BASED ON CONVENTIONAL FINITE ELEMENT FORMULATION. HOWEVER, BOTH ARE REFINED ENOUGH TO MODEL THE DYNAMIC BEHAVIOR OF EACH SYSTEM. THE DEGREE OF REFINEMENT IS SIMILAR IN BOTH MODELS.



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	STRUCTURAL FINITE ELEMENT MODEL OF 4TCO TANK	FIGURE 3-17b



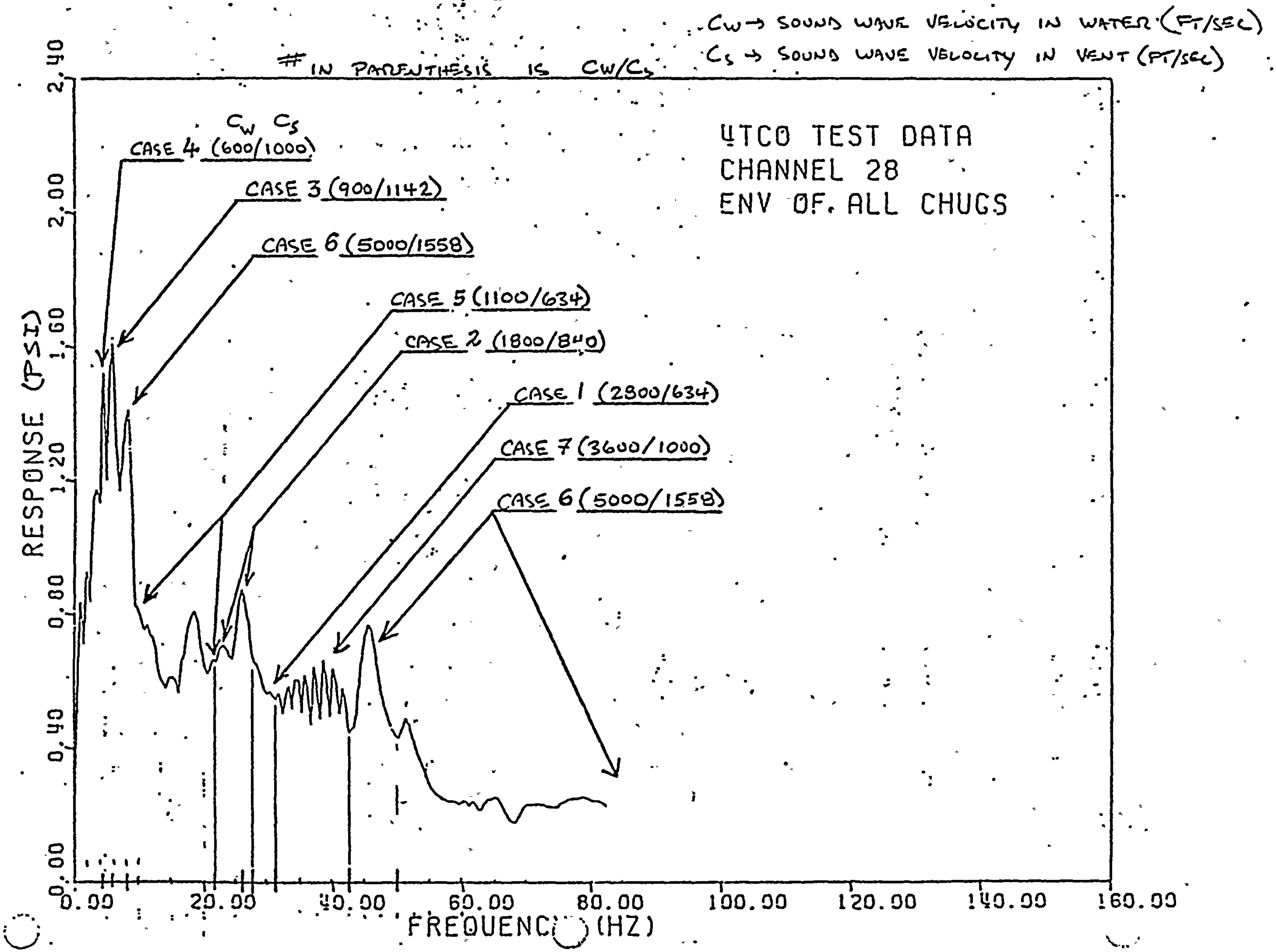
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	REACTOR BUILDING MODEL	FIGURE 5-5

2. The finite elements used to model the WNP-2 suppression pool are on the average an order of magnitude bigger than the elements used to model the 4T suppression pool. Since element size affects stiffness, and so response, comment on the effect this difference in element size may have on the load methodology.

SIZE OF FINITE ELEMENTS

THE B&R CHUGGING LOAD CONSISTS OF SEVEN CASES, EACH CASE IS DESIGNED TO ENVELOPE PART OF THE REQUIRED FREQUENCY SPECTRUM, SUCH THAT

CASES 3, 4, 6	ENVELOPE VENT MODES
CASES 1, 2, 5, 6, 7	ENVELOPE POOL MODES



Cw → SOUND WAVE VELOCITY IN WATER (FT/SEC)
Cs → SOUND WAVE VELOCITY IN VENT (FT/SEC)
IN PARENTHESIS IS Cw/Cs
Cw Cs
CASE 4 (600/1000)
CASE 3 (900/1142)
CASE 6 (5000/1558)
CASE 5 (1100/634)
CASE 2 (1800/840)
CASE 1 (2800/634)
CASE 7 (3600/1000)
CASE 6 (5000/1558)
4TCO TEST DATA
CHANNEL 28
ENV OF. ALL CHUGS
RESPONSE (PSI)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
FREQUENCY (HZ)

TWO FACTS CAN BE ESTABLISHED:

- CASES WITH LOWER C_W WILL RESULT IN LOWER POOL FREQUENCIES AND CASES WITH HIGHER C_W WILL RESULT IN HIGHER POOL FREQUENCIES, FIG. 3-29, B&R REPORT.

- THE RELATION

$$F_{MAX} = \frac{C}{4L} \tag{1}$$

CAN BE USED TO ESTABLISH THE REQUIRED ELEMENT SIZES, WHERE

F_{MAX} = MAXIMUM FREQUENCY THAT CAN BE TRANSMITTED BY A FLUID ELEMENT WITH LENGTH "L" AND ACOUSTIC SPEED "C".

SINCE $F_R < F_{MAX}$ IN ALL CASES, IT IS CONCLUDED THAT THE ELEMENT SIZES ARE SUFFICIENT.

CASE	MAX. FREQUENCY REQUIRED TO ENVELOPE SPECTRA (Hz) (SEE ATTACHED FIGURE)	MAX. FREQUENCY TRANSMITTED BY FINITE ELEMENTS USED (F_{MAX})
1	32.0	58.33
2	28.0	37.50
5	22.0	22.92
6	80.0	104.17
7	42.0	75.00
3	6.0	~~12.50~~ 18.75
4	4.0	~~18.75~~ 12.50

3. WNP-2 has 18 vents with a 28" diameter. All data on which the chugging sources are based came from 24" vents. For lateral loads data, extrapolation showed that loads are increased by 34% in going from 24" to 28" vents. Where are the 28" vents located in WNP-2 and how is the effect of the larger vents on boundary pressures accounted for?

TREATMENT OF 28" DIAMETER VENTS

BASIC ASSUMPTION:

$$S_{28} = S_{24} \times \frac{A_{28}}{A_{24}}$$

S_{28} = STRENGTH OF 28" VENT CHUGS

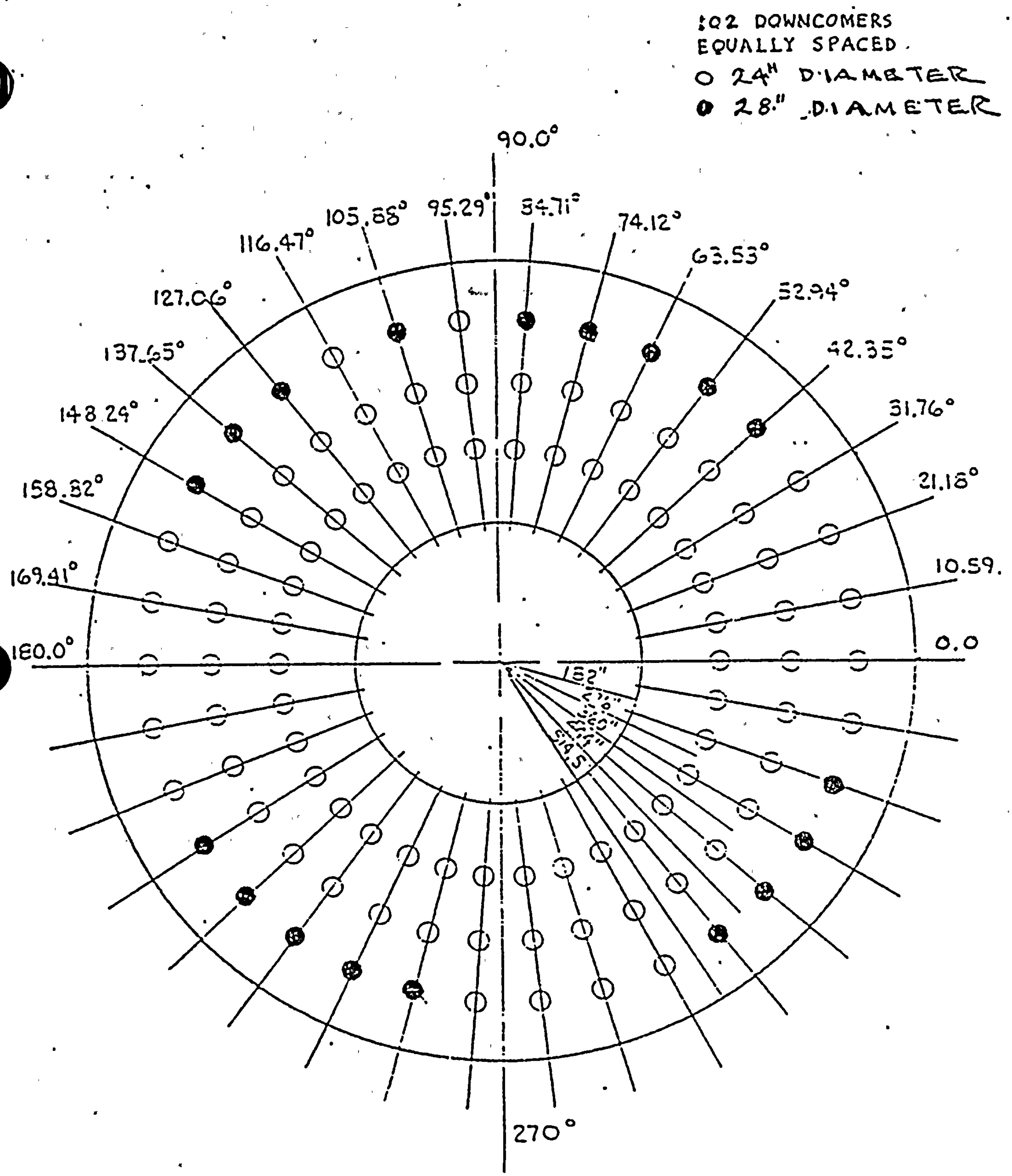
S_{24} = STRENGTH OF 24" VENT CHUGS

A_{28} = CROSS-SECTIONAL AREA OF 28" DIAMETER VENTS

A_{24} = CROSS-SECTIONAL AREA OF 24" DIAMETER VENTS

$$S_{28} = S_{24} \times 1.361$$

BASED ON THIS ASSUMPTION, IT IS POSSIBLE TO ACCOUNT ANALYTICALLY FOR THE 28" DIAMETER VENTS BY INCREASING THE 4TCO BASED CHUGGING SOURCES BY 36.1%.



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	WETWELL PLAN VIEW AT ELEVATION OF DOWNCOMER EXITS	FIGURE [illegible]

* DEFINE A FACTOR $\propto$ WHERE

$$\propto = \frac{R_{28}}{R_{24}}$$

R_{28} = SUPPRESSION POOL RESPONSE IN WNP-2 IF THE 28" DIAMETER VENTS ARE ACCOUNTED FOR.

R_{24} = SUPPRESSION POOL RESPONSE IN WNP-2 IF THE 28" DIAMETER VENTS ARE NOT ACCOUNTED FOR.

- TWO APPROACHES WERE INVESTIGATED

1. ASSUME THAT SUPPRESSION POOL IS INCOMPRESSIBLE.
2. ASSUME THAT SUPPRESSION POOL IS COMPRESSIBLE.

1. SUPPRESSION POOL IS INCOMPRESSIBLE

$$\left\{\begin{array}{l}\text{BOUNDARY PRESSURES}\\ \text{DUE TO THE } I^{TH} \text{ VENT}\end{array}\right\} \propto \frac{1}{R_I}$$

$$R_{28} = \sum_{I=1}^{102} A_I \times \frac{1}{R_I}$$

A_I = 1.0 FOR 24" DIAMETER VENTS

= 1.361 FOR 28" DIAMETER VENTS

$$R_{24} = \sum_{I=1}^{102} \frac{1}{R_I}$$

R_I = DISTANCE BETWEEN THE I^{TH} VENT AND THE REFERENCE POINT ON THE BOUNDARY (CONTAINMENT BOUNDARY WAS CHOSEN FOR ADDITIONAL CONSERVATISM).

2. SUPPRESSION POOL IS COMPRESSIBLE

R_{28} AND R_{24} WILL BE CALCULATED FOR AN ACTUAL CHUGGING LOAD DEFINITION. THE GENERIC SOURCE NUMBER 804 WAS USED. β_I WAS CALCULATED AS

$$\beta_I = \frac{|R_{28}^I(T)|_{MAX}}{|R_{24}^I(T)|_{MAX}} \quad , \; I = 1, 2 \ldots, 34$$

THE SUPERSCRIPT "I" INDICATES THE PRESSURE RESPONSE AT THE CONTAINMENT BOUNDARY, VENT EXIT ELEVATION, AND I^{TH} ROW OF VENTS.

$$\alpha = |\beta_I|_{AVE}$$

METHOD	α
INCOMPRESSIBLE FLUID	1.09
COMPRESSIBLE FLUID	1.10

BASED ON THE ABOVE, THE STRUCTURAL RESPONSES OF WNP-2 ARE CALCULATED FOR 24" DIAMETER VENTS CASE, THEN IT WILL BE INCREASED BY A FACTOR OF 1.1 TO ACCOUNT FOR THE 28" DIAMETER VENTS.

4. The asymmetric load for WNP-2 is obtained by increasing loads by 14% on one side of the pool and decreasing them by 14% on the other with a linear transition from one side to the other. The 14% differential is roughly comparable to the asymmetric factors approved for the generic method. However, in the generic method one entire half of the pool is 15% higher and the entire other half is 15% lower. Calculations show that the linear transition of the WNP-2 method results in an overturning moment which is only 60% of the moment obtained using the step transition of the generic method. Justify this smaller asymmetric load.

ASYMMETRIC LOADING CASE

THE GENERIC LOAD APPROACH DEFINED THE FOLLOWING EQUATIONS:

$$M^* = E(M) + 3.45\,(V(M))^{1/2}$$

$$E(M) = E(P) \sum_{I=1}^{N} L_I$$

$$V(M) = V(P) \sum_{I=1}^{N} L_I^2$$

$$V(P) = 0.108\,(E(P))^2 \text{, FROM JAERI RESULTS}$$

THEN

$$M^* = E(P) \left[\sum_{I=1}^{N} L_I + 3.45 \left(0.108 \sum_{I=1}^{N} L_I^2\right)^{1/2} \right]$$

WHERE

$E(P)$, $E(M)$ = EXPECTED VALUES OF PRESSURES AND MOMENTS

$V(P)$, $V(M)$ = VARIANCES OF PRESSURES AND MOMENTS

L_I = MOMENT ARM OF THE I^{TH} VENT

M^* = DESIGN MOMENT, CORRESPONDING TO AN EXCEEDANCE OF NO MORE THAN ONCE PER HOUR.

BUT

$$\sum_{I=1}^{N} L_I = 0 \text{ , DUE TO SYMMETRY}$$

$$M^* = E(P) \times A \times \left(\sum_{I=1}^{N} L_I^2\right)^{1/2} \qquad (1)$$

$$A = 3.45 \sqrt{.108}$$

ASYMMETRIC LOADING CASE (CONT'D)

AN ASYMMETRY PARAMETER α WAS DEFINED AS

$$\alpha = \frac{M^*}{2.0\ P^* \sum_{I=1}^{N/2} L_I} \qquad (2)$$

P^* = BOTTOM CENTER PRESSURES CALCULATED FOR DESIGN SOURCES.

ASYMMETRIC LOADING CASE (CONT'D)

FROM (1) AND (2)

$\alpha = B \times G \times F$

B = CONSTANT

$= A/2.0 = 0.567$

G = GEOMETRIC FACTOR, DEPENDENT ON THE ASSUMED SOURCE STRENGTHS AT DIFFERENT VENT EXITS

$$= \frac{\left(\sum_{I=1}^{N} L_I^{2}\right)^{1/2}}{\left(\sum_{I=1}^{N/2} L_I\right)}$$

F = LOAD FACTOR, DEPENDENT ON THE DEGREE OF CONSERVATISM IN THE DESIGN LOAD

$$= \frac{E(P)}{P^*} \leqslant 1.0$$

ASYMMETRIC LOADING CASE (CONT'D)

FOR THE GENERIC LOAD, IT WAS FOUND THAT (TABLE 2-2)

$F_{MAX} = 1.02 \simeq 1.00$

G (WNP-2) GEOMETRY) = 0.224

$\alpha_{MAX} = 0.129$

Table 2-2

SUMMARY OF EXPECTED VALUE, VARIANCE, AND DESIGN SOURCE RMS VALUES USED IN THE ASYMMETRIC LOAD CASE

Design Source	$E[P_{rms}]$ kPa (psi)	$V[P_{rms}]$ kPa^2 (psi^2)	P^*_{rms} kPa (psi)
801			
802			
803			
804			
805			
806		PROPRIETARY	
807			
808			
809			
810			

ASYMMETRIC LOADING CASE (CONT'D)

THE ASYMMETRIC PARAMETER γ OF B&R APPROACH CAN BE DEFINED AS

$$\gamma = B \times G_B \times F_B$$

G_B = B&R GEOMETRIC FACTOR, BASED ON LINEAR LOAD DISTRIBUTION

$= 0.350$

F_B = B&R LOAD FACTOR

$= 0.448$

$$\gamma = 0.089$$

ASYMMETRIC LOADING CASE (CONT'D)

THE FACT THAT $\gamma < \alpha$ IS BECAUSE THE DESIGN LOAD (P^*_B) IS MUCH GREATER THAN THE AVERAGE (EXPECTED) LOAD (E(P)), FIG. 4.3 OF B&R REPORT. THE GENERIC (P^*_G MEANWHILE, IS VERY CLOSE TO (E(P)), TABLE 2-2 OF THE GENERIC LOAD REPORT.

See:

"Chugging Loads - Revised Definition and Application Methodology for Mark II Containments (Based on 4TCO Test Results)."

