ENVIRONMENTAL QUALIFICATION

FOR CLASS 1E LEAD-ACID

STORAGE BATTERIES

BYRON/BRAIDWOOD

COMMONWEALTH EDISON

SARGENT AND LUNDY ENGINEERS

P.O. 194757, 758

KE 5145, 5147, 5149, 5186

GOULD INC.

INDUSTRIAL BATTERY DIVISION

LANGHORNE, PA.

PREPARED BY:

R. W. HOPEWELL

APPROVED BY:

R. H. DESAI

PCT/11Z-0

INDEX

TEST PROCEDURES

FOR THE

GENERIC QUALIFICATION OF CLASS IE LEAD-ACID STORAGE BATTERIES

PLANTE & CALCIUM TYPES

Document No. GB-3454

Revision #11-Z November 19, 1982

Architectural/Engineering Firm:	Sargent & Lundy Engineers
Customer:	Commonwealth Edison Co.
Project:	Byron/Braidwood
P.O. Number:	194757, 758
Shop Order No.:	KE 5145, 5147, 5149, 5186

GOULD INC.

INDUSTRIAL BATTERY DIVISION

LANGHORNE, PA.

Appl. Eng'g. File No.
-068399

Ref: IEEE Std. 323-1974

PCT/11Z-1

SECTION #1

TEST PROCEDURE

GB-3454

A. Revisions #1 through #10 involved testing of accelerated heat aging of lead-acid storage batteries as outlined in IEEE 535-1979 Section 8.

B. Revision #11 and any subsequent revision involves the use of naturally aged lead acid storage batteries as outlined in IEEE 535-1979 Section 8.

1.0 SCOPE

1.1 This test plan outlines the steps to be used by Gould Inc. Industrial Battery Division to establish the qualified life of their stationary battery cells, as described in Paragraph 1.2. The test program will be performed in accordance with the requirements of IEEE 323-1974, IEEE 344-1975 and as a guidance IEEE 450-1980 and IEEE 535-1979.

Seismic qualification of battery racks will be done by analysis on a job-by-job basis, and is not to be considered a part of this Test Procedure.

Cells to be tested are NCX-1680 type cells, which are in the mid-range size for this type. IEEE 535-1979 states "that qualification may be accomplished by type testing". It also states that "General practice is to qualify one or more sizes of a cell type and interpolate or extrapolate to other size cells of that type.

Definitions Section 2, Page 5 defines Cell Type as cells of identical design, for example, plate size, alloy, construction details, but that may have differences in the number of plates and spacers, quantity of electrolyte, or length of container.

The aging mechanism and seismic test portion of the test program shall consist of the following sequence.

1. Naturally Aged Cells
2. Pre-Seismic Capacity Test
3. Seismic Qualification Test
4. Post Seismic Capacity Test
5. Functional Analysis

The test specimens have the following history. Specimens were owned and operated by New Jersey Bell Telephone Company in their Bordentown, New Jersey Central Office for telephone standby service. Cells are ten years old and have been operated in a full float method of charge @ 2.17 V.P.C. Battery was located in an air-conditioned room with an average ambient temperature of 78°F. Relative humidity was 40%. Vibration level was not obtainable.

1.2 Seismic Test Cell Description (See Appendix II)

	Type	Quantity	Size (WxLxH)	Weight (Approx.)	8 Hr. Capaci
#1	MCX-510	3	11.125" x 6.5" x 18.25"	119 lbs. ea.	510
#2	NCX-1680	3	11.375" x 14.5" x 22.5"	332 lbs. ea.	1680
#3	FPR-23	3	13.0" x 12.5" x 19.875"	270 lbs. ea.	880
#4	*FPS-25	3	13.0" x 12.5" x 19.875"	287 lbs. ea.	996

* FPR and FPS are of identical design. Change of designation to FPS was capacity rerating only.

1.3 Test Fixtures

Special racks for holding the battery cells during seismic qualification will be provided by Gould IBD. Calculations demonstrating fitness of these racks for Gould's Required Response Spectra and comments or extrapolation of these racks to all seismic racks of similar design will be demonstrated in Section 5, "Seismic Calculations for Test Rack".

1.4 Test Cells

The test cells used shall be naturally aged cells obtained from utility customer installations, thus exposing the cells to actual operating conditions and natural environmental influences. A description of each specimen source and operating conditions will be provided in the final report.

2.0 PRE-SEISMIC CAPACITY TEST

2.1 Naturally aged test cells obtained from the utility customers will be transported to an outside test facility. Test specimens to be inspected and evaluated at customer installation to assure suitability for qualification purposes.

2.2 Test cells will be given an equalizing charge per IEEE 450-1980 to ensure a fully charged condition. Cells will then be placed on float charge at ambient temperature for 3 to 6 days prior to the Pre-Seismic qualification capacity test. MCX and NCX types will be on float charge @ 2.25 V.P.C. average and FPR and FPS types @ 2.19 V.P.C. average. Each three cell group voltage will be maintained through the float period within a tolerance of ± 0.01 volt per three cell group.

2.3 Test cell electrolyte level will be maintained within 1/4 inch below and at the high level line during the float charge period.

2.4 Following the float charge period, a Pre-Seismic capacity test will be conducted at the published 3 hour rate to 1.75 V.P.C. average per IEEE 535-1979 Para. 8.2.2 (1). If the capacity test is less than 80 percent of rated capacity, the cells may be recharged, returned to float at ambient temperature for a minimum period of 72 hours and retested. If the cells fail the second capacity test, the cells shall have failed.

3.0 SEISMIC QUALIFICATION (PER IEEE 344-1975)

3.1 Seismic Mounting and Orientation

Each group of three fully recharged cells mounted in Gould-furnished racks, attached to a test lab-fabricated surface mounting fixture, hereinafter called the specimen, will be installed on a Multiaxis Simulator Table such that its longitudinal axis will be colinear with the longitudinal axis of the table. For the second axis of the test, the specimen will be rotated 90 degrees in the horizontal plane.

The racks are designed so that the natural frequency of the racks is in the rigid region (above 33 cps.).

Rack calculations will be provided in the final test report along with transmissibility plots to demonstrate rigidity of the rack design.

3.2 Specimen Tie-down

The mounting of specimen will simulate the actual in-service configuration as closely as practical, using standard intercell connectors, terminal plates, terminal cables and terminal hardware. The test racks will be bolted to the test lab-fabricated surface mounting fixture. The surface mounting fixture will be welded to the shock table using 2" skip welds.

3.3 Excitation

3.3.1 Simultaneous Biaxial Excitation

Each horizontal axis will be excited separately, but each one will be excited simultaneously with the vertical axis (longitudinal simultaneously with vertical, then lateral simultaneously with vertical). The horizontal and vertical input acceleration levels will be phase incoherent during the multifrequency tests.

3.3.2 Low-Level Resonant Search

A low-level (approximately 0.2g both horizontally and vertically) sine sweep will be performed on each axis of the test configuration from 0.5 Hz to 35 Hz to 0.5 Hz at a sweep rate of one-half octave per minute to establish major resonances. Transmissibility plots of the resonant search will be provided in the test report.

3.3.3 Multifrequency Tests

The specimen shall be subjected to 30-second duration simultaneous horizontal and vertical inputs of random waveforms motions consisting of frequencies spaced one-third octave apart over the range of 0.5 Hz to 40 Hz. The amplitude of each one-third octave frequency band width will be independently adjusted in each axis until the Test Response Spectra (TRS) envelop the Required Response Spectra (RRS) (Appendix III, IV or V).

The resulting TRS will be analyzed by a spectrum analyzer at 0.5, 1, 2, 3 and 5 percent damping and plotted at one-third octave frequency intervals over the frequency range of interest. The Zero Period Acceleration (ZPA) of the RRS could be exceeded in order to meet the peak responses of the curves. The horizontal and vertical inputs will be phase incoherent.

3.3.4 Operational Basis Earthquake (OBE) Tests

Five OBE tests shall be performed in each test axis. Duration of the OBE tests will be 30 seconds. The TRS for the OBE tests will be analyzed at 0.5, 1, 2, 3 and 5 percent damping.

3.3.5 Safe Shutdown Earthquake (SSE) Tests

One SSE test will be performed in each test axis. Duration of the SSE test will be 30 seconds. The TRS for the SSE tests will be analyzed at 0.5, 1, 2, 3 and 5 percent damping.

4.0 INSTRUMENTATION

4.1 Excitation Control

Control accelerometers will be mounted on the table at locations near the base of the specimen.

4.2 Specimen Response

Eight specimen mounted uniaxial accelerometers will be provided during the test. Placement of the accelerometers will be as directed by the Gould Technical Representative and the Test Engineer. Control and specimen accelerometer plots at the required damping of the SSE test in each axis will be provided in the test report.

Accelerometer placement will be similar to previous seismic tests performed by Gould at Wyle Labs, and used by many consulting engineers and utilities. All accelerometers will be placed in a proper position engineering-wise and will be located to provide the best possible, most meaningful results. Actual locations and photographs of accelerometer placement will be provided in the Final Test Report.

4.3 Electrical Monitoring

One (1) electrical monitoring channel will be provided by the test lab. This channel will be used to continuously monitor the electrical discharge of the test cells during the seismic test. The discharge load will be approximately 2% of the three hour discharge rate of the largest cell being tested on the shock table at the time. Each 3 cell test group shall be connected in series using standard inter-cell connectors and terminal plates with terminal cables to simulate installed conditions. When more than one 3 cell group is tested on the shock table simultaneously, all 3 cell groups will be connected in series to provide electrical monitoring of all groups during the test.

5.0 POST-SEISMIC CAPACITY TEST

5.1 Following completion of the Seismic Test, each 3 cell group will be recharged to replace ampere hours withdrawn during the Seismic Test. Ampere hours charge will be equal to 110% of the ampere hours withdrawn.

Cells will then be given a Post Seismic Capacity Test at the published 3 hour rate to 1.75 V.P.C. average per IEEE 535-1979 Para. 8.2.2 (1).

6.0 INSPECTION

During and after seismic testing, the test specimens will be examined for abnormalities and the conditions recorded.

7.0 IN-PROCESS INSPECTION

The records of TRS plots will be compared with the RRS plots to assure compliance with requirements before proceeding with next test run. All vibration effects will be logged and analyzed.

7.1 The specimens will be examined for any damage following all tests. If necessary, a physical tightening of hardware will be performed after each seismic test event, with justification expressed in Section 7, "Test Series Summary".

7.2 During the seismic testing, the cells are connected in series and placed in a discharge mode. The series string voltage and current are monitored before, during and after seismic testing. Photographs will be taken of any noticeable physical damage that may occur as well as all specimen-mounted accelerometers.

8.0 FAILURE CRITERIA

A string of three cells must meet 80 percent of its 3-hour ampere hour capacity when discharged to an average final voltage of 1.75 V.P.C. If the initial Pre-Seismic capacity test indicates less than 80% of rated capacity, the cells may be recharged, returned to float at ambient temperature for a minimum period of 72 hours and the capacity test repeated. If the cells fail the second capacity test, the cells shall have failed.

8.1 During the seismic test, the cells shall be electrically monitored for current or voltage fluctuations which could indicate circuit interruptions.

If there is a failure, the failure shall be analyzed, the cause identified, and the designation of random or common mode justified.

8.2 If the failure is demonstrated to be random nature, the test will be repeated using a different group of naturally aged cells from the original or similar source. If the failure is of common mode origin, the equipment is not qualified and Gould has two choices. [See IEEE 535-1979 7.3 (1) and (2).]

8.2.1 The equipment can be redesigned.

8.2.2 A different group of naturally aged cells from the original or similar sources will be used for retesting. Retesting will use the same or lesser TRS. (Original TRS level was generically established to accommodate maximum anticipated future requirements.) The lower level TRS selected will satisfy the required RRS.

9.0 GENERIC & CUSTOMERS' TEST REPORTS

Customers' Test Reports (Environment Qualification Report, No. GB-3454) will be generated from the generic test program report to satisfy the requirements of individual contracts on a job-to-job basis. A comparison will be provided in the report between applicable RRS curves and the TRS at 2% and 5% damping. The report will comprise a summary, conclusions, and recommendations including a statement of qualified life.

Ten copies of a certification-type report will be issued subsequent to completion of generic testing. This report will be signed by a Registered Professional Engineer and will summarize the capacity test results, the response spectrum plots of the table motion, transmissibility plots of the resonant search, results and conclusions, details and recommendations concerning deficiencies and repairs, photographs of test setup, description and analysis of failures, etc. The report will also contain a list of test equipment used, functional capabilities, calibrations, calculations and instrumentation log sheets.

The Generic Qualification Test Report "Wyle Nuclear Environmental Qualification Program Report No. 44681-2", shall include the following:

1. The qualification information.
2. Identification of the specific feature(s) to be demonstrated by the test.
3. Test Procedure.
4. Report of test results. The report shall include:
    - A. Objective.
    - B. Equipment tested.
    - C. Description of test facility (test setup) and instrumentation used, including calibration records reference.
    - D. Test procedure, frequency of readings, and input data (for example, seismic acceleration and spectra).

9.0 GENERIC & CUSTOMERS' TEST REPORTS (Cont'd.)

E. Test data and accuracy (results).

F. Signature of test personnel and date.

G. Supporting data.

H. Approval signature and date.

I. All malfunctions, whether or not they are detrimental.

Appendix I
References

1. IEEE Std. 323-1974 — Qualifying Class 1E Equipment for Nuclear Power Generating Stations

2. IEEE Std. 344-1975 — Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

3. IEEE Std. 535-1979 — Qualifying Class 1E Lead Storage Batteries for Nuclear Power Generating Stations

4. IEEE Std. 450-1980 — Recommended Practice for Large Lead Storage Batteries for Generating Stations and Substations (ANSI 41.15)

Appendix II

Gould Inc.
Industrial Battery Division
Langhorne, PA

Generic Qualification Program
Naturally Aged Cells
Initial Program

A. Test Group — Natural Age In Years

Calcium & Plante

#1	MCX-510	(Calcium)	8 Years
#2	NCX-1680	(Calcium)	10 Years
#3	FPR-23	(Plante)	16 Years
#4	FPS-23	(Plante)	10 Years

Note: Testing will be as outlined in Test Procedure.

Ongoing Qualification Program

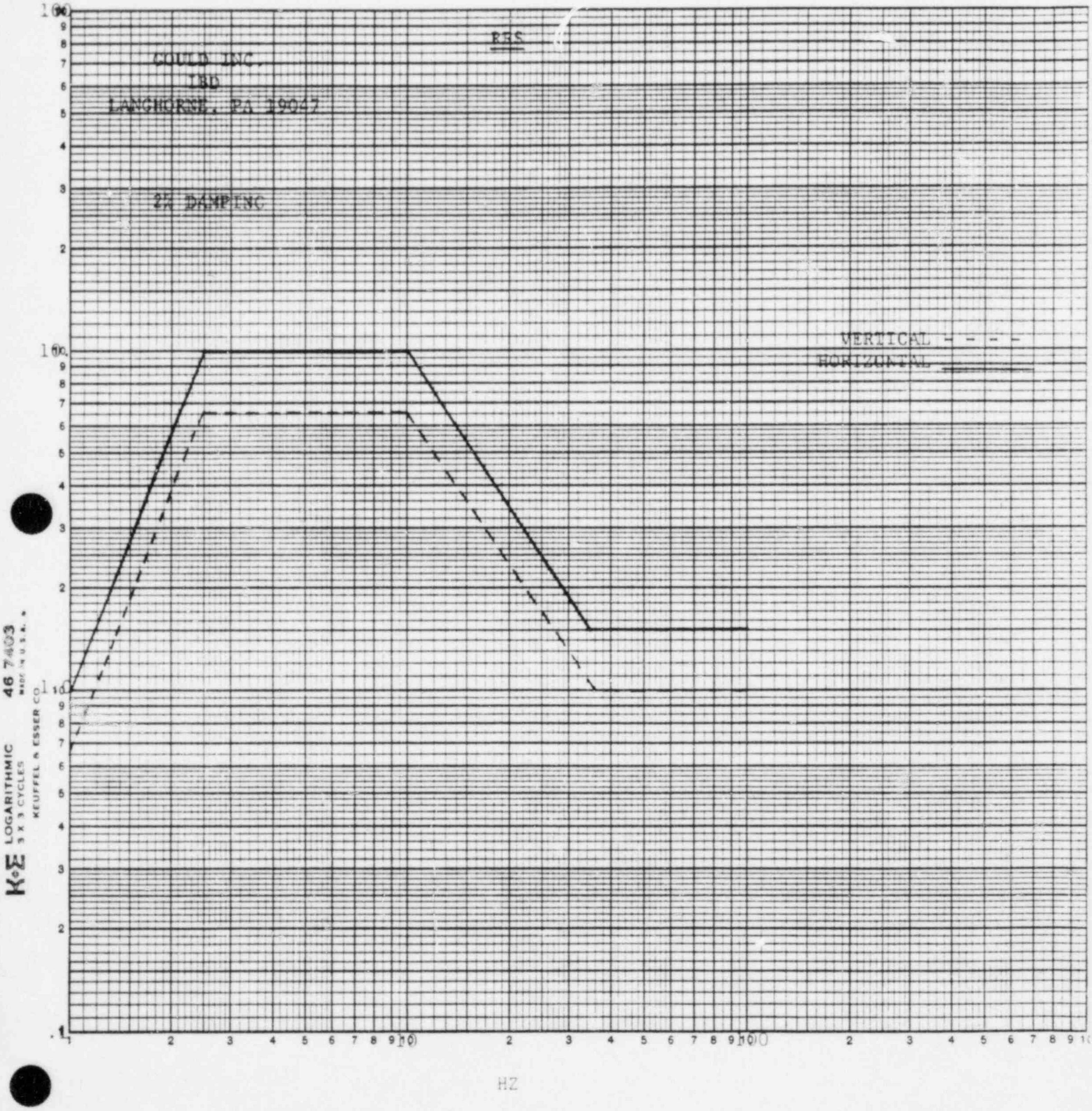
B. Test Group* — Natural Age In Years

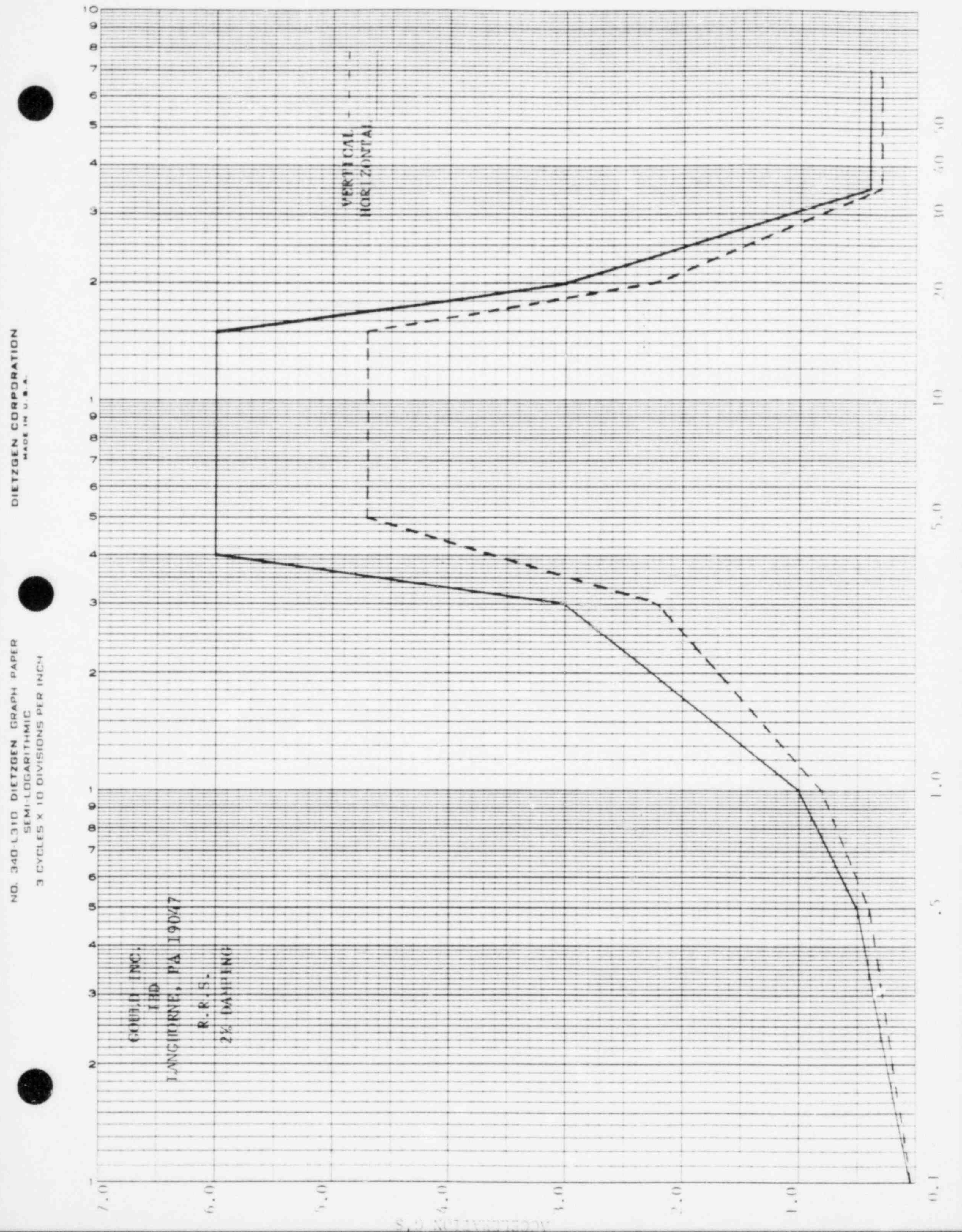
Calcium

#1	MCX-510	(Calcium)	15 Years
#2	NCX-1680	(Calcium)	15 Years

Note: Test Group B will be composed of naturally aged cells which have attained the required age period in actual customer service. In the event additional test cells from the same source as in Test Group A are not available due to customer reluctance or abnormal degradation of original installation, alternate sources will be pursued. Attempt will be made to obtain test cells of the same size or as close to the same as possible.

Feasibility of ongoing qualification beyond 15 years will be determined following test results on the 15 year naturally aged groups.


RRS
GOULD INC.
IBD
LANGHORNE, PA 19047
2% DAMPING
VERTICAL - - - -
HORIZONTAL ———
1.0
10
100
HZ
K&E LOGARITHMIC 3 X 3 CYCLES
46 7403
KEUFFEL & ESSER CO.


VERTICAL
HORIZONTAL
GOULD INC.
ITD
LANGHORNE, PA 19047
R.R.S.
2% DAMPING
ACCELERATION G'S
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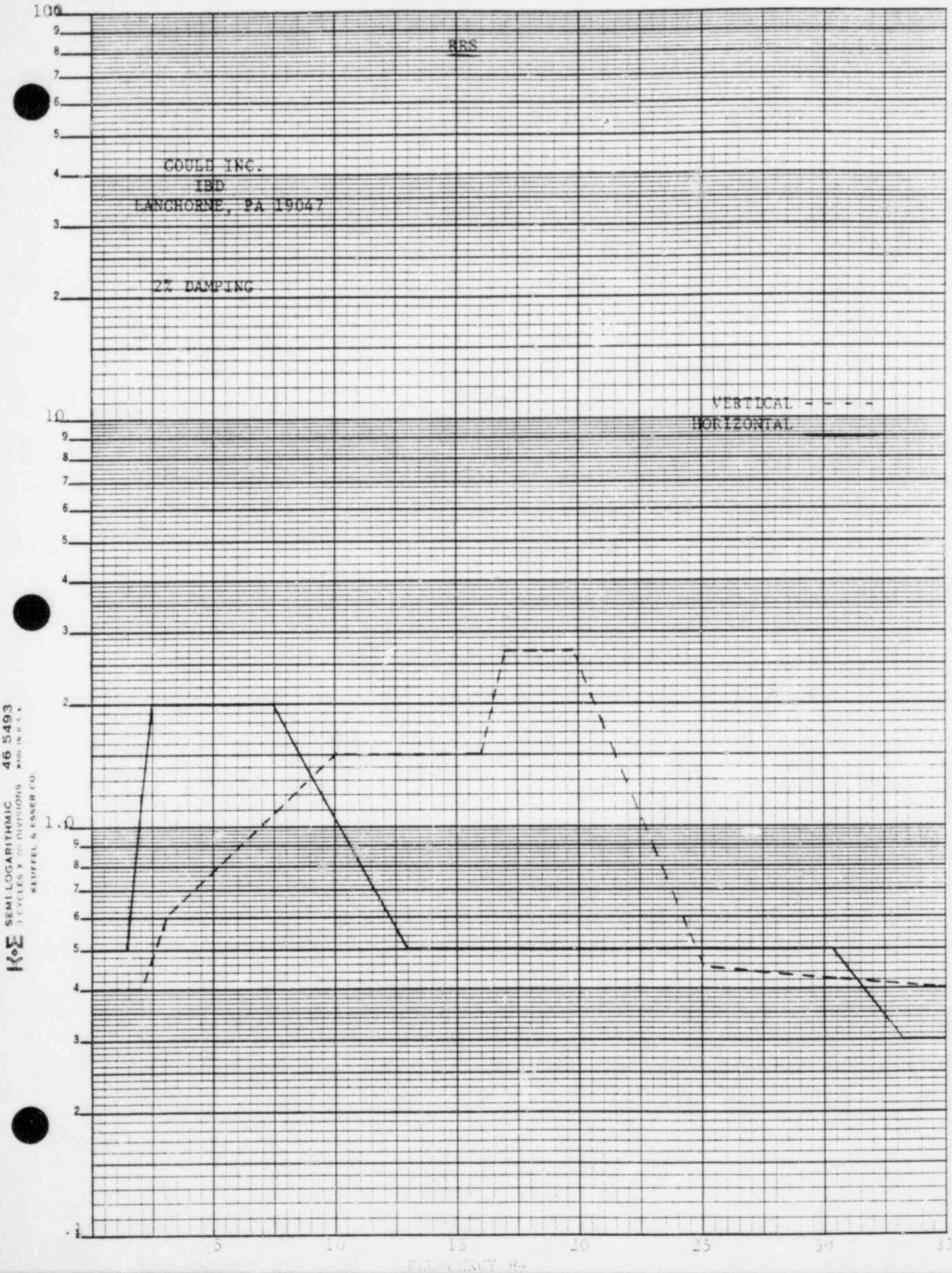
6.0
5.0
4.0
3.0
2.0
1.0
0.1
.5
1.0
5.0
10
20
30
40
50
NO. 340-L310 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
3 CYCLES X 10 DIVISIONS PER INCH
DIETZGEN CORPORATION
MADE IN U.S.A.


RRS
GOULD INC.
IBD
LANGHORNE, PA 19047
2% DAMPING
VERTICAL - - - -
HORIZONTAL ———
100
10
1.0
.1
5
10
15
20
25
30
35
K&E SEMI-LOGARITHMIC 46 5493
KEUFFEL & ESSER CO.

SARGENT & LUNDY
ENGINEERS
CHICAGO

ATTACHMENT A
(FORM 350)

RESPONSE SPECTRA
FOR
STORAGE BATTERIES

BYRON/BRAIDWOOD STATION - UNITS 1 & 2
SPECIFICATION F/L-2819

ATTACHMENT A

CONTENTS

SARGENT & LUNDY ENGINEERS

CLIENT COMMONWEALTH EDISON CO.
PROJECT BYRON/BRAIDWOOD JOB NO. 4391/4683
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CHECKED BY GSB DATE 3-22-73 SHEET 28 OF 15[illegible]

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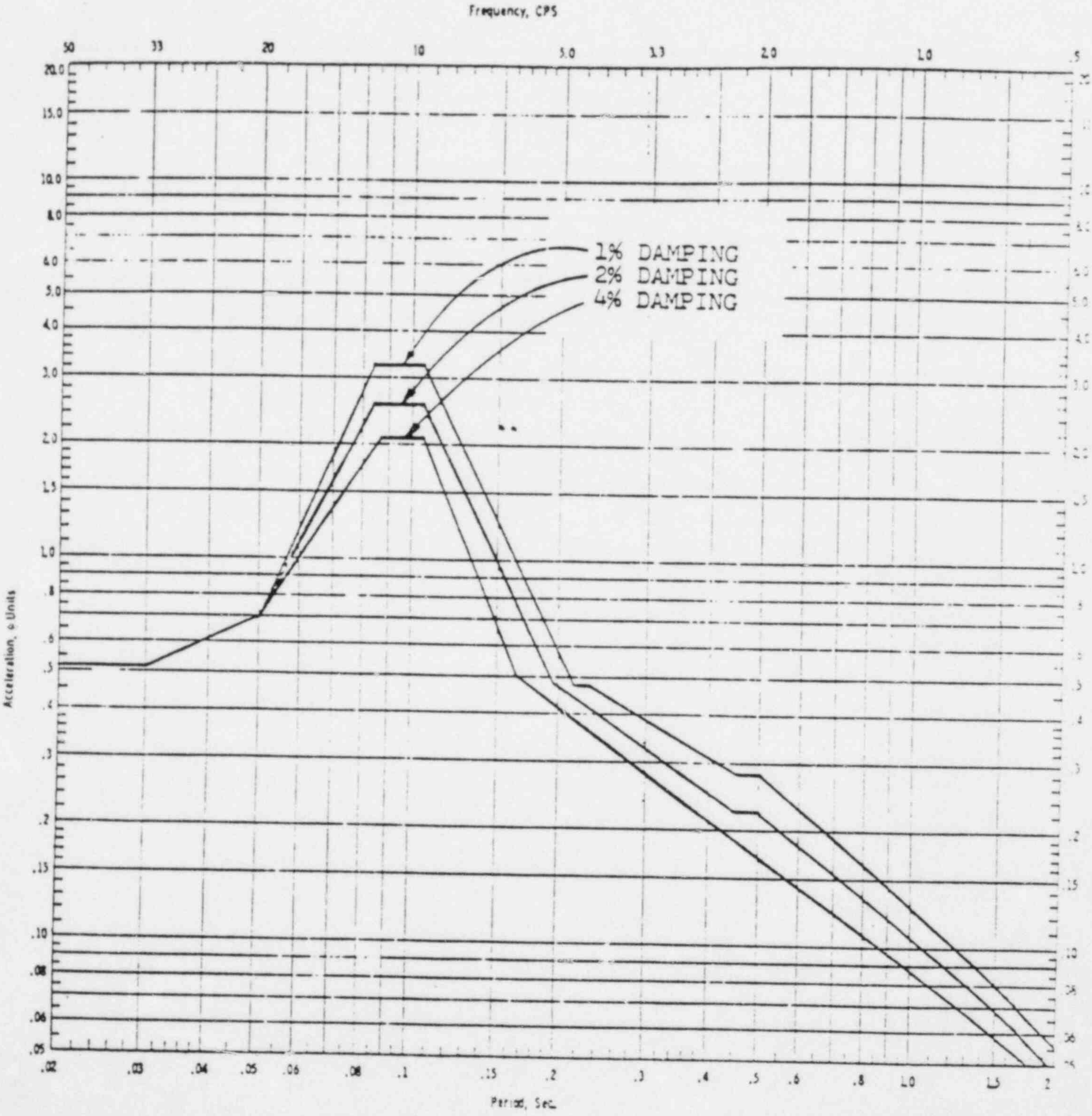
INITIALS	HS						



Vertical Response Spectra
O.B.E.
El. 426'-0", 439'-0" & 451'-0"
Auxiliary Building Slab

Spectra No.
108-OB-VS
109-OB-VS
110-OB-VS

SARGENT & LUNDY ENGINEERS

CLIENT COMMONWEALTH EDISON CO.
PROJECT BYRON/BRAIDWOOD JOB NO. 4391/468
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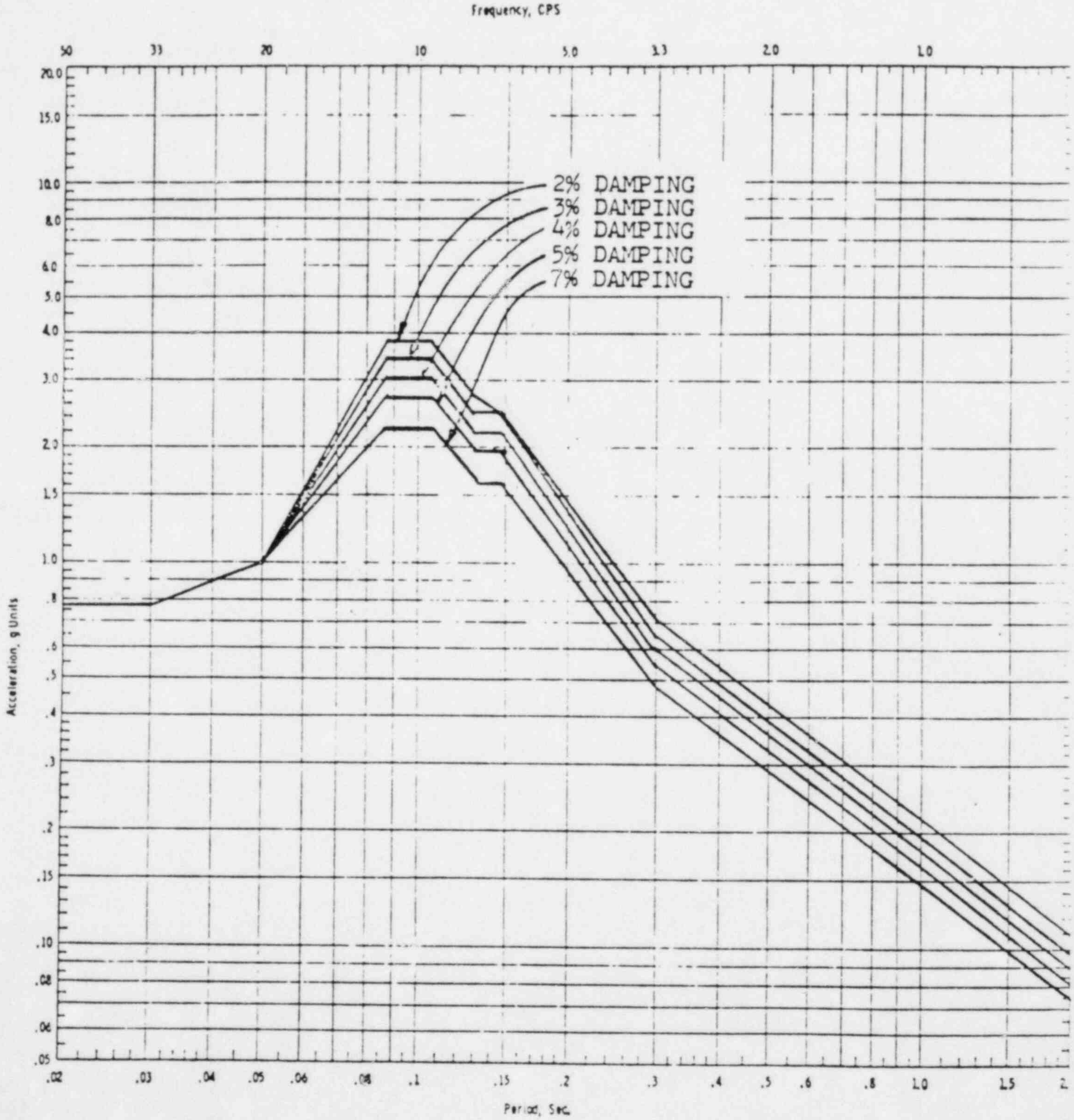

Vertical Response Spectra
S.S.E./Blast
El. 426'-0", 439'-0" & 451'-0"
Auxiliary Building Slab

Spectra No.
108-SS-VS
109-SS-VS
110-SS-VS

CLIENT	COMMONWEALTH EDISON CO.
PROJECT	BYRON/BRAIDWOOD — JOB NO. 4391/4683
DESIGN BY	HS — DATE 3-22-73
CHECKED BY	GSB — DATE 3-22-73 — SHEET 37 OF 150

SARGENT & LUNDY ENGINEERS

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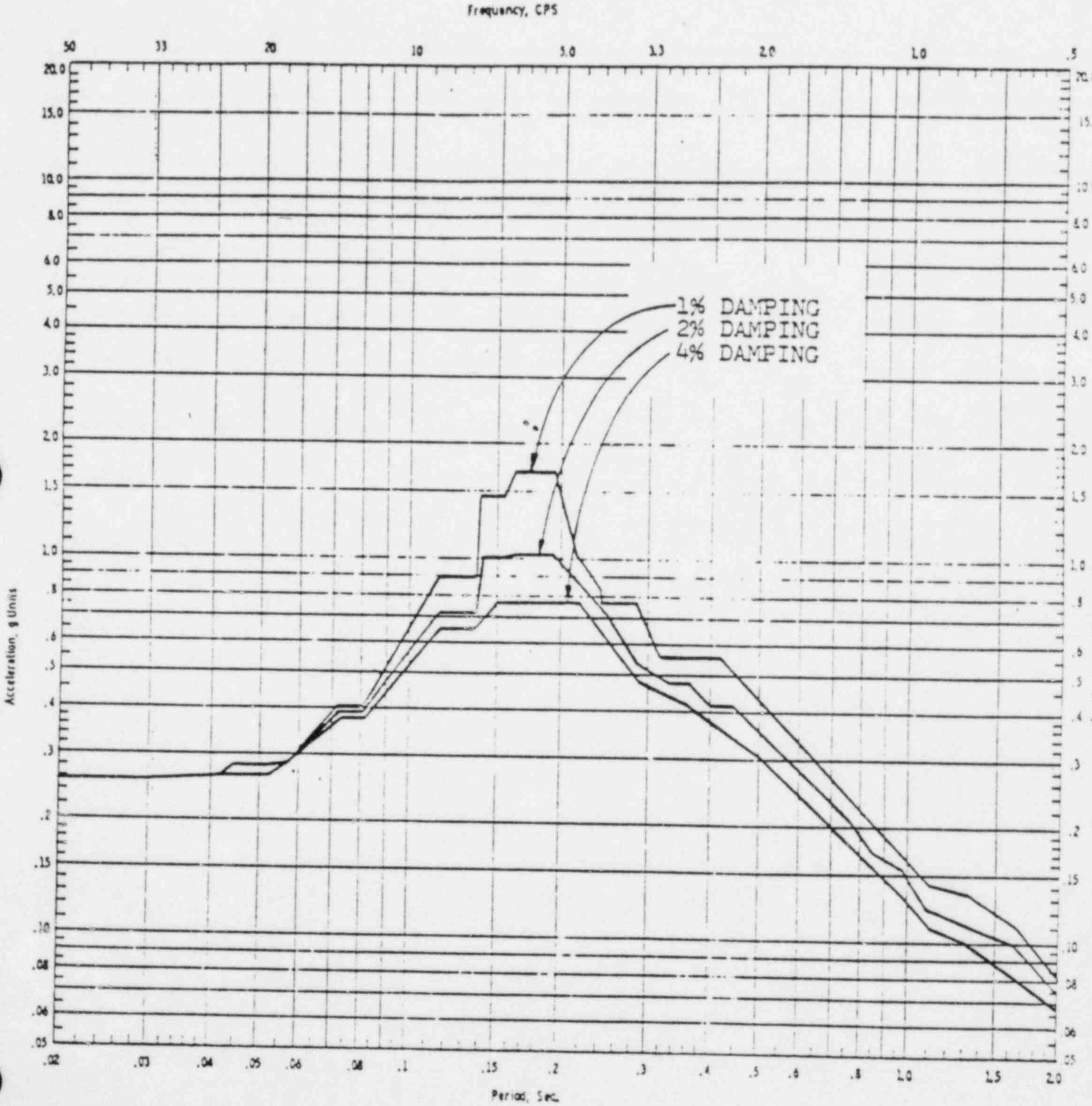

Horizontal Floor Response Spectra
North-South Component (O.B.E.)
El. 451'-0"
Auxiliary-Turbine-Heater Bay Building

Spectra No.
110-OB-NS

SARGENT & LUNDY ENGINEERS

CLIENT COMMONWEALTH EDISON CO.
PROJECT BYRON/BRAIDWOOD JOB NO. 4391/4683
DESIGN BY HS DATE 3-22-73
CHECKED BY GSB DATE 3-22-73 SHEET 38 OF 150

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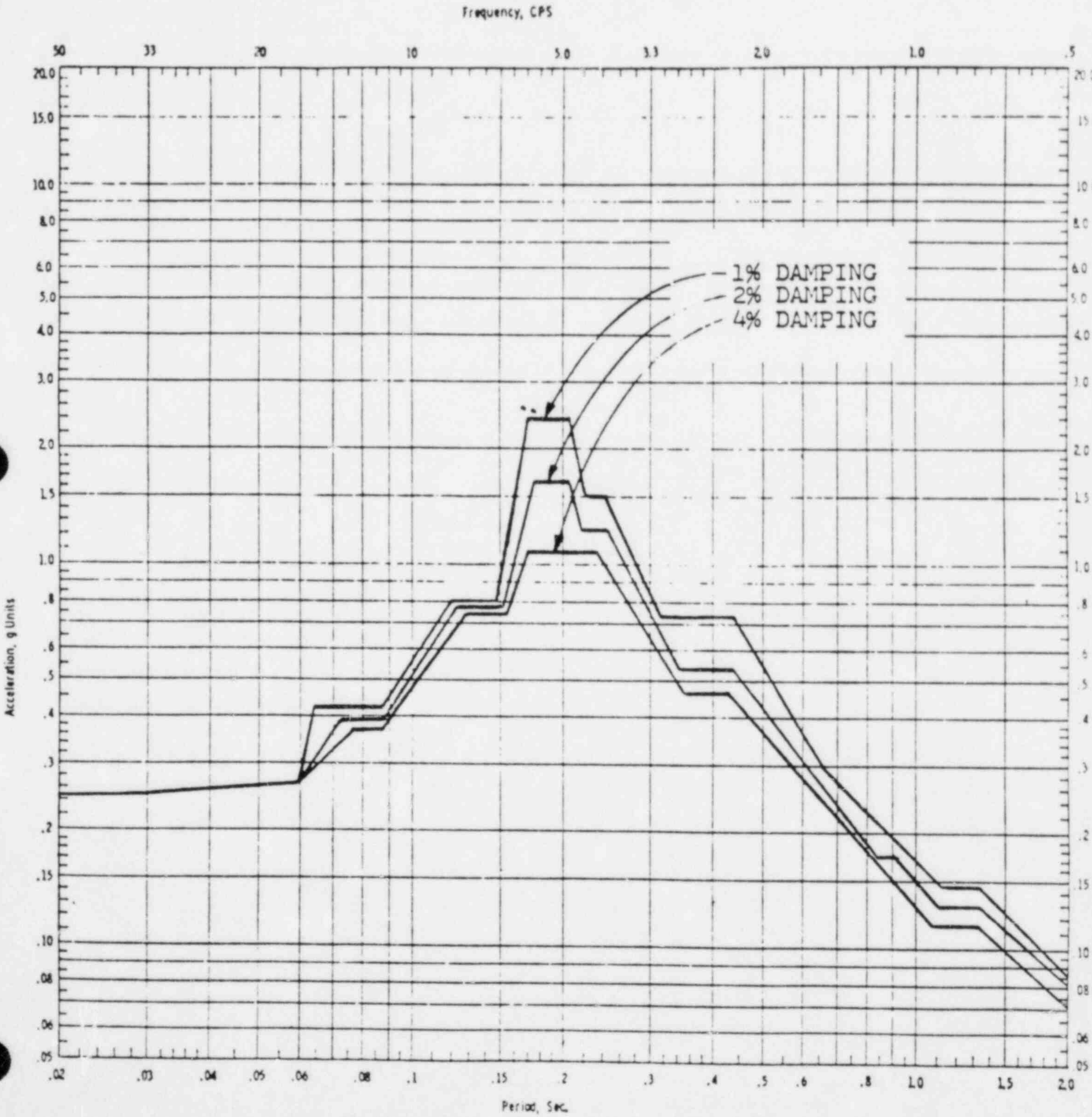

Horizontal Floor Response Spectra
East-West Component (O.B.E.)
El. 451'-0"
Auxiliary-Turbine-Heater Bay Building

Spectra No.
110-OB-EW

CLIENT	COMMONWEALTH EDISON CO.
PROJECT	BYRON/BRAIDWOOD
JOB NO.	4391/4581
DESIGN BY	HS
DATE	3-22-73
CHECKED BY	GSB
DATE	3-22-73
SHEET	39 OF 150

SARGENT & LUNDY ENGINEERS

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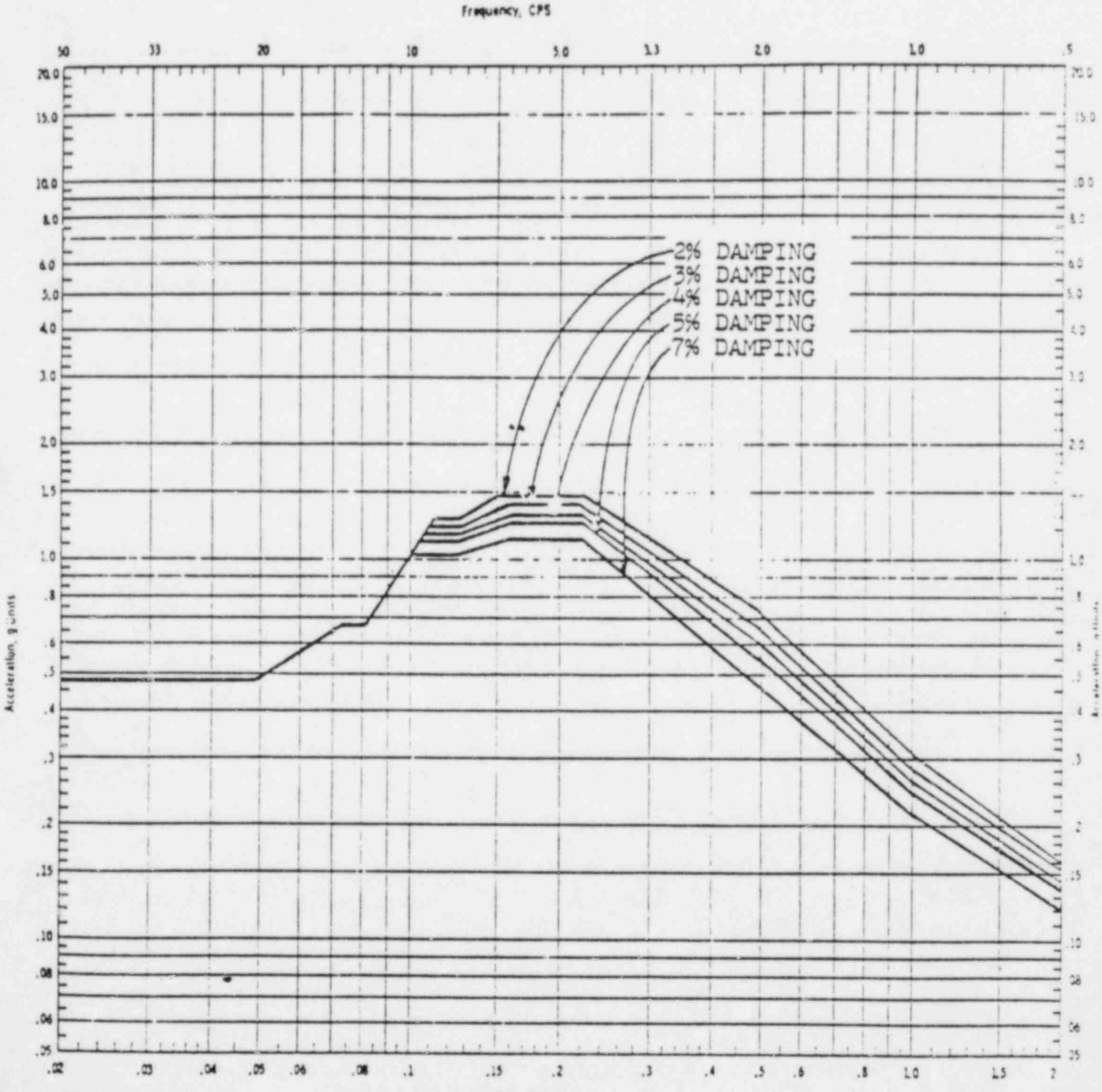

Horizontal Floor Response Spectra
North-South Component (S.S.E./Blast)
El. 451'-0"
Auxiliary-Turbine-Heater Bay Building

Spectra No.
110-SS-NS

SARGENT & LUNDY
ENGINEERS

CLIENT COMMONWEALTH EDISON CO.
PROJECT BYRON/BRAIDWOOD JOB NO. 4391/4683
DESIGN BY HS DATE 3-22-73
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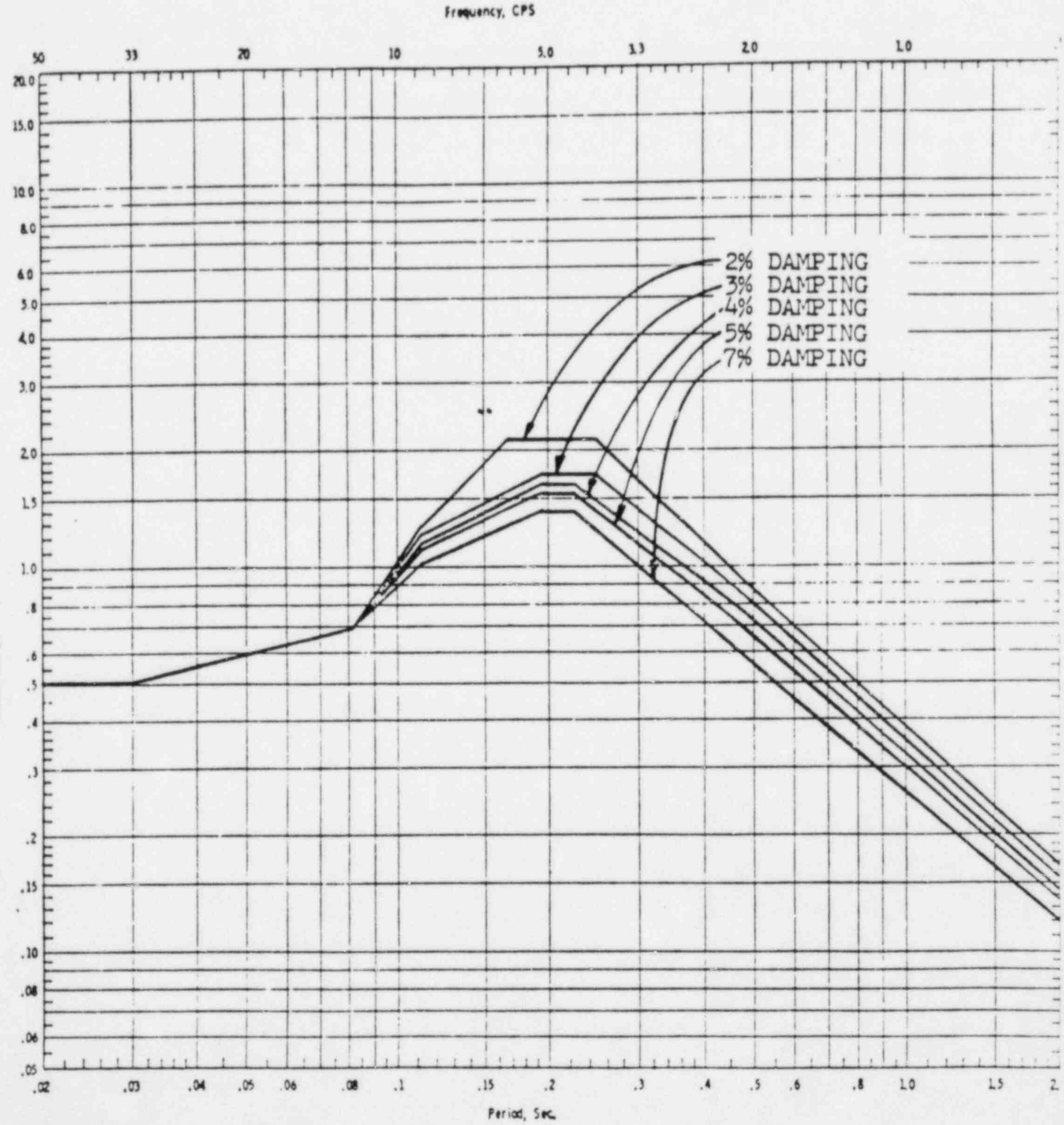


Horizontal Floor Response Spectra
East-West Component (S.S.E./Blast)
El. 451'-0"
Auxiliary-Turbine-Heater Bay Building

Spectra No.
110-SS-EW

SECTION #2

TEST SPECIMEN HISTORY

1.0 SOURCE

The test specimens submitted to Wyle Laboratories for a seismic simulation test program were naturally aged cells obtained from New Jersey Bell Telephone Bordentown Central Office, Bordentown, New Jersey 08505.

1.1 Cells were manufactured in Gould manufacturing facilities located at 467 Calhoun Street, Trenton, New Jersey. Manufacturing date was 6/71 on Gould Order #T-62232. Shipment was made to customer the same month. Complete batter shipped consisted of 27 cells of NCX-1680 type. The NCX-1680 designation is the Gould commercial identification. This type cell when sold to Western Electric for resale to the Associated Bell Companies, is identified as a 27 KS-15544 List 508 battery. This is the Western Electric method of identifying equipment classification and specific size. There are no design differences between the commercial and Western Electric type designations.

Final negotiations for acquisition of the test cells was with George F. Hughes, Network Design, New Jersey Bell Telephone, Camden, New Jersey.

2.0 LOCATION OF BATTERY

Battery was in service at the New Jersey Bell Telephone Central Office located at 195 Crosswicks Road, Bordentown, New Jersey 08505.

3.0 APPLICATION

Battery was used for telephone standby service in the event of commercial A.C. power failure. The battery would, therefore, assume the function of sustaining telephone equipment operation in such emergencies.

Battery was installed on a two-tier steel rack with cells #1-2 and #17-23 on the upper tier and cells #3 through 16 on the lower tier. Emergency cells were #1-4.

Twenty-three of the twenty-seven cells are used in the 48 volt main string. The remaining four cells are used as "End Cells" which are used during emergency discharges and are switched into use to sustain total system voltage requirements as the main string voltage declines during discharge.

4.0 CHARGING METHOD

The battery was maintained on a float method of charge at an average of 2.17 V.P.C. a Western Electric Model 302A voltage regulated power supply.

5.0 BATTERY RECORDS

Customer battery records are available for the first quarter of 1972 through the fourth quarter of 1980. See Battery Records Section #3. Battery is identified as 48 volt - String "B".

These records reflect quarterly individual cell float voltage readings on the 23 cell main string as well as cell voltage readings on the 4 cells in the emergency group #1.