Transmitted by:

Letter G02-81-189, dated July 22, 1981, Supply System to NRC

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2.	DESIGN SPECTRUM AND REQUIRED AVERAGE SPECTRUM - CHANNEL 28	FIGURE 4-3

ASYMMETRIC LOADING CASE (CONT'D)

HOWEVER, THE FINAL DESIGN OVERTURNING MOMENTS ARE APPROXIMATELY EQUAL FOR BOTH APPROACHES FOR

$\alpha = 0.129$, AND

$\gamma = 0.089$, SINCE

$$M^*_G = 2.0(P^*_G)\left(\sum_{I=1}^{N/2} L_I\right)(\alpha) \qquad \text{GENERIC APPROACH}$$

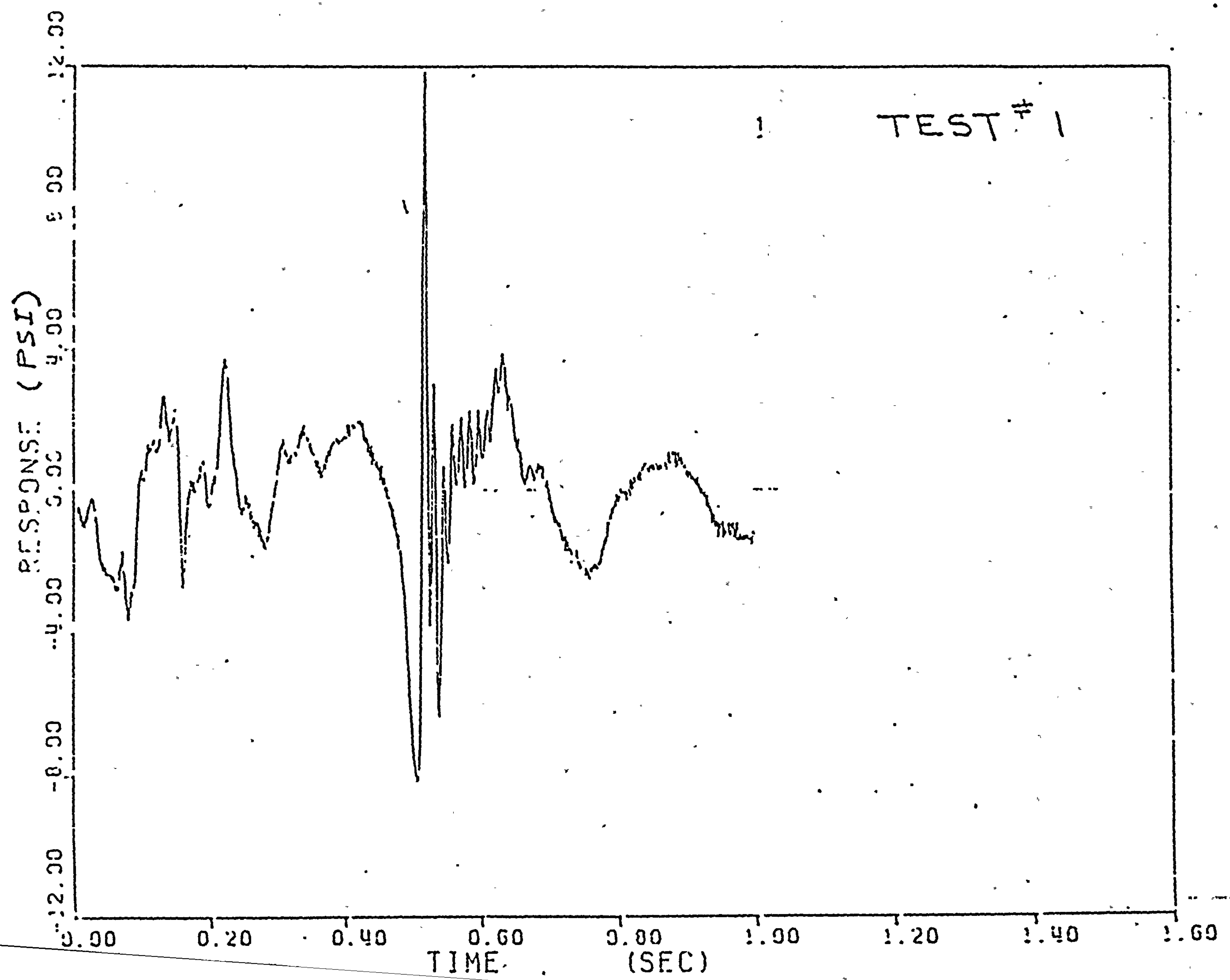
$$M^*_B = 2.0(P^*_B)\left(\sum_{I=1}^{N/2} \theta_I L_I\right)(\gamma) \qquad \text{B\&R}$$

$$P^*_B \Big|_{MAX} = 12.06 \text{ PSI}$$

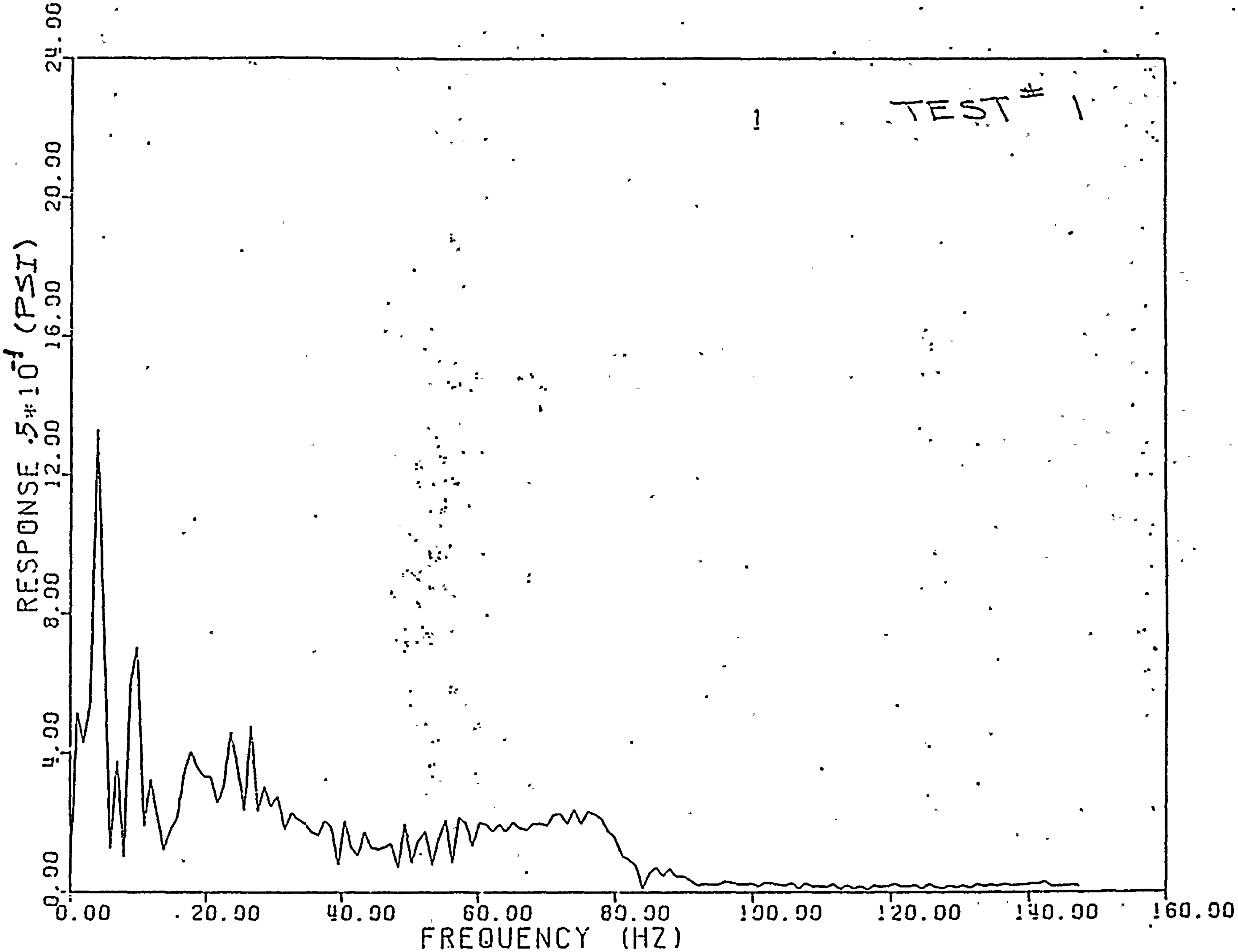
$$\sum_{I=1}^{N/2} L_I = 11{,}700. \text{ IN}$$

$$\sum_{I=1}^{N/2} \theta_I L_I = 7{,}464. \text{ IN}$$

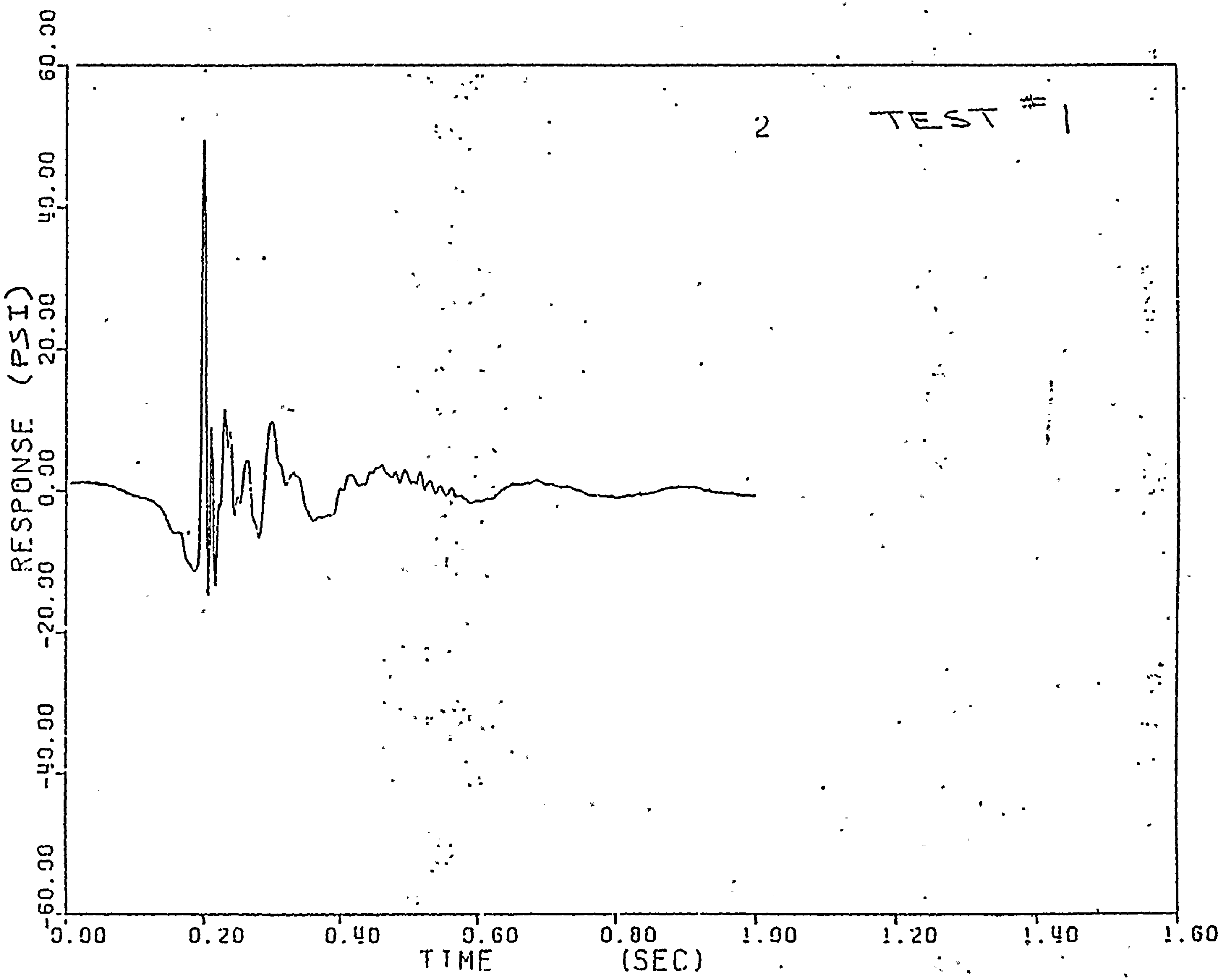
COMPANION CHUG - B+R



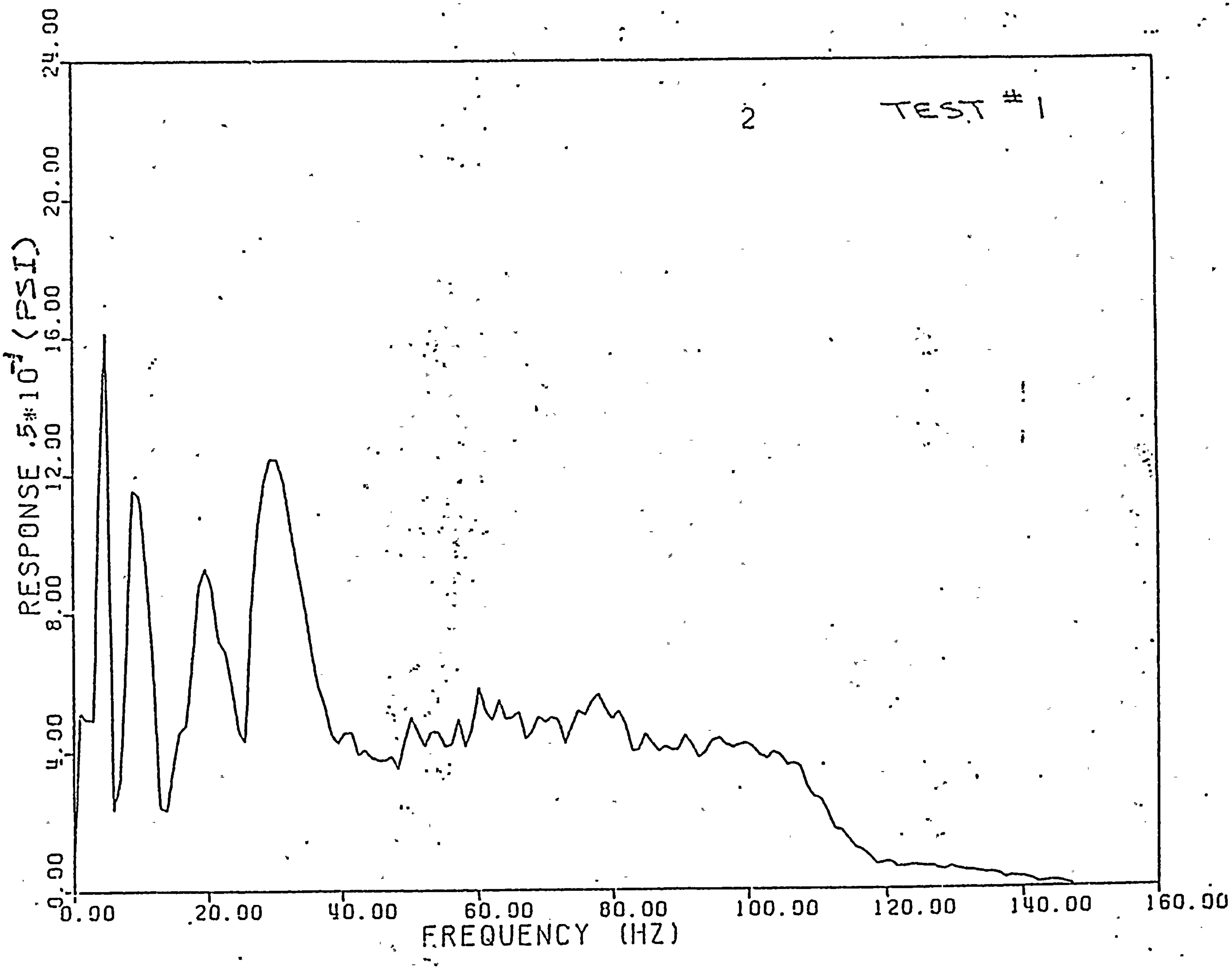
COMPANION CHUG - B+R



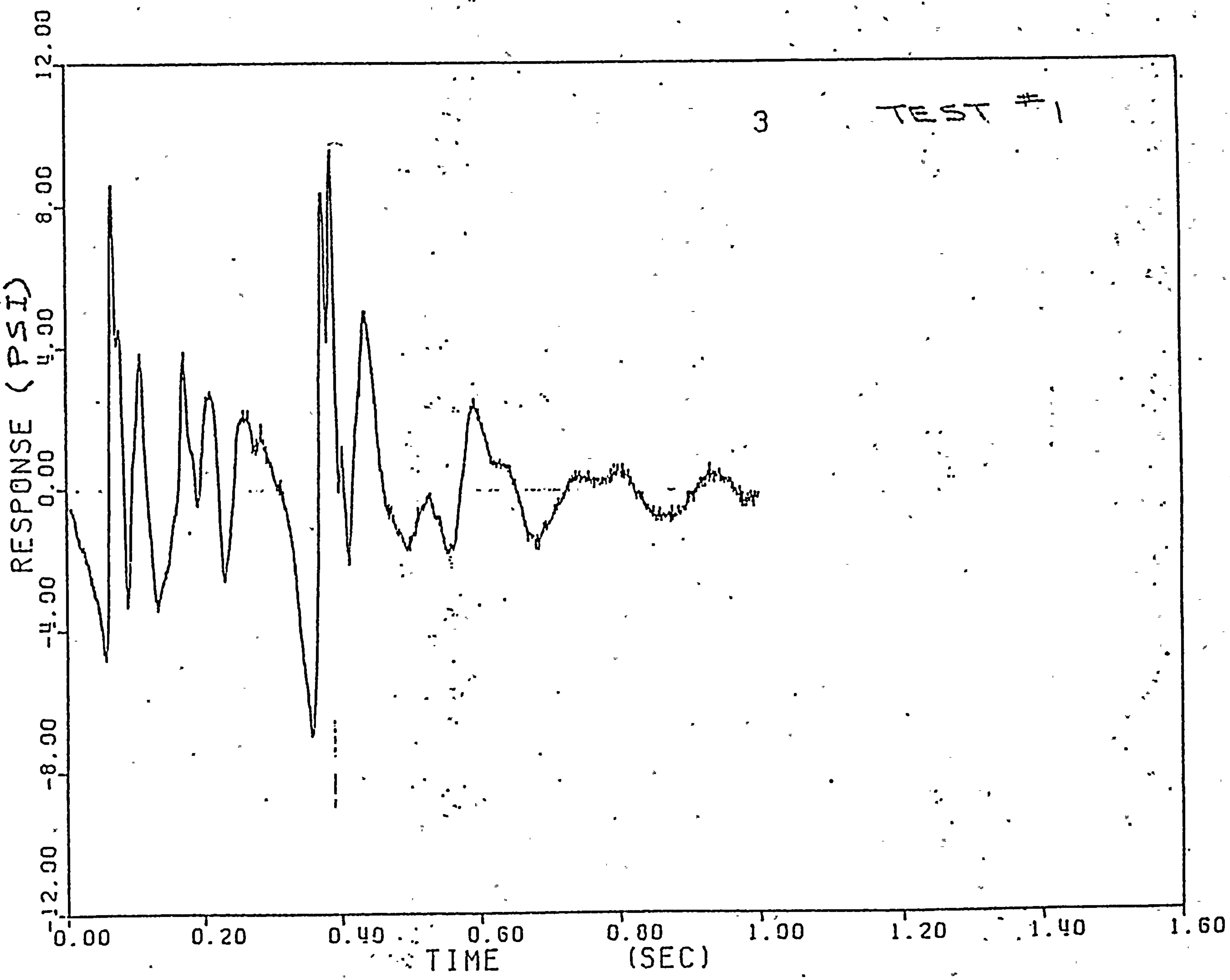
KEY CHUG - B+R/G.E.



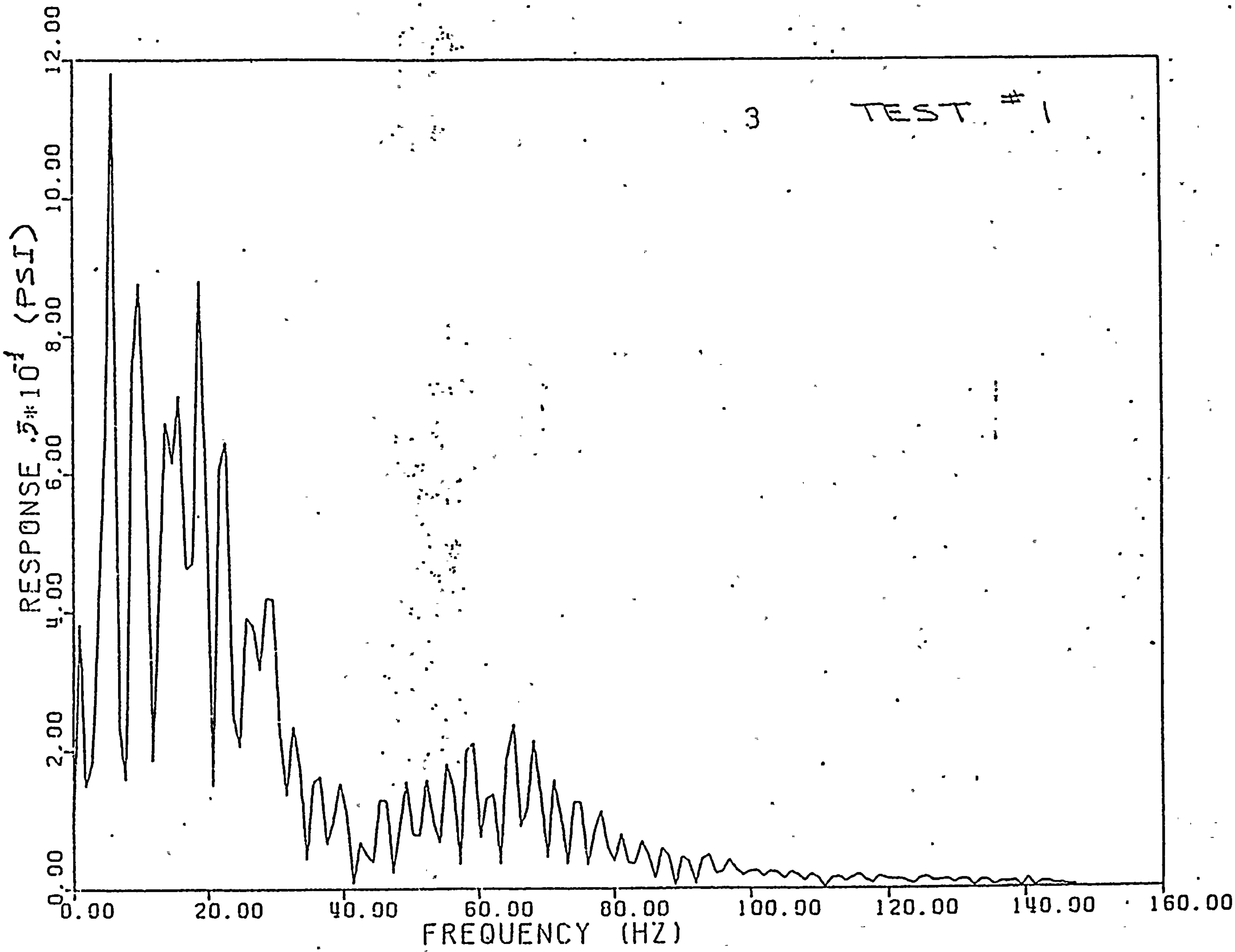
KEY CHUG - B+R/GE



COMPANION CHUG - GE



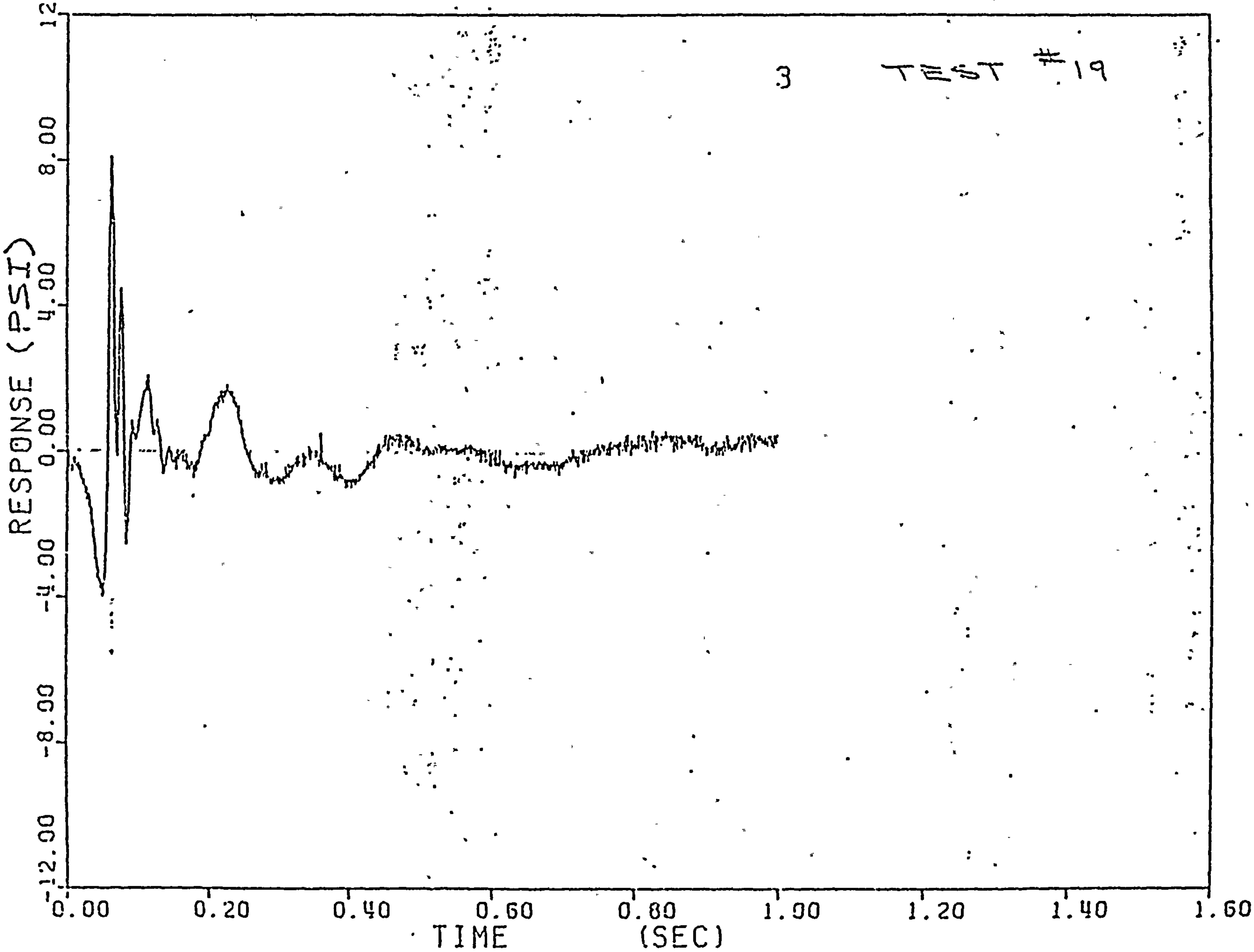
COMPANION CHUG - G.E.



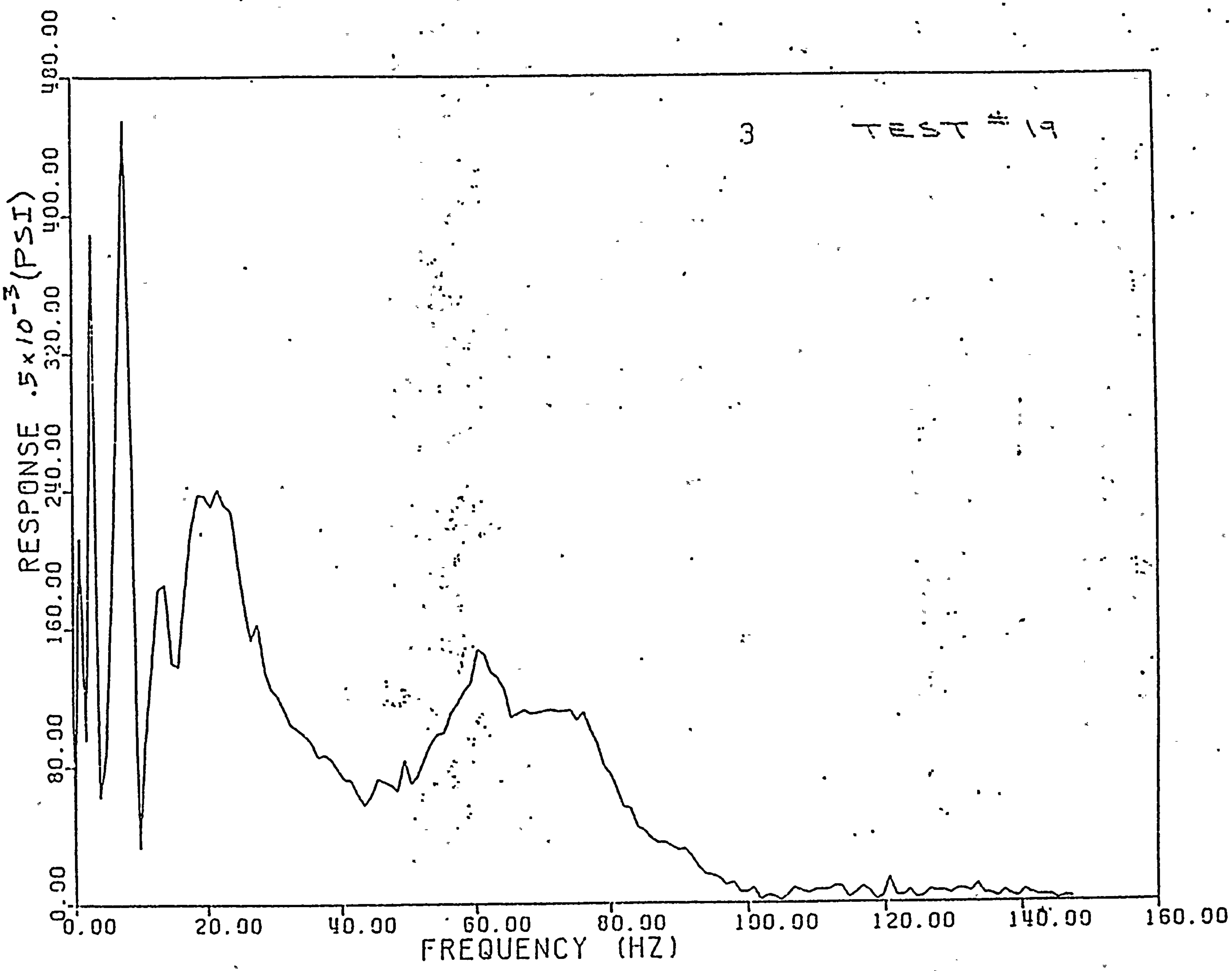
2. COMPANION CHUG NO. 19.3 (B&R) vs. 19.5 (GE)

I. CHUG NO. 4.3 IS MORE CRITICAL IN THE HIGH FREQUENCY ZONE THAN 4.5.

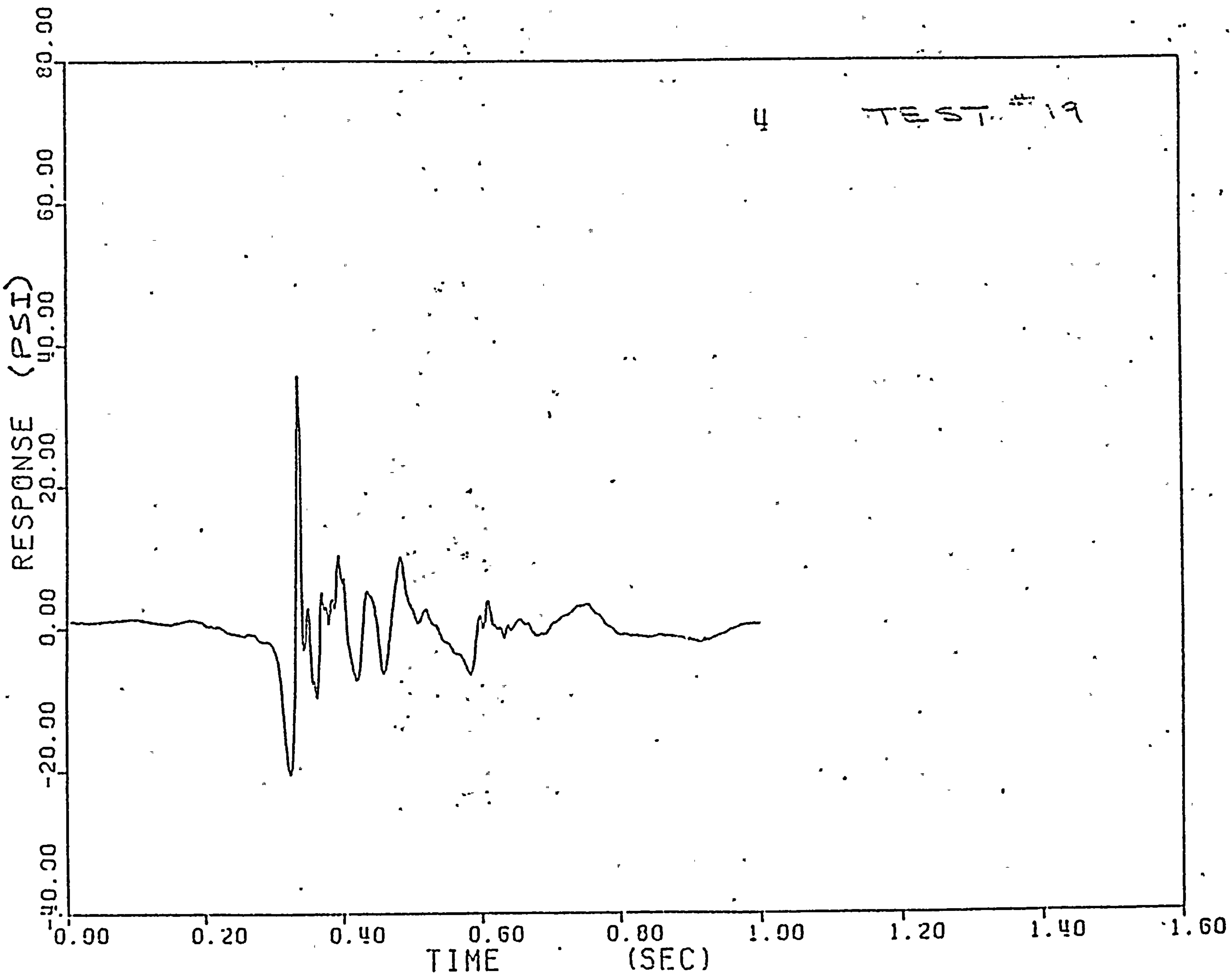
COMPANION CHUG - B&R



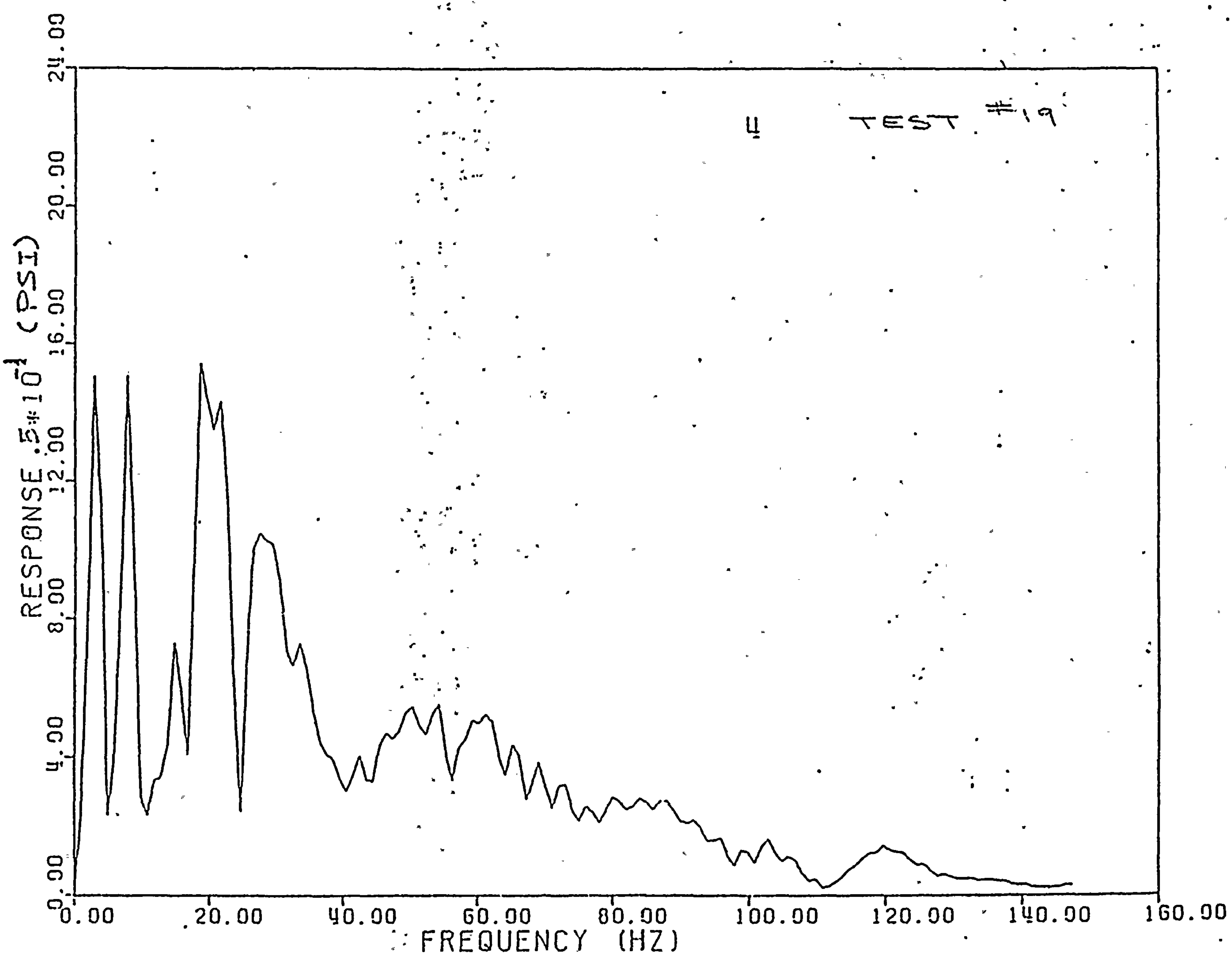
COMPANION CHUG - B+R



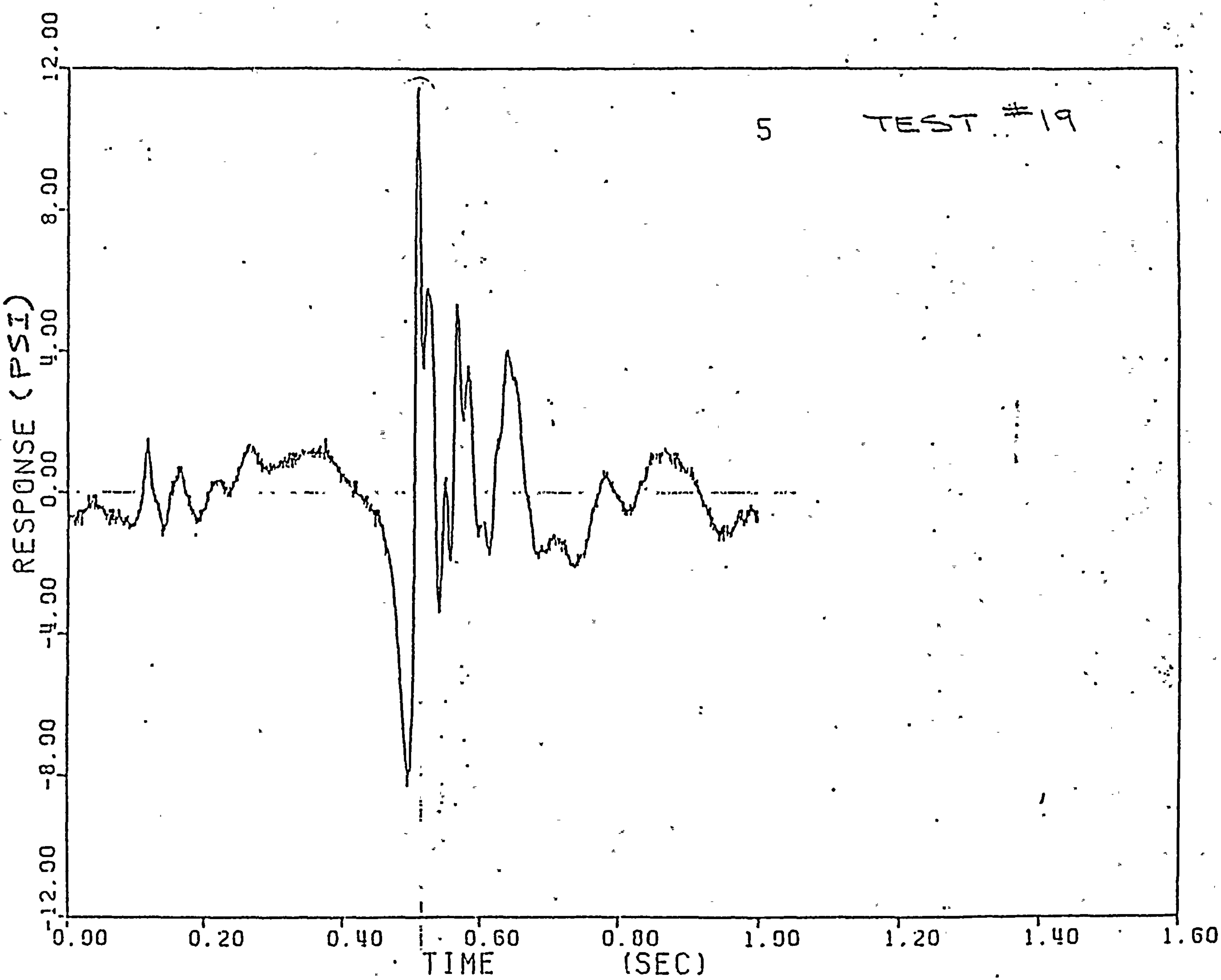
KEY CHUG - B&R/GE.