5.0 BATTERY RECORDS (Cont'd.)

In addition, the records include semi-annual specific gravity readings of cell in the main string as well as those in the emergency group #1.

Temperature readings of pilot cell electrolyte is also recorded.

6.0 TEMPERATURE RANGE

The battery area temperature was controlled by using air conditioning. As reflected by the records, cell electrolyte temperature ranged from a low of 70°F to a high of 81°F. Based on temperature data available, the average yearly electrolyte temperature was 78°F. Relative humidity while not recorded was approximately 30 to 60%.

Recorded temperature values reflect no greater than a 2°F spread in battery temperature at any given time.

7.0 OPERATING-MAINTENANCE PROCEDURES

Battery has been maintained in accordance with Bell System Practices which are comparable with Gould Installation and Operating Instructions GB-3384-B.

8.0 RADIATION EXPOSURE

The test specimens were exposed to normal background radiation for their operating life span of 10 years. There are no environmental specification requirements for other than low level background radiation exposure, therefore, test specimens did not receive augmented radiation exposure prior to the seismic simulation test program.

9.0 BATTERY USAGE (EMERGENCY PERIODS)

Batteries of this type are normally sized to provide three to five hours of emergency power. Actual ampere load is a variable which is determined by total telephone subscribers handled as well as subscriber traffic which varies during a 24 hour period as well as from day to day.

SECTION #3

CUSTOMER RECORDS

The customer records which are part of this section are actual record copies obtained from New Jersey Bell Telephone Company, for NCX-1680 type cells installed at their Bordentown Central Office located at 195 Crosswicks Road, Bordentown, New Jersey 08505.

The records represent quarterly individual cell voltages on the main string as well as the emergency group #1 cells. (Figs. # 3-1, 3-2, 3-3)

In addition, semi-annual specific gravity readings of cells referenced above are also included together with representative electrolyte temperatures on cells from the upper and lower tiers to reflect min.-max. as well as average battery temperatures prevailing.

As outlined in Section #2 Test History Item 1.1, the customer identification of the NCX-1680 is KS-15544 List 508 which is shown on the records. The design is exactly the same.

P-4032 (0)

BSP 157-601-301

QUARTERLY INDIVIDUAL CELL VOLTAGE
SEMI-ANNUAL CORRECTED SPECIFIC GRAVITY

OFFICE

BATTERY NO. -48B

QUARTERLY INDIVIDUAL CELL VOLTAGE

CELL NO.	1972 1 QTR	1972 2 QTR	1972 3 QTR	1972 4 QTR	1973 1 QTR	1973 2 QTR	1973 3 QTR	1973 4 QTR	1974 1 QTR	1974 2 QTR	1974 3 QTR	1974 4 QTR	1975 1 QTR	1975 2 QTR	1975 3 QTR	1975 4 QTR
MONTH	1-3	6 18	9-5	12-13	3 8	6 28	9 26	12 28	2 15	6 27	9-2	12/27				
1	2.16	2.16	2.16	2.16	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.17				
2	2.15	2.18	2.16	2.16	16	15	18	15	16	18	18	2.17				
3	2.21	20	20	2.22	20	22	23	23	21	20	20	17				
4	16	16	16	16	18	19	18	18	18	18	18	17				
5	18	18	18	17	18	[illegible]	[illegible]	24	20	18	18	17				
6	18	18	19	17	20	[illegible]	[illegible]	16	20	18	18	17				
7	18	18	18	16	20	15	20	24	18	18	16	15				
8	21	[illegible]	[illegible]	[illegible]	[illegible]	24	24	24	18	20	20	15				
9	16	16	15	[illegible]	[illegible]	24	24	20	20	18	15	18				
10	16	16	16	[illegible]	[illegible]	24	24	19	18	18	18	18				
11	18	16	16	[illegible]	[illegible]	18	20	19	18	18	18	18				
12	20	20	18	[illegible]	[illegible]	[illegible]	20	15	18	18	18	17				
13	16	16	16	[illegible]	[illegible]	[illegible]	15	26	20	20	15	17				
14	17	17	16	[illegible]	[illegible]	[illegible]	18	19	20	20	18	18				
15	20	18	18	[illegible]	[illegible]	[illegible]	15	14	18	18	18	15				
16	18	18	16	[illegible]	[illegible]	20	15	18	20	18	18	18				
17	18	18	18	[illegible]	18	[illegible]	20	24	18	18	20	15				
18	20	20	20	21	18	[illegible]	14	24	20	20	18	15				
19	21	18	18	14	18	24	20	18	20	18	13	13				
20	21	20	18	16	20	18	15	16	18	20	18	15				
21	20	20	16	16	20	18	18	17	20	18	18	18				
22	18	18	18	16	18	18	18	18	15	18	18	18				
23	2.18	2.18	2.16	2.15	2.18	2.18	2.18	2.16	18	20	2.18	2.18				
24																
25																
EM. CELL GRP1																
1	2.20	2.20	2.20	2.20	2.20	2.18	2.18	2.20	2.20	2.20	2.20	2.18				
2	2.20	2.20	2.20	2.20	2.18	18	18	20	20	18	18	18				
3	2.20	2.20	2.20	2.22	2.24	18	18	20	20	18	18	18				
4	2.20	2.20	2.18	2.19	2.20	2.18	2.18	2.15	20	20	18	18				
EM. CELL GRP2																
5																
6																
7																
8																
DATE	1-3	6 18	9-5	12-13	3 8	6 28	9 26	12 28	2 15	6 27	9-2	12-27				
BY	RK	RK	RK	ES	RK	RK	RK	RK/RC	RC	RC	RK	RES				
REMARKS																
WATER ADDED: DATE																
QUANTITY																

SEMI ANNUAL CORRECTED SPECIFIC GRAVITY

CELL NO.	YEAR 72 1 HLF	YEAR 72 2 HLF	YEAR 73 1 HLF	YEAR 73 2 HLF	YEAR 74 1 HLF	YEAR 74 2 HLF	YEAR 75 1 HLF	YEAR 75 2 HLF
MONTH	6 15	12-13	6 28	12/28	6/27	12-30		
1	1200	1210	1207	1206	1206	1206		
2–22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
23	1204	1204	1206	1207	1206	[illegible]		
EM. CELL GRP1 1	1204	1204	1200	1204	1204	1200		
2	1202	1202	[illegible]	1200	[illegible]	10		
3	1206	1206	[illegible]	1202	[illegible]	10		
4	1204	1204	1204	1204	[illegible]	[illegible]		
DATE	6 15	12 13	6 28	12/28	6/27	12 30		
BY	RK	ES	RK	RK/RC	RC	RES		

CELL NOS. FROM	CELL NOS. TO	REF. CELL NO.		TEMP	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP
			UPPER TIER	77		78	76		72		
			CENTER TIER								
			LOWER TIER	76		77	79		70		

BATTERY INFORMATION

TYPE-KS 15577	LIST 57
SPECIFIC GRAVITY RANGE	[illegible]
NUMBER OF CELLS	23
PILOT CELL NO.	23
DATE INSTALLED	
*INITIAL CHARGE PILOT CELL VOLTAGE	
*INITIAL CHARGE PILOT CELL SPEC. GRAV.	

* - FROM WE. CO. RECORDS.

BATTERY RECORDS
NEW JERSEY BELL TELEPHONE
BORDENTOWN C. O.
BORDENTOWN, NEW JERSEY 08505

Fig 3-1

P-4033 (0)

QUARTERLY INDIVIDUAL CELL VOLTAGE
SEMI-ANNUAL CORRECTED SPECIFIC GRAVITY
OFFICE

BSP 157-601-301

BATTERY NO. - 18 v B

MONTH	CELL NO.	QUARTERLY INDIVIDUAL CELL VOLTAGE YEAR 1975 1 QTR	2 QTR	3 QTR	4 QTR	YEAR [illegible] 1 QTR	2 QTR	3 QTR	4 QTR	YEAR 1 QTR	2 QTR	3 QTR	4 QTR	YEAR [illegible] 1 QTR	2 QTR	3 QTR	4 QTR	SEMI ANNUAL CORRECTED SPECIFIC GRAVITY YEAR 75 1 HLF	2 HLF	YEAR 1 HLF	2 HLF	YEAR 1 HLF	2 HLF	YEAR 1 HLF	2 HLF
																	[illegible]	5							
	1	2.17	2.18	2.15	[illegible]	2.17	2.19	[illegible]	[illegible]	[illegible]	2.16	[illegible]	22	2.15	2.16	16	18	1206	[illegible]	1208	[illegible]	[illegible]	1209	[illegible]	1208
	2	17	17	2.15			2.19			[illegible]	2.16	[illegible]	22	15	15	17	16	[illegible]	[illegible]			[illegible]	1209	[illegible]	1208
	3	17	18	18			2.19		[illegible]	[illegible]	14	[illegible]	[illegible]	14	14	18	16	[illegible]				[illegible]	[illegible]	[illegible]	1206
	4	17	18	18	[illegible]		2.19			[illegible]	17	[illegible]	[illegible]	19	19	20	18	[illegible]				[illegible]	1206	1210	1210
	5	17	18	20	[illegible]		2.22			[illegible]	20	[illegible]	2.17	17	[illegible]	19	19	[illegible]				[illegible]	1210	1214	1210
	6	18	18	20			2.22			[illegible]	13	[illegible]	[illegible]	15	15	19	17	[illegible]				[illegible]	1210	1214	1210
	7	18	18	18			2.2[illegible]			[illegible]	16	[illegible]	[illegible]	15	[illegible]	17	17	[illegible]				[illegible]	1208	1212	1208
	8	18	18	18			2.19			[illegible]	15	[illegible]	17	15	[illegible]	17	17	[illegible]				[illegible]	1210	1210	1208
	9	17	16	18	[illegible]		2.20			17	19	[illegible]	17	15	13	17	16	[illegible]				[illegible]	1210	1212	1210
	10	17	18	19	[illegible]		2.19			14	16	14	[illegible]	17	13	18	18	[illegible]				[illegible]	1208	1212	1210
	11	17	18	17	[illegible]		2.19			16	18	[illegible]	[illegible]	17	17	18	19	[illegible]				[illegible]	1210	1210	1210
	12	17	18	17			2.15			14	17	16	[illegible]	15	16	17	17	[illegible]				[illegible]	1210	1212	1210
	13	17	17	17	[illegible]		2.20	[illegible]		13	19	16	17	15	15	18	16	[illegible]		[illegible]		[illegible]	1206	1214	1208
	14	17	17	17	[illegible]		2.20	[illegible]		11	19	[illegible]	18	20	19	17	18	[illegible]		[illegible]		[illegible]	1208	1214	1210
	15	18	18	18	[illegible]		2.18	[illegible]		15	18	17	16	17	18	18	16	[illegible]	06	[illegible]		[illegible]	1209	1212	1209
	16	17	18	18			2.20	[illegible]		15	18	17	[illegible]	15	16	17	17	[illegible]	02	[illegible]		[illegible]	1206	1210	1209
	17	17	17	19	[illegible]		2.21	[illegible]		19	20	17	[illegible]	18	18	[illegible]	[illegible]	[illegible]	04	[illegible]		[illegible]	1208	1212	1210
	18	17	17	19			2.22	[illegible]		14	19	18	[illegible]	15	15	17	17	[illegible]	[illegible]			[illegible]	1210	1212	1210
	19	17	17	18			2.22	[illegible]		16	19	[illegible]	[illegible]	15	13	[illegible]	17	[illegible]	[illegible]			[illegible]	1212	1214	1208
	20	17	17	15			2.19	15		15	18	[illegible]	[illegible]	21	20	17	18	[illegible]	04			[illegible]	1210	1212	1210
	21	17	17	18	[illegible]		2.18			12	14	[illegible]	17	15	15	16	16	06	06			[illegible]	1208	1210	1210
Pilot	22	17	18	15			2.19			15	18	18	[illegible]	18	18	17	16	[illegible]	02			[illegible]	1210	1208	1206
	23	17	17	18			2.20	[illegible]		18	18	18	[illegible]	2.16	2.17	[illegible]	18	08	02	[illegible]		[illegible]	1210	1208	1206
	24																								
	25																								
EM. CELL GRP 1				[illegible]																					
Pilot	1	3.18	2.22	2.09	2.08	2.10	2.10	[illegible]	2.26	2.23	2.24	224	224	2.32	2.32	228	226	1204	1204	06		[illegible]	1208	1210	1208
EM CELL GRP 2	2	18	20	2.09	2.07	2.10	2.10	[illegible]	2.26	[illegible]	2.23	222	[illegible]	2.28	2.30	224	222	[illegible]	[illegible]	06		[illegible]	1208	1208	1208
Pilot	3	18	20	2.20	2.10	2.18	2.12	1A	2.26	26	2.23	222	[illegible]	2.28	2.26	228	226	[illegible]	[illegible]	[illegible]		[illegible]	1210	1208	1210
	4	18	12	2.15	[illegible]	2.18	2.15	[illegible]	2.26	23	2.20	220	2.20	2.26	2.26	224	222	[illegible]	[illegible]	[illegible]		[illegible]	1210	1210	1208
~~EM CELL GRP 2~~	5																								
	6																								
	7																								
	8																								
DATE		3.31	5-28	10-24	12.11	1/2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	11/8	5-25	11/26	[illegible]	[illegible]			[illegible]	[illegible]
BY		RES	PR	NA	RR	RES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			NA	NA	[illegible]	[illegible]	KK	KA	[illegible]	[illegible]			[illegible]	[illegible]
REMARKS																									

WATER ADDED:
DATE
QUANTITY

	CELL NOS. FROM	TO.	REF. CELL NO.	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP
UPPER TIER				76	81		[illegible]	72	77	70	
CENTER TIER							[illegible]	75	77	[illegible]	
LOWER TIER				77	81			[illegible]	77	70	

BATTERY INFORMATION

TYPE-KS [illegible] LIST [illegible]

SPECIFIC GRAVITY RANGE

NUMBER OF CELLS 23

PILOT CELL NO. [illegible]

DATE INSTALLED

*INITIAL CHARGE PILOT CELL VOLTAGE

*INITIAL CHARGE PILOT CELL SPEC. GRAV.

* = FROM WE. CO. RECORDS

BATTERY RECORDS
NEW JERSEY BELL TELEPHONE
BORDENTOWN C. O.
BORDENTOWN, NEW JERSEY 08505

Fig 3-2

P-4032 (O)

QUARTERLY INDIVIDUAL CELL VOLTAGE
SEMI-ANNUAL CORRECTED SPECIFIC GRAVITY

BSP 157-601-301

OFFICE

BATTERY NO. -48 B

MONTH	CELL NO.	Voltage 1979 1 QTR	1979 2 QTR	1979 3 QTR	1979 4 QTR	Voltage 1980 1 QTR	1980 2 QTR	1980 3 QTR	1980 4 QTR	Sp. Gr. 1979 1 HLF	1979 2 HLF	Sp. Gr. 1980 1 HLF	1980 2 HLF
	1	2.16	2.18	2.18	2.17	2.15	2.16		2.16	1205	[illegible]	1210	1214
	2	2.15	2.14	2.17	[illegible]	2.14	2.15		.15	[illegible]	[illegible]	1206	1206
	3	2.14	2.18	2.18	[illegible]	2.16	2.16		.16	1204	[illegible]	1208	1206
	4	2.14	2.18	2.18	2.17	2.15	2.16		.17	1202	[illegible]	1208	1210
	5	2.18	2.18	2.19	[illegible]	2.16	2.18		.18	1200	1216	1212	1210
	6	2.17	2.18	2.17	[illegible]	2.16	2.17		.18	1202	[illegible]	1210	1208
	7	2.18	2.18	2.17	[illegible]	2.15	2.16		2.17	1202	[illegible]	1210	1206
	8	2.16	2.17	2.18	2.17	2.15	2.15		2.16	1200	[illegible]	1206	1204
	9	2.14	2.14	2.15	[illegible]	2.17	2.17		2.17	1202	[illegible]	1206	1204
	10	2.17	2.18	2.21	[illegible]	2.15	2.17		2.20	1200	1206	1212	1208
	11	2.15	2.18	2.20	2.14	2.15	2.17		2.18	1200	[illegible]	1206	1218
	12	2.18	2.17	2.17	[illegible]	2.15	2.15		2.16	1204	[illegible]	1210	1210
	13	2.17	2.18	2.18	[illegible]	2.15	2.11		2.17	1202	[illegible]	1202	1210
	14	2.17	2.18	2.18	[illegible]	2.15	2.16		2.16	1200	[illegible]	1204	1208
	15	2.16	2.18	2.17	[illegible]	2.15	2.15		2.17	1202	[illegible]	1210	1208
	16	2.16	2.18	2.17	[illegible]	2.15	2.15		2.16	1202	1210	1200	1208
	17	2.18	2.18	2.18	[illegible]	2.16	2.16		2.17	1202	1210	1206	1210
	18	2.17	2.18	2.17	[illegible]	2.15	2.15		2.15	1202	1200	1202	1206
	19	2.16	2.18	2.17	[illegible]	2.16	2.15		2.15	1203	[illegible]	1204	1208
	20	2.17	2.16	2.17	[illegible]	2.15	2.15		2.14	1204	1212	1204	1208
	21	2.17	2.18	2.18	[illegible]	2.14	2.14		2.14	1202		1204	1208
PILOT	22	2.18	2.18	2.18	[illegible]	2.15	2.15		2.15	1200	1208	1200	1202
	23	2.17	2.18	2.18	[illegible]	2.15	2.16		2.15	1200		1204	1202
	24								2.16				
	25												
EM. CELL GRP1													
	1	2.28	2.24	2.40		2.23	2.07		2.25	1202		1204	1206
	2	2.24	2.24	2.39		2.18	2.08		2.22	1203		1200	1204
	3	2.3	2.25	2.40		2.22	2.29		2.24	1204		1204	1210
	4	2.23	2.23	2.27		2.18	2.26		2.21	1204		1202	1208
EM. CELL GRP2													
	5												
	6								[illegible]			[illegible]	[illegible]
	7								[illegible]			[illegible]	[illegible]
	8												
DATE				7/11									
BY				[illegible]									
REMARKS													
WATER ADDED: DATE													
QUANTITY													

	CELL NOS. FROM	TO.	REF. CELL NO.	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP
UPPER TIER			19	78°		77	81				
CENTER TIER											
LOWER TIER			14	76°		77	79				

BATTERY INFORMATION

TYPE-KS 15544 LIST 508

SPECIFIC GRAVITY RANGE

NUMBER OF CELLS 23

PILOT CELL NO. 22

DATE INSTALLED

*INITIAL CHARGE PILOT CELL VOLTAGE

*INITIAL CHARGE PILOT CELL SPEC. GRAV.

* = FROM WE. CO. RECORDS.

BATTERY RECORDS
NEW JERSEY BELL TELEPHONE
BORDENTOWN C. O.
BORDENTOWN, NEW JERSEY 08505

Fig. 3-3

SECTION #4

DESIGN CONTINUATION DOCUMENTATION

The cell design for batteries supplied for Byron/Braidwood as well as test cells submitted to Wyle Laboratories for seismic simulation testing are of the same design.

Included in this section are cell section drawings covering all cell sizes in the NCX line of cells.

Types	Drawing #	Fig. #
NCX-600 through 1200	107006D Rev. F	#4-1
NCX-1344 through 1500	107012D Rev. F	#4-2
NCX-1650 through 1950	106288D Rev. K	#4-3
NCX-2016 through 2550	106302D Rev. E	#4-4

These drawings demonstrate that cell type NCX-1200 & 1500 being supplied for Class 1E use is the same design as the NCX-1680 naturally aged test cells submitted to Wyle Laboratories for seismic qualification.

Additional documentation of design continuation is afforded by Gould Specification Sheets GB-3325 dated 6/71 (Fig. #4-5) current at the time the test cells were manufactured.

In addition, Gould Specification Sheet GB-3325 dated 2/80 (Fig. #4-6) is the latest issue and demonstrates design continuance for currently produced cells.

The revisions noted on the cell section drawings were minor dimensional changes, change of accessory options or redrawing of original drawing with no changes.

The materials used in cell construction have remained unchanged and traceability can be provided.

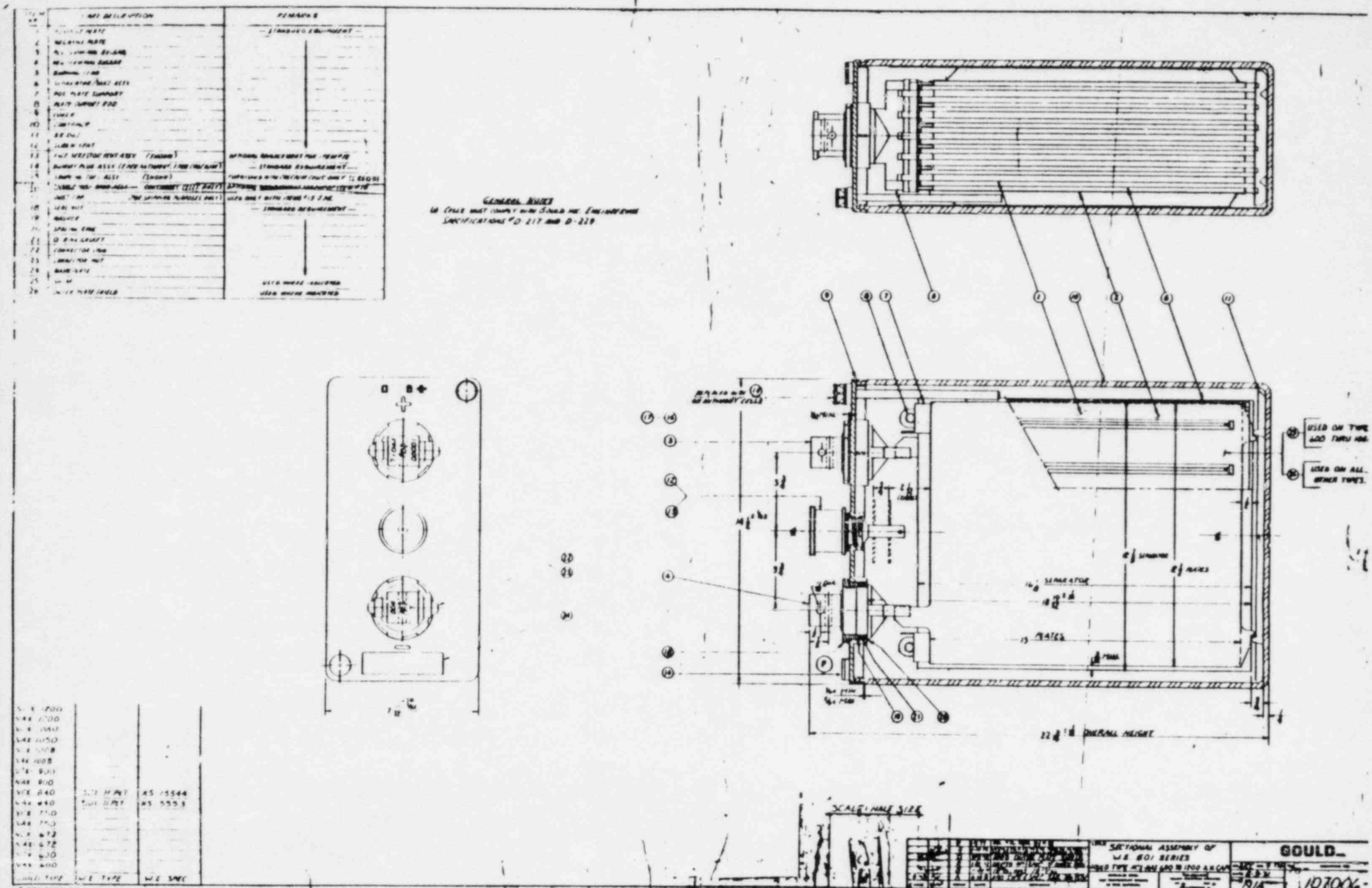

GENERAL NOTES
SECTIONAL ASSEMBLY OF
W.E. 801 SERIES
GOULD
SCALE: HALF SIZE
OVERALL HEIGHT
SEPARATOR
PLATES
USED ON ALL OTHER TYPES.

FIG #4-1

DRAWING #107006-D REVISION F

REV. A — 6-10-71 Added type and specification tabulation. Revised Revised title to include commercial types.

REV. B — 11-24-71 Revised mounting height dimension from 18-17/32" ± 1/32" to 18-19/32" ± 1/32".

REV. C — 1-24-72 Deleted reference to plastic plug used in withdrawal tube opening in cell cover.

REV. D — 2-2-72 Added outside negative plate shield.

REV. E — 1-15-73 Overall height dimension changed from 22-1/8" ± 1/8" to 22-3/16" ± 1/16". All general notes replaced with reference to Gould Engineering Specifications #D-217 and #D-229.

REV. F — 1-5-77 Deleted Item #16 Parts Description with Item #14 (Accessory Item).

DRAWING #107006-D REVISION F

ITEM NO.	PART DESCRIPTION	REMARKS
1	POSITIVE PLATE	----STANDARD EQUIPMENT----
2	NEGATIVE PLATE	
3	POS. TERMINAL BUSBAR	
4	NEG. TERMINAL BUSBAR	
5	BURNING LEAD	
6	SEPARATOR/MAT ASSY.	
7	POS. PLATE SUPPORT	
8	PLATE SUPPORT ROD	
9	COVER	
10	CONTAINER	
11	BRIDGE	
12	SCREW VENT	
13	FIRE ARRESTOR VENT ASSY. (SHOWN)	OPTIONAL REPLACEMENT FOR ITEM #12
14	DUMMY PLUG ASSY. (2 PER ANTIMONY, 1 PER CALCIUM)	----STANDARD REQUIREMENT----
15	SAMPLING TUBE ASSY. (SHOWN)	FURNISHED WITH CALCIUM CELLS ONLY (2 REQ'D)
16	(DELETED)	
17	DUST CAP (FOR SHIPPING PURPOSES ONLY)	USED ONLY WITH ITEM #15
18	SEAL NUT	----STANDARD REQUIREMENT----
19	WASHER	
20	SPACING RING	
21	"O" RING GASKET	
22	CONNECTOR STUD	
23	CONNECTOR NUT	
24	NAMEPLATE	
25	SHIM	USED WHERE INDICATED
26	OUTER PLATE SHIELD	USED WHERE INDICATED

FIG 4-1b

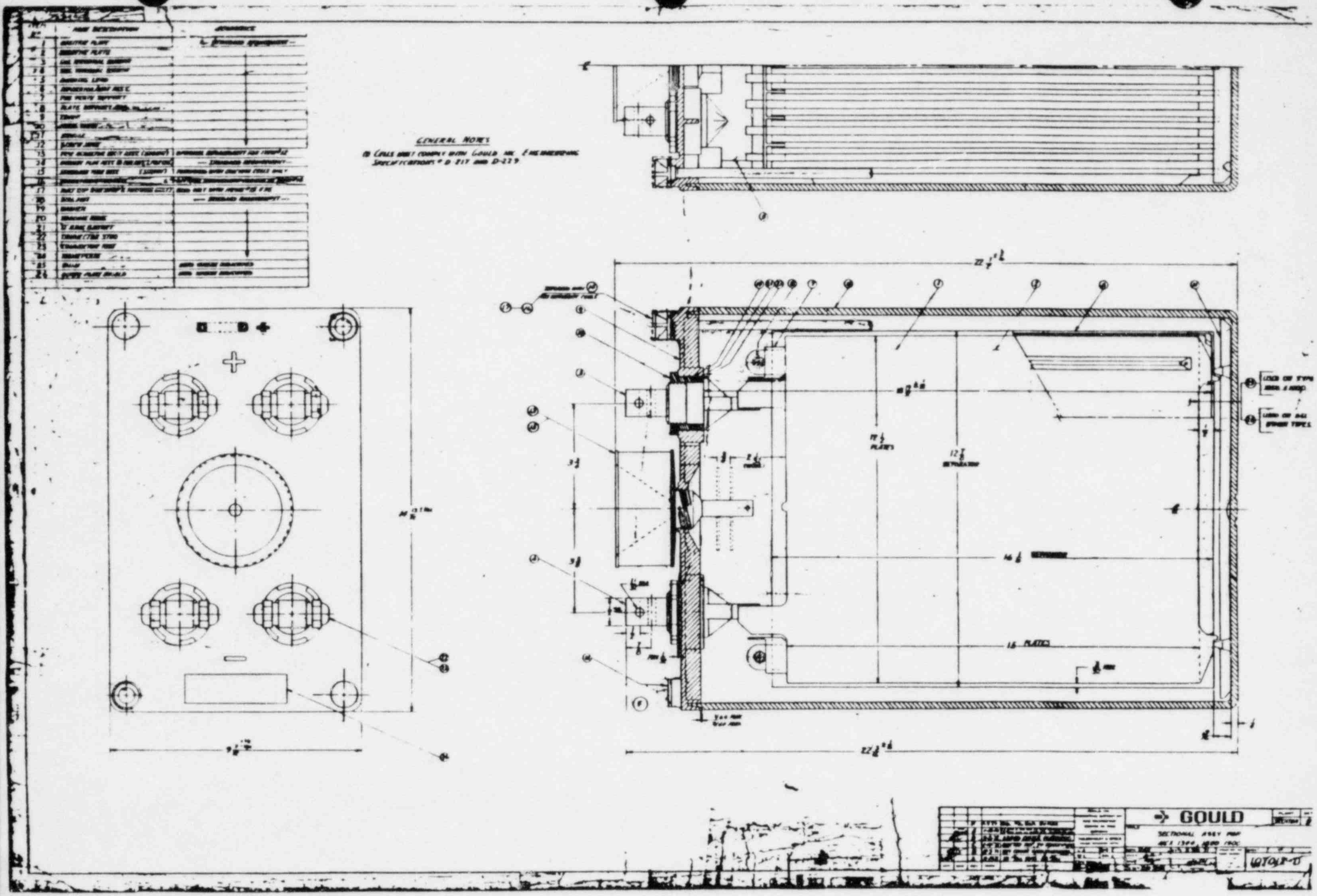

GENERAL NOTES
1) CELLS MUST COMPLY WITH GOULD INC. ENGINEERING SPECIFICATIONS D-217 AND D-229
PLATES
SEPARATOR
GOULD
SECTIONAL ASSY

FIG #4-2

DRAWING #107012-D REVISION F

REV. A 6-10-71 Revised mounting height dimension from 18-17/32" ± 1/32" to 18-19/32" ± 1/32".

REV. B 12-3-71 Revised cover ribs and vent opening boss.

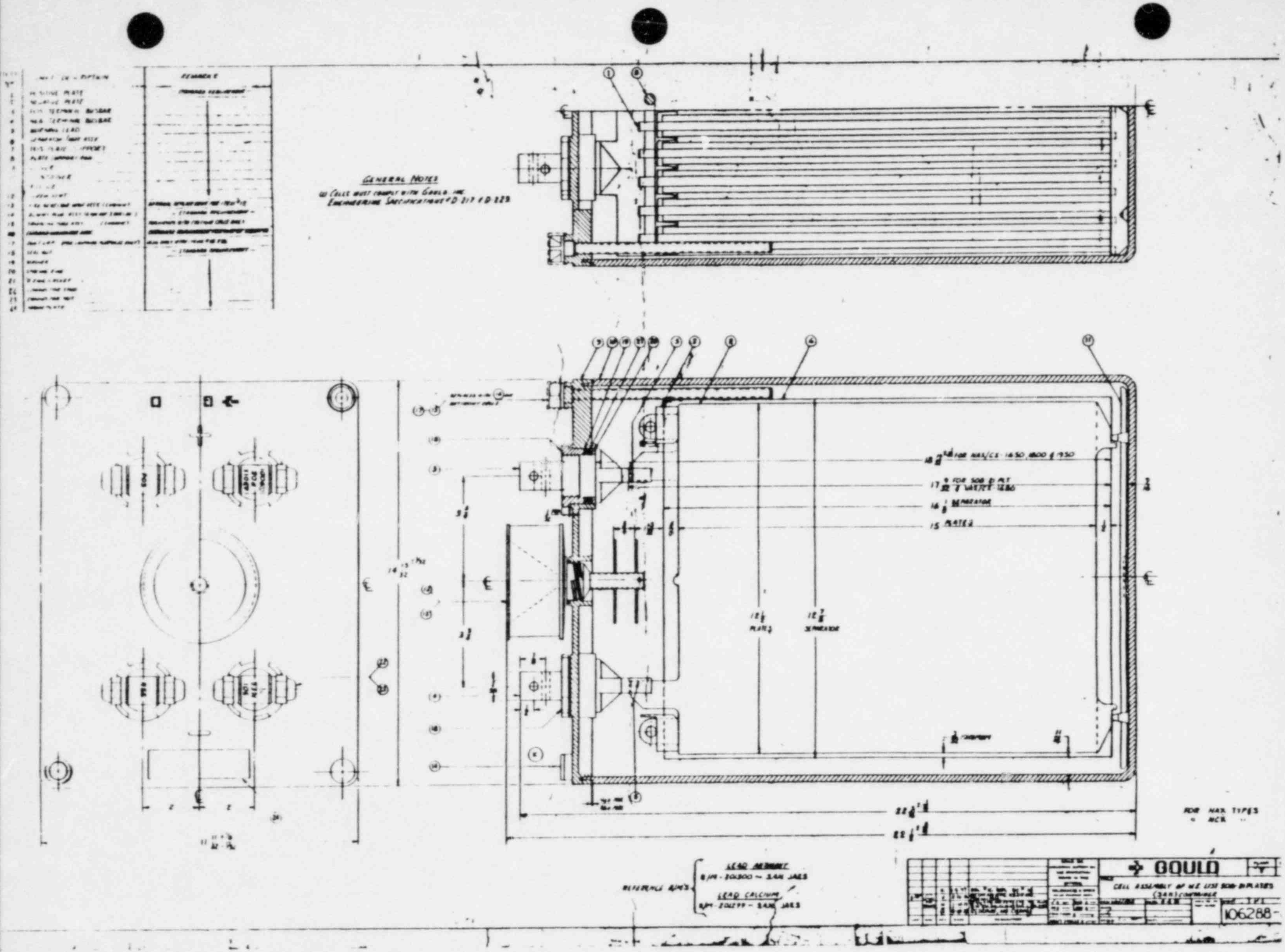
REV. C 1-14-72 Deleted reference to plastic plug used in withdrawal tube opening in cell cover.

REV. D 2-2-72 Added outside negative plate shield.

REV. E 1-15-73 Overall height dimension changed from 22-1/8" ± 1/8" to 22-3/16" ± 1/16". All general notes replaced with reference to Gould Engineering Specifications #D-217 and #D-229.

REV. F 1-5-77 Deleted Item #16 Parts Description with Item #14 (Accessory Item).

FIG 4-2a


GENERAL NOTES
(1) CELLS MUST COMPLY WITH GOULD INC
ENGINEERING SPECIFICATIONS D 217 & D 223
REMARKS
15 PLATES
16 SEPARATOR
FOR NAX TYPES
" NCX "
REFERENCE DWGS
LEAD ANTIMONY
LEAD CALCIUM
GOULD
CELL ASSEMBLY
106288-

DRAWING #107012-D REVISION F

ITEM NO.	PART DESCRIPTION	REMARKS
1	POSITIVE PLATE	----STANDARD EQUIPMENT----
2	NEGATIVE PLATE	
3	POS. TERMINAL BUSBAR	
4	NEG. TERMINAL BUSBAR	
5	BURNING LEAD	
6	SEPARATOR/MAT ASSY.	
7	POS. PLATE SUPPORT	
8	PLATE SUPPORT ROD	
9	COVER	
10	CONTAINER	
11	BRIDGE	
12	SCREW VENT	
13	FIRE ARRESTOR VENT ASSY. (SHOWN)	OPTIONAL REPLACEMENT FOR ITEM #1
14	DUMMY PLUG ASSY. (2 PER ANTIMONY, 1 PER CALCIUM)	----STANDARD REQUIREMENT----
15	SAMPLING TUBE ASSY. (SHOWN)	FURNISHED WITH CALCIUM CELLS ONL (2 REQ'D)
16	(DELETED)	
17	DUST CAP (FOR SHIPPING PURPOSES ONLY)	USED ONLY WITH ITEM #15
18	SEAL NUT	----STANDARD REQUIREMENT----
19	WASHER	
20	SPACING RING	
21	"O" RING GASKET	
22	CONNECTOR STUD	
23	CONNECTOR NUT	
24	NAMEPLATE	
25	SHIM	USED WHERE INDICATED
26	OUTER PLATE SHIELD	USED WHERE INDICATED

FIG 4-2b

DRAWING #106288-D REVISION K

REV. A   4-28-70 Added Note 6, revised for lead antimony.

REV. B   5-19-70 Cell length, width and overall height dimensions revised. Notes 8 and 9 added.

REV. C   7-13-70 Dimension from top of separator to low level line changed from 1-1/2" to 1-13/32".

REV. D   4-16-71 Added letter "X" to top of negative post for identification.

REV. E   5-3-71 Letter "X" changed from top of negative post to top of positive post.

REF. F   11/24/71 Revised mounting height dimension from 18-17/32" to 18-19/32".

REV. G   8-18-72 Redrawn - no changes.

REV. H   1-10-73 Overall height dimension changed from 22-1/8" ± 1/8" to 22-3/16" ± 1/16". Tolerance added to 18-19/32" mounting height (± 1/32"). All notes replaced with reference to Engineering Specification #D-229.

REV. J   2-26-73 Separator height dimension changed from 16-1/16" to 16-1/8". Height of separator above plates was changed from 9/16" to 5/8".

REV. K   1-5-77 Deleted Item #16 Parts Description with Item #14 (Accessory Item).

FIG 4-3a

DRAWING #106288-D REVISION K

ITEM NO.	PART DESCRIPTION	REMARKS
1	POSITIVE PLATE	----STANDARD REQUIREMENT----
2	NEGATIVE PLATE	
3	POS. TERMINAL BUSBAR	
4	NEG. TERMINAL BUSBAR	
5	BURNING LEAD	
6	SEPARATOR/MAT ASSY.	
7	POS. PLATE SUPPORT	
8	PLATE SUPPORT ROD	
9	COVER	
10	CONTAINER	
11	BRIDGE	
12	SCREW VENT	
13	FIRE ARRESTOR VENT ASSY. (SHOWN)	OPTIONAL REPLACEMENT FOR ITEM #1
14	DUMMY PLUG ASSY. (4 PER ANTIMONY, 2 PER CALCIUM)	----STANDARD REQUIREMENT----
15	SAMPLING TUBE ASSY. (SHOWN)	FURNISHED WITH CALCIUM CELLS ONL
16	(DELETED)	
17	DUST CAP (FOR SHIPPING PURPOSES ONLY)	USED ONLY WITH ITEM #15
18	SEAL NUT	----STANDARD REQUIREMENT----
19	WASHER	
20	SPACING RING	
21	"O" RING GASKET	
22	CONNECTOR STUD	
23	CONNECTOR NUT	
24	NAMEPLATE	

FIG 4-3b

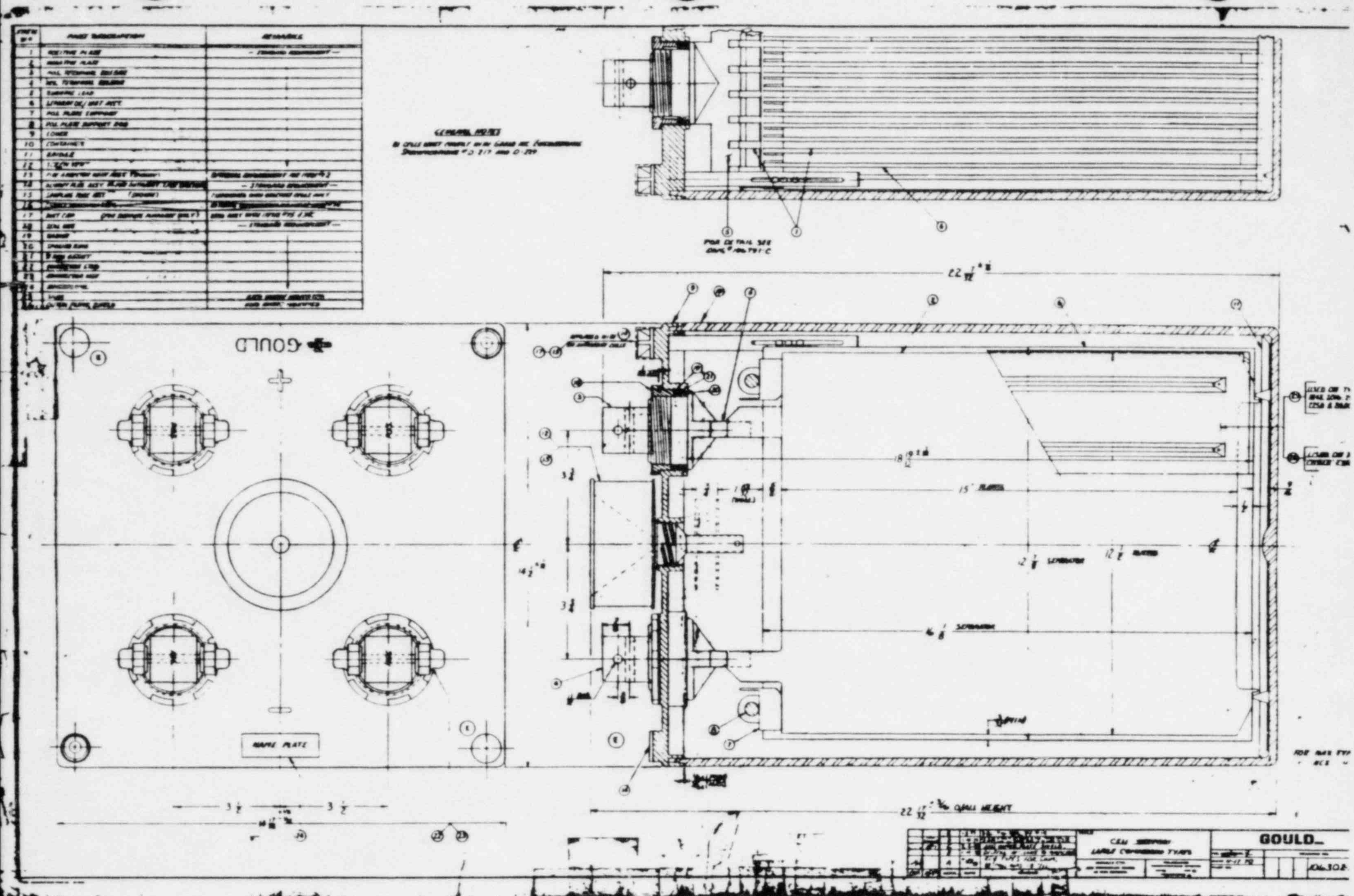


FIG #4-4

DRAWING #106302-D REVISION E

REV. A 11-29-71 Revised to include cell types using shim. Revised mounting height from 18-17/32" ± 1/32" to 18-19/32" ± 1/32".

REV. B 1-14-72 Deleted reference to plastic plug used in withdrawal tube opening in cell cover.

REV. C 2-2-72 Added outside negative plate shield.

REV. D 1-15-73 Overall cell height to post changed from 22-5/32" ± 1/8" to 22-7/32" ± 1/16". All general notes replaced with reference to Gould Engineering Specification #D-229.

REV. E 1-5-77 Deleted Item #16 Parts Description with Item #14 (Accessory Item).

FIG 4-4a

DRAWING #106302-D REVISION E

ITEM NO.	PART DESCRIPTION	REMARKS
1	POSITIVE PLATE	----STANDARD REQUIREMENT----
2	NEGATIVE PLATE	
3	POS. TERMINAL BUSBAR	
4	NEG. TERMINAL BUSBAR	
5	BURNING LEAD	
6	SEPARATOR/MAT ASSY.	
7	POS. PLATE SUPPORT	
8	POS. PLATE SUPPORT ROD	
9	COVER	
10	CONTAINER	
11	BRIDGE	
12	SCREW VENT	
13	FIRE ARRESTOR VENT ASSY. (SHOWN)	OPTIONAL REPLACEMENT FOR ITEM #12
14	DUMMY PLUG ASSY. (4 PER ANTIMONY, 2 PER CALCIUM)	----STANDARD REQUIREMENT----
15	SAMPLING TUBE ASSY. (SHOWN)	FURNISHED WITH CALCIUM CELLS ONLY
16	(DELETED)	
17	DUST CAP (FOR SHIPPING PURPOSES ONLY)	USED ONLY WITH ITEM #15
18	SEAL NUT	----STANDARD REQUIREMENT----
19	WASHER	
20	SPACING RING	
21	"O" RING GASKET	
22	CONNECTOR STUD	
23	CONNECTOR NUT	
24	NAMEPLATE	
25	SHIM	USED WHERE INDICATED
26	OUTER PLATE SHIELD	USED WHERE INDICATED

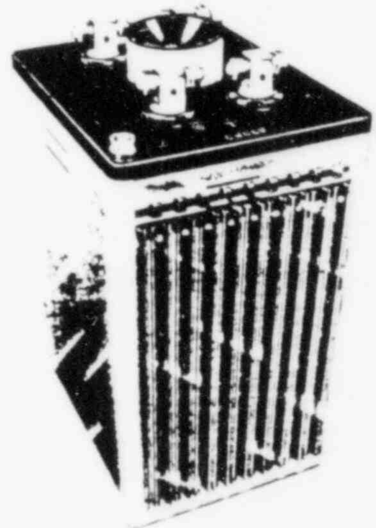
FIG 4-4b

GOULD

Stationary Power Cells —Calcium

TYPE-NCX

CAPACITIES—1650 A.H. TO 1950 A.H. @ 8 HOUR RATE TO 1.75 V.P.C. AVERAGE.



SPECIFICATIONS

Container—Styrene-Acrylonitrile Plastic.[1]

Cover—Acryl.-Buta.-Styr. Terpolym. Plastic.[1]

Separators—Duropor-Microporous Material.

Retainers—Fiberglass Mats.

Posts—Four 1" Square.

Post Seals—Floating O-Ring—Seal Nut.

Vents—Screw Type—Spray Proof.[2]

Level Lines—High and Low—All Jar Faces.

Electrolyte—Height Above Plates—2-3/4".

Electrolyte Withdrawal Tube—Each Cell.

Sediment Space—1-1/16".

Specific Gravity—1.215 @ 77°F. (25°C.).

Inter-Cell Connectors—Lead Plated Copper.

[1] Modified Polyvinyl Chloride which will not support combustion is available at additional cost.

[2] Combined Filling Funnel—Explosion resistant vent is available at additional cost. Specify Gould "Pre-Vent".**

Plate Dimensions	Height	Width	Thick-ness
Positive Plate	15-1/2"	12"	.320
Negative Plate	15-1/2"	12"	.215

Type	Plates Per Cell	Ampere Hour Capacities to 1.75 V.P.C. Average*				1 Minute Rate in Amperes*		Overall Dimensions in inches			Approximate Wgt. in Lbs.		Elect. Gals. Per Cell
		8 Hr.	5 Hr.	3 Hr.	1 Hr.	To 1.75 V.P.C. Avg.	To 1.50 V.P.C. Avg.	L	W	H	Net Wgt.	Packed Wgt.	
NCX-1650	23	1650	1485	1287	825	1782	3390	11-3/8"	14-1/2"	22-1/2"	348	366	8.1
NCX-1680	21	1680	1470	1230	750	1530	2910	11-3/8"	14-1/2"	22-1/2"	332	350	8.3
NCX-1800	25	1800	1620	1404	900	1932	3675	11-3/8"	14-1/2"	22-1/2"	364	382	7.8
NCX-1950	27	1950	1755	1521	975	2080	3955	11-3/8"	14-1/2"	22-1/2"	380	398	7.6

* Includes voltage drop across intercell connections used in standard layouts.

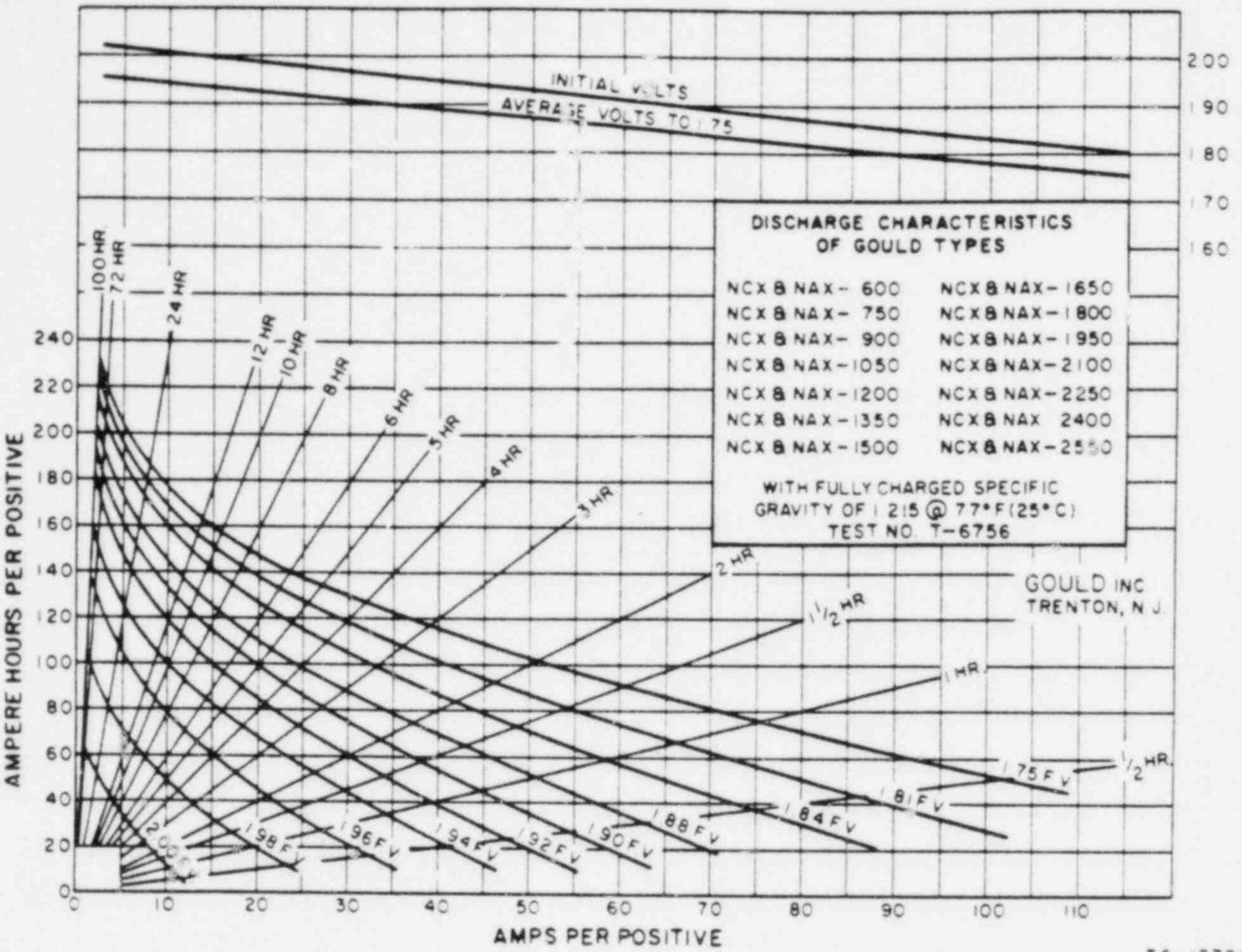
** TM Gould, Inc.

GOULD

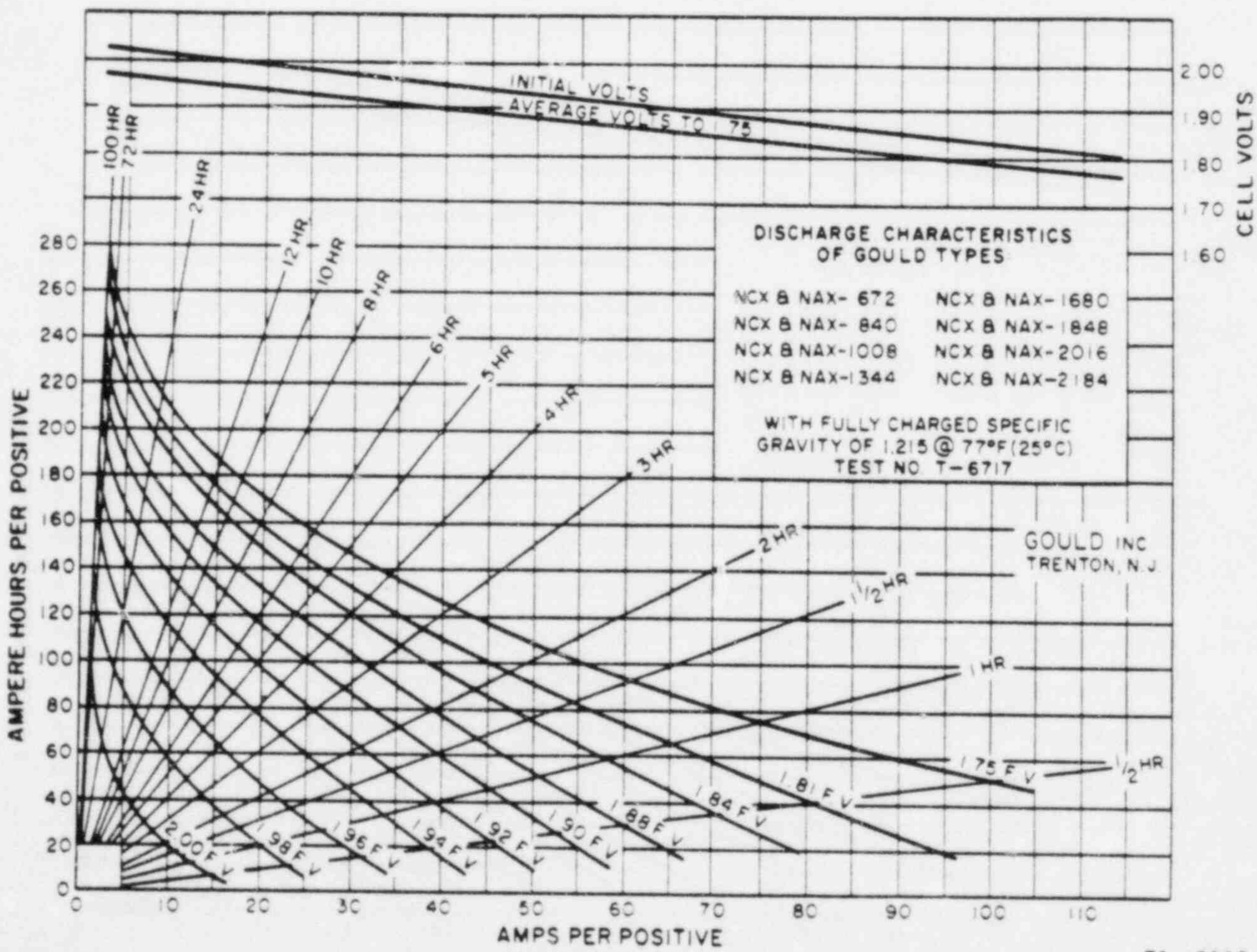
Gould Inc., Industrial Battery Division
487 Calhoun Street, Trenton, New Jersey 08607
Telephone (609) 392-3111

Fig #4-5

GB-3325 6/71 3MW
Printed in U.S.A.