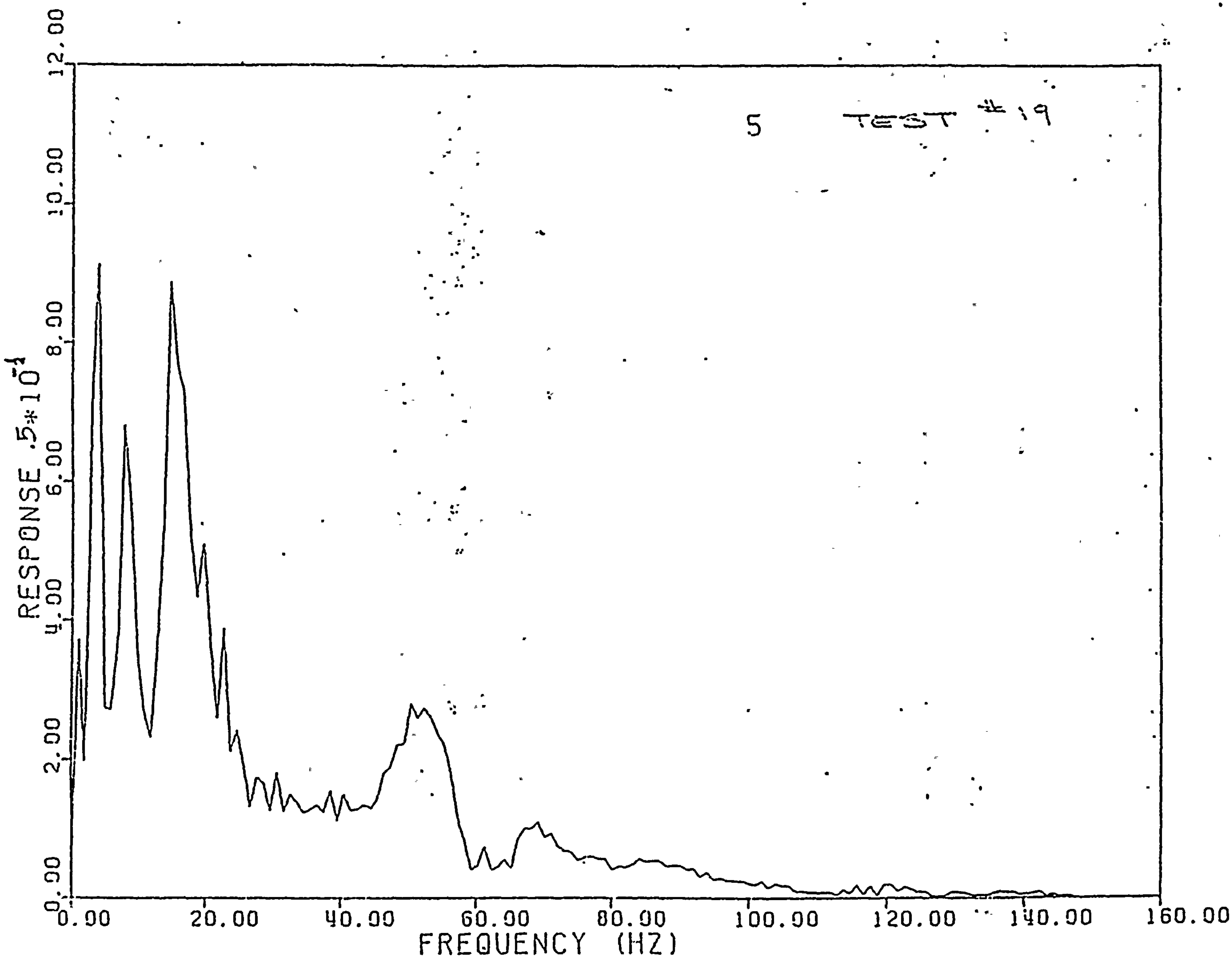
KEY CHUG - B+R/G.E.



COMPANION-CHUG - G.E.



COMPANION CHUG - G.E.

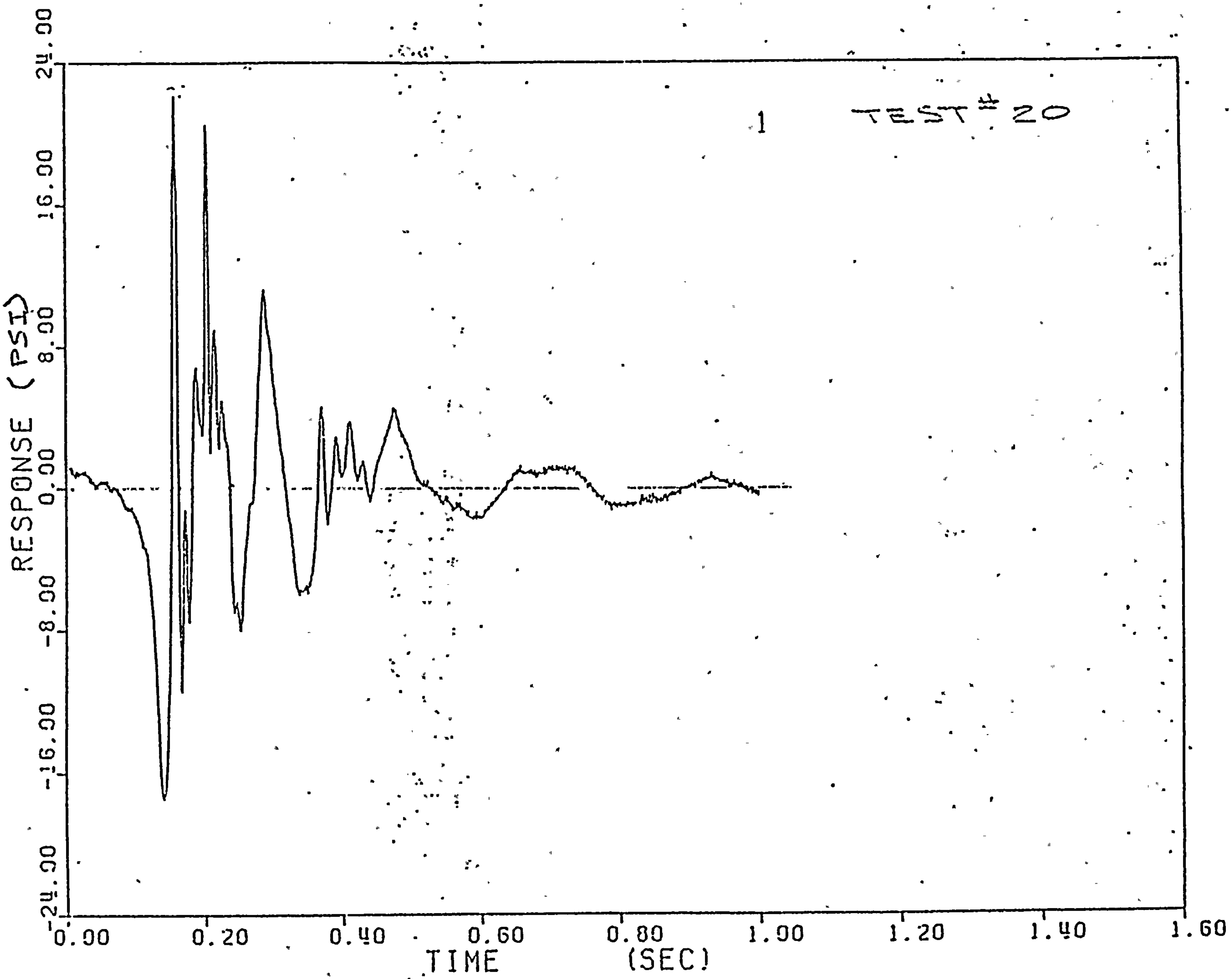


3. KEY CHUG NO. 20.2 (B&R) vs. 20.6 (GE), AND COMPANION CHUG NO. 20.1 (B&R) vs. 20.5 (GE).

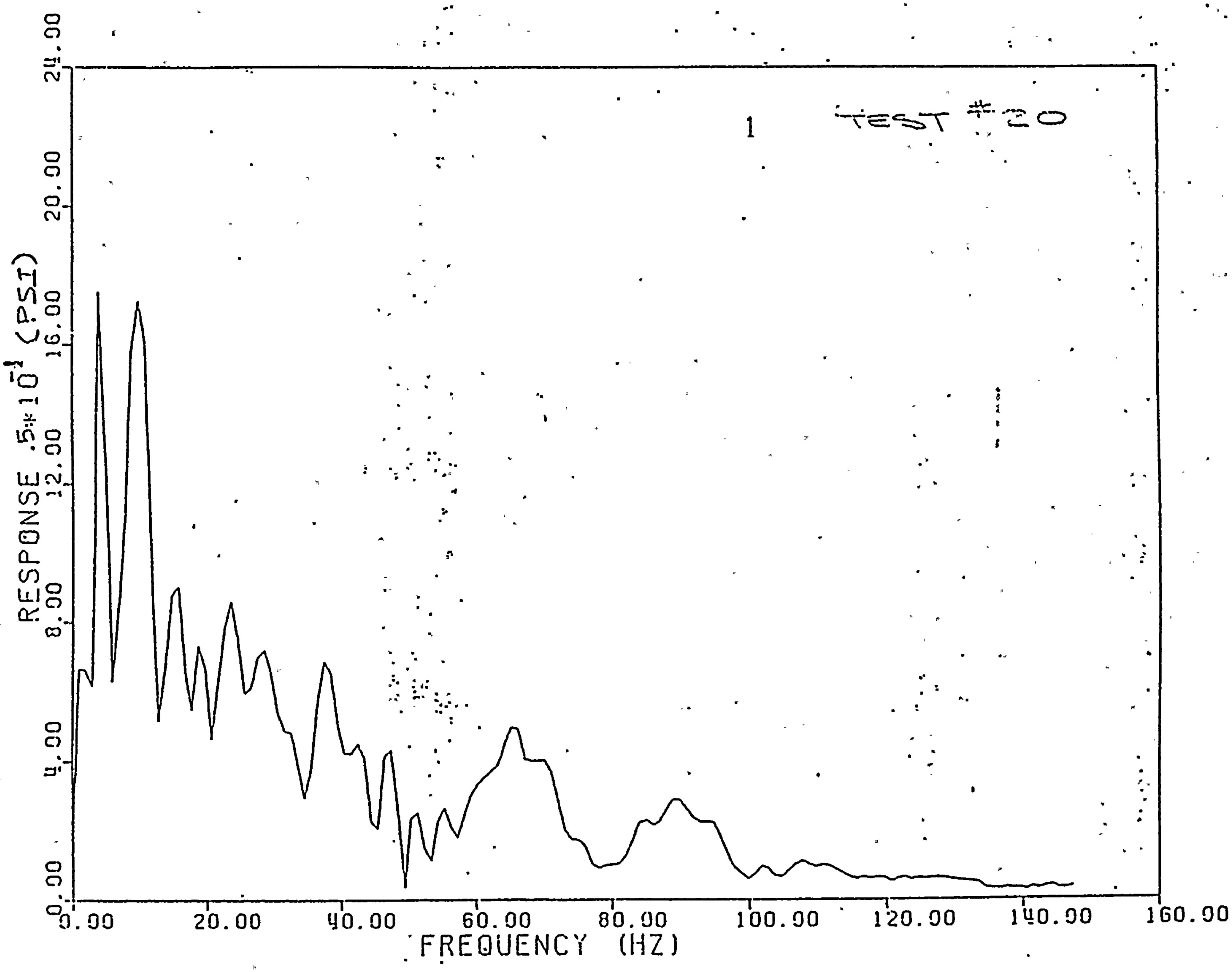
I. MAXIMUM PRESSURE AMPLITUDE OF CHUG NO. 20.2 (24.7 PSI) IS HIGHER THAN THAT OF CHUG NO. 20.6 (14.9 PSI). MAXIMUM PRESSURE AMPLITUDE OF CHUG NO. 20.1 (23.1 PSI) IS HIGHER THAN THAT OF CHUG NO. 20.5 (12.1 PSI).

II. CHUGS 20.1 AND 20.2 ARE MORE CRITICAL IN THE HIGHER FREQUENCY ZONES.

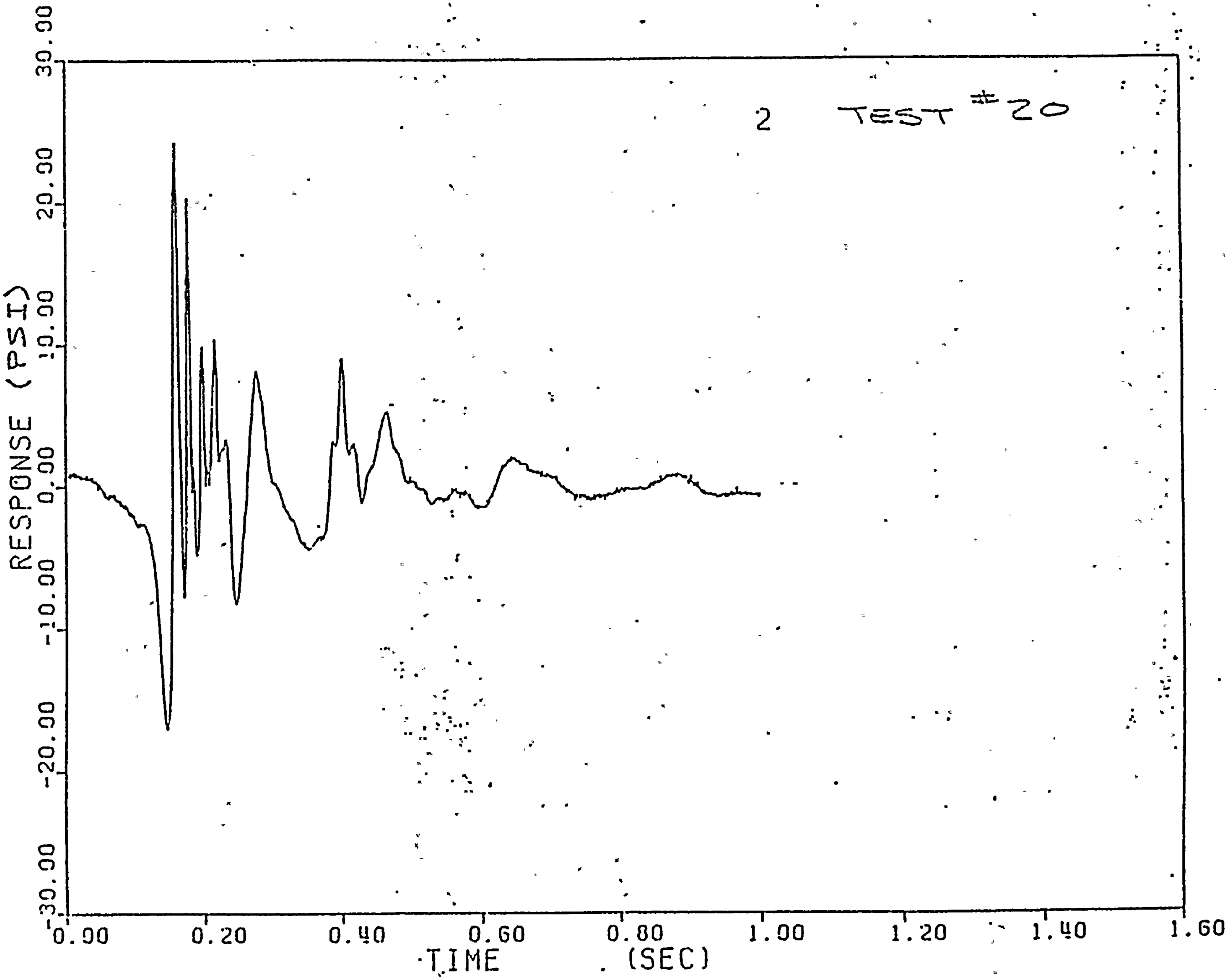
COMPANION CHUG - B+R



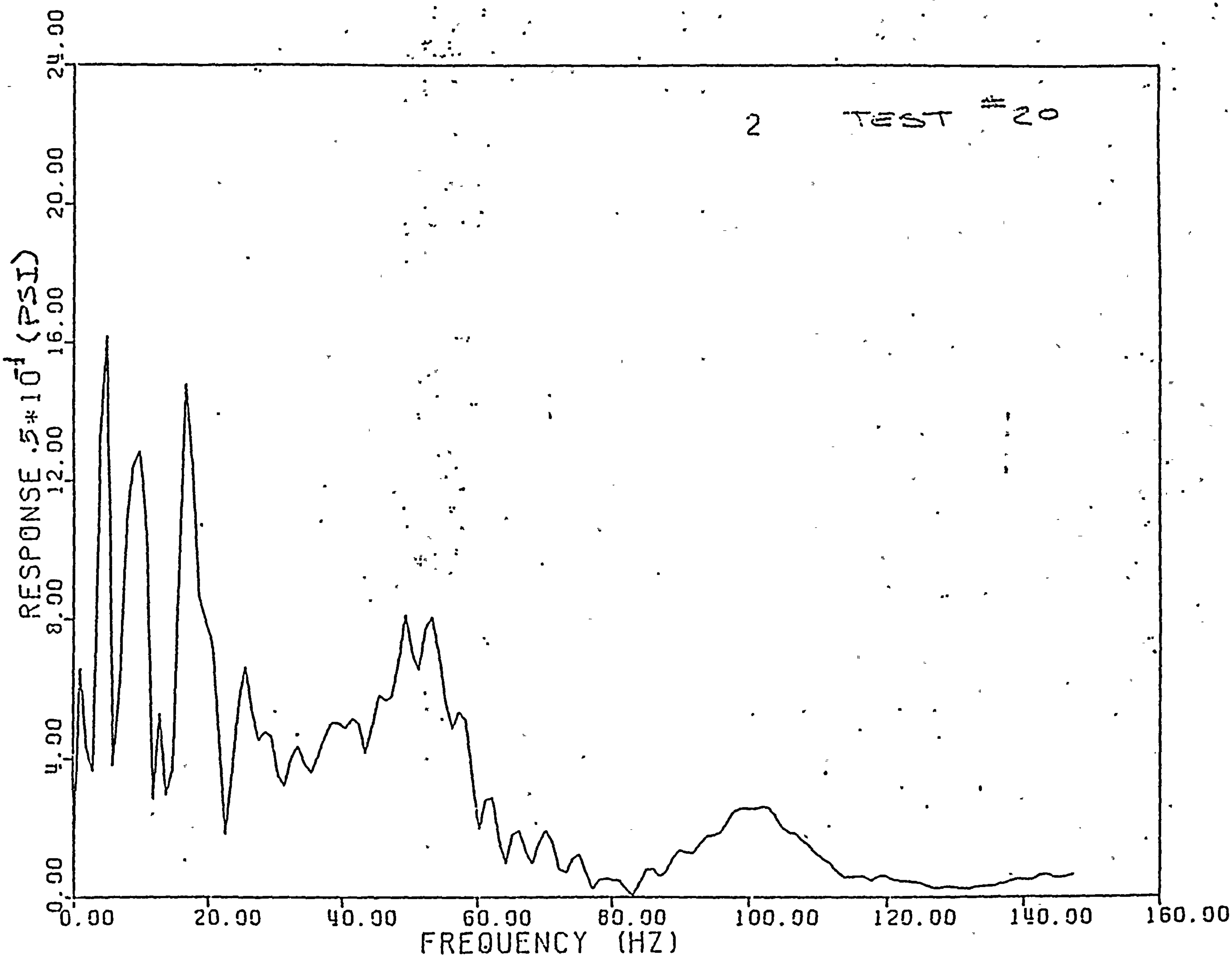
COMPANION CHUG - B+R



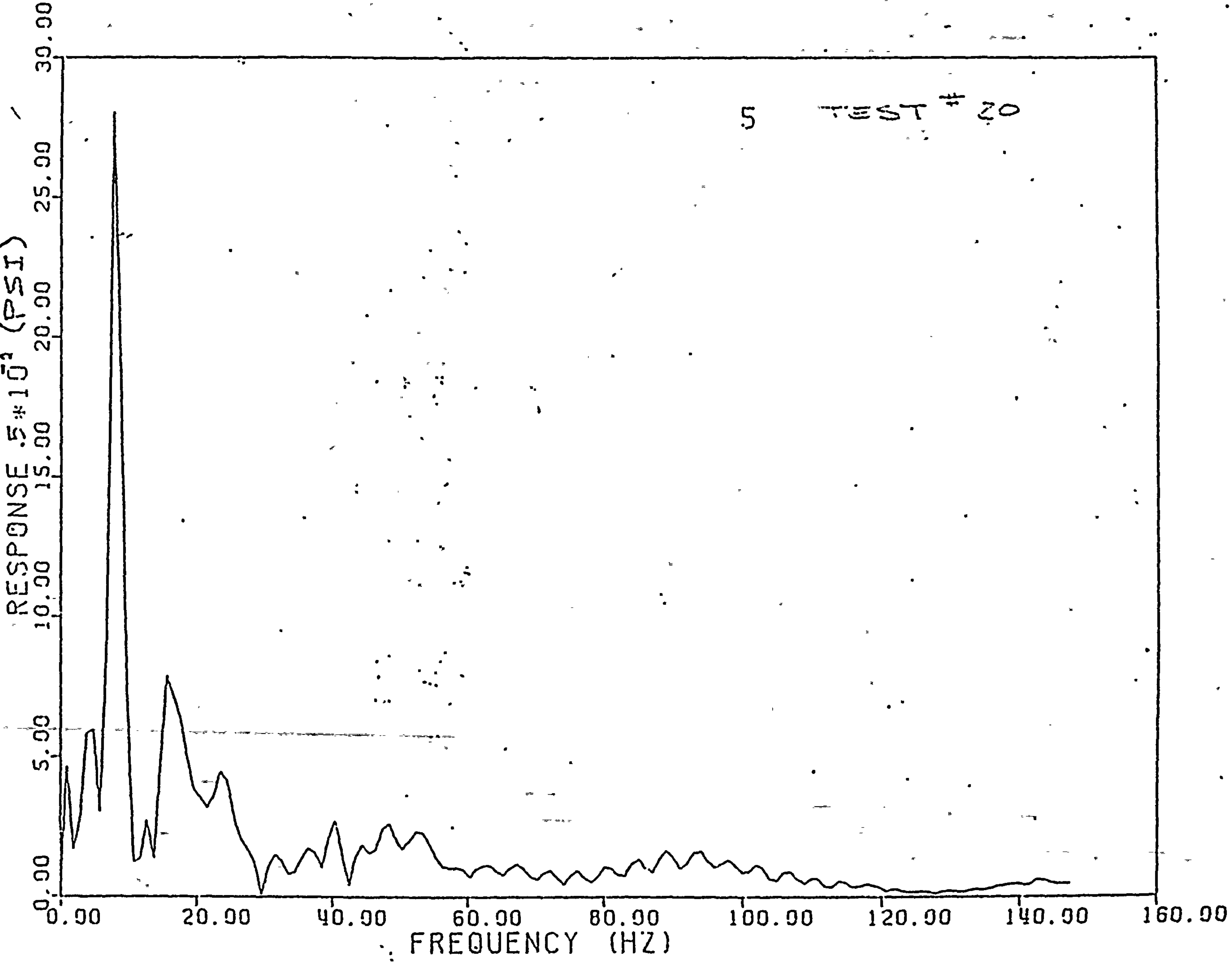
KEY CHUG - B+R


2 TEST #20
RESPONSE (PSI)
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
TIME (SEC)

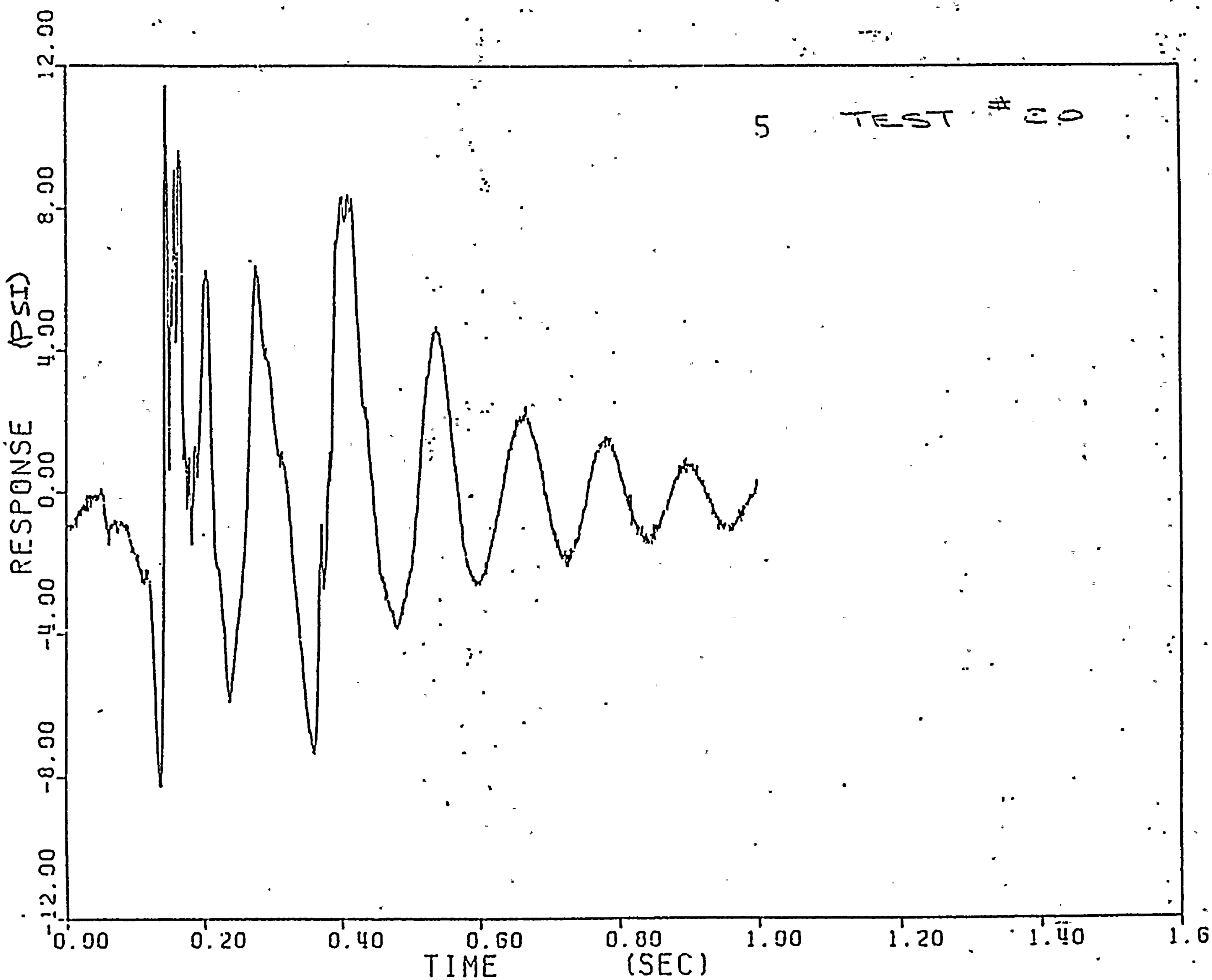
KEY CHUG - B+R


2 TEST #20
RESPONSE .5*10⁻¹ (PSI)
0.00
4.00
8.00
12.00
16.00
20.00
24.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
FREQUENCY (HZ)

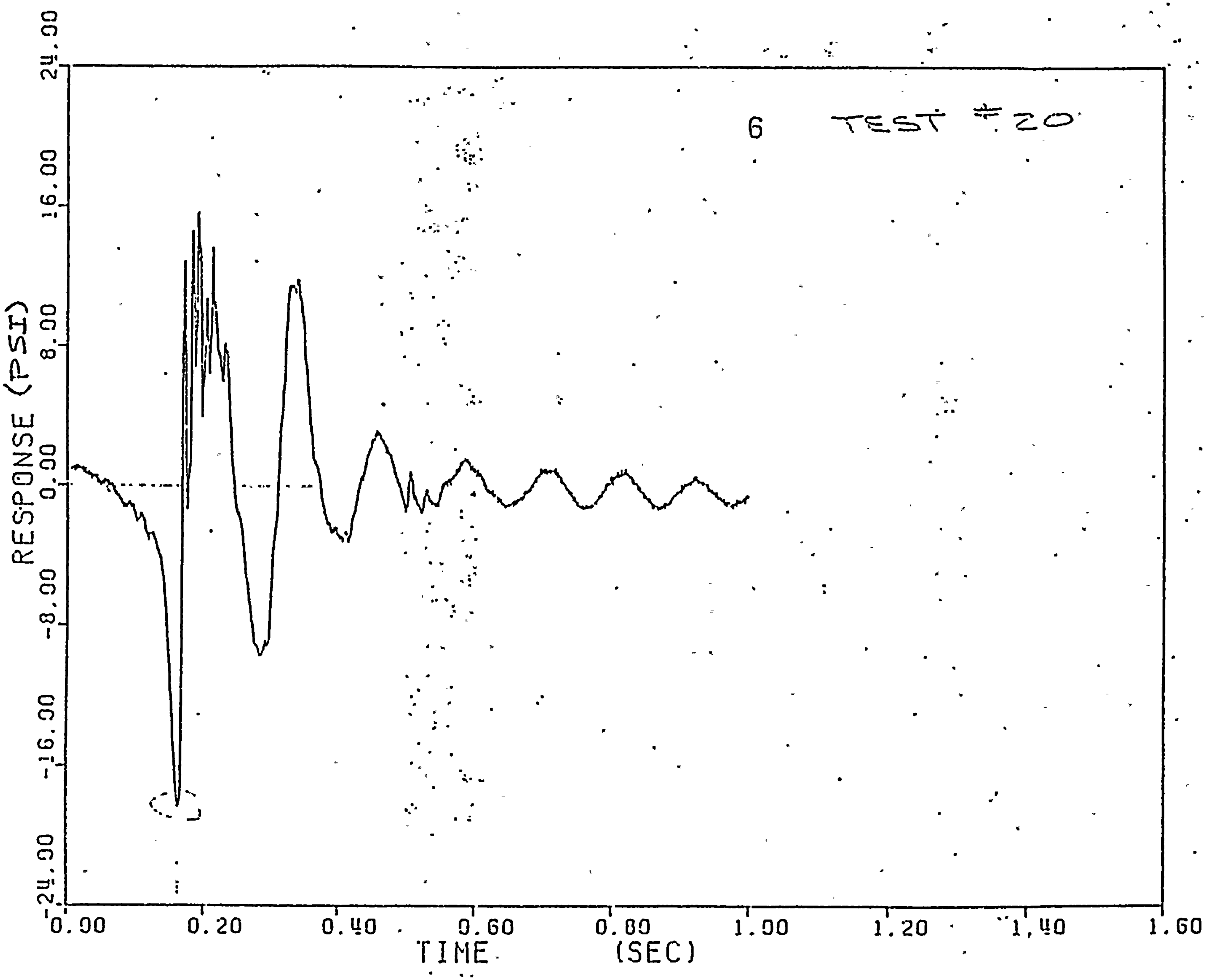
COMPANION CHUG - G.E.



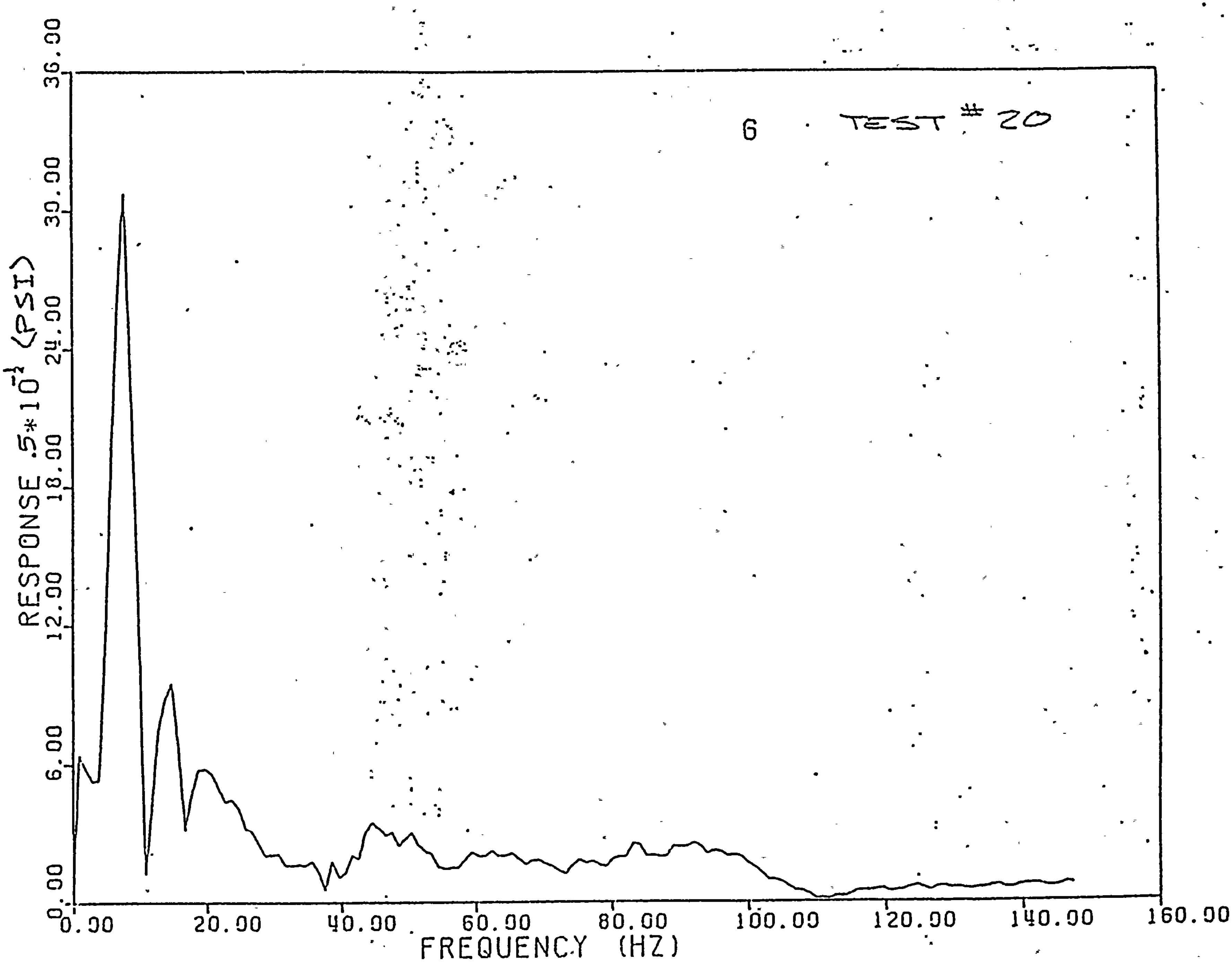
COMPANION CHUG - G.E.



KEY CHUG - G.E.


6 TEST #20
RESPONSE (PSI)
24.00
16.00
8.00
0.00
-8.00
-16.00
-24.00
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
TIME (SEC)

KEY CHUG - G.E.


6
TEST # 20
RESPONSE .5*10^{-1} (PSI)
0.00
6.00
12.00
18.00
24.00
30.00
36.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
FREQUENCY (HZ)

7. The statement is made that the single vent design source load developed for WNP-2 envelopes the 4T data. Provide additional clarification, e.g., bound all 4T data in amplitude, and frequency.

DESIGN ENVELOPE vs. REQUIRED ENVELOPE

FIGURES 4-7 THROUGH 4-10 IN THE B&R CHUGGING REPORT SHOW THAT THE DESIGN SPECTRA DEVELOPED FOR WNP-2 ENVELOPES ALL 4TCO DATA IN AMPLITUDE AND FREQUENCY.

See:

"Chugging Loads - Revised Definition and Application Methodology for Mark II Containments (Based on 4TCO Test Results)."

Transmitted by:

Letter G02-81-189, dated July 22, 1981, Supply System to NRC.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2.	DESIGN SPECTRUM AND REQUIRED ENVELOPE SPECTRUM - CHANNEL 28	FIGURE 4-7

See:

"Chugging Loads - Revised Definition and Application Methodology for Mark II Containments (Based on 4TCO Test Results)."

Transmitted by:

Letter G02-81-189, dated July 22, 1981, Supply System to NRC.

See:

"Chugging Loads - Revised Definition and Application Methodology for Mark II Containments (Based on 4TCO Test Results)."

Transmitted by:

Letter G02-81-189, dated July 22, 1981, Supply System to NRC.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2.	DESIGN SPECTRUM AND REQUIRED ENVELOPE SPECTRUM - CHANNEL 24	FIGURE 4-9

See:

"Chugging Loads - Revised Definition and Application Methodology for Mark II Containments (Based on 4TCO Test Results)."

Transmitted by:

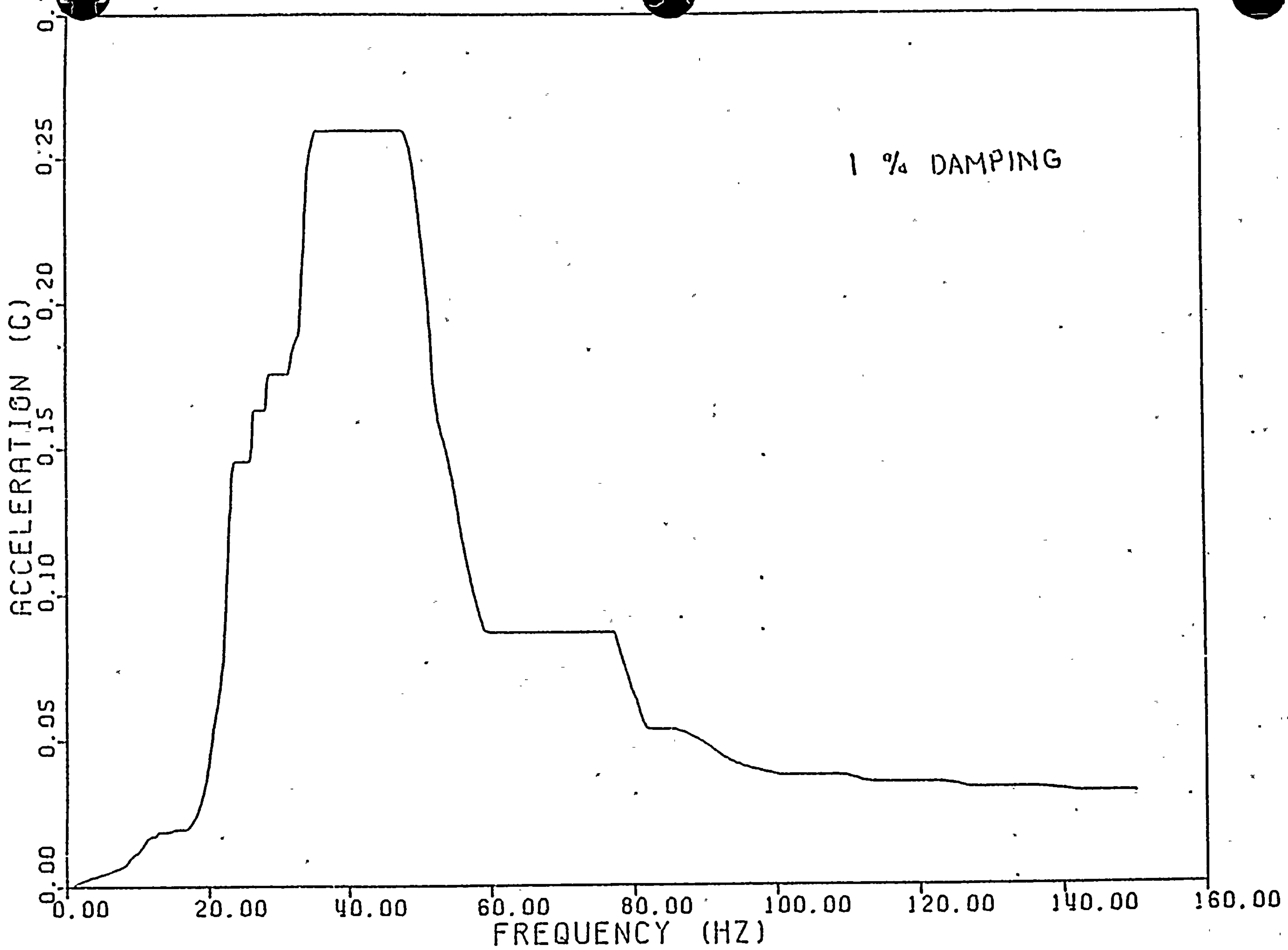
Letter G02-81-189, dated July 22, 1981, Supply System to NRC.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2.	DESIGN SPECTRUM AND REQUIRED ENVELOPE SPECTRUM - CHANNEL 20	FIGURE 4-10

8. Discuss if the three vents in one radial direction where the source strength is increased by 24% are chosen at random or specifically chosen to compensate for any asymmetric load that might occur due to variation in times at which chugs occur.