TC-107011



TC-10860

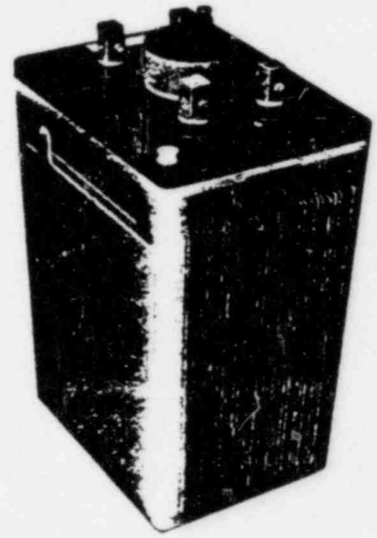
Fig #4-5R

GOULD

An Electrical/Electronics Company

Stationary Power Cells (Calcium)

TYPE: NCX



CAPACITIES—600 A.H. TO 2550 A.H. @ 8 HOUR RATE TO 1.75 V.P.C. AVERAGE

SPECIFICATIONS

Container – Styrene-Acrylonitrile Plastic.
Cover – Butadiene Styrene.
Separators – Microporous Material.
Retainers – Fiberglass Mats.
Posts – See Below.①
Post Seals – Floating O-Ring – Seal Nut.
Vents – Gould "Pre-Vent".**
Level Lines – High and Low – All Jar Faces.
Electrolyte – Height Above Plates – 2-3/4".
Electrolyte Withdrawal Tubes – Each Cell.
Sediment Space – 1-1/16".
Specific Gravity – 1.215 @ 77°F. (25°C.).
Inter-Cell Connectors – Lead Plated Copper.

Plate Dimensions	Height	Width	Thick-ness
Positive Plate	15"	12½"	.320
Negative Plate	15"	12½"	.215

Posts—600 A.H. to 1200 A.H. Two—1½" square. 1344 A.H. to 1950 A.H. Four—1" square (Except 1848 A.H.). 1848 A.H. to 2550 A.H. Four—1½" square.

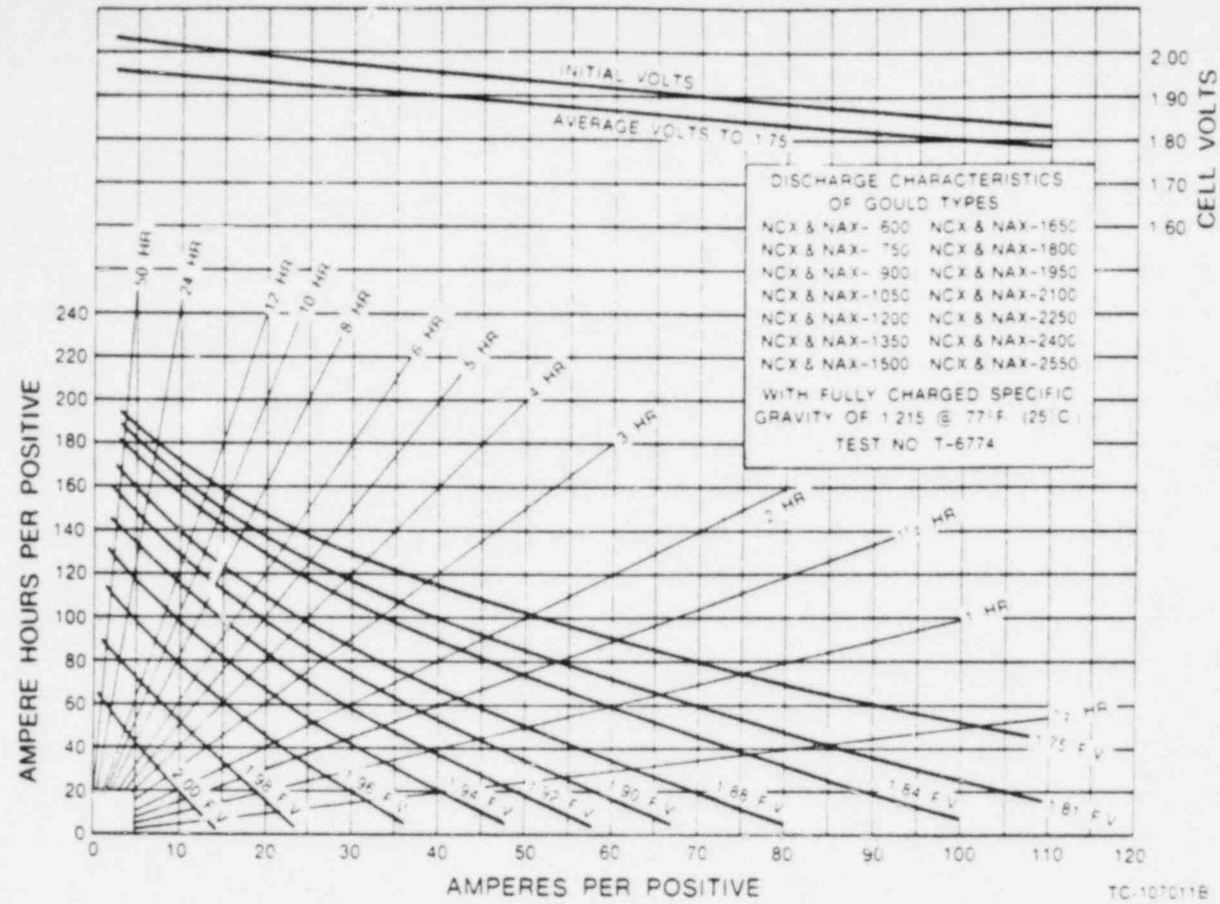
Type	Plates Per Cell	Ampere Hour Capacities to 1.75 V.P.C. Average* 8 Hr.	5 Hr.	3 Hr.	1 Hr.	1 Minute Rate in Amperes* To 1.75 V.P.C. Avg.	To 1.50 V.P.C. Avg.	Overall Dimensions in inches L	W	H	Approximate Wgt. in Lbs. Net Wgt.	Packed Wgt.	Elect. Gals. Per Cell
NCX-600	9	600	540	468	300	712	1355	7-3/8	14-1/2	22-1/8	177	189	6.0
NCX-672	9	672	588	492	300	636	1210	7-3/8	14-1/2	22-1/8	178	190	6.0
NCX-750	11	750	675	585	375	880	1675	7-3/8	14-1/2	22-1/8	195	207	5.6
NCX-840	11	840	735	615	375	790	1500	7-3/8	14-1/2	22-1/8	196	208	5.6
NCX-900	13	900	810	702	450	1044	1985	7-3/8	14-1/2	22-1/8	213	225	5.1
NCX-1008	13	1008	882	738	450	942	1790	7-3/8	14-1/2	22-1/8	214	226	5.1
NCX-1050	15	1050	945	819	525	1204	2290	7-3/8	14-1/2	22-1/8	231	243	4.9
NCX-1200	17	1200	1080	936	600	1360	2585	7-3/8	14-1/2	22-1/8	249	261	5.0
NCX-1344	17	1344	1176	984	600	1240	2360	9-1/4	14-1/2	22-1/2	268	280	6.8
NCX-1350	19	1350	1215	1053	675	1494	2840	9-1/4	14-1/2	22-1/2	282	294	6.3
NCX-1500	21	1500	1350	1170	750	1620	3080	9-1/4	14-1/2	22-1/2	301	313	6.0
NCX-1650	23	1650	1485	1287	825	1782	3390	11-3/8	14-1/2	22-1/2	348	366	8.0
NCX-1680	21	1680	1470	1230	750	1530	2910	11-3/8	14-1/2	22-1/2	332	350	8.3
NCX-1800	25	1800	1620	1404	900	1932	3675	11-3/8	14-1/2	22-1/2	364	382	7.6
NCX-1848	23	1848	1617	1353	825	1661	3160	14-9/16	14-1/2	22-1/2	397	415	12.6
NCX-1950	27	1950	1755	1521	975	2080	3955	11-3/8	14-1/2	22-1/2	380	398	7.3
NCX-2016	25	2016	1764	1476	900	1788	3400	14-9/16	14-1/2	22-1/2	415	433	12.1
NCX-2100	29	2100	1890	1638	1050	2240	4260	14-9/16	14-1/2	22-1/2	446	464	11.5
NCX-2184	27	2184	1911	1599	975	1924	3660	14-9/16	14-1/2	22-1/2	433	451	11.5
NCX-2250	31	2250	2025	1755	1125	2400	4565	14-9/16	14-1/2	22-1/2	462	480	10.9
NCX-2400	33	2400	2160	1872	1200	2560	4865	14-9/16	14-1/2	22-1/2	479	497	10.3
NCX-2550	35	2550	2295	1989	1275	2720	5170	14-9/16	14-1/2	22-1/2	496	514	9.7

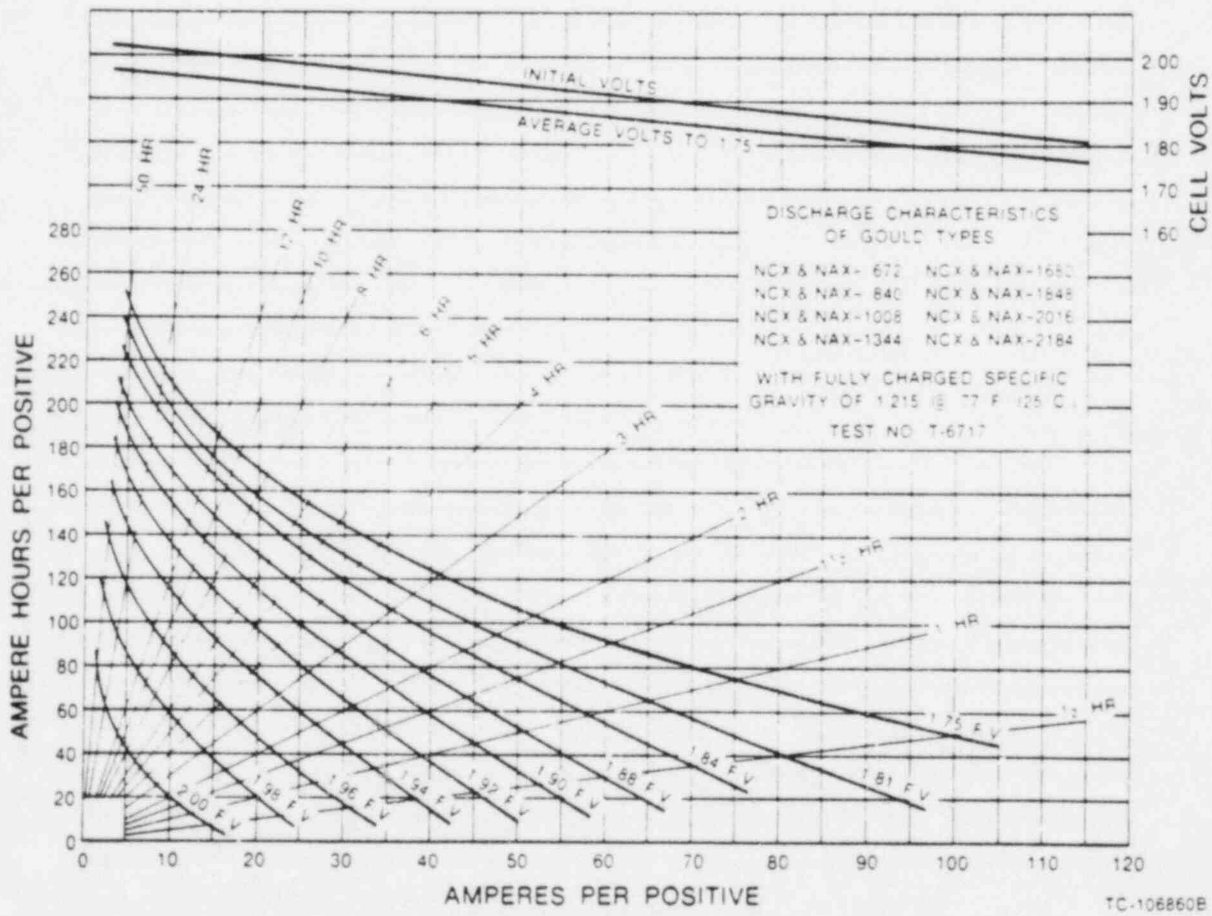
*Includes voltage drop across intercell connections used in standard layouts. **™Gould Inc.

GB-3325E 2/80 2.5M

Fig #4-6

Printed in U.S.A.





Gould Inc., Industrial Battery Division
2050 Cabot Boulevard West, Langhorne, Pa 19047
Telephone (215) 752-0555

CABLE GOULNATBAT, LANGHORNE, PA - TWX GOULD LAHN 510-667-2056

GOULD
An Electrical/Electronics Company

Fig #4-6R

SECTION #5

TEST RACK DRAWING

AND

CALCULATIONS

SECTION #5

TEST RACK DRAWING
AND
CALCULATIONS

ASSEMBLY [illegible]S:

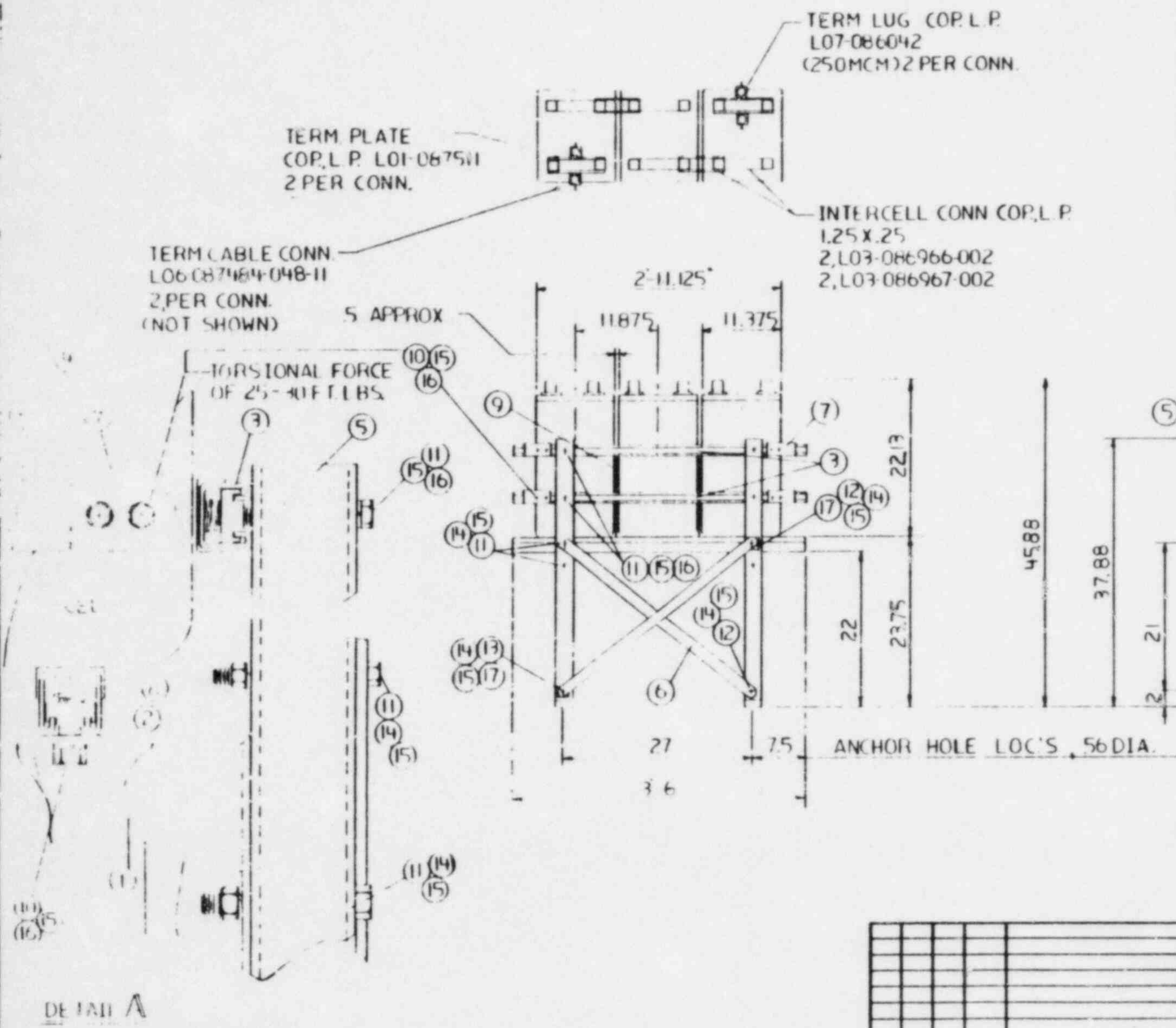
1) RACK [illegible] CONNECTIONS TO BE TIGHTENED WITH A TORSIONAL FORCE OF 50 FT. LBS. UNLESS NOTED.

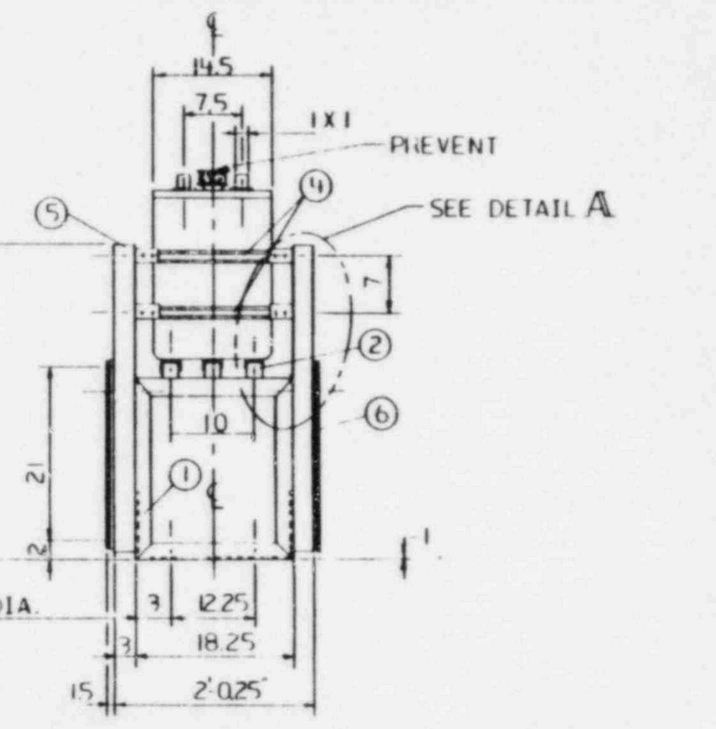
2) BATTERY A) ALL POST CONNECTIONS TO BE MADE WITH 5/16-18 X 2.5 LG. S.S. HEX. HD. BOLT NUT & WASHERS.

B) TERM CONNS TO BE ATTACHED WITH 5/16-18 X 1.25 LG. S.S. HEX. HD. BOLT NUT & WASHERS.

C) ABOVE CONN'S TO BE TIGHTENED WITH A TORSIONAL FORCE OF 12-13 FT. LBS.

MATERIAL REQ.D FOR 1,S07-0[illegible]876 RACK				
PC#	QTY.	DESCRIPTION		PART NO.
1	2	STEEL SUPPORT		S01-065899-009
2	3	BASE STRINGER		S02-043301-002
3	4	SIDE STRINGER		S02-043301-002
4	4	END STRINGER		S02-043301-024
5	4	UPRIGHT TUBING		S05-078947-073
6	4	BRACING		S07-074940-018
7	8	CORNER FITTING		S05-078440-002
8	9	CELL STRIP		S04-106749-002
9	2	CELL SPACER		S05-106333-007
10	38	1/2-13 HEX HD BOLT	1.25"	W02-005330
11	14		4"	W02-074552
12	4		4.5"	W02-074385
13	2		5"	W02-078931-002
14	12	1/2 HEX NUT		W06-000383
15	58	1/2 SPLIT LOCKWASHER		W03-005069
16	46	1/2-13 CLAMPING NUT		S02-040124
17	4	1/2 SPACING WASHER		S05-074400-009





GOULD

TITLE LAYOUT FOR 3 CELLS NAX/NCX-1680 ON SPECIAL TEST RACK S07-078437-676

DRN MAL DATE 4-1-81 SHEET 1 OF 1

A 10-7-81 Revised Brace Part #

078437C

SHEET #1 OF
JOB 881

STRUCTURAL DESIGN OF TEST RACK
FOR 3 CELLS OF NAX/NCX-1680
GOULD BATTERIES

INDEX

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL ENGINEER
RALPH C. DUMACK
No 332A

Ralph C. Dumack

ASSEMBLY [illegible]

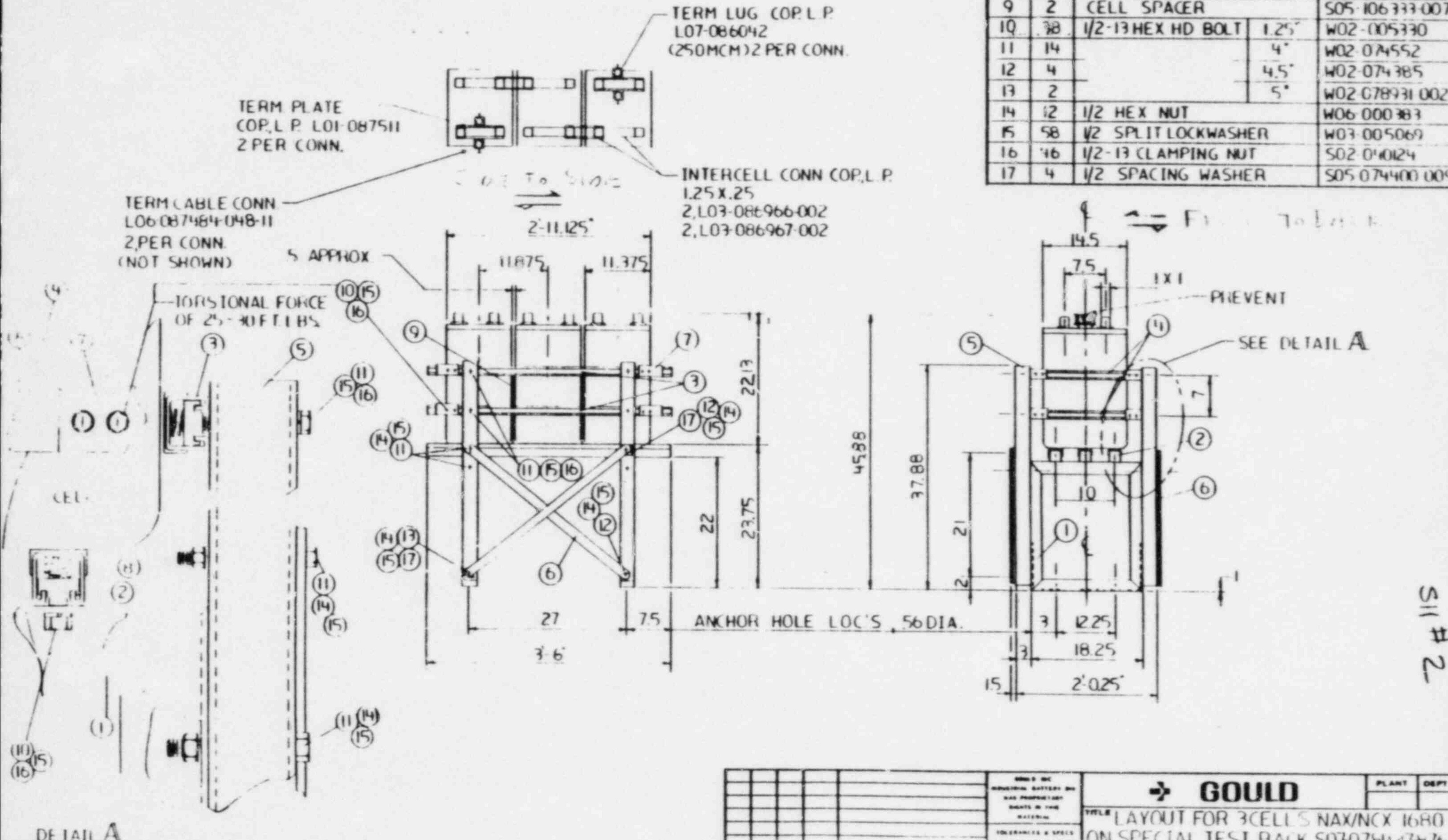
1) RACK [illegible] CONNECTIONS TO BE TIGHTENED WITH A TORSIONAL FORCE OF 50 FT. LBS. UNLESS NOTED.

2) BATTERY A) ALL POST CONNECTIONS TO BE MADE WITH 5/16-18 X 2.5 LG. S.S. HEX HD BOLT NUT & WASHERS.

B) TERM CONNS TO BE ATTACHED WITH 5/16-18 X 1.25 LG. S.S. HEX HD. BOLT NUT & WASHERS.

C) ABOVE CONN.S TO BE TIGHTENED WITH A TORSIONAL FORCE OF 12-13 FT. LBS.

MATERIAL REQ D FOR 1,S07 [illegible]37-876 RACK				
PC#	QTY.	DESCRIPTION		PART NO.
1	2	STEEL SUPPORT		S01-065899-009
2	3	BASE STRINGER		S02-043301-002
3	4	SIDE STRINGER		S02-043301-002
4	4	END STRINGER		S02-043301-024
5	4	UPRIGHT TUBING		S05-078917-073
6	4	BRACING		S07-074940-018
7	8	CORNER FITTING		S05-078440-002
8	9	CELL STRIP		S04-106749-002
9	2	CELL SPACER		S05-106333-007
10	38	1/2-13 HEX HD BOLT	1.25"	W02-005330
11	14		4"	W02-074552
12	4		4.5"	W02-074385
13	2		5"	W02-078931-002
14	12	1/2 HEX NUT		W06-000383
15	58	1/2 SPLIT LOCKWASHER		W03-005069
16	46	1/2-13 CLAMPING NUT		S02-040124
17	4	1/2 SPACING WASHER		S05-074400-009



GOULD

TITLE LAYOUT FOR 3CELLS NAX/NCX 1680 ON SPECIAL TEST RACK S07-07843-7876

STRUCTURAL DESIGN OF TEST RACK
FOR 3 CELLS OF NAX/NCX-1680
GOULD BATTERIES

SHEET # 5

JOB 881

DESIGN DATA:

NATURAL FREQUENCIES:

23 HZ FRONT TO BACK/VERTICAL } REFER TO DYNAMIC
70 HZ SIDE TO SIDE/VERTICAL } COMPUTER PRINTOUTS

DAMPING: 2% FOR BOLTED STEEL FRAMEWORK

SEISMIC LOADING FACTORS:

SSE (SAFE SHUTDOWN EARTHQUAKE) REF. GOULD FULL SCALE SHOCK SPECTRUM. FIG-8-5 & FIG. 8-6

HORIZ: GROUND ACCELERATION = 2.3 x g
VERT: " " = 1.7 x g
] FRONT TO BACK/VERTICAL

HORIZ: GROUND ACCELERATION = 2.3 x g
VERT: " " = 1.7 x g
] SIDE TO SIDE/VERTICAL

ALLOWABLE WORKING STRESSES

FOR NORMAL LOADINGS: AS PER AISC EIGHTH EDITION

FOR SSE: SHALL NOT EXCEED 0.9 x YIELD STRESS

WEIGHTS: (NAX/NCX-1680 BATTERIES)

3 CELLS = 3x332 = 996 #

WT OF RACK (REF. GOULD DWG # 078437C) = 265 #

MATERIALS:

STRUCTURAL STEEL SHAPES & PLATES: ASTM A-36, F_y = 36 K/□

UNISTRUTS STEEL SHEET: ASTM A 570, GR. C, F_y 33 K/□

[illegible] A [illegible]

OD

SHEET #4
JOB 881

DESIGN DATA (CONT'D):

WELDING ELECTRODES: SMAW, AWS A5.1 OR A5.5 E70XX

SPECIFICATIONS:

A.I.S.C. 8TH EDITION

A.W.S. D1.1

TEST RACK COMPONENTS:

SUPPORT, SIDE & END STRINGERS – $1\frac{5}{8}$" × $1\frac{5}{8}$" × 12 GA. UNISTRUT P1000

SUPPORT FRAMES – L $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$

VERTICAL TUBES – TS 3×3×0.25

DIAGONAL BRACING – PL $1\frac{1}{2} \times \frac{3}{8}$

SH #5

REFERENCE:
WYLE REPORT PAGE III - 444
FULL SCALE SHOCK SPECTRUM (g PEAK)
100
DAMPING 2%

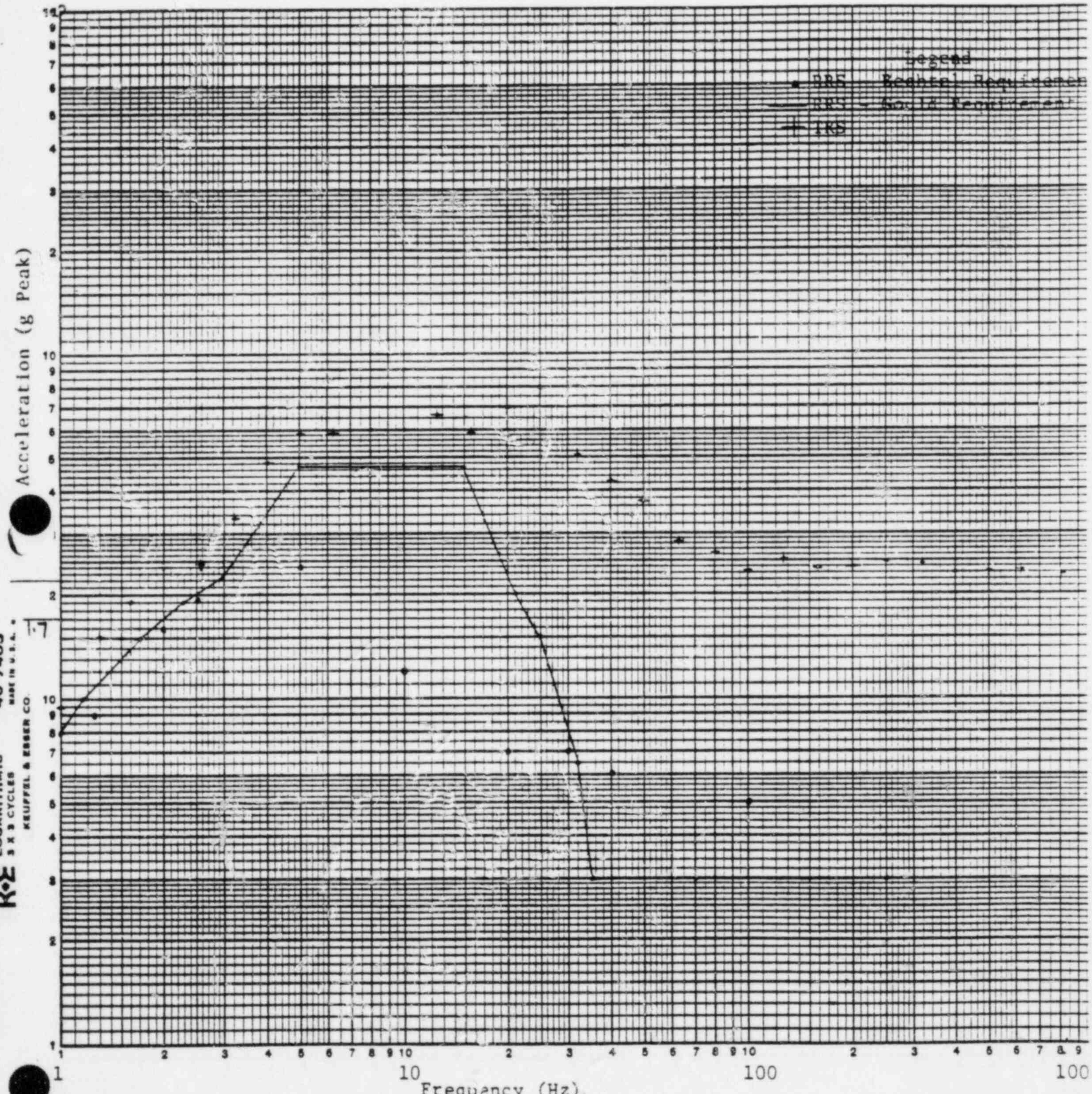


Fig. 3-5
Vertical Side Shutdown Earthquake
Front-to-back/vertical

REFERENCE:
WYLE REPORT PAGE III - 439
FULL SCALE SHOCK SPECTRUM (g PEAK)
100
DAMPING 2%

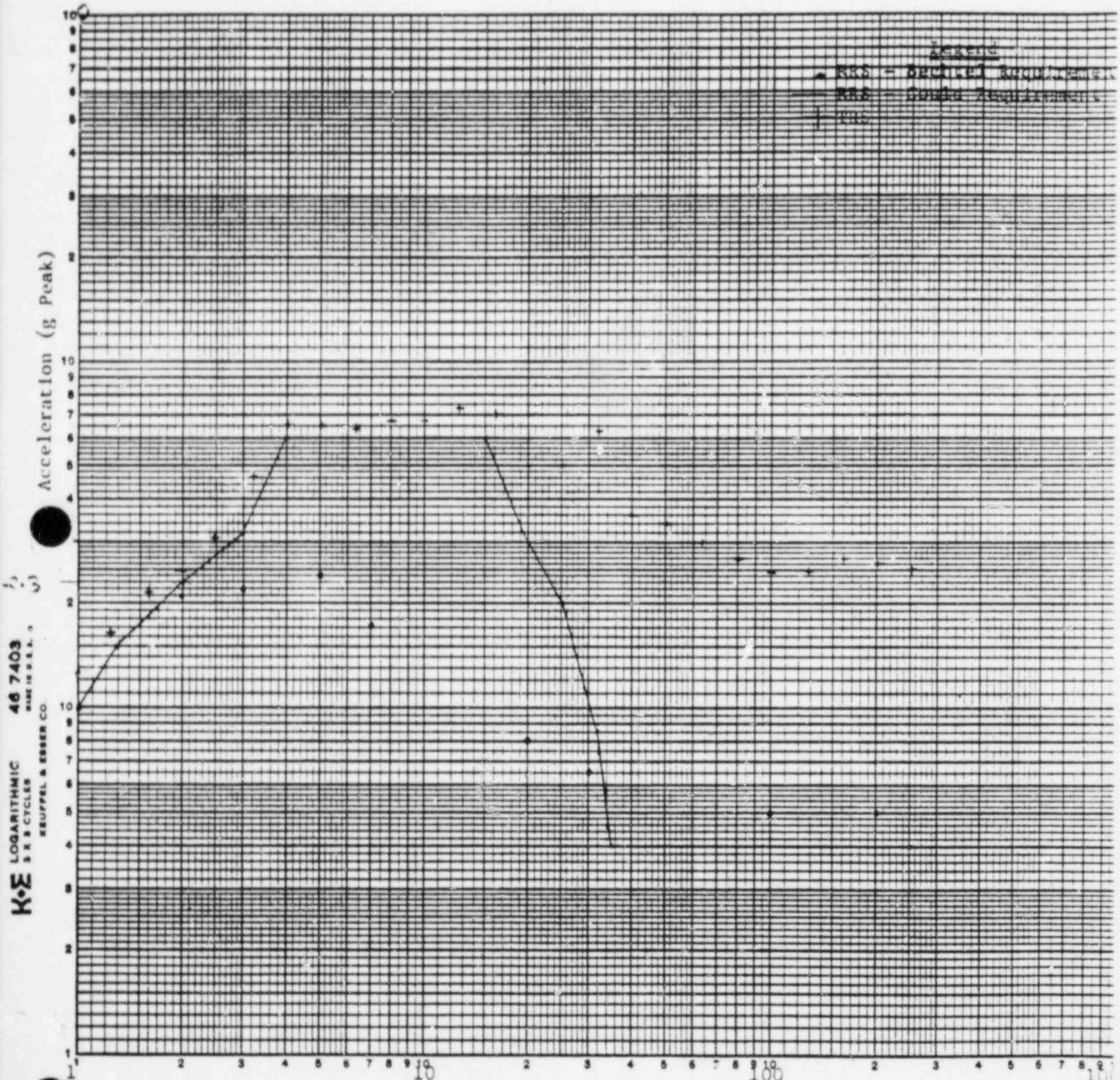


Fig. 8-6
Horizontal Side Shutdown Earthquake
Front-to-back/vertical

I. J. P. 5-6-82

SHEET # 7

JOB 881

DESIGN OF MAIN STRINGERS:

TOTAL WT. OF THREE NCX/NAX-1680 CELL = 3×332 = 996 #

THERE ARE THREE STRINGERS TO SUPPORT THIS LOAD. THEREFORE

LOAD FOR ONE STRINGER = 996/3 = 332 #

U.D.L. ON ONE STRINGER = $\frac{332}{2.93}$ = 113.4 + 1.9 (SELF WT) = 115.3 #/FT

CASE I WT. OF STRINGER + WT OF CELL

w = 115.3 #/FT

RA = RB = $115.3 \times \frac{2.93}{2}$ = 168.9 #

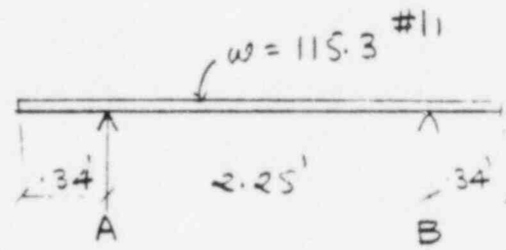
MA = MB = $-115.3 \times \frac{.34^2}{2}$ = −6.67 #-FT

= −80 #-IN.

MOMENT @ CENTER = $168.9 \times \frac{2.25}{2} - 115.3 \times \frac{1.465^2}{2}$

= 66.28 #-FT

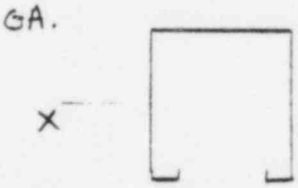
= 795.4 #-IN.



STRINGERS ARE UNISTRUT P1000 − 1.63×1.63×12 GA.

A = 0.555 I_x = .186 I_y = .239 r_x = .579

S_x = .203 S_y = .294 r_y = .655



∴ $f_{bx} = \frac{795.4}{.203}$ = 3918 PSI < .66×33000 = 21780 PSI

CASE II WT. OF STRINGER + WT OF CELL + SSE (FRONT TO BACK) −Y

w = 1.7×115.3 + 115.3 = 311.3 #/I

MA = MB = $-80 \times \frac{311.3}{115.3}$ = −216 #-IN.

MOMT @ CENTER = $795.4 \times \frac{311.3}{115.3}$ = 2147.6 #-IN.

$f_{bx} = \frac{2147.6}{.203}$ = 10579 PSI < 0.9×33000 = 29700 PSI ∴ O.K.

∴ P1000 AS MAIN STRINGER IS O.K.

DESIGN OF SIDE STRINGERS:

CASE II DEAD LOADS + SSE (FRONT TO BACK) +Z

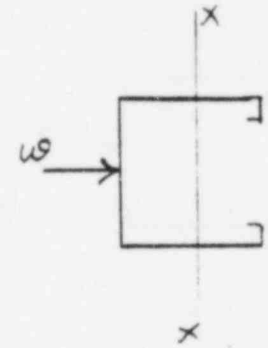
w = 2.3×115.3×3/2 = 397.8 #/FT

SIDE STRINGERS ARE UNISTRUT P1000 − 1.63×1.63×12 GA.

S_x = .203 A = .555

MOMT M_x (MAX) $= 795.4 \times \frac{397.8}{115.3} = 2744.3$ #-IN.

AXIAL LOAD = 30# (REF. COMP. OUTPUT MEMB #20 LOAD-2)



$f_{bx} = \frac{2744.3}{.203} = 13518$ PSI

$\frac{KL}{r_{min}} = \frac{27}{.579} = 46.6 \quad F_a = 18.61 \times \frac{33}{36} = 17$ KSI

$\therefore$ Fa FOR SSE $= 0.9 \times 33 \times \frac{17}{21.78} = 23.26$ KSI

$f_a = 30/.555 = 54$ PSI

CHECK AISC FORMULA 1.6-1a.

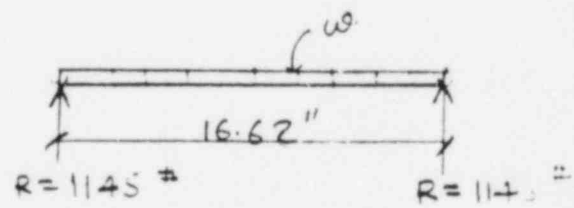
$\frac{54}{23260} + \frac{13518}{29700} = .0023 + 0.46 = 0.457 < 1.0 \quad \therefore$ O.K.

$\therefore$ P1000 AS A SIDE STRINGER IS O.K

DESIGN OF END STRINGERS:

TOTAL WT OF CELLS = 3×332 = 996#

CASE II DEAD LOADS + SSE (SIDE TO SIDE) +X



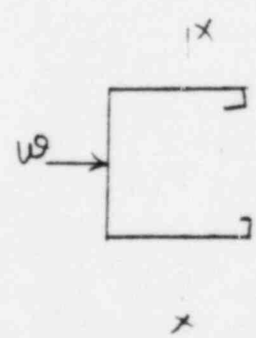
$w = \frac{2.3 \times 996}{16.62} = 137.8$ #/IN.

THERE ARE TWO STRINGERS TO RESIST THIS LOAD

$\therefore$ LOAD w PER STRINGER $= \frac{137.8}{2} = 68.92$ #/IN.

MOMT $= 68.92 \times \frac{16.62^2}{8} = 2379.56$ #-IN.

END STRINGERS ARE P1000 UNISTRUTS.



$\therefore f_{bx} = \frac{2379.56}{.203} = 11722$ PSI $< .9 \times 33000 = 29700$

$\therefore$ O.K.

CHECK VIBRATION:

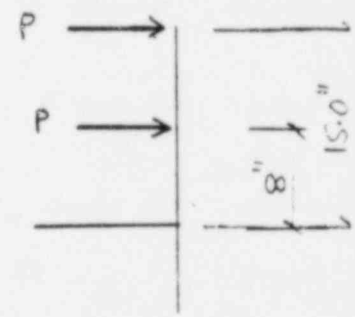
Δ OF S.S. BEAM UNDER ITS OWN WT $\frac{5}{384} \times \frac{1.9 \times 1.385 \times 12^3 \cdot 4}{29 \times 10^6 \times .186}$

$= 2.9 \times 10^{-5}$

[illegible] = 657 CYCLE/SEC

I. J. P. 5-10-82 SHEET # 9

DESIGN OF VERTICAL TUBES:



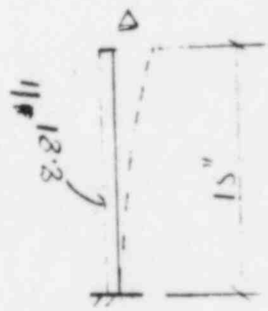
THE UPRIGHT TUBES ARE 3x3x.25 TUBES.
$I_x = I_y = 3.16\ IN^4$ AREA = 2.59 IN^2
$S_x = S_y = 2.1\ IN^3$

CASE II DEAD WT + SSE (SIDE TO SIDE) +X
P = REACTION FROM END STRINGER
= 68.92x 16.62/2 = 572.7 #

MOMT = 572.7(8 + 15) = 13172 #-IN.

$f_{bx} = \frac{13172}{2.1} = 6272$ PSI < .9x36000 = 32400 PSI ∴ O.K.

CHECK VIBRATION:



DEAD WT OF TUBE = 8.81 #/FT.

$\Delta = \frac{wL^4}{8EI} = \frac{8.81 \times 1.25^4 \times 12^3}{8 \times 29 \times 10^6 \times 3.16} = 5.07 \times 10^{-5}$

$f = \frac{3.89}{\sqrt{\Delta}} = 546$ CYCLES/SEC

CHECK THE BOLTS WHICH CONNECT SIDE STRINGERS TO END STRINGERS:

REACTION AT EACH END OF END STRINGER = 1145 # ← SSE
THERE ARE TWO BOLTS AT EACH END
∴ LOAD PER BOLT = 573 #
FROM UNISTRUT CATALOG NO. 9 PAGE 14
EACH BOLT HAS RESISTANCE TO SLIP = 1500 # ∴ O.K.
" " " PULL OUT STRENGTH = 2000 # ∴ O.K.

I. J. P. 5-13-82

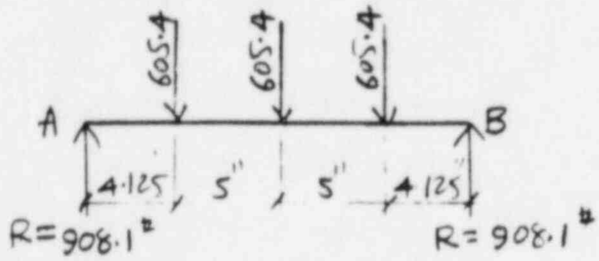
SHEET # 10

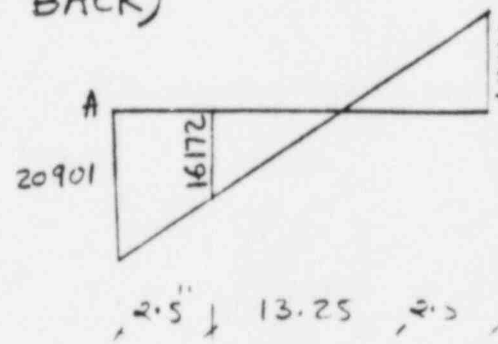
JOB 881

DESIGN OF ANGLE FRAME:
DESIGN OF HORIZ. MEMBER.

CASE II DEAD LOADS + S S E (FRONT TO BACK)

L2½×2½×¼ A_X = 1.19 S_x = .394 r = .491

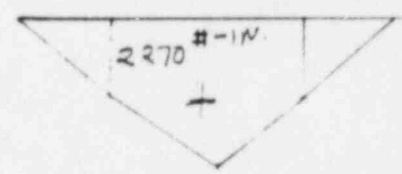




MOMENT OF CONT.TY
REF. COMP. OUTPUT
MEMB # 35 LOAD # 1

SIMPLE SUPP. MOMT AT 2.5" FROM A & B
= 908.1×2.5 = 2270 #-IN.

∴ DESIGN MOMT AT 2.5" FROM A
= 16172 − 2270
= 13902 #-IN.



SIMPLE SUPP MOMT.

COMPUTER ANALYSIS WAS PERFORMED APPLYING THE RACK WT + BATT. WT. HORIZ. COMPONENT AT THE TOP. BUT RACK WT IS UNIFORMLY DISTRIBUTED THROUGH THE HEIGHT OF RACK. ADJUSTING FOR THIS EFFECT: NET HORIZ. LOAD AT THE TOP = 3×332×$\frac{2.3}{2}$ = 1145.4#
AS COMPARED TO APPLIED LOAD = 1547.19#

∴ REDUCTION FACTOR = $\frac{1145.4}{1547.19}$ = 0.74

∴ NET DESIGN MOMENT = .74×13902
= 10291.8 #-IN.

$f_{bx} = \frac{10291.8}{.394} = 26121$ PSI

AXIAL LOAD = 844#   ∴ $f_a = \frac{844}{1.19} = 709$ PSI

$\frac{KL}{r} = \frac{13.25}{.491} = 26.9$ F_a = 20.15 KSI = .56F_y

[illegible] FOR SSE = .9×36×[illegible] = 57.5 [illegible]

CHECK AISC FORMULA 1.6-1 a

$$\frac{26121}{.9 \times 36000} + \frac{709}{27500} = 0.80 + .025 = 0.825 < 1.0 \therefore O.K.$$

DESIGN OF VERTICAL MEMBER:
MAX MOMT = 13918 #-IN. (COMP OUTPUT MEMB # 2 LOAD # 2)
AXIAL LOAD = 2019 #
∴ NET DESIGN MOMENT = .74 × 13918 = 10299 #-IN.

$$f_{bx} = \frac{10299}{.394} = 26140 \text{ PSI} \qquad f_a = \frac{2019}{1.19} = 1697 \text{ PSI}$$

$$\frac{26140}{.9 \times 36000} + \frac{1697}{27500} = 0.80 + 0.062 = 0.86 < 1.0 \therefore O.K.$$

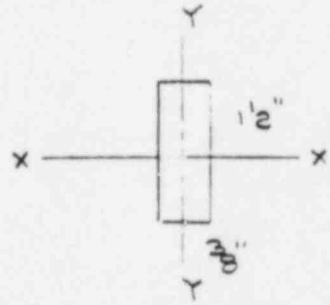
VRH 5-13-82

SHEET # 12
JOB 381

DESIGN OF BRACING:

MAX LOAD : ± 1550#
MEMBER - 1½" × ⅜" FLAT PL

$l = 17.4^{in}$



$A = 0.563\ in^2$ $J = 0.026\ in^4$
$I_x = 0.106\ in^4$ $I_Y = 0.0066\ in^4$
$S_x = 0.14\ in^3$ $Z_y = 0.0352\ in^3$
$r_x = 0.432\ in$ $r_y = 0.108\ in$

$Kl/r = 17.4/0.108 = 161.1 < 200$ ∴ OK
→ $F_a = 7.25^{KSI}$ FROM AISC TABLE [illegible]

$f_a = 1.55/0.563 = 2.75^{KSI} < F_a$ ∴ OK (COMPRESSION)

($\frac{1}{2}$" ⌀ BOLT)
NET AREA = 0.563 - 0.625 × ⅜ = 0.329 in^2 ← GOVERNS
= 0.85 × 0.563 = 0.479 in^2

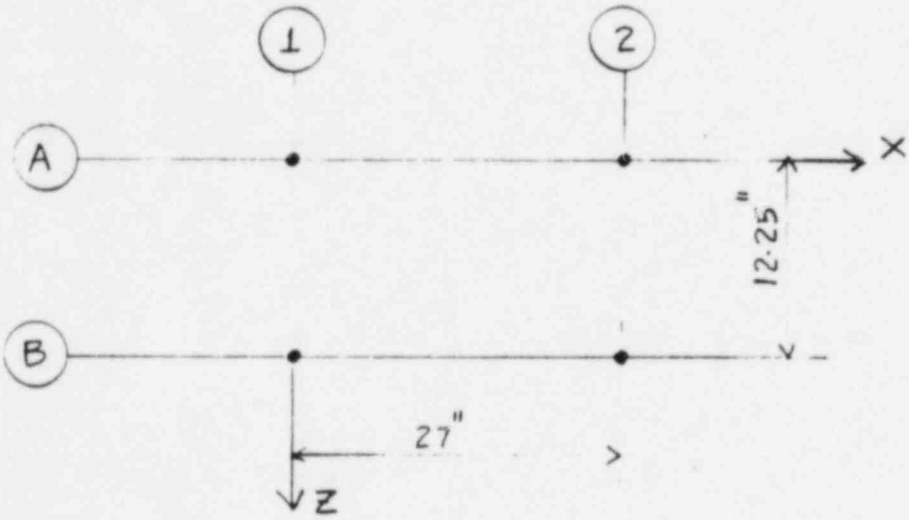
$f_a = 1.55/0.329 = 4.71^{KSI}$

$F_a = 0.5\,(58) = 29^{KSI}$
$0.6\,(36) = 22^{KSI} > f_a$ ∴ OK

I. J. P. 5-11-82 SH # 13

JOB [illegible]

FOUNDATION LOADING TABLE: ALL LOADS ARE IN LBS.



LOADING \ LOCATION			A-1, A-2 B-1, B-2
WT. OF RACK + CELLS + S S E (FRONT TO BACK/ VERT.)	VERTICAL		4662
	HORIZ.	Z	1057
		X	100
WT. OF RACK + CELLS + SSE (SIDE TO SIDE/ VERT.)	VERTICAL		3029
	HORIZ.	X	815
		Z	211
NET UPLIFT. SSE (FRONT TO BACK/VERT.)			3990
NET UPLIFT. SSE (SIDE TO SIDE/ VERT.)			2356

DRH 5-13-82

SHEET # 14
JOB 381

DESIGN OF ANCHOR BOLTS:

NET UPLIFT = 3.989^K
HORIZ. SHEAR, X = 0.151^K
" " Z = 1.147^K

RESULTANT SHEAR = $\sqrt{0.151^2 + 1.147^2}$ = 1.157^K

ANCHOR BOLTS ARE ½" Φ A-307 BOLTS. A = 0.196 IN²

$f_v = 1.157/0.196 = 5.9^{KSI} < F_v = \frac{0.166}{0.666} \times 60 \times 0.9 = 13.6^{KSI}$

$f_t = 3.989/0.196 = 20.3^{KSI}$

(SEISMIC) $F_t = \frac{0.33}{0.666} \times 0.9 \times 60 = 27^{KSI}$ (W/O SHEAR)

(W/O SEISMIC) $F_t = 26 - 1.8(5.9) = 15.4^{KSI}$ (W/ SHEAR)

f_v

(W/ SEISMIC) $F_t = \frac{0.75}{0.666} \times 0.9 \times 60 = 21^{KSI}$ (W/ SHEAR)

$f_t < F_t$ ∴ OK (COMBINED STRESSES)

I. J. P. 5-11-82 SHEET # 15

JOB 881

ARITHMATIC FOR COMPUTER LOADINGS:

DYNAMIC ANALYSIS: WT. OF THE BATTERIES HAS BEEN TAKEN INTO ACCOUNT BY INCREASING THE DENSITY OF THE CORRESPOND MEMBERS.

STRESS ANALYSIS:

MAIN STRINGER REACTION ON ANGLE FRAME DUE TO NORMAL (WT. OF STRINGER + WT. OF CELLS) LOADINGS = 168.9 # REF SH #

TOTAL NO OF STRINGER REACTIONS ON ANGLE FRAME = 2x3 = 6

WT. OF RACK = 265 # RACK WT IS TAKEN INTO ACCOUNT BY INCREACING THE STRINGER REACTIONS.