NEARLY SYMMETRIC LOAD DEFINITION

THE THREE RADIAL VENTS WHERE THE SOURCE STRENGTH IS INCREASED BY 24% ARE CHOSEN TO ACCOUNT FOR ANY IMBALANCE THAT MIGHT OCCUR. THIS RESULTED IN BUILDING RESPONSES ABOUT 10% HIGHER THAN THOSE OF THE AXISYMMETRIC CASE.

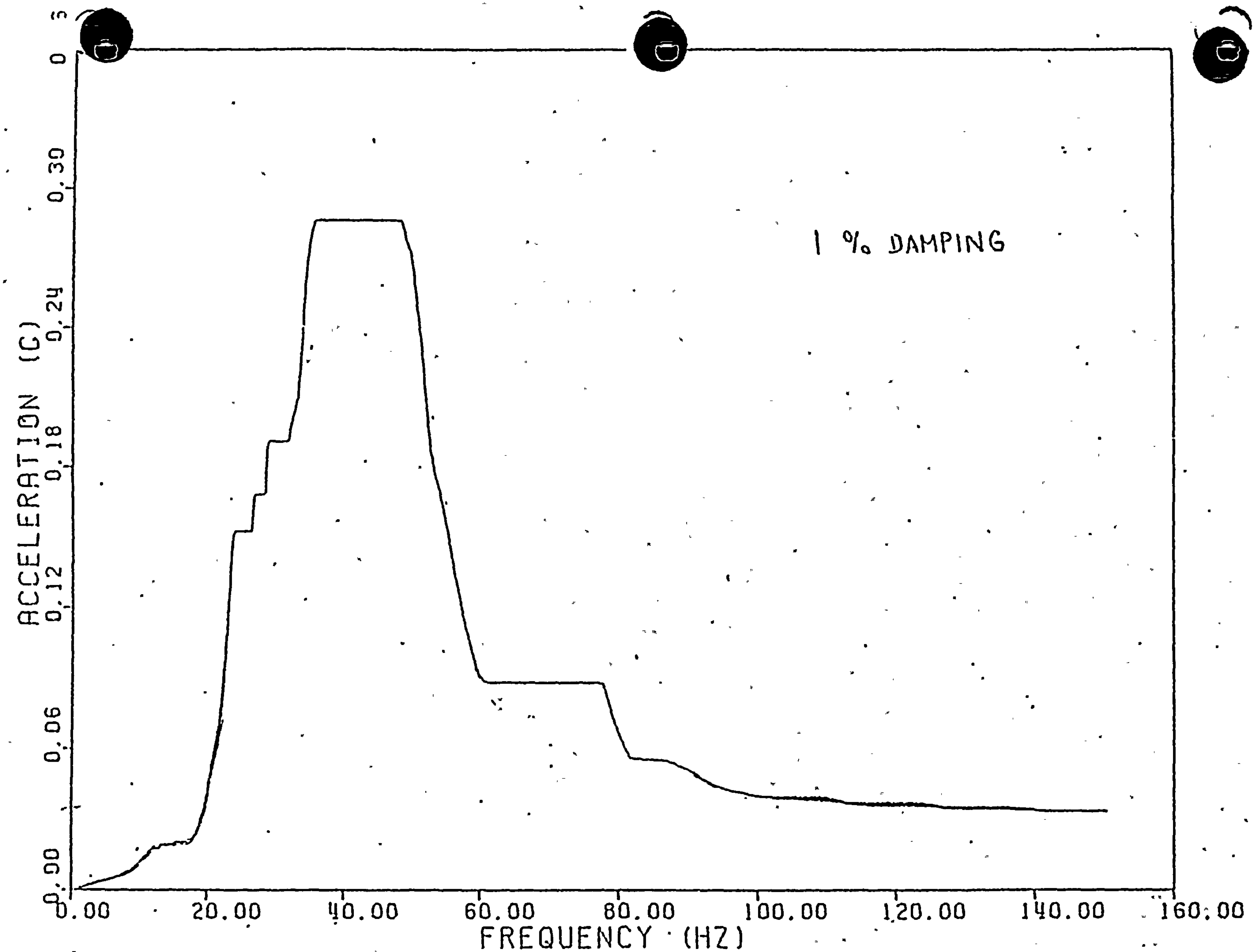


WPPSS-2 - CHUGGING - FULLY AXISYMMETRIC*

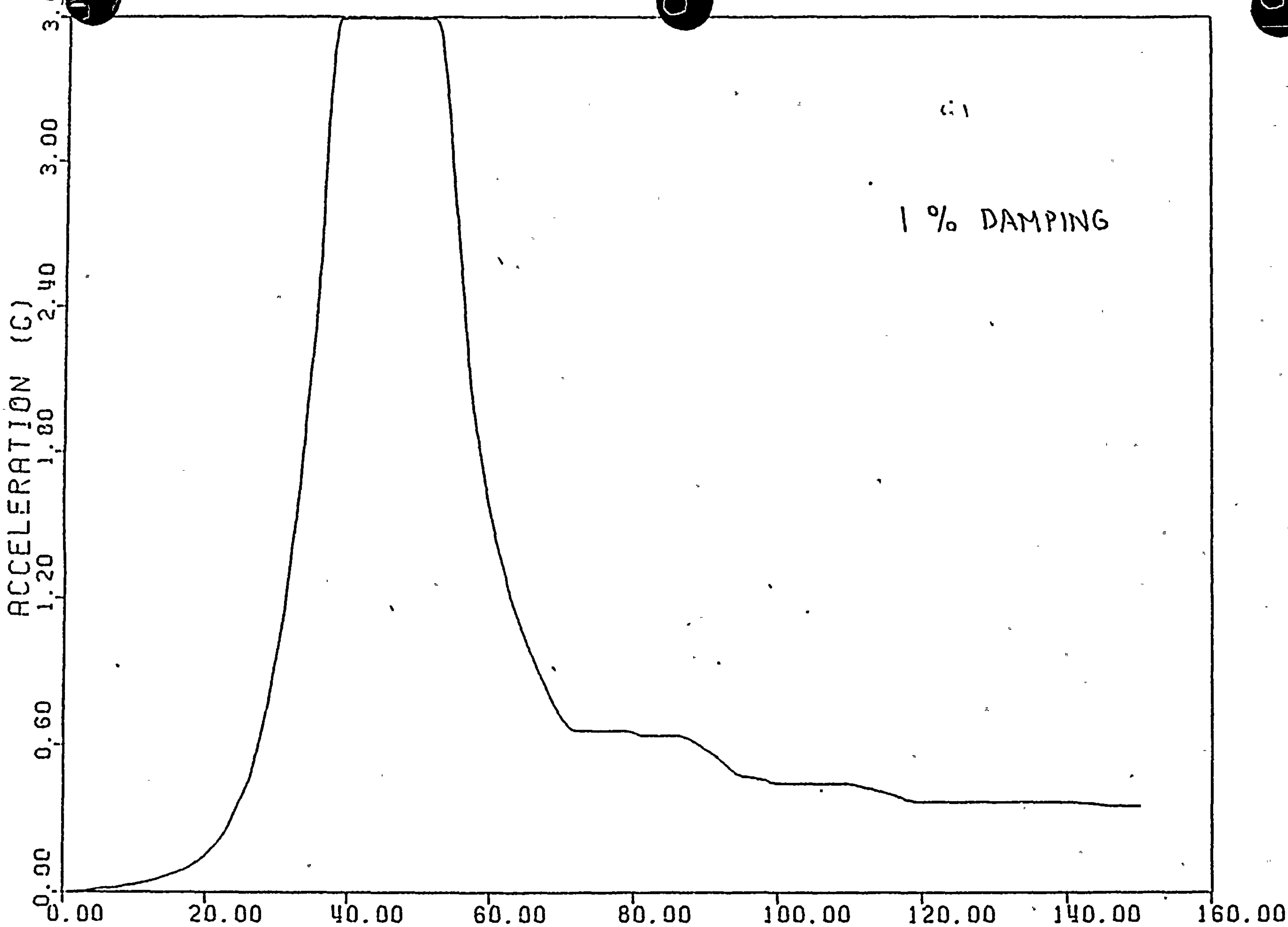
MASS NO. 21 EL.564.83 FT. HORIZ. TRANSLATION

CONTAINMENT VESSEL (DRYWELL)
AT STABILIZER TRUSS

* ALL VENTS FIRING EQUAL

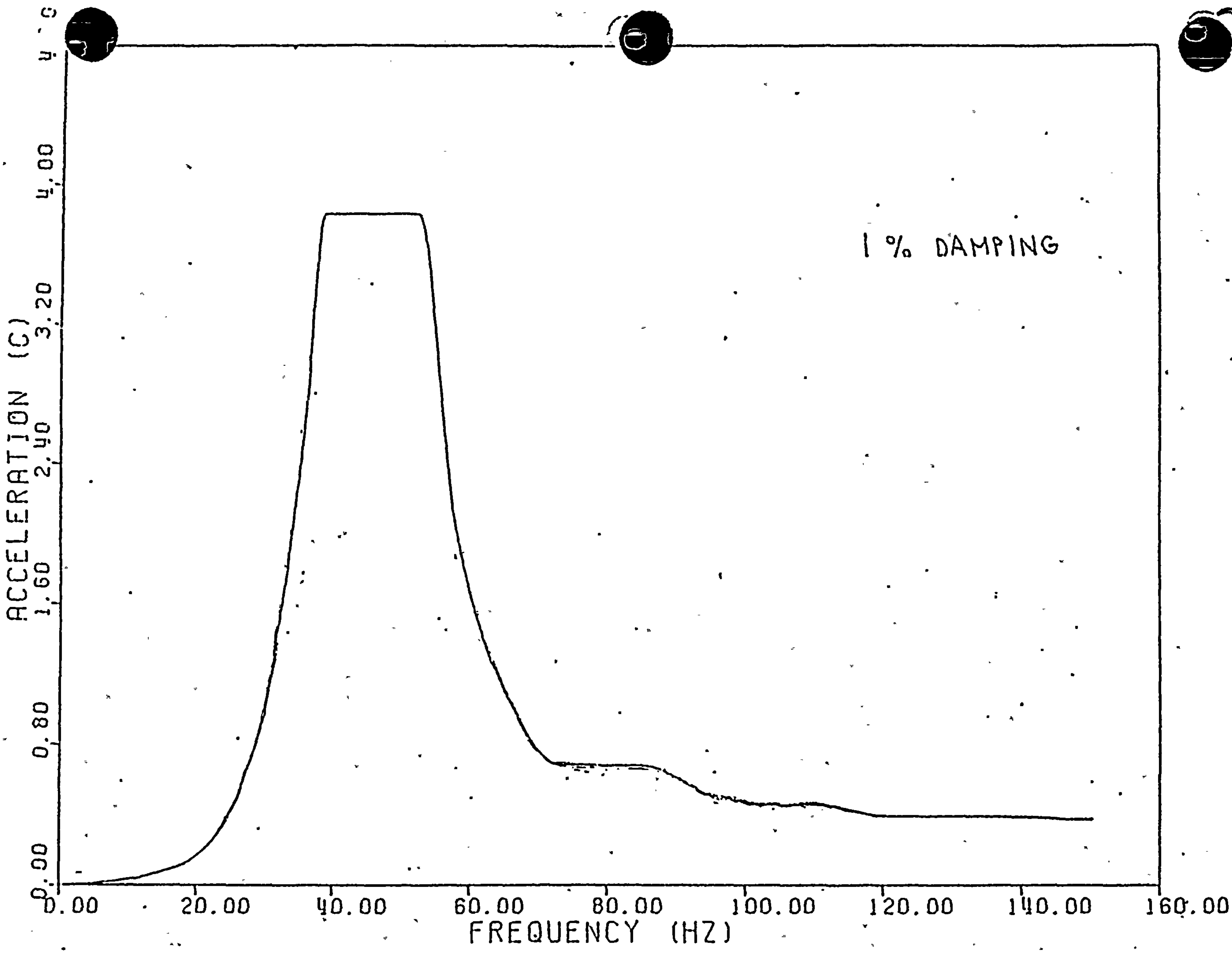


WPPSS ≡2 - NEARLY SYMMETRIC CHUGGING - (BASED ON 4TCO DATA)
MASS NO: 21 EL.504.83 FT. HORIZ. TRANSLATION
CONTAINMENT VESSEL (DRYWELL)
AT STABLIZER TRUSS

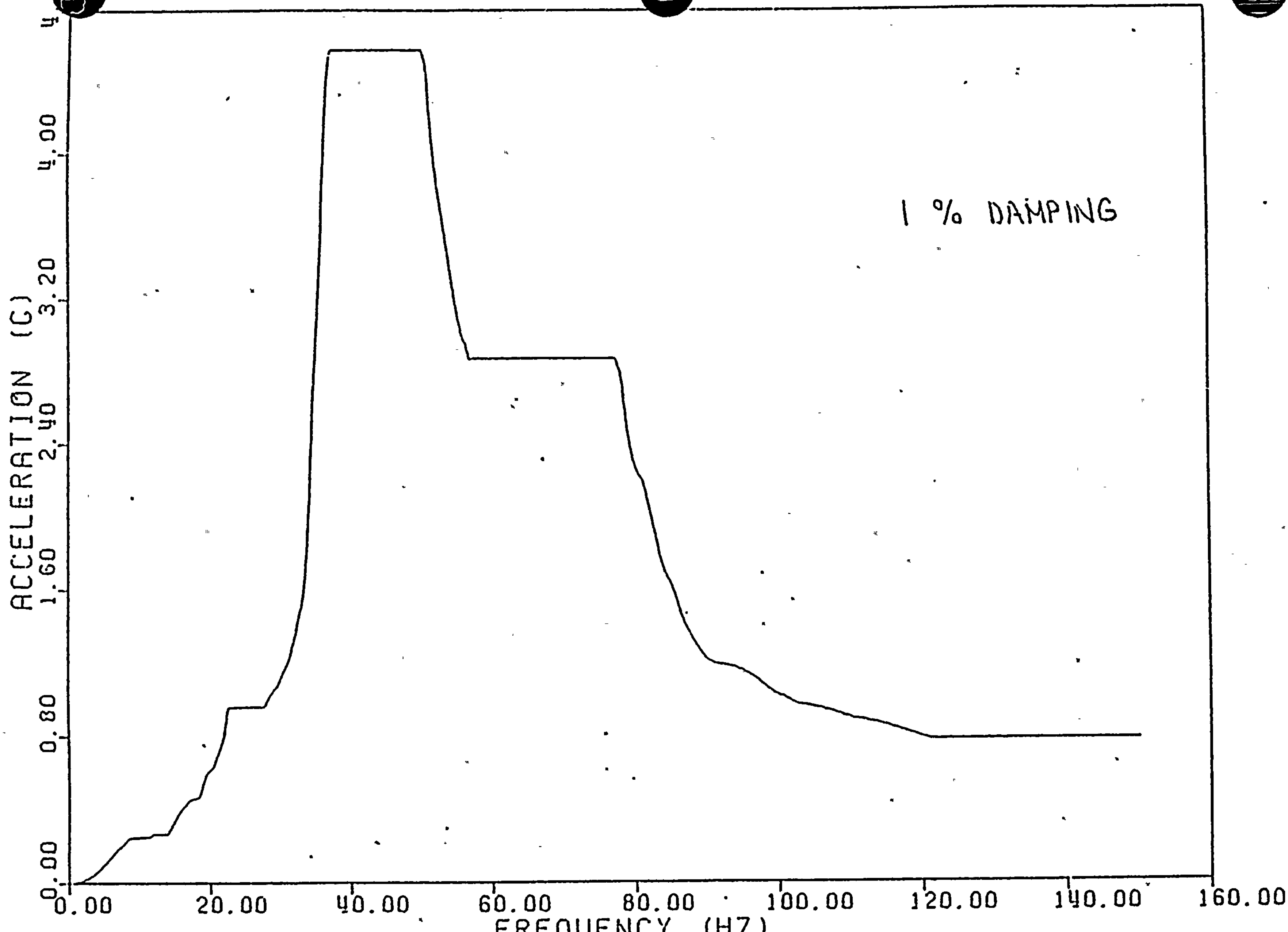


WPPSS-2 - CHUGGING - FULLY AXISYMMETRIC *
MASS NO. 76 EL. 500.69 FT. HORIZ. TRANSLATION
CONTAINMENT VESSEL (DRYWELL)
AT DIAPHRAGM FLOOR

* ALL VENTS FIRING EQUAL STRENGTH

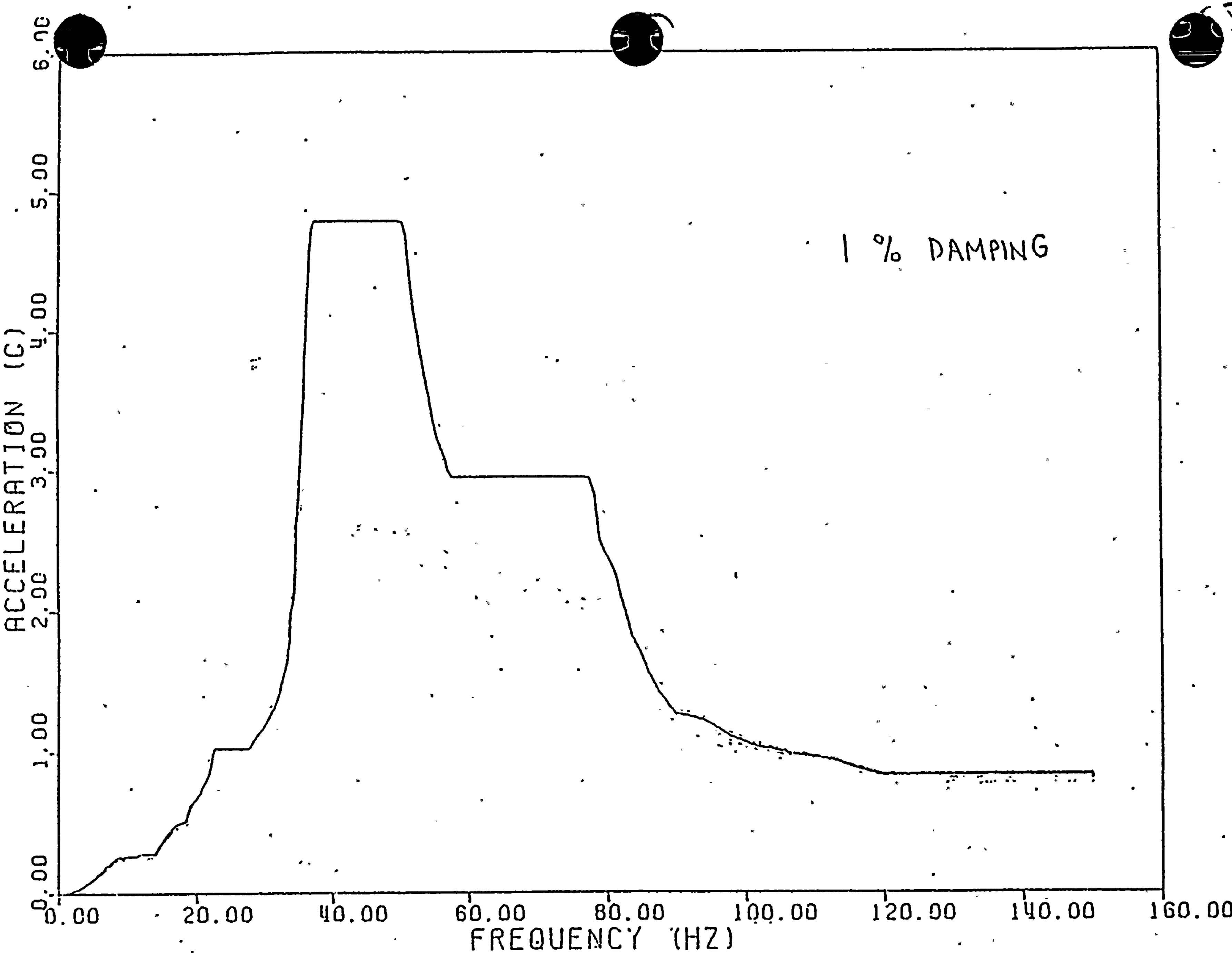


WPPSS ≡2 - NEARLY SYMMETRIC CHUGGING - (BASED ON 4TCO DATA)
MASS NO. 76 EL.500.69 FT. HORIZ. TRANSLATION
CONTAINMENT VESSEL (DRYWELL)
AT DIAPHRAGM FLOOR



WPPSS-2 - CHUGGING - FULLY AXISYMMETRIC *
MASS NO. 123 EL.409.33 FT. HORIZ. TRANSLATION
CONTAINMENT VESSEL (WETWELL)
AT VENT EXIT

* ALL VENTS FIRING EQUAL STRENGTH



WPPSS ≡2 - NEARLY SYMMETRIC CHUGGING - (BASED ON 4TCO DATA)

MASS NO. 123 EL. 459.33 FT. HORIZ. TRANSLATION

CONTAINMENT VESSEL (WETWELL)

AT VENT EXIT

9. The assumption that chugs at 3 vent pipes in one radial direction are synchronized for the asymmetric load is not conservative specially at higher frequency. Provide the rationale for not assigning different chuggging start time to each vent.

SYNCHRONIZED RADIALLY LOCATED VENTS

THE B&R APPROACH IS CONSERVATIVE IN THE HIGHER AS WELL AS THE LOWER FREQUENCY RANGE SINCE THE JAERI TEST RESULTS WERE ENVELOPED COMPLETELY BY THE PRESSURES THAT WERE USED FOR THE DESIGN OF WNP-2, FIGURE 5.6 OF B&R REPORT OVER ALL FREQUENCY RANGE OF INTEREST. THE CONSERVATISM CRITERIA HERE IS BASED ON COMPARISON WITH ACTUAL FULL SCALE TEST DATA (JAERI).

See:

"Chugging Loads - Revised Definition and Application Methodology for Mark II Containments (Based on 4TCO Test Results)."

Transmitted by:

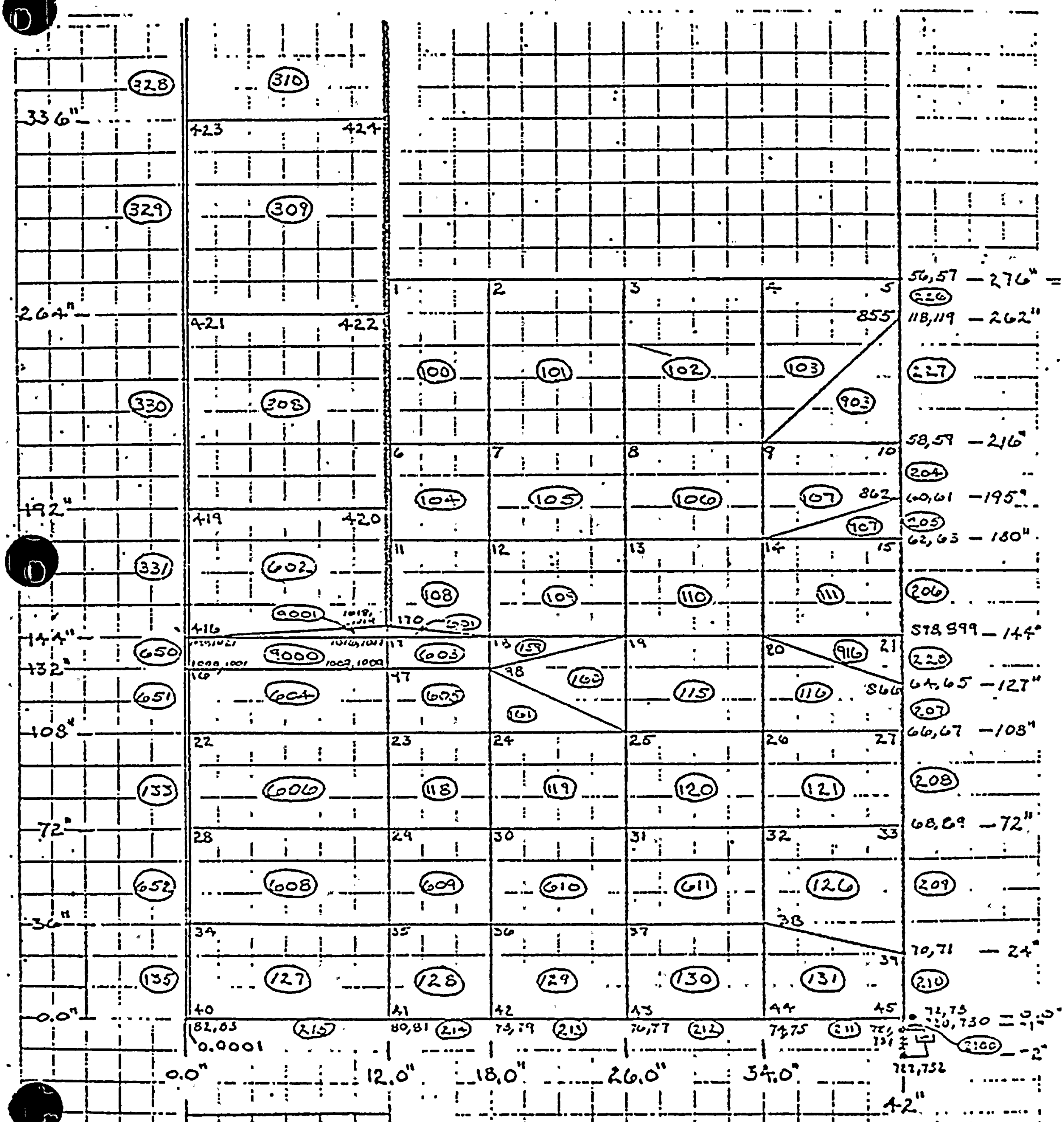
Letter G02-81-189, dated July 22, 1981, Supply System to NRC.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	ENVELOPES OF CALCULATED RESPONSES FOR WNP-2 AND MEASURED RESPONSES AT JAERI-CONTAINMENT AT VENT EXIT ELEVATION	FIGURE 5-6

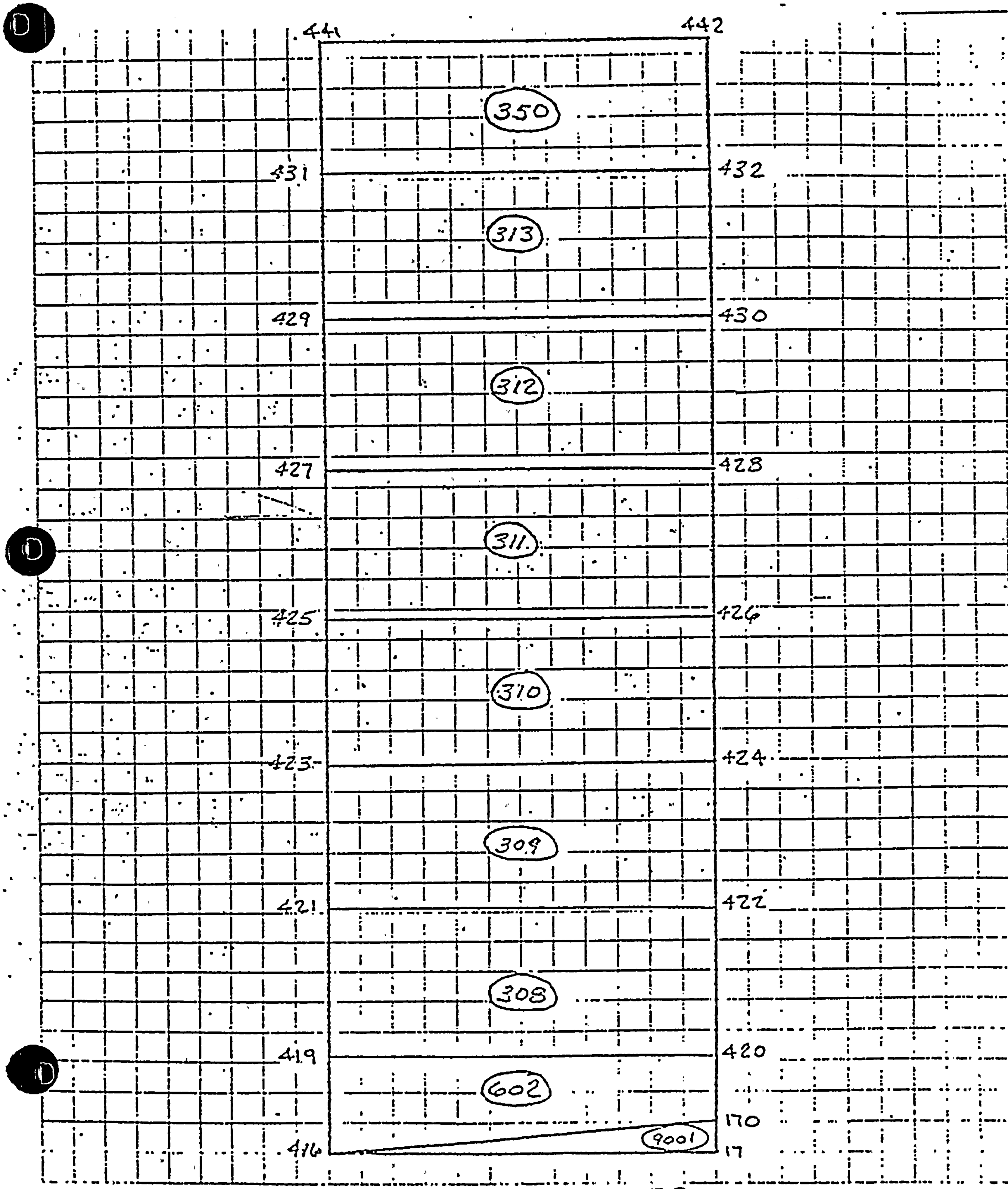
10. Provide detailed description of the analytical model used to deduce the sources and containment boundary pressures.

4-T MODEL

- 4-T MODEL CONSISTS OF 3 TYPES OF ELEMENTS:
  1. FLUID ELEMENTS (WATER, C_W)
  2. FLUID ELEMENTS (STEAM, C_S)
  3. SHELL ELEMENTS (STEEL)
- MODEL IS AXISYMMETRIC.
- PROPERTIES OF MODEL ARE DESCRIBED IN TWO B&R CHUGGING REPORTS.
- NASTRAN FINITE ELEMENT PROGRAM WAS USED IN THE ANALYSIS.

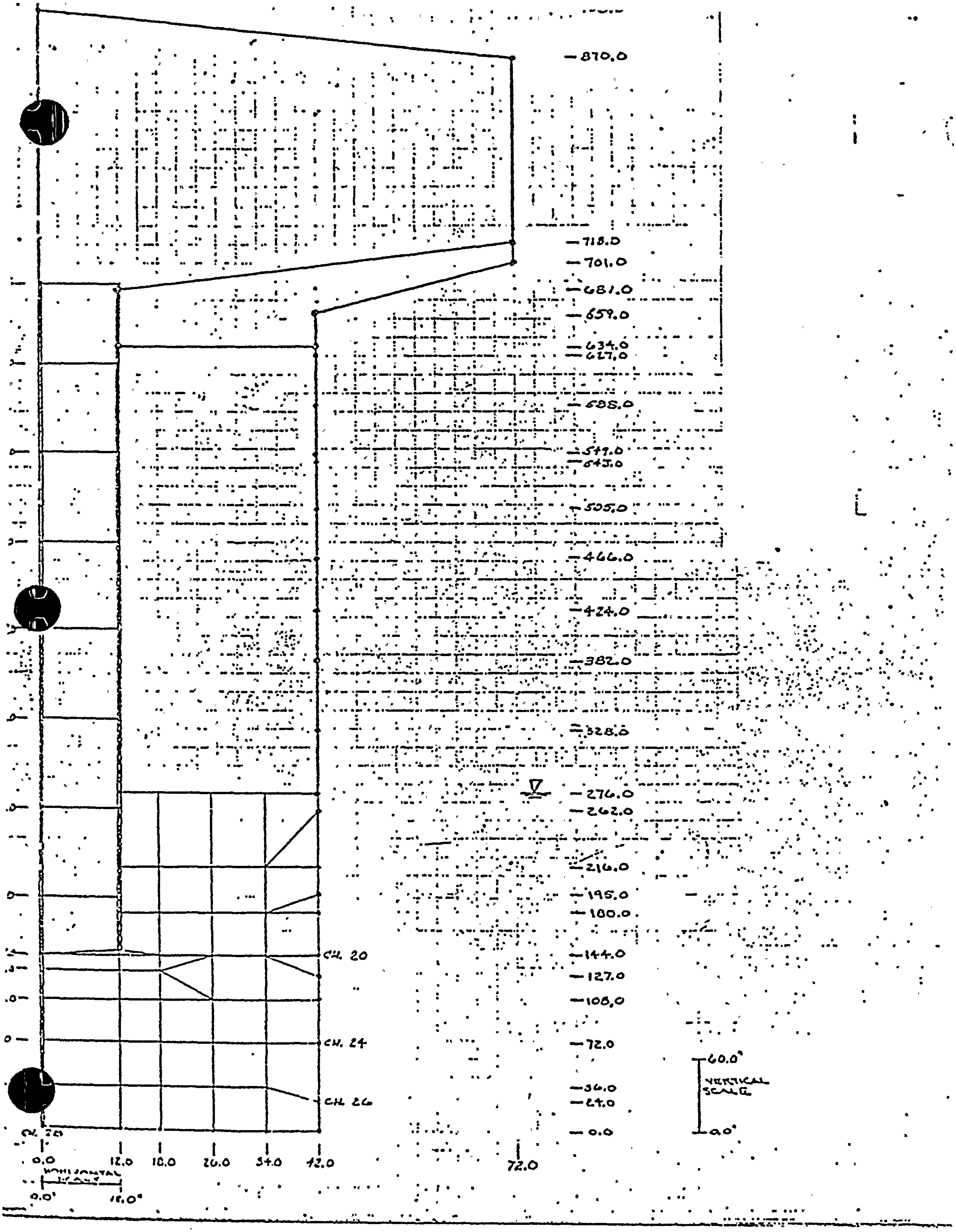


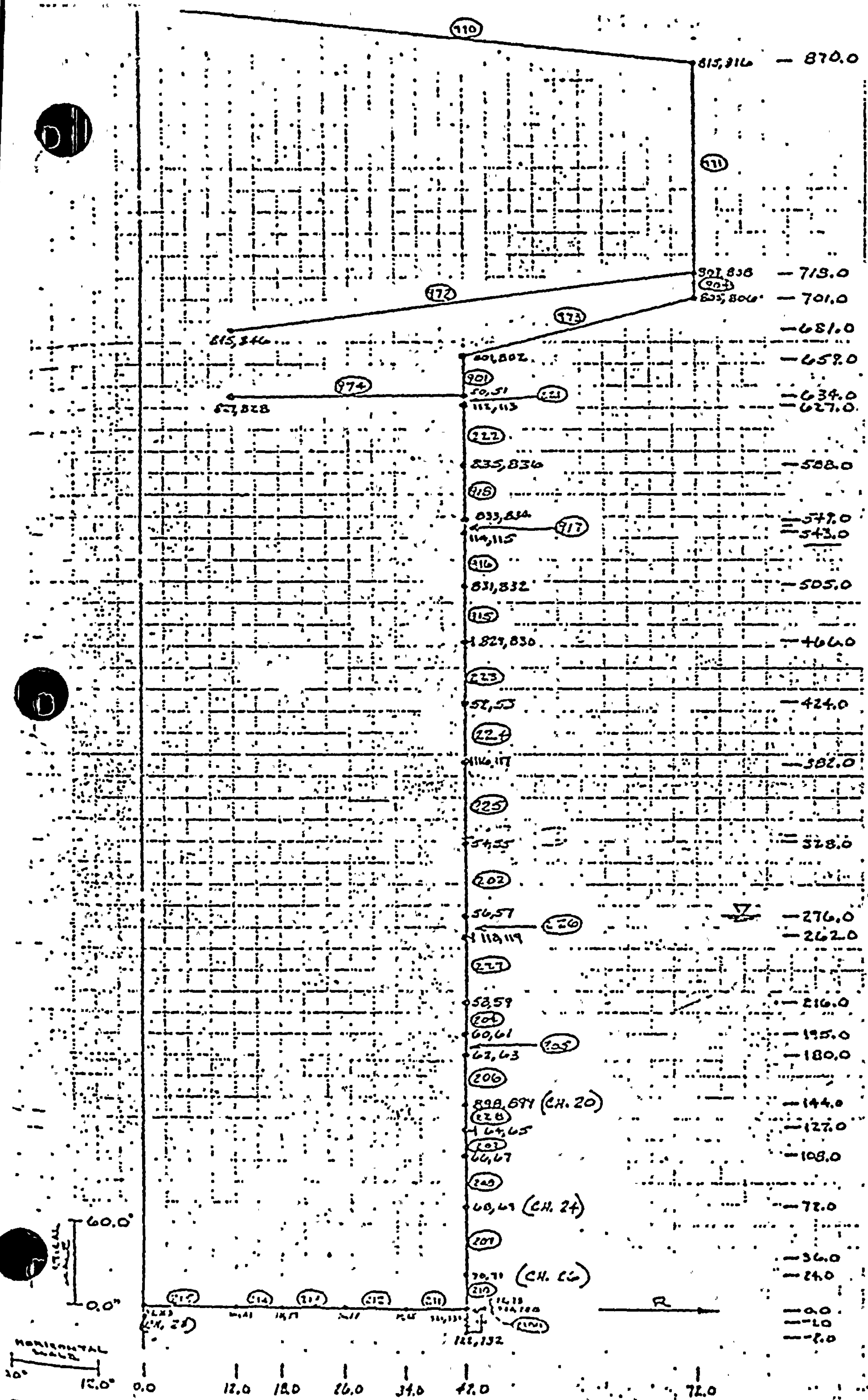
MODEL WITH 24" VENT



Form BR 5002-2

VENT ELEMENTS


870.0
718.0
701.0
681.0
659.0
634.0
627.0
588.0
549.0
545.0
505.0
466.0
424.0
382.0
328.0
276.0
262.0
216.0
195.0
180.0
144.0
127.0
108.0
72.0
36.0
24.0
0.0
CH. 20
CH. 24
CH. 26
60.0'
VERTICAL SCALE
0.0'
0.0
12.0
18.0
26.0
34.0
42.0
72.0
HORIZONTAL SCALE
0.0'
16.0'



870.0
718.0
701.0
681.0
659.0
634.0
627.0
588.0
549.0
543.0
505.0
466.0
424.0
382.0
328.0
276.0
262.0
216.0
195.0
180.0
144.0
127.0
108.0
72.0
36.0
24.0
0.0
(CH. 20)
(CH. 24)
(CH. 26)
(CH. 28)
R
60.0"
0.0"
HORIZONTAL SCALE
12.0"
0.0
12.0
18.0
26.0
34.0
42.0
72.0

WNP-2

HYDRODYNAMIC MODEL

- WNP-2 MODEL CONSISTS OF TWO TYPES OF 3-DIMENSIONAL HYDRODYNAMIC ELEMENTS:

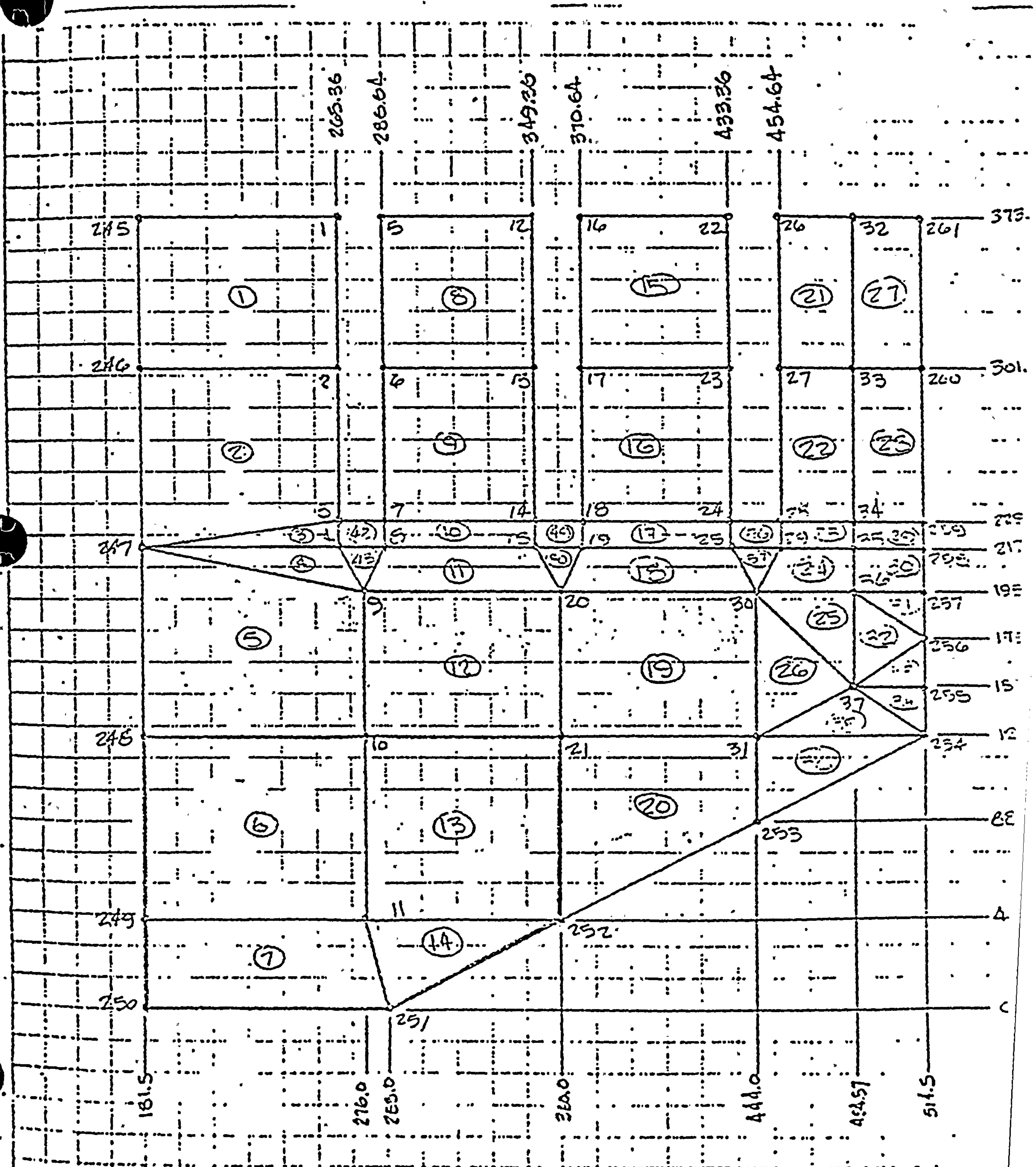
  1. FLUID ELEMENTS (WATER, C_W)

  2. FLUID ELEMENTS (STEAM, C_S)

- PROPERTIES OF ELEMENTS ARE DESCRIBED IN B&R CHUGGING REPORT.

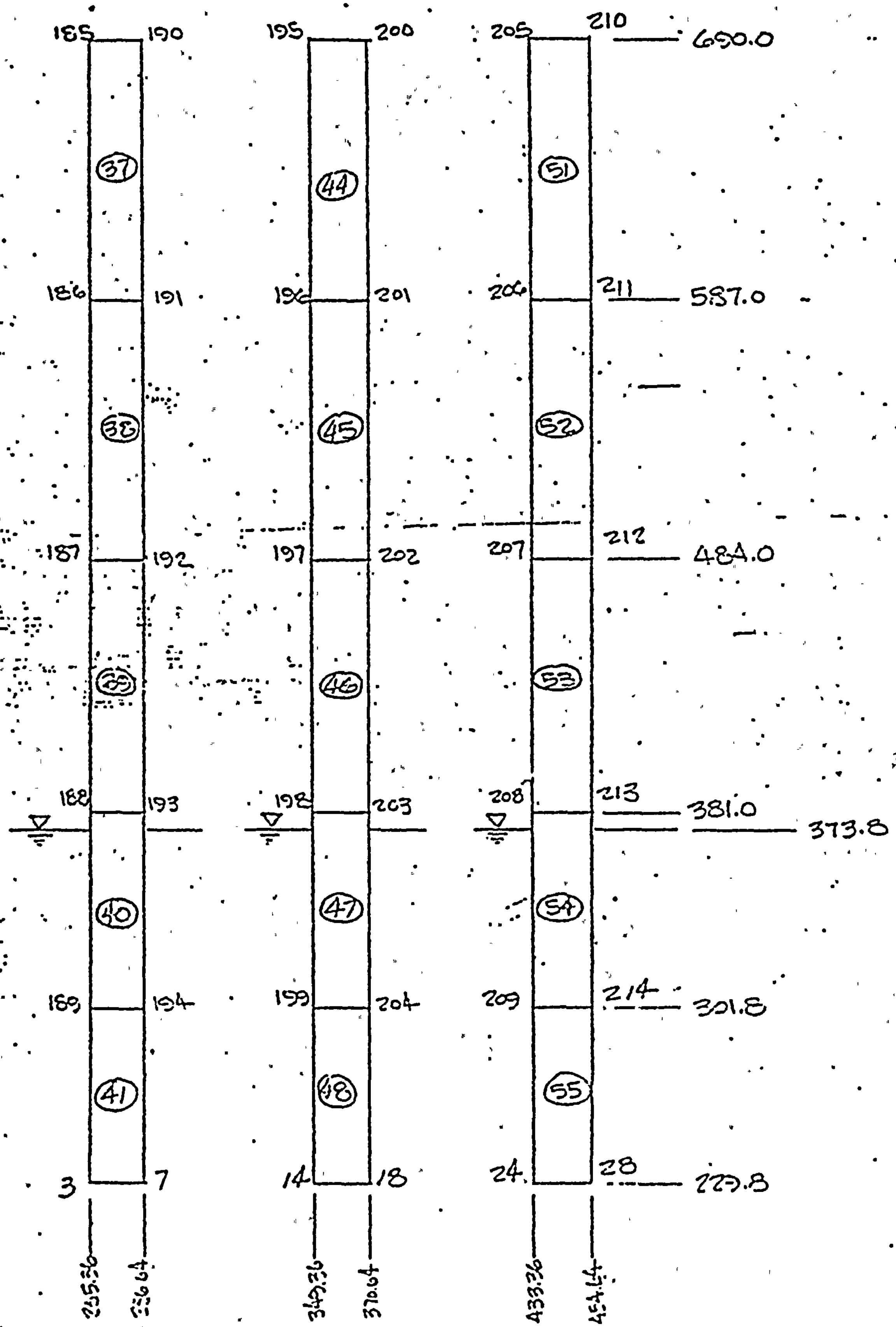
- IN-HOUSE FINITE ELEMENT PROGRAM "HYD-1" WAS USED IN THE ANALYSIS.

- ANALYSIS METHODOLOGY IS DESCRIBED IN ORIGINAL B&R CHUGGING REPORT.



SECTION 1 @ 0°

Form DR 8002-2 (5/78)



Form LiL 8002-2 (5/78)

VENTS - SECTION 1 @ 0°

ASYMMETRIC LOAD CASE (CONT'D)

DESIGN SOURCE	P_G^*	α	M_G^*
801	5.54	.114	14,778
802	3.22	.120	9,041
803	3.46	.121	9,796
804	5.14	.112	13,470
805	4.39	.124	12,738
806	3.34	.119	9,300
807	3.56	.129	10,746
808	5.06	.111	13,142
809	6.90	.095	15,338
810	5.36	.123	15,427

ASYMMETRIC DESIGN MOMENTS OF THE GENERIC LOAD

ASYMMETRIC LOAD CASE

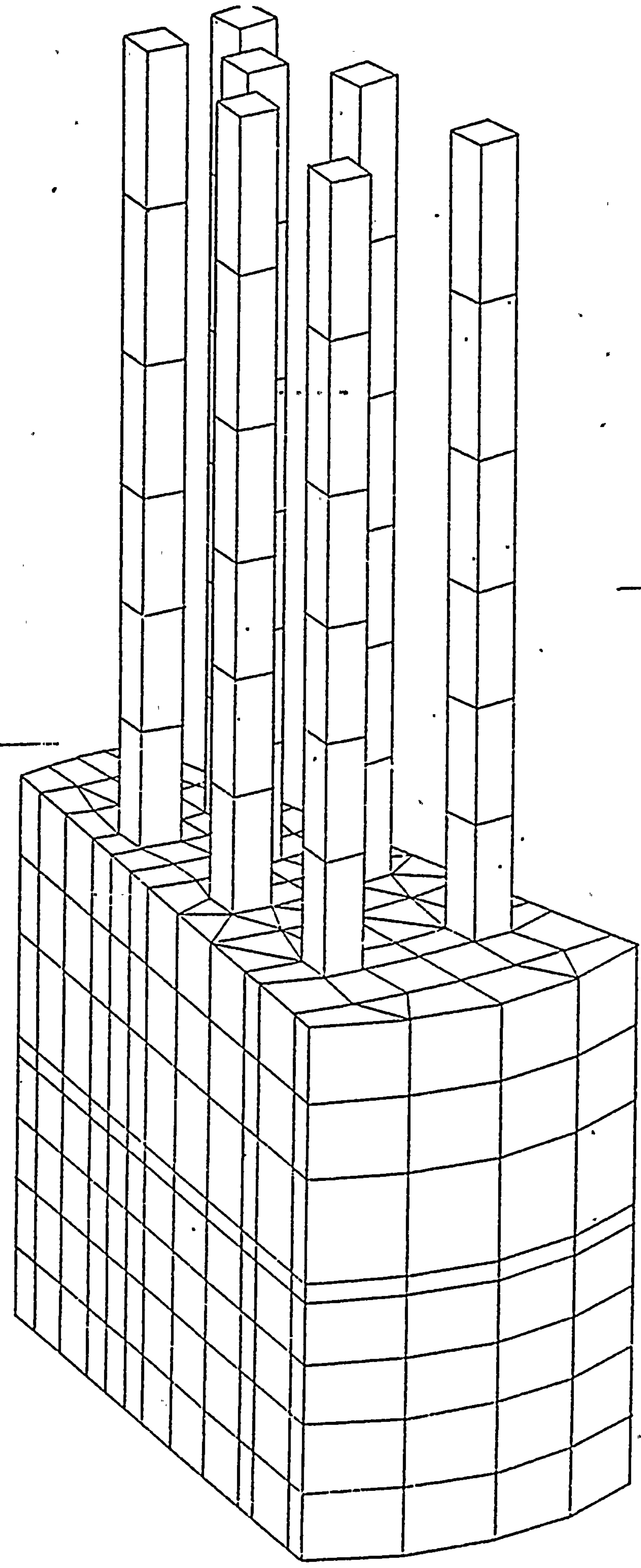
M*, MAX (PSI.IN)		
GENERIC	B&R, REQUIRED (γ = .089)	B&R, DESIGN (γ = .14)
15,427	16,022	25,203

COMPARISON BETWEEN B&R AND GENERIC
DESIGN ASYMMETRIC MOMENTS

5. The comparisons of the WNP-2 method with the JAERI data are not made directly since the JAERI facility was not modeled and so the comparisons are not very convincing. What can be done to model the JAERI facility or at least compare the results with the data in a more meaningful way?

JAERI COMPARISON

- 3D HYDRODYNAMIC FLUID ELEMENTS MODEL.
- APPLY THE B&R METHODOLOGY, WITH DESYNCHRONIZED VENT FIRING TIMES.
- COMPUTE PRESSURE TIME HISTORIES AT DIFFERENT LOCATIONS, COMPARE WITH TEST RESULTS.



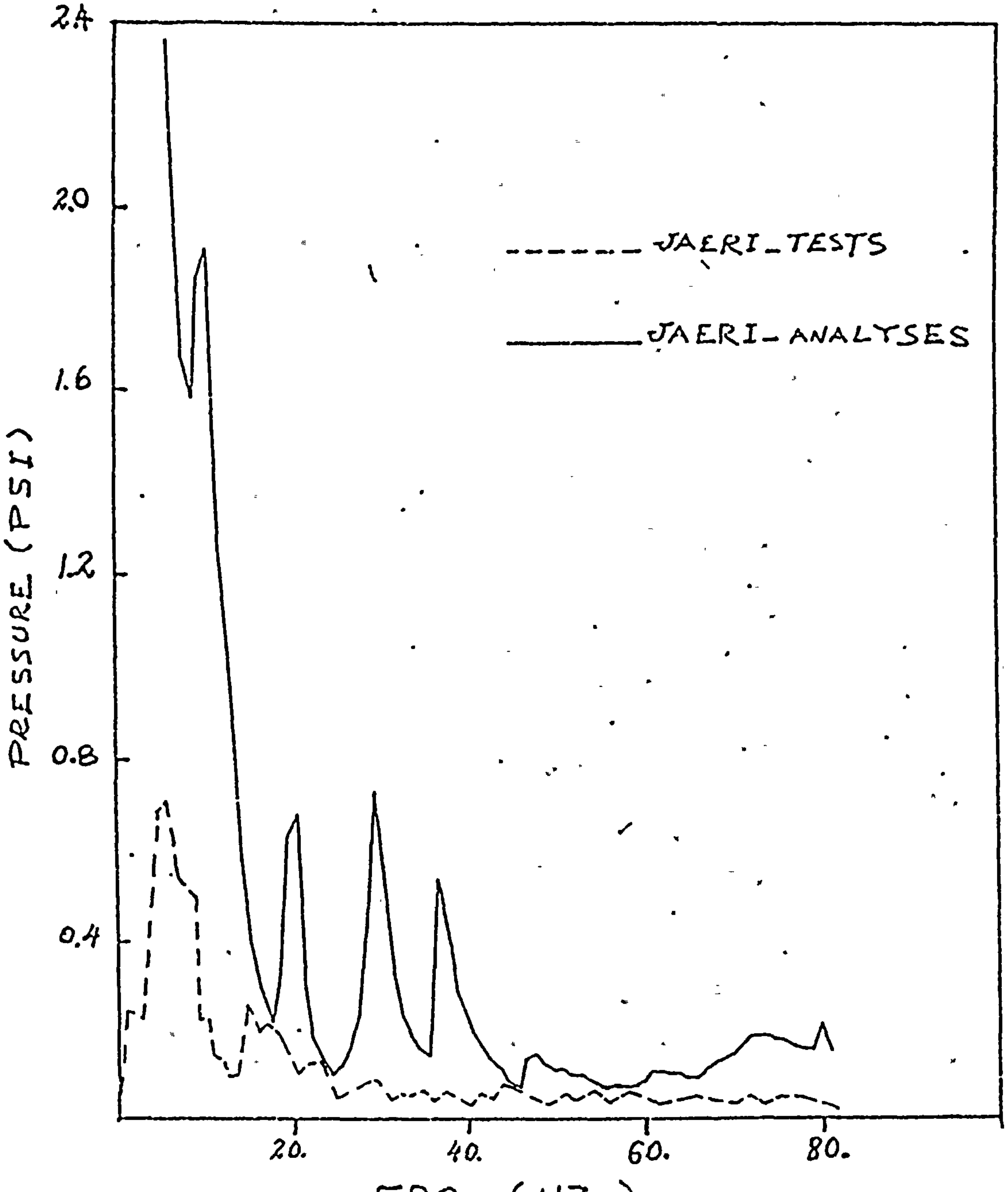
JAERI-F.E.MØDEL

VENT NO.	VENT CHUG TIME (SEC.)
1	0.001676
2	0.0065803
3	0.0094434
4	0.0016364
5	0.011538
6	0.005721
7	0.00089657

RANDOM VENT CHUG TIMES - JAERI

CASE NO.	MAXIMUM RIGID WALL PRESSURE (PSI)
1	12.50
2	12.31
3	30.01
5	47.76
6	30.10
7	7.39
9	10.41

MAXIMUM RIGID WALL PRESSURES CALCULATED FOR JAERI TEST FACILITY - VENT EXIT ELEVATION



AMP. OF FRQ. SPECTRA - VENT EXIT ELEVATION

6. Compare the 7 key chugs chosen by WNP-2 with those chosen by GE in NEDE-24302-P (Table 4-3). Also compare the companion chugs that are used in the averaging process to obtain the RAS for WNP-2 with the adjacent chugs used by GE to develop the generic design sources listed in Table 4-4 of NEDE-24302-P. If a key chug and/or companion chug is different from those chosen in NEDE-24302-P, provide comparison based on pressure time history and PSD to show that sources developed for WNP-2 are conservative.

COMPARISON BETWEEN KEY AND COMPANION
CHUGS CHOSEN BY B&R AND GE

THE KEY AND COMPANION CHUGS CHOSEN BY B&R AND GE ARE IDENTICAL IN MOST CASES. HOWEVER, THEY ARE DIFFERENT IN THREE TESTS. THE TABLE SHOWS THE DIFFERENCES.

TIME WINDOW NO.	RUN NO. REGION NO.	KEY CHUG NO.		COMP. CHUG NO.	
		B&R	GE	B&R	GE
1	1	1.2	1.2	1.1	1.3
2	15A	15A.2	15A.2	15A.3	15A.3
3	15B	15B.3	15B.3	15B.4	15B.4
4	19	19.4	19.4	19.3	19.5
5	20	20.2	20.5	20.1	20.5
6	25	25.2	25.2	25.3	25.3
7	26	26.4	26.4	26.5	26.5

EFFECTS OF DIFFERENCES BETWEEN B&R AND GE

THE DIFFERENCES BETWEEN GE AND B&R WERE SHOWN TO RESULT IN A MORE CONSERVATIVE CHOICE FOR KEY AND COMPANION CHUGS FOR THE WNP-2 APPLICATION. HOWEVER, THE DESIGN LOAD OF B&R IS BASED ON ENVELOPING ALL 4TCO DATA BASE AT ALL FREQUENCIES AT THE BOTTOM CENTER OF THE 4T SYSTEM. THIS MEANS THAT THESE DIFFERENCES DO NOT AFFECT THE B&R LOAD DEFINITION.

See:

"Chugging Loads - Revised Definition and Application Methodology for Mark II Containments (Based on 4TCO Test Results)."

Transmitted by:

Letter G02-81-189, dated July 22, 1981, Supply System to NRC.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2.	DESIGN SPECTRUM AND REQUIRED ENVELOPE SPECTRUM - CHANNEL 28	FIGURE 4-7

REASONS FOR THE DIFFERENCES
IN EACH CASE .

1. COMPANION CHUG NO. 1.1 (B&R) vs. 1.3 (GE)

I. MAXIMUM PRESSURE AMPLITUDE OF CHUG NO. 1.1 IS (11.7 PSI) WHICH IS GREATER THAN THAT OF CHUG NO. 1.3 (9.2 PSI).

II. CHUG NO. 1.1 IS MORE CONSERVATIVE IN THE HIGHER FREQUENCY ZONE. THE REACTOR BUILDING OF WNP-2 IS MORE SUSCEPTIBLE TO HYDRODYNAMIC LOADS WITH HIGHER FREQUENCY CONTENT THAN THOSE OF LOWER FREQUENCY CONTENT (FIRST NATURAL FREQUENCY OF THE CONTAINMENT SHELL IS ABOUT 25 Hz). THUS, CHUG NO. 1.1 IS MORE CRITICAL TO WNP-2 THAN CHUG NO. 1.3.

III. THE BEHAVIOR OF THE 4T SYSTEM, AS WELL AS THE TEMPORAL AND FREQUENCY BEHAVIOR OF CHUG NO. 1.1 IS MORE SIMILAR TO KEY CHUG NO. 1.2 THAN THAT OF CHUG NO. 1.3. THIS MAKES ANY AVERAGING BETWEEN 1.1 AND 1.2 MORE REASONABLE THAN THAT BETWEEN 1.2 AND 1.3.