∴ ADDITIONAL LOAD AT REACTION POINTS = 265/6 = 44.20 #

∴ MAIN STRINGER REACTION ON ANGLE FRAME DUE TO RACK WT + BATT. WT. P = 168.9 + 44.2 = 213.10 # + 5% MISC = 224.23 #

LOAD-1 RACK WT. + BATT. WT. + S S E FRONT TO BACK|VERT. (−Y, +Z)

P = 224.23 x 2.7 = 605.42 #

HORIZ. FORCE Z AT EACH ANGLE FRAME = 3x224.23x2.3 = 1547.20

LOAD-2 RACK WT. + BATT. WT. + S SE FRONT TO BACK|VERT. (+Y, +Z)

P = 224.23 − 1.7x224.23 = −156.96 #

HORIZ. FORCE Z AT EACH ANGLE FRAME = 1547.20 #

LOAD-3 RACK WT. + BATT. WT. + S SE SIDE TO SIDE|VERT. (+X, −Y)

P = 224.23x2.7 = 605.42 #

HORIZ. FORCE X AT EACH END JOINT = 1547.20 #

LOAD-4 RACK WT. + BATT. WT. + S S E SIDE TO SIDE|VERT. (+X, +Y)

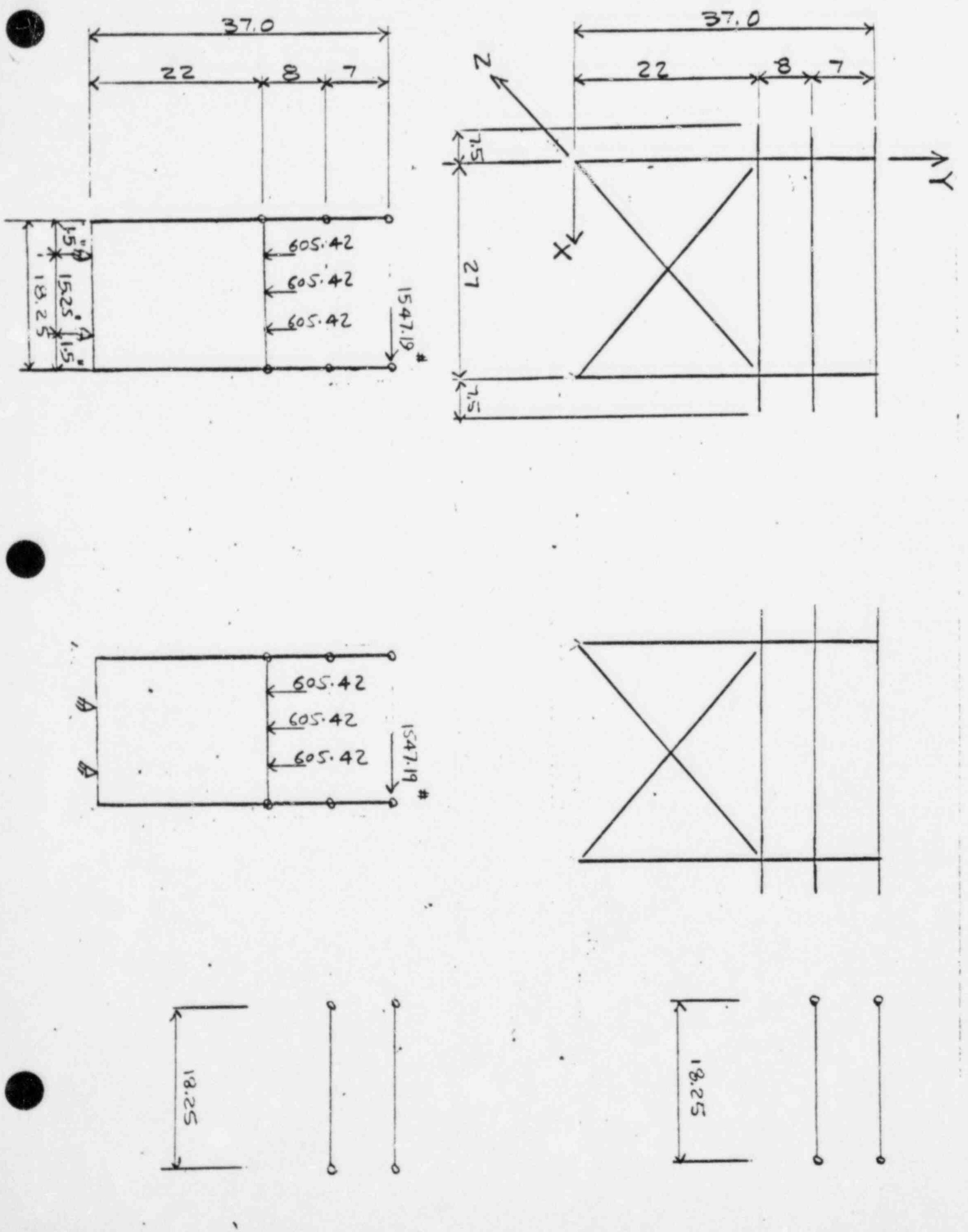
P = 224.23 − 1.7x224.23 = −156.96 #

HORIZ. FORCE X AT EACH END JOINT = 1547.20 #

LOAD- 1

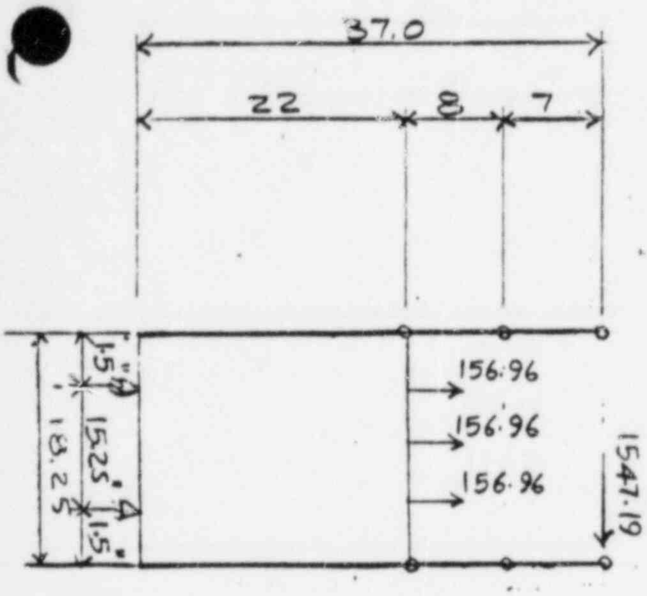
RACK WT. + BATT. WT + SSE FRONT TO BACK/VERT. (-Y, +Z)

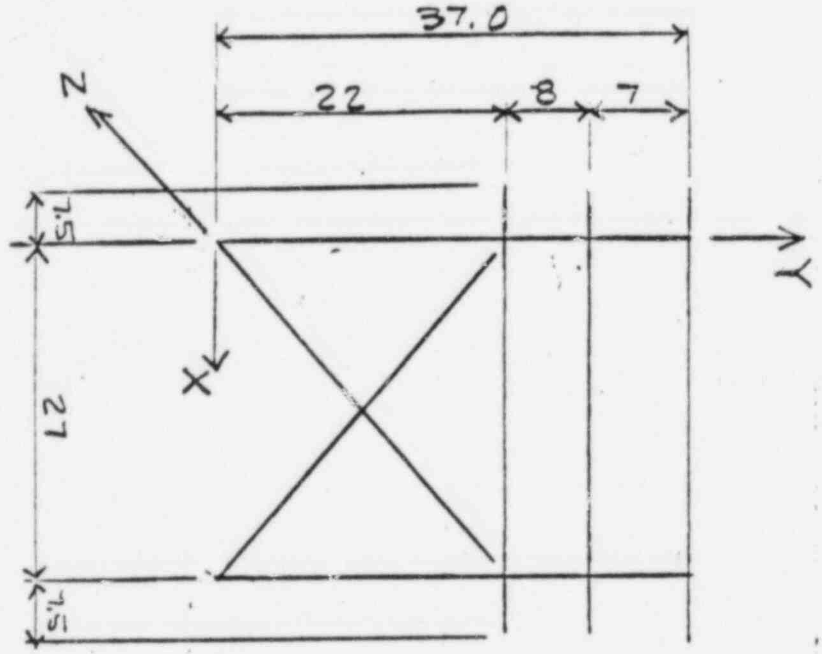
SH #76

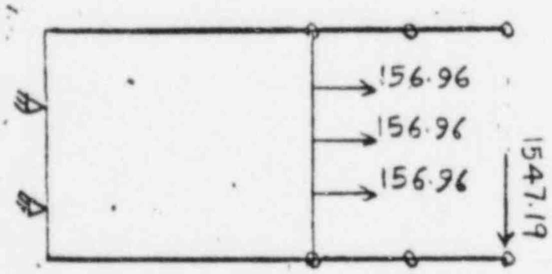


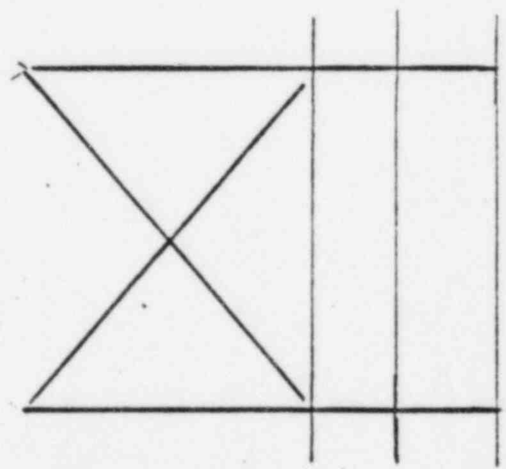
LOAD - 2

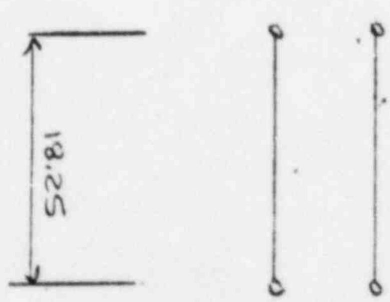
RACK WT + BATT. WT. + SSE FRONT TO BACK | VERT. (+Y, +Z)

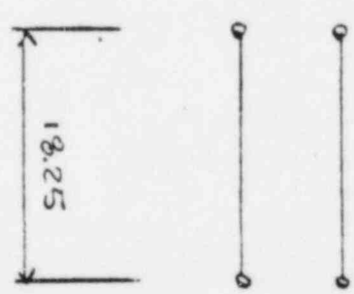








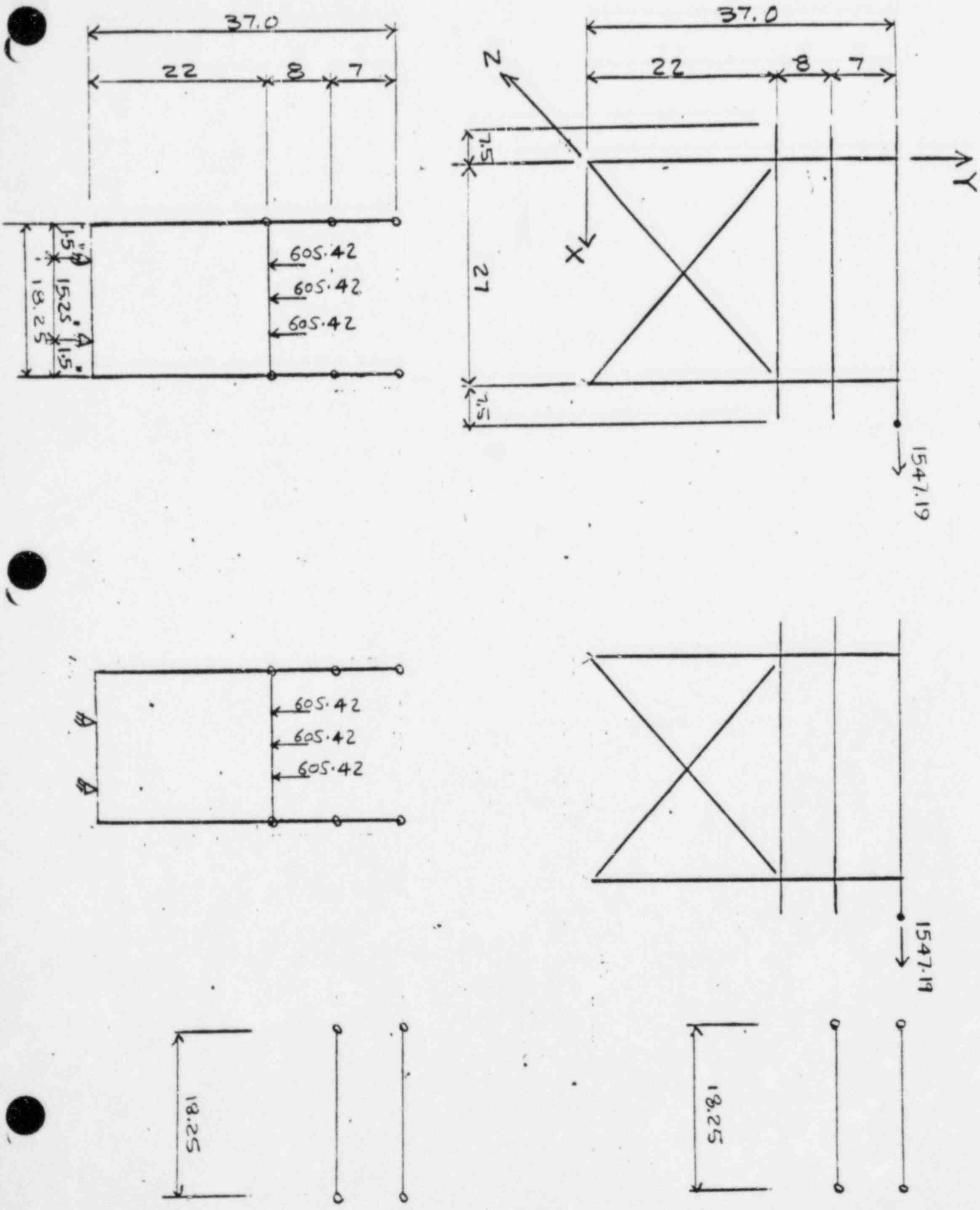




LOAD-3

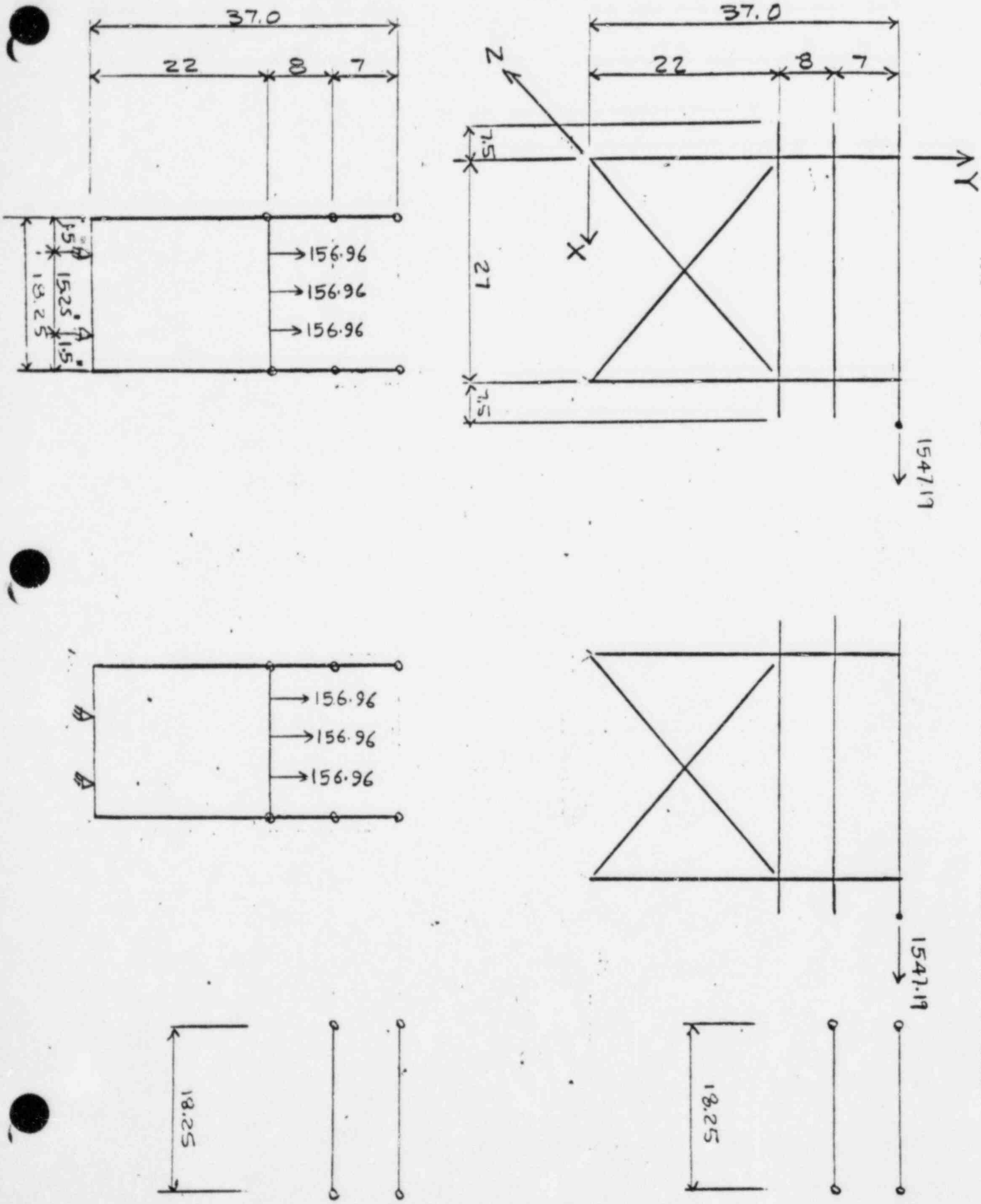
RACK WT + BATT. WT. + SSE SIDE TO SIDE | VERT. (+X, -Y)

SH#75



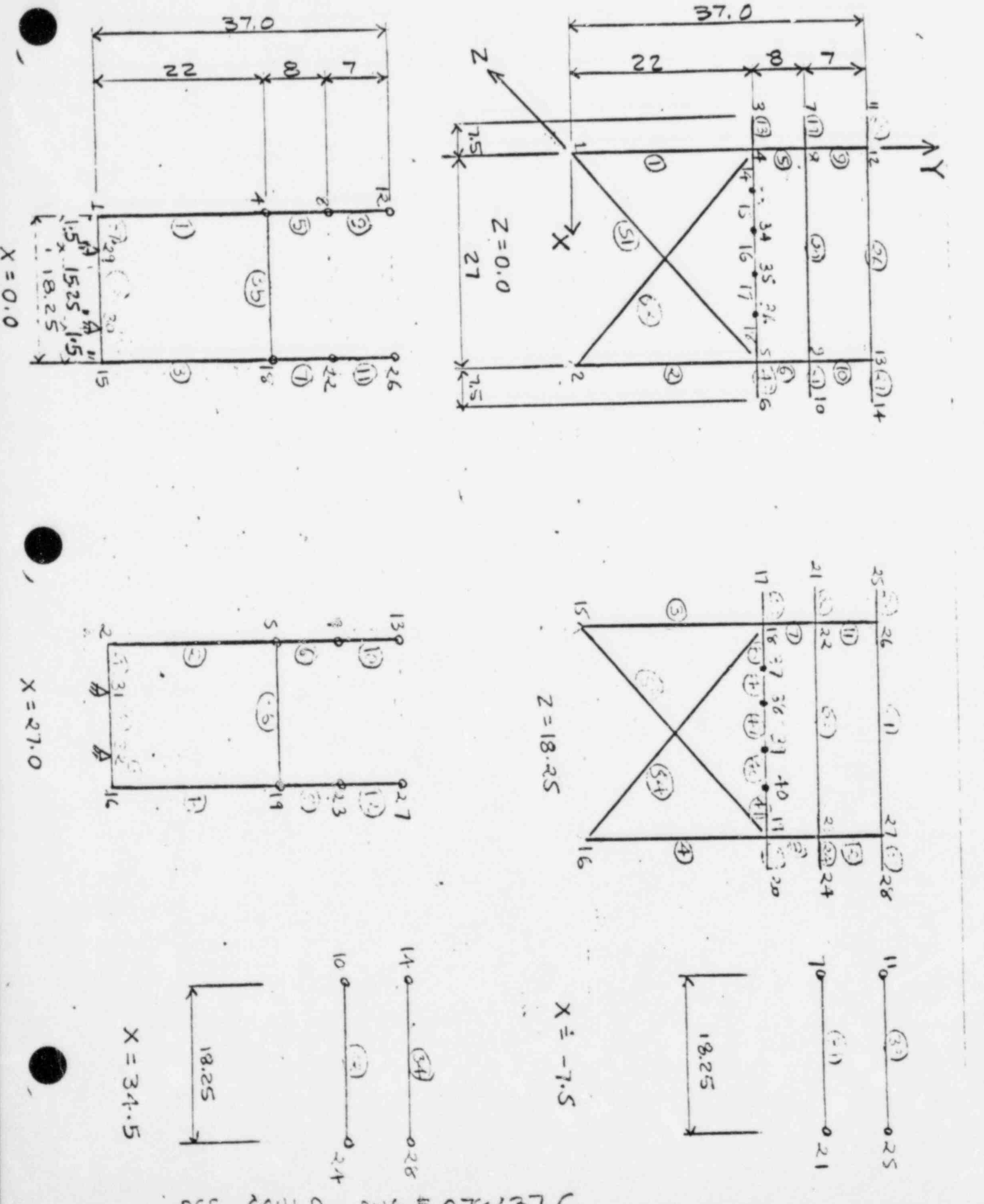
LOAD-4

RACK WT. + BATT WT. ∓ SSE SIDE TO SIDE/VERT. (+X, +Y) SH #19



I. J. P. 5-3-82

SH # 20
JOB 881



REF. GOULD DWG # 073437 C

R.C.D. 5-12-82

SHEET #21 OF #.

JOB 881

CONCLUSION:

A DYNAMIC ANALYSIS WAS MADE OF THE TEST RACK AS A WHOLE CONSIDERING TWO LOADING CASES AND THEIR RESULTING MINIMUM NATURAL FREQUENCIES AS FOLLOWS:

1. COMBINED VERTICAL AND FRONT TO BACK DIRECTIONS MIN. 23 CYCLES PER SECOND.

2. COMBINED VERTICAL AND SIDE TO SIDE DIRECTIONS MIN. 73 CYCLES PER SECOND.

THE TEST RACK AS A WHOLE AS WELL AS THE MAX. EFFECT STRINGER FREQUENCIES WERE DETERMINED BY THE GT STRUDL COMPUTER PROGRAM. THE NATURAL FREQ. [illegible] OF OTHER COMPONENT PARTS WAS COMPUTED USING A STATIC ANALYSIS OF DEFLECTION.

A STRESS ANALYSIS OF THE TEST RACK WAS PERFORMED USING THE MAXIMUM VALUE OF GROUND ACCELERATION FROM THE RESPECTIVE FULL SCALE SHOCK SPECTRUM CURVES FOR THE MINIMUM NATURAL FREQUENCY OF 23 CYCLES PER SECOND. STRESSES WERE COMPUTED BY USING THE GT STRUDL STIFFNESS ANALYSIS FOR [illegible] LOADS AND GROUND ACCELERATION LOADS FOR [illegible] OF THE TWO LOADING CASES. THE MAXIMUM STRESS EXPERIENCED BY ANY TEST RACK MEMBER IS LESS THAN THE YIELD STRESS VALUE FOR A SAFE SHUTDOWN EARTHQUAKE. THEREFO THE TEST RACK IS CAPABLE OF SAFELY TRANSFERING THE GROUND ACCELERATION FREQUENCIES TO THE BATTERIES

DESIGNED BY: Ishwar J Patel

CHECKED BY: [signature]

ISHWAR J. PATEL, M.S.
PROJECT STRUCTURAL ENGINEER
RALPH C. DUMACK, P.E. & ASSOC.
STRUCTURAL ENGINEERS

RALPH C. DUMACK, P.E.
PRESIDENT
RALPH C. DUMACK, P.E. & ASSOC.
STRUCTURAL ENGINEERS

SECTION #6

RACK DRAWINGS

AND

CALCULATIONS

ASSEMBLY NOTES

1) RACK A) ALL CONNECTIONS TO BE TIGHTENED WITH A TORSIONAL FORCE OF 25-30 FT LBS.

2) BATT. A) ALL POST CONNECTIONS TO BE MADE WITH 5/16-18 x 2.75" LG. S.S. HEX. HD. BOLT, NUT & WASHERS

B) SEE SHEET #3 FOR DETAIL OF TERMINAL BUSBAR CONN. NOTES

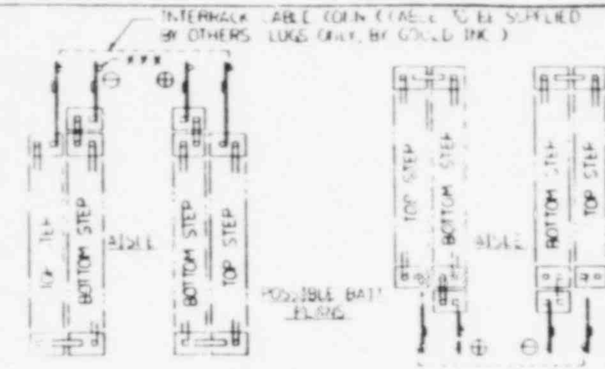
C) ABOVE CONNECTIONS TO BE TIGHTENED WITH A TORSIONAL FORCE OF 12-13 FT LBS (100 IN LBS)

THIS DWG. COMPLIES WITH S&L SPEC. NF-F/L-289

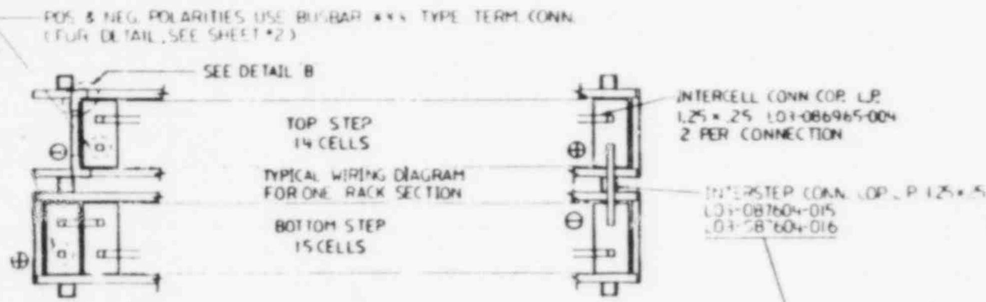
APPROXIMATE WEIGHTS	
1 NCX-1200 CELL	261#
1S07-074520-8 6 RACK	1015#
TOTAL ASSEMBLED BATT & RACK (INCL. CONN.)	17275#

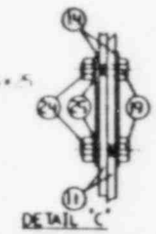
PUBLIC SERVICE CO. OF INDIANA
PLAINFIELD, IND.
SARGENT & LUNDY ENGINEERS
CHICAGO, ILL.
MARBLE HILL NUCLEAR GENERATING STATION
NEW WASHINGTON, IND.
CLASS 1E EQUIPMENT
S&L PROJECT #4808/4923
SPEC #Y-2819
UNIT #1, P.O. #1197-89-Q CN#1
ITEM #1, GOULD ORDER #807318
UNIT #2, P.O. #2075-89-Q CN#1
ITEM #1, GOULD ORDER #807322

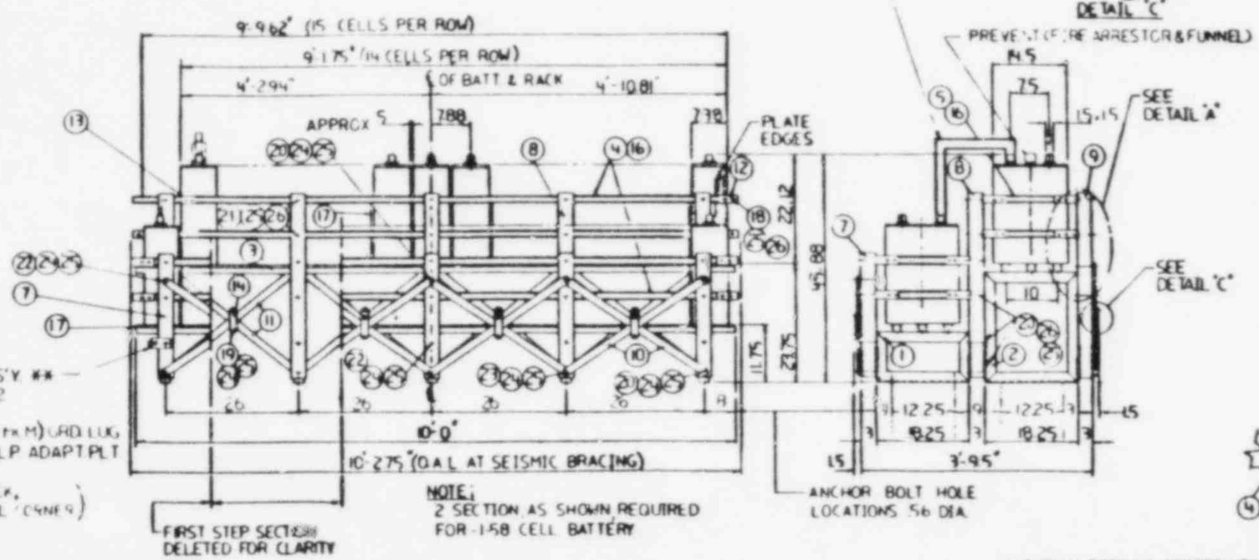
CUSTOMER ITEM NUMBERS
RACK 111 1DC01E
RACK 112 1DC02E
RACK 211 2DC01E
RACK 212 2DC02E



POS. & NEG. POLARITIES USE BUSBAR *** TYPE TERM. CONN. (FOR DETAIL, SEE SHEET #2)

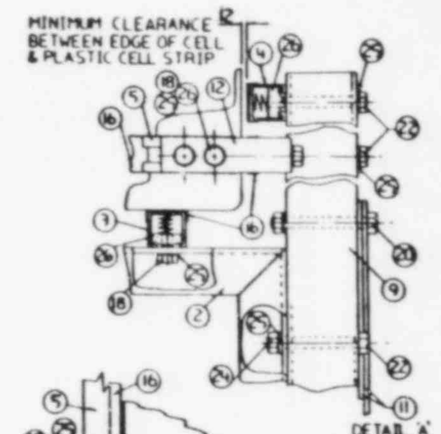



DETAIL 'C'

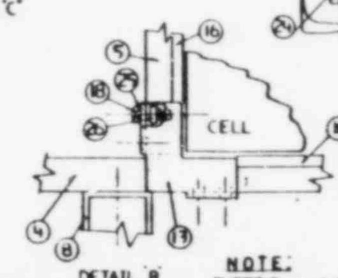


NOTE:
2 SECTION AS SHOWN REQUIRED FOR 1-58 CELL BATTERY

ANCHOR BOLT HOLE LOCATIONS .56 DIA.



DETAIL 'A'



DETAIL 'B'

NOTE:
SHEET 2 064745C BUSBAR TERM DETAIL

* (HEAVY SEISMIC RESISTANT)

PC. NO.	QTY	MATERIAL REQD. FOR 1S07-074520-846 DESCRIPTION		PART NUMBER
1	5	STEEL SUPPORT 2.5 x 2.5 x .38		S01-074972-036
2	5			S01-074972-037
3	[illegible]	STEEL STRINGER 1.62 x 1.62 x 12 GA.	BASIC	S02-04770
4	[illegible]		SIDE	S02-047701-069
5	8		END	S02-047701-024
7	5	STEEL UPRIGHT TUBING 3 x 3 x .25		S05-078947-012
8	5			S05-078947-049
9	5			S05-078947-050
10	[illegible]	STEEL BRACE 1.5 x .38		S07-074940-093
11	[illegible]			S07-074940-074
12	[illegible]	STEEL CORNER FITTING		S05-074596
13	[illegible]			S05-078440-008
14	16	STEEL BRACING PAD		S05-074970-005
16	30	PLASTIC CELL STRIP 9 LG.		S04-106749-003
17	27	PLASTIC CELL SPACER		S05-106777-007
18	94	1/2-13 HEX. HD. BOLT	1.25 LG	W02-005330
19	16		1.75 LG	W02-078931-001
20	25		4.50	W02-074385
21	35		4 LG	W02-074552
22	12		4.25 LG	W02-074573
23	8		5.00 LG	W02-078931-002
24	72	1/2-13 HEX. NUT		W06-000383
25	190	1/2 SPLIT LOCK WASHER		W03-005069
26	118	1/2-13 CLAMPING NUT		S02-040024
27	4	1/2 SPACING WASHER		S05-074400-008

THIS DRAWING TO SUPERSEDE DWG. # 062813D

EQUIPMENT IDENTICAL TO COMMONWEALTH EDISON CO.
BYRON & BRAIDWOOD STATIONS
DWG. 064459C & 064459D

GOULD

LAYOUT FOR 58 CELL NCX 1200 BATT. ON 2 S07-074520-846 * TWO STEP RACK

064745D

SEISMIC CALCULATIONS
FOR
SARGENT & LUNDY, CHICAGO
MARBLE HILL NUCLEAR GENERATING STATION
UNIT 1 & 2

CONTENTS

SECTION I. ABSTRACT

In these calculations the natural frequencies of the rack are computed in all principal directions, i.e., vertical transverse-horizontal and longitudinal-horizontal. Then the stresses in all members and connections of the rack structure are determined.

The calculations are based on a static analysis of deflections of the component parts of the rack. The deflection of the individual components are then added arithmetically to find the deflection of the assembly in either horizontal and vertical direction. One section of the rack is used, as the other sections are geometric repetitions. The sum of deflections of the individual components is always greater than the whole deflection of the entire structure. This is thus a conservative approach and hence the frequency calculated by this method results in a value on the safer side and adds to the safety of the rack design.

Based on the deflection calculations, an equivalent system with single degree of freedom is defined and the natural frequency is computed.

The frequency in all principal directions, vertical, transverse-horizontal and longitudinal-horizontal, is above 33 cycles per second.

The acceleration factors for seismic design are based on the Response Spectra given in Sargent and Lundy Specification Y-2819 for Marble Hill Nuclear Generating Station Unit 1 & 2.

SECTION II. DATA AND ASSUMPTIONS

1. Rack Components

The complete equipment consists of two (2) identical racks each containing 29 cells. Within each rack the cells are installed in two parallel steps, each step containing 15 cells and 14 cells respectively.

The battery arrangement is shown in Gould Drawing 064745-D titled:
Layout for 58 cell NCX-1200 Battery on 2-S07-074520-846 Rack
(Heavy Seismic Res.)

The approximate weights are listed on the Drawing as follows:

NCX-1200 Cell	261#
(1)-Rack S07-074520-846	1,015#
58 Cells NCX-1200 Battery & 2 Racks	17,275#

The weight of the 58 cells itself is 58 X 261 = 15,138# equal to 87 percent of the total assembled rack and cell weight.

Each step of each rack consists of 4 repetitive units 26 inches long aligned in a row with out to out length of 10 ft.

The structural components of a unit are:

- Stringers: Made of Unistrut Section P-1000 roll formed of #12 gauge strip steel. In addition to the support stringers on which the cells are mounted, there are side- and end-stringers.

- Support Frames: Angles 2 1/2" X 2 1/2" X 3/8" welded with mitred joints, to form a four-sided rectangular frame.

- Uprights: Structural tubing TS 3 X 3 X 0.25

- Bracing: Flat Bar 1-1/2" X 3/8"

The properties of these sections are tabulated below:

PROPERTIES OF SECTIONS								
			X - X AXIS			Y - Y AXIS		
Designation And Size	Weight Lbs/Ft	Area in^2	I in^4	S in^3	r in	I in^4	S in^3	r in
Unistrut P-1000 1.625 X 1.625 X 0.105	1.90	.555	.186	.203	.579	.239	.294	.655
Angle 2 1/2 X 2 1/2 X 3/8"	5.90	1.73	.984	.566	.753	Same as X - X axis		
Structural Tube 3 X 3 X 0.25	8.80	2.59	3.16	2.10	1.10	Same as X- X axis		
Flat Bar 1.5 X 0.375	1.91	0.56	0.29	0.39	0.43	0.007	0.035	0.108

2. <u>Seismic Acceleration</u>

The rack is designed for Safe Shutdown Earthquake S.S.E. and Operating Basis Earthquake O.B.E. S.S.E. is the earthquake which produces the vibratory ground motion for which the battery must be able to perform its safety function. This earthquake is expected to be the largest which could rationally occur at the site during the life of the plant.

O.B.E. is the earthquake which produces the vibratory ground motion for which the battery must be able to perform its intended function.

TABLE OF ACCELERATION FACTORS			
	Horizontal Component		Vertical
	N-S	E-W	
O.B.E.	1.35	1.75	3.20
Reference: Specification Y-2819 Sheet No.	37	38	28
S.S.E.	1.90	2.40	4.50
Reference: Specification Y-2819 Sheet No.	39	40	29

In the design the maximum accelerations are used:

O.B.E. Horizontal 1.75 Vertical 3.20
S.S.E. Horizontal 2.40 Vertical 4.50

3. <u>Natural Frequency</u>

Based on the deflection calculations, an equivalent system with single degree of freedom is substituted in accordance with the method presented by M.I.T. Professor John M. Biggs in his book "Structural Dynamics" Chapter 5, pages 206 to 211. In this method transformation factors are used which convert the structural elements into the equivalent single degree system.

$\omega = \sqrt{g/y\, M_f}$, where ω (Omega) is the frequency in radians per second

g = gravity acceleration = 386 lbs/sec^2

y = Sum of deflections

M_f = Mass Transformation Factor from the Tables on Pages 209 and 210 of Biggs "Structural Dynamics"

3. Natural Frequency (cont'd.)

The value M_f depends on the loading and support conditions. For uniform loading in the elastic strain range.

M_f = 0.50 for simply supported beams,
M_f = 0.41 for fixed end beams

The value ω is then divided by 2 Pi = 6.28 to obtain the natural frequency "f" in cycles per second (cps).

The natural frequencies of the rack are computed in vertical, transverse-horizontal and longitudinal-horizontal directions and in all cases this frequency is above 33 cps.

4. Codes & Allowable Stresses

The structural steel conforms to ASTM A-36. The allowable stresses for O.B.E. conditions are based on the ASCI Specification for rolled shapes and the Unistrut data for the cold formed members.

For S.S.E. conditions, a stress increase of 33% is permitted. The allowable stresses for bending (F_b) tension (F_t) and shear (F_v) are listed in table below in kips per square inch.

Allowable Stresses KSI	OBE			SSE		
Steel Member	F_b	F_t	F_v	F_b	F_t	F_v
Cold Formed Unistrut	25.0	22.0	15.0	33.0	30.0	20.00
Rolled Shapes	24.0	22.0	15.0	32.0	30.0	20.00
Bolts A-307		20.00	15.00		25.6	20.00

The design fabrication and installation of the rack conforms to the following codes and standards:

-IEEE Standard 484-1975-Recommended Practice for Installation and Design of Large Lead Storage Batteries for Generating Stations and Substations

-IEEE 344-1975-Recommended Practices for Seismic Qualification of Class IE Equipment and Nuclear Power Generating Stations

-ANSI C1-1978 National Electrical Code Article No. 480

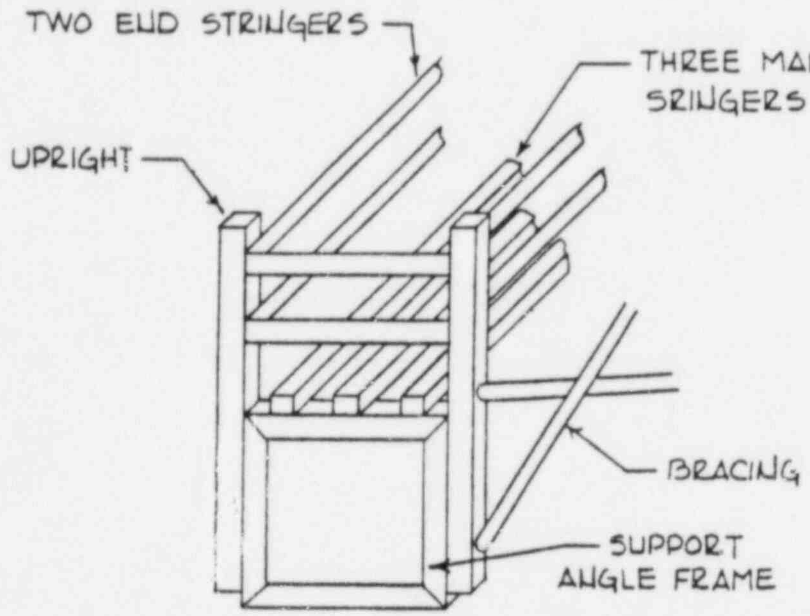
-AISC.-Specification for the Design, Fabrication and Erection of Structural Steel

-AISI-American Iron and Steel Institute--Specification for the Design of Cold-Formed Steel Structural Members

SECTION III. DEFLECTION ANALYSIS

1. Principal Directions

The deflections in three directions are analyzed. The vertical deflection is the sum of the deflections of the main stringers and the top angle of the support frame.



STRUCTURAL MEMBERS OF RACK UNIT

The displacement in transverse horizontal direction is the sum of the deflections of the side stringers and the upright.

The displacement in longitudinal horizontal direction is the sum of the deflections of the end stringers, the upright and the bracing.

The weight of the unit consists of the weight of the cells and the weight of the supporting framing, accessories and hardware. There are 58 cells in two racks each consisting of 8 units. Thus the number of cells per unit is: n = 58/2 X 8 = 3.625. The weight of cells per unit is 3.625 X 261 = 946.13 lbs. The weight of the framing and accessories is 1015 lbs. per 8-unit rack, thus 1015/8 = 126.87 lbs. Total weight of rack unit is 126.87 + 946.13 = 1073 lbs.

2. Vertical Deflection

2a. Main Stringer

The cells are placed on stringers spanning 26" between angle frames. There are 3 lines of stringers in each 4-span row. Thus each stringer is a continuous four-equal span beam uniformly loaded with the weight of cells.

There are 15 cells in one row Weight 15 X 261 =	3,915#
Own weight of 3 stringers 10 ft. long, 3 X 10 X 1.9 =	57#
Total	3,972#
There are 4 units in a row Load each unit 3,972/4 =	993#
Uniform load w = 993/26 =	38.19 lbs./in.

Use uniform load 38 lbs/in

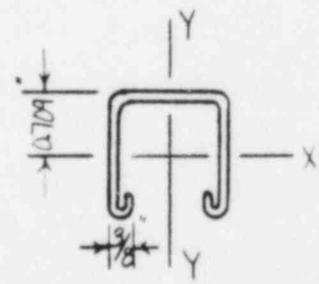
The deflection of a continuous beam is the result of a downward deflection y, as for a simply supported beam and upward deflections y_2 and y_3 from the support moments. The support moments are computed on next page by the Moment Distribution Method.

First interior support M = 2,651 in-lbs

Center interior support M = 1,886 in-lbs

The upward deflection is

$y = \frac{3Ml^2}{48EI}$ where l = 26" $E = 29 \times 10^6$ psi
$I = 3 \times 0.186 = 0.558\ in^4$



1 5/8 x 1 5/8 x 0.105"

Call $l^2/EI = k$

$k = 26^2/(29 \times 10^6 \times 0.558) = 676/(16.18 \times 10^6) = 41.78 \times 10^{-6}$

$y = 3Mk/48 = Mk/16 = M \times 41.78 \times 10^{-6}/16 = 2.61M \times 10^{-6}$

The deflection of a simply supported beam is
$y_1 = (5/384) \times wl^4/EI$

$y_1 = (1/76.8) \times 38 \times 26^2 \times k = 38 \times 676 \times 41.78 \times 10^{-6}/76.8 = 13,973 \times 10^{-6}$

MAIN STRINGER - MOMENT DISTRIBUTION

Uniform load on 3 stringers	$w = 38$ lbs/in
4-span continuous beam, each span	$l = 26''$
Fixed End Moment: F.E.M. $= wl^2/12 = 38 \times 26^2/12 =$	2141 in-lbs
Distribution Factor at intermediate support	0.5
at end support	1.0
Free span moment $M_o = wl^2/8 = 38 \times 26^2/8 =$	3211 in-lbs
Free shear $V = wl/2 = 38 \times 26/2 =$	494 lbs

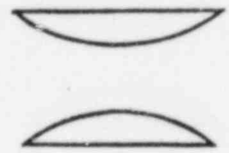
Symmetry Axis ←

F.E.M.	+2141	-2141	+2141	-2141	+2141	
1st Distrib.	-2141	0	0	0	0	
Carry Over	0	-1020	0	0	0	
2-nd Distrib.	0	+510	+510	0	0	
Carry Over	+255	0	0	+255	-255	
3-d Distrib.	-255	0	0	0	0	
Final Moment	0	-2651	+2651	-1886	+1886	
Free Span Mom	+3211		+3211			
$1/2\ (M_1 + M_2)$	-1325		-2268			
Net Span Mom	+1886		+943			+943
Free Shear	494	494	494	494	494	
$(M_1 - M_2)/l$	-102	+102	+29	-29	-29	
Final Shear	392	596	523	523	523	
Reaction	392	1119		1046		

Summary:	$wl = 988$ lbs;	$wl^2 = 25{,}688$ in-lbs
Neg. Mom. First Int. Support	$M = 0.104\ wl^2 =$	-2651 in-lbs
Neg. Mom. Center Int. Support	$M = 0.073\ wl^2 =$	-1886 in-lbs
Posit. Mom. End-Span	$M = 0.073\ wl^2 =$	+1886 in-lbs
Posit. Mom. Int. Span	$M = 0.037\ wl^2 =$	+943 in-lbs
End Reaction	$R = 0.395\ wl =$	392 lbs
Reaction First Int. Support	$R = 1.137\ wl =$	1119 lbs
Reaction Center Support	$R = 0.937\ wl =$	1046 lbs

2a. Main Stringer Deflection (cont'd.)

End Span $M_L = 0$ $M_R = 2651$ in-lbs



Downward Def. of Simple Beam.

Upward Def. Due to Support Moment.

Upward Deflection from M_R

$y_3 = 26.10\ M \times 10^{-6} = 2651 \times 2.61 \times 10^{-6} = 6893 \times 10^{-6}$

$y \quad = y_1 - y_3 = (13{,}973 - 6{,}893) \times 10^{-6} = 7{,}080 \times 10^{-6}$

Interior Span - Upward Deflection

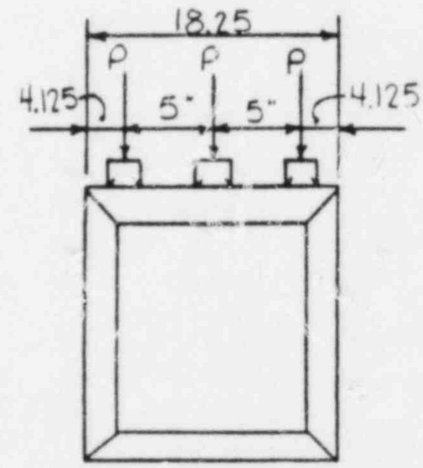
$y_2 + y_3 = 2.61 \times 10^{-6}\ (2651 + 1886)$
$= 4537 \times 2.61 \times 10^{-6} = 11{,}842 \times 10^{-6}$

$y \quad = y_1 - (y_2 + y_3) = (13{,}973 - 11{,}842) \times 10^{-6} = 2131 \times 10^{-6}$

The End-Span deflection governs. Use for all spans of the main stringers $y \quad = 7080 \times 10^{-6}$ (on the safer side).

This is approximately half the deflection of a simply supported beam $7080 \times 10^{-6} / 13{,}973 \times 10^{-6} = 0.5$.

2b. Angle Frame

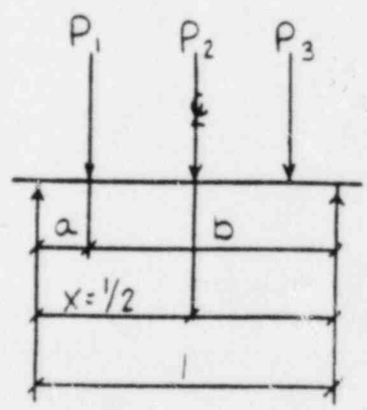


The top angle is welded to the vertical members of the box frame and is treated as a rigidly supported beam with 3 point loads, symmetrically placed. The maximum deflection occurs at the center of span and is caused by the center load and the two loads placed 5" on either side of the center.

The load on the top angle is the reaction from the stringers. Due to continuity of the stringers, the maximum reaction is

$R = 1.137\ wl$
$R = 1119$ lbs (See Moment Distribution for Main Stringers).

Add weight of angle $5.9 \times 18.25/12 = 9.0$ lbs
Total load $1119 + 9 = 1128$ $P = 1128/3 = 376$ Use 376 lbs.



From "Roark-Formulas for Stress and Strain" the deflection at point x from load P_1 located at distance a from support is:

$y = 1/6\ [P_1 a^2 (l-x)^2] / (EIl^3)]\ \times\ [(3b+a)(l-x) - 3bl]$

Here $P_1 = 376$ lbs. $l = 18.25$ in. $x = 9.125$ in
$a = 4.125$ in $b = 14.125$ $E = 29 \times 10^6$ psi; $I = 0.984$ in^4

2b. Angle Frame (cont'd.)

Substitute x = 1/2 The formula simplifies to:

$y_1 = 1/48\ (P_1 a^2)(a-3b)/EI$
$y_1 = 1/48\ (376 \times 4.125^2)(4.125 - 3 \times 14.125)/(29 \times 10^6 \times 0.984)$
$y_1 = (7.83 \times 17.01) \times (-38.25)/(28.54 \times 10^6) = -178.7 \times 10^{-6}$

Deflection at midspan from center load P_2

$y_2 = -1/192\ (P_2 l^3)/EI = -1/192\ (376 \times 18.25^3/(29 \times 10^6 \times 0.984)$
$y_2 = -11{,}903.5/(28.54 \times 10^6) = -417.1 \times 10^{-6}$

Deflection for load P_3 is $y_3 = -y_1 = -178.7 \times 10^{-6}$

Total deflection $y = y_1 + y_2 + y_3 = -(178.7 + 417.1 + 178.7) \times 10^{-6}$
$y = -774.5 \times 10^{-6}$

2c. Natural Frequency - Vertical Direction

The sum of stringer deflection and angle deflection is:

$y = (7080 + 774.5) \times 10^{-6} = 7854.5 \times 10^{-6}$ Use 7855×10^{-6}

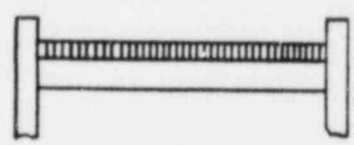
The circular frequency is:

$\omega = \sqrt{g/(yM_f)}$ where g = 386 $y = 7{,}855 \times 10^{-6}$ M_f is 0.41

$\omega = \sqrt{386/(7{,}855 \times 10^{-6} \times 0.41)} = \sqrt{119{,}855} = 346.2$ radians/sec

$f = \omega /2 Pi = 346.2/6.28 = 55.12 > 33$ O.K.

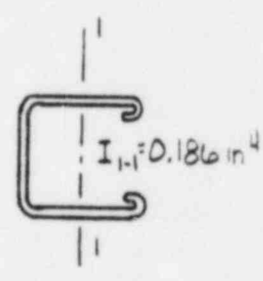
The rack is rigid in vertical direction.



3. Transverse Horizontal Deflection

3a. Side Stringers

The load is same as on the 3 main stringers, w = 38 lbs/in. The two side stringers are continuous beams and the moment distribution is same as for the main stringers. The maximum deflection occurs in the end span of the continuous beam and is half of the deflection for a simply supported beam, (see item 2a. of this Section III).

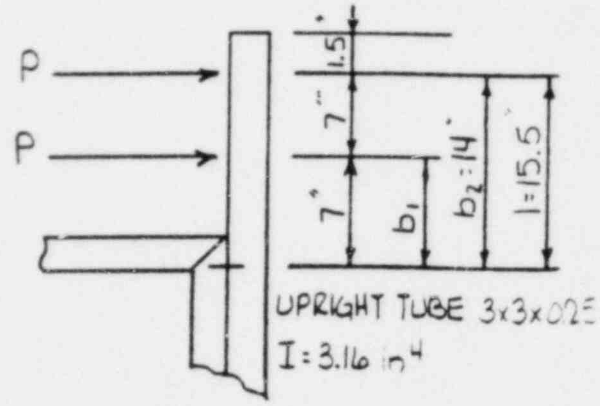


$y = 0.5 \times (5/384) \times wl^4/(EI)$ where w = 38 lbs/in, l = 26"
$E = 29 \times 10^6$ psi, $I = 2 \times 0.186 = 0.372$

$y = 0.5 \times (5/384) \times (38 \times 26^4)/(29 \times 10^6 \times 0.372) = 10{,}480 \times 10^{-6}$ in

3b. Upright

The upright is treated as a cantilever beam with two concentrated loads P at distance 7" and 14" above the point of support of the cantilever. The load R is the reaction from the side stringer. Due to continuity, the max. reaction is:



R = 1.137 wl, (See item 2a - Moment Distribution). w = 38 lbs/in, l = 26"

R = 1.137 X 38 X 26 = 1119 lbs.
P = R/2 = 559.5 lbs.

The deflection of a cantilever from point load at distance b from base of cantilever is $y = Pb^2\,(3l-b)/6EI$ where P = 559.5 lbs, l = 15.5"; $E = 29 \times 10^6$, $I = 3.16\ in^4$

The dimension b_2 = 14" for upper load and b_1 = 7" for lower load.

$y = 559.5\ b^2\ (3 \times 15.5-b)/(6 \times 29 \times 10^6 \times 3.16)$
$y = b^2\ (46.5-b) \times 1.01 \times 10^{-6}$

For b_1 = 7" $b^2 = 49$, $46.5 - 7 = 39.5$, $b^2\ (46.5-b) = 1935.5$
For b_2 = 14" $b^2 = 196$, $46.5 - 14 = 32.5$, $b^2\ (46.5-b) = 6370.0$

$y = (1935.5 + 6370) \times 1.01 \times 10^{-6} = 8389 \times 10^{-6}$

3c. Natural Frequency in Transverse Horizontal Direction

The sum of side stringer and upright deflections, is:

$y = (10{,}480 + 8{,}389) \times 10^{-6} = 18{,}869 \times 10^{-6}$ in

$\omega = \sqrt{g/(y \times M_f)}$ where ω is the frequency in radians per sec

$g = 386$, $y = 18{,}869 \times 10^{-6}$, M_f is Transformation Factor

From Biggs Table $M_f = 0.41$

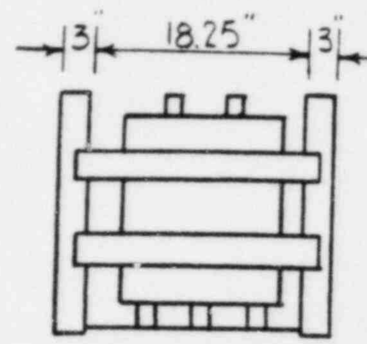
$\omega = \sqrt{386/(18{,}869 \times 10^{-6} \times 0.41)} = \sqrt{49{,}895} = 223.37$ radians/sec

$f = \omega/2Pi = 223.37/6.28 = 35.6$ cps > 33

The rack system is rigid in transverse horiz. direction.

4. Longitudinal Horizontal Direction

4a. End Stringers



The end stringer is treated as a simply supported beam. Each unit of the rack carries 3.625 cells at 261 lbs.
Load: 3.625 X 261 = 946.13

Own weight of 2 stringers:

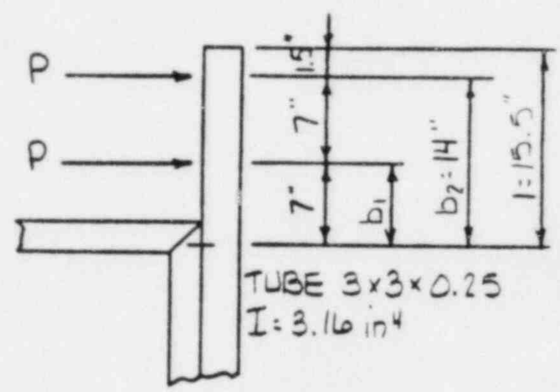
2 X 1.9 X 24.25/12 = 7.67
Total 953.80 lbs.

per lin. inch w = 953.8/24.25 = 39.33
say 39.5 lbs/in

Deflection $y = 5/384 \times wl^4/EI$ where

$w = 39.5$ lbs/in; $l = 24.25$ in; $E = 29 \times 10^6$ psi; $I = 2 \times 0.186 = 0.372$ in^4
$y = 5/384 \times (39.5 \times 24.25^4)/(29 \times 10^6 \times 0.372) =$
$1/76.8 \times (471{,}027)/0.372 \times 10^6) = 16{,}487 \times 10^{-6}$

4b. Upright



Upright is treated as a cantilever with projection above point of support $l = 15.5"$ and with concentrated loads P at distance $b_1 = 7"$, $b_2 = 14"$.
The load P is the reaction from end stringer $2P = 1/2 \times (39.5 \times 24.25) = 478.94$
$P = 1/2\ (478.94) = 239.47$ Say 239.5 lbs

$y = Pb^2\ (3l-b)/(6\ EI)$ where $P = 239.5$ lbs,
$b_1 = 7"$ $b_2 = 14"$ $l = 15.5"$
$E = 29 \times 10^6$ psi, $I = 3.16$ in^4

$y = 239.5 \times b^2\ (3 \times 15.5-b)/(6 \times 29 \times 10^6 \times 3.16)$

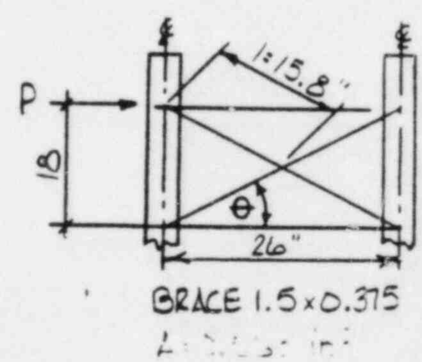
$y = 0.435 \times b^2 \times (46.5-b)$

For $b_1 = 7"\cdot b^2 = 49$, $46.5 - 7 = 39.5$ $b^2\ (46.5-b) = 1935.5$

For $b_2 = 14"$ $b^2 = 196$, $46.5 - 14 = 32.5$ $b^2\ (46.5-b) = 6370.0$

$y = (6370 + 1935.5) \times (0.435 \times 10^{-6}) = 3618 \times 10^{-6}$

4c. Bracing



The total weight of a rack unit is P = 1073 lbs (see item 1 of Section III.)

$\tan\theta = 18/26 = 0.692$; $\theta = 34.7°$
$\sin\theta = 0.569$ $\cos\theta = 0.822$
$2l = 26/\cos\theta = 26/0.82 = 31.6"$

Braces are connected at point of intersection
$l = 31.6/2 = 15.8"$
Axial load in brace $N = P/\cos\theta = 1073/0.822 = 1305$ lbs
Deflection $y = (N/A)\ l/E$ where $N = 1305$ lbs, $A = 0.563$ in^2
$l = 15.8"$ $E = 29 \times 10^6$
$y = (1305/0.563) \times (15.8/29 \times 10^6) = 1263.0 \times 10^{-6}$

4d. Natural Frequency - Longitudinal Horizontal Direction

The total displacement in longitudinal horizontal direction is the sum of the deflections of end stringers, upright and bracing.

$y = (16{,}487 + 3618 + 1263) \times 10^{-6} = 21{,}368 \times 10^{-6}$

Circular frequency:

$\omega = \sqrt{g/y\, M_f}$, where $g = 386$, $y = 21{,}368 \times 10^{-6}$

M_f = Transformation Factor from Bigg's Table
M_f = 0.41

$\omega = \sqrt{386/21{,}368 \times 10^{-6} \times 0.41)} = \sqrt{44{,}060} = 209.9$

$f = \omega/2Pi = 209.9/6.28 = 33.4$ c.p.s. > 33

The rack is rigid in longitudinal horizontal direction.

5. Summary of Deflections and Frequencies

The total deflections y (in) and the natural frequencies f (cps) in principal directions are as follows:

Vertical	$y = 7{,}885 \times 10^{-6}$	f = 55.12 cps
Transverse Horizontal	$y = 18{,}869 \times 10^{-6}$	f = 35.6 cps
Longitudinal Horizontal	$y = 21{,}368 \times 10^{-6}$	f = 33.4 cps

Frequencies in all principal directions are above 33 cps. The rack is rigid, so that any amplification of load to the cells is negligible.

SECTION IV. STRESS ANALYSIS

1. General

The stress analysis is done for O.B.E. and S.S.E. forces. The acceleration values are: (see Item 2 of Section II).

O.B.E.	Horizontal	1.75	Vertical	3.20
S.S.E.	Horizontal	2.40	Vertical	4.50

For determining the stresses multiply gravity loads

For O.B.E.	Horizontal by 1.75	Vertical by 4.20
S.S.E.	Horizontal by 2.40	Vertical by 5.50

All components of the rack are analyzed separately to demonstrate that the stress in each component is below the allowable stresses, as listed in item 3 of Section II.

2. Main Stringer

The stringer is a four-span continuous beam with the maximum moment (see Moment Distribution item 2a of Section III) is M = 1/3 X 2651 = 883.67 in-lbs The Section Modulus of the Unistrut stringer is s_x = 0.203 in^3. For vertical acceleration sv = M/S = 883.67/0.203 = 4353 psi
sy = 0.294 in^3 For horizontal acceleration sH = $\frac{883.67}{0.294}$ = 3006 psi

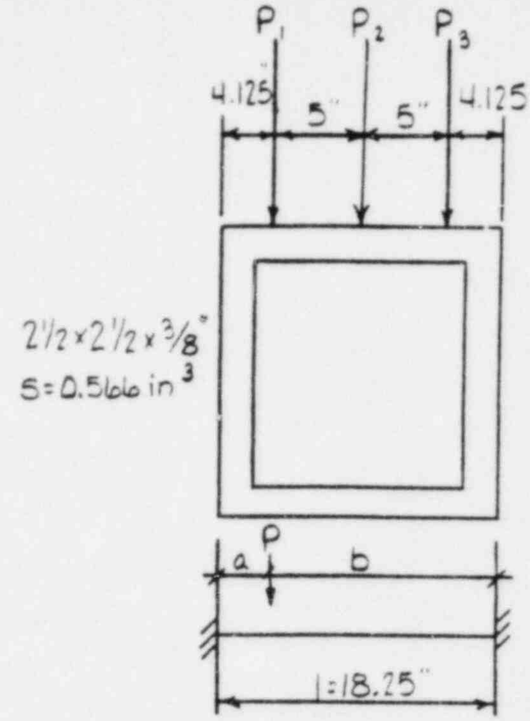
The stresses under seismic loads are found by multiplying the stress so by acceleration factors. For vertical loads the multiplying factor is 1 + a where a is the vertical seismic acceleration.

As per Unistrut Tables, strength for cold formed member for bending is 25 ksi. This is to be used for O.B.E. For S.S.E. stress increase of 33% = 33 ksi.

Stress Under Gravity Loads sv = 4353 psi sH = 3006 psi	Stress in Main Stringer Under Seismic Forces					
	O.B.E.			S.S.E.		
	Vertical	Horizontal	Combined	Vertical	Horizontal	Combined
Multiply by Acceleration Factor	4.20	1.75		5.50	2.40	
Stress s psi	18,283	5,261	23,543	23,942	7,214	31,156
Allowable F psi			25,000			33,000
Safety Factor F/s			1.06			1.05

The main stringers are safe under gravity and seismic loads.

3. Angle Frame



The top angle is treated as a rigidly supported beam with 3 equal concentrated loads symmetrically placed. The load is the maximum reaction from the continuous main stringers.

$P = 376$ lbs
(See item 2b of Section III)

The top angle is welded to the vertical members of the angle frame so that rigidity at support is provided.

From Roark Formulas:

Moment at center of span from load at distance a from support.

$M = -P\ ab^2/l^2 + R_1\ l/2 - P\ (l/2-a)$

$R_1 = P\ b/l$ where $P = 376$ lbs $b = 14.125"$ $l = 18.25"$

$R_1 = 376 \times 14.125/18.25 = 291$ lbs

$M_1 = -376 \times 4.125 \times 14.125^2/18.25^2 + 291 \times 18.25/2 - 376\ (18.25/2-4.125)$

$M_1 = -929.1 + 2655.5 - 1880 = -153.6$ in-lbs

Moment at midspan under center load

$M_2 = Pl/8 = 376 \times 18.25/8 = 857.75$ in-lbs

Total moment at midspan

$M = M_2 + M_1 + M_3$ where $M_3 = M_1$

$M = 857.75 - 153.6 - 153.6 = 550.55$ in-lbs

Moment at support

From P	$M_1 = P\ ab^2/l^2$	$= 376 \times 4.125 \times 14.125^2/18.25^2$	=	929.10 in-lbs
From P	$M_3 = P\ a^2/b/l^2$	$= 376 \times 4.125^2 \times 14.125/18.25^2$	=	271.30 in-lbs
From P_2	$M_2 = Pl/8$	$= 376 \times 18.25/8$	=	857.80 in-lbs
		Total		2058.20 in-lbs

Maximum Moment is at support

$M = 2058.2$ in-lbs $S = 0.566\ in^3$ $s = M/S = 2058.2/0.566 = 3636$ psi

3. Angle Frame (cont'd.)

Stress in Top Angle Under Gravity Loads so = 3636 psi	Stress in Top Angle Under Seismic Forces					
	O.B.E.			S.S.E.		
	Vertical	Horizontal	Combined	Vertical	Horizontal	Combined
Multiply by Acceleration Factor	4.20	1.75	-	5.50	2.40	-
Stress s psi	15,271	6,363	21,634	19,998	8,726	28,724
Allowable F psi			23,760			32,400
Safety Factor F/s			1.10			1.13

The angle frame is safe under gravity and seismic loads.

4. Side Stringer

There is no direct vertical load on the side stringers. The only force acting is the horizontal seismic force.

The design moment on the pair of side stringers is the same as on the set of three main stringers. Max. moment for the 4-span continuous beam is M = 2651 ft lbs. The Section modulus of the two side stringers is S = 2 X 0.203 = 0.406 in^3

so = M/S = 2651/0.406 = 6530 psi

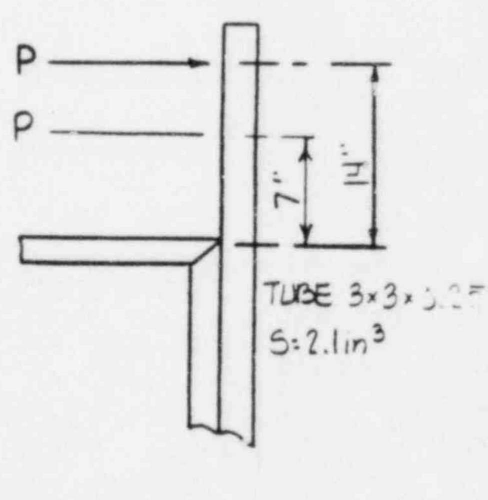
O.B.E. Multiply stress so by 1.75
s = 1.75 X 6530 = 11,428 psi Safe Factor 23,760/11,428 = 2.1

S.S.E. Multiply stress so by 2.40
s = 2.40 X 6530 = 15,672 psi Safe Factor 32,400/15,672 = 2.1

The side stringers are safe under O.B.E. and S.S.E. forces.

5. Intermediate Upright

There is no direct vertical load. The load consists only of horizontal seismic forces. The upright is treated as a cantilever with concentrated loads located at distance 7" and 14" above the point of support. The loads P are the reactions from the side stringers. P = 559.5 lbs (see item 3b of Section II).



M = 559.5 X (7" + 14") = 11,750 in-lbs
so = M/S = 11,750/2.1 = 5,595 psi

5. Intermediate Upright (cont'd.)

O.B.E. Multiply so by 1.75 s = 5595 X 1.75 = 9791 psi
Safety factor 23,760/9791 = 2.42

S.S.E. Multiply so by 2.40 s = 2.4 X 5595 = 13,428 psi
Safety factor 32,400/13,428 = 2.41

The uprights are safe under O.B.E. and S.S.E. forces.

6. End Stringers

There is no direct vertical load on the end stringers. The only force acting is the horizontal seismic load. The stringer is treated as a simply supported beam, see item 4a of Section III.

l = 24.25" Section Modulus of two end stringers $S = 2 \times 0.203 = 0.406 \text{ in}^3$

O.B.E. $W = 39.5 \times 1.75 = 69.13$ lbs/in $M = (1/8) \times (69.13 \times 24.25^2) = 5081$ in-lbs
$s = 5081/0.406 = 12,515$ psi
Safety Factor 23,760/12,515 = 1.90

S.S.E. $W = 39.5 \times 2.4 = 94.8$ lbs/in $M = (1/8) \times (94.8 \times 24.25^2) = 6969$ in-lbs
$s = 6969/0.406 = 17,164$ psi
Safety Factor 32,400/17,164 = 1.88

The end stringers are safe under O.B.E. and S.S.E. forces.

7. Corner Upright

There is no direct vertical load. The only force acting is the horizontal seismic load. The upright is treated as a cantilever with concentrated equal loads at distance 7" and 14" from point of support. See item 4b of Section III. The reaction from end stringer is Po = 239.5 lbs. The upright is a tube 3 X 3 X 0.25
Section Modulus $S = 2.10 \text{ in}^3$

O.B.E. $P = 239.5 \times 1.75 = 419.13$ lbs
$M = 419.3 \times (7 + 14) = 8801.6$ in-lbs
$s = 8801.6/2.1 = 4191$ psi
Safety Factor 23,760/4191 = 5.66

S.S.E. $P = 2.4 \times 239.5 = 574.8$
$M = 574.8 \times (7 + 14) = 12,070.8$ in-lbs
$s = 12,070.8/2.1 = 5748$ psi
Safety Factor 32,400/5748 = 5.63

Note: This upright at the corner of the rack supports also half a span of side stringers. The stress in the upright due to side stringers is half the stress computed in item 5 of this Section IV.

O.B.E. $s = 0.5 \times 9791 = 4895.5$ psi
S.S.E. $s = 0.5 \times 13,428 = 6714$ psi

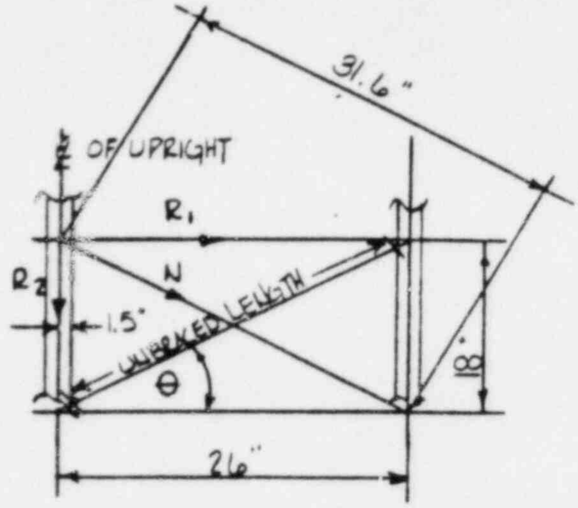
The combined stress is the geometrical resultant of the stresses from end and side stringers.

O.B.E. $s^2 = 4191^2 + 4895.5^2 = 17,564,481 + 23,965,920 = 41,530,401$
$s = 6444$ psi Safety Factor 23,760/6444 = 3.68

S.S.E. $s^2 = 5748^2 + 6714^2 = 33,039,504 + 45,077,796 = 78,117,300$
$s = 8838$ psi Safety Factor 32,400/8838 = 3.66

The corner uprights are safe under O.B.E. and S.S.E. forces.

8. Brace



B[illegible]E 1.5 x 0.375

A = 0.563 in^2

The load in the brace is the resultant of the horizontal component R_1 and vertical component R_2.

$N = R_1 \cos\theta + R_2 \sin\theta$

$\tan\theta = 18/26 = 0.692, \quad \theta = 34.7°$

$\sin\theta = 0.569, \quad \cos\theta = 0.822$

$21 = 26/\cos\theta = 26/0.822 = 31.6"$

$1 = 15.8 \quad 1_1 = 1 - c = 15.5 - \dfrac{1.5}{0.822} = 14"$

The weight of the rack unit is 1073 lbs, see item 4c of Section III.

O.B.E. Horizontal $R_1 = 1.75 \times 1073 = 1877.75$ lbs

Vertical $R_2 = 4.20 \times 1073 = 4506.6$ lbs

$N = R_1 \cos\theta + R_2 \sin\theta = 1877.75 \times 0.822 + 4506.6 \times 0.569 =$
$1543.5 + 2564.3 = 4107.8$ lbs

$s = N/A = 4107.8/0.563 = 7296$ psi

Check for buckling. Radius of gyration r = 0.108

Slenderness $1/r = 14/0.108 = 130$

From A.I.S.C. Manual, allowable Fa = 8,840 psi

Safety Factor Fa/s = 8,840/7,296 = 1.21

S.S.E. Horizontal $R_1 = 2.40 \times 1073 = 2757.2$ lbs

Vertical $R_2 = 5.50 \times 1073 = 5901.5$ lbs

$N = R_1 \cos\theta + R_2 \sin\theta = 2757.2 \times 0.822 + 5901.5 \times 0.569 =$
$2266 + 3358 = 5624$ lbs

$s = N/A = 5624/0.563 = 9,989$ psi

Slenderness $1/r = 14/0.108 = 130$

From A.I.S.C. Manual, Fa = 8,840 psi Multiply by ratio 0.90/0.66 = 1.36

$F = 8840 \times 1.36 = 12,022$ psi

Safety Factor F/y = 12,022/9,989 = 1.20

The braces are safe under gravity and seismic loads.

9. Connections

9a. Anchor Bolts

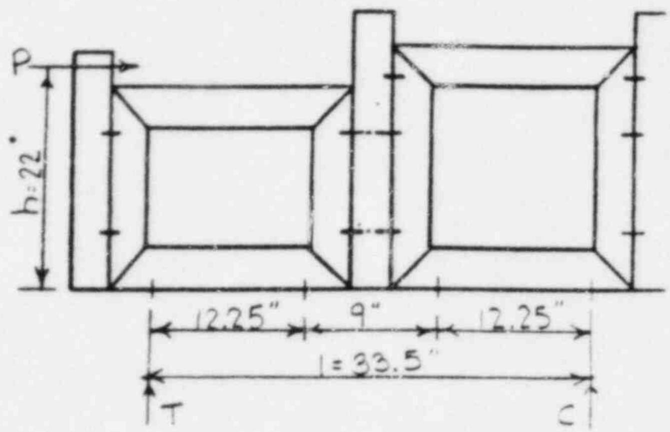
The bottom angle of the box-frame is anchored to the floor. Maximum load on the anchor bolts is caused by the horizontal acceleration force acting at top of frame.

Total weight of 8-unit rack with 29 cells, see Section II.

$P = 29 \times 261 + 1015 = 8,584$ lbs

$M = P \times h = 8584 \times 22 = 188,848$ in-lbs

9a. Anchor Bolts (cont'd.)



There are 4 rows of 1/2" diameter anchor bolts, 5 bolts per row.

Resisting moment, considering exterior rows only is:

M = T X l = T X 33.5
T = M/L = 188,848/33.5 = 5637 lbs

Cross sectional area of 5 bolts

A = 5 X 0.16 = 0.8 in^2
s_o = T/A = 5637/0.8 = 7047 psi

O.B.E. Horizontal Multiply stress s_o by 1.75
s = 1.75 X 7047 = 12,332 psi
Safety Factor 20,000/12,332 = 1.62

S.S.E. Horizontal Multiply stress s_o by 2.40
s = 2.4 X 7047 = 16,913 psi
Allowable: Fa = (0.90/0.66) X 20,000 = 27,270 psi
Safety Factor 27,270/16,913 = 1.61

The anchor bolts are safe under O.B.E. and S.S.E. forces.

9b. Upright Connection

The reaction from side stringers is 1119 lbs, see item 5 of this Section.

O.B.E. P = 1119 X 1.75 = 1958.3 lbs s = P/A = 1958.3/0.16 = 12,239 psi
Safety Factor 20,000/12,239 = 1.63

S.S.E. P = 2.4 X 1119 = 2685.6 lbs s = 2685.6/0.16 = 16,785 psi
Safety Factor 27,270/16,785 = 1.62

The connection is safe under O.B.E. and S.S.E. forces.

9c. Stringer Connection

Maximum reaction from (3) main stringers is 1119 lbs. See item 2a of Section III. Cross section area of 3 bolts A = 3 X 0.16 = 0.48 in^2

O.B.E. Horizontal P = 1119 X 1.75 = 1958.3 lbs
s = P/A = 1958.3/0.48 = 4079 psi
Safety Factor 20,000/4079 = 4.9

S.S.E. Horizontal P = 1119 X 2.4 = 2685.6 lbs
s = P/A = 2685.6/0.48 = 5,595 psi
Safety Factor 27,270/5595 = 4.86

The connection of stringer to angle frame is safe under O.B.E. and S.S.E. forces.

10. Table of Stresses

TABLE OF STRESSES		
	O.B.E.	S.S.E.
Allowable Stress psi		
a. Structural Members	23,760	32,400
b. Bolts	20,000	27,270
c. Unistrut Stringer (Main)	25,000	33,000
Maximum Computed Stress psi		
-Main Stringer	23,543	31,156
-Angle Frame	21,634	28,724
-Side Stringer	11,428	15,672
-End Stringer	5,081	6,969
-Intermediate Upright	9,791	13,428
-Corner Upright	6,430	8,838
-Brace	7,296	9,055
-Anchor Bolt	12,332	16,913
-Upright Connection Bolt	12,239	16,785
-Stringer Connection Bolt	4,079	5,595

CONCLUSIONS

Based upon the analysis shown on the foregoing pages, the data adequately shows that the battery and rack will meet the requirements of the specification and will perform adequately during and after the seismic event.

The equipment should be considered rigid as the design frequency of the rack is higher than 33 c.p.s.

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SECTION #7

TEST SERIES SUMMARY

WYLE TEST REPORT NO. 44681-2

1.0 SERIES 1 AND 2

The original testing procedure as defined in Gould Test Procedure GB-3454 up through Revision #10 dated November 14, 1980 was designed to attempt generic qualification of Gould plante and calcium type batteries for Class 1E application in nuclear power generating stations by using accelerated heat aging of the test specimens.

Test Series #1 and #2 disclosed that the accelerated heat aging resulted in degradation of cell components other than the positive and negative plates. The degree of degradation of certain components was in excess of that which would occur in actual service. Other components experienced degradation that would not have occurred during actual service.

This component degradation adversely affected the discharge capacity performance as well as the capability to satisfy the seismic requirements.

Accelerated heat aging was originally employed to evaluate the electrochemical performance and, specifically, the positive plate deterioration and its effect on discharge capacity delivery. No seismic requirement was involved.

Based on the test results, it was concluded that accelerated heat aging was not a viable method to properly evaluate the complete lead-acid cell system with respect to discharge capacity and seismic requirement capability.

1.0 SERIES 1 AND 2 (Cont'd.)

The decision was made to discontinue testing using accelerated heat aging, but to continue the test program using naturally aged cells from actual in service customer installations. (Reference IEEE 535-1979 Section 8 Item 8.2 Aging Procedure).

2.0 SERIES 3 (Wyle Test Report 44681-1 Appendix VIII)

This test series involves testing of Gould plante type cells which is not pertinent to the report on Gould calcium type cells and will not be addressed.

3.0 SERIES 4

3.1 Specimen #1

Specimen was comprised of 3 cells #'s 1, 2, 3 Type NCX-1680 naturally aged (10 years) from New Jersey Bell Telephone Co., Bordentown, N. J.

3.2 Specimen #2

Specimen was comprised of 3 cells #'s 3B1, 3B2, 3B3. Accelerated heat aged (10 years equivalency).

3.3 Specimen #3

Specimen was comprised of 3 cells #'s 12, 13, 14 Type MCX-510 naturally aged (8 years) from Enterprise Telephone Co., Intercourse, Penna.

NOTE: Specimens #1, 2, and 3 were run concurrently, resulting in a common test response spectra (TRS).

Specimen #1 pertains only to the qualification of N-line cells.

Specimen #2 was a repeat test of an additional group of cells for comparison purposes with a previously tested group and is not presented for qualification.

Specimen #3 pertains only to the qualification of M-line cells.

3.4 Pre-Seismic Capacity Discharge Test

All 3 specimen groups were given a pre-seismic capacity test per Gould Test Procedure GB-3454 Revision 11. Section 2.0 Pre-Seismic Capacity Test - IEEE 450-1980. - IEEE 535-1979. Capacity test results were as follows:

Specimen #	Cell Type	Cell #	% Capacity*
1	NCX-1680	1	107
1	NCX-1680	2	106
1	NCX-1680	3	96
2	NCX-1200	3B1	92
2	NCX-1200	3B2	93
2	NCX-1200	3B3	93
3	MCX-510	12	115
3	MCX-510	13	109
3	MCX-510	14	109

*Corrected For Temperature

Documentation of above test results contained in Wyle Report #44681-2 Vol. #1 Section 11 Table II-I - Discharge Data Pages II-8, II-9 and Data Sheet II-69, II-72 and II-73 for N-line cells and Data Sheet II-70 for M-line cells.

4.0 SEISMIC TESTING SERIES #4

4.1 Seismic Qualification

See Section III Pages III-1 through III-27

NOTE: Test Series #4 is presented as the complete qualification of M-line cells. Proceding Test Series #5 and #6 will complete the qualification of N-line cells.

4.2 Test Run Descriptions

Page III - 16 Table III - III

4.3 Required Response Spectrum

Appendix III

Page III - 20 Fig #1

Page III - 21 Fig #2

Page III - 22 Fig #3

Page III - 23 Fig #4

4.4 Photographs

Refer to Pages III-41 through III-49. Photographs III-12 through III-20.

4.5 Transmissibility Plots Appendix V

Test #1 Front-To-Back/Vertical Orientation

Pages III-115 through III-126

Test #9 Side-To-Side/Vertical Orientation

Pages III-127 through III-138

4.0 SEISMIC TESTING SERIES #4 (Cont'd.)

4.6 Test Response Spectrum Plots Appendix VI

Run #7 Front-To-Back/Vertical - OBE

Pages III-305 through III-314

Run #8 Front-To-Back/Vertical - SSE

Pages III-315 through III-314

Run #14 Side-To-Side/Vertical - OBE

Pages III-337 through III-346

Run #15 Side-To-Side/Vertical - SSE

Pages III-347 through III-368

4.7 Instrumentation Log Sheets and Instrumentation Equipment Sheets Appendix VII

Pages III-493 through III-500

5.0 TEST PROCEDURES AND RESULTS SECTION 3.0 3.3.1 RANDOM MULTIFREQUENCY TEST RESULTS TEST SERIES #4 COMMENTS FOR N-LINE CELLS

5.1 Battery Rack Cross Braces - Specimen 1

See Anomaly 14 Page III-11.

Also Photographs III-13 Page III-42 and Photograph III-14 Page III-43.

Deformation of cross braces which resulted was due to use of improper 3/16" thick cross braces as shipped from factory. Proper thickness (3/8") braces were substituted and testing resumed.

5.2 Cell Container Cracking - Specimen 2

See Anomaly 14 Page III-11.

As addressed in 3.3 of this report, specimen #2 was a repeat test of an additional group of accelerated heat aged cells for comparison purposes with previously tested groups and is not part of this report.

5.3 Cell Container Cracking - Specimen 1

See Anomaly 14 Page III-11.

The crack in the bottom of one cell (#3) container resulted in minimal loss of electrolyte. Specimen was removed from test table and transported to another test site.

5.4 Post Seismic Capacity Discharge Test

Test cells were recharged to replace ampere hours withdrawn during seismic testing (110% return). Post seismic capacity discharge test per IEEE 450-1980 IEEE 535-1979 was conducted on Specimen 1. At start of test, 16 hours had elapsed from time container (#3 cell) cracked until start of capacity discharge test. Electrolyte level at start of test was down 3/4" (low level line). At end of 3 hour test, electrolyte level was down 1" (plates still covered).

5.4 Post Seismic Capacity Discharge Test (Cont'd.)

Capacity test results were as follows:

Specimen	Cell Type	Cell #	% Capacity*
1	NCX-1680	1	101
1	NCX-1680	2	104
1	NCX-1680	3	92

*Corrected For Temperature

2	NCX-1200	3B1	---**
2	NCX-1200	3B2	19
2	NCX-1200	3B3	28

For documentation of above data, see Wyle Report Vol. II Table IV-I Pages IV-6 and IV-7. Also, data sheets Pages IV-41, IV-42 and IV-43.

**Note: Cell container cracked during seismic test releasing all electrolyte thus preventing capacity discharge evaluation.

Cell #3 with cracked container in Specimen 1 group delivered 92% capacity. Even though this capacity percentage satisfied IEEE 535 - 8.3.1.4 acceptance criteria, Gould did not classify this as acceptable.

5.5 Cell Container Cracking Cause

Examination of cell #3 container disclosed a crack in the bottom across the cell width dimension about 1" in from the bottom-jar juncture. The cell bottom upon returning to contact with the rack rails following a vertical excursion during the test, did not return flush or perpendicular to the rack rails. Therefore, severe concentrated stresses resulted.

5.5 Cell Container Cracking Cause (Cont'd.)

Examination of the 1/2" thick urethane (open cell) spacer material used between cells disclosed considerable permanent compression. The compression was wedge shape, starting about 1/3 the way down from the top and extending to the bottom where the thickness was about 1/8". Both spacers between the three cells were in similar condition.

This compression occurred during the side-to-side/vertical orientation operating basis earthquake tests.

Due to the spacer permanent compression, uniform spacing between cells was not maintained during testing thus permitting undue independent pendulous type movement.

5.6 Conclusions

Evaluations of conditions outlined in 5.3 and 5.4 were made and a decision made to repeat the testing of another 3 cell group of naturally aged NCX-1680 cells. In addition, the cell spacer material was changed to a foamed polyethylene (closed cell) material.

RESULTS TEST SERIES #4 COMMENTS FOR M-LINE CELLS

5.7 Seismic Testing

Specimen #3 possessed sufficient integrity to withstand, without compromise of structures, the prescribed simulated seismic environment. (See 3.3.1 - Random Multifrequency Test Results.)

5.8 Electrical Monitoring Results

It was demonstrated that the specimen possessed sufficient integrity to withstand, without compromise of electrical function, the prescribed simulated seismic environment.

5.9 Post Seismic Capacity Discharge Test

Test cells were recharged to replace the ampere hours withdrawn during seismic testing (110% return). Post seismic capacity discharge test was conducted per Gould Test Procedure GB-3454 Revision 11 Section 5.0 Post-Seismic Capacity Test - IEEE 450-1980 - IEEE 535-1979.

Capacity test results were as follows:

Specimen #	Cell Type	Cell #	% Capacity
3	MCX-510	12	111
3	MCX-510	13	107
3	MCX-510	14	107

Specimen #3 (MCX-510) cells #12, 13, and 14 satisfied IEEE 535 8.3.1.4.

5.10 Conclusions

Refer to Sections 3.4 Pre-Seismic Capacity Discharge Test; Section 5.1 Seismic Testing and Section 5.3 Post Seismic Capacity Discharge Test.

This demonstrates that Specimen #3 (MCX-510) naturally aged cells 8 years old are capable of performing before, during, and after a seismic event.

6.0 TEST SERIES #5

6.1 Specimen #1

Specimen was comprised of 3 cells #'s 4, 5, 6 Type NCX-1680 naturally aged (10 years) from New Jersey Bell Telephone Co., Bordentown, N.J.

6.2 Specimen #2

Specimen was comprised of another 3 cell group of accelerated heat aged cells (10 years equivalency). Cell #'s 4B1, 4B2, 4B3

Note: 6.1 - Only Specimen #1 is pertinent to this report.

6.2 Specimen #2 was a repeat test for comparison purposes with previously tested groups and is not part of this report.

6.3 Pre-Seismic Capacity Discharge Test

Each specimen group was given a pre-seismic capacity test per Gould Test Procedure GB-3454 Revision 11-B dated January 28, 1982 Section 2.0 Pre-Seismic Capacity Test - IEEE 450-1980 - IEEE 535-1979. Capacity test results were as follows:

Specimen #	Cell Type	Cell #	% Capacity*
1	NCX-1680	4	96
1	NCX-1680	5	96
1	NCX-1680	6	98
2	NCX-1200	4B1	88
2	NCX-1200	4B2	86
2	NCX-1200	4B3	85

*Corrected for Temperature

6.3 Pre-Seismic Capacity Discharge Test (Cont;d.)

Documentation of above test results contained in Wyle Report #44681-2 Vol. #1 Section II Table II-I - Discharge Date - Pages II-8, II-9 and Data Sheet II-69 II-72.

Note: The above specimens were tested concurrently with those specimens referenced Test Series #4.

7.0 SEISMIC TESTING SERIES #5

7.1 Photographs

Refer to Pages III-50, III-51, III-52. Photographs III-21, III-22, III-23.

7.2 Transmissibility Plots Appendix V

Test #1 Front-To-Back/Vertical Orientation

Pages III-140 through III-147

Test #8 Side-To-Side/Vertical Orientation

Pages III-148 through III-155

7.3 Test Response Spectrum Plots Appendix VI

Run #6 Side-To-Side/Vertical - OBE

Pages III-370 through III-379

Run #7 Side-To-Side/Vertical - SSE

Pages III-380 through III-397

Run #13 Front-To-Back/Vertical - OBE

Pages III-398 through III-407

Run #14 Front-To-Back/Vertical - SSE

Pages III-408 through III-425

7.4 Instrumentation Log Sheets and Instrumentation Equipment Sheets Appendix VII

Pages III-501 through III-508

7.5 Seismic Qualification

See Section III Pages III-1 through III-27

7.6 Test Procedure and Results Section 3.0

3.3.1 Random Multifrequenty Test Results

7.7 Specimen Integrity

As indicated in 3.3.1, there were no exceptions with regard to demonstration of specimen integrity. (Test Series 5)

7.8 Post Seismic Capacity Discharge Test

Test cells were recharged to replace ampere hours withdrawn during seismic testing (110% return). Post seismic capacity discharge test per IEEE-450-1980 - IEEE-535-1979 was conducted on Specimen 1.

7.8 Post Seismic Capacity Discharge Test (Cont'd.)

Capacity test results were as follows:

Specimen #	Cell Type	Cell #	% Capacity*
1	NCX-1680	4	92
1	NCX-1680	5	68
1	NCX-1680	6	69
	*Corrected For Temperature		
2	NCX-1200	4B1	26
2	NCX-1200	4B2	45
2	NCX-1200	4B3	60

Cells #5 and #6 failed to deliver the minimum of 80% capacity, therefore, Specimen 1 group did not satisfy acceptance per IEEE 535-1979 Section 8.3.1.4.

For documentation of above data, see Wyle Report Vol. II Table IV-1 Pages IV-6 and IV-7. Also data sheets Page IV-45 and IV-46.

7.9 Conclusions Test Series 5

Specimen 1 group (cells #4-5-6) failed qualification. Cells returned to Gould laboratory for evaluation of capacity discharge failure.

7.10 Specimen 1 Failure Evaluation

Cells #4, 5, 6 of Specimen 1 were examined at the Gould laboratory and it was determined that cells #5 and #6 failed the post-seismic capacity test as a result of the excessive RRS, particularly at low frequencies (3 to 4 cycles) at 10g acceleration. It was decided to conduct another test at a reduced RRS which would still envelope the contract specifications.

8.0 TEST SERIES #6

8.1 Specimen 1

Specimen was comprised of 3 cells #7, 8, 9 Type NCX-1680 naturally aged (]0 years) from New Jersey Bell Telephone Co., Bordedtown, N.J.

8.2 Pre-Seismic Capacity Discharge Test

Specimen 1 was given a pre-seismic capacity discharge test per Gould Test Procedure GB-3454 Revision 11 Section 2.0 Pre-Seismic Capacity Test IEE-450-1980 - IEEE-535-1979.

Capacity test results were as follows:

Specimen #	Cell Type	Cell #	% Capacity*
1	NCX-1680	7	104
1	NCX-1680	8	116
1	NCX-1680	9	106

*Corrected For Temperature

For documentation of above test results, see Wyle Report #44681-2 Vol. 1 Section II Table II-I Discharge Date - Pages II-8, II-9 and data sheets Pages II-75 and II-76.

9.0 SEISMIC TESTING SERIES #6

9.1 Photographs

See Pages III-53 and III-54. Photographs III-24 and III-25.

9.2 Transmissibility Plots Appendix V

Test #1 Front-To-Back/Vertical Orientation

Pages III-157 through III-160

Test #10 Side-To-Side/Vertical Orientation

Pages III-161 through III-164

9.3 Test Response Spectrum Plots Appendix VI

Run #8 Front-To-Back/Vertical - OBE

Pages III-427 through III-436

Run #9 Front-To-Back/Vertical - SSE

Pages III-437 through III-450

Run #15 Side-To-Side/Vertical - OBE

Pages III-451 through III-460

Run #16 Side-To-Side/Vertical - SSE

Pages III-461 through III-474

9.4 Instrumentation Log Sheets and Instrumentation Equipment Sheets Appendix VII

Pages III-509 through III-515

9.5 Seismic Qualification

See Section III Pages III-1 through III-27

9.6 Test Procedure and Results Section 3.0

3.3.1 Random Multifrequency Test Results

9.7 Specimen Integrity

As indicated in Section 3.0 Item 3.3.1, there were no exceptions with regards to demonstration of specimen integrity. (Test Series 6)

10.0 POST SEISMIC CAPACITY DISCHARGE TEST

Test cells were recharged to replace ampere hours withdrawn during seismic testing (110% return). Post seismic capacity discharge test per IEEE-450-1980 - IEEE-535-1979 was conducted on Specimen 1.

10.0 POST SEISMIC CAPACITY DISCHARGE TEST (Cont'd.)

Capacity test results were as follows:

Specimen #	Cell Type	Cell #	% Capacity*
1	NCX-1680	7	102
1	NCX-1680	8	110
1	NCX-1680	9	103

*Corrected For Temperature

For documentation of above test results, see Wyle Report #44681-2 Vol. I Section II Table II-1 Discharge Data Pages II-8, II-9 and data sheet IV-48 and IV-49.

11.0 CONCLUSIONS - TEST SERIES 6

Based on data presented in Sections Nos. 8.0, 9.0 and 10.0, it is demonstrated that the naturally aged (10 years) cells of NCX type are capable of performing before, during, and after a seismic event.

SECTION #7

ADDENDUM

Stress Levels

As indicated in comment on failure analysis of test series 5, the RRS was reduced approximately 40% at low frequencies (3-15 C.P.S.) along both horizontal and vertical axis during Test Series 6. Refer to Appendix III which is the original RRS used for Test Series 4 and 5. Appendix 4 portrays RRS for Test Series 6. The RRS for Test Series 6 are significantly above the RRS specified in the contract.

In conclusion, the stress levels were considerably reduced in Test Series 6 compared to Test Series 4 and 5.

Wyle Report Vol. I Table V Page-9

Cell No. 6 should have pre-seismic capacity of 98% as supported by test disclosure data sheet 11-69 dated 6-19-81. This was a typographical error by Wyle, and, secondly, this cell is not a part of qualification group.

How To Derive Capacity

The temperature correction was per I.E.E.E. 450-1975 (Table 1, Page 11) which corrects the capacity in terms of time and not current. This correction term was used to temperature correct capacity of each cell individually.

Example: Cell #6 of Page II-69

Starting temperature is 82°

The correction factor is 1.014

Time requirement at 82° is (1.014 X 180 =) 182.5 minutes

The capacity is (179 ÷ 182.5=) 98.07%

Photograph Numbers (Refers to Page III-7, 44681-2)

This is a typographical error by Wyle. This again is not relevant to the qualification group. Photographs III-16 and III-17 apply, not VII-16 and VII-17.

Spacing Material

The material was changed to polyethelyne foam closed cell type Dow Chemical (Ethe Foam #220) on 3-12-82 E.C.O. #0017. This material has been standardized for all Class IE or non-IE applications. This material can be readily identified by compressing it with thumb and index finger. The original material (Urethane) when compressed, remains that way whereas the present ethefoam compresses and then returns to its original dimension after pressure release.

Temperature Margins

For every 15° rise in battery electrolyte temperature above 77°, (92°F), the qualified battery life would reduce by 50%. Any prevailing annual average battery electrolyte temperature either within or beyond will affect battery life in direct proportion.

Gould Inc.
Trenton, N.J.

SUMMARY SHEET

Test No. M 6065

Per Cent Capacity to 1.75 VPC @ 77° F.

No.	Cell #1	Cell #2	Cell #3	Cell #4	Cell #5	Cell #6	Remarks
1	92.7	101.4	114.6	108.7	111.3	110.0	As received (12/9/65) 5-hour rate
2	1 Mo. float 111.1	113.4	123.9	117.4	121.2	119.5	(1/7/66) 5-hour rate
3	2 Mo. float 113.0	113.0	121.6	116.1	119.9	118.2	(3/11/66) 5-hour rate
4	4 Mo. float 110.7	111.4	118.0	114.5	116.1	115.4	(7/18/66) 5-hour rate
5	8 Mo. float 116.1	115.6	122.9	116.6	122.2	119.9	(3/17/67) 5-hour rate
6	16 Mo. float	Capacity test conducted to wrong cut-off voltage.					(7/17/68)
7	32 Mo. float 110.8	113.5	120.0	116.9	119.3	120.7	(4/1/71) 5-hour rate

TABLE V (Continued)

TEST SUMMARY

CELL TYPE	NATURAL OR ARTIFICIAL AGING	CELL NO.	PRE-SEISMIC CAPACITY (PERCENT) 1st DISCH./2nd DISCH.	POST-SEISMIC CAPACITY (PERCENT) 1st DISCH./2nd DISCH.	ORIGIN OF CELLS
MCX-1680	10 Years - Nat.	1	107	101	New, June, 1971 from New Jersey Bell Telephone, Bordentown, New Jersey.
		2	106	104	
		3	96	92	
		4	96	92***	
		5	96	68	
		6	~~108~~ 98	69	
MCX-510	8 Years - Nat.	12	115	111	New, June, 1973 from Enterprise Telephone, Intercourse, Pennsylvania.
		13	109	107	
		14	108	107	
MCX-1200	10 Years - Act. (1st Disch.)	3B1	84/92	*	New from Gould for test.
		3B2	86/93	19	
		3B3	86/93	28	
		4B1	88/99	26	
		4B2	86/92	45	
		4B3	85/92	60	
MCX-1680	10 Years - Nat.	7	104	102	New, June, 1971 from New Jersey Bell Telephone, Bordentown, New Jersey.
		8	116	110	
		9	106	103	

*Damaged in Seismic - No discharge performed.

**Stopped test when first cell did not reach 80% capacity.

***Stopped test to prevent voltage reversal.

TABLE II-I. DISCHARGE DATA (POST-AGING) (Continued)

CELL TYPE	NATURAL OR ARTIFICAL AGING	CELL NO.	INITIAL TEMPERATURE (°F)	INITIAL SPECIFIC GRAVITY	DISCHARGE RATE (AMPERES)	TIME TO REACH 1.75 VPC (MINUTES)	FINAL TEMPERATURE (°F)	FINAL SPECIFIC GRAVITY	CAPACITY (PERCENT)
FPS-25	10 yrs-Art.	17	78	1.222	256	179	79	1.139	108
		18	78	1.218		204*	80	1.135	122*
		21	78	1.226		204*	82	1.132	122*
FPR-23	16 yrs-Nat.	46	77	1.222	226	236	81	1.140	134
		47	77	1.220		226	81	1.137	128
		48	77	1.220		229	87	1.135	130
NCX-1680	10 yrs-Nat.	1	81	1.214	410	195	85	1.136	107
		2	81	1.211		192	85	1.133	106
		3	81	1.210		174	85	1.136	96
		4	80	1.210		175	87	1.134	96
		5	82	1.212		175	87	1.136	96
		6	82	1.214		179	87	1.136	~~108~~ 98
MCX-510	8 yrs-Nat.	12	74	1.219	133	205	80	1.139	115
		13	74	1.215		194	81	1.134	109
		14	74	1.213		192	81	1.135	108
NCX-1200	10 yrs-Art. (1st Disch.)	3B1	82	1.210	312	154	83	1.124	84
		3B2	84	1.208		157	85	1.122	86
		3B3	82	1.210		157	84	1.125	86
		4B1	80	1.216		160	81	1.132	88
		4B2	82	1.210		157	86	1.130	86
		4B3	80	1.212		154	83	1.128	85
	(2nd Disch.)	3B1	80	1.208	312	167	83	1.107	92
		3B2	80	1.210		169	82	1.111	93
		3B3	80	1.214		168	83	1.112	93
		4B1	79	1.215	312	180	84	1.117	99
		4B2	79	1.214		167	83	1.116	92
		4B3	79	1.214		168	83	1.112	92
NCX-1680	10 yrs-Nat.	7	74	1.214	410	186	78	1.140	104
		8	74	1.213		206	80	1.132	116
		9	74	1.214		188	80	1.137	106

*Test stopped to prevent voltage reversal.

3.0 TEST PROCEDURES AND RESULTS (Continued)

3.3.1 Random Multifrequency Test Results (Continued)

Test Series 4 (Continued)

During Test Run 15, one (1) battery of Specimen 2 jammed against the horizontal restraint of the battery rack cracking the transparent battery jar, which allowed the electrolyte solution to leak out as documented in Notice of Anomaly 14 (Appendix I) and shown in Photograph III-15.

A post-test inspection (at the completion of Test Run 15) revealed a crack along the bottom of one of the batteries of Specimen 1, which allowed the electrolyte solution to leak out as documented in Notice of Anomaly 14 (Appendix I) and shown in Photographs ~~VII-16~~ III-16 and ~~VII-17.~~ III-17

Descriptions of the test runs are contained in Appendix II.

TRS plots of the control accelerometers from a selected OBE test and the SSE test in each orientation for each test series at 0.5, 1, 2, 3, and 5% damping are contained in Appendix VI.

The Functional Test results are contained in Section IV.

3.4 Specimen Response Procedures

Four (4) uniaxial piezoelectric accelerometers were located on each specimen for each test series. The placement of the accelerometers was at the direction of the Gould Technical Representative. An FM tape recorder provided a record of each accelerometer response. The horizontal accelerometers were oriented in the front-to-back direction during the FB/V testing, and reoriented in the side-to-side direction during the SS/V testing. The number of specimen response accelerometers mounted on the specimens for each series are as follows:

MOUNTED SERIES	NUMBER OF ACCELEROMETERS	PHOTOGRAPHS
1	16	III-3 thru III-6
2	12	III-9 thru III-11
4	12	III-18 thru III-20
5	8	III-22 thru III-23
6	4	III-25

Revised 6/29/82

DATA SHEET

Page No. IV-48
Report No. 44681-2

WYLE LABORATORIES

Customer Gould
Specimen Battery
Part No. NCX-1680
Spec. -
Para. -
S/N See Below
GSI No

Amb. Temp. 72°F
Photo No
Test Med. Air
Specimen Temp. No

Job No. 44681-02
Report No. 44681-2
Start Date 8-14-81

Test Title Post-Siesmic Discharge, 410 Amps (3hr. Rate)

TIME	CELL #7	CELL #8	CELL #9	TOTAL	Remarks
	1214	1213	1214		Spec. Grav.
	76°F	76°F	76°F		Temp.
	34	35	36	37	Monitor Channel
8:35	2.067	2.064	2.063	6.103	O.C.V.
8:40	1.933	1.935	1.933	5.794	5 min. Elapsed Time
8:50	1.933	1.936	1.933	5.794	
9:05	1.924	1.927	1.925	5.770	30 min. Elapsed Time
9:20	1.916	1.920	1.917	5.746	
9:35	1.908	1.911	1.908	5.720	60 min. Elapsed Time
9:50	1.898	1.902	1.899	5.691	
10:05	1.887	1.891	1.888	5.660	90 min. Elapsed Time
10:20	1.875	1.879	1.876	5.623	
10:35	1.861	1.867	1.863	5.584	120 min. Elapsed Time
10:50	1.844	1.850	1.846	5.532	
11:05	1.824	1.833	1.827	5.476	150 min. Elapsed Time
11:20	1.797	1.812	1.800	5.401	
11:35	1.759	1.784	1.764	5.299	180 min. Elapsed Time
11:37	(1.749)	1.778	1.755	5.275	182 min. Elapsed Time
11:39	1.743	1.775	(1.749)	5.261	184 min. Elapsed Time
11:48	1.696	(1.749)	1.705	5.143	~~193~~ min. Elapsed Time

193 min

Specimen Failed —
Specimen Passed —
NOA Written —

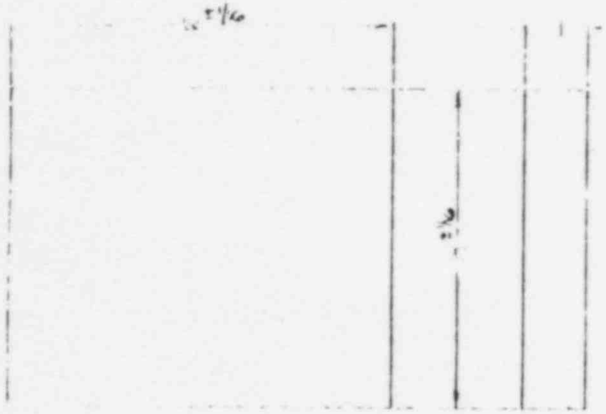
Tested By James K. Purdue Date: 8-14-81
Witness — Date: —
Sheet No. 1 of 2
Approved Robert Wianda

WH-614A

revised 6-29-82

T	W	H	[illegible] TYPES	PART NUMBER
1/2	6 3/4	7	[illegible]	505-106333-029
1/2	7 1/16	[illegible]	[illegible]	505-106333-030

T	W	H	[illegible]	PART NUMBER
1/2	6 [illegible]	[illegible]	[illegible]	505-106-334
1/2	[illegible]	[illegible]	ETA & F[illegible]	505-106-[illegible]
[illegible]	[illegible]	[illegible]	ETA & FT[illegible]	505-106-[illegible]
1/2	[illegible]	[illegible]	ELC,F[illegible]	505-106-[illegible]
1/2	11 [illegible]/16	9 [illegible]	FLS,[illegible]	505-106-[illegible]
1/2	6 [illegible]	4 [illegible]/16	[illegible]	505-[illegible]-001
1/2	6 3/4	6 1/16	DS-5,[illegible]	-002
3/4	5 7/8	5	[illegible]	-003
1/2	11 [illegible]/16	14	FPS (SPEC)	-004
1/2	11 [illegible]/16	12 [illegible]/16	FPS ([illegible])	-005
1/2	6 [illegible]	7 1/8	[illegible]	-006
1/2	14 1/2	13 1/2	MAX.MCX	-007
1/2	3 [illegible]/16	4 7/16	ET.CDE	-008
1/2	8 7/8	9 [illegible]/16	EPR ([illegible])	-009
1/2	14 1/2	12 7/8	MAX.MCX (SPEC)	-010
1/2	14 1/2	14 1/2	MAX.MCX (SPEC)	-011
1 1/4	4 4 1/4	15	MAX.MCX (SPEC)	-012
1/2	6 5/8	6 7/8	DPR	-013
1/2	6 3/8	8 7/8	DC 13	-014
1/2	11 1/8	11 1/16	MAX.MCX	-015
1/2	10 7/8	6 1/16	DS-5,3 (SPEC)	-016
7/16	6 13/16	6 1/16	DS-5,3 (SPEC)	-017
1/2	14 1/2	15	MAX.MCX (SPEC)	-018
1/2	14 1/2	14 11/16	MAX.MCX (SPEC)	-019
1/2	9 [illegible]/16	9 7/16	ETA,ETC (SPEC)	-020
1/2	3	3	AS-5	-021
1 1/8	6 1/16	4	2 AS-5	-022
1/2	12 1/2	5 3/4	AUTO	-023
3/8	8 7/8	8 3/16	EPR (SPEC)	-024
1/4	6 1/8	6 13/16	DC (SPEC)	-025
1/2	7 9/16	7 1/16	DCP-1	-026
1/2	9 1/2	10 3/8	4 KDF-2700	-027
1/2	9 1/2	16	4 KDF-2700	-028



NOTE:
PEICES TO BE SQUARE, CUT UNIFORM, AND FREE OF CUTTING DUST.

MATERIAL : POLYETHELYENE FOAM (CLOSED CELL)
APPROVED SOURCE: DOW CHEMICAL - ETHA FOAM #220
OR APPROVED EQUIVALENT.

DATE OF ADDITIONS TO PART NO 1-14-81

[illegible]	I	3-12-82 / 1-28-80	MAT'L WAS URETHANE P.C.D. #0017; PART #106334-029 & 030 IS NOW 106333-029 + 106333-030
[illegible]	H	8-2-80	MAT'L WAS MAT'L-GYPSUM "ZER-O-CELL"
KB	G	6/24/75	REDRAWN, NO CHANGE

CELL SPACER FOR [illegible] PACKING

PR [illegible] 6-10-70

106333 B

KKK

SECTION #8

COMPARISON OF SEISMIC TEST TRS VS. RRS

(NCX)

Seismic test was conducted on naturally aged cells as described in Gould Test Procedure GB-3454 Revision #11.

Gould response spectra at both O.B.E. and S.S.E. levels at 2% damping (Fig. 5, 6, 7, 8 - Page III-24-25-26-27 in Wyle Report) were enveloped during the seismic test at all frequencies.

Following comparison response spectra curves are provided at 2% damping:

Fig. 8-1	Vertical operating basis earthquake front-to-back/vertical
Fig. 8-2	Horizontal operating basis earthquake front-to-back/vertical
Fig. 8-3	Vertical operating basis earthquake side-to-side/vertical
Fig. 8-4	Horizontal operating basis earthquake side-to-side/vertical
Fig. 8-5	Vertical safe shutdown earthquake front-to-back/vertical
Fig. 8-6	Horizontal safe shutdown earthquake front-to-back/vertical
Fig. 8-7	Vertical safe shutdown earthquake side-to-side/vertical
Fig. 8-8	Horizontal safe shutdown earthquake side-to-side/vertical

These plots compare the Byron/Braidwood R.R.S. and Gould R.R.S. with T.R.S. T.R.S. envelopes Byron/Braidwood and Gould R.R.S. at all frequencies.

All the cells were capacity tested prior and after the seismic test as required by I.E.E.E. 535 documentation regarding the capacity test date as provided in Section SA of this report. All cells met the capacity requirement. The cells were also examined visually and no physical damage was observed.

The required transmissibility plots are provided in Wyle Test Report for Series 6 as follows:

Test #1 Front-to-back/vertical axis for both horizontal and vertical control accelerometers - Pages III-157 through III-160.

Test #10 Side-to-side/vertical axis for both horizontal and vertical control accelerometers - Pages III-161 through III-164.

These plots indicate that the fixture is a rigid one and amplification due its structure is insignificant.

Section 5 and Section 6 of this report analyze the test fixture and contract rack using static analysis approach to prove that both the test fixture and the contract racks are rigid structures.

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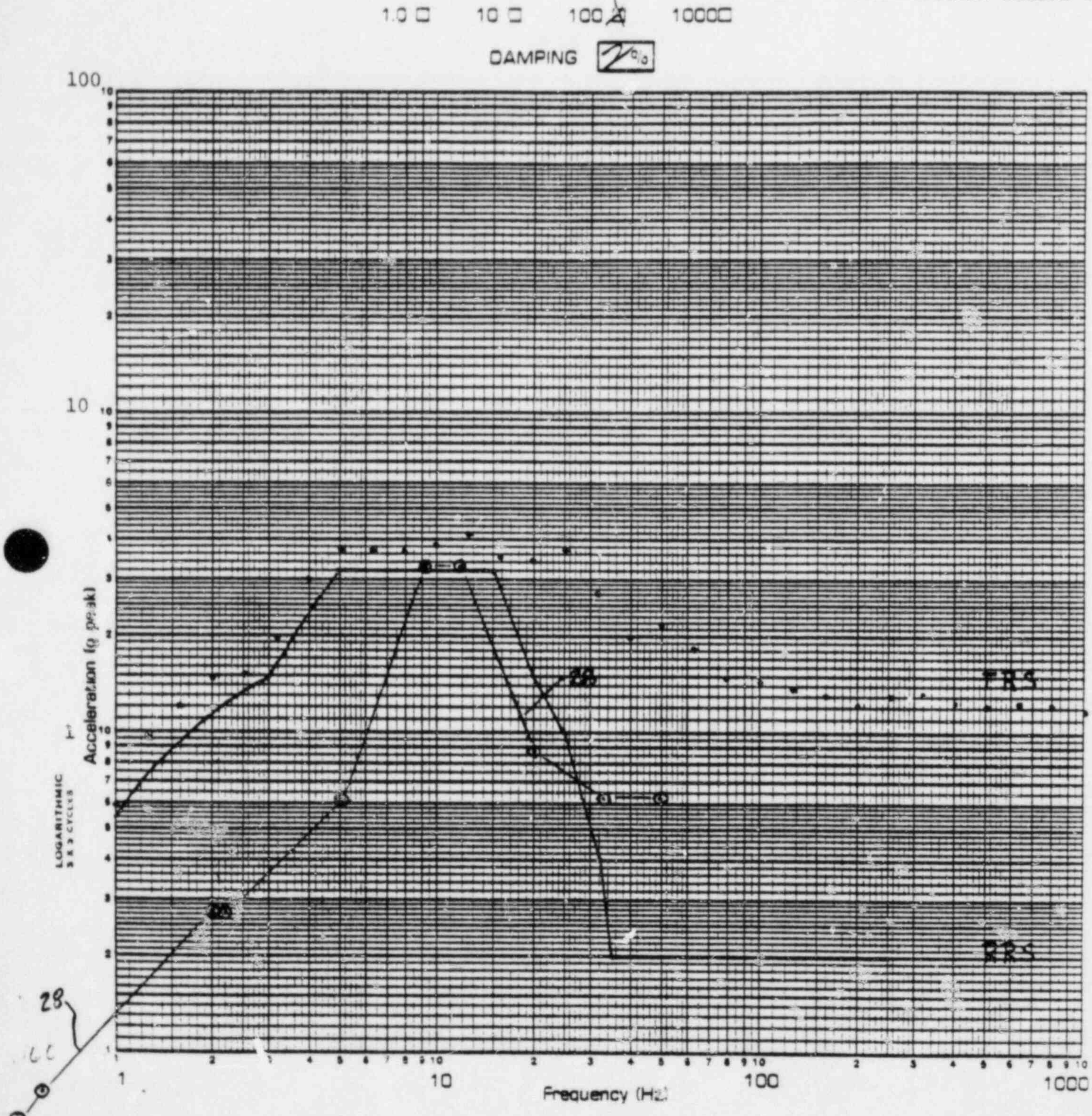
Report No. 44681-2

Legend

• TRS
⊙ Byron/Braidwood RRS

Byron/Braidwood Station
Commonwealth Edison Co

FULL SCALE SHOCK SPECTRUM (g Peak)



SPECIMEN —
AXIS FB/V
LOCATION NO. VCA
TEST RUN NO. 8

Fig. 8.1

Comparison of TRS vs RRS Vertical OBE
Front-to-Back/Vertical 2% Damping

Legend

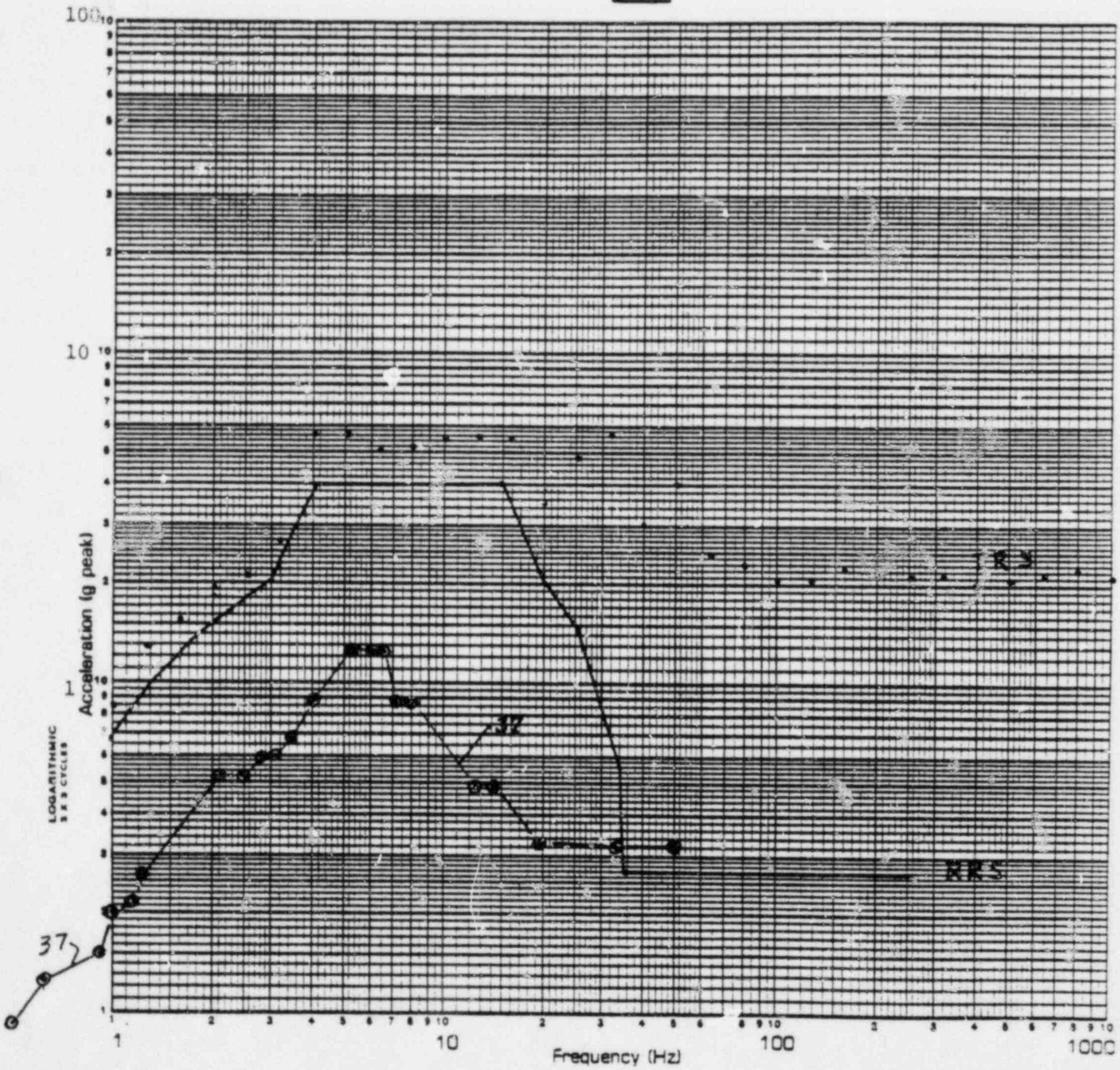
- • TRS
- ⊙ Byron/Braidwood RRS

Byron/Braidwood Station
Commonwealth Edison Co.

FULL SCALE SHOCK SPECTRUM (g Peak)

1.0 ☐ 10 ☐ 100 ☒ 1000 ☐

DAMPING [2%]



SPECIMEN —

AXIS FB/V

LOCATION NO. HCA

TEST RUN NO. 8

Fig. 8.2

Comparison of TRS vs RRS Horizontal OBE Front-to-Back/Vertical 2% Damping

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Report No. 44681-2

FULL SCALE SHOCK SPECTRUM (g Peak)

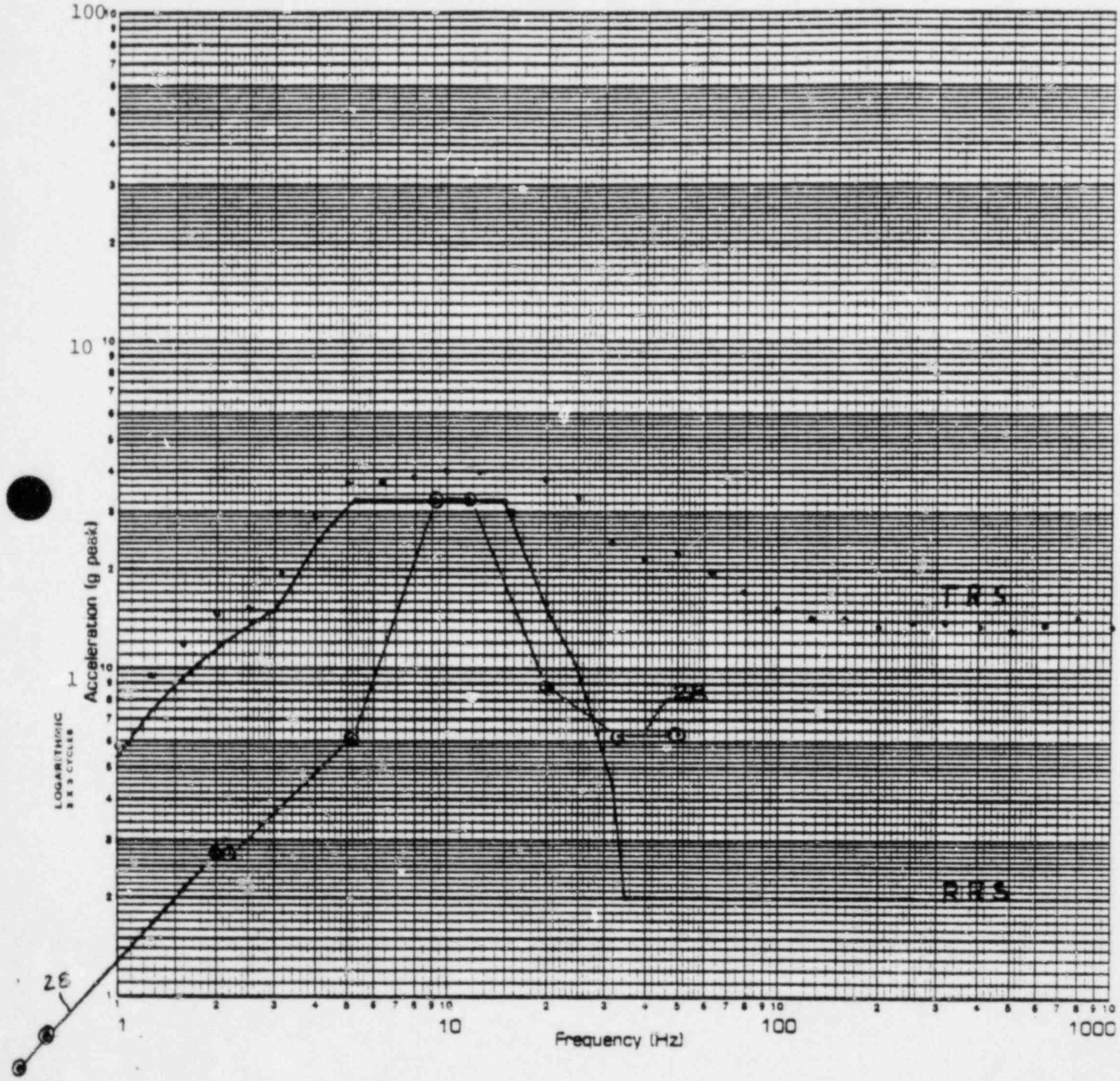
1.0 ☐ 10 ☐ 100 ☒ 100

DAMPING 2%

Legend

• TRS
⊙ Byron/Braidwood RRS

Byron/Braidwood Station
Commonwealth Edison Co.



SPECIMEN ___

AXIS SS|V

LOCATION NO. VCA

TEST RUN NO. 15

Fig. 8.3

Comparison of TRS vs RRS Vertical OBE
Side-to-Side/Vertical 2% Damping

Page No. III-453
Report No. 44681-2

FULL SCALE SHOCK SPECTRUM (g Peak)

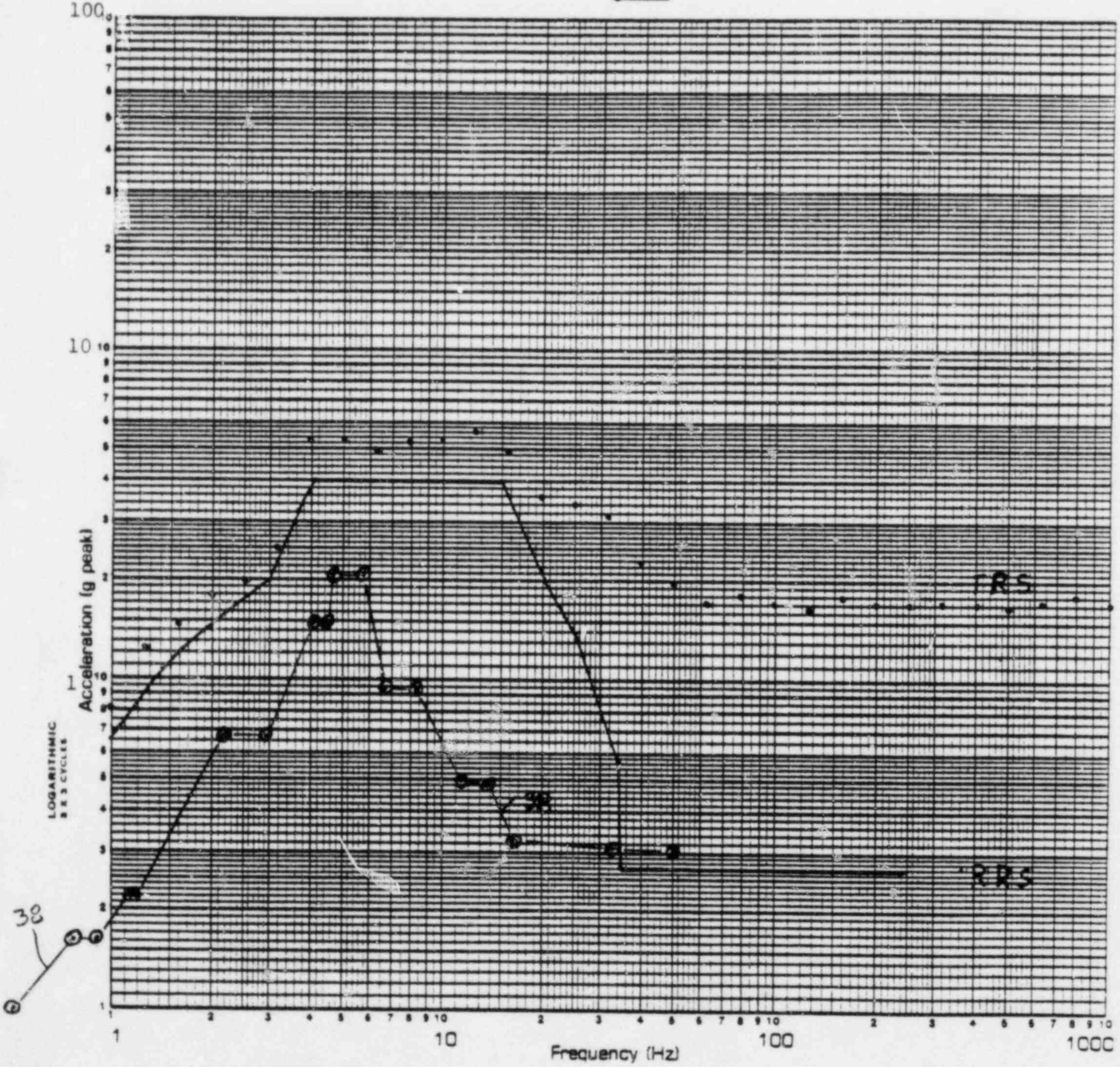
1.0 ☐ 10 ☐ 100 ☒ 1000☐

DAMPING [2%]

Legend

- · TRS
- ʘ Byron/Braidwood RRS

Byron/Braidwood Station
Commonwealth Edison Co.



SPECIMEN —

AXIS SS|V

LOCATION NO. 4CA

TEST RUN NO. 15

Fig. 8.4

Comparison TRS vs RRS Horizontal OBE
Side-to-Side/Vertical 2% Damping

Page No. III-444
Report No. 44681-2

FULL SCALE SHOCK SPECTRUM (g Peak)

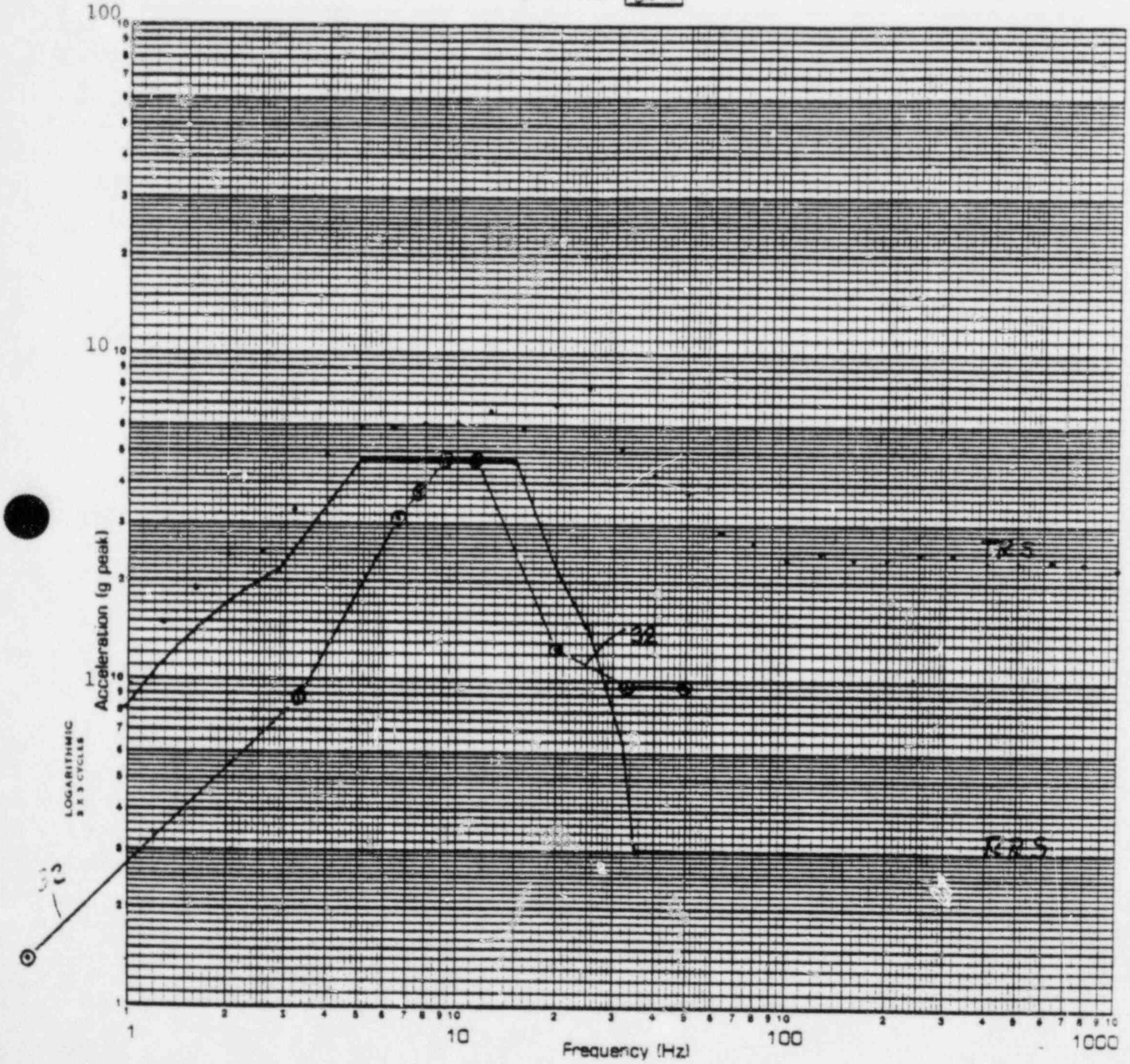
1.0 ☐ 10 ☐ 100 ☒ 1000☐

DAMPING [2%]

Legend

• TRS
⊙ Byron/Braidwood RRS

Byron/Braidwood Station
Commonwealth Edison Co.



SPECIMEN —

AXIS FB/V

LOCATION NO. VCA

TEST RUN NO. 9

Fig 8.5

Comparison of TRS vs RRS Vertical DBE (SSE)
Front-to Back/Vertical 2% Damping

Legend

- TRS
- ⊙ Byron/Braidwood RRS

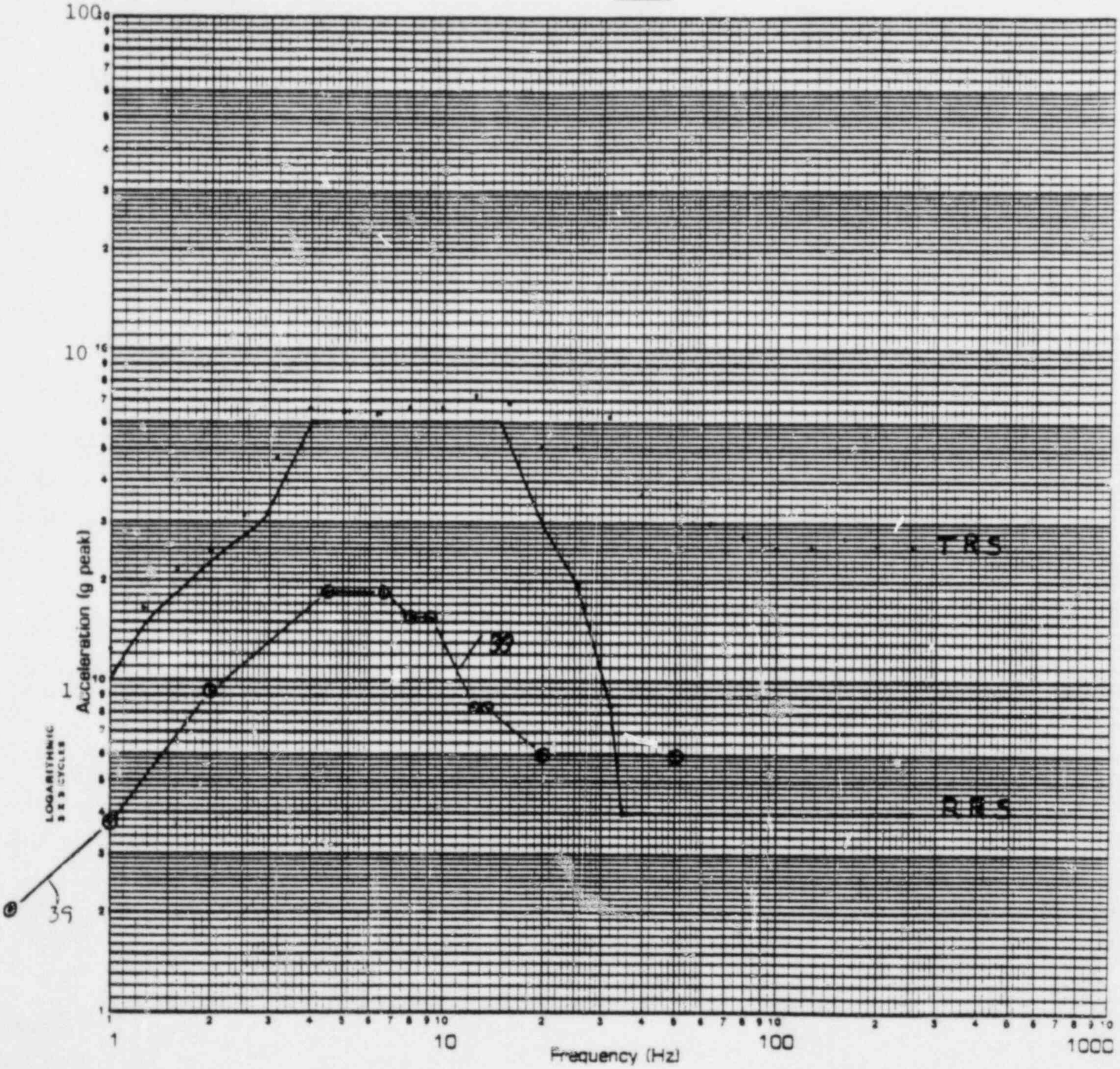
Byron/Braidwood Station
Commonwealth Edison Co

Page No. III-439
Report No. 44681-2

FULL SCALE SHOCK SPECTRUM (g Peak)

1.0 ☐ 10 ☐ 100 ☒ 1000☐

DAMPING 2%



SPECIMEN —

LOCATION NO. HCA

AXIS FB/V

TEST RUN NO. 9

Fig. 8.6

Comparison of TRS vs RRS Horizontal DBE (SSE)
Front-toBack/Vertical 2% Damping

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Report No. 44681-2

FULL SCALE SHOCK SPECTRUM (g Peak)

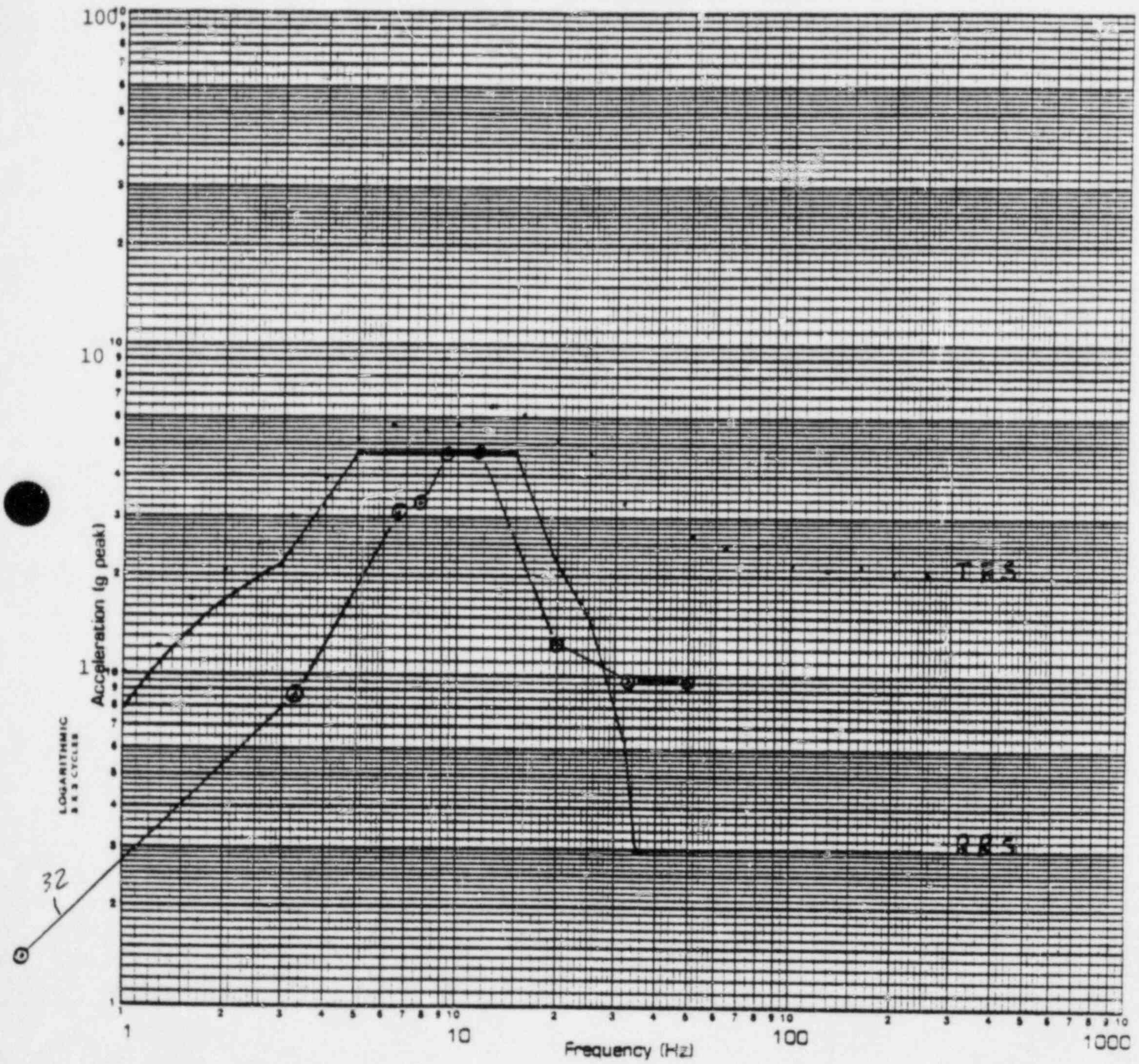
1.0 ☐ 10 ☐ 100 ☒ 1000 ☐

DAMPING 2%

Legend

- · TRS
- ⊙ Byron/Braidwood RRS

Byron/Braidwood Station
Commonwealth Edison Co.



SPECIMEN —

AXIS SS/V

LOCATION NO. VCA

TEST RUN NO. 16

Fig. 8.7

Comparison of TRS vs RRS Vertiacl DBE (SSE)
Side-toSide/Vertical 2% Damping

Legend

- • TRS
- ⊙ Byron/Braidwood RRS

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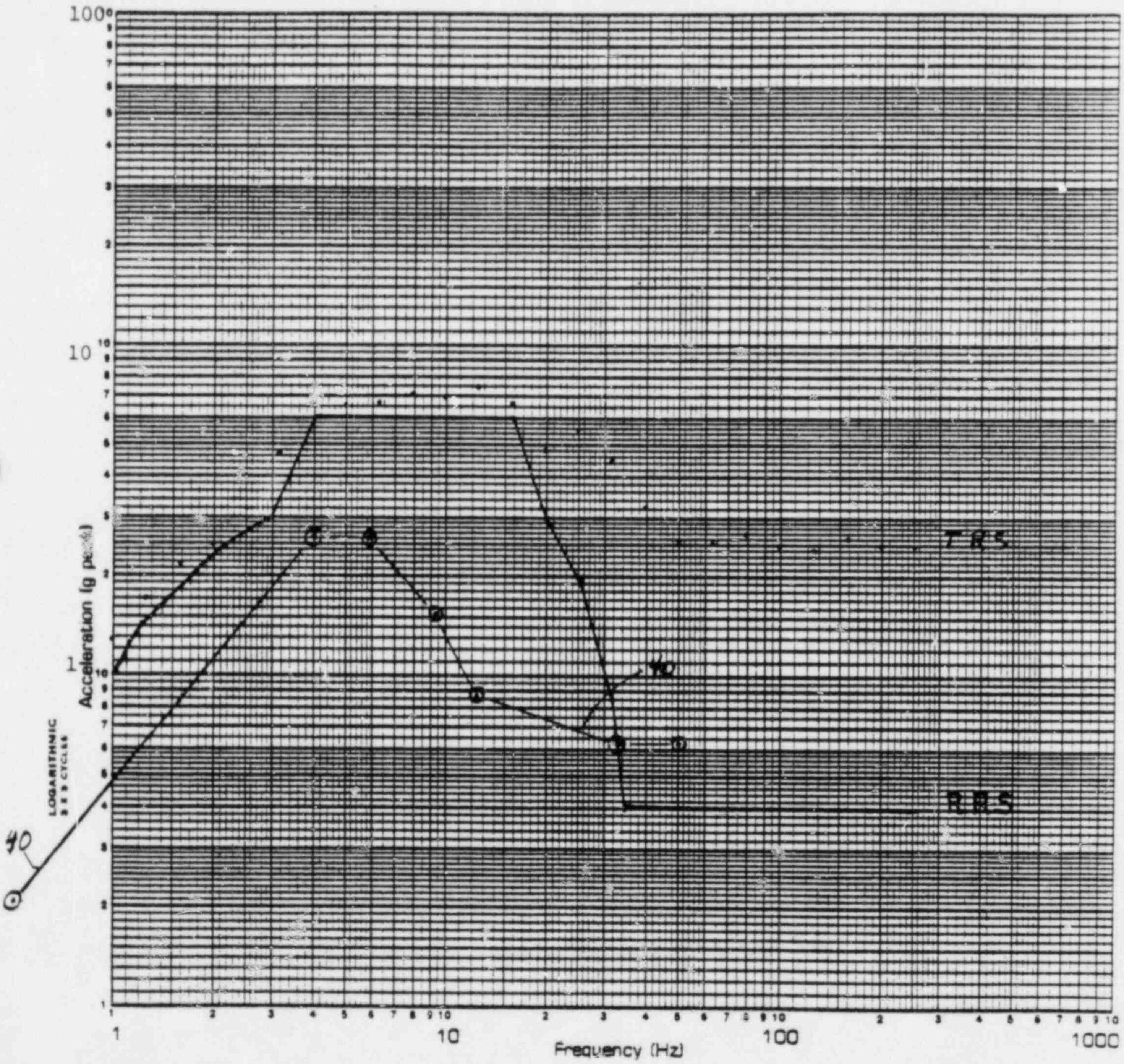
Report No. 44681-2

FULL SCALE SHOCK SPECTRUM (g Peak)

Byron/Braidwood Station
Commonwealth Edison Co.

1.0 ☐ 10 ☐ 100 ☒ 1000☐

DAMPING 2%



SPECIMEN —

LOCATION NO. HCA

AXIS SS/V

TEST RUN NO. 16

Fig 8.8

Comparison of TRS vs RRS Horizontal DBE(SSE)
Side-to-Side/Vertical 2% Damping

SECTION #9
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WYLE LABORATORY TEST REPORT #44681-2
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SECTION I THERMAL AGING

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SECTION III SEISMIC QUALIFICATION

Series 2

Test #1 Front-To-Back/Vertical Axis

HCA = Horizontal Control Accelerometer.

VCA = Vertical Control Accelerometer.

Pages III-90 through III-101

Test #10 Side-To-Side/Vertical Axis

HCA = Horizontal Control Accelerometer.

VCA = Vertical Control Accelerometer.

Pages III-102 through III-113

Series 4

Test #1 Front-To-Back/Vertical Axis

HCA = Horizontal Control Accelerometer.

VCA = Vertical Control Accelerometer.

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Test #9 Side-To-Side/Vertical Axis

HCA = Horizontal Control Accelerometer.

VCA - Vertical Control Accelerometer.

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Series 5

Test #1 Front-To-Back/Vertical Axis

HCA = Horizontal Control Accelerometer.

VCA = Vertical Control Accelerometer.

Pages III-140 through III-147

Test #8 Side-To-Side/Vertical Axis

HCA = Horizontal Control Accelerometer.

VCA = Vertical Control Accelerometer.

Pages III-148 through III-155

Series 6

Test #1 Front-To-Back/Vertical Axis

HCA = Horizontal Control Accelerometer.

VCA = Vertical Control Accelerometer.

Pages III-157 through III-160

Test #10 Side-To-Side/Vertical Axis

HCA = Horizontal Control Accelerometer.

VCA = Vertical Control Accelerometer.

Pages III-161 through III-164

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Test Series 1

Run #5 Side-To-Side/Vertical Axis - OBE

HCA = Horizontal Control Accelerometer.

VCA = Vertical Control Accelerometer.

Pages III-167 through III-176

Run #9 Front-To-Back Vertical Axis - OBE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-177 through III-186

Run #14 Front-To-Back/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-187 through III-210

Run #17 Side-To-Side/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
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Test Series 2

Run #8 Front-To-Back/Vertical Axis - OBE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-240 through III-249

Run #9 Front-To-Back/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-250 through III-271

Run #15 Side-To-Side/Vertical Axis - OBE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
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Run #16 Side-To-Side/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-282 through III-303

Test Series 4

Run #7 Front-To-Back/Vertical Axis - OBE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-305 through III-314

Run #8 Front-To-Back/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
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Run #14 Side-To-Side/Vertical Axis - OBE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-337 through III-346

Run #15 Side-To-Side/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
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Test Series 5

Run #6 Side-To-Side/Vertical Axis - OBE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-370 through III-379

Run #7 Side-To-Side/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
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Run #13 Front-To-Back/Vertical Axis - OBE
HCA = Horizontal Control Accelerometer.
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Run #14 Front-To-Back/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-408 through III-425

Test Series 6

Run #8 Front-To-Back/Vertical Axis - OBE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
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Run #9 Front-To-Back/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
Pages III-437 through III-450

Run #15 Side-To-Side/Vertical Axis - OBE
HCA = Horizontal Control Accelerometer.
VCA = Vertical Control Accelerometer.
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Run #16 Side-To-Side/Vertical Axis - SSE
HCA = Horizontal Control Accelerometer.
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Instrumentation Equipment Sheets

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SECTION IV POST-SEISMIC CAPACITY DISCHARGE TEST

SECTION #10

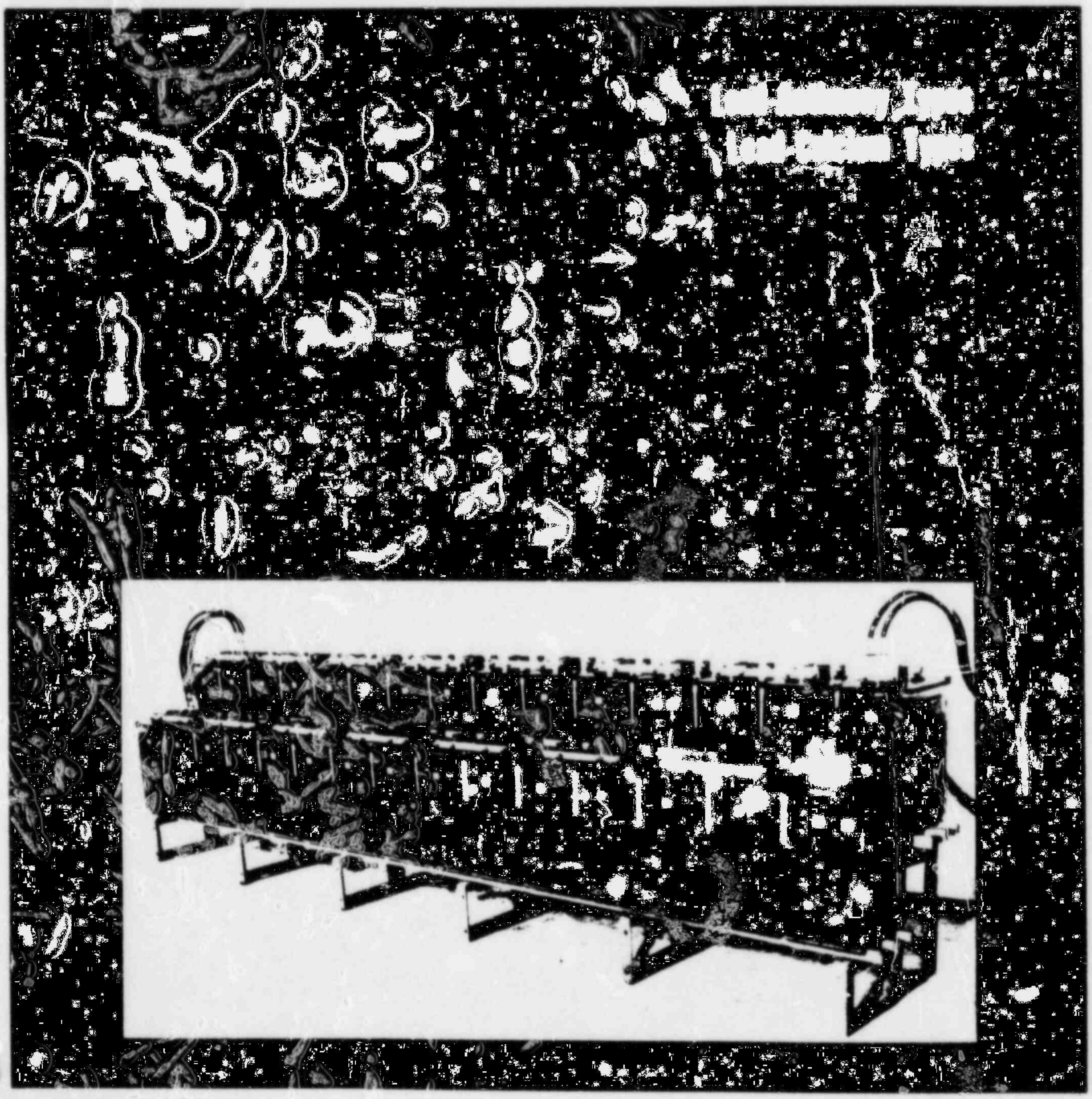
GOULD INSTALLATION AND OPERATING INSTRUCTIONS

GB-3384B 6/80

These instructions are designed to cover a wide variety of battery applications and are, therefore, not finite for specific usage.

Additional guidance for Class 1E lead storage batteries is referenced in IEEE 484-1975 and IEEE 450-1980. These shall be used as the final determinent.

Stationary Battery Installation and Operating Instructions



GOULD

Electronics & Electrical Products

YOUR GOULD REPRESENTATIVE

SALESPERSON ______________________________

TELEPHONE ______________________________

LOCATION ______________________________

STATIONARY BATTERY INSTALLATION AND OPERATING INSTRUCTIONS

LEAD-ANTIMONY TYPES

LEAD-CALCIUM TYPES

Gould Inc., Industrial Battery Division
2050 Cabot Boulevard West, Langhorne, Pa. 19047
Telephone (215) 752-0555

GOULD
Electronics & Electrical Products

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SECTION I

1.0 GENERAL INFORMATION

Caution! Before proceeding with the unpacking, handling, installation and operation of this lead-acid storage battery, the following general information should be reviewed together with the recommended safety precautions.

A lead-acid battery is an electro-chemical device containing an electrolyte which is a dilute solution of sulfuric acid and water. This electrolyte is corrosive and can cause injury.

Lead-acid batteries, when installed, are capable of high voltage which can cause electrical shocks to personnel.

All lead-acid batteries, in the course of normal operation, generate gases which can be explosive.

Stationary batteries (when installed) are usually on float charge continually, unless on discharge in the event of A.C. failure.

SECTION II

2.0 SAFETY PRECAUTIONS

A. Wear rubber apron, gloves and safety goggles (or face shield) when handling, installing or working with batteries. This will help prevent injury due to splashing or spillage of sulfuric acid.

B. Prohibit smoking. Keep flames and sparks of all kinds away from vicinity of storage batteries as liberated or entrapped hydrogen gas in the cells may be exploded, causing injury to personnel and damage to cells.

C. Never place metal tools on top of cells, since sparks due to shorting across cell terminals may result in an explosion of hydrogen gas in or near the cells. Insulate tool handles to protect against shorting.

D. When preparing electrolyte, always pour acid into water, <u>NEVER water into acid.</u> Failure to follow this precaution will result in excess heat and violent chemical reaction which may cause serious injury to personnel.

E. If electrolyte comes into contact with skin or clothing, immediately wash with water and neutralize with a solution of baking soda and water. Secure medical treatment. If electrolyte comes into contact with the eyes, wash or flush with plenty of clean water. Secure medical treatment immediately.

F. Exercise care when handling cells. When lifting straps and strap spreaders are provided, use them with appropriate mechanical equipment to safely handle cells and avoid injury to personnel.

G. Promptly neutralize and remove any electrolyte spilled when handling or installing cells. Use a baking soda/water solution (1 lb. per gallon of water) to prevent possible injury to personnel.

H. Make sure that all battery connections are properly prepared and tightened to prevent possible injury to personnel or failure of system.

I. Familiarize personnel with battery installation, charging and maintenance procedures. Restrict access to battery area, permitting trained personnel only, to reduce the possibility of injury.

J. Whenever possible, when making repairs to charging equipment and/or batteries, interrupt AC and DC circuits to reduce the possibility of injury to personnel and damage to system equipment.

NOTE

If the foregoing precautions are not fully understood, clarification should be obtained from your nearest Gould representative. Local conditions may introduce situations not covered by Gould Safety Precautions. Here again, contact the nearest Gould representative for guidance with your particular safety problem; also refer to applicable federal, state and local regulations as well as industry standards.

SECTION III

3.0 RECEIPT OF SHIPMENT

Immediately upon delivery by the carrier, examine for possible damage caused in transit. Damaged packing material or staining from leaking electrolyte would indicate rough handling. If such conditions are found, make descriptive notation on delivery receipt before signing. If cell damage is found, request an inspection by the carrier and file a damage claim.

3.1 CONCEALED DAMAGE

Shortly after receipt (within 15 days), examine all cells for concealed damage. Pay particular attention to packing material exhibiting damage or electrolyte staining. Cells with electrolyte levels more than 1/2" below top of plates have suffered probable permanent damage due to plate exposure to air. If this condition or other cell damage is found, request an inspection by the carrier immediately and file a concealed damage claim.

3.2 ELECTROLYTE LEVELS

Cells are shipped with electrolyte levels about 1/8" below the high level line. During shipment, the levels drop due to the loss of gases from internal cell components. The amount of drop in level will vary with each type of cell. Electrolyte levels, when received, may range from the high level line to slightly below the low level line. If this condition exists, make no addition of electrolyte or water at this time *(see Section 8.3)*. If certain cells have low electrolyte levels, with less than 1/2" of plates exposed to air, add battery grade sulphuric acid of the same specific gravity as the remaining cells; thus bringing low level cells up to the average level of other cells.

SECTION IV

4.0 STORAGE PRIOR TO INSTALLATION

4.1 STORAGE LOCATION

If the battery is not to be installed at the time of receipt, it is recommended that it be stored indoors in a cool [60°F (15.6°C) to 90°F (32°C)], clean, dry location. Do not tier pallets or possible cell damage may occur.

4.2 STORAGE INTERVAL

For batteries shipped wet, fully-charged, the following storage intervals from date of shipment to date of installation and initial charge should not be exceeded:

Lead-Antimony Types:
Three (3) Months

Lead-Calcium Types:
Six (6) Months

Storage beyond the above stated periods can result in sulphated plates which can be detrimental to battery life and performance.

The battery should be given its initial charge *(see Section 8.0)* before the end of the above stated storage intervals and repeated for each additional storage interval.

Failure to charge in accordance with the above can void the battery's warranty.

4.3 DRY-CHARGED BATTERIES

For batteries shipped dry-charged, follow special handling and preparation instructions supplied as well as appropriate sections of this Manual.

SECTION V

5.0 RACK ASSEMBLY

Assembly of the battery rack should be completed in accordance with the Gould drawing and/or instructions included with the rack, GB-3492 or GB-3493.

SECTION VI

6.0 UNPACKING AND HANDLING

Most cells are packed in individual corrugated cartons. Some smaller size cells are packed in a master carton containing 2 (two) or 3 (three) cells. Cartons are shipped on wood pallets. Remove material holding cartons to pallets, exercising care when cutting banding material to prevent injury. If individual cells are to be moved to another location, do not remove carton at this time. Exercise caution if using a two-wheeled hand truck and, to prevent spillage of electrolyte, do not tilt cell more than 25 degrees from vertical. When cells have been brought to the installation site, remove carton sleeve and top corrugated spacers.

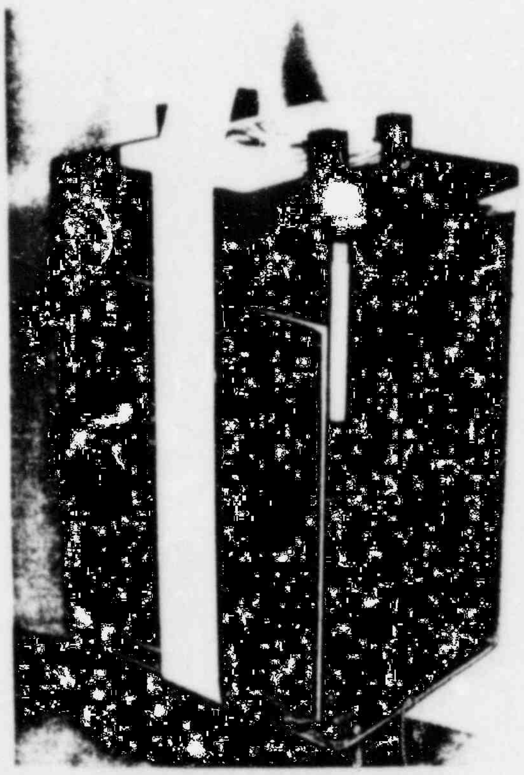

FIGURE 1

DO NOT LIFT CELLS BY THEIR TERMINAL POSTS. Support the cells from the bottom when handling and unpacking. In general, units weighing less than 75 pounds are handled manually, being supported from the bottom.

After removal of outer carton and top spacers, the cell should still be resting in the bottom corrugated tray. This tray is designed to be easily broken away to permit positioning of a lifting strap under the cell with a minimal amount of cell tilting.

A lifting strap and a strap spreader are furnished for use with mechanical lifting devices, when cells weigh 75 pounds or more. See *Figure 1* which shows typical positioning of strap and spreader.

Always use lifting straps and spreaders, when provided, together with suitable mechanical lifting devices to prevent injury to personnel or damage to cells.

Never slide cells across rough surfaces as severe scratching of plastic container bottom may result in stressing and rupturing of the jar with subsequent loss of electrolyte. At all times, exercise care when handling cells to prevent scratching of plastic jars and covers.

SECTION VII

7.0 INSTALLATION

7.1 BATTERY LOCATION

It is recommended that the battery be installed in a clean, cool, dry location. Cells should not be exposed to heating units, strip heaters, radiators, steam pipes or sunshine through a window.

7.2 TEMPERATURE

A battery location having an ambient temperature of 75°F (24°C) to 77°F (25°C) will result in optimum battery life. Batteries operated in high ambient temperatures will result in reduced life. Therefore, for longer life and ease of maintenance, locations having cooler ambient temperatures are recommended.

The normal battery operating temperatures are between 60°F (16°C) and 90°F (32°C).

7.3 TEMPERATURE VARIATION

The location or rack arrangement should result in no greater than 5°F (2.78°C) variation in cell temperatures of a series string at any given time. If a greater variation is found, steps should be taken to correct the condition. When uniform cell temperature is maintained, the need for equalizing charges may be eliminated or reduced in frequency.

7.4 VENTILATION

Ventilation should be provided in the battery room or area to prevent hydrogen, liberated from the cells in service, from exceeding a 1% concentration. Concentrations about this percentage can result in an explosive mixture, which could be ignited by sparks from adjacent electrical equipment as well as accidental sparks or open flames introduced by personnel. All air moved by ventilation in the battery room or area should be exhausted into the outside atmosphere and should not be allowed to recirculate into other confined areas.

7.5 PLACEMENT OF CELLS

It is assumed at this point that the battery rack has been assembled. Study the rack layout and wiring drawings to determine proper location of the positive and negative terminals of the battery; this will establish correct positioning of the initial cell on each rack row. Cells are normally installed with plate edges perpendicular to rack length.

Measure and mark the center of the rack stringer length. Determine the number of cells to be placed in each row. When an odd number of cells are in the row, place the center of the initial cell at the center point of the rack stringer length.

When an even number of cells are in the row, locate the initial cells so that the center of the space between cells coincides with the center mark of the stringer length.

When installing cells on the rack, start at the lower step or tier for stability and safety reasons.

Place cells on the rack so that the positive terminal (marked "+") of each cell adjoins the negative terminal (marked "-") of the next cell. The standard spacing between cells is 1/2" at the top of the jars.

Adjacent cells should not touch; nor should any cell contact the metal rack supports or metal cable conduits. Check for proper alignment and 1/2" spacing between cells. Adjust cell position where necessary. This should be completed before installation of intercell connectors.

The cell post surfaces have a coating of No-Ox-Id "A"* grease applied at the factory. Do not remove any grease from posts. Re-coat any surfaces that may have been exposed during handling of the cells.

7.6 CELL TERMINAL HARDWARE

On Gould "D", "E", and "F" type cells, two lead-covered brass nuts are used in conjunction with a brass stud on each post. These are pre-greased at the factory with No-Ox-Id "A" grease and are shipped installed on cell posts. During installation of the intercell connectors (*see Section 7.7*), exercise care to provide equal extension of the brass stud past each connector. Hold one end of the stud and install one of the lead-covered nuts finger tight. Install second nut while holding first nut. This will provide equal engagement of the nuts and stud.

On Gould "M" and "N" type cells, pre-greased stainless steel bolts, nuts and washers are supplied for cell terminals.

7.7 CONNECTING CELLS

Refer to the cell arrangement drawing to determine the quantity, size and correct positioning of the intercell connectors. On the "N" type cells using 1-1/4" wide connectors, the bolt holes are located off-center. Position connector so that the lesser dimension faces downward on the cell post.

**Trademark of the Dearborn Chemical Co.*

Gently clean contact surfaces only, of the lead plated intercell connectors, terminal plates and cable lugs using a brass suede brush or #00 grade sandpaper. Caution: Do not use powered wire brush or coarse abrasives, as lead plating may be removed exposing copper.

As contact surfaces are cleaned, apply a thin coating of No-Ox-Id "A" grease to these surfaces only.

Starting at center of the cell row, install connectors per wiring diagram and cell arrangement drawing.

On cells using stainless steel bolts, washers and nuts, make sure a washer is placed between the bolt head and connector as well as between the nut and connector.

CAUTION

> When installing terminal hardware, do not permit any items to fall into cell. If such material remains in the cell, contamination will result; requiring replacement of the cell.

As intercell connectors are installed, adjust them to a level position and finger tighten hardware.

All terminal hardware installed on connectors should now be tightened as outlined in the following table:

<u>"D" type single cells</u> –
(2 lead-covered nuts with 1/4" stud.)
Tighten to 75 inch pounds.

<u>"E" and "F" type cells</u> –
(2 lead-covered nuts with 5/16" stud.)
Tighten to 100 inch pounds.

<u>"M" type cells</u> –
(Stainless steel hardware). Tighten to 100 inch pounds.

<u>"N" type cells</u> –
(Stainless steel hardware). *See Figure 2.*

NOTE

Torque both lead-covered nuts as well as the bolt head and nut of stainless steel hardware to their prescribed torque values. Torquing only one side of either combination will not provide the desired tightness.

FIGURE 2

Following the torquing of stainless steel hardware, apply a thin coating of No-Ox-Id "A" grease to bolts, washers and nuts using a 1" paint brush.

Complete connecting of cells by installing necessary inter-row, inter-tier or inter-rack cable connectors. <u>Do not</u> connect battery to charger at this time.

Re-check to be certain that the cells are connected positive (+) to negative (-) throughout the battery string. Measure the total voltage at the battery terminals. The voltage should be equal to the number of cells times the voltage of one of the cells. Example: 60 cells times 2.05 volts = 123 volts.

7.8 COMPLETING INSTALLATION

Cells of 1200 ampere hours or less may have been shipped with Gould Pre-Vent ™ vent/filling funnels in place. These vents have flexible plastic caps installed for shipping purposes. These caps may be removed and discarded, or they may be left in place if the battery environment is dusty. *(See Figure 3).*

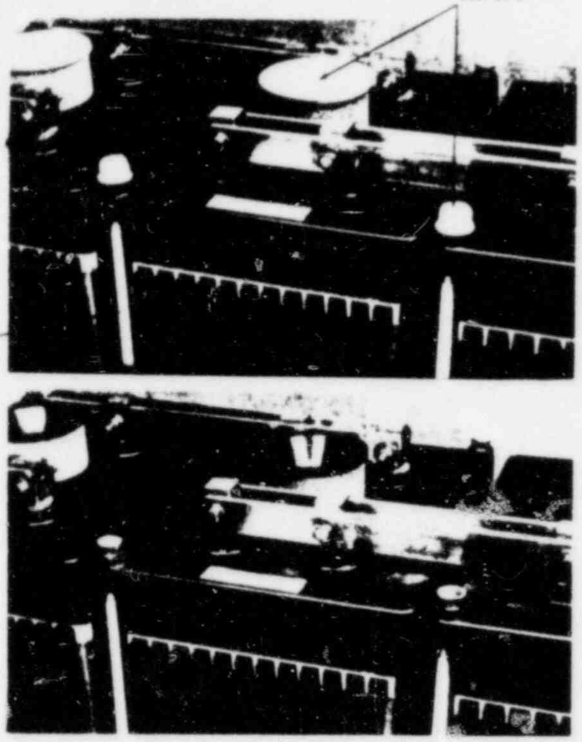

FIGURE 3

FIGURE 4

Cells from 1344 ampere hours up through 2550 ampere hours may have been supplied with a Gould Pre-Vent. For this size cell, the Pre-Vent units are not shipped in place. A standard screw-type vent is used for shipping purposes. If Pre-Vent units were specified, they would have been packed separately with other accessories. Remove the screw-type shipping vent one-at-a-time and install a Pre-Vent unit. Discard the shipping vent.

Other type cells may have separate explosion resistant vents installed at time of shipment. Separate plastic filling funnels are supplied along with this type vent. These funnels also have flexible plastic shipping caps. Here again, these may be removed and discarded or left in place if environment is dusty.

The Gould Pre-Vent assembly and other explosion resistant vents are designed to prevent external sparks or flames from igniting and exploding internal cell gases. *(See Figure 4).*

CAUTION

Before disposing of flexible plastic caps or screw-type shipping caps, neutralize any electrolyte on them in a baking soda - water solution to prevent injury to anyone handling these discarded items.

Electrolyte Withdrawal Tubes

Certain calcium cells are equipped with two electrolyte withdrawal tubes which are installed in the diagonal corners of the cell. These permit the taking of specific gravity readings at a point about one-third from the top of the plates. *(See Section 11.1.)* Refer to Figure 3.

A flexible shipping cap is installed on each withdrawal tube. These may be removed and discarded after neutralizing or left in place as dust covers.

Plastic Numerals *(See Page 15)*
Plastic cell numerals and battery terminal polarity labels are provided for 12-cell batteries of 40 ampere hours and over. These should be installed per instructions included with the numerals. The positive terminal cell is usually designated as cell #1 in the series string

Battery-to-Charger Connection
The positive (+) terminal of the battery should be connected to the positive (+) terminal of the charger and the negative (-) terminal of the battery to the negative (-) terminal of the charger.

SECTION VIII

8.0 INITIAL CHARGE

Batteries lose some charge during shipment as well as during the period prior to installation. The battery should be installed and given its initial charge as soon after receipt as possible. *(See Section 4.0).*

8.1 CONSTANT VOLTAGE METHOD

Constant voltage is the principal method to give the initial charge, as most modern chargers are of the constant voltage design. In addition, some systems have equipment with voltage limitations making the use of constant current charging undesirable.

Determine the maximum voltage that may be applied to the system equipment. This voltage divided by the number of cells connected in series will establish the maximum voltage per cell that may be used.

Establish whether the battery is of lead-antimony, Planté or lead-calcium construction by referring to type on cell name plate and compare this with the cell type listings on pages 14 and 15.

For lead-antimony and Planté types, refer to Table A and for lead-calcium types refer to Table B to obtain various voltages and associated time periods recommended. Select the highest voltage the system will allow, to perform the initial charge in the shortest period of time.

INITIAL CHARGE

Recommended Voltages and Time Periods

TABLE A

Lead-Antimony and Planté Types

Cell Volts	Time-Hrs.
2.24	200
2.27	150
2.30	120
2.33	90
2.36	75
2.39	60

TABLE B

Lead-Calcium Types

Cell Volts	Time-Hrs. 1.215 sp. gr.	Time-Hrs. 1.250 sp. gr.	Time-Hrs. 1.300 sp. gr.
2.24	444	------	------
2.27	333	------	------
2.30	210	------	------
2.33	148	333	------
2.36	100	235	400
2.39	67	160	267
2.42	------	108	182
2.45	------	73	125
2.48	------	------	83

NOTE

Time periods listed in Tables A and B are for cell temperatures from 70°F (21°C) to 90°F (32°C). For temperatures 55°F (13°C) to 69°F (20.5°C) double the number of hours. For temperatures 40°F (4°C) to 54°F (12°C) use four times the number of hours.

The above recommended time periods are considered minimum. Raise the voltage to the maximum value permitted by the system equipment. When charging current has tapered and stabilized (no further reduction for 3 hours), charge for the hours shown in the appropriate table and for the battery temperature, at the time of stabilization, until the lowest cell voltage ceases to rise. Monitoring of cell voltages should be started during the latter 10% of the applicable time period to determine lowest cell in battery.

8.2 CONSTANT CURRENT METHOD

If there is no limitation to the voltage that may be applied to the system equipment, constant current charging may be used for the initial charge. Charge the battery at its finish rate listed in the Tables on pages 14 and 15. Continue to charge at this value until the lowest cell specific gravity remains stable over a 5 hour period. If the ampere charge rate used is below the listed finish rate, increase the 5 hour stable period proportionately. For example, if the charge rate is 1/2 the finish rate, increase the stable period from 5 hours to 10 hours. Where high ambient temperatures prevail, cell temperatures should be monitored so that 110°F (43°C) is not exceeded. A reduction in the charge rate or temporary suspension of the charge should be made to permit cells to cool. Resume charging when cell temperatures are at 90°F (32°C) or below.

8.3 INITIAL CHARGE – ELECTROLYTE LEVELS

During the initial charge, there will be an increase in the electrolyte levels and they may go above the high level mark. *(See Section 3.2)*. This is due to gases, that were lost during transportation or standing in storage, being restored to the cells. Do not remove any electrolyte even though levels may be above high level. When battery is placed on floating charge *(See Section 9.2)*, the electrolyte levels should return close to the high level line.

SECTION IX

9.0 OPERATION

9.1 FLOATING CHARGE METHOD

In this type of operation, the battery is connected in parallel with a constant voltage charger and the critical load circuits. The charger should be capable of maintaining the required constant voltage at battery terminals and also supply a normal connected load where applicable. This will then sustain the battery in a fully charged condition and also make it available to assume the emergency power requirements, in the event of an AC power interruption or charger failure.

9.2 FLOAT CHARGE – FLOAT VOLTAGES

The following are the float voltage ranges recommended for the various types of batteries. Select any "volts per cell" value within the range listed that will result in the series string having an average volts per cell equal to that value. Do not interchange voltage ranges from one type to another.

TABLE C
Recommended Float Voltages

Lead-Antimony Types	2.15 to 2.17 volts per cell
Planté Types	2.17 to 2.19 volts per cell
Lead-Calcium Types:	
Nominal 1.215 sp. gr.	2.17 to 2.25 volts per cell
Nominal 1.250 sp. gr.	2.23 to 2.33 volts per cell
Nominal 1.300 sp. gr.	2.28 to 2.37 volts per cell

Modern constant voltage output charging equipment is recommended for the floating charger method of operation of Gould stationary type batteries. This type of charger, properly adjusted to the recommended float voltages, together with adherence to recommended maintenance procedures, will assist in obtaining consistent serviceability and optimum life.

After the battery has been given its initial charge *(see Section 8.0)*, the charger should be adjusted to provide the recommended float voltage *(see Table C)* at the battery terminals. For example, a 60-cell lead-antimony battery should have 130 volts maintained at its terminals ... 60 cells x 2.17 volts per cell (V.P.C.) = 130 volts.

Do not use float voltages for lead-antimony or Planté types higher than shown in Table C, as excessive water consumption and reduced battery life will result.

Lead-calcium types may be floated at any of the voltage values (Table C) shown for a particular nominal specific gravity. Use the lower V.P.C. value in the appropriate nominal specific gravity group, where system equipment voltage limitations will not permit higher values. The use of higher V.P.C. values may make it unnecessary to give an equalizing charge. However, the use of higher float voltages where high ambient temperatures prevail, may result in reduced battery life.

9.3 VOLTMETER CALIBRATION

Panel and portable voltmeters used to indicate battery float voltages should be accurate at the operating voltage value. The same holds true for portable meters used to read individual cell voltages. These meters should be checked against a standard every six months and calibrated when necessary.

9.4 CYCLE METHOD OF OPERATION

This method is recommended for lead-antimony and Planté type cells only. Lead-calcium cells should not be cycle operated.

In cycle operation, the degree of discharge will vary for various applications. Therefore, the frequency of recharging will also vary. The recharge is conducted by manually starting the charge, generally using the normal finish rate listed on pages 14 and 15. The amount of charge necessary depends on the number of ampere hours discharge. If a shorter recharge period is desired, higher charge rates equal to the eight-hour rate of discharge may be used when the battery is more than 25% discharged and the cell voltage on charge is below 2.33 volts. When the cell voltage reaches 2.33, the charge rate should be reduced to the normal finish charge rate. The charge should be stopped when the specific gravity is ten (.010) points below the normal fully charged value.

The battery is now available for the next discharge requirement. The battery should be given an equalizing charge monthly by continuing the regular charge until there is no increase in specific gravity of the pilot cell for three hours, when using the finish charge rate.

9.5 RECHARGE

All batteries should be recharged as soon as possible following a discharge (within 8 hours). With constant voltage chargers, this will be accomplished automatically. However, to recharge in the shortest period of time, raise the charger output voltage to the highest value which the connected system will permit. Do not exceed those voltage values listed in Table D or Table E on page 10.

SECTION X

10.0 EQUALIZING CHARGE

An equalizing charge is a special charge given a battery when non-uniformity in voltage or specific gravity has developed between cells. It is given to restore all cells to a fully charged condition using a charging voltage higher than the normal float voltage and for a specified number of hours, as determined by the voltage used.

Non-uniformity of cells may result from low floating voltage due to improper adjustment of the charger or a panel voltmeter which reads incorrect (higher) output voltage. Also, variations in cell temperatures greater than 5°F (2.78°C) in the series string at a given time, due to environmental conditions or rack arrangement, can cause low cells.

10.1 EQUALIZING FREQUENCY

The following guidelines cover lead-antimony, Planté and lead-calcium types. Recommendations not applying to all types will be so designated.

A. An equalizing charge should be given quarterly or as required by conditions in the following paragraphs (Note: lead-calcium types at nominal 1.215 sp. gr. floated at 2.20 V.P.C. to 2.25 V.P.C., nominal 1.250 sp. gr. floated at 2.27 V.P.C. to 2.33 V.P.C. and nominal 1.300 sp. gr. floated at 2.31 V.P.C. to 2.37 V.P.C. may not require equalizing charges).

B. Equalize when the temperature corrected specific gravity of the pilot cell (or any cell for the quarterly reading) is more than 10 points below its full charge value. *(See Section 11.2.)*

C. Equalize when the floating voltage of the pilot cell (or any cell for the quarterly reading) is below 2.13 volts (nominal 1.215 sp. gr.), 2.18 volts (nominal 1.250 sp. gr.), and 2.23 volts (nominal 1.300 sp. gr.) or more than .04 volts below the average for the battery.

D. Equalize to complete a recharge of the battery in a minimum length of time following an emergency discharge.

E. If accurate quarterly records are maintained *(See Section 14.0)* and the individual cell voltages and temperature corrected specific gravities show no increase in spread from the previous quarterly readings, equalizing may be deferred. *(See Section 11.2).*

F. Equalize once a year even though preceding conditions did not require. (Lead-calcium types floated per paragraph A, may not require annual equalizing.)

10.2 EQUALIZING CHARGE METHOD

Constant voltage charging is the preferred method for giving an equalizing charge. Determine the maximum voltage that may be applied to the system equipment. This voltage, divided by the number of cells connected in series, will establish the maximum voltage per cell that may be used to perform the equalizing charge in the shortest period of time.

For lead-antimony and Planté types, refer to Table D and for lead-calcium types, refer to Table E to obtain various voltage and associated time periods recommended.

EQUALIZING CHARGE

Recommended Voltages and Time Periods

TABLE D

Lead-Antimony & Planté Types

Cell Volts	Time-Hrs.
2.24	80
2.27	60
2.30	48
2.33	36
2.36	30
2.39	24

TABLE E

Lead-Calcium Types

Cell Volts	Time-Hrs. 1.215 sp. gr.	Time-Hrs. 1.250 sp. gr.	Time-Hrs. 1.300 sp. gr.
2.24	222	....	......
2.27	166	....	......
2.30	105	....	......
2.33	74	166	......
2.36	50	118	200
2.39	34	80	134
2.42	......	54	91
2.45	......	36	62
2.48	......	....	42

NOTE

Time periods listed in Tables D and E are for cell temperatures from 70°F (21°C) to 90°F (32°C). For temperatures 55°F (13°C) to 69°F (20.5°C) double the number of hours. For temperatures 40°F (4°C) to 54°F (12°C) use four times the number of hours.

The above recommended time periods are considered minimum. Raise the voltage to the maximum value permitted by the system equipment. When charging current has tapered and stabilized (no further reduction for 3 hours), charge for the hours shown in the appropriate table and for the battery temperature at the time of stabilization, until the lowest cell voltage ceases to rise. Monitoring of cell voltages should be started during the latter 10% of the applicable time period to determine lowest cell in battery.

SECTION XI

11.0 SPECIFIC GRAVITY

In a lead-acid cell, the electrolyte is a dilute solution of water and sulfuric acid. Specific gravity is a measure of the weight of acid in the electrolyte as compared to an equal volume of water. Therefore, electrolyte with a specific gravity of 1.215 means it is 1.215 times heavier than an equal volume of water which has a specific gravity of 1.000.

11.1 HYDROMETER READINGS

Specific gravity is used in determining a cell's state of charge. It decreases as the cell discharges and increases as the cell is charged; reaching its original value when the cell is fully charged. Specific gravity is expressed to the third decimal place (1.215) and is measured by a hydrometer float enclosed in a glass barrel/rubber bulb syringe. Draw sufficient electrolyte into the barrel, holding the syringe vertical and with no hand pressure on bulb, so that float is freely floating without touching sides or top of syringe.

The gravity is read on the hydrometer scale at the flat surface of the electrolyte. *(See Figure 5).*

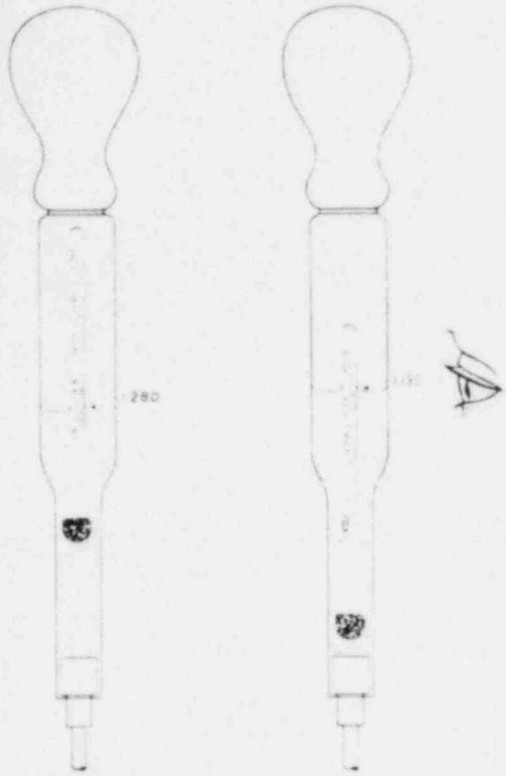

FIGURE 5

Clean the hydrometer glass barrel and float with soap and water as required for ease of reading and float accuracy.

When recharging a lead-calcium cell, the specific gravity reading lags behind the ampere hour input due mainly to the very low end of charge currents. Mixing of the electrolyte is slow due to the small amount of gas generated; so the gravity readings do not reflect the actual state of charge. A similar condition exists after water additions. Therefore, meaningful gravity readings can only be obtained at the top of the cell after an equalizing charge or after six weeks on float.

For this reason, most Gould lead-calcium cells have electrolyte withdrawal tubes to permit sampling of the electrolyte at a point one third down from the top of the plates. A long rubber tip on the hydrometer is inserted into the tube to provide an average value of cell specific gravity and a more accurate indication on the state of charge.

When taking a hydrometer reading, the base of the hydrometer syringe should be pressed firmly against the tube opening to prevent back splash of electrolyte. Fill and empty the hydrometer at least once in each cell before reading. This will give a more accurate reading of the average electrolyte density.

11.2 CORRECTION FOR TEMPERATURE

When taking specific gravity readings, corrections must be made for variations in temperature of the electrolyte. For each 3°F (1.67°C) in temperature of the electrolyte above 77°F (25°C) add one point (.001) in specific gravity to the observed hydrometer readings; and for each 3°F (1.67°C) in temperature below 77°F (25°C) subtract one (.001) in specific gravity from the observed hydrometer reading.

EXAMPLE:

Hydrometer Reading	Cell Temperature	Correction	Reading Corrected to 77°F (25°C)
1.213 sp. gr.	68°F (20°C)	-.003 points =	1.210 sp. gr.
1.207 sp. gr.	86°F (30°C)	+.003 points =	1.210 sp. gr.
1.204 sp. gr.	95°F (35°C)	+.006 points =	1.210 sp. gr.

11.3 CORRECTION FOR ELECTROLYTE LEVEL

The loss of water from the electrolyte due to evaporation as well as conversion of the water to hydrogen and oxygen by charging current; also affects the specific gravity value. For example: A fully charged cell with correct high level at 77°F (25°C) will have a nominal specific gravity of 1.215. When the electrolyte level has been reduced from evaporation and charging by 1/4", the specific gravity will be approximately 6 points (.006) higher or 1.221 @ 77°F (25°C). Therefore, when taking hydrometer readings, the electrolyte level referenced to the high level line should be recorded for proper evaluation of the specific gravity value. This applies when taking a pilot cell reading or for 10% of the cells when taking a quarterly set of readings.

11.4 SPECIFIC GRAVITY RANGE

Gould stationary batteries are furnished with a nominal fully charged specific gravity of 1.215 @ 77°F (25°C).

For special applications, nominal specific gravities such as 1.250 or 1.300 @ 77°F (25°C) may be used.

The specific gravity may range ±.010 points within a battery for any of the nominal values @ 77°F (25°C) with the electrolyte level at the high level line and still be considered satisfactory.

SECTION XII

12.0 CELL VOLTAGE VARIATION

The tabulation below indicates the normal cell voltage variation that may exist with the battery on float and no greater than a 5°F (2.78°C) variation in cell temperature of a series string at any given time.

NORMAL VOLTAGE VARIATION

Type	Float Voltage	Variation
Lead-Antimony	2.15 to 2.17 V.P.C.	±.04 V.P.C.
Planté	2.17 to 2.19 V.P.C.	±.04 V.P.C.
Lead-Calcium		
Nominal 1.215 sp. gr.	2.17 to 2.25 V.P.C.	±.05 V.P.C.
Nominal 1.250 sp. gr.	2.23 to 2.33 V.P.C.	±.05 V.P.C.
Nominal 1.300 sp. gr.	2.28 to 2.37 V.P.C.	±.05 V.P.C.

SECTION XIII

13.0 PILOT CELL

A pilot cell is selected in the series string to reflect the general condition of all cells in the battery regarding specific gravities, float voltage and temperature. It serves as an indicator of battery condition between scheduled overall individual cell readings.

A slight amount of electrolyte may be lost each time a specific gravity reading is taken, even though it is recommended that all electrolyte in the hydrometer be returned to the cell after reading. Therefore, it is suggested that the pilot cell be changed to another cell annually to provide a representative specific gravity indicator for the battery.

SECTION XIV

14.0 RECORDS

A complete recorded history of the battery operation is most desirable and helpful in obtaining satisfactory performance. Good records will also show when corrective action may be required to eliminate possible charging, maintenance or environmental problems.

The following data should be read and permanently recorded for review by supervisory personnel:

A. Upon completion of the initial charge and with the battery floating at the desired float voltage for one week, read and record individual cell voltages, specific gravities (corrected to 77°F(25°C), ambient temperature plus cell temperatures and electrolyte levels for 10% of the cells. The cell temperature readings should be from each step or tier of the rack to reflect temperature range of the battery.

This first set of readings will be the basis for comparison with subsequent readings to reflect possible operating problems and the need for corrective action.

B. Weekly - Pilot cell voltage and also total battery float voltage at battery terminals.

C. Monthly - Pilot cell voltage, specific gravity, temperature and electrolyte level.

D. Quarterly - A complete set of individual cell readings as recommended in "A" above.

E. Any time the battery is given an equalizing charge *(see Section 10.1)*, an additional set of individual cell readings should be taken after battery has been returned to normal float for one week. These will serve as an updated basis for comparison with future readings.

F. Record dates of any equalizing charges as well as total quantity of water when added. Also record any maintenance and/or testing performed.

The foregoing suggested frequency of record taking may have to be modified somewhat to suit local requirements.

See Page 15 for Battery nameplate

SECTION XV

15.0 WATER ADDITIONS

There are two conditions in the operation of batteries which cause a reduction in the amount of water in the electrolyte, resulting in a lowering of the electrolyte level. These are normal evaporation and the conversion of water into hydrogen and oxygen gases by the charging current. These gases are liberated through the cell vents. Periodically, this water loss must

be replaced with approved or distilled water to maintain the electrolyte level between the high and low level lines.

If suitability of the local water supply for use in storage batteries is questionable, contact your nearest Gould representative for instructions regarding procedure for submitting a sample for analysis. A report will be rendered as to whether or not the water is suitable.

If water is to be stored in containers, they should be clean and of non-metallic material; such as: glass, hard rubber, porcelain or plastic.

Infrequently used water lines should be purged to remove accumulated impurities; thus preventing their introduction into the battery.

Water additions should be scheduled prior to an equalizing charge so that mixing with the electrolyte occurs. Also at unheated installations, arrange water additions when battery temperature is above 50°F (10°C).

Never introduce "battery additives" into a Gould battery.

SECTION XVI

16.0 TAP CONNECTIONS

It is not recommended that tap connections be used on a battery, as possible unbalance between the groups of cells may result. This can cause overcharging of the untapped group of cells and undercharging of the tapped cells supplying the load. This condition can cause unsatisfactory operation and reduced battery life.

SECTION XVII

17.0 TEMPORARY NONUSE

An installed battery that is permitted to stand idle for a period of time should be treated in the following manner. With the battery on normal float, add approved water to cells to bring electrolyte level to the high level line. Give the battery an equalizing charge per Section 10.2. Following completion of the equalizing charge, open connections at the battery terminals to separate charger and load circuit from battery.

Every three months, temporarily connect battery to charger and give it an equalizing charge.

To return to normal service, re-connect all open connections, give equalizing charge and then return battery to normal float voltage.

SECTION XVIII

18.0 BATTERY CLEANING

Periodically, clean cell jars and covers with a water dampened cloth to remove accumulated dust. Cell parts damp with electrolyte should be neutralized with a baking soda - water solution (1 lb. of soda per gallon of water). Apply with cloth dampened with the solution, making sure none is allowed to enter the cell. Continue to neutralize until fizzing action ceases, then wipe area with a water dampened cloth to remove soda solution. Wipe dry with a clean cloth.

CAUTION:

Do not clean plastic cell jars or covers with solvents, detergents, oils or spray type cleaners, as these materials may cause crazing and cracking of the plastic materials.

SECTION XIX

19.0 CONNECTIONS

Battery terminal and intercell connections should be corrosion free and tight to provide satisfactory operation while on float charging or when supplying emergency power. Periodically, these connections should be inspected. For proper removal of corrosion, disconnect the connections involved. Where circuit continuity must be maintained, use temporary flexible cables, of adequate current carrying capability, as parallel connections. Remove corrosion by neutralizing with a baking soda - water solution. Gently clean the affected area using a suede brush or #00 grade sandpaper. Apply a thin coating of No-Ox-Id "A" grease to the cleaned contact surfaces and re-establish connection. Reinstalled terminal hardware should be torqued to values in Section 7.7 (Connecting Cells). Annually, all terminal and intercell connections should be re-torqued per Section 7.7.

BATTERY TYPES*

LEAD-ANTIMONY CELL TYPE	8 HR. A. H.	ELECTRO-LYTE GALS. PER CELL	SPECIFIC GRAVITY RANGE**	LEAD-CALCIUM CELL TYPE	LEAD-ANTIMONY CELL TYPE	8 HR. A. H.	ELECTRO-LYTE GALS. PER CELL	SPECIFIC GRAVITY RANGE**	LEAD-CALCIUM CELL TYPE
AS-5	10	0.09	55	–	–	1200	6.6	80	FTC-21
2 AS-5	10	0.09	55	–	–	1320	6.5	90	FTC-23
3 AT-5	10	0.08	67	–	–	1440	6.4	95	FTC-25
2, or 3 BS-5	15	0.115	80	–	–	1560	8.3	85	FTC-27
2 BS-9	30	0.25	80	–	–	1680	8.2	90	FTC-29
3 BT-7	30	0.16	90	–	–	1800	8.2	95	FTCS-29
2, or 3 CS-7	50	0.32	85	–	2 MAX-170	170	1.3	75	2MCX-170
2, or 3 CSO-7	50	0.32	85	–	2 MAX-190	190	1.3	85	2MCX-190
2, or 3 CS-13	100	0.54	95	–	2 MAX-255	255	1.2	100	2MCX-255
2, or 3 CSO-13	100	0.54	95	–	MAX-285	285	1.7	80	MCX-285
2, or 3 DS-5	50	0.29	100	2, or 3 DSC-5	MAX-340	340	1.6	100	MCX-340
2, or 3 DSO-5	50	0.29	100	2, or 3 DSCO-5	MAX-380	380	2.1	90	MCX-380
2, or 3 DS-7	75	0.40	100	2, or 3 DSC-7	MAX-425	425	1.9	105	MCX-425
2, or 3 DSO-7	75	0.40	100	2, or 3 DSCO-7	MAX-475	475	2.8	110	MCX-475
2, or 3 DS-9	100	0.50	100	2, or 3 DSC-9	MAX-510	510	2.7	105	MCX-510
2, or 3 DSO-9	100	0.50	100	2, or 3 DSCO-9	MAX-595	595	2.7	120	MCX-595
DKR-5	50	0.34	85	DC-5	NAX-600	600	6.0	65	NCX-600
DKR-7	75	0.64	75	DC-7	NAX-672	672	6.0	60	NCX-672
DKR-9	100	0.59	95	DC-9	NAX-750	750	5.5	85	NCX-750
DKR-11	125	0.90	80	DC-11	NAX-840	840	5.6	80	NCX-840
DKR-13	150	0.86	105	DC-13	NAX-900	900	5.1	105	NCX-900
DKR-15	175	1.00	95	DC-15	NAX-1008	1008	5.1	100	NCX-1008
EKR-11	200	1.7	55	EC-11	NAX-1050	1050	4.9	125	NCX-1050
EKR-13	240	1.6	80	EC-13	NAX-1200	1200	5.0	150	NCX-1200
EKR-15	280	1.5	100	EC-15	NAX-1344	1344	6.8	100	NCX-1344
EKR-17	320	1.8	100	EC-17	NAX-1350	1350	6.3	100	NCX-1350
EKR-19	360	2.3	85	EC-19	NAX-1500	1500	6.0	120	NCX-1500
EKR-21	400	2.2	95	EC-21	NAX-1650	1650	8.0	90	NCX-1650
EKR-23	440	2.7	90	EC-23	NAX-1680	1680	8.3	100	NCX-1680
EKR-25	480	2.6	100	EC-25	NAX-1800	1800	7.6	115	NCX-1800
EKR-27	520	3.1	90	EC-27	NAX-1848	1848	12.6	80	NCX-1848
EKR-29	560	3.0	100	EC-29	NAX-1950	1950	7.3	150	NCX-1950
FKS-17	626	3.6	90	FCS-17	NAX-2016	2016	12.1	90	NCX-2016
FKS-19	704	3.4	105	FCS-19	NAX-2100	2100	11.5	105	NCX-2100
FKS-21	782	4.9	90	FCS-21	NAX-2184	2184	11.5	100	NCX-2184
FKS-23	860	4.8	105	FCS-23	NAX-2250	2250	10.9	115	NCX-2250
FKS-25	938	6.7	90	FCS-25	NAX-2400	2400	10.3	130	NCX-2400
FKS-27	1017	6.5	100	FCS-27	NAX-2550	2550	9.7	150	NCX-2550
FKS-29	1095	6.3	105	FCS-29	PLANTE TYPE CELLS				
FKS-31	1173	6.1	110	FCS-31	2, or 3 CPE-3	8	0.12	50	–
2, or 3 ETA-5	120	1.3	45	2, or 3 ETC-5	2, or 3 CPE-5	16	0.115	90	–
2, or 3 ETA-7	180	1.2	80	2, or 3 ETC-7	2, or 3 CPE-7	24	0.171	85	–
ETA-9	240	1.7	75	ETC-9	DPR-5	40	0.35	85	–
ETA-11	300	2.0	75	ETC-11	DPR-7	60	0.65	65	–
ETA-13	360	2.9	60	ETC-13	DPR-9	80	0.64	100	–
ETA-15	420	2.7	75	ETC-15	DPR-11	100	0.90	90	–
ETA-17	480	3.5	65	ETC-17	DPR-13	120	1.01	90	–
ETA-19	540	3.4	75	ETC-19	DPR-15	140	1.27	85	–
ETA-21	600	4.2	75	ETC-21	DPR-17	160	1.17	90	–
ETA-23	660	4.1	75	ETC-23	EPR-9	160	1.8	45	–
FTA-13	720	4.6	75	–	EPR-11	200	1.7	75	–
FTA-15	840	4.2	85	–	EPR-13	240	1.6	110	–
FTA-17	960	5.6	80	–	EPR-15	280	1.8	115	–
FTA-19	1080	5.3	90	–	EPR-17	320	2.5	95	–
FTA-21	1200	6.8	80	–	EPR-19	360	2.4	115	–
FTA-23	1320	6.5	90	–	FPS-11	415	5.2	75	–
FTA-27	1560	8.3	85	–	FPS-13	498	4.6	90	–
FTA-29	1680	8.2	90	–	FPS-15	581	4.0	105	–
FTAS-29	1800	8.2	95	–	FPS-17	664	3.7	120	–
–	720	4.0	75	FTC-13	FPS-19	747	5.5	90	–
–	840	3.9	85	FTC-15	FPS-21	830	4.9	100	–
–	960	5.5	80	FTC-17	FPS-23	913	6.4	100	–
–	1080	5.4	90	FTC-19	FPS-25	996	6.1	110	–

* Refer to Paragraph 8.2 for use of these tables.

**Specific gravity range applies to an 8 hour capacity discharge.

INSTRUCTIONS

STATIONARY POWER BATTERY
PLASTIC CELL NUMERAL APPLICATION

To insure proper adhesion of the pressure sensitive plastic cell numerals, and polarity markings supplied with your Gould Stationary Power Battery, the following procedure should be followed:

1. Numerals and polarity markings should not be applied until after the cells have been installed on the rack. It is recommended that they be applied to jar surfaces only, and not to cell covers or rack rails.

2. Clean the plastic jar surface, in the area where numeral is to be located, by using a cloth dampened with a washing soda solution. Immediately dry the area using a soft dry cloth to remove residual washing soda. CAUTION!! Do not use any solvent type materials as they may cause damage to the plastic jar material.

3. It is a general practice to designate the positive terminal cell as #1 with succeeding cells in series in ascending order.

4. Numerals are shipped mounted on a plastic backing strip. They are easily removed by peeling back the plastic strip. Keep finger contact with adhesive backing on numeral to a minimum.

5. Locate and place numeral on side of jar, being careful that there is no conflict with electrolyte level lines or side rails of SEISMIC TYPE RACKS. For clean appearance, exercise care in numeral placement so that all numerals are in the same relative position on each cell.

Install polarity markings on the appropriate cells in the same manner.

6. Following application of cell numerals and polarity markings use a dry cloth to rub entire surface of each label to insure proper surface contact.

TYPICAL BATTERY NAMEPLATE

GOULD

NO. OF CELLS ____________ TYPE ____________ SERIAL NO. ____________

CAPACITY ____________ AMPERE HRS. AT ____________ HR. RATE

SPECIFIC GRAVITY ________________________

GOULD INC., INDUSTRIAL BATTERY DIVISION, LANGHORNE, PA. 19047

ROI-041921

Gould Inc., Industrial Battery Division
2050 Cabot Boulevard West, Langhorne, Pa. 19047
Telephone (215) 752-0555

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GOULD
Electronics & Electrical Products

SECTION #11

DYNAMIC CELL ANALYSIS

As described in this report, a battery three plate model was established using intermediate plates as mass points on the double cantilever beam. The busbar is treated as a center point of the cantilever. This model was analyzed using strudel software programming.

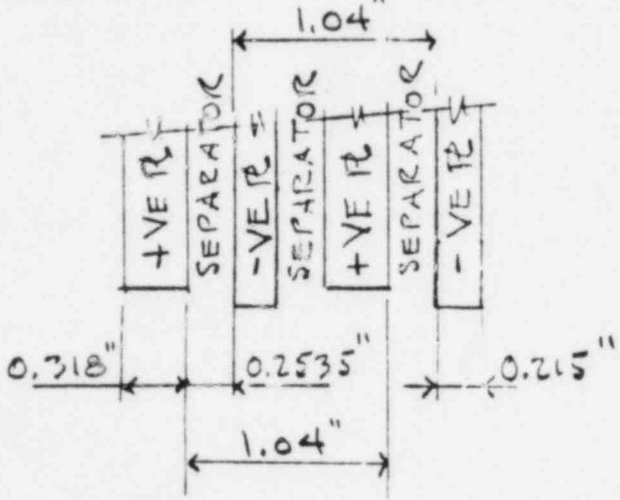
It was determined that the NCX-1680 cell has a first mode at 92.89 hz whereas the NCX-2550's first mode occurred at 105.11 hz. This analysis establishes that the NCX-1680 and NCX-2550 are similar in behavior as far as vibration is concerned.

As established in the other portion of this report, NCX-1680 and NCX-2550 are similar in design and also have the same materials for their component parts. The NCX-1680 weighs 332 lbs. whereas NCX-2550 weighs 496 lbs. The difference is due to the number of plates used in both designs. NCX-1680 uses 21 plates whereas NCX-2550 uses 35 plates.

REPORT ON THE MATHEMATICAL DETERMINATION OF THE LOWEST NATURAL FREQUENCY OF THE INTERNAL ELEMENT OF GOULD BATTERIES NCX/NAX-1680 AND NCX/NAX-2550

CONSTRUCTION OF THE NCX/NAX-1680 BATTERY:

THIS BATTERY CONSISTS OF 10 POSITIVE PLATES AND 11 NEGATIVE PLATES ARRANGED ALTERNATELY AS FOLLOWS:



FOR PLATE DETAILS REFER TO GOULD DRAWINGS:

105722-C-001, POSITIVE GRID
105723-C NEGATIVE GRID

THE NEGATIVE PLATES REST ON THE BOTTOM OF THE BATTERY CASING AT TWO POINTS AND ARE INTERCONNECTED TO EACH OTHER AT THE TOP BY A COMMON TERMINAL BAR

THE POSITIVE PLATES ARE SUPPORTED AT THE TOP AT TWO POINTS BY PLASTIC RODS AND ANGLES THAT IN TURN REST ON THE TOP OF THE NEGATIVE PLATES. EACH POSITIVE PLATE IS ALSO SUPPORTED AT THE TOP BY A COMMON TERMINAL BAR.

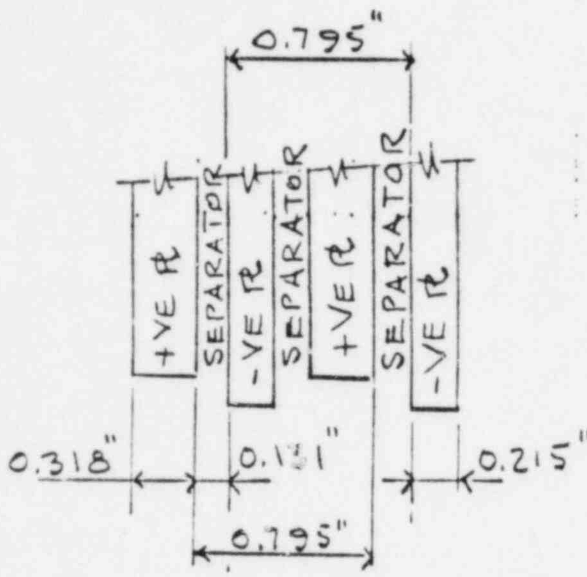
THE PLATES ARE CONSIDERED INFINITELY RIGID IN THE PERPENDICULAR PLANE BY VIRTUE OF THE TIGHTLY PACKED SEPARATORS. FOR DRAWINGS OF PARTS AND ASSEMBLY REFER TO GOULD DRAWINGS:

105792-B TERMINAL POST (POS)
105853-A PLATE SUPPORT ROD
106238-D CELL ASSEMBLY
106303-C PLATE SUPPORT (ANGLE)

A.C.D. 6-10-82 SH #2

CONSTRUCTION OF THE NCX/NAX-2550 BATTERY: JOB 8

THIS BATTERY IS SIMILAR TO THE 1680 BATTERY EXCEPT THAT IT CONSISTS OF 17 POSITIVE PLATES AND 18 NEGATIV PLATES ARRANGED ALTERNATELY AS FOLLOWS:



FOR PLATE DETAILS REFER TO GOULD DRAWINGS

105722-C-001, POSITIVE GRI
105723-C NEGATIVE GR

FOR DRAWINGS OF PARTS AND ASSEMBLY REFER TO GOULD DRAWINGS:

105853-A PLATE SUPPORT ROD
106302-D CELL SECTION
106303-C PLATE SUPPORT (ANGLE)
107123-D POSITIVE BUS BAR

MATERIAL PROPERTIES COMMON TO BOTH BATTERIES:

LEAD-CALCIUM UNIT WGT. = 691.2 #/FT³; SUBMERGED DENSITY = 615.4 #/
E = 2×10⁶ P.S.I.; POISSON'S RATIO = 0.4

PLASTIC ROD UNIT WGT. = 71.8 #/FT³; SUBMERGED DENSITY = 0
E = 0.5×10⁶ P.S.I.; POISSON'S RATIO = 0.42

PLASTIC PLATE UNIT WGT. = 44 #/FT³; SUBMERGED DENSITY = 0
E = 0.32×10⁶ P.S.I.; POISSON'S RATIO = 0.42

ELECTROLYTE SPECIFIC GRAVITY = 1.215

DEVELOPMENT OF STRUCTURAL MODELS REPRESENTING THE INTERNAL ELEMENTS OF EACH BATTERY.

NATURAL FREQUENCY IS DIRECTLY RELATED TO THE ELEMENT STIFFNESS. THE STIFFER THE ELEMENT IS, THE HIGHER THE NATURAL FREQUENCY WILL BE. COMPARING THE NEGATIVE PLATES WITH THE POSITIVE PLATES SUPPORT SYSTEM IT IS EVIDENT THAT THE NEGATIVE PLATES HAVE A STIFFER SUPPORT CONDITION. SINCE WE ARE INTERESTED IN THE ELEMENTS WITH THE LOWEST NATURAL FREQUENCY, ONLY THE POSITIVE PLATES WERE INVESTIGATED. ALL SOLUTIONS UTILIZED COMPUTER DYNAMIC ANALYSIS OFFERED BY GT STRUDL PROGRAMMING.

EACH POSITIVE PLATE IS SUPPORTED AT THE TOP AT THREE POINTS; AT EACH END BY THE PLASTIC ROD AND PLATE ANGLE REPRESENTING TWO SUPPORTS, THE THIRD SUPPORT BEING TH BUS BAR LOCATED NEAR ONE END SUPPORT POINT.

THE PRINCIPAL FEATURES OF THE STRUCTURAL MODEL ARE AS FOLLOWS:

1. EACH POSITIVE PLATE IS FABRICATED FROM LEAD IN A GRID PATTERN. TO SIMPLIFY OUR ANALYSIS WE CREATED AN IDEALIZED FRAME BY MAINTAINING THE GRID WEIGHT AS A CONSTANT. THE WET PASTE THAT IS ADDED TO THE GRID WAS CONSIDERED AS MASS ONLY AND NOT CONTRIBUTING TO RIGIDITY. ALL POSITIVE PLATES ARE IDENTICAL IN SIZE, SHAPE AND WEIGHT FOR BOTH BATTERIES.

2. ONLY TWO SUPPORTS WERE CONSIDERED ACTING FOR EACH POSITIVE PLATE AS A CONSERVATIVE ASSUMPTIO ONE AT THE BUS BAR AND THE SECOND AT THE THE MOST DISTANT PLASTIC ROD LOCATION.

3. EACH BATTERY MODEL CONSISTED OF 3 FULL POSITIVE PLATE POSITIONED AT THE MOST FLEXIBLE LOCATIONS IN ORDER TO CONTROL COMPUTER DYNAMIC ANALYSIS WITH

REASONABLE LIMITS. THE BUS BAR OF BOTH BATTERIES ARE SINGLE SPAN, DOUBLE CANTILEVER MEMBERS. FULL PLATES WERE PLACED AT THE ENDS OF EACH CANTILEVER AND THE THIRD FULL PLATE WAS POSITION[ED] AT MID-SPAN (BETWEEN TERMINALS) OF THE BUS BA[R]. SINCE THE 1680 BATTERY HAS AN EVEN NUMBER OF PLATE[S] BETWEEN TERMINALS, THE POSITIVE PLATE NEAREST MI[D]SPAN POSITION WAS CONSIDERED. THE REMAINING POSITIVE PLATES FOR EACH BATTERY WAS ASSUMED AS MASS CONCENTRATIONS ALONG RESPECTIVE BUS BAR AND PLASTIC ROD LOCATIONS.

RESULTS OF DYNAMIC ANALYSIS OF STRUDL PROGRAMMING

LOWEST NATURAL FREQUENCY OF:

NCX-1680 BATTERY = 92.8 CYCLES/SEC.

NCX-2550 BATTERY = 105.1 CYCLES/SEC.

CONCLUSION:

THE RIGIDITY OF THE NCX-2550 BATTERY IS GREATER THAN THE RIGIDITY OF THE NCX-1680 BATTERY.

I.J.P. 6-10-82

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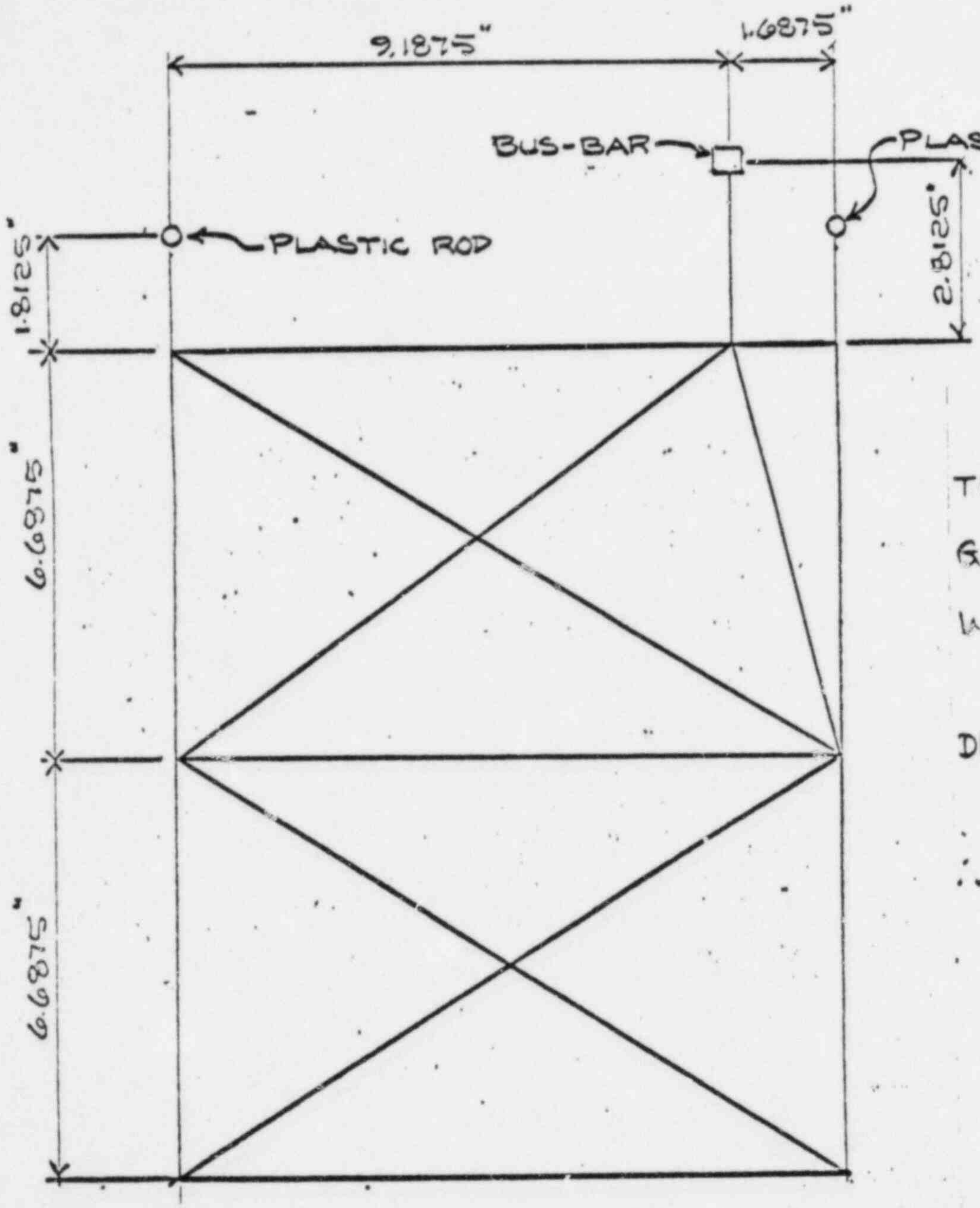
MODEL OF POSITIVE PLATES



THICKNESS OF +VE GRID = 0.318"

WGT. OF +VE GRID = 5.9 #

DESITY OF LEAD = 0.4 #/IN^3

∴ VOL. OF GRID = $\frac{5.9}{.4}$ = 14.75 IN^3

PROPERTIES OF MEMBERS:

TOTAL LENGTH OF ALL MEMBERS = 2x15.1875 + 4x12.77 + 3x10.9 = 114"

TOTAL VOL. OF ALL MEMBERS = 14.75 IN^3

∴ CROSS SECTIONAL AREA OF MEMBERS = $\frac{14.75}{114}$ = 0.13 IN^2

∴ EQUIVALENT WIDTH OF MEMBERS = 0.13/0.318 = 0.41 IN

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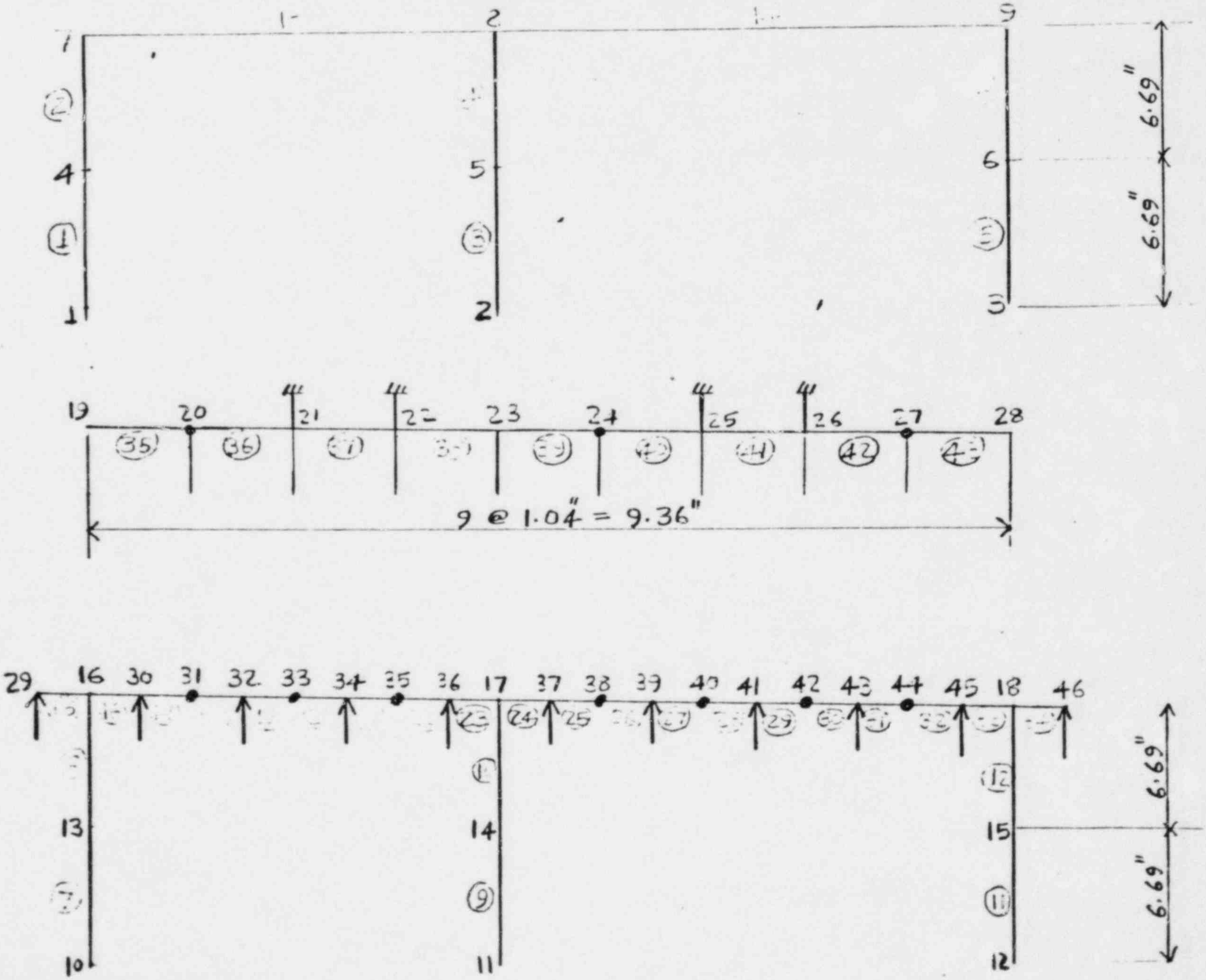

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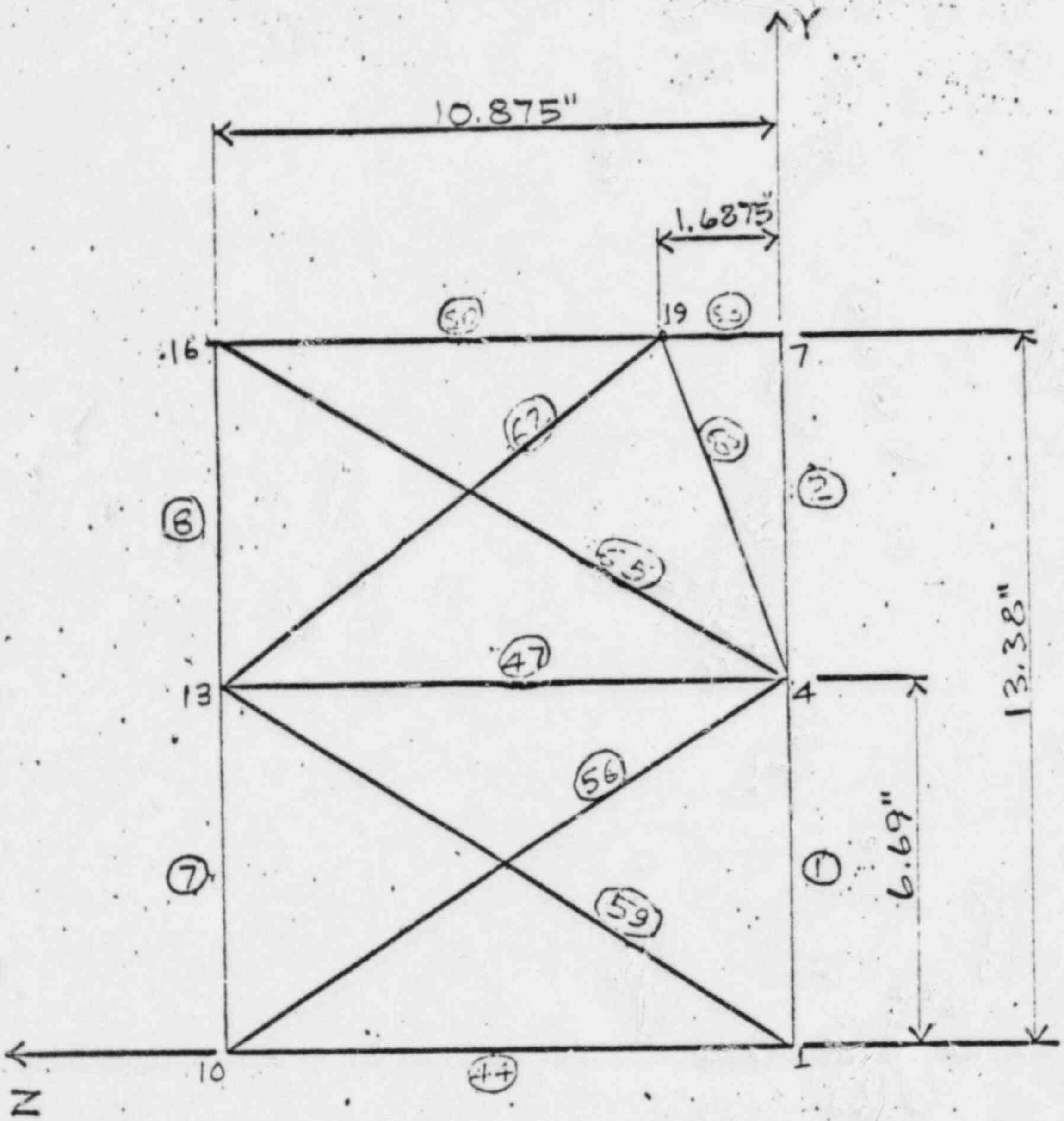

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SHEET # 5
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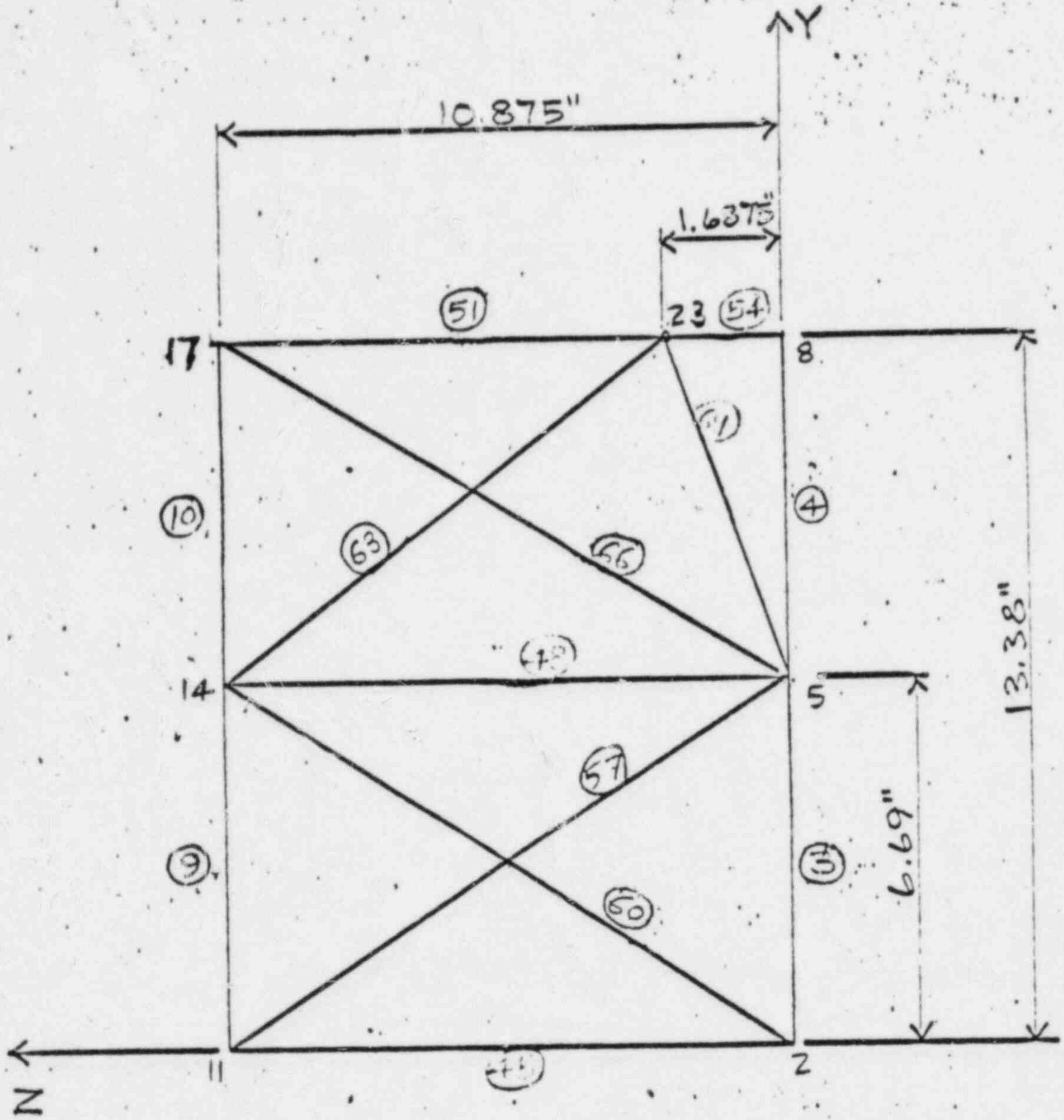

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SHEET# 9
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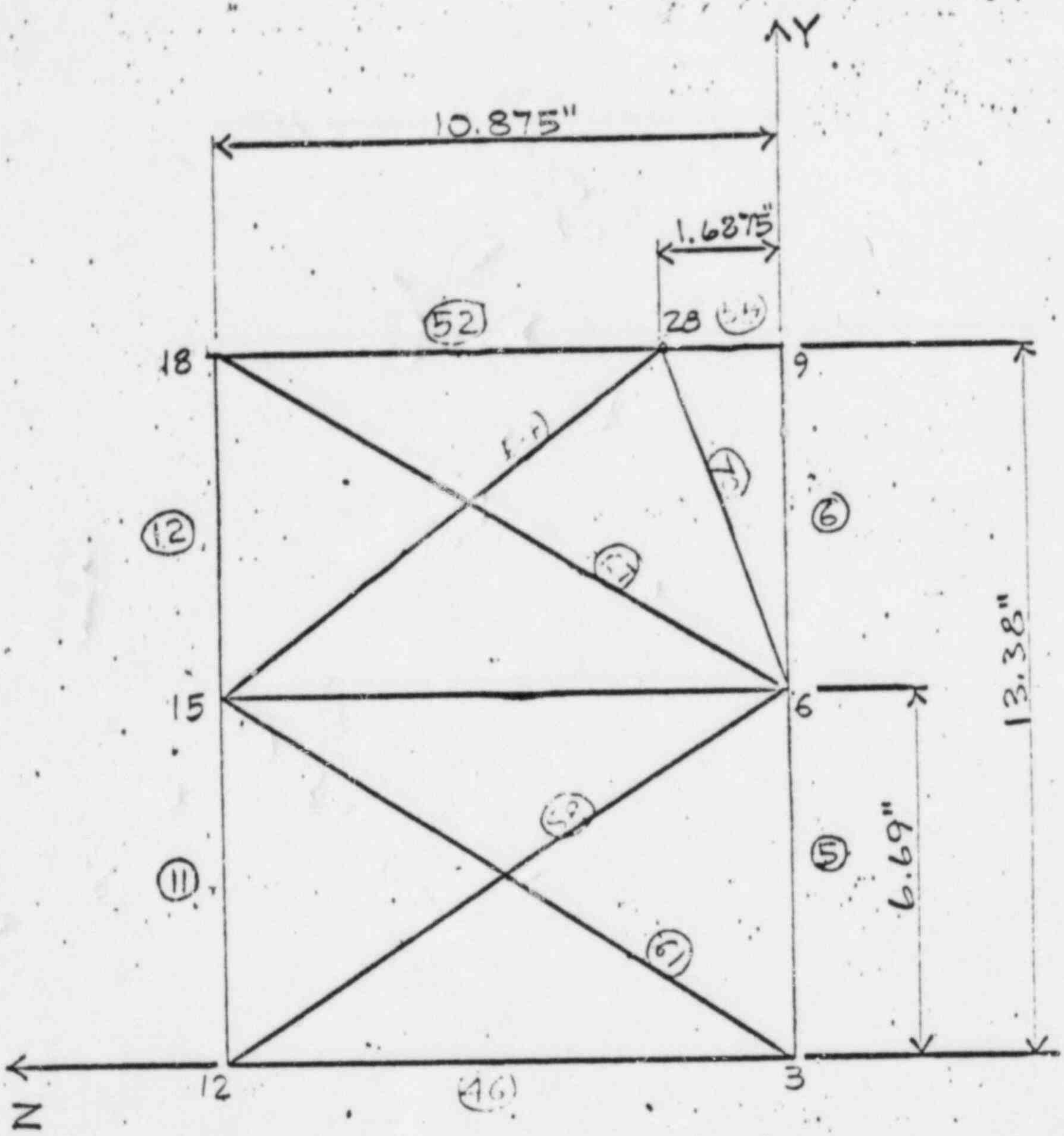

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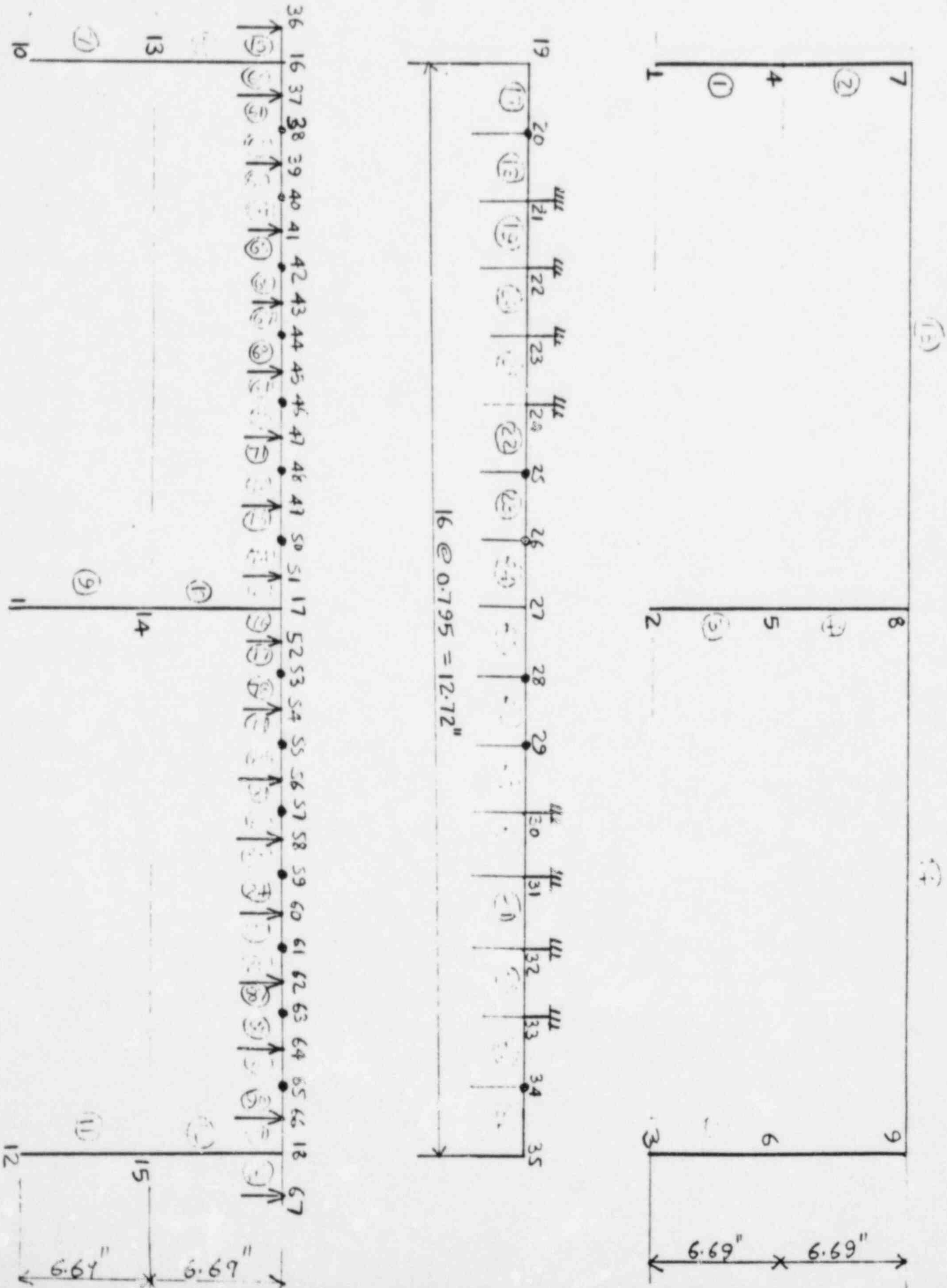

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SHEET # 11
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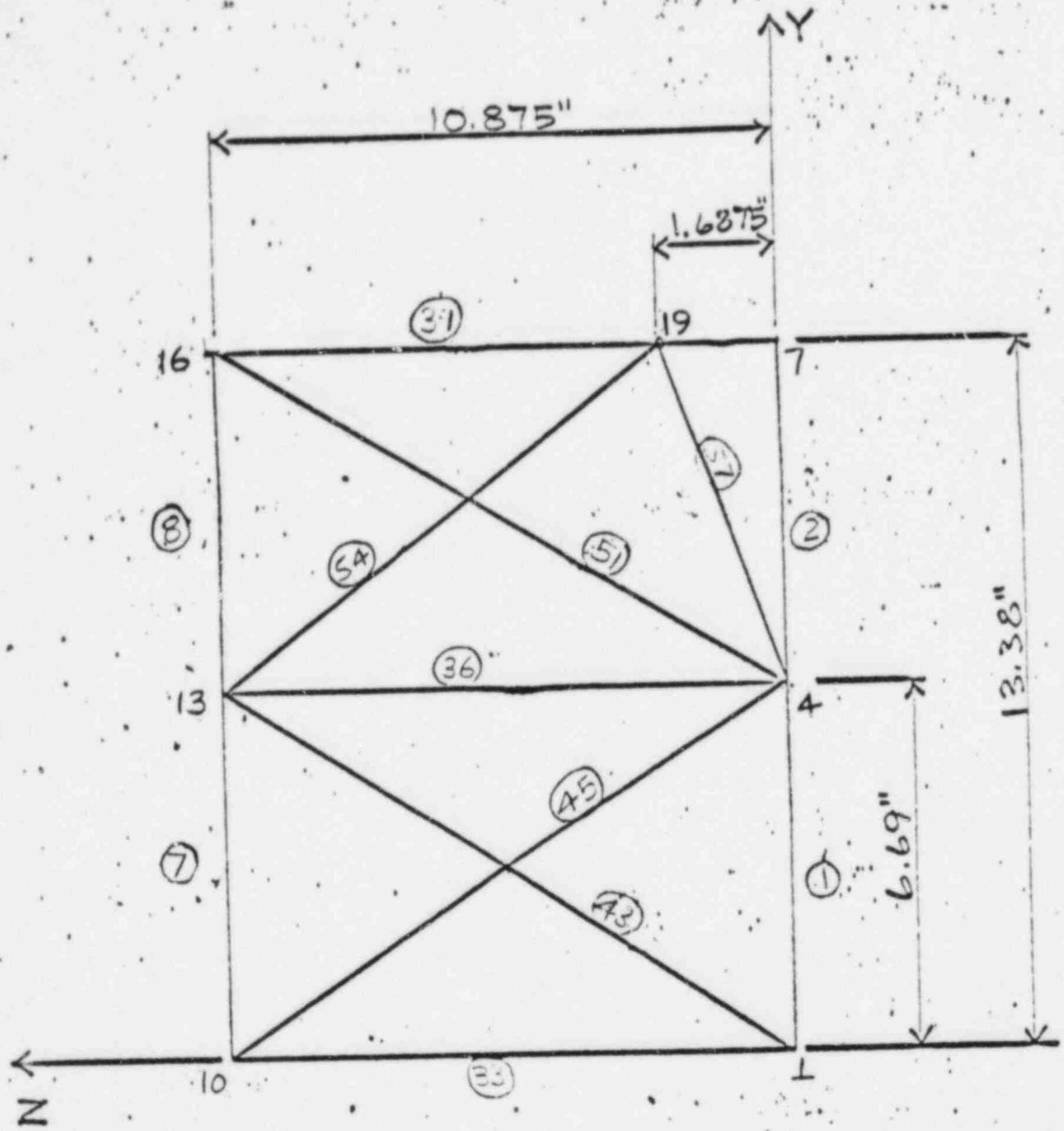

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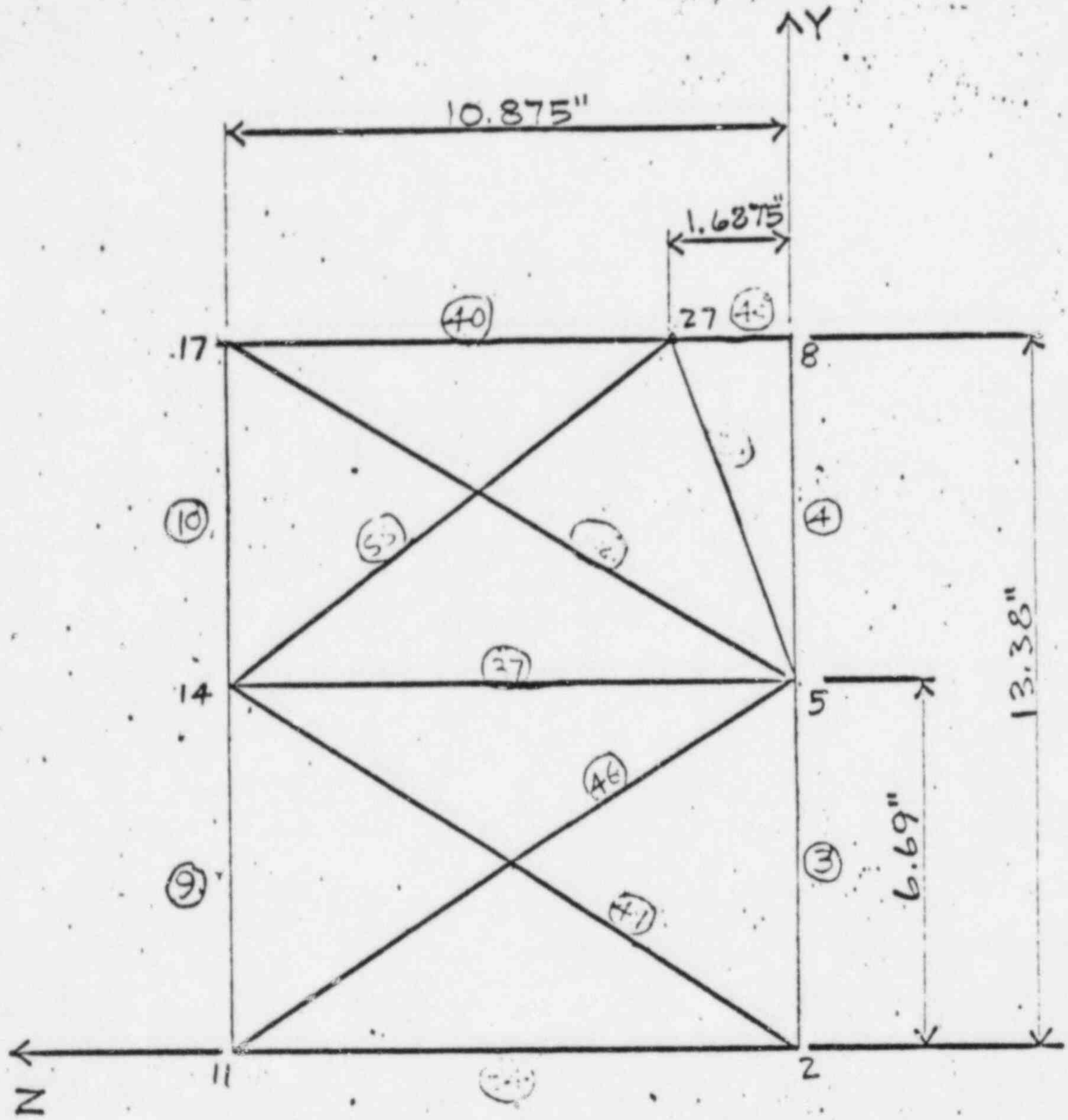
SHEET # 12

JOB 890



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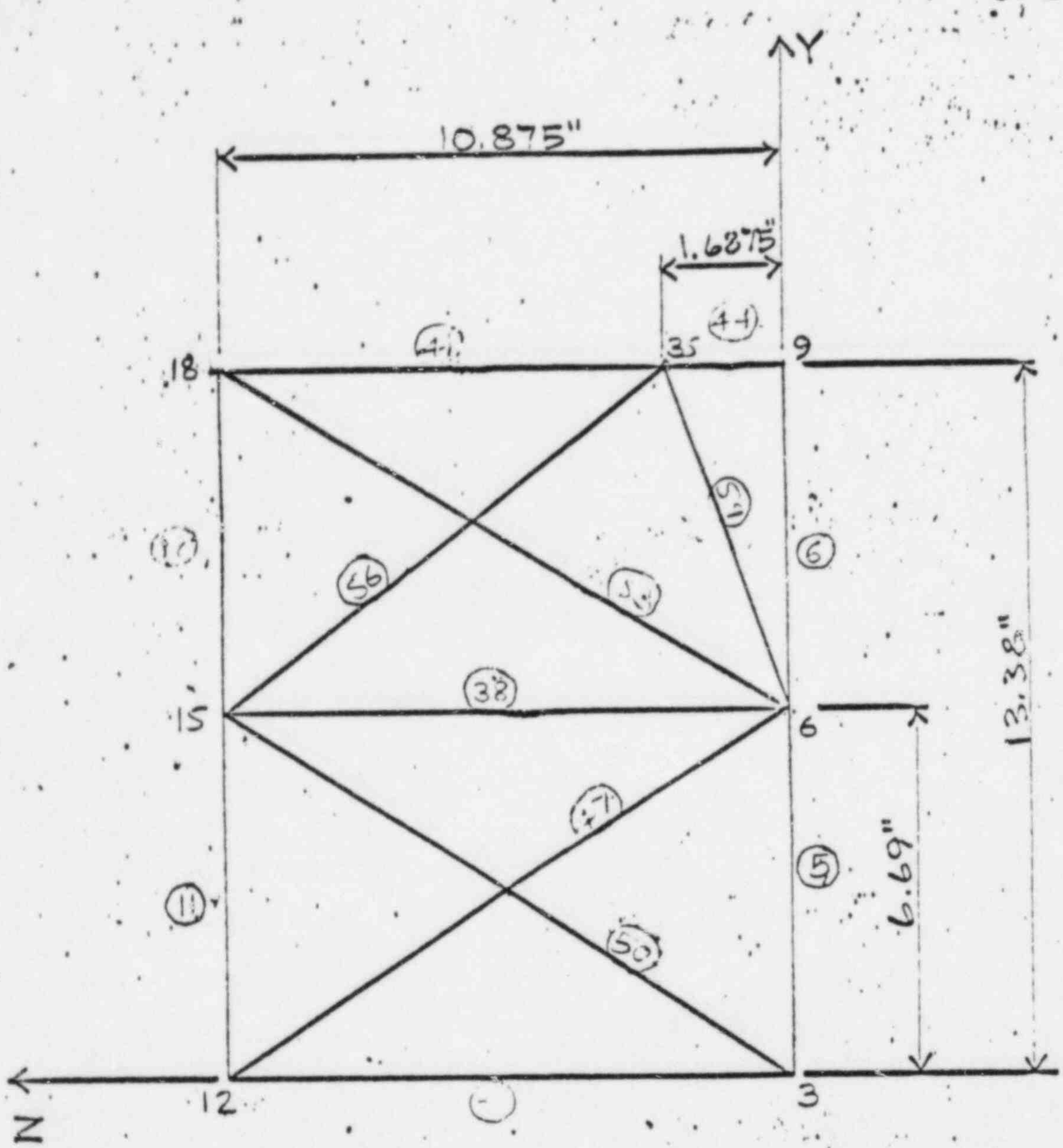
SHEET # 13 OF #
JOB 890



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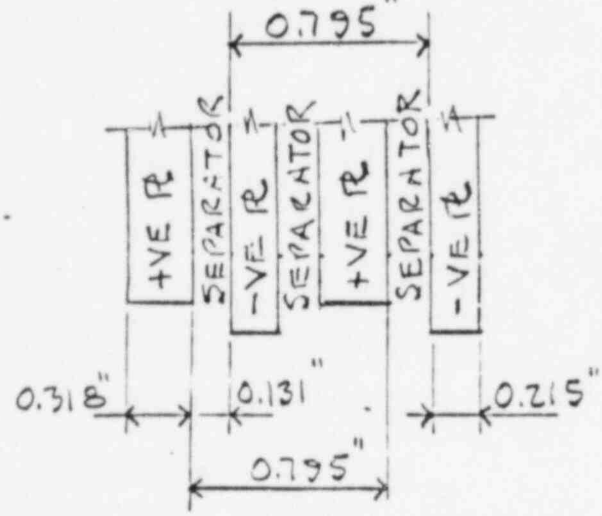
SHEET #1 OF

JOB 890

REPORT ON THE MATHEMATICAL DETERMINATION OF THE LOWEST NATURAL FREQUENCY OF THE INTERNAL ELEMENTS OF GOULD BATTERY NCX/NAX-600.

CONSTRUCTION OF THE NCX/NAX-600 BATTERY:



FOR PLATE DETAILS REFER TO GOULD DRAWINGS:

105722-C-001, POSITIVE GR
105723-C NEGATIVE G

THIS BATTERY CONSISTS OF 4 POSITIVE PLATES AND 5 NEGATIVE PLATES ARRANGED ALTERNATELY AS SHOWN ABOVE.

THE NEGATIVE PLATES REST ON THE BOTTOM OF THE BATTERY CASING AT TWO POINTS AND ARE INTERCONNECTED TO EACH OTHER AT THE TOP BY A COMMON TERMINAL BAR.

THE POSITIVE PLATES ARE SUPPORTED AT THE TOP AT TWO POINTS BY PLASTIC RODS AND ANGLES THAT IN TURN REST ON THE TOP OF THE NEGATIVE PLATES. EACH POSITIVE PLATE IS ALSO SUPPORTED AT THE TOP BY A COMMON TERMINAL BAR.

THE PLATES ARE CONSIDERED INFINITELY RIGID IN THE PERPENDICULAR PLANE BY VIRTUE OF THE TIGHTLY PACKED SEPARATORS. FOR DRAWINGS OF PARTS AND ASSEMBLY REFER TO GOULD DRAWINGS:

105853-A PLATE SUPPORT ROD
106303-C PLATE SUPPORT (ANGLE)
107006-D SECTIONAL ASSEMBL
107121-C POSITIVE BUS BAR

MATERIAL PROPERTIES:

LEAD-CALCIUM UNIT WGT = 691.2 #/FT^3; SUBMERGED DENSITY = 615.4
E = 2x10^6 P.S.I.; POISSON'S RATIO = 0.4

PLASTIC ROD UNIT WGT. = 71.8 #/FT^3; SUBMERGED DENSITY = 0
E = 0.5x10^6 P.S.I.; POISSON'S RATIO = 0.42

PLASTIC PLATE UNIT WGT = 44 #/FT^3; SUBMERGED DENSITY = 0
E = 0.32x10^6 P.S.I.; POISSON'S RATIO = 0.42

ELECTROLYTE SPECIFIC GRAVITY = 1.215

DEVELOPMENT OF STRUCTURAL MODEL REPRESENTING THE INTERNAL ELEMENTS OF THE BATTERY:

NATURAL FREQUENCY IS DIRECTLY RELATED TO THE ELEMENT STIFFNESS. THE STIFFER THE ELEMENT IS, THE HIGHER THE NATURAL FREQUENCY WILL BE. COMPARING THE NEGATIVE PLATES WITH THE POSITIVE PLATES SUPPORT SYSTEM IT IS EVIDENT THAT THE NEGATIVE PLATES HAVE A STIFFER SUPPORT CONDITION. SINCE WE ARE INTERESTED IN THE ELEMENTS WITH THE LOWEST NATURAL FREQUENCY, ONLY T POSITIVE PLATES WERE INVESTIGATED. THE SOLUTION UTILIZES COMPUTER DYNAMIC ANALYSIS OFFERED BY GT STRUDL PROGRAMMING.

THE PRINCIPAL FEATURES OF THE STRUCTURAL MODEL ARE AS FOLLOWS:

1. EACH POSITIVE PLATE IS FABRICATED FROM LEAD IN A GRID PATTERN. TO SIMPLIFY OUR ANALYSIS WE CREATED AN IDEALIZED FRAME BY MAINTAINING THE GRIC WEIGHT AS A CONSTANT. THE WET PASTE THAT IS ADDED TO THE GRID WAS CONSIDERED AS MASS ONLY AND NOT CONTRIBUTING TO RIGIDITY. THE POSITIVE PLATES FOR THI BATTERY ARE IDENTICAL IN SIZE, SHAPE AND WEIGHT T

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JOB 890

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ALL THE N-LINE BATTERY CELLS.

ONLY TWO SUPPORTS WERE CONSIDERED ACTING FOR EACH POSITIVE PLATE AS A CONSERVATIVE ASSUMPTION; ONE AT THE BUS BAR AND THE SECOND AT THE MOST DISTANT PLASTIC ROD LOCATION.

THE BATTERY MODEL CONSISTS OF 3 FULL POSITIVE PLATES. TWO ARE POSITIONED AT THE EXTREME ENDS OF THE BUS BAR AND ONE AT AN INTERIOR LOCATION. THE REMAINING POSITIVE PLATE WAS ASSUMED AS A MASS CONCENTRATION ALONG RESPECTIVE BUS BAR AND PLASTIC ROD LOCATIONS. THE PRIMARY REASON FOR MODELING 3 FULL POSITIVE PLATES FOR THIS BATTERY IS TO MATCH THE SELECTED MATHEMATICAL MODEL OF THE 1680 AND 2550 BATTERIES SO THAT A CREDITABLE COMPARISON COULD BE MADE.

RESULTS OF DYNAMIC ANALYSIS OF STRUDL PROGRAMMING:

LOWEST NATURAL FREQUENCY FOR THE

NCX-600 BATTERY = 112.8 CYCLES PER SECOND

COMPARISON WITH THE NCX-1680 BATTERY:

LOWEST NATURAL FREQUENCY FOR THE

NCX-1680 BATTERY = 92.8 CYCLES PER SECOND

THEREFORE THE RIGIDITY OF THE NCX-600 BATTERY IS GREATER THAN THE NCX-1680 BATTERY.

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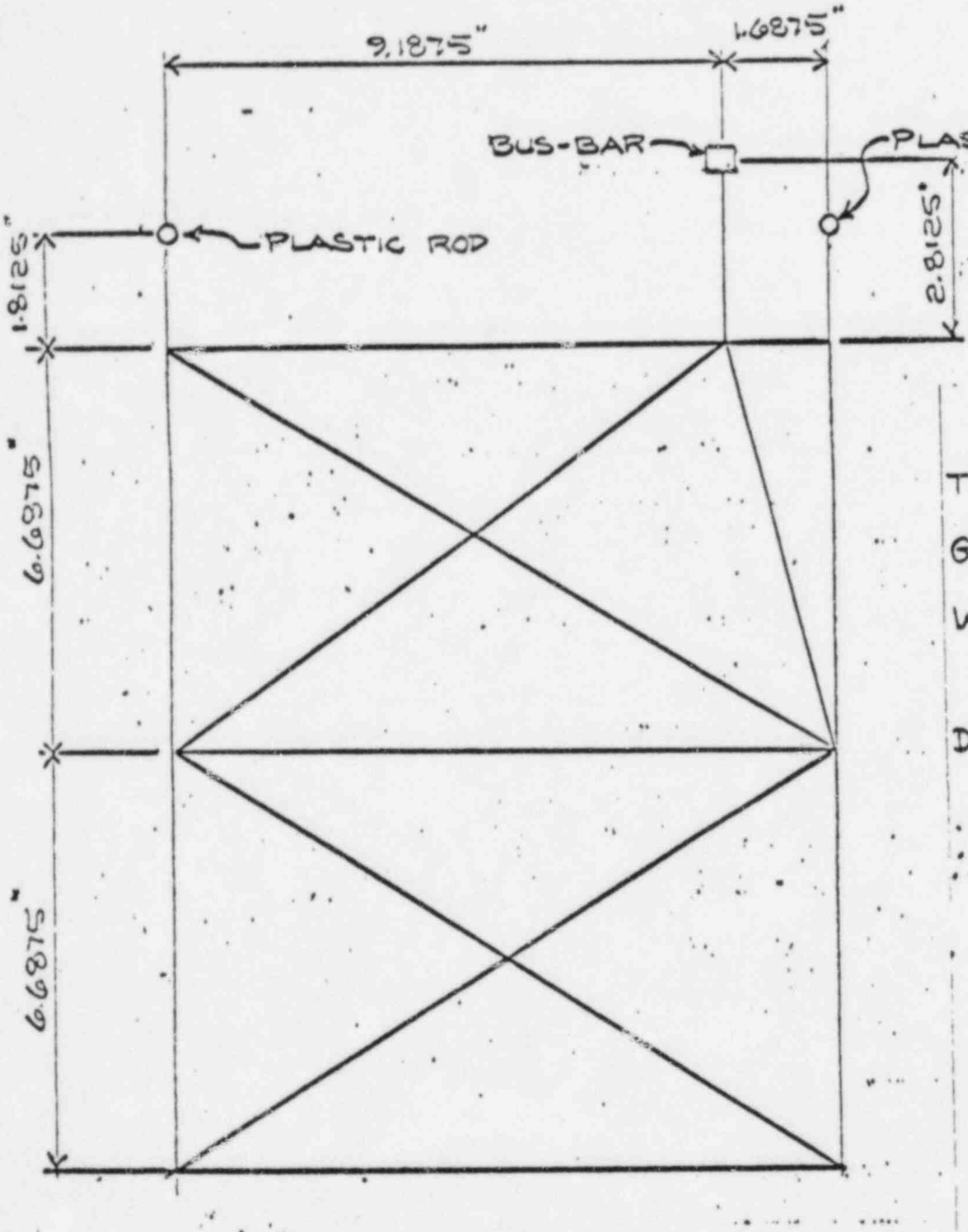
MODEL OF POSITIVE PLATES



THICKNESS OF +VE GRID = 0.318"
WGT. OF +VE GRID = 5.9 #
DESITY OF LEAD = 0.4 #/IN^3
∴ VOL. OF GRID = 5.9/.4 = 14.75 IN

PROPERTIES OF MEMBERS:

TOTAL LENGTH OF ALL MEMBERS = 2x15.1875 + 4x12.77 + 3x10 = 114"

TOTAL VOL. OF ALL MEMBERS = 14.75 IN^3

∴ CROSS SECTIONAL AREA OF MEMBERS = $\frac{14.75}{114}$ = 0.13 IN

∴ EQUIVALENT WIDTH OF MEMBERS = 0.13/0.318 = 0.41 IN

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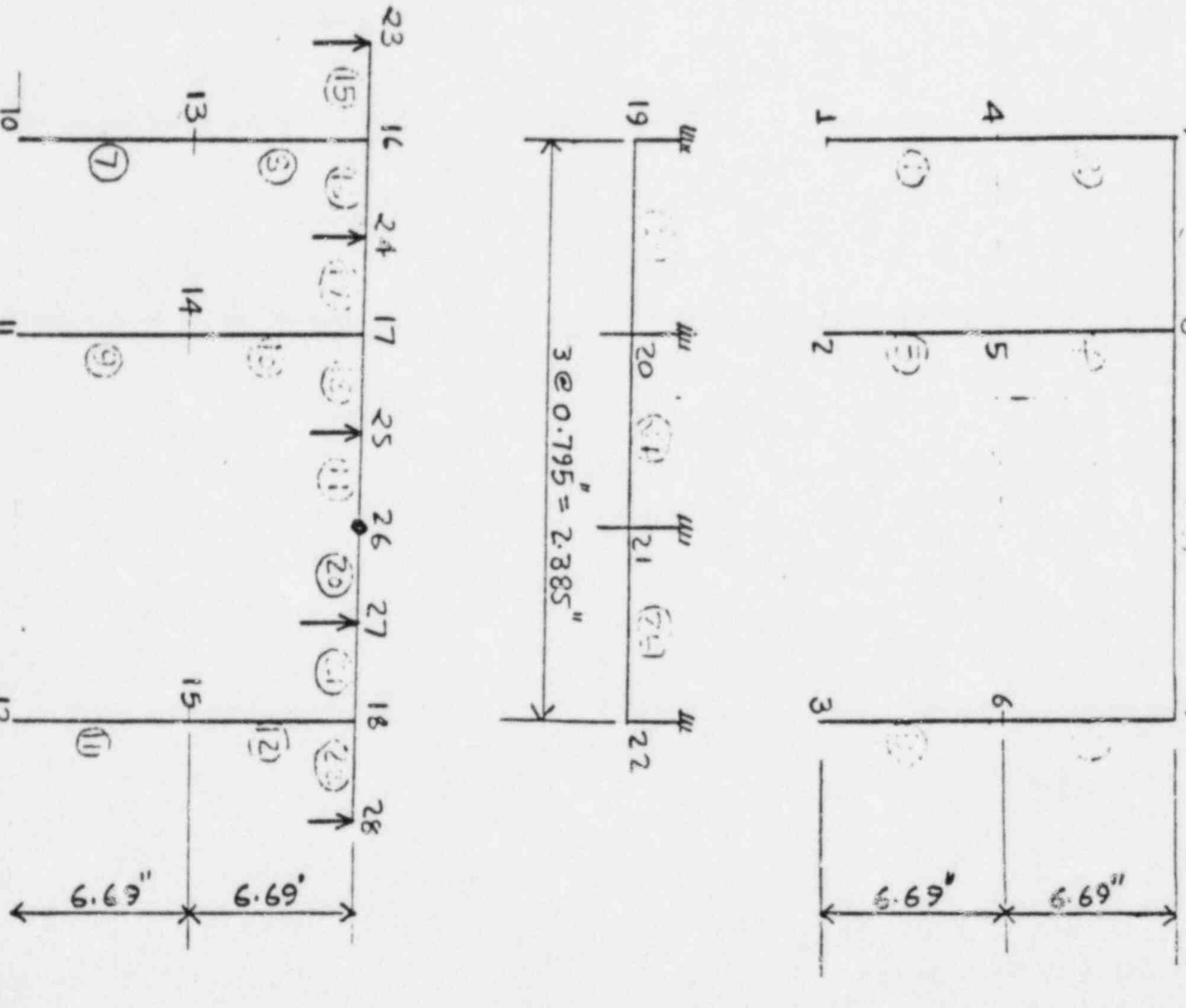

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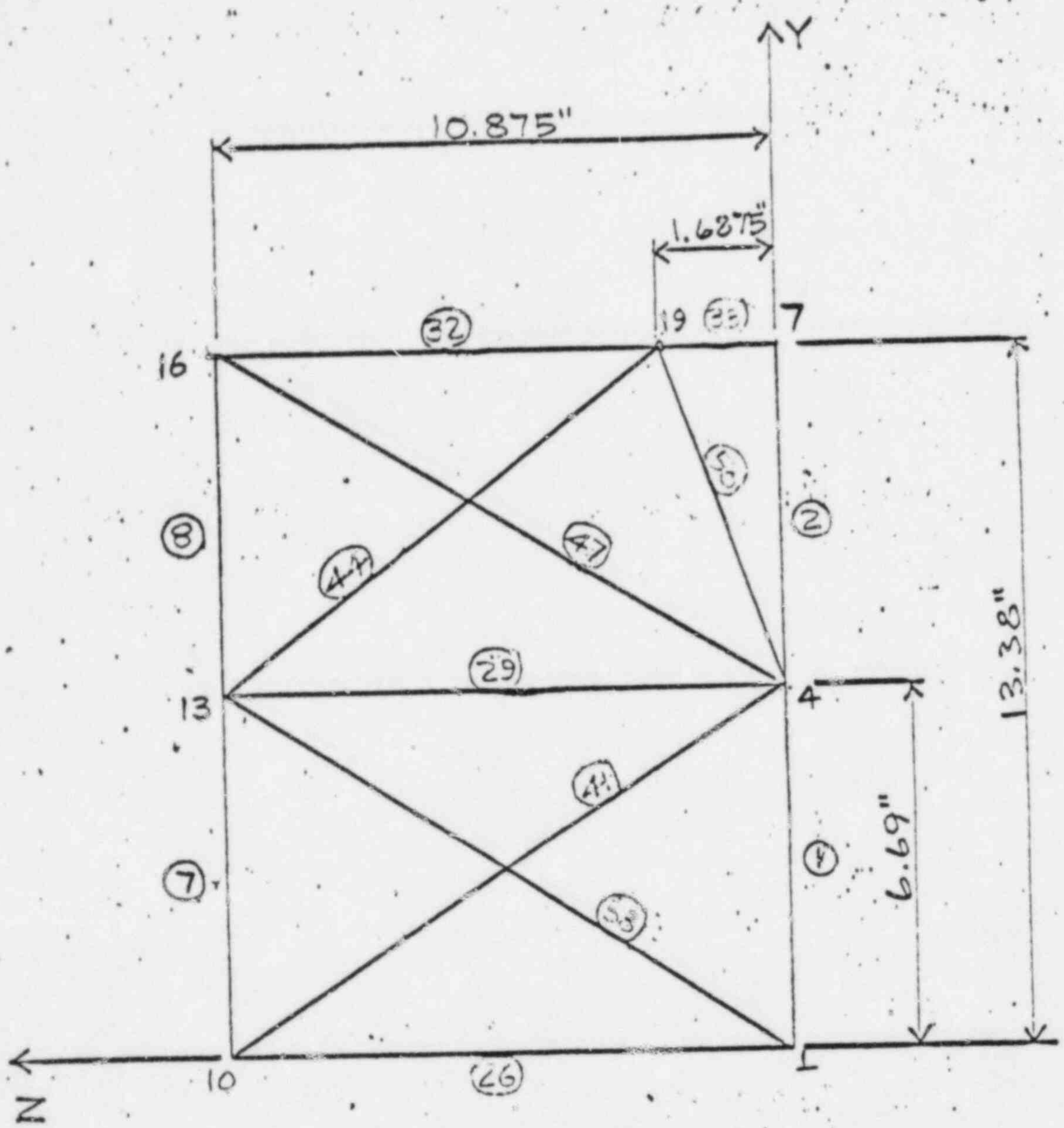

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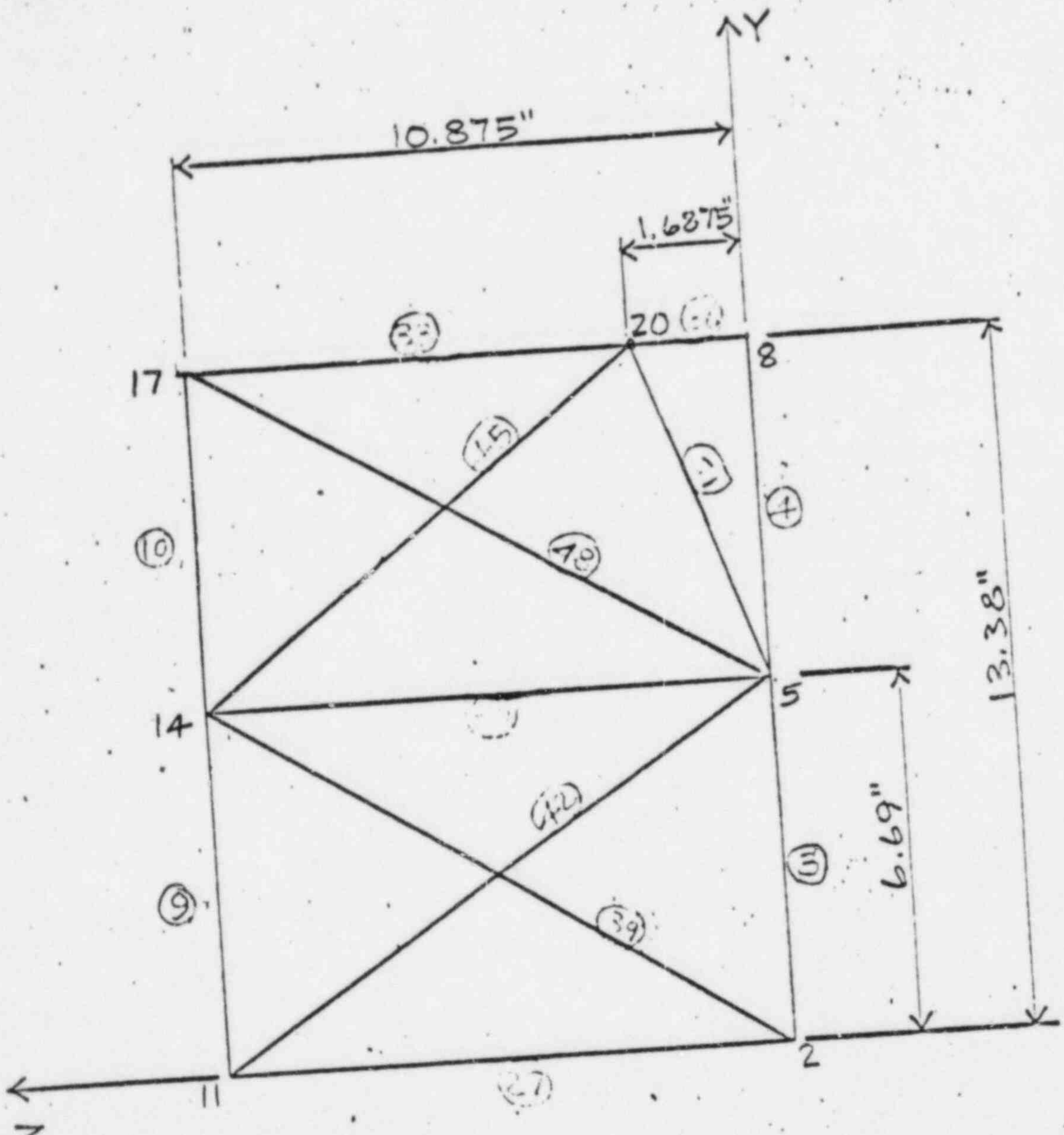

SHEET # 8 OF # 8

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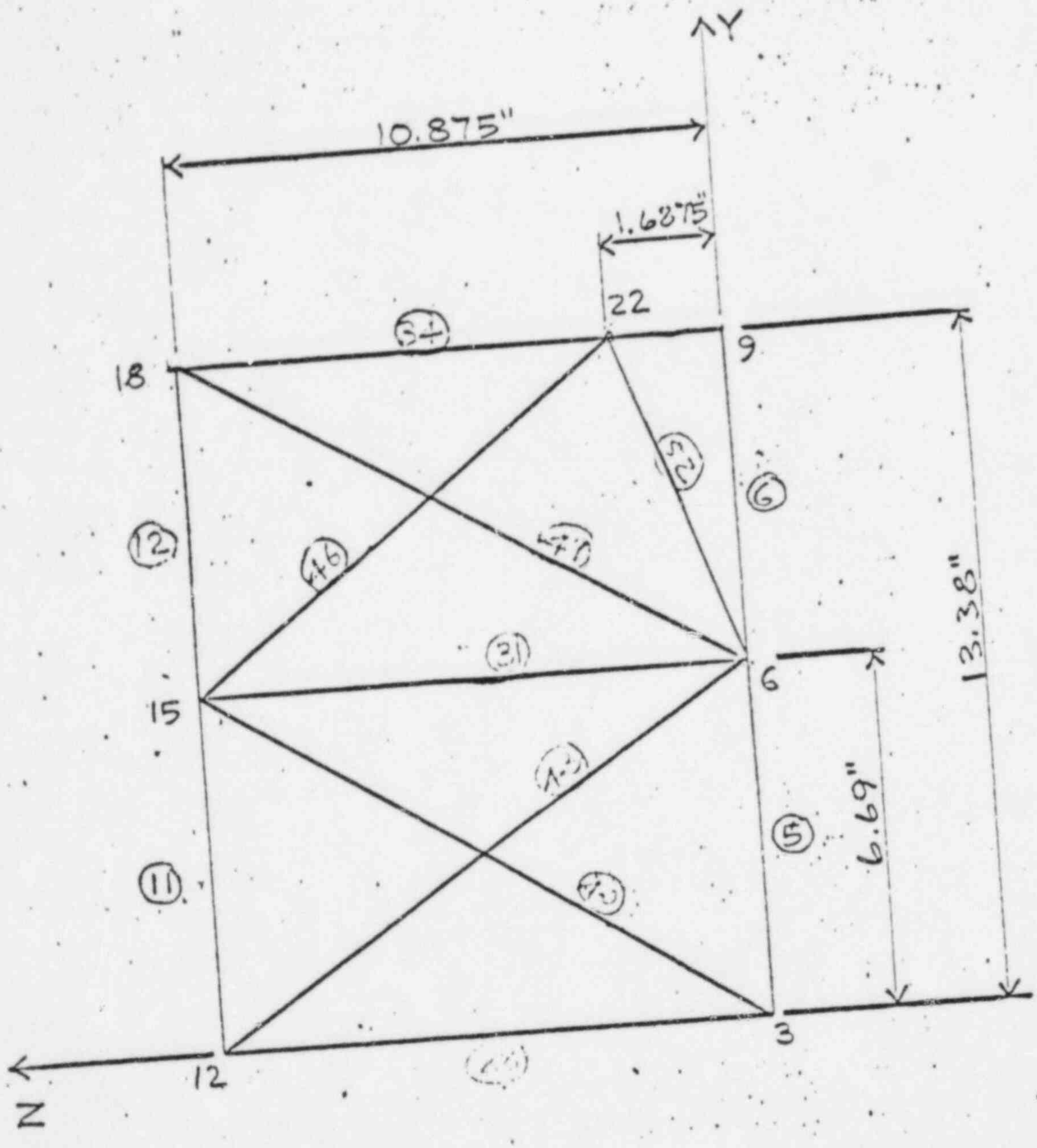

SECTION #12

CONCLUSIONS

The primary objective of this test program was to demonstrate capability of our batteries and racks in accordance with the following documents in general and Sargent & Lundy Specification F/L 2819 for the Commonwealth Edison Company Byron/Braidwood Project in particular.

1. ANSI/IEEE Std 279-1971, Criteria for Protection Systems for Nuclear Power Generating Stations.
2. IEEE Std 308-1978, Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.
3. IEEE Std 323-1974, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.
4. ANSI/IEEE Std 450-1975, Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations.
5. ANSI/IEEE Std 484-1975, Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations.
6. ANSI/IEEE Std 344-1975, Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.
7. IEEE Std 380-1975, Definitions of Terms Used in IEEE Standards on Nuclear Power Generating Stations.
8. IEEE Std 485-1978, Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations.
9. American Institute of Steel Construction (AISC) Standard Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, New York, 1965.
10. IEEE Std 535-1979 IEEE, Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations.

Sections #1 and #7 of this test report describe the methodology used in carrying out this test program.

Sections #2 and 3 demonstrate the origin as well as the environmental and operating conditions to which the naturally aged test specimens were exposed.

Section #4 demonstrates that the naturally aged test specimens and those cells being supplied on the Commonwealth Edison Co./Sargent & Lundy contract for Byron/Braidwood Project are of the same design and materials.

Section #5 demonstrates that the test fixture used for this test program is adequately strong for the Gould required response spectra.

Section #6 demonstrates that the racks supplied under Commonwealth Edison Co./ Sargent & Lundy Engineers contract for Byron/Braidwood Project are also adequately strong and are rigid structures having natural frequency of vibrations above 33 hz.

Section #7 summarizes the test series involving all naturally aged specimens. Each test series is comprised of pre and post seismic capacity discharge tests and random multi-frequency vibration test.

Sections #8 demonstrates that the test response spectra envelopes the required response spectra of Gould as well as Commonwealth Edison Co./Sargent & Lundy Engineers contract for the Byron/Braidwood -- all frequencies at 2% damping.

Section #9 contains two Wyle test reports -- No. 44681-1 and 44681-2. 44681-1 demonstrates the capability of Gould plante' type of batteries. This report is not part of this documentation. 44681-2 demonstrates the capability of Gould

calcium flat pasted plate type of batteries. These types of batteries are supplied under Commonwealth Edison Co./Sargent & Lundy Engineers contract for Byron/ Braidwood Project.

The complete report, as described above, describes, documents and demonstrates that the batteries supplied by the Industrial Battery Division of Gould, Inc. under Commonwealth Edison Co. contract for Byron/Braidwood Project are capable of meeting with Sargent & Lundy Engineers Specification F/L 2819. The NCX type is qualified for a period of (10) ten years when operated in a yearly average temperature of 77°F and when installed and operated in accordance with IEEE 484-1981, IEEE 450-1980 and Gould Installation and Operating Instruction GB-3384B 6/80.

The Industrial Battery Division of Gould Inc. intends to pursue an ongoing qualification program to determin maximum qualified life beyond currently established 10 year qualified life for NCX type